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EXECUTIVE CHAMBERS

HONOLULU

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JOHN WAIHEE
GOVERNOR

August 31, 1994

TO: Keith W. Ahue, Chairperson
Department of Land and Natural Resources

SUBJECT: Final Supplemental Environmental Impact Statement: Maalaea Harbor For Light-Draft Vessels

I am pleased to accept the Final Supplemental Environmental Impact Statement for the Maalaea Harbor for Light-Draft Vessels, Wailuku, Maui as satisfactory fulfillment of the requirements of Chapter 343, Hawaii Revised Statutes.

This environmental impact statement will be a useful tool in the process of deciding if the action described therein should be allowed to proceed. My acceptance of the statement is an affirmation of the adequacy of that statement under the applicable laws but does not constitute an endorsement of the proposed action.

I am particularly concerned about the loss and degradation of surf sites at Maalaea. This is one of the most popular surfing sites on Maui.

When the decision is made regarding the proposed action itself, I expect the appropriate legislative bodies and government agencies to consider if the societal benefits justify the economic, social, and environmental impacts which will likely occur. These impacts are adequately described in the statement which, together with the comments made by reviewers, provides useful analysis of the proposed action.

/S/ John Waihee

JOHN WAIHEE

c: Office of Environmental Quality Control

FINAL

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
FOR
MAALAEA HARBOR FOR LIGHT-DRAFT VESSELS
MAUI, HAWAII

Prepared by: U.S.ARMY ENGINEER DISTRICT, HONOLULU
Directorate of Engineering
Planning Division
Building 230
Fort Shafter, Hawaii 96858-5440

Sponsored by: STATE OF HAWAII
Department of Land and Natural Resources
Division of Boating and Ocean Recreation
79 South Nimitz Highway
Honolulu, Hawaii 96813

JULY 1994

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR MA'ALAEA HARBOR FOR LIGHT-DRAFT VESSELS MAUI, HAWAII

Tax Map Keys: 3-6-01:2, 41, 43, 45, 49, 50, 51

This Joint Document is Submitted Pursuant to 42 USC 4321, 40 CFR 1500-1508, 33 CFR 230, ER 1105-2-100, and Chapter 343, HRS

FEDERAL PROPONENT:
U.S. Army Engineer District, Honolulu

STATE PROPONENT:
Hawaii Department of Land and Natural Resources
Division of Boating and Ocean Recreation

ACCEPTING AUTHORITIES:

DISTRICT ENGINEER, HONOLULU ENGINEER DISTRICT
AND
GOVERNOR, STATE OF HAWAII

14 JUL 94

M. Bruce Elliott — **Date**
Lieutenant Colonel, U.S. Army
District Engineer

JUL 22 1994

Keith W. Ahue — **Date**
Chairperson, Board of Land and Natural Resources

Prepared by:
U.S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858-5440
July 1994

COVER SHEET

Co-Lead Agencies:
Federal: **U.S. Army Engineer District, Honolulu**
State: **Hawaii Department of Land and Natural Resources, Division of Boating and Ocean Recreation**

Proposed Action: **Improve Ma'alaea Harbor for Light-Draft Vessels, Ma'alaea Harbor, Maui, Hawaii**

Type of Report: **Joint Federal and State of Hawaii Final Supplemental Environmental Impact Statement**

Abstract:
The U.S. Army Engineer District, Honolulu, in partnership with the State of Hawaii, is planning to construct improvements to the Ma'alaea Harbor for light-draft vessels at Ma'alaea, Maui, Hawaii. The Federal portion of the improvements consists of realigning the entrance channel and modifying the existing breakwater to protect the new entrance channel. These improvements would reduce the surge within the harbor basin, reduce navigation hazards in the entrance channel, and provide opportunity for addition of commercial and recreational berthing spaces and attendant harbor facilities. The local sponsor, the State of Hawaii Department of Land and Natural Resources, Division of Boating and Ocean Recreation, will provide expanded berthing facilities and improved infrastructure, including fuel, sewage treatment, and pumpout facilities. Total construction costs are estimated at $11.7 million ($8.45 million in Federal funds and $3.25 in non-Federal funds).

A General Design Memorandum and Final Environmental Impact Statement (EIS) was prepared, circulated, and approved by the Chief of Engineers in 1980, and a State of Hawaii Revised EIS was circulated and accepted by the Governor in 1982. The project remained unfunded until fiscal year 1989. The 1980 and 1982 plans of improvement were modifications of the plan originally approved by Congress in 1968.

Present studies conducted for this SFEIS indicate that the preferred alternative will fully achieve the Federal and State project purposes. Environmental effects include degradation of water quality within the harbor, destruction or alteration of 12 acres of marine habitat, including coral reefs, destruction of a small sandy beach, and destruction and modification of surfing sites.

Please provide your comments on this Final Supplemental Environmental Impact Statement (FSEIS) by ________ to the address shown below:

Commander
U.S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV (Lennan)
Building T-1
Fort Shafter, Hawaii 96825-5440
Telephone (808) 438-2264; Fax (808) 841-1581

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CHAPTER 1

SUMMARY

1.1 MAJOR CONCLUSIONS

1.1.1 MAJOR CONCLUSIONS FROM PREVIOUS STUDIES

The Corp's 1980 General Design Memorandum (GDM) and Final Environmental Impact Statement (FEIS) concluded that all three of the alternative plans presented met the primary objectives of reducing surge within the harbor; reducing the navigational hazards in the entrance channel; and thereby, increasing the berthing capacity of the harbor. The report further concluded that Plan 1 was the National Economic Development (NED) plan because it would maximize net economic benefits, and therefore was the recommended plan. It also concluded that all the alternative plans would have a net benefit on the marine environment because of the increased habitat provided by the improved breakwater. Although the plans would have a positive benefit because of the habitat improvement provided by the breakwater, some dredged material would be disposed upland, creating a negative impact. *It was not possible to quantify and compare these two* impacts, so that an Environmental Quality Plan (EQ) was not selected.

The State of Hawaii's Revised Environmental Impact Statement (REIS) concluded that a berthing plan for approximately 250 boats was the most appropriate for this harbor, and indicated the desired mix of sizes was for about 90 percent of the boats to be 40 feet and shorter.

1.1.2 MAJOR CONCLUSIONS FROM PRESENT STUDIES

This SEIS concludes that a modification of the 1980 Plan 1 is the Preferred Alternative because it would fulfill all the needs identified for the Federal and State actions. Plan 2 is the Environmentally Preferred Alternative because it would fulfill most of the purposes of the project, have less effect on Buzz's surf site, and would destroy less aquatic habitat. The proposed alternative plan would result in the unavoidable alteration of approximately 12 acres of marine habitat, including destruction of approximately 2 acres of coral reef habitat, and the destruction of one surf site and the modification of another.

It concludes that for the State of Hawaii's portion of the plan, the 250 boat general berthing layout is still the recommended layout, with some minor modifications, and a slight reduction in the number of berths. The current plan is for 220+/- boats, with the berthing layout revised appropriately from that shown in the 1982 FEIS. In addition to berths, the State of Hawaii will provide roads, bus turn-around, parking, electricity, lighting, water, fuel, pumpout facilities and improved waste oil storage, restrooms, and sewage treatment. The proposed improvements would result in the destruction of a small sandy beach. The increased vessel traffic is anticipated to result in increased turbidity in the harbor.

1.2 AREAS OF CONTROVERSY

Some of the residents near the harbor object to the expansion of the harbor with its increased traffic, noise and general increased activity. The surfing community also objects to the loss or degradation of the surf sites known as "Off-the-Wall", "Buzz's No. 1" (Sea Flight) and "Buzz's No. 2", and to any possible degradation of the world famous site known as "Ma'alaea Pipeline" or "Freight Trains". This objection is not limited to local surfers, but includes surfers worldwide and has been highlighted prominently in U.S. mainland surfing publications.

1.3 ISSUES YET TO BE RESOLVED.

One issue yet to be resolved is the elimination of Alternative Plan 6 from detailed consideration. The U.S. Fish and Wildlife Service (FWS) in its draft Fish and Wildlife Coordination Act (FWCA) Report had requested additional consideration of an alternative which restricted all improvements within the existing harbor boundaries to avoid any impacts to the marine environment outside the harbor. Further study of Alternative 6 resulted in the determination that it was not feasible because of hydraulic considerations. Alternative 6 would not meet the purposes of the proposed action and would actually worsen existing navigation and safety conditions. The reasons for not further considering Alternative 6 in detail are being provided to the FWS so that a final FWCA report can be prepared.

Another issue relates to mitigation for destruction of reef habitat. Approximately 2 acres of coral reef habitat will be directly impacted during project construction. Although the proposed improvements will create additional habitat for marine life in the form of stone revetment, the stones will not fully replace the physical heterogeneity, interstitial complexity, and vertical relief of existing habitat. Therefore, additional mitigation is recommended by FWS in the form of construction of an artificial reef and/or official protection of remaining reef habitat.

Finally, mitigation for the destruction of a surf site and a small sandy beach remains an unresolved issue. The Corps has conducted a feasibility study on mitigation for the loss of surf sites, and recommended modifications to the proposed project have been adopted from that study. The project design for navigation improvements has been modified and refined in order to avoid and minimize impacts to the extent practicable.

1.4 COMPLIANCE WITH ENVIRONMENTAL PROTECTION LAWS

At this stage of the planning process the project is in full or partial compliance with all applicable environmental protection laws, although additional compliance actions may be required during later stages (See Table 1).

TABLE 1
COMPLIANCE WITH FEDERAL AND STATE ENVIRONMENTAL PROTECTION LAWS.

Federal Statutes	Applicability	Compliance Status
American Folklore Preservation Act	No	NA
Anadromous Fish Conservation Act	No	NA
Antiquities Act of 1906	No	NA
Archaeological Resources Protection Act	No	NA
Bald Eagle Act	No	NA
Clean Air Act	Yes	Full
Clean Water Act	Yes	Partial
Coastal Zone Management Act	Yes	Partial
Endangered Species Act	Yes	Full
Estuaries Protection Act	No	NA
Federal Environmental Pesticide Control Act	No	NA
Federal Water Project Recreation Act	No	NA
Fish and Wildlife Coordination Act	Yes	Partial
Historic Sites Act	No	NA
Hawaiian Islands National Marine Sanctuary Act	Yes	Partial
Land and Water Conservation Fund Act	No	NA
Marine Mammal Protection Act	Yes	Full
Marine Protection, Research and Sanctuaries Act	Yes	Partial
Migratory Bird Conservation Act	Yes	Full
Migratory Bird Treaty Act	Yes	Full
National Environmental Policy Act	Yes	Partial
National Historic Preservation Act	Yes	Full
Native American Graves Protection and Repatriation Act	No	NA
Native American Religious Freedom Act	No	NA
Resource Conservation and Recovery Act	Yes	Full
River and Harbor Act of 1899	Yes	Partial
Submerged Lands Act	No	NA
Surface Mining Control and Reclamation Act	No	NA
Toxic Substances Control Act	No	NA
Watershed Protection and Flood Prevention Act	Yes	Full
Wild and Scenic Rivers Act	No	NA
Presidential Executive Orders		
11514 - Protection and Enhancement of Environmental Quality	Yes	Full
11593 - Protection and Enhancement of the		

Cultural Environment	Yes	Full
Presidential Executive Orders	**Applicability**	**Compliance Status**
11988 - Floodplain Management	Yes	Full
11990 - Protection of Wetlands	Yes	Full
12088 - Federal Compliance with Pollution Control Standards	Yes	Full
State Of Hawaii Statutes		
HRS Chapter 343 - EIS Rules	Yes	Partial
HRS Chapter 6E - Historic Preservation	Yes	Full
Ocean Resources Management Plan	Yes	Full

Notes:

Yes (Statute is Applicable). Statute is applicable and compliance is required.

No (Statute is Not Applicable). Statute is not applicable or resource covered is not in the project area.

Partial (Partial Compliance). Having met all requirements of the statute for the current stage of planning, but anticipate future obligations.

Full (Full Compliance). Having met all requirements of the statute.

NA (Not Applicable). No requirement for the statute, or the resource is not present at the project site.

CHAPTER 2

PURPOSE OF AND NEED FOR THE PROPOSED ACTION

2.1 BACKGROUND

Ma'alaea Harbor on the island of Maui (Figures 1 & 2) was first developed by the Territory of Hawaii in 1952, and was modified by the Territory and State in 1955, 1959 and 1979 to its present configuration (Figure 3). In 1968 Congress approved a Federal plan of improvement (Figure 4) for the harbor. In response to community concern for the destruction of the surf break known as "Ma'alaea Pipeline" that would be caused by the 1968 design, a post-authorization study and redesign was conducted and approved in 1980 (Figure 5). Users and potential users identified a shortage of berths, vessel damage, serious navigation problems, inadequate harbor facilities, and concerns about impacts on surfing sites.

No new civil works construction starts were authorized during most of the 1980's. In 1989, Congress added construction funds for the Ma'alaea project to the FY 90 Water and Energy Appropriations Bill, and work on the project resumed. A draft Environmental Assessment (EA) was prepared and circulated in October 1989, and a final EA in October 1990. The final EA determined that a supplemental EIS was required because some of the environmental conditions in the project area had changed, and new information concerning environmental constraints had surfaced.

2.2 PURPOSE OF THE PROPOSED ACTION

2.2.1 <u>PURPOSE OF THE FEDERAL PROJECT</u>

The purpose of the project is to provide needed improvements to the Ma'alaea Harbor for light-draft vessels, Maui, Hawaii. The improvements are intended to reduce the surge and resultant damage to vessels caused by wave action in the harbor and entrance channel and to provide opportunity for the addition of berthing space and attendant harbor facilities.

The objectives of the proposed action are specifically directed to the need for navigation improvements for commercial and recreational purposes at Ma'alaea Harbor. Specific goals include:

a. to reduce surge within the harbor basin;

b. to reduce navigation hazards in the entrance channel; and

c. to provide opportunity for addition of commercial and recreational berthing spaces and attendant harbor facilities.

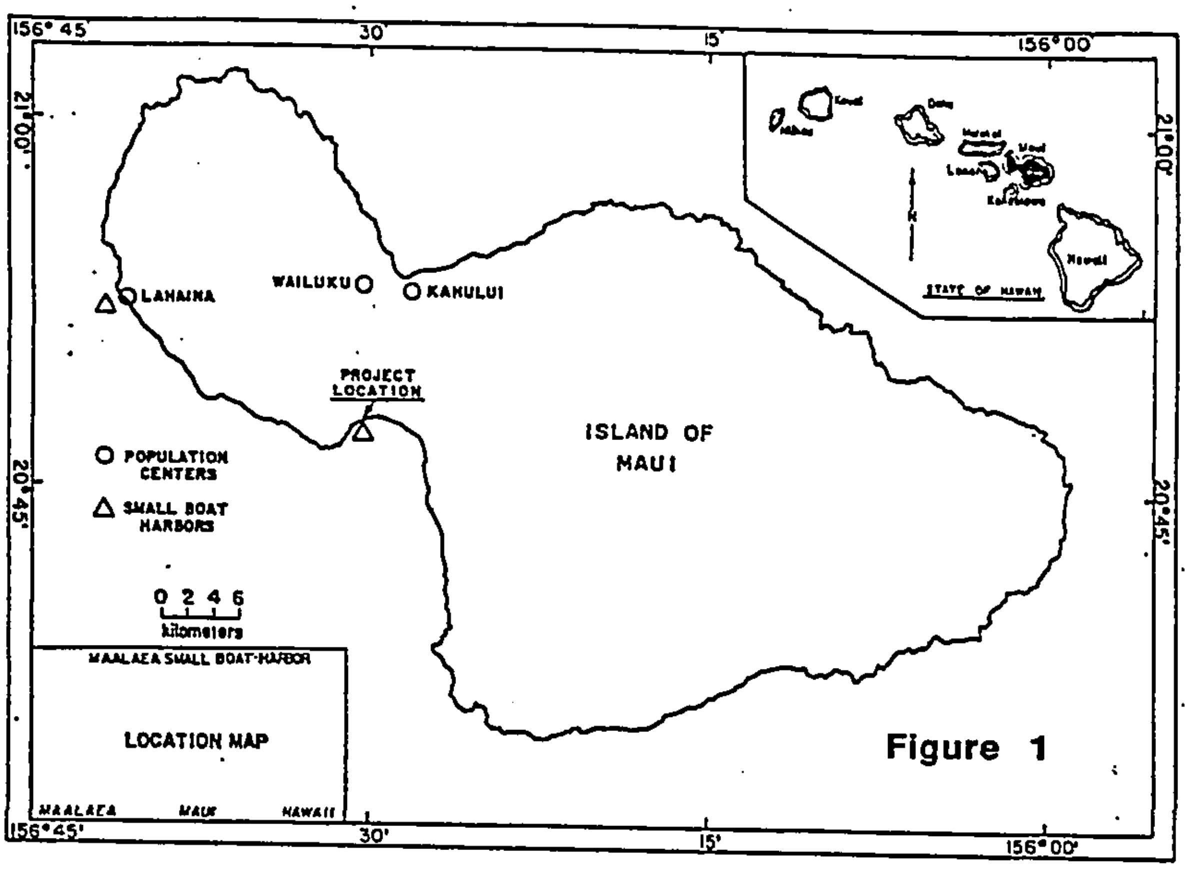

Figure 1

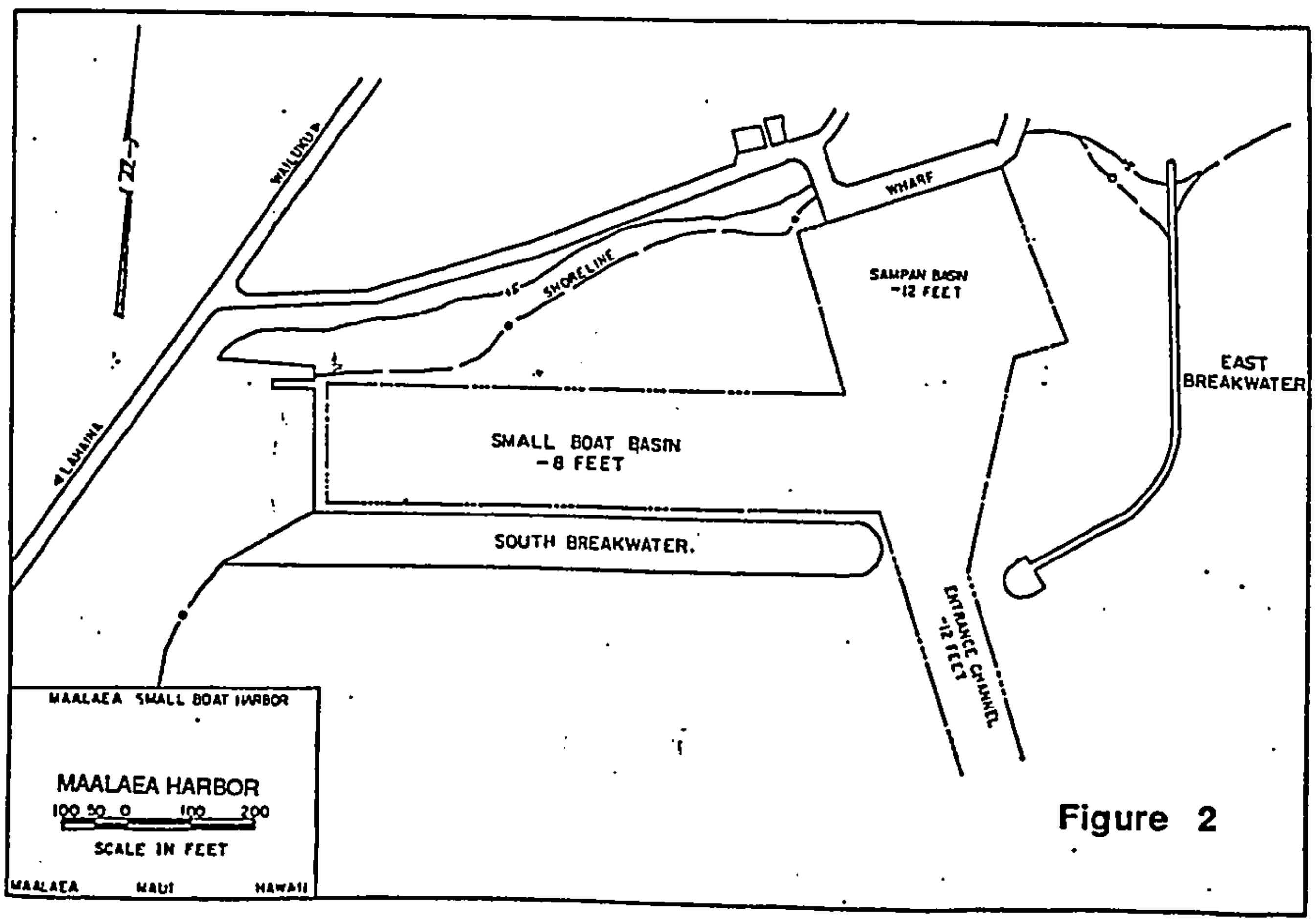

Figure 2

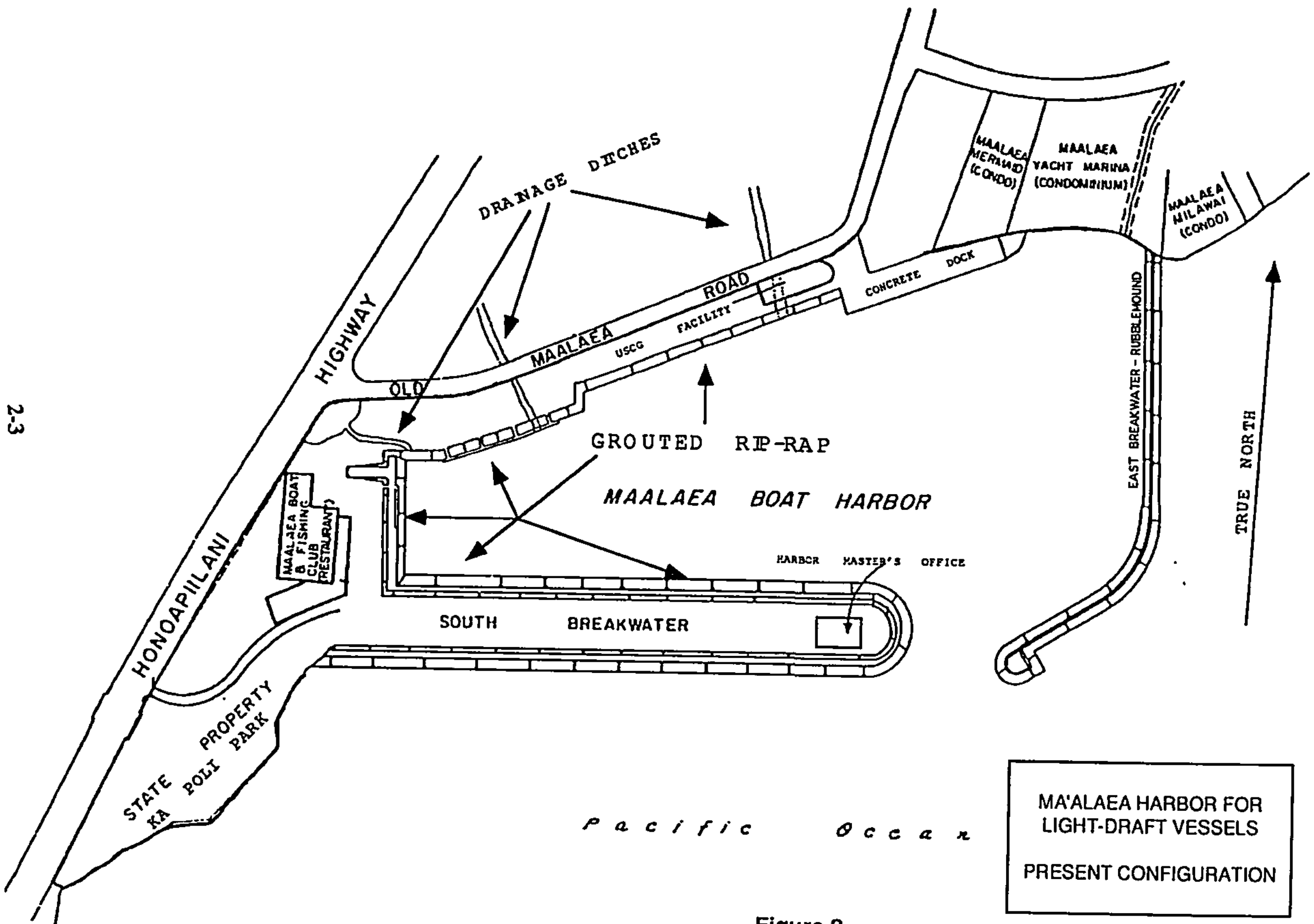
DRAINAGE DITCHES
HIGHWAY
HONOAPIILANI
OLD
MAALAEA ROAD
USCG FACILITY
CONCRETE DOCK
MAALAEA MERMAID (CONDO)
MAALAEA YACHT MARINA (CONDOMINIUM)
MAALAEA KILAWAI (CONDO)
EAST BREAKWATER - RUBBLEMOUND
TRUE NORTH
GROUTED RIP-RAP
MAALAEA BOAT HARBOR
HARBOR MASTER'S OFFICE
MAALAEA BOAT & FISHING CLUB (RESTAURANT)
SOUTH BREAKWATER
STATE PROPERTY KA POLI PARK
Pacific Ocean
MA'ALAEA HARBOR FOR LIGHT-DRAFT VESSELS
PRESENT CONFIGURATION

Figure 3

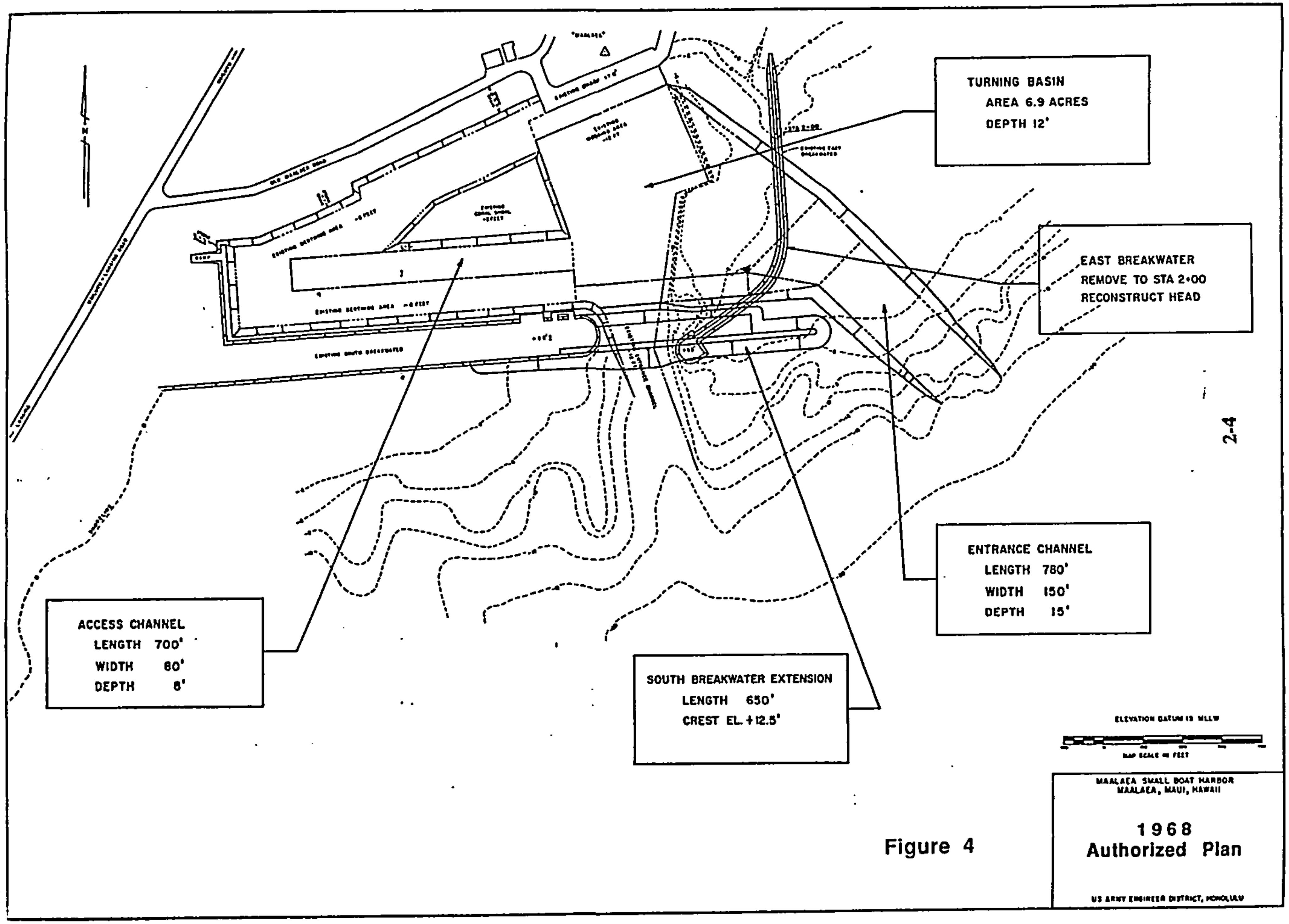

Figure 4

1968 Authorized Plan

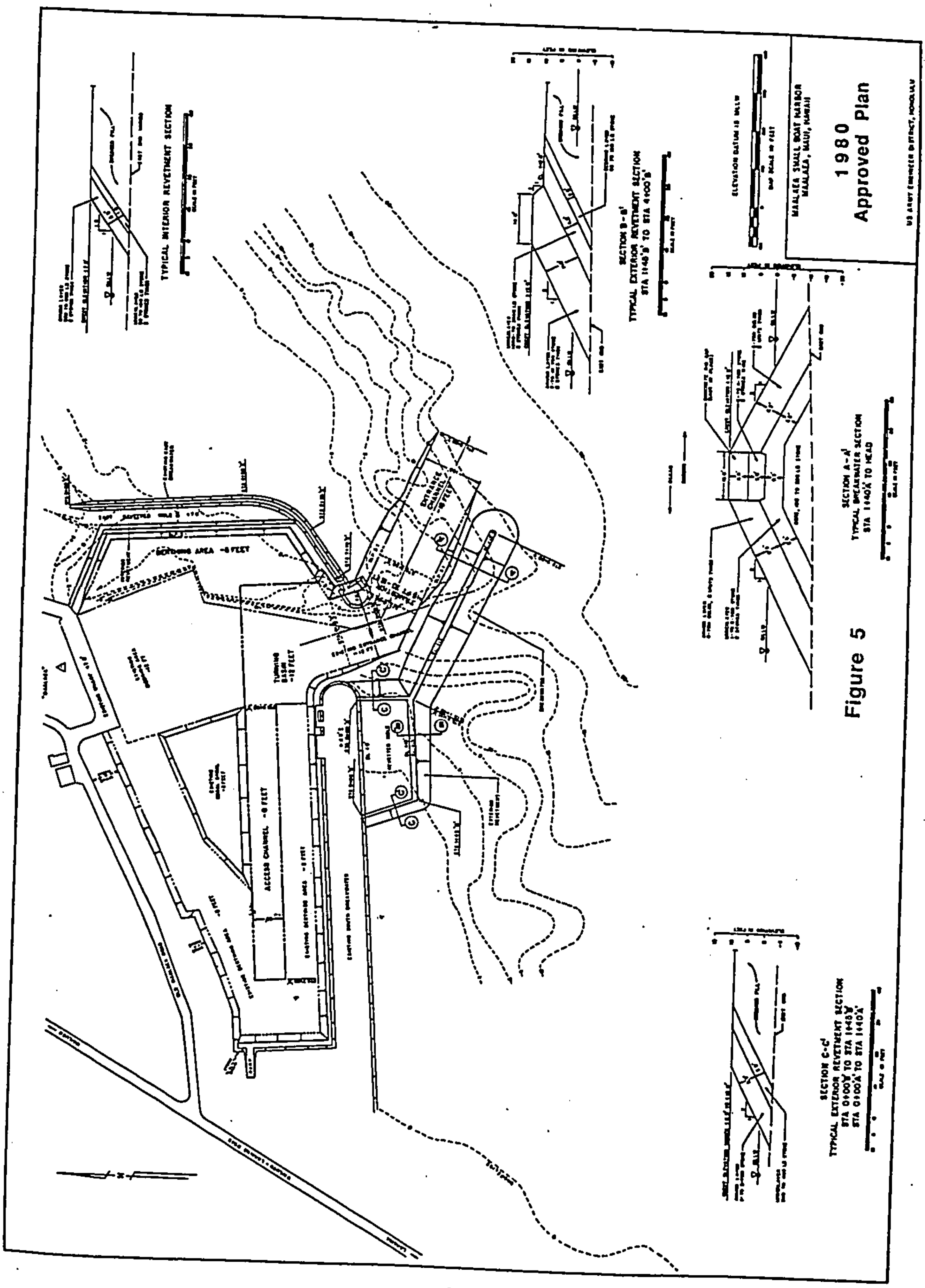
MAALAEA SMALL BOAT HARBOR
MAALAEA, MAUI, HAWAII
1980
Approved Plan
TYPICAL INTERIOR REVETMENT SECTION
SECTION B-B'
TYPICAL EXTERIOR REVETMENT SECTION
SECTION A-A'
TYPICAL BREAKWATER SECTION
SECTION C-C'
TYPICAL EXTERIOR REVETMENT SECTION
ACCESS CHANNEL -8 FEET
ENTRANCE CHANNEL
TURNING BASIN

Figure 5

2.2.2 PURPOSE OF THE STATE PROJECT

The purpose of the State (local sponsor) project is to develop the internal improvements to the boat harbor which will be feasible once the Federal navigation improvements are developed. Objectives include increasing the number of berths that presently exist in the harbor and improving the existing harbor facilities in conformance with the Federal plan for navigation improvements in the harbor. The additional berthing facilities and infrastructure are not included in the Federal portion of the project and will be provided by the Department of Land and Natural Resources, Division of Boating and Ocean Recreation (DBOR) (formerly Department of Transportation, Harbors Division, Boating Branch). The development of the State project is dependent upon the construction of the Federal improvements.

2.3 NEED FOR THE PROPOSED PROJECTS

Problems and needs related to the harbor are numerous and have been expressed by harbor users, potential harbor users, and persons and organizations concerned with commercial, recreational and other uses of the harbor area. Navigation problems include severe harbor surge which causes vessel damage, difficulties navigating in the entrance channel, and shortage of berths and adequate harbor facilities. Related problems and needs include other recreational uses of the harbor and nearby area, and environmental problems.

Reduction of surge within the existing harbor basin is the primary concern of existing harbor users. Surge occurs in various locations within the harbor basin when wave heights exceed about 2 feet at the harbor entrance. The current configuration and alignment of the harbor entrance allows direct wave attack through the channel opening. Damage to boats and broken mooring lines have been repeatedly attributed to severe surge. Some vessels must leave the harbor when heavy surge occurs; this poses a particularly dangerous situation during storms.

Navigation is hazardous within the entrance channel when wave heights exceed about 6 feet. Dangers include boats hitting the channel bottom, broaching, and grounding on the breakwater structures. In addition, surfers occasionally attempt to ride breaking waves through the harbor entrance, creating an additional hazard to themselves and other harbor users.

A shortage of berthing space for light-draft vessels has existed for many years. In 1993 there were approximately 300 individuals and corporations on the waiting list for berths at Ma'alaea Harbor. This long-standing shortage has resulted, among other things, in several illegal moorings, which have adverse effects to navigation and to endangered species.

Harbor users indicate an inadequate availability of fresh water, electricity, fuel and equipment storage space. Inadequate boat launching and retrieving capability, a shortage of parking spaces for automobiles and trailers, and lack of a bus turnaround have also been identified.

There is also a need to resolve conflicting recreational uses of the harbor area among boaters, surfers, and other uses. Alterations of the existing configuration of the harbor structures have the potential to destroy or interfere with use of prime surfing areas.

Environmental needs include protection of reef resources, conservation/improvement of existing water quality within the harbor, protection of threatened and endangered species and other fish and wildlife resources, and minimizing impacts to surf sites.

2.4 INCORPORATION BY REFERENCE

The General Design Memorandum (GDM) and Final Environmental Impact Statement (FEIS) for the post-authorization modification plan, revision of 26 September 1980, and the State of Hawaii, Department of Transportation, Harbors Division, Revised Environmental Impact Statement (REIS) for Improvements to the Ma'alaea Boat Harbor Ma'alaea, Maui, July 1982 are incorporated herein by reference.

CHAPTER 3

ALTERNATIVES

3.1 BACKGROUND AND PREVIOUS STUDIES

3.1.1 FEDERAL PROJECT

The U.S. Army Corps of Engineers, Honolulu District, previously described the feasibility and the impacts of navigation improvements for Ma'alaea Harbor in the General Design Memorandum and Final Environmental Impact Statement, Ma'alaea Harbor for Light-Draft Vessels, Maui, Hawaii, dated 26 September 1980. That report presented the results of the post-authorization studies for modification of the small boat harbor. The purpose of the post-authorization studies was to reaffirm the basic planning decisions made during the pre-authorization studies, while responding to changes in the physical, social, economic, and environmental conditions related to the project, and to changes in Corps water resources planning policies. These post-authorization studies included reevaluation of problems and needs, public attitudes regarding the authorized plan of improvement, possible alternatives, and social, environmental, and economic analyses. The studies and investigations were performed in cooperation with the Harbors Division, Department of Transportation, State of Hawaii.

The original authorized plan for construction of harbor improvements was contained in the Chief of Engineers' report, dated 11 April 1968 (contained in House Document No. 353, 90th Congress, 2nd Session). The plan's features included: (a) a 650-foot-long extension to the existing south breakwater; (b) a 780-foot-long, 150-foot-wide, 15-foot deep main entrance channel, including a 150-foot-long transition area providing a change in depth from 15 feet to 12 feet and flaring of width from 150 feet to about 300 feet; (c) a 6.9-acre turning basin; (d) a 700-foot-long, 80-foot-wide, 8-foot-deep access channel; (e) removal of portions of the east breakwater; and (f) tree plantings for project beautification. The harbor, as authorized, would accommodate about 260 boats.

The objectives of the pre-authorization studies were to analyze the remaining requirements for additional base harbors to satisfy most of the State's projected light-draft vessel needs to the year 2020 and to study the need for harbors intended exclusively for refuge purposes. The 1980 updated planning objective was to contribute to navigation improvement for commercial and recreational purposes at Ma'alaea Harbor for the 1985 to 2035 period of analysis. Specific goals were to (a) reduce surge within the harbor basin; (b) reduce navigation hazards in the entrance channel; and (c) to provide opportunity for addition of commercial and recreational berthing space and attendant harbor facilities.

The formulation and evaluation of alternatives were guided by technical, economic, and environmental criteria. Technical criteria included: (a) harbor improvements should provide safe navigation and protection for the design vessel (110 feet, beam 24 feet, draft 7.5 feet) during all reasonably expected weather and sea conditions; (b) improvements should include a turning basin adequate for maneuvering of the design vessel, and berthing areas suitable for commercial fishing boats and pleasure boats; (c) the entrance channel should be of adequate depth and width to safely permit navigation by the design vessel concurrent with navigation by a typical 55-foot-long recreation craft; and (d) protective structures should be designed to withstand the most severe combination of weather and sea conditions that are reasonably characteristic of the study area.

Economic criteria were: (a) net benefits which result from implementation of the recommended plan should be maximized; and (b) the benefits and costs should be expressed in comparable quantitative economic terms to the fullest extent possible. Environmental criteria included: (a) long-term disturbances to the physical environment should be minimized; (b) short-term disturbances to the physical environment should be controlled to prevent long-term effects; (c) environmental protection guidelines should be followed to the maximum extent practicable; (d) impacts on surfing sites should be minimized; and (5) impacts on the endangered humpback whale should be minimized.

Information received and developed during the problem identification stage of post-authorization planning confirmed the need for an investigation of possible alternative locations for the authorized entrance channel. Local interests expressed a desire to minimize changes to existing structures, particularly with regard to relocation of any existing berths. The State of Hawaii (local sponsor) also expressed the need for additional parking and a bus turnaround on the modified breakwater. Alternatives to the authorized plan were developed to respond to the technical, economic, and environmental criteria, to the planning objectives, to public desires, and to the local sponsor's needs.

Preliminary planning during the 1980 GDM preparation resulted in three alternative plans to the authorized plan. Alternative Plan 1 included an extension to the existing south breakwater; addition of a revetted mole on the seaward side of the existing south breakwater; entrance channel, turning basin; removal of 80 feet of a portion of the east breakwater; and other improvements by the sponsor. Alternative Plan 2 was similar to Alternative Plan 1, except that the revetted mole on the seaward side of the existing south breakwater would be replaced by a wave absorber. Alternative Plan 3 is the same as Alternative Plan 1 except that the revetted mole on the seaward face of the existing south breakwater is not included, and the breakwater is detached from the existing structure. The estimated average annual costs of Alternative Plans 1, 2, and 3 was $380,000, $368,000 and $430,000, respectively, based on January 1980 price levels.

Investigation of alternative harbor sites was not performed because of the substantial investment already committed at the authorized site, because of the need to upgrade the existing harbor, and because of anticipated extensive environmental and economic impacts of developing a new site. Non structural alternatives were also not investigated because of the failure of such measures to meet the planning objectives. The original authorized plan was modified because of unacceptable recreational and environmental impacts associated with the location of the entrance channel.

The selected plan in the 1980 GDM was Alternative Plan 1 (Figure 4), which was the National Economic Development Plan, and which was favored by the local sponsor.

3.1.2 STATE PROJECT

Development of the a Federal plan permitted the formulation of design guidelines by the State of Hawaii for the interior harbor improvements in July 1982 (R. M. Towill Corp 1982). The objectives of this plan were to increase internal berthing accommodations and improve the support facilities throughout the harbor. Criteria developed for design and construction efforts included (a) minimize environmental losses; (b) maximize beneficial environmental consequences; (c) assure efficient utilization of water and land areas; (d) provide adequate, safe and appropriate facilities; (e) enhance existing and potential recreational opportunities; (f) assure consistency with the objectives and policies of the Hawaii Coastal Zone Management Program; and (g) develop resulting projects in the best interest of the State of Hawaii.

Additional design constraints included: (a) dredging within the harbor and excess off-site dredge spoil disposal should be minimized to reduce construction costs; (b) the distribution of berth lengths within the harbor should be a reasonable extrapolation of the boat population both existing and on the waiting list; (c) existing facilities in good repair should be retained to the extent practicable to reduce the cost of new construction; (d) support facilities must be expanded and improved to accommodate the increased use of the harbor; (e) a 1:1 ratio of parking stalls to boat berths is desired within a reasonable distance from parking stalls to berths; (f) good vessel, vehicle and pedestrian circulation must be maintained; (g) the recommended plan must lend itself to phased construction to accommodate available funds and minimize disruption of harbor use; and (h) revenues from land and water use must be maximized to cover capital investment and O&M (operations and maintenance) costs.

The State's recommended plan included: (a) construction of a harbor center mole; (b) construction of an east mole; (c) administration building; (d) increased number of berths (251) ranging from 20 feet to 100 feet; (e) increased number of parking stalls and paved areas; (f) fueling and service dock; and (g) new utilities.

3.2 PRESENT STUDIES

Because of the amount of time that had passed since the preparation of the 1980 GDM and EIS, the alternatives formulation and evaluation studies have been updated to consider current needs and purposes of the local sponsor and affected publics, and changes in environmental conditions and regulations.

The planning objectives and goals have not changed since the 1980 studies were completed. No major changes have occurred in the technical criteria used to formulate and evaluate alternatives. Although the U.S. Coast Guard has since 1980 replaced its 95-foot patrol boat with a small boat station operation, the harbor is occasionally used by two tour boats measuring over 100 feet long. Any changes in environmental conditions and regulations have been considered in the reevaluation of alternatives.

The alternatives considered in the current study are basically the same as those evaluated in 1980, with some modifications and/or refinements to respond to the local sponsor's and affected publics' concerns and to avoid or minimize adverse environmental effects.

The purpose of the Federal plan of improvement is to reduce surge in the harbor basin, to reduce navigation hazards in the entrance channel, and to provide opportunity for expansion of the harbor and other local improvements. DBOR's plan is to provide additional berthing spaces and supporting facilities and services. DBOR's plan is discussed first; then the various Federal alternatives which allow their plan to be developed.

3.2.1 STATE PLAN

The proposed State plan is similar to the 1982 State plan (Figures 6 and 7). The construction of the improvements for navigation will allow the State of Hawaii Department of Land and Natural Resources, Division of Boating and Ocean Recreation, to construct improvements within the harbor. The level of development and improvement designs are dependent on which Federal alternative is constructed. The berthing and development plan for the State's improvements will be finalized after a Federal plan is approved. However, the State's currently proposed improvement plan is based on the construction of the harbor configuration of Federal Alternatives 1, 2, and 3. A modification of the State's Plan would be required if Alternative 4 were selected.

The State's proposed plan of improvements includes (a) construction of a harbor center mole; (b) construction of an east mole; (c) administration facilities; (d) an increase in the number of berths (220) ranging from 20 feet in length to 100 feet; (e) an increase in the number of parking stalls and paved areas; (f) fueling and service dock; and (g) new utilities.

The sewage disposal system would be upgraded as the first element of the State's overall plan. The State has received funding authorization to plan and design the upgrade of the wastewater system to meet Department of Health requirements. As additional wastewater is generated from the infrastructure expansion, including new pumpout and comfort stations, the system will be upgraded to handle treatment of the additional load.

Widening of the boat ramp is planned, as well as improvements to the loading dock. Administrative facilities (baseyard/maintenance) would be built. A center mole would be constructed, including berths, parking, sewage pumpout, fuel facilities (fuel tank and pumps), and a sewage wharf. Parking, berths, and landscaping improvements are planned

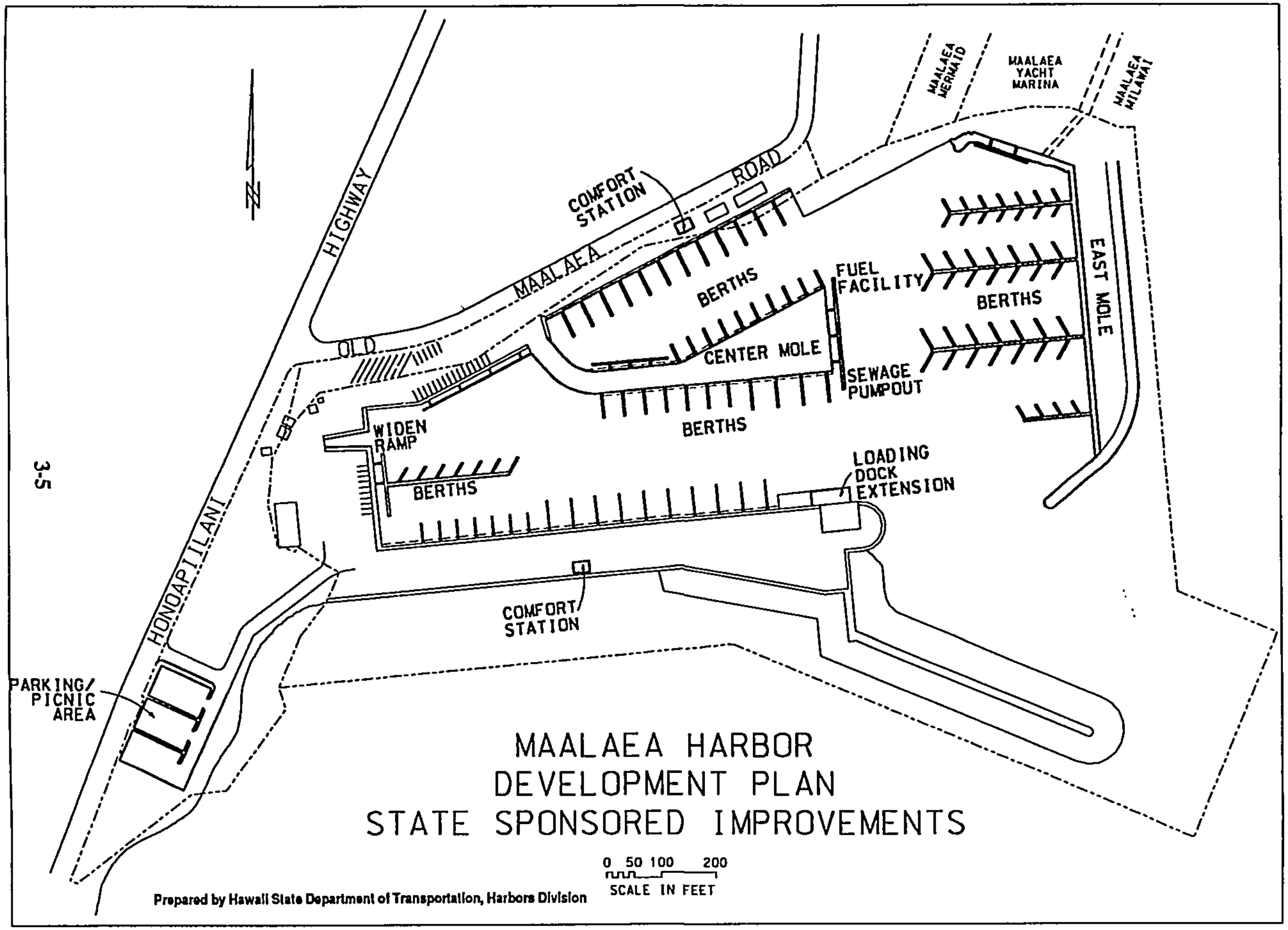

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Figure 6

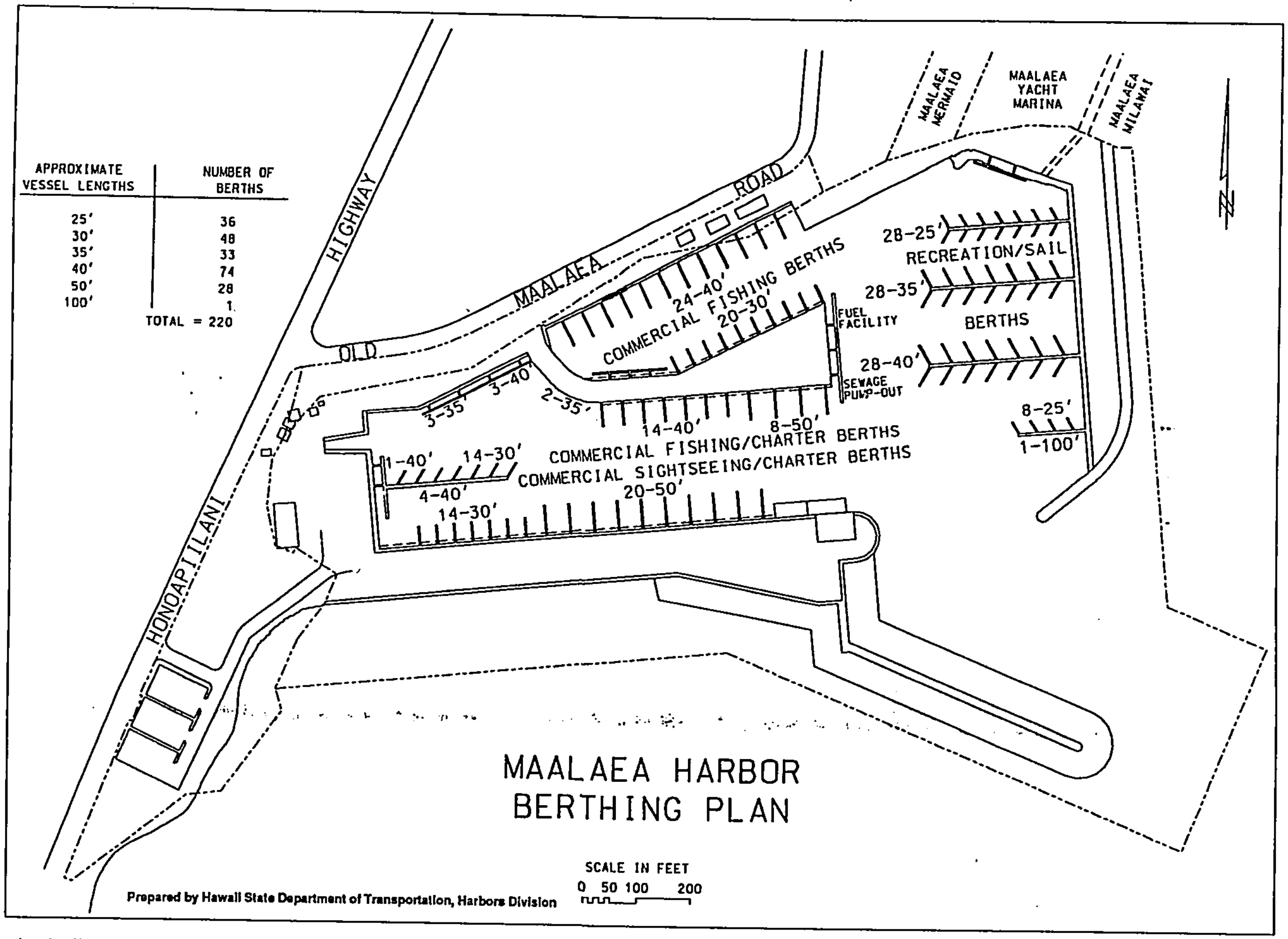

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Figure 7

for the south mole. The State's Plan would increase the harbor capacity to 220 vessels.

The State's planned improvements would require 33,200 cubic yards of coral fill and 20,680 tons of stone or concrete. Approximately 7,000 cubic yards would be dredged from the berthing areas.

If the State Department of Transportation's programmed highway widening project were delayed, intersection improvements would be made to Honoapiilani Highway and Ma'alaea Wharf Road. East mole improvements would include construction of berths, access to them, and landscaping. Construction of the east revetted mole would require construction of a storm drain to conduct rainwater through the mole. A comfort station would be constructed near the Coast Guard Station. Finally, parking and picnic areas would be developed at the west end of the harbor.

The completion of all improvements is scheduled to take about 10 years (Table 2). Initial funding has already been provided in the FY88-89 Biennium. The schedule for construction is dependent upon the completion of the Federal navigation improvements.

3.2.2 FEDERAL ALTERNATIVES CONSIDERED IN DETAIL

Alternative Plan 1. This alternative (Figure 8) is similar to the selected plan identified in the 1980 GDM/FEIS. This new plan would provide an extension to the existing south breakwater 620 feet long; an entrance channel 610 feet long, varying in width from 150 feet to 180 feet, and varying in depth from 12 to 15 feet; a 1.7-acre turning basin, 12 feet deep; a 720-foot-long, 80-foot-wide and 8-foot-deep main access channel; and the addition of a revetted mole 400 feet long on the seaward side of the existing south breakwater for a bus turn-around. The south breakwater revetted mole has been substantially reduced in area from the design in the 1980 selected plan.

About 80 feet of the existing east breakwater head would be removed, and about 27,000 cubic yards of material would be dredged from the harbor basin, including the turning basin, access channel, and new entrance channel. About 11,200 cubic yards of that amount would be used for construction of the breakwater extension and revetted mole. An additional 56,700 tons of stone would be placed in the construction of the revetted mole. Modification of the aids to navigation would also be included in the federal project. Construction is expected to take approximately 26 months. The construction costs are estimated to be $8.45 million. Non-Federal costs are estimated at $3.25 million, for a total of $11.7 million.

Primary construction materials would consist of dredged material, basalt stone, and concrete. Material dredged from the entrance channel and harbor would be used to the extent possible in the construction of the breakwater extension. The stone material can be obtained from three commercial quarries on Maui. In addition, 23,900 cubic yards of concrete would be required for construction of armor units on the main breakwater. Figures 9, 10, and 11 show typical sections.

TABLE 2

ESTIMATED SCHEDULE OF STATE OF HAWAII IMPROVEMENTS FOR MA'ALAEA SMALL BOAT HARBOR

PROJECT	DESCRIPTION	AGENCY	CONSTRUCTION SCHEDULE	REMARKS
Navigational Improvements	Breakwater, Entrance and Access Channels, Revetted Moles	Corps of Engineers/ DLNR-BOR	1994-96	State Share Funded by Acts 390/88 and 316/89
Sewage System Improvements	Upgrade of Disposal System			Coordination with DOH Funded by Act 296/91
•Planning/Design		DLNR-BOR	1993-95	
•Construction		DLNR-BOR	1995-97	
Ramp improvements	Widening of Ramp	DLNR-BOR	1997	
Loading Dock Improvements	"Sea-flite" Dock Improvements	DLNR-BOR	1997	
Center Mole Improvements	Berths, Parking, Sewage Pump-out, Fuel and Sewage Wharf	DLNR-BOR	1997-98	Schedule depends on completion of Navigational Improvements
South Mole Improvements	Landscaping, Berths, Comfort Station	DLNR-BOR	1997-98	Schedule depends on completion of Navigational Improvements
Fuel Facility	Fuel Tanks and Pumps	DLNR-BOR (Lease Arrangement	1998	Schedule depends on completion of Navigational Improvements
Intersection Improvements	Widening of Honoapiilani Hwy. and Ma'alaea Wharf Road Intersection	DLNR-BOR/ Coordination with DOT-HWY	1999-2000	Interim improvements should highway widening be delayed (Schedule depends on completion of Navigational Improvements)
East Mole Improvements	Access, Landscaping, Berths	DLNR-BOR	2000-01	Schedule depends on completion of Navigational Improvements
Comfort Station	Near Coast Guard Station	DLNR-BOR	2001	Schedule depends on completion of Navigational Improvements
Development of West End	Parking and Picnic Areas	DLNR-BOR	2002-04	

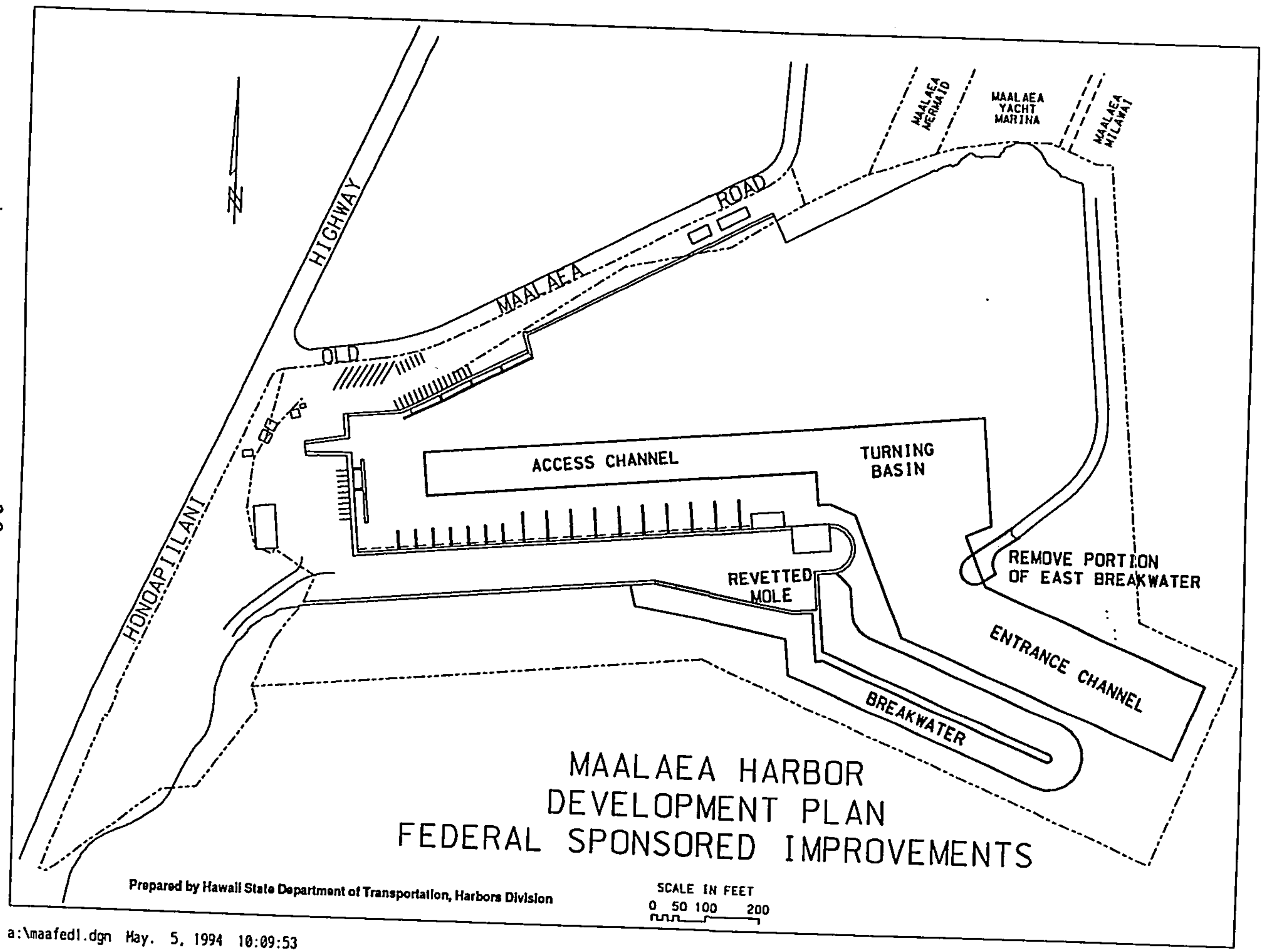

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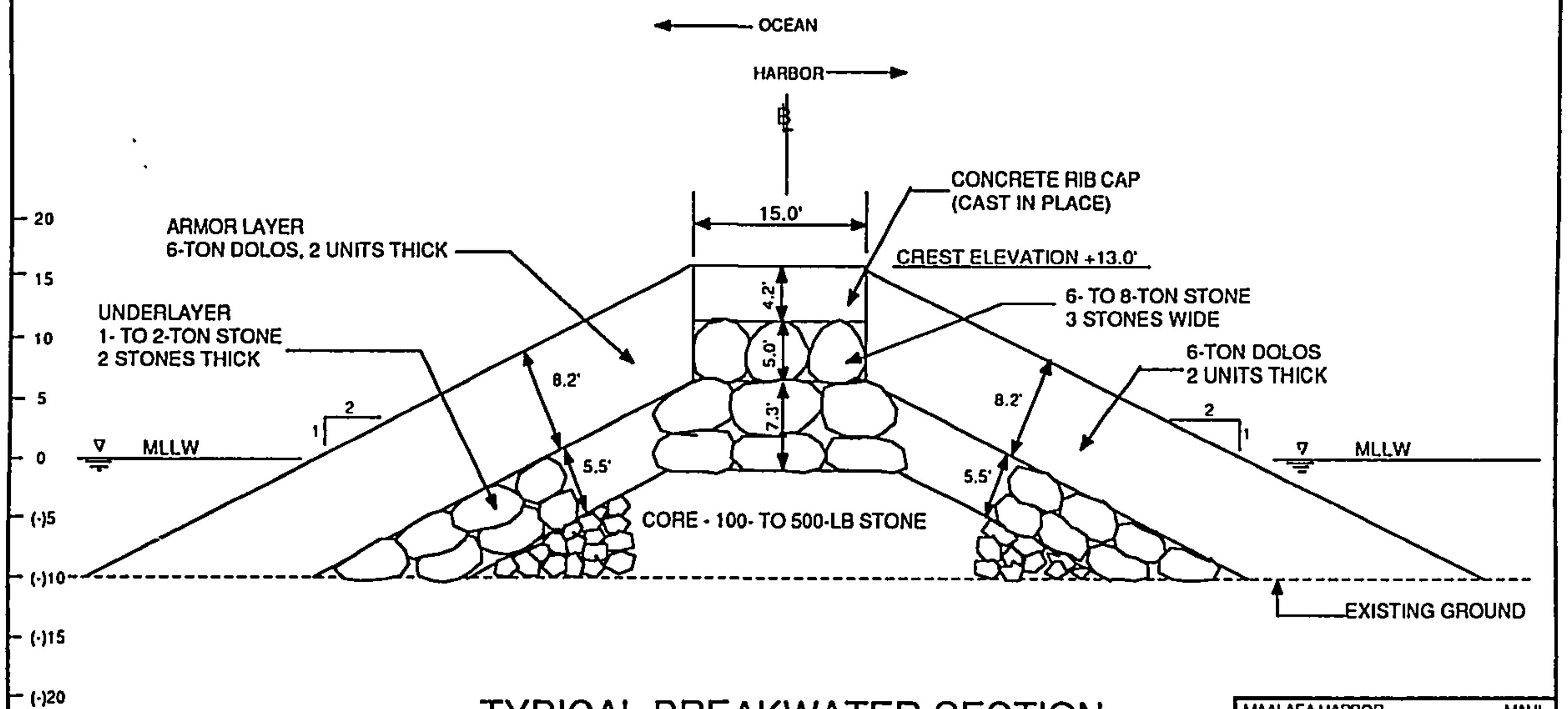
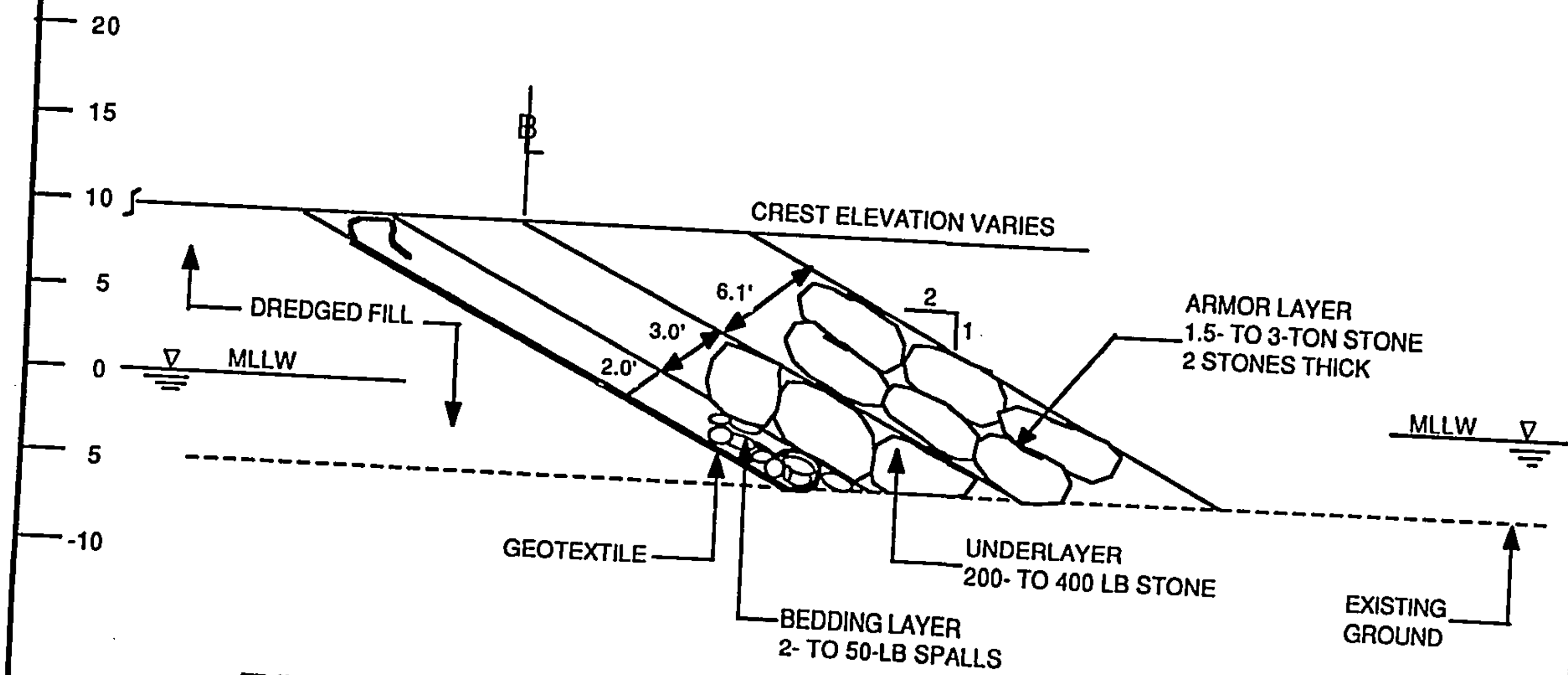
Figure 8



TYPICAL BREAKWATER SECTION
STA. 1+65 'A' TO HEAD

Figure 9

MAALAEA HARBOR	MAUI
TYPICAL BREAKWATER SECTION	
US ARMY ENGINEER DISTRICT	HONOLULU



TYPICAL EXTERIOR REVETMENT SECTION
STA. 0+00 'B' TO STA. 1+30 'B'
SCALE: 1" =10'

Figure 10

MAALAEA HARBOR MAUI

TYPICAL EXTERIOR REVETMENT SECTION

US ARMY ENGINEER DISTRICT HONOLULU

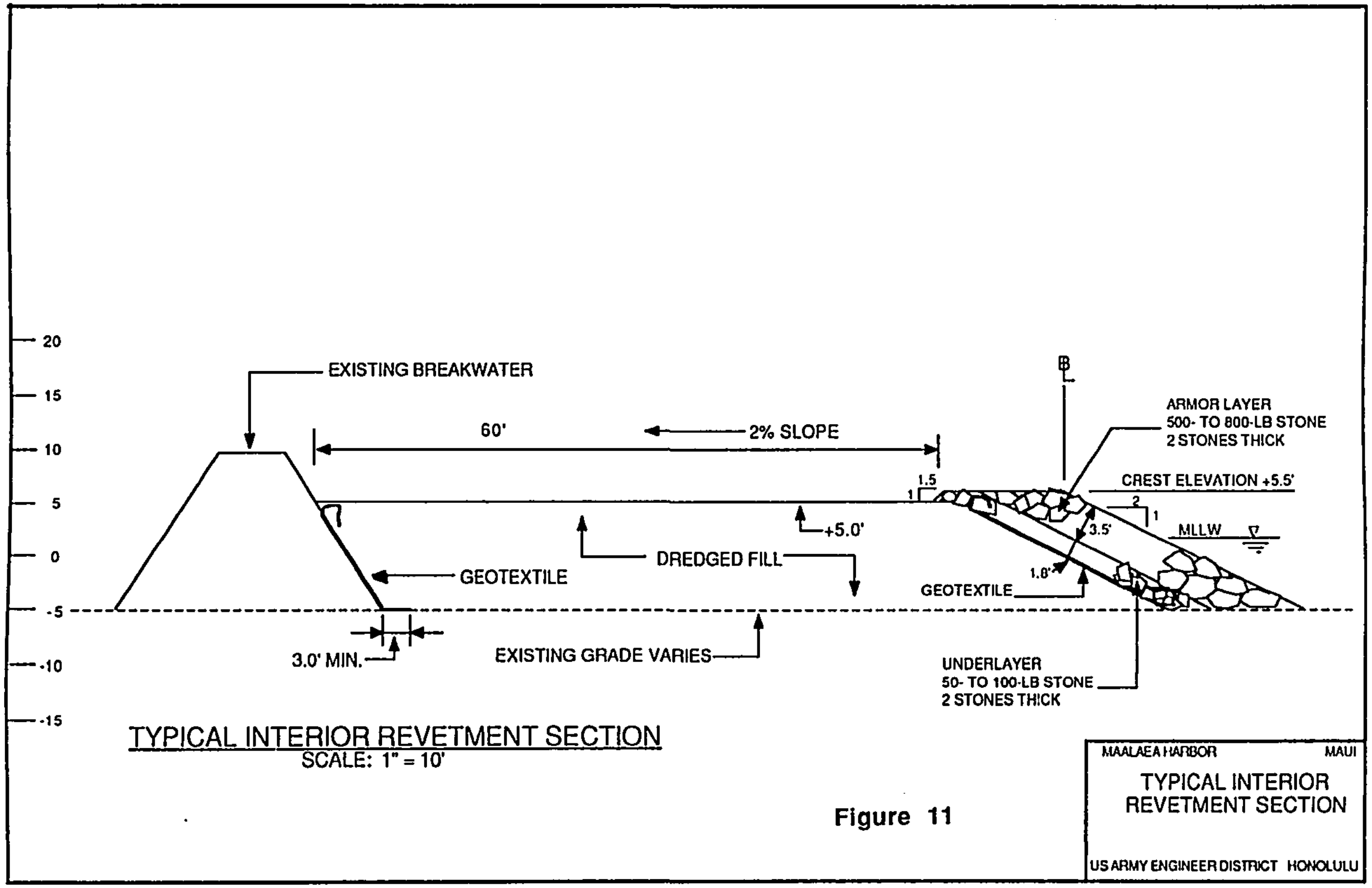

20
15
10
5
0
-5
-10
-15
EXISTING BREAKWATER
60'
2% SLOPE
GEOTEXTILE
DREDGED FILL
+5.0'
3.0' MIN.
EXISTING GRADE VARIES
ARMOR LAYER
500- TO 800-LB STONE
2 STONES THICK
CREST ELEVATION +5.5'
1.5
1
2
1
MLLW
3.5'
1.8'
GEOTEXTILE
UNDERLAYER
50- TO 100-LB STONE
2 STONES THICK
TYPICAL INTERIOR REVETMENT SECTION
SCALE: 1" = 10'
MAALAEA HARBOR
MAUI
TYPICAL INTERIOR
REVETMENT SECTION
US ARMY ENGINEER DISTRICT HONOLULU

Figure 11

Conventional dredging equipment would be used. In addition, isolated spot blasting may be required to initiate excavation.

It is estimated that Federal dredging requirements will be approximately 8,000 cubic yards every 10 years. An additional 1,000 cubic yards will need to be dredged from the harbor by nonfederal interests every 10 years.

Alternative Plan 2. This alternative (Figure 12) was developed to minimize the potential impacts to Buzz's Surf sites and to minimize the amount of fill material used for the breakwater extension. Alternative Plan 2 is the same as Alternative Plan 1, except that the 400-foot-long revetted mole on the seaward face of the existing south breakwater would be replaced by a wave absorber 200 feet long. Approximately 27,000 cubic yards of material will be dredged from the harbor basin, including turning basin, access channel, and the new entrance channel. All of this dredged material would be used to construct the breakwater extension, east mole and central mole. Construction periods would be similar to Alternative Plan 1. Construction costs are estimated at $7.6 million. Non-Federal construction costs are estimated at $2.5 million, for a total of $10.1 million.

Construction methods and materials will be the same as for Alternative Plan 1.

Alternative Plan 3. This alternative (Figure 13) was developed to minimize modification to existing structures. This alternative is similar to Plan 1, except that the seaward revetted mole would be eliminated, and the breakwater extension would be detached from the existing structure and would be 650 feet long instead of 620 feet. Approximately 27,000 cubic yards of material would be dredged from the harbor basin, including the turning basin, access channel, and new entrance channel. All of that amount would be used for construction of the breakwater extension, east mole and center mole. Modification of the aids to navigation would also be included in the federal project. Construction is expected to take approximately 26 months and is estimated to cost $7.8 million. Non-Federal construction costs are estimated at $2.5 million, for a total of 10.3 million.

Construction methods and materials would be the same as for Alternative Plan 1.

Alternative Plan 4. Alternative Plan 4 (Figure 14) was developed to minimize impacts to the surfing site located to the east of the existing entrance channel. This alternative consists of an 850-foot long extension of the existing east breakwater; an entrance channel 960 feet long, 150 to 200 feet wide, varying in depth from 12 to 15 feet; a 2.8 acre turning basin 12 feet deep; and a main access channel 600 feet long, 80 feet wide and 8 feet deep. Approximately 81,300 cubic yards of material will be dredged from the harbor basin (including berthing areas) and the new entrance channel; approximately half of this dredged material would be used to construct the breakwater extension. An additional 45,900 cubic yards of stone revetment would be placed in the construction of the east breakwater extension. Construction periods would be similar to Alternative Plan 1.

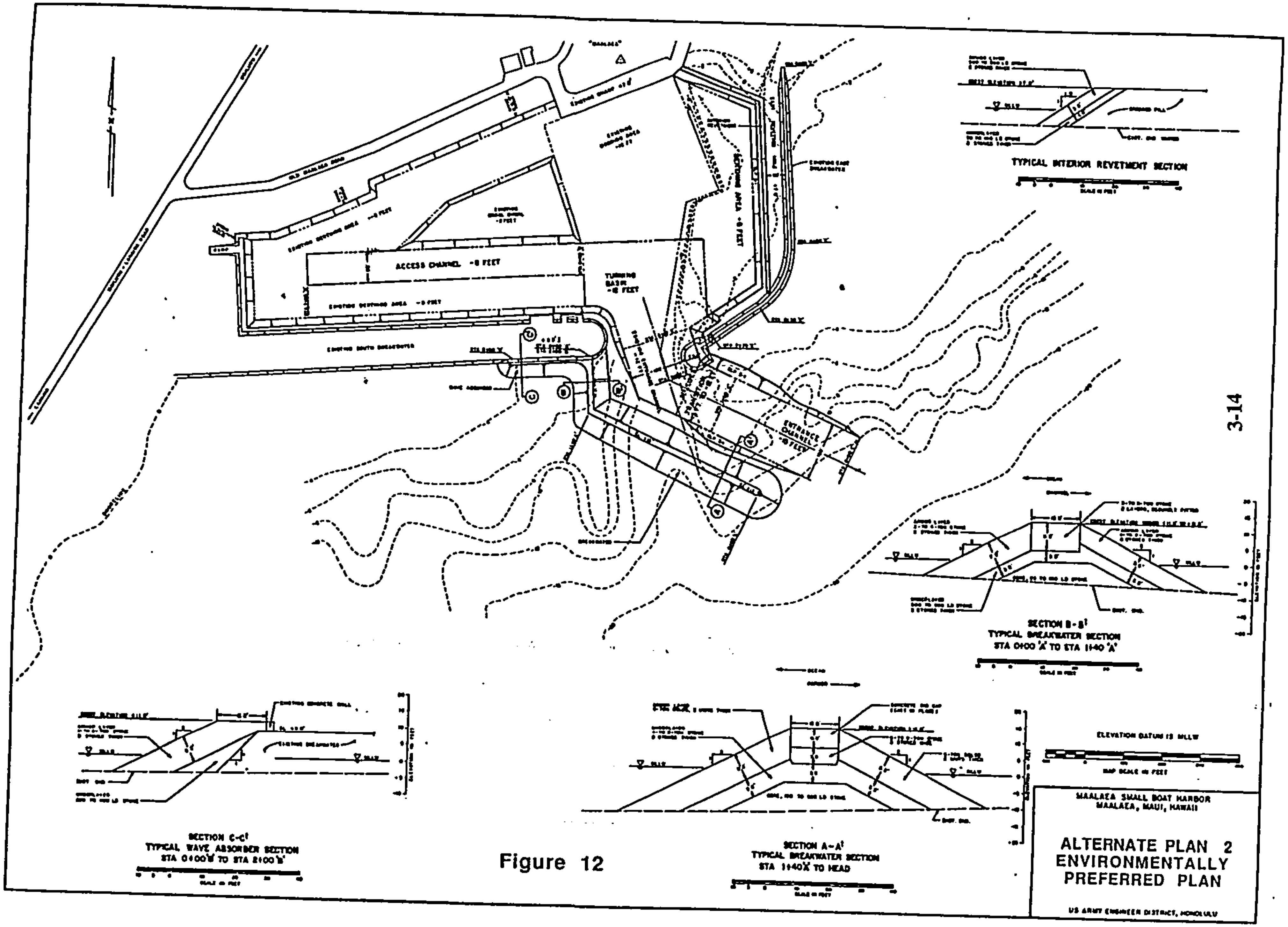

ACCESS CHANNEL -8 FEET
TYPICAL INTERIOR REVETMENT SECTION
SECTION B-B'
TYPICAL BREAKWATER SECTION
STA 0+00 'A' TO STA 11+40 'A'
SECTION C-C'
TYPICAL WAVE ABSORBER SECTION
SECTION A-A'
TYPICAL BREAKWATER SECTION
STA 11+40 'A' TO HEAD
ELEVATION DATUM IS MLLW
MAALAEA SMALL BOAT HARBOR
MAALAEA, MAUI, HAWAII
ALTERNATE PLAN 2
ENVIRONMENTALLY
PREFERRED PLAN
US ARMY ENGINEER DISTRICT, HONOLULU

Figure 12

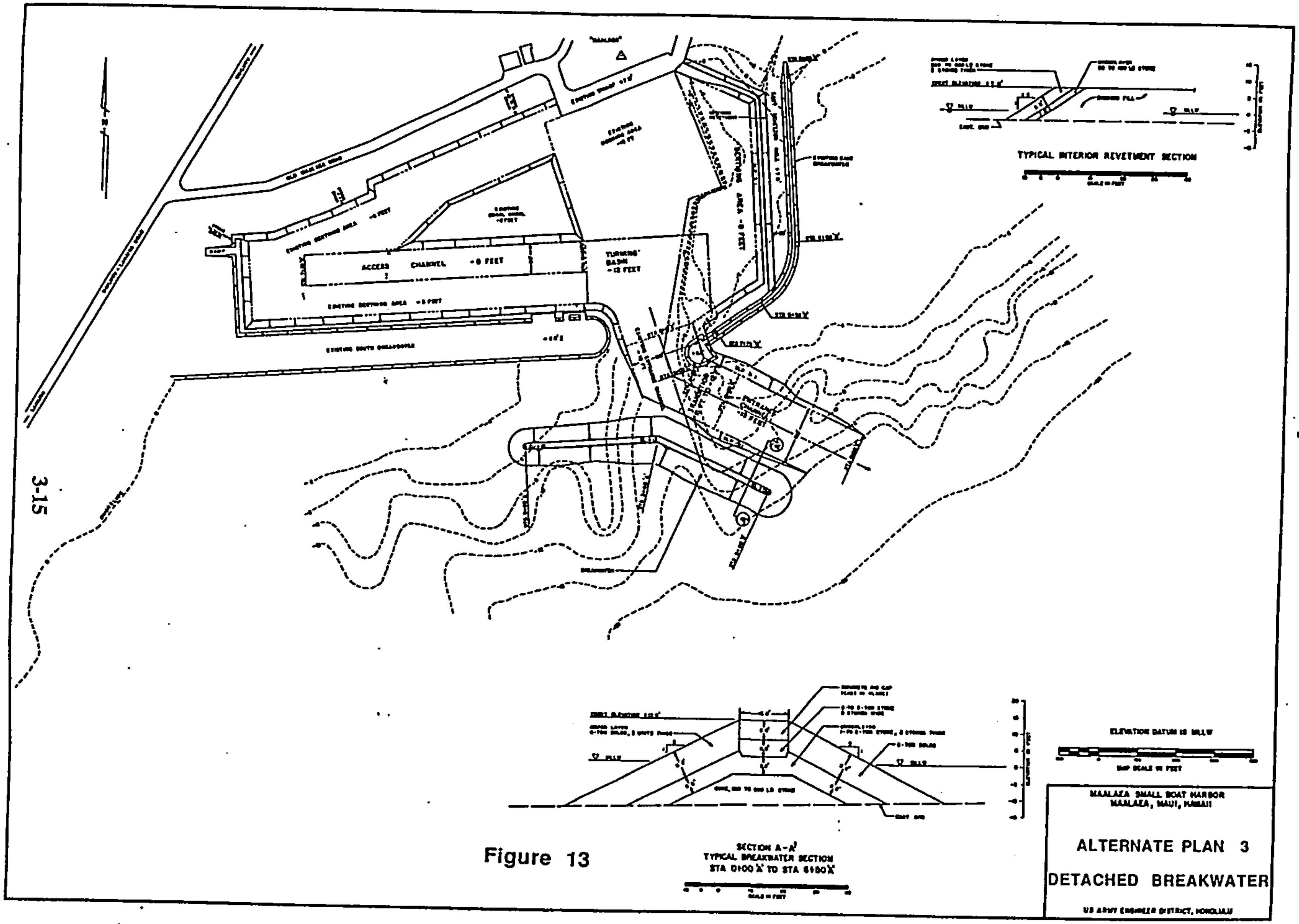
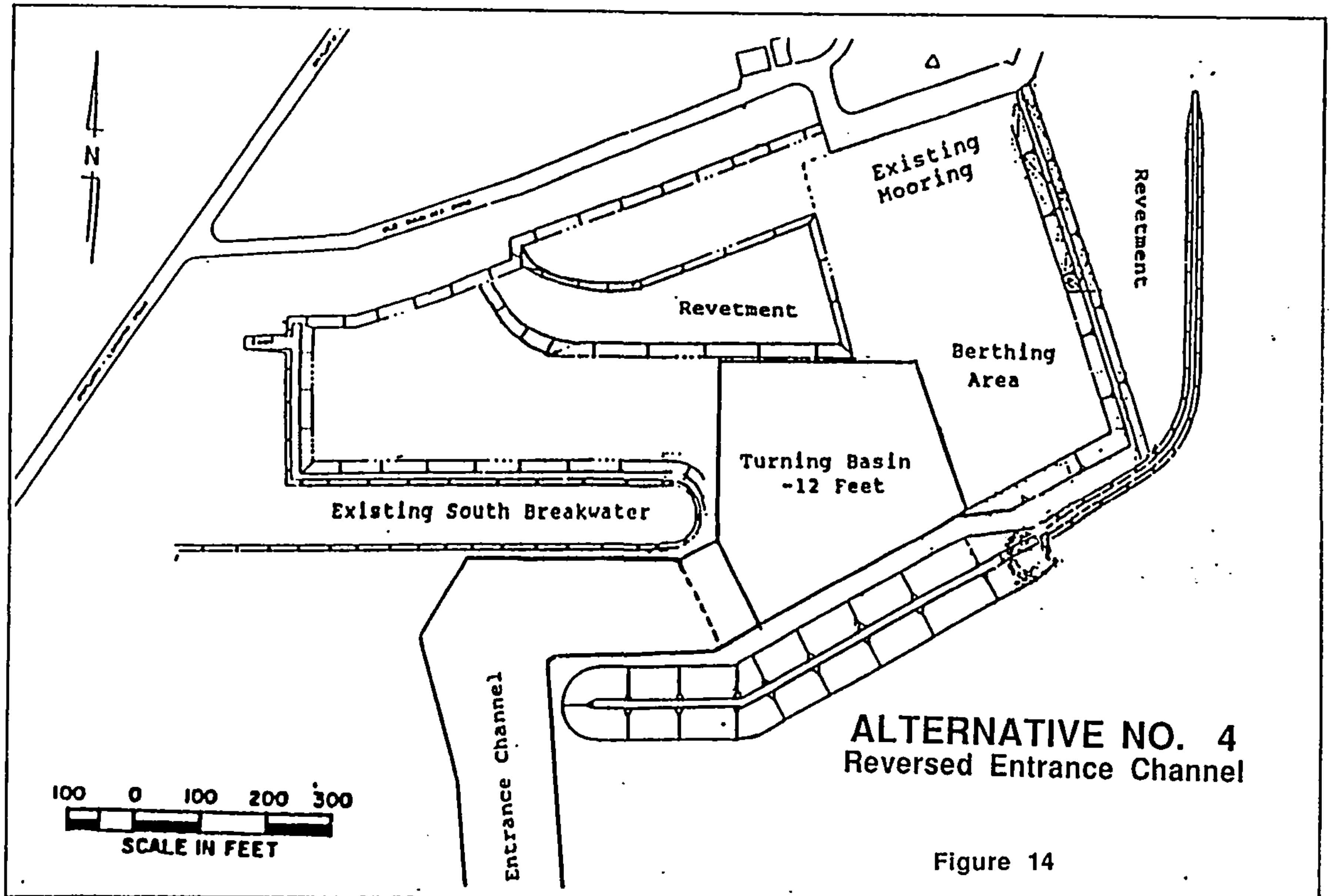

ACCESS CHANNEL -8 FEET
TURNING BASIN -12 FEET
TYPICAL INTERIOR REVETMENT SECTION
SECTION A-A'
TYPICAL BREAKWATER SECTION
ELEVATION DATUM IS MLLW
MAALAEA SMALL BOAT HARBOR
MAALAEA, MAUI, HAWAII
ALTERNATE PLAN 3
DETACHED BREAKWATER
US ARMY ENGINEER DISTRICT, HONOLULU

Figure 13



ALTERNATIVE NO. 4
Reversed Entrance Channel

Figure 14

Construction costs would be approximately $11.7 million. Non-Federal costs are estimated at $2.5 million, for a total of $14.2 million.

Construction materials and methods would be the same as for Alternative 1.

Detailed construction plans for the State's infrastructure improvements have not yet been developed.

3.3 NO ACTION ALTERNATIVE

The No Action Alternative (Figures 2 and 3) would leave the harbor as it is, without any Federal improvements or State of Hawaii improvements that depend on the Federal improvements. The State would continue with plans to upgrade the existing sewage system and to improve the loading dock adjacent to the Harbor Master's office on the south mole. In addition, the existing launching ramp would be widened and improved. These three improvements are independent of the Federal improvements. Additional environmental documentation would be required.

3.4 OTHER ALTERNATIVES CONSIDERED

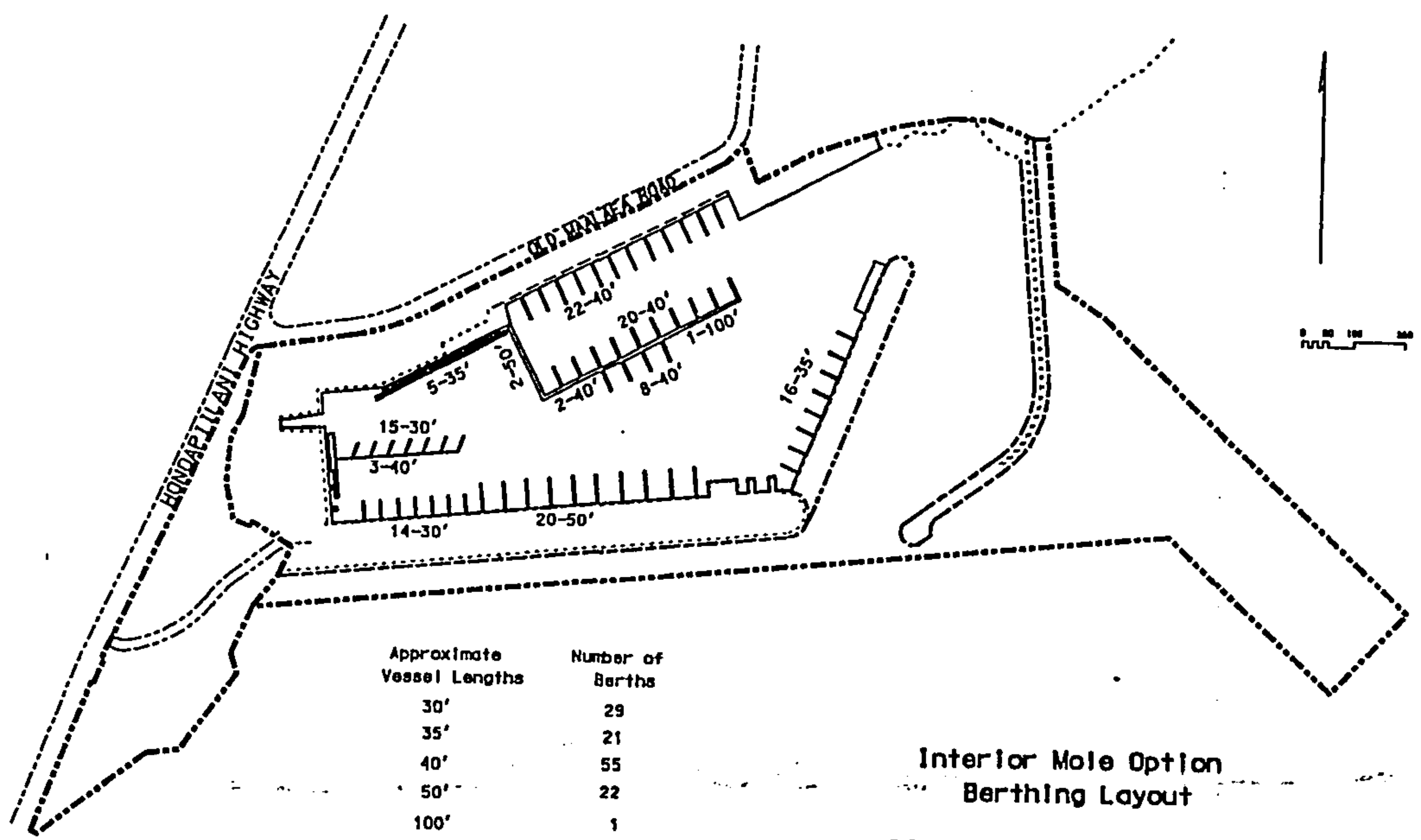
Two new alternatives (Alternative Plan 5 & Alternative Plan 6) were proposed by Moffat and Nichol (1992) in their Evaluation of Project Impacts on Surf Sites (Appendix E).

Alternative Plan 5 is only a slight refinement of Alternative Plan 2 and was not evaluated separately. The alignment of the south breakwater would be changed slightly in order to minimize the impacts to the Buzz's surf sites.

Alternative Plan 6 (Moffat & Nichol Alternatives 5A, 5B, 5C) (Figure 15) was developed to avoid any impacts outside the existing harbor boundaries. This plan consists of an internal breakwater to reduce wave action within the harbor, and two sub-alternatives for harbor expansion, inland to the north, or east along the shore (Appendix E). The interior mole would be approximately 425 feet long.

3.5 ALTERNATIVES ELIMINATED FROM DETAILED PLANNING

Alternative locations for a new harbor in Ma'alaea Bay were not considered because of the greatly increased potential for environmental damage and costs compared to the proposed improvements to the existing harbor. Aside from the great costs associated with development of a new harbor, the development of new harbors in the project region is strongly opposed by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service because of probable significant adverse effects on endangered species.



Approximate Vessel Lengths	Number of Berths
30'	29
35'	21
40'	55
50'	22
100'	1
Total	128

Interior Mole Option
Berthing Layout

ALTERNATIVE NO. 6
(Eliminated from Detailed Consideration)

Figure 15

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The 1968 approved Plan of Improvement (Figure 4) was eliminated early in the planning process because dredging the new entrance channel and turning basin would essentially destroy the entire world famous surf site called "Ma'alaea Pipeline".

Alternative Plan 5 was not evaluated separately because it consists of only a slight modification of Alternative Plan 2. The final alignment of the breakwater extension will be determined during the detailed engineering design for the project.

Alternative Plan 6 (Figure 15) was eliminated from detailed analysis primarily because of hydraulic and navigational safety considerations. Utilizing the entrance channel during south swell conditions would be very hazardous because of the waves entering the channel and the wave reflections and refractions from the channel walls and protective structures. The wave reflections and stern seas would continue to create a problem for boat steering control. The loss of maneuverability within the confined area could prove to be very unsafe. In addition, any vessel docked at the Coast Guard pier would make access to the rest of the harbor hazardous for other vessels even during normal sea conditions. Under Alternative Plan 6, wave attenuation in the eastern expansion area would not be sufficient without additional, more elaborate protective structures.

Alternative Plan 6 was studied utilizing a state-of-the-art computer model of harbor oscillation at the U.S. Army Corps of Engineers Waterways Experiment Station (WES). The model showed that during south swell conditions an internal oscillation would develop in the harbor, causing damage to berthed vessels.

The flushing characteristics of the harbor under Alternative Plan 6 were the worst of those analyzed, increasing the flushing period from the present 2.9 days to an estimated 6.3 days (Wang et al. undated).

Alternative Plan 6 would eliminate the possibility of developing berthing facilities along the east breakwater and would eliminate the potential for development of a fuel pier. This alternative would allow only about 128 berths of the expected sizes. In addition, expansion inland would eliminate needed space for harbor support facilities and the high costs to the State to acquire the land (at least $10 million) would make the project economically not feasible. Expansion eastward would likely meet with considerable opposition from residents of the affected adjacent condominiums, as well as being much more costly than the proposed alternatives.The detailed construction costs of this alternative were not estimated. Ultimately, for all of the various reasons stated above, Alternative 6 was determined to be not practicable.

3.6 COMPARATIVE EVALUATION OF ALTERNATIVES

The effects of each of the construction alternatives would be essentially the same for most resources. Many of the effects are related to construction activities and secondary effects due to the increase in berthing capacity and resulting land and boat traffic. Alternatives differ in the amount of dredging and filling (thus, effects on the aquatic environment vary) and the impacts on surf sites.

3.6.1 EFFECTS COMMON TO ALL ALTERNATIVES

Achievement of Project Purposes

All alternatives would effectively reduce surge within the harbor basin by preventing waves from directly entering the basin. The new entrance channel would provide for safe navigation by the design vessel and other vessels expected to use the harbor during all but the most severe conditions. All alternatives considered in detail would significantly improve navigation conditions and increase the berthing capacity of the harbor. The number of boats berthed within the harbor basin would increase from 87 to about 220 boats under the DBOR's proposed berthing plan, a 250-percent increase.

Other Effects

Boat traffic and fishing pressures in the area may be expected to increase. Vehicular traffic would also be expected to increase in the harbor area.

Increased harbor usage would tend to further degrade the water quality within the basin. Ongoing deposition of sediments into the harbor will continue to degrade harbor waters. Future development planned for the surrounding Ma'alaea area will increase storm water input to the harbor, possibly necessitate maintenance dredging with its associated effects, and result in cumulative effects on water quality and marine life. Turbulence caused by increased boat traffic within the harbor will resuspend fine sediments, further reducing water quality. The project may improve the efficiency of the harbor to act as a sediment trap and may lessen siltation impacts on the marine environment outside the harbor.

Dredging of the entrance channel and placement of the breakwater extension would destroy rich coral reef and benthic organisms. The amount of habitat depends upon the alternative constructed. The new breakwater extension would provide habitat for many reef dwelling species, but will result in a net loss of reef habitat and an adverse impact on displaced highly specialized reef species. An increase in the populations of generalized, reef dwelling species would be expected in the harbor vicinity after completion of construction. Increased fishing activity would be expected near the new structures.

The impacts of harbor construction and expansion and the increased boat traffic expected to occur may adversely affect but is not expected to jeopardize endangered species. Humpback whales may be displaced from a portion of habitat by increased boat traffic, and a small number of green sea turtles may be adversely affected by displacement, injury, or mortality and loss of habitat due to blasting, dredging, and construction. Consultation with the National Marine Fisheries Service (NMFS) has determined that, with appropriate provisions, none of the proposed alternatives would jeopardize these animals.

Dredging during harbor construction would temporarily stimulate predator feeding as prey organisms are exposed or attracted to the dredging activities. Dredging noise would attract some species while it may disturb others such as the endangered humpback whale. Blasting during dredging, if required, would kill and injure some marine organisms and is likely to disturb the humpback whale if that species were present.

Suspended fine coralline material resulting from dredging activities would temporarily increase water turbidity. A turbid plume would be expected to be carried offshore in a southwesterly direction by the prevailing wind-driven surface currents. The stresses associated with the turbidity would be temporary and would not last appreciably longer than the dredging activity.

Surfing areas located adjacent to the existing entrance channel would be destroyed or modified by the placement of the new structures and dredging of the new entrance channel. A new surfing site may develop. The Ma'alaea Pipeline, identified by worldwide surfing interests as being of major importance, would not be affected.

All alternatives would result in the destruction of a small sandy beach at the east end of the harbor if the proposed State improvements are made to the east mole.

All of the dredged material would be utilized as fill material in the construction of project features. It is anticipated that there will be no excess material for upland disposal.

All alternatives would result in adverse effects on traffic conditions in the project area. Levels of service at the intersections of all three roads leading to and exiting the harbor area would be reduced one level, resulting in very long delays or severe congestion during peak hours.

Real property in the harbor area would probably increase in value after completion of the harbor project. Associated tax revenues would also increase.

Social well-being would be enhanced because of the safer berthing and navigation conditions resulting from harbor improvements.

3.6.2 EFFECTS UNIQUE TO ALTERNATIVES

Table 3 contains a summary comparison of features and expected impacts for the four alternatives considered in detail.

Achievement of Project Purposes

The number of boats berthed within the harbor basin would increase from 87 to about 220 boats under the DBOR's proposed berthing plan, a 250-percent increase. Full development of the local sponsor's planned improvements could occur with Alternative Plan 1. Alternatives 2 and 3 would allow development of all of the State's improvements, except for a bus turnaround on the south breakwater. Alternative 4 would allow fewer berths to be developed, and would not allow for a bus turnaround on the south breakwater.

Flushing

None of the alternatives studied in detail would significantly increase the flushing rate of the harbor. For alternatives 1, 2, and 3, the flushing rate would increase from 2.9 days to 3.3 days, still well within the safe design criteria established by Clark (in Wang et al. undated).

Although not studied by Wang et al., the flushing rate for Alternative 4 is not expected to increase significantly over existing conditions. The reason for this is that the entrance channel in this alternative is in alignment with the prevailing winds, and since the harbor flushing is primarily wind driven, the prevailing winds would push the surface waters out of the harbor without restrictions, allowing bottom water to flow into the harbor.

Effects on Aquatic Ecosystem

Alternative 1. Approximately 11.9 acres of coral reef, coral rubble, and sand bottom and associated benthic organisms would be destroyed or altered by placement of the structures and dredging. About 5.8 acres would be covered and 6.1 acres would be dredged. About 15,700 cubic yards of material would be dredged from the new entrance channel. Within the existing harbor basin, 3.9 acres would be dredged.

Alternative 2. Approximately 11.5 acres of coral reef, coral rubble, and sand bottom and associated benthic organisms would be destroyed or altered by placement of the structures and dredging. About 5.4 acres would be covered and 6.1 acres would be dredged. About 15,700 cubic yards of coral reef and sand would be dredged from the new entrance channel. Within the existing harbor basin, 3.9 acres would be dredged.

Alternative 3. Approximately 11.7 acres of coral reef, coral rubble, and sand bottom and associated benthic organisms would be destroyed or altered by placement of the structures and dredging of the entrance channel. About 5.6 acres would be covered and 6.1 acres would be dredged. Within the existing harbor basin, 3.9 acres would be dredged.

Alternative 4. Approximately 15.2 acres of coral reef, coral rubble, and sand bottom and associated benthic organisms would be destroyed by placement of the structures and dredging. About 5.6 acres would be covered and 9.6 acres would be dredged. Within the existing harbor basin, 3.9 acres would be dredged.

Effects on Surf Sites

Alternative Plans 1, 2, and 3 would all result in the complete destruction of the Off-the-Wall surf site. Alternatives 1 and 3 would also result in the modification of Buzz's No. 2

site, while Alternative 2 would avoid direct encroachment on the site, but may result in a decrease in the quality of the waves at that site.

None of the alternatives would destroy the Ma'alaea Pipeline surf site. A decrease in the density of use was predicted with Alternatives 1, 2, or 3 because of safety concerns in the take-off area near the realigned channel entrance. However, this is not considered to be likely because the takeoff point is 500 feet east of the breakwater in shallow water.

Alternative 4 would completely destroy Buzz's No. 2 and 3 and result in a reduction of the quality of the waves at Buzz's No. 1 and Off-the-Wall. The Ma'alaea Pipeline would not be affected.

Table 3 - Comparison of Alternatives

Component/ Resource	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Number of Berths	87 (no change)	220	220	220	Less than 220
Excavation Entrance Channel Harbor Basin	None	15,700 CY 11,300 CY	15,700CY 13,300CY	15,700CY 11,300CY	Total 81,300CY
Entrance Channel Width Length Depth	No change from existing conditions	150-180 feet 610 feet 12-15 feet	150-180 feet 610 feet 12-15 feet	150-180 feet 610 feet 12-15 feet	150-200 feet 960 feet 12-15 feet
Turning Basin	No change	1.7 acres	1.7 acres	1.7 acres	2.8 acres
Harbor Structures	None	400-ft-long revetted mole; 620-ft-long south breakwater extension; 80 ft of east breakwater to be removed	Same as Alt. 1, but 200-ft-long wave absorber replaces revetted mole	Similar to Alt. 1 but revetted mole replaced by detached breakwater	850-ft-long east breakwater extension
Construction Period	None	26 months	26 months	26 months	26 months
Construction Cost	——	$11.7 million	$10.1 million	$10.3 million	$14.1 million
Surge Reducation	No change from existing conditions	Yes	Yes	Yes	Yes
Safe Navigation	No change from existing conditions	Yes	Yes	Yes	Yes
Basin Flushing	2.9 days	3.3 days	3.3 days	~3 days	Undetermined, but not expected to increase significantly
Accommodates Local Sponsor's Plans	Partially. Allows improvements to sewage system, ramp, loading dock, baseyard/maintenance facilities, and parking/picnic areas at west end of harbor.	Accommodates all of the local sponsor's improvements	Accommodates all of the local sponsor's improvements, except for bus turnarounds	Accommodates all of the local sponsor's improvements, except for bus turnarounds	Accommodates most of the local sponsor's improvements, except that fewer berths would be accommodated

Table 3 (cont'd) - Comparison of Alternatives

Component/Resource	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Reef Resources/Aquatic Habitat	No change from existing conditions	5.81 acres filled 6.12 acres dredged	5.35 acres filled 6.12 acres dredged	5.56 acres filled 6.12 acres dredged	5.63 acres filled 9.58 acres dredged
Endangered Species	Continued increase in vessel traffic and illegal moorings; new harbor facilities elsewhere may exceed jeopardy threshold	Adverse effects from increased boating not likely to jeopardize whales or turtles; with mitigation, less adverse than No Action	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surfing Sites	No change	Complete loss of Off-the-Wall; modification of Buzz's Nos. 1, and 2; unlikely decrease in density of use of Ma'alaea Pipeline	Complete loss of Off-the-Wall; modification of Buzz's Nos. 1 and 2; unlikely decrease in density of use of Ma'alaea Pipeline	Complete loss of Off-the-Wall and Buzz's No. 1; Partial loss of Buzz's No. 2; unlikely decrease in density of use of Ma'alaea Pipeline and Buzz's No. 3	Complete loss of Buzz's No. 2; modification of Off-the-Wall, Buzz's No. 3, and Ma'alaea Pipeline
Water Quality	Continued turbidity in harbor from upland drainage. sediment deposition in harbor minimizes impact on coastal water quality	Increase in turbidity due to increased boat traffic	Increase in turbidity due to increased boat traffic	Increase in turbidity due to increased boat traffic	Increase in trubidity due to increased boat traffic.
Traffic	Improvements to be implemented through DOT's Maui Long-Range Highway Planning Study	13% (70 vehicles) projected peak-hour traffic increase	Same as Alternative 1	Same as Alternative 1	Similar to Alternative 1; slightly lesser impact due to fewer berths
Land Use	Future development of upland areas surrounding Ma'alaea.	Destruction of sandy beach as a result of local sponsor's improvements	Destruction of sandy beach as a result of local sponsor's improvements	Destruction of sandy beach as a result of local sponsor's improvements	Destruction of sandy beach as a result of local sponsor's improvements
Community Well-Being	Continued regional urban development in upland areas. Harbor environs unchanged	Safer navigation for boaters; increase in unsafe surfing conditions; adjacent residents may be adversely affected by increased harbor activities; property values/tax revenues may increase	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1; Ma'alaea Pipeline surfers would have safer conditions

CHAPTER 4

AFFECTED ENVIRONMENT

4.1 INTRODUCTION

This chapter summarizes the discussion of the affected environment contained in the General Design Memorandum (GDM) and Final Environmental Impact Statement (FEIS), for the post-authorization modification plan revision of 26 September 1980 and the State of Hawaii Revised Environmental Impact Statement dated July 1982, and incorporates additional information that has been obtained since publication of those documents.

This chapter describes the existing and projected physical and sociocultural environment without any of the proposed actions. The order of descriptions matches, to the extent possible, the order of impacts discussed in chapter 5.

4.1.1 LOCATION

The island of Maui is the second largest island in the Hawaiian chain. Ma'alaea Harbor is located on the southwest shore of the island, about seven miles south of the county seat, Wailuku, and about eight miles south of the commercial and business center of Kahului. The shoreline of Ma'alaea Bay is part of an isthmus connecting two large, inactive volcanoes which form the geologically older west Maui and the more recent East Maui. The east Maui volcano, Haleakala, rises to 10,023 feet above sea level. The shoreline of Ma'alaea Bay is characterized by a long, narrow white coral sand beach which attracts many visitors from around the world.

4.1.2 DESCRIPTION

Ma'alaea Harbor is located at the extreme western end of the approximately 7.5 mile long Ma'alaea Bay shoreline, (Figures 1,2 and 3). It was first developed by the Territory of Hawaii in 1952, and modified in 1955, 1959, and 1979. Ma'alaea Harbor provides the western end of Ma'alaea Bay its only public access point. The closest small boat harbor is approximately 14 nautical miles to the northwest, at Lahaina. The present Ma'alaea Harbor, used by both commercial and recreational boaters, is protected by a south revetted mole approximately 1100 feet long and 90 feet wide and an eastern rubble mound breakwater approximately 850 feet long and 8 feet wide. There is an entrance channel approximately 90 feet wide and 13 feet deep, and an interior dredged basin of about 11.3 acres. The south revetted mole provides parking for about 164 autos and buses, berths for about 30 of the larger commercial vessels, and contains the office building for the Regional Boating Manager and Ma'alaea Harbor Master. The total present berthing capacity of the harbor is 87, and the harbor is at maximum capacity with a waiting list of approximately 300 craft. Of the craft currently moored in the harbor, 25 are recreation vessels, 13 are subsistence fishing vessels, 15 are commercial fishing, and 37 are a combination of charter fishing and commercial passenger. Use of the harbor is managed in accordance with Hawaii Administrative Rules, Title 13, Subtitle 11, Part 1, Small Boat Harbors.

On the northwest corner of the harbor is a one-lane concrete ramp which serves as both a haul out ramp and a trailered boat launching ramp. On the harbor's west side are parking spaces for boat trailers, a haul out facility, small restroom with sewage treatment and ejection well and two small harbor storage buildings, as well as space for boat repair and maintenance. The north side of the harbor contains berths mainly occupied by recreational, charter and other fishing boats, the U. S. Coast Guard facility and a concrete loading dock with parking spaces.

There are about 277 marked parking stalls at the harbor. Additional parking is available along the roadways and adjacent to some of the boat slips on the north side. There are also two condominiums adjacent to the harbor west of the east breakwater (Ma'alaea Mermaid & Ma'alaea Yacht Marina), and others east of the breakwater (Ma'alaea Milawai is the closest).

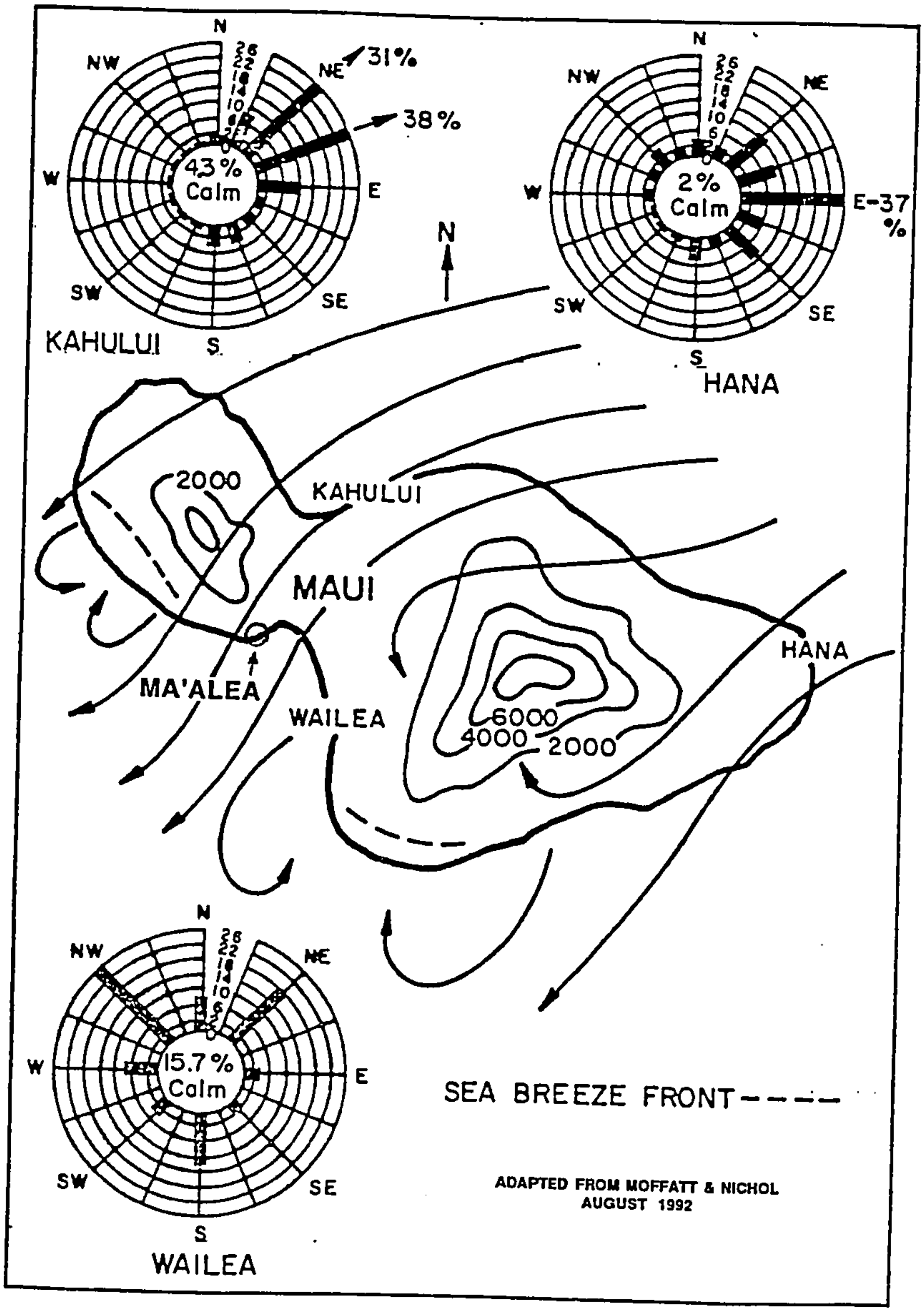
4.2 CLIMATE

The climate of Maui is semi-tropical, with a mean annual temperature of about 75°F. The Ma'alaea Bay area is relatively dry, with a mean annual rainfall of about 13.8 inches, generally occurring between October and April. Northwest trade winds averaging 10 to 20 miles an hour predominate and may frequently exceed 25 miles per hour because of the Venturi effect created over the low isthmus between the island's steep eastern and western mountains (Figure 16).

The predominant ocean current flow near Ma'alaea Harbor has been characterized as a trade wind-generated surface movement generally toward the southwest. Under normal trade wind conditions, the speed of this current is typically less than 1 knot (1.2 mph) and is not strong enough to cause navigational problems. During periods of high swell activity, especially during Kona storms, strong wind-generated rip currents may develop. Tidal currents within the Bay are weak and have little effect on navigation. (U.S. Fish and Wildlife Service 1993).

4.3 NATURAL HAZARDS

Hurricanes are an infrequent source of large destructive waves. Defined as storms with sustained wind speeds equal to or greater than 64 knots (73.6 miles per hour), hurricanes generally occur during the summer and fall months. Damaging hurricanes passed through the Hawaiian chain in 1950 (Hiki), 1957 (Della), 1978 (Fico), 1982 (Iwa) and 1992 (Iniki). Appendices E and G contain additional information regarding storms and wave activity.



TYPICAL TRADE WIND PATTERN ON MAUI

Figure 16

Tsunami are impulse-generated waves caused by catastrophic geological occurrences. Ma'alaea Bay is subject to potential tsunami or seismic sea wave inundation as are most low-lying coastal areas in the Hawaiian Islands. The 100-year tsunami inundation elevation at Ma'alaea is about 13 feet above the mean lower low water datum, placing Ma'alaea Harbor within the 100-year tsunami zone, or flood plain, for purposes of Executive Order 11988 on flood plain management.

4.4 AIR QUALITY

Air quality at the harbor is excellent most of the time. The main sources of pollution are dust conditions due to low rainfall, high winds through the "saddle area" and cane harvesting; the periodic burning in the sugar cane fields; the operation of vehicles and motorized vessels in the harbor; and volcanic eruptions on the island of Hawaii. There are no heavy industries in the area. The strong off-shore winds quickly disperse any air pollutants generated locally.

The Federal standard for particulate matter less than 10 microns in diameter (PM10) is 150 ug/m^3; for sulfur dioxide, the 24-hour standard is 365 ug/m^3.

Sulfur dioxide and PM10 concentrations are routinely monitored by the State at Kihei, a few miles east of Ma'alaea Harbor. Kihei is a fast developing residential and rural community with little commercial and no industrial activity. Samples taken several times per month throughout 1988-1991 consistently met the standards. Samples for PM10 ranged from 8 to 51 ug/m^3, and samples for sulfur dioxide were always 5 ug/m^3 or less (Hawaii Department of Health undated).

4.5 NOISE

The noise level in and around the harbor is usually low, with vehicles and motorized vessels being the main source, although frequently the wind is the dominant noise. During 1989 the aircraft traffic pattern for Kahului Airport was changed, so that now jet aircraft approaching Kahului Airport fly over the area, intermittently adding to the noise level. However, noise compatibility studies conducted by Belt Collins & Associates et al. (1989) for the Hawaii Department of Transportation concluded that noise levels incompatible with underlying land use are concentrated around the airport; noise contour maps show that outside 2 miles of the airport, noise levels are compatible with underlying land uses.

4.6 WATER QUALITY

The waters within Ma'alaea Harbor are designated Class A waters by Chapter 11-54, Hawaii Administrative Rules. This is a lesser classification than the adjacent waters of Ma'alaea Bay, which are Class AA. The water is moderately turbid due to accumulated fine sediments from terrestrial sources which enter the harbor through three drainage ditches on the northern side of the harbor and are resuspended by wind and harbor boat traffic.

The harbor presently acts as a sediment basin to slow the rate of sediment entering the Class AA waters of Ma'alaea Bay, thereby reducing potential adverse effects on the nearby marine biota. The Waiakoa Gulch empties directly into Ma'alaea Bay near the west side of the harbor, where, during periods of high rainfall the sediment load in near shore waters of the bay increases substantially because of drainage from erosion prone uplands (U.S. Fish and Wildlife Service 1993).

Ongoing deposition of sediments into the harbor will continue to degrade harbor waters. Future development planned for the area surrounding Ma'alaea may increase storm water discharges and sedimentation, possibly necessitating maintenance dredging, and may result in cumulative adverse effects on water quality and marine life.

The west Maui coastline has several monitoring stations within and near Ma'alaea Harbor (within 5-10 miles). These are located at the harbor, at the Kihei Boat Ramp and at Kihei South, Kalama Beach, and at Kamaole Beach.

Water samples taken by the Hawaii Department of Health from the harbor are consistently within the State of Hawaii Water Quality Criteria, except for turbidity, chlorophyll A, and enterococci (Table 4).

TABLE 4
SUMMARY OF SELECTED WATER QUALITY DATA
FOR MA'ALAEA HARBOR

	Number of Exceedences			
Parameter	1991	1992	1993	Criteria
Fecal Coliform (counts/100 ml)	0	0	0	200
Enterococci (counts/100 ml)	1	1	3	7
Temperature (degrees C.)	N/A	N/A	N/A	N/A
Salinity (parts/1000)	N/A	N/A	N/A	N/A
pH (pH units)	0	0	0	8.1+/-0.5
Turbidity (NTU's)	1	3	3	1.5*
Nitrogen (dissolved (ug/L))	0	0	0	8
Ammonia (ug/L)	0	0	0	6.0
Phosphorus (dissolved) (ug/L)	0	0	0	25*, 20
Chlorophyll A (ug/L)	1	2	2	1.5*, 0.5

*Wet Season Values
Note: The water quality criteria are somewhat complex and involve various percentages of samples exceeding different criteria. The values shown are the most stringent.

Source: Hawaii Department of Health 1993, 1994. Storet Data

Turbidity criteria were exceeded in one of three samples in 1991, in three of seven samples in 1992, and in three of ten samples in 1993. In three years of sampling, criteria have consistently been exceeded for turbidity in over one-third of all measurements. Exceedences of chlorophyll A were recorded in 5 to 18 percent of samples.

All ocean waters, bays, and estuaries in the State fully support beneficial uses, except that along the west Maui coat line, seasonal macroalgae blooms have begun to interfere with aquatic recreational activities. The causes of these blooms and possible measures to alleviate the problem are being studied by a Task Force headed by the Department of Health. The monitored basis for fully supporting designated use is enterococci; the criterion is that 7 counts/100 ml is exceeded in less than 10 percent of measurements. Where criteria are exceeded in 11-25 percent of measurements, the waters are considered to partially support designated use, and pollution sources are present but may not affect use. Exceedences in more than 25 percent of the measurements indicates that designated use is not supported, and use is likely to be impaired.

Measurements for enterococci from 1991 through 1993 at Ma'alaea Harbor indicate that in 1991, one of nine samples exceeded the criteria (7 counts/100 ml), meaning 11 percent of samples were in exceedence. In 1992, only 1 sample of 12 (8 percent) was in exceedence, therefore fully supporting designated use. Twenty-five percent of samples in 1993 (3 of 12 samples) exceeded the criteria, indicating only partially or not supporting designated use. Measurements at Kihei Boat Ramp, Kihei South, and at Kalama Beach showed that 63 to 100 percent of samples exceeded the criteria.

The State Department of Health (DOH) is concerned about the continued use of existing cesspools at the harbor. The existing wastewater system, a series of cesspools, is considered by the DOH (1991) to be a failed system due to overflows and frequent pumpout services. The cesspools serving the boat harbor are constructed almost entirely in water, since the water table in the area is very high. There is a potential for serious contamination of coastal waters.

Septic tanks and injection wells are two of five major sources of groundwater contamination and are top priorities for the State's groundwater protection program (Hawaii Department of Health undated). The only known groundwater contamination on Maui is at Lahaina and on the windward coast.

4.7 FLUSHING

Circulation in the harbor is driven mainly by tide and wind. The tidal range is about 2 to 3 feet. Wind is steady in direction (predominantly from the north and northeast). The velocity of the currents is relatively weak; velocity is approximately 2-5 cm/s. Within the regular tidal fluctuations, the northerly wind drives the surface water flow in a southerly direction. Surface water flows out of the harbor, and bottom water flows in. Circulation within the harbor is a clockwise flow pattern set up due to the northeast wind pushing water against the south breakwater.

Flushing is the term used to describe the amount of time that it takes to exchange the water within the harbor with the receiving water. The primary factors that influence flushing of a shallow, enclosed basin are tide, wind velocity and direction, basin topography, and entrance control. Flushing time is one of the key criteria in measuring the physical influence of a project on the aquatic system.

Wang et al. (undated), from the Corps of Engineers Waterways Experiment Station (WES) laboratory, recently completed a study of the flushing rate of the harbor. They found that the flushing is driven by both tidal and wind forces, and that the flushing rate for the existing harbor is conservatively estimated at about 2.9 days. Clark (1983, in Wang et al., undated) established a maximum time of 2-4 days as a safe design criterion for harbors, while a period of more than 10 days should be considered unacceptable. The details of that study are included in "Numerical Hydrodynamic Modeling and Flushing Study at Ma'alaea Harbor Maui, Hawaii," in Appendix B.

4.8 LITTORAL PROCESSES, BEACHES, AND SHORELINE STRUCTURES

Currents near Ma'alaea Harbor are dominated by the northeast trade winds-generated surface current. Current speed is estimated to be typically less than 1 knot (1.2 mph) under normal trade wind conditions and does not cause navigational problems. Wave-generated rip currents may exist when high waves are breaking, but this phenomenon has not been documented. Tidal currents in Ma'alaea Bay are weak and insignificant with regard to navigation considerations.

There does not appear to be any substantial longshore transportation of material in the harbor area as evidenced by the fact that the harbor entrance channel has never been dredged, and there is no entrapment of sand by the existing structures.

A small beach is located within the harbor next to the east breakwater (Figure 17), allowing easy wading access to the water for fishermen and surfers. The beach is State

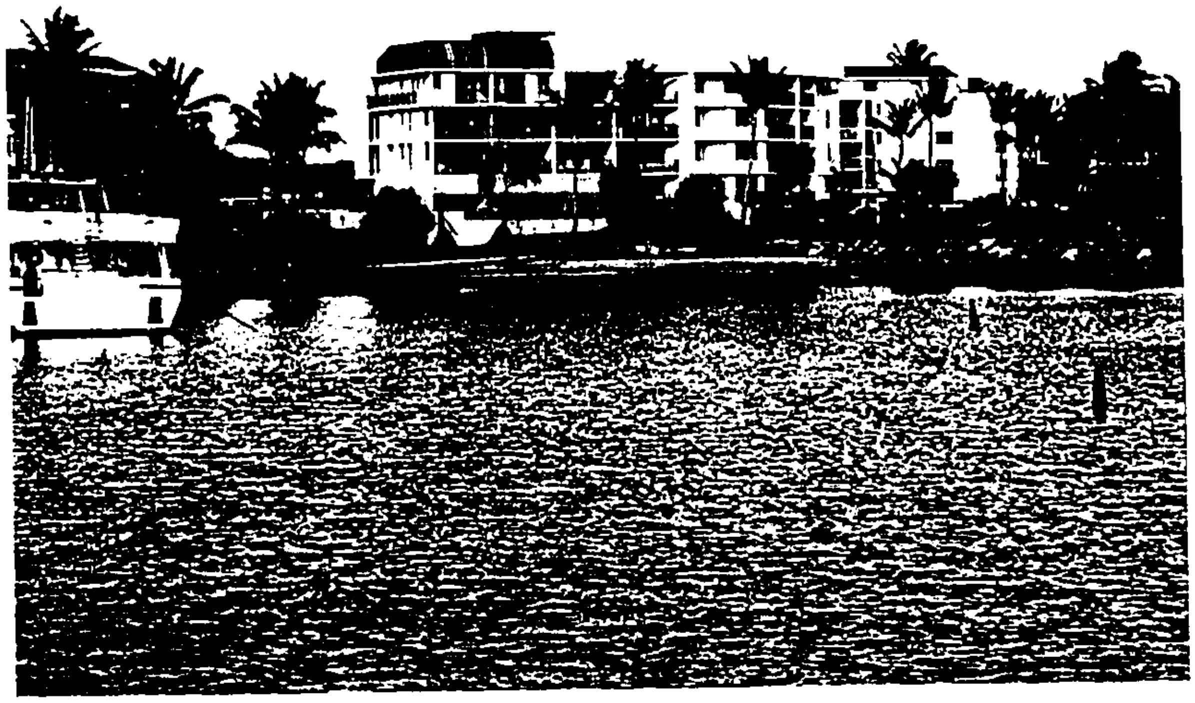


Figure 17 Northeast corner of Ma'alaea Harbor showing the small beach next to the east breakwater.

Figure 18 Seawalls fronting the condominiums east of the east breakwater.

property, part of the harbor, and under the control of the State of Hawaii Department of Transportation, Harbors Division.

Most of the condominiums east of the east breakwater have erected seawalls to protect their property from eroding (Figure 18). These nearly vertical to vertical seawalls themselves may contribute to erosion as waves scour the substrate fronting the walls. The structures' high wave reflectivity likely retards or prevents substantial deposition of sand along this reach.

4.9 SURFACE DRAINAGE, COASTAL FLOODING, AND SEDIMENT DEPOSITION PATTERNS

According to the Federal Emergency Management Agency's Floodway Flood Boundary and Floodway Maps #150003 0235 and 150003 0255, dated June 1, 1981, Ma'alaea Harbor is in a coastal high hazard area which extends from Kihei to Malalowaiaole Gulch.

Three drainage ditches enter Ma'alaea Harbor (Figure 3). These ditches carry water and sediment from the upland agricultural fields north of the harbor. Rainfall in the area is low, so that the actual amount of runoff is relatively small. There is also a small swale between the Ma'alaea Yacht Marina condominium and the Ma'alaea Malawai condominium.

Sediment from the three drainage ditches tends to accumulate in the vicinity of the outfalls. The finer particles slowly flush out into Ma'alaea Bay as they are entrained in the wind-driven harbor currents.

During periods of high rainfall, the sediment load in nearshore waters of Ma'alaea Bay increases significantly as a result of drainage from erosion-prone uplands. The greatest increase occurs in the eastern portion of the bay where Waiakoa Gulch empties directly into the bay. In the western portion of the bay, three drainage channels empty into the harbor and contribute to the Bay's total sediment load. The harbor does to some degree act as a sediment trap, but finer sediments are regularly resuspended by boat activity (Maciolek 1971 and Kinzie 1972 in U.S. Fish and Wildlife Service 1993).

4.10 BIOLOGICAL RESOURCES

The FWS completed field surveys in 1979, which included a brief reconnaissance of terrestrial flora and fauna within the harbor area and surveys of marine species and habitats in the harbor and the inner reef flat, outer reef flat, reef margin, and reef slope outside the harbor. Additional surveys conducted by the U.S. Fish and Wildlife Service in 1992 and 1993 consisted of reconnaissance-level surveys of the fringing reef outside the harbor and within the entrance channel; terrestrial flora and fauna around the harbor area for comparison with 1979 survey results; distribution and relative abundance of fishes, corals, other macro invertebrates, and algae within and outside the harbor; and substrate coverage data. The details of those surveys are included in the Draft Fish and Wildlife Coordination Act Report dated July 1993 (see Appendix A).

4.10.1 TERRESTRIAL RESOURCES

The terrestrial portion of the project has been highly altered by construction of the harbor and associated facilities. There are no wetlands or sensitive upland habitats located within the harbor area (U.S. Fish and Wildlife Service 1993). No listed, candidate, or proposed threatened or endangered terrestrial species are known to exist at the proposed project site.

Flora. The dominant terrestrial plants found at the harbor site include *kiawe* (mesquite) and bristly foxtail, both of which are exotics. Coconuts and ironwood are also present along the western end of the harbor. Ground cover is primarily seaside purslane and beach fan flower.

Fauna. Terrestrial birds observed at the site include common mynahs and house sparrows. Wandering tattlers, ruddy turnstones, golden plovers, and sanderlings are among the migratory shorebirds expected to use the intertidal flats at the site. Terrestrial mammals include domestic cats and dogs, mice and rats, and the mongoose. Terrestrial reptiles present at the site include introduced skinks and geckos.

4.10.2 MARINE RESOURCES

The reef seaward of Ma'alaea Harbor is well developed, with a diverse community of corals and common reef organisms. The biota of Ma'alaea Bay was described as unusual in that the number and forms of various marine species, uncommon elsewhere in the Hawaiian Islands, were common in the bay (Kinzie 1972 in U.S. Fish and Wildlife Service 1993). A later author (Butler 1977) stated that the bottom was dying and indicated fish were less abundant, and mollusks and coral and other invertebrates were suffering from a strange blight. The most recent data are from the U.S. Fish and Wildlife Service surveys in 1992 and 1993.

Ma'alaea Harbor currently acts as a silt trap for three previously mentioned drainage channels, which accounts in part for the turbidity typical in the harbor. Nonetheless, the harbor supports sport and subsistence fishing and the coral reef fronting it also provides resting and foraging habitat for the threatened green sea turtle. The reef slope fronting and eastward of the east breakwater is the richest and most valuable area adjacent to the harbor, with large coral heads and abundant, diverse biological resources (U.S. Fish and Wildlife Service 1993).

The FWS classifies the coral reef fronting Ma'alaea Harbor as a Resource Category 2 habitat. The habitat in this category is defined as habitat of high value that is relatively scarce or becoming scarce on a national basis or in the ecoregion. The FWS resource goal for Category 2 habitat is no net loss of in-kind habitat values (U.S. Fish and Wildlife Service 1993).

The western half of the harbor is underlain by a low-relief shoal covered with thick sand, mud and silt. The red alga (*Hypnea musciformis*) was observed over most of the shoal in 1993. Small colonies of corals have inhabited basalt boulders on the northern and western edges of the shoal, and nerite and sea urchins are common. Several species of fish, both singly and in schools, were seen in this shoal area. The eastern portion of the harbor is a shallow reef flat near the east breakwater. The existing turning basin is located in this area. The inner portion of this shallow reef flat is sand and a few rocks, covered by red alga and other algae species. Mollusks and crustaceans occur on the reef and near the breakwater, as do fishes such as wrasse and parrot fishes.

The substrate of the reef is rockier near the mouth of the harbor, and the fish community is more typical of the outer-reef. Mollusk species found inside the harbor are also found in this area, as are other mollusks, crustaceans and macro invertebrates that inhabit the breakwater boulders. The existing entrance channel is sand covered and is relatively depauperate of marine life. Isolated outcroppings of limestone occur at the seaward end of the channel; these outcroppings support a scattering of coral and reef fishes. The entrance channel outside of the harbor is fringed by a flat reef platform with small pockets of sand, scattered coral heads, and small crevices.

The inner reef flat outside the harbor is covered primarily by coral rubble. Much of the rubble is covered by algae. The rubble decreases with depth over the outer reef flat, and small patches of coral occur in depressions. The boulders at the end of the east breakwater just beyond the reef margin are covered with red algae. Urchins are abundant on these boulders, as are a few common species of mollusks and crustaceans. Seaward of the end of the east breakwater the reef platform is shallow and covered with a dense population of the boring sea urchin.

Corals on the reef slope increase from 10 percent coverage from the front of the east breakwater to 50- to 75-percent coverage, decreasing sharply into the sand flats. This reef system contains extensive ledges, depressions, knobs, and coral heads; it is the richest and most valuable area in terms of abundance and diversity of biological resources adjacent to the harbor.

The marine life on the boulders of the south mole on the other side of the entrance channel are basically the same as those on the east breakwater. The area fronting the east section of the mole is low-relief limestone pavement with high densities of boring sea urchins. Substrate in the location proposed for filling for expansion of the south revetted mole is primarily limestone pavement with less than 10 percent coral coverage. Algae covers the substrate towards the western end of the mole. Immediately fronting the south mole, corals are scarce, but coverage increases to 50 percent in deeper water further out. In addition to urchins and sea cucumber, fish species such as surgeonfish, butterfly fishes, goatfishes, damselfishes and triggerfish are abundant in this reef area.

Species important to subsistence fishermen such as octopus, lobster, white crabs, sea urchins, and herbivorous reef fish are reported to be very scarce (Eckert 1994 pers. comm.). The decline of the near shore subsistence fishery throughout Hawaii has been noted by the State Department of Land and Natural Resources, Aquatic Resources Division (Eckert 1994 pers. comm.), and a long-term study has been funded by the Hawaii State Legislature to determine the cause. There is no evidence to indicate Ma'alaea Harbor is responsible for the perceived fishery decline.

An edible seaweed, *Grateloupia filicina*, has traditionally been used by the Hawaiian people and is found in scattered locations throughout the state. It has been reported that Ma'alaea Bay is one of the few areas where this red algae species is locally abundant. In March and July 1990, McDermid (1990a, 1990b) conducted surveys to identify macro algae in and around Ma'alaea Harbor, with special emphasis on the uncommon *G. filicina*. She found the shallow reef flat adjacent to the harbor (to a depth of about 4 feet) was dominated by the introduced alga *Hypnea musciformis*, but in deeper water the algae community was more diverse. *G. filicina* was found where intertidal hard substratum is interspersed with sand cover or sand scour and is subject to freshwater inflow. It was found in scattered clumps just seaward of the south breakwater and to the east of the east breakwater. It has also been observed at the eastern end of the bay near Kihei.

Figure 19 shows the locations of the habitats discussed above.

4.10.3 THREATENED AND ENDANGERED SPECIES

Threatened and endangered species that may occur in the project area are primarily the endangered humpback whale *(Megaptera novaeangliae)* and the green turtle (*Chelonia mydas)*.

Humpback Whale. Ma'alaea Bay is an important calving, breeding and nursing area for the endangered humpback whale (*Megaptera novaengliae*). Until recently, the bay was one of two areas designated by the National Marine Fisheries Service (NMFS) for stricter approach limits (300 yards vs. 100 yards), and Ma'alaea Bay is included in the Hawaiian Islands Humpback Whale Sanctuary designated by Congress in the Oceans Act of 1992 (Figure 20). The purposes of the Sanctuary are to (a) protect whales and their habitats, (b) educate and interpret for the public the relationship of humpback whales to the area marine environment, (c) manage such human uses of the Sanctuary consistent with the Oceans Act of 1992 and the Marine Protection, Research and Sanctuaries Act of 1972, and (d) provide for the identification of marine resources and economic systems of national significance for possible inclusion in the sanctuary. A comprehensive management plan and implementing regulations are currently being developed by the Department of Commerce, National Oceanic and Atmospheric Administration.

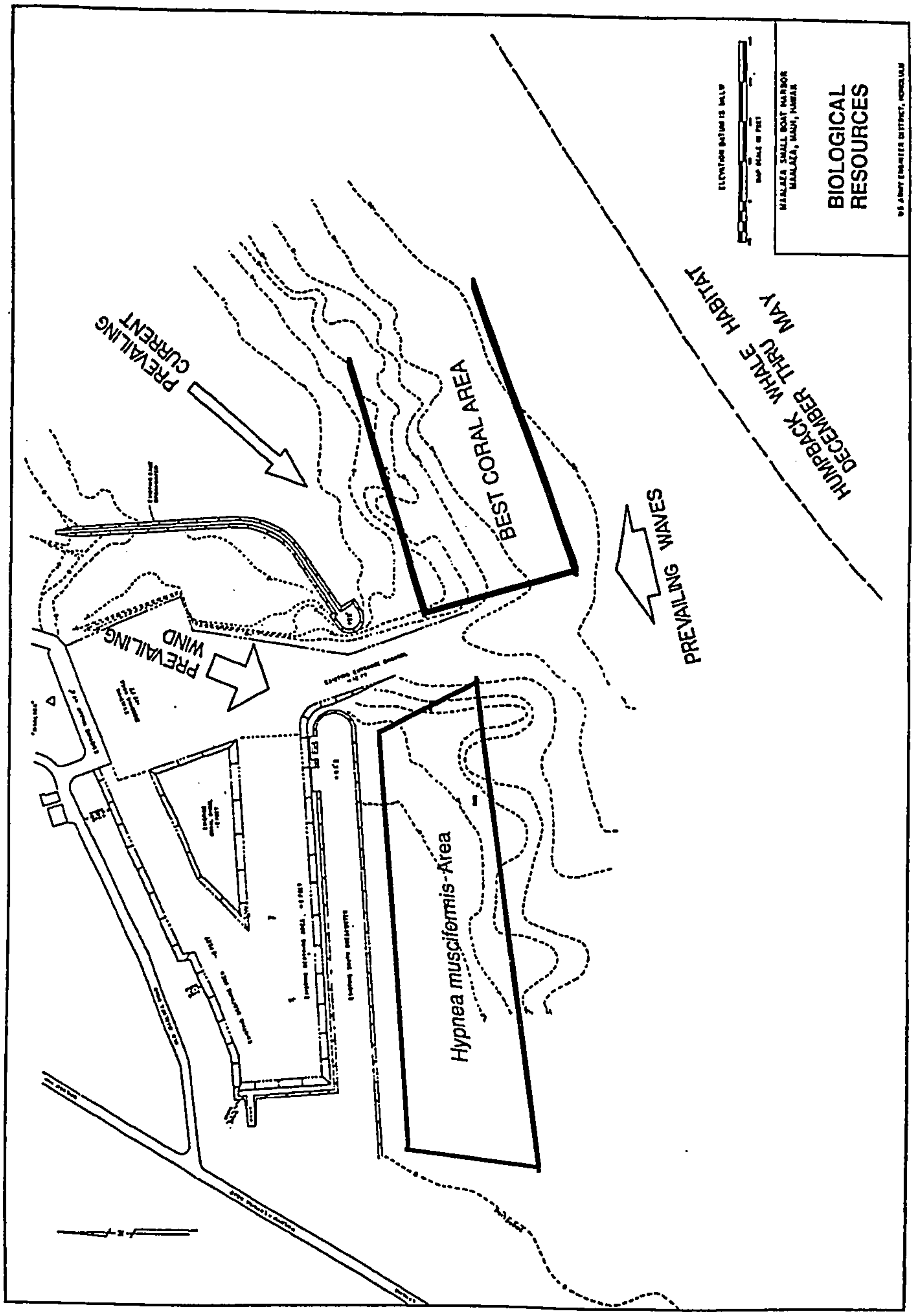
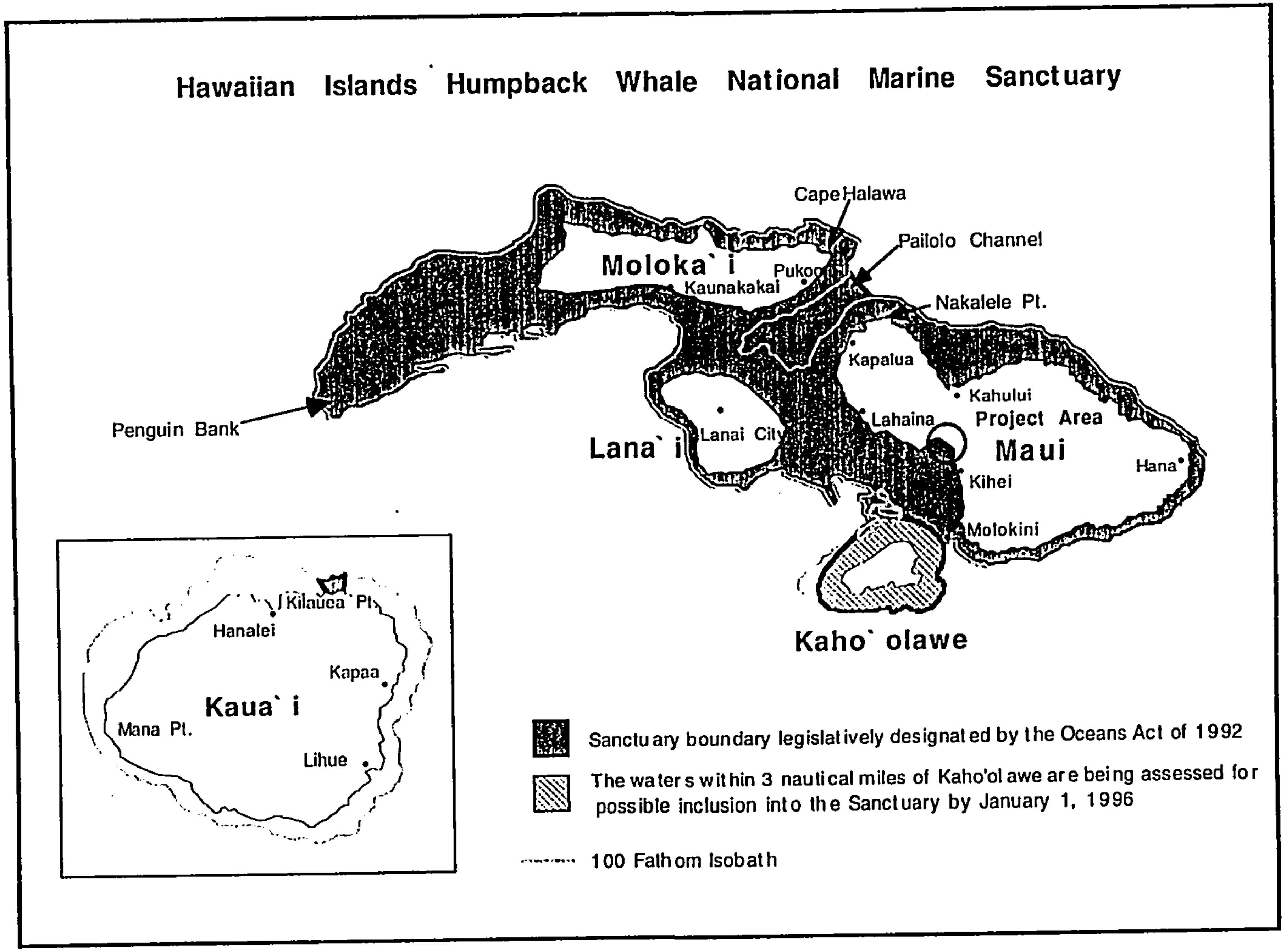

BIOLOGICAL
RESOURCES
MAALAEA SMALL BOAT HARBOR
MAALAEA, MAUI, HAWAII
HUMPBACK WHALE HABITAT
DECEMBER THRU MAY
BEST CORAL AREA
PREVAILING CURRENT
PREVAILING WIND
PREVAILING WAVES
Hypnea musciformis Area

Figure 19



Hawaiian Islands Humpback Whale National Marine Sanctuary
Cape Halawa
Pailolo Channel
Nakalele Pt.
Moloka` i
Pukoo
Kaunakakai
Kapalua
Kahului
Lahaina
Project Area
Maui
Hana
Kihei
Molokini
Lana` i
Lanai City
Penguin Bank
Kaho` olawe
Kaua` i
Kilauea Pt.
Hanalei
Kapaa
Mana Pt.
Lihue
Sanctuary boundary legislatively designated by the Oceans Act of 1992
The waters within 3 nautical miles of Kaho'olawe are being assessed for possible inclusion into the Sanctuary by January 1, 1996
100 Fathom Isobath

Figure 20

Information gathered by aerial and small boat surveys between 1985 and 1991 indicates the whales appeared to have no preference for any one of the study sub-regions overall; however, the 25 meter depth contour seems to be a preferred region. The number of humpback whales visiting the area each year can vary widely. For example, during small boat surveys by the Pacific Whale Foundation in 1989 a total of 399 whales were observed, while in 1991 a total of 949 were seen. The reason for such fluctuation is not known.

These endangered animals are resident in Hawaiian waters only during the period between December and May each year. Appendices A and B contain more detailed information about the use of Ma'alaea Bay by humpback whales.

Green Turtle. The threatened green sea turtle (*Chelonia mydas*) is also known to frequent Ma'alaea Bay throughout the year. A large male green sea turtle resting in the coral reef fronting the south breakwater of the harbor was observed by USFWS during its survey in May 1993. Green turtles are not known to regularly nest or breed in Ma'alaea Bay. The distribution and quantity of algal food resources and availability of resting habitat for green turtles within and around the project site has not been determined (National Marine Fisheries Service 1990). Appendices A and B contain more detailed information about the use of Ma'alaea Bay by green sea turtles.

Other Listed Species. There has been one report of an endangered hawksbill turtle (*Eretmochelys imbricata*) nesting in the bay, but these turtles do not generally frequent Ma'alaea Bay. Endangered Hawaiian monk seals (*Monachus schauinslandi*) are observed along the coast of Maui on rare occasions. In February 1993 one was observed basking on a beach at Ma'alaea, east of the Harbor.

4.11 CULTURAL RESOURCES

Ma'alaea Bay was important to the early residents of the area. The reef provided a valuable subsistence fishery, and a spring (no longer present) located in the harbor area provided fresh water. It was also an important launching point for canoes from which people interred the bones of their ancestors far out to sea.

A cultural history overview conducted by Hawaii Marine Research, Inc. in 1979 (Appendix H) concluded that "(I)t does not appear from our investigations that Ma'alaea Small Boat Harbor is eligible for inclusion on the National Register of Historic Places". The State Historic Preservation Officer (SHPO) concurred with the Corps' "no effect" determination in 1980 and again by letter dated November 17, 1989 (Appendix A).

Subsequently, a literature review and further coordination with the SHPO's office revealed the presence of two artifacts, a *piko* stone and a grinding stone (King's table) identified as site 50-50-09-1440 (-1286). These items were moved from their original unknown location sometime in the past and are now located in the grassed area in front of Buzz's Restaurant.

4.12 RECREATION

4.12.1 SURFING SITES

There are three surfing sites (5 breaks) adjacent to the harbor: the Ma'alaea Pipeline, Off-the-Wall, and Buzz's (Figure 21): These surf sites were characterized by Moffatt and Nichol (in Belt Collins 1992) in order to determine the possible effects of alterations to the Ma'alaea Harbor. Parameters used to characterize surfing sites include surfing quality, frequency of use, density of use, uniqueness, required surfing skills and percentage of time surfable conditions occur at the site. Surf quality is determined by the break's wave size, speed, shape or type, and peel angle, as well as the length of the ride. Frequency of use is an estimate of how often the site is used. Density refers to the number of surfers that can normally utilize the site at a given time. The uniqueness of a site is determined by the number of sites in the same general area that have similar characteristics. The range of skills required is determined by the diversity of abilities that are needed under various wave conditions. Finally, the percentage of time surfable conditions exist is determined by the relative proportion of time the site experiences favorable surfing conditions.

East of the entrance channel is the world renowned "Ma'alaea Pipeline", also sometimes referred to as "Freight Trains". This surf site has been acclaimed by professional surfers as having some of the best waves in the world. Surfer Magazine has ranked it as one of the ten best waves in the world and the fastest breaking right in the world. The Ma'alaea Pipeline experiences high quality waves with surfable conditions over 50 percent of the time. The site is very unique and has one of the longest rides in Hawaii. Under normal conditions, the waves tend to form in four sections. On a good surf day (4 to 6 feet of surf), there may be as many as 80 surfers at this break (Belt Collins 1992). Surfers of all abilities are attracted to this site.

To the west near the harbor entrance channel is another area, called "Off-the-Wall" which is considered unique because it is one of the few hollow plunging waves in the area. It is surfed when waves are 2 feet or greater. Off-the-Wall is ridden by both surfers and body boarders. Density of use is approximately 15 surfers, and frequency of use is high. Surfable conditions occur over 50 percent of the time.

A third popular site called "Buzz's" extends along the south breakwater on the west side of the entrance channel. Three separate breaks have been identified along the breakwater. Buzz's No.1, also known as "Sea Flight", is at the eastern end of the south breakwater opposite the former Sea Flight office (the new harbor administration office). It is a high surf, deep water break and is rarely ridden. It only breaks when wave heights are six feet or greater, and the ride is shorter, waves are poorly shaped and break locations are inconsistent. This site has the lowest density of use. Surfable conditions are present only 20 percent of the time.

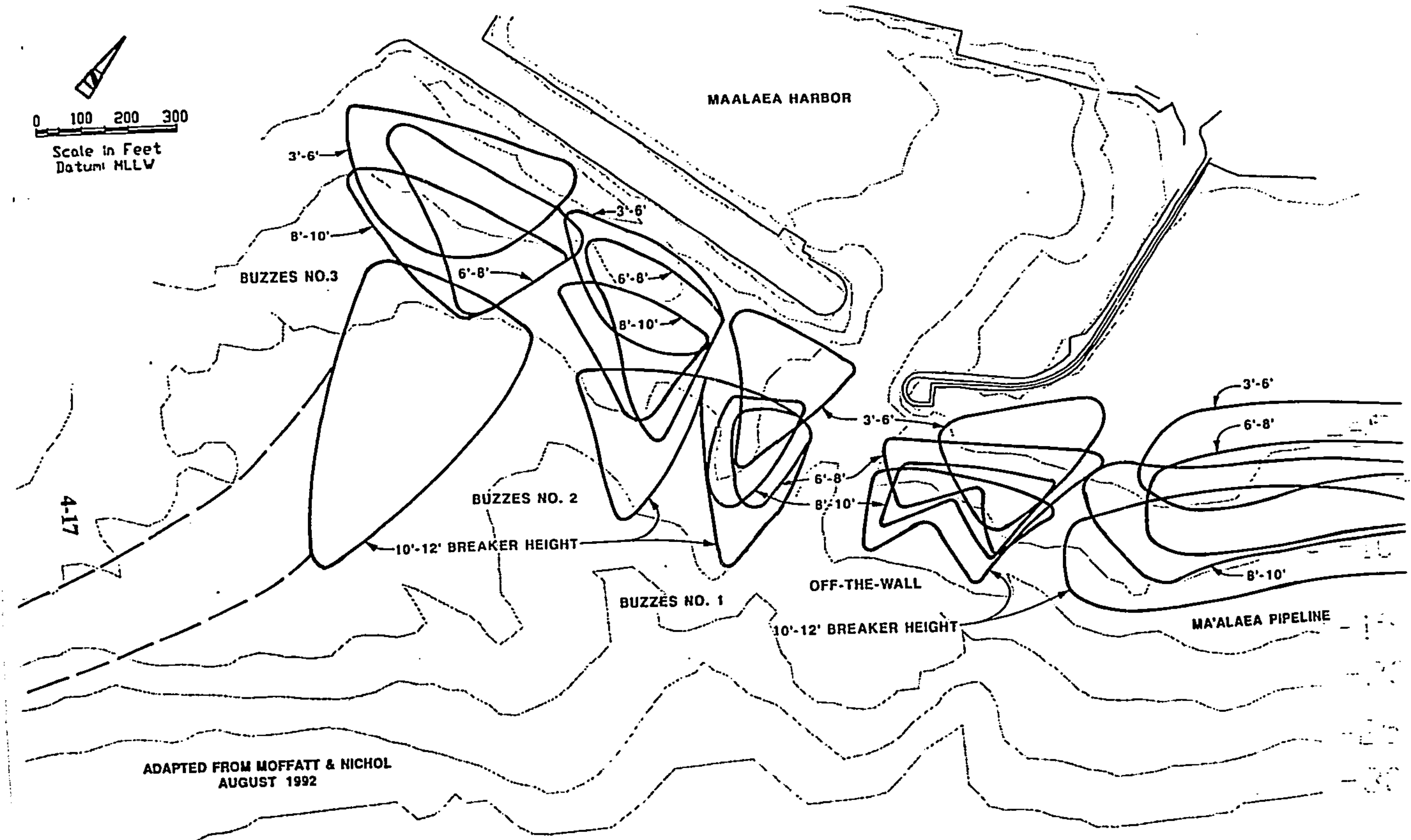


Figure 21

SURF BREAK LOCATIONS

Buzz's No. 2 is the most popular and consistent peak, and the break most surfers identify as "Buzz's". This break attracts 40 surfers and body boarders at one time. This site has unique characteristics (consistency of peak), but is similar to others in the area. Surfable conditions exist slightly less than 50 percent of the time.

Buzz's No. 3 is at the western end of the south breakwater and is usually only ridden by body boarders. Waves tend to be smaller and more poorly-shaped than No. 2. During high surf, Nos. 2 and 3 may merge. This site is similar to others in the area and is not of high quality. Density of use is moderate. Surfable conditions exist over 50 percent of the time. Appendix E contains more detailed information about the surf sites associated with Ma'alaea Harbor.

4.12.2 BOATING AND NAVIGATION

There are presently 87 berths in Ma'alaea Harbor. Approximately 25 recreation vessels, 13 subsistence fishing, 15 commercial fishing, and 34 charter fishing and commercial passenger vessels are berthed there. Sizes range from approximately 35 feet to 100 feet, with the 35- to 45-foot size being most common. Because of the harbor configuration, the harbor basin in subject to surge problems that prevent its full utilization, and navigation is hazardous in the entrance channel when waves exceed about 6 feet.

4.12.3 FISHING

The harbor supports sport and subsistence fishing. Pole and line fishing from the south mole and east breakwater are popular, as well as spear fishing on the reef platform fronting the harbor. Although fishing is not permitted within the existing harbor basin, bait fish are occasionally caught, and seasonally *halalu* (*Trachiurops crumenophthalmus*). In addition, several species of edible algae are found in and around the harbor, although not in great abundance.

4.13 TRAFFIC

4.13.1 TRAFFIC ANALYSIS

The traffic impact analysis report contained in the Ma'alaea Triangle Special Management Area Use Permit Application shows traffic counts on Honoapiilani Highway were about 12,000 vehicles per day in 1980, and increased to about 18,000 in 1985. The counts projected for 1990 were about 25,800, using the 7.7 percent increase assumed in the study. The traffic study conducted for this project in mid-1991 (Appendix D) found actual 24-hour traffic counts on Honoapiilani Highway to be slightly under 21,000 vehicles per day, with about 490 per day attributed to the boat harbor.

The only improved highway connection between central and west Maui is the Honoapiilani Highway. Access to the Ma'alaea area is provided by Old Ma'alaea Road, a two-lane road intersecting Honoapiilani Highway at two locations about 3,000 feet apart. Existing operating conditions at critical intersections were characterized in 1991 by Parsons Brinckerhoff Quade & Douglas, Inc. (1994) for the State of Hawaii Department of Transportation, Harbors Division.

The Highway Capacity Manual (Transportation Research Board 1985 in Parsons Brinckerhoff Quade and Douglas, Inc. 1994) was used to determine the existing capacity for project area roads. Level-Of-Service (LOS) ratings are as follows:

- LOS A - Free traffic movement; low traffic density, 90 percent of free flow speed. For signalized intersections, no vehicle waits longer than one signal cycle; average stop delay less than 5 seconds per vehicle. For unsignalized intersections, little or no delay.

- LOS B - Delay is not unreasonable; stable traffic flow; 70 percent of free flow speed. For signalized intersections, on a rare occasion, motorists wait through more than one signal cycle. Average stop delay is 5.1 to 15 seconds. For unsignalized intersections, short traffic delays.

- LOS C - Stable condition; movements somewhat restricted due to higher volumes, but not objectionable for motorists; 50 percent of free flow speed. At signalized intersections, occasionally drivers wait through more than one signal cycle and backups may develop behind left-turning vehicles. Traffic flow is still stable and acceptable. Average stop delay is 15.1 to 25 seconds. At unsignalized intersections, average traffic delays may be experienced.

- LOS D - Movements more restricted; backups and delays may occur during short peaks, but lower demands occur often enough to permit clearing; 40 percent of the free flow speed. Delays at signalized intersections may become extensive with some, especially left-turning vehicles, waiting two or more signal cycles. Average stop delay 25.1 to 40 seconds. At unsignalized intersections, very long traffic delays may occur.

- LOS E - Roadway conditions and traffic volumes create delay to all motorists. 30 percent of free flow speed. Very long backups may create lengthy delays at signalized intersections, especially for left-turning vehicles. Average stop delay is 40.1 to 60 seconds. Very long traffic delays are experienced at unsignalized intersections.

- LOS F - Forced flow with volumes greater than capacity, resulting in complete congestion; less than 30 percent of free flow speed. At signalized intersections, the arrival rate of traffic exceeds the intersection's ability to handle traffic. Unacceptable conditions. Average stop delay exceeds 60 seconds per vehicle. At unsignalized intersections, traffic volumes exceed the land's ability to handle the traffic.

In urban areas, transportation planners and engineers consider LOS D to be generally acceptable.

4.13.2 EXISTING LEVELS OF SERVICE

• Left turns from Honoapiilani Highway to the Ma'alaea Wharf Access Road experience Level Of Service (LOS) A and B during the a.m. and p.m. peak hours respectively. The lane exiting Ma'alaea Harbor is a shared left/right lane which experiences LOS D during the a.m. peak hours and LOS E during the p.m. peak hours.

• Left turns from the highway into Ma'alaea Harbor at the southern intersection of Old Ma'alaea Road and Honoapiilani Highway operate at LOS A and B during the a.m. and p.m. peak hours, respectively. Right turns exiting Ma'alaea experience LOS D during the a.m. peak and LOS E during the p.m. peak hour.

• Left turns from Honoapiilani Highway onto Old Ma'alaea Road north of the harbor, and right turns onto Honoapiilani Highway from Old Ma'alaea Road both operate at LOS A during the a.m. peak hour ; during the p.m. peak hour, Levels of Service are at C and D, respectively.

• All movements at the Intersection of Old Ma'alaea Road and Hauoli Road (a two-land road providing access to the residential area of Ma'alaea) operate at LOS A during all peak hours.

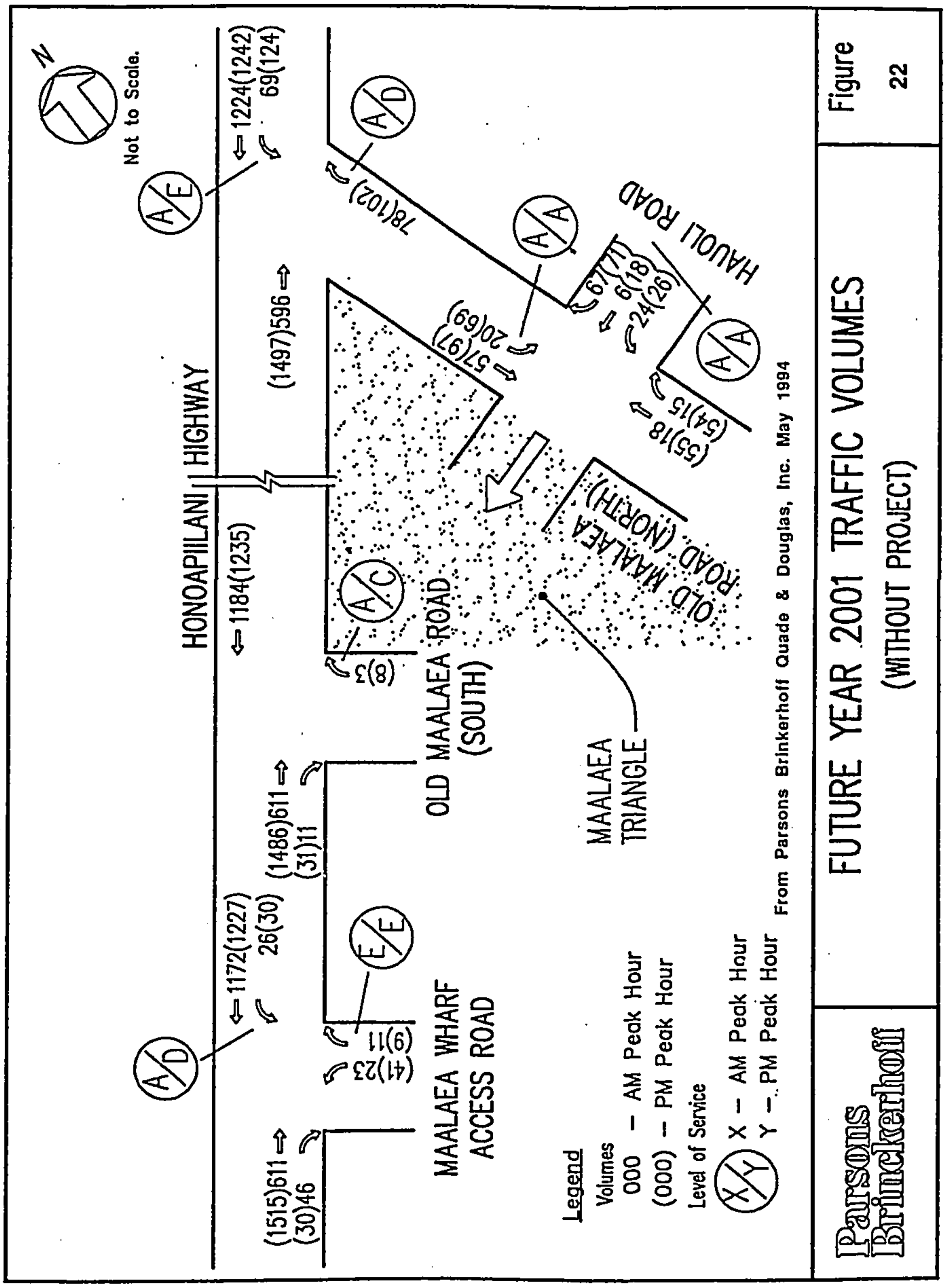
• Honoapiilani Highway operates at LOS E north and south of Ma'alaea Harbor during both peak hours.

4.13.3 FUTURE TRAFFIC CONDITIONS WITHOUT THE PROJECT

The traffic volumes for the future without-project condition were based on information from the Maui Long-Range Hiway Planning Study (Hawaii Department of Transportation 1991 in Parson Brinckerhoff Quade & Douglas, Inc. 1994) and on historic traffic information collected by the Hawaii DOT. Traffic volumes along Honoapiilani Highway in the general project area were assumed to grow at 2.9 percent on an average annual basis through the year 2001. Traffic volumes from the planned Ma'alaea Triangle Development (a large shopping center bordered by the north and south Old Ma'alaea Roads and Honoapiilani Highway) were also added. It was also assumed that left-turn traffic at the southern intersection of Old Ma'alaea Road and Honoapiilani Highway would be diverted to the intersection of Ma'alaea Wharf Access Road and Honoapiilani Road.

The future traffic conditions without the proposed project are summarized below and are shown in Figure 22.

• Left turns from Honoapiilani Highway onto the Ma'alaea Wharf Access Road would continue to operate at LOS A during the a.m. peak hour, but would go from LOS B to nearly LOS D conditions during the p.m. peak hour. Traffic exiting the harbor would experience LOS E conditions during both peak hours.



FUTURE YEAR 2001 TRAFFIC VOLUMES
(WITHOUT PROJECT)

Figure 22

4/28/94

• Because the left-turn lane from Old Ma'alaea Road (south) onto Honoapiilani Highway would be restricted to right turns only, the level of service at this intersection would be improved over existing conditions, from LOS D and E during a.m. and p.m. peak hour, respectively, to LOS A and C during the same periods, respectively.

• Left turns from the highway onto Old Ma'alaea Road north of the harbor would be expected to operate at LOS A during the a.m. peak hour; during the p.m. peak, the intersection would experience a drop in level of sevice from LOS C to LOS E. Right turns from Old Ma'alaea Road would continue to operate at LOS A during the a.m. peak hour; level of service would drop from LOS C to LOS D during the p.m. peak hour.

• All movements at the intersection of Old Ma'alaea Road and Hauoli Road would continue to experience LOS A during all hours.

• Honoapiilani Highway is expected to experience conditions over the capacity of the highway during the p.m. peak hour and would operate at LOS E during the a.m. peak hour.

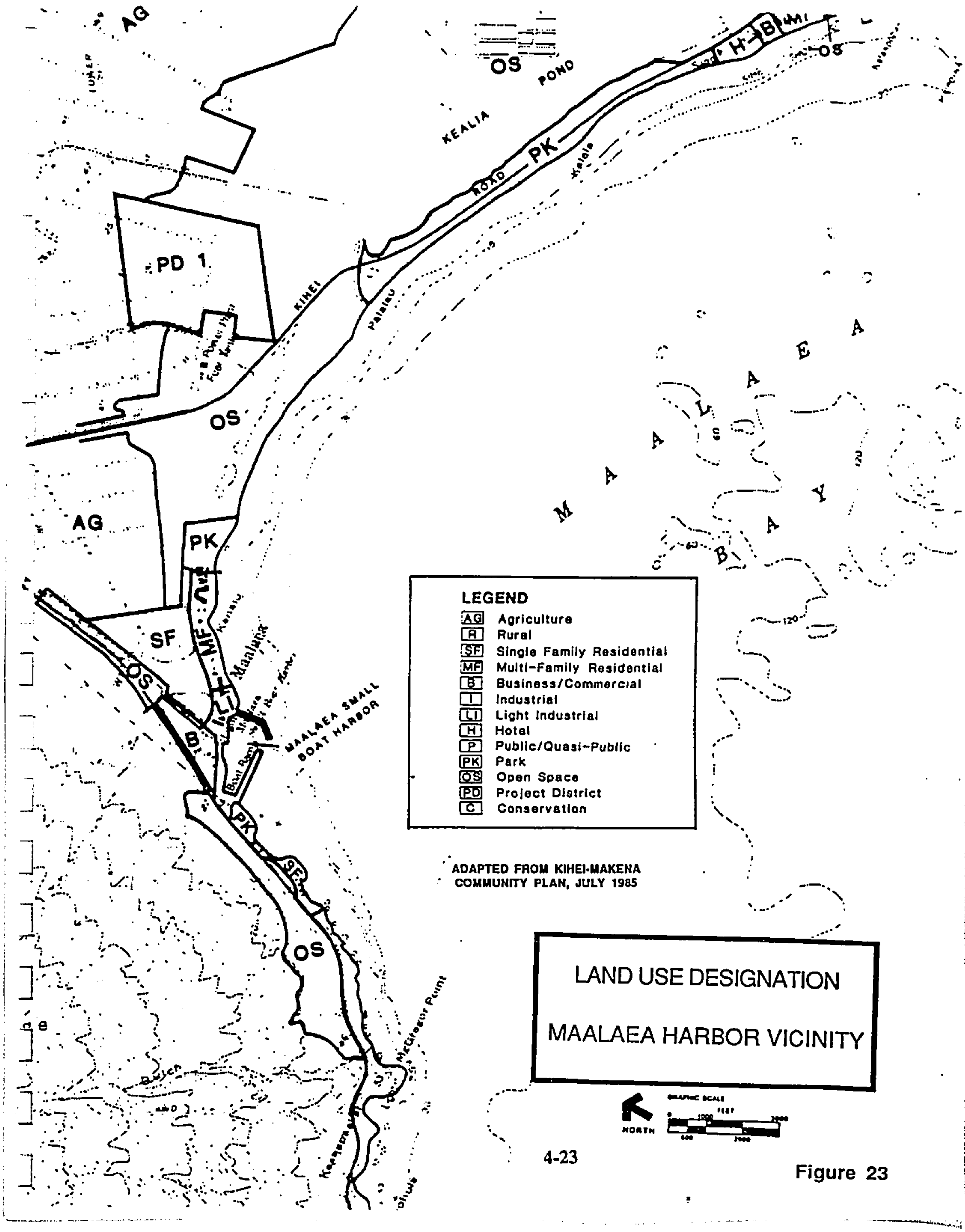
4.14 LAND USE

The land use designation for the project area is Business and Light Industrial (Figure 23), and the property is under the jurisdiction of the Department of Land and Natural Resources, Division of Boating and Ocean Recreation (DLNR, DBOR). A portion along the western coast is designated for park use by the Kihei-Makena Community Plan dated July 1985; however, DLNR, DBOR has indicated they intend to use the land for harbor purposes and not transfer control to Maui County for a park (Parsons, pers. comm.).

Adjacent land to the east along the shore is designated for multi-family use and contains a series of condominiums. Fronting the Ma'alaea Yacht Marina condominium is a small sand beach next to the east breakwater. The beach is within the harbor, and the land below the vegetation line is owned by the State of Hawaii. To the west of the harbor, property along the shoreline is designated for single-family homes. Most of the inland land across Honoapiilani Highway is designated for agriculture and is used for pineapple and sugar cane production. Recently the Maui Planning Commission changed the land use designation of 825 acres of this agriculture land to "future growth reserve".

4.15 SOCIOECONOMICS

Maui's economy is based almost completely on its tourist industry and sugar plantations, with pineapple, diversified agriculture, and cattle ranching playing lesser roles. Ma'alaea Harbor is located approximately 7 miles south of the adjacent communities of Wailuku and Kahului, the urban and commercial hub of Maui Island. Two major resort communities have developed on the Island: Lahaina-Kaanapali, located on the west end of Maui and extending from Lahaina town north approximately 10 miles; and Kihei-Wailea, extending from Kihei village south about 10 miles. Kihei lies approximately 4 miles east of Ma'alaea



LAND USE DESIGNATION

MAALAEA HARBOR VICINITY

Figure 23

Harbor. The population of the island was estimated at 88,100 in mid-1989. About 8 percent of the workers are employed in agriculture and food processing. Some 15 percent are employed by the hotels while another 15 percent are employed in other services. The government employs some 11 percent while finance, trade and transportation account for 37 percent of the jobs. The island has approximately 15,000 hotel rooms. The Kihei-Wailea resort area has 5,200 rooms and the Lahaina-Kaanapali resort area has 8,800 rooms. Both the Kihei-Wailea and the Wailuku-Kahului areas contribute users to Ma'alaea Harbor.

CHAPTER 5

ENVIRONMENTAL CONSEQUENCES

5.1 INTRODUCTION

This chapter assesses the probable environmental consequences of the four alternative plans, identified in Chapter 3 of this document, which were evaluated in detail. Unless indicated otherwise, the project impacts on the following environmental resources are expected to be essentially the same for all four plans. In addition, the No Action alternative is addressed, as appropriate throughout this chapter and noted by exception. Generally, the No Action alternative should result in no significant change from the existing environmental setting described in Chapter 4, Affected Environment. The discussion of impacts follows, to the extent possible, the order of resource descriptions provided in the previous chapter.

5.2 CLIMATE

The project as proposed will have no effect on the climate of the area.

5.3 NATURAL HAZARDS

None of the four alternatives would affect the frequency or magnitude of hurricanes or tsunamis, nor will it increase tsunami runup; however, with the increased number of boats to be berthed in the harbor, damage from these natural hazards will be increased to an unknown degree. The project features are designed for structural integrity for moderate level hurricane waves, but they do not provide protection against high wind conditions associated with hurricanes and severe tropical storms.

5.4 AIR QUALITY

Construction activities would increase dust and vehicle exhaust emissions in the project area; however, these effects will be temporary, affecting only the near vicinity of the project site. Since the Federal project does not involve extensive shoreside grading or earth moving, these temporary impacts are expected to be very minor. The State portion of the project would require more earth moving, especially in the area west of the harbor, where a combination parking lot and park are planned for eventual construction by DLNR, Division of Boating and Ocean Recreation. After construction there would be some increase in exhaust emissions from vehicles and power boats, but these emissions are not expected to have a significant effect on air quality because of the low ambient concentrations and the strong offshore winds typical of the area would blow them out to sea.

5.5 NOISE

Noise levels will be increased during construction of both the Federal and State portions of the project by the operation of heavy construction equipment. There will also be a slight increase in noise after project completion because of the greater number of power boats and increased vehicle traffic; however, the prevailing wind would continue to be the dominant noise much of the time, and aircraft flying overhead would still be the loudest intermittent source of noise. Noise levels would be compatible with surrounding land uses.

5.6 WATER QUALITY

Regardless of whether any Federal or State projects are constructed, the ongoing deposition of sediments into the harbor will continue to degrade harbor waters. Future development planned for the area surrounding the Harbor may increase storm water and sediment loads of the three ditches that drain into the harbor, further adversely affecting water quality. Maintenance dredging may be required, with its associated impacts on water quality and marine life. Resuspension of sediments by boats will continue, resulting in continued exceedences of water quality standards for turbidity.

During construction activities for any of the alternatives, water quality impacts would be expected. Turbidity would be increased while dredging, blasting, filling, and dredge spoil dewatering activities are completed. Additional exceedences in water quality standards for turbidity would be expected, both during construction, and as a result of increased turbulence caused by the additional vessel traffic. The three storm water drainage ditches will continue to be the primary cause of sedimentation and high turbidity levels, both with and without any Federal or State improvement projects.

The major cause of algae blooms and chlorophyll A exceedences is unknown, and the effects of construction and future increased vessel traffic on these parameters is unknown. The causes of these blooms are being studied by a DOH Task Force, and methods to alleviate the problem will be determined at that time.

The probable source of enterococci in the harbor may be stormwater runoff from the three drainage ditches discharging into the harbor. Runoff from the drainage ditches is expected to continue and to increase in the future with development of upland areas in the drainage basins, regardless of whether the Federal or State projects are constructed. If this is the major source of the enterococci, levels would be expected to increase in the future, and exceedences would also be expected to increase. These effects are not related to the proposed action.

In addition, illegal dumping of wastewater and sewage from harbor vessels and overflows of existing cesspools could contribute to the elevated enterococci levels. The construction of harbor sewage facilities by the State should decrease the amount of any illegal dumping of sewage from boats, as well as overflows of cesspools into the harbor. If this practice is the major source of enterococci in the harbor, levels of these bacteria would be expected to decrease after construction of the sewage disposal/pump-out facilities, possibly resulting in fewer exceedences of standards, or eliminating exceedences altogether.

5.7 FLUSHING

The effects of the proposed harbor modifications were evaluated by Wang et al. (undated) of the U. S. Army Corps of Engineers Waterways Experiment Station. The modeling study was done for a harbor configuration similar to that of Alternatives 1 and 2, based on (a) a 620-foot-long extension to the existing south breakwater; (b) an additional 400-foot-long revetment on the seaward side of the existing south breakwater, and (c) a 610-foot-long entrance channel, 150 to 180 feet wide and 12 to 15 feet deep.

The proposed breakwater configurations with Alternatives 1, 2, and 3 would deflect the incoming flow from the southwest direction to a south direction with increased velocity. The original southwestward flow would change to a northward compensation flow behind the proposed breakwater. An eddy would be generated around the tip of the proposed breakwater, which would affect flows around the harbor mouth and vicinity. Inside the harbor, the velocity pattern would be similar to existing conditions.

The wind-induced two-layer flow would be maintained (surface layer flows out, bottom layer flows inward). The flow pattern is expected to be less influenced by wind, and more in tune with oscillatory tidal flow.

For Alternatives 1, 2, and 3, flushing time would be increased from 2.9 days to 3.3 days. Because this increased flushing time still falls within the 2 to 4 days established as a safe design criteria, the increase in flushing time is not considered significant.

Alternative 4 was not studied by Wang et al. (undated) for effects on flushing. However, based on wind and circulation patterns, this alternative would likely not have an adverse effect on flushing conditions because of the alignment of the new entrance channel. North/northeast prevailing winds would push the surface waters out of the unobstructed harbor entrance and allow bottom waters with a northeasterly direction to quickly replace those surface waters.

5.8 LITTORAL PROCESSES, BEACHES AND SHORELINE STRUCTURES

Based on site investigations and observations throughout the study period, there is no discernible longshore transport of sand within the project area. Longshore currents generally flow from east to west; therefore, any detectable sand movement along the shore would result in accumulation of sand along the east breakwater, functioning as a groin, or within the existing harbor entrance channel. No evidence of significant sand accumulation has been found in either location. Similarly, there is no evidence of longshore transport of sand toward the east.

Since there is no substantial longshore movement of material in the vicinity of the project, none of the proposed alternative plans is likely to have an effect on littoral processes and therefore it is unlikely that any beaches east of the east breakwater will be affected by the project.

On this basis, the small sandy beach east of the east breakwater, as well as others further east along the coast are not likely to be affected by any new breakwater extensions. The small sand beach in the northeast corner of the harbor would be directly destroyed by a road connecting the new east mole to the rest of the harbor.

The four alternatives would not intensify or otherwise significantly change the longshore currents in the area. Hence, there is no reason to believe that harbor modifications would have any effect on the seawalls east of the east breakwater. On the other hand, vertical seawalls themselves are known to cause rapid erosion of the beaches in front of them and somewhat down current, as well as scouring and undermining of the wall foundations, resulting from direct wave action and reflection off the walls' vertical faces.

5.9 SURFACE DRAINAGE, COASTAL FLOODING AND SEDIMENT DEPOSITION PATTERNS

Coastal flooding in the area will not change as result of any of the four alternative plans. Ma'alaea Harbor will still be in a high hazard area (tsunami inundation area) with no change in expected elevation.

The four alternatives would not increase or decrease the surface drainage or coastal flooding patterns in the project area, and will be designed to comply with applicable Federal, State of Hawaii and County of Maui rules and regulations pertaining to flood plain management.

Surface drainage and sediment deposition patterns are not expected to increase from the existing condition as a result of any of the four alternative plans. There are currently no plans to relocate the drains which enter the harbor, and the uplands which drain into the harbor are expected to be developed in the future, increasing storm water runoff and sedimentation to the harbor. This effect is unrelated to the proposed action. There will be a culvert in the road to the east mole to accommodate the small flow from the swale between the Ma'alaea Yacht Marina and the Ma'alaea Milawai condominiums.

5.10 BIOLOGICAL RESOURCES

5.10.1 TERRESTRIAL RESOURCES

There would be no significant effects on terrestrial resources from any of the four alternative plans. Since the location of the source site for armor stone has not been determined at this time, impacts of this related activity have not been assessed. The stone is likely to come from existing commercial sources.

5.10.2 MARINE RESOURCES

The following discussion of impacts on the marine biological environment is largely based on the July 1993 Fish and Wildlife Service Coordination Act (FWCA) Report which is reproduced in Appendix A of this document. Each of the four alternative plans would result in direct and secondary adverse impacts to aquatic resources. The primary direct impacts of dredging and filling include loss of corals, demersal fishes, sedentary macro invertebrates, and benthic algae and the permanent alteration and elimination of existing marine benthic habitat. Secondary effects include impacts on corals and other filter-feeding organisms and algae, resulting from temporary degradation of near shore water quality. This degradation is caused by increased levels of suspended sediments and turbidity generated by project-related blasting and dredging of reef substrate, dewatering of dredged material, and discharging of fills.

Because of modifications and refinements made to the alternative plans, acreages have been recalculated since the FWCA report was prepared; therefore, project effects differ somewhat from those presented in the FWCA report.

Alternative Plan 1 would destroy or otherwise alter approximately 13.0 acres of aquatic habitat and associated biological community when the new entrance channel, turning basin, access channel, and berthing areas are dredged and the protective structures and south, east, and center moles are constructed. Alternative Plan 2 would destroy or alter a total of about 11.5 acres because the south mole would be replaced by a much smaller wave absorber. Alternative Plan 3 would also destroy or alter about 11.7 acres because of the smaller footprint of the detached breakwater.

Each of these three plans would require dredging a new harbor entrance channel that would cross barren sand on the existing channel floor, but would also traverse an area of relatively rich coral, with live coral coverage at about forty percent. Alternative Plan 4 would destroy the greatest area of reef substrate as a result of the longer entrance channel and extension of the east breakwater. Although less live coral would be lost from the consolidated pavement/sand pocket substrate, the overall loss of acreage includes green sea turtle resting and potential foraging habitat. Total area affected would be 15.2 acres. Many of the fish and more motile invertebrates are expected to move out of the dredging or construction area. The newly dredged channel may provide new "edge" habitat, thereby increasing diversity in an area that is presently a relatively featureless reef flat. The anticipated increase in habitat diversity is dependent upon the degree to which the freshly exposed reef surfaces become recolonized by reef-building organisms and their ability to overcome high levels of turbidity resulting from the ongoing discharge of terrigenous sediments into the harbor. The proposed entrance channel would be similar in design to the existing channel that continues to be relatively devoid of marine macro organisms, likely a result of high turbidity and sedimentation. Because of the poor water quality of the harbor and the potential for nonsuccess of displaced reef fish into surrounding reef habitats, there may be a net decrease in the standing crop of reef fishes in the area dredged for the new entrance channel.

The armor stones of the new breakwater and revetment sections will also provide increased vertical habitat in areas of soft bottom (harbor) or relatively featureless reef flat, resulting in local enhancement of fishery resources. The net habitat replacement value of armor stones for lost coral reef habitat depends on many factors, including its suitability for shelter, effects on light penetration levels, and localized current patterns that influence food availability. However, the stone would not duplicate the physical heterogeneity, interstitial complexity and vertical relief of the existing habit.

Filling activities associated with Alternatives 1, 2, and 3, adjacent to the inner portion of the east breakwater, would be confined to nearly one hundred percent sediment-covered harbor shallows. The affected infauna residing in the sediment and the benthic algae growing over it serve as limited food and shelter for juvenile fishes.

Alternative 1 also includes filling to widen the end of the south revetted mole. Live coral coverage at this location is only nine percent; however, the ledge where a resting green sea turtle was observed in 1993 lies very near the proposed footprint of this fill. Construction of the wave absorber in lieu of an expanded revetted mole in Alternative 2 would affect relatively flat reef pavement. Alternative 3 involves no modification to the south revetted mole.

The breakwater extension associated with Alternatives 1 and 2 would affect the reef slope where nearly half of it would traverse reef substrate with forty percent live coral coverage. The detached breakwater for Alternative 3 would impact on the green sea turtle resting habitat fronting the south revetted mole and would destroy 2 acres of a relatively rich coral habitat off the end of the east breakwater. The extension of the east breakwater in Alternative 4 would also destroy green sea turtle resting and potential foraging habitat.

All alternatives would indirectly impact corals and other filter-feeding organisms and algae during and for a short time after construction due to increased levels of suspended sediments and turbidity generated by blasting, dredging, filling and dewatering of dredge spoil. Impacts could include smothering corals and other filter feeders, abrasion of coral polyps by sediments, and reduced primary productivity from decreased light penetration.

Dredging within the harbor area could attract fish to the area to feed on exposed benthic organisms; however, high turbidity caused by dredging could limit this temporary benefit.

The algae rich areas adjacent to the harbor include the seaward side of the south breakwater, and the areas east of the east breakwater and at Kapoli Beach Park. In addition, the edible red algae, *Grateloupia filicina* was observed in the harbor, along the shoreline. The algal communities seaward of the south breakwater would be affected by the revetted mole construction in Alternative 1 and to some degree by the detached breakwater in Alternative 4. The algal communities to the east of the east breakwater should not be affected by any of the four alternatives since no structures or dredging is planned in that area, and as discussed earlier, no change to the longshore currents, deposition or movement of sand along this coastline is expected as a result of the proposed plans.

5.10.3 THREATENED AND ENDANGERED SPECIES

The results of the aerial and small boat surveys of humpback whales in the general vicinity of Ma'alaea Bay indicate that presently pods of whales without calves tend to avoid areas of heavy boat traffic, but that pods with calves do not. It is not known why this occurs, but it is speculated that the calf pods' need for shallow water overshadows the avoidance reaction. According to the Biological Opinion from the National Marine Fisheries Service (NMFS) issued on 25 April 1990, the project is expected to have an adverse effect on the endangered humpback whale, but with mitigation will have less adverse effect than the present situation.

There may be some increase in boat/green turtle contact, and the portion of the reef flat covered by the new protective structures will no longer be available for turtle foraging or resting. This is not expected to cause any adverse impact to the turtle population of Ma'alaea Bay because of the very small number of boat/turtle interactions expected, and the availability of other foraging/resting areas in the near vicinity of the harbor.

No effects are expected on endangered hawksbill turtles or Hawaiian monk seals, which occur in Ma'alaea Bay only very rarely.

5.11 CULTURAL RESOURCES

There are no physical remains of man-made cultural resources in the project area except for the two stone artifacts noted in Chapter 4. Neither of these artifacts will be affected by the project. Improvement of the harbor will have no effect on historic properties. This determination of "no effect" was concurred in by the State of Hawaii Historic Preservation Officer in 1980, 1989, and 1993.

5.12 RECREATION

5.12.1 SURFING SITES

A brief description of the expected impact to surf sites by each of the four alternatives follows. A more detailed analysis is contained in Appendix E. None of the four alternatives would adversely affect the world famous "Ma'alaea Pipeline".

Alternative 1 (Figure 24). Two surfing sites adjacent to the harbor will be affected. The site presently known as "Off the Wall" will be destroyed, and "Sea Flight" (Buzz's No. 1) and a small portion of the site known as "Buzz's " (Buzz's No. 2) will be modified in an unknown way by the proposed revetted mole to be constructed on the south breakwater.

Alternative 2 (Figure 25). The site presently known as "Off the Wall" will be destroyed, and "Sea Flight" (Buzz's No. 1) and a small portion of the site known as "Buzz's " (Buzz's No. 2) will be very slightly modified in an unknown way by the proposed south breakwater extension and wave absorber. Buzz's No. 2 would be less affected than by Alternative 1.

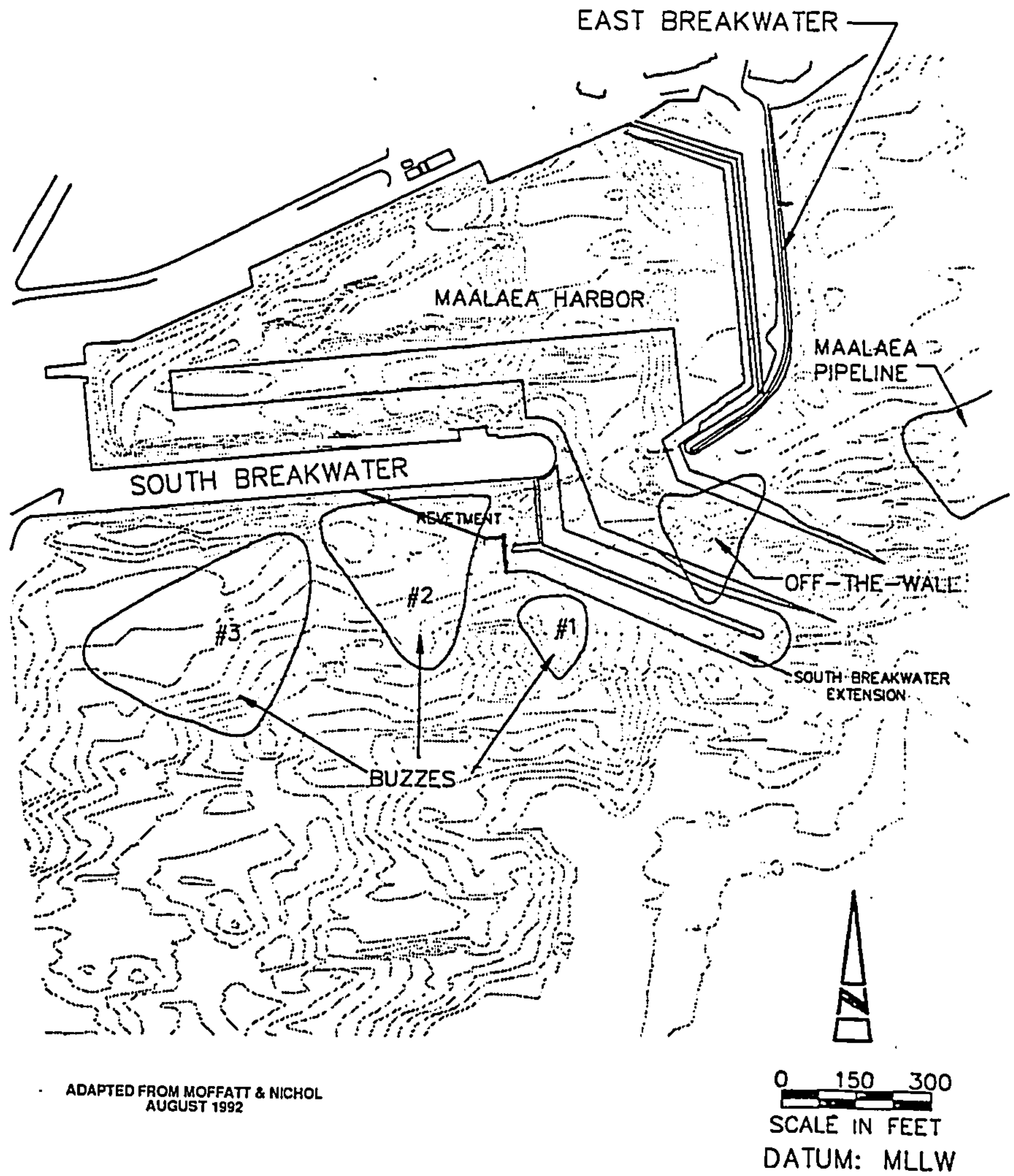
Alternative 3 (Figure 26). The site presently known as "Off the Wall" would be destroyed, and "Sea Flight" (Buzz's No. 1) and a portion of the site known as "Buzz's " (Buzz's No. 2) will be modified in an unknown way by the proposed detached breakwater; however, it appears that Buzz's No. 2 would be more affected than by Alternative 1 or 2.

Alternative 4 (Figure 27). Buzz's No. 2 would be completely destroyed, and Buzz's No. 3 essentially destroyed by the new entrance channel and close boat traffic. The sites presently known as "Off the Wall" and "Sea Flight" (Buzz's No. 1) would be modified by wave reflection to an unknown degree by the proposed east breakwater extension.

5.12.2 BOATING AND NAVIGATION

Each of the four alternative plans would result in an increase in berthing space for vessels ranging in size from approximately 25 to 100 feet, with the majority in the 30- to 40-foot range. Surge within the harbor basin would be reduced substantially, and the hazardous navigation conditions in the entrance channel would be eliminated.

Construction of the harbor improvements is not expected to significantly restrict the boating community. Much of the boating activity at Ma'alaea is commercial; hence, construction would accommodate boating interests. There will be some inconvenience when changing berthing locations, but this should not restrict boating activity. Overall, both commercial and recreational boating would benefit from the expanded harbor facilities, improved navigation conditions, and enhanced shoreside amenities and support facilities.



SURF BREAKS IN RELATION TO
ALTERNATIVE PLAN 1

Figure 24

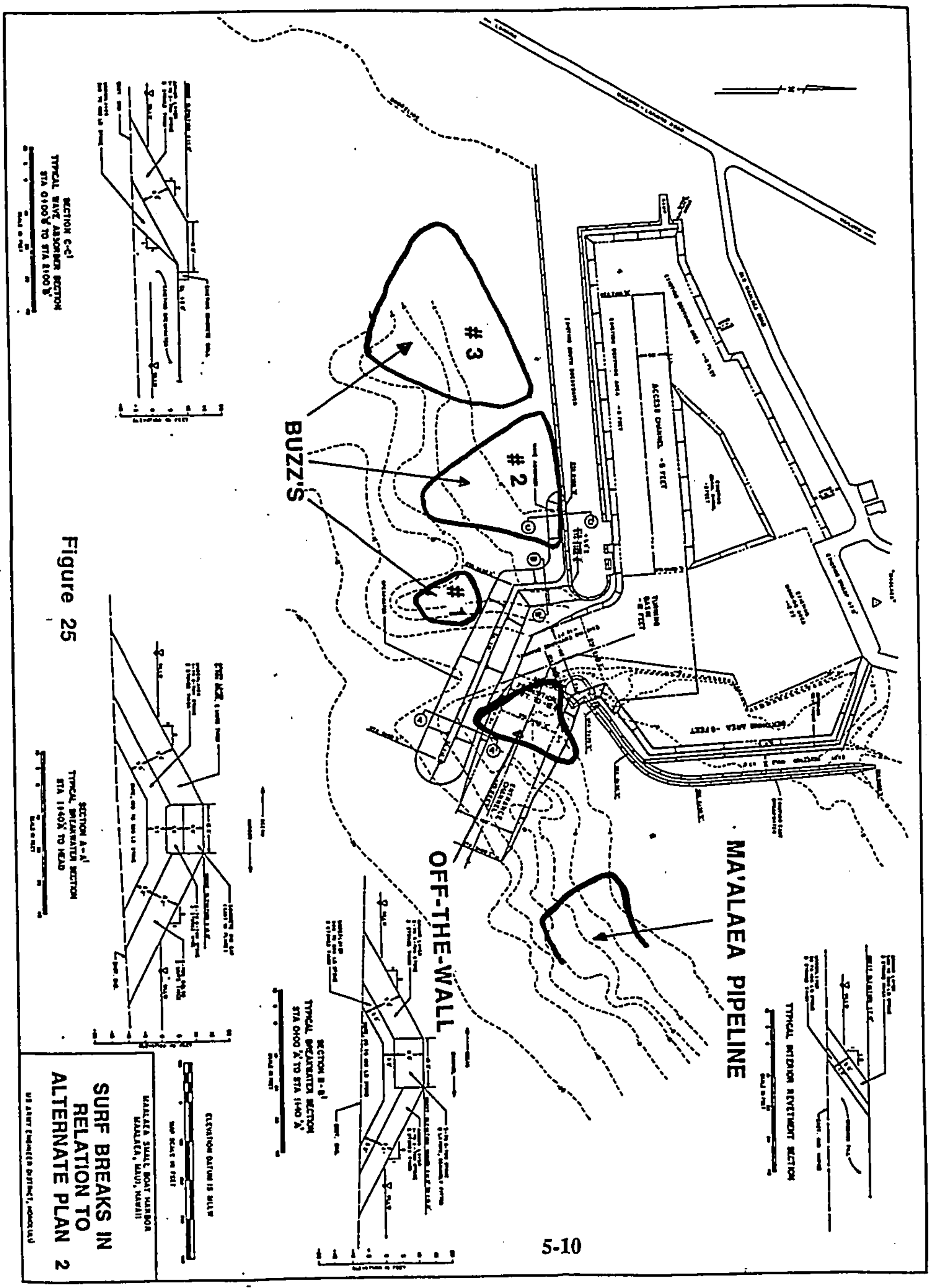
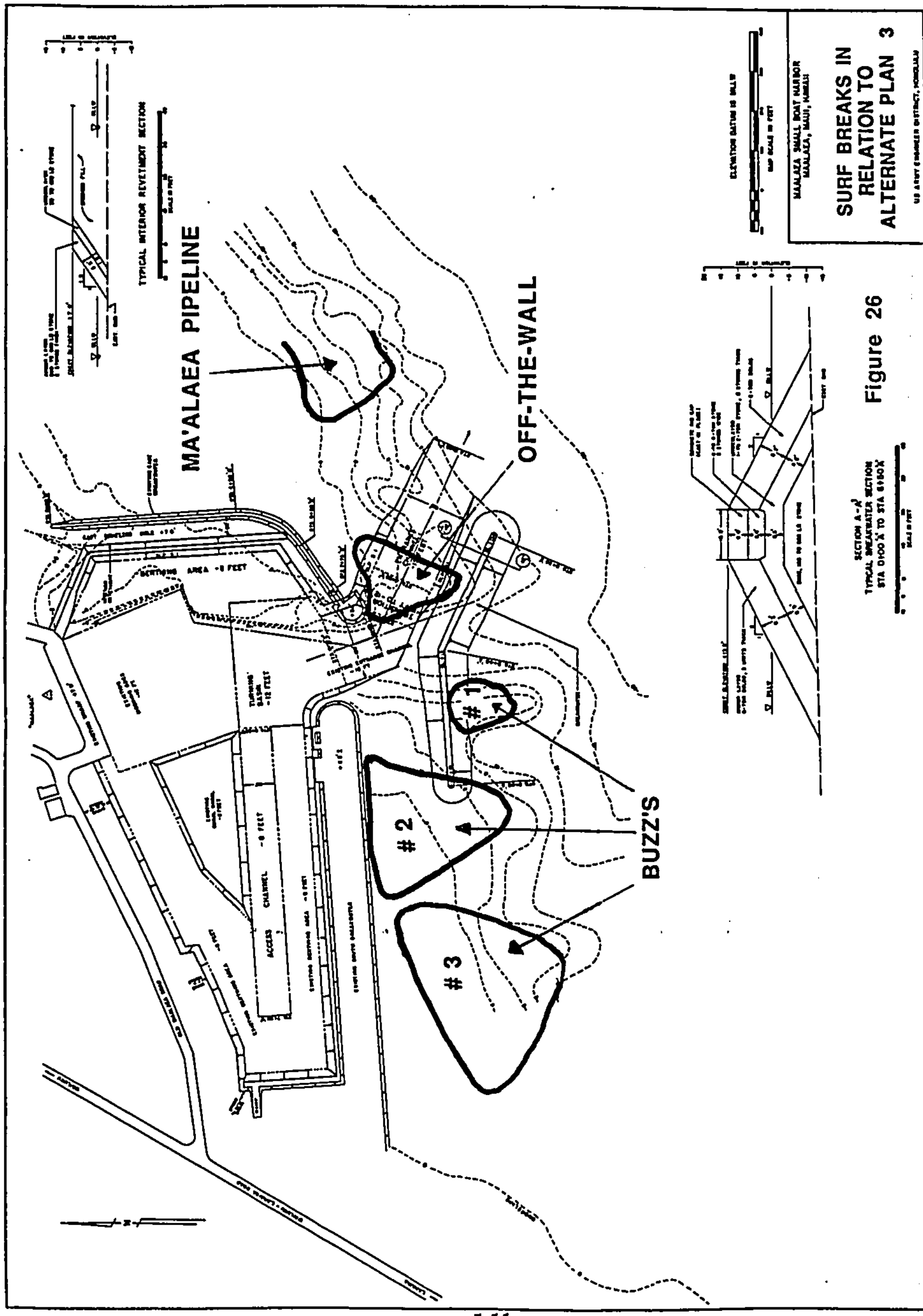
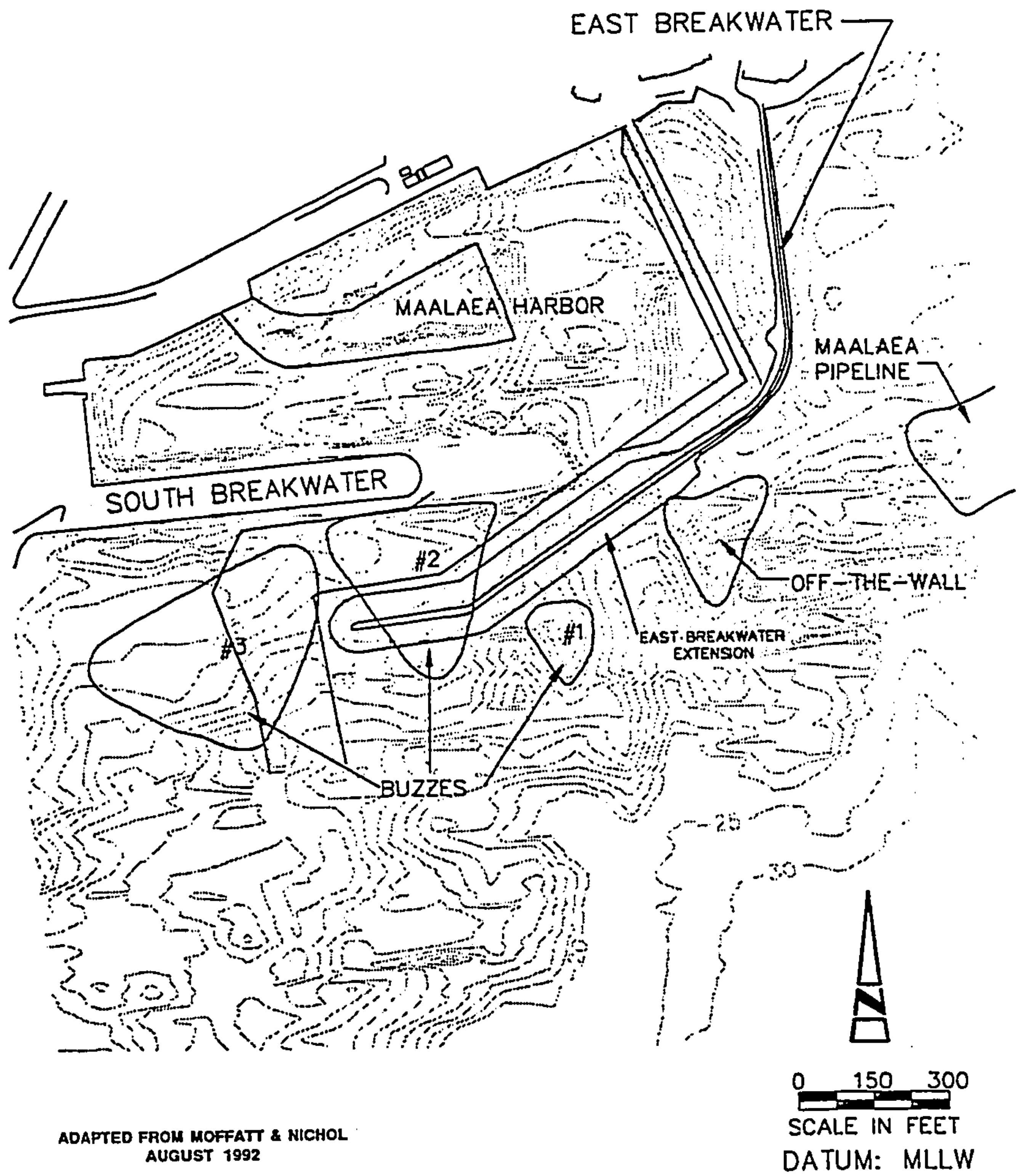


Figure 25

SURF BREAKS IN RELATION TO ALTERNATE PLAN 2


MA'ALAEA PIPELINE
OFF-THE-WALL
BUZZ'S
1
2
3
ACCESS CHANNEL
SURF BREAKS IN RELATION TO ALTERNATE PLAN 3
Figure 26
PLATE D-3



SURF BREAKS IN RELATION TO ALTERNATIVE PLAN 4

Figure 27

5.12.3 FISHING

Fishing from the breakwater and revetted moles will likely not decrease, and success may increase slightly since deeper water with better habitat will be available to fishermen from the new breakwater extension. Spearfishing in the area fronting the harbor will likely not change substantially, since very little of the good reef habitat fronting the harbor will be affected.

The increase in the number of fishing boats would likely lead to a small increase in fishing pressure on the commercially important species, including the bottom fishery. However, most of the fishing boats which would eventually be berthed in the harbor are either now trailered or moored elsewhere, so that they are already exploiting the fisheries resources. The exact incremental increase is unknown, but is expected to be small. Recreational fishermen within the harbor area may also be inconvenienced by temporary restrictions from certain areas; however, they will likely be able to fish from alternate locations of the harbor. Overall fishing effort is expected to return to normal levels following project completion.

With regard to impacts on the Molokini Atoll Marine Life Conservation District, the Aquatic Resources Division of the State Department of Land and Natural Resources, in conjunction with the local project sponsor, the Division of Boating and Ocean Recreation intends to limit the number of commercial permits allowed at Ma'alaea. In addition, the Aquatic Resources Division is developing regulations for the use of Molokini to ensure that increased boating activity will not place excessive commercial fishing pressures on the Conservation District.

5.13 TRAFFIC

5.13.1 TRAFFIC IMPACT STUDY

According to the traffic impact study reproduced in Appendix D, the expansion of the harbor to provide about 130 additional berths, including 21 for commercial passenger vessel operations, would change traffic volumes entering and exiting Ma'alaea Harbor. Based on the expected mix of boat sizes and their uses, and the new bussing rules being developed by DBOR, the projected p.m. peak hour traffic increase for any of the alternatives is 125 vehicles. Based on a projected peak hour count of about 2,359 for Honoapiilani Highway, the increase attributable to the harbor is only about 3 percent. Appendix D contains details of the existing traffic, the traffic projections, and the expected effects of the proposed project.

Traffic expected as a result of the proposed harbor expansion was estimated assuming a policy change is made by the DBOR which would require commercial passenger vessels with 25 or more passengers to provide transportation to and from the harbor. For commercial passenger vessels, 37 new vessels were assumed, with an average occupancy rate of 70 percent. The trip generation for vessels with 25 passengers or more was based on a split of 40 percent of the passengers using cars and 60 percent using vans or buses. It was also assumed that cars would have an occupancy rate of 2.5 people per vehicle.

Trip generation for the additional commercial passenger vessels was estimated at 202 vehicles per hour (vph) entering the harbor and 23 vph exiting during the a.m. peak hour. During the p.m. peak hour 23 additional vph would enter and 202 additional vph would exit.

For noncommercial passenger vessels, trip generation is based upon 93 new berths. Trip generation was estimated at 10 vph entering and 6 vph exiting the harbor during the a.m. peak hour and 10 vph entering and 10 vph leaving during the p.m. peak hour.

The reduction in traffic due to the proposed policy change requiring larger commercial vessels to provide transportation to and from the harbor was estimated at 108 vph entering and 12 vph exiting during the a.m. peak hour and 12 vph entering and 108 vph exiting during the p.m. peak. Therefore, the net traffic increase due to the proposed project is 104 vph entering and 17 vph exiting the harbor during the a.m peak hour. An additional 21 vph would enter during the p.m. peak hour, and 104 vph would exit.

Distribution of the projected traffic increase among the three intersections entering/exiting the harbor was based on existing traffic distribution.

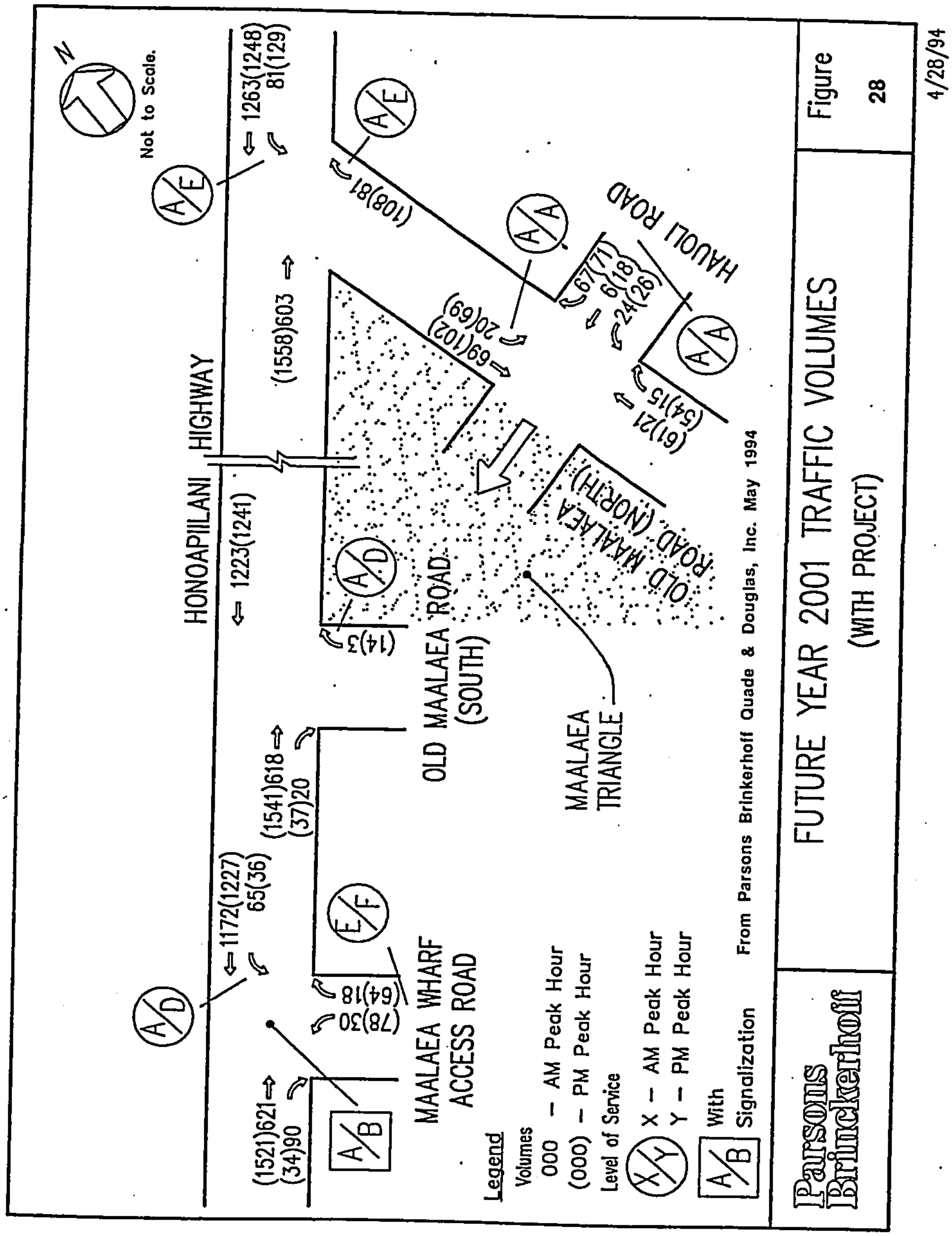
5.13.2 PROJECTED LEVELS OF SERVICE FOR MA'ALAEA HARBOR RELATED ROADS

Traffic generated by the proposed project was added to the Base Year 2001 traffic volumes without the project. The results are discussed below and are shown in Figure 28.

- Left-turn movement at the intersection of Ma'alaea Wharf Access Road and Honoapiilani Highway would continue to operate at LOS A during the a.m. peak hour. Traffic turning left from the highway onto Ma'alaea Wharf Access Road would operate at LOS D conditions during the p.m. peak hour. Traffic exiting the harbor would continue to operate at LOS E during the a.m. peak hour and would fall to LOS F during the p.m. peak hour.

- Right turns from Old Ma'alaea Road (south) onto Honoapiilani Highway would continue to operate at LOS A during the a.m. peak hour. It would drop from LOS C to LOS D during the p.m. peak hour.

- No changes in level of service would be expected for left-turn movement from Honoapiilani Highway onto Old Ma'alaea Road (north) during either peak hour. Right-turning vehicles from Old Ma'alaea Road (north) would experience no change in level of service during the a.m. peak hour, but would experience a drop during the p.m. peak from LOS D to LOS E.


Not to Scale.
N
HONOAPIILANI HIGHWAY
1263(1248)
81(129)
(1558)603
1223(1241)
1172(1227)
65(36)
(1541)618
(37)20
(1521)621
(34)90
(64)18
(78)30
(14)3
(108)81
20(69)
69(102)
67(71)
6(18)
24(26)
(54)15
(61)21
HAUOLI ROAD
OLD MAALAEA ROAD (NORTH)
OLD MAALAEA ROAD (SOUTH)
MAALAEA TRIANGLE
MAALAEA WHARF ACCESS ROAD
Legend
Volumes
000 – AM Peak Hour
(000) – PM Peak Hour
Level of Service
X – AM Peak Hour
Y – PM Peak Hour
With Signalization
From Parsons Brinkerhoff Quade & Douglas, Inc. May 1994
Parsons Brinckerhoff
FUTURE YEAR 2001 TRAFFIC VOLUMES
(WITH PROJECT)
Figure
28
4/28/94

• All movements at the intersection of Old Ma'alaea Road and Hauoli Road would continue to operate at LOS A during both peak hours.

The effects of the proposed expansion results in a decrease in the level of service for traffic exiting the harbor during the p.m. peak hour at all three unsignalized intersections. Traffic exiting the harbor during the p.m. peak hour would experience long traffic delays at the Old Ma'alaea Road (south) intersection with Honoapiilani Highway; very long traffic delays at the Old Ma'alaea Road (north) intersection with the highway; and extreme delays and severe congestion at the intersection of Ma'alaea Wharf Access Road and Honoapiilani Highway.

Levels of service along Honoapiilani Highway itself would not change from the projected LOS E during the a.m. peak hour and LOS F during the p.m. peak hour.

5.14 THE RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREA

There will be no deviation from the present Land Use Designation as a result of this project. The area immediately west of the harbor shown as a park in the Kihei-Makena Community Plan is intended to be eventually used for harbor parking by the Department of Land and Natural Resources, Division of Boating and Ocean Recreation. The parking area will be designed to incorporate green areas and simple recreational facilities such as picnic tables as well as parking stalls. The small sand beach in the northeastern corner of the harbor will be destroyed. It will be fronted and partially covered by the road connecting the new east mole to the rest of the harbor. There will be no change to land use policies or controls as a result of the proposed project.

The proposed action is consistent with most of the objectives and policies of the State's Coastal Zone Management Program in that: (1) it assists in providing adequate accessible and diverse recreational opportunities in the area by providing and managing adequate public access to and along shorelines with recreational value and by encouraging expanded public recreational use of County, State, and Federally owned or controlled shoreline lands and waters having recreational value; (2) it provides public or private facilities and improvements important to the State's economy in suitable locations by concentrating coastal dependent development in appropriate areas, by ensuring that coastal development is located to minimize adverse impacts in the coastal zone management area, and by directing the location and expansion of coastal dependent development to areas presently designated and used for such development; and (3) reducing hazards to life and property from storm waves by reducing surge and navigation hazards.

The proposed project is inconsistent with the State's CZM policy that requires replacement of coastal resources having significant recreational value, including surfing sites and sandy beaches, when such resources will be unavoidably damaged by development; or by requiring monetary compensation to the State when replacement is not feasible or desirable. The Federal portion of the project would destroy and/or modify unique surfing areas. The State portion of the project would destroy a small sandy beach as a result of road placement. In addition, the addition of parking areas on the breakwaters in inconsistent with the policy to encourage those developments which are not coastal dependent to locate in inland areas.

A Consistency Determination Statement has not yet been submitted to the Office of State Planning. A copy of the draft CZM Assessment is included in Appendix A.

5.15 SOCIOECONOMICS

With safer navigation conditions, improved navigation facilities, and additional berthing, the four plans of improvement would increase community well-being for the boaters who utilize the facility. Concomitantly, the increased level of harbor activities may result in inconvenience, disturbances, and disruption of daily living patterns for the nearby residents of the harbor. These adverse effects can be mitigated through careful enforcement of harbor rules and regulations, as well as implementation of ancillary improvements to shoreside support facilities such as roadways, utilities, etc. These improvements would be addressed in the harbor master plan and subsequent detailed design to be undertaken by the Division of Boating and Ocean Recreation. The impact on neighboring property values cannot be precisely determined at this time; however, based on similar projects in other locations, property values and associated tax revenues are expected to increase with the completion of harbor improvements.

5.16 THE RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF HUMANITY'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The improvements for navigation and harbor expansion will result in some unavoidable adverse effects on water quality, coral reef habitat, surfing sites and sandy beach. These effects have been minimized to the extent practicable. The expansion of an existing harbor and the resulting increases in land and sea traffic are necessary to meet the needs of the local community, while avoiding the development of new harbors with associated environmental effects. Utilizing an existing harbor area for needed facilities will limit adverse effects to the local area, whereas the creation of new harbors to meet recreation needs would spread adverse impacts over a larger area. The adverse effects associated with improvements of Ma'alaea Harbor will be offset by the long-term maintenance of undeveloped marine environments.

5.17 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE PROPOSED ACTION

The proposed action would involve the irreversible and irretrievable commitment of approximately 12 acres of benthic marine habitat, including the dredging of approximately 2 acres of existing coral reef. This loss would be partially offset by the creation of new marine habitat in the form of stone revetments but would still result in a net loss of coral reef. A small sandy beach within the harbor would be destroyed by the construction of a road to the east breakwater. The proposed action would also involve the destruction of one surf site and the modification of another to an unknown extent. Although it might be possible to reverse these commitments of resources in the future by restoring the marine habitat, small beach, and surf sites, it would be expensive.

The proposed action will involve the irreversible and irretrievable use of human labor and a nonrenewable energy source (equipment fuel).

5.18 PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED.

There would be temporary potentially significant effects on the aquatic ecosystem as a result of increased turbidity during construction activities, such as blasting, dredging and filling.

Approximately 12 acres of marine benthic habitat would be filled or dredged to create structures. This would include dredging of approximately 2 acres of coral reef to construct the new harbor channel. This loss would be partially offset by the creation of new marine habitat in the form of stone revetments but would still result in a net loss of coral reef. A small sandy beach within the harbor would be destroyed by the construction of a road to the east breakwater.

One surf site would be destroyed and another would be modified to an unknown extent.

The water quality of the harbor would continue to degrade as a result of increased inland development unrelated to the proposed project. The increased vessel traffic anticipated as a result of the harbor improvements would increase turbidity in the harbor, resulting in additional exceedences of water quality standards for turbidity.

5.19 MITIGATION

The unavoidable impacts identified above can be mitigated as follows:

Air Quality and Noise. During construction of both the Federal and State of Hawaii portions of the project the construction contractor will be required to adhere to applicable Federal, State of Hawaii and Maui County air quality and noise regulations. This is a standard requirement in all Corps and State of Hawaii construction contract specifications. For the Federal portion of the project, the contractor will be required to develop an environmental protection plan, which will detail the measures to be used, based on the construction methods to be used, to comply with the regulations. This requirement for an environmental protection plan is standard in Corps construction contracts. The plan must be approved by the Corps Contracting Officer who is responsible to assure that the contractor's operations do not violate State of Hawaii standards.

Water Quality. Turbidity caused by dredging and construction of the harbor improvements will comply to the maximum extent practicable with existing known methods to control turbidity. Turbidity within the harbor will not be controlled during construction, although it will be monitored and documented. The State of Hawaii Department of Health will continue to sample water in the harbor on their normal schedule, and the Corps will also monitor water quality during construction, and post construction.

Aquatic Resources. Construction of the new portions of the breakwaters and revetted moles will provide mitigation for the relatively depauperate reef flat habitat destroyed, by providing increased vertical habitat. In addition, the feasibility of constructing an artificial reef in the vicinity of the harbor will be investigated with the assistance of the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the DLNR Division of Aquatic Resources.

The U.S. Fish and Wildlife Service recommended several measures to minimize the degradation of coastal water quality and impacts to fish and wildlife resources and habitats. These measures are as follows:

- If blasting is required, shaped or directional charges should be used to minimize impacts on marine organisms.

- Turbidity and siltation should be minimized and confined to the immediate vicinity of construction through the use of effective silt containment devices and the curtailment of construction during adverse sea conditions. Construction practices should be employed, especially during dredging, to prevent persistent turbidity and excessive sediment transport into areas of significant living corals.

- All spoil temporarily stored at the project site should be placed behind watertight berms above the influence of the tides.

- No dredged spoil should be stockpiled in the marine environment.

- Fills should be protected from erosion with armor stone as soon after completion as practicable.

- Breakwaters and revetments should be constructed of large boulders and/or dolosse to dissipate wave energy and resist erosion.

- All construction-related materials should be placed or stored in ways to avoid or minimize disturbance to the reef.

- All construction-related materials should be free of pollutants.

• No contamination of the marine environment should result from construction activities.

• Measures to control project-related increases in the discharge of sediments from Ma'alaea Harbor into the marine environment of Ma'alaea Bay should be developed.

• A contingency plan for containing and controlling accidental spills of petroleum products at the construction site, including storing absorbent pads and containment booms on-site to facilitate the clean-up of such spills, should be developed.

The Contractor's Environmental Protection Plan, required by the specifications for the construction contract, will include details of how marine resources will be protected from secondary effects of construction. The following items will be included among others in the Environmental Protection Plan:

• Lumber or other construction materials treated with creosote or other preservatives substances will not be permitted to contact the water until after at least one week of drying.

• Construction materials, petroleum products, human wastes, debris and landscaping substances (herbicides, fertilizers, pesticides) will not be permitted to fall, flow or leach into the ocean or the drainage ditches which enter the harbor.

Construction contract specifications for the State of Hawaii portions of the project will include the following specific requirements:

• Construction and fabrication of dock assemblies, etc., should take place in so far as possible on fast land.

• Lumber or other construction materials treated with creosote or other preservatives substances will not be permitted to contact the water until after at least one week of drying.

• Construction materials, petroleum products, human wastes, debris and landscaping substances (herbicides, fertilizers, pesticides) will not be permitted to fall, flow or leach into the ocean or the drainage ditches which enter the harbor.

Endangered and Threatened Species. To mitigate the adverse effects on the humpback whale, NMFS made several recommendations in their Biological Opinion, which will be implemented by DLNR and the Corps as appropriate. These recommendations are:

• The Corps, Hawaii State Department of Land and Natural Resources (DLNR) and NMFS should review the Statewide Boating Plan current and future harbor and ramp siting needs and the locations and capacities of designated mooring areas with respect to listed species, and revise as necessary.

- All non-permitted mooring structures in Ma'alaea Bay should either be removed, relocated within a state designated mooring area, or into Ma'alaea Harbor, whichever would be appropriate; future requests for mooring structures outside of state designated zones within Ma'alaea Bay should be denied.

- The DLNR, U.S. Coast Guard, and NMFS, in cooperation with the Corps should develop and implement, as appropriate, ingress/egress corridors for the expanded small boat harbor at Ma'alaea, and vessel speed limits within the cow/calf area of Ma'alaea Bay as defined in 50 CFR 22.31 (Approaching Humpback Whales in Hawaii) for the period December 15 to May 15 annually.

In addition the Corps has the following standard mitigation measures to protect humpback whales and turtles which are usually incorporated into the Plans and Specifications for any project constructed in the ocean. These measures would also protect a Hawaiian monk seal if one were present in the bay during construction.

- If blasting is required, the Contractor will be required to prepare a blasting plan. The blasting plan will be developed in coordination with and approved by NMFS and the Contracting Officer. In general, blasting will be avoided during December through May if possible. If blasting must occur, charges will be kept small, sound suppression measures (such as a bubble curtain or heavy tamping) and other methods will be used to reduce the effect on marine mammals or turtles to the minimum practical.

- If blasting is required, the Contractor will be required to conduct a survey for turtles and marine mammals in the vicinity. The survey methodology will be included in the blasting plan to be approved by NMFS and the Contracting Officer.

Surfing Sites. In order to avoid or minimize impacts to surf sites, the design of the proposed plan incorporates the following:

- Reduction in the size of the seaward extension of the revetted mole at the base of the breakwater extension to a minimal distance. Prior to this effort, the revetted mole extended seaward approximately 150 feet into Buzz's No. 2. The design modifications maintain the toe of the extension within 100 feet of the existing structure. This limits development to be within the existing trench located seaward of the existing mole and out of the Buzz's No. 2 riding area.

- The revetted mole at the base of the breakwater extension will be tapered from Station 0+00 to the full width at approximately Station 3+70B. This will add additional maneuvering area for the surfers.

• A minor realignment and shaping of the east wall of the entrance channel will be considered for inclusion in the design to help restore a small left ride without affecting the Ma'alaea Pipeline, nor navigation.

Other measures that have been recommended to mitigate impacts to surf sites include:

• Buzz's No. 3 surf area infrequently breaks greater than 6 feet in height offshore. Options were considered that may enhance existing sites or create new sites. Surf enhancement may be achieved by sculpturing the ocean bottom by making small cuts in the rock bottom or by filling a shoal with a layer of concrete-filled bags.

• Sea cliffs on the Lahaina side of the harbor are actively eroding. Waves attacking the bluffs are causing silts and clays to enter the ocean environment, causing turbidity during periods of even moderate waves. This wave attack has also created a hazard by making this bluff area unstable. If this area were stabilized by shore protection, surfing opportunities could be enhanced for the majority of surfers and the public by improving the water quality, providing safe access to the water in this area, and possibly providing easier access to other underutilized surf sites.

Traffic. The Department of Transportation Highways Division Master Plan includes widening Honoapiilani Highway. At the same time the intersections for the harbor will be improved to include long acceleration and holding lanes, as well as signals. These improvements would be required even without the proposed harbor expansion. It is expected that the roadway improvements will be in place before all the infrastructure improvements are completed.

The traffic impact study recommended the following additional improvements to accommodate the additional traffic due to the proposed harbor expansion.

• Provide a dedicated left-turn lane and deceleration lane on Honoapiilani Highway at the Wharf Access Road intersection.

• Provide separate left-turn and right-turn lanes on Ma'alaea Wharf Access Road for egress at its intersection with Honoapiilani Highway.

• Adopt a policy requiring commercial passenger vessels with a capacity of 25 or more passengers to provide bus and van service.

• Provide additional parking.

Land Use. The area west of the harbor identified as Kapoli Park will be enhanced by the minimal recreational facilities to be provided in conjunction with the planned parking area. No mitigation is planned for the destruction of the small beach inside the harbor because it is of limited recreational use.

CHAPTER 6

LIST OF PREPARERS

Name	Specialty	Experience	Action
William Lennan	Ecology	BS Pol. Sci.,BA Zoology; 2 yrs. grad. studies; 3 yrs. environ. studies USFWS; 13 yrs. environ. studies, Corps of Engineers	SEIS preparer
Candace Thomas	Ecology	BS Biol., 1 yr. grad. studies; 9 yrs. environ. studies, Corps of Engineers	SEIS reviewer
Ruby Mizue	Ecology	BA Biol., MLIS; 21 yrs. environ. studies, Corps of Engineers.	SEIS reviewer
Patricia Billington	Environmental Law	BA, MA Phil., JD; 8 yrs. Corps of Engineers, 6 yrs. environ. law	SEIS reviewer
George Young	Engineering	BS, MS Civil Engrg.; 11 yrs. project engineering, Corps of Engineers	Project Engineer/ Manager
Stanley J. Boc	Engineering	BA, MS Mar. Sci.; 14 yrs. project engineering, Corps of Engineers	Project Engineer/ Manager
Patricia E. Beggerly	Archaeology	PhD Archaeology, 2 yrs. arch studies US Navy, 3 yrs. arch studies Corps of Engineers	Archaeological library research

Belt Collins & Associates	Engineering	Consulting engineering firm (prime contractor)	Assessment of recreational surfing sites
John Clark	Ocean Recreation	Ocean Recreation Consultant	Assessment of recreational surfing sites
Moffatt & Nichol, Engineers	Engineering	Consulting engineering firm	Evaluation of project impacts on surf sites

CHAPTER 7

PUBLIC INVOLVEMENT, REVIEW, AND CONSULTATION

7.1 PUBLIC INVOLVEMENT PROGRAM

Several meetings were held on Maui with special interest groups (3-15-90, 3-27-90, 4-23-91, 5-24-91, 6-25-91, 7-23-91) during the Environmental Assessment stage of planning, and two meetings with the general public were held (12-5-89, 2-28-91). The latest was a public scoping meeting, which generated the following list of public concerns. These concerns have all been considered in planning for this project. Those issues outside the scope of this impact statement are indicated by an asterisk.

7.2 ISSUES IDENTIFIED DURING SCOPING

The following identified issues have been grouped so that like issues appear together:

- Safety (mentioned by many individuals present) - especially the lack of any Coast Guard presence for search and rescue
- * Lack of a search and rescue boat
- Need to address whether design ensures safe moorings: the current design does not
- Need to assess the continued property damage to moored boats due to a lack of slips
- The need to provide for safety within the harbor
- The need to provide for safety of property within the harbor
- The need to take care of and address the surge problem at the harbor
- The need to correct the current poor harbor design; wind was mentioned as a critical concern

- The need for a fuel depot
- Need to provide parking for boat trailers
- The need for more moorings especially for existing commercial fishing vessels
- The need for more slips
- The current problem with fuel delivery (currently a two day wait)
- There is a lack of facilities: restrooms etc.
- Look at current inadequate docking
- Need to address ramp design as current ramp does not allow launch if there is a surge
- Need to look at location of added slips in new design
- * Whether meters at the current harbor are faulty
- * Need to address the current lack of repair and conditions of the existing harbor

- Need to provide for sewage disposal from boats
- Need for a facility to deposit waste oil
- Berthing system needs improvements
- Lack of a fuel dock
- * Need for more dry-dock facilities
- * The need to address the situation that allows slips to be incorporated and sold which creates a waiting list that some people have been on for twenty years
- * The need to look at current harbor management
- * Currently rules are unclear and inconsistent
- * There are loopholes on who gets docking privileges and until these are dealt with expansion should be put on hold so that when and if expansion happens it will deal with the local needs and the commercial fishermen who have been on the waiting list
- * Current problems with the issuing of slips and poor management of existing facility
- * Need to provide a secure land boat storage area

- Need to look at the benefit to local fishermen
- * Need to look at the different impacts caused by commercial fishing as opposed to tourist operations and decide on a desirable %
- * Concerns that enlarging the harbor means the capacity to bring in larger tour vessels and that this is not desirable
  The need to look at effects on the entire area land, water and coastal ecosystems
- The intent and type of expansion proposed
- Need to look at the impact of large boats and if a maximum size should be set on boats allowed in the harbor
- * Need to limit size of boats - i.e. Stardancer too loud and too big
- * Expansion should be limited to serve local needs; those persons on the waiting list for a long time with commercial fishing operations
- * Need to look at reducing commercial use from 30% to 10-15%
- * Limit number of commercial slips
- * Need to assess pleasure use versus commercial use and impacts
- * Need to assess whether the number of boats moored nearby would really be reduced by the expansion and ways to assure that this happens
- Does current expansion plan conform to the Ocean Resources Management Plan - Is it legal?
- * Need to assure that there is no freight operation at harbor

- Analyze, look at, and model direction of swells
- The need to look at expansion in the light of the current mooring system: doesn't work in large storms
- Need to look at baffling entrance
- Need to have a solution based on technical data, computer modeling and physical modeling from Army Corps Facility in Vicksburg

- Look at and assess other harbor sites on Maui if more slips are needed rather than expansion of this one
- Need to look at moving harbor
- Need to look at other proposed sites in Kihei

- The need to make sure that any expansion if done does not adversely impact wildlife and endangered species
- Currently marine life is adversely impacted by the harbor - there is no longer any tako in the area - what does expansion mean
- Need to address National Marine Fisheries concerns
- Impact of expansion on whale population
- Need to assess the impact of more slips and more boats on Molokini Island especially as it relates to the number of anchors being dropped
- EIS needs to provide for mitigation

- Look at recreational uses of the surrounding area and how or if the harbor ties in or impacts these
- Look at *impact of design on SE swell*
- Need to look at turning breakwall right (lose only 1 of 4 surf sites)
- Impact on surf
- * Look at international impact of loss of a world class surf site
- Impact on recreational resources in the area for those children who can not afford to fish
- Need to engineer a design for surf break - utilizing appropriate designers with the right expertise
- Need to assure that no surf sites are lost

- Need to look at a mauka parking alternative with underpass
- Parking on east breakwater is a concern - it is not safe
- The proposed plan designates bus parking on the area designated public park this should not be allowed - the public needs that park area
- No jetty parking
- Impacts on the highway of increased boat and tourist traffic related to harbor expansion - highway already exceeds capacity and parking is already insufficient

- Need to look at the current problem with design in the area of dredging - harbor design allows the siltation from mauka to drain into the harbor thus requiring frequent dredging
- Need for sewer treatment and the pollution caused by lack of it at the current harbor and in the surrounding condominiums
- * Impact of sewerage from condominiums
- * Need to assess the effect of pollution from storms on the harbor
- * Look at the pollution impact from the area as a whole - on a cumulative basis i.e. impact of harbor, moorings, condominiums etc.

- Impact of expanding harbor on remaining sandy beaches - after construction of original harbor the sandy beach disappeared
- The need to look at the effects of increased activity on the entire area
- The need to look at and deal with impacts long term not just short term
- * Need to look at job creation potential of harbor expansion
- * Need to look at the community needs in that area not just the - boaters
- Need to look at impact of project on condominium owners deeds which guarantee ocean front property
- * Need to look at impacts of rental condos on traffic and harbor etc.
- * Expansion needs to deal with the needs of the residents in the area
- * We need to work together to come out with a cohesive plan that we can all live with
- * Need to set up a task force to work through this

7.3 REQUIRED COORDINATION

Formal coordination for this project has been completed with the US Fish and Wildlife Service and National Marine Fisheries Service in accordance with Section 7 of the Endangered Species Act; and with the State of Hawaii Historic Preservation Officer. Coordination has also been partially completed with the U.S. Fish and Wildlife Service in accordance with the Fish and Wildlife Coordination Act. In conjunction with circulation of the FSEIS, coordination will also be accomplished with the State Office of Planning for CZM consistency determination. An application for water quality certification from the State Department of Health will be submitted after publication of the FSEIS.

7.4 LIST OF AGENCIES/INDIVIDUALS RECEIVING DSEIS

The following agencies and individuals were sent copies of the Draft Supplemental Environmental Impact Statement.

7.4.1 FEDERAL AGENCIES

Senator Daniel Akaka
Senator Daniel Inouye
Representative Neil Abercrombie
Representative Patsy Mink
Department of Commerce, National Marine Fisheries Service
Department of the Interior, Fish and Wildlife Service, Pacific Islands Office
Department of the Interior, Geological Survey
Department of Transportation
U.S. Coast Guard
Environmental Protection Agency

7.4.2 STATE OF HAWAII AGENCIES

Governor John Waihee
President of the Senate
Senators from Maui County
Speaker of the House
Representatives from Maui County
Department of Business, Economic Development and Tourism
Department of Health
Department of Land and Natural Resources
Department of Transportation
Office of State Planning
Office of Environmental Quality Control
Office of Hawaiian Affairs
University of Hawaii, Environmental Center

7.4.3 MAUI COUNTY AGENCIES

Mayor Linda Crockett Lingle
County Council Members
Department of Parks and Recreation
Department of Planning
Department of Public Works

7.4.4 GENERAL PUBLIC

Lesley Ann Bruce
Ellen Bruno
Gordon A Chapman
Jamie G. Hunter
N. Edward (Ted) Ion
Scott Jenkins
Jerome Kaiser
Rodney Kilborn
Life of the Land
Ma'alaea Community Association
Loren Malenchek
Mark A. Massara
John K. McCandless III
Donna Neal
Protect Ma'alaea Coalition
Eve Samuel
Sierra Club, Hawai'i Chapter, Maui Group
Sierra Club Legal Defense Fund, Inc.
Chris C. Svendsen
Reeve Woolpert
Hans Antal

Marc Bedard
Mac Blaker
Ben Bland, III
Brian Bludell
Chris Ann Bows
Barry Brown
Eric Brown
Robert K. Burns
Frank Byrnes
Nancy Callahan
Cosco Carlbom
Scott Castil
Stephie Cawood
Walter G. Chuck
Billy Choy
George Clark
Craig Comen
R.B. Coon, Jr.
J. Scott Cumming
Mike Cumming
Joe Dandrea
Douglas or Theodore Deponte
Daniel Dixon
Peter Figgis
Regina Finnegan
Chris Ford
Paul Forestell
Hugh Gallagher
Ada and Raymond Galli
Gene E. Guthrie
Isaac D. Hall
Paul Hanada
Doug Harms
Skijppy Hau
Barbara and Brian Henderson
Steven Hogan
Scott Iverson
Jill Izumigawa
Allston James
Dickson James
Grover Jeane
Jody Jones
Fred Ketteman
Mary Kiehn
Laura King/Ann Nottoff

Donna and Jim Klingler
Ralph Kohler
Betty J Leggerup
Dick and Jane Lewis
Bob Liddell
Andrew L. Lissner
Bobby Luuwai
John Luuwai
Craig Mathison
Al Matson
Charles K. Maxwell, Sr.
Jeanne D. McJannet
James Medeiros
William Meyer
Gilbert J. Morales
Michael Moyers
Jack F. Mueller
Edwin S. Murai
Al Oakey
Bert Oliveira
Rich Olson
Wendy Oram
Tom Pratte
Shawn Reid
Patrick L. Santos
Marjorie Schmiege
Teri Schulz
Ralph Sharpe
Seymour Shiner
Marsha Smith
Mari A. Smultea
Lois H. Stark
Brad Tarr
Mike Trotto
Anthony Ventura
Conrad Ventura
David Ventura, Jr.
Eric Ventura
Paul J. von Hartman
Mike Wilson
Wallace Yost

Letters of comment on the draft Supplemental EIS were received from the following agencies, organizations and individuals:

7.5 LETTERS WITH NO SUBSTANTIVE COMMENTS

7.5.1 STATE OF HAWAII AGENCIES

Department of Business, Economic Development and Tourism
State of Hawaii Department of Defense
Department of Budget and Finance
Department of Accounting and General Services

7.5.2 MAUI COUNTY AGENCIES

County of Maui, Department of Parks and Recreation

7.5.3 ORGANIZATIONS

Antal, Nautique & Companies

7.6 LETTERS WITH SUBSTANTIVE COMMENTS (REPRODUCED IN APPENDIX C)

7.6.1 FEDERAL AGENCIES

Department of the Interior, Fish and Wildlife Service
Environmental Protection Agency
Department of Commerce, National Marine Fisheries Service
U. S. Coast Guard
Advisory Council on Historic Preservation

7.6.2 STATE OF HAWAII AGENCIES

Department of Health
Department of Land and Natural Resources
Office of Environmental Quality Control
University of Hawaii, Environmental Center

7.6.3 MAUI COUNTY AGENCIES

Mayor, Maui County
Mayor, Maui County
County of Maui, Department of Water Supply

7.6.4 ORGANIZATIONS

Allston James, SURFER Magazine
Association of Apartment Owners of Maalaea Yacht Marina

Management Consultants of Hawaii, Inc., for the
Association of Apartment Owners of Ma'alaea Yacht Marina,
Eric K. Brown, Pacific Whale Foundation
Jan Pinney - Activity Owners Association of Hawaii
Life of the Land
Mark A. Massara, Surfrider Foundation
Maui Classic Charters, Inc.
Maui-Molokai Sea Cruises
N. Edward Ion, The Alternative

7.6.5 INDIVIDUALS

Lesley Ann Bruce
Dr. Jack R. Estes
Regina M. Finnegan
Hugh Gallagher
Raymond & Ada Galli
Ron Gammie
Jamie Hunter
Miles Lopes
Jack F. Mueller, P.E.
Chris C. Svendsen
David Ventura Jr.

CHAPTER 8

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CHAPTER 9

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APPENDIX A

COMPLIANCE REPORTS

Endangered Species Act - NMFS Section 7 Coordination

Endangered Species Act - USFWS Section 7 Coordination

Fish and Wildlife Coordination Act - Report

National Historic Preservation Act - Section 106 Coordination

Clean Water Act - Section 404 (b)(1) Practicable Alternatives Analysis and Evaluation

Coastal Zone Management Act - Determination of Federal Consistency

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1335 East-West Highway
Silver Spring, MD 20910
OFFICE OF THE DIRECTOR

JUL 23 1990

P2L
PV

Mr. Clarence Fujii
Acting Director, Engineering
Honolulu District
U.S. Army Corps of Engineers
Fort Shafter, Hawaii 96858-5440

Dear Mr. Fujii:

Enclosed is the biological opinion prepared by the National Marine Fisheries Service (NMFS) pursuant to Section 7(b) of the Endangered Species Act of 1973 (ESA), concerning the potential impacts to humpback whales and green turtles from the expansion and improvement of the small boat harbor at Maalaea, Maui, Hawaii, and its operation.

Based on the available information, we conclude that the proposed activities are not likely to jeopardize humpback whales or green turtles in Hawaiian waters. We believe the project will help reduce the number of illegal moorings and consolidate vessel traffic so that adverse impacts to whales from vessel traffic will be reduced compared to impacts from expected increases in vessel traffic without the project. As a Conservation Recommendation, discussions with the Hawaii State Department of Transportation should be initiated regarding the adequacy of their Statewide Boating Plan relative to the need to conserve humpback whale habitat in Maalaea Bay.

It has been determined that the proposed activity may result in the injury or mortality of green turtles. Therefore, pursuant to Section 7(b)(4) of the ESA, we have established a low level of incidental take and terms and conditions necessary to minimize and monitor this impact. These terms and conditions are contained in the enclosed incidental take statement. Compliance with the specified terms and conditions is the responsibility of the U.S. Army Corps of Engineers and their designated representative(s). No incidental taking of humpback whales has been authorized. Section 7(b)(4)(c) of the ESA specifies that the incidental take of marine mammals must also be authorized under Section 101(a)(5) of the Marine Mammal Protection Act before an incidental take can be allowed under the ESA.

Consultation must be reinitiated if: (1) the amount or extent of taking specified in the Incidental Take Statement is exceeded; (2) new information reveals effects of the action that may affect listed species in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species that was not considered; or (4) a new species or critical habitat is designated that may be affected by the action.

Sincerely,

for Michael F. Tillman
William W. Fox, Jr.

Enclosures

ENDANGERED SPECIES ACT

SECTION 7 CONSULTATION

BIOLOGICAL OPINION

Agency: U.S. Army Corps of Engineers (Corps), Honolulu District

Activities Considered During Consultation: Issuance of a permit for modification and expansion of a small boat harbor at Maalaea, Maui, Hawaii.

Consultation Conducted By: National Marine Fisheries Service (NMFS), Southwest Region

Date of Issuance: JUL 23 1990

Background

On November 22, 1989, on the recommendation of the Southwest Region, NMFS, the Corps requested reinitiation of formal consultation on the proposed expansion and modification of the small boat harbor at Maalaea, Maui and associated impacts on humpback whales (Megaptera novaeangliae) and green turtles (Chelonia mydas). It was determined that sufficient new information regarding listed species in or near the project area and analysis of the potential impacts from the construction and operation of the proposed small boat harbor required that consultation be reinitiated in order to re-examine the validity of previous Biological Opinions completed for this project by NMFS in 1980 and 1982. NMFS Southwest Region acknowledged reinitiation of consultation on December 4, 1989.

Proposed Activities

The Corps proposes to modify the entrance channel and associated protective structures as well as expand the interior space at Maalaea Small Boat Harbor. Blasting may be used to facilitate excavation in the basin and entrance channel. Additional infrastructure for additional berthing within the harbor is to be developed by the State of Hawaii. The harbor would provide additional berthing and protected waters in the West Maui area.

The harbor will consist of a 12 to 15 foot deep entrance channel varying in width from 150 to 180 feet; a 620 foot extension of the existing south breakwater; the addition of a 400 foot revetted mole on the seaward side of the existing south breakwater; and 1.7 acre turning basin. About 80 feet of the existing east breakwater head would be removed. A portion of the harbor basin will be dredged to provide additional berthing space. An interior revetted mole will be constructed by the State of Hawaii adjacent to the existing east breakwater.

The harbor is currently designed to accommodate approximately 100 vessels of which 30% may be commercial vessels and the remainder privately owned. The current plans are to increase the harbor capacity to about 250 berths with the allotment of commercial slips remaining at 30%. Infrastructure includes a boat ramp, piers, service area, potable water and fire water, drainage, power, and light.

List of the Species That May Occur in the Activity Area

Humpback whale	(*Megaptera novaeangliae*)	endangered
Green turtle	(*Chelonia mydas*)	threatened

Biology and Distribution of Species

Humpback Whale

North Pacific humpback whales are the second most depleted endangered cetacean in the Pacific, second numerically only to the right whale, which is assumed to be nearing biological extinction (Braham 1984). The available biological information is insufficient for NMFS to determine whether the population is stable, increasing, or decreasing in numbers.

The North Pacific population of humpback whales is estimated at 1200 to 2000 animals (Johnson and Wolman 1984; Darling and Morowitz 1986; Baker and Herman 1987), of which 550 to 1000 are thought to winter in the main Hawaiian Islands. Whales wintering in Hawaii begin arriving from higher latitude North Pacific summer feeding grounds in December. Their numbers peak in late January through February. In April, they begin migrating out of Hawaiian waters and by late May or early June the last whales usually have departed.

Humpback whales concentrate during the winter breeding season in shallow waters, usually less than 100 fathoms, and are particularly attracted to broad bank areas. In the Hawaiian Islands, major areas of concentration are Penguin Bank, the "four island area" between Molokai, Maui, Kahoolawe, and Lanai, and the nearshore waters of Hawaii Island between Upolu Point and Keahole Point.

Humpback whales are known to use the waters of Hawaii to nurse their young. In addition, calving, courtship, and mating are thought to occur in or near Hawaii, though confirmed observations of these behaviors have not been recorded to date. Aggressive male-male competition for sexually mature females, including cows with calves, is evident throughout the season in Hawaii (Baker and Herman 1984). Cows with newborn calves are commonly found throughout the winter, and general areas of high usage by these pairs have been observed. Herman, Forestell, and Antinoja (1980) defined the north coast of Lanai as an area of high cow-calf density. Hudnall (1978) suggested Maalaea Bay, Maui as major nursery area. Glockner-Ferrari and Ferrari (1985) characterized the southwest coast of Maui from MacGregor Point to Kaanapali as an area of high cow/calf use. Forestell (1989) found roughly three times as many calves in the four island area as over Penguin Bank during aerial surveys.

Green Turtle

Green turtles are found throughout the Hawaiian Archipelago. Their distribution, however, has been reduced in recent historical times, with breeding aggregations being eliminated and certain foraging areas no longer utilized in the main Hawaiian Islands (Balazs 1980). Presently, more than 90 percent of the breeding and nesting activity of Hawaiian green turtles occurs at French Frigate Shoals, in the Northwest Hawaiian Islands (NWHI). The number of females nesting there fluctuates annually, the mean being estimated as high as 300 from 1973-1982 (Balazs 1980; Wetherall 1983). The total mature female population at French Frigate Shoals is estimated at approximately 750 animals.

Feeding and resting areas, where adult Hawaiian Chelonia live the greater portion of their lives during non-breeding periods, are located in coastal waters of both the main islands and the NWHI. The principal food sources, benthic marine algae of several genera, are restricted to shallow depths where sunlight, substrate, and nutrients are conducive to plant growth. Feeding pastures used by adults are usually less than 10 m deep and frequently not more than 3 m deep, often right up to the shoreline (Balazs et al., 1987). The underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas (called "nests") that are relatively free of strong currents and disturbance from natural predators and man. In the main islands, these areas for adults usually occur at depths greater than 10 m, but probably not normally exceeding 40 m. Available information indicates that the resting areas are in proximity to the feeding pasture. Periods of rest near the feeding pasture are also known to take place while floating at the surface during light winds and calm seas.

Green turtles presumably rest and feed near the project area, and are occasionally seen by recreational fishermen, surfers, and charter boat operators to the north and west of the harbor. The distribution and quantity of algal food resources and the availability of resting habitat for green turtles within and around the project site has not been determined.

Potential Impacts on Species

Potential direct impacts to green turtles from the proposed project such as mortality, injury, harassment, disturbance or displacement may result from blasting, dredging, and filling.

Smothering of subtidal and intertidal algal food sources may result from dredging for the harbor. Construction of the breakwater and revetted moles will also add to the sediment load of the affected waters. Disturbance of resting and/or foraging turtles may result from dredging, blasting and placement of the armor stone.

Harbor construction activities such as blasting, dredging, and filling will also affect humpback whales during the winter breeding and calving season in Hawaii. Disturbance and injury to humpback whales may result from these activities.

Humpback whales and green turtles are subject to disturbance and displacement from vessel traffic currently originating from the harbor. How the increase in vessels attributable to the harbor expansion will add to the disturbance and displacement of both species in proximity to the small boat harbor site and contribute to habitat degradation and loss for these species is dependant on the type of vessel, its activity and distribution. The activities associated with vessel traffic from the harbor include commercial, recreational and charter fishing, dive charters, sightseeing, and whale watch tours.

A number of collisions between humpback whales and vessels in Hawaiian waters have been documented. However no mortality has been reported as a result of these incidents. In 1981, a whale breached on the starboard pontoon of a 40 ft. trimaran off of the island of Hawaii, causing extensive damage but no injuries to the crew (McCamant 1981). On January 5, 1987, a dive charter vessel travelling at high speed near the approach to Honokohau Harbor, hit what was estimated to be a juvenile humpback on the dorsal surface. The extent of injury to the whale could not be determined as it swam away, but pieces of skin and blubber were recovered from the outdrive (Siler 1987). On March 25, 1988, a 24 ft. pleasure craft travelling at 30 mph near Molokini Island off of Maui collided with a humpback whale. Observers in the boat judged it to be an adult. The extent of injury to the whale could not be determined but an aggressive display of fluke slapping toward the boat by the whale and its companion was noted by the occupants before the whales departed (Stevens 1988; Tanji 1988). The addition of vessel traffic from the proposed facility to west Maui waters will likely increase the probability of collisions. If we assume a linear relationship between the number of vessel and number of collisions, we would expect the incidents of encounters to more than double. Since the majority or the new or relocated vessels will be recreational vessels, we do not expect serious injury or mortality as a result of collisions to be a problem.

Several studies of whale distribution indicate that increasing nearshore vessel traffic will likely result in displacement of humpback whales from preferred habitat. During a series of aerial surveys (Herman et al. 1980; Forestell 1989) the observed distribution of humpback whales suggested a preference of whales for subregions removed from areas of dense human habitation or activity. Whales were noticeably absent in the Lahaina, Maui area--an area of high vessel density and a small boat harbor site. Aerial surveys in 1985 also noted this "hole" at Lahaina as well as one off Keawakapu, Maui, where a public boat ramp was built in 1983.

A continuing decline in the percentage of cow/calf pairs sighted in nearshore waters off west Maui has been noted by Glockner-Ferrari and Ferrari (1985, 1987). In their early studies (1977-79) they found approximately 80% of the cows and calves observed in the area within the 10-fathom isobath. By 1983, this percentage had declined to 17.2% and in 1985 only 5.7% of the cows and calves observed in their study area were found within 10 fathoms. Although there is some debate about the magnitude of this decline because of a change in survey technique used by Glockner-Ferrari and Ferrari, the trend appears real. Possible factors suggested in this apparent decline were direct interactions between whales and vessels, increased use of specific areas by boaters and concessionaires (i.e. thrillcraft), increased land runoff, and the occurrence of changing water quality and pollution.

Bauer and Herman (1986) investigated short-term reactions of whales to vessel traffic and found that humpback whales respond to vessels at distances of at least 1 km. They were able to detect behavioral changes, such as increased dive times and increased threat behaviors, at statistically significant levels.

These distributional and behavioral data (Herman et al. 1980; Bauer and Herman 1986; Glockner-Ferrari and Ferrari 1987; Forestell 1989) indicate the potential for long-term negative effects such as displacement, reduced reproductive success, and reduced recruitment. Baker et al. (in press) hypothesize that "chronic human disturbance or displacement from preferred habitats could stress individuals, resulting in disruption of pregnancy, or simply a reduction in the amount of energy available to females for reproduction." Disruption of nursing activities, reduced nursing success, or interrupted resting may also result in lowered recruitment rates as neonate calves become more susceptible to predation, or adverse oceanic conditions such as strong swells and currents. Older, undernourished calves may also be unable to complete the northward migration to their summer feeding grounds.

Nearshore shallow water habitat is still available to humpback whale cow/calf pairs along the southwest coast of Maui and off the north coast of Lanai, but it is being lost to resort and shoreline development. Specifically, the state has identified two sites in west Maui, at Launiupoko and Olowalu, for priority consideration as private marina developments, in addition to the two new private hotel/resort complexes which are under construction at Wailea. If the proposed moorings and berthing facilities are authorized for Maui, considerably more nearshore activity will result than from this proposed project.

There is no indication that there has been a redistribution of cow/calf pairs in nearshore waters; only that this habitat is no longer used by these groups at previous levels and may be due to increasing human activities. While expansion and operation of the small boat harbor at Maalaea could be expected to add to nearshore vessel activity and adversely affect the use of the nearshore shallow waters in proximity to Maalaea Harbor by humpback whale cows and calves, vessel traffic in west Maui will likely increase even without new facilities. Indications of this are evident in the total number of state registered vessels on Maui. The number of registered vessels has increased from 890 in 1982 (175 moored; 715 dry-stored) to 1303 in 1988 (197 moored; 1106 dry-stored), an increase of nearly 46%. As the human population on Maui continues to grow it is expected that in particular, the number of dry-stored vessels and vessels moored outside of harbors or marinas (both legally and illegally) will continue to increase as well, irrespective of the development of new facilities. Based on informal surveys of nearshore areas in West Maui, there appear to be significant numbers of undocumented moorings, as well as permitted moorings and vessels which should be placed within the expanded harbor to reduce vessel and mooring impacts elsewhere.

According to an economic analysis prepared for this project by the Corps, there are 162 craft now on the waiting list for slips in Maalaea Harbor. Of these, 73 are trailered, moored elsewhere, or at another harbor, and 89 are proposed to be built or purchased. Commercial vessels which are moored elsewhere constitute almost 60% of the waiting list for existing vessels as of 1988. Commercial activities include commercial fishing, charter fishing, and commercial passenger tours.

While State Harbors Division records show only 88 out of 99 available berths currently occupied, the harbor is at capacity since a number of vessels take up two or more slips. The current mix of commercial vessels berthed in Maalaea Harbor is illustrated by the following breakdown.

Maalaea Harbor - Existing Fleet
(From Corps of Engineers Economic Analysis)

Type Craft	No. in Harbor
Recreation	26
Other Miscellaneous	1
Subsistence Fishing	13
Commercial Fishing	19
Charter Fishing and Commercial Passenger	29[1]
Total	88

[1] Breakdown between charter fishing and commercial passenger vessels not available.

The percentage of commercial vessels overall is to be 30%. Thus, with the expansion of the harbor, the proportion of commercial vessels compared to the total projected number of berths will go down. Although daily use data is not available, the bulk of the daily traffic emanating from the harbor will likely be commercial in nature, with recreational and subsistence fishing activity limited to primarily weekends or holidays.

In order to protect remaining nearshore humpback whale cow/calf habitat and allow for critical postnatal behaviors in these waters, no new harbor or shoreside development should occur between Lahaina Harbor and Cape Hanamanioa. Recognizing that an existing small boat harbor is in place at Maalaea and that certain impacts to humpback whales and green turtles are attributable to the vessel traffic already emanating from it, expansion of this facility would likely have the least impact when considering other possible alternatives such as illegal moorings, increasing numbers of offshore moorings in designated areas, and additional small boat harbors, marinas or boat ramps in identified essential humpback whale habitat. Other potential benefits of the expansion include consolidation of a number of vessels moored elsewhere to within the harbor and containment of pollution incidents resulting from fuel spills and holding tank leaks and discharges.

Critical Habitat

Critical habitat for humpback whales or green turtles has not been designated or proposed within or near the project site.

Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. At this time there are no known projects or activities of this type ongoing or planned within the project site.

Conclusions

Based on the best available information, NMFS believes that the proposed activity is not likely to jeopardize the continued existence of humpback whales or green turtles in Hawaiian waters. However, the increased vessel activity associated with the expansion and operation of the proposed small boat harbor at Maalaea, Maui, may adversely affect humpback whales in Hawaiian waters. This determination is based on the likelihood of displacing humpback whales from a portion of cow/calf habitat and subsequently impeding recovery of the North Pacific population as a result of potentially lowered recruitment. While the exact proportion of impact attributable to the expansion cannot be estimated, it is additive to the increasing level of vessel traffic in west Maui waters. Despite the potential for adding vessel traffic to nearshore waters we believe the benefits of consolidating vessel activity in existing facilities and preserving nearshore cow/calf habitat in other areas of west Maui outweigh the possible adverse effects of displacement of humpback whales from around Maalaea Harbor. Therefore, NMFS concludes that the adverse effects of the project will not likely jeopardize the continued existence of humpback whales in Hawaiian waters. We also find that future development of new harbors and boat ramps along the west Maui coast may likely exceed the jeopardy threshold. Accordingly, no new moorings outside of state designated mooring areas should be authorized and no new harbors, marinas or boat ramps should be built in west Maui. If it is determined that additional berthing is necessary to relieve congestion at Lahaina Harbor and reduce or eliminate offshore moorings in west Maui, then existing state facilities at Mala Wharf should be expanded and developed for this purpose.

A small number of green turtles may be adversely affected by displacement, injury, or mortality and loss of foraging habitat from blasting, dredging, and construction. Green turtles may also be adversely affected by the added vessel traffic associated with the harbor through harassment and displacement. We believe that these adverse impacts are not likely to jeopardize the green turtle in Hawaiian waters as it is not dependent upon the project area for its continued existence and the affected numbers of individuals are low.

Conservation recommendations to reduce or eliminate adverse impacts to humpback whale and green turtles are provided below.

Conservation Recommendations

The following conservation recommendations are provided pursuant to Section 7(a)(1) of the ESA to assist the Corps and the Hawaii State Department of Transportation (HSDT) in reducing or eliminating adverse impacts to green turtles and humpback whales resulting from the construction to expand and improve Maalaea Harbor.

(1) The Corps, HSDT, and NMFS should review the Statewide Boating Plan and revise as necessary, current and future harbor and ramp siting needs and the locations and capacities of designated mooring areas with respect to listed species.

(2) All non-permitted mooring structures in Maalaea Bay should either be removed, relocated within a state designated mooring area, or into Maalaea Harbor, whichever would be appropriate; future requests for mooring structures outside of state designated zones within Maalaea Bay should be denied.

(3) The HSDT, U.S. Coast Guard, and NMFS, in cooperation with the Corps should develop and implement, as appropriate, ingress/egress corridors for the expanded small boat harbor at Maalaea, and vessel speed limits within the cow/calf area of Maalae Bay as defined in 50 CFR 22.31 (Approaching Humpback Whales in Hawaii) for the period December 15 to May 15 annually.

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Statement Regarding Incidental Taking
Pursuant to Section 7(b)(4) of
the Endangered Species Act of 1973, as Amended

Section 7(b)(4) of the Endangered Species Act (ESA) requires that when a proposed agency action is found to be consistent with Section 7(a)(2) of the ESA and the proposed action is likely to take individuals of some species incidental to the action, the National Marine Fisheries Service will issue a statement that specifies the impact (amount or extent) of such incidental taking, and will provide reasonable and prudent measures that are necessary to minimize such impacts. Terms and conditions that must be complied with are set forth to implement these measures.

Based on the available information regarding green turtle distribution within and around Maalaea Small Boat Harbor the following allowable levels of incidental take for green turtles have been determined for the proposed construction activities. An incidental take (by injury or mortality) of one green turtle during the course of construction is set for this activity. Also, five turtles per day may be disturbed or temporarily displaced. If the incidental take meets or exceeds this level, the Corps of Engineers (Corps) must reinitiate consultation. The National Marine Fisheries Service (NMFS), Pacific Area Office (PAO) will cooperate with the Corps in the review of the incident to determine the need for developing further mitigation measures.

If blasting is required to facilitate excavation for the improvements at Maalaea Small Boat Harbor, the following terms and conditions must be complied with:

(1) Blasting will be restricted to the months of June through November inclusive.

(2) The Protected Species Management Branch, PAO, Southwest Region, NMFS, Honolulu, Hawaii, must be notified at least 10 days before initiation of blasting in order to monitor blasting activities. Personnel from NMFS must be allowed to monitor any or all portions of the construction activities.

(3) Due caution must be taken by the applicant to ensure that no green turtles are in the immediate vicinity (100 yards) of any blasting. Blast sites must be monitored and surveyed by small boats and divers and considered clear of sea turtles before blasting can occur.

(4) Charge size must be limited to the smallest practicable for each shot. Maximum charge size must be determined for each activity through consultation with NMFS, the Corps, and the

applicant. All explosives must be placed in drilled holes to reduce impacts on living marine resources.

(5) Any incidents of disturbance or injury/mortality to listed species must be reported within 24 hours to the Protected Species Management Branch, PAO.

(6) A final report summarizing the information gathered during the monitoring of the project site must be submitted within 30 days after completion of the project to the PAO. The report should include, among other information, the number of turtles observed, captured and removed from the area, the number of blasts, size of the charge(s) used in a blast, and time of day of the blast.

This incidental take statement applies only to the endangered green sea turtle. In order to allow an incidental take of a marine mammal species, the taking must be authorized under Section 101(a)(5) of the Marine Mammal Protection Act of 1972. No marine mammal take is authorized until appropriate small take regulations are in place and related "Letters of Authorization" are issued.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
PACIFIC ISLANDS OFFICE
P.O. BOX 50167
HONOLULU, HAWAII 96850

PV: Did we remember to coord w/NMF ?

FEB 13 1991

Mr. Kisuk Cheung
Director of Engineering
Planning Division
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

This replies to your February 6, 1991 request for our review of the proposal to improve the small boat harbor at Maalaea, Maui, Hawaii. The improvement will consist of extending and realigning the entrance channel and extending the existing breakwater to protect the new entrance channel.

Specifically, you requested we review the project and comment on possible impacts it may have on listed and proposed species of plants and animals. We have done so, and concur with your determination that the construction and operation of the facility will not affect any listed, proposed or candidate endangered or threatened species within this Service's jurisdiction. We suggest, however, that you consult with the National Marine Fisheries Service as to any possible requirements under Section 7 of the Endangered Species Act on behalf of sea turtles and whales.

Sincerely yours,

Robert P. Smith

Robert P. Smith
Field Supervisor
Fish and Wildlife Enhancement

DRAFT

FISH AND WILDLIFE COORDINATION ACT REPORT

MAALAEA HARBOR FOR LIGHT-DRAFT VESSELS

MAALAEA, MAUI, HAWAII

prepared by

U.S. Department of the Interior
Fish and Wildlife Service
Pacific Islands Office
Honolulu, Hawaii

prepared for

U.S. Army Corps of Engineers
Pacific Ocean Division
Fort Shafter, Hawaii

July 1993

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INTRODUCTION

Authority, Purpose and Scope:

This is the U.S. Fish and Wildlife Service's (Service) draft report on revised plans developed by the U.S. Army Corps of Engineers (Corps) for navigation and berthing improvements at the Maalaea Harbor for Light-Draft Vessels, Maalaea, Maui, Hawaii. This report has been prepared under the authority of the Fish and Wildlife Coordination Act of 1934 [48 Stat. 401; 16 U.S.C. 661 et seq.], as amended, (FWCA) and other authorities mandating Department of the Interior (DOI) concern for environmental values. This report is also consistent with the National Environmental Policy Act of 1969 [83 Stat. 852; 16 U.S.C. 4321 et seq.], as amended, (NEPA). The purpose of this report is to document the existing fish and wildlife resources in the proposed project area and to insure that fish and wildlife conservation receives equal consideration with other proposed project objectives as required under the FWCA. The report includes an assessment of the significant fish and wildlife resources in the proposed project area, an evaluation of potential impacts associated with the proposed project design alternatives, and recommendations for fish and wildlife mitigation measures.

Maalaea Harbor was constructed in phases during 1952, 1955, and 1959. In 1967, the Corps completed a feasibility study on Hawaiian Islands harbors for light-draft vessels (Corps, 1967). In response to that study, federal participation in the proposed project was authorized in 1968 under Section 10 of the Rivers and Harbors Act of 1899 [30 Stat. 1151; 33 U.S.C. 403]. Also in 1968, the U.S. Congress approved a federal plan of improvement for navigation and berthing at Maalaea Harbor. Additional berths were added to the harbor by the State of Hawaii in 1979. A Corps post-authorization study and redesign for navigation and berthing improvements was approved in 1980, and a General Design Memorandum and Final Environmental Impact Statement (FEIS) for the redesigned project was prepared (Corps, 1980). A State of Hawaii Revised Environmental Impact Statement (State of Hawaii, 1981) was accepted by the Governor in 1982. Project funding became available in 1989, and a Draft Supplemental Environmental Impact Statement (DSEIS) for the proposed project was released for review (Corps, 1992).

Wave action and surge have caused problems at Maalaea Harbor since it was first opened. Navigation in the entrance channel has been hazardous, vessels berthed in the harbor have been damaged, and part of the harbor has been rendered unusable for berthing because of these factors. The purpose of the proposed project is to provide improvements that will reduce hazards to navigation in the entrance channel during high wave conditions, reduce surge inside the harbor, and provide additional berthing space within the harbor basin. The actual scope of the federal portion of the proposed project is dependant on the alternative plan selected but will encompass modifications of the harbor entrance channel, the expansion of an existing turning basin and berth access channel, and the creation of additional space for berthing within the harbor. New harbor facilities and infrastructure, including new berths, a fueling facility, restrooms, and water and electrical outlets, will be provided by the State of Hawaii as part of their contribution to the proposed project.

Coordination with Federal and State Resource Agencies:

Service biologists have discussed the proposed project with staff of the National Marine Fisheries Service (NMFS) of the U.S. Department of Commerce (DOC), the Division of Aquatic Resources (DAR) of the Hawaii Department of Land and Natural Resources, and the Coastal Zone Management Program (CZMP) of the Hawaii Office of State Planning. Copies of the Service's 1979 Biological Reconnaissance Report were provided to the NMFS and DAR. Copies of the Service's 1980 FWCA Report were provided to the NMFS, DAR, and the U.S. Environmental Protection Agency (EPA). Copies of the Service's 1992 Planning Aid Letter were sent to the NMFS, EPA, and DAR. Hawaii DAR and CZMP concerns relative to the protection and conservation of important fish and wildlife resources are incorporated into this draft updated FWCA report on the proposed project.

Prior Fish and Wildlife Service Studies and Reports:

In March 1979, the Service released a Biological Reconnaissance Report on the concepts developed by the Corps for proposed navigation improvements at Maalaea Harbor (Service, 1979). This report incorporated the results of field work conducted at the harbor by Service biologists in 1979. In the report, the Service recommended that the Corps consider modifying the existing harbor entrance channel rather than cutting a new channel. The Service stated that if relocation of the channel was selected as the preferred alternative then the Corps should investigate artificial reef creation as mitigation for the loss of reef resources. The report also presented Service concern for the use and effectiveness of the harbor as a sediment trap for stormwater runoff and a recommendation that measures to minimize sedimentation of harbor waters from stormwater drainage be included in the proposed project design.

In July 1979, the Corps requested project-related section 7 consultation with the Service under the Endangered Species Act of 1973 [87 Stat. 884; 16 U.S.C. 1531 et seq.], as amended, (ESA). The Service responded by advising the Corps that the federally-listed endangered humpback whale (Megaptera novaeangliae) may occur in the general project area and that the Corps should consult with the NMFS on this species. The matter was referred to the NMFS by copy of the Service's response to the Corps.

Subsequent to public hearings held in 1979, the Corps modified the design alternatives for the proposed project. A preliminary FWCA report based on field surveys conducted by the Service for the revised proposed project was issued in February 1980 (Service, 1980a). The preliminary report presented information contained in the 1979 Biological Reconnaissance Report with the addition of a comparative description of three proposed alternative configurations for relocation of the entrance channel and a recommendation for the Corps to initiate section 7 consultation with the NMFS on the humpback whale. Service concern over the discharge of silt-laden runoff from uplands into the harbor and the recommendation for employing measures to control sedimentation in harbor waters were reiterated.

A final FWCA report on the proposed project was released by the Service in June 1980 (Service, 1980b). The final report added to information included in the preliminary FWCA report and provided an in-depth evaluation and discussion of impacts related to the proposed federal plan of improvement. Measures recommended by the Service for minimizing and compensating for adverse project-related impacts on fish and wildlife resources were presented. Service concern regarding the discharge of silt-laden runoff from uplands into the harbor and the recommendation for employing measures to control sedimentation in harbor waters were restated.

Also in June 1980, the Service transmitted comments to the Corps through the DOI's Office of Environmental Affairs (OEA) on the Corps' Draft Design Memorandum No. 1 for Light-Draft Vessels, Maalaea Harbor, Maui, Hawaii. The Service concurred with the recommendation made by the NMFS in their biological opinion on the humpback whale that project-related blasting be restricted to the months of May through December when the whales are not expected to be present in Maalaea Bay. The Service recommended that the Corps incorporate sedimentation control measures into the project design to mitigate project-related adverse impacts on water quality. The Service expressed concern that greater boat usage in the harbor as a result of the proposed project will slow the settlement of newly-introduced sediments and increase the resuspension of existing sediments in harbor waters. This increase in suspended sediments would add to the threat to nearby coral-reef habitats already posed by the existing large load of upland sediments entering the harbor with stormwater runoff. The Service further recommended that the location of project-related spoil disposal sites be identified so that associated impacts could be addressed in the final project document and that project-related breakwaters be designed to provide safe access for fishers.

In December 1981, the Service reviewed the draft Hawaii State Environmental Impact Statement (EIS) for Improvements to the Maalaea Boat Harbor, Maalaea, Maui, Hawaii and provided comments on the document to the Hawaii State Office of Environmental Quality Control. The Service recommended that the Corps implement measures during the construction period to (1) prevent debris or any type of pollutant from entering the water, (2) insure that all construction materials treated with creosote or other preservatives be completely dry before those materials are placed in the water, (3) control and minimize erosion and turbidity, and (4) restrict blasting to within the months of May through December to avoid impacting humpback whales.

In February 1991, the Corps reinitiated section 7 consultation with the Service on federally listed or proposed species of plants and animals. The Service responded in the same month by concluding that the proposed project would not affect any listed, proposed or candidate endangered and threatened species within the Service's jurisdiction and recommending that the Corps consult with the NMFS regarding the effects of the proposed project on federally-listed sea turtles and whales. Also in February 1991, the Corps requested that the Service update the 1980 final FWCA report since the marine environment surrounding Maalaea Harbor could have changed since 1979 and since the Corps intended to prepare a supplement to update the 1980 EIS for the proposed project.

Based on this request, the Service conducted a brief reconnaissance survey at the site and provided a Planning Aid Letter (PAL) to the Corps in April 1992 (Service, 1992). The letter briefly addressed the direct loss of fish and wildlife habitats from dredging and filling and secondary impacts to reef corals from sedimentation. The Service stated that more detailed field studies would be conducted in order to update the 1980 FWCA report. Specific comments on adverse impacts related to the 1980 approved plan were provided, and the existence of another proposed design alternative being considered by the Corps, which included constructing a stub breakwater extension into the harbor basin, was acknowledged. The Service stated that implementing this other alternative would not significantly impact coral-reef habitats at the site but that it would apparently preclude berthing of a U.S. Coast Guard (USCG) cutter in the harbor. Service recommendations for mitigation were also presented, including the construction of an artificial reef and the perpetual protection of reef platform habitats within Maalaea Bay.

In February 1993, Service comments on the Corps's 1992 DSEIS were transmitted to the Corps through the OEA. The Service stated that the DSEIS addressed neither the potential project-related adverse impacts to aquatic resources identified in the 1992 PAL, nor any potential mitigation measures to offset losses to reef-flat communities in the proposed project area. The Service also stated that additional field studies would be conducted in order to submit an updated draft FWCA report for the proposed project.

DESCRIPTION OF THE PROJECT AREA

The proposed project area is the island of Maui (20° 52' N and 156° 22' W) in the State of Hawaii. With 193 km (120 mi) of coastline encompassing approximately 1888 km^2 (729 mi^2) of land, Maui is the second largest island in the Hawaiian archipelago. The island was created by the eruptions of two volcanoes that were subsequently connected by a low isthmus formed from lava flows. Maui's highest peak, Pu'u Ula'ula on Haleakala Crater, reaches an elevation of 3055 m (10,023 ft) on the eastern side of the isthmus, and Pu'u Kukui reaches 1764 m (5788 ft) on the west side (University of Hawaii, 1983).

The proposed project site is located at Maalaea on the southern shore of the Maui isthmus in the northwestern corner of Maalaea Bay (Figure 1). Maalaea Harbor was constructed on a large fringing reef flat at the western end of Maalaea Bay. The shoreline of Maalaea Bay is approximately 12 km (7.5 mi) in length, but the bay is accessible along only two thirds of this shore. The harbor serves as the only public access point to Maalaea Bay from its western end. The closest small boat harbor to Maalaea is approximately 14 nautical miles away at Lahaina. Maalaea Harbor is currently used by both commercial and recreational boaters. In the past, the U.S. Coast Guard has based a 29-m (95-ft) patrol vessel at Maalaea Harbor for the primary purpose of conducting emergency search and rescue (SAR) operations. However, the last patrol vessel stationed at Maalaea Harbor was removed approximately two and a half years ago and decommissioned shortly thereafter. The USCG has continued SAR operations out of the harbor with two 7 m (24 ft) high-speed, rigid-hull inflatable boats, which have provided efficient SAR response coverage for the area (Pers. Com. Cmdr. Reed and Lt. Cmdr. Quedens, USCG, 1993).

Existing features at Maalaea Harbor include a south revetted mole that is approximately 335 m (1100 ft) long and 27 m (90 ft) wide, an east breakwater that is approximately 259 m (850 ft) long and 8 m (26 ft) wide, an entrance channel that is approximately 27 m (90 ft) wide and 4 m (13 ft) deep, and an interior basin that is approximately 4.6 hectares (11.3 acres) in size (Figure 2). Local interests have constructed a cold storage plant with a capacity of 45,455 kg (100,000 lb) and a boat haul-out and repair facility at the west end of the harbor basin. A one-lane concrete ramp at the northwestern corner of the basin serves as both a haul-out ramp and a trailered boat launching ramp.

The south revetted mole extends from shore entirely on the outer reef flat and is oriented parallel with the reef margin. The east breakwater extends across the inner reef flat with an initial orientation roughly perpendicular to the reef margin. Upon reaching the outer reef flat the east breakwater curves west toward the harbor entrance channel and eventually crosses the reef margin at an oblique angle just before it terminates. Three upland stormwater drainage channels empty into the northern side of the harbor basin.

The average daytime high temperature recorded at Pu'unene Airport, approximately 10 km (6.3 mi) north of Maalaea in the town of Kahului, is 24° C (75° F). Average annual precipitation recorded at the same location is 35 cm (13.8 in), although the windward slopes of the island receive 889-1016 cm (350-400 in) of rainfall per year. The majority of the rainfall at Maalaea occurs between October and April, but intermittent rainfall may be expected in any month of the year, including the summer months, which are generally drier (University of Hawaii, 1983).

Northeast tradewinds with an average velocity of 9-17 kts (10-20 mph) blow fairly consistently across Maui from May through September. Average wind velocities at Maalaea are often greater than 22 kts (25 mph) due to a Venturi effect created over the low isthmus between the island's steep eastern and western mountains (Corps, 1980). Between October and April winds may decrease in velocity and shift direction in response to the northerly winds that follow or the southwesterly winds that precede cold fronts and southerly winds of "Kona" storms. Thus, winter is the season of more frequent cloudiness and rainstorms (University of Hawaii, 1983).

The predominant ocean current flow near Maalaea Harbor has been characterized as a tradewind-generated surface movement generally toward the southwest. Under normal tradewind conditions, the speed of this current is typically less than 1 kt (1.2 mph) and is not strong enough to cause navigational problems. During periods of high swell activity, especially during Kona storms, strong wave-generated rip currents may develop (Corps, 1980). Although tidal currents in Maalaea Bay are usually too weak to affect navigation, tidal fluctuations working in concert with prevailing wind-driven currents may result in the nearly continuous flushing out of the harbor of suspended fines that are introduced into the harbor with stormwater runoff from upland sources.

During periods of high rainfall, the sediment load in nearshore waters of Maalaea Bay increases significantly as a result of drainage from erosion-prone uplands (Maciolek, 1971). The greatest increase occurs in the eastern portion of the bay where Waiakoa Gulch empties directly into the bay. In the mid-portion of the bay, Kealia Pond and adjacent wetland and mudflat areas act as a settling basin for four major drainages that are potential contributors to the sediment load of the bay (Maciolek, 1971; Kinzie, 1972). In the western portion of the bay, the three drainage channels that empty into Maalaea Harbor also contribute to the bay's total sediment load. Although the harbor does act to some degree as a sediment trap, finer sediments in the harbor are regularly resuspended by boat activity.

At the request of the State of Hawaii, the DOC's National Oceanic and Atmospheric Administration (NOAA) designated Maalaea Bay as a proposed protected area for endangered humpback whales. In November 1992, the U.S. Congress passed the Oceans Act of 1992 (P.L. 102-587), which established the Hawaiian Islands Humpback Whale National Marine Sanctuary. Maalaea Bay was included within the sanctuary's boundaries. In December 1992, the 283-ha (700-ac) Kealia Pond National Wildlife Refuge, located approximately 915 m (3000 ft) east of Maalaea Harbor, was established by the Service. The wetlands within this refuge are essential for the recovery of the endangered Hawaiian stilt, Himantopus mexicanus knudseni, and Hawaiian coot, Fulica americana alai, and provide important habitat for many species of migratory shorebirds and waterfowl. The Service does not expect these wetlands to be adversely affected by the proposed modification of the harbor.

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

The Service's primary concerns with the proposed project include impacts to endangered species and other fish and wildlife resources and their habitats from dredging and filling in the marine environment. Specific Service planning objectives are to maintain and enhance the existing significant habitat values at the proposed-project site by (1) obtaining basic biological data for the proposed-project site, (2) evaluating and analyzing the impacts of proposed-project alternatives on fish and wildlife resources and their habitats, (3) identifying the proposed-project alternative least damaging to fish and wildlife resources, and (4) recommending mitigation for unavoidable project-related habitat losses consistent with the FWCA and the Service's Mitigation Policy.

Under the authority of the ESA, the DOI and the DOC share responsibility for the conservation, protection and recovery of federally-listed endangered and threatened species. Authority to conduct consultations has been delegated by the Secretary of the Interior to the Director of the Service and by the Secretary of Commerce to the Assistant Administrator for Fisheries of the NOAA. Section 7(a)(2) of the ESA requires federal agencies, in consultation with and with the assistance of the Service or NMFS, to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitats. The Biological Opinion is the document that states the opinion of the Service or the NMFS as to whether the Federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

The Service's Mitigation Policy (Service, 1981) outlines internal guidance for evaluating project impacts affecting fish and wildlife resources. The Mitigation Policy compliments the Service's participation under the NEPA and the FWCA. The Service's Mitigation Policy was formulated with the intent of protecting and conserving the most important fish and wildlife resources while facilitating balanced development of this nation's natural resources. The policy focuses primarily on habitat values and identifies four resource categories and mitigation guidelines. The resource categories are the following:

a. Resource Category 1: Habitat to be impacted is of high value for the evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section.

b. Resource Category 2: Habitat to be impacted is of high value for the evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.

c. Resource Category 3: Habitat to be impacted is of high to medium value for the evaluation species and is relatively abundant on a national basis.

d. Resource Category 4: Habitat to be impacted is of medium to low value for the evaluation species.

The coral reef fronting Maalaea Harbor is the habitat of major concern. Although corals are very small and sensitive organisms, healthy coral colonies are fundamentally important in providing the basic foundation for habitat that supports diverse communities of other highly-specialized aquatic organisms. Corals contribute the bulk of the calcareous raw material that forms and maintains the basic structural framework of the reef. Coral colonies add significantly to the submarine topographic relief in which a large number of fish and invertebrate species find shelter and food. Coral polyps themselves are an important food source for some fishes and other marine life. The institutional significance of coral reefs has been established through their formal designation as "special aquatic sites" (40 CFR Part 230 §230.44 / FR v.45 n.249). Such sites possess special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values and contribute to the general overall environmental health or vitality of an entire ecosystem of a region.

The Service considers coral reef habitats to be Resource Category 2 habitats. The Service's resource goal for Category 2 habitat is no net loss of in-kind habitat values. Under this designation, the Service will recommend ways to avoid or minimize the losses. If losses are unavoidable, mitigation measures to immediately rectify, reduce, or eliminate these losses over time will be recommended. As necessary, compensation by replacement of the in-kind habitat values may be incorporated as integral project features.

Sea turtles and reef fishes have been selected as the evaluation species for the coral reef habitats that may be affected by the proposed project. The green sea turtle, Chelonia mvdas, is federally listed and protected under the ESA as a threatened species. The Maalaea reef encompasses shallow substrates that support the growth of algal species commonly fed upon by green sea turtles and shallow ledges and depressions in the reef slope that provide suitable resting sites for C. mvdas near these foraging areas. Reef fishes were selected because of their potential importance as sources of food and recreation for humans. The harbor area supports subsistence and sport fisheries for reef fishes, lobsters, crabs, octopi, and algae. Hook and line fishing from the existing mole and breakwater, spear fishing on the reef slope, and hand harvesting of edible algae from intertidal and shallow subtidal areas fronting the harbor are commonly practiced. Also, reef fishes are among the marine resources most important to resident and visiting recreational skin and SCUBA divers.

EVALUATION METHODOLOGY

In 1979, the Service conducted field surveys at Maalaea Harbor to evaluate the proposed-project design criteria in effect at the time. The methodology used during the surveys included a brief reconnaissance of terrestrial flora and fauna within a radius of 61 m (200 ft) around the harbor and surveys of marine species and habitats. The marine surveys included the collection of data on the species composition and relative abundances of fishes, corals, other macroinvertebrates, and algae along 20-m (66-ft) transect lines placed on the inner reef flat, outer reef flat and reef margin, and reef slope outside of the harbor. These data were supplemented by observations of fish and benthic organisms made during random swims on the fringing reef flat and reef slope to a depth of 6 m (20 ft) and inside the harbor along the existing northern shoreline and shallows adjacent to the inner portion of the east breakwater. Details concerning the surveys have been reported previously (Service, 1979; 1980a; 1980b). Information gained from the surveys is incorporated into this report.

In 1992, Service biologists conducted a preliminary reconnaissance-level survey of the fringing reef outside of the harbor. The survey consisted of an inspection of subtidal marine habitats to a depth of 7.5 m (25 ft) along the south revetted mole and the east breakwater and within the existing entrance channel leading to the harbor mouth. Observations on the distribution and relative abundances of corals and reef fishes were made during random swims through these areas. The details of this reconnaissance have been reported previously (Service, 1992) and results of the survey are incorporated into this report.

In 1993, Service biologists conducted additional surveys at the harbor site in order to evaluate potential impacts of the revised, proposed-project alternatives on fish and wildlife resources. A brief reconnaissance of the terrestrial flora and fauna around the harbor was repeated for comparison with the 1979 survey results. Observations on the distribution and relative abundances of fishes, corals, other macroinvertebrates, and algae were compiled during random swims over substrates both inside and outside of the harbor. Within the harbor, surveys were made on the submerged western shoal and over the shallows adjacent to the east breakwater. Outside the harbor, surveys were conducted on the fringing reef to a maximum depth of 7.5 m (25 ft). Substrate coverage data collected along 150-m (492-ft) transects at the locations of the proposed channel dredging and mole and breakwater filling were used to assess the potential value of existing reef habitat. The complete results of this survey are contained in this report.

DESCRIPTION OF FISH AND WILDLIFE RESOURCES

Existing Conditions:

Terrestrial:

The terrestrial portion of the proposed project site has been highly altered by construction of the harbor and ancillary buildings, roads, parking lots, docks and piers. There are no wetlands or sensitive upland habitats located within the harbor area.

Prosopis pallida, a type of mesquite known locally as "kiawe", and bristly foxtail, *Setaria verticillata*, are among the dominant terrestrial plants present at the harbor site. Both of these species are exotic introductions to Hawaii. According to local boaters, the large kiawe trees growing immediately west of the harbor act as windbreaks that help reduce navigational difficulties during periods of high winds. Coconut, *Cocos nucifera*, and ironwood, *Casuarina equisetifolia*, are present along the western end of the south revetted mole. The ground cover in this area consists principally of seaside purslane, *Sesuvium portulacastrum*, and beach fan flower, *Scaevola sericea*, known locally as "beach naupaka." *Gossypium tomentosum*, a rare endemic wild cotton known locally as ma'o, had previously been reported to exist in the general vicinity of Maalaea Harbor, but Service biologists did not observe ma'o at the proposed project site.

Service biologists observed common mynahs, *Acridotheres tristis*, and house sparrows, *Passer domesticus*, at the site. Ring-necked pheasants, *Phasianus colchicus torquatus*, grey francolins, *Francolinus pondicerianus*, and lace-necked and barred doves, *Streptopelis chinensis* and *Geopelia striata*, respectively, may occasionally be found in the uplands surrounding the harbor (State of Hawaii, 1975). The only migratory bird observed by Service biologists during visits to the Maalaea Harbor is the wandering tattler, Heteroscelus incanus. However, other migratory shorebirds expected to use the intertidal flats at the site include ruddy turnstones, Arenaria interpres, golden plovers, Pluvialis dominica, and sanderlings, Caladris alba.

Terrestrial mammals at the site are limited to introduced species including the domestic cat, Felis catus, and dog, Canis familiaris, house mouse, Mus musculus domesticus, roof or black rat, Rattus rattus, brown rat, R. norvegicus, Polynesian rat, R. exulans hawaiiensis, and mongoose, Herpestes auropunctatus. Introduced skinks (Scincidae) and gekkos (Gekkonidae) are also present at the site (State of Hawaii, 1975).

Marine:

Lists of the marine organisms observed by Service biologists at the proposed project site during the 1993 surveys are presented in Tables 1-6. A total of 66 species of marine fishes (Table 1), eight species of reef corals (Table 2), 29 species of marine molluscs (Table 3), eight species of marine crustaceans (Table 4), 10 species of echinoderms (Table 5), and eight species of miscellaneous marine animals (Table 6) were recorded during the surveys.

A shoal that is trapezoidal in shape and submerged in approximately 1 m (3 ft) of water lies within the western half of the harbor. The low-relief shoal is covered with a thick layer of sand, mud and silt. During the 1993 surveys, Service biologists noted thick clumps of the red alga, Hypnea musciformis, floating just above the substrate over most of the shoal. The shoal is bordered on its northern and western edges by basalt boulders that have provided substrates for a few small colonies of the corals, Porites rus and Pocillopora damicornis. The nerite, Nerita picea, and the sea urchins, Diadema paucispinum and Echinometra mathaei, are also common on the boulders. The wrasses, Thalassoma duperrey and Stethojulis balteata, the damselfish, Abudefduf abdominalis, the surgeonfish, Acanthurus triostegus, the butterflyfish, Chaetodon lunula, the boxfish, Ostracion meleagris, and the moorish idol, Zanclus cornutus, are among the more conspicuous fishes seen near the boulders. Schools of the goatfish, Parupeneus vanicolensis, the flagtail, Kuhlia sandvicensis, the anchovy, Stolephorus purpureus, and the great barracuda, Sphyraena barracuda, are conspicuous above the shoal away from the boulders.

The eastern portion of the harbor includes an existing turning basin and a shallow reef flat adjacent to the east breakwater. The inner portion of this shallow reef is mostly covered with sand and a few scattered rocks. Like the shoal, this substrate was blanketed by extensive algal patches of Hypnea musciformis during the 1993 surveys. Other less abundant algae present on this reef include the green algae, Bryopsis pinnata, Codium reediae, C. reticulata and Ulva fasciata, and the brown alga, Sargassum echinocarpum. Mollusc species occurring on this reef include the limpet, Cellana exarata, the morula, Morula granulata, the nerite, Nerita picea, and the venus shell, Periglypta reticulata. The rock crab, Grapsus tenuicrustatus, is the most common crustacean occurring on the breakwater. Subtidally, the crab, Etisus splendidus, is the most conspicuous crustacean occurring near the breakwater. Juvenile wrasses (Labridae) and parrotfishes (Scaridae) closely associated with benthic algae are the dominant types of fishes present over the majority of this harbor reef flat.

Near the harbor mouth, the substrate of the harbor reef becomes rockier, and fishes typical of an exposed outer-reef community become more numerous. Within the harbor mouth itself, Service biologists have repeatedly observed large schools of the goatfish, Muloides vanicolensis, and smaller schools of the flagtail, Kuhlia sandvicensis, swimming between the ends of the east breakwater and south revetted mole. In addition to the mollusc species observed on the inner portion of the harbor reef, the dotted periwinkle, Littorina pintado, the cowrie, Cypraea caputserpentis, and the cone, Conus lividus, are also common closer to the end of the breakwater. The rock crab, Grapsus tenuicrustatus, and the collector urchin, Pseudoboletia indiana, are the most conspicuous macroinvertebrates living on the breakwater boulders.

The existing entrance channel is continuous with a broad sand channel that runs from the mouth of the harbor out to the extensive, offshore sand flats that characterize Maalaea Bay. The sand-covered entrance channel, originally dredged to a depth of 4.6 m (15 ft), is relatively depauperate of marine life. At the seaward end of the channel, isolated outcroppings of limestone that rise above the sand flats support scattered coral colonies, primarily Pocillopora meandrina and P. eydouxi, and localized aggregations of reef fishes. Outside of the harbor, the entrance channel is flanked by a fringing reef platform comprised of consolidated limestone pavement with small pockets of sand. Except for scattered coral heads, small crevices in the reef framework, and the sand pockets, the inner portion of this reef platform has a relatively flat topographic relief. The reef extends for several hundred feet offshore from the toe of the east breakwater and south revetted mole before gently grading into the offshore sand flats.

Outside the harbor, marine habitat composition varies most markedly across the fringing reef adjacent to the east breakwater. The substrate on the inner reef flat is comprised primarily of loose coral rubble. The red crustose coralline alga, Porolithon onkodes, covers much of this rubble and has likely played a major role in the reef's formation and maintenance. Green algae of the genus Ulva are commonly attached to these pieces of rubble. Over the outer reef flat, depth decreases and the reef substrate becomes relatively free of coral rubble. Small patches of coral, comprised mainly of Pocillopora damicornis and isolated colonies of Porites, occur in depressions on the outer reef flat. Coral coverage on the reef flat is highest on the narrow reef margin ridge that lies approximately 183 m (600 ft) offshore. Porites is the dominant coral genus in this zone of high wave energy.

The east breakwater crosses and terminates just beyond the reef margin. Marine algae, primarily the red algae, Ahnfeltia concinna and Pterocladia capillacea, cover the wave-washed boulders on the outer part of the east breakwater. The helmet urchin, Colobocentrotus atratus, is conspicuous on the intertidal surfaces of these boulders. The collector urchin, Pseudoboletia indiana, is more abundant on the boulders subtidally, especially near the channel mouth where low numbers of the long-spined urchin, Echinothrix diadema, also exist. The nerite, Nerita picea, and the limpet, Cellana exarata, are the most common molluscs residing on the boulders. The rock crab, Grapsus tenuicrustatus, is the most conspicuous crustacean occurring on the breakwater.

Seaward of the reef margin and the end of the east breakwater, the reef platform gradually descends until it reaches the offshore sand flats of Maalaea Bay. Immediately seaward of the breakwater the reef platform is shallow and pitted by a dense population of the boring sea urchin, Echinometra mathaei. In 1979, Service biologists estimated the maximum density of this species at this location to be 62 urchins/m^2. In 1993, the density of this population was not measured, but it appeared to be very high. The long-spined sea urchin, Echinothrix diadema, is common in the deeper depressions on this part of the reef.

Live coral coverage on the platform immediately in front of the east breakwater is approximately 10%. However, corals on the reef slope increase with depth and distance from the breakwater until they provide an estimated substrate coverage of 50-75% before decreasing abruptly as the reef grades into the sand flats at an approximate depth of 8 m (25 ft). The most common corals present on the reef slope fronting the east breakwater are Porites lobata, Pocillopora meandrina, Pocillopora damicornis, Pocillopora eydouxi, and Montipora flabellata. P. lobata and P. meandrina contribute the greatest amount of relief at this location.

Other dominant macroinvertebrates residing on this reef include the widespread Christmas tree worm, Spirobranchus giganteus, and the spiny lobster, Panulirus marginatus. Butterflyfishes (Chaetodontidae), damselfishes (Pomacentridae), and wrasses (Labridae) are the most ubiquitous fishes on this reef. Large feeding aggregations of herbivorous surgeonfishes (Acanthuridae), including Acanthurus blochii, A. olivaceus, A. xanthopterus, Naso lituratus, and N. unicornis, forage across extensive areas of the reef-slope substrate.

The Corps (1980) reported that the reef slope fronting and eastward of the east breakwater contained extensive ledge systems, depressions, raised knobs, and large Porites coral heads. In terms of the abundance and diversity of biological resources, the Corps concluded that this area of reef slope is the richest and decidedly most valuable area adjacent to the harbor. Observations made by Service biologists in 1993 corroborate the Corps' observations and support this conclusion.

On the other side of the harbor entrance channel, the boulders of the south revetted mole support the same organisms that exist on boulders of the east breakwater. The reef immediately fronting the eastern section of the mole is characterized by relatively low-relief limestone pavement colonized by high densities of boring sea urchins and pitted with pockets of sand and coral rubble. Two relatively large, sand-filled depressions exist immediately seaward of and parallel to the eastern half of the existing mole. The water in this area is generally cloudy, which is characteristic of conditions of suspended fine sediments.

At the location of proposed filling for expansion of the south revetted mole the substrate coverage is approximately 89% consolidated limestone pavement, 9% live coral, 1% coral rubble, and 1% unconsolidated calcareous sand. Toward the western end of the mole, the reef pavement becomes more widely covered with coral rubble grading to calcareous sands. During the 1993 surveys, a thick accumulation of detached benthic algae, dominated by Hypnea musciformis, almost completely covered the substrate in this area.

Corals are nearly absent on the reef pavement immediately fronting the south revetted mole, but in deeper water further out on the reef slope, coral coverage increases to approximately 50%. Porites lobata and Montipora flabellata are the most common species on this reef. Other conspicuous corals include Porites compressa, Pocillopora meandrina, and Pocillopora damicornis. Dominant macroinvertebrates include the sea urchins, Echinometra mathaei, Echinothrix diadema, Diadema paucispinum, Heterocentrotus mammillatus, and the sea cucumber, Holothuria atra. The surgeonfish, Acanthurus triostegus, is the most common fish species on this reef platform, especially near mole boulders by the existing channel mouth. The goatfishes, Mulloides flavolineatus, M. vanicolensis, and Parupeneus multifasciatus, the butterflyfishes, Chaetodon lunula, C. miliaris, C. ornatissimus, and C. unimaculatus, the damselfishes, Abudefduf abdominalis, Stegastes fasciolatus, and Stethojulis balteata, and the triggerfish, Rhinecanthus rectangulus, are conspicuous on the reef fronting the south revetted mole.

The harbor supports existing sport and subsistence fisheries. Hook and line fishing from the mole and breakwater are commonly practiced, as is spear fishing on the reef platform fronting the harbor. Although fishing is not officially permitted within the existing harbor basin, Hawaiian anchovy or "nehu," S. purpureus, are occasionally caught for bait. Fish and shellfish taken by local fishers include the surgeonfish, Acanthurus triostegus, the jack, Caranx ignobilis, the bonefish, Albula vulpes, the mullet, Mugil cephalus, the flagtail, Kuhlia sandvicensis, the goatfish, Mulloidichthys spp., spiny lobster (Panuliridae), octopus (Octopodidae), and grapsid crabs (Grapsidae). Occasional inshore runs of fish such as the mackerel scad known locally as "opelu," Decapterus macarellus, may occur.

The culturally important, edible red alga or "limu huluhuluwaena," Grateloupia filicina, has been recorded at the proposed project site (McDermid, 1990). This species has a patchy distribution throughout the Hawaiian Islands and is locally abundant in only a few areas in the state. Maalaea Bay is one of those areas, and the proposed project site is known to contain populations of G. filicina during summer and winter months (McDermid, 1990). Populations of this species develop and are maintained on intertidal and shallow subtidal hard substrates where intermittent sand scour occurs and where a source of freshwater is nearby. Another species of edible red algae, Gracilaria coronopifolia, or "limu manauea," is found on the seaward faces of the east breakwater and the south revetted mole (McDermid, 1990).

The coral reef fronting Maalaea Harbor also supports the green sea turtle. Green sea turtles are federally listed as threatened and are commonly sighted within the vicinity of the proposed project site. During the 1993 surveys, Service biologists observed a large male turtle, estimated to weigh approximately 136 kg (300 lbs), resting under a ledge in 3 m (10 ft) of water in front of the eastern end of the south revetted mole.

Seven of the 25 algal species recorded at the site by McDermid (1990) have been documented by Forsyth and Balazs (1989) as being food resources used by green sea turtles in the main Hawaiian Islands. These species are Pterocladia capillacea, Amansia glomerata, Acanthophora spicifera, Codium edule, Uva fasciata, Uva reticulata, and Ahnfeltia concinna. Hypnea musciformis is also regarded as a potential food resource for green sea turtles in Hawaii (Pers. Com. G. Nitta, NMFS, 1993), and Bryopsis pinnata is a known food resource of green sea turtles at Johnston Atoll (Forsyth and Balazs, 1989). Both of these algal species are also present at Maalaea. All but U. reticulata are common on the reef platform outside of the harbor, and the other eight species are known to exist on the reef substrate fronting the south revetted mole. Seasonal variations in distribution and abundance associated with some of these species have been observed; however, H. musciformis is considered abundant at the harbor throughout the year (McDermid, 1990).

Maalaea Bay is one of four major breeding, calving, and nursing areas for endangered humpback whales in Hawaii. During the 1979 survey, Service biologists observed six humpback whales near the proposed project site. Three of these whales were within one-half mile of the harbor. During the 1992 reconnaissance survey, Service biologists sighted an adult and calf approximately 150 m (500 ft) southeast of the tip of the east breakwater. A biological opinion assessing the potential project-related impacts to both green sea turtles and humpback whales has been issued by the NMFS (1990).

Future Without the Project:

Kinzie (1972) described the biota of Maalaea Bay as unusual in that the numbers and forms of various marine species, which are uncommon elsewhere in the Hawaiian Islands, are common in the bay. Several species of algae and corals, rarely found in Hawaii, are relatively abundant in the bay. The bay also has a rich fish and invertebrate fauna and is a favorite area for shell collectors. Humpback whales are common seasonal residents within Maalaea Bay.

Although the bay is potentially very productive in terms of biomass, that productivity may be limited by the effects of siltation (Kinzie, 1972). Maalaea Harbor currently acts as a silt trap for three drainage channels emptying into the harbor basin. Water visibility in the harbor is typically very poor and salinity is often lower than 35 parts per thousand. Nevertheless, the harbor does provide habitat for species tolerant of estuarine conditions, such as barracuda, flagtails, herrings, and other fishes. The reef platform immediately fronting Maalaea Harbor, especially adjacent to the south revetted mole, provides resting and potential foraging habitat for threatened green sea turtles. Further out from the harbor in deeper water, especially on the reef slope fronting the east breakwater, a zone of coral cover provides habitat for a wide variety of marine organisms, including food-fish species important to humans.

The reasons for the special character of the biological resources of Maalaea Bay remain largely unknown, and for this reason extreme caution in undertaking any action that would alter any aspect or condition of the bay has been urged (Kinzie, 1972). Without the proposed-project, the resuspension of large amounts of sediment, which may adversely impact the health of corals and filter-feeding organisms and reduce available light for photosynthetic organisms, would be avoided. The loss of potential green sea turtle habitat and a relatively rich area of coral important to reef fishes and many other organisms, as a result of proposed-project dredging and filling, would be avoided. Although the direct destruction of habitats within or fronting Maalaea Harbor would be avoided without the project, the unabated drainage of stormwater carrying sediments and chemical pollutants (eg., agricultural fertilizers, pesticides, and herbicides) into the harbor may result in adverse cumulative impacts to marine resources. Runoff from future development in the vicinity of Maalaea Harbor may add to this sediment and chemical load if new stormwater drainage is routed to the harbor unless steps are taken to protect good water quality in the harbor.

DESCRIPTION OF ALTERNATIVES EVALUATED

Seven alternative actions are identified by the Corps in the DSEIS (Corps, 1992). One of the proposed actions is a No Action Alternative that would leave the existing harbor as it is with no action taken to install any of the proposed federally-planned improvements. Table 7 provides a comparison of the volume and area of reef substrate to be dredged and area of reef substrate to be filled for each of the other six design alternatives. Additional details on these six proposed alternative actions are summarized below.

Alternative 1: Federal Plan of Improvement. This action would provide a breakwater extension of 189 m (620 ft) to the head end of the south revetted mole; a widened mole area stretching 122 m (400 ft) along the seaward side of the south revetted mole; a widened mole area along approximately 24 m (80 ft) of the east breakwater; a realigned harbor entrance channel 186 m (610 ft) long, 46-55 m (150-180 ft) wide, and 3.5-4.5 m (12-15 ft) deep; a turning basin 1.4 ha (1.7 ac) large and 3.5 m (12 ft) deep; a main access channel 219 m (720 ft) long, 24 m (80 ft) wide and 2.4 m (8 ft) deep; and the removal of 24 m (80 ft) from the head end of the east breakwater. Approximately 44,000 m^3 (57,542 yd^3) of reef material would be dredged from 2.1 ha (5.3 ac) for construction of the harbor basin and new entrance channel. The reef area to be filled would be approximately 1.7 ha (4.0 ac) (Figure 3).

Alternative 2: Same as Alternative 1, except that the revetted mole along the seaward side of the south breakwater would be replaced with a wave absorber 61 m (200 ft) long. The estimated amount of dredging would be the same as for Alternative 1, but approximately 1.1 ha (2.6 ac) of reef area would be filled (Figure 4).

Alternative 3: Same as Alternative 1, except that the revetted mole would be eliminated and the south breakwater extension would be detached from the existing structure and would be 198 m (650 ft) long. The estimated amount of dredging would be the same as for Alternative 1, but approximately 1.0 ha (2.4 ac) of reef area would be filled (Figure 5).

Alternative 4: This action would consist of a 259 m (850 ft) long extension of the east breakwater; an entrance channel 293 m (960 ft) long, 46-61 m (150-200 ft) wide, and 3.5-4.5 m (12-15 ft) deep; and a main access channel 183 m (600 ft) long, 24 m (80 ft) wide, and 2.4 m (8 ft) deep. An unspecified volume of reef material would be dredged from approximately 3.2 ha (7.8 ac), and approximately 1.0 ha (2.4 ac) of reef area would be filled (Figure 6).

Alternative 5: This design is similar to Alternative 2 with a slight realignment of the south breakwater extension. The estimated amount of dredging would be the same as for Alternative 1, but approximately 1.1 ha (2.6 ac) of reef area would be filled (Figure 7).

Alternative 6: This design includes leaving the existing harbor entrance channel as is and constructing an interior extension off the end of the south revetted mole to reduce wave action within the harbor (Figure 8). The Corps stated in the DSEIS that this alternative was eliminated from detailed planning and discussion because it would not allow adequate maneuvering space for a 33.5-m (110-ft) U.S. Coast Guard (USCG) cutter, would make access to the rest of the harbor hazardous for other vessels when the cutter is docked, and would preclude development of additional berthing space along the east breakwater.

PROJECT IMPACTS

Terrestrial Resources:

Construction activities associated with the proposed project are not expected to adversely impact terrestrial biological resources at the harbor. However, acquisition of armor stone for breakwater construction and disposal of excess dredged spoil on land could result in adverse impacts to federally listed or proposed endangered and threatened species and other wildlife outside of the immediate project site. Since exact upland borrow and spoil disposal sites have not been designated, the Service cannot evaluate the potential impacts at those sites.

Marine Resources:

With the exception of the No Action Alternative, all project-related actions under consideration would result in direct and secondary adverse impacts to marine fish and wildlife resources. The implementation of Alternatives 1, 2, 3 or 5 would each result in the direct and permanent alteration of approximately 2.1 ha (5.3 ac) of marine benthic habitat from channel and turning basin dredging. With the implementation of Alternative 4, approximately 3.2 ha (7.8 ac) of benthic habitat would be dredged for these purposes. Concurrently, the direct and permanent elimination of approximately 1.6 ha (4.0 ac), 1.1 ha (2.6 ac), 1.0 ha (2.4 ac), 1.0 ha (2.4 ac), or 0.8 ha (1.9 ac) of benthic habitat from filling for breakwater and mole construction would result from the implementation of Alternatives 1, 2, 3, 4, or 5, respectively (Table 7).

The major dredging impacts associated with Alternatives 1-5 include the direct loss of corals, demersal fishes, sedentary macroinvertebrates, and benthic algae and the permanent alteration and elimination of existing marine benthic habitat. In particular, Alternatives 1, 2, 3 and 5 require dredging of approximately 0.9 ha (2.3 ac) of reef substrate fronting the east breakwater to create a new harbor entrance channel. The dimensions and orientation of the new channel would be the same for each of these alternatives. Although part of the new channel would cross barren sand on the existing channel floor, much of it would traverse an area of relatively rich coral where the substrate is covered by consolidated limestone pavement (54%), live coral (40%), coral rubble (5%), and unconsolidated calcareous sand (1%).

The new channel created by implementing Alternative 4 would result in the destruction of an even greater area of reef substrate (1.6 ha or 3.9 ac), although less live coral would be lost since the reef platform at this location is mostly consolidated pavement interspersed with pockets of sand. Nevertheless, this greater area of substrate does include green sea turtle resting and potential foraging habitat which would be destroyed by implementing this alternative.

Although reef surfaces freshly exposed by dredging often eventually become recolonized by reef-building organisms, poor water quality resulting from the unabated discharge of terrigenous sediments into Maalaea Harbor may inhibit normal recovery at the site and prevent the use of affected areas by reef-dwelling species. Even though a new harbor entrance channel would provide additional "edge" habitat, and thereby increase habitat diversity within the project vicinity, the new channel may not provide suitable replacement habitat for the reef fishes displaced by the dredging. This is expected since the proposed entrance channel will be similar in structure to the existing channel that is relatively devoid of marine organisms, probably due to the impacts of high turbidity and sedimentation. Reef fishes displaced by dredging may be unable to recruit into surrounding reef habitats if those habitats are occupied and successfully defended by resident fishes. Thus, there may be a net decrease in the standing crop of reef fishes on the portion of reef platform modified by dredging of the new entrance channel.

The major impacts resulting from proposed filling activities associated with Alternatives 1-5 include the direct loss of corals, demersal fishes, sedentary macroinvertebrates, and benthic algae and the permanent alteration and elimination of existing marine benthic habitat. Implementation of Alternatives 1, 2 or 3 would each result in the filling of 0.3 ha (0.7 ac) of nearly 100% sediment-covered harbor shallows adjacent to the inner portion of the east breakwater. The infauna residing in the sediments and the benthic algae growing over it would be lost. These limited resources provide food and shelter for juveniles of several important foodfishes, including wrasses and parrotfishes. No filling of benthic habitat along the east breakwater is proposed under Alternatives 4 and 5.

Implementation of Alternative 1 would also result in the filling of an additional 0.7 ha (1.7 ac) of reef in order to widen the end of the south revetted mole. Although the reef substrate at this location is only about 9% covered with live coral, the ledge under which Service biologists observed a resting green sea turtle in 1993 either lies within or very near to the proposed footprint of this fill. This and any other ledges and depressions used for resting by green sea turtles that may lie within the mole expansion footprint would be lost under the proposed fill. Alternative 2 includes only a wave absorber at the end of the south revetted mole and no mole expansion. Construction of the wave absorber would destroy approximately 0.1 ha (0.2 ac) of substrate comprised mostly of relatively flat reef pavement. No modification to the end of the south revetted mole would be made under Alternative 3.

Alternatives 1 and 2 also include a new breakwater extension attached to the end of the south revetted mole that would cover approximately 0.7 ha (1.7 ac) of reef slope. Although a portion of the new breakwater would cross barren sand on the existing channel floor, nearly half of it would traverse reef substrate that is approximately 40% covered by live coral. With the implementation of Alternative 3 a new detached breakwater of similar size would be constructed across the existing entrance channel and in front of the ends of the south revetted mole and east breakwater. Portions of the green sea turtle resting habitat fronting the south revetted mole and the relatively rich coral habitat off the end of the east breakwater would be lost under this new breakwater. Implementation of Alternatives 4 and 5 would result in filling approximately 1.0 ha (2.4 ac) of reef front to extend the east breakwater and approximately 0.8 ha (1.9 ac) of reef for a breakwater extension attached to the south revetted mole, respectively. The east breakwater extension under Alternative 4 would destroy green sea turtle resting and potential foraging habitat fronting the south revetted mole; and the breakwater extension under Alternative 5 would destroy a portion of the relatively rich coral habitat off the end of the east breakwater.

Alternative 6 was eliminated from detailed planning and discussion primarily because it would not allow adequate maneuvering space for a 33.5-m (110-ft) U.S. Coast Guard (USCG) cutter. Since design figures and other details of the plan are not presented in the DSEIS, the Service cannot fully assess project-related impacts to fish and wildlife resources expected from the implementation of Alternative 6. It is clear, however, that among the proposed actions discussed in the DSEIS, only Alternative 6 would restrict direct adverse project-related impacts to an area within the existing harbor basin where the marine habitat is already very disturbed and relatively depauperate. An additional benefit to this alternative is that the area of direct impact is not currently used by federally-listed species. As stated in the Service's 1992 PAL on the proposed project, implementation of this alternative would not significantly impact coral-reef habitats at the project site.

With the exception of the No Action Alternative, all other alternatives presented in the DSEIS would secondarily impact corals and other filter-feeding organisms and algae by temporarily degrading nearshore water quality as a result of increased levels of suspended sediments and turbidity generated by project-related blasting and dredging of reef substrate, dewatering of dredged spoil, and discharging of fills. Secondary impacts may include smothering of reef corals and other filter-feeders from excessive sediment deposition, abrasion of coral polyps by current-driven suspended sediments, and reduced primary productivity of benthic algae, zooxanthellae, and phytoplankton from decreased light levels.

Reduction of surge within the harbor is one of the objectives of the proposed project. This reduction may improve the efficiency of the harbor to act as a sediment trap and lessen siltation impacts on the marine habitat outside the harbor. However, the ongoing deposition of terrigenous sediments into the harbor basin will continue to degrade harbor waters. The DAR has expressed concern that future development planned for the area surrounding Maalaea will increase stormwater input to the harbor, necessitate more frequent harbor maintenance dredging with its associated impacts, and result in cumulative adverse impacts to water quality and marine habitats (Pers. Com. P. Kawamoto, DAR, 1993). In addition, adverse impacts are anticipated from an increase in boat traffic due to improved harbor safety and increased berthing capacity. The turbulence caused by increased boat traffic within the harbor will resuspend fine sediments, further reducing water quality. The new breakwater extensions could deflect longshore currents and create eddies, which could disperse suspended sediments exiting the harbor over a more extensive area of productive reef, spreading adverse impacts to a greater amount of corals and other sediment-sensitive marine organisms. Thus, with regard to lessening impacts to marine habitats these negative factors make the reduction of surge within the harbor a dubious benefit.

Fisheries may be locally enhanced as a result of the partial placement of breakwater and revetment structures on barren sand or other relatively depauperate substrate. The armor stones would provide new habitat for some algae, benthic invertebrates, and reef fishes. Nevertheless, the stones would not duplicate the physical heterogeneity, interstitial complexity, and vertical relief of the existing habitat that they would cover. Not only would the physical structure of the armor stones reduce opportunities for many organisms to find suitable shelter, it would affect the levels of light penetration and localized current patterns that influence food availability. As a result, competition among organisms for food and space and interactions between predators and prey would also be affected. Many highly-specialized coral-reef species, displaced by the loss of coral-reef habitat, may attempt to use the new armor-stone habitat. However, only the most generalized of these species would be successful in this endeavor, and the growth and survival of these organisms may be adversely affected. Therefore, the habitat values of the armor stones would not replace the values of the coral-reef habitat that would be lost.

Project dredging at Maalaea Harbor may attract fish to the dredge site to feed on benthic organisms exposed by dredging. However, high turbidity caused by dredging and other project-related disturbances may limit or preclude this from happening. Harvesting marine resources from the area would have to be restricted for safety reasons during any implemented construction period. Overall fishing effort is expected to return to projected levels following project completion, although fishing success may be reduced. The Hawaii CZMP and DAR have both expressed concern for the stocks of edible algae, especially Grateloupia filicina or "limu huluhuluwaena," currently harvested at the harbor. The DAR has expressed a desire that these traditional algal resources be protected (Pers. Com. P. Kawamoto, DAR, 1993). The CZMP is concerned that the destruction of limu beds may potentially conflict with their program policy (Pers. Com. J. Nakagawa, CZMP, 1993). If the proposed project changes the deposition or movement of sand in the area so as to eliminate the habitat of this species of limu, then the populations present at the site will be adversely affected (McDermid, 1990).

Blasting and other project activities could harm or disturb green sea turtles and humpback whales in the nearshore waters of Maalaea Bay. Increased boat traffic in Maalaea Bay, as a result of expanded harbor facilities, will unavoidably increase the risk of harassment of both species. An assessment of potential project-related impacts to green sea turtles and humpback whales and recommendations to avoid or mitigate for these impacts are included in a 1990 Biological Opinion issued by the NMFS. However, this opinion may warrant revision based on new information relavent to the documented green sea turtle resting and foraging habitat at the proposed project site.

FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The Corps indicates in the DSEIS that Alternative 6 was not given serious consideration primarily because the plan does not spatially accommodate the berthing of a USCG cutter that is 33.5 m (110 ft) long. The dimensions of such a cutter were used as engineering constraints in designing alternative plans for the proposed project. However, USCG plans for future operations at Maalaea Harbor no longer include stationing a 33.5-m cutter at the site (USCG, 1993).

The USCG has stated that an alternative should not be ruled out solely on the basis of whether it can accommodate a cutter. The USCG has made it clear that although Alternative 1 appears as if it would minimally accommodate a cutter, the final selection of an alternative will not dictate that a cutter be placed at Maalaea Harbor. In no way should the use of the cutter as a design vessel be interpreted as a USCG commitment to station one at the harbor in the future (USCG, 1993).

The Service believes that Alternative 6 was not given due consideration and development relevant to its potential to accomplish proposed-project goals and that it was rejected on the basis of project goals which no longer apply. Based on the Service's assessment of important fish and wildlife resources at the proposed project site and our evaluation of the alternatives presented in the DSEIS, Alternative 6 is the least damaging alternative when considering potential adverse impacts to fish and wildlife resources and direct environmental destruction of the coral-reef habitat at Maalaea Harbor. Therefore, the Service recommends that the Corps investigate and develop a workable plan based on the concepts underlying Alternative 6.

In addition, the results of the Service's 1993 surveys at Maalaea Harbor provided documentation that the reef fronting the harbor is used by green sea turtles as resting habitat. Data collected by McDermid (1990) provided documentation that several species of algae known to be eaten by green sea turtles are present at the site. Based on this new information, the Service recommends that the Corps consult further with the NMFS on green sea turtles and that measures designed to protect this species be made part of the project. The Service supports the project-related conservation recommendations of the NMFS regarding the protection of humpback whales and recommends that these measures, including the development of boat traffic controls in Maalaea Bay, be made part of the project.

Maalaea Bay is a productive system that may be limited by the effects of siltation. The biota of Maalaea Bay has been described as being unusual in that the abundance and diversity of various marine species, which are uncommon elsewhere in the Hawaiian Islands, are common in the bay. The reasons for the special character of the biological resources of the bay remain largely unknown and extreme caution in undertaking any action which would alter any aspect or condition of the bay has been urged (Kinzie, 1972). The maintenance of good water quality in Maalaea Harbor is of great importance since cumulative impacts to water quality could contribute to the degredation of the biological resources and ecological features of Maalaea Bay. Therefore, the Service recommends that the Corps develop measures to protect the quality of water in Maalaea Harbor from project-related impacts and incorporate these measures as part of the proposed project.

The site to be used for the upland disposal of excess dredged spoil for the proposed project has not been identified. The Service, therefore, cannot evaluate potential disposal-related impacts to fish and wildlife resources, including threatened and endangered species. It is important that the disposal site be evaluated and that Service recommendations be included in the Final Supplemental Environmental Impact Statement (FSEIS). Therefore, we recommend that the Corps consult with the State of Hawaii to determine the location of the disposal site and provide this information to the Service.

If the proposed project proceeds, compensation for the unavoidable destruction of fish and wildlife resources and habitats will have to be finalized based on the alternative ultimately selected. At this time, possible mitigation measures recommended by the Service include the construction of an artificial reef at Maalaea and the perpetual designation of Maalaea reef and associated living resources as a protected area. If project impacts are kept primarily within the bounds of the harbor, as they would with the implementation of Alternative 6 or a similar plan, then the recommended mitigation would be correspondingly reduced.

Finally, the Service recommends that the following measures to minimize the degredation of coastal water quality and impacts to fish and wildlife resources and habitats be incorporated into the design and construction of the selected alternative:

a. If blasting is required, shaped or directional charges should be used to minimize impacts on marine organisms;

b. Turbidity and siltation should be minimized and confined to the immediate vicinity of construction through the use of effective silt containment devices and the curtailment of construction during adverse sea conditions;

c. All spoil temporarily stored at the project site should be placed behind watertight berms above the influence of the tides;

d. No dredged spoil should be stockpiled in the marine environment;

e. Excess dredged spoil should be placed in upland disposal sites acceptable to the Service, and appropriate erosion control measures, such as vegetative cover, should be applied;

f. Fills should be protected from erosion with armor stone as soon after completion as practicable;

g. Breakwaters and revetments should be constructed of large boulders and/or dolosse to dissipate wave energy and resist erosion.

h. All construction-related materials should be placed or stored in ways to avoid or minimize disturbance to the reef;

i. All construction-related materials should be free of pollutants;

j. No contamination of the marine environment should result from construction activities;

k. Measures to control project-related increases in the discharge of sediments from Maalaea Harbor into the marine environment of Maalaea Bay should be developed; and

l. A contingency plan for containing and controlling accidental spills of petroleum products at the construction site, including storing absorbent pads and containment booms on-site to facilitate the clean-up of such spills, should be developed.

SUMMARY AND FISH AND WILDLIFE SERVICE POSITION

Some of the most well-developed coral-reef habitat within Maalaea Bay is located in the area adjacent to Maalaea Harbor. The coral reef fronting the harbor has been identified as the habitat of major concern for the proposed project because of its high value to federally-listed threatened green sea turtles and to reef-fish resources. Coral-reef habitats are relatively scarce on a national basis, and because they are currently subjected to relatively frequent adverse impacts in the main Hawaiian Islands, the extent of healthy and productive coral reefs on a local basis may be declining. The degraded, marine benthic habitats within the harbor are considered to be important but of lesser value.

Significant impacts to the coral reef fronting the Maalaea Harbor would be avoided with the implementation of Alternative 6, which would restrict major impacts to within the harbor boundaries. It is the opinion of the Service that of the six alternative designs identified for the proposed project, Alternative 6 would be the one least damaging to fish and wildlife resources. With the exception of Alternative 4, the federal plan of improvement (Alternative 1) would be the most environmentally destructive in terms of the amount of dredging and filling required.

The NEPA indicates that an environmental impact statement (EIS) should rigorously explore and objectively evaluate a range of alternatives that represents the full spectrum of reasonable possibilities [40 CFR § 1502.14]. Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of a proposed project sponsor. A decisionmaker must consider all the alternatives discussed in an EIS [40 CFR § 1505.1(e)]. In the case of the proposed Maalaea Harbor project, the Service does not believe that this mandate can be fully met without further consideration of Alternative 6 as a reasonable and practical project alternative.

One of the primary goals of the FWCA is to insure that fish and wildlife resources receive equal consideration with other project features [§ 661]. The FWCA states that a federal agency responsible for a water-resource development project must consult with the Service with a view to conserve fish and wildlife resources by preventing their loss and damage and providing for their development and improvement within the scope of the project [§ 662 (a)]. Therefore, the Service recommends that the Corps give the development of Alternative 6 the same level of consideration given to the development of Alternatives 1-3.

The Service requests that the Corps refine a workable design based on the concept underlying Alternative 6 and provide the Service with an analysis of this alternative comparable to the analyses of Alternatives 1-3 presented in the 1980 General Design Memorandum and FEIS. The Service will evaluate this information prior to providing the Corps with a final FWCA report, which should be incorporated into the FSEIS.

The maintenance of good water quality in Maalaea Harbor is of great importance since cumulative adverse impacts to water quality could lead to degredation of the special biological resources and ecological aspects of Maalaea Bay. Therefore, the Service recommends that the Corps incorporate measures to protect the water quality in Maalaea Harbor as part of the proposed project and present these measures in the FSEIS.

Until sites have been designated for the project-related disposal of dredged spoil and acquisition of construction stone, the Service cannot evaluate potential impacts to fish and wildlife resources that may result from the disposal and excavation activities. The Service recommends that these sites be designated so that an evaluation and discussion of associated potential impacts can be presented in the FSEIS.

The Service understands that the Corps will have to conduct additional work in order to fully consider all potential alternatives and impacts related to the proposed project. To this end, the Service intends to fully cooperate with the Corps in identifying, evaluating, and selecting a preferred design alternative that is based on sound, current biological and ecological information and affords fish and wildlife conservation equal consideration with other proposed project features.

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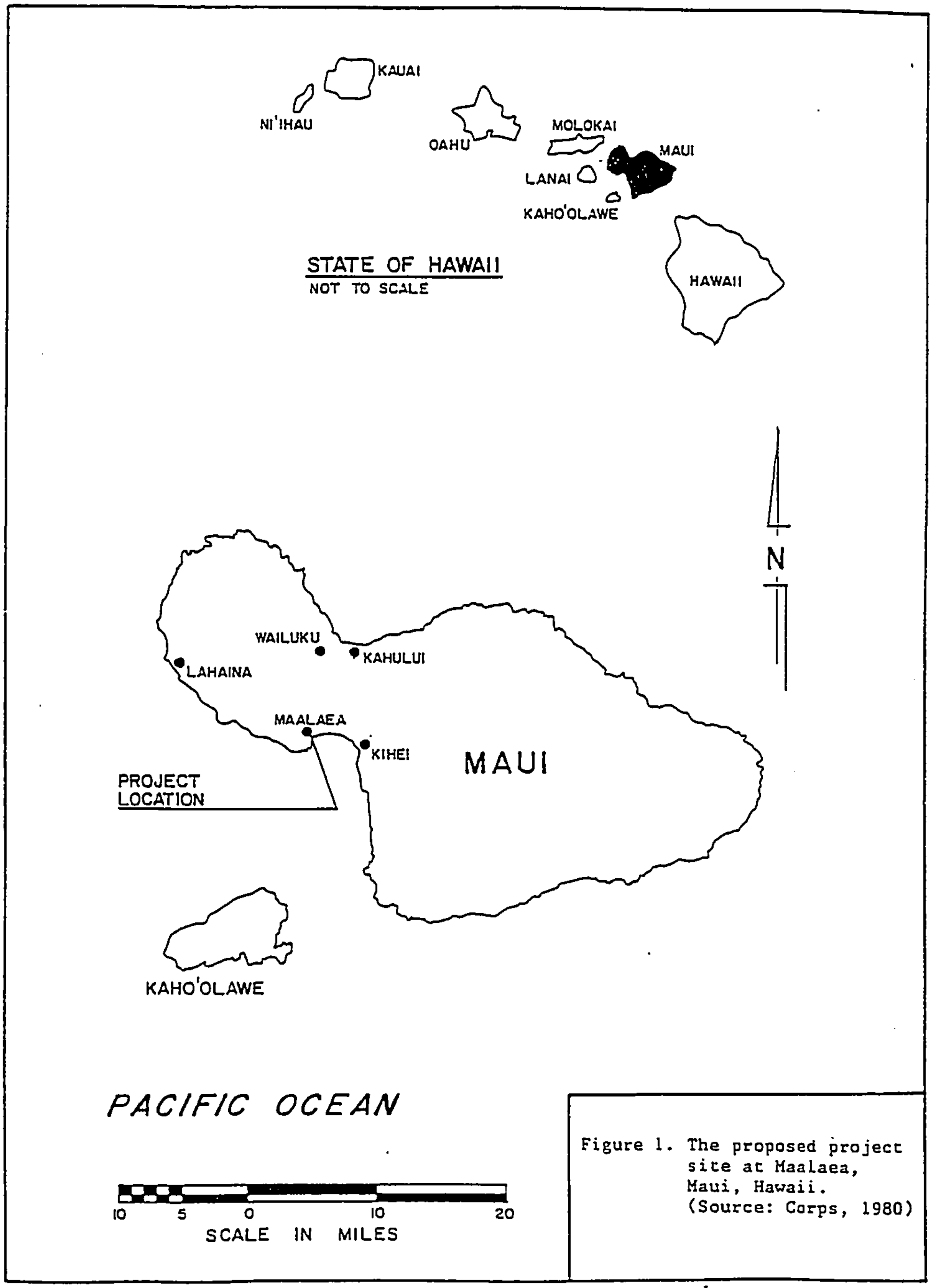

Figure 1. The proposed project site at Maalaea, Maui, Hawaii. (Source: Corps, 1980)

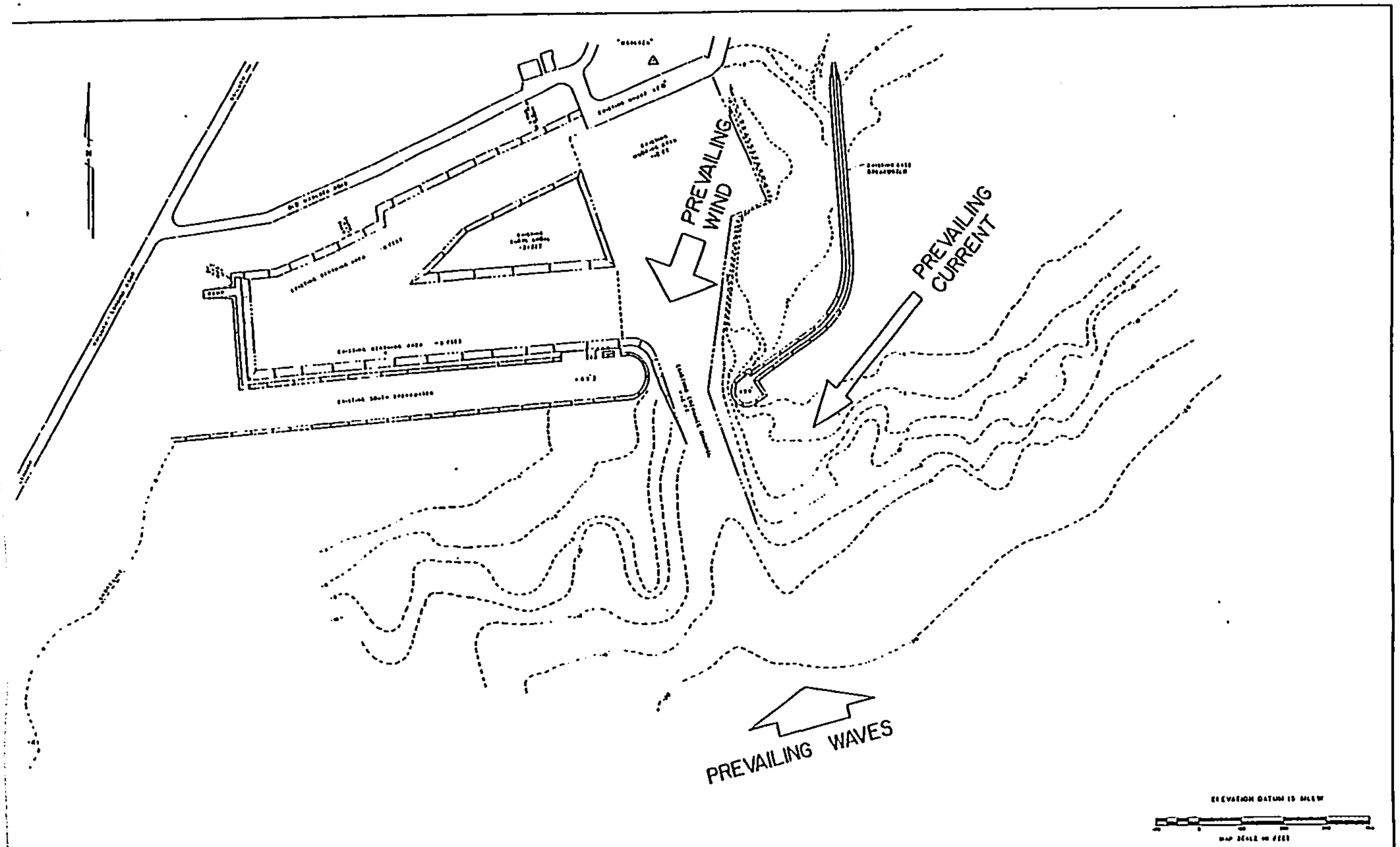

Figure 2. Existing features of Maalaea Harbor, Maui, Hawaii. (Source: Corps, 1980)

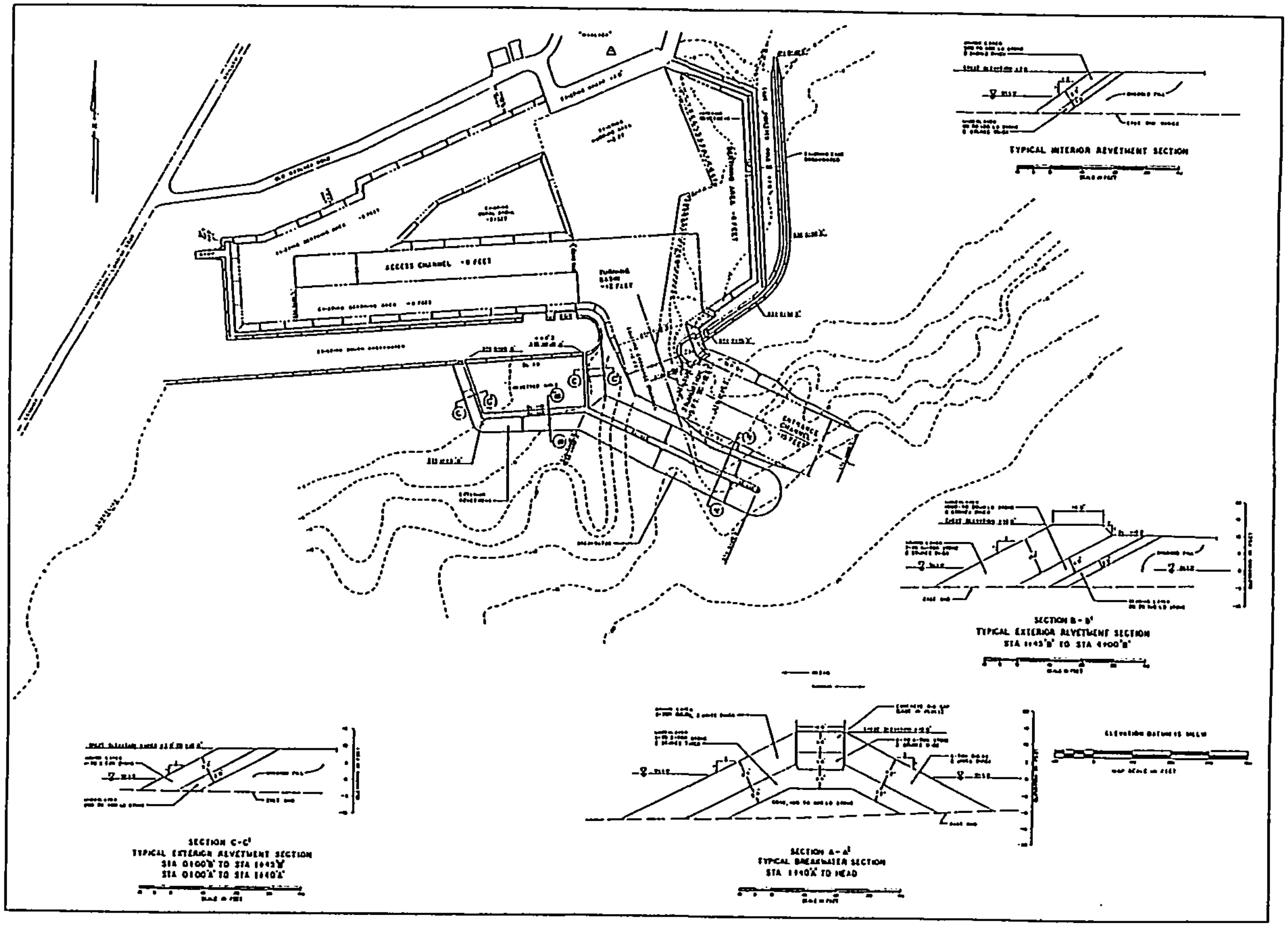

Figure 3. Proposed project design Alternative 1.
(Source: Corps, 1980)

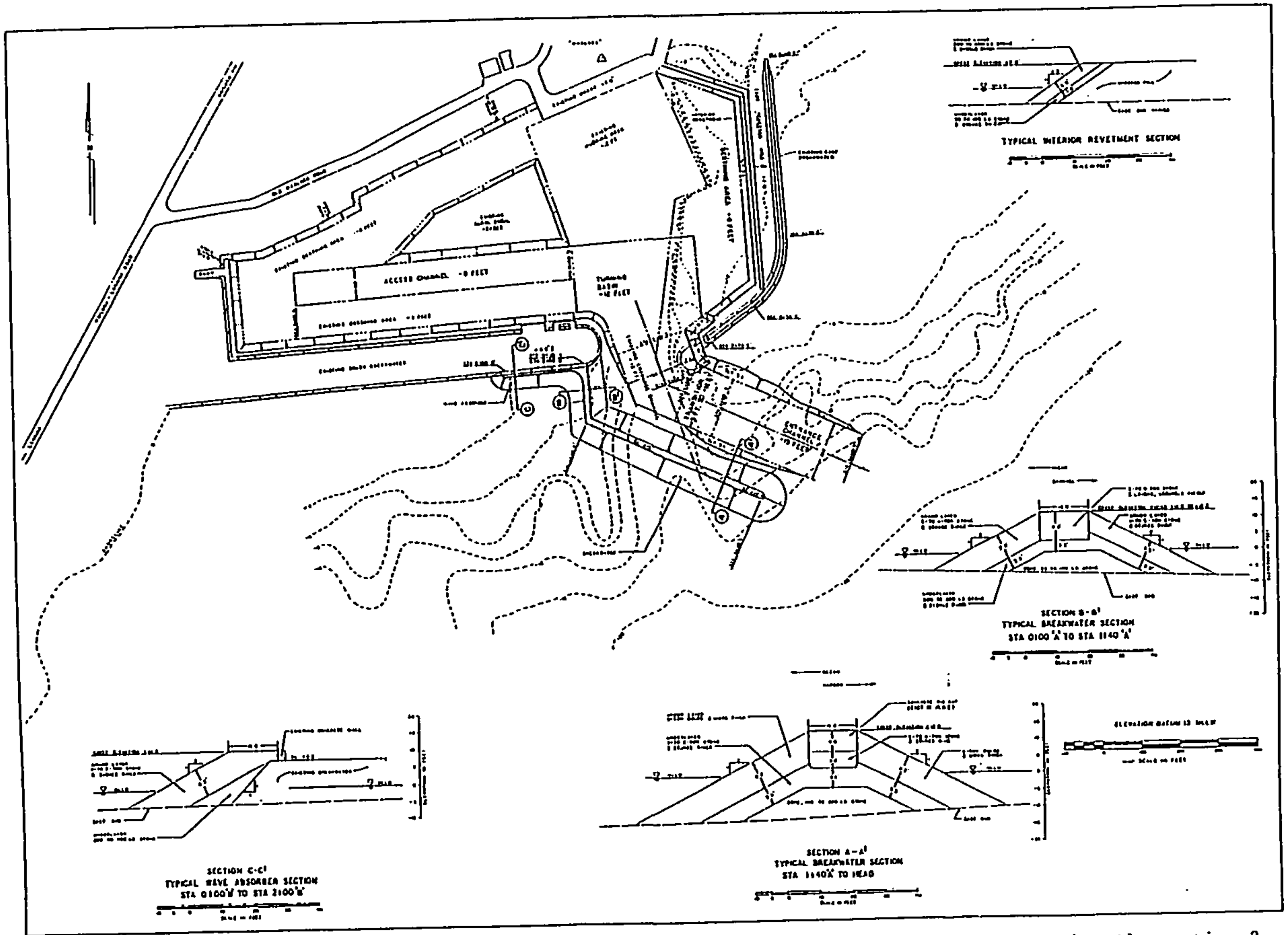

Figure 4. Proposed project design Alternative 2.
(Source: Corps, 1980)

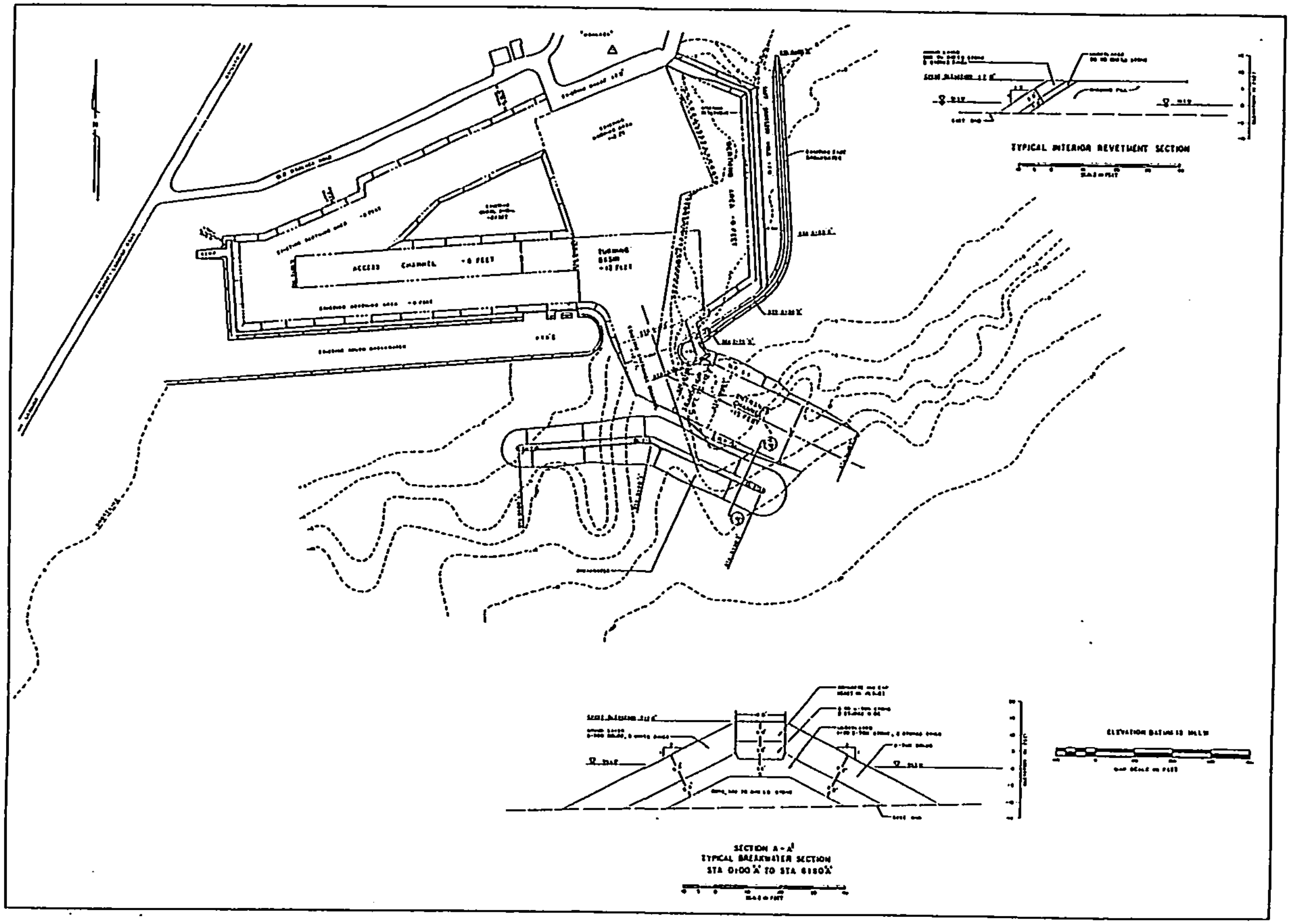

Figure 5. Proposed project design Alternative 3.
(Source: Corps, 1980)

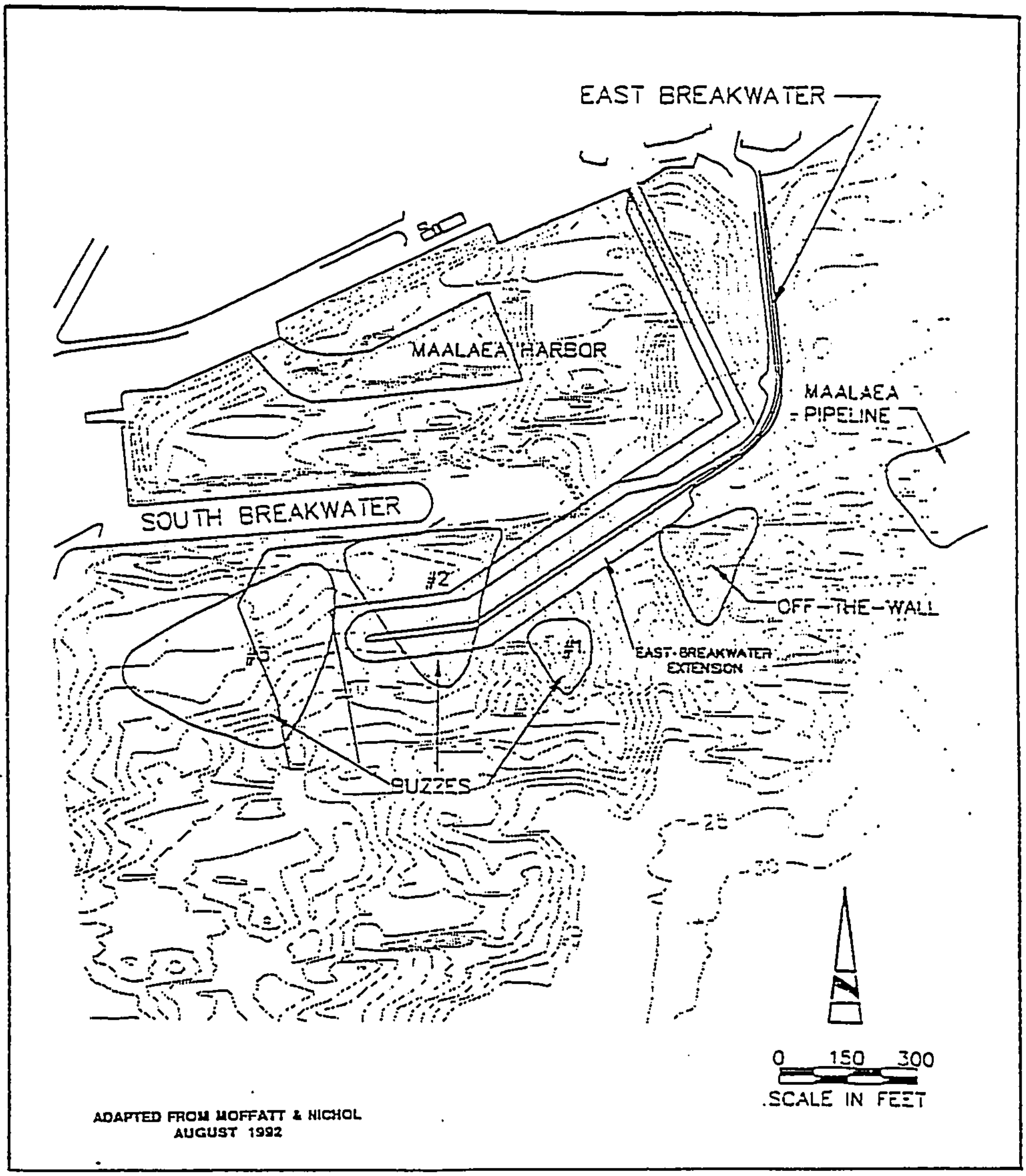

Figure 6. Proposed project design Alternative 4.
(Source: Corps, 1992)

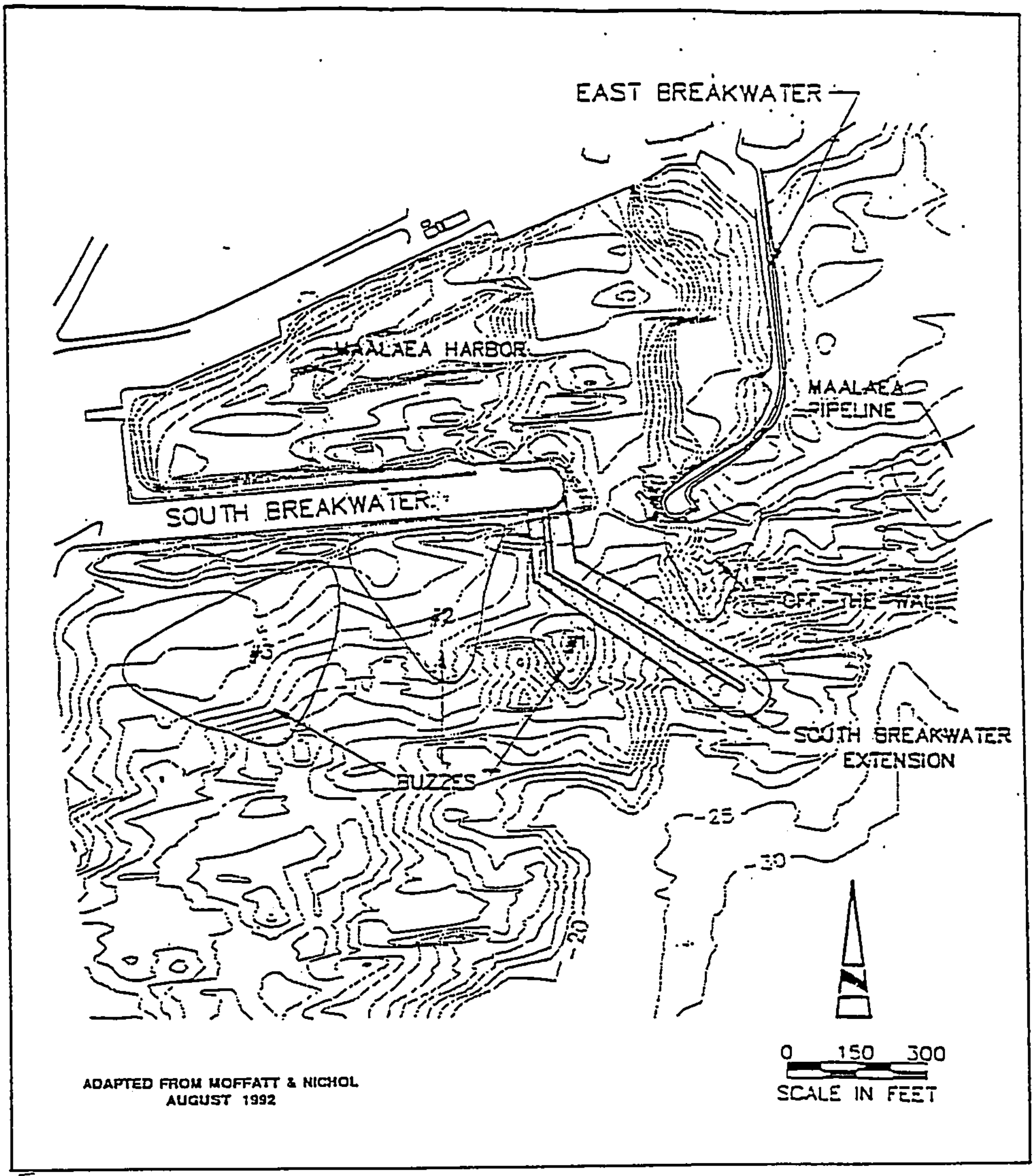

Figure 7. Proposed project design Alternative 5. (Source: Corps, 1992)

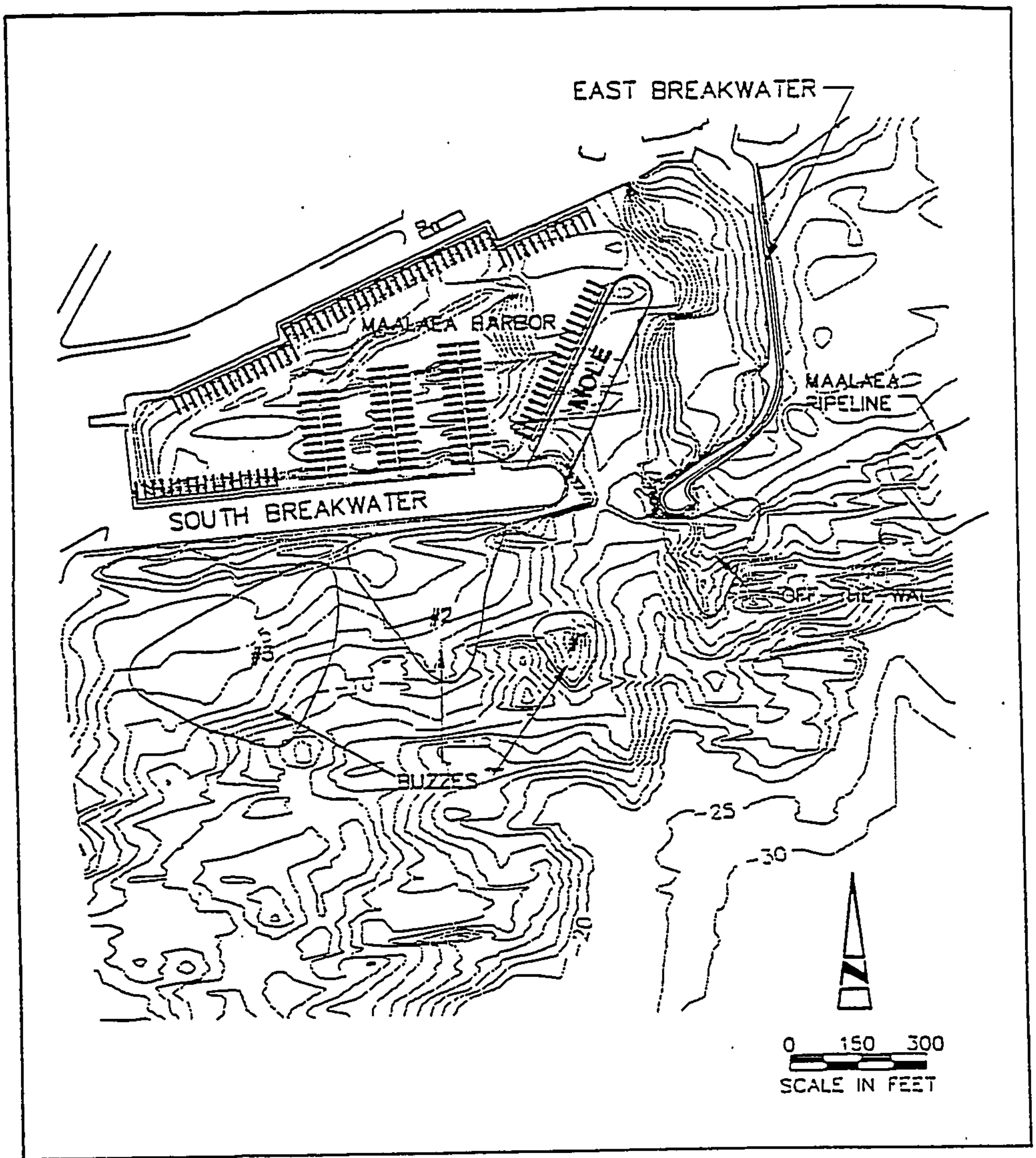

Figure 8. Proposed project design Alternative 6.
(Source: Corps, 1992)

Table 1. Marine fishes observed at the Maalaea Harbor, Maui, Hawaii, during April 20-22, 1993.

FAMILY
    Species

MURAENIDAE (Moray Eels)
- *Echidna nebulosa*
- *Gymnothorax eurostus*

CLUPEIDAE (Herrings, Sardines)
- *Spratelloides delicatulus*

ENGRAULIDAE (Anchovies)
- *Stolephorus purpureus*

SCORPAENIDAE (Scorpionfishes)
- *Sebastapistes coniorta*

KUHLIIDAE (Flagtails)
- *Kuhlia sandvicensis*

CARANGIDAE (Jacks, Trevallies)
- *Caranx melampygus*
- *C. ignobilis*

MULLIDAE (Goatfishes)
- *Mulloides vanicolensis*
- *Parupenus multifasciatus*
- *P. porphyreus*

CHAETODONTIDAE (Butterflyfishes)
- *Chaetodon auriga*
- *C. fremblii*
- *C. lunula*
- *C. miliaris*
- *C. ornatissimus*
- *C. quadrimaculatus*

POMACENTRIDAE (Damselfishes)
- *Abudefduf abdominalis*
- *Chromis vanderbilti*
- *C. verator*
- *Chrysiptera* sp.
- *Dascyllus albisella*
- *Plectroglyphidodon imparipennis*
- *P. johnstonianus*
- *P. sinodus*
- *Stegastes fasciolatus*

Table 1. (Cont.)

FAMILY Species
CIRRHITIDAE (Hawkfishes)
Cirrhitops fasciatus
Paracirrhites arcatus
P. forsteri
SPHYRAENIDAE (Barracudas)
Sphyraena barracuda
LABRIDAE (Wrasses)
Anampses cuvier
Cheilinus bimaculatus
C. unifasciatus
Coris gaimard
Gomphosus varius
Halichoeres ornatissimus
Labroides phthirophagus
Macropharyngodon geoffroy
Novaculichthys taeniourus
Stethojulis balteata
Thalassoma duperrey
SCARIDAE (Parrotfishes)
Calotomus carolinus
Scarus dubius
S. psittacus
S. rubroviolaceus
S. sordidus
BLENNIIDAE (Blennies)
Exallias brevis
Plagiotremus goslinei
ACANTHURIDAE (Surgeonfishes)
Acanthurus achilles
A. blochii
A. dussumieri
A. leucoparieus
A. nigrofuscus
A. nigroris
A. olivaceus
A. triostegus
Ctenochaetus strigosus
Naso brevirostris
N. lituratus

Table 1. (Cont.)

FAMILY Species
ZANCLIDAE (Moorish Idols)
Zanclus cornutus
BALISTIDAE (Triggerfishes)
Rhinecanthus rectangulus
MONACANTHIDAE (Filefishes)
Cantherhines sandwichiensis
Pervagor spilosoma
OSTRACIONTIDAE (Boxfishes)
Ostracion meleagris
TETRAODONTIDAE (Smooth Puffers)
Arothron hispidus
Canthigaster jactator

TOTAL NUMBER OF SPECIES OBSERVED: 66

Table 2. Reef corals observed at the Maalaea Harbor, Maui, Hawaii, during April 20-22, 1993.

FAMILY Species
PORITIDAE
Porites compressa
P. lobata
P. rus
POCILLOPORIDAE
Pocillopora damicornis
P. eudouxi
P. meandrina
ACROPORIDAE
Montipora flabellata
M. verrucosa

TOTAL NUMBER OF SPECIES OBSERVED: 8

Table 3. Marine molluscs observed at the Maalaea Harbor, Maui, Hawaii, during April 20-22, 1993.

FAMILY Species
PATELLIDAE (Limpets)
Cellana exarata
TURBINIDAE (Turbans)
Turbo sandwicensis
NERITIDAE (Nerites)
Nerita picea
LITTORINIDAE (Littorines)
Littorina pintado
CERITHIIDAE (Horn-Shells)
Rhinoclavis sinensis
CYPRAEIDAE (Cowries)
Cypraea caputserpentis
C. carneola
C. isabella
CYMATIIDAE (Trumpets)
Cymatium intermedius
C. pileare
MURICIDAE (Murexes)
Favartia garrettii
THAIDIDAE (Thaidids)
Morula granulata
MITRIDAE (Miters)
Mitra aurora aurora
CONIDAE (Cones)
Conus flavidus
C. lividus
ARCIDAE (Ark-Shells)
Arca ventricosa
Barbatia alia
B. decussata

Table 3. (Cont.)

FAMILY Species
PTERIIDAE (Pearl Oysters)
Pinctada margaritifera
P. radiata
SPONDYLIDAE (Thorny Oysters)
Spondylus histrix
S. linguaefelis
ISOGNOMONIDAE (Toothed Pearl Shells)
Isognomon perna
MALLEIDAE (Hammer Oysters)
Malleus regula
OSTREIDAE (True Oysters)
Crassostrea gigas
CHAMIDAE (Rock Oysters)
Chama cf. *fibula*
CARDIIDAE (Cockles)
Trachycardium orbita
VENERIDAE (Venus Shells)
Lioconcha hieroglyphica
Periglypta reticulata

TOTAL NUMBER OF SPECIES OBSERVED: 29

Table 4. Marine crustaceans observed at the Maalaea Harbor, Maui, Hawaii, during April 20-22, 1993.

FAMILY Species
GNATHOPHYLLIDAE (Zebra Shrimps)
Gnathopylum americanum
PALINURIDAE (Spiny Lobsters)
Panulirus marginatus
DIOGENIDAE (Hermit Crabs)
Trizopagurus strigatus
PAGURIDAE (Hermit Crabs)
Paguritta harmsi
XANTHIDAE (Xanthid Crabs)
Carpilius corallinus
C. maculatus
Edisus splendidus
GRAPSIDAE (Rock Crabs)
Grapsus tenuicrustatus

TOTAL NUMBER OF SPECIES OBSERVED: 8

Table 5. Echinoderms observed at the Maalaea Harbor, Maui, Hawaii, during April 20-22, 1993.

FAMILY Species
OPHIDIASTERIDAE (Sea Stars)
Linckia multifora
DIADEMATIDAE (Sea Urchins)
Diadema paucispinum
Echinothrix calamaris
E. diadema
TOXOPNEUSTIDAE (Collector Urchins)
Pseudoboletia indiana
Tripneustes gratilla
ECHINOMETRIDAE (Sea Urchins)
Colobocentrotus atrata
Echinometra mathaei
Heterocentrotus mammillatus
HOLOTHURIDAE (Sea Cucumbers)
Actinopyga mauritiana
Holothuria atra
SYNAPTIDAE (Sea Cucumbers)
Synapta maculata

TOTAL NUMBER OF SPECIES OBSERVED: 10

Table 6. Miscellaneous marine animals observed at Maalaea Harbor, Maui, Hawaii, during April 20-22, 1993.

PHYLUM FAMILY Species
PORIFERA (Sponges)
Unidentified orange encrusting sponge
COELENTERATA (Hydroids Only)
Unidentified hydroid with dark branches and white tips
ANNELIDA (Segmented Worms)
AMPHINOMIDAE (Fire Worms)
Pherecardia striata
TEREBELLIDAE (Spaghetti Worms)
Loimia medusa
SABELLIDAE (Feather-duster Worms)
Sabellastarte sanctijosephi
SERPULIDAE (Tube Worms)
Spirobranchus giganteus
CHORDATA (Tunicates and Turtles Only)
Unidentified brown colonial tunicate
CHELONIIDAE (Sea Turtles)
Chelonia mydas

TOTAL NUMBER OF SPECIES OBSERVED: 8

Table 7. Summary of estimated reef dredging and filling activities for the six proposed project design alternatives identified in the 1992 Draft Supplemental Environmental Impact Statement (DSEIS) for Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii. Estimates were obtained from specifications and other information provided in the DSEIS. NA = Not Available from information in the DSEIS; m = meters; ha = hectares; ac = acres.

Alternative	Volume Dredged	Area Dredged	Area Filled
1	44,000 m^3	2.1 ha (5.3 ac)	1.7 ha (4.0 ac)
2	44,000 m^3	2.1 ha (5.3 ac)	1.1 ha (2.6 ac)
3	44,000 m^3	2.1 ha (5.3 ac)	1.0 ha (2.4 ac)
4	NA	3.2 ha (7.8 ac)	1.0 ha (2.4 ac)
5	44,000 m^3	2.1 ha (5.3 ac)	0.8 ha (1.9 ac)
6	NA	NA	0.4 ha (0.9 ac)

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LAND MANAGEMENT
STATE HISTORIC PRESERVATION
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:HP-AL

NOV 17 1989

Kisuk Cheung
Chief, Engineering Division
Department of the Army
U.S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

SUBJECT: Compliance with Section 106, National Historic Preservation Act -- Draft EA for Maalaea Harbor for Light-Draft Vessels
Maalaea, Wailuku, Maui
TMK 3-6-01

Thank you for the opportunity to review this undertaking.

This Draft EA states that an archaeological study of the project area was conducted in 1979 by Hawaii Marine Research and found no evidence of historic remains (page 12). It also states that the State Historic Preservation Officer (SHPO) concurred with this determination. We again concur with this finding and determine that the proposed project will have "no effect" on significant historic sites. We also recommend that copies of the archaeological study and the review from the SHPO be included in the final EA.

Very truly yours,

WWPaty

WILLIAM W. PATY
Chairperson and State
Historic Preservation Officer

SECTION 404(B)(1)
PRACTICABLE ALTERNATIVES ANALYSIS AND EVALUATION

Navigation Improvements for Ma'alaea Small Boat Harbor
Ma'alaea, Maui, Hawaii

1. Introduction and Background

This evaluation of compliance with Section 404(b)(1) Guidelines, as established by the U.S. Environmental Protection Agency in 40 CFR Part 230 and hereafter referred to as the Guidelines, is prepared in conjunction with pre-construction planning studies and finalization of a Supplemental Environmental Impact Statement (FSEIS) for the proposed improvements. The navigation improvements would be constructed by the U.S. Army Engineer District, Honolulu, in partnership with the State of Hawaii.

2. Proposed Project Characteristics

The *overall project purpose* is to provide additional berthing and attendant harbor facilities at Ma'alaea Harbor for light-draft vessels, Maui, Hawaii. Construction of the breakwater is a federal action which is water dependent. The *basic purpose* of the breakwater is to reduce surge within the harbor basin and to reduce navigation hazards in the entrance channel. Additional fill areas for access to berthing areas, fuel facilities, and drop-off areas for boating supplies and equipment are entirely funded by the State of Hawaii and have been designed to provide the minimum area needed for utilization of the berthing areas. Therefore, both the basic purpose of the navigation improvements and the attendant harbor facilities by the State, as part of the overall project purpose, are substantially water dependent activities.

The formulation and evaluation of alternatives were guided by technical, logistic, and cost criteria, as specified in the Guidelines. In addition to the Federal criteria, the State of Hawaii (local sponsor) expressed a desire to minimize changes to existing structures and berthing arrangements as well as the need for a bus turnaround on the modified breakwater. Cumulatively, these criteria served as a basis for reevaluation and development of four alternative plans at Ma'alaea Harbor.

3. Description of Alternatives

Alternative Site Avoidance

Federal improvements to Ma'alaea Harbor, originally constructed by the Territory of Hawaii in 1952, were first authorized by Section 101 of the River and Harbor Act of 13 August 1968. The objectives of the pre-authorization studies contained in the Chief of Engineers report on *Coasts of the Hawaiian Islands, Harbors for Light-Draft Vessels* were (a) to analyze the remaining requirements for additional base harbors to satisfy most of the State's projected light-draft vessel needs to the year 2020, and (b) to study the need for harbors intended exclusively for refuge purposes. Ma'alaea Harbor was selected as an additional base harbor to satisfy boating demand for the south-central Maui area.

Post-authorization investigations initiated in 1978 were conducted to reaffirm the basic planning decisions made during the preauthorization studies, while responding to changes in the physical, social, economic and environmental conditions related to the project, as well as to changes in Corps water resources planning policies. The reevaluation focused on formulation of alternative plans specific to satisfying boating demand for south-central Maui by addressing navigation problems and needs at Ma'alaea Harbor.

This reduced project costs because of (1) the substantial investment already committed at the authorized site, (2) the expressed desire of harbor users to upgrade the existing harbor, and (3) the anticipated extensive environmental and economic impacts of developing a new site. In addition, to significant environmental damage and costs associated with development of a new project site, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service strongly opposed new harbor locations in the region because of probable adverse effects on endangered species.

Between 1987 and 1988 the Corps studied the potential for an increase in light-draft navigation facilities for Hawaii. The findings were published in *Review of the Coasts of the Hawaiian Islands, Navigation Facilities*, March 1989. Among the potential facilities considered for increased capacity on the southern coast of Maui were Lahaina and Olowalu. Both of these facilities were considered not practicable to expand because of environmental and economic considerations. In each case expansion would require a much larger footprint, resulting in a significant increase in environmental effects. In addition, the benefits of both projects would not justify the expense of construction. The most environmentally benign and cost effective facilities expansion in this part of Maui is at Ma'alaea.

This Section 404(b)(1) analysis has been prepared to reflect the reformulation and reevaluation of alternatives in response to current needs and purposes of the local sponsor and the affected public, as well as changes in environmental conditions and regulations since the 1980 report was approved.

Minimization of Fill Areas

Earlier approved plans and variations of them were eliminated from further consideration because of significantly adverse impacts to the world famous surf site, "Ma'alaea Pipeline." Given the existing harbor location, efforts were made to develop an alternative which would avoid any impacts beyond the limits of the existing harbor.

In order to confine new structures and fills within the harbor limits, a plan was developed which consists of an internal breakwater to reduce wave action within the harbor. This alternative would eliminate any dredging or filling beyond the existing limits of the harbor basin. While this plan may be environmentally preferable and best meets the avoidance and minimization aspects of the Guidelines, it was eliminated from detailed analysis for significant navigational safety considerations. In addition, this plan would allow only 128 more berths to be constructed, involve land acquisition costs which would render the project infeasible, and result in the worst flushing characteristics (more than double the flushing period) among the alternatives evaluated. In summary, this plan failed to meet either the overall or basic project purposes.

The four plans considered in detail are described in Chapter 3 of the FSEIS. Table 1 summarizes the areas and quantities of fill required for each alternative, based on placement of fill below the mean high water mark.

Each of the four alternatives effectively reduces surge within the harbor basin by preventing waves from directly entering the basin. The new entrance channel for each alternative would provide for safe navigation by the design vessel and other vessels expected to use the harbor in all but the most severe conditions. All four alternatives would significantly improve navigation conditions and also increase the berthing capacity of the harbor.

Only Plan 1 allows for all of the local sponsor's desired shoreside improvements. Plans 2, 3, and 4 do not include 0.4 acres of fill adjaent to the breakwater extension for a bus turnaround. Additionally, Plan 4 would provide for fewer berths than the other three plans.

COMPARISON OF FILL AREAS AND QUANTITIES

STRUCTURE/FILL	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4
FEDERAL PROJECT: (COST)	($8,449,539)	($7,605,743)	($7,809,179)	($11,659,822)
BREAKWATER	64,000 SF (1.5 acres) 1,120 6-TON DOLOS 31,320 TONS ROCK	78,000 SF (1.8 acres) 1,055 6-TON DOLOS 29,925 TONS ROCK	87,000 SF (2.0 acres) 1,325 6-TON DOLOS 26,850 TONS ROCK	90,000 SF (2.1 acres) 1,580 6-TON DOLOS 42,400 TONS ROCK
REVETTED MOLE AT BREAKWATER	32,000 SF (0.7 acres) 6,720 CY CORAL FILL 11,400 TONS ROCK	NONE, WAVE ABSORBER INCORPORATED WITH BREAKWATER	NONE	NONE
NON-FEDERAL WORK: (COST)	($2,485,173)	($2,485,173)	($2,485,173)	($2,485,173)
E. REVETTED MOLE	73,000 SF (1.7 acres) 6,300 CY CORAL FILL 2,335 TONS ROCK	SAME AS ALTERNATIVE 1.	SAME AS ALTERNATIVE 1.	SAME AS ALTERNATIVE 1.
CENTER MOLE (FUEL STATION)	82,000 SF (1.9 acres) 13,620 CY CORAL FILL 8,485 TONS ROCK	SAME AS ALTERNATIVE 1.	SAME AS ALTERNATIVE 1	SAME AS ALTERNATIVE 1.
SUMMARY TOTALS (BELOW MHW LINE)				
AREA OF FILL	251,000 SF OR 5.8 ACRES (5.4 acres water dependent)	233,000 SF OR 5.3 ACRES (5.3 acres water dependent)	242,000 SF OR 5.6 ACRES (5.6 acres water dependent)	245,000 SF OR 5.6 ACRES (5.6 acres water dependent)
QUANTITY OF CORAL FILL	26,640 CY	19,200 CY	19,920 CY	19,920 CY
QUANTITY OF ROCK	53,540 TONS	40,745 TONS	37,670 TONS	53,220 TONS
NO. OF 6-TON DOLOS	1,120 UNITS	1,055 UNITS	1,325 UNITS	1,580 UNITS
TOTAL COST	$10,934,712	$10,090,916	$10,294,352	$14,144,995

On this basis, Plan 1 was designated the preferred alternative since it fulfills all of the stated project purposes. Plan 2 is the Environmentally Preferred Alternative because it requires the least amount of fill among the four plans and has less adverse impact on one surf site, while meeting most of the project purposes. Plan 2 is also the least expensive of the four plans.

4. Factual Determinations

In accordance with 40 CFR 230.11, potential short- and long-term effects of the discharge on the chemical, physical, and biological components of the aquatic environment are addressed for the preferred Plan 1. The discharge site (fill area) is described in Chapter 4 of the FSEIS, and the construction period is estimated at 26 months. Coral fill material would be obtained from dredging the channels and basins, with the balance obtained from commercial sources. All rock, ranging from 50-pound bedding stones to eight-ton capstones, would come from existing commercial sources.

a. Physical substrate determinations: The bottom contours and substrate elevations both within and outside the harbor would be changed by placement of coral fill, rock, and concrete dolos units. The changes would be permanent for the life of the project. The changes within the existing harbor proper would involve fills for access to berthing, drop-off, and fuel facilities, or a total of 3.6 acres. The new breakwater and revetted mole seaward of the existing breakwater will result in 2.6 acres of water dependent fill beyond the limits of the existing harbor.

b. Water circulation, fluctuation, and salinity determinations: The proposed discharges would not have significant effects on water chemistry, salinity, clarity, color, odor, taste, dissolved gas levels, temperature, nutrients, eutrophication, nor would the overall hydrologic regime of Ma'alaea Bay be significantly altered. The flushing rate for this plan has been calculated at 3.3 days, well within the safe design criteria.

c. Suspended particulate/turbidity determinations: Temporary turbidity will occur during placement of the coral fill and stones. Turbidity and siltation would be minimized and confined to the immediate vicinity of the construction through the use of silt containment devices and the curtailment of construction during adverse sea conditions. Water quality both within and outside the harbor would be monitored during construction.

d. Contaminant determinations: The material to be discharged consists of clean, naturally occurring basaltic rock, dredged coral material from the harbor and entrance channel, and concrete units. Neither the rock nor dredged materials is suspected of containing contaminants. Concrete cast in dolos would not result in any discharge of leaching of contaminants. Based on this information, no bioassay or water quality testing of the material is required.

e. Aquatic ecosystem and organism determinations: The proposed breakwaters and moles would cover existing benthic communities associated with the coral reef flat and sand bottom substrate. The new rock structures will provide vertical relief, voids, and crevices and increase biodiversity and biomass.

Two types of special aquatic sites as specified in the Guidelines are found in the project area. Vegetated shallows are found along the existing harbor shoreline, seaward of the existing south breakwater and along the shoreline and nearshore area to the east of the existing east breakwater. Ma'alaea Bay is one of the few areas where the edible seaweed *Grateloupia filicina* is locally abundant, and it has been observed in each of these areas, being most abundant during the summer. The algal communities outside and adjacent to the harbor are richer and more diverse than the assemblage found within the harbor limits.

The algal communities along the inner harbor shoreline and seaward of the south breakwater would be adversely affected by the construction of the interior berthing and the revetted moles. Those communities to the east of the east breakwater would not be affected since no structures or fills are planned in that area. Moreover, no change to the longshore currents, deposition or movement of sand along this coastline is expected as a result of the project.

Coral reefs would also be directly affected by construction of structures and fills . Filling activities within the existing harbor limits involve almost exclusively sediment-covered harbor shallows. Outside the harbor, about half of the breakwater extension and revetted mole adjacent to it are located in an area where live coral coverage is about forty percent.

Corals and other filter-feeding organisms as well as algae would be indirectly affected due to increased levels of suspended sediments and turbidity generated during the construction period. These indirect impacts would be minimized through the water quality mitigation measure described earlier.

According to the April 25, 1990 Biological Opinion issued by the National Marine Fisheries Service, the impacts of harbor construction and expansion, as well as increased boat traffic expected to occur may adversely affect, but should not jeopardize the continued existence of endangered species. Humpback whales would probably be displaced from a portion of habitat by increased boat traffic, and a small number of green sea turtles may be adversely affected by displacement, injury, or mortality and loss of habitat due to blasting, dredging, and construction. No effects are expected on endangered hawksbill turtles or Hawaiian monk seals, which occur only rarely in Ma'alaea Bay.

To mitigate the adverse effects on the humpback whales and green sea turtles, all of the recommendations provided in the Biological Opinion would be implemented by the Corps of Engineers and the State project sponsor. These recommendations are listed in Chapter 5, paragraph 5.19 of the FSEIS, along with additional measures to develop approved blasting plans and associated turtle and marine mammal surveys if blasting is required.

f. Proposed disposal site determinations: The proposed disposal sites are the locations of the protective structures and moles. The structures and related fill areas have been designed to minimize the amount of material to be discharged into the water. With use of appropriate silt containment devices and other measures to minimize sediment transport, the placement of material would be confined to the immediate construction area.

As described in paragraph 4.6 of the FSEIS, the waters within Ma'alaea Harbor are designated Class A by Chapter 11-54, Hawaii Administrative Rules, while the adjacent waters of Ma'alaea Bay are Class AA. During dredging and filling activities, standards for turbidity would be exceeded despite efforts to minimize or localize the impacts of construction. In addition, increased vessel traffic and continued runoff into the harbor from upland development would contribute to turbid water conditions after harbor construction is complete.

The effects of harbor expansion and increased vessel traffic on algal blooms and chlorophyll A exceedences is unknown. Bacterial levels in the harbor are affected by stormwater runoff discharging into the harbor and from harbor activities directly. Construction of new harbor sewage facilities should improve water quality within the harbor by eliminating harbor-generated sources of bacterial contamination.

With respect to human use characteristics of the project area, both recreational and commercial fisheries would benefit from the expanded harbor facilities, improved navigation conditions, and enhanced shoreside amenities and support facilities. The importance of the surfing sites identified within the project area has been a major planning consideration. Although the proposed project will not adversely affect the world famous "Ma'alaea Pipeline," the entrance channel would destroy the site called "Off the Wall," and both "Sea Flight" (Buzz's No. 1) and a small portion of the site known as "Buzz's" (Buzz's No. 2) would be modified in an unknown way by the revetted mole to be constructed adjacent to the south breakwater extension.

Finally, although the existing harbor facility has committed the area to navigation activities, the new breakwater extension and revetted moles seaward of the harbor limits would extend and expand the visual impact of the harbor, both from the shoreline and from the open ocean. Furthermore, the shoreside developments and new facilities within the harbor basins would also change the aesthetics of the area to a fully developed harbor facility.

g. Determination of cumulative effects on the aquatic ecosystem: The project site was committed to navigation uses when the harbor was originally constructed over 40 years ago. With the exception of the two revetted moles on the seaward side of the existing breakwater and the breakwater extension itself, all other fill areas are located within the limits of the existing harbor. Cumulatively, these fill activities expand and establish the commitment of the site to navigation activities.

h. Determination of secondary effects on the aquatic ecosystem: With increased use of the harbor, human impacts on the harbor area ecosystem would also increase. The harbor would continue to serve as a settling basin for sediment-laden stormwaters, and the project area would be subject to potential oil and fuel spill contaminants, as well as trash and debris. Ultimately, the accumulation of contaminants in the harbor waters and bottom sediments presents the potential for bioaccumulation in the marine life inhabiting the site. In addition, the presence of contaminants in the bottom sediments raises problems for disposal of maintenance dredged material through the life of the project. These potential secondary impacts can be minimized through adherence to State water quality standards and proper management of marina operations.

5. Findings of Compliance or Non-Compliance With the Restrictions on Discharge

a. The proposed activity is water dependent. Adaptations of the Guidelines were made in this evaluation with respect to the extent to which offsite alternatives were considered and to the weight given to the local sponsor's objectives in developing the related shoreside facilities. These adaptations are explained in paragraphs 1-3 of this evaluation.

b. An alternative which would eliminate physical impacts beyond the existing harbor limits was developed. Although it would best meet the avoidance and minimization aspects of the Guidelines, it failed to meet the basic and overall project purposes. It was also eliminated for serious navigation safety problems, failure to provide adequate shoreside area for development, and excessive land acquisition costs. Among the four plans evaluated in detail, the preferred plan was the only one which fully met the local sponsor's plans for shoreside development. Another alternative, Plan 2, resulted in 0.4 acres less fill and was designated the Environmentally Preferred Plan.

c. The planned disposal of dredged coral material, rock, and concrete units would not violate any applicable State water quality standards with the exception of turbidity. Use of silt containment devices as appropriate, monitoring during construction, and curtailment of construction during adverse sea conditions would be implemented to mitigate these conditions. The disposal operation is not expected to violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The proposed disposal would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, nor on aquatic ecosystem diversity, productivity and stability. The effects on coral reefs and vegetated shallows found in the project area, endangered species, water related recreation and aesthetics are summarized earlier in paragraph 4., *Factual Determinations.*

e. Appropriate steps to minimize potential adverse impacts of the discharges on aquatic systems are addressed earlier in this evaluation and are listed in paragraph 5.19 of the FSEIS.

f. On the basis of the Guidelines, the proposed disposal site for the discharge of dredged and fill material is specified as complying with the Guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.

Signature____________________________Date____________

M. BRUCE ELLIOTT
Lieutent Colonel, U. S. Army
Honolulu District Engineer

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

DETERMINATION OF FEDERAL CONSISTENCY FOR NAVIGATION IMPROVEMENTS FOR MA'ALAEA SMALL BOAT HARBOR MA'ALAEA, MAUI, HAWAII

May 1994

ASSESSMENT FORMAT

RECREATIONAL RESOURCES

Objective: Provide coastal recreational opportunities accessible to the public.

Policies:

1) Improve coordination and funding of coastal recreation planning and management.

2) Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by:

a) Protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas;

b) Requiring replacement of coastal resources having significant recreational value, including but not limited to surfing sites and sandy beaches, when such resources will be unavoidably damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable;

c) Providing and managing adequate public access, consistent with conservation of natural resources, to and along shorelines with recreational value;

d) Providing an adequate supply of shoreline parks and other recreational facilities suitable for public recreation;

e) Encouraging expanded public recreational use of County, State, and Federally owned or controlled shoreline lands and waters having recreational value;

f) Adopting water quality standards and regulating point and non-point sources of pollution to protect and where feasible, restore the recreational value of coastal waters;

g) Developing new shoreline recreational opportunities, where appropriate, such as artificial reefs for surfing and fishing; and

h) Encouraging reasonable dedication of shoreline areas with recreational value for public use as part of discretionary approvals or permits by the land use commission, boat of land and natural resources, County planning commissions; and crediting such dedication against the requirements of section 46-6.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.		X	Will the proposed action involve or be near a dedicated public right-of-way?
2.	X		Does the project site abut the shoreline?
3.		X	Is the project site near a State or County park?
4.		X	Is the project near a perennial stream?
5.	X		Will the proposed action occur in or affect a surf site?
6.	X		Will the proposed action occur in or affect a popular fishing area?
7.	X		Will the proposed action occur in or affect a recreational or boating area?
8.	X		Is the project site near a sandy beach?
9.	X		Are there other recreational uses in the area?

Discussion

2. The project site is the Ma'alaea Small Boat Harbor on Maui.

5. Depending on the alternative, a few surf sites in the area would be destroyed or adversely impacted. The selected plan has been designed to avoid most impacts and minimize others.

6. The area adjacent to the harbor is fished.

7. The harbor provides berths for both commercial and recreational boats.

8. A small sandy beach is located in the northeast portion of the harbor. This beach would be destroyed by the construction of a new road to the east mole. The effects on this beach would result from the State improvements.

9. Surfing, body boarding, snorkeling, fishing, and other water sports also occur in the area.

HISTORIC RESOURCES

Objective: Protect, preserve, and where desirable, restore those natural and man-made historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policies:

1) Identify and analyze significant archaeological resources;

2) Maximize information retention through preservation of remains and artifacts or salvage operations; and

3) Support State goals for protection, restoration, interpretation, and display of historic resources.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.		X	Is the project site within a historic/cultural district?
2.		X	Is the project site listed on or nominated to the Hawaii or National Register of Historic Places?
3.		X	Does the project site include undeveloped land which has not been surveyed by an archaeologist?
4.	X		Has a site survey revealed any information on historic or archaeological resources?
5.		X	Is the project site within or near a Hawaiian fishpond or historic settlement area?

Discussion

4. A literature review and coordination with the SHPO's office revealed the presence of two artifacts, a piko stone and a grinding stone (King's table) identified as site 50-50-09-1440 (-1286). These items were moved from their original unknown location sometime in the past, and are now located in the grassed area in front of Buzz's Restaurant. The harbor improvements will have no effect on either artifact. Coordination with the SHPO has completed pursuant to Section 106 of the National Historic Preservation Act.

SCENIC AND OPEN SPACE RESOURCES

Objective: Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

Policies:

1) Identify valued scenic resources in the coastal zone management area:

2) Insure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.

3) Preserve, maintain and, where desirable, improve and restore shoreline open space and scenic resources; and

4) Encourage those developments which are not coastal-dependent to locate in inland areas.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.		X	Does the project site abut a scenic landmark?
2.		X	Does the proposed action involve the construction of a multi-story structure or structures?
3.	X		Is the project site adjacent to undeveloped parcels?
4.		X	Does the proposed action involve the construction of structures visible between the nearest coastal roadway and the shoreline?
5.	X		Will the proposed action involve construction in or on waters seaward of the shoreline? On or near a beach?

Discussion

3. There is an undeveloped parcel to the west of the developed portion of the harbor. It is planned for development in the future for parking for harbor users.

5. The project will involve construction in the water. It is a navigation improvement project to increase the capacity of the harbor and reduce surge and wave action in the harbor to

acceptable limits. The small sandy beach next to the the east breakwater will be destroyed by construction of the proposed east mole access road.

COASTAL ECOSYSTEMS

Objective: Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems.

Policies:

1) Improve the technical basis for natural resource management;

2) Preserve valuable coastal ecosystems of significant biological or economic importance.

3) Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land uses, recognizing competing water needs; and

4) Promote water quantity and quality planning and management practices which reflect the tolerance of fresh water and marine ecosystems and prohibit land and water uses which violate State water quality standards.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.	X		Does the proposed action involve dredge or fill activities?
2.		X	Is the project site within the Shoreline Setback Area (20 to 40 feet inland of the shoreline)?
3.		X	Will the proposed action require some form of effluent discharge into a body of water?
4.	X		Will the proposed action require earthwork beyond clearing and grubbing?
5.	X		Will the proposed action include the construction of special waste treatment facilities, such as injection wells, discharge pipes, or cesspools?
6.		X	Is an intermittent or perennial stream located on or near the project site?

7.	X		Does the project site provide habitat for endangered species of plants, birds, or mammals?
8.	X		Is any such habitat located nearby?
9.		X	Is there a wetland on the project site?
10.		X	Is the project site situated in or abutting a Natural Area Reserve?
11.		X	Is the project site situated in or abutting a Marine Life Conservation District?
12.		X	Is the project site situated in or abutting an estuary?

<u>Discussion</u>

1. A new entrance channel and berthing areas will be dredged, and an extension of the existing south breakwater will be constructed using the dredged material, as well as other construction materials.

4. A new bus parking area will be constructed by the State sponsor in the future on the west side of the present harbor. The exact nature of the earthwork is not known at this time.

5. The State improvements include upgrading the sewage disposal system for the harbor. The new system is presently being designed, and the details of the system are not known at this time. The proposed design will be coordinated with the Department of Health, and will comply with State requirements.

7. Ma'alaea Bay is an important habitat area for endangered humpback whale cows and calves. In addition, the project site provides some foraging habitat for the green sea turtle. Coordination has been completed with the National Marine Fisheries Service under Section 7 of the Endangered Species Act.

8. See 7 above.

ECONOMIC USES

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

Policies:

1) Concentrate in appropriate areas the location of coastal-dependent development necessary to the State's economy;

2) Insure that coastal-dependent development such as harbors and ports, visitor industry facilities, and energy generating facilities are located, designed, and constructed to minimize adverse social, visual, and environmental impacts in the coastal zone management area; and

3) Direct the location and expansion of coastal-dependent developments to areas presently designated and used for such development and permit reasonable long-term growth at such areas, and permit coastal-dependent development outside of presently designated areas when:

a) Utilization of presently designated locations is not feasible;

b) Adverse environmental effects are minimized; and

c) Important to the State's economy.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.	X		Does the project involve a harbor or port?
2.		X	Is the project site within a designated tourist destination area?
3.		X	Does the project site include agricultural lands or lands designated for such use?
4.	X		Does the proposed activity relate to commercial fishing or seafood production?
5.		X	Does the proposed activity relate to energy production?
6.		X	Does the proposed activity relate to seabed mining?

Discussion:

1. The project is for navigation improvements to the Ma'alaea Small Boat Harbor, Maui, Hawaii.

2. The harbor is used by both subsistence and commercial fishermen and charterboat fishermen.

COASTAL HAZARDS

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence.

Policies:

1) Develop and communicate adequate information on storm wave, tsunami, flooding, and subsidence;

2) Control development in areas subject to storm wave, tsunami, flood erosion, and subsidence hazard;

3) Ensure that developments comply with requirements of the Federal Flood Insurance Program; and

4) Prevent coastal flooding from inland projects.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.	X		Is the project site on or abutting a sandy beach?
2.	X		Is the project site within a potential tsunami inundation area as depicted on the National Flood Insurance Program flood hazard map?
3.	X		Is the project site within a potential flood inundation area according to a flood hazard map?
4.		X	Is the project site within a potential subsidence hazard area according to a subsidence hazard map?
5.	X		Has the project site or nearby shoreline areas experienced shoreline erosion?

Discussion:

1. A small sandy beach is located in the northeast portion of the harbor. This beach will be destroyed by construction of a road to the east harbor mole.

2. The project site is located on the coast of Maui, in an area subject to coastal flooding according to the Flood Insurance Rate Map panel 150003 0235B.

3. According to FEMA Maps, the harbor is located in a coastal high hazard area which extends from Kihei to Malalowaiaole Gulch.

5. The area adjacent, east of the harbor, experienced erosion sometime in the past, but it is now protected by seawalls.

MANAGING DEVELOPMENT

Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

Policies:

1) Effectively utilize and implement existing law to the maximum extent possible in managing present and future coastal zone development.

2) Facilitate timely processing of application for development permits and resolve overlapping or conflicting permit requirements; and

3) Communicate the potential short- and long-term impacts of proposed significant coastal developments early in their life cycle and in terms understandable to the general public to facilitate public participation in the planning and review process.

Check either "Yes" or "No" for each of the following questions.

	Yes	No	
1.	X		Will the proposed activity require more than two (2) permits or approvals?
2.	X		Does the proposed activity conform with the State and County land use designations for the site?
3.	X		Has or will the public be notified of the proposed activity?
4.	X		Has a draft or final environmental impact statement or an environmental assessment been prepared?

Discussion:

1. In addition to this CZM coordination, this action is being coordinated with the U.S. Fish and Wildlife Service under the Endangered Species Act, the State Historic Preservation Office under Section 106 (National Historic Preservation Act), and other State and County agencies for approvals or exemptions therefrom.

2. The land use designation for the site is Light Industrial.

3. Public and special interest group workshops were held on 3/15/90, 3/27/90, 4/23/91/, 5/24/91, 6/25/91, and 7/23/91. A formal public scoping meeting was held on 2/28/91 to receive

public input for the Draft Supplemental Environmental Impact Statement (DSEIS). A public meeting was held to obtain comments on the DSEIS.

4. A Federal Final EIS for the project was circulated in 1980, and a Revised Final State EIS was circulated in 1982. A Draft Supplemental EIS was circulated in November 1992, and a Final Supplemental EIS is being circulated with this consistency determination.

FEDERAL CONSISTENCY SUPPLEMENTAL INFORMATION FORM

Project/Activity Title or Description: MA'ALAEA HARBOR FOR LIGHT DRAFT VESSELS

Island: Maui Tax Map Key No.: 3-6-01, 2, 34, 43, 49, 50 and 3-8-14, 28, 31

Est. Start Date: 1994

APPLICANT OR AGENT

Name and Title: M. Bruce Elliott
Lieutenant Colonel, U.S. Army
District Engineer

Agency/Organization: U.S. Army Engineer District, Honolulu
Address: Building 230
Fort Shafter, Hawaii 96858-5440

TYPE OF APPLICATION

(x) I. Federal Activity

"The proposed activity is consistent with and will be conducted in a manner consistent to the maximum extent practicable with the Hawaii Coastal Zone Management Program."

Signature:______________________________

M. BRUCE ELLIOTT
Lieutenant Colonel, U.S. Army
District Engineer

APPENDIX B

ECOLOGICAL REPORTS

Ma'alaea Boat Harbor Algal Survey

Ma'alaea Boat Harbor Algal Survey Addendum

Description of Humpback Whale Use of Maalaea Bay, Maui, Hawaii

Numerical Hydrodynamic Modeling and Flushing Study at
Maalaea Harbor, Maui, Hawaii

MĀ'ALAEA BOAT HARBOR ALGAL SURVEY

Karla J. McDermid, Ph. D.

submitted March 12, 1990
to the
US Army Engineer District, Honolulu
Environmental Resources Branch, attn: Bill Lennan
Fort Shafter, Hawai'i 96858-5440

MĀ'ALAEA BOAT HARBOR ALGAL SURVEY

INTRODUCTION AND PURPOSE

Mā'alaea Bay, Maui is well-known as habitat for adundant and diverse marine flora and fauna. Mā'alaea Bay has been considered as a potential State Marine Park and Federal Marine Sanctuary. Improvements to the Mā'alaea Boat Harbor in the northwest corner of the bay are planned by the U. S. Army Engineers District, Honolulu. Previous surveys of marine biological resources in the Mā'alaea Bay Area did not focus on marine algae. This study was undertaken 1) to characterize the marine algal community in the areas expected to be impacted by the proposed harbor improvements, with special emphasis on the edible red algal species, *Grateloupia filicina* or *limu huluhuluwaena*; and 2) to evaluate the possible impact of the harbor improvement project on the *G. filicina* population.

METHODOLOGY

Field surveys and algal collections were made on February 25 and 26, 1990 at Kapoli Beach Park, Mā'alaea Boat Harbor, Mā'alaea Beach (Palalau area), Mai Poina 'Oe la'u Beach Park near the old Kīhei Landing, and the Kawililīpoa area of Kalama Beach Park (Līpoa Street Beach Access) (Fig. 1). At the Mā'alaea Boat Harbor, Zones 1, 2 and 4 (previously designated in USFWS Detailed Report 1980), and the inner perimeter of the existing south breakwater were surveyed and sampled (Fig. 2). Surveys were accomplished by walking along the shoreline, reef-walking in the intertidal zone and/or snorkeling in the shallow subtidal zone.

Voucher specimens of marine algae were prepared and will be deposited in the herbarium at the Bernice P. Bishop Museum, Honolulu (Appendix 1).

In order to augment the understanding of *Grateloupia filicina* distribution and abundance on Maui, dried herbarium specimens of *G. filicina* collected in the Hawaiian Islands were examined at the Bishop Museum. In addition, published information on the distribution and abundance of *G. filicina* in Hawai'i was reviewed.

RESULTS & DISCUSSION

Literature Survey

Grateloupia filicina (Rhodophyta) is a soft, limp, slippery alga with few to many somewhat flattened branches (Magruder and Hunt 1979). The thallus can range from 2-30 cm long and may be red, green, brown or blackish purple. *Grateloupia filicina* usually grows in the intertidal zone at about 0 feet MLLW on rocky coastlines or shallow reef flats on wave-washed boulders or rocks partially covered with sand (Fortner 1978, Magruder and Hunt 1979). This species can adapt to low salinity or brackish water (Zablackis 1987), and is often found near stream mouths and springs (Abbott 1947, Fortner 1978).

Since prehistoric time, *Grateloupia filicina* has been collected for human consumption in Hawai'i (Reed 1907, Abbott 1978, 1984, Abbott and Williamson 1974). *Grateloupia filicina* is known in Hawaiian as *limu huluhuluwaena* (pubic hair) or "chop-chop" or *limu pakeleawa'a* (slipping from the canoe). This alga is traditionally prepared by rinsing, chopping, and combining it with raw liver (*ake*), raw fish (*i'a maka*), limpets (*'opihi*) or other *limu*, or by adding it to beef stew or broiled octopus (*he'e*) (Abbott 1984).

The first known scientific collections of Hawaiian *G. filicina* were made in the 1800's (Chamberlain 1880, 1889). Since then there have been several published reports of *G. filicina* in Hawai'i (Setchell 1905, Reed 1907, Rock 1913, MacCaughey 1918, Abbott 1947, Magruder and Hunt 1979). Abbott (1984) states that *G. filicina* was transplanted from Honokōwai, Maui to Waikīkī, O'ahu for Queen Lili'uokalani, and also from Moloka'i to the Waikīkī Aquarium area. *Grateloupia filicina* is reported to be "occasional" on major Hawaiian Islands, occurring at the following specific locations (Abbott 1984): Honokōwai, Mā'alaea and Māla, Maui; Kūpeke, Moloka'i; Waikīkī, and Hanauma Bay, O'ahu; Hilo, Hawai'i. Hawaiian *G. filicina*, because of the commercially valuable carrageenan gel in its cell walls, has been the subject of recent aquaculture experiments on O'ahu (Zablackis 1987), and was grown successfully in tank culture.

Museum Herbarium Specimens

Grateloupia filicina has been previously collected from most of the major Hawaiian Islands (Table 1). The Bishop Museum holdings consist of 2 collections from Kaua'i, 39 collections from O'ahu, 5 from Moloka'i, 1 from Lana'i, 15 from Maui and 8 from Hawai'i. However, the number of collections only documents distribution and frequency of scientific collecting, and is **not** an assessment of comparative abundance of the alga. The oldest specimen of *G. filicina* dates back to 1863; the most recent is 1989. Collection data indicate that *G. filicina* has a year-round presence in the Hawaiian Islands. Many specimen labels describe the habitat of the collected *G. filicina* as intertidal to 1 m deep, on boulders or eroded coral reef in sand-scoured areas.

Field Survey

Grateloupia filicina was present at 4 of the 7 sites surveyed in the Mā'alaea Bay Area (Table 2). *Grateloupia filicina* was found only in the low intertidal zone on rocks and boulders surrounded by sand which are intermittently covered or scoured by sand. Rocks in the swash zone on Mā'alaea Beach just east of the Harbor were 50-90% covered by *G. filicina*. *Grateloupia filicina* grew in small clumps, forming a "skirt" around the base of intertidal boulders at Kapoli Beach Park.

The areas adjacent to the Mā'alaea Boat Harbor, namely Kapoli Beach Park and Harbor Zones 2 and 4, are rich in seaweeds, with representatives of each of the major algal divisions, Rhodophyta, Chlorophyta and Phaeophyta. Few species were found within the Mā'alaea Boat Harbor (Zone 1 and inner South Breakwater).

Habitats

Based on literature reports, herbarium collections and this field survey, the development and maintenance of populations of *Grateloupia filicina* seem to have two prerequisites: 1) intertidal hard substratum surrounded by sand with intermittent sand cover or sand scour, and 2) some freshwater inflow into the intertidal zone. *Grateloupia filicina* is found throughout the Hawaiian Islands in the specific localities where these habitat requirements are met. Mā'alaea Bay is one of these "suitable habitats" for *G. filicina* (Fortner 1978, Abbott 1984), and the standing crop is one of the largest in the state during ceratin times of the year (Abbott pers. comm. 1990, Magruder pers. comm. 1990).

CONCLUSIONS

Grateloupia filicina is an edible seaweed with a cultural history of use by people in Hawai'i. *Grateloupia filicina* has a patchy distribution throughout the major Hawaiian Islands, but may be locally abundant at certain sites where intertidal hard substratum is surrounded by sand with intermittent sand cover or sand scour, and where a source of freshwater is nearby. Mā'alaea Bay is one of the few areas in the state where *G. filicina* is locally abundant. In this study *G. filicina* was observed in areas adjacent to the Mā'alaea Boat Harbor and elsewhere at the eastern end of the bay towards Kīhei. A follow-up survey will be conducted later this year to assess any seasonal variability in this abundance.

In conclusion, the existence of *Grateloupia filicina* populations is dependent on 1) intertidal hard substratum surrounded by sand with intermittent sand cover or sand scour, and 2) some freshwater inflow into the intertidal zone. If the proposed Mā'alaea Harbor improvements will change the deposition or movement of sand in the area so as to eliminate the habitat of *G. filicina*, then the populations will be *adversely affected*. It is beyond the scope of this study to determine the amount of alteration of longshore currents by the Breakwater Extension and the resultant movement of sand and suspended sediments.

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Magruder, Dr. William H. 1990. Associate Botanist, Department of Botany, B. P. Bishop Museum, Honolulu, HI.

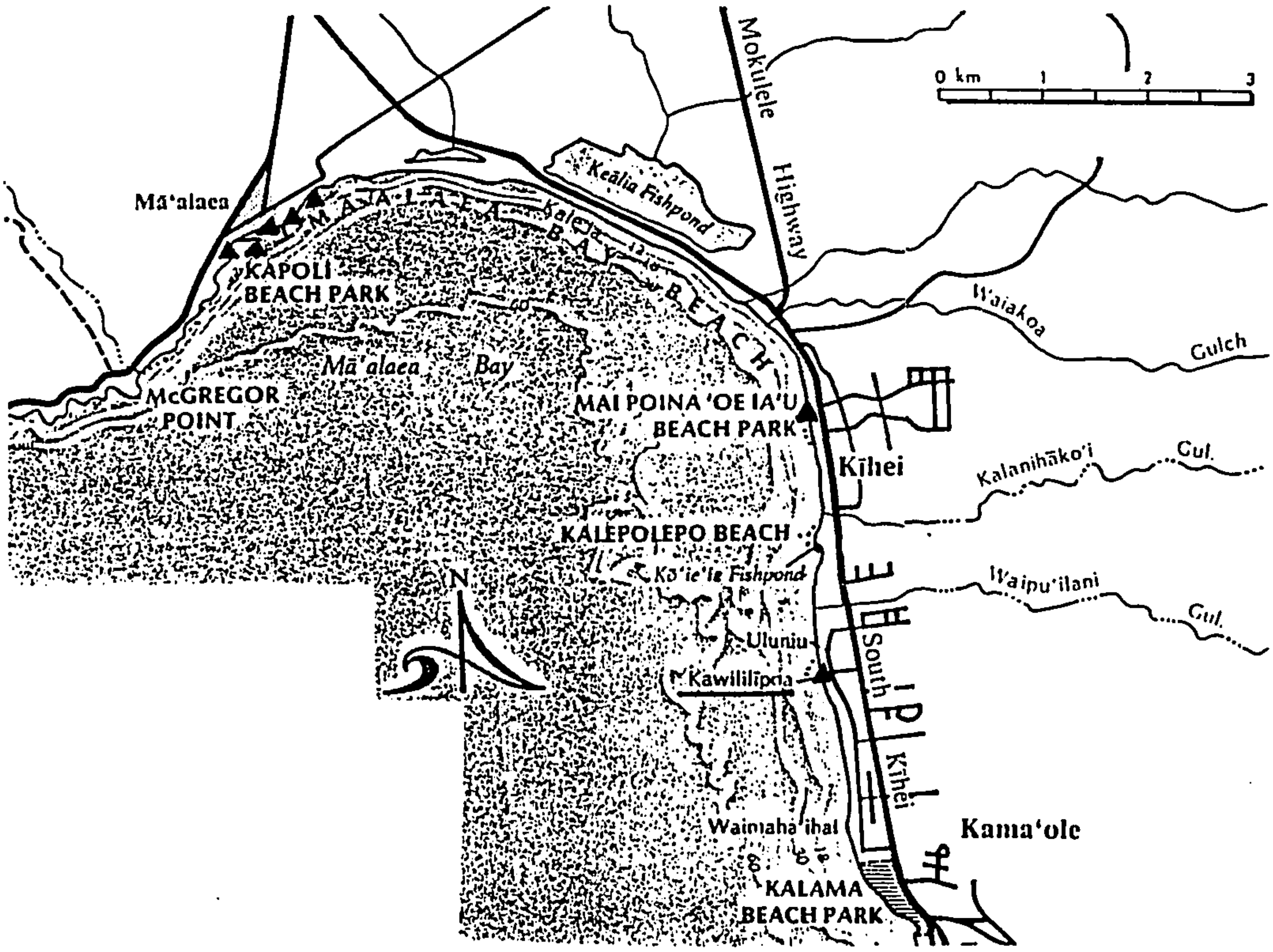

Figure 1.
Mā'alaea Bay Area Sampling Sites
February 25-26, 1990

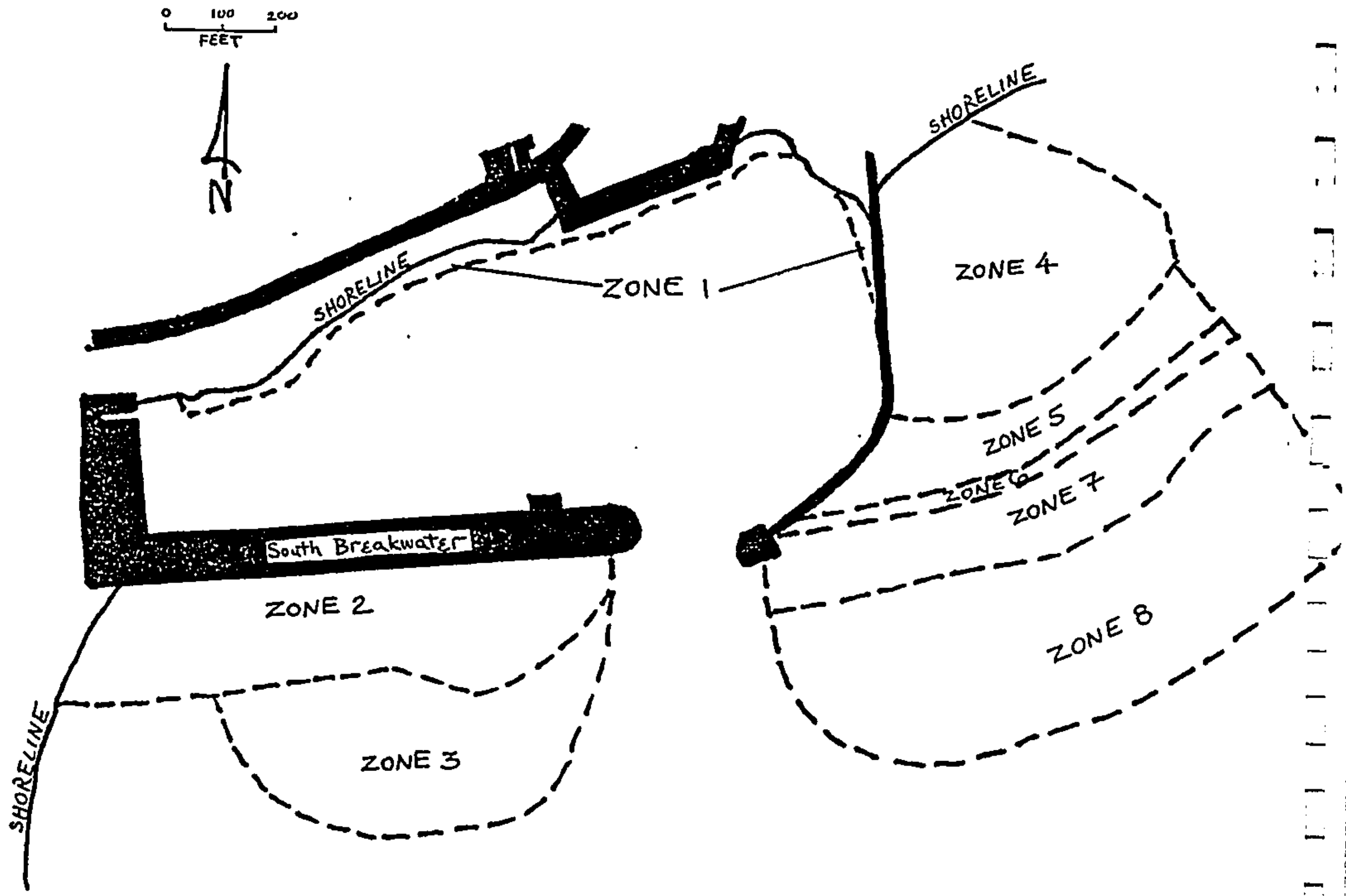

Figure 2.
Mā'alaea Boat Harbor Survey Zones

TABLE 1.
BISHOP MUSEUM HERBARIUM SPECIMENS OF *GRATELOUPIA FILICINA*

KAUA'I
Kapa'a VII-1900
Kaua'i V-1983

O'AHU
Barber's Point VI-1944, IV-1975
Black Point XI-1934
Castle Beach X-1975, III-1976
Ewa Beach VI-1944, IV-1965, XI-1977, XI-1979,
Hale'iwa I-1989
Kāhala Park V-1953
Kahalu'u VI-1975
Kahuku II-1980
Kailua II-1962
Kāne'ohe Bay III-1978
Ke'ehi X-1983
Magic Is. II-1970, III-1974, III-1978, II-1980
Reef Runway III-1978
Sans Souci Beach III-1959
Waikīkī (near Aquarium) IV-1908, V-1908, VI-1926, XI-1950, I-1952, XI-1958, IV-1975
Waimānalo IV-1977, V-1989
O'ahu 1863, 1876, XI-1882

MOLOKA'I
Ke'awanui Pond VIII-1944
Kūpeke Pond VIII-1944
Nī'aupala Pond IV-1984
'Ualapu'e Pond X-1976

LANA'I
Lana'i 1876

MAUI
Kā'anapali III-1959, II-1967
Kahana Beach IV-1965
Kahului VIII-1955
Kīhei X-1982
Launiupoko III-1976
Mā'alaea Beach I-1971, VIII-1972, VIII-1978
Mā'alaea Boat Harbor XI-1958, IV-1965
Māhinahina Point IX-1971

HAWAI'I
Hilo II-1953, V-1985
Ho'okena IX-1972
Kailua-Kona X-1960, VIII-1975
Ke'alakekua VIII-1975
Nāpō'opo'o IX-1975
Pu'ukoholā Park IV-1976

TABLE 2.

MACRO-ALGAE OBSERVED	SITES SURVEYED * Kap	H2	H1	H4	MB	Mai	Lip
Rhodophyta							
Acanthophora pacifica	+	+	-	-	-	-	-
Acanthophora spicifera	+	+	-	+	-	-	-
Ahnfeltia concinna	+	+	-	+	+	+	-
Amphiroa sp.	+	-	-	-	-	-	-
Gracilaria coronopifolia	-	-	-	-	-	-	+
Grateloupia filicina	+	-	-	-	+	+	+
Grateloupia hawaiiana	+	+	-	+	+	-	-
Haliptilon subulatum	+	+	-	+	-	-	-
Hypnea musciformis	+	+	+	+	-	-	+
Laurenica yamadana	+	-	-	-	-	-	-
Pterocladia capillacea	+	+	+	+	+	+	-
Chlorophyta							
Bryopsis pinnata	-	-	+	-	-	-	-
Chaetomorpha antennaria	+	-	-	-	+	-	-
Cladophora vagabunda	-	-	-	-	-	-	+
Codium edule	+	+	-	+	-	-	+
Codium reediae	-	-	+	-	-	-	-
Ulva fasciata	+	-	+	+	-	-	+
Ulva reticulata	-	-	+	-	-	-	-
Phaeophyta							
Colpomenia sinuosa	+	-	-	+	-	-	-
Dictyota spp.	+	+	-	+	-	-	-
Sargassum echinocarpum	+	+	-	+	-	-	-
Sargassum obtusifolium	+	-	+	-	-	-	-

* Site Abbreviations:
Kap = Kapoli Beach Park
H2 = Harbor Zone 2 (outer south breakwater)
H1 = Harbor Zone 1 (inner shoreline)
H4 = Harbor Zone 4 (reef flat east of Harbor)
MB = Mā'alaea Bay Beach (area east of Zone 4)
Mai = Mai Poina 'Oe Ia'u Beach Park
Lip = Kawililīpoa area of Kalama Beach Park

APPENDIX 1

voucher algal specimens
deposited in the Bishop Museum Herbarium
(xerox copies 64% of original size)

(NOT INCLUDED IN THIS DOCUMENT)

MĀ'ALAEA BOAT HARBOR ALGAL SURVEY ADDENDUM

Karla J. McDermid, Ph. D.

submitted July 31, 1990
to the
US Army Engineer District, Honolulu
Environmental Resources Branch, attn: Bill Lennan
Fort Shafter, Hawai'i 96858-5440

MĀ'ALAEA BOAT HARBOR ALGAL SURVEY ADDENDUM

On July 21 and 22, 1990, algal surveys were repeated on Maui at Kapoli Beach Park, Mā'alaea Boat Harbor, Mā'alaea Beach (Palalau area), and Mai Poina 'Oe Ia'u Beach Park near the old Kīhei Landing to supplement the surveys made at these sites in February 1990. The purpose of the July study was to assess seasonal differences, if any, in the abundance of the edible red algal species, *Grateloupia filicina* or *limu huluhuluwaena* in the areas expected to be impacted by proposed Mā'alaea Boat Harbor improvements. Surveys were accomplished by walking along the shoreline, reef-walking in the intertidal zone and/or snorkeling in the shallow subtidal zone. Surveys were made with the assistance of Dr. W. H. Magruder of the Bernice P. Bishop Museum.

RESULTS & DISCUSSION

Field Survey

Grateloupia filicina was present at 5 of the 6 sites surveyed in the Mā'alaea Bay Area (Table 1). *Grateloupia filicina* was found predominantly in the low intertidal zone on rocks and boulders surrounded by sand which are intermittently covered or scoured by sand. *Grateloupia filicina* also occurred in scattered clumps subtidally (1.5 - 2.0 m deep) in Harbor Zone 2 (Fig. 1). Rocks in the swash zone on Mā'alaea Beach just east of the Harbor, and at Mai Poina 'Oe Ia'u Beach Park were 60-100% covered by *G. filicina*.

The areas adjacent to the Mā'alaea Boat Harbor, namely Kapoli Beach Park and Harbor Zones 2 and 4, are rich in seaweeds, with representatives of each of the major algal divisions, Rhodophyta, Chlorophyta and Phaeophyta. Fewer species were found within the Mā'alaea Boat Harbor (Zone 1 and inner South Breakwater).

Seasonal Comparison

Summer abundance of *Grateloupia filicina* in the Mā'alaea Bay Area showed a slight increase in abundance and distribution. *Grateloupia filicina* was found in Harbor Zones 1 and 2 in July, but not in February. In July, on Mā'alaea Beach east of the Harbor and at Mai Poina 'Oe Ia'u Beach Park, more low intertidal rock surface was exposed, sand-free, and colonized by *G. filicina* than in February;

whereas, sand cover had increased at Kapoli Beach Park. In general, populations of *Grateloupia filicina* showed higher percent cover in July than in February.

Other algal species also showed changes in abundance. For instance, the *Acanthophora pacifica* and *Grateloupia hawaiiana* populations at Harbor Zone 2 were denser in February than July. More *Gracilaria coronopifolia* was seen growing in Harbor Zones 1, 2, and 4 in July than February. *Hypnea musciformis* distribution and abundance did not show much seasonal change. A few species included in the February survey were not observed in the July survey, e. g. *Codium reediae*, *Ulva reticulata* and *Laurencia yamadana*.

CONCLUSIONS

In this study, *Grateloupia filicina* was observed in the Mā'alaea Boat Harbor, in areas adjacent to the Mā'alaea Boat Harbor and elsewhere at the eastern end of the bay towards Kīhei. *Grateloupia filicina* was locally abundant at sites where intertidal or shallow subtidal hard substratum is surrounded by sand with intermittent sand cover or sand scour, and where a source of freshwater is nearby.

Grateloupia filicina populations in the Mā'alaea Bay Area are present in winter and summer months, and probably occur year-round with slight fluctuations in biomass due to shifts in sand cover.

As was stated in the first report (submitted in March 1990), the Mā'alaea Bay Area is one of the few sites in the state where *Grateloupia filicina* is locally abundant. Development and maintenance of *G. filicina* populations is dependent on 1) intertidal or shallow subtidal subtratum surrounded by sand with intermittent sand cover or sand scour and 2) some freshwater inflow into the intertidal zone. If the proposed Mā'alaea Harbor improvements will change the deposition or movement of sand in the area so as to eliminate the habitat of *G. filicina*, then the populations will be adversely affected. It is beyond the scope of this study to determine the amount of alteration of longshore currents by the Breakwater Extension and the resultant movement of sand and suspended sediments.

TABLE 1.

MACRO-ALGAE OBSERVED	SITES SURVEYED JULY 1990* Kap	H2	H1	H4	MB	Mai
Rhodophyta						
Amansia glomerata	+	+	-	+	-	-
Acanthophora pacifica	-	+	-	-	-	-
Acanthophora spicifera	+	+	+	+	+	+
Ahnfeltia concinna	+	+	-	+	+	+
Amphiroa sp.	+	-	-	-	-	-
Dasya sp.	-	-	-	-	+	-
Gracilaria coronopifolia	-	+	+	+	-	-
Grateloupia filicina	+	+	+	-	+	+
Grateloupia hawaiiana	+	+	-	+	+	-
Haliptilon subulatum	+	+	-	+	-	-
Hypnea musciformis	+	+	+	+	+	+
Laurencia yamadana	-	-	-	-	-	-
Pterocladia capillacea	+	+	-	+	+	+
Chlorophyta						
Bryopsis pinnata	-	+	-	-	-	-
Chaetomorpha antennaria	+	-	-	-	-	-
Cladophora vagabunda	-	+	-	+	-	-
Codium edule	+	+	-	+	-	-
Codium reediae	-	-	-	-	-	-
Ulva fasciata	+	+	+	+	+	+
Ulva reticulata	-	-	-	-	-	-
Phaeophyta						
Colpomenia sinuosa	+	+	-	+	-	-
Dictyota spp.	+	+	-	+	-	-
Padina japonica	-	-	+	+	+	-
Sargassum echinocarpum	+	+	-	+	-	-
Sargassum obtusifolium	+	-	+	-	-	-

* Site Abbreviations:
Kap = Kapoli Beach Park
H2 = Harbor Zone 2
H1 = Harbor Zone 1
H4 = Harbor Zone 4
MB = Mā'alaea Bay Beach (area east of Zone 4)
Mai = Mai Poina 'Oe Ia'u Beach Park

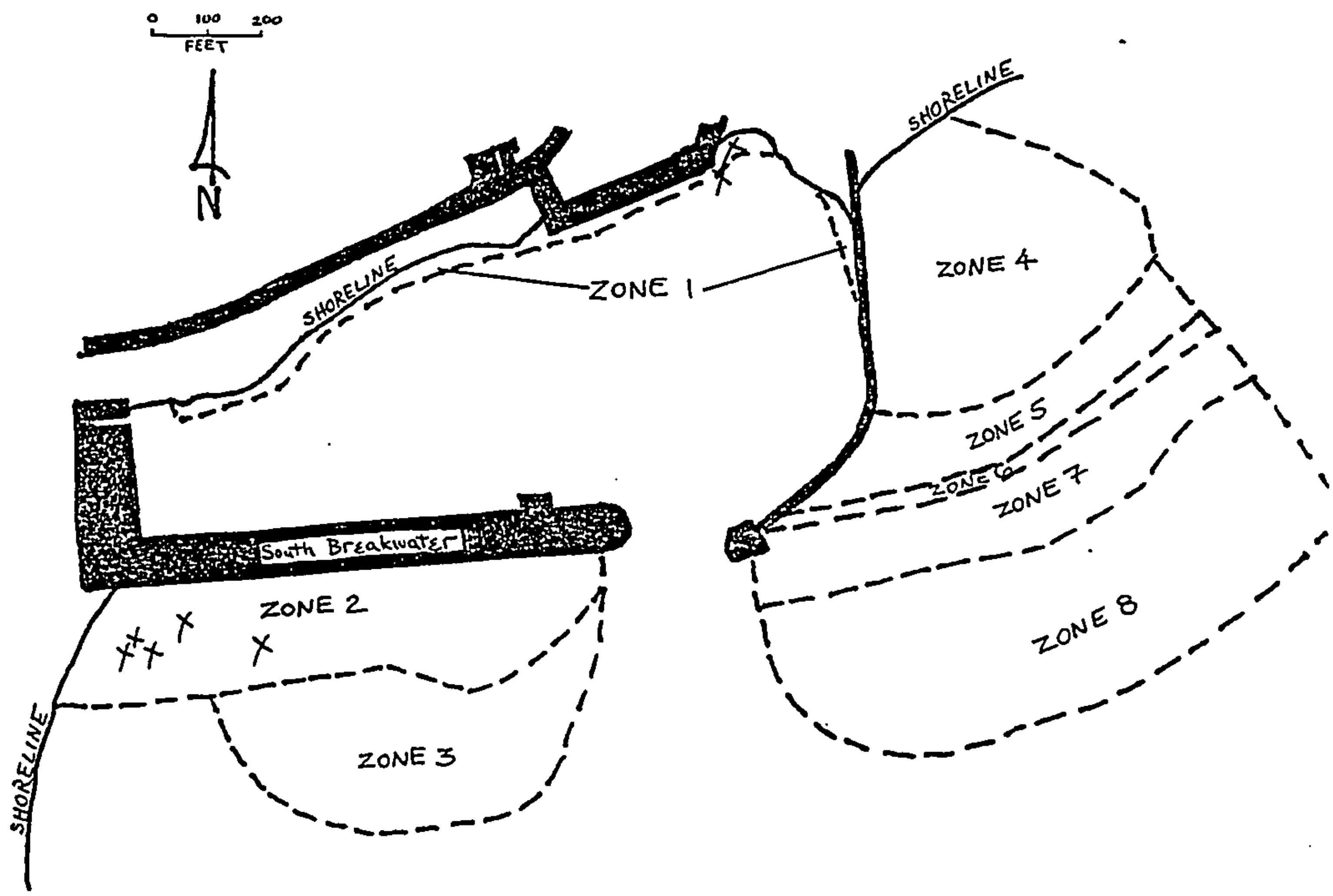

Figure 1.
Location of *Grateloupia filicina* in Mā'alaea Boat Harbor Survey Zones

Description of Humpback Whale Use of Maalaea Bay, Maui, Hawaii

Final Report to the
US Army Engineer District, Honolulu
Corps of Engineers

CONTRACT NO. DACW83-91-P-0601

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Submitted: 12/31/91
Approved: 05/29/92

DESCRIPTION OF HUMPBACK WHALE USE OF MAALAEA BAY, MAUI, HAWAII[1]

INTRODUCTION

In 1968 the United States Congress approved funding for a plan to construct improvements to the Maalaea Harbor for light-draft vessels at Maalaea, on the island of Maui in Hawaii (Figure 1). A General Design Memorandum and Final Environmental Impact Statement (FEIS) was prepared, circulated and approved by the Chief of engineers in 1980, but the project remained unfunded until the 1989 Fiscal Year. Although the 1980 FEIS concluded that the construction of the harbor improvements would have no effect on the endangered humpback whale, concerns remained that the associated increase in vessel traffic may have an adverse effect on this species.

The humpback whale (*Megaptera novaeangliae*) is one of the most endangered of the great whales, primarily due to commercial whaling during the first half of this century. According to Rice (1978), a pre-exploitation population estimated at 15,000 humpback whales in the North Pacific was reduced to fewer than 1,200 animals by the mid-1960's. In 1966 the International Whaling Commission approved a prohibition on commercial whaling of this species in the North Pacific. Following passage of the Endangered Species and Conservation Act of 1969 (superseded by the Endangered Species Act of 1973), humpback whales were declared an endangered species in 1970. Currently, the population is estimated as ranging between 2,500 and 3,500 animals (Darling and Morowitz, 1986; Baker and Herman, 1987; Chaloupka, Kaufman, and Forestell, 1989).

A significant portion of the North Pacific population of humpback whales migrates to Hawaii each winter (Johnson and Wolman, 1984). Animals arrive as early as late October, and some are still observed through the end of May. Whales may be reliably observed in the vicinity of the leeward coast of Maui from late December through late April (Kaufman and Forestell, 1986). The Hawaiian Islands comprise one of three general wintering areas for the humpback in the North Pacific. The other two are off the Baja's Pacific coast of Mexico (Urban and Aguayo, 1989), and throughout the islands south of Japan (stretching from Ogasawara through the Northern Marianas to the southeast of Tokyo, and down through the Ryukuan Islands to the southwest) (Helweg, Herman, Yamamoto, and Forestell, 1990; Darling, 1991). The number of whales

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1 FORESTELL, P.H. AND E.K. BROWN, 1991.
Description of humpback whale use of Maalaea Bay, Maui, Hawaii.
Report to Corps of Engineers, US Army Engineer District, Forth Shafter, HI 96858
Contract DACW83-91-0601

Reprints available from: Pacific Whale Foundation, 101 N. Kihei Rd., Kihei, Hi 96753

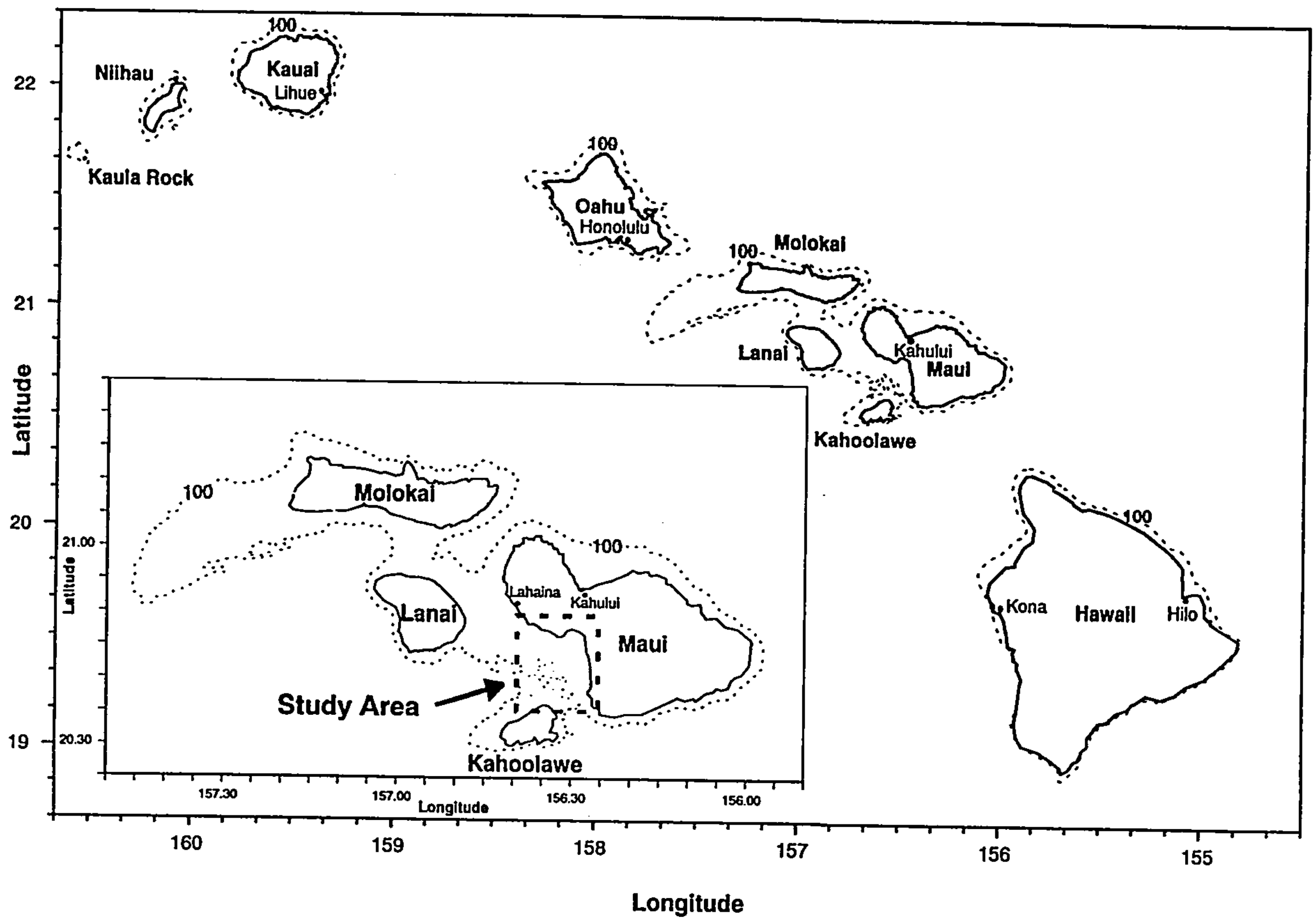

Figure 1: The main Hawaiian Islands showing the Four Island Region as an inset (Depths in Fathoms).

observed in Hawaii in winter exceed the number currently observed either along the Mexican coast or through the islands of Asia (Baker et al., 1986).

The relationship between the humpback whales observed in Hawaii, and those observed in Mexico and Japan is not yet well understood. It is generally considered that discrete feeding stocks occur throughout the lower latitudes in summer, and these co-mingle to some degree in the three high-latitude wintering areas for breeding and calf-rearing during the winter. Whales identified by photograph of unique fluke markings during one winter in Hawaii have been photographed in Mexico in both the same winter (Helweg et al, 1990), and in earlier or later winters (Perry, Baker, and Herman, 1990). Recently, it was reported that a whale observed in Ogasawara in one winter, was photographed near Kauai the following winter (Darling, 1991). However, the number of observed exchanges between wintering areas is quite small relative to the number of identified whales overall.

While in Hawaii, humpback whales may be found in the vicinity of all major islands. They show a general preference for wide, relatively shallow bank areas, leading to especially large concentrations of whales on Penguin Bank, of the northwestern end of Molokai; through the Auau Channel between Maui, Molokai, Lana'i and Kahoolawe; off the Kona Coast of the Big Island, and in the vicinity of Niihau and Kaula Rock (northwest of Kauai) (Wolman and Jurasz, 1977; Rice and Wolman, 1978). Whales are only rarely observed outside the 100-fathom contour during the winter residency period (Herman, Forestell, and Antinoja, 1980).

Under authority of the Marine Mammal Protection Act (MMPA) of 1972, the National Marine Fisheries Service (NMFS) is charged with ensuring the protection and recovery of this species. The MMPA specifically prohibits, among other acts, the harassment of marine mammals, except by federal permit. In 1979 NMFS published a Notice of Interpretation (NOI) to inform the public of activities that would be interpreted as harassment of whales in Hawaii. Unless otherwise exempted by federal permit, the NOI prohibited operation of any aircraft within 1000 feet of a humpback whale, disruption of the normal behavior or prior activity of a whale by any act or omission, or the approach by any means within specified distances of any humpback whale. The specified distances were 100 yards within 200 nautical miles of the Islands of Hawaii, except for two areas in which the specified distances were 300 yards. The two 300-yard limit areas are within 2 nautical miles of the mean high-water line between Kaena and Kamaiki Points on Lana'i (i.e. the northeast and southeast coasts of Lana'i) and in Maalaea Bay, inside of a line drawn from Olowalu Point to Puu Olai (Figure 2).

In November of 1986, NMFS published a proposed rule governing approach to humpback whales in Hawaiian waters. As a result of difficulty in prosecuting violators of the guidelines contained in the NOI, NMFS elected to replace the NOI with regulations, thereby enhancing the legal status of the protective measures. Initially, the proposed regulations did not designate calving areas because available data did not support the conclusion that distinct calving areas existed. However, the Marine Mammal Commission argued that the regulations should not be less restrictive than the original guidelines, and NMFS subsequently amended the proposed regulations in November of 1987 to include the original 300-yd restriction in Maalaea Bay and along the northeast coast of Lana'i. The regulations were codified in December, 1988.

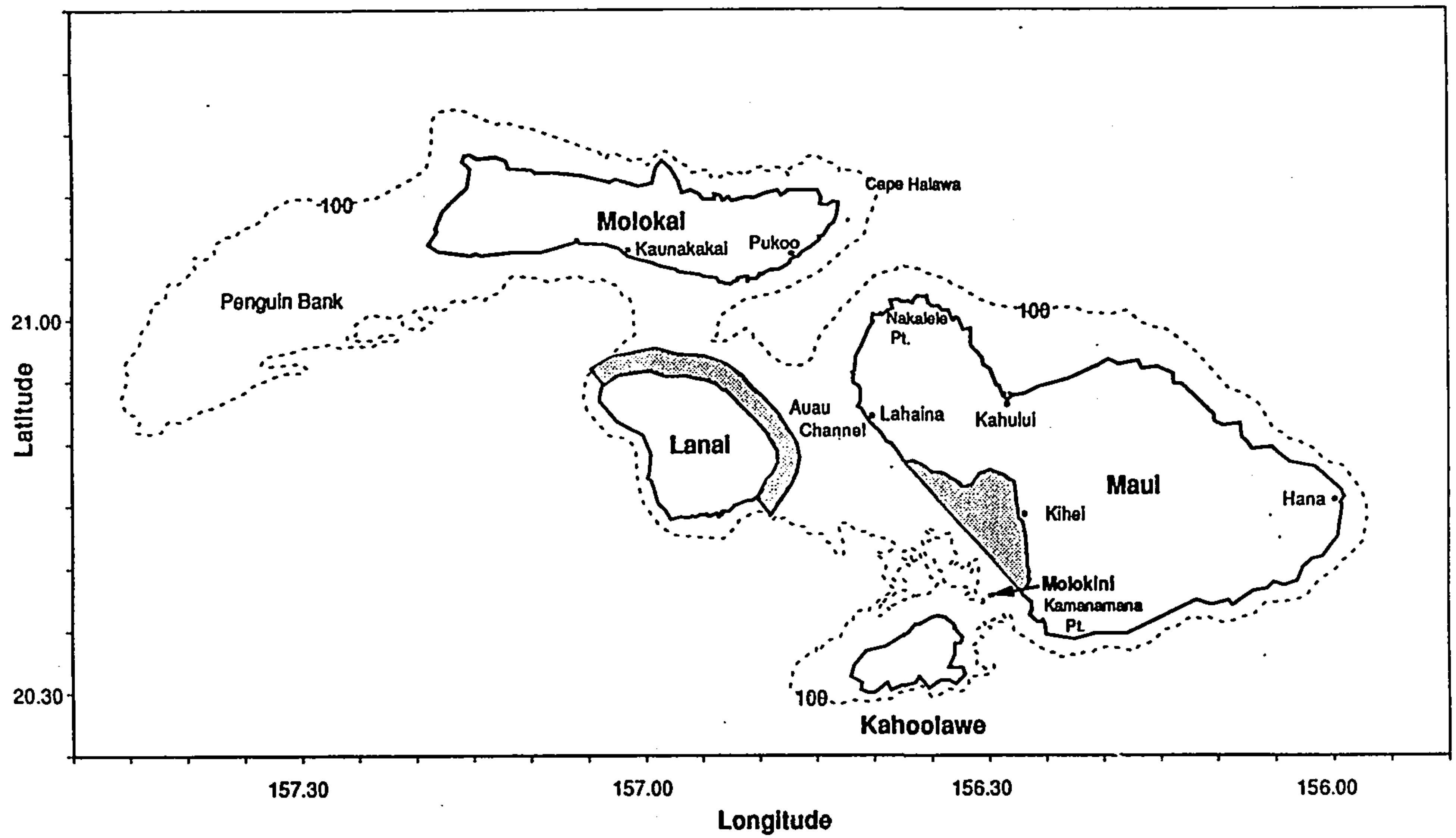

Figure 2:Cow/calf waters in the four-island region as designated by National Marine Fisheries Service.

DESIGNATION OF MAALAEA BAY AS A CALVING AREA

The original rationale for imposing stricter approach limits in Maalaea Bay and along the Lana'i shoreline was based on the perception that these areas were distinct "calving areas" in which greater protection from human disturbance should be afforded. Maalaea Bay has been considered an important area for mothers and calves since early observations (summarized in an unpublished 1980 report prepared by Muller, Carini, and Hudnall, cited by Nitta and Naughton, 1989) documented observations of mother-calf pods from a shore-based lookout near McGregor Pt. The study was prompted by a concern that an inter-island hydrofoil, travelling at high speeds into a passenger terminal at Maalaea Small Boat Harbor, might strike a whale. The study by Muller *et al.* did not compare relative frequencies of mother-calf sightings in Maalaea Bay with other areas, hence it is not possible to infer from their observations whether the area in question constitutes a distinct calving area.

Herman et al. (1980), on the basis of six days of aerial surveys, concluded that there was a wide distribution of calves among various subregions of the islands. In particular, they identified the northeast coast of Lanai, the Kihei region of Maui, the southwest coast of Molokai, and the western half of Penguin Bank. Their conclusions were based on observations of 17 of 38 calves in those areas.

Forestell (1989) found significantly more mother- calf pods throughout the Four Island Area (26) than on Penguin Bank (9) during one season of aerial surveys. The exact locations of mother calf pods were not documented, therefore the relative importance of Maalaea Bay as a calving ground is not apparent from that study.

Glockner-Ferrari and Ferrari (1990) reported on their studies of mothers and calves in the Auau Channel between 1977 and 1988. Their observations sometimes extended throughout all of the channel waters between Maui and Lana'i, from Kaanapali in the north, southward to McGregor Point. However, their primary efforts have concentrated on an area between Kaanapali and Olowalu on the Maui side, out to about half-channel (Glockner and Venus, 1983; Glockner-Ferrari and Ferrari, 1984, 1985, 1987). Their success in studying mothers and calves in this area since 1977 suggests it to be as important an area for mothers and calves as elsewhere in the islands.

Mobley (1991) conducted one year of aerial surveys around all major islands using procedures identical to those employed from 1977 through 1980 by Herman et al. (1980) and Baker and Herman (1981). In comparing his 1990 results with earlier 1977-1980 results, Mobley found increases in the rate of whale observations per hour were on the order of 44 -58% greater for whales overall, and 76-107% greater for pods with calf. His findings agreed with those of Herman et al. (1980), that Penguin Bank and Auau Channel areas are substantially higher in relative frequency of calf sightings. Mobley's 1990 observations found the distribution of calves to be equivalent throughout Maalaea Bay and the Auau Channel, except for a slightly higher incidence of calves along the northeast coast of Lanai. He found no indication that Maalaea Bay was a distinct calving area. Overall, Mobley documented 74 confirmed calf observations, compared with 38 confirmed calf sightings by Herman et al. (1980).

In general, the data with respect to the use of Maalaea Bay by mothers and calves relative to other areas in the islands are inconclusive. While mothers and calves are found there, it has yet to be shown they occur with a frequency any greater than elsewhere.

A secondary issue of importance is whether the designation of Maalaea Bay as a calving area, and the subsequent stricter distance regulations imposed by NMFS, actually afford the whales any greater level of protection from human activity. Finally, a systematic description of the abundance and distribution of whales and boats in the general vicinity of Maalaea Bay will provide a data-base on humpback whales for use in ongoing management decisions.

Periodic systematic observations of whale distribution and abundance patterns in this area will facilitate both short- and long-term observations of quantitative and qualitative changes over time. The data will permit ongoing monitoring of changes in humpback whale patterns which may be associated with identifiable changes in human patterns. Ultimately, mitigation of potential impacts will be most successful if there is an opportunity to assess current patterns, and monitor future changes in those patterns.

SCOPE OF THE PRESENT REPORT

The Pacific Whale Foundation has conducted annual aerial surveys throughout the Four Island Area (i.e., the waters bounded by the islands of Molokai, Lana'i, Kahoolawe, and Maui) including Maalaea Bay during five winter seasons since 1985. In addition, two years of systematic surveys from small boats have been carried out in Maalaea Bay and adjacent waters. In September of 1991 the US Army Engineer District in Honolulu issued Purchase Order No. DACW83-91-P-0601 for a report describing the use of Maalaea Bay and the immediate vicinity by humpback whales. The scope of work for the report was to:

1. Review currently available information on humpback whale behavior and use of Maalaea Bay.

2. Provide summary and analysis of data collected from aerial and small boat surveys on:

   a. location of whales, as a function of time of day, time of season, depth, and pod composition;

   b. locations of boats, as a function of time of day, time of season, and type of vessel, as well as the frequency of observations of vessels within .25 mi of whales;

   c. general activity of whales as a function of location, pod composition, and time of year.

3. Prepare written report documenting references cited, scope of work, methodology employed, quantification of results, and discussion of findings relative to the planned expansion of the Maalaea Small Boat Harbor.

As detailed in the present report, all phases of the proposed study effort have been completed.

METHODS

STUDY AREA

The study area was comprised of two regions: the waters inside Maalaea Bay, and an equal-sized area outside of but adjacent to Maalaea Bay. The border between the two regions was the line developed by NMFS to demarcate the calf resting area. Each equal-sized region was further divided into 3 equal-sized subregions. The six sub-regions were developed by integrating the areas of 60 trapezoids determined from NOAA chart 19347 along a line drawn directly from Hekili Point to Pu'u Olai. Each sub-region is approximately 13 mi^2 (Figure 3).

VESSEL SURVEYS

Survey Platforms and Apparatus: Surveys were conducted from a 16' fiberglas Radon equipped with a 40-hp Tohatsu engine (1989), a 13' Boston Whaler with a 25-hp Johnson outboard (1989), a 14' Zodiac inflatable equipped with a 25-hp Johnson outboard (1989 and 1991) or a 16' Achilles hard-bottom inflatable equipped with a 75-hp Yamaha outboard. Each boat carried a crew complement of four people: a driver, a recorder, and two observers. Each survey was accompanied by at least one experienced

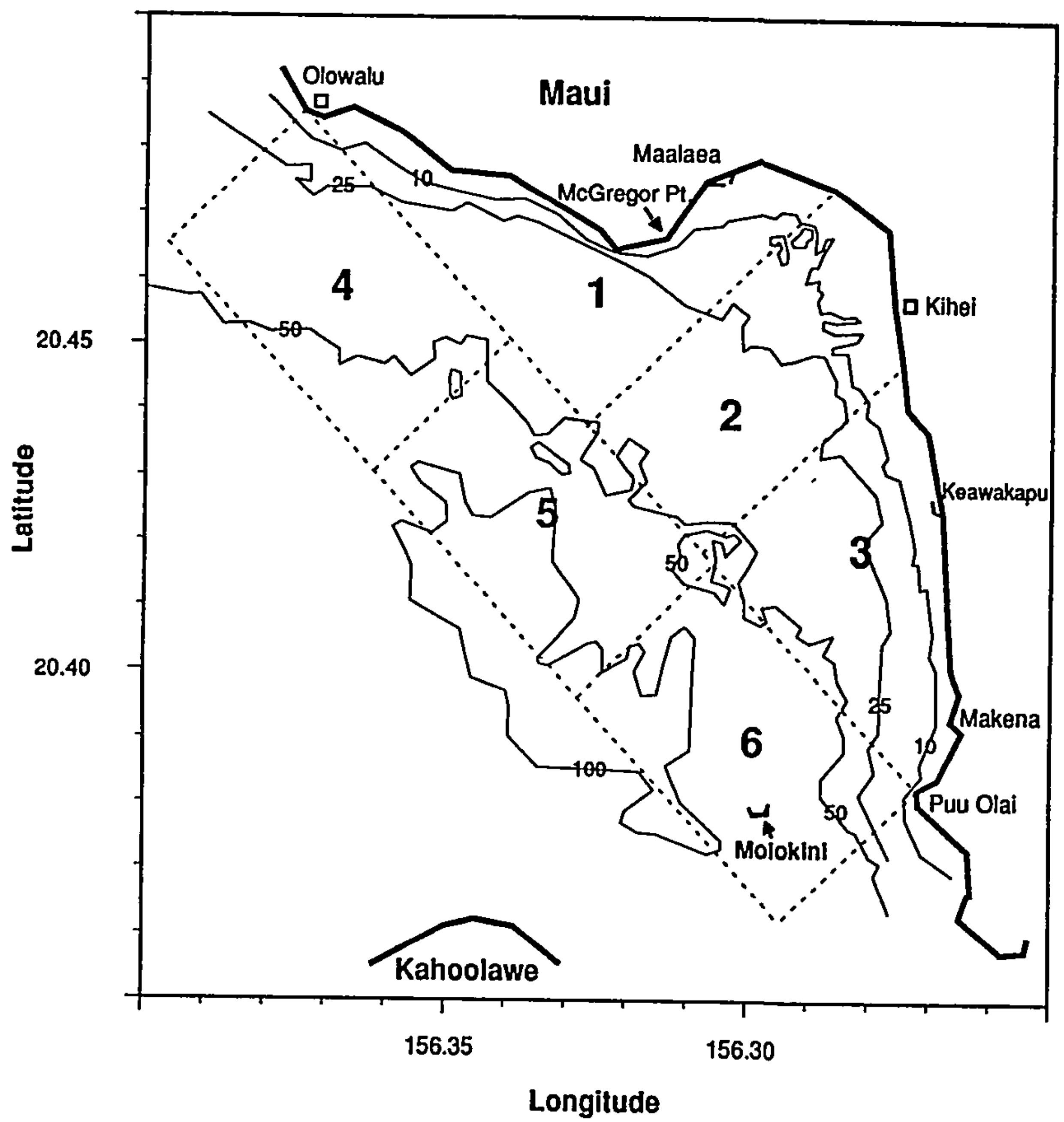

Figure 3: The study area, showing major landmarks on Maui and the depth contour in fathoms.

researcher, with three or more years of relevant field experience. Additional personnel were drawn from volunteers, who received a minimum of two days training in field protocol and observation techniques. Many of the volunteers had prior relevant experience, and all became easily familiar with the demands of the current project.

Generally, at least two boats operated each day. Locations were determined with the aid of a Morin 2000 hand-held compass. Readings were taken on a minimum of 3 pre-selected prominent landmarks. The particular landmarks used depended upon the sub-region being surveyed. Data were recorded by hand on prepared forms, and later coded for computer entry into an Excel spreadsheet.

Survey Period: Surveys were conducted on a daily basis, weather permitting, during a 16-wk period from January 10 through April 26 in 1989, and from January 10 through April 30, 1991. Because Maalaea Bay is frequently exposed to strong, gusty trade winds in the late-afternoon period, surveys were generally conducted between 0800 and 1600 hrs each day. Surveys were not conducted in conditions of Beaufort Sea State 5 or greater (Windspeed > 16 mph; extensive whitecapping with moderate waves). Sampling was constrained to ensure that each of the six sub-regions was surveyed an equivalent number of times within each two week period.

Survey transects: Daily surveys were conducted along randomly-determined, pre-selected transects running parallel to the line demarcating the division between the 100-yd and 300-yd areas designated by NMFS. Surveys ran either east to west, or west to east, with equal frequency. Survey transects were randomly selected from a computer-generated listing of all possible survey transects through the study area at 50 possible points along border. The computer model used to generate the sampling scheme was developed in the Smart Spreadsheet for PCs. Sub-regions were surveyed according to a quasi-random schedule, with all sub-regions surveyed equally often during each two week period of the study.

During each daily survey, the survey boat was launched from Keawakapu Small Boat Ramp, just south of Kihei, and proceeded to that day's pre-determined starting point. The survey boat approached the starting point indirectly, in a somewhat circuitous manner, to avoid coming within one mile of the transect line that was to be surveyed, in order to minimize the impact of the survey vessel on subsequent sighting probabilities.

Once the vessel reached the starting point, an approximate 15 minute "stabilization" period was initiated prior to beginning the survey transect. During this period the starting point, (as with all subsequent location data) was determined with the aid of a hand-bearing compass. A minimum of three readings was taken, using prominent landmarks as noted on NOAA charts of the area. The recorder also noted sea state, wind direction, wind speed, visibility, and cloud cover periodically during the survey.

Survey time: Survey time was defined as time spent underway along the survey transect, at a constant speed of approximately 5 knots with two observers maintaining continual surveillance over their respective observation area. Observers were instructed to scan the area directly ahead of the survey boat, around to a position at either 4 or 8 o'clock (depending upon which side of the boat they were monitoring), and indicate to the driver and recorder each whale or boat observed within 1.6 km of the survey boat (visually estimated).

Each time a pod of whales was seen, the driver assumed responsibility for maintaining visual contact with the pod, while the observers continued their systematic scan of the observation area. Once the driver determined the survey boat was at its closest point of approach to the observed pod, survey time was suspended. The location of the boat was documented through three compass readings. The pod of whales that had been seen was then approached closely enough to verify the number of whales in the pod, and whether or not a calf was present.

If additional pods were observed in the interval between the first sighting and the suspension of survey time, the driver would approach all pods seen in order of proximity to the boat once survey time was suspended. However, whales observed during suspended survey periods were not included in survey observations, because it was not possible to determine to what degree observation of such whales was biased by remaining in the same general area.

For purposes of the present study, a boat-whale interaction was operationally defined as any occasion on which a vessel was seen within .4 km of a whale, regardless of what the boat was doing. (The only exception was an occasion on which the boat was either at anchor or on a mooring). Because of time constraints, it was not possible to suspend survey effort each time a boat was observed near a whale in order to document precisely the nature of the interaction. The distance of .4 km was selected because it is consistent with other studies conducted in Hawaii (Herman et al., 1980; Bauer and Herman, 1986; Forestell, 1989). The survey vessel was not included as a vessel within .4 km, regardless of its location relative to the pod.

Once the relevant data were collected, the boat resumed its original heading, and survey procedures were re-instated. Only time actually underway along the transect searching for whales was considered survey time. In general, each time the boat changed directions (either to approach whales or to resume survey) survey time was suspended and its location was documented by taking three compass readings.

As an additional precaution to maintain as accurate a record as possible of the survey boat's daily course, the boat would stop after twenty minutes of no observations or course changes. Survey time would be briefly suspended, and the boat's location determined through three compass readings. This permitted later determination of how much survey time was actually spent in each of the 6 sub-regions during the course of the study.

AERIAL SURVEYS

Aerial surveys were conducted bi-weekly from January through May, 1985 - 1991, using procedures from Forestell (1989). A single-engine, high-wing Cessna 172, outfitted with standard navigational equipment, flew along a pre-determined transect at constant air speed (90 knots) and altitude (300 m). The aircraft did not leave the transect during the survey period. The transect (Figure 4) was designed to provide complete coverage of the survey area, and maintain as much similarity as possible to transects used by Herman et al. (1980) and Baker and Herman (1981). Each survey required approximately two hours to complete, and included the near-shore and mid-channel areas between Maui, Molokai, Lana'i and Kahoolawe, (the Four-Island Area). Only whales observed in the boat survey study area (Sub-regions 1 through 6) are considered in the present report.

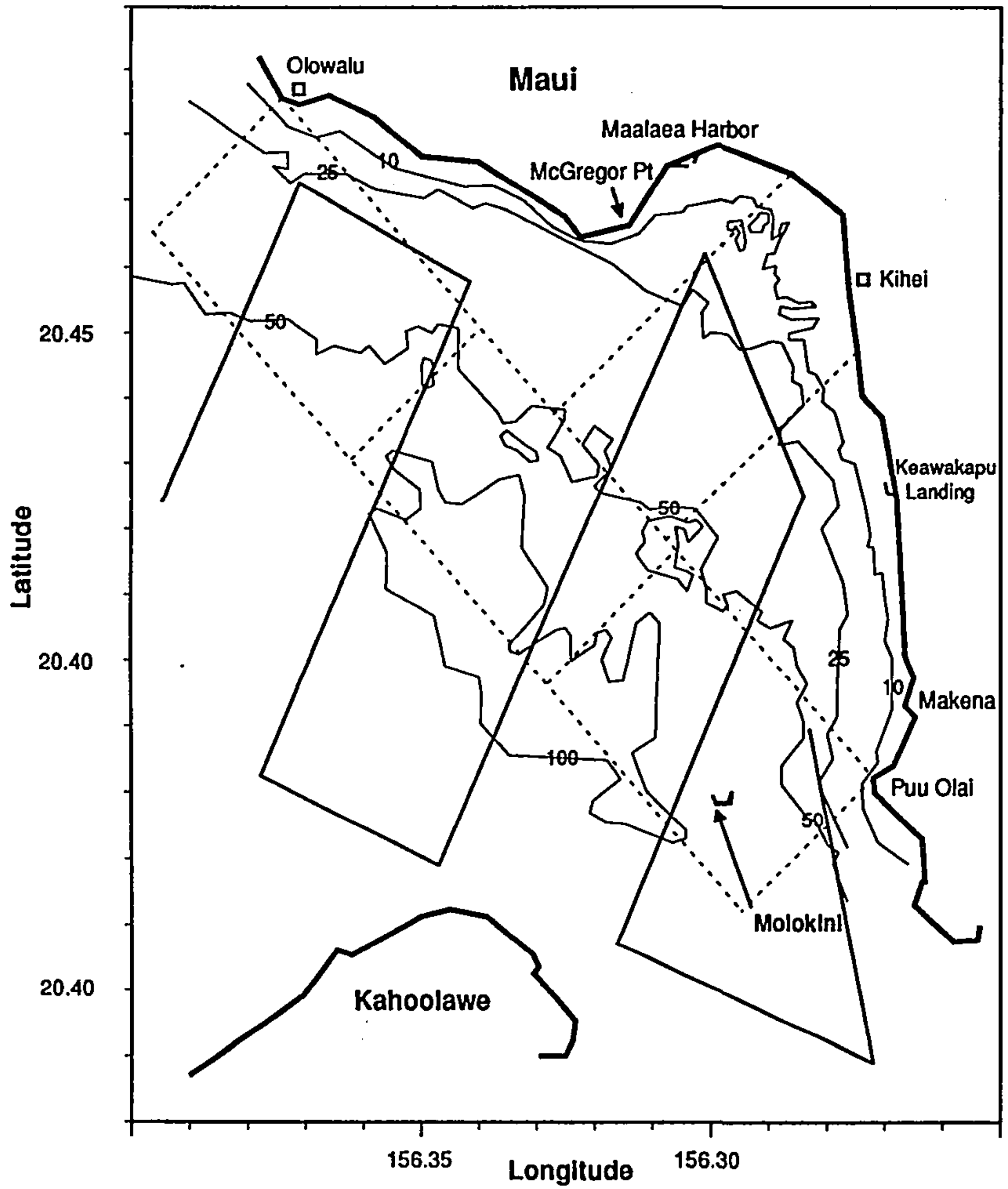

Figure 4: The aerial survey transect used during all surveys from 1985 - 1991 .

Two back-seat observers scanned their respective sides of the aircraft out to a distance of 2.4 km in a sweep 30° - 90° from dead ahead. The aircraft wing-struts were marked with black tape to provide a straight-line sighting aid, when lined up with a mark on the observer's window, in estimating distances of 2.4 km, 1.6 km, and .8 km (after Scott and Winn, 1980). Sighting cue and pod location relative to the aircraft were recorded on a standardized data form for each observation. Weather and sea state were also recorded. These aerial surveys have been ongoing since 1985, and provide data on changes in patterns during those years. The data also allow comparison with aerial surveys conducted by the University of Hawaii from 1977 - 1980 (Herman et al.,1980; Baker and Herman, 1981; and Forestell, Herman, and Kaufman, 1985).

ANALYSIS

Location data for the survey vessel and aircraft, and all whales and boats observed during survey time were entered into an Excel spreadsheet for the Macintosh. Survey time spent in each sub-region, and data on pod composition, boat type and activity, date, time of day, and weather conditions were also entered into the data base. Pod and boat locations were plotted using longitude and latitude, derived either from compass bearings or from data on time, location and direction and distance to the pod or boat from the survey vessel. The alogorithms used to generate the longitude and latitude readings for aerial surveys were developed by Michael Hoffhines of QED Software (Hoffhines, 1991).

Charts of the study area, including depth contours and landmarks, were constructed using Delta Graph. Statistical analyses were carried out on selected portions of the data using Fastat for the Macintosh.

RESULTS

GENERAL FINDINGS

Table 1 presents a summary of observations during small vessel surveys for each month of study in 1989 and 1991. In 1989, there were 309 adults, 25 sub-adults, and 65 calves observed (total = 399 whales) during 158.1 hours of vessel survey. In 1991 there were 714 adults, 49 sub-adults, and 186 calves observed (total = 949) during 190.3 hours of vessel survey. There was a substantial increase in the observation rate (number of whales per hour), from 2.52 whales observed for each hour of survey effort in 1989, to 4.99 in 1991. The proportion of calves (.163 in 1989 and .196 in 1991) also increased, although this may have been due to a greater relative survey effort in April of 1991, since April is typically a time when mother and calf pods predominate. It is not clear what factors were associated with the difference in abundance across the two years. Continuation of survey effort in future would help determine the natural fluctuation of such patterns.

Figure 5 shows locations of all pods of whales observed in 1989. Figure 6 shows locations of all pods of whales observed in 1991. Note that each plot in Figures 5 and 6 represent one pod of whales, which may have included from one to several animals. There appeared to be a tendency for whales to be distributed along the 25-fathom contour inside Maalaea Bay, and along the 50-fathom contour outside the Bay. Given the general preference of humpback whales for relatively shallow, near-shore areas, it should not be surprising to find their distribution influenced by bottom contour. This finding is consistent with earlier work by Forestell (1989), which showed a significantly larger number of whales over the northwesterly edge of Penguin Bank (cf. Figure 2) which averages 25 fathoms in depth, compared with the nearshore end of the Bank, which averages 40 fathoms.

The distribution data from Figures 5 and 6 suggest that humpback whales moved, both inside and outside the Bay, along the major contours in a general SSE to NNW direction (or vice versa), rather than in a distinct pattern across the contours, for example from north to south. On the other hand, when one looks at the distribution of boat locations in 1991 (Figure 7), it is clear that the boat distribution followed a distinct north to south pattern, from Maalaea Small Boat Harbor to Molokini and back, with considerable traffic along the Kihei coast from the boat ramp at Keawakapu to the boat ramp at Makena. One of the first things that becomes clear from the present data is that the general movement patterns of whales, and those of humans, are somewhat more perpendicular to each other, rather than parallel or random, within the study area.

CALF DISTRIBUTION

One of the primary goals of the study was to determine whether more calves were found inside Maalaea Bay than outside. Table 2 summarizes the number of observations of whales and boats and hours of survey effort in each of the six sub-regions during 1989 and 1991. It can be seen that the amount of time spent in each sub-region varied, ranging from 21.5 hours in sub-region 4 during 1989, to 33.6 hours in sub-region 2 during 1991. In order to remove any effect of differences in observations due to differences in amount of effort, the number of observations has been divided in each case by the amount of time spent surveying, in order to determine the observation rate, defined as the rate at which observations were made per hour of survey effort. Note that observation rate is determined on the basis of survey time, rather than amount of time on the water.

TABLE 1: TOTAL SURVEY TIME, NUMBERS OF WHALES AND BOATS OBSERVED, AND AVERAGE HOURLY RATE AT WHICH ADULTS, CALVES, AND BOATS WERE OBSERVED DURING EACH MONTH OF SURVEY IN 1989 AND 1991.

Month	Year	Survey Hours	Total Pods	Total Whales	Total Calves	Adults Per Hr*	Calves Per Hr	Total Boats	Boats Per Hr
JAN	1989	43.0	39	70	7	1.21	.16		
	1991	37.8	43	90	20	2.06	.13	95	2.51
FEB	1989	31.1	62	137	20	2.47	.64		
	1991	41.0	119	303	44	4.39	1.07	212	5.17
MAR	1989	59.0	73	151	33	.93	.56		
	1991	45.4	132	310	73	2.03	1.61	170	3.75
APR	1989	25.0	17	41	5	.84	.20		
	1991	66.1	129	246	64	.98	.97	202	3.05
Sub-	1989	158.1	191	399	65	1.30	.41		
Total	1991	190.3	405	949	186	2.18	.98	679	3.57
TOTAL		348.4	596	1348	251	1.78	.72		

* INCLUDES ONLY WHALES OBSERVED IN PODS THAT DID NOT CONTAIN A CALF.

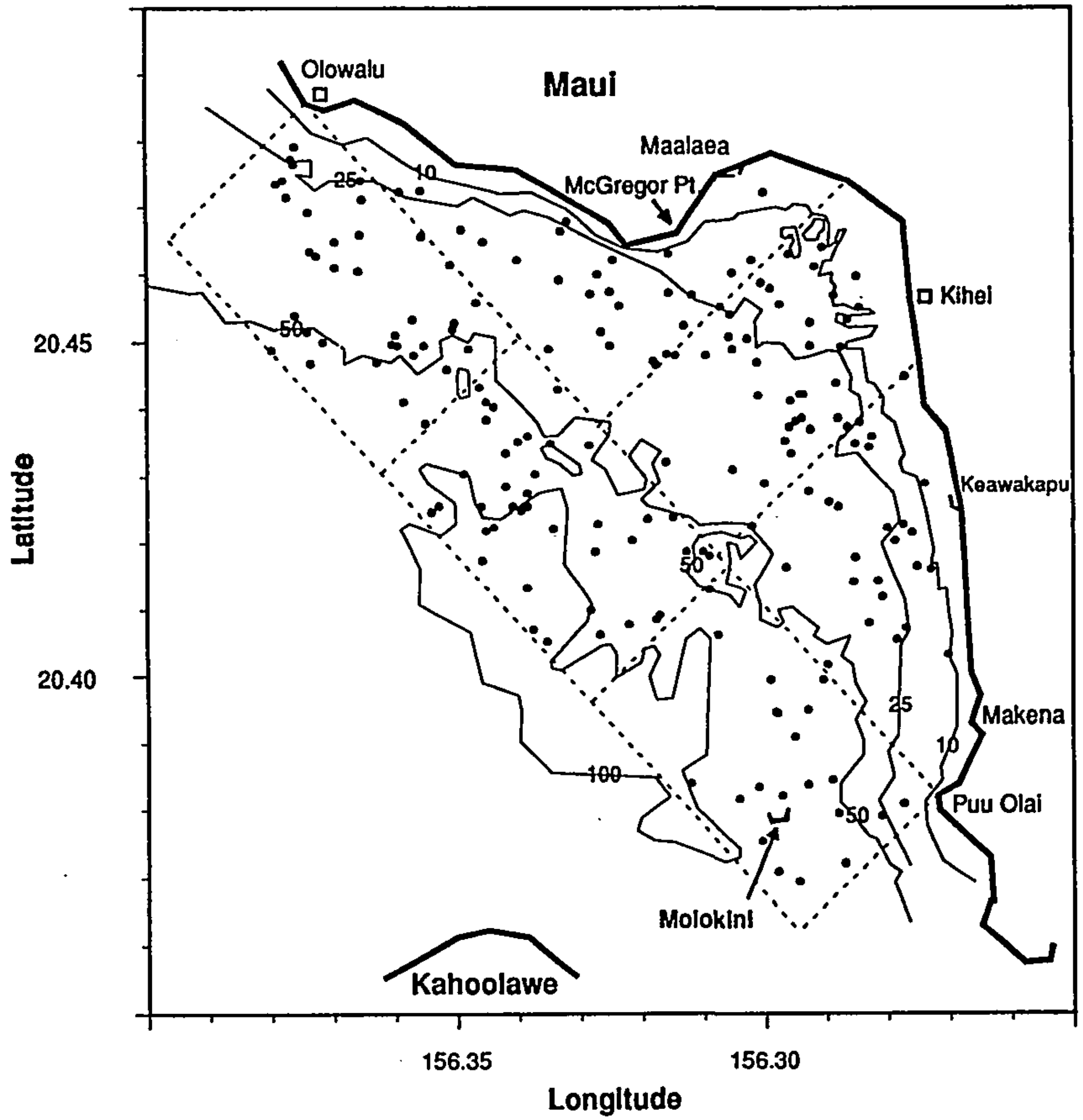

Figure 5: Location of all pods of whales observed during small boat surveys in 1989 (n=191).

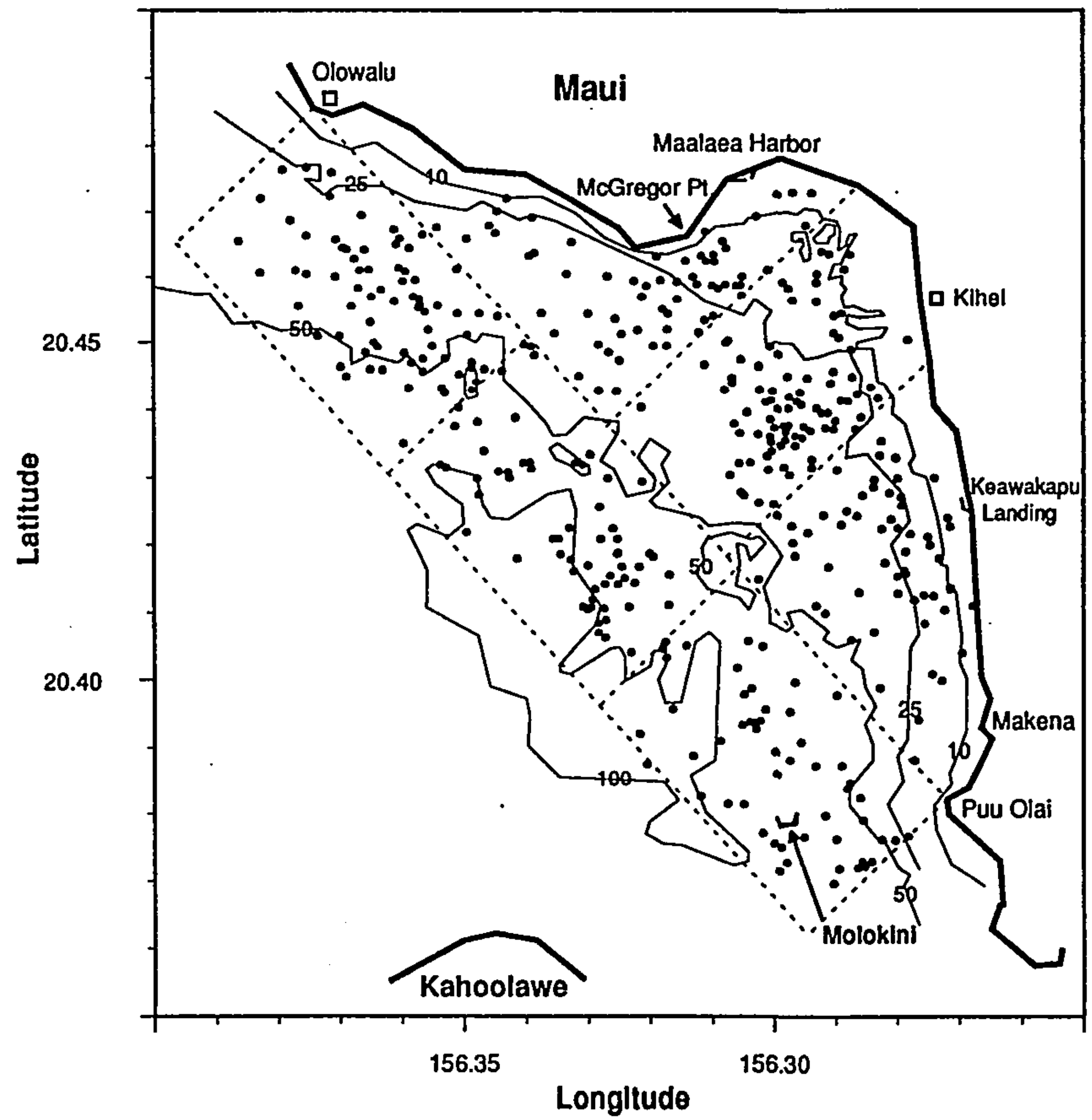

Figure 6: Location of all pods of whales observed during small boat surveys in 1991 (n=405).

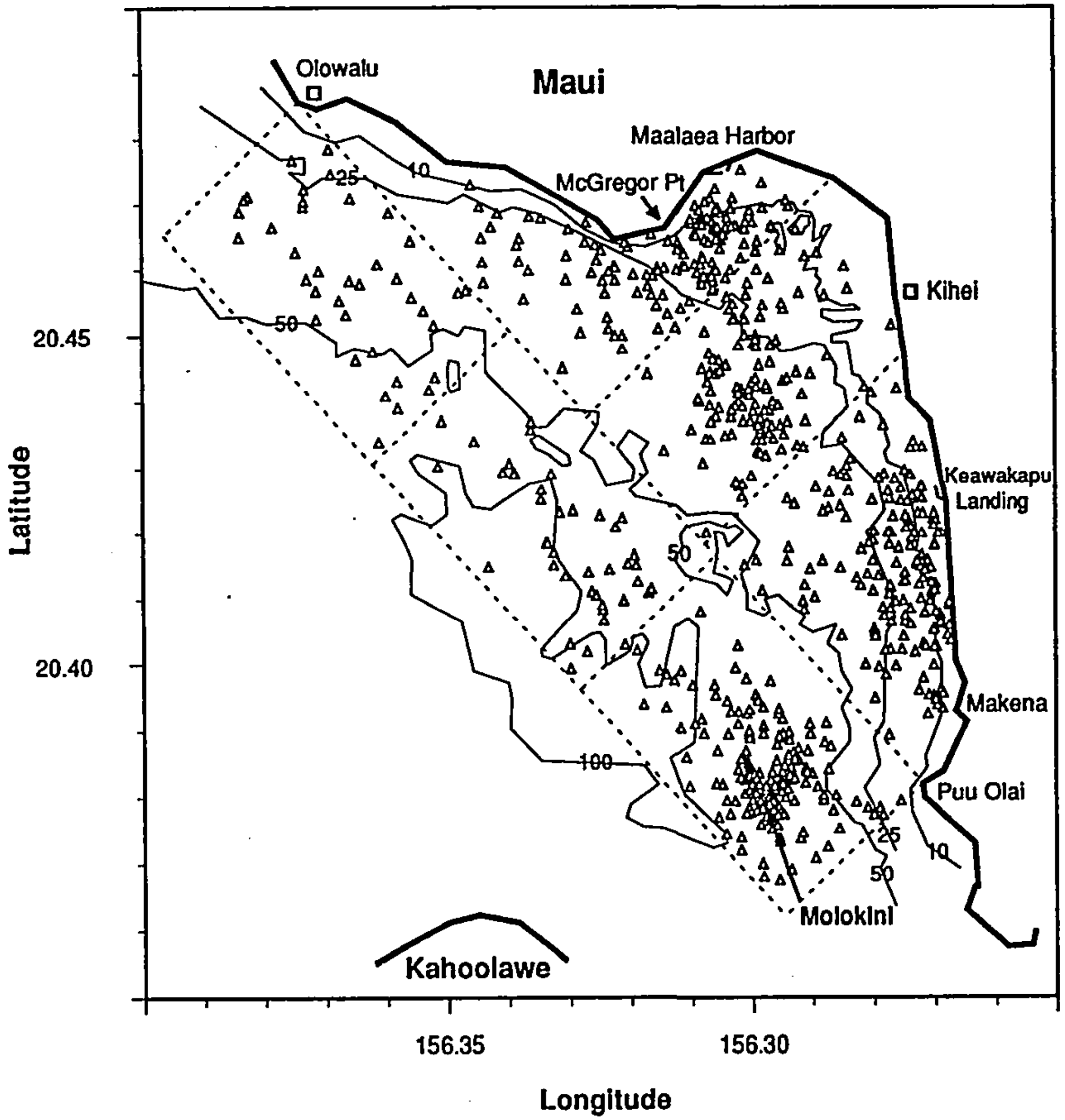

Figure 7: Location of all boats observed during small boat surveys in 1991 (n=679).

TABLE 2: TOTAL SURVEY TIME, NUMBERS OF WHALES AND BOATS OBSERVED, AND AVERAGE HOURLY RATE AT WHICH ADULTS, CALVES, AND BOATS WERE OBSERVED IN EACH SUB-REGION DURING 1989 AND 1991.

YEAR	SUB-REGION	SURVEY HOURS	TOTAL PODS	TOTAL WHALES	TOTAL CALVES	ADULTS PER HR*	CALVES PER HR	TOTAL BOATS	BOATS PER HR
1989	1	22.0	25	45	6	1.27	.27		
	2	30.4	37	75	18	.92	.59		
	3	26.8	27	50	11	.75	.41		
	4	21.5	40	94	14	2.05	.65		
	5	31.2	39	76	5	2.05	.16		
	6	26.2	23	59	11	.80	.42		
SUB-TOTAL		158.1	191	399	65	1.30	.41		
1991	1	31.2	64	142	32	1.70	1.02	134	4.29
	2	33.6	95	244	54	2.85	1.61	125	3.72
	3	32.0	56	130	26	1.60	.81	166	5.20
	4	29.0	76	175	32	2.62	1.10	38	1.31
	5	31.5	59	142	25	2.32	.79	43	1.37
	6	33.0	55	116	17	2.00	.52	173	5.24
SUB-TOTAL		190.3	405	949	186	2.18	.98	679	3.57
TOTAL		348.4	596	1348	251	1.78	.72		

* INCLUDES ONLY WHALES OBSERVED IN PODS THAT DID NOT CONTAIN A CALF.

Figure 8 presents the hourly rate at which calves were observed during each month of survey effort in 1989 and 1991 combined. The observation rate for calves over all months was greater inside the Bay (.80/hr) than outside (.63), but a Chi-square test indicated the difference was not significantly different from chance. It has previously been suggested, however (Forestell, 1979; Herman et al., 1980), that new-born calves may spend the first few weeks with their mothers relatively close to shore, and then move successively further off shore as they grow, mixing more and more frequently with adult pods. In such a case, one would expect relatively more calves inside the Bay early in the season, with an increasing equivalence of calves inside and out later in the season. Again, while the present data do show such a trend, the differences do not reach statistical significance.

Forestell (1989) described a technique for estimating size of animals based on photographs taken during aerial surveys, and it is suggested that such an effort would help establish whether calves outside the Bay are, on the average, significantly larger than those inside the Bay. Photographic analysis could also reduce the likelihood of confusing new calves with yearlings, which is a problem with boat-based observations.

Figure 9 shows the hourly rate at which adults not accompanying a calf were observed during each month of survey effort in 1989 and 1991 combined. Other than the clear influx of adults during February, there is little that is remarkable in these data. Clearly, adults did not show a preference for either inside or outside the Bay.

SUB-REGIONAL DISTRIBUTION

In addition to determining whether calves were more often observed inside the Bay than out, we also looked at whether whales showed a preference for any of the six sub-regions of the study area. Figure 10 shows the relative rates at which adults (excluding mothers) and calves were observed in each area of the study area during 1989 and 1991 combined. Not unexpectedly, the number of adults was far greater than the number of calves; however, there appeared to be no pattern of preference for any one of the sub-regions overall. Chi-square analysis showed the observed values in the six sub-regions did not differ significantly from those expected by chance.

Neither the NMFS-determined boundary demarcating the 300-yard approach area from the 100-yard approach area, or the six artificially determined equal-sized sub-regions appear to bear much relationship to the distribution and movement patterns of humpback whales. For the most part, the depth contour seems to generate the clearest influence.

BEHAVIORAL OBSERVATIONS

No clear differences in type of activity were found as a function of pod size or composition. Activity type did not vary as a function of sub-region, time of day, or time of season. Observations on differences in respiration patterns as a function of pod size and compostion have been reported elsewhere (Brown and Forestell, 1991). In general, increasing numbers of whales and the presence of a calf, act as independent factors to increase the amount of time a pod spends at the surface. However, other identifiable activity characteristics have not yet been identified. The number of observations required to obtain a sufficient sample size for detecting activity differences is extremely large. Additional survey effort is recommended in order to provide sufficent data.

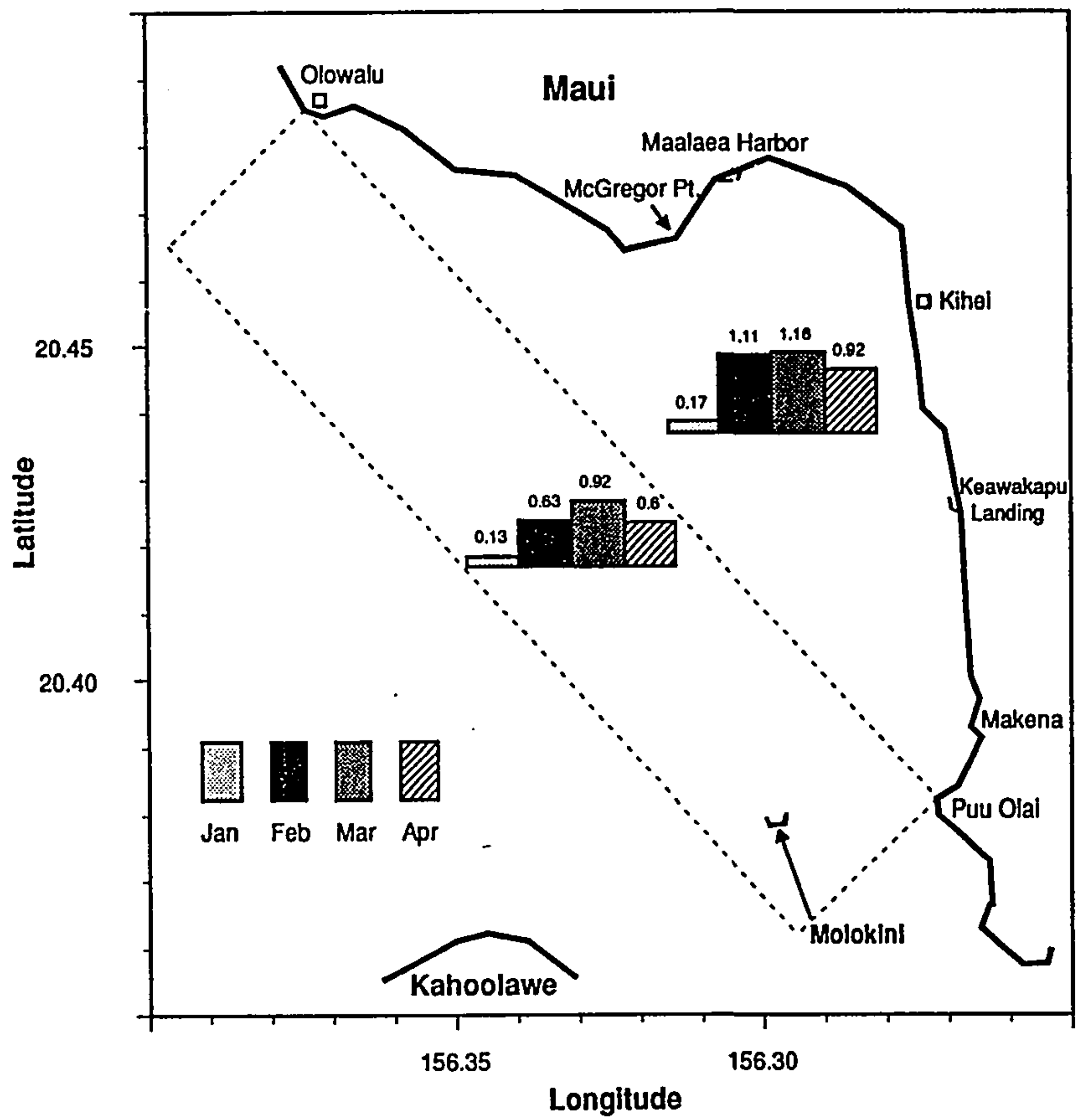

Figure 8: Rate (Whales/Hr.) at which calves were observed both inside and outside of Maalaea Bay in each month during small boat surveys in 1989 and 1991.

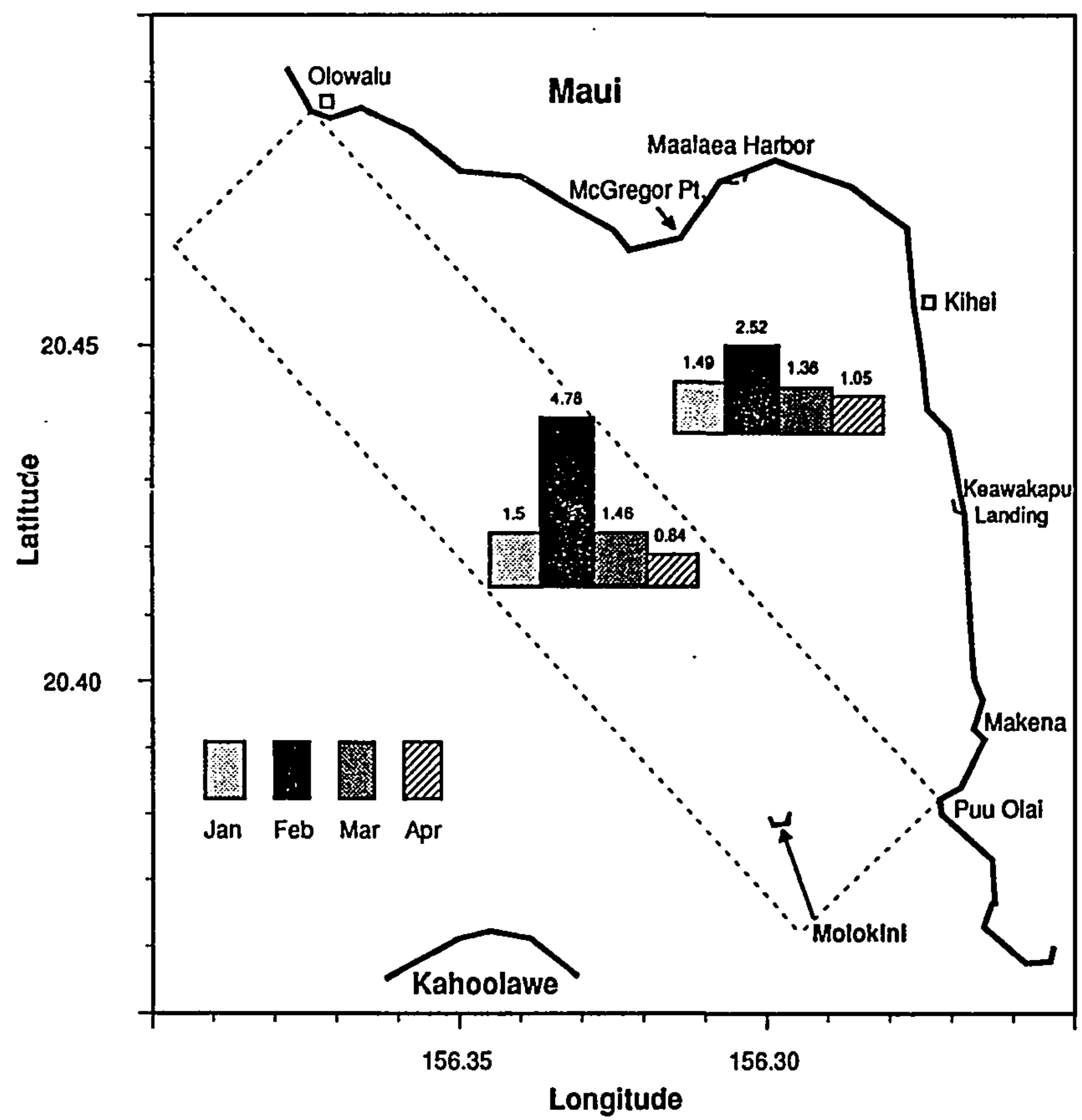

Figure 9: Rate (Whales/Hr.) at which adults not accompanying a calf were observed both inside and outside of Maalaea Bay in each month during small boat surveys in 1989 and 1991.

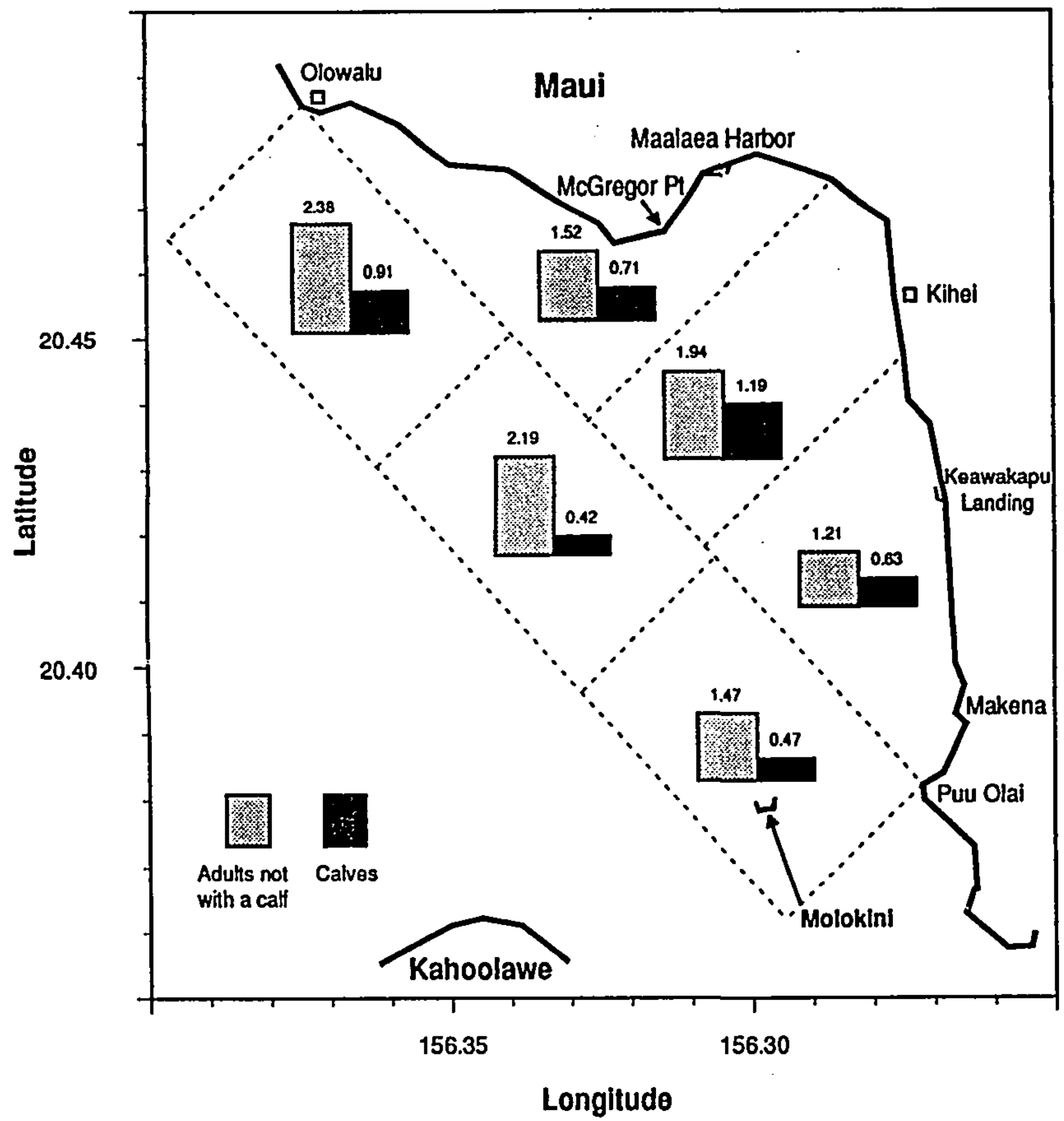

Figure 10: Rate (Whales/Hr.) at which calves and adults not accompanying a calf were observed in the six sub-regions of the study area during small boat surveys in 1989 and 1991.

IMPACT OF VESSEL TRAFFIC

An additional factor of importance in considering humpback whale activity in the study area is the boat traffic that was observed (Figure 7). We looked at two aspects of boat impacts: the relationship between boat density and whale density in each sub-region, and the frequency and location of boat - whale interactions.

Temporal Distribution of Whales and Boats: To determine the nature of the relationship between whale and boat density, we looked at the changes in distribution of each across three two-hour time periods of the day: from 0900 - 1100 hrs., from 1100 - 1300 hrs., and from 1300 - 1500 hrs. The amount of survey effort conducted between 0700 hrs. and 0900 hrs., and after 1500 hrs. was insufficient to justify inclusion of those time periods in our analysis.

Figures 11 through 19 show the locations of boats, pods without a calf, and pods with a calf observed in each two-hour block of time between 0900 and 1300 hrs. during the 1991 survey effort. It should be noted that the amount of total survey effort tended to decrease across the two-hour blocks, since weather conditions were more likely to deteriorate later in the day than earlier. Therefore, the differences in numbers of plots in Figures 11 through 19 reflect differences in survey time as well as any other effects.

In general, it can be seen that early in the day, boats were concentrated primarily in sub-regions 3 and 6. This was associated with the popularity of Molokini Crater as a snorkel destination for tourists. Between 0900 and 1000 hrs., boats that had left Maalaea Small Boat Harbor between 0700 and 0800 had arrived at Molokini, and smaller boats from Keawakapu Boat Ramp and Makena Landing were on their way out for diving and snorkeling trips.

Between 1100 and 1300 hrs., boats were returning to Maalaea and Keawakapu, and sub-regions 1, 2 and 3 showed the largest relative use by boats. Finally, between 1300 and 1500, smaller boats from Keawakapu and Makena were off the water, while larger boats (particularly those engaged in whalewatching) out of Maalaea Bay were still out, particularly in sub-regions 1 and 2.

The distribution of boats, calves, and whales not accompanying calves can be better understood by adjusting for survey effort. The rate at which boats, calves, and whales not accompanying calves were observed during each time block in each sub-region are presented in Table 3. The two sub-regions with the highest rates for boats and whales in each time block are as follows:

From 0900 - 1100: boats were highest in sub-regions 3 and 6;
calves were highest in sub-regions 1 and 2;
whales not with calves were highest in sub-regions 4 and 5.

From 1100 - 1300: boats were highest in sub-regions 1 and 3;
calves were highest in sub-regions 2 and 4;
whales not with calves were highest in sub-regions 2 and 5.

From 1300 - 1500: boats were highest in sub-regions 1 and 2;
calves were highest in sub-regions 2 and 4;
whales not with calves were highest in sub-regions 3 and 4.

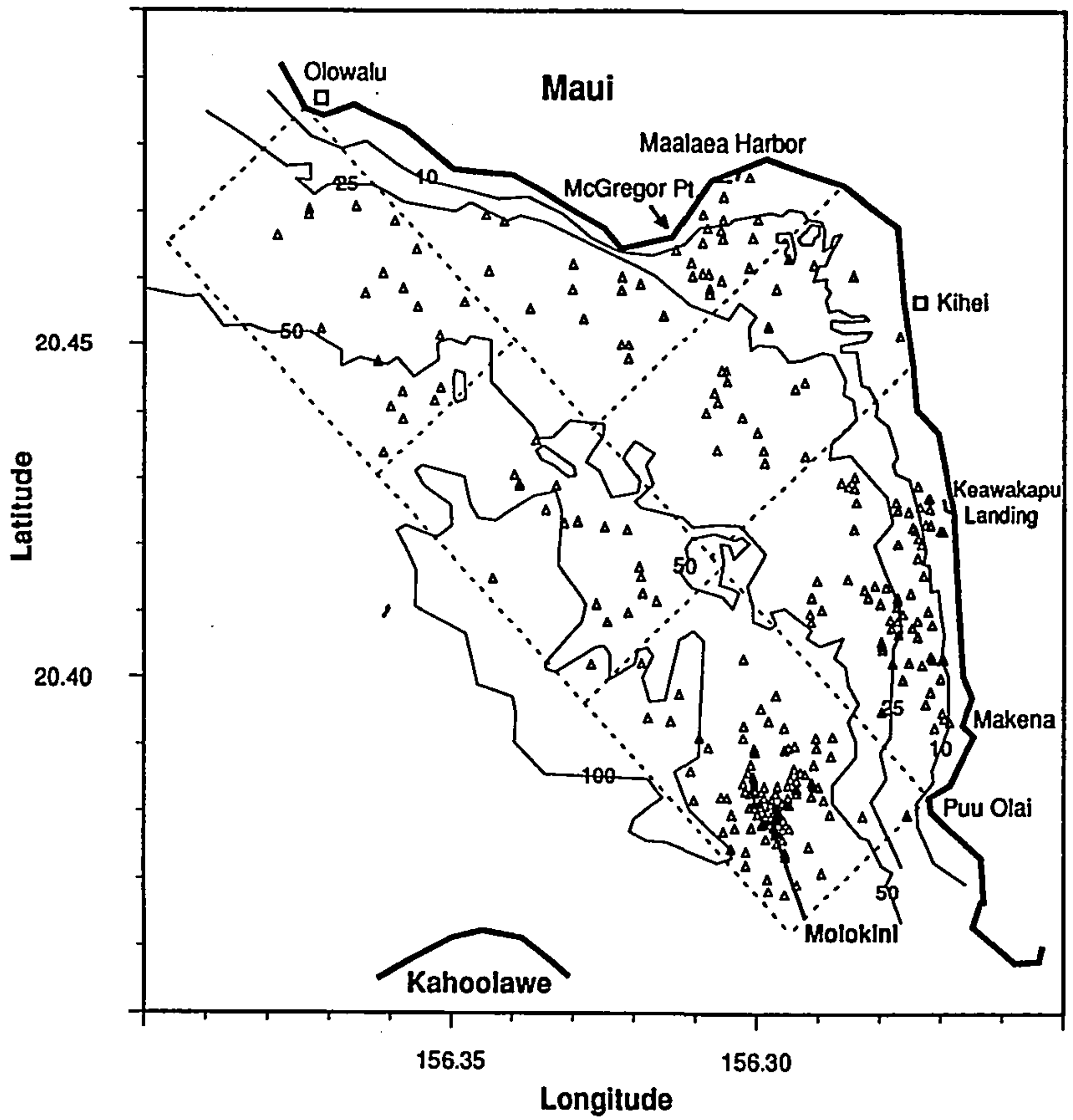

Figure 11: Location of boats observed during small boat surveys in 1991 from 9:00-11:00 (n=272).

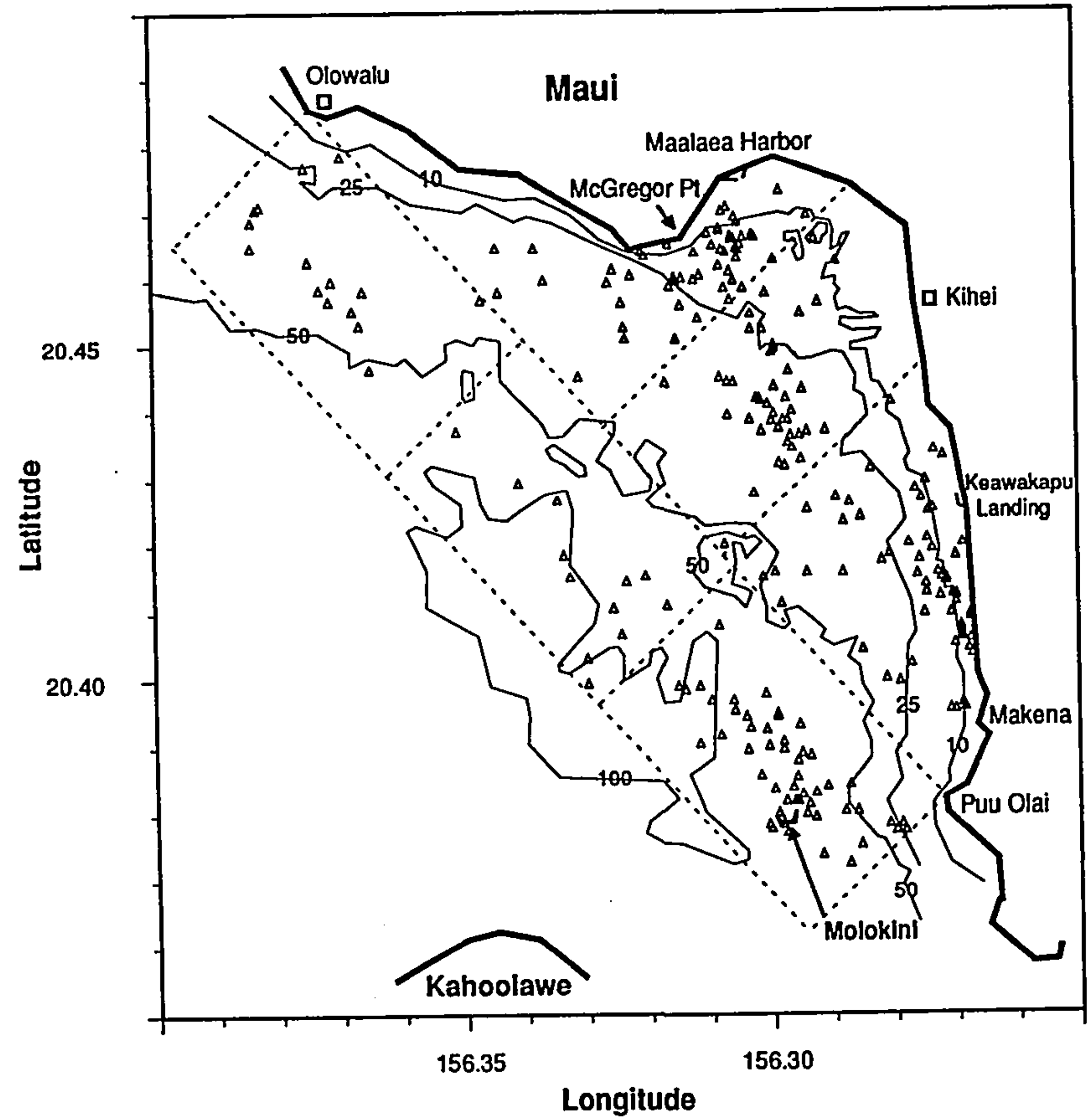

Figure 12: Location of boats observed during small boat surveys in 1991 from 11:00-13:00 (n=240).

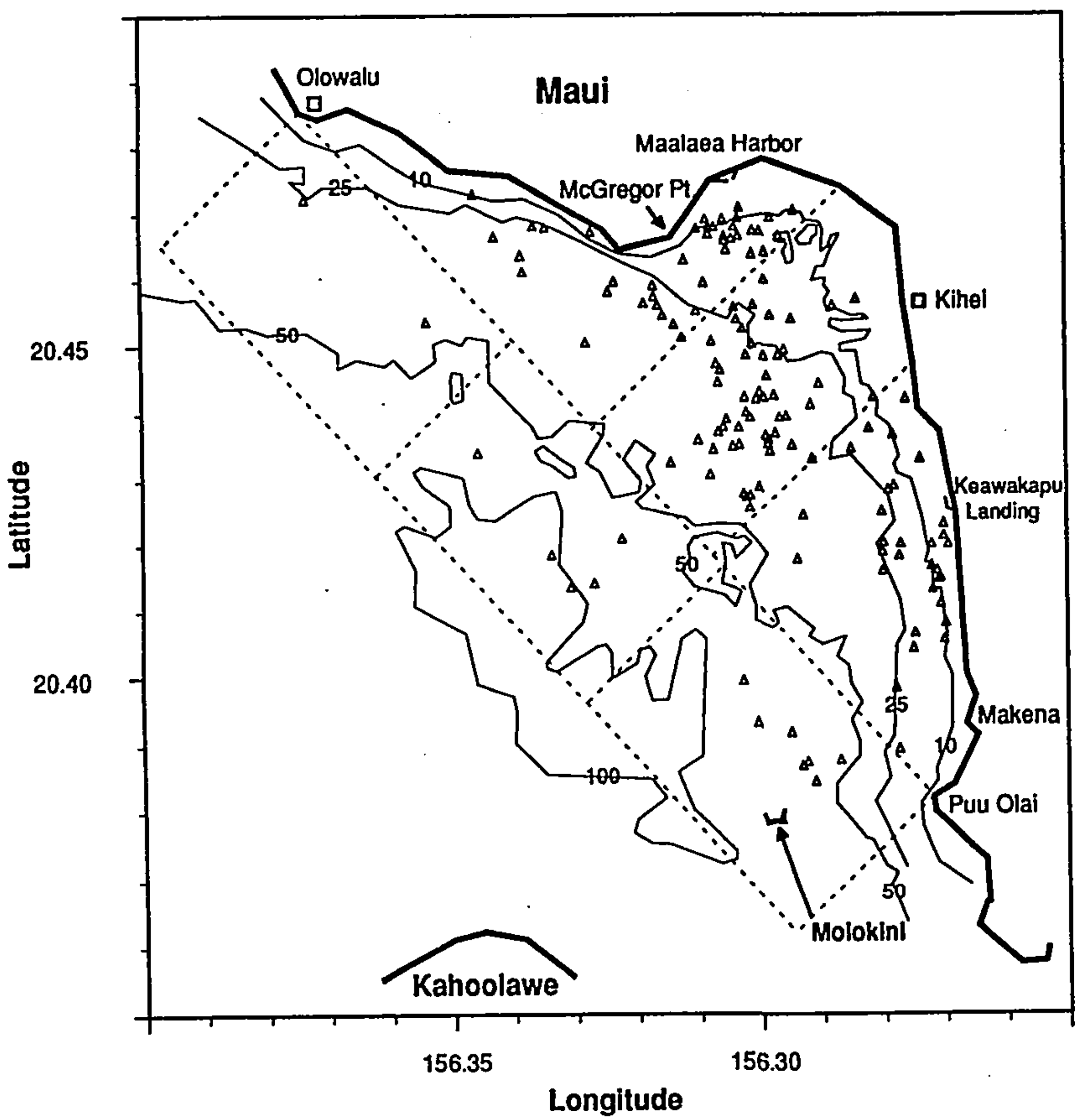

Figure 13: Location of boats observed during small boat surveys in 1991 from 13:00-15:00 (n=140).

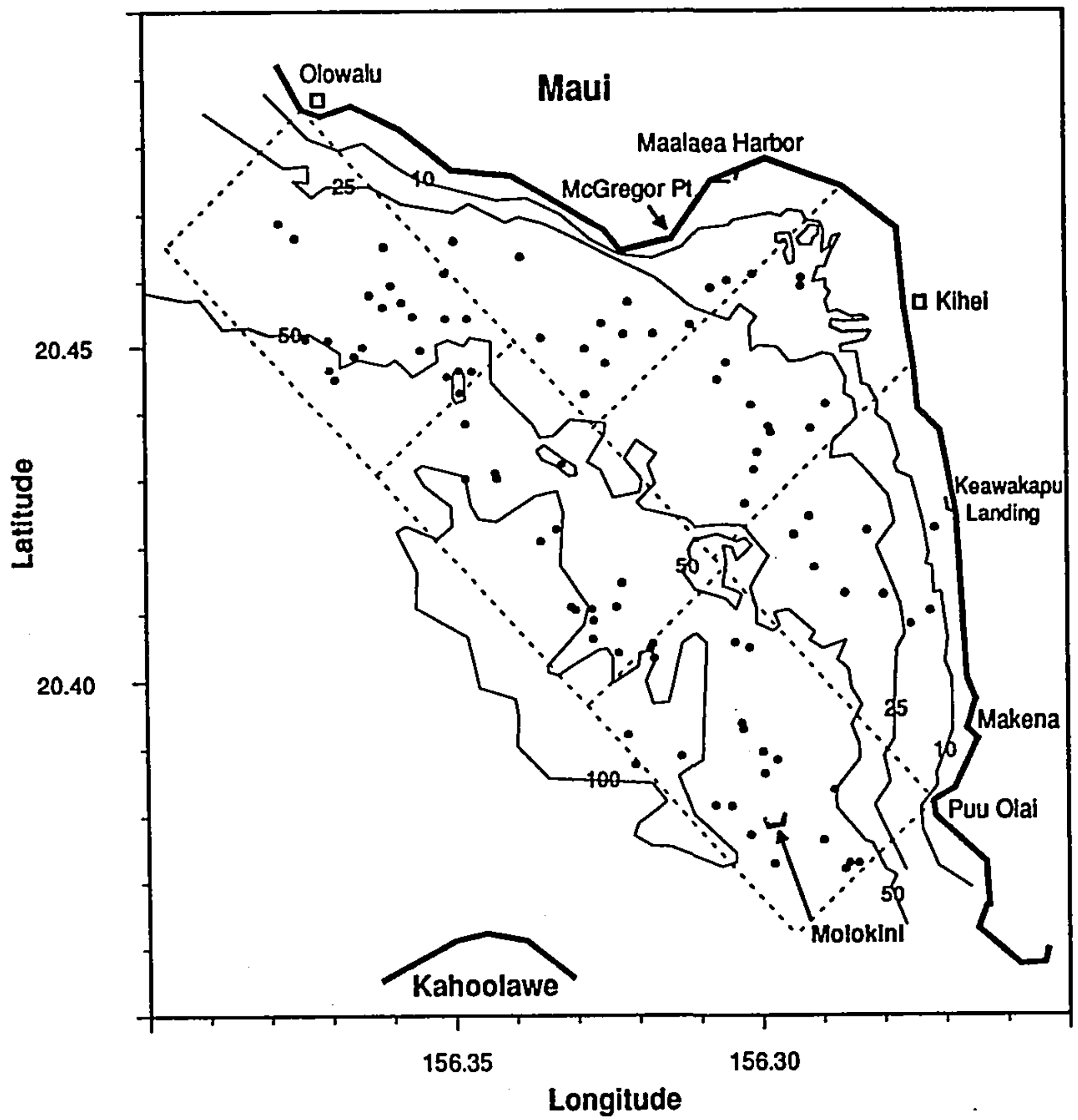

Figure 14: Location of adults not accompanying a calf observed during small boat surveys in 1991 from 9:00-11:00 (n=101).

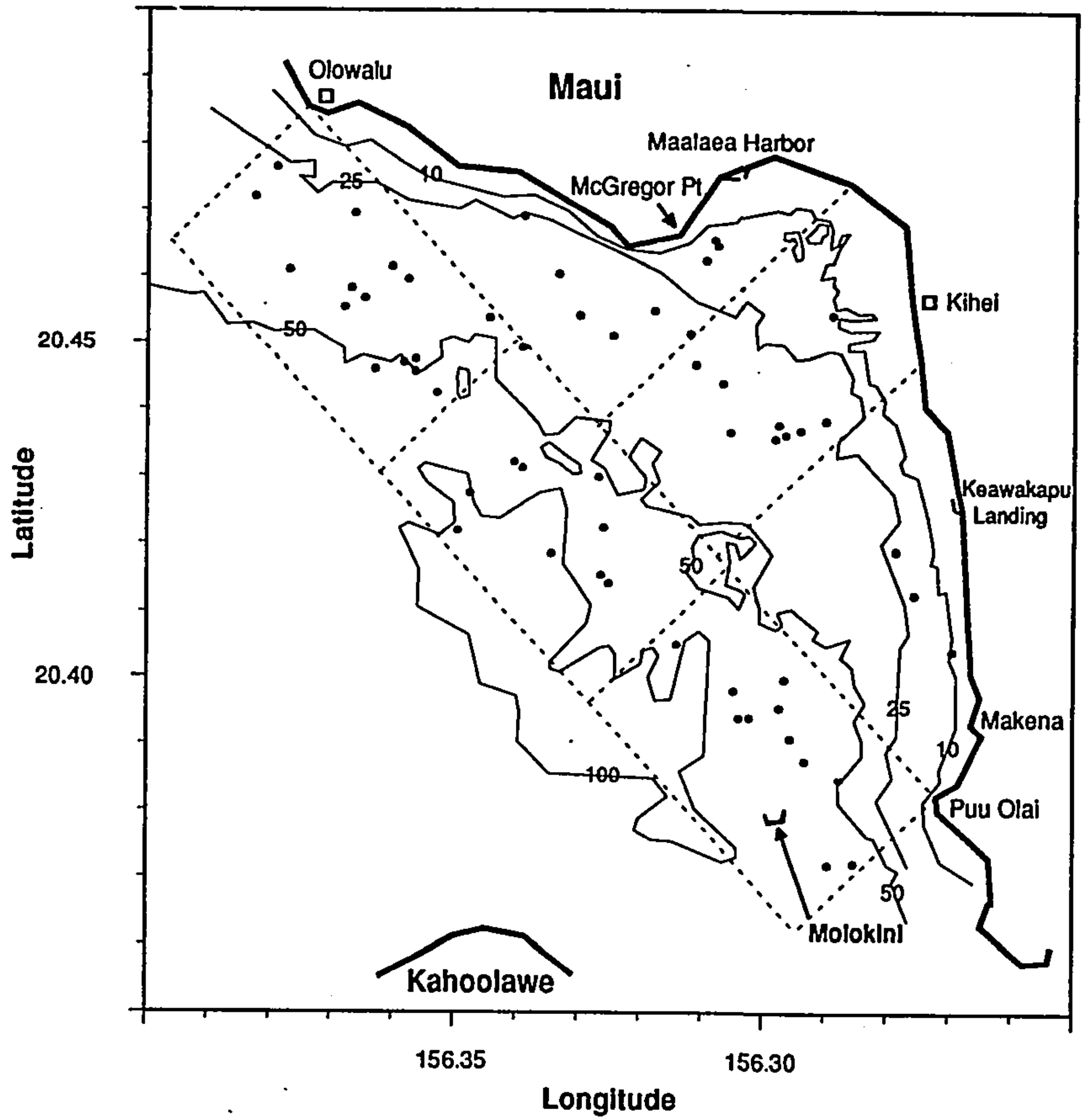

Figure 15: Location of adults not accompanying a calf observed during small boat surveys in 1991 from 11:00-13:00 (n=59).

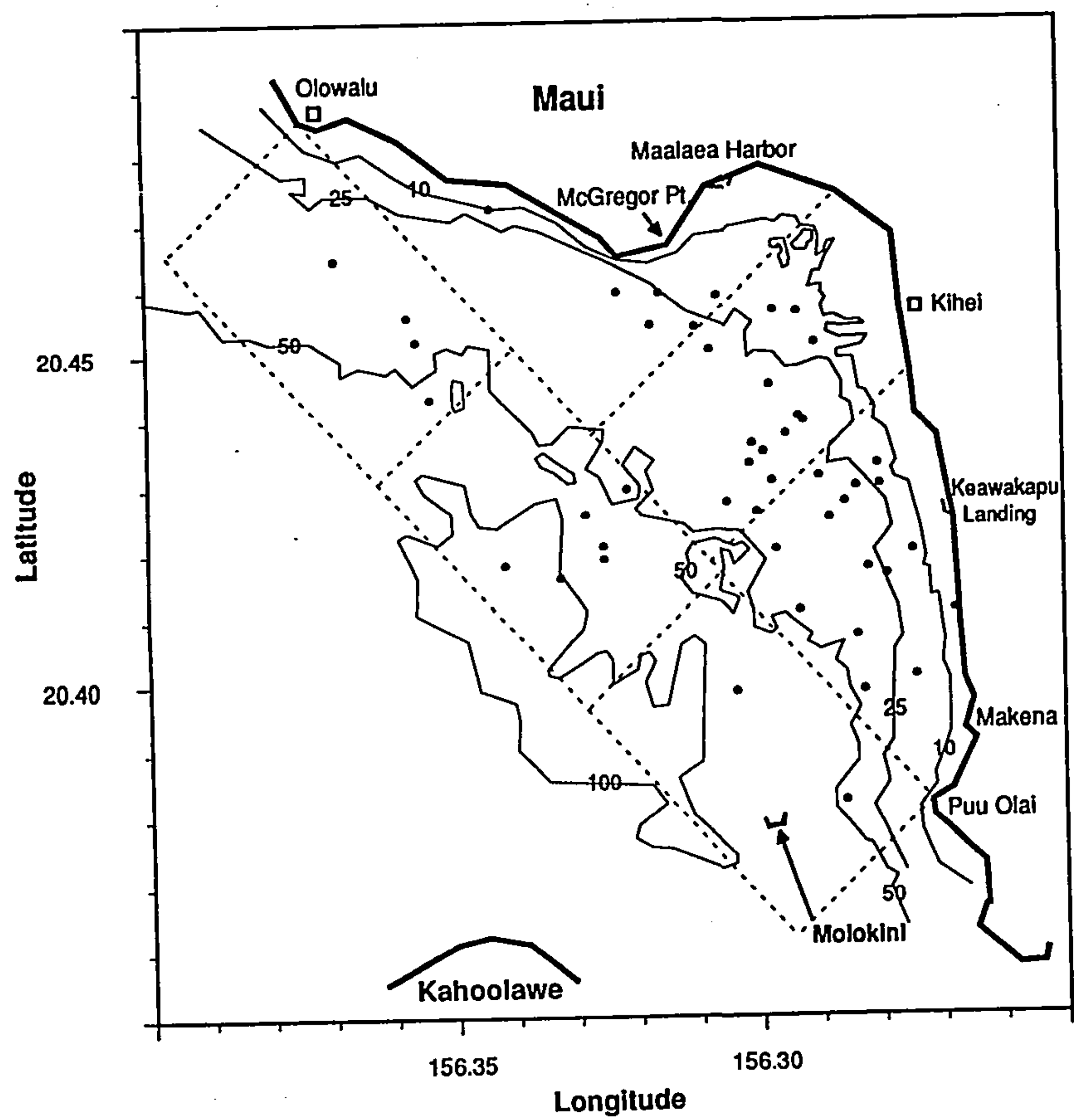

Figure 16: Location of adults not accompanying a calf observed during small boat surveys in 1991 from 13:00-15:00 (n=47).

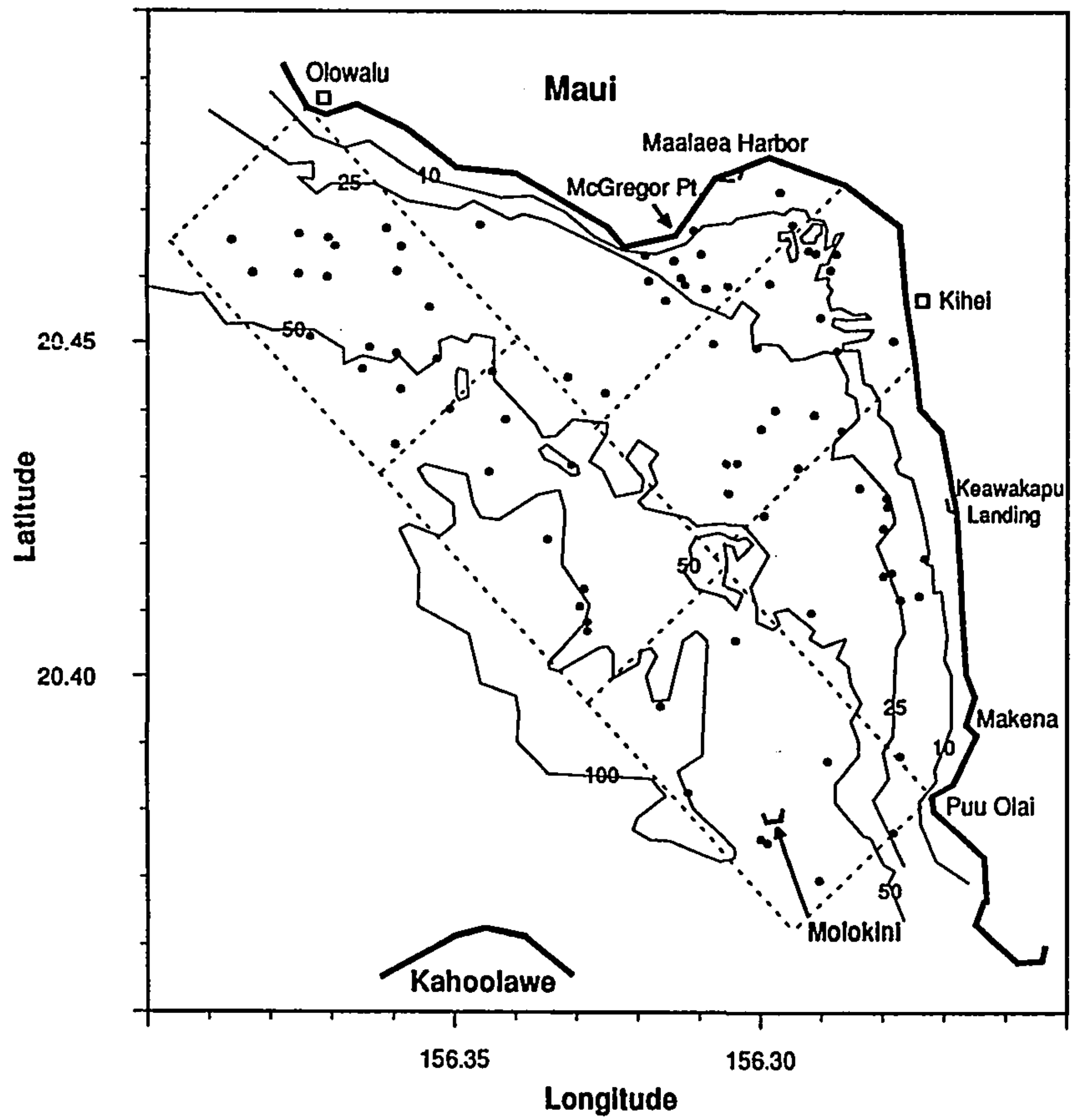

Figure 17: Location of calves observed during small boat surveys in 1991 from 9:00-11:00 (n=82).

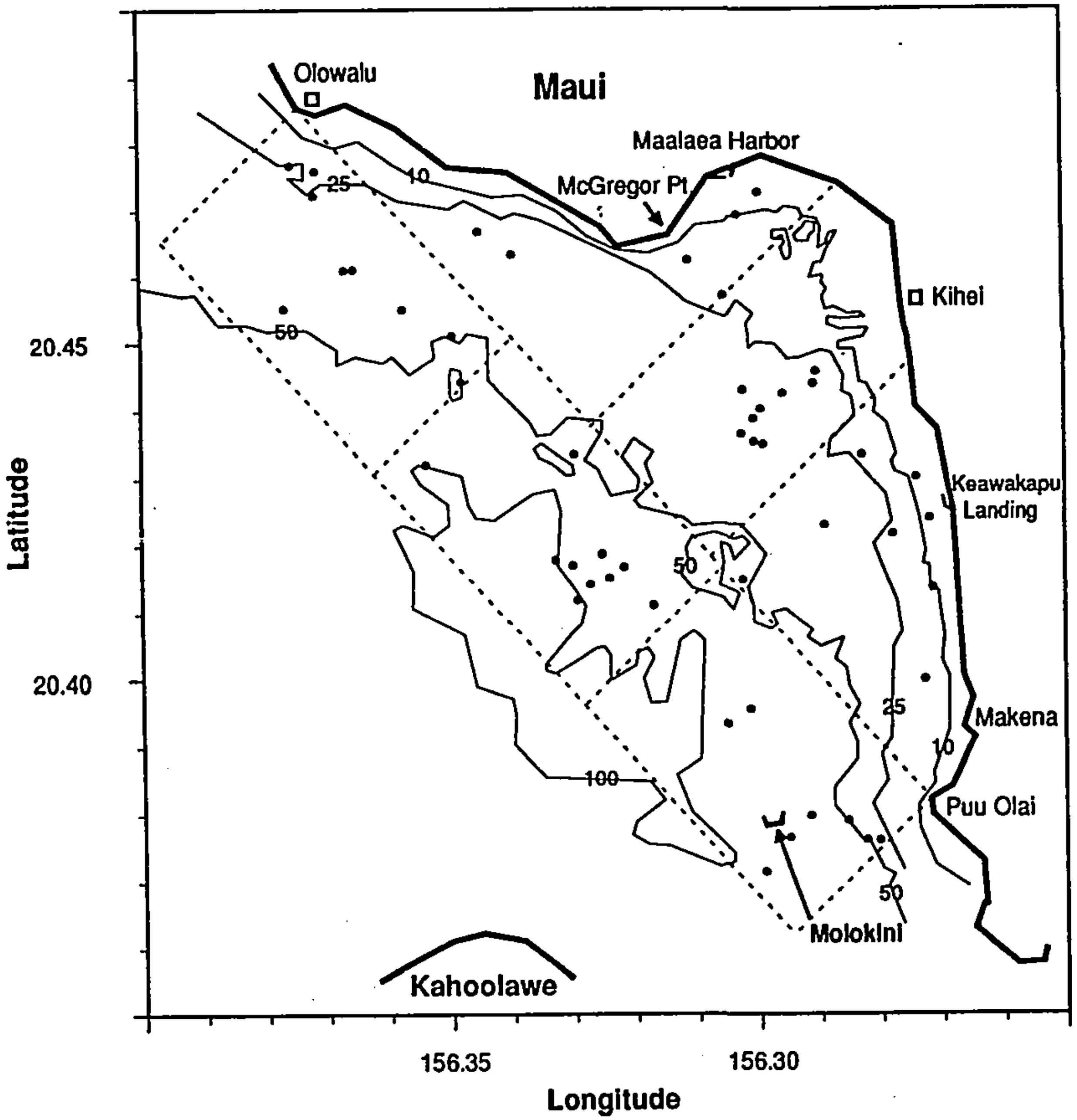

Figure 18: Location of calves observed during small boat surveys in 1991 from 11:00-13:00 (n=50).

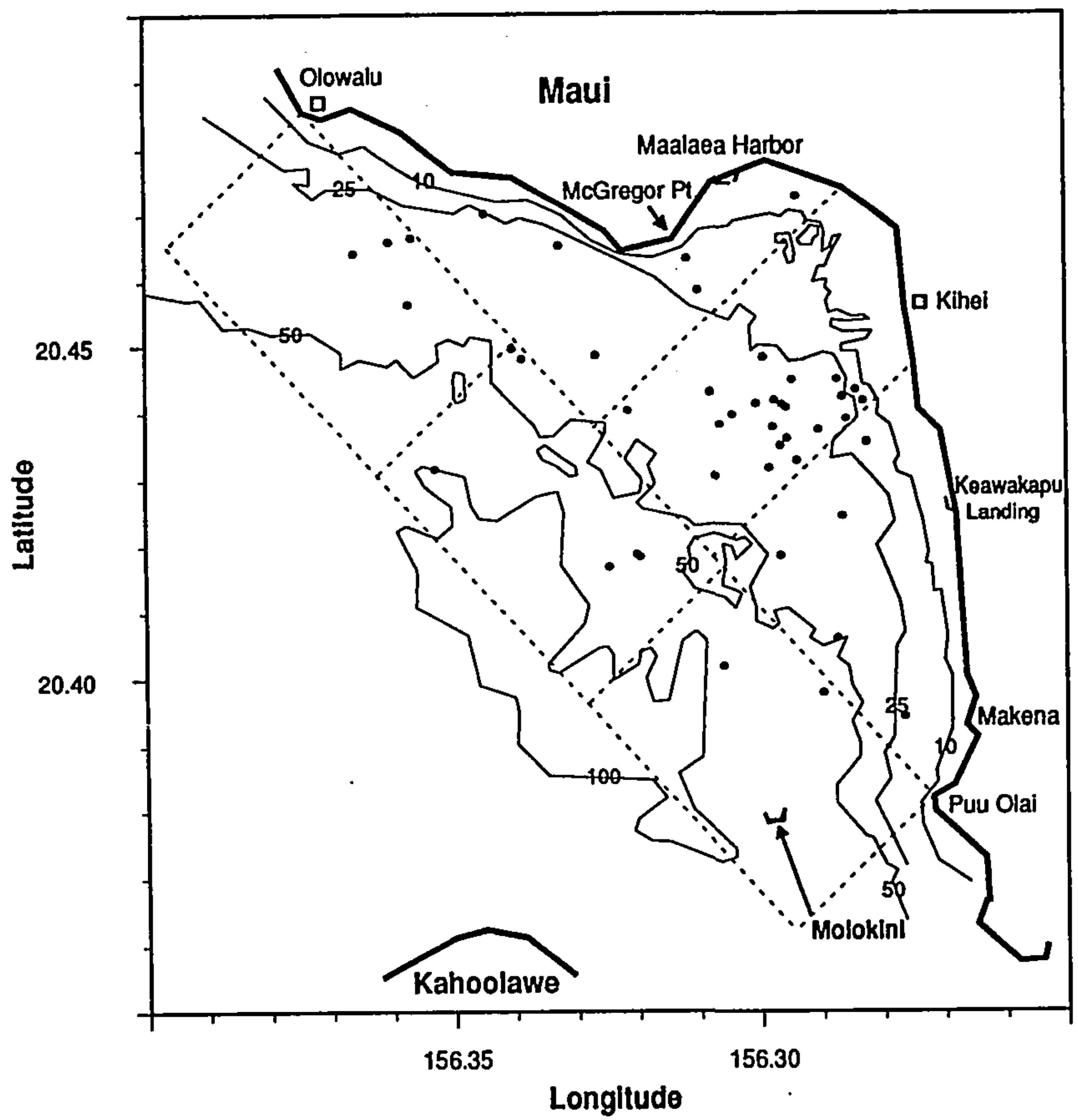

Figure 19: Location of calves observed during small boat surveys in 1991 from 13:00-15:00 (n=46).

TABLE 3: AVERAGE HOURLY RATE AT WHICH ADULTS NOT ACCOMPANYING CALVES, CALVES, AND BOATS WERE OBSERVED IN EACH SUB-REGION DURING EACH TWO-HOUR INTERVAL BETWEEN 0900 AND 1500 HRS IN 1989 AND 1991.

TIME START	SUB-REGION	SURVEY HOURS	ADULTS PER HR*	CALVES PER HR	BOATS PER HR
0900	1	26.1	2.18	1.05	2.11
	2	32.8	1.98	1.47	1.61
	3	26.8	1.00	1.00	5.92
	4	27.0	2.74	1.00	1.05
	5	30.0	2.73	.53	1.40
	6	27.0	2.41	.47	6.41
1100	1	12.2	2.00	1.00	7.57
	2	15.3	3.57	1.29	6.43
	3	13.0	.44	.89	6.89
	4	16.5	3.00	1.29	2.29
	5	14.2	3.13	1.25	1.50
	6	22.2	2.27	.64	4.73
1300	1	11.0	.67	1.33	6.67
	2	13.0	3.42	1.92	4.50
	3	16.0	3.46	.56	3.46
	4	6.0	3.50	2.00	1.00
	5	12.5	1.45	.73	.91
	6	6.0	.50	.50	2.00

* INCLUDES ONLY WHALES OBSERVED IN PODS THAT DID NOT CONTAIN A CALF.

These patterns show evidence that as the focal areas of boat traffic changes through the day, the distribution of whales also changes. This can be better assessed by looking at a Pearson Correlation Matrix of observation rates. The correlation between boats and calves, based on 18 paired observations (6 sub-regions during 3 time blocks) is a negative .08, suggesting that calf distribution is quite independent of boat distribution. However, the correlation between boats and whales not with calves is a negative .28, a moderate but important indication that movement of whales not in calf pods is influenced by boats.

Boat-Whale Interactions: The locations of all observations of whales with boats within .4 km are shown in Figure 20. of the 73 pods observed with boats nearby, 33 (45.2%) were calf pods. Of the 405 pods observed during 1991, 186 (45.9%) were calf pods, therefore it appears that calf pods are no more likely to be approached by boats than non-calf pods. The present data do not allow a determination of whether boats may behave differently around calf pods, or stay longer, or get closer.

The rate of boat-whale encounters is at least 50% greater inside the Bay (.46 encounters per hour of survey) than outside (.30 encounters per hour). The highest encounter rates overall were found in sub-regions 4 (.24/hr), 1 (.22/hr), and 2 (.21/hr). The observations rates in sub-regions 5 (.10/hr), 3 (.13/hr), and 6(.15/hr) were considerably lower.

AERIAL SURVEY DATA

Changes in Frequency of Observations: Figure 21 shows the location of all pods of whales observed during flights conducted in 1978, 1979, 1985, 1986, 1989, 1990, and 1991. The data from 1978 and 1979 are from Forestell et al. (1985), using procedures described in Herman et al., 1980. The remaining data are from Forestell (1989, 1991) using procedures described in Forestell (1989). Survey effort across all years is essentially equivalent, providing a reasonable index of abundance changes during the period 1978 - 1991. The data were grouped in blocks of two years each, from 1978 - 1990. The locations of whales observed in each two-year interval is shown in Figures 22 - 24. Figure 25 shows the results for 1991 alone.

A Chi-square test was conducted on the frequency of sightings for the three two-year periods: 1978-1979, 1985-1986, and 1989-1990. There was a significantly greater than chance increase in frequency of sightings ($X^2 = 14.03$, df = 2, $p<.001$) indicating that the use of Maalaea Bay and the adjoining waters by whales has increased during that period. The observation of 71 pods in 1991 indicates the trend continues. The number of calves observed in each two-year period, however, has not shown a significant change, either up or down. There were 10 calf pods observed in 1978-1979; 9 in 1985-1986; 19 in 1989 - 1990; and 11 in 1991 alone. Although the numbers do show an upward trend, the increase is not yet statistically significant. Continuation of surveys should help establish whether calf observations are increasing.

Comparison of Boat and Aerial Observations: A comparison of the boat survey data and the aerial survey data provides an opportunity to look at the correspondence between patterns observed from the water with patterns observed from the air.

The degree of correspondence can be seen by comparing Figure 6, showing the locations of all pods of whales observed during boat surveys in 1989 and 1991, with Figure 21, showing the locations of all pods of whales observed during aerial surveys

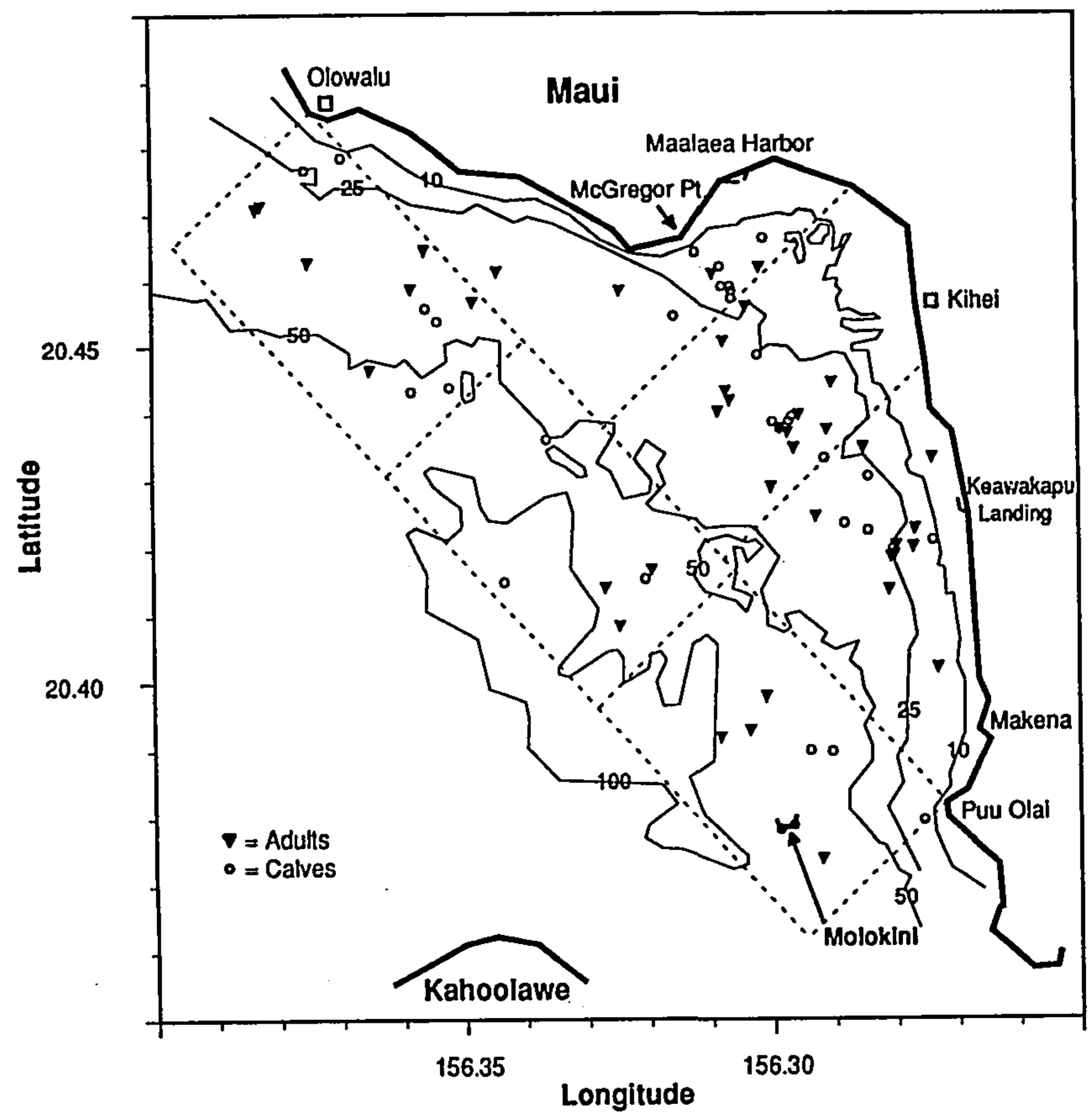

Figure 20: Location at which boats were observed within .25 miles of adult and calf pods during small boat surveys in 1991 (n=73).

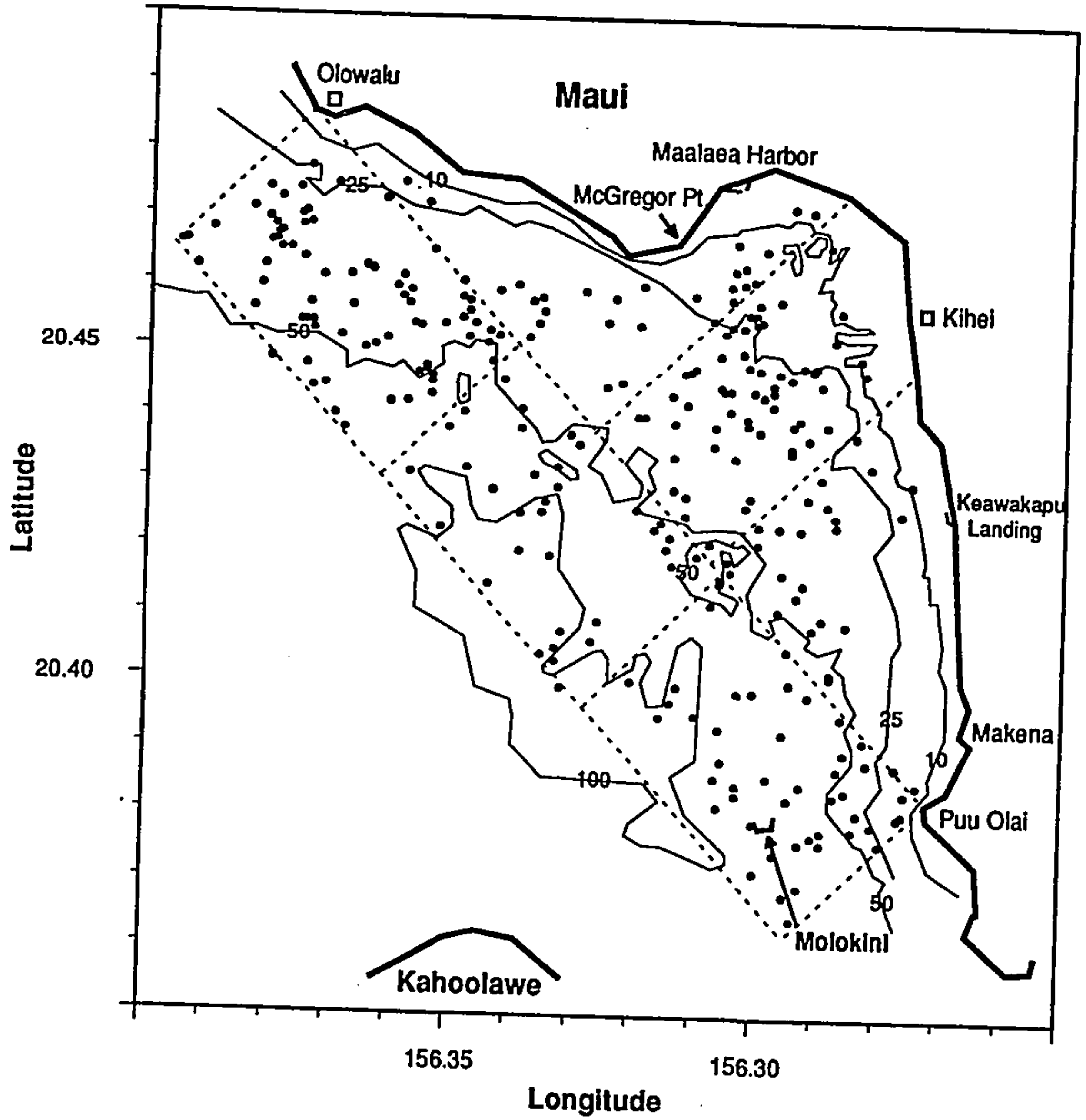

Figure 21: Location of all pods observed during aerial surveys from 1978 to 1991 (n=272).

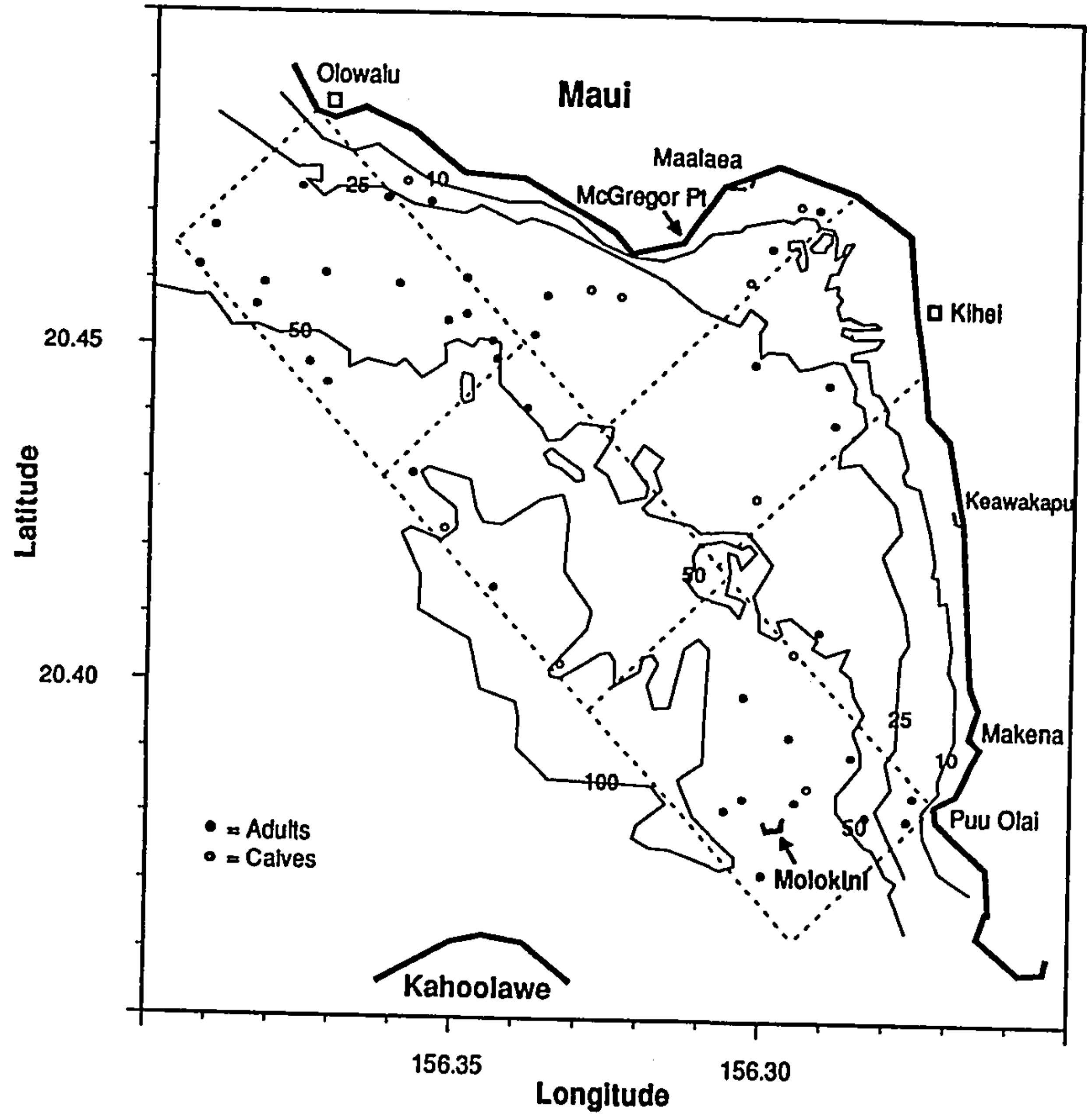

Figure 22: Location of adult and calf pods observed during aerial surveys in 1978 and 1979 (n=47).

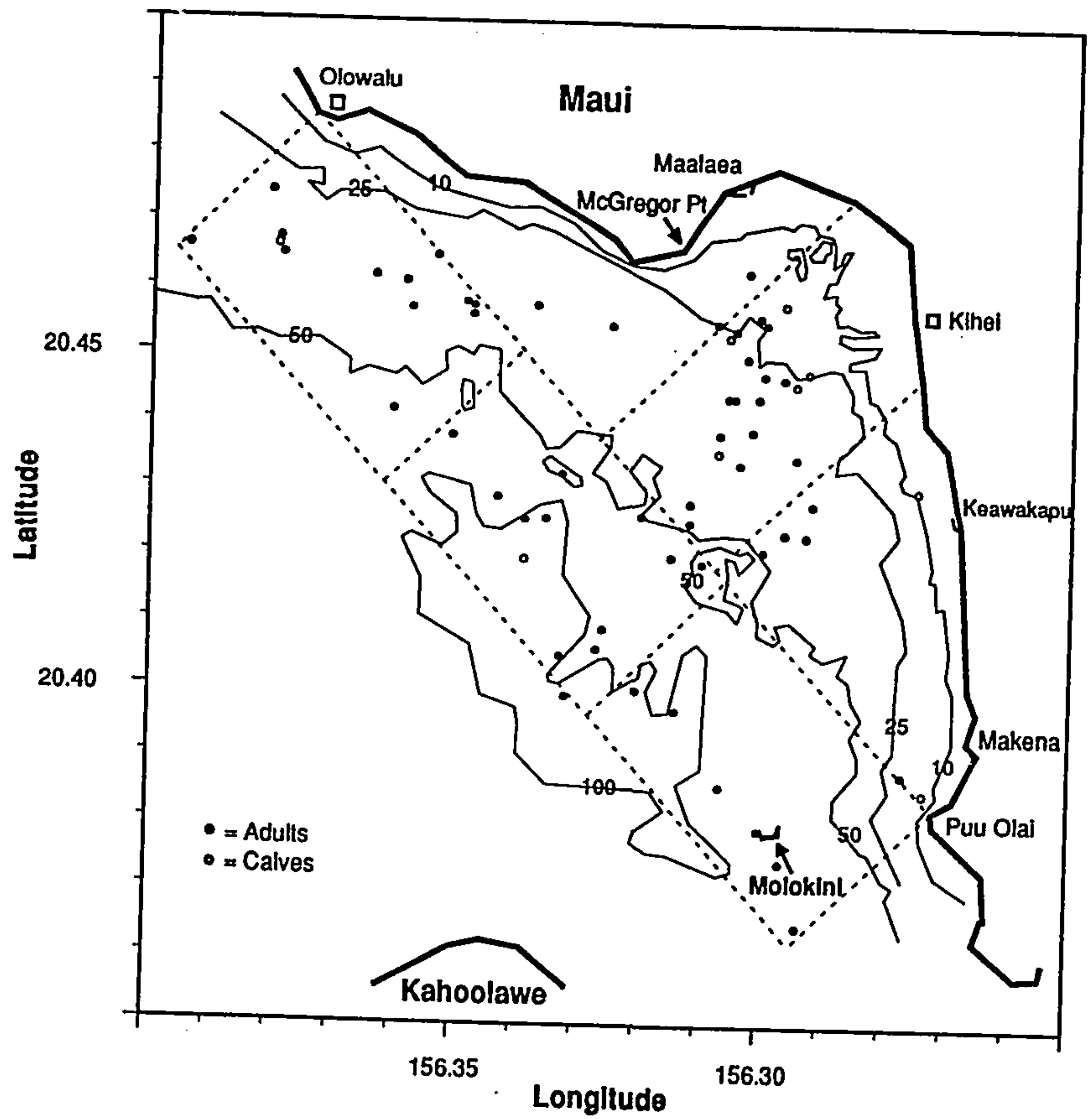

Figure 23: Location of adult and calf pods observed during aerial surveys in 1985 and 1986 (n=64).

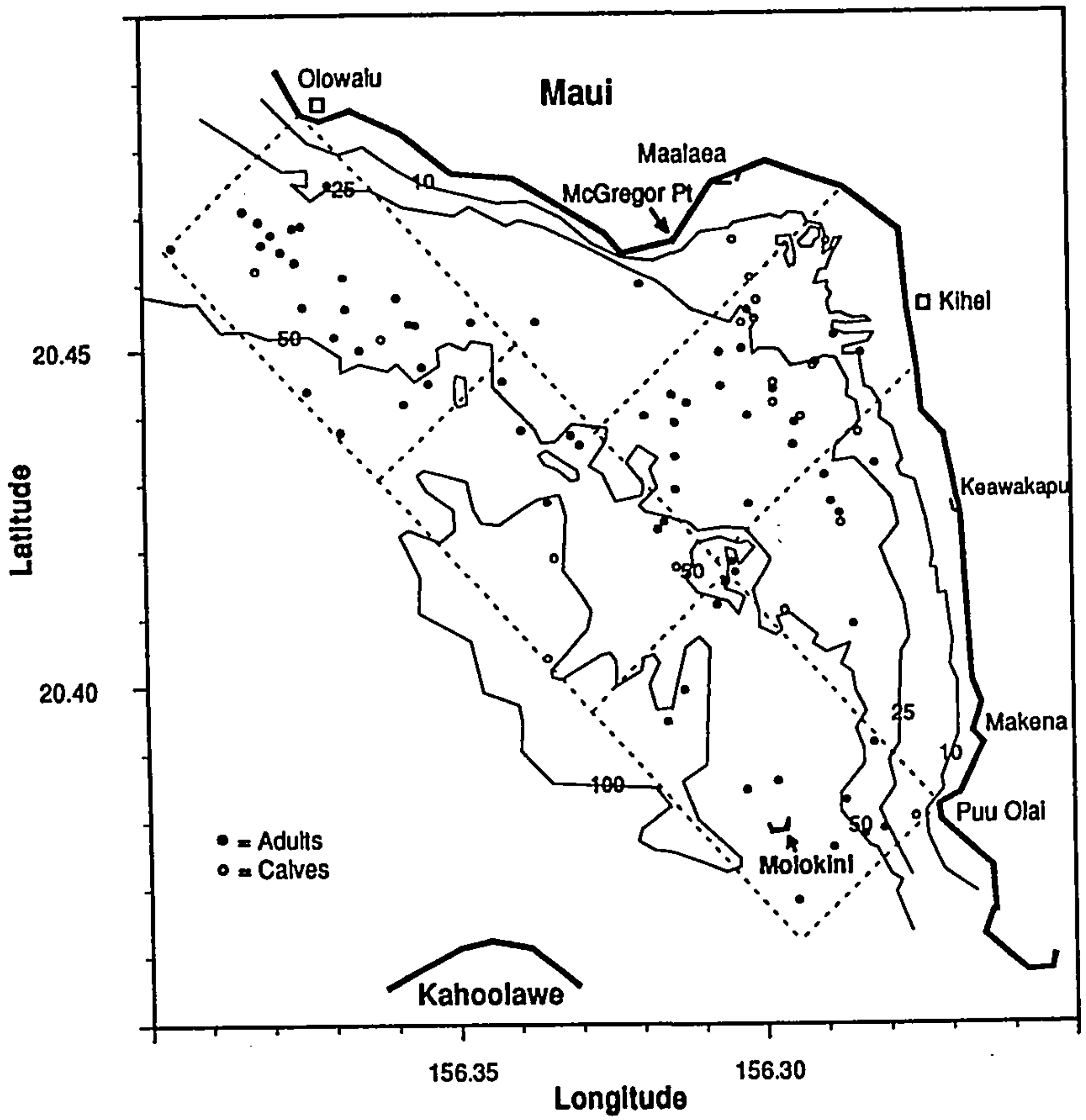

Figure 24: Location of adult and calf pods observed during aerial surveys in 1989 and 1990 (n=90).

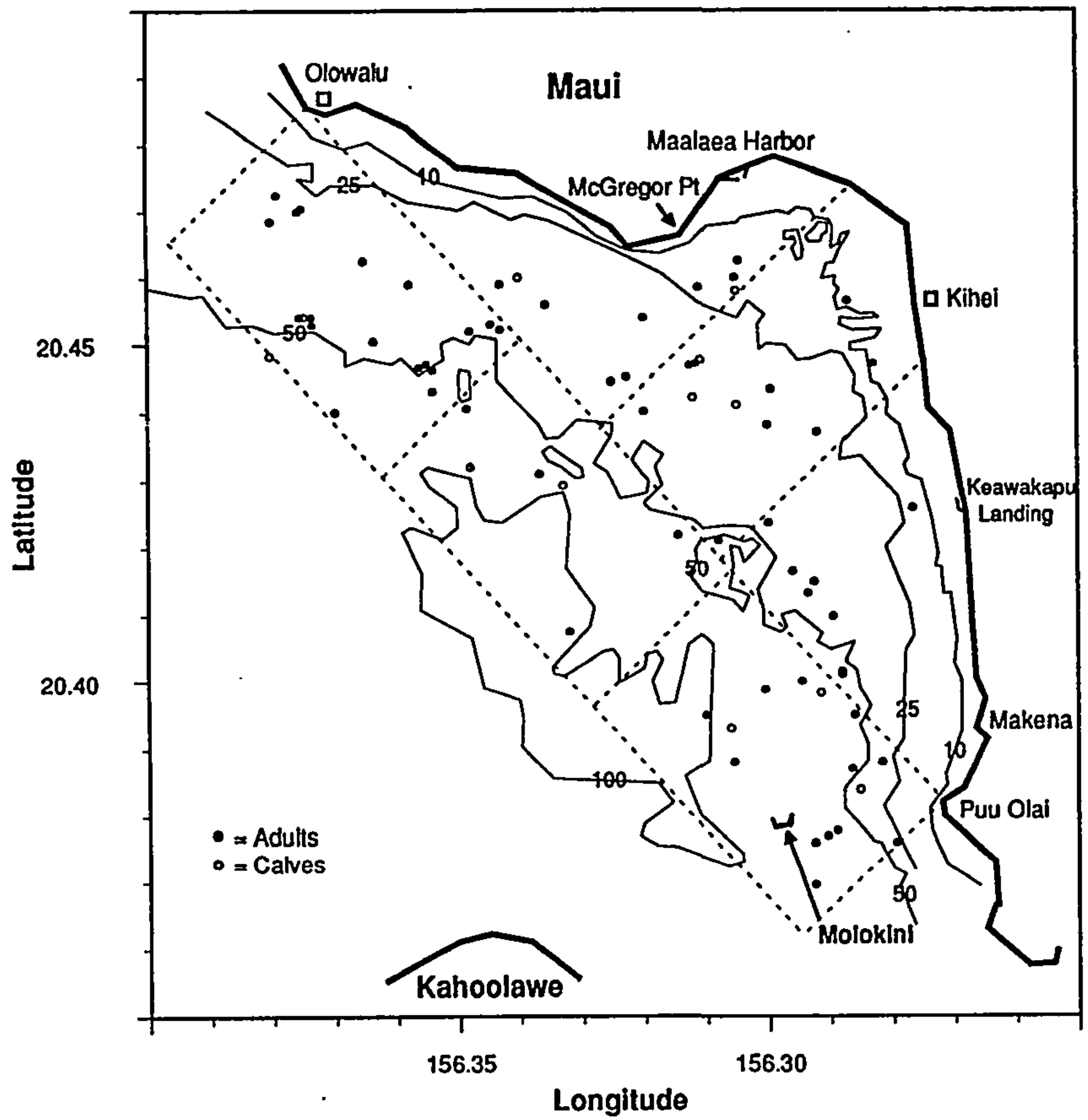

Figure 25: Location of adult and calf pods observed during aerial surveys in 1991 (n=71).

between 1978 and 1991. In general, the tendency for whales to be observed along the 25- and 50-fathom contours is apparent in both figures. One striking difference is seen in sub-region 1 in the vicinity of McGregor Point, and sub-region 3, from Keawakapu to Makena. Figure 6 shows a large number of observations of whales from the survey boats in each of those areas. Figure 21 shows few sightings in these areas during aerial surveys. Baker, Herman, Bays, and Bauer (1983) and Bauer and Herman (1986) have shown that one of the most clearly observable responses of whales to intrusive boat activity is increased dive time. Data from the current study indicate that both sub-regions 1 and 3 have the highest densities of boat traffic. It is possible that the impact of the boat activity is not in reducing the numbers of whales in the area, but rather in increasing their average down times, resulting in a smaller probability of being observed during aerial surveys.

Another difference between boat data and aerial data is that a higher proportion of pods observed from boats are calf pods (.42), compared with the proportion of pods observed from aircraft that are calf pods(.18). The proportion of pods observed from boats containing a calf in the present study agrees with the results of a similar boat survey study conducted near Lahaina in 1990. In that study, Forestell, Brown, Herman and Mobley (1991) reported the proportion of observed pods that contained a calf was .41. This is probably an artifact of survey protocol differences between the boat surveys and the aerial surveys. During boat surveys, survey time is suspended while pods are approached closely enough to verify whether or not a calf is present. The aerial surveys (except for those in 1978 and 1979) do not approach pods to verify composition, so it is likely that calf pods are under-represented in the final counts.

SUMMARY AND RECOMMENDATIONS

SUMMARY

The work described in the present report may be summarized as follows:

1. Observations of 1348 whales, including 251 calves, were made during 348 hours of boat survey time in 1989 and 1991. During 1991, 679 boats were observed in 190 hours of survey effort. During aerial surveys between 1978 and 1991, 272 pods, including 49 calves, were observed.

2. Both the vessel and aerial survey data indicate that whales are distributed along the major contours in the study area. Boat distribution patterns lie perpendicular to the whale distribution patterns.

3. There is no significant difference in the rate of observation of either calves or adults on either side of the NMFS-designated 300-yard boundary marker.

4. Throughout the day, adults appear to shift their locus of distribution to avoid areas of greatest boat activity. Calf pods do not.

5. The NMFS-designated 300-yard zone does not appear to result in a lower incidence of whale-boat interactions.

6. Aerial survey data show there has been a significant and steady increase in the number of whales observed in the study area between 1978 and 1991. There has not been a significant increase in calves, although this may be due to an artifact in survey protocol.

7. Whales in areas of high boat density spend less time at the surface.

RECOMMENDATIONS

We believe there is compelling evidence that the current level of boat activity in Maalaea Bay and vicinity already influences humpback whale distribution and behavior. Avoidance of high boat areas by adults, and longer down times by whales in high boat areas are established indices of impact recognized by other researchers (cf. Bauer and Herman, 1986, for an excellent review).

At the same time, we recognize that although there is an observable impact, the long-term significance of that impact must be viewed in the context of the data that suggests a steady increase in the number of whales using the Maalaea Bay area during the past decade. At least with respect to the data on adults, the long-term impact of human activity has not led to a reduction in numbers. The data on calves is not so straightforward. They appear to not show active avoidance of the high boat areas at certain times of the day. This may well be a result of the more topographically-specific needs of a mother with a new-born calf. In other words, adults can move away from high-boat areas, and avoid a long-term reduction in fitness. It is worthy of note that calves do not show a tendency to avoid areas of high boat density, nor have they shown evidence of a significant increase in numbers over the same time period that adult numbers have increased. Does this provide evidence of a long-term reduction in fitness of calves? It is unclear. The calf numbers are relatively small, they tend to be under-represented in aerial survey data, and it seems that it would be difficult for adult numbers to increase if calves weren't surviving.

Most importantly, we urge the responsible agencies to recognize that as the numbers of whales increase, increases in the numbers of boats will almost certainly result in increased occurrences of whale-boat collisions, which have only been reported once to date in the Maui area (Stevens, 1988). The cost of such collisions, both to the endangered humpback whale and to the humans involved, will be a direct function of the frequency with which such incidents happen, and the force vectors of the collision (i.e, size and speed of vessel, size of whale, fullness of contact, etc.)

The findings of the present work lead us to suggest that any changes in boat distribution patterns should be mitigated by a geographical centralization of activity to the greatest degree possible, and a reasonable reduction in any factor that can be viewed to add to the opportunities for negative impact on whales. Consequently, we recommend that any increase in the number of boats operating out of Maalaea Bay be accompanied by an enforced reduction of offshore moorings, in particular those that may be illegal, throughout other areas of the Bay. Every effort should be made to funnel increases in boat activity into more and more highly localized areas, rather than providing the circumstances for more diverse distribution, which will prevent whales from finding areas low in boat density.

We recommend that speed limits be imposed throughout Maalaea Bay in order to reduce the unpredictable nature of boat activity, and to allow whales a greater amount of time to adjust to incidences of close approach by boats. A secondary effect of speed limits will be to provide boat operators a greater ability to respond to the sudden appearance of a whale, and will reduce the probability of death or serious destruction in the ever-increasing likelihood of a collision. Such speed limits might be developed in consideration of the size of the vessel. For example, smaller, more maneuverable vessels (under 25 ft.) could be limited to 15 knots; vessels between 25 and 75 feet could be limited to 10 knots, and vessels over 75 feet limited to five knots. Although the 300-yard zone in Maalaea Bay does not seem to be based on an accurate understanding of whale movement or calf distribution, it is a clearly defined area that would be an appropriate site for implementing speed limits for at least that period of time when whales are present.

The work described in the present report did not address the nature of the acoustic environment, and this is something that almost certainly needs to be considered. In addition, ongoing monitoring of distribution and abundance patterns should be a high priority for both state and federal funding to determine that the baseline conditions described in the present report do not deteriorate.

Overall, we believe that it should be possible for some degree of expansion at Maalaea Small Boat Harbor, but urge that appropriate steps be taken to reduce the breadth of area over which boats may be distributed. In addition, we believe controls over speed and movement should be implemented, and that a cost-efficient long-term monitoring program be initiated to document the ongoing status of the whale population in this important area.

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Numerical Hydrodynamic Modeling and Flushing Study at Maalaea Harbor Maui, Hawaii

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Editors Note:

The alternative numbers contained in this report on Flushing are different than those in the text of the Supplemental EIS. Cross reference key follows.

SEIS alternative	Report alternative
Existing Condition	Existing harbor conditions and Figures 1.2, 3.1, 3.2, 4.3, 4.11, 4.12, 4.13
1968 Authorized Plan	Not evaluated
1980 Appproved Plan	Alternative Plan 2 and Figures 5.4, 4.14, 4.15
Alternative Plan 1	Not evaluated
Alternative Plan 2	Not evaluated
Alternative Plan 3	Not evaluated
Alternative Plan 4	Not evaluated
Alternative Plan 5	Not evaluated
Alternative Plan 6	Alternative Plan 6 and Figures 4.7, 4.16, 4.17

Contents

1. Introduction

Maalaea Harbor is located on the southwest coast of the Island of Maui, Hawaii, approximately 8 miles south of Kahului (Figure 1.1). The existing harbor facility consists of a 90-ft wide, 12 ft-deep channel and an 11.3 acre dredged basin. The Harbor is surrounded by a 100 ft long, 90 ft wide breakwater on the south side of the basin, an 870 ft long breakwater on the east side, and a 300 ft long, 50 ft wide paved wharf on the north side of the basin (Figure 1.2).

During severe wave condition, Maalaea Harbor experiences severe harbor surge and navigation difficulties in the entrance channel. The surge results from the existing configuration and alignment of the harbor entrance, which allow direct wave propagation through the channel opening. Surge problems cause navigational hazards and prevent safe berthing in some portions of the harbor (Lillycrop et al, 1993). The general Design Memorandum for Maalaea Harbor for Light-Draft Vessels contains a record of the research and planning (U.S.Army Engineering District, Honolulu, 1980). A hydraulic model study was conducted at the Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC), Vicksburg, MS, to investigate the stability of breakwater cross sections for the various proposed plans (Carver and Markle, 1981).

While the purpose of the improvements are aimed at navigation and economic issues described above, it is important that the proposed designs have sound technical bases in meeting the environmental design criteria for small harbor (U.S. EPA, 1985). One of the key criteria in measuring the physical influence of water on the aquatic system is the flushing time, the amount of time that it takes to exchange the water within the harbor with the receiving water body.

In estimating flushing time, the tidal prism technique has been widely used (Harleman, 1966; Dyer, 1973; Callaway, 1981; van de Kreeke, 1983). However, the tidal prism method has two severe limitations for this application: (1) It does not account for wind effect, which is important in the Maalaea Harbor and (2) It assumes that the receiving water body is itself well flushed within tidal cycles. As pointed out by Sanford et al (1992), the tidal flushing depends on the relative phases and speeds of the embayments channel currents and coastal currents, and on the amount of mixing that occurs outside the embayment. In order to accurately predict the flushing time in a wind dominant water body such as Maalaea Harbor, we develop a harbor-bay coupled system and invoke CH3D-WES (Curvilinear Hydrodynamic Three Dimension-WES) numerical model to conduct the study.

The purposes of this report are: (1) to document the flushing analysis methodology using numerical model techniques (2) to estimate the flushing characteristics in the Maalaea Harbor and provide necessary information for assessing the environmental impact resulted from proposed improvement plans. The organization of this report is as follows. Section 2 presents the numerical model formulation including the governing equations and the solution procedure. In Section 3, the model was calibrated and validated using field data collected during July and August, 1993. In section 4, we first present the scenario description, then the hydrodynamic results and finally the impact of the proposed plans on the flushing characteristics. In section 5, the conclusion from the various parts of the study are summarized.

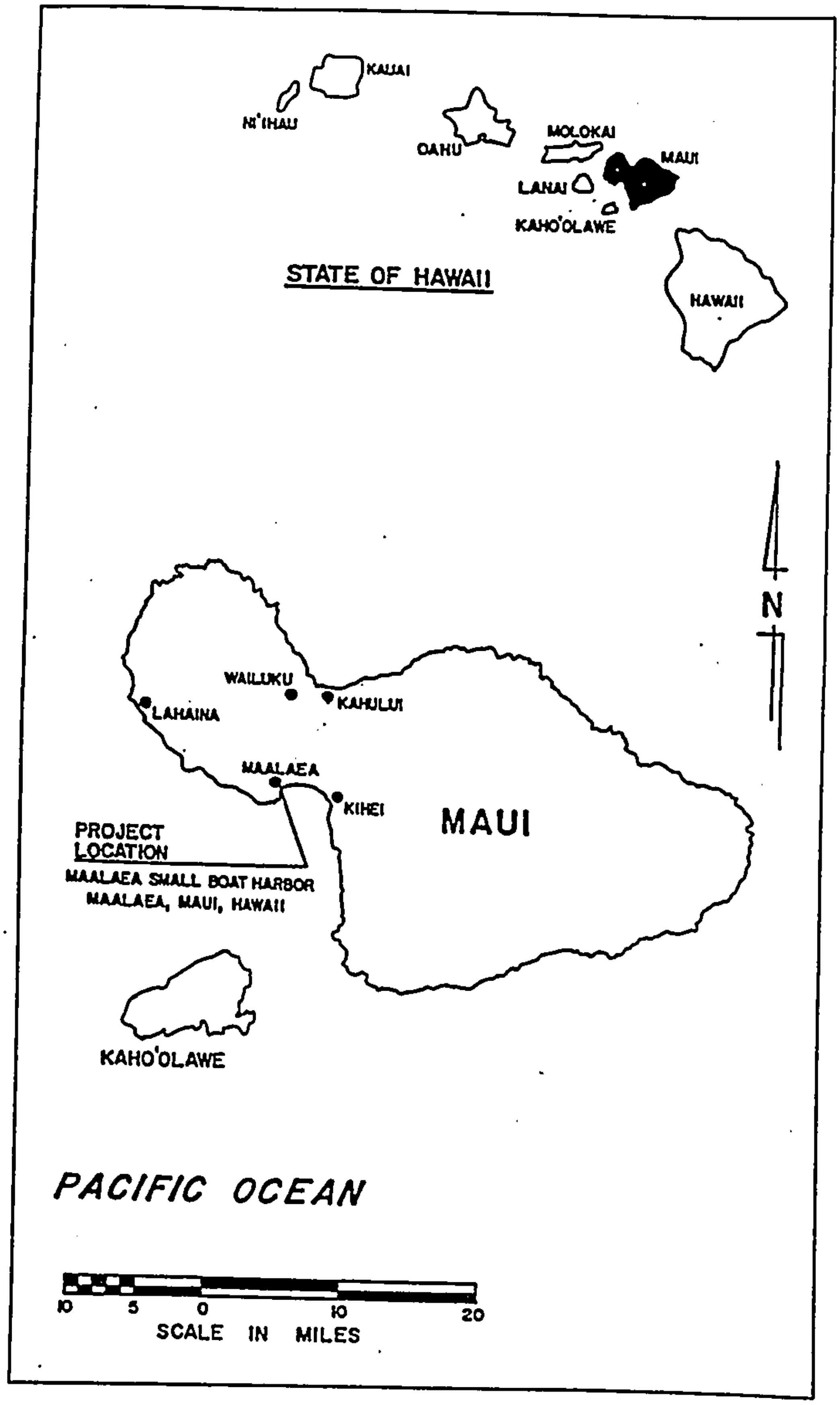


Figure 1.1 Study location

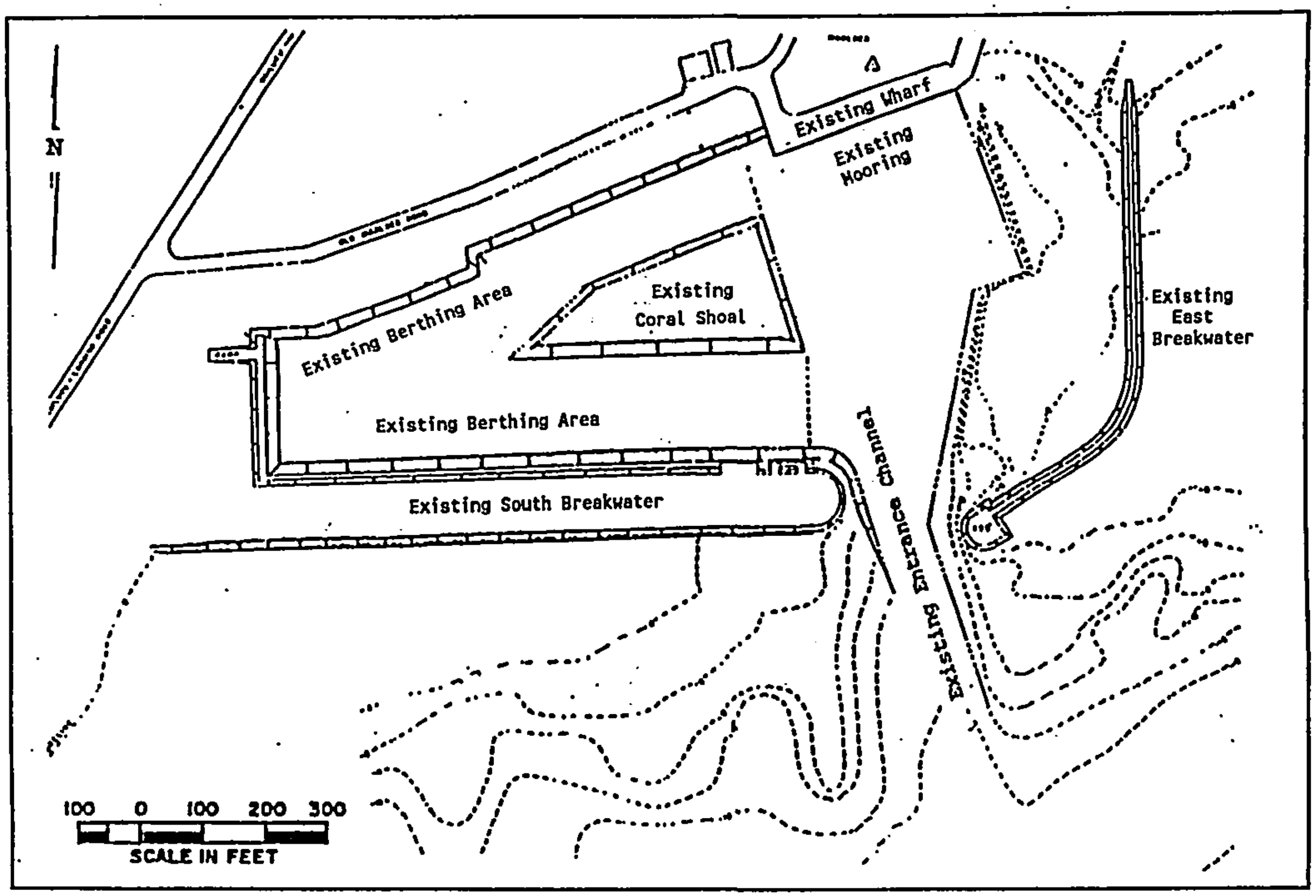


Figure 1.2 Existing harbor condition

2. Description of the Numerical Hydrodynamic Model

The numerical hydrodynamic model CH3D-WES (Curviliner Hydrodynamics in Three Dimensions - WES) was selected to provide hydrodynamic flow field for input to a flushing study. The basic model was originally developed by Sheng (1986). Subsequently, it was extensively modified by WES through algorithm re-coding and implementing numerical formulation (Johnson et al, 1991).

Governing equations

The hydrodynamic equations used in CH3D are derived from the classical Navier-Stokes equations. The governing partial differential equations are based on the following assumptions:

a. The hydrostatic distribution adequately describes the vertical distribution of fluid pressure.

b. The Boussinesq approximation is appropriate.

c. The eddy viscosity approach adequately describes turbulent mixing in the flow.

The basic equations in a right-handed Cartesian coordinate system (x,y,z) are :

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \qquad (1)$$

$$\frac{\partial u}{\partial t} + \frac{\partial u^2}{\partial x} + \frac{\partial uv}{\partial y} + \frac{\partial uw}{\partial z} = fv - \frac{1}{\rho_o}\frac{\partial p}{\partial x} + \frac{\partial}{\partial x}\left[A_H \frac{\partial u}{\partial x}\right] + \frac{\partial}{\partial y}\left[A_H \frac{\partial u}{\partial y}\right] + \frac{\partial}{\partial z}\left[A_v \frac{\partial u}{\partial z}\right] \qquad (2)$$

$$\frac{\partial v}{\partial t} + \frac{\partial uv}{\partial x} + \frac{\partial v^2}{\partial y} + \frac{\partial vw}{\partial z} = -fu - \frac{1}{\rho_o}\frac{\partial p}{\partial y} + \frac{\partial}{\partial x}\left[A_H \frac{\partial v}{\partial x}\right] + \frac{\partial}{\partial y}\left[A_H \frac{\partial v}{\partial y}\right] + \frac{\partial}{\partial z}\left[A_v \frac{\partial v}{\partial z}\right] \qquad (3)$$

$$\frac{\partial p}{\partial z} = -\rho g \tag{4}$$

$$\frac{\partial T}{\partial t} + \frac{\partial uT}{\partial x} + \frac{\partial vT}{\partial y} + \frac{\partial wT}{\partial z} = \frac{\partial}{\partial x}\left[K_H \frac{\partial T}{\partial x}\right] + \frac{\partial}{\partial y}\left[K_H \frac{\partial T}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_v \frac{\partial T}{\partial z}\right] \tag{5}$$

$$\frac{\partial S}{\partial t} + \frac{\partial uS}{\partial x} + \frac{\partial vS}{\partial y} + \frac{\partial wS}{\partial z} = \frac{\partial}{\partial x}\left[K_H \frac{\partial S}{\partial x}\right] + \frac{\partial}{\partial y}\left[K_H \frac{\partial S}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_v \frac{\partial S}{\partial z}\right] \tag{6}$$

$$\rho = \rho\ (T,S) \tag{7}$$

where (u,v,w) = velocities in (x,y,z) directions
t = time
f = Coriolis parameter defined as $2\Omega \sin \phi$
Ω = rotational speed of the earth
ϕ = latitude
ρ = density
p = pressure
A_H, K_H = horizontal turbulent eddy coefficients
A_v, K_v = vertical turbulent eddy coefficients
g = gravitational acceleration
T = temperature
S = salinity

Equation 4 implies that vertical accelerations are negligible and thus the pressure is hydrostatic. Various forms of the equation of state can be specified for Equation 7. In the present model, the formulation given below is used:

$$\rho = P/(\alpha + 0.698P) \tag{8}$$

where

$$P = 5890 + 38T - 0.375T^2 + 3S$$

$$\alpha = 1779.5 + 11.25T - 0.0745T^2 - (3.8 + 0.01T)S$$

and T is temperature in degrees Celsius, S is salinity in parts per thousand, and ρ is density in grams per cubic centimeter.

Non-dimensionalization of governing equations

The dimensionless forms of the governing equations are used to facilitate relative magnitude comparisons of the various terms in the equations. The following dimensionless variables are used:

$$(u^*, v^*, w^*) = (u, v, wX_r/Z_r)/U_r$$

$$(x^*, y^*, z^*) = (x, y, zX_r/Z_r)/X_r$$

$$(\tau_x^*, \tau_y^*) = (\tau_x^w, \tau_y^w)/\rho_o f Z_r U_r$$

$$t* = tf$$

$$\zeta^* = g\zeta/fU_rX_r = \zeta/S_r$$

$$\rho^* = (\rho - \rho_o)/(\rho_r - \rho_o) \qquad (9)$$

$$T^* = (T - T_o)/(T_r - T_o)$$

$$A_H^* = A_H/A_{Hr}$$

$$A_v^* = A_v/A_{vr}$$

$$K_H^* = K_H/K_{Hr}$$

$$K_v^* = K_v/K_{vr}$$

where (τ_x^w, τ_y^w) = wind stress in (x,y) directions

ζ = water surface elevation

These definitions yield the following dimensionless parameters in the governing equations:

Vertical Ekman Number: $E_v = A_{vr}/fZ_r^2$

Lateral Ekman Number: $E_H = A_{Hr}/fX_r^2$

Vertical Prandtl (Schmidt) Number: $Pr_v = A_{vr}/K_{vr}$

Lateral Prandtl (Schmidt) Number: $Pr_H = A_{Hr}/K_{Hr}$

Froude Number: $F_r = U_r/(gZ_r)^{1/2}$

Rossby Number: $R_o = U_r/fX_r$ (10)

Densimetric Froude Number: $Fr_D = F_r / \sqrt{\epsilon}$

where $\epsilon = (\rho_r - \rho_o)/\rho_o$

S_r, T_r, U_r, ρ_r, X_r, Z_r, A_{Hr}, A_{vr}, K_{Hr}, and K_{vr} are arbitrary reference values of the salinity, temperature, velocity, density, etc.

External-internal modes

The basic equations (Equations 1-4) can be integrated over the depth to yield a set of vertically integrated equations for the water surface ζ and unit flow rates U and V in the x and y directions. Using the dimensionless variables (asterisks have been dropped) and the parameters previously defined, the vertically integrated equations constituting the external mode are:

$$\frac{\partial \zeta}{\partial t} + \beta \left[\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y}\right] = 0 \qquad (11)$$

$$\frac{\partial U}{\partial t} = - H \frac{\partial \zeta}{\partial x} + \tau_{sx} - \tau_{bx} + V$$

$$- R_o \left[\frac{\partial}{\partial x}\left(\frac{UU}{H}\right) + \frac{\partial}{\partial y}\left(\frac{UV}{H}\right)\right]$$

$$+ E_H \left[\frac{\partial}{\partial x}\left(A_H \frac{\partial U}{\partial x}\right) + \frac{\partial}{\partial y}\left(A_H \frac{\partial U}{\partial y}\right)\right]$$

$$- \frac{R_o}{Fr_D^2} \frac{H^2}{2} \frac{\partial \rho}{\partial x} \qquad (12)$$

$$\frac{\partial V}{\partial t} = - H \frac{\partial \zeta}{\partial y} + \tau_{sy} - \tau_{by} - U$$

$$- R_o \left[\frac{\partial}{\partial x}\left(\frac{UV}{H}\right) + \frac{\partial}{\partial y}\left(\frac{VV}{H}\right)\right]$$

$$+ E_H \left[\frac{\partial}{\partial x}\left(A_H \frac{\partial V}{\partial x}\right) + \frac{\partial}{\partial y}\left(A_H \frac{\partial V}{\partial y}\right)\right]$$

$$- \frac{R_o}{Fr_D^2} \frac{H^2}{2} \frac{\partial \rho}{\partial y} \qquad (13)$$

where $\beta = gZr/f^2X_r^2 \equiv (R_o/F_r)^2$
$H = totaldepth$

As will be discussed later, the major purpose of the external mode is to provide the updated water-surface field for input to the internal mode equations.

The internal mode equations from which the 3-D velocity, salinity, and temperature fields are computed are:

$$\frac{\partial hu}{\partial t} = - h \frac{\partial \zeta}{\partial x} + E_v \frac{\partial}{\partial z}\left(A_v \frac{\partial hu}{\partial z}\right) + hv$$

$$- R_o \left[\frac{\partial huu}{\partial x} + \frac{\partial huv}{\partial y} + \frac{\partial huw}{\partial z} \right]$$

$$+ E_H \left[\frac{\partial}{\partial x} \left[A_H \frac{\partial hu}{\partial x} \right] + \frac{\partial}{\partial y} \left[A_H \frac{\partial hu}{\partial y} \right] \right]$$

$$- \frac{R_o}{Fr_D^2} \left[\int_z^\zeta \frac{\partial \rho}{\partial x} \, dz \right] \qquad (14)$$

$$\frac{\partial hv}{\partial t} = - h \frac{\partial \zeta}{\partial y} + E_v \frac{\partial}{\partial z} \left[A_v \frac{\partial hv}{\partial z} \right] - hu$$

$$- R_o \left[\frac{\partial hvu}{\partial x} + \frac{\partial hvv}{\partial y} + \frac{\partial hvw}{\partial z} \right]$$

$$+ E_H \left[\frac{\partial}{\partial x} \left[A_H \frac{\partial hv}{\partial x} \right] + \frac{\partial}{\partial y} \left[A_H \frac{\partial hv}{\partial y} \right] \right]$$

$$- \frac{R_o}{Fr_D^2} \left[\int_z^\zeta \frac{\partial \rho}{\partial y} \, dz \right] \qquad (15)$$

$$W_{k+1/2} = W_{k-1/2} - \left[\frac{\partial uh}{\partial x} + \frac{\partial vh}{\partial y} \right] \qquad (16)$$

$$\frac{\partial hT}{\partial t} = \frac{E_v}{Pr_v} \frac{\partial}{\partial z} \left[K_v \frac{\partial T}{\partial z} \right] - R_o \left[\frac{\partial huT}{\partial x} + \frac{\partial hvT}{\partial y} + \frac{\partial hwT}{\partial z} \right]$$

$$+ \frac{E_H}{Pr_H} \left[\frac{\partial}{\partial x} \left[K_H \frac{\partial hT}{\partial x} \right] + \frac{\partial}{\partial y} \left[K_H \frac{\partial hT}{\partial y} \right] \right] \qquad (17)$$

$$\frac{\partial hS}{\partial t} = \frac{E_v}{Pr_v} \frac{\partial}{\partial z} \left[K_v \frac{\partial S}{\partial z} \right] - R_o \left[\frac{\partial huS}{\partial x} + \frac{\partial hvS}{\partial y} + \frac{\partial hwS}{\partial z} \right]$$

$$+ \frac{E_H}{Pr_H} \left[\frac{\partial}{\partial x} \left[K_H \frac{\partial hS}{\partial x} \right] + \frac{\partial}{\partial y} \left[K_H \frac{\partial hS}{\partial y} \right] \right] \qquad (18)$$

In these equations h is the thickness of an internal layer and $k+1/2$ and *k-1/2* represent the top and bottom, respectively, of the k^{th} vertical layer and *W* is the transcript in the z-direction

Transformation of governing equations

The CH3D model utilizes a boundary-fitted or generalized curvilinear planform grid which can be made to conform to flow boundaries, providing a detailed resolution of the complex horizontal geometry of the flow system. This necessitates the transformation of the governing equations into boundary-fitted coordinates (ξ,η). If only the (x,y) coordinates are transformed, a system of equations similar to those solved by Johnson (1980) for vertically averaged flow fields is obtained. However, in the CH3D model not only are the (x,y) coordinates transformed into the (ξ,η) curvilinear system but the velocity is also transformed such that its components are perpendicular to the (ξ,η) coordinate lines. This is accomplished by employing the definitions below for the components of the Cartesian velocity (u,v) in terms of contravariant components $\bar{u}$ and $\bar{v}$.

$$u = x_\xi \bar{u} + x_\eta \bar{v}$$

$$v = y_\xi \bar{u} + y_\eta \bar{v} \tag{19}$$

along with the following expressions for replacing Cartesian derivatives

$$f_x = \frac{1}{J}\left[(f y_\eta)_\xi - (f y_\xi)_\eta\right]$$

$$f_y = \frac{1}{J}\left[-(f x_\eta)_\xi + (f x_\xi)_\eta\right] \tag{20}$$

where *f* is an arbitrary variable and *J* is the Jacobian of the coordinate transformation defined as

$$J = x_\xi y_\eta - x_\eta y_\xi$$

With the governing equations written in terms of the contravariant components of the velocity, boundary conditions can be prescribed on the boundary-fitted grid in the same manner as on a Cartesian grid because $\bar{u}$ and $\bar{v}$ are perpendicular to the curvilinear cell faces (e.g., at a land boundary, either $\bar{u}$ or $\bar{v}$ is set to zero).

The vertical dimension is represented through the use of what is commonly referred to as a sigma-stretched grid. The vertical depth is discretized in a fixed number of layers, each layer equal in thickness to a fixed percentage of the local depth. The sigma-stretched grid is then transformed to a fixed-space grid where the computations are easily performed.

With both the Cartesian coordinates and the Cartesian velocity transformed, the following boundary-fitted equations for $\bar{u}$, $\bar{v}$, w , S , and T to be solved in each vertical layer are obtained.

$$\frac{\partial h\bar{u}}{\partial t} = - h \left[\frac{G_{22}}{J^2} \frac{\partial \zeta}{\partial \xi} - \frac{G_{12}}{J^2} \frac{\partial \zeta}{\partial \eta} \right] + \frac{h}{J} (G_{12}\,\bar{u} + G_{22}\,\bar{v}) + \frac{R_o x_\eta}{J^2} \left[\frac{\partial}{\partial \xi} (Jy_\xi h\bar{u}\bar{u}\right.$$

$$\left. + Jy_\eta h\bar{u}\bar{v}\,) + \frac{\partial}{\partial \eta} (Jy_\xi h\bar{u}\bar{v} + Jy_\eta h\bar{v}\bar{v}) \right] - \frac{R_o y_\eta}{J^2} \left[\frac{\partial}{\partial \xi} (Jx_\xi h\bar{u}\bar{u} + Jx_\eta h\bar{u}\bar{v}) \right.$$

$$\left. + \frac{\partial}{\partial \eta} (\,Jx_\xi h\bar{u}\bar{v} + Jx_\eta h\bar{v}\bar{v}\,) \right] - R_o \left[(w\bar{u}\,)_{top} - (w\bar{u}\,)_{bot} \right]$$

$$+ E_v \left[\left[A_v \frac{\partial \bar{u}}{\partial z} \right]_{top} - \left[A_v \frac{\partial \bar{u}}{\partial z} \right]_{bot} \right] - \frac{R_o h}{Fr_D^2} \left[\int_z^\zeta \left[\frac{G_{22}}{J^2} \frac{\partial \rho}{\partial \xi} \right.\right.$$

$$\left.\left. - \frac{G_{12}}{J^2} \frac{\partial \rho}{\partial \eta} \right] dz \right] + \text{Horizontal Diffusion} \qquad (21)$$

$$\frac{\partial h\bar{v}}{\partial t} = - h \left[- \frac{G_{21}}{J^2} \frac{\partial \zeta}{\partial \xi} + \frac{G_{11}}{J^2} \frac{\partial \zeta}{\partial \eta} \right] - \frac{h}{J} (G_{11}\,\bar{u} + G_{21}\,\bar{v}\,) - \frac{R_o x_\xi}{J^2} \left[\frac{\partial}{\partial \xi} (\,Jy_\xi h\bar{u}\bar{u} \right.$$

$$\left. + Jy_\eta h\bar{u}\bar{v}) + \frac{\partial}{\partial \eta} (Jy_\xi h\bar{u}\bar{v} + Jy_\eta h\bar{v}\bar{v}) \right] + \frac{R_o y_\xi}{J^2} \left[\frac{\partial}{\partial \xi} (Jx_\xi h\bar{u}\bar{u} + Jx_\eta h\bar{u}\bar{v}) \right.$$

$$+ \frac{\partial}{\partial \eta} \left(J x_\xi h \overline{u} \overline{v} + J x_\eta h \overline{v} \overline{v} \right) \Big] - R_o \left[(w\overline{v})_{top} - (w\overline{v})_{bot} \right]$$

$$+ \text{Horizontal Diffusion} \qquad (22)$$

$$w_{top} = w_{bot} - \frac{1}{J} \left[\frac{\partial J \overline{u} h}{\partial \xi} + \frac{\partial J \overline{v} h}{\partial \eta} \right] \qquad (23)$$

$$\frac{\partial hS}{\partial t} = \frac{E_v}{Pr_v} \left[\left[K_v \frac{\partial S}{\partial z} \right]_{top} - \left[K_v \frac{\partial S}{\partial z} \right]_{bot} \right] - \frac{R_o}{J} \left[\frac{\partial hJ\overline{u}S}{\partial \xi} + \frac{\partial hJ\overline{v}S}{\partial \eta} \right]$$

$$- R_o \left[(wS)_{top} - (wS)_{bot} \right] + \text{Horizontal Diffusion} \qquad (24)$$

$$\frac{\partial hT}{\partial t} = \frac{E_v}{Pr_v} \left[\left[K_v \frac{\partial T}{\partial z} \right]_{top} - \left[K_v \frac{\partial T}{\partial z} \right]_{bot} \right] - \frac{R_o}{J} \left[\frac{\partial hJ\overline{u}T}{\partial \xi} + \frac{\partial hJ\overline{v}T}{\partial \eta} \right]$$

$$- R_o \left[(wT)_{top} - (wT)_{bot} \right] + \text{Horizontal Diffusion} \qquad (25)$$

where

$$G_{11} = x_\xi^2 + y_\xi^2$$

$$G_{22} = x_\eta^2 + y_\eta^2 \qquad (26)$$

$$G_{12} = G_{21} = x_\xi x_\eta + y_\xi y_\eta$$

Similarly, the transformed external mode equations become:

$$\frac{\partial \zeta}{\partial t} + \beta \left[\frac{\partial \bar{U}}{\partial \xi} + \frac{\partial \bar{V}}{\partial \eta} \right] = 0 \qquad (27)$$

$$\frac{\partial \bar{U}}{\partial t} = - \frac{H}{J^2} \left[G_{22} \frac{\partial \zeta}{\partial \xi} - G_{12} \frac{\partial \zeta}{\partial \eta} \right]$$

$$+ \frac{1}{J} \left(G_{12} \bar{U} + G_{22} \bar{V} \right) + \frac{R_o x_\eta}{J^2 H} \left[\frac{\partial}{\partial \xi} \left(J y_\xi \bar{U} \bar{U} + J y_\eta \bar{U} \bar{V} \right) + \frac{\partial}{\partial \eta} \left(J y_\xi \bar{U} \bar{V} + J y_\eta \bar{V} \bar{V} \right) \right]$$

$$- \frac{R_o y_\eta}{J^2 H} \left[\frac{\partial}{\partial \xi} \left(J x_\xi \bar{U} \bar{U} + J x_\eta \bar{U} \bar{V} \right) + \frac{\partial}{\partial \eta} \left(J x_\xi \bar{U} \bar{V} + J x_\eta \bar{V} \bar{V} \right) \right]$$

$$+ \tau_{s\xi} - \tau_{b\xi} - \frac{R_o}{Fr_D^2} \frac{H^2}{2} \left[G_{22} \frac{\partial \rho}{\partial \xi} - G_{12} \frac{\partial \rho}{\partial \eta} \right]$$

$$+ \text{Horizontal Diffusion} \qquad (28)$$

$$\frac{\partial \bar{V}}{\partial t} = - \frac{H}{J^2} \left[- G_{21} \frac{\partial \zeta}{\partial \xi} + G_{11} \frac{\partial \zeta}{\partial \eta} \right] - \frac{1}{J} \left(G_{11} \bar{U} + G_{21} \bar{V} \right)$$

$$- \frac{R_o x_\xi}{J^2 H} \left[\frac{\partial}{\partial \xi} \left(J y_\xi \bar{U} \bar{U} + J y_\eta \bar{U} \bar{V} \right) + \frac{\partial}{\partial \eta} \left(J y_\xi \bar{U} \bar{V} + J y_\eta \bar{V} \bar{V} \right) \right]$$

$$+ \frac{R_o y_\xi}{J^2 H} \left[\frac{\partial}{\partial \xi} \left(J x_\xi \bar{U} \bar{U} + J x_\eta \bar{U} \bar{V} \right) + \frac{\partial}{\partial \eta} \left(J x_\xi \bar{U} \bar{V} + J x_\eta \bar{V} \bar{V} \right) \right]$$

$$+ \tau_{s\eta} - \tau_{b\eta} - \frac{R_o}{Fr_D^2} \frac{H^2}{2} \left[- G_{21} \frac{\partial \rho}{\partial \xi} + G_{11} \frac{\partial \rho}{\partial \eta} \right]$$

$$+ \text{Horizontal Diffusion} \qquad (29)$$

Equations 27-29 are solved first to yield water-surface elevations which are then used to evaluate the water-surface slope terms in the internal mode equations. The horizontal diffusion terms are quite lengthy and thus are omitted in this report. Full documentation of the terms is presented in Johnson et al. (1991) for the internal mode equations. Similar expressions for the diffusion terms in the vertically averaged equations can be inferred from those for the internal mode.

Finite difference scheme

Finite differences are used to replace derivatives in the governing equations, resulting in a system of linear algebraic equations to be solved in both the external and internal modes. The external mode solution consists of the surface displacement and vertically integrated contravariant unit flows $\bar{U}$ and $\bar{V}$. All terms in the transformed vertically averaged continuity equation are treated implicitly whereas only the water-surface slope terms in the transformed vertically averaged momentum equations are treated implicitly. If the external mode is used only as a vertically averaged model, the bottom friction is also treated implicitly. Those terms treated implicitly are weighted between the new and old time-steps. The resulting finite difference equations are then factored such that a ξ-sweep followed by an η-sweep of the horizontal grid yields the solution at the new time-step.

Writing Equations 11-13 as

$$\frac{\partial \zeta}{\partial t} + \beta \left[\frac{\partial \bar{U}}{\partial \xi} + \frac{\partial \bar{V}}{\partial \eta} \right] = 0 \tag{30}$$

$$\frac{\partial \bar{U}}{\partial t} + \frac{H}{J^2} G_{22} \frac{\partial \zeta}{\partial \xi} = M \tag{31}$$

$$\frac{\partial \bar{V}}{\partial t} + \frac{H}{J^2} G_{11} \frac{\partial \zeta}{\partial \eta} = N \tag{32}$$

the ξ-sweep is

$$\xi\text{-sweep} \Rightarrow \zeta_{ij}^{*} + \frac{\beta\theta\Delta t}{\Delta\xi} \left(\bar{U}_{i+1,j}^{*} - \bar{U}_{ij}^{*} \right) = \zeta_{ij}^{n}$$

$$- (1-\theta) \frac{\Delta t}{\Delta\xi} \left(\bar{U}_{i+1,j}^{n} - \bar{U}_{ij}^{n} \right)$$

$$- \frac{\Delta t}{\Delta\eta} \left(\bar{V}_{i,j+1}^{n} - \bar{V}_{ij}^{n} \right) \tag{33}$$

$$= \bar{U}_{ij}^{n}$$

$$\bar{U}_{ij}^{n+1} + \frac{\theta \Delta t H G_{22}}{\Delta\xi \; J^2}\left(\zeta_{ij}^{*} - \zeta_{i-1,j}^{*}\right)$$

$$-(1-\theta)\,\frac{\Delta t H G_{22}}{\Delta\xi \; J^2}\left(\zeta_{ij}^{n} - \zeta_{i-1,j}^{n}\right) + \Delta t\; M^{n} \tag{34}$$

and the η-sweep then provides the updated ζ and V at the n+1 time level.

$$\eta\text{-sweep} \Rightarrow \zeta_{ij}^{n+1} + \frac{\beta\theta\Delta t}{\Delta\eta}\left(\bar{V}_{i,j+1}^{n+1} - \bar{V}_{ij}^{n+1}\right) = \zeta_{i,j}^{*}$$

$$- (1-\theta)\frac{\Delta t}{\Delta\eta}\left(\bar{V}_{i,j+1}^{n} - \bar{V}_{i,j}^{n}\right)$$

$$+ \frac{\Delta t}{\Delta\eta}\left(\bar{V}_{i,j+1}^{n} - \bar{V}_{i,j}^{n}\right) \tag{35}$$

$$\bar{V}_{i,j}^{n+1} + \frac{\theta \Delta t H G_{11}}{\Delta\eta \; J^2}\left(\zeta_{i,j+1}^{n+1} - \zeta_{i,j}^{n+1}\right)$$

$$= V_{i,j}^{n}$$

$$-(1-\theta)\,\frac{\Delta t H G_{11}}{\Delta\eta \; J^2}\left(\zeta_{i,j+1}^{n} - \zeta_{i,j}^{n}\right) + \Delta t\; N^{n} \tag{36}$$

A typical value of θ of 0.55 yields stable and accurate solutions.

The internal mode consists of computations from Equations 21-25 for the three velocity components $\bar{u}$, $\bar{v}$, and w, salinity, and temperature. The only terms treated implicitly are the vertical diffusion terms in all equations and the bottom friction and surface slope terms in the momentum equations. Values of the water-surface elevations from the external mode are used to evaluate the surface slope terms in Equations 21 and 22. As a result, the extremely restrictive speed of a free-surface gravity wave is removed from the stability criteria. Roache's second upwind differencing scheme is used to represent the convective terms in the momentum equations, whereas a spatially third-order scheme developed by Leonard (1979) (called QUICKEST) is used to represent the advective terms in Equations 24 and 25 for salinity and temperature, respectively. For example, if the velocity on the right face of a computational cell is positive, then with QUICKEST the value of the salinity used to compute the flux through the face is

$$S_R = \frac{1}{2}\left(S_{i,j,k}+S_{i+1,j,k}\right)$$

$$-\frac{1}{6}\left[1-\left(\frac{\bar{U}_{i+1,j,k}\,\Delta t}{\Delta\xi}\right)^2\right]\left(S_{i+1,j,k}-2\,S_{i,j,k}+S_{i-1,j,k}\right)$$

$$-\frac{1}{2}\,\frac{U_{i+1,j,k}\,\Delta t}{\Delta\xi}\left(S_{i+1,j,k}-S_{i,j,k}\right) \qquad (37)$$

The more interested reader is referred to the paper by Leonard (1979).

It should be noted that once the $\bar{u}$ and $\bar{v}$ velocity components are computed, they are slightly adjusted to ensure conservation of mass. This is accomplished by forcing the sum of $\bar{u}$ over the vertical to be the vertically averaged velocity $\bar{U}/H$ and the sum of $\bar{v}$ over the vertical to equal $\bar{V}/H$, where H is the total water depth.

Turbulence parameterization

Vertical turbulence is handled by using the concept of eddy viscosity and diffusivity to represent the velocity and density correlation terms that arise from time averaging of the governing equations. These eddy coefficients are computed from mean flow characteristics using a simplified second-order closure model originally developed by Donaldson (1973). The closure model has been further developed and applied to various types of flows by Lewellen (1977) and Sheng (1982, 1986). A discussion of the implementation of the turbulence model taken from Sheng (1990) follows. For more details, the interested reader should refer to these references and to Johnson et al. (1991).

Assuming local equilibrium of turbulence, i.e., there is no time evolution or spatial diffusion of the second-order correlations, an equation relating the turbulent kinetic energy and the macro-scale of turbulence to the mean flow shear and stratification (given by the Richardson number *Ri*) can be derived as

$$
\begin{aligned}
3A^2b^2sQ^4 &+ A[(bs + 3b + 7b^2s)Ri - Abs(1 - 2b)]Q^2 \\
&+ b(s + 3 + 4bs)Ri^2 + (bs - A)(1 - 2b)Ri \\
&= 0
\end{aligned}
\tag{38}
$$

where $b = 0.125$, $s = 1.8$, $A = 0.75$ and

$$
Q = \frac{q}{\Lambda\sqrt{(\partial\bar{u}/\partial z)^2 + (\partial\bar{v}/\partial z)^2}} \tag{39}
$$

In the above expression, q is defined as

$$
q = \left(\overline{u'u'} + \overline{v'v'} + \overline{w'w'}\right)^{1/2}
$$

and Λ is the macro-scale of turbulence. The quantities u', v', *and* w' are the turbulent velocity fluctuations and the overbar indicates time averaging.

It can also be shown that the following relations hold:

$$
\overline{u'w'} = -\frac{\frac{\partial\bar{u}}{\partial z}\Lambda}{q}\,\frac{1 + \frac{\bar{\omega}}{A}}{1 - \omega}\,\overline{w'w'} \tag{40}
$$

$$
\overline{v'w'} = -\frac{\frac{\partial\bar{v}}{\partial z}\Lambda}{q}\,\frac{1 + \frac{\bar{\omega}}{A}}{1 - \omega}\,\overline{w'w'} \tag{41}
$$

$$
q^2b = \left[\frac{(1 + \frac{\bar{\omega}}{A})}{Q^2(1 - \omega)} + \bar{\omega}\right]\overline{w'w'} \tag{42}
$$

where

$$\omega = \frac{Ri}{AQ^2} \tag{43}$$

and

$$\bar{\omega} = \frac{\omega}{1 - \frac{\omega}{bs}} \tag{44}$$

Thus, after the velocity shear and flow stratification are determined q can be computed from Equations 38 and 39. $\overline{w'w'}$ is then determined from

$$\overline{w'w'} = \frac{\frac{q^2}{2} - q^2 b}{\frac{3}{2}(1 - 2\omega)} \tag{45}$$

Finally, after Λ is prescribed, $\overline{u'w'}$ and $\overline{v'w'}$ can be computed from Equations 40 and 41 and the vertical eddy coefficients can be determined from

$$A_v = \frac{\overline{-u'w'}}{\frac{\partial \bar{u}}{\partial z}} = \frac{\Lambda}{q} \frac{A + \bar{\omega}}{A(1 - \omega)} \overline{w'w'} \tag{46}$$

$$K_v = \frac{\overline{-\rho'w'}}{\frac{\partial \rho}{\partial z}} = \frac{\Lambda}{q} \frac{bs}{(bs - \omega)A} \overline{w'w'} \tag{47}$$

In addition to setting $\Lambda = 0.65z$ near boundaries, three basic constraints are used to compute Λ at a vertical position z

$$\left|\frac{d\Lambda}{dz}\right| \leq 0.65 \tag{48}$$

$$\Lambda \leq \frac{q}{N} = q/\left[-\frac{g}{\rho}\frac{\partial\rho}{\partial z}\right]^{0.5} \tag{49}$$

$$\Lambda \leq Q_{cut}\left(z_{q=qmax} - z_{q=qmax/2}\right) \tag{50}$$

where N is the Brunt-Vaisala frequency. Equation 50 states that Λ is less than a fraction of the spread of turbulence as measured by the distance between the location of a maximum q^2 to where q^2 is equal to 25 percent of the maximum. The coefficient Q_{cut} is on the order of 0.15 to 0.25.

3. Implementation of the Hydrodynamic Model

In the previous section, we have discussed the governing equation for the three-dimensional model and the finite-difference scheme used to solve the model equation. In this section, we examine more fully on implementation of the hydrodynamic model. Three additional elements need to be furnished before a numerical model can be enacted. These are: (1) a computational grid with realistic topography assigned to it; (2) appropriate initial and boundary conditions to be specified in the beginning of the simulation and at the boundary of the computational domain; (3) the calibration and the independent validation of the numerical calculation by field measured data.

The computational grid and the topography

The CH3D-WES numerical model, using boundary fitted coordinate features, provides enhancement for fitting the deep channel and irregular shoreline. It also permits adoption of an accurate and economical grid schematization with the aid of grid generation software (Jin, 1993). The curvilinear grid used in Maalaea Harbor shown in Figure 3.1 was generated from a Army Corps of Engineer topographic and hydrographic map for the Maalaea small boat harbor. With the boundary fitted coordinate, CH3D allows the shoreline and the geometry of the breakwater to be well resolved in detail. The grid is represented by 81 cells in the east-west direction and 60 cells in the north-south direction for a total of 4860 cells. With two layers in the vertical direction, the total number of grid cells doubles. A portion of the grid inside the harbor which is oriented in a nearly west-east direction was blocked from the computational grid to represent the submerged coral reef. The average grid was on the order of 50 feet on a side. The grid's finest resolution concentrated in the harbor itself. Cells in this area measured approximately 25 feet on a side. The grid extends southward of the harbor entrance about 1100 feet and eastward from the east breakwater about 800 feet. The computational domain was bounded by the shoreline to the west and north, and by open boundary condition in the east and south.

The topography shown in Figure 3.2 was read directly from the 1:800 scale chart and smoothed out somewhat through the discrete digitization. The greatest depth is 25-30 feet in the southeast portion of the computational domain and is shallowest to the east of the east breakwater with depths of 2-4 feet. In the harbor basin itself, the depth is generally on the order of 8-10 feet except for a ship channel from the entrance to the north pier where the depth is on the order of 14 feet.

A vertically stretched, staggered grid scheme is used internally for computation. Figure 3.3 illustrates schematically the staggered grid, in which vertical velocity is shifted one half an interval relative to the density, while the horizontal velocity grid is shifted by half an interval horizontally relative to density. The vertically stretched grid preserves the same order of vertical resolution for the shallow and deeper part of the water body, which leads to a smooth representation of the topography.

Initial and boundary conditions

When initiating a run of CH3D-WES, the values of ζ, $\bar{u}$, $\bar{v}$, $\bar{w}$, $\bar{U}$ and $\bar{V}$ are set to zero. Values of salinity and temperature are read from input files. These initial data are generated from prototype measurements at a limited number of locations. Once the values in individual cells are determined by interpolating from the field data, the resulting 3-D field is smoothed. Generally, the salinity and temperature fields are held constant for the first few days of a simulation.

The boundary conditions at the free surface are

$$A_v\left(\frac{\partial \bar{u}}{\partial z}, \frac{\partial \bar{v}}{\partial z}\right) = \left(\tau_{s_\xi}, \tau_{s_\eta}\right)/\rho = \left(C\,W_\xi^2, C\,W_\eta^2\right)$$

$$\frac{\partial T}{\partial z} = \frac{Pr_v}{E_v} K\,(T - T_e) \tag{30}$$

$$\frac{\partial S}{\partial z} = 0$$

whereas the boundary conditions at the bottom are

$$A_v\left(\frac{\partial \bar{u}}{\partial z}, \frac{\partial \bar{v}}{\partial z}\right) = \left(\tau_{b_\xi}, \tau_{b_\eta}\right)/\rho$$

$$= \frac{U_r}{A_{vr}} Z_r\, C_d \left(\bar{u}_1^2 + \bar{v}_1^2\right)^{1/2} \left(\bar{u}_1, \bar{v}_1\right)$$

$$\frac{\partial T}{\partial z}, \frac{\partial S}{\partial z} = 0 \tag{31}$$

where

C = surface drag coefficient
W = wind speed
K = surface heat exchange coefficient
T_e = equilibrium temperature
C_d = bottom friction coefficient
$\bar{u}_1$, $\bar{v}_1$ = values of the horizontal velocity components next to the bottom

C_d is given by

$$C_d = k^2 \left[\ln (z_1/z_o)\right]^{-2} \tag{32}$$

With z_l equal to one half the bottom layer thickness,

where

z_o = bottom roughness height
k = von Karman constant

A Manning's coefficient is selected for the bottom friction in the external mode equations if the model is used only to compute vertically averaged flow fields. The surface drag coefficient is computed according to Garratt (1977) as follows

$$C = (0.75 + 0.067\ W) \times 10^{-3} \tag{33}$$

where

W is the wind speed in m/s

with the maximum allowable value being 0.003. The surface heat exchange coefficient K and the equilibrium temperature T_e are computed from meteorological data (wind speed, cloud cover, wet and dry bulb air temperatures, and relative humidity) as discussed by Edinger, Brady, and Geyer (1974).

At the ocean boundary, the water-surface elevation is prescribed along with time-varying vertical distributions of salinity and temperature. Specified values of salinity and temperature are employed during flood flow, whereas, during the ebb, interior values are advected out of the grid. The normal component of the velocity, viscosity, and diffusivity are set to zero along solid boundaries.

In the Maalaea harbor application, since the salinity and temperature are virtually unchanged during the experiment period, a constant value was employed for the boundary condition.

Three stations were used to collect prototype measurement (Figure 3.4). They are: stations CM1 (inside the harbor) and CM2 (at the entrance) for current velocity, and gauge TG1 (at the entrance) for surface height. Tidal elevation data shown in Figure 3.5 was obtained from the field experiment during the period of July 27 through August 4, 1993. During this period, the tidal record shows the tidal range is 2 to 2.5 feet with strong semi-diurnal and diurnal signals. The wind data obtained are the actual Maalaea harbor wind data telemetered to Kahului Airport. The data are recorded 3 times a day, i.e. hour 0000, 0600 and 1800. Figure 3.6 shows the wind speed and direction data during the experiment period. For the first 3 days, the wind is from the northeast with speeds ranging between 5-20 knots. For the rest of the experiment period, the wind is predominantly from the north with speed ranging from 2-25 knots. During July 28-30, wind data were estimated from nearby weather stations due to the malfunction of the transmitter at the Maalaea weather station.

Calibration and validation of hydrodynamic model

Numerical modeling of hydrodynamic and transport in three dimensions is a highly complicated task. To demonstrate the capability of the model, it must undergo calibration and validation. Calibration is the procedure where certain model parameters are adjusted to maximize the agreement between model results and measured field data. The adjustable parameters in this model are friction, drag and mixing coefficient. Once the calibration procedure is completed, the model is applied without further adjustment of the parameters for validation. Obtaining good comparisons between model and measured data provides confidence that the model can simulate the hydrodynamic condition in the study area.

The Maalaea harbor numerical model calibration was conducted over a 2.5 day period starting at 0800 on the 1st of August and ending at 1930 on the 3rd. Velocity data for both single-depth and multi-depth profiles at station 4 was measured during this time period and used for the calibration. Measured tidal elevations were used to drive the open boundary condition. Semi-diurnal and semi-monthly spring tide is evident in the tide record. Wind data were used to compute the surface stress. The wind direction shown is the direction from which the wind is blowing. The angle of the direction is based on true north convention; an angle equal to zero defines a wind blowing from north to south, and angle increase in a clockwise direction. The average wind speed experienced during this period of simulation was 12 knots (6 m/s), with the wind direction blowing predominantly from the northeast.

At the outset of the calibration, a Manning n, the friction parameter, equal to 0.035 was used for the entire area. However, to better calibrate against the velocity measurement data, a Manning's n 0.040 was assigned to the area with depth less than 5 feet, a Manning's n of 0.037 was assigned to the area having depths less than 10 feet and greater than 5 feet while n equal to 0.035 was used for the rest of the area. With the refinement, satisfactory results were obtained. Figures 3.7 - 3.8 show the final comparisons of channel velocity for surface and bottom layer at station 4. Observation 1 was measured every 2 minutes by single depth Endeco current meter while observation 2 was a profile profiler measurement with 30 minutes as time interval. A good agreement was obtained for both data set with numerical model calculations. Notable exceptions occurred during brief periods, such as hour 15 19 and 22 where the model under-predicts the surface current speed. It appears that during periods of high wind, wind generated waves can degrade the accuracy of the Endeco current meter readings.

The final set of model coefficients thus determined are: The Manning's coefficient n equal to 0.035 for the global area; shallow areas having depths less than 5 feet but greater than 10 feet, a Manning's n equal to 0.037 was assigned and areas having depth less than 10 feet, n equal to 0.040 was assigned. Horizontal mixing coefficient equals 1000 cm^2/sec and base vertical mixing coefficient equals 10 cm^2/sec. The wind drag coefficient is calculated by the formula:
$C = (0.75+0.67\ W) x\ 10(^{-3})$, Where W is measured in m/s. In summary:

Manning coefficient	n = 0.035-0.040
Horizontal mixing coefficient	$A_H = 1000\ cm^2/sec$
Base vertical mixing coefficient	$A_V = 10\ cm^2/sec$

Wind drag coefficient is: $C = (0.075+0.67\ W) \times 10$

where W is wind speed in meter/sec

The validation of Maalaea harbor hydrodynamic model was conducted over a 5 day period starting at 0730 on 27 July and ending at 0730 on the 1 August. Figure 3.9 shows the overall tide and wind conditions, which are similar to the calibration period except that tide amplitude is somewhat reduced in magnitude. Measured velocity data at two locations were used for the validation: station 2 and the station 4. The water depth at station 4 was 11 feet. Current measurements were taken at 3 feet and 7 feet above the bottom. Results are shown in Figure 3.10. The predicted velocity components match the prototype measurement reasonably well. At station 2, the water depth was 8 feet. Current measurements were taken at 3 feet above the bottom. The comparison was made using depth averaged results with the single depth measurements. The results are presented in Figure 3.11. The predicted and measured north-south component velocity agreed reasonably well. It appears that the velocity was relatively small at this site. For the east-west component velocity, there was a lesser degree of agreement between measured and predicted values. For instance, between day 1 and day 1.5, the model under-predicts the measured data. This discrepancy of the comparison may be due to the inaccuracy of the wind data, which was an estimation from nearby stations. Comparing the surface and bottom velocity reveals that, most of the time, they flow in opposite directions .ie. the surface layer flows out of the harbor while the bottom layer flows into the harbor. This two layer flow pattern was set up because the surface layer moves in the north wind direction while the bottom layer forms a compensating flow in the opposite direction.

Figure captions - section 3

Figure 3.1 Curvilinear grid layout for Maalaea Harbor and its vicinity.

Figure 3.2 Maalaea Harbor and Maalaea Bay topography.

Figure 3.3 Vertical stretched and staggered numerical grid.

Figure 3.4 Current meter, tidal gauge locations and stations for model output.

Figure 3.5 Tidal gauge data, 27 July - 4 August, 1993.

Figure 3.6 Wind speed and direction, 27 July - 4 August, 1993 at Maalaea Harbor.

Figure 3.7 Numerical model calibration: model and data comparison for surface layer at station 4, 1 August - 3 August, 1993.

Figure 3.8 Numerical model calibration: model and data comparison for bottom layer at station 4, 1 August - 3 August, 1993.

Figure 3.9 Numerical model validation: model and data comparison for surface layer at station 4, 27 July - 1 August, 1993.

Figure 3.10 Numerical model validation: model and data comparison for bottom layer at station 4, 27 July - 1 August, 1993.

Figure 3.11 Numerical model validation: model and data comparison for depth averaged u velocity at station 2, 27 July - 1 August, 1993.

Figure 3.12 Numerical model validation: model and data comparison for depth averaged v velocity at station 2, 27 July - 1 August, 1993.

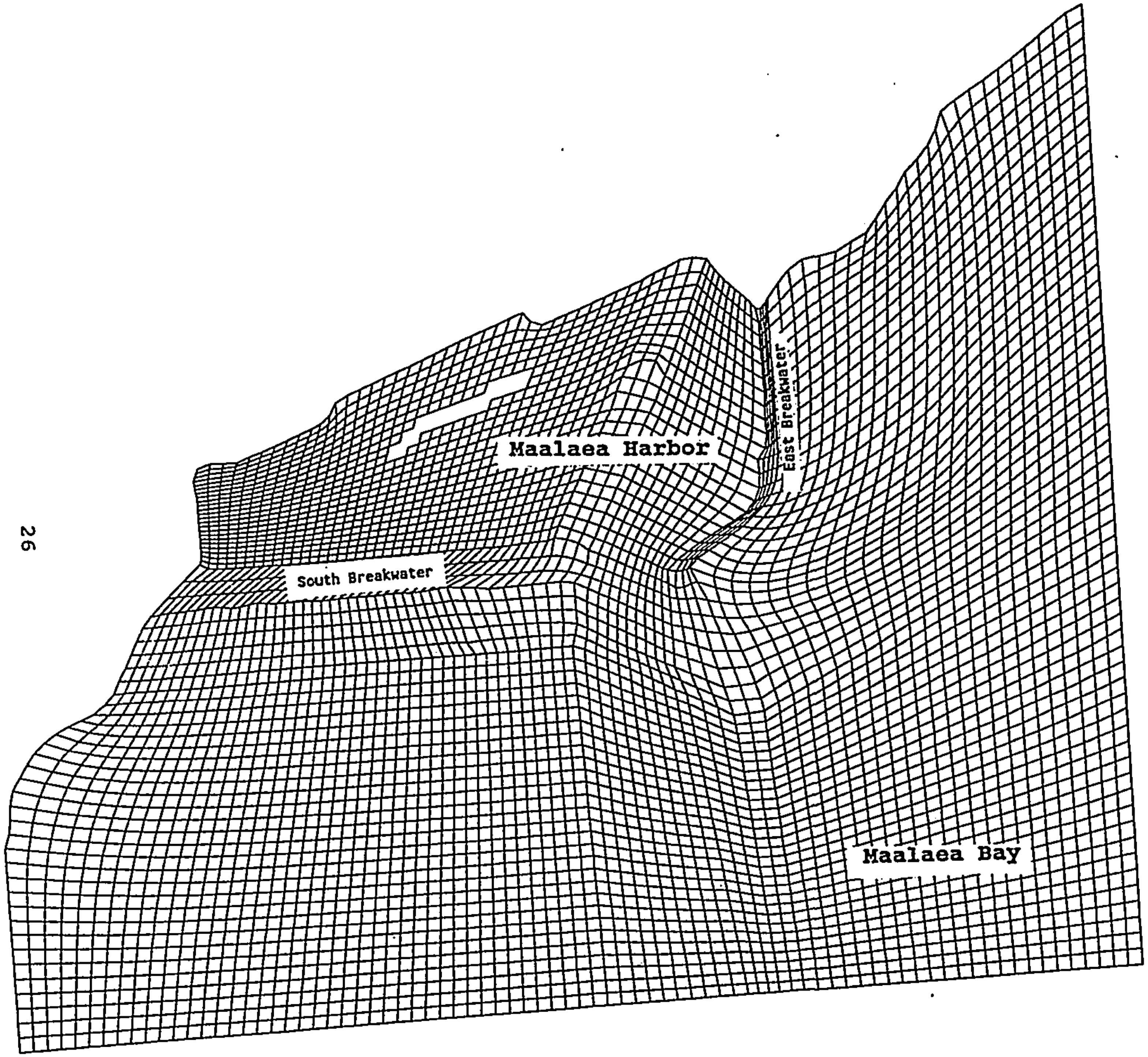

Maalaea Harbor
East Breakwater
South Breakwater
Maalaea Bay

Figure 3.1

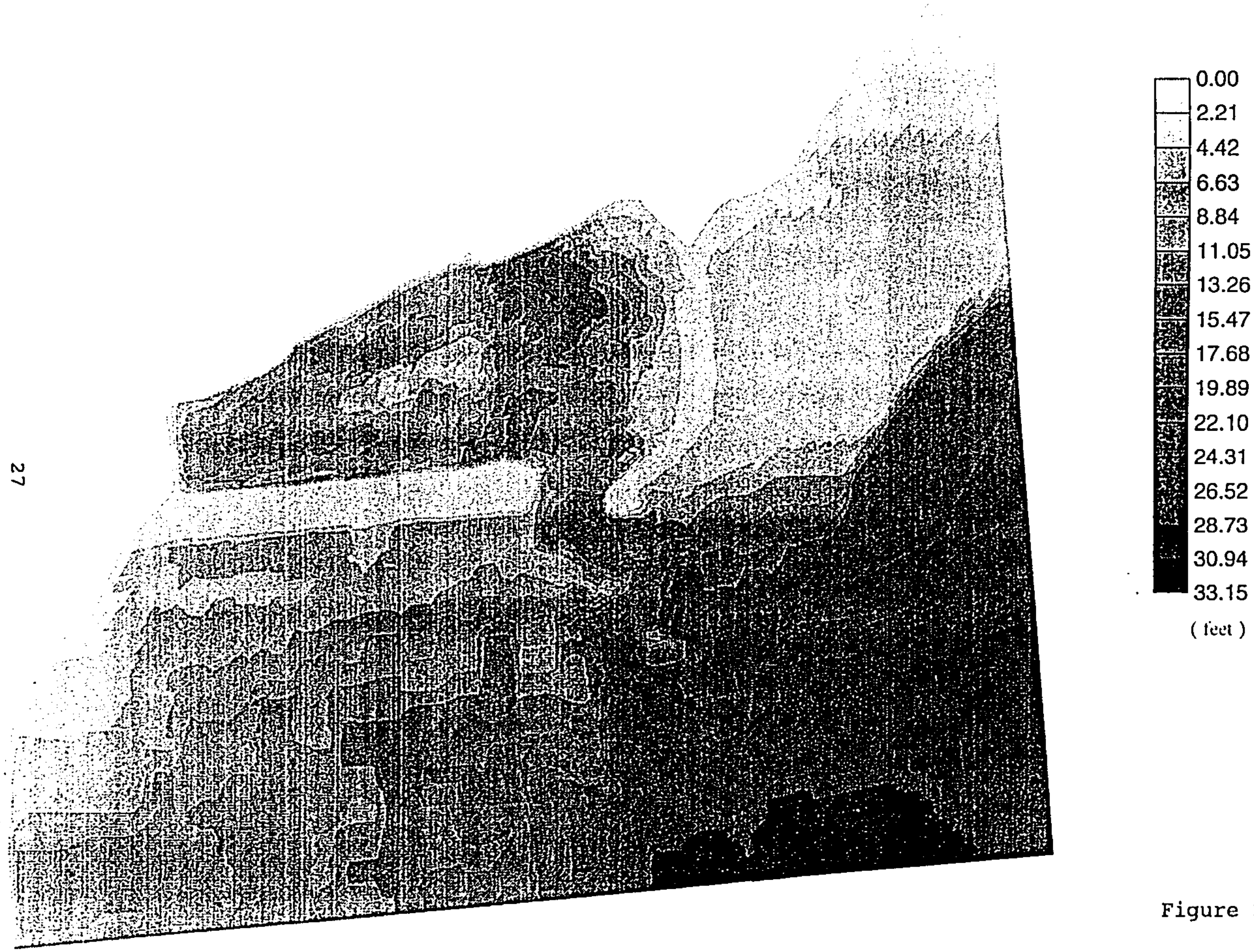

0.00
2.21
4.42
6.63
8.84
11.05
13.26
15.47
17.68
19.89
22.10
24.31
26.52
28.73
30.94
33.15
(feet)

Figure 3.2

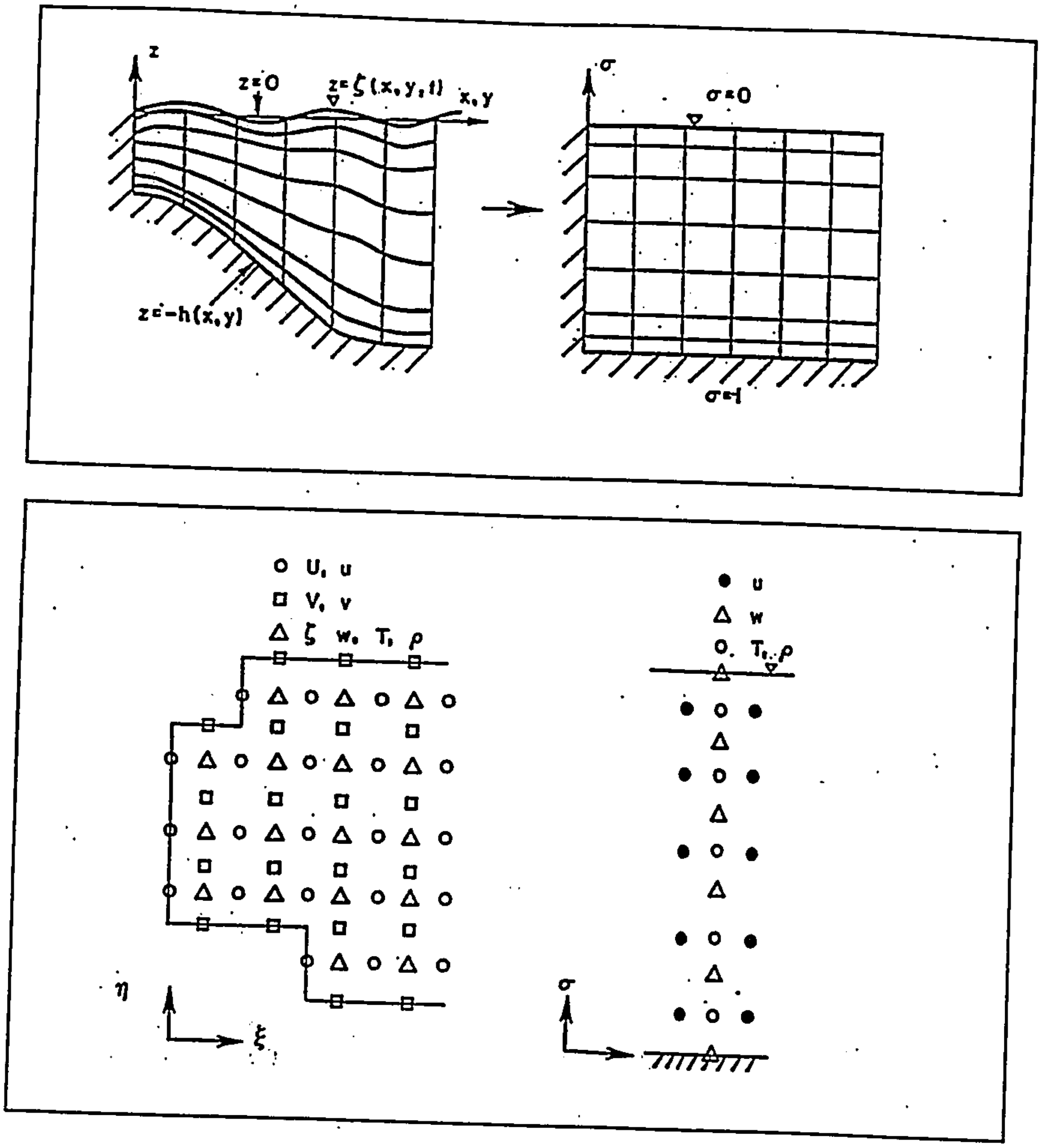


Figure 3.3 Vertically stretched (top), staggered (bottom) numerical grid

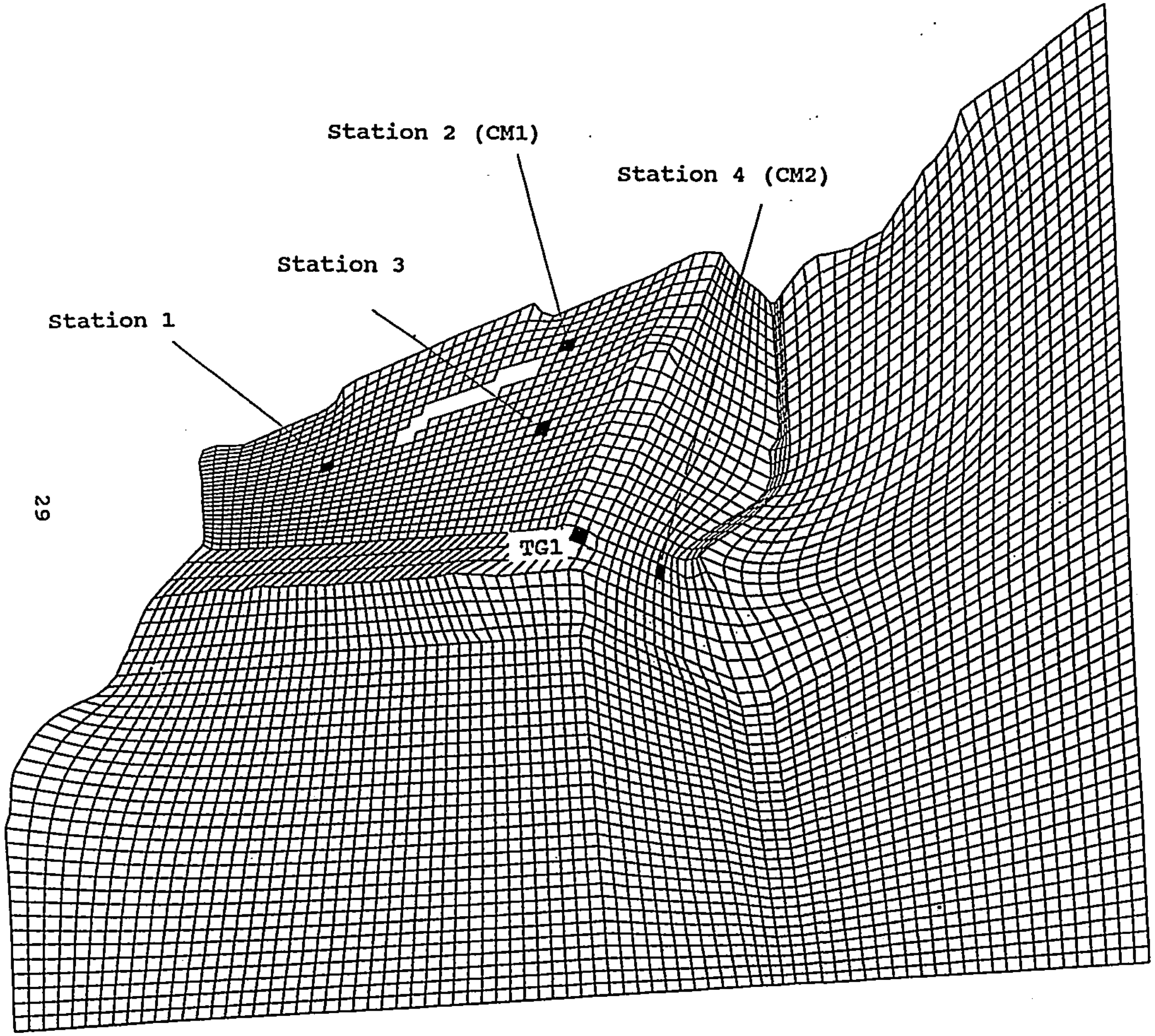


Figure 3.4

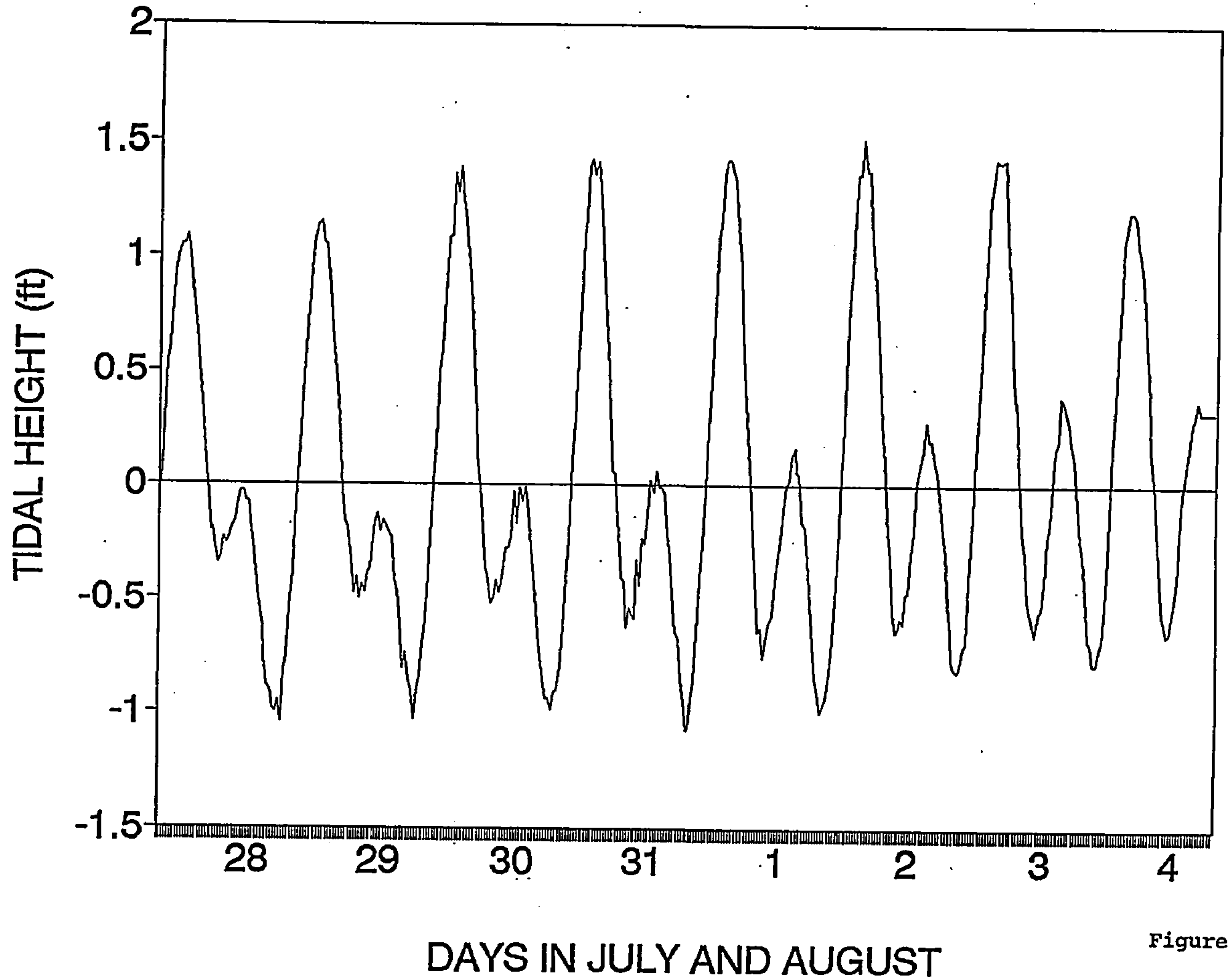

TIDAL HEIGHT (ft)
2
1.5
1
0.5
0
-0.5
-1
-1.5
28
29
30
31
1
2
3
4
DAYS IN JULY AND AUGUST

Figure 3.5

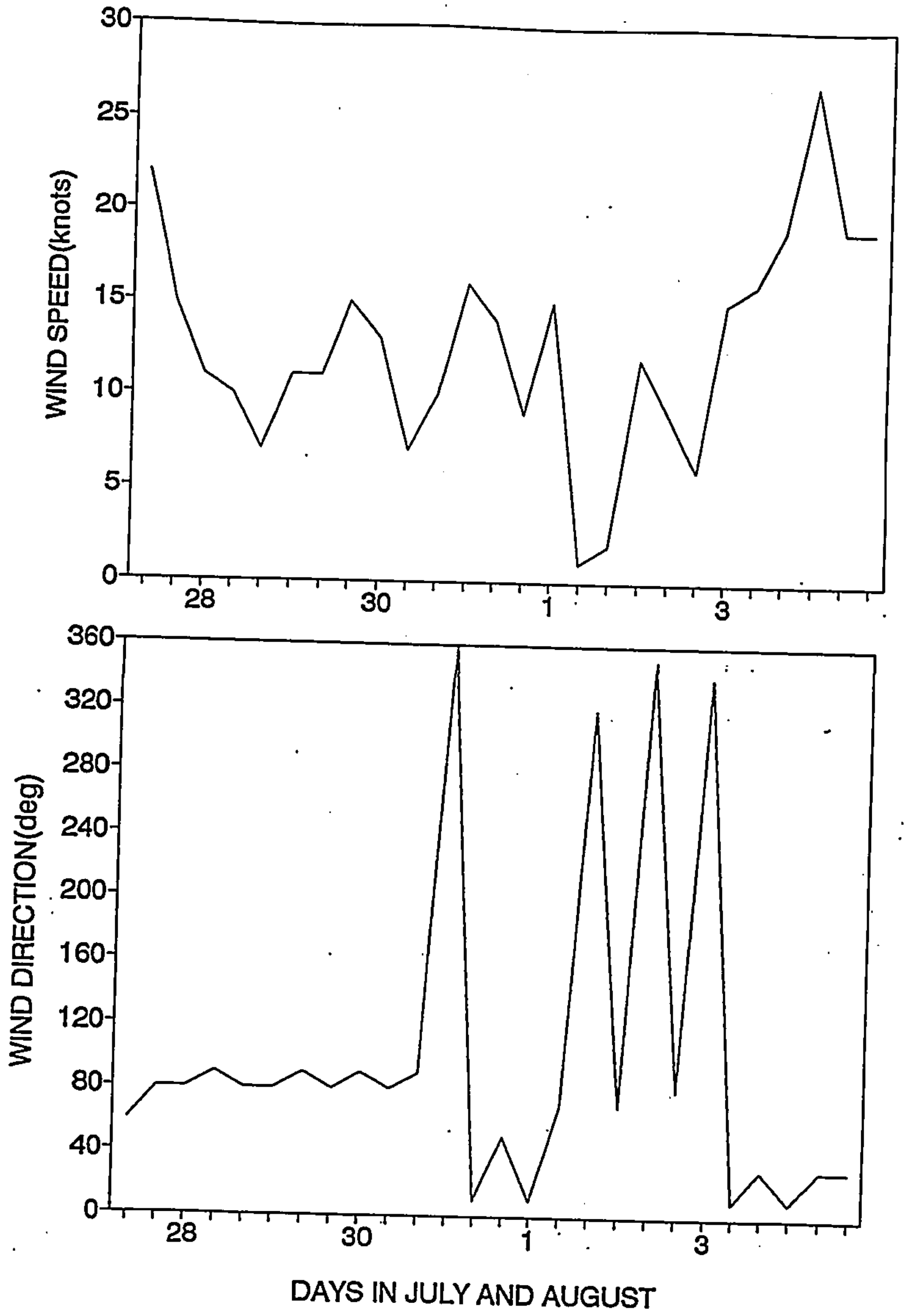


Figure 3.6 Wind speed and direction in Maalaea Harbor

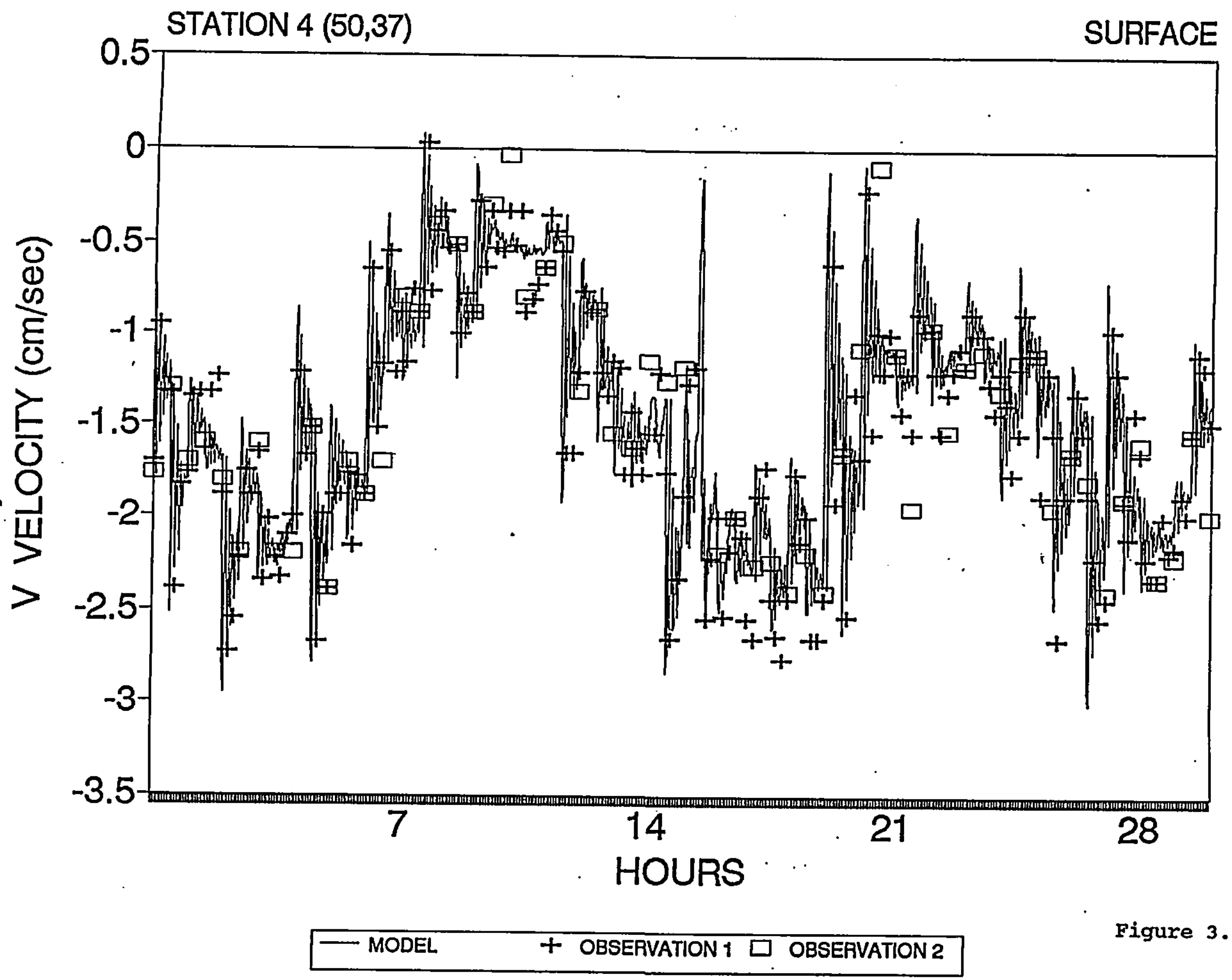

STATION 4 (50,37)
SURFACE
V VELOCITY (cm/sec)
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
7
14
21
28
HOURS
MODEL
OBSERVATION 1
OBSERVATION 2

Figure 3.7

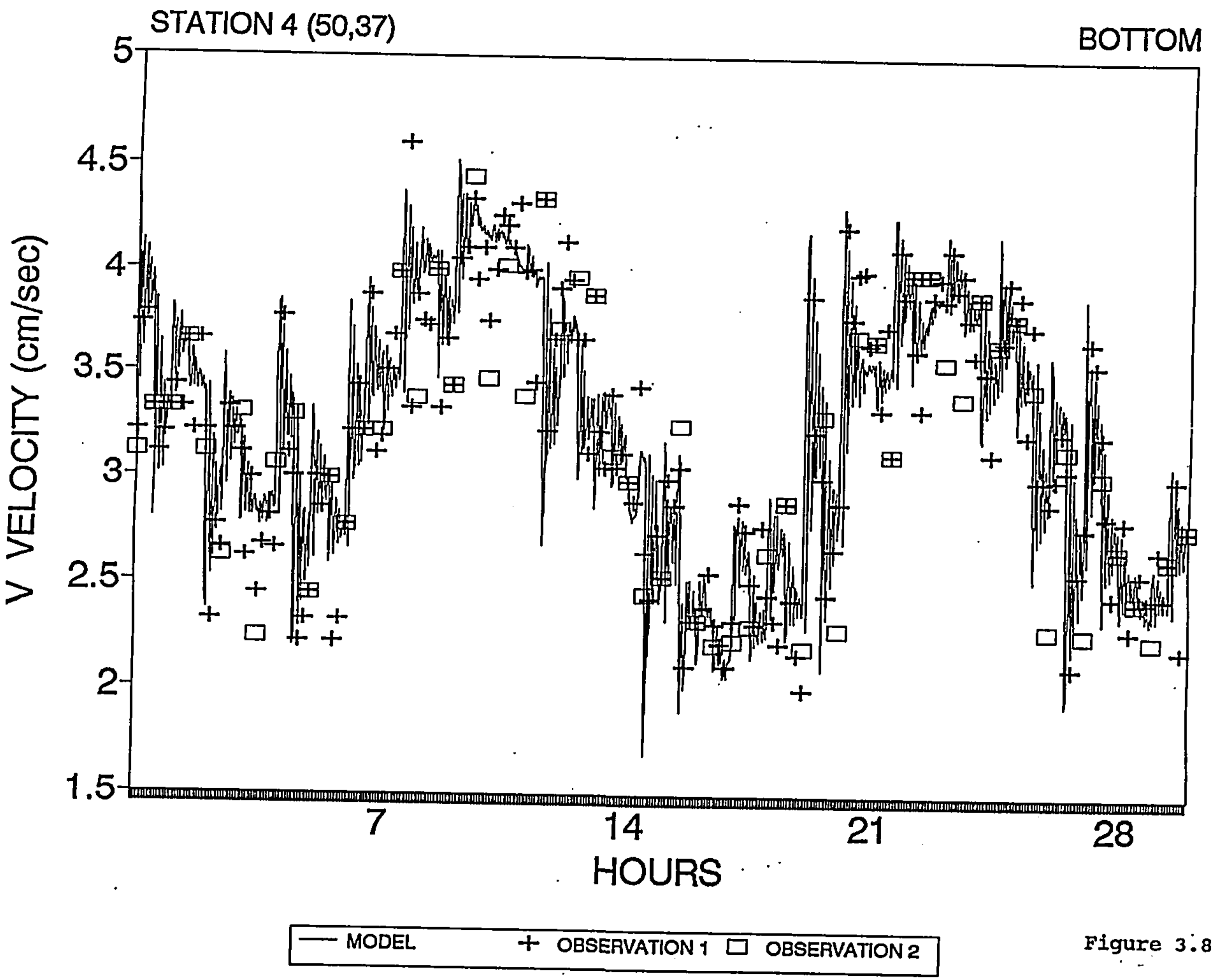

STATION 4 (50,37)
BOTTOM
V VELOCITY (cm/sec)
5
4.5
4
3.5
3
2.5
2
1.5
7
14
21
28
HOURS
MODEL
OBSERVATION 1
OBSERVATION 2

Figure 3.8

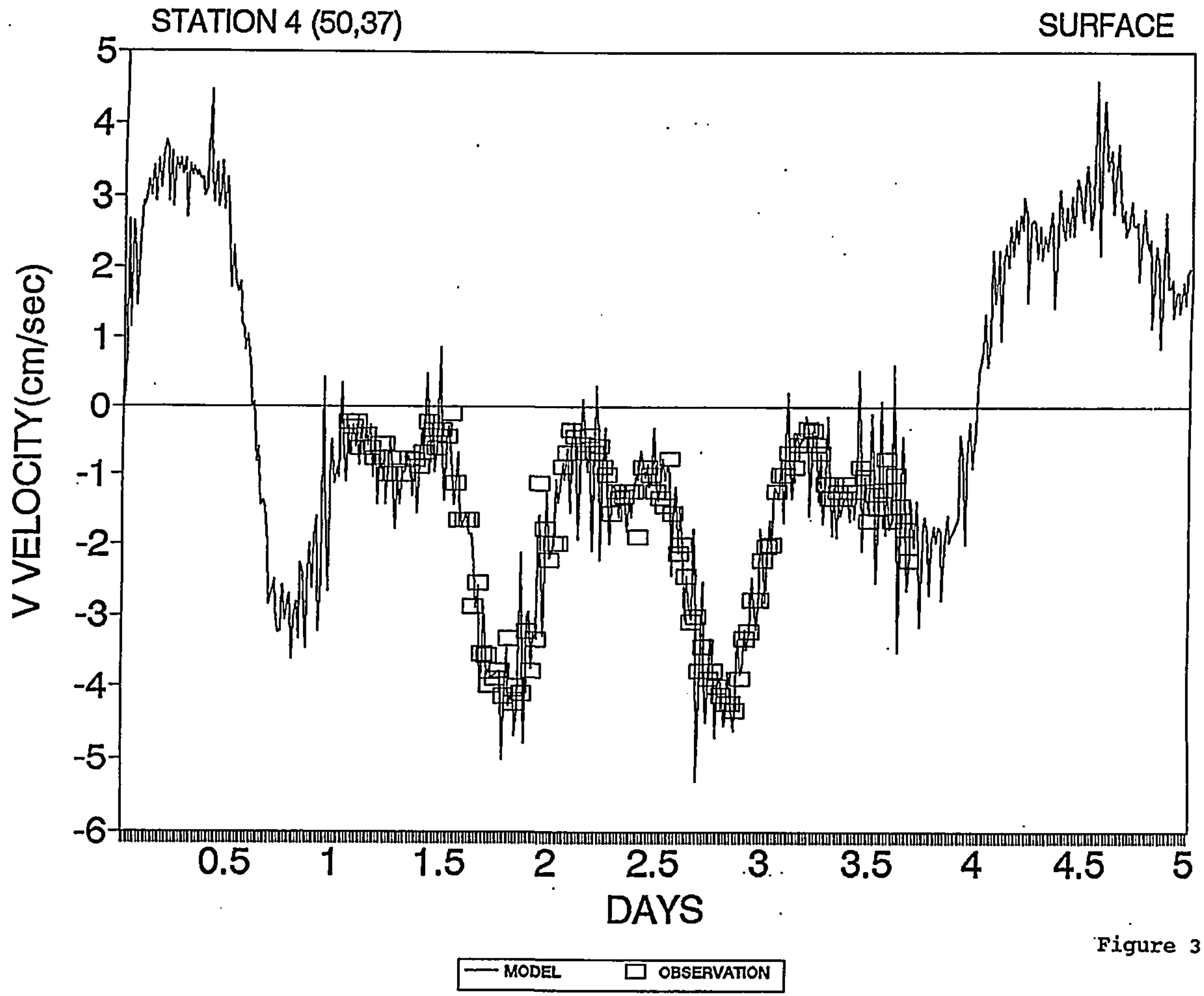

STATION 4 (50,37)
SURFACE
V VELOCITY(cm/sec)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
DAYS
MODEL
OBSERVATION

Figure 3.9

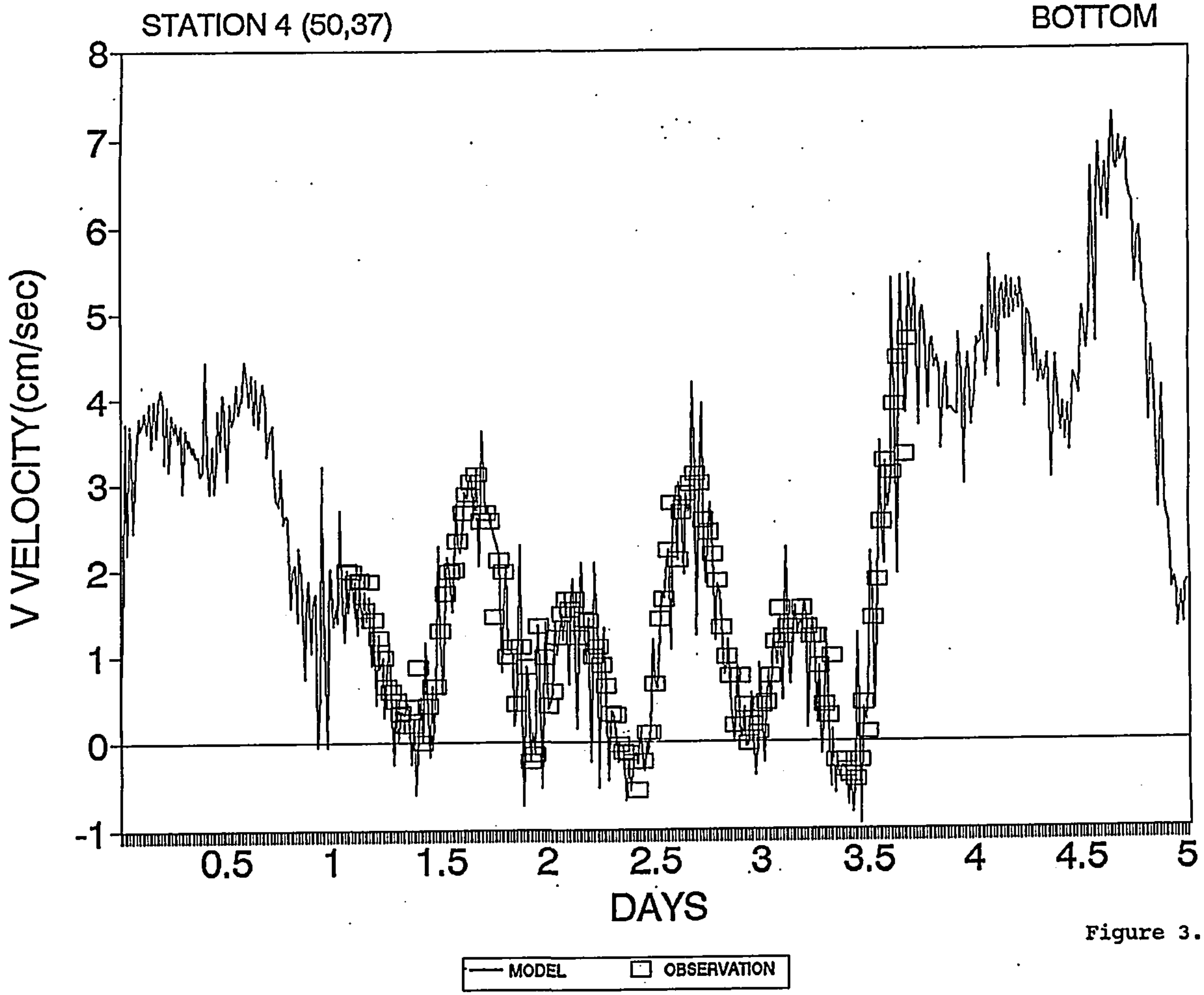

STATION 4 (50,37)
BOTTOM
V VELOCITY(cm/sec)
8
7
6
5
4
3
2
1
0
-1
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
DAYS
MODEL
OBSERVATION

Figure 3.10

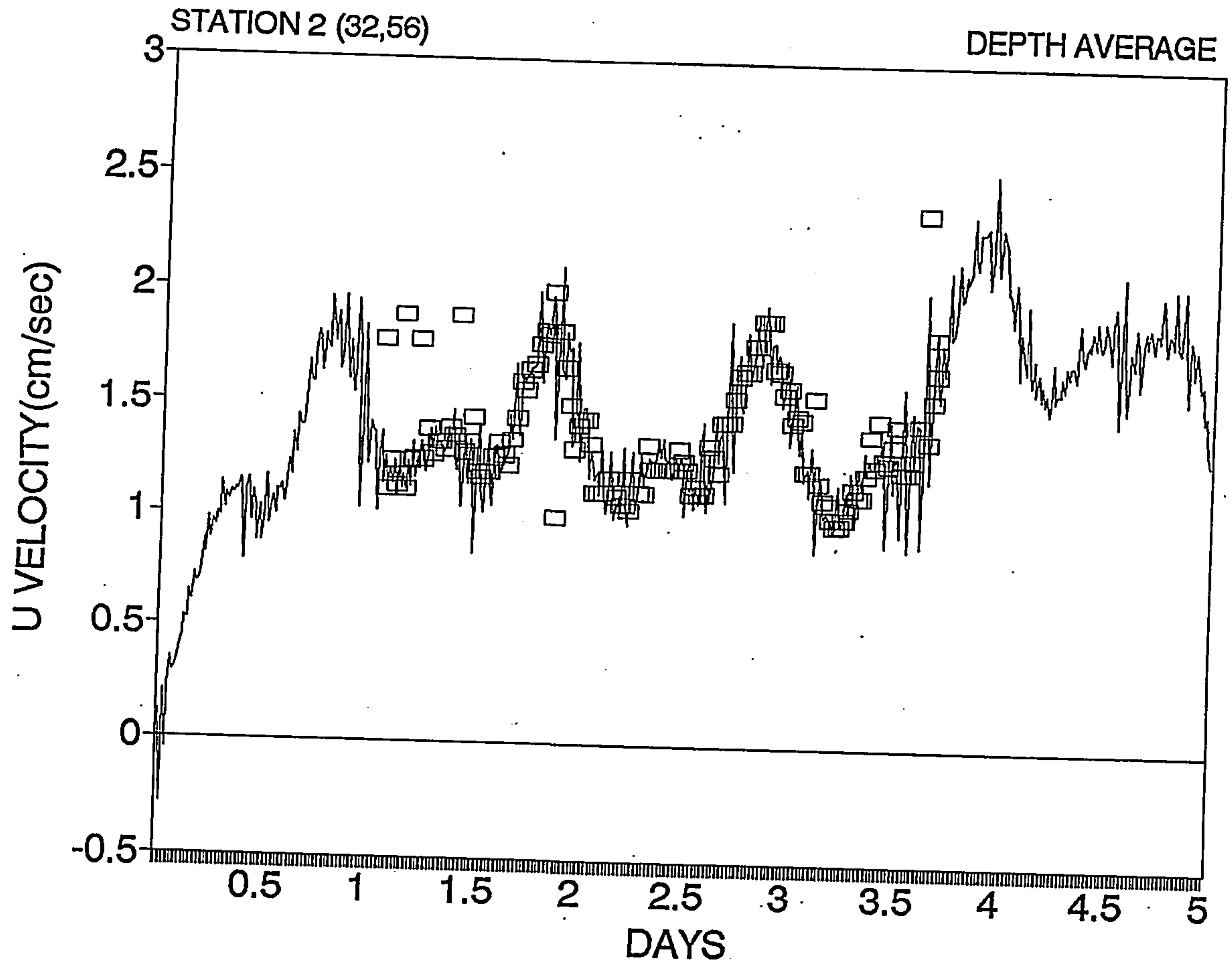

STATION 2 (32,56)
DEPTH AVERAGE
U VELOCITY(cm/sec)
3
2.5
2
1.5
1
0.5
0
-0.5
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
DAYS

Figure 3.11

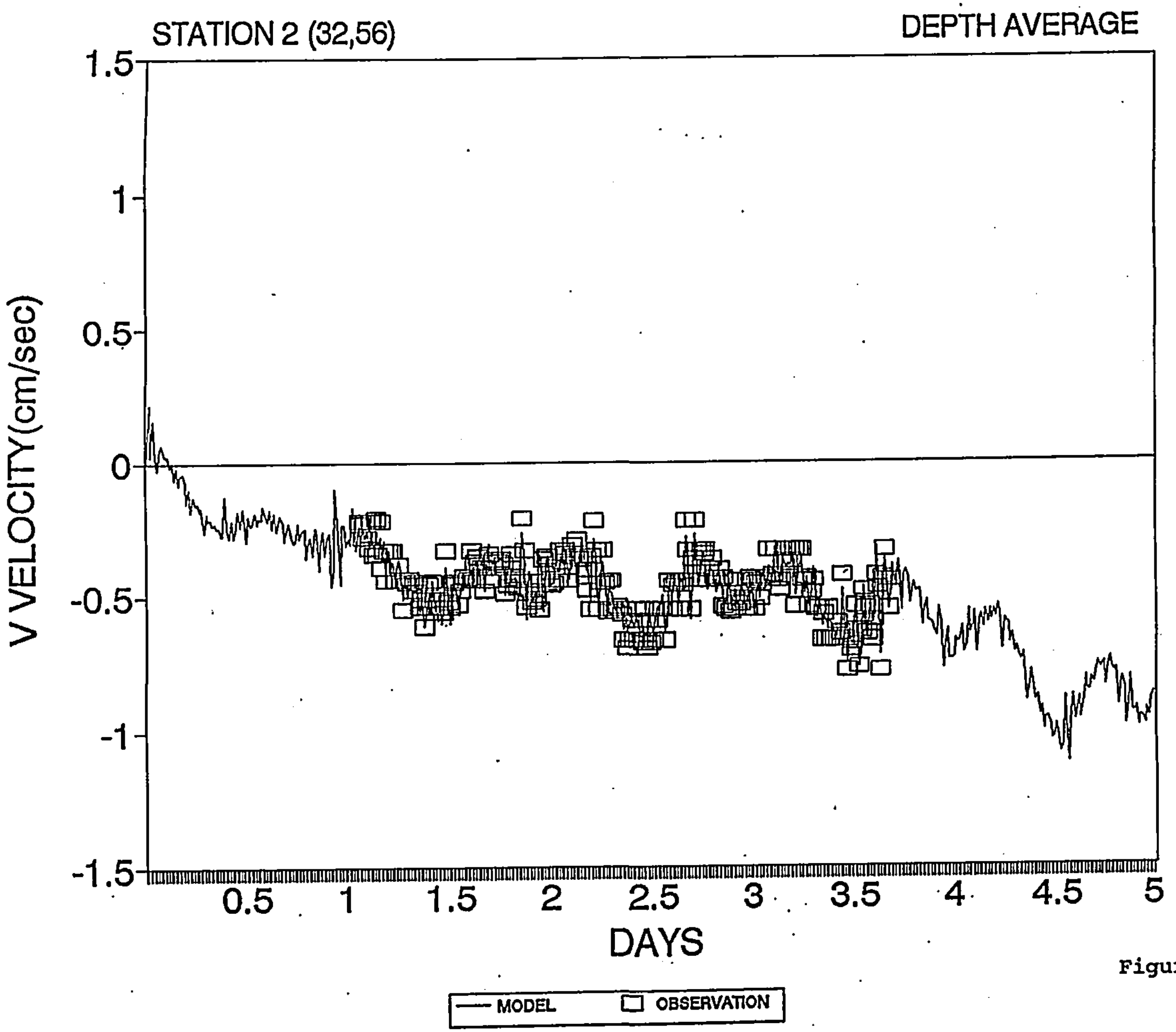

STATION 2 (32,56)
DEPTH AVERAGE
V VELOCITY(cm/sec)
1.5
1
0.5
0
-0.5
-1
-1.5
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
DAYS
MODEL
OBSERVATION

Figure 3.12

4. Scenario description and results

In section 3, a calibrated and validated numerical hydrodynamic model has been developed along with its computational grid and the initial and boundary conditions. With the satisfactory comparison between model results and the field measured data, confidence is established that the numerical model so developed is a reliable tool and can be utilized for scenario runs. In this section, the numerical model will be used to test two proposed plans in Maalaea harbor. The results will be used to assess the possible impacts from the proposed plans on hydrodynamic and flushing conditions.

Scenario description

Two proposed plans, alternative plan 2 and alternative plan 6 shown in Figure 4.1-4.2, were the focus of the hydrodynamic and flushing study.

Under alternative plan 2 (hereafter AP 2), changes from the existing harbor are:

1. A 620-foot-long extension to the existing south breakwater.
2. An additional 400-foot-long revetment on the seaward side of the existing south breakwater.
3. A 610-foot-long entrance channel with width varying from 150 to 180 feet and depth varying from 12 to 15 feet.

Under alternative plan 6 (hereafter AP 6), changes are:

1. A 600-foot-long mole structure built in the existing harbor.
2. An additional berth facility on the inward side of the mole.
3. Removal of a submerged coral reef in the existing harbor to provide more berth space for the existing south breakwater.

Model input files for grid and topography were changed to reflect the configuration of the above changes. Other than those two files, the initial and boundary condition for the proposed plans are set to be identical to that of existing condition. Each plan was run using the same condition of tide, wind and calibrated parameters. Comparisons of circulation pattern, current velocity and flushing time can then be made between existing condition and the two alternatives. The period selected for the simulation begins on July 27 and ends on August 1, 1993. For the hydrodynamic impact study, the results are presented in terms of circulation pattern (vector plot) and current velocity (time series plot). For the flushing study, the results are presented in terms of contour plot and the time series of the tracer concentration. Four stations shown in Figure 3.4 are again used for presenting the time series data.

Analysis of hydrodynamic impact from proposed plans

1. The results for existing condition

With little fresh water input, circulation in a small harbor is often driven by the tide. However, with a prolonged steady wind, current induced by wind can be as significant as that from astronomical tide. The tidal range in the Maalaea harbor is on the order of 2 to 3 feet. Wind is steady in direction, predominantly from the north and northeast, with speed vary from 2 to 25 knots. Trade winds funneled by two mountain range Puu Lalua (5788 feet) and Puu Kukui (10,023 feet) on two sides of the harbor was rectified into north and northeast direction at a slightly magnified velocity is the reason for the prolonged winds (Nakashima, 1994). This is evident by the wind record in this region.

Figure 4.3 shows the vector plot of the surface layer circulation at day 3 when it is during flood tide with wind from the northeast. One can readily observe that the entire circulation outside the harbor, driven by northeast winds, is from northeast toward southwest with current speed in the bay varying from 10-15 cm/s. A small portion of the flow outside the east breakwater actually has a reversal and a separation due to westward flow interacting with the breakwater. Velocity is somewhat diminished and the direction turned toward the south when approaching the west coastline. Circulation inside the harbor, on the other hand, is such that a clockwise flow pattern was set up due to the northeast wind pushing the water against the south breakwater. Overall, the velocity is 2-5 cm/s, which is about an order of magnitude smaller than the velocity outside the harbor.

Figure 4.4 shows the time series plots of velocity for the surface and bottom layers at the entrance of the harbor. Comparing the direction of the surface and bottom velocity confirms the wind driven two layer flow pattern found in the previous section. It becomes obvious that superposed on the regular rise and fall of astronomical tide, there is a significant vertical shear set up by a prolonged north wind. This steady wind driven two layer circulation is what makes dynamics of Maalaea Harbor circulation unique from many of the small harbors, in which tide is the only dominant force.

<u>2. The results for alternative plan 2</u>

In AP 2, a breakwater was proposed to extend from the existing south breakwater in southeast direction (Figure 4.1). Figure 4.5 presents the surface layer circulation at day 3 when it was at flood tide with wind from the northeast direction – the same condition presented for the existing condition. An immediate effect of the proposed breakwater on the circulation was seen in the bay water. The proposed breakwater deflects the incoming flow from the southwestward direction to straight south with a increased velocity. This was clearly shown in the east and the southeast portion of bay from the vector plot. Related to the deflection, the original southwestward flow becomes a northward compensation flow behind the proposed breakwater. Therefore, a large area between the proposed breakwater and the west coastline derive a flow direction different from that of the existing condition. Also, a noticeable eddy was generated around the tip of the proposed breakwater which has an effect on the flow around the mouth of the harbor and its vicinity. The previously separated and reversed flow near the east breakwater disappears. Inside the harbor, the velocity pattern is similar to the existing condition.

Figures 4.6 show time series of the surface and bottom velocity at the entrance of the harbor for AP 2. The velocity variation is similar to the existing condition but slightly smaller in magnitude. Comparing the direction of the surface and bottom flow, the wind induced two layer flow persists, .ie. surface layer flows outward while bottom layer flows inward. However, the flow pattern appears to be less influenced by transient wind and more in tune with oscillatory tidal flow.

3. The results for alternative plan 6

In AP 6, a mole was proposed to be placed inside the existing harbor toward the northeast direction (Figure 4.2). Figure 4.7 shows surface layer circulation at day 3 again for comparison. Unlike AP 2, the flow in the bay was hardly changed in comparison with the existing condition. Inside the harbor, velocity was seen slightly increases along the tip and east side of the mole presumably due to the new configuration. Figure 4.8 shows channel velocity at surface and bottom layer for AP 6 in the harbor entrance. It was revealed that AP 6 has the smallest channel velocity at the harbor entrance. By plotting time series of all three condition .ie. existing, AP 2 and AP 6 together, Figures 4.9 - 4.10 further confirm that velocity for AP 6 was only 30 to 40 % of the existing condition (a drop of 60-70 %). This is significant in terms of flushing because ultimately the flushing rate is dependent on how much water is exchanged between the harbor and the bay water through the harbor entrance. The reduction of channel velocity at the entrance is attributed to two factors associated with AP 6. First, a restriction section was created between the mole and the north bank which act like a control section limiting the velocity variation otherwise possible. Second, the mole structure itself decreases the harbor area with which water can freely exchange.

Analysis of impact on flushing characteristics from proposed plans

1. Definition of flushing time

A measure of flushing of a semi-enclosed water body can be defined as the time required for a conservative tracer C to decrease to 36.8 % (1/e, e=2.71828) of its initial concentration C_0 . Given the fixed amount of tracer to be diluted, the longer the flushing time required, the poorer the flushing rate is. Conversely, a higher flushing rate will result in a shorter time to exchange the prescribed amount of water. For adequate flushing of a basin, Clark(1983) recommends that a maximum time of 2-4 days should be safe as a design criteria while a period of more than ten days should be considered an unacceptable flusing time.

2. Method of Calculating flushing time

The flushing of a shallow, semi-enclosed basin is dynamically related to the rate of exchange between the basin and the large water body to which the basin is connected. Primary factors that influence the flushing of a shallow basin include: astronomical tide, wind force, the basin geometry and topography, and the concentration of the receiving water body .

In calculating flushing time, the tidal prism method is the most widely used. However, the tidal prism method is limited by following shortcomings: (1) it does not account for wind effect; (2) it assumes that the receiving water body itself is well flushed within tidal cycles; and (3) in most of the cases, it does not account for complex geometry and topography. In the present approach, all three factors are included. Furthermore, the harbor and the bay are consider as a coupled system in the numerical model framework. With three-dimensional flow field available, it remains to introduce the conservative tracer into system to calculate the flushing time numerically. The equation used to calculate the concentration is an advection-diffusion equation, similar to the one used for calculating salinity (see Section 2). Both are without internal source and sink terms.

3. Flushing characteristics in Maalaea Harbor

In the initial time, a 0 ppt (part per thousand) tracer concentration was set for the entire bay water while a tracer of 100 ppt was introduced into the entire harbor. As the time passes, the tracer gradually spreads over a large area. The boundary condition is such that during ebb, interior concentration values are advected out of the grid while during flood, the specified return value will be applied.

For a conservative tracer, the concentration must become more and more diluted with time. Figures 4.11 - 4.13 show the time evolution of the tracer one day after it was introduced into the harbor during a flood tidal cycle. Figure 4.11 shows the concentration at the beginning time, a low tide, while figure 4.13 shows the concentration at the end time, a high tide. Figure 4.12 shows the intermediate concentration. While the contour usually has irregular shapes and grow in a highly complex manner, there are consistent patterns recognizable throughout the simulation period. First, the highest concentration is always located at the west corner of the harbor, a region at far side of the harbor entrance. Second, a strong concentration gradient is present at the harbor entrance separating two relatively well mixed region, one inside the harbor, the other in the bay. Third, the concentration in the north bank of the harbor is slightly but always higher than the south bank. Fourth, the concentration inside the harbor is gradually but steadily being diluted. Even in a half tidal cycle, Figure 4.11- 4.13 clear show that the tracer is being diluted by the incoming flood waters. This flushing process will continue until the concentration in the harbor approaches that of the bay water.

The contour plots during the same time for plan 2 and plan 6 are shown in Figures 4.14 - 4.17. Comparing all the plots just shown, it is clear that plan 6 has the highest concentration (poorest flushing) of all. Further examination on the contour pattern shows that the concentration near the restricted section has the greatest gradient. This further suggests that the restricted section indeed acts like a control section for the exchange process.

Time history of the tracer concentration inside the harbor were also recorded at three locations, stations 1, 2 and 3 (Figure 3.4) as shown in Figures 4.18 - 4.20. Figure 4.14 shows that at station 1, the concentration takes 2.9 days to drop to 37 ppt of its initial 100 ppt concentration for exisiting condition, which is by definition its flushing time. Similar calculations show the flushing time leads to be 3.3 days (a 14% increase from existing condition) for AP 2 and 6.3 days (a 117% increase from existing condition) for AP 6. Figure 4.19 shows that at station 2, the flushing time is 2.7 days for existing condition, 3.2 days (a 18% increase) for AP 2 and 5.5 days (a 103% increase). Figure 4.20 shows at station 3, the flushing time is 2.1 days for existing condition, 2.3 days (a 9.5 increase) for AP 2 and 5.3 days (a 152% increase) for AP 6. Table 4.1 summarizes the flushing time calculated under various conditions at different locations.

The proposed new breakwater under AP 2, essentially a extension of the existing south breakwater, does not change the channel configuration and the exchange area of the harbor. Consequently, a minimum impact on flushing characteristics was created. The result is a small increase of flushing time. By contrast, AP 6 proposes a mole structure built into the harbor, which not only creates a new restriction section but changes the harbor configuration in a way such that the exchange between harbor and the bay is reduced. As a result, a significant increase of flushing time is realized.

Figure captions - section 4

Figure 4.3 Vector plot of surface layer circulation at day 3 (0730, 30 July, 1993) for the existing condition.

Figure 4.4 Time series of surface and bottom channel velocity at the entrance of the harbor for the existing condition.

Figure 4.5 Vector plot of surface layer circulation at day 3 (0730, 30 July, 1993) for alternative plan 2.

Figure 4.6 Time series of surface and bottom channel velocity at the entrance of the harbor for alternative plan 2.

Figure 4.7 Vector plot of surface layer circulation at day 3 (0730, 30 July, 1993) for alternative plan 6.

Figure 4.8 Time series of surface and bottom channel velocity at the entrance of the harbor for alternative plan 6.

Figure 4.9 Time series of channel velocity (surface layer) at the entrance of the harbor for existing condition, alternative plan 2 and alternative plan 6.

Figure 4.10 Time series of channel velocity (bottom layer) at the entrance of the harbor for existing condition, alternative plan 2 and alternative plan 6.

Figure 4.11 Contour plot of conservative tracer concentration at low tide, one day after it was introduced into the existing harbor condition.

Figure 4.12 Contour plot of conservative tracer concentration at half tide, one day after it was introduced into the existing harbor condition.

Figure 4.13 Contour plot of conservative tracer concentration at high tide, one day after it was introduced into the existing harbor condition.

Figure 4.14 Contour plot of conservative tracer concentration at low tide, one day after it was introduced into alternative plan 2 harbor condition.

Figure 4.15 Contour plot of conservative tracer concentration at high tide, one day after it was introduced into alternative plan 2 harbor condition.

Figure 4.16 Contour plot of conservative tracer concentration at low tide, one day after it was introduced into alternative plan 6 harbor condition.

Figure 4.17 Contour plot of conservative tracer concentration at high tide, one day after it was introduced into alternative plan 6 harbor condition.

Figure 4.18 Time series of conservative tracer concentration at station 1, covering existing, alternative plan 2 and alternative plan 6 conditions.

Figure 4.19 Time series of conservative tracer concentration at station 2, covering existing, alternative plan 2 and alternative plan 6 conditions.

Figure 4.20 Time series of conservative tracer concentration at station 3, covering existing , alternative plan 2 and alternative plan 6 conditions.

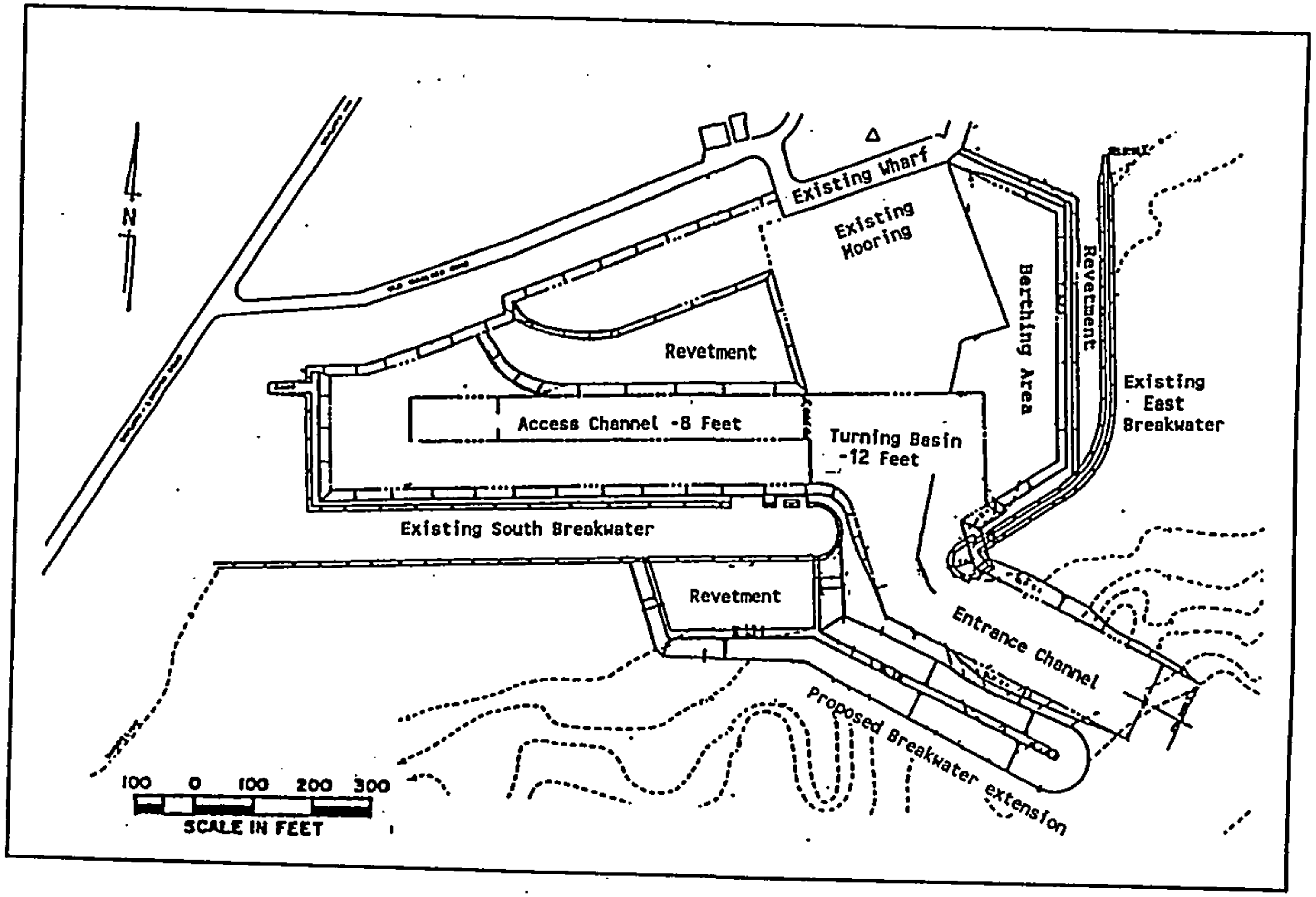


Figure 4.1 Alternative Plan 2

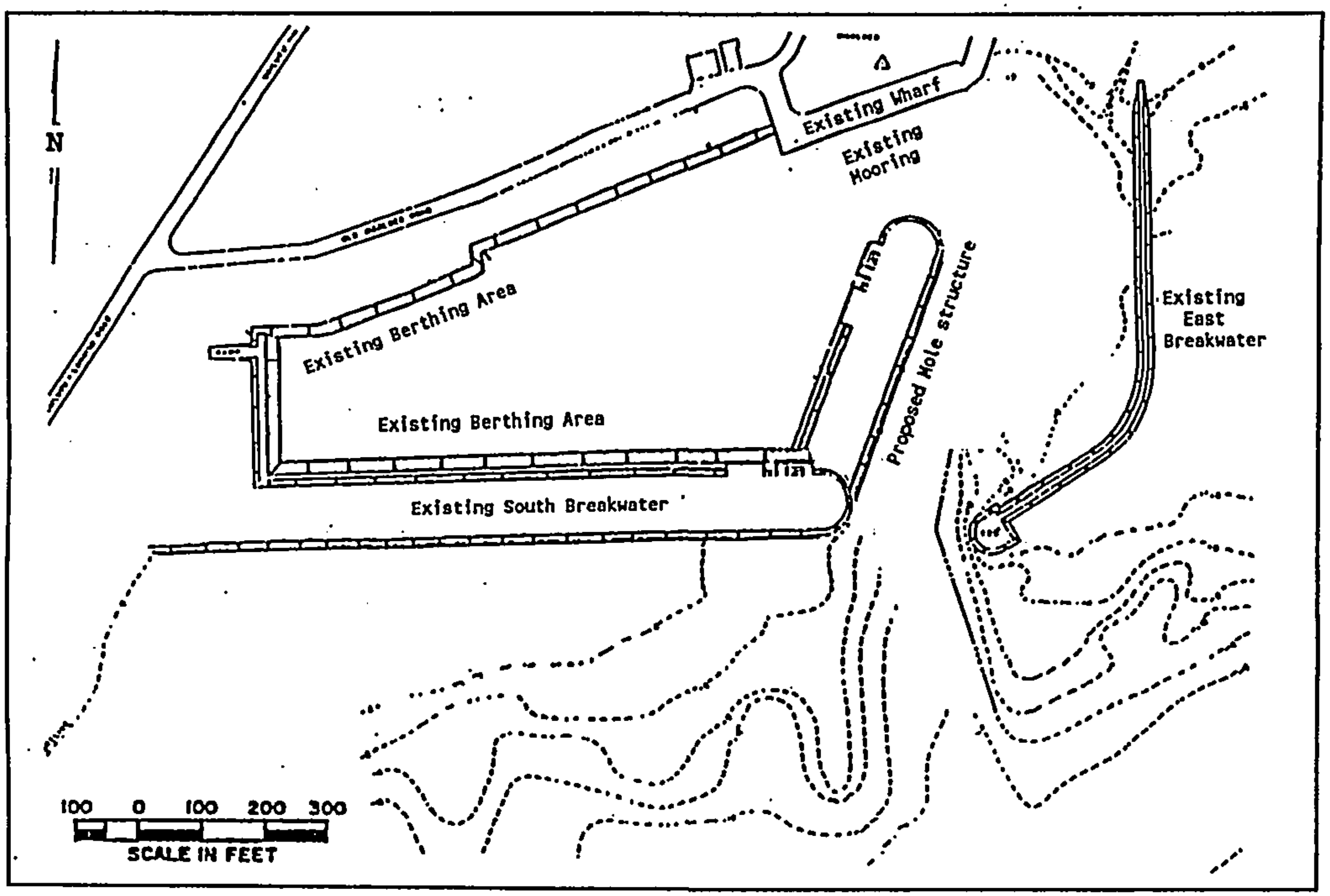


Figure 4.2 Alternative Plan 6

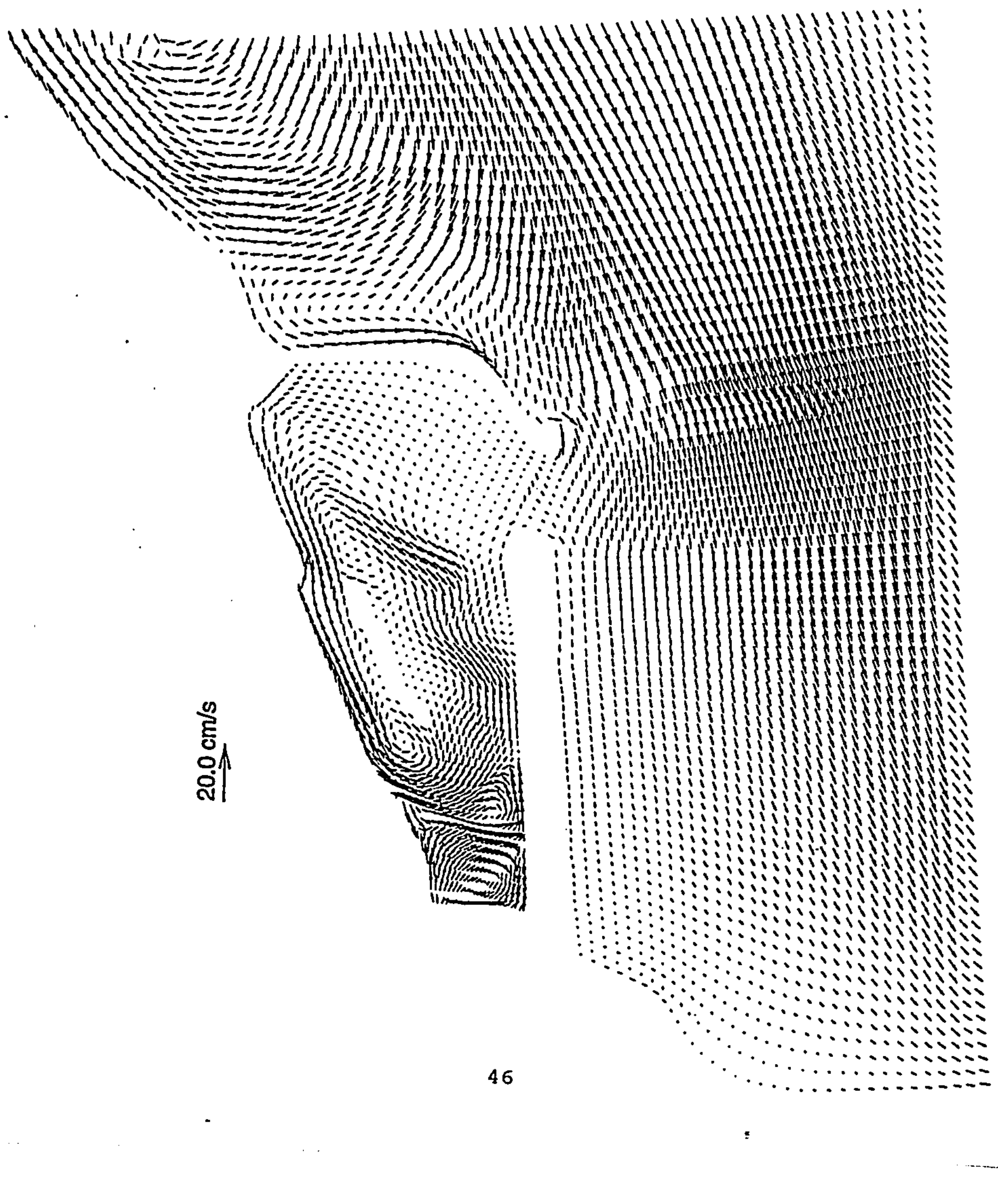


Figure 4.3

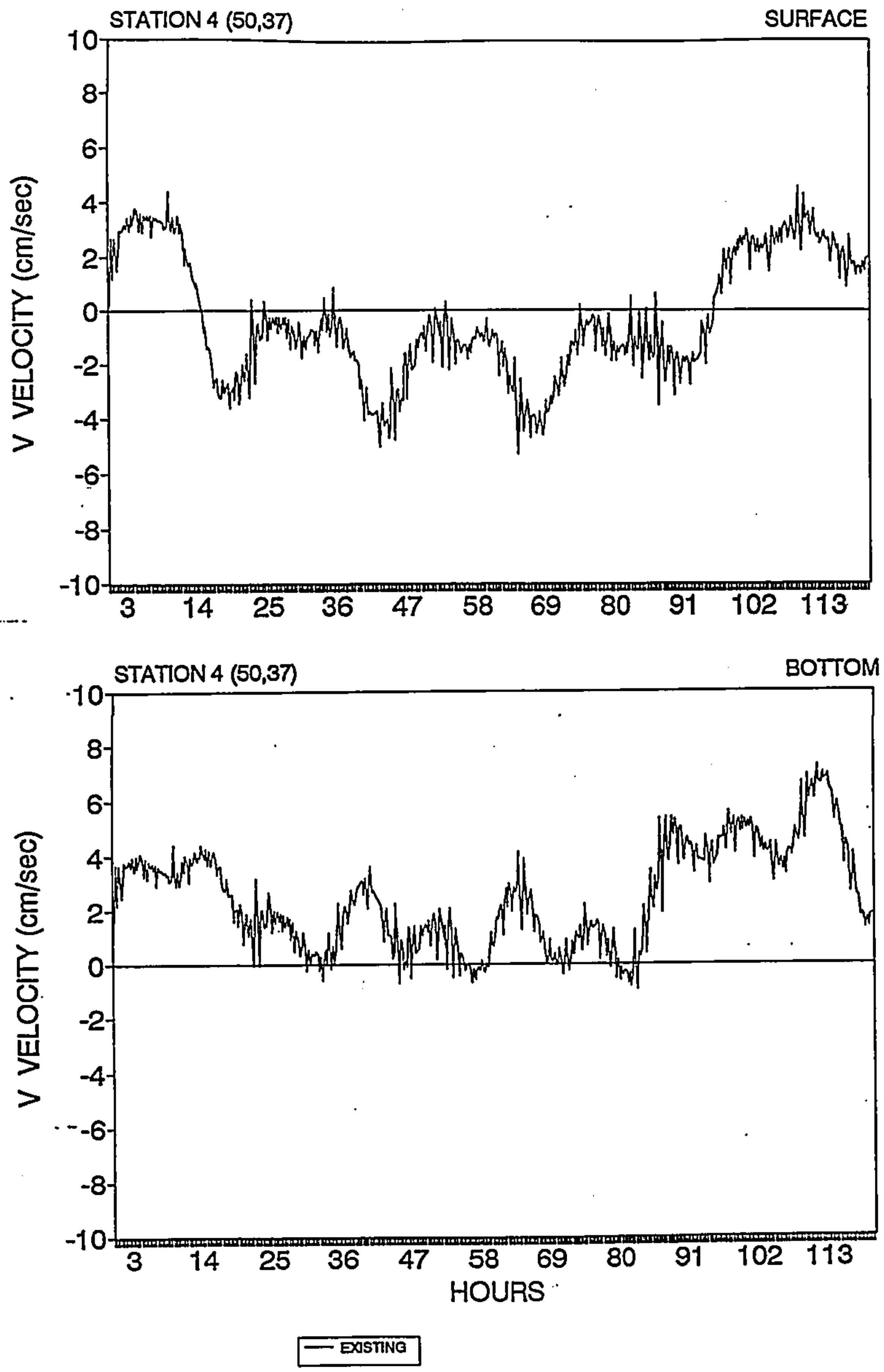

STATION 4 (50,37)
SURFACE
V VELOCITY (cm/sec)
10
8
6
4
2
0
-2
-4
-6
-8
-10
3
14
25
36
47
58
69
80
91
102
113
STATION 4 (50,37)
BOTTOM
V VELOCITY (cm/sec)
HOURS
EXISTING

Figure 4.4

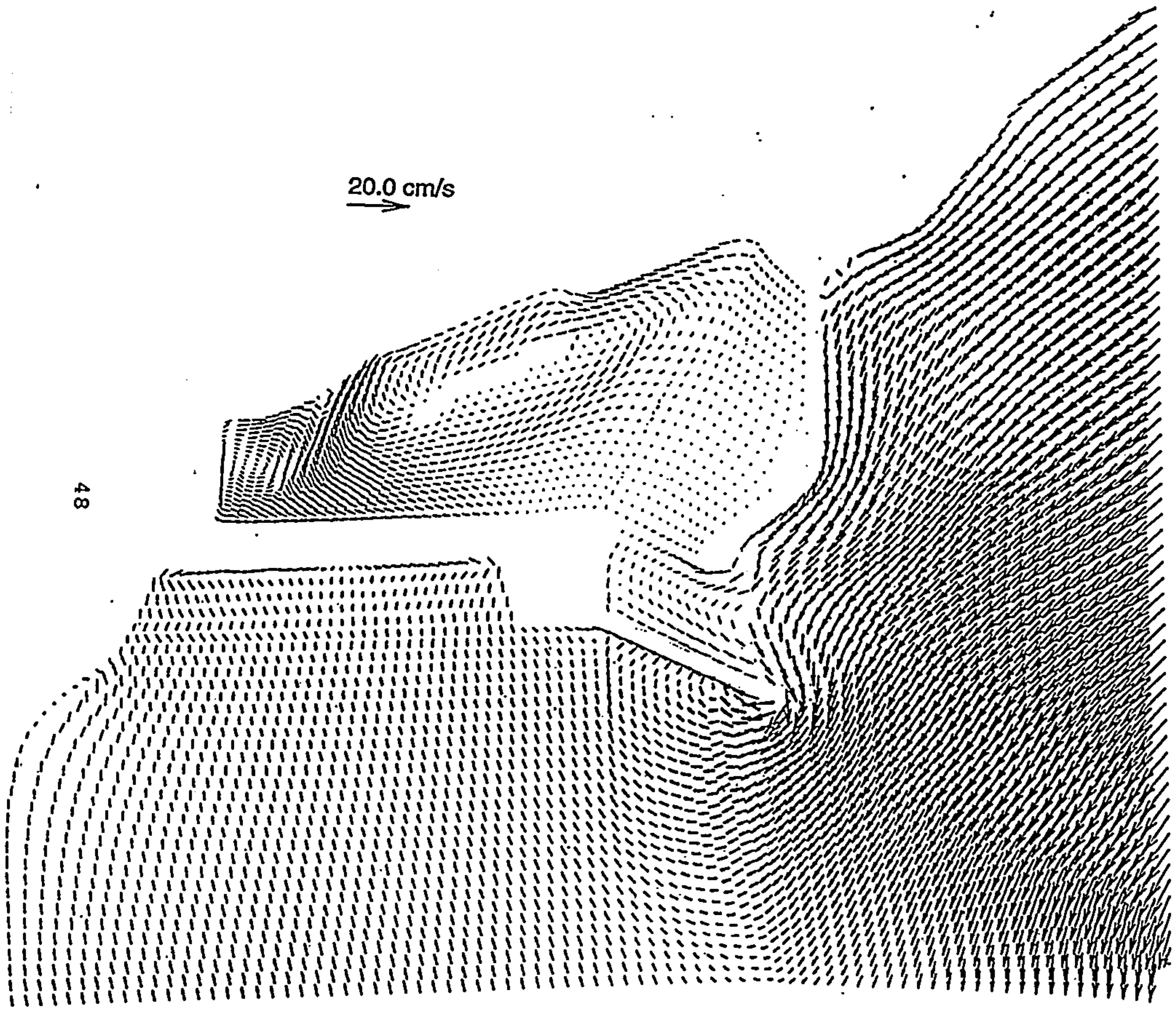


Figure 4.5

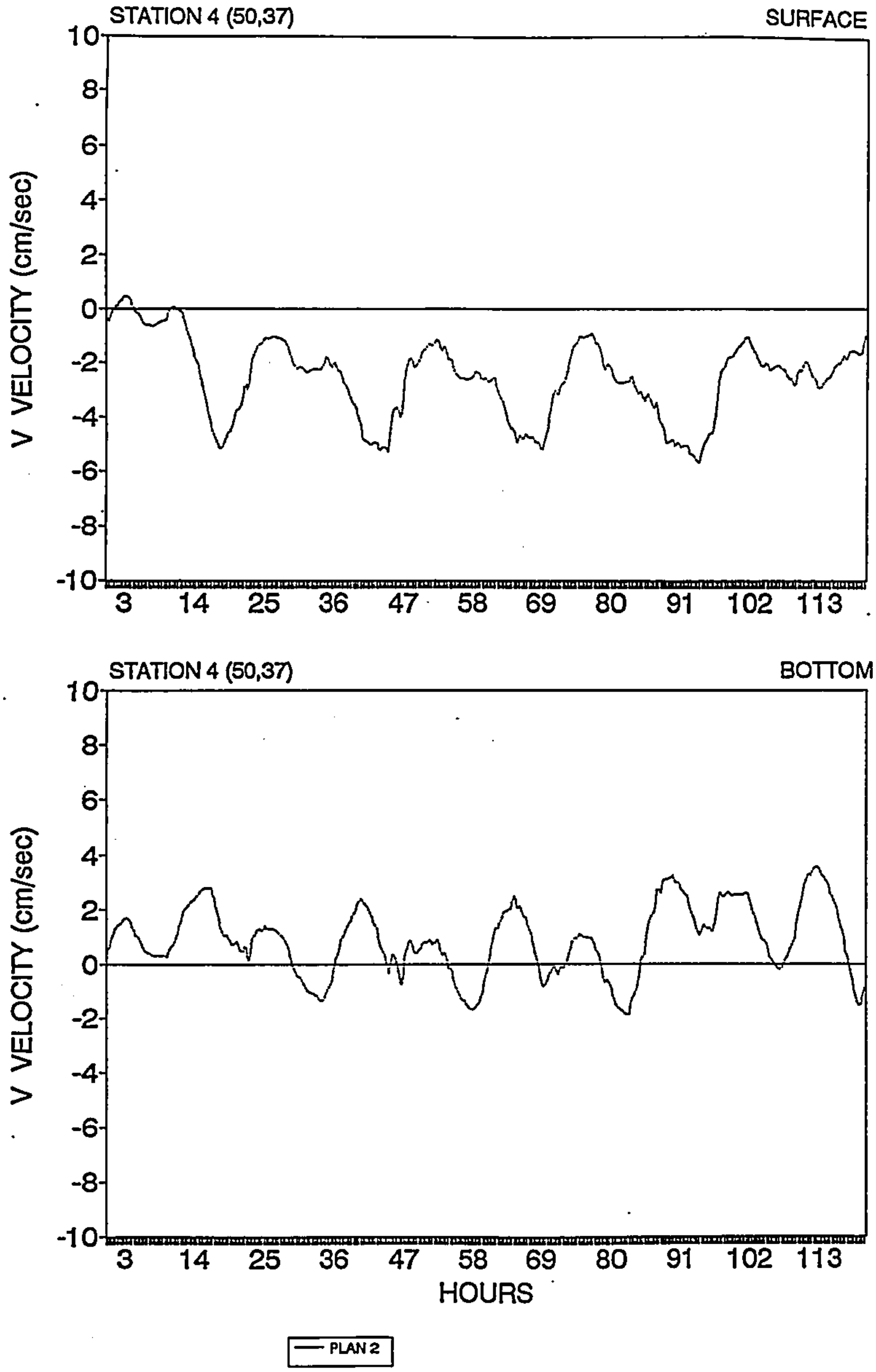
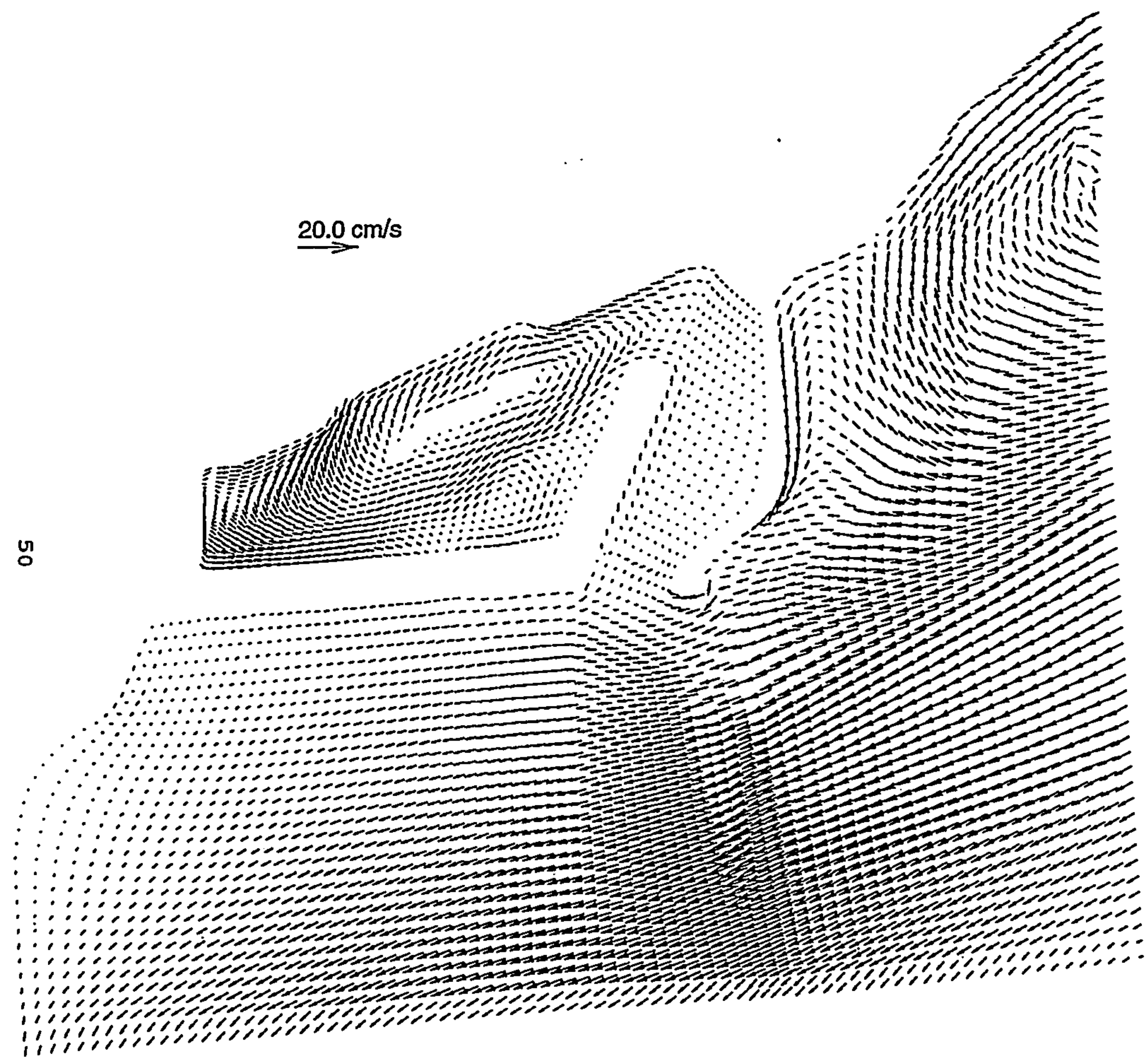

STATION 4 (50,37)
SURFACE
V VELOCITY (cm/sec)
10
8
6
4
2
0
-2
-4
-6
-8
-10
3
14
25
36
47
58
69
80
91
102
113
STATION 4 (50,37)
BOTTOM
V VELOCITY (cm/sec)
HOURS
PLAN 2

Figure 4.6



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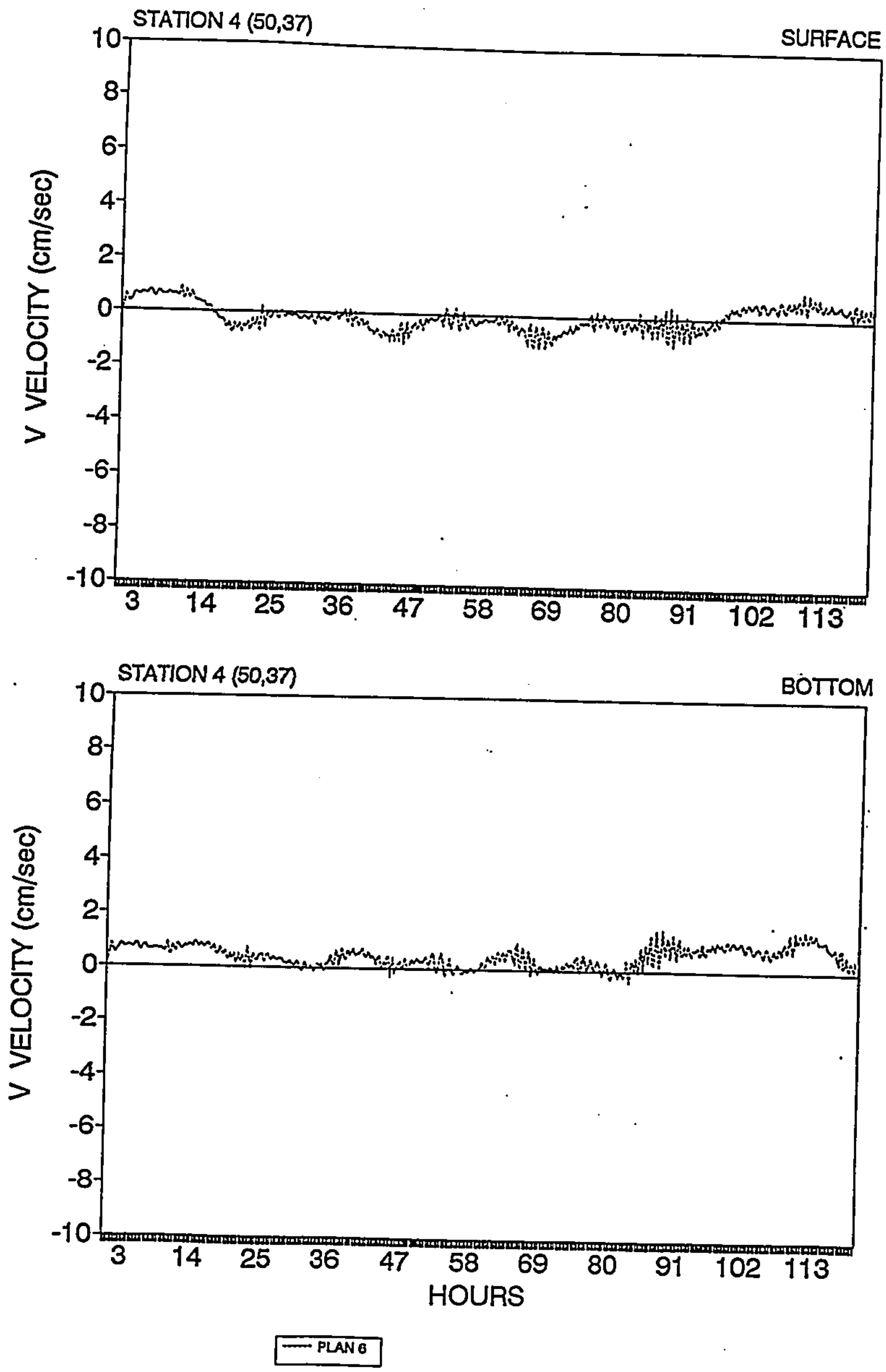
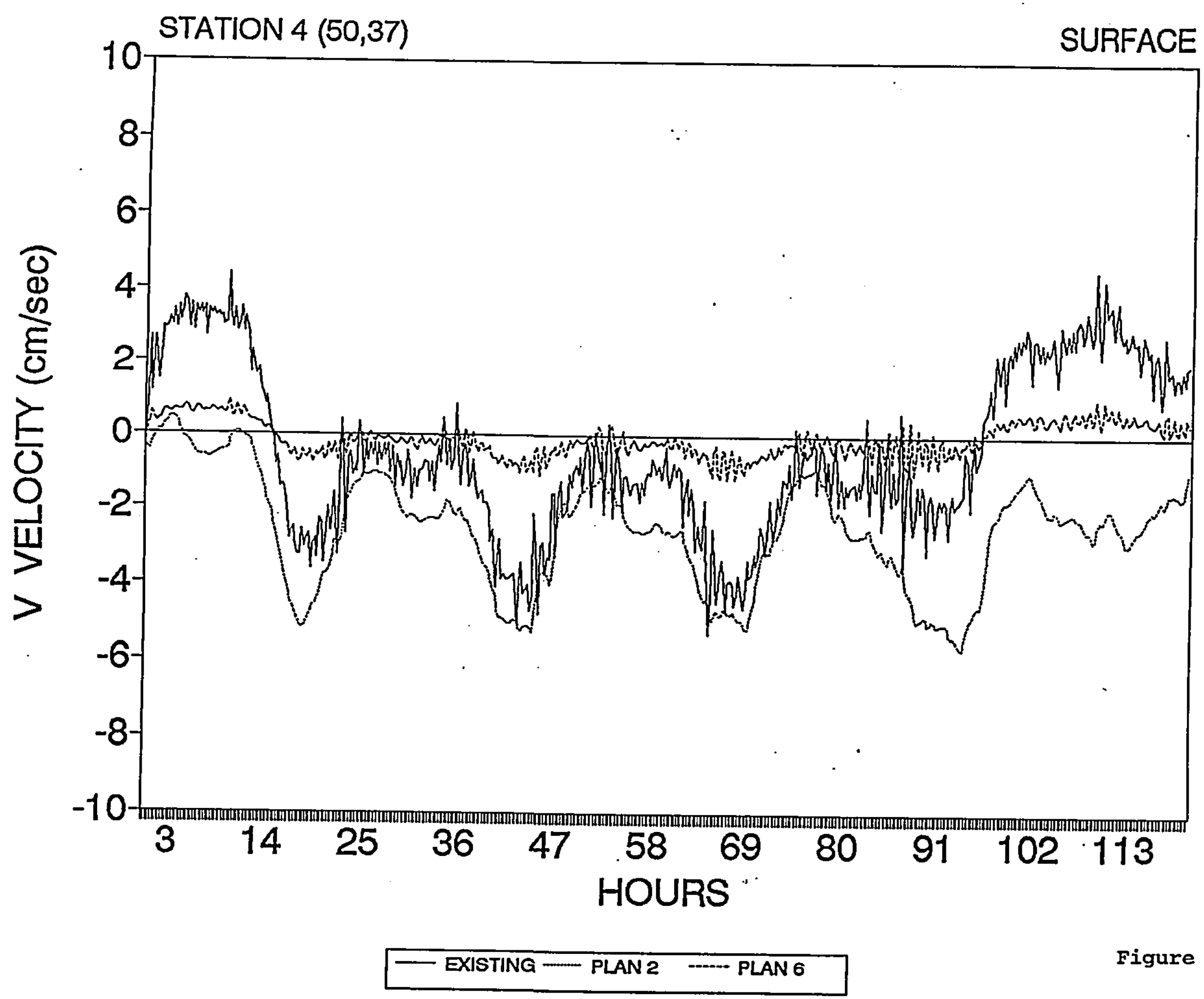


STATION 4 (50,37)
SURFACE
V VELOCITY (cm/sec)
10
8
6
4
2
0
-2
-4
-6
-8
-10
3 14 25 36 47 58 69 80 91 102 113
STATION 4 (50,37)
BOTTOM
V VELOCITY (cm/sec)
10
8
6
4
2
0
-2
-4
-6
-8
-10
3 14 25 36 47 58 69 80 91 102 113
HOURS
PLAN 6

Figure 4.8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SURFACE
V VELOCITY (cm/sec)
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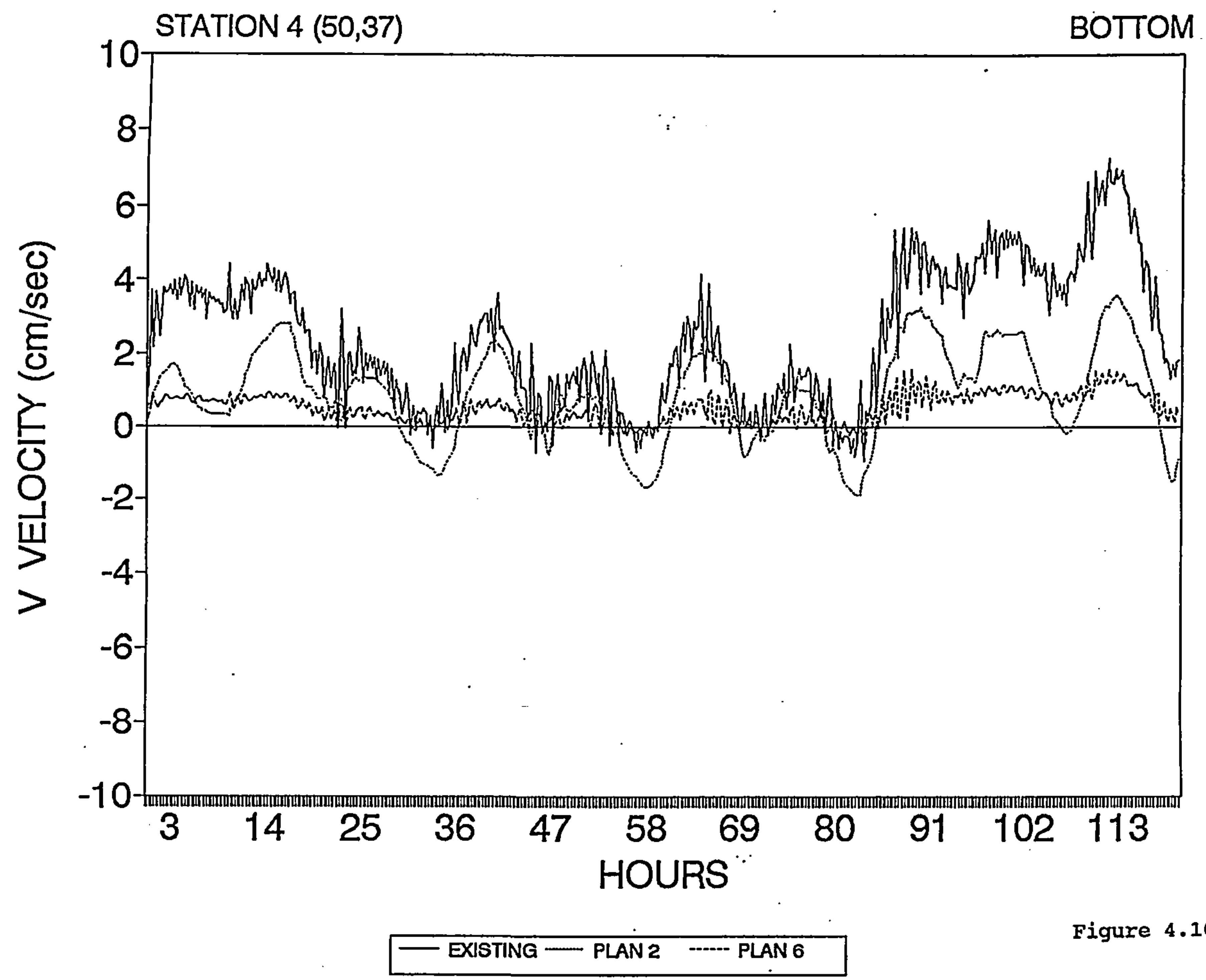
8
6
4
2
0
-2
-4
-6
-8
-10
3
14
25
36
47
58
69
80
91
102
113
HOURS
EXISTING
PLAN 2
PLAN 6

Figure 4.9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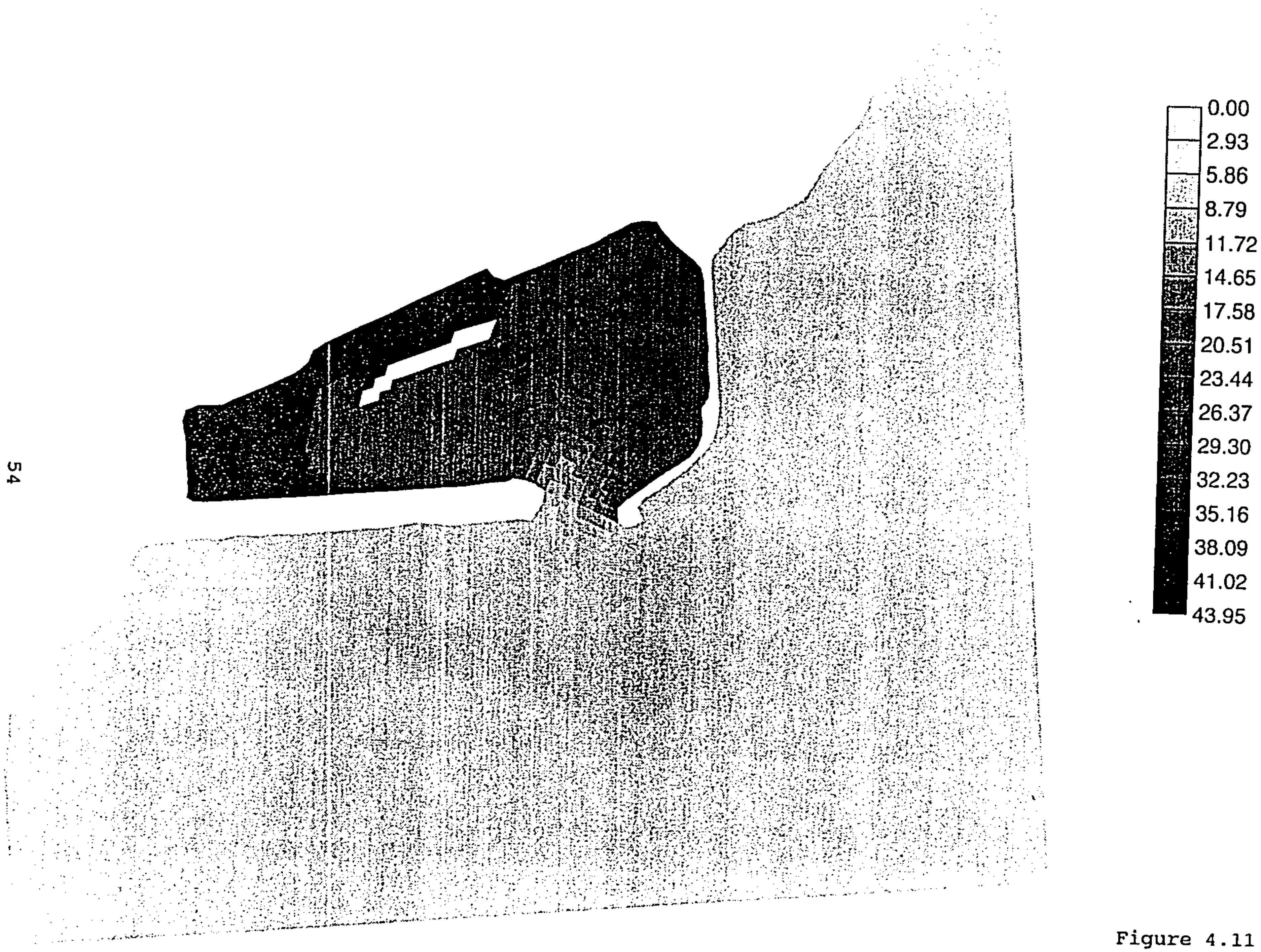
BOTTOM
V VELOCITY (cm/sec)
10
8
6
4
2
0
-2
-4
-6
-8
-10
3
14
25
36
47
58
69
80
91
102
113
HOURS
EXISTING
PLAN 2
PLAN 6

Figure 4.10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2.93
5.86
8.79
11.72
14.65
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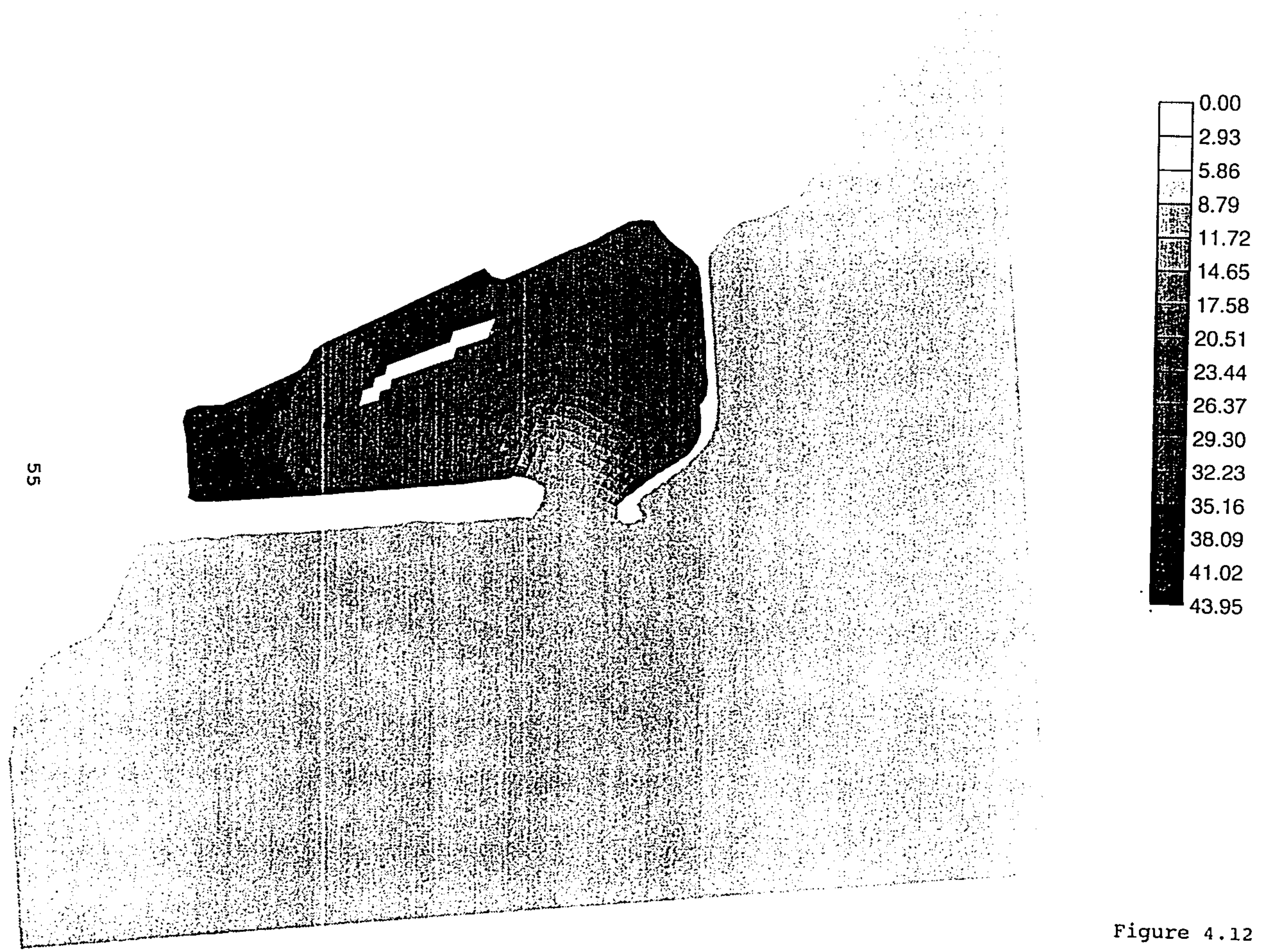
23.44
26.37
29.30
32.23
35.16
38.09
41.02
43.95

Figure 4.11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2.93
5.86
8.79
11.72
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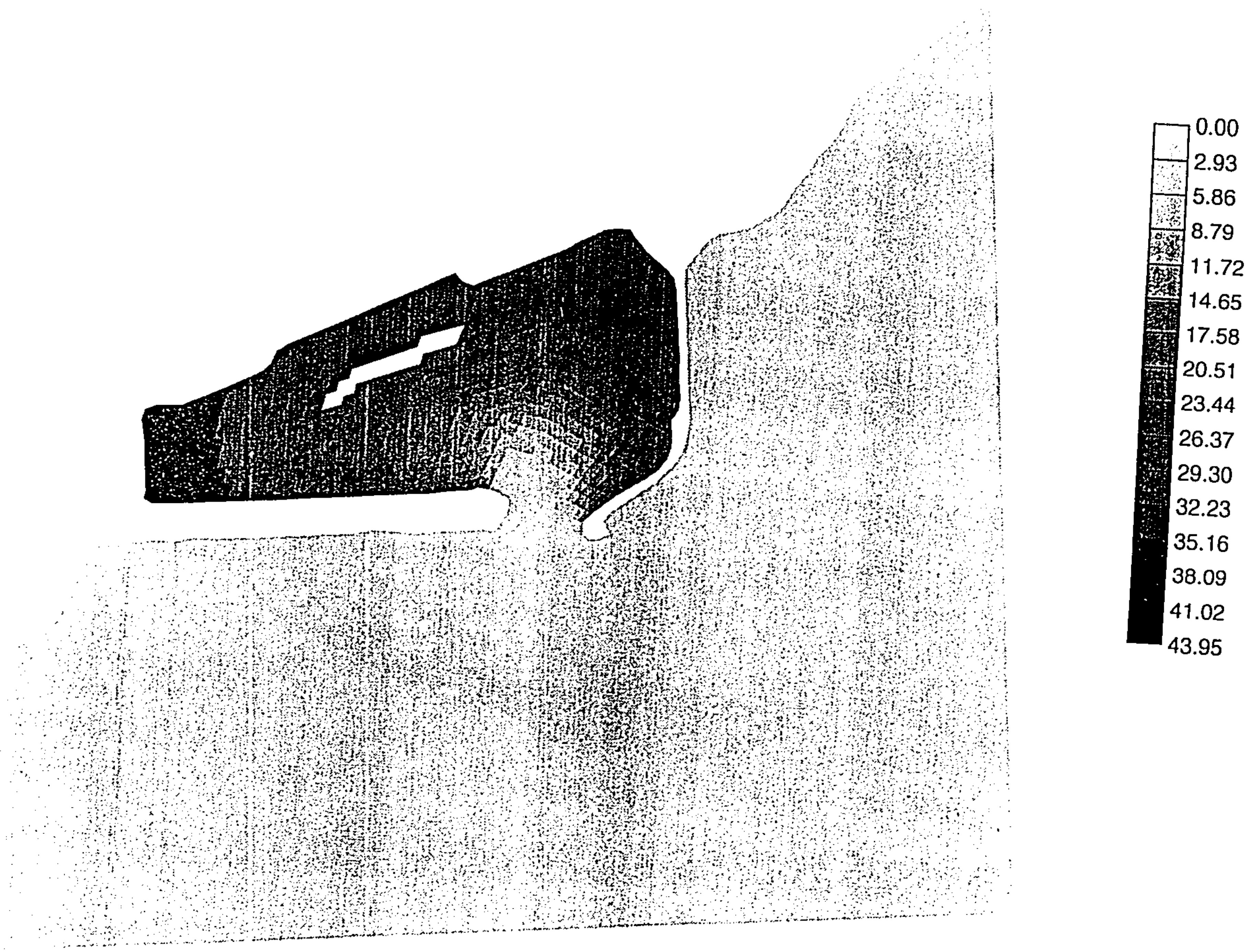
23.44
26.37
29.30
32.23
35.16
38.09
41.02
43.95

Figure 4.12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5.86
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11.72
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26.37
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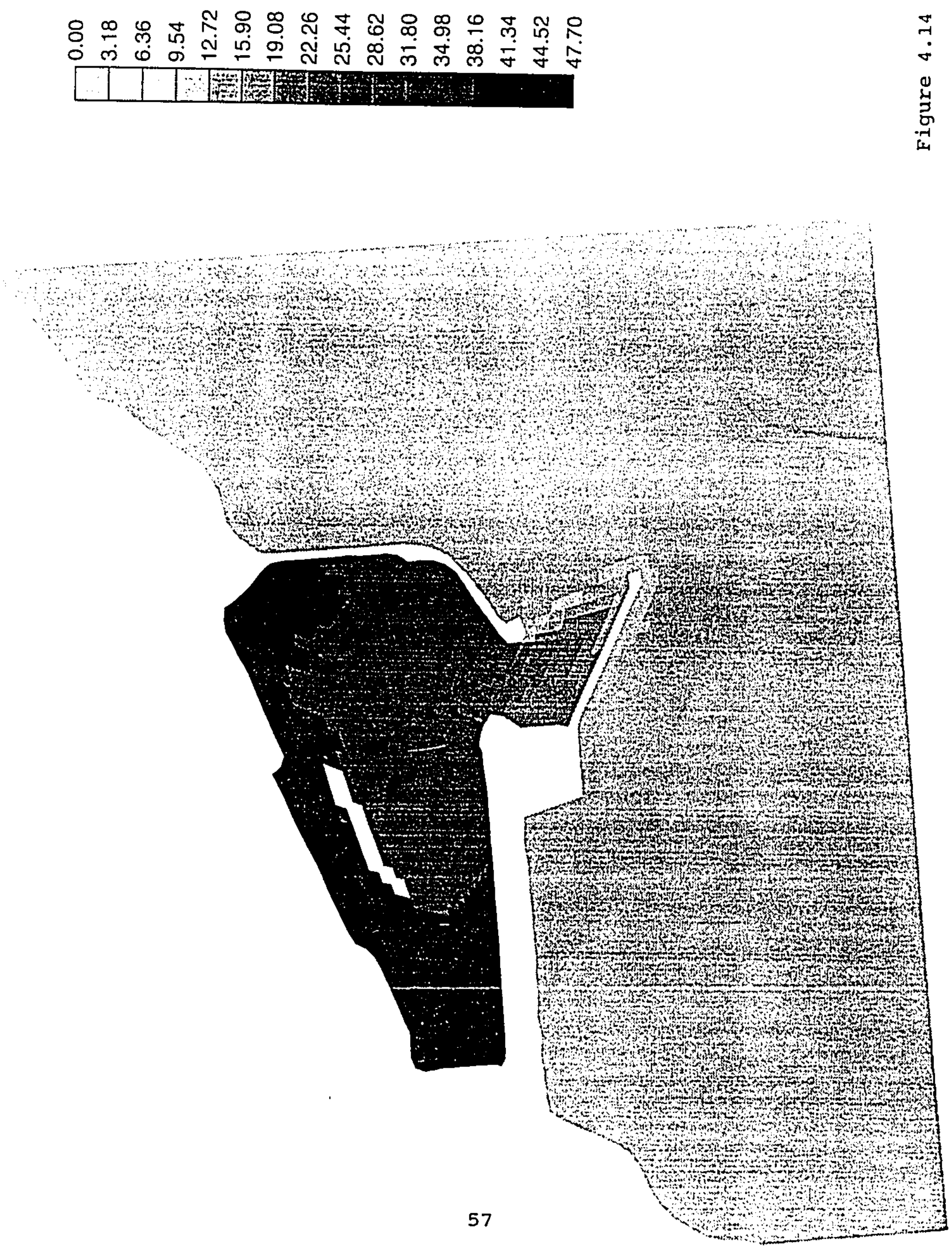
35.16
38.09
41.02
43.95

Figure 4.13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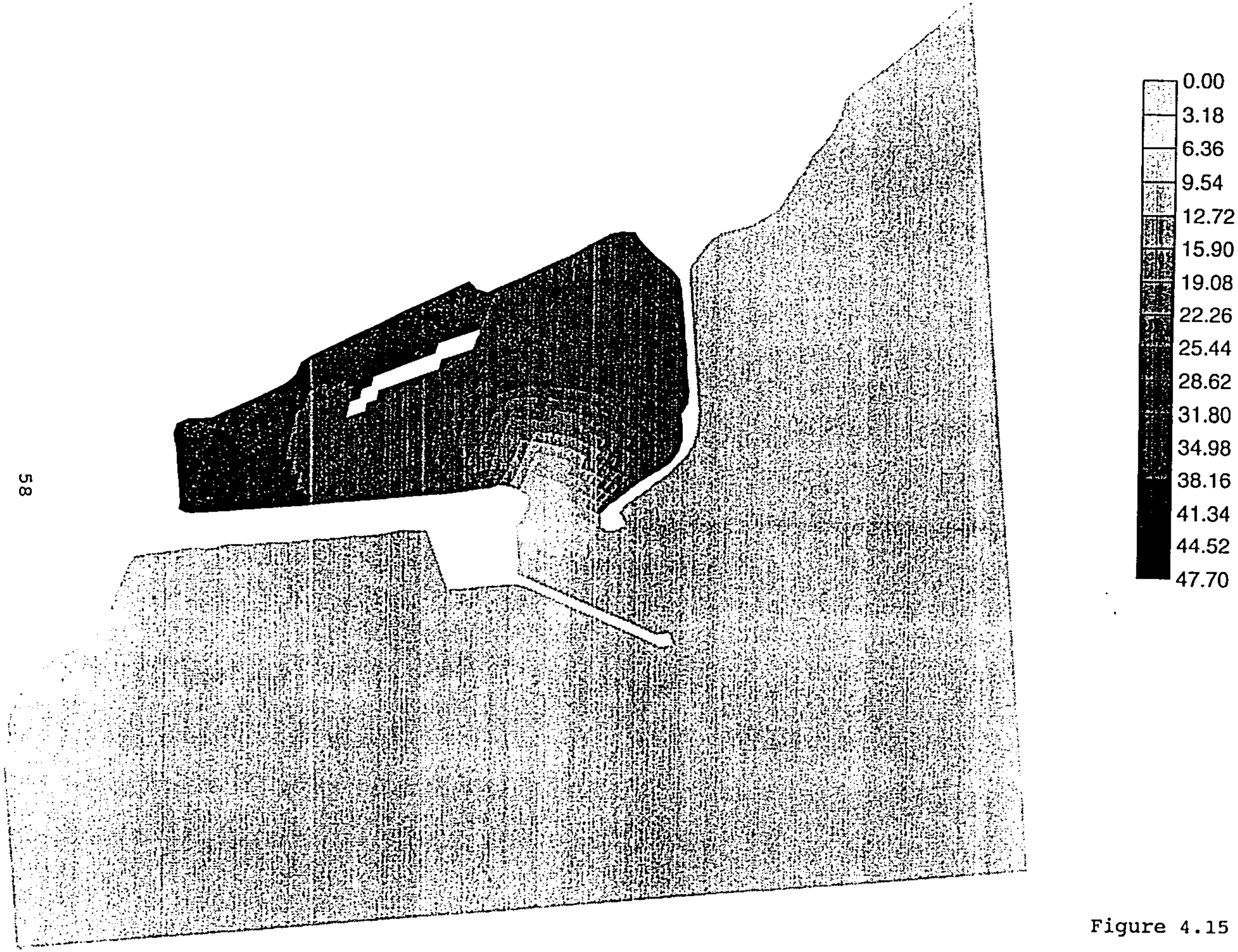
6.36
9.54
12.72
15.90
19.08
22.26
25.44
28.62
31.80
34.98
38.16
41.34
44.52
47.70

Figure 4.14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3.18
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9.54
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28.62
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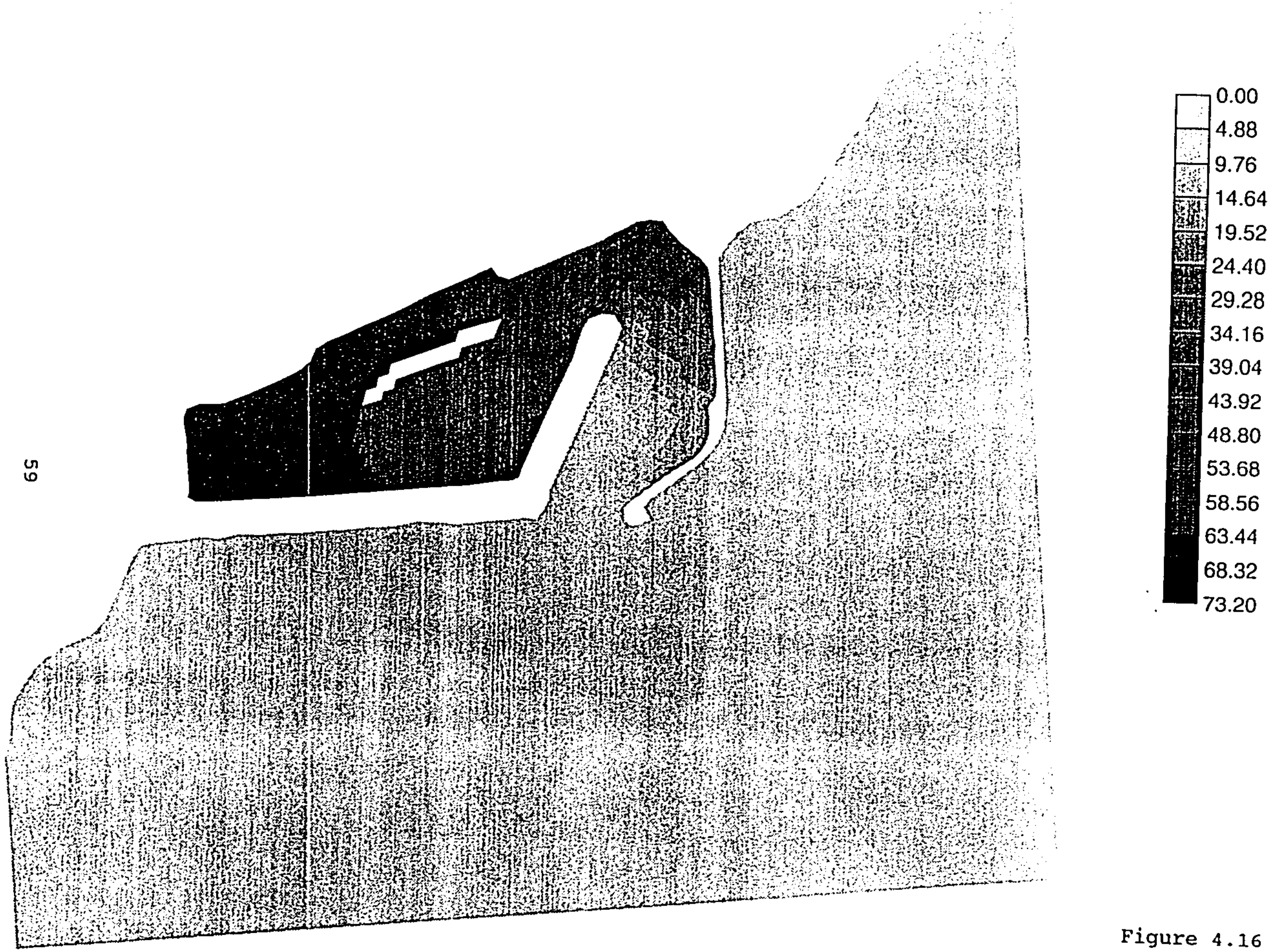
38.16
41.34
44.52
47.70

Figure 4.15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4.88
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19.52
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39.04
43.92
48.80
53.68
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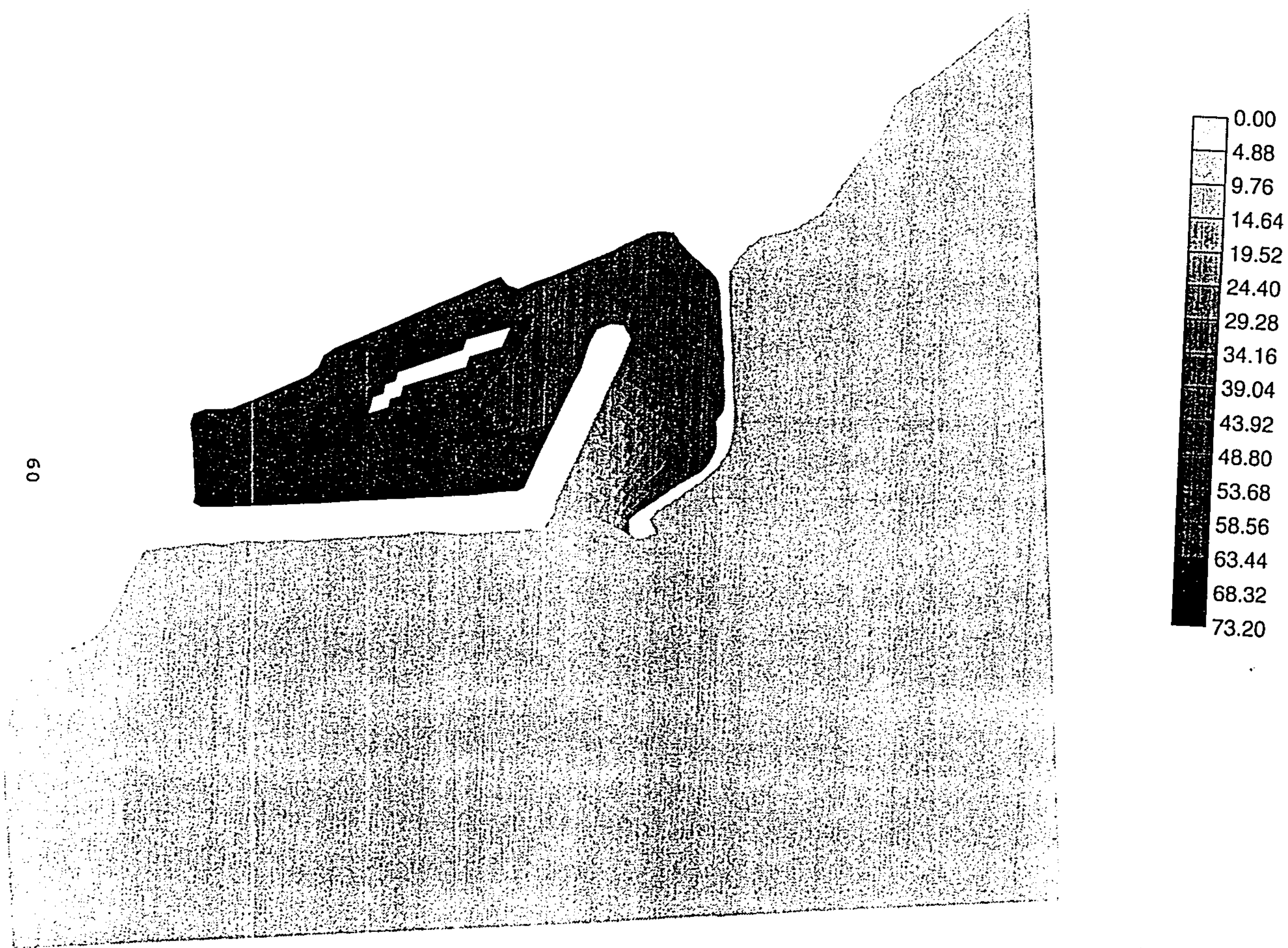
68.32
73.20

Figure 4.16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53.68
58.56
63.44
68.32
73.20

Figure 4.17

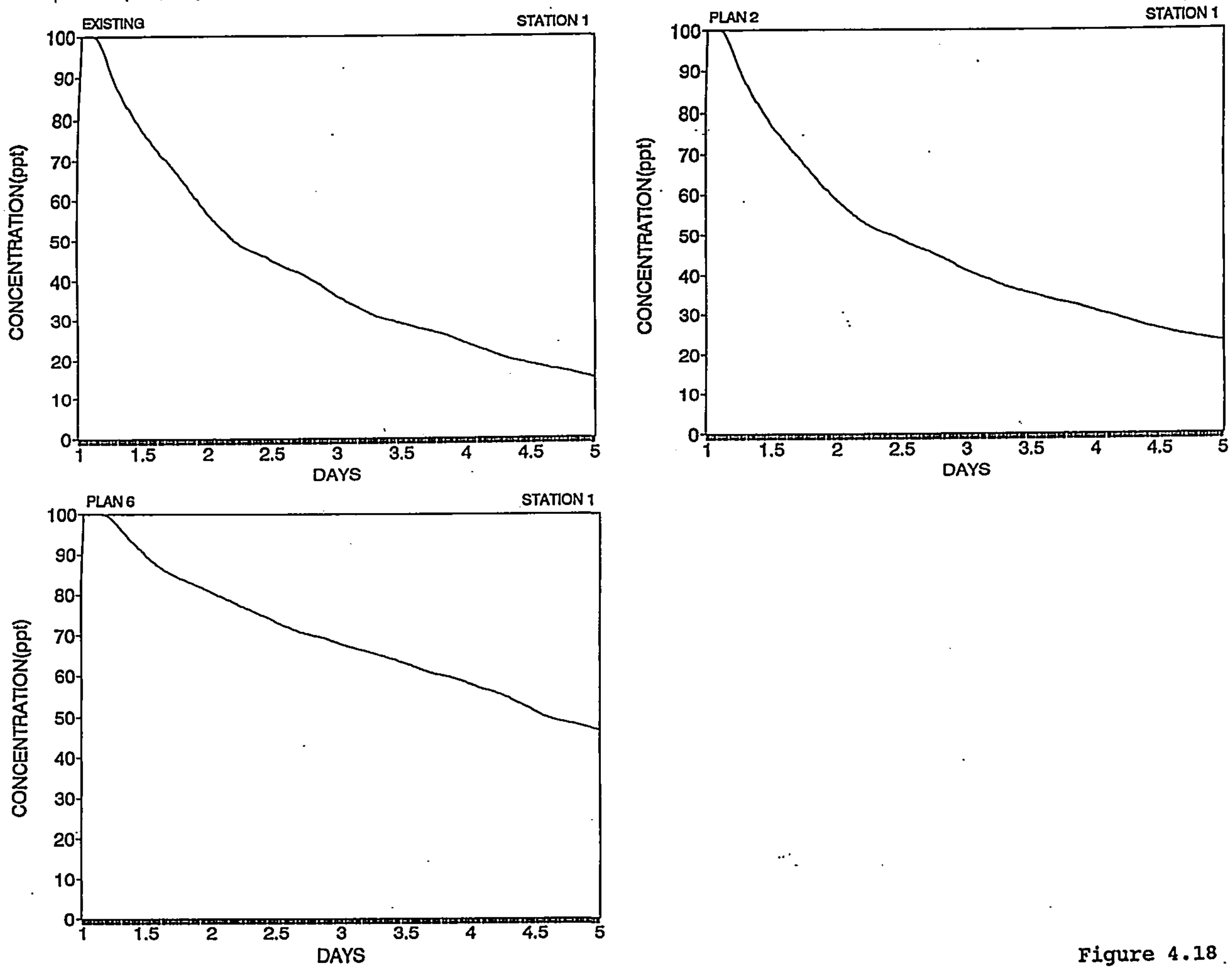

EXISTING
STATION 1
CONCENTRATION(ppt)
DAYS
PLAN 2
STATION 1
CONCENTRATION(ppt)
DAYS
PLAN 6
STATION 1
CONCENTRATION(ppt)
DAYS

Figure 4.18

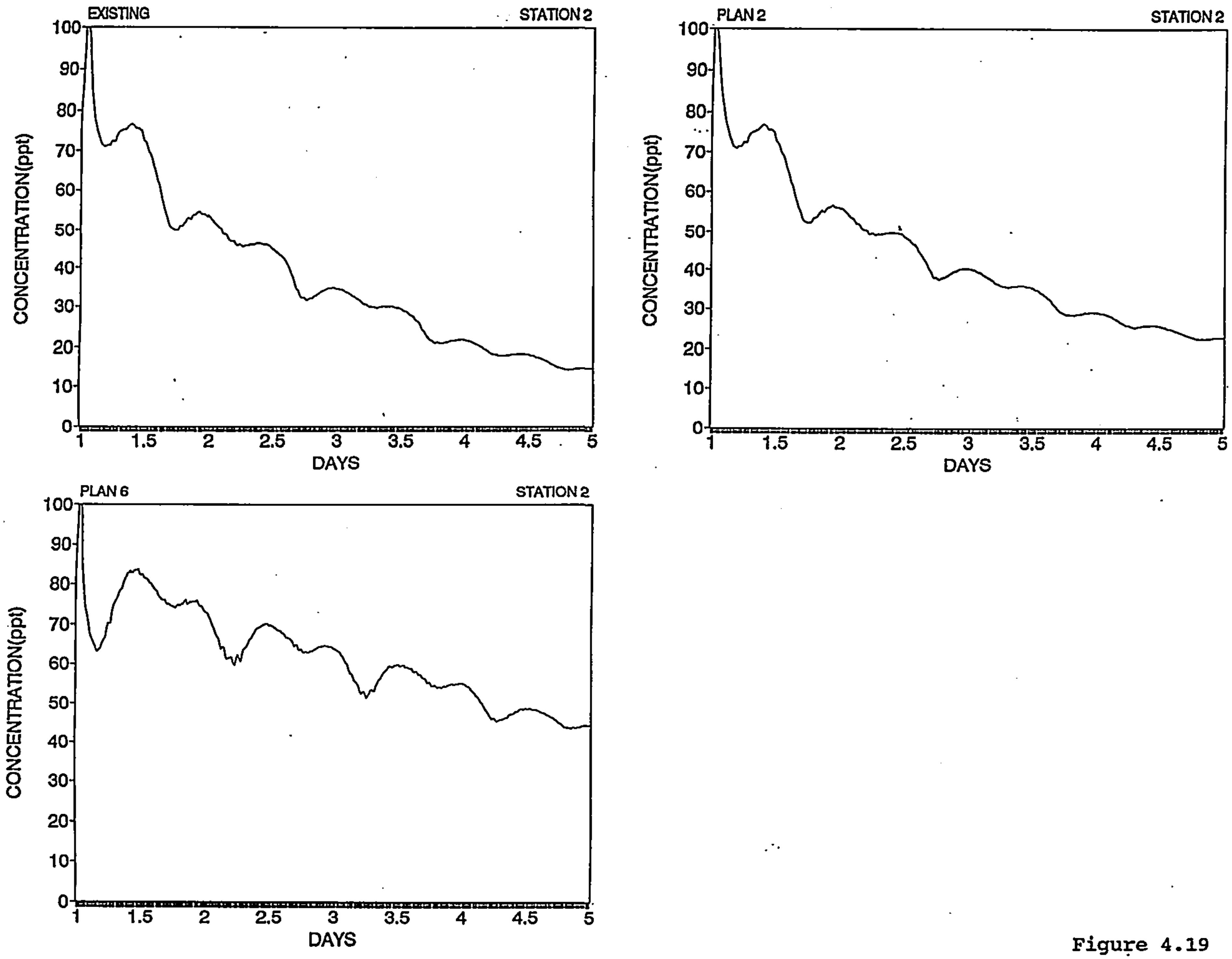
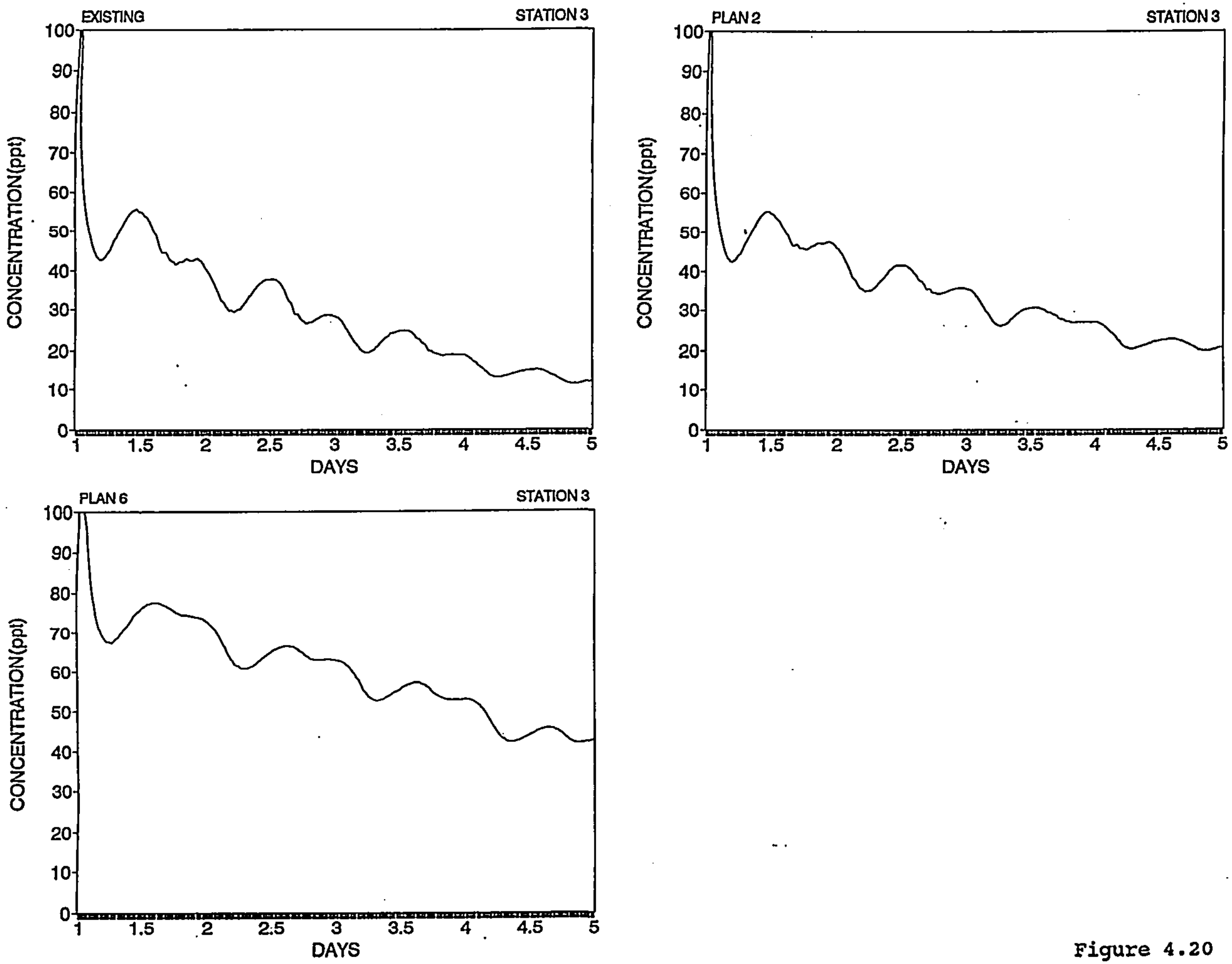

EXISTING
STATION 2
PLAN 2
STATION 2
PLAN 6
STATION 2
CONCENTRATION(ppt)
DAYS
0
10
20
30
40
50
60
70
80
90
100
1
1.5
2
2.5
3
3.5
4
4.5
5

Figure 4.19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STATION 3
CONCENTRATION(ppt)
DAYS
PLAN 2
STATION 3
CONCENTRATION(ppt)
DAYS
PLAN 6
STATION 3
CONCENTRATION(ppt)
DAYS

Figure 4.20

Table 4.1 Flushing time calculated under different conditions

	Existing condition	Alternative plan 2	Alternative plan 6
Station 1	2.9 days	3.3 days	6.3 days
Station 2	2.7 days	3.2 days	5.5 days
Station 3	2.1 days	2.3 days	5.3 days
Average flushing time in the harbor	2.6 days	2.9 days	5.7 days
Longest flushing time in the harbor	2.9 days	3.3 days	6.3 days

5. Summary and Conclusion

Based on the results presented in section 2 through 4, we are able to draw a number of conclusions regarding the performance of the numerical model, the degree to which it matches field observations, and its ability to predict the hydrodynamic and flushing characteristics under the proposed plans. We have grouped our conclusion according to the subject treated in each section:

1. The computational grid

A curvilinear boundary fitted coordinate was used to generate the computational grid, which provides enhancement for fitting the irregular shoreline and discrete digitizing topography. The grid represented by 81 x 60 cells with an average grid size of 50 feet covers Maalaea harbor as well as the adjacent bay as a whole. This harbor-bay system approach is critical for the success of modeling the flushing character of the harbor.

2. The performance of the numerical model

Calibration was made by comparing field data and the model calculations during the intensive measurement period, which shows that the model can account for the major features seen in the data with proper parameters assigned to it. The best fit of the parameters to the observed velocity distribution are found for:

Manning coefficient	$n = 0.035\text{-}0.040$
Horizontal mixing coefficient	$A_H = 1000\ cm^2/sec$
Base vertical mixing coefficient	$A_V = 10\ cm^2/sec$
Wind drag coefficient is:	$C = (0.075+0.67\ W) x\ 10$

where W is wind speed in m/sec

During validation, our comparison of model calculations with measured data reinforced the conclusion from calibration comparison, and in addition, highlighted the wind driven component of the circulation. A two layer circulation, with surface water flowing out and bottom water flowing into the harbor, was observed at the entrance and inside the harbor during the prevailing north wind condition.

3. The hydrodynamic results

For the existing condition, we see from the spatial vector plot that bay water was strongly influenced by the wind driven circulation. During the simulation period, the bay water was following the northeast wind and flowing toward the southwest. The velocity magnitude diminished and the direction turned southward, when the flow approached west coastline. For AP 2, the proposed breakwater has an impact on the bay circulation in that it deflects the incoming flow from southwest bound to south bound, which in turn drives a northward compensation flow in the region west of the proposed breakwater. Unlike AP 2, the impact from AP 6 is inside the harbor. The proposed mole structure appears to have two effects. First, it reduces the direct exchange area between harbor and bay water. Second, it creates a restriction section which limits the amount of velocity available through the harbor entrance.

4. Analysis of flushing time

A concentration of conservative tracer was calculated in the numerical framework with an advection-diffusion equation. Initially, a 100 ppt conservative tracer were introduced into the Maalaea harbor in a 0 ppt environment. As the concentration evolves with time, we found, the following general patterns regardless of the plans. First, the highest concentration is always located at the west corner of the harbor. Second, a strong concentration gradient is present at the narrow section of the harbor configuration, either at the harbor entrance or at the restricted section created in AP 6. Third, the concentration in the north bank of the harbor is higher than in the south bank. We further calculated the flushing time based on the e-folding time formulation under different conditions at various location in the harbor. Taking the longest time calcualted in the harbor, it was shown that the existing harbor has a flushing time on the order of 2.9 days. The AP 2 has a 3.3 day flushing time (a 14 % increase) and AP 6 has a 6.3 days flushing time (a 117 % increase).

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APPENDIX C

LETTERS OF COMMENT AND REPLIES

Editor's Note:

The replies to the letters of comment will be dated and reduced in size, similar to the letters of comment, for the copies of the document distributed to the public. Letters will be dated and mailed to addressees at approximately the same time the document is mailed.

COMMENTS
ON
DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
FOR
MAALAEA HARBOR FOR LIGHT DRAFT VESSELS
MAUI, HAWAII

COMMENTOR: **NAME:** Miles Lopes

STREET: 429 Kaao Cr

CITY Kahului, Hawaii, 96732

COMMENTS:

I believe that the expansion of the Harbor at Maalaea should be done as soon as possible to insure the safety of vessels in the Harbor. I have been working in this Harbor for two years now and have seen the surge that comes in when there is a south swell. To insure safe Berthing and Navigation within the harbor area the plan of the extended sea wall at the channel entrance would be the best solution to this problem. Having seen the conceptual plan of the sea wall I do not see how it will affect the famous surfing spot known as the Maalaea Pipe. This area that can be surfed is a good hundred and fifty yards from the channel entrance. I think that this break would not be harmed even with the extension of the sea wall.

Another one of my concerns is about parking. With the addition of onehundred more vessels berthing in the harbor will there be enough parking in the harbor area to accommodate the cars from these vessels. Parking is very scarce at it is right now. Another question is about the maneuverability of vessels in the harbor once the additional slips have been completed.

Thank You very much
Miles Lopes

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Miles Lopes
429 Kaao Circle
Kahului, Hawaii 96732

Dear Mr. Lopes:

Thank you for your undated comments on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments and this response are reproduced in Appendix C of the final SEIS. The following paragraphs follow the order of your specific comments:

a. Your comments concerning the surge within the harbor and your opinion concerning the effect of the project on the "Maalaea Pipeline" were considered as part of the selection process for the recommended alternative.

b. Additional parking for the harbor will be provided by the local sponsor, the Boating and Ocean Recreation Division of the Department of Land and Natural Resources.

c. There will be ample room for vessels to maneuver when the additional slips have been added. The turning basin will be approximately 190 feet by 315 feet, and the access channel will be 80 feet wide.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

COMMENTS
ON
DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
FOR
MAALAEA HARBOR FOR LIGHT DRAFT VESSELS
MAUI, HAWAII

COMMENTOR: **NAME:** David Ventura Jr.

STREET: 226 [illegible] Pl.

CITY Kihei Maui Hi. 96753

COMMENTS: I SUPPORT ALT. PLAN #1 OF THE S.E.I.S. BECAUSE IT BEST SATISFIES THE NEEDS OF THE U.S. COAST GUARD, BOATS WITH MINIMAL HORSEPOWER AND LIMITED MANEUVERABILITY, AN ALLOWS DISTRESSED BOATS TO BE RETRIEVED/TO TO THE LAUNCH RAMP AS SAFELY AS POSSIBLE.

UNFORTUNATELY, THOSE WHO ARE ASKING "WHY NOT CONSIDER ALT. PLAN #6" WERE NOT INVOLVED ALMOST 13 YRS. AGO WHEN WE DROPPED THIS PLAN BECAUSE IT DID NOT STOP THE SURGE PROBLEM, DID NOT MAXIMIZE THE USE OF THE INTERIOR OF THE HARBOR, ELIMINATED THE COAST GUARD BERTH AND POSED SERIOUS PROBLEMS IN SAFE NAVIGATION.

MAALAEA IS KNOWN AS THE "WINDY HARBOR" FOR GOOD REASON. WE NORMALLY HAVE 20 M.P.H. CROSS WINDS. THE WINDS BLOW 99% OF THE TIME NORTH TO SOUTH. IT MAKES FOR TRICKY, QUICK, MANEUVERING IN MANY SLIPS NOW! JUST IMAGINE HOW IT WOULD BE IF ALT. PLAN # 6 WAS IMPLEMENTED. BOATS TRYING TO APPROACH THEIR BERTHS EAST OR WEST WOULD HAVE AN EXTREMELY DIFFICULT TIME. FURTHERMORE, SOME WOULD NOT BE ABLE TO RECOVER AN BE TRAPPED AGAINST THE SOUTH BREAKWALL. SURELY YOU CAN EXPECT DAMAGED VESSELS.

THE APPROACH ANGLE OF THE MAIN ENTRANCE CHANNEL SHOWN IN ALT. PLAN #1 SEEMS TO BE THE MOST REASONABLY SAFE FOR ALL BOATING CONCERNED. WE MUST KEEP IN MIND THAT THIS ENTRANCE SHOULD BE MADE AS WIDE AS POSSIBLE SO THAT IT CAN ACCOMMODATE DISTRESSED VESSELS UNDER TOW IN ADVERSE SEA CONDITIONS. SINCE OUR MOST ADVERSE CONDITIONS, HIGH SURF, KONA WIND STORMS, COME FROM THE SOUTHERLY DIRECTION, IT MAKES SENSE TO HAVE A BREAKWALL THAT PROTECTS YOU WHILE YOU ENTER THE HARBOR — NOT ONLY AFTER YOU'RE INSIDE. THE MOST UNSAFE PERIOD IS ENTERING THIS HARBOR WITH WAVES BREAKING AT YOUR STERN.

David Ventura Jr.

COMMENTS
ON
DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
FOR
MAALAEA HARBOR FOR LIGHT DRAFT VESSELS
MAUI, HAWAII

COMMENTOR: **NAME:** DAVID VENTURA JR
STREET: 226 [illegible] PL
CITY [illegible] MAUI HI. 96753

COMMENTS: I SUPPORT ALT. PLAN #1 OF THE S.E.I.S. BECAUSE IT BEST SATISFIES THE NEEDS OF THE U.S. COAST GUARD, BOATS WITH MINIMAL [illegible] POWER AND LIMITED MANUEVERABILITY, AN ALLOWS DISTRESSED BOATS TO BE RETRIEVED TO THE LAUNCH RAMP AS SAFELY AS POSSIBLE.

UNFORTUNATELY, THOSE WHO ARE ASKING "WHY NOT CONSIDER ALT. PLAN #6" WERE NOT INVOLVED ALMOST 13 YRS. AGO WHEN WE DROPPED THIS PLAN BECAUSE IT DID NOT [illegible] THE SURGE PROBLEM, DID NOT MAXIMIZE THE USE OF THE INTERIOR OF THE HARBOR, ELIMINATED THE COAST GUARD BERTH AND POSED SERIOUS PROBLEMS IN SAFE NAVIGATION.

MAALAEA IS KNOWN AS THE "WINDY HARBOR" FOR GOOD REASON. WE NORMALLY HAVE 20 MPH. CROSS WINDS. THE WINDS BLOW 99% OF THE TIME NORTH TO S. IT MAKES FOR TRICKY, QUICK, MANUVERING IN MANY SLIPS NOW! JUST IMAGINE HOW IT WOULD BE IF ALT. PLAN # 6 WAS IMPLEMENTED. BOATS TRYING TO APPROACH THEIR BERTHS EAST OR WEST WOULD HAVE AN EXTREMELY DIFFICULT TIME. FURTHERMORE, SOME WOULD NOT BE ABLE TO PROCEED AN BE TRAPPED AGAINST THE SOUTH BREAKWALL. SURELY YOU CAN EXPECT DAMAGED VESSELS.

THE APPROACH ANGLE OF THE MAIN ENTRANCE CHANNEL SHOWN IN ALT. PLAN #1 SEEMS TO BE THE MOST REASONABLY SAFE FOR ALL BOATING CONCERNED. WE MUST KEEP IN MIND THAT THIS ENTRANCE SHOULD BE MADE AS WIDE AS POSSIBLE SO THAT IT CAN ACCOMODATE DISTRESSED VESSELS UNDER TOW IN ADVERSE SEA CONDITIONS. SINCE OUR MOST ADVERSE CONDITIONS, HIGH SURF, KONA WIND STORMS, OCCUR FROM THE SOUTHERLY DIRECTION, IT MAKES SENSE TO HAVE A BREAKWALL THAT PROTECTS YOU WHILE YOU ENTER THE HARBOR — NOT ONLY AFTER YOU'RE INSIDE. THE MOST UNSAFE PERIOD IS ENTERING THIS HARBOR WITH WAVES BREAKING AT YOUR STERN.

David Ventura Jr.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. David Ventura Jr.
226 Mahie Place
Kihei, Hawaii 96753

Dear Mr. Ventura:

Thank you for your undated comments on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-Draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

Certified Mail # P 054 360 544

COMMENTS ON DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR MAALAEA HARBOR FOR LIGHT DRAFT VESSELS MAUI, HAWAII

COMMENTOR: **NAME:** Chris C. Svendsen

STREET: RR 1 Box 383 Apt. 103

CITY Wailuku, HI 96793

COMMENTS:

1. The proposed alternative of an extension to the existing south breakwater including the removal of 80 feet of the existing east breakwater does not address protection from a southeasterly storm. Furthermore, the subject of costs of littorial rights of property owners and leaseholders at properties such as Maalaea Yacht Marina and Hilowai is not addressed.

2. The issue of proper sanitary facilities for boats (holding tanks) and for land based toilet facilities is not addressed.

3. The conclusions by the Pacific Whale Foundation should be reviewed by a member organization of the Pacific Humpback Whale Working Group. The conclusion that a dramatic increase in boating will not negatively impact the designated Maalaea Bay as a calving are is questionable at best. Since the Pacific Whale Foundation has a slip and operates a commercial boat from Maalaea Harbor I, and many others, question the objectivity and validity of their conclusions.

4. The traffic projections appear to be flawed and need further review. A Mr. Jack Mueller has written in considerable detail to you on this issue.

5. An internal mole to reduce wave action within the harbor and accepting a smaller expansion of slips would appear to be a more sensible alternative.

Chris C. Svendsen

Chris C. Svendsen

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Chris C. Svendsen
Rural Route 1, Box 383, Apartment 103
Wailuku, Hawaii 96793

Dear Mr. Svendsen:

Thank you for your undated comments on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The following responses are numbered to correspond with the numbers in letter of comment.

a. Alternative Plan 1 (the 1980 approved plan) does provide protection from southeasterly waves approaching from 180-160 degrees. Large waves more southeasterly than 160 degrees cannot approach Ma'alaea directly because of the geography of Maui and Kahoolawe.

b. The State of Hawaii claims all submerged lands and all lands seaward of the high tide line. In addition, Executive Order NO. 02605 dated June 3, 1972 assigns the filled and underwater areas adjacent to the harbor to the Department of Transportation as an addition to Ma'alaea Harbor.

c. Sanitary facilities, including sewage treatment, restroom and pumpout facilities will be part of the infrastructure improvements to be constructed by the local sponsor, the Department of Land and Natural Resources, Division of Boating and Ocean Recreation.

d. The determination that the proposed harbor facilities would not jeopardize the continued existence of the humpback whale was made by the National Marine Fisheries Service long before the Pacific Whale Foundation prepared the report contained in Appendix B of the SEIS, and had no bearing on their determination. Their report is a public document, and was contained in the draft SEIS. To date, no individual or organization has indicated that there are errors in the report.

e. The traffic analysis has been reviewed and changes made where needed. A detailed response was made to Mr. Jack Mueller, which is reproduced in Appendix C of the final SEIS.

f. The internal mole alternative has been reanalyzed. As explained in section 3-5 of the final SEIS, this plan is not acceptable from either the navigational safety or economic standpoints. Under south swell conditions the entrance channel would not be protected, and internal oscillations would develop in the harbor. In addition, the cost of landward expansion would more than double the cost of the harbor.

Sincerely,

James D. Nakasone

Ray H. Jyo, P.E. fr
Director of Engineering

Kisuk Cheung, P.E.
District Engineer
U.S. Army Engineer District
Honolulu, Hawaii.

Dear Mr. Cheung,

In response to your Draft Supplemental Environmental Impact Statement for the Haalaea Harbor expansion, we are still dismayed at your obvious exclusion of its effects upon local residents. Apparently the Army Corps of Engineers has forgotten that Homo Sapiens have been an integral part of the environment for the last couple of million years or so.

While we are tremendously concerned about the surf, turtles, whales and all variety of flora and fauna, we are more personally conerned with our own welfare in connection with the Harbor plans.

We are permanent residents of unit #310 in the Maalaea Yacht Marina. Our bedroom is approximately thirty to forty feet from the shoreline directly above the harbor. Our view from the living and master bedroom is of the ocean, harbor and small beach.

Our peace is often disturbed by tour boats leaving the harbor at 6:30 and 7:00 am with their speaker systems blaring. We have had to call the police on more than one occasion in the last six months for loud music and partying in the harbor as late as midnight. On one occasion the music was so loud the glass in our sliding door was actually vibrating. Now we are apparently supposed to be accepting of a plan to build a road just twenty feet from our bedroom window. A road for fishermen and tourists to travel on at all times of the day and night, and to tolerate not only the destruction of our beach, but the noise, traffic, fumes, and general disturbance at all hours that the fishing and tourboat businesses generate.

Three years ago we wrote to the Corps of Engineers with our concerns about the obvious exclusion of all the Maalaea Condominiums from all illustrations of your proposed plans. Now we see that there has been no change ---- the condominiums are still conspicuously absent from any of your plans. You have still not addressed the effects of any of the harbor plans upon the local residents, our beach and homes, our peace and tranquility or our property values.

If any plan is less offensive than the others it is #6 or #5B. Since you failed to number the pages of the E.I.S. one cannot even refer to any specific page, paragraph, or plan.

Plan #6 seems to be called #5B on some pages and #6 on others. It is nevertheless the plan with the interior mole. It is the only proposal that seems to be without the offensive road and parking directly behind the Mermaid, Yacht Marina, and Milowai condominiums.

Your E.I.S. so far seems to be about three pounds of computerized charts showing tidal and wave action, and biological statistics available in most libraries. It's too bad you have yet to address the human factor.

Raymond & Ada Galli
Raymond Galli
Ada Galli
RR1 Box 377 #310
Wailuku, Hawaii
96793

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Raymond Galli
Ms. Ada Galli
Rural Route 1, Box 377, Apartment 310
Wailuku, Maui, Hawaii 96793

Dear Raymond and Ada Galli:

Thank you for your undated letter of comment on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS.

The enforcement of the Hawaii County noise ordinance is the responsibility of the local police department. The proposed project will have no effect on the enforcement of that ordinance.

The proposed road to the east revetted mole will be located seaward of the present shoreline, a little over 100 feet from any building. The boats expected to be berthed at the revetted mole are unlikely to have commercial permits, and therefore tourists will not be frequenting that part of the harbor. Commercial fishing vessels are also not expected to be berthed in that area. They are expected to be berthed on the interior revetted mole.

The condominiums which front the harbor have been included on Figure 3, the Present Configuration. No direct effects are expected on local residents or their homes. The beach inside the harbor is part of the harbor, and does not belong to the adjacent land owners. The State of Hawaii claims all lands seaward of the vegetation line. It is likely that property values will increase as a result of the improved boat harbor.

Alternative Plan #6 (interior mole) was shown in Figure 10 on page 16 of the draft SEIS, as listed in the Table of Contents on page ii. As explained in section 3-5 of the final SEIS, this plan is not acceptable from either the navigational safety or economic standpoints. Under south swell conditions the entrance channel would not be protected, and internal oscillations would develop in the harbor. In addition, the cost of landward expansion would more than double the cost of the harbor.

Sincerely,

James A. Nelson

Ray H. Jyo, P.E. for
Director of Engineering

Jack F. Mueller, P.E.
RR 1, Box 388 #301
Wailuku, HI 96793
December 5, 1992

7 JAN 1993
HED
SECY
CLK-TYP
ED-P
PV
CF: PH

James T. Muratsuchi
Lieutenant Colonel, U.S.Army
District Engineer
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, HI 96858-5440

Re: Draft Supplemental, Environmental Impact Statement for Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii.

Dear Colonel:

The protection of public safety and public health and the protection of property should be the first priorities in any public work. The Ma'alaea Small Boat Harbor is not a safe harbor, in my opinion, and it should be made so. There are several public health problems that should be solved and certain properties, in the harbor and outside it, need to be protected. Therefore, I support the idea of improving the harbor and solving these problems.

This letter is being written to point out certain deficiencies in the S.E.I.S. It is my hope these may be addressed so that the project can move forward. The deficiencies are as follows:

1. There are gross discrepancies in the S.E.I.S. Traffic Impact Study, Appendix D.

Appendix D, pg.3 states "...the average daily traffic utilizing Honoapiilani Highway was found to be slightly under 21,000 vehicles per day." This was based on traffic counts taken during the month of June 1991. The DOT Highways traffic counts in 1990 for this section of the highway were 23,800 vehicles per day. A highway design is based on the maximum flows, not average flows. If the consultant takes traffic counts during a low flow period of the year, those figures must be modified to accurately represent the peak flows which occur during January-February. This was not done. In addition the peak hour flows listed by the consultant show a highway operating under Level of Service F.

<u>Level of Service F</u> describes a condition in which traffic demands exceed capacity. Forced flow, with extreme delays and long queues, occur.
Definition from <u>Highway Capacity Manual</u>.

In addition the present DOT Harbors regulations presently call for 30% of the slips at the Maalaea Small Boat Harbor to be reserved for Commercial-Tourist vessels. This would allow an additional 38 vessels with 149 passenger capacity in the harbor. With one trip per day this would generate up to 5624 more people per day through the harbor; two trips per day would mean 11,248 more. The additional vehicles to transport these people, plus the crews, have not been counted or considered. The state has indicated that it intends to limit the Commercial-Tourist vessels to a lower number, approximately the number now using the harbor. The state has not acted to institute this policy. Until they so the Highway capacity will not meet the requirements of the Coastal Zone Management Acts, state and federal (CZMA's).

The CZMA's require that a harbor cannot be built without adequate land transportation to serve them. Obviously, the public safety has not been adequately observed in regard to land transportation. A higher capacity highway is needed to meet the requirements. The state has indicated that this is to be done, but there is no commitment to do this in the S.E.I.S.

2. The S.E.I.S. does not adequately address either the public health problem relating to the disposal of sanitary sewage or the degradation to the harbor and the bay relating to that disposal.

The State of Hawaii Department of Health (DOH) in their correspondence with the State Department of Transportation (DOT), Harbors, to Mr. Calvin M. Tsuda, Deputy Director, July 1990 stated as follows:

> "The State Department of Health (DOH) wishes to express concern regarding the continued usage of the existing cesspools at the Maalaea Boat Harbor. It is our understanding from your letter of May 29, 1990 to Mr. David Nakagawa, Chief Sanitarian on Maui, that the DOT has not included upgrading the cesspools in its current plans but will do so in the near future.
>
> There are many factors prompting the DOH to pursue the upgrading of the existing cesspools. Chapter 11-62, Wastewater Systems, states in Section 11-62-31(g) that no cesspool shall be utilized as the wastewater system by any public building. As such, the DOH is requiring the construction of treatment wastewater systems for new public constructions and the upgrading of existing cesspools when public buildings are renovated. In addition, the cesspools serving the boat harbor is almost entirely constructed in water as the watertable is very high in the area. There is a potential for serious coastal water contamination from these cesspools.
>
> The DOH is requiring the counties and people in the private sector on Oahu under similar circumstances to upgrade their cesspools. Government agencies are anticipated to set the lead for the upgrading of wastewater systems. This situation would set a bad precedent if not pursued. We, therefore, ask your cooperation in providing us with a specific schedule and commitment to upgrade the Maalaea Boat Harbor cesspools in an effort to protect our environment."

The State promised and committed itself to construct a sewage treatment plant and all necessary sewerage facilities at the harbor in its 1980 E.I.S. The existing harbor and the expanded harbor both require new facilities. The state should live up to its obligations and to the public health regulations to protect the health of the harbor users and the public.

The November 1992 S.E.I.S. does not require that proper sewagerage facilities be constructed concurrently with the state's construction of the interior facilities for the harbor. The S.E.I.S. is therefore deficient and has not properly addressed a public health problem and the potential contamination of the harbor and Ma'alaea Bay.

3. There have been a series of letters, beginning with an October 28, 1989 letter to Colonel Donald T. Wynn, informing the Corps of a potential problem. The matter has not been addressed in this or in any previous E.I.S. We have state maps showing that a sandy beach extended throughout this section of Ma'alaea Bay from the Kihei area all the way to McGregor Point before the East Breakwater was constructed. The demise of a substantial part of that beach occurred immediately after the installation of the first East Breakwater. It appears that when the East Breakwater, extending approximately 650' south into the bay, was completed that approximately 1900' of sandy beach extending from it towards Kihei disappeared. The S.E.I.S. appears to recommend Plan 1 for construction. This plan extends a breakwater an additional approximate 300' into the bay beyond the existing East Breakwater alinement. Using a simple algebraic proportion this means that we can expect an additional approximate 900' of beach to be destroyed. This would mean that the existing sandy beach fronting the last three condominium complexes (Kana'i a Nalu, Hono Kai and Makani a Kai) and the public beach at the county park (Haycraft Park) will be lost to the public forever.

Obviously, a simple mathematical expression will not exactly delineate precisely what will happen. However, history shows what previously occurred and we should learn by it.

The two CZMA's, both Federal and State, are quite clear in their requirements to preserve beaches and on the need to mitigate any losses that might occur.

Please address this problem! Attached to this letter are two additional letters that indicate the scope of the financial loss to impacted property owners. One hundred and forty-nine condo units would be affected with a potential property value loss of $ 3,725,000.

Your consultant's Alternative 6 would eliminate this problem entirely. I suggest it should be considered as the best solution for the improved harbor for this reason and because of the additional safety is provides over Plan 1.

Thank you for your consideration of this data. It is my hope you will address and take actions to solve and mitigate the omissions, deficiencies and problems presented.

Very truly yours,

Jack F. Mueller

Jack F. Mueller, P.E.

cc. Rex D. Johnson, Director of Transportation

Maalaea Bay Rentals
[illegible]
RR1 Box 389
Maalaea Village
Wailuku, Maui, Hawaii 96793

December 9, 1992

Mr. Jack Mueller
RR 1, Box 388
#301 Kana'i a Nalu
Wailuku, HI 96793

Dear Jack,

This letter is in reference to your phone call of December 4, 1992, about the potential property value loss to owners in Kana'i a Nalu. The sandy beach in front of Kana'i a Nalu, Hono Kai and Makani a Kai and adjacent to the south line of your property is a very valuable asset to condo ownership, not only aesthetically, but additionally for your recreation. I know you and the other owners enjoy water sports and swimming and the easy access you have to the water as a result of the sandy beach and sandy bottom in front of Kana'i a Nalu. Other condos west of you do not have this advantage. It is an asset worth a great deal in dollars as well as convenience and recreational enjoyment.

Our firm manages a number of condos in Kana'i a Nalu, Hono Kai, and Makani a Kai, and in many of the other seven complexes at Ma'alaea. We have acted as agents in the sale of many of these properties. In my considered opinion the sandy beach in front of KAN adds at least $ 25,000 to the total value of your condo. You would lose that value if the beach was somehow removed, destroyed or disappeared.

Please contact us for any of our services. I'm pleased to help you with this information.

Sincerely,

Jeanne McJannet

Jeanne McJannet

(808) 244 7012 • (808) 242-6553 • (808) 244-5627 • Toll Free (800) 367-6084

STINSON REALTY
WAILUKU EXECUTIVE CENTER • 34 N. CHURCH ST. • WAILUKU, MAUI, HAWAII 96793 • TELEPHONE 244-0031

December 9, 1992

Jack Mueller
Apt. # 311
Kanai A Nalu
Maalaea, Maui, HI

Dear Mr. Mueller:

I will try to give you an answer to the question you posed to me over the phone:

" What effect, if any, would there be on the monetery value of the condominium apartment units situated along the white sand beaches in Maalaea if the sand were to erode away ?"

Jack, as you know, I was the real estate broker back in 1976 that was marketing and selling the apartment units in your building, the Kanai A Nalu condominium. Our very best marketing tool was the fact that it was on the white sand beach in Maalaea. They sold out fast and I'm sure the primary reason was due to its' location. I hesitate to quote you a dollar value because of the beach location but let me say this: Your loss, and indeed the loss to all apartment owners on Hauoli Street, would be very substantial;in the conglomerate, millions of dollars.

Your concerns are very valid regarding the possible beach erosion brought about by th Army Engineers plans to extend a breakwater an additional three hundred feet out into the bay in order to enlarge the Maalaea Small Boat Harbor. If there is an alternate plan to the breakwater extension then by all means use it and I wish you success in your endeavors in this regard.

Sincerely,

James W. Stinson

James W. Stinson

- EVERYTHING IN REAL ESTATE -

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Jack F. Mueller, P.E.
Rural Route, Box 388, #301
Wailuku, Maui, Hawaii 96793

Dear Mr. Mueller:

Thank you for your letter of comment dated December 5, 1992 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments:

a. The traffic impact analysis was based entirely on peak-hour traffic flows, not average flows. A revised traffic impact analysis utilizes information presented in the Maui Long-Range Highway Planning Study, historic traffic count information collected by the Hawaii Department of Transportation (DOT), and projected traffic volumes from the proposed Ma'alaea Triangle Development to estimate future traffic conditions without the proposed harbor expansion. Assumptions included:

(1) Traffic volumes were estimated to increase by 2.9 percent per year, on an average annual basis;

(2) Left-turn movements at the southern intersection of Old Ma'alaea Road and Honoapiilani Highway would be diverted to the intersection Ma'alaea Wharf Access Road and Honoapiilani Highway; and

(3) The DOT would implement a policy that requires commercial passenger vessels with 25 or more passengers to provide bus or van service to and from the harbor.

b. Trip generation was recalculated based on the types, uses, and sizes of the expected vessel makeup, as well as the expected number of passengers and employees. Section 4.13 describes the existing and future without-project traffic conditions, section 5.13 identifies impacts of the proposed harbor expansion on traffic, and section 5.19 discusses potential mitigation measures for project impacts.

c. The DOT has committed to improving the sewage treatment at Ma'alaea Harbor. As discussed in section 3.2.1 and shown in Table 2 of the final SEIS, upgrading the sewage treatment facilities is the first State of Hawaii improvement planned. Although the major cause of degraded water quality within the harbor results from the discharge of runoff from three drainage ditches, the proposed upgrade of the sewage treatment facilities would eliminate any existing or potential water quality impacts occurring.

d. First, the minimal longshore currrent generally flows from east to west, so if there was significant sand movement along the shore, the east breakwater would act as a groin, and accumulate sand. Second, vertical seawalls are known to cause rapid erosion of the beaches in front of them and somewhat down current. Third, it appears there is no significant longshore transport of sand in the vicinity of the harbor, since there is no accumulation of sand in the harbor entrance channel. Although a beach may have existed adjacent to the present harbor before the harbor was constructed, it is highly unlikely that the harbor had anything to do with its demise.

e. The effect of the proposed project on property values is expected to be positive as described in section 5.15 of the FSEIS.

f. The consultant's alternative which you recommend is not a feasible alternative from both cost and navigation standpoints as explained in Paragraph 3.5 of the final SEIS.

Sincerely,

James A. Nelson

Ray H. Jyo, P.E. for
Director of Engineering

Maui-Molokai Sea Cruises

December 8, 1992

U.S. Army Corps of Engineers
Building 230
Fort Shafter, Hawaii 96858-5440

State of Hawaii
Department of Transportation (D.L.N.R.)
Harbors Division
79 South Nimitz Highway
Honolulu, Hawaii 96813

RE: Comments on Draft Supplemental Environment Impact Statement for Maalaea Harbor for Light-Draft Vessels - Maui, Hawaii
Public Hearing: December 10, 1992

To whom it may concern,

My name is Michael V. Peavy. I speak in favor of the harbor improvements. I live at 194 Auoli Drive, Makawao, Maui, Hawaii. I am 37 years old. I have been employed by Maui-Molokai Sea Cruises, out of Maalaea Harbor, for the past eight (8) years. My position is Vice-President of Operations and lead Captain on the Company's commercial vessel. The Company operates the MV Prince Kuhio, a mono hull power craft licensed to carry 149 passengers. At 97 tons, the Prince Kuhio is one of the larger vessels using Maalaea Harbor.

During the past eight and one-half (8 1/2) years, I have experienced numerous occasions that highlighted the dangerous conditions that exist at Maalaea Harbor during times of Kona or south winds and wave actions. On September 11, 1992, these conditions nearly cost me my life!

A strong Kona condition existed that morning due to Hurricane Iniki some distance to the west. I know that once again I would have to take the Prince Kuhio out of the harbor to "ride out" the storm. The surge action was severe enough that morning that it

831 Eha St. • Wailuku, Maui, Hawaii 96793 • (808) 242-8777
Call Toll Free 1-800-468-1287 FAX (808) 244-5890

snapped <u>four</u> 1-1/2" Samsen braid lines on the Prince Kuhio. At the same time other boaters near the entrance were in danger of losing their craft. Surge action was creating havoc with the docks most northeastern in the harbor. I spent as much time as I felt prudent within the harbor, using our dinghy to help other boaters move and secure their vessels.

When I felt we could no longer stay, I went aboard the Prince Kuhio and instructed Captain David Suppi to take it out while I checked the boat to make sure all was secure. I was on deck securing the anchor chain locker when we turned through the entrance of the harbor. I sensed, rather than saw, the rough wave approach. When I looked up, I had perhaps a second or two to grab for the rail and hang on.

The boat as seen from shore, approached near vertical in the harbor entrance. When the bow came down, I was partially "airborne", <u>slamming</u> down on the deck. The next wave came over and I knew I was hurt, but must hang on. I didn't know if I would ever breath again! The reports from shore said the water went over the wheel house! The next wave wasn't quite as bad, but I was still under water for a long, long time. The crew was finally able to retrieve me from the bow.

An ambulance was called and when it arrived, Captain Suppi had to once gain "pick a wave set" that allowed entry into the harbor, deposit me with the ambulance crew, and again depart through <u>near impossible conditions</u>. The crew had to ride the storm out in the lee of Molokini Crater. A very stressful night!

I spent ten (10) days in the hospital. My injuries included my pelvis shattered in ten (10) pieces, a large gouge from my side, loss of blood from that injury, fourteen (14) stitches to my head, and a nearly severed large toe. I finally returned to work full time just ten (10) days ago, on November 30, 1992. I still have nightmares thinking of what might have been if I could not hang on or was unconscious.

I share this story with you to illustrate the extreme surge danger in the harbor. Maalaea Harbor, in the current configuration is a tragedy or disaster just waiting its time to happen.

The U.S. Corps of Engineers, along with the Hawaii Department of Transportation have been going through the process of trying to fix this for 20 years or more. The Supplemental Environment Impact Statement, just released, shows that these agencies have gone through extraordinary efforts to address the concerns of the different interest groups. The process is down to just a couple of issues to solve.

The plans show gain for the fishermen and divers with increased habitat. Shoreside issues have been addressed and largely mitigated. The alternatives suggested to make a safe haven in Haalaea, impact some surf areas. The engineers and designers have tried to keep their degradation to an absolute minimum.

I am here to urge all concerned, with as much emotion as I can muster, to open your minds and hearts, to consider all of the interests involved, and support this plan.

Up to now, we have indeed been fortunate. What if Iniki had come closer. It is ludicrous to have to leave your harbor when extreme weather approaches. We are on borrowed time! The money is here to do it! We must begin this project now! We can have an environmentally sensitive harbor and a safe harbor.

If we don't, there is a high degree of certainty, that some of us will become statistics in another Haalaea Harbor tragedy!

Sincerely,

Captain Michael V. Peavy

Captain Michael V. Peavy

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Maui-Molokai Sea Cruises
Attention: Captain Michael V. Peavy
831 Eha Street
Wailuku, Hawaii 96793

Dear Captain Peavy:

Thank you for your letter dated December 8, 1992 commenting on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. The story of your experiences during Hurricane Iniki certainly points out the need for improved protection for Ma'alaea Harbor. Your letter and this response are reproduced in Appendix C of the final SEIS.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

Comments regarding the Draft Supplemental Environmental Impact Statement for Ma'alaea Harbor for Light Draft Vessels.

Maui, Hawaii

My name is Ron Gammie. I live along the shoreline of Ma'alaea several hundred yards southwest of the Ma'alaea Harbor.

I am President of the Ma'alaea Community Association and a member of the Ma'alaea Boat and Fishing Club.

The Ma'alaea Community Association has <u>not</u> taken a position regarding the draft supplemental EIS being discussed today. We hope to do so prior to the deadline for comments.

My comments:

1. I support the modified version of the breakwater in Fig. 16 as suggested by the Ma'alaea Boat & fishing Club. Moving the parking area to the west end of the south breakwater would still permit the use of surfing sites #1,#2, most of #3 and Ma'alaea Pipeline.

2. I believe that the harbor arrangement 5B, on page 69, showing an interior mole and a landward expansion of the harbor would be a definite possibility. I believe the cost of obtaining the land from the new owners would be very high and the work involved very considerable because of the extreme slope of the land. The cost of the project would increase substantially and the current return of the proposed project is questionable as it is.

3. The traffic impact study does not address the traffic impact caused by the expanded harbor facilities on the road about 200 yards southwest of the Ma'alaea Wharf Access Road. This road, opposite the Mile 7 sign, is dead ended and is part of the old Honoapiilani Highway. There are 8 dwellings on this road. While the state of Hawaii has announced plans to expand the Honoapiilani Highway from 2 to 4 lanes to the harbor, there are no plans to relieve the current extremely dangerous problems of access to and from this section of the old Honoapiilani Highway. The situation will obviously worsen if nothing is done.

4. The current State of Hawaii conceptual plan for the interior of the harbor, figure 5, page 10, shows a number of ideas for berthing. The interior plan does not now show the following:

a. A sewage disposal tank for boats and a sewage treatment plant for the harbor. It is currently using two overloaded cesspools, ~~at the most~~.

b. An oil disposal tank for use by the vessels.

c. The sand beach that is located in the northeast corner of the harbor should be maintained. A road could be built around the sand beach to serve the new slips with a single row of parking. This would then permit the state to landscape the road and parking areas which if left bare would undoubtedly be noxious to the condominium dwellers overlooking the harbor.

d. Figure 5 shows parking in the area southwest of the Ma'alaea Wharf Access Road. A drainage gulch runs from the Honoapiilani Highway to the ocean through part of the parking area shown. The gulch is bridged by an abandoned concrete structure which I believe has been condemned. The gulch is an active natural barrier. I would suggest that the state retain the use of the land up to the gulch for use by the harbor, but use the other side of the gulch as a park (if partially cleared it would have a beautiful view) with access only by foot across the abandoned bridge.

Thank you,

Ron Gammie

Ron Gammie

RR 1, Box 453
Wailuku, HI 96793

CORRECTION

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

Comments regarding the Draft Supplemental Environmental Impact Statement for Ma'alaea Harbor for Light Draft Vessels.

Maui. Hawaii

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Thank you,

Ron Gammie

Ron Gammie
RR 1. Box 453
Wailuku. HI 96793

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Ron Gammie
Rural Route 1, Box 453
Wailuku, Hawaii 96793

Dear Mr. Gammie:

Thank you for your letter of comment dated December 10, 1992 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments.

a. Your preference for the modified version of the breakwater and parking lot is noted. This version is now Alternative Plan 2, shown in Figure 6 of the final SEIS.

b. The interior mole and landward expansion alternative shown in Figure 8-3 of Appendix E is not feasible from either a navigation or economic standpoint. The cost of the land would more than double the cost of the project. In addition, this is not an acceptable configuration from the navigation safety standpoint. See Section 3.5 of the FSEIS for a discussion of reasons this alternative was eliminated from detailed study.

c. Because this area is not expected to be impacted by project-related traffic, it has not been specifically addressed in this SEIS.

d. Sewage treatment and pump-out facilities are part of the infrastructure to be provided by the local sponsor, the Department of Land and Natural Resources, Division of Boating and Ocean Recreation as part of the harbor improvement project. The exact location has not yet been determined, but they will be located west of the Coast Guard Station, so there will be no effect on local residents.

e. An oil disposal tank is also part of the infrastructure improvements. The exact location has not yet been determined, but it will likely be co-located with the fuel facility.

f. The access road to the planned east revetted mole will be aligned seaward of the present shoreline, and landscaped appropriately, as discussed in EIS sections 4.8 and 5.8. The small sandy beach will be destroyed.

g. Detailed plans have not been developed for the parking lot west of the south breakwater. Some park-type facilities will be included in the design; however, this parcel of land is part of the harbor, and will be used primarily for harbor activities.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

December 14, 1992

U.S. Army Corps. of Engineers
District Engineer
U.S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV/Lennan
Bldg. 230
Ft. Shafter, Hi 96858-5440

Re: Support of Maalaea Harbor Expansion

My name is Jan Pinney and I am the Executive Director for the Activity Owners Association of Hawaii. We are a trade association representing the interests of over 127 activity provider businesses in the State of Hawaii, the majority of which are ocean recreation businesses, many, currently operating out of Maalaea Harbor. As such, the proposed plan for the expansion of the Maalaea Harbor is of vital concern to us, especially in the areas of safety and protecting vessels.

In past meetings there have been concerns raised with regards to environmental impacts, changes to established surfing areas and impact to condo owners in Maalaea. The proposed expansion of the harbor has been on the books for over twenty years and this is the third time that the _________ has gone back to the drawing board to try and work out any potential problems raised by the public. We appreciate the extra time and effort that has been expended to address these concerns and feel there has been a real effort to correct potential problem areas and establish workable alternatives. Therefore, we feel it is time to affect a compromise and move forward on this project to make Maalaea a "safe harbor".

The funding is available now to extend the sea wall and provide additional slips in the harbor. Once the expansion of the sea wall is underway we can address the infrastructure problems of the harbor interior directly with the state. As any boat owner will attest, the surge problem in the Maalaea Harbor is a potential danger to boat owners, their passengers and their vessels. If boat owners are forced to leave the harbor during inclement weather in order to protect their vessels from damage there is definitely something wrong. The sole purpose of having a harbor is to provide a "safe berthing" area for vessels and passengers. As evidenced during the recent high surf caused by Hurricane Iniki a few months ago, Maalaea Harbor has the potential to be a serious accident hazard and financial disaster to owners occupying slips.

We support the expansion of the Maalaea Harbor but feel strongly that all concerned should remain active in the development of the plans for the interior infra-structure of the harbor to ensure the needs of the community and its occupants are equally met.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Jan Pinney, Executive Director
Activities Owners Association of Hawaii
355 Hukilike, Suite 202
Kahului, Maui, Hawaii 96732

Dear Mr. Pinney:

Thank you for your comments dated December 14, 1992 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The Corps appreciates your interest and support of the project.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

December 22, 1992

Honolulu District Engineer
Building 230
Fort Shafter, Oahu, Hawaii 96858-5440

Dear Sirs:

While I'm currently traveling the entire U.S.A. and am residing on the great Oregon Coast, I spend from four to six months each year in the Maalaea and Kihei areas of Maui, so have a great interest in changes and developments on my favorite island. As an informed citizen, I urge the utmost care before proceeding on the proposed expansion of Maalaea Harbor.

My concerns are mainly with possible threats to the sandy beaches in that area. I'm not a board surfer, but have spent most of my life body-surfing all over the world, and have seen disastrous results, including Oceanside, California and other sites, as a result of well-intentioned harbor expansion and dredging. It is relatively easy to draft harbor plans, but many of these "expert" proposals have wrought havoc, often over the protestations of knowledgeable persons whose warnings went unheeded until the irreparable damage was done. At the same time, I acknowledge some great work done by the Corps of Engineers in the past.

Although I often am a boat owner, I question the feasibility of increasing the berthing capacity of the present harbor from 87 to 220 boats. While "progress" is fine on the surface, I as a retired professor and psychologist, have witnessed the damaging results from this simple word in much of our world, from the standpoint of environmental upsets and emotional trauma, from congestion, overcrowding, and over-building.

As a frequent resident of Maui, I for one would be highly concerned with the increased noise, congestion, traffic, and air pollution which would obviously result from an increase in boating capacity, since the increased number of owners would be using facilities already at their peak of usage. It is my feeling that local residents who are concerned about these factors have just cause; as well as the local and mainland surfers, who have more wisdom on these matters than they are credited with by most officials.

Further, with our National Debt at a record-breaking peak and the State of Hawaii and county officials pleading a shortage of funds, it appears extravagant and unwise to squander such large sums of money on a highly questionable enterprise.

Sincerely yours,
Jack R. Estes
Dr. Jack R. Estes
3545-A NW Highway 101
Lincoln City, Oregon 97367

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Dr. Jack R. Estes
3545-A Northwest, Highway 101
Lincoln City, Oregon 97367

Dear Dr. Estes:

Thank you for your letter of comment dated December 22, 1992 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments:

a. A significant increase in noise, congestion, traffic and air pollution as a direct result of the improvements planned for Ma'alaea Harbor is unlikely. The dominant sound in the harbor area now is the wind, and that is not likely to change. The proposed projects are expected to result in an increase in traffic in the project area. In order to minimize that increase, the State intends to require that vessels carrying more than 15 passengers must provide bus or van service. Because of the strong trade winds which blow toward the ocean, there is presently not an air pollution problem at Ma'alaea, and that condition is not likely to change because of the increase in the number of boats.

b. Funds for construction of the harbor improvements have already been appropriated by Congress and the State of Hawaii Legislature. Our economic analysis shows that the monetary benefits of the improvements are greater than the costs, and the environmental effects have been minimized to the extent practicable.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

1843 Taylor St.
San Francisco, CA 94133
Dec. 30, 1992

District Engineer
US Army Engineer District, Honolulu
ATTN: CEPOD-ED-PV/Lennan
Ft. Shafter, HI

Dear Sirs:

I am in receipt of the Draft Supplemental EIS for Maalaea Harbor and have reviewed its contents. As a senior contributing editor for SURFER Magazine (Dana Point, CA), I have reported on the harbor project, focusing, naturally, on the magazine's interest in the premier surfing breaks at the site. It is significant that the draft emphatically acknowledges that the harbor expansion's various alternatives all promise some impact on surfing spots there. Surf breaks represent extraordinarily complex natural systems. When a system is as finely-attuned as Maalaea's Pipeline is (bottom contour, swell "window", seasonal weather patterns, etc.), it doesn't take much to alter or destroy it.

This is why surfers worldwide are expressing their dismay over this project. Maalaea, as your own draft states, is a unique, world-class wave, one that surfers from all over the planet have travelled to to surf. Like any rare thing, it is worth preserving. Stated simply, when it is gone, it is gone forever.

As none of the alternative designs as described in the EIS can insure that the surf breaks at Maalaea will be unaffected, I join with surfers everywhere in my continued opposition to the harbor project. It is time to abandon the pursuit of the project.

Sincerely,

Allston James,
Senior Contributing Editor
SURFER Magazine

cc: Dr. Scott Jenkins, Surfrider Foundation
Steve Hawk, Editor/SURFER Magazine

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Allston James
Senior Contributing Editor
SURFER Magazine
1843 Taylor Street
San Francisco, California 94133

Dear Mr. James:

Thank you for your letter of comment dated December 30, 1992 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS.

The design of the proposed project has been modified to avoid and minimize impacts to surf sites to the extent practicable. Some impact to surf sites is unavoidable.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

Ma'alaea Community Association
RR 1, Box 453
Wailuku, HI 96793

HED	
CHEC	
SECY	
CLK-T/P	
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January 6, 1993

James T. Muratsuchi
Lieutenant Colonel, U.S.Army
District Engineer
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, HI 96858-5440

Re: Draft Supplemental Environmental Impact Statement for Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii.

Dear Colonel:

Our association is in favor of improving Maalaea Harbor to make it safe for vessels berthed there and those using the harbor and for the people using and working in it.

We are in favor of improvements within the harbor to improve public health conditions and to modernize the harbor facilities.

We want these goals accomplished without compromising the safety of the general public and of those people who travel to and from the harbor. We believe that all public health regulations must followed in this process. We are concerned about an omissions of pertenant data in reference to public safety, public health and potential property damage in the SEIS as follows:

1. Our records show State of Hawaii data listing Honoapiilani Highway at the harbor to be at Level of Service F since mid 1991. Therefore, the SEIS should call for the widening of the highway to provide adequate public transportation facilities for the public safety.

2. Our records show that the Department of Health has required new sewage facilities to be constructed at the harbor to meet public health requirements and to eliminate the contamination of the harbor and the bay. The SEIS should state this.

3. We believe that the SEIS should address the potential loss of sandy beach east of the east breakwater when the new breakwater extension is constructed and that an assesment of mitigation costs for this and for, damage to the condominiums property values abutting the harbor should be listed and discussed.

We believe that the SEIS must cover all the pertenant liabilities as well as the pertenant benefits of this project to be a valid document and meet EIS requiremants.

Very truly yours,

Ron Gammie

Ron Gammie, President

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DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Ron Gammie, President
Maalaea Community Association
Rural Route 1, Box 453
Wailuku, Hawaii 96793

Dear Mr. Gammie:

Thank you for your letter of comment dated January 6, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments.

a. The traffic study contained in Appendix D of the draft SEIS also showed that Honoapiilani Highway was at level of service F at certain times of the day. The State of Hawaii Department of Transportation, Highways Division does not believe that highway widening is justified by the relatively short periods of time that the level of service is F. Since the projected traffic increase induced by the harbor improvement project will not change the level of service for Honoapiilani Highway during any time period, a highway widening project does not appear justified at this time.

b. Sewage treatment and pump-out facilities are an integral part of the infrastructure improvements to be provided by the State of Hawaii. The Department of Land and Natural Resources, Boating and Ocean Recreation Division will develop the detailed plans for the infrastructure improvements.

c. The small sandy beach east of the east breakwater is not likely to be affected by the new breakwater extension. It appears that long-shore currents generally flow from east to west; therefore the new breakwater is unlikely to have an effect on that beach or others further to the east. It is likely that the property values of the condominiums will increase rather than decrease, since this is the typical pattern for property adjacent to small boat harbors.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
John P. Keppeler, II
Dona L. Hanaike

REF:OCEA:KCK

JAN 6 1993

File No.: 93-297
DOC. ID.: 2000

Brig. Gen. Ralph Locurcio
District Engineer
U.S. Army Engineer District, Honolulu
ATTN: Operations Division
Building T-1, Room 105
Fort Shafter, Hawaii 96858-544

Dear Gen. Locurcio:

Subject: Draft Supplemental Environmental Impact Statement (DSEIS) for the Ma'alaea Harbor for Light-Draft Vessels, Maui

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the materials you submitted and have the following comments.

BRIEF DESCRIPTION:

The U.S. Army Honolulu Engineer District in partnership with the State of Hawaii is planning to make improvements to the Ma'alaea Harbor for light-draft vessels at Ma'alaea, Maui, Hawaii. The Federal portion of the improvements consists of realigning the entrance channel and modifying the existing breakwater to protect the new entrance channel.

A General Design Memorandum and Final Environmental Impact Statement (EIS) was prepared, circulated and approved by the Chief of Engineers in 1980, and a State of Hawaii Revised EIS was circulated and accepted by the Governor in 1982. The project remained unfunded until FY89.

DIVISION OF AQUATIC RESOURCES COMMENTS:

Our previous comments of December 2, 1980 and December 8, 1981 (copies attached) remain applicable.

We note that nothing is proposed to improve the water in the Harbor, such as by reducing the amount of silt that enters through the three existing drainages, particularly near the boat launching ramp. It appears appropriate that the Soil and Water Conservation Service has been be asked to assist in this soil erosion problem.

HISTORIC PRESERVATION PROGRAM CONCERNS:

Our records indicate that this document is correct in stating on page 21 that the State Historic Preservation Officer concurred with the Corps' "no effect" determination in 1980 and in 1989. But also on page 21 is a reference to a personal communication with Mr. Charles Maxwell that Ma'alaea Bay was traditionally important for it was the launching point of canoes and the entry point for interment of the dead on the reef. We contacted Mr. Maxwell by phone on December 10, 1992, to obtain more information as to the location of the interment. Mr. Maxwell indicated that the interment did not take place in the harbor area, but far offshore. The ocean current from McGregor Point carried canoes away that were launched from Ma'alaea Bay. With this information, our previous concurrence with the Corps' "no effect" determination remains unchanged.

Expansion of the Ma'alalea Harbor seaward will also require a Conservation District Use Application (CDUA) and Governor's executive order to DOBOR (Division of Boating and Ocean Recreation).

Thank you for you cooperation in this matter. Please feel free to contact our Office of Conservation and Environmental Affairs at 587-0377, should you have any questions.

Very truly yours,

John P. Keppeler II

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources
State Historic Preservation Officer

Attachments

State of Hawaii
Department of Land and Natural Resources
DIVISION OF FISH AND GAME

MEMORANDUM

Date December 2, 1980

TO: Henry M. Sakuda, Chief, Fisheries Branch
THROUGH: Paul Kawamoto, Chief, Marine Section
_______________, Chief, Freshwater Section

FROM: Mike N. Yamamoto, Aquatic Biologist
SUBJECT: Comments on ___ 1. Conservation District Use Application
_x_ 2. CZM Consistency Determination

Comment Requested by: Hideto Kono, Director, DPED
Date of Request 11/14/80 Date Rec'd 11/18/80

Summary of Proposed Project

Title: MAALAEA HARBOR IMPROVEMENT PROJECT

Project by: U. S. Army Corps of Engineers

Location: Maalaea, Maui

Brief Description:

The Maalaea Harbor navigation improvement project, located on the southwest coast of the island of Maui, involves: construction of a 620 foot-long extension to the existing south breakwater; replacement of a 400 foot-long exterior revetted mole; dreding of a 610 foot-long, 150 to 180 foot-wide, 12 to 15 foot-deep entrance channel; and deposition of dredged spoils as landfill to provide an additional .75-acre area for auto and trailer parking.

Comments:

We concur that the needs of the boating public should be considered, and agree that those needs may be best met by expansion of existing facilities. Therefore, our present concern is to minimize the impact of the proposed action on the State's aquatic resources.

We take exception to the statement provided to Sect. 205A-2 (b)(4), Policy (b), that, "Although project construction may temporarily disturb the nearby coastal ecosystems, those ecosystems will be enhanced after project completion due to the large and diverse marine habitat which will be provided by the project." Inasmuch as part of the seafloor to be destroyed is rich coral reef, and despite the assertion that new substratum will be provided in the form of an extended breakwater structure, the statement that the nearby coastal ecosystems will be enhanced by the project appears tenuous, at best.

We understand from the letter dated July 22, 1980, addressed from Kisuk Cheung to Susumu Ono, that the design alternative selected (Alternate Plan 1) was chosen in part because, rather than being disposed on land, the dredged materials would be used as fill to provide an additional .75-acre parking area. We maintain our preference for Alternate Plan 2 since this would leave intact an additional .84 acres of prime reef habitat. Therefore, from an aquatic resources standpoint, we fail to see that the overall environmental impacts of Alternate Plan 1 and Alternate Plan 2, "are not substantially different."

Mike N. Yamamoto
MIKE N. YAMAMOTO

State of Hawaii
Department of Land and Natural Resources
DIVISION OF AQUATIC RESOURCES

MEMORANDUM

Date December 8, 1981

TO: Henry M. Sakuda, Chief, Fisheries
THROUGH: Paul Kawamoto, Chief, Marine Section
Stanley Swerdloff, Fisheries Development
FROM: David Eckert, Aquatic Biologist
SUBJECT: Comments on ___ 1. Conservation District Use Application
_x_ 2. Environmental Impact Statement

Comment Requested by Gordon Soh, Planning Office, DLNR
Date of Request 11/25/81 Date Rec'd 11/30/81

Summary of Proposed Project

Title: MAALAEA HARBOR IMPROVEMENTS

Project by: Department of Transportaion, Harbors

Location: Maalaea, Maui, Hawaii

Brief Description:

The State Department of Transportation and the U.S. Army Engineer District Honolulu are jointly engaged in an effort to improve and expand facilities of the existing Maalaea Boat Harbor. The Corps of Engineers is to dredge a new entrance channel and construct a protective extension of the existing south breakwater along the new channel's seaward edge. The proposed design, dredging, and construction have been previously addressed in a Federal EIS [to which we have provided the attached comments]. The applicant is to be responsible for the "internal" harbor improvements, collectively designated the "State project," which are the subject of the present EIS. "The proposed [State] project would not extend beyond the physical limits of the present harbor area" (p. 8-1).

The "State project" would include dredging and construction of a "Harbor Center" peninsula extending into the existing harbor, widening the existing east mole (by addition to the inner margin), installations of new piers, docks, slips, and a fueling dock, and construction of parking facilities, sewage treatment plants, utilities outlets, comfort stations, lighting, landscaping, and so forth.

Comments:

We note that the subject document is titled simply "Environmental Impact Statement...," however we understand from a December 2 telephone conversation with Mr. Dan Tanaka (Planning Section, DOT/H) that it is a "final draft."

RE: Maalaea Harbor Improvements; DOT/H

We continue to support the general intent and purpose of the proposed project, which is to increase the safety and berthing capacity of the existing harbor. While the applicant observes that "construction will interfere with the normal [existing] water-borne activity to some extent" (p. 52), we also note that "the harbor is...extensively used by commercial fishermen" (p. 3-15) and that there now exists a waiting list of 170 individuals desiring berths at Maalaea (p. 2-3). Therefore we concur with the applicant's assessment that the project would "contribute significantly to...increased fishing and recreational activities" (p. 8-1). Moreover, we note that "Maalaea is one of the few harbors with the potential for additional mooring capacity" (p. 3-16). Inasmuch as we believe disturbance of marine environments from harbor development may be minimized generally by expansion of existing harbors rather than by construction of additional harbors in new locations, the subject proposal appears consistent also with our programmatic interests in environmental protection.

Nevertheless there are several aspects of the proposal with which we have additional concerns:

1. Destruction of aquatic organisms—we note that surveys within the existing harbor (p. 3-10) have identified "abundant" quantities of Japanese oysters (Crassostrea gigas), pipipi (Nerita picea), makaawa (Morula granulata), akolea (Littorina pintado), and manini (Acanthurus triostegus) all of which are edible; and with the exception of the Japanese oysters, are recreational/subsistence resources; additionally, the "abundant" grey-foot opihi (Cellana exarata) are prized by recreational and commercial fishers; and the "abundant" nehu (Stolephorus purpureus), vital to the aku fishery, are harvested for bait from Maalaea Boat Harbor. It should be further noted that Maalaea Boat Harbor supports a short, but intense seasonal, recreational fishery for halalu. These resources are virtually ignored in Section 6, PROBABLE ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED, and Section 9, IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES. It appears that the project shoreline/"marginal wharf" area and "Harbor Center" fill area and causeway would result in a loss of habitats for oysters, makaawa, manini, and nehu; these structures, together with the proposed docks and piers, may on the other hand provide an enhanced substrate for benthic organisms.

2. Water circulation--whether or not any of the above organisms would return to, and persist in, the remodeled harbor would depend not only on substrate suitability but also on the subsequent water quality. Inasmuch as the proposed configuration of the entrance channel is intended to reduce surge, it would also inevitably diminish exchange of water between the harbor and the open ocean. We are particularly concerned that the proposed "Harbor Center" may result in stagnant areas inhospitable to marine life (and aesthetically unappealing). We note that "water circulation will be maintained under the causeway by use of culverts" (p. 2-9): as represented in Figure 5, there would be two culverts, each between five and six feet in diameter.

RE: Maalaea Harbor Improvements; DOT/H

3. Pollution--the quality and quantity of aquatic resources in the rebuilt harbor would be affected also by potentially harmful substances introduced to the waters. We concur with the applicant that "pollution by sewage disposal and oil spills is a matter of some concern" (p. 5-7). We fully support the applicant's proposals of additional comfort stations, a pumpout station to receive sewage from vessel holding tanks, and on-site, "interim" sewage treatment plants to serve the stations. We would further strongly urge that the applicant not allow residential use ("live-aboards") at Maalaea Boat Harbor. However we are less certain of the suitability of the proposed disposal "primarily by injection wells" (p. 2-16) at unspecified locations: if the proposed wells would be situated such that nutrients seep excessively into the harbor, eutrophication may result in degredation of the water quality, especially if water circulation is inadequate. We note moreover that "litter, debris and oil from small spills will probably increase" as a result of the proposed project (p. 5-6). We find no proposals to mitigate the potential problems of litter, debris, and oil spills, simply the observation that "dumping of oil within the harbor is also prohibited by law" (p. 5-7). Inasmuch as the responsibility for enforcing harbor laws and rules lies with the applicant, the applicant should indicate what additional enforcement measures would be taken to mitigate the above potential impacts.

4. Parking--proposed are at least 388 additional parking stalls (104 stalls, including bus spaces, on the fill area adjacent to the south mole; 73 on the south breakwater; an indefinite number of possible trailer stalls adjacent to the existing access roadway; 65 stalls fronting the new wharf; 50 stalls on the "Harbor Center" fill area; and 96 stalls on the expanded east mole; pp. 2-5 to 2-10). This is likely to increase the amount of traffic-related pollutants (exhaust residues, leaked lubricants and fluids, rubber particles abraded from tires, and such) and debris (e.g., empty cans and bottles, discarded food wrappers, cigarette butts, etc.).

All of the above concerns could be at least partially relieved by maintenance of adequate water circulation in the restructured harbor. We therefore suggest the applicant insure that conditions unfavorable to marine life do not develop (e.g., that "back bay" waters--between the Harbor Center causeway and Old Maalaea Road--and "east bay" waters--between the causeway and south breakwater--be exchanged with open ocean waters at least once in every 24-36 hours). If necessary, the proposed design might be modified to include replacement of the proposed causeway culverts with a section of roadway elevated on pilings, increasing the number or size of the culverts, installation of passage of water circulation at the eastern end of the south breakwater, or some combination of these.

RE: Maalaea Harbor Improvements; DOT/H

We also note that "some blasting may be used to aid in harbor depth excavation...(which) could possibly have an adverse impact" (p. 54) on the humpback whales which winter and calve in Maalaea Bay. We are concerned that these endangered and valued animals not be subjected to such disturbance; we therefore strongly urge that the mitigating measures mentioned (keeping blasting to a minimum and confining all blasting to seasons in which humpback whales absent themselves from Hawaiian waters; ibid.) be employed.

Finally, we suggest that the potential for adverse impacts from construction on marine resources could be minimized by adherence to the following routine precautions: 1) construction and fabrication (e.g., of dock assemblies and armor units) should take place in so far as is possible on fast land; 2) construction practices and special mitigative measures should be employed, especially during dredging, to prevent persistent turbidity and excessive sediment transport into areas of significant living coral coverage; 3) lumber and other construction materials treated with creosote or other preservative substances should not be permitted to contact the water until after at least one week of drying; 4) construction materials, petroleum products, human wastes, debris, and landscaping substances (herbicides, fertilizers, pesticides) should not be permitted to fall, flow, or leach into the ocean.

We appreciate this opportunity to provide our comments.

David Eckert
DAVID ECKERT

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Keith W. Ahue
Chairperson, Board of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Ahue:

Thank you for your letter of comment dated January 6, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments:

a. Aquatic Resources Comments

(1) Three drainage ditches empty into the harbor from the upland agricultural fields. In spite of this, samples taken by the Department of Health usually meet water quality standards, except for turbidity. Even though the samples may exceed the standards, the level of turbidity is very low, averaging less than 2 NTU's . The turbidity is not always caused by runoff. It is usually caused by resuspension of silt from the harbor bottom by the action of the wind or the passage of boats. Occasionally, criteria for chlorophyll A are exceeded, and enterocci criteria are exceeded 10%-25% of the time.

b. 1980 Comments

(1) It appears that the area within the footprint of the proposed bus turnaround (the south mole) has changed since your 1980 comments. The area is not rich coral reef. Rather, it is relatively depauperate except for the rich growth of algae. There is almost no live coral or vertical topography. Most of the biomass of algae is the introduced *Hipnea musciformis*. The new structures will provide increased vertical habitat, and the footprint of the presently proposed plan has been reduced from that approved in 1980 and shown as Alternative Plan 1 in the 1992 DSEIS.

(2) Alternative Plan 2 has been designated the Environmentally Preferred Alternative, because it would fill less of the reef flat, and have less effect on the surf site called "Buzz's" (No. 2).

c. **1981 Comments**

(1) The biological community within the harbor has evidently changed since 1981, either because the resources have been over exploited, or for some natural reason. The present biological community is common in soft bottom habitats, and although there will be some disruption during construction, the post-construction community is expected to be very similar to the present.

(2) The Corps' Waterways Experiment Station (WES) has examined the circulation in the harbor and modeled the proposed project to predict the changes which will occur. The report of their findings is contained in the final SEIS in Appendix B, Environmental Reports.

(3) The proposed project will increase available parking although the exact number of parking spaces has not yet been determined. At the present time, littering and air quality in the harbor do not appear to be a problem, and there is no reason to believe that increased parking will result in an increase in littering or a decrease in air quality. The harbor is well maintained, and the strong tradewinds provide for good air exchange. Expanded sewage treatment and pump-out facilities are part of the infrastructure improvements planned for the harbor, and the design will be coordinated with the State Health Department to assure harbor water quality will not be degraded.

(4) As stated in Paragraph 5.10.4d various techniques are available which will reduce the effects of blasting to the absolute minimum practical.

(5) The routine precautions you recommended have been incorporated into Paragraph 5.10.3

Sincerely,

James S. Nakasone

Ray H. Jyo, P.E. for
Director of Engineering

THE ALTERNATIVE

Ted & Linda Ion

January 7, 1993

U. S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV/Lennan
Building T - 1
Fort Shafter, Hawaii 96825-5440

Subject: Response to the Draft Supplemental Impact Statement for Maalaea Small Boat Harbor.

Dear Sirs:

Thank you for the opportunity to respond to the Draft Supplemental Impact Statement for Maalaea Small Boat Harbor.

You start off the statement by reporting that you are in compliance with Federal and State Environmental Protection Laws, but I feel that you have missed three very important areas from *HRS 205A* which is titled "Planning and Economic Development." This section deals with the shoreline and beaches. The beach that I am referring to is the one located in front of the Maalaea Yacht Marina Condominium on the west side of the Harbor Breakwater. This beach is used daily by many people including fishermen, boaters and bathers. It is included within the harbor area, but it is a used sandy beach.

The three sections of *HRS 205A* that I feel are important and have been left quiet are *HRS 205A-21 Findings; HRS 205A-26(1)(A)* and *HRS 205A-26(3)(B)*.

HRS 205A-21 "Findings and Purposes. The legislature finds...to avoid permanent losses...public owned or used beaches...to restore the natural resources of the coastal zone of Hawaii."

HRS 205A-26(1)(A) "Adequate access...to publicly owned or used beaches..." This is provided by the Maalaea Yacht Marina Condominium.

HRS 205A-26(3)(B) "Any development which would reduce the size of any beach or other area usable for public recreation;"

The next area of concern is the taking of shoreline property from the Maalaea Yacht Marina Condominium and replacing the shoreline with a road and parking lot. The land description of the Maalaea Yacht Marina Condominium recorded in the Bureau of Conveniences in Honolulu, Hawaii states that the complete southern property line of MYM is shoreline. This has not been addressed in the report. This concern has to be resolved before anything can be finalized.

The final area of concern is the use of <u>The Pacific Whale Foundation</u>, which is one of the State Harbor Lessees and runs a commercial operation out of the Maalaea Small boat Harbor. I find this a major conflict of interest. The Pacific Whale Foundation has been investigated by the State of Hawaii, but the investigation has not been released. This also throws a cloud on their report. Other non-interested parties should be used not one of the State's commercial tenants.

Thank you again for the opportunity to respond to the Draft Supplemental Impact Statement for Maalaea Small Boat Harbor.

Yours very truly,

N. Edward Ion

Attachment:

Maalaea Yacht Marina #406 • RR1 Box 377 #406 • Wailuku, Hawaii 96793 • (808) 244-5367

PART II. SPECIAL MANAGEMENT AREAS

§ 205A-21. Findings and purposes.

The legislature finds that, special controls on developments within an area along the shoreline are necessary to avoid permanent losses of valuable resources and the foreclosure of management options, and to ensure that adequate access, by dedication or other means, to public owned or used beaches, recreation areas, and natural reserves is provided. The legislature finds and declares that it is the state policy to preserve, protect, and where possible, to restore the natural resources of the coastal zone of Hawaii. [L 1975, c 176, pt of § 1; am L 1977, c 188, § 5]

CASE NOTES

Cited in Mahuiki v. Planning Comm'n, 65 Haw. 506, 654 P.2d 874 (1982); Alaloa v. Planning Comm'n, Haw., 705 P.2d 1042 (1985).

LEGAL PERIODICALS

University of Hawaii Law Review. Article, Whither Hawaii? Land Use Management in an Island State, 1 U. Haw. L. Rev. 48 (1979).

1982 Survey, Laws Affecting the Development of Ocean Resources in Hawaii, 4 U. Haw. L. Rev. 227 (1982).

§ 205A-22. Definitions.

As used in this part, unless the context otherwise requires:

(1) "Applicant" means any individual, organization, partnership, or corporation, including any utility, and any agency of government.

(2) "Authority" means the county planning commission, except in counties where the county planning commission is advisory only, in which case "authority" means the county council or such body as the council may by ordinance designate. The authority may, as appropriate, delegate the responsibility for administering this part.

(3) "Development" means any of the uses, activities, or operations on land, in or under water, within the special management area that are included below, but not those uses, activities, or operations excluded in subparagraph (B).

(A) "Development" includes the following:

(i) The placement or erection of any solid material or any gaseous, liquid, solid, or thermal waste;

(ii) Grading, removing, dredging, mining, or extraction of any materials;

(iii) Change in the density or intensity of use of land, including but not limited to the division or subdivision of land;

(iv) Change in the intensity of use of water, ecology related thereto, or of access thereto; and

(v) Construction, reconstruction, demolition, or alteration of the size of any structure.

§ 205A-23. County special management area boundaries.

(a) The special management area in each county shall be as shown on such maps filed with the authority as of June 8, 1977.

(b) On or before December 31, 1979, the authority shall review and pursuant to chapter 91, amend as necessary its special management area boundaries, to further the objectives and policies of this chapter, provided that any contraction of the special management area boundaries as provided for in subsection (a), shall be subject to lead agency review and determination as to compliance with the objectives and policies of this chapter and any guidelines enacted by the legislature. Copies of the existing and amended maps shall be filed with the authority and the lead agency.

(c) Nothing in this chapter shall preclude the authority from amending its special management area boundary at any point in time; provided that the procedures and requirements outlined in subsection (b) shall be complied with and provided further that any future special management area boundary adjustments shall be restricted to the coastal zone management area. [L 1975, c 176, pt of § 1; am L 1977, c 188, § 7; am L 1979, c 200, § 8]

CASE NOTES

Cited in Alaloa v. Planning Comm'n, Haw., 705 P.2d 1042 (1985).

OPINIONS OF ATTORNEY GENERAL

In establishing "special management areas" under this part, the counties had to reasonably determine whether land areas located in excess of 100 yards from the bodies of water to be protected were land areas the use of which would have a direct and significant impact on such bodies of water; if not, those land areas should not have been included, notwithstanding their significant environmental value. Op. Att'y Gen. No. 75-18 (1975).

§§ 205A-24, 205A-25. Repealed. L 1977, c 188, §§ 8, 9.

§ 205A-26. Special management area guidelines.

In implementing this part, the authority shall adopt the following guidelines for the review of developments proposed in the special management area:

(1) All development in the special management area shall be subject to reasonable terms and conditions set by the authority in order to ensure:

(A) Adequate access, by dedication or other means, to publicly owned or used beaches, recreation areas, and natural reserves is provided to the extent consistent with sound conservation principles;

(B) Adequate and properly located public recreation areas and wildlife preserves are reserved;

(C) Provisions are made for solid and liquid waste treatment, disposition, and management which will minimize adverse effects upon special management area resources; and

(D) Alterations to existing land forms and vegetation, except crops, and construction of structures shall cause minimum adverse effect to water resources and scenic and recreational amenities and minimum danger of floods, landslides, erosion, siltation, or failure in the event of earthquake.

(2) No development shall be approved unless the authority has first found:

(A) That the development will not have any substantial adverse environmental or ecological effect, except as such adverse effect is minimized to the extent practicable and clearly outweighed by public health, safety, or compelling public interests. Such adverse effects shall include, but not be limited to, the potential cumulative impact of individual developments, each one of which taken in itself might not have a substantial adverse effect, and the elimination of planning options;

(B) That the development is consistent with the objectives, policies, and special management area guidelines of this chapter and any guidelines enacted by the legislature; and

(C) That the development is consistent with the county general plan and zoning. Such a finding of consistency does not preclude concurrent processing where a general plan or zoning amendment may also be required.

(3) The authority shall seek to minimize, where reasonable:

(A) Dredging, filling or otherwise altering any bay, estuary, salt marsh, river mouth, slough or lagoon;

(B) Any development which would reduce the size of any beach or other area usable for public recreation;

(C) Any development which would reduce or impose restrictions upon public access to tidal and submerged lands, beaches, portions of rivers and streams within the special management areas and the mean high tide line where there is no beach;

(D) Any development which would substantially interfere with or detract from the line of sight toward the sea from the state highway nearest the coast; and

(E) Any development which would adversely affect water quality, existing areas of open water free of visible structures, existing and potential fisheries and fishing grounds, wildlife habitats, or potential or existing agricultural uses of land. [L 1975, c 176, pt of § 1; am L 1977, c 188, § 10; am L 1979, c 200, § 9; am L 1984, c 113, § 2]

CASE NOTES

Findings are mandated prior to issuance of permit. — This chapter mandates that the county planning commission make findings that proposed development projects are consistent with the policies and objectives of protecting and preserving historic and pre-historic resources before a special management area use permit can be issued; the granting of conditional use permits conditioned on the permittees undertaking a further archaeological survey and excavation and allowing their archaeologist to determine the significance of various sites was not sufficient. Alaloa v. Planning Comm'n, Haw. , 705 P.2d 1042 (1985).

Guidelines must be followed. — Where a county agency that has been delegated authority to pass on applications for special management area use permits exercises this authority

EXHIBIT "A"

All of that certain parcel of land (portion of the land described in and covered by Royal Patent Grant Number 3152 to Henry Cornwell) situate, lying and being on the southerly side of Hauoli Street at Waikapu, District of Wailuku, Island and County of Maui, State of Hawaii, being LOT NUMBER FOUR-A (4-A) of the "MAALAEA BEACH LOTS", same being all of Lots Numbers 3 and 4 of the Maalaea Beach Lots Subdivision, and thus bounded and described, as per survey of Albert S. Saiki, Registered Professional Surveyor, dated March 3, 1976, to-wit:

Beginning at a pipe at the northwest corner of this lot, being also the northeast corner of Lot 2, Maalaea Beach Lots, the coordinates of which referred to Government Survey Triangulation Station "PUU HELE" being 6,980.50 feet South and 1,705.19 feet West and running by azimuths measured clockwise from true South:

Along the southerly side of Hauoli Street on a curve to the left with a radius of 620.00 feet, the chord azimuth and distance being:

1.	255°	59'	01"	252.65 feet to a pipe;
2.	23°	41'		94.35 feet along Lot 5, Maalaea Beach Lots, along the center of the drainage ditch;
3.	9°	11'		212.84 feet along Lot 5, Maalaea Beach Lots, along the center of the drainage ditch to a pipe;
4.	113°	16'	10"	14.28 feet along the seashore;
5.	91°	10'		30.00 feet along the seashore;
6.	101°	45'		19.00 feet along the seashore line;
7.	86°	30'		9.00 feet along the seashore line;
8.	68°	30'		7.16 feet along the seashore line;
9.	91°	10'		11.41 feet along the seashore;
10.	81°	07'		103.12 feet along the seashore;
11.	72°	11'		35.00 feet along the seashore;
12.	191°	15'	20"	259.76 feet along Lot 2, Maalaea Beach Lots to the point of beginning and containing an area of 55,250 square feet, more or less.

SUBJECT, HOWEVER, to the following:

1. Reservation in favor of the State of Hawaii of all mineral and metallic mines.

2. Location of the seaward boundary in accordance with the law of the State of Hawaii, and shoreline setback line in accordance with County regulation and/or ordinance.

3. A perpetual easement 20 feet in width in favor of the County of Maui for ingress and egress to and along existing natural drainage ditch and 10 feet on each side of the common boundary between Lots 4 and 5, as shown on Map entitled "Maalaea Beach Lots", dated March 15, 1951 and on file in the Office of East Maui Irrigation Company, Limited.

4. A grant of littoral rights in favor of the State of Hawaii, its successors, assigns, licensees and permittees, appurtenant to the lands described as Parcel D of Maalaea Bay Front (Lot 3, Maalaea Beach Lots) and Parcel E of Maalaea Bay Front (Lot 4, Maalaea Beach Lots), by Deed of Maui Fisheries & Marine Products, Ltd., dated October 29, 1958, recorded in the Bureau of Conveyances of the State of Hawaii in Liber 3515 on Page 425.

5. Grant in favor of Maui Electric Company, Limited, a Hawaii corporation, dated February 28, 1979, and recorded in Liber 13555 on Page 734; granting an easement (10.00 feet wide) for electrical purposes over, under, upon, across and through said Lot 4-A.

END OF EXHIBIT "A"

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. N. Edward Ion
Rural Route 1, Box 377, #406
Wailuku, Hawaii 96793

Dear Mr. Ion:

Thank you for your letter of comment dated January 7, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments:

a. The beach in front of the Ma'alaea Yacht Marina is not a beach within the meaning of HRS 205A. Executive Order No. 2605 assigned that shore land to the Department of Transportation for harbor purposes, therefore it would not be intended as a recreational beach.

b. The owners or leaseholders of the condominiums adjacent to Ma'alaea Harbor generally have no littoral rights and therefore no "taking" or payment for them will be required. For example, the State of Hawaii was granted the littoral rights of the Maalaea Yacht Marina Condominium by deed dated October 29, 1958. Secondly, the State of Hawaii claims all submerged lands and all lands seaward of the high tide line. In addition, Executive Order No. 02605 dated June 3, 1972 assigns the filled and underwater areas adjacent to the harbor to the Department of Transportation as an addition to Ma'alaea Harbor.

c. The National Marine Fisheries Service rendered their Biological Opinion before the report by the Pacific Whale Foundation was prepared. The report is a compilation of data the Foundation has gathered over several years, and was provided as additional information to the public and decision makers. There has been no information presented by any agency or individual that the data contained in the report is anything but factual. The data in the report had nothing to do with the decision by NMFS concerning the effects of the project on humpback whales. Another study of humpback whales will not be conducted for this project.

Sincerely,

Ray H. Jyo, P.E. for
Director of Engineering

PACIFIC WHALE
FOUNDATION
Kealia Beach Plaza • 101 N. Kihei Rd. Suite 21
Kihei, Maui, HI, USA 96753-8833
(808)879-8860 FAX (808)879-2615

January 12, 1993

District Engineer
U.S. Army Engineer District, Honolulu
Attention: CEPOD-ED-PV/Lennan
Building 230
Fort Shafter, HI 96858-5440

Dear Mr. Lennan,

Comments Regarding:

**Supplemental Environmental Impact Statement
For
Maalaea Harbor For Light-Draft Vessels
Maui, Hawaii**

The reviewer appreciates the opportunity to respond to the EA and acknowledges efforts to address biological impacts from the proposed harbor improvements. There are several points that need clarification and they are listed below:

Section 5.2.2 Aquatic Resources

It appears that loss of coral reef habitat is inevitable both from the direct dredging activity and suspended sediments if Alternative plan #1 or #2 is implemented. It is unclear, however, what level of "compensation" the new breakwater extension will provide in the form of increased habitat. Some species of coral that will be removed during dredging operations may not attach in areas of high surf along the new breakwater. This will change the composition of the reef structure and hence the corresponding community of reef fishes. Alternative plan #5 will probably have the least impact on existing coral reef communities.

Further clarification is needed concerning different agency assessments of impact on coral reef communities. The U.S. Fish and Wildlife Service (USFWS) plans to provide quantitative baseline data on distribution and abundance of reef fish and invertebrates yet the report on the evaluation of EPA Guidelines with reference to Maalaea Harbor appears to have already come to a conclusion. The authors state:

"There is very little live coral on the reef flat adjacent to the harbor in the area to be effected by the discharge". On what findings is this based? Especially since the USFWS has concluded that additional work is needed. The Pacific Whale Foundation has been conducting coral reef surveys since 1989 along the West Maui coastline and our evidence indicates that an intensive effort is required to establish definitive patterns and structure of existing reef communities. To date I am unaware of any long term, intensive studies that have been conducted in this region.

There also appears to be no long-term monitoring program implemented to document adverse effects from the immediate destruction of the reef as well the damage from suspended sediments. A cost-effective program would give future planners quantitative data to address pre and post construction impacts on corals and their associated fish communities.

Section 5.2.3 Threatened and Endangered Species.

The recommendations for prevention of adverse impacts on endangered humpback whales and threatened sea turtles appears appropriate. The question remains though, how would construction other than blasting, proceed upon the appearance of these animals or even in the presence of rare Hawaiian Monk Seals. Some type of protocol (e.g. cessation of activities within a certain distance) probably needs to be developed to deal with these occurrences.

I appreciate the chance to respond to this EA and look forward to the resolution on all issues facing the Planning Division.

Sincerely,

Eric K Brown

Eric K. Brown
Senior Research Associate

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Eric K. Brown
Senior Research Associate
Pacific Whale Foundation
Kealia Beach Plaza
101 North Kihei Road, Suite 21
Kihei, Hawaii 96753-8833

Dear Mr. Brown:

Thank you for your letter of comment dated January 12, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments:

a. The final SEIS more fully describes the potential impacts of the alternatives to marine habitat, the area of reef which would be affected under each alternative is stated in paragraph 5.10.2. This habitat would be partially replaced by habitat provided by the new revetment. The area within the footprint of the modified south breakwater has a dense covering of algae, with the introduced red alga, *Hipnea musciformis* dominating. Further offshore in deeper water there is less of the introduced alga, more coral, and in general better fish habitat. The ungrouted armor stone will provide good vertical habitat, although the community composition may change and a net loss of coral habitat would occur.

b. The draft evaluation of EPA Guidelines for Ma'alaea was based on a site survey by a Corps marine ecologist. The final evaluation in Appendix A of the final SEIS is based on the draft Fish and Wildlife Coordination Act report prepared by the U.S. Fish and Wildlife Service (also contained in Appendix A), and additional site surveys by a Corps marine ecologist.

c. A long-term monitoring program is not planned for this project. Generally the Corps develops a long-term monitoring program only for areas with unique resources which can be monitored in a cost effective manner.

d. Although it is highly unlikely that whales, turtles or monk seals would approach close enough to construction activities to be harmed, a protocol will be included in the contractor's Environmental Protection Plan, which is a standard requirement of all Corps project contract specifications.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

LIFE OF THE LAND

January 14, 1983

Comments on Supplemental EIS for Maalaea Harbor for Light-Draft Vessels

U.S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV/Lennan
Building T-1
Fort Shafter, Hawaii 96825-5440

Gentlemen:

Thank you for the opportunity to comment on the Draft Supplemental EIS for Maalaea Light-Draft Harbor. Please send us a copy of the Final Supplemental EIS when it is submitted to the Office of Environmental Quality Control for State approval.

Enclosed is a letter to the Office of State Planning (OSP) requesting interpretation of requirements imposed by the Hawaii Coastal Zone Management (CZM) Program on proposed harbor improvements. We request that you reprint our letter and OSP's response in the Final Supplemental EIS.

Please amend the project description in the Final Supplemental EIS to include alternatives for replacement of surfing sites which would be damaged or destroyed by development. The Hawaii CZM Program requires replacement of surfing sites damaged by development unless OSP determines that replacement is not desirable or feasible. We strongly contend that it is desirable and feasible to replace surfing sites damaged by Maalaea harbor improvements. No contrary evidence is provided in the Draft Supplemental EIS.

In the event that the project description is not amended as requested, then we still ask that the costs, benefits, and impacts of feasible alternatives for replacement of surfing sites be thoroughly discussed in the Final Supplemental EIS. You have a legal obligation to provide this information pursuant to either Section 11-200-17(f) or Section 11-200-17(m), State EIS Rules.

On the same basis, we ask that the Final Supplemental EIS seriously address the feasibility of increasing sheltered berths and moorings without affecting surfing sites by inland excavation and filling to the west and/or north. Options include public land acquisition and/or private inland expansion of the harbor. We ask that the Final Supplemental EIS include written comments by private property owners north of the existing harbor setting forth conditions, if any, under which

19 Niolopa Place, Honolulu, Hawaii 96817. Tel. 595-3903

they are willing to consider private for-profit inland expansion of the harbor. We also ask that the Final Supplemental EIS include cost comparisons between feasible alternatives for inland expansion of the harbor and proposed alternatives for seaward improvements which would damage surfing sites.

The statement is made in the Draft Supplemental EIS that an "Alternate Plan 6" is not feasible because Maalaea Harbor must accommodate a 110-foot Coast Guard vessel. There currently is no such vessel in Maalaea Harbor. We request that the Final Supplemental EIS include an evaluation by the Coast Guard of reasonable alternatives to docking of a 110-foot vessel in Maalaea Harbor.

The Draft Supplemental EIS improperly fails to assess the relative risk of surfer injuries arising from alternative harbor improvements. If Maalaea Harbor is modified, and if a surfer is smashed by whitewater from a broken wave onto a revetment, won't the State of Hawaii be liable for the injury? Moreover, the Draft Supplemental EIS inaccurately summarizes the analysis of technical appendices concerning impacts on surfing sites from "Alternative Plan 2."

Despite our timely written comments on the Supplement EIS Preparation Notice, the Draft Supplemental EIS improperly fails to disclose potential environmental impacts from commercial uses of an expanded harbor on the Molokini Atoll Marine Life Conservation District and bottomfish fisheries in Maui waters. Appendix F of the Draft Supplemental EIS shows that such uses are likely. The Draft Supplemental EIS also improperly fails to discuss the potential to mitigate impacts by simply requiring only non-commercial use of new slips and berths.

Sincerely,

Fred Paul Benco
Vice President for
Coastal Zone Management

Enclosure

cc: Office of Environmental Quality Control
Bickerton Ramos-Saunders & Dang Attorneys at Law
Surfrider Foundation

LIFE OF THE LAND

January 14, 1993

Subject: Consistency of Proposed Maalaea Harbor Improvements with the Hawaii CZM Program

Harold Masumoto, Director
Office of State Planning
Office of the Governor
State of Hawaii
P.O. Box 3540
Honolulu, Hawaii 96811-3540

Dear Mr. Masumoto:

Life of the Land would appreciate being consulted by the Office of State Planning (OSP) when the U.S. Army Corps of Engineers (Corps) formally submits a Federal Consistency Determination for Maalaea Harbor improvements for OSP review and action. Life of the Land was recently provided with a copy of the Draft Supplemental EIS for Maalaea Harbor for Light Draft Vessels (Draft EIS). Appendix A of the Draft EIS includes a draft document, dated October 30, 1992, titled "Determination of Federal Consistency: for Navigation Improvements for the Maalaea Small Boat Harbor, Maalaea, Maui, Hawaii."

The Draft EIS and draft Federal Consistency Determination allege proposed Maalaea Harbor improvements will be consistent with the Hawaii CZM Program without:

- replacement of surfing sites which will be damaged by development and
- restriction of commercial uses which will damage valuable coastal ecosystems.

Life of the Land disagrees. Our dispute centers on how OSP interprets the Hawaii CZM Program. For that reason, we request that OSP provide Life of the Land, the Corps, and affected State agencies with written answers to the following two questions.

(1) If public harbor improvements will damage or destroy surfing sites of significant recreational value, then as a prerequisite to finding that proposed Federal improvements and permits are consistent with the Hawaii CZM Program, will OSP require that those surfing sites be replaced?

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(2) If public harbor improvements will induce commercial overutilization and damage to a popular Marine Life Conservation District and overfishing of economically significant fisheries, then as a prerequisite to finding that proposed Federal improvements and permits are consistent with the Hawaii CZM Program, will OSP require restrictions on commercial harbor use until appropriate management alternatives are adopted?

According to the Draft EIS, all alternatives now being considered to increase sheltered berths and moorings in Maalaea Harbor would either damage or destroy surfing sites of significant recreational value. Under Section 205A-2(c)(1)(B), Hawaii Revised Statutes, it is the State of Hawaii's CZM policy to:

> Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by: ...
>
> (ii) Requiring replacement of coastal resources having significant recreational value, including but not limited to surfing sites and sandy beaches, when such resources will unavoidably be damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable....

The Corps, and by implication the State Department of Transportation (DOT), contend that even when it is feasible and desirable to replace surfing sites that would be damaged by development, Section 205A-2(c)(1)(B), Hawaii Revised Statutes only requires "reasonable monetary compensation to the State for recreation." The Draft EIS implies that expenditures for public recreational boating at Maalaea, regardless how small, amount to "reasonable monetary compensation to the State for recreation". The Draft EIS also implies that the Corps and DOT, not OSP, have the final say whether to replace surfing sites damaged by harbor development.

In contrast, Life of the Land contends that absent conclusive proof that it would not be feasible or desirable to replace surfing sites that would be damaged by development, State law and the Hawaii CZM Program require replacement. Life of the Land further contends that OSP makes the final decision, rather than some other agency, concerning the feasibility and desirability of replacing surfing sites that will be damaged by development. To date, OSP's public stand on the feasibility and desirability of replacing surfing sites has been to propose amendment of State law to always require replacement of surfing sites that would be damaged by development.

Appendix F of the Draft EIS predicts that many new slips at Maalaea Harbor will be filled with commercial tour boats and fishing vessels. Existing environmental problems stemming from commercial overuse of the Molokini Marine Life Conservation District are discussed in case studies prepared by the State Department of Business, Economic Development, and Tourism Ocean Resources Branch. Bottomfish fisheries around the main Hawaiian Islands are already near or beyond their sustainable yield according to Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region 1991 Annual Report published by the Western Pacific Regional Fishery Management Council in August 1992.

It logically follows that commercial use of new berths and moorings in Maalaea Harbor will aggravate commercial overutilization of Molokini Atoll and overfishing for bottomfish (especially opakapaka, onaga, and ulua) in Maui waters. The Molokini Atoll Marine Life Conservation District has significant biological and and economic importance. Maui's bottomfisheries have significant economic importance. Under Section 205A-2(c)(4)(B), Hawaii Revised Statutes, it is the State of Hawaii's CZM policy to "Preserve valuable coastal ecosystems of significant biological or economic importance...."

The Corps and DOT contend that regardless how commercial uses induced by harbor expansion impact on coastal ecosystems, Section 205A-2(c)(4)(B), Hawaii Revised Statutes, does not require restrictions on expanded commercial use of Maalaea Harbor. In contrast, Life of the Land contends that if harbor expansion will facilitate commercial uses which will damage valuable coastal ecosystems, then State law and the Hawaii CZM Program require restrictions on commercial harbor uses.

The fundamental criteria which the Corps uses for decision-making on Corps projects encourages economically inefficient, environmentally destructive decisions. The cost-benefit ratio calculated by the Corps for 100 new slips in Maalaea Harbor would not be affected if ten surfing sites were destroyed, or none, or even if 5,000 boat moorings were destroyed outside the harbor. That is because the cost-benefit methodology used by the Corps excludes all environmental costs. If CSP does not set contrary policy at Maalaea, then significant surfing sites will be destroyed by development and valuable coastal ecosystems will be damaged by commercial uses.

Sincerely,

[signature]

Fred Paul Benco
Vice President for
Coastal Zone Management

cc: U.S. Army Corps of Engineers ✓
Office of Environmental Quality Control
Department of Transportation Harbors Division
Department of Land and Natural Resources
Division of Boating and Ocean Recreation
Bickerton Ramos-Saunders & Dang Attorneys at Law
Surfrider Foundation

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Fred Paul Benco
Vice President for Coastal Zone Management
Life of the Land
19 Niolopa Place
Honolulu, Hawaii 96817

Dear Mr. Benco:

Thank you for your letter of comment dated January 14, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments.

a. Your letter to the State of Hawaii Office of State Planning dated January 14, 1993 has been included in Appendix C of the final SEIS. The Corps has not received a copy of their reply.

b. A Consistency Determination has not been made; however, modifications have been made to the proposed project that would minimize impacts to surf sites to the extent practicable.

c. In addition, recommended mitigation for potential impacts to surfing sites is contained in Chapter 5 of the final SEIS.

d. Alternative Plan 6 was eliminated from detailed analysis because of navigational and cost considerations. Entering the entrance channel during south swell conditions would be very hazardous because of the wave angle and the reflections and refraction's generated in the entrance channel. It would also eliminate the possibility of developing berthing facilities along the east breakwater and would eliminate the fuel pier. In addition, any vessel docked at the Coast Guard pier would make access to the rest of the harbor hazardous for other vessels even during normal sea conditions. The proposed expansion inland would eliminate needed space for harbor support facilities and the high cost to the State to acquire the land would make the project economically not feasible. The expansion eastward would likely meet with considerable opposition from residents of the affected adjacent condominiums, as well as being much more costly and environmentally destructive. It is also possible that wave reflection/refraction from the protective structure could affect in some unknown way the surf site known as "Ma'alaea Pipeline" or "Freight Trains." In addition, wave attenuation in the eastern expansion area would not be sufficient without additional, more elaborate protective structures. The flushing characteristics of the internal mole alternative were the worst of those analyzed.

e. Private development of the harbor is not considered desirable by the Department of Land and Natural Resources, Division of Boating and Ocean Recreation .

f. Costs of the feasible alternatives are included in Appendix G.

g. The capability to accommodate a 110-foot Coast Guard vessel is no longer a mandatory requirement; however, the design vessel is nearly the same size. The harbor needs to accommodate this size commercial vessel.

h. It does not appear that the expanded harbor would be more hazardous to surfers than is the present configuration. At present, the left break known as "Off-the-Wall" requires surfers to ride directly toward the east breakwater. This break will be destroyed by the proposed entrance channel. The right break known as the "Ma'alaea Pipeline" or "Freight Trains" causes surfers to ride away from the breakwater, which appears to be a more safe direction.

i. Liability for injuries sustained by a surfer hitting the modified breakwater would likely be similar to the current situation, and would be determined by a court proceeding.

j. The final SEIS fully summarizes the results of the surf site impact studies in the appendices. It may be confusing since the alternatives have been renumbered since that study was done. This has been clarified by a cross reference sheet in front of the study.

k. Expansion of Ma'alaea Harbor is not expected to have any effect on the Molokini Atoll Marine Life Conservation District. Many of the boats which will be berthed in the expanded harbor are trailered boats which already visit Molokini Atoll. In addition, the Department of Land and Natural Resources is presently developing rules for the use of Molokini, which are likely to reduce the impacts in the future below the present levels.

l. Expansion of Ma'alaea Harbor is not expected to have a significant effect on the bottom fishery in Maui waters since most of the fishermen on the waiting list for berths currently have trailered boats and may already be exploiting the bottom fishery.

m. The U.S. Army Corps of Engineers no longer builds or improves recreational boating facilities. Each harbor project must be justified by commercial benefits, therefor an alternative which would eliminate commercial use of the new facilities would eliminate Federal participation in the project. Additionally, it is very difficult to separate commercial from non-commercial use since many recreational boaters are also part-time commercial fishermen.

Sincerely,

James A. Nakason

Ray H. Jyo, P.E. for
Director of Engineering

Memorandum to the U.S. Army Corps of Engineers

From: Jamie Hunter, Protect Maalaea Coalition

Re: Maalaea Harbor Draft S.E.I.S

Date: January 14, 1993

1. Introduction

I have lived on Maui since 1969. I am a licensed attorney, surfer, and president of the Protect Maalea Coalition.

2. The New Consultant's Plan (Internal Mole) Is the Best Alternative

The new draft S.E.I.S. is a big improvement over former documents because it does a much better job of locating surf areas and admitting that some surf sites would be destroyed by the "approved" plan (formerly called Alternate Plan 1). We believe that even this new description understates the damage, especially regarding "Maalaea Pipeline." The only plan which does not damage those surf areas is the new consultant's plan (Alternative Plan 6 shown in Fig. 10 on p. 15, derived from Dr. Kimo Walker's Alternatives 5 and 5A in Appendix AO. 67 & 69). Dr. Walker has been hired many times in the past by the Corps and by the State. His plan would provide about 165 slips, a 90% increase from the present 87 slips now at Maalaea Harbor.

This plan would be a good compromise for surfers because it would minimize damage to surf areas. It would be a good compromise for boat owners because they would get an immediate increase in harbor capacity from 87 to 165 berths. It would be a good compromise for property owners because it would leave their side of the harbor alone rather than replacing their beach with a parking lot and restrooms.

The Corps rejects the consultant's plan because "it would not allow enough space for the Coast Guard's 110' vessel to safely enter and leave the harbor." Mr. Lennan of the Corps stated at the December 10, 1992 informational meeting that the Coast Guard would station a 110' vessel at Maalaea as soon as the "approved plan" was built. I asked the Coast Guard's planning office about this situation, and they said that they had not been asked to analyze and compare the various harbor designs; that they had no plans to station a 110' vessel at Maalaea in any case, that such a vessel needs to be going 9 knots to be under control and even faster if there is any wind. Finally, if you carefully compare the "approved" plan with the rejected plan (internal mole) you will see that there is less clearance in the approved plan than there is in the rejected plan! So the reality is that the Coast Guard is being used here to further an argument with no verifiable fact or logic.

When I revealed these facts at the December 10 informational meeting, Mr. Ventura of the Maalaea Fishing Club answered that he had information from a confidential source within the government that the Coast Guard planned to put a twin screw 47' vessel at Maalaea as soon as the new harbor was finished! This is very interesting because (a) such a vessel could easily fit in the present harbor or any other design configuration, and (b) it proves that the fishermen's organization knew that the Corps' argument was without factual basis!

This internal mole design should be modified, however, to align the slips into the prevailing wind direction (NE) rather than across the wind as shown in the drawing. This would not be difficult to accomplish. Since the purpose of this S.E.I.S. is NOT the internal harbor slip alignment, I will not pursue this point any further.

Finally, if the State and the Corps insist that a harbor of 228 slips is somehow necessary, then it should expand the harbor inland in the area of the Maalaea triangle property. This property is now for sale and the State could condemn it or purchase it. A complete safe marina could be built there with a canal from the existing harbor. Some of this land could be used for the required widening of Honoapiilani Highway. Ultimately, this could provide all the slips being urged here, plus haul out facilities for repair, dry storage, and commercial boat supplies and services.

3. Swell Direction and Harbor Safety.

Over the past three years the Protect Maalaea Coalition held a series of meetings with the U.S. Army Corps of Engineers and the State Department of Transportation and other interested groups. At these meetings we criticized the "approved" plan because it fails to protect from S/E swells. The approved plan is to extend the west side (Lahaina side) breakwall 620' toward the southeast at approximately 165 degrees and remove 80' from the end of the east side (Kihei side) breakwall, enlarging the harbor entrance. In fact these changes would not protect the harbor from a swell between 180 and 160 degrees. On the contrary, this plan would open the harbor to such a swell making the area where the additional moorings would be located susceptible to more surge and damage than at present. We asked Colonel Wynn about this at a 1990 meeting and he answered:

> "Is there a possibility that there still might be a condition of waves that will get in the harbor? Ah, possibly yes, but we believe that this design is the best possible design given the restrictions that we were working with ..." (March 27, 1990).

The designer of the approved plan, Gary Wible of the Corps, made the same equivocation:

> "That plan resulted in a harbor plan that is not in my opinion the best protective harbor." (March 27, 1990.

These comments were made before the internal mole was suggested by Dr. Walker. Now it is clear that the only safe design is the internal mole.

Examination of the Moffat and Nichol study (Appendix A, p. 30 figure 4-1) shows the path of the big swells that come into Maalaea, and it is from S/E, from 160 - 180 degrees. Yet it then states: "analysis revealed that wave(s) approach from 185 - 215 degrees."

But this "analysis" is not given anywhere in this extensive document! Again in Appendix B (Belt Collins Study) prepared by John Clark at p.2, he says swells come from the south, but he gives no basis for this opinion.

The swells we surf at Maalaea may start as true south swells (180 degrees) from south of Tahiti, even from Antarctic storms. They may even come into Oahu (where John Clark surfs them) as true south (180 degree) swells. But as they approach Maui they must pass between the Big Island and Kahoolawe, and these two islands form a funnel which amplifies their size. These swells are also diffracted around the eastern side of Kahoolawe, and by Molokini, changing their direction as they head for Maalaea at 160 - 170 degrees.

John Clark states that the scope of his study includes interviewing local surfers. I spoke to him on the phone about this and he said the Corps had failed to provide him with a list of interested surfers on Maui who had participated in this long process, and that the Corps had not provided him with the memoranda on swell direction which we wrote and gave to the Corps at our 1990 meetings. He promised to call me when he came to Maui so that we could visit these sites together, but he failed to do so. He also ignored the published material in Surfer Magazine's famous 1985 picture article on Maalaea showing aerial photographs and a diagram of how swells come into Maalaea from 160 - 180 degrees.

At the December 10, 1992 meeting surfers noticed that the computer analysis of swells was limited to 185 - 215 degrees, and questioned the Corps about this. Mr. Lennan acknowledged that the study was incomplete, and was in the process of being expanded to include 185 - 160 degree swells. We believe that this study should have been completed <u>before</u> the Draft S.E.I.S. was published, before any alternative plan was "approved." It is impossible to analyze the safety of the "approved" plan without this data. The Corps had 25 years to complete this analysis and it failed to meet its own deadline, and still has not done so. If you haven't done your homework, you cannot know the facts and you cannot reach a reasonable conclusion. The Corps approach is reminiscent of the famous judge who stated "First we are going to give you a fair trial and then we are going to hang you."

The Corps' approach has been to reach a conclusion first, then study the data; to hire a consultant unfamiliar with local conditions and deprive this consultant of the information and informants who know the conditions; to make bold statements about Coast Guard cutters which have no basis in fact. This approach will not result in a safe harbor. Nor is it legally adequate. We are entitled to a fair and informed <u>process</u>, and we are not getting it. The State and the Corps are serving as both proponent of this plan, and as reviewer of this plan's adequacy. Their role as proponent has apparently overwhelmed their role as reviewer.

4. <u>Endangered Species</u>.

There is a serious omission in this Draft S.E.I.S. which must be corrected before it can become final. The biological opinion in Appendix A does not mention hawksbill turtles (Eretmochelys imbrecata). It discusses green sea turtles, but it does not mention hawksbill turtles. Nor does it analyze the effect of dynamiting a new channel and 620' seawall extension upon the known habitat and nesting site of the hawksbill turtle. It is noteworthy that a hawksbill turtle nested in the summer of 1991 at Maalaea Bay, and that the Corps plans to dynamite in the summer to avoid disturbing the humpback whales in the winter.

The hawksbill is one of the most endangered species in Hawaii. Dr. George Balazs informed me that only 15 females lay eggs each year, and that they do not nest elsewhere as does the green sea turtle at French Frigate Shoal. When I learned of this situation, I phoned Mr. William Paty of the State Department of Land and Natural Resources, and he told me that he would send a note to the Department of Transportation to be sure to include this information in the Draft S.E.I.S. Yet it was completely omitted.

Also omitted in this Draft S.E.I.S. is any analysis of the impact of increased traffic and pollution upon the rare sea shells of Maalaea. At a Coalition meeting with State and Corps officials, we provided magazine articles stating that Maalaea Bay was the most important home of rare sea shells in the entire state, and that pollution of their habitat was already having serious deleterious effects upon them in 1977, when traffic was much less than today. Yet none of this data has been incorporated in this Draft S.E.I.S. See Hawaiian Shell News, November 1977, p.3 and letter of W.Y. Thompson, chairman, BLNR in March 1978, p. 11.

5. <u>Failure to Consider Property Owners' Littoral Rights</u>.

The Draft S.E.I.S. fails to include the cost to the State of condemning real property owners' littoral rights. These owners and their lessees own property "to the sea" and "along the sea." Hawaii law requires compensation for the loss of this recognized property right. The Draft S.E.I.S. fails to provide any estimate of this cost as required by State and Federal law.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Jamie Hunter
569 Pi'iholo Road
Makawao, Maui, Hawaii 96768

Dear Mr. Hunter:

Thank you for your letter of comment dated January 14, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments:

a. The internal mole alternative (Alternative Plan 6) was eliminated from detailed consideration for a number of reasons. The principal reason was navigation safety. Section 3-5 of the FSEIS discusses this in detail:

(1) Based on the mix of sizes of vessels presently berthed in the harbor and those expected in an expanded harbor, only about 128 berths can be accommodated, not 165. Expansion of the harbor inland to accommodate the desired number of boats would require the State to buy the "Ma'alaea Triangle" property, with a present tax assessed value of over $10 million.

(2) The entrance channel would be open to southerly waves and would be subject to the same navigation problems as presently exist.

(3) The flushing characteristics of this alternative were the worst of those studied.

(4) The capability to berth the Coast Guard vessel is no longer considered one of the design criteria for this project. However, the design vessel is approximately the same size and therefore the proposed project design concept is based on that size.

b. The 1980 final EIS included a discussion of the wave attack at Ma'alaea Harbor, and indicated that a detailed, computer-aided refraction analysis was performed on waves for azimuths of 165, 170, 175 and 180 degrees north. In addition, the Corps' Waterways Experiment Station recently completed an analysis of waves from 135 to 270 degrees. Their report is contained in Appendix G. The alignment of the south breakwater extension was selected to provide protection of the harbor from all feasible wave angles.

c. The Biological Opinion of the National Marine Fisheries Service (NMFS) (Appendix A) discussed the effects of the harbor improvement project on humpback whales and green sea turtles. Later informal consultation with NMFS determined that the project would not affect hawksbill turtles or Hawaiian monk seals, and therefore formal consultation under Section 7 of the Endangered Species Act was not required.

d. There is no evidence that Ma'alaea Harbor has contributed to the decline of rare sea shells in Ma'alaea Bay, but the Hawaiian Shell News of November 1977 which you referenced speculates that the "blight" was caused by "sewage and waste water from the recent "bloom" of developments along the shore."

e. Littoral rights are addressed in the FSEIS in Section 4-14. The State of Hawaii was granted the littoral rights of the Maalaea Yacht Marina Condominium by deed dated October 29, 1958. The State of Hawaii claims all submerged lands and all lands seaward of the high tide line. In addition, Executive Order No. 02605 dated June 3, 1972 assigns the filled and underwater areas adjacent to the harbor to the Department of Transportation as an addition to Ma'alaea Harbor.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

Advisory
Council On
Historic
Preservation

The Old Post Office Building
1100 Pennsylvania Avenue, NW, #809
Washington, DC 20004

Reply to: 730 Simms Street, #401
Golden, Colorado 80401

January 14, 1993

Mr. Kisuk Cheung, P.E.
Director of Engineering
Department of the Army
U.S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858-5440

RE: Draft Supplemental Environmental Impact Statement for Maalaea Harbor

Dear Mr. Cheung:

Thank you for providing us with the opportunity to review the Draft Supplemental Environmental Impact Statement (DSEIS) for Maalaea Harbor. We were disappointed not to find a copy of the 1979 archaeological study that was conducted in the harbor included among the documents in the DSEIS. As a result, it is not possible for us to evaluate the adequacy of attempts to identify historic properties within the area of potential effect. Although the SHPO did concur with the Army's finding of no effect for this project, the archaeological study was conducted more than a decade ago and may not meet current standards for such studies.

In a letter dated November 2, 1990 to Mr. Bill Lennan of the U.S. Army Engineer District, Council expressed concern about offshore and underwater archaeological sites that may exist in the Maalaea Harbor area and that may be eligible for listing on the National Register of Historic Places. We were also concerned about the potential for Hawaiian traditional cultural properties in the area. Although telephone conversations in 1990 indicated that the Army planned to conduct additional underwater surveys for submerged properties, the DSEIS does not indicate that this measure has been taken. We also find no evidence that Hawaiian cultural groups were consulted about the possibility of traditional cultural properties in the area.

We request a copy of the archaeological study for the Maalaea Harbor area for our review. If this study did not include an underwater survey, we suggest that such a study be implemented. We also recommend that Hawaiian cultural groups be consulted concerning the presence of traditional cultural properties in the Maalaea Harbor area.

Thank you again for providing us with the opportunity to review this document. We look forward to consulting with you further concerning the Maalaea Harbor Project. If you have questions concerning this letter, please contact Catherine Cameron of our staff at (303) 922-6127.

Sincerely,

Claudia Nissley
Director, Western Office
of Review

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Claudia Nissley, Director
Western Office of Review
Advisory Council on Historic Preservation
730 Simms Street, #401
Golden, Colorado 80401

Dear Ms. Nissley:

Thank you for your letter of comment dated January 14, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments.

a. The 1979 Cultural History Overview study was included in the original final Environmental Impact Statement for the project, which was made a part of the draft SEIS by reference. Based on your comments and the recommendation of the SHPO the study has been included in Appendix H. Although this study is 15 years old, SHPO evaluation agrees that the initial assessment and recommendations are appropriate and relevant and further study is not warranted.

b. Although the Army had originally considered underwater survey of the proposed project area, further review indicated there was little likelihood of submerged historic properties in the area of potential effect. It was therefore decided to eliminate the underwater survey from consideration. If you are aware of any evidence which might indicate the existence of submerged historic properties at the project site, we will reconsider our decision.

c. The draft SEIS was reviewed by the State of Hawaii Office of Hawaiian Affairs without comment. As stated in the draft and final SEIS, the area was used as a launching site for canoes carrying the bones of ancestors for burial beyond the reef far offshore. Although native Hawaiians have attended all the public meetings and many of the workshops for this project, the only traditional cultural significance identified was as a canoe launching site. The informant for this information was Mr. Charles Maxwell Jr., a well known and very knowledgeable native Hawaiian from Maui. He is the Hawaii Governor's representative on the Presidents Commission on Native Americans and the Chairman for the Hawaiian subcommittee of that Commission.

Sincerely,

Ray H. Jyo, P.E. for
Director of Engineering

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

25 JAN 1993
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JAN 15 1993

Lieutenant Colonel James T. Muratsuchi
District Engineer
Honolulu District
U.S. Army Corps of Engineers
ATTN: CEPOD-ED-PV/Lennon
Building T-1
Fort Shafter, HI 96825-5440

Dear Lt. Colonel Muratsuchi:

The Environmental Protection Agency (EPA) has reviewed the Draft Supplemental Environmental Impact Statement (SDEIS) for the project entitled Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii. Our review is provided pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508) and Section 309 of the Clean Air Act.

The Army Corps of Engineers (Corps) in partnership with the State of Hawaii propose to construct improvements to the existing Maalaea Harbor for light-draft vessels at Maalaea, Maui, Hawaii. The Federal portion of the improvements consists of realigning the entrance channel and modifying the existing breakwater to protect the new channel. The local sponsor will provide expanded berthing facilities and improved infrastructure. Berth capacity will be expanded from 100 to 220 berths accommodating 30% commercial and 70% recreational craft. The primary objective of the project is to reduce the surge within the harbor in order to allow expansion of berthing facilities. The no action alternative and four alternative entrance channel and breakwater alignments are evaluated. Alternative 1 is the National Economic Development (NED) plan because it would maximize net economic benefits by utilizing all the dredged material for fill. Approximately 44,000 cubic yards of material would be dredged from the harbor basin, berthing areas and new entrance channel. A FEIS was prepared, circulated and approved by the Corps in 1980. The project remained unfunded until Fiscal Year 1989. The 1980 plan of improvement is a modification of the plan originally approved by Congress in 1968.

The SDEIS does not contain sufficient information to fully assess environmental impacts that should be avoided in order to fully protect the environment. EPA is gravely concerned with the lack of detailed information on existing conditions (e.g., water quality and aquatic resources inside the harbor) and environmental consequences (e.g., impacts of the fill, cumulative impacts). Furthermore, it is very difficult to determine whether the SDEIS fully evaluates the potential impacts on all environmental resources from both the Federal and local sponsor actions. We recognize that some detailed information is available in the attachments. Nevertheless, the lack of proper referencing or more detailed summarization of these appendices in the main body of the SDEIS hinders adequate review and assessment of environmental impacts.

EPA is further concerned with the limited alternatives analysis, water quality evaluation, mitigation proposals, and cumulative impact analysis. Because of the above concerns, EPA has classified this SDEIS as category EC-2, Environmental Concerns - Insufficient Information (see attached "Summary of the EPA Rating System"). Our detailed comments are enclosed.

We appreciate the opportunity to review this SDEIS. Please send three copies of the SFEIS to this office at the same time it is officially filed with our Washington, D.C. office. If you have any questions, please call Jacqueline Wyland, Chief, Office of Federal Activities, (415) 744-1584, or Laura Fujii, of her staff, at (415) 744-1579.

Sincerely,

Deanna M. Wieman

Deanna Wieman, Director
Office of External Affairs

Enclosures: EPA Comments, 6 pages

92-422
HI001767
filename: maalaead.eis

cc: USFWS, Pacific Islands Office, Robert Smith, Honolulu
NMFS, Pacific Area Office, John Naughton, Honolulu
HI DOH, Clean Water Br., Edward Chen, Honolulu
HI DOT, Rex D. Johnson, Honolulu

COMMENTS

National Environmental Policy Act Comments

Alternatives Analysis

We understand that the primary objective of the proposed project is to increase berth capacity by reducing the navigational hazards (e.g., surge) in the harbor. Furthermore, berth capacity benefits are necessary to make the project feasible (telephone conversation 1/6/93, Bill Lennon, Corps). Given the project purpose to increase berth capacity for light-draft vessels in Maui, EPA believes the Corps fails to rigorously explore and objectively evaluate all reasonable alternatives as required by NEPA (40 CFR §1502.14(a)). There is no evidence of consideration of alternative locations for increasing berth capacity (e.g., expanding other existing harbors or developing new harbors). In addition, alternatives recommended by Moffat and Nichol (subcontractor for the Corps) to avoid surf site impacts were not evaluated. Nor is there a discussion of alternatives which were eliminated from detailed study and the reasons for their elimination.

Pursuant to NEPA, the FSEIS should address the feasibility of alternate locations for increasing berth capacity and other reasonable alternatives not within the jurisdiction of the lead agency (40 CFR §1502.14(a) & (c)). It is critical the document fully discuss justifiable reasons for eliminating alternatives from further consideration (e.g., financial infeasibility, land use conflicts, significant environmental impacts).

Affected Environment

The FSEIS should provide sufficient information on the following existing conditions to permit an understanding of the potential effects of the proposed project and alternatives:

- water quality and aquatic resources inside the harbor,
- characteristics of the fill area (e.g., bottom type),
- harbor configuration (e.g., bulkhead, seawall, berth locations), and
- traffic patterns, road capacity, and transportation improvement plans.

Environmental Consequences Analysis

EPA is very concerned with the limited evaluation of environmental consequences. For instance, the potential impacts of placing fill for revetted moles and new breakwaters does not

appear to be addressed. Other areas of insufficient information are:

- local air quality impacts from increased traffic (e.g., local carbon monoxide impacts),
- impacts to the existing coral shoal inside the harbor,
- impacts to nearby algae beds and edible algae from dredging activity and increased turbidity,
- recreational impacts (e.g., fishing, boating restrictions during construction), and
- impacts on sand replenishment and longshore transport (littoral movement).

Furthermore, there appears to be no discussion of potential cumulative impacts except for effects to endangered and threatened species.

The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences (40 CFR§1500.1(c)). The lack of sufficient information in the SDEIS makes this intent difficult to achieve. The FSEIS must fully address all potential effects of the proposed action. We urge the Corps to carefully consider all potential impacts of the project and to remedy the current deficiencies in the SDEIS.

Mitigation

The only mitigation measures described in the SDEIS address potential impacts to the humpback whale and green turtle (pg.26). NEPA requires inclusion of appropriate mitigation measures not already included in the proposed action or alternatives (40 CFR §1502.14(F)). The FSEIS should include a full discussion of mitigation measures for potential impacts, including temporary and cumulative impacts. We recommend the Corps include a separate section in the FSEIS which lists potential mitigation measures, mitigation measures which will be implemented, implementation schedules, and the parties responsible for implementation. Include an evaluation of the effectiveness and feasibility of each mitigation measure. For instance, describe the standard Corps mitigation measures to protect humpback whales and turtles mentioned on page 26. We suggest the Corps and local sponsor consider mitigation measures such as dust control (e.g., road watering, wheel washracks), construction scheduling, and construction traffic scheduling, to reduce temporary air quality and noise impacts.

Water Quality Comments

The discussion of existing water quality inside Maalaea Harbor should be expanded to describe existing circulation and flushing characteristics, compliance with water quality standards, maintenance dredging, storm drain locations and potential contamination from these storm drains, spill history (e.g., waste oil released from boats), storm drain sediment loads, contamination from released bilge water or sewage from boats, and trash problems. Define the water quality class designations cited in the text. We understand support facilities such as sewage and waste oil disposal facilities are lacking. The absence of such facilities may increase the risk of chronic contamination of the harbor from waste oil and sewage disposal. The FSEIS should indicate whether such contamination is a problem.

The FSEIS should address the potential impacts of the proposed reconfiguration of the inner harbor. For instance, discuss the potential effects of the internal revetted mole (island) on harbor circulation, flushing, and sediment accumulation patterns. In addition, the FSEIS should evaluate potential cumulative effects of maintenance dredging and increased number of boats on harbor water quality.

Section 404

Approximately 2.6 acres of relatively productive vegetative shallows and coral reef habitat will be destroyed (via dredging) by selection and construction of any of the proposed alternatives. In addition, the National Marine Fisheries Service (NMFS) has identified potential impacts to the endangered humpback whale and green turtle.

Assuming the SDEIS represents a full range of project alternatives, compliance with the 404(b)(1) Guidelines can be met through 1) minimization of adverse impacts and 2) compensatory mitigation for unavoidable adverse impacts. The FSEIS should provide additional information to demonstrate adverse impacts have been minimized. For instance, provide data to support the assumption that dredged and fill material is not contaminated as stated in Appendix A, 404(b)(1) Guidelines Analysis.

To offset unavoidable impacts to the special aquatic sites involved, the FSEIS should include precautions during construction and compensatory mitigation for the direct loss of 2.6 acres functional coral reef flat. Although it may be true that the breakwater will provide new habitat, this alone will not compensate for all the lost functions and values of the destroyed

biological community (see US Fish & Wildlife Service letter dated April 21, 1992, Appendix A).

The Corps and local sponsor should commit to all reasonable and prudent measures to minimize impacts of construction activities and use of the expanded harbor on endangered species as listed in the NMFS Biological Opinion dated July 23, 1990 (Appendix A) and the Pacific Whale Foundation Report of Humpback Whale Use of Maalaea Bay (Appendix B). We also recommend a harbor education program to advise the public of appropriate endangered species interactions. EPA supports the NMFS recommendation that vessel traffic be consolidated and use of existing state designated mooring areas be the focus for future development (NMFS Biological Opinion, Appendix A).

Air Quality/Traffic Comments

The FSEIS should provide additional information on the existing conditions and potential impacts to traffic and local air quality. We recommend that the specific information provided in the Traffic Study, Appendix D, either be moved into the main report or summarized in more detail. For example, the existing level of service (LOS) for Honoapilani Highway and harbor access roads should be described. Indicate whether road capacity is currently a problem and whether there are road improvement projects planned. Potential air quality and cumulative impacts should be addressed in more detail. Include an estimate of the number of cars and boats expected and the potential increase in air emissions (e.g., CO, particulate matter less than 10 microns (PM10)). Mitigation measures to address potential impacts should be evaluated in the FSEIS.

General Comments

1. We recommend that the FSEIS not be completed prior to the completion of US Fish and Wildlife Coordination Act consultation. Include the final Coordination Act Report in the FSEIS.

2. When references to previous documents are used, the FSEIS should provide a summary of critical issues, assumptions and decisions complete enough to stand alone without depending upon continued referencing of other documents. Since the FEIS was completed in 1980, providing a detailed summary of this previous documentation is especially critical.

3. Include in the FSEIS the estimated length of the construction period for both the Federal and State portions of the project.

4. The FSEIS should address conformance with the Ocean Resources Management Plan.

SUMMARY OF RATING DEFINITIONS
AND FOLLOW-UP ACTION*

Environmental Impact of the Action

LO--Lack of Objections
The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC--Environmental Concerns
The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

EO--Environmental Objections
The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alterna tive or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU--Environmentally Unsatisfactory
The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the CEQ.

Adequacy of the Impact Statement

Category 1--Adequate
EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2--Insufficient Information
The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS.

Category 3--Inadequate
EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

*From EPA Manual 1640 Policy and Procedures for the Review of Federal Actions Impacting the Environment.

Figure 4-1

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Deanna Wieman, Director
Office of External Affairs
United States Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, California 94105

Dear Ms. Wieman:

Thank you for your letter of comment dated January 15, 1993, on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-Draft Vessels, Maui, Hawaii. Your comments were considered during the selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments.

a. Alternative Analysis

(1) The Alternatives chapter has been revised to provide a discussion of previous studies done in the early 1980's, a discussion of the alternative development and evaluation process, and a discussion of the alternatives eliminated from further consideration and the reasons for their elimination.

(2) The SEIS also provides a clearer discussion of the purpose of the project, which is to reduce surge in the harbor and to eliminate navigation hazards in the entrance channel. These improvements would allow the increase of berthing capacity, which is a third purpose identified, but would also improve navigation safety and reduce property damage caused by the existing surge problems. One of the reasons for not considering alternative harbor locations, either existing or new, is because these types of alternatives do not meet the identified purpose, which is to reduce surge in Ma'alaea Harbor and eliminate navigation hazards in its entrance channel. In addition, the creation of new harbors is opposed for significant environmental reasons, and conflicts with Federal and State policies.

(3) We have discussed the alternatives recommended by Moffatt and Nichol to avoid surf site impacts in section 3.5. The preferred alternative has been modified to avoid surf sites to the extent possible.

b. Affected Environment

(1) This chapter has been revised to incorporate available information on water quality and aquatic resources. State water

quality sampling data for the harbor were incorporated, as well as information from the State's current water quality report. In addition, the results of surveys and other descriptions of aquatic resources provided by the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Pacific Whale Foundation, and other scientific sources have been added. The studies contained in the appendices have been summarized and included in the Affected Environment chapter.

(2) We have also included descriptions of the fill area, harbor configuration, and traffic information as summarized from the appendix which contains the Traffic Impact Study.

c. Environmental Consequences Analysis

(1) This chapter has been expanded to include evaluations of potential project effects upon all resources and as described in the appendices. This includes a description of the effects of dredging and filling on water quality and on the marine environment and on recreation. Local air quality impacts are discussed but were not quantified because existing ambient levels are so far below standards and because of the clearing effects of strong winds.

(2) The cumulative effects of the project are basically the same as those direct and indirect impacts that would be expected with the proposed action.

d. Mitigation: We have expanded the discussion of the steps that have been taken to avoid and minimize adverse effects and those that have been recommended to mitigate for other effects. These are listed separately at the end of the Environmental Consequences chapter.

e. Water Quality Comments

(1) All available data concerning the water quality in Ma'alaea Harbor has been incorporated into the SEIS. This includes water quality sampling provided by the State Department of Health as well as information contained in the State's most recent 305 report. It is believed that the major cause of water quality problems in the harbor is related to the discharge of runoff from three storm water drains that empty into the harbor. Overflow from overloaded cesspools may also contribute to the problem. The effects of the elevated turbidity and other parameters are not related to the proposed action and will occur with or without the project. The State's proposed harbor improvements include foremost an upgrade of the sewage treatment system, which will alleviate any pollution problems resulting from the existing system.

(2) We have also included the results of flushing studies

and have identified potential changes in harbor circulation and sediment accumulation patterns.

f. Section 404: A discussion has been added that describes the steps taken to avoid impacts where possible, and then to minimize those that cannot be avoided. For example, slight design modifications to the south breakwater have been made in order to minimize the effects to the surf site known as "Buzz's No. 2," a popular surfing area. We have also listed recommended mitigation measures which will be considered by decision makers, including mitigation for loss of coral reef.

g. Air Quality/Traffic Comments: The sections on air quality and traffic have been expanded to include the results of the State's air quality monitoring efforts and the results of an updated traffic impact study.

h. General Comments

(1) The final Fish and Wildlife Coordination Act report is not yet available and cannot be included in the final SEIS.

(2) The SEIS now includes summaries and important points from referenced documents, as well as a background of previous studies and conclusions.

(3) We have included an estimate of the length of the construction periods for both the Federal and State portions of the proposed projects. The Federal portion of the project is expected to take a little over 2 years, and the State's portions are scheduled to take 10 years to complete all of the planned improvements.

(4) Conformance with the Ocean Resources Management Plan is addressed in the section on Threatened and Endangered Species.

Sincerely,

James A. Nakamura

Ray H. Jyo, P.E. for
Director of Engineering

Association Of Apartment Owners Of
Maalaea Yacht Marina RR-1 BOX 377 WAILUKU, HAWAII 96793-9502 (808) 242-5997

20 JAN 1993
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DHED 13/20
SECY
CLK-TYP

January 15, 1993

James T. Muratsuchi
Lt. Col. U. S. Army
District Engineer
U.S Army Engineer District Honolulu
Building 230, Fort Shafter
Honolulu, HI 96858-5440

Dear Sir:

I am writing to you on behalf of the Association of Apartment Owners (A.O.A.O.) and the rental tenants of Maalaea Yacht Marina.

At a meeting last night (1/11/93) of the Save Maalaea Coalition, I had an opportunity to see the proposed plans for the harbor expansion. I noted with some dismay that on none of the proposed plans, were there any mention of drawings of the 3 condominiums which will be most affected by the construction of a road and boating facilities right outside our windows. Anybody who is not familiar with the area would conclude by looking at these plans that there are no buildings or people living in the immediate area of proposed expansion. This is contrary to the truth; there are 3 condominiums (Mermaid, Maalaea Yacht Marina and Milowai) which will be adversely affected by the effects of this expansion.

It would seem that nobody has taken into consideration how a road and parking lot and berths as in Proposal 5, would impact the lives of the people who live directly next to these "improvements."

First, obviously, is the health and safety of people living in the 3 condos. We will have to breath in fumes from all these extra cars and diesel engine buses and boats coming and going at all hours of the night and day, disrupting our lifestyles. The clean air and quiet is why we bought our apartments in these buildings in the first place.

There is also a problem of safety related to the vast increase in traffic in the area, which has not been addressed satisfactorily. People living in these buildings, along with the children, who are used to just walking on the beach and breakwater wall, now will have to dodge traffic and walk through parking lots.

Secondly, the proposed plan will also have a negative effect on our property values--nobody will want to buy an apartment in a building overlooking a parking lot, and with the air and noise

Association Of Apartment Owners Of
Maalaea Yacht Marina RR-1 BOX 377 WAILUKU, HAWAII 96793-9502 (808) 242-5997

pollution, and it will be vastly more difficult to sell or rent apartments in the buildings. In Maalaea Yacht Marina, all of our off-island owners are dependent on rentals in order to pay their mortgages. If nobody wants to rent in this building because of the expansion, these people will have a financial crisis, and may very well lose their property.

Third, it is not clear to me that the State has the right to build a road across the front of our property. According to the Survey of March 3, 1976, our property line extends to the shoreline. See attached copy of survey. We feel at this point that we should consult with a lawyer to find out where we stand on this, and if necessary to file a lawsuit against the State of Hawaii to stop them from encroaching on our property.

Fourth, we are also concerned about the effect of the blasting, which will obviously be necessary to widen and deepen the harbor, on the integrity of our buildings, not to mention the effect on the sea turtles which live just outside the harbor and the Humpback whales. I've also heard there is a colony of Hawksbill turtles which are very rare, almost to the point of being extinct, which now live in Maalaea Bay, and as far as I know, no impact study has been done on them to determine any adverse effects on their breeding and living in the area.

Lastly, I am enclosing an article from the January/February 1993 edition of Maui, Inc., regarding the Hawaiian Islands Humpback Whale National Marine Sanctuary Bill signed by President Bush on November 4, 1992. As the E.I.S. was signed by you on November 2, 1992, I'm sure that any provisions of this bill were not taken into consideration when the E.I.S. was being compiled.

Sincerely,

Brian Henderson
President, Maalaea Yacht Marina A.O.A.O.

EXHIBIT "A"

All of that certain parcel of land (portion of the land described in and covered by Royal Patent Grant Number 3152 to Henry Cornwell) situate, lying and being on the southerly side of Hauoli Street at Waikapu, District of Wailuku, Island and County of Maui, State of Hawaii, being LOT NUMBER FOUR-A (4-A) of the "MAALAEA BEACH LOTS", same being all of Lots Numbers 3 and 4 of the Maalaea Beach Lots Subdivision, and thus bounded and described, as per survey of Albert S. Saiki, Registered Professional Surveyor, dated March 3, 1976, to-wit:

Beginning at a pipe at the northwest corner of this lot, being also the northeast corner of Lot 2, Maalaea Beach Lots, the coordinates of which referred to Government Survey Triangulation Station "PUU HELE" being 6,980.50 feet South and 1,705.19 feet West and running by azimuths measured clockwise from true South:

				Along the southerly side of Hauoli Street on a curve to the left with a radius of 620.00 feet, the chord azimuth and distance being:
1.	255°	59'	01"	252.65 feet to a pipe;
2.	23°	41'		94.35 feet along Lot 5, Maalaea Beach Lots, along the center of the drainage ditch;
3.	9°	11'		212.84 feet along Lot 5, Maalaea Beach Lots, along the center of the drainage ditch to a pipe;
4.	113°	16'	10"	14.28 feet along the seashore;
5.	91°	10'		30.00 feet along the seashore;
6.	101°	45'		19.00 feet along the seashore line;
7.	86°	30'		9.00 feet along the seashore line;
8.	68°	30'		7.16 feet along the seashore line;
9.	91°	10'		11.41 feet along the seashore;
10.	81°	07'		103.12 feet along the seashore;
11.	72°	11'		35.00 feet along the seashore;
12.	191°	15'	20"	259.76 feet along Lot 2, Maalaea Beach Lots to the point of beginning and containing an area of 55,250 square feet, more or less.

SUBJECT, HOWEVER, to the following:

1. Reservation in favor of the State of Hawaii of all mineral and metallic mines.

2. Location of the seaward boundary in accordance with the law of the State of Hawaii, and shoreline setback line in accordance with County regulation and/or ordinance.

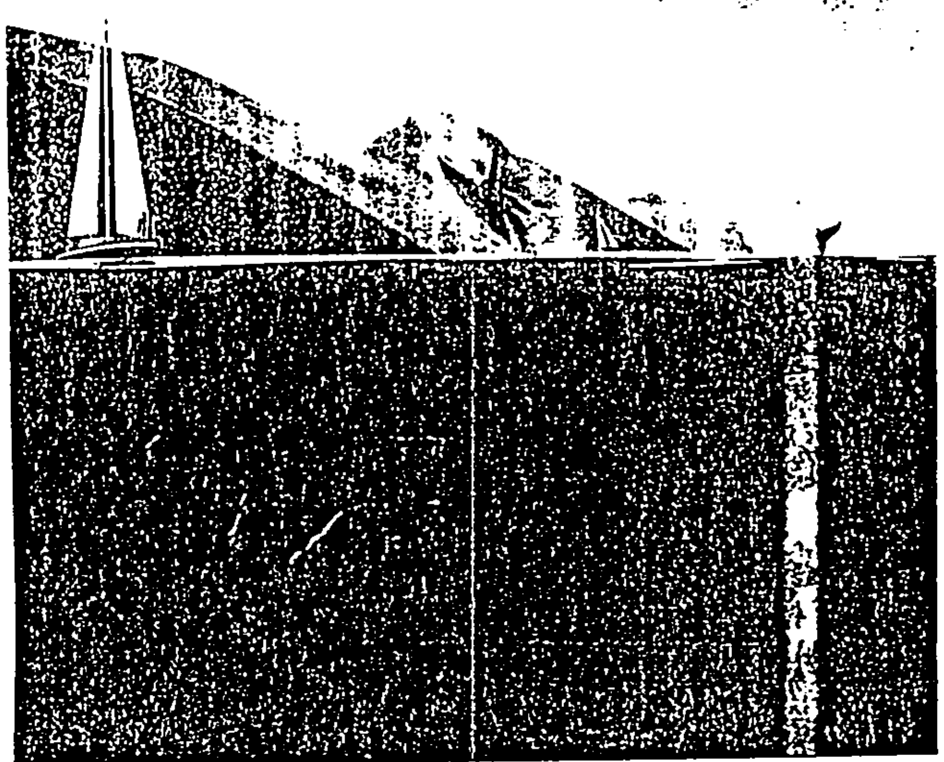
3. A perpetual easement 20 feet in width in favor of the County of Maui for ingress and egress to and along existing natural drainage ditch and 10 feet on each side of the common boundary between Lots 4 and 5, as shown on Map entitled "Maalaea Beach Lots", dated March 15, 1951 and on file in the Office of East Maui Irrigation Company, Limited.

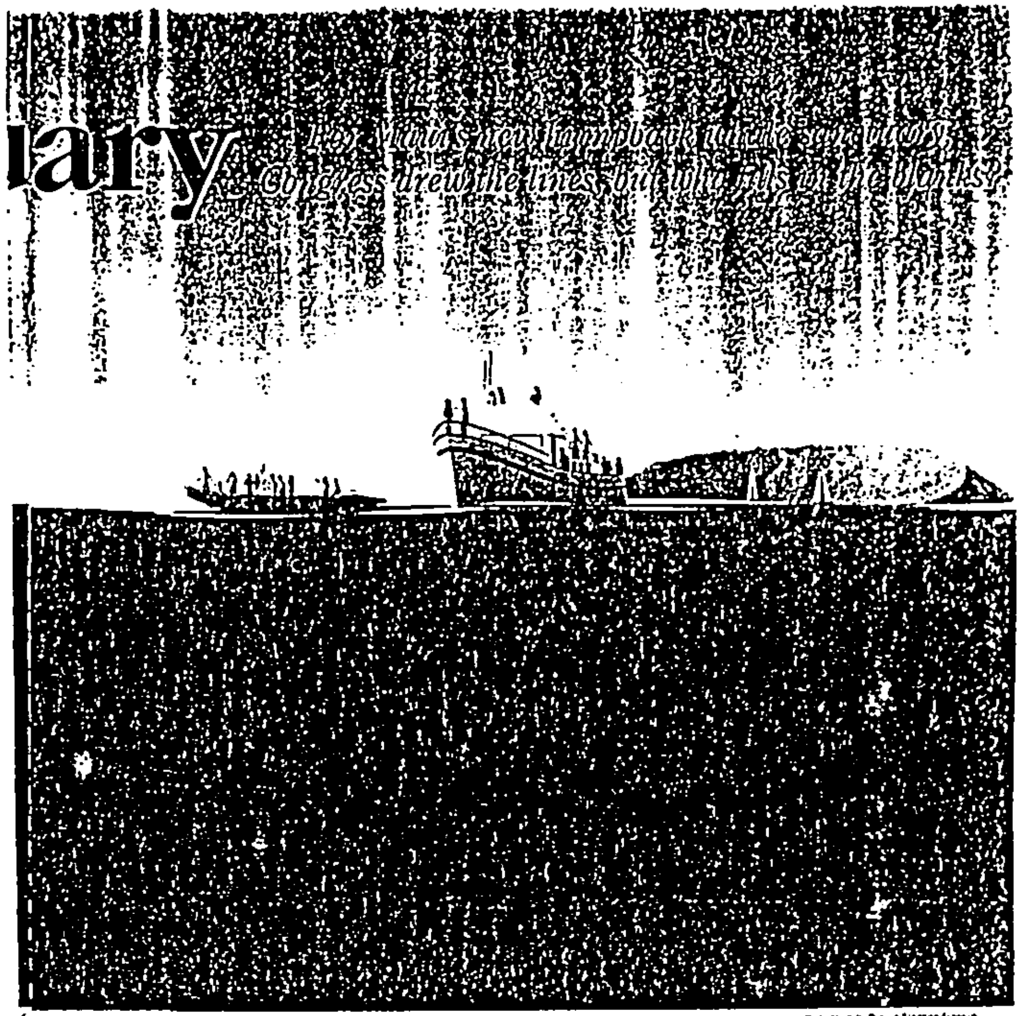
4. A grant of littoral rights in favor of the State of Hawaii, its successors, assigns, licensees and permittees, appurtenant to the lands described as Parcel D of Maalaea Bay Front (Lot 3, Maalaea Beach Lots) and Parcel E of Maalaea Bay Front (Lot 4, Maalaea Beach Lots), by Deed of Maui Fisheries & Marine Products, Ltd., dated October 29, 1958, recorded in the Bureau of Conveyances of the State of Hawaii in Liber 3515 on Page 425.

5. Grant in favor of Maui Electric Company, Limited, a Hawaii corporation, dated February 28, 1979, and recorded in Liber 13555 on Page 734; granting an easement (10.00 feet wide) for electrical purposes over, under, upon, across and through said Lot 4-A.

END OF EXHIBIT "A"

Seeking Sanctuary





Troubled waters — *The ocean covers two thirds of our planet. But humpback whales and humans prefer the narrow coastline around the islands of Hawaii. Will a marine sanctuary keep the peace?*

By Paul Forestell, Ph.D

On November 4, 1992, President George Bush signed a bill creating the Hawaiian Islands Humpback Whale National Marine Sanctuary.

Virtually all Maui County waters are included in the sanctuary, but most of Maui's residents have never even heard of it.

The sanctuary includes all waters out to the 100 fathom contour between Maui, Lanai and Molokai, over Penguin Bank, off the northwestern end of Molokai, and in the waters adjoining Kilauea National Wildlife Refuge on the north end of Kauai.

The legislation authorizing the sanctuary was shepherded through the House of Representatives by Congressman Abercrombie, and through the Senate by Senator Daniel Inouye.

The questions now: what exactly does this act accomplish? And perhaps more interesting, how will Hawaii's environmental community and ocean-related industries react?

Interestingly, although the island of Kahoolawe will initially be excluded, the "Hawaiian Islands National Marine Sanctuary Act" is the result of a feasibility study on declaring the waters adjacent to that island as a sanctuary.

According to the feasibility study, made public by the National Oceanic and Atmospheric Administration's Sanctuaries and Reserves Division in 1991, there was not enough information available to determine whether there should be a sanctuary around Kahoolawe.

At the same time, however, the report noted that additional areas within the Hawaiian Islands did warrant consideration as components of a multiple site, multiple species sanctuary, and that such a sanctuary could enhance marine resource protection in Hawaii.

From the beginning there has been a major difference in opinion as to what should be included in the sanctuary.

The Sanctuaries and Reserves Division of the National Oceanic and Atmospheric Administration (NOAA) has stated that, "any marine protection mechanism developed by the National Marine Sanctuary Program would include the humpback whale as one

C...ter of the s...ctuary — *Four boats to Molokini islet must pass through whales' breeding grounds. Kahoolawe in distance.*

Sanctuary Defined

Webster's defines sanctuary as, *"A place of refuge or protection."* Easy enough to understand and it fits for nearly any kind of sanctuary. However, when it comes to *marine* sanctuaries, there are as many definitions as there are sites.

To date NOAA (National Oceanic & Atmospheric Administration) has established 9 National Marine Sanctuaries and at least 7 more are under active consideration. Four are off the coast of California, two in Florida, one each off Georgia and North Carolina and one in American Samoa.

The sanctua...s cover several marine ecosystem types, from near shore coral reefs to deep ocean seamounts, and include a wide range of sea life, much of it endangered.

The management plans for each sanctuary are based on its location, its specific resources, the user groups affected and the perceived threats to its resources

The management plans include provisions for encouraging public use in some and prohibiting in others. All sites prohibit discharging substances. M...t also prohibit altering the seabed, removing or damaging natural features, or disturbing endangered species

Sanctuaries also contain valuable aesthetic or harvestable resources, and include spots for diving, sportfishing and variety of commercial enterprises. Some permit traditional fishing practices, recreational diving or sportfishing or sustainable harvest of marine l... In all sanctuaries research and education programs are encouraged.

The exact range of prohibited and allowed activities in Hawaii's marine sanctuary are yet to be defined. Theoretically that will be the focus of the public meeting process scheduled for the next 18 months

component of a comprehensive, habitat based management approach to marine resource protection

The state of Hawaii, through the office of State Planning, has made it just as clear that it favors a single species sanctuary, but is opposed to a sanctuary that includes multiple sites or resources.

On the face of it, the gap between the state and federal agencies appears impossibly wide.

However, discussions with officials at both levels make it clear that what is at issue is mechanism, not goal.

Harold Matsumoto, director of the office of State Planning, has been appointed by Governor Waihee to develop the state's position on such a sanctuary.

He views the issue of single-species versus multiple resource sanctuary as using different means to achieve the same goal.

According to Matsumoto, "The state does indeed favor the consideration of non-humpback resources as potential marine sanctuary candidates.

"But," he adds, "mixing objectives and resources to be managed within a single sanctuary proposal will not only be confusing to the public but would extend the implementation process because of its complexity."

Matsumoto also feels that it would be inappropriate to designate the resources without scientific evidence and appropriate baseline studies equivalent to that already available for humpback whales.

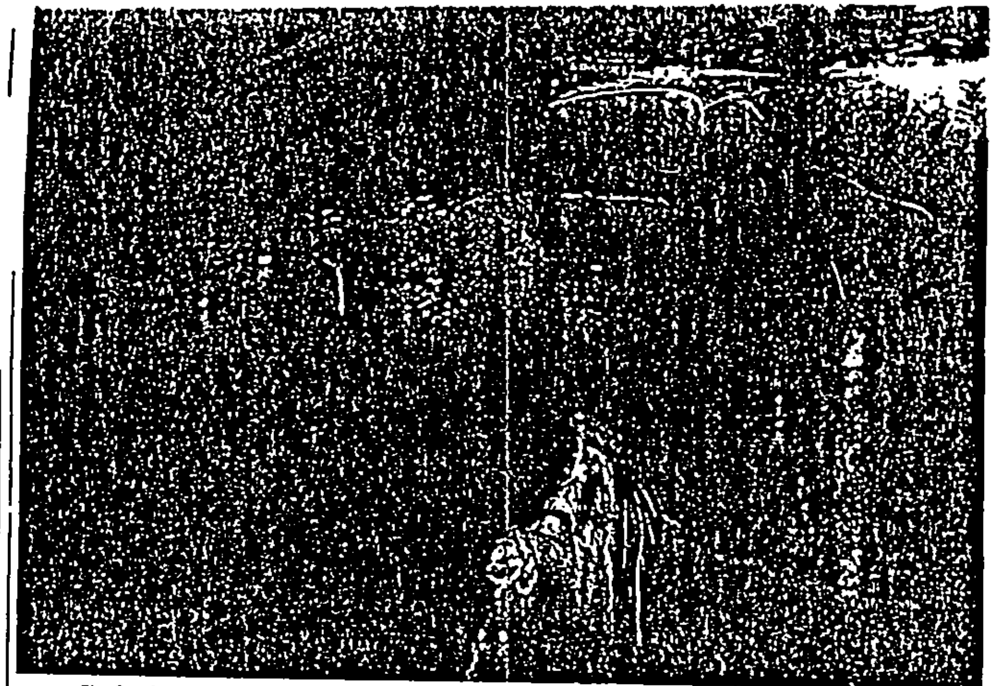
While the state continues to stand by its position favoring a single species sanctuary, it recognizes the need expressed by federal officials to enhance protection of Hawaii's marine resources. But the state wants to consider the issue on a case-by-case basis, thereby increasing the chances for public input and acceptance.

"We need to start with something that's generally acceptable to everybody," says Dick Poirier of the planning office, "then we can add to it as appropriate."

NOAA's Sanctuaries and Reserves Division faces a major dilemma in dealing with the state initiative to create a humpback whale sanctuary.

The division was hoping for legislation that would provide more emphasis on multiple resource protection.

"We don't really have any problem with the geographical boundaries," ex-



The Gentlest Giants — *Mother humpback guards her newborn calf.*

plains Steve Olson, a program specialist with NOAA's Sanctuaries Office.

"But it's no secret we would have liked to see additional resources included.

We recognize the need to start with something that would be agreeable to the state, yet allow the Sanctuary Office to eventually get other resources included."

On another front, support for a multiple resource designation has been expressed by some environmental groups. The Center for Marine Conservation, located in Washington, has lobbied for the development of marine sanctuaries over the past 15 years. Staff member Katie Patterson has indicated that the center prefers the multiple resource designation.

Greg Kaufman, president of the Maui based Pacific Whale Foundation also notes the importance a broader sanctuary designation.

"We appreciate the state's concern about simplifying the designation process," Kaufman says, "but if we are going to have to settle for a single-species sanctuary as the first step, we'd like to see a pretty definite plan of action laying out how future modifications can be made. Otherwise we're really just dealing with a sanctuary in name, with minimal substance."

" I'm concerned about the false impression that the humpback whales...are being harassed and driven away."

For some, the creation of a humpback whale sanctuary raises a more fundamental question: what perception of the whales are we legitimizing in declaring sanctuary status?

Dave Jung is the owner of Maui Cruise Company, and has operated charter vessels in Hawaii for over 20 years. Each winter of the past 12 years he has run daily whale watch excursions out of Lahaina.

Six years ago he founded a non profit group called Whale Aid of Hawaii.

A portion of his proceeds is disbursed, through Whale Aid, to researchers conducting scientific study of humpback whales throughout the islands. Recent recipients include Joe Mobley, a professor at the University of Hawaii, and Sal Cerchio, a graduate student from Moss Landing Marine Laboratory in California.

"I'm concerned about the false impression that the humpback whales that come to Hawaii each winter are being harassed and driven away," says Jung, "and that we need a sanctuary to keep them from being wiped out. In fact, the number of whales in Hawaii has been increasing over the past 15 years. I don't want to see a sanctuary developed on the basis of false assumptions that will create more and more restrictive levels of enforcement."

Jung's concerns over the developing view that Hawaii's whales are decreasing and require increased regulations are well founded and not restricted to Hawaii.

A recent article in a newspaper from Queensland, Australia, for example, notes that "humpback whale numbers off Maui, Hawaii have decreased alarmingly in the past few years as a result of uncontrolled whale watching, jet skiing and parasailing."

Even Hawaii Congressman Neil Abercrombie, speaking in the U.S. Congress in favor of the sanctuary, lamented the "continued decline in humpback whale numbers."

However, despite these well intentioned fears, scientific data indicate that humpback whale numbers have increased since 1976 in every area of the world in which they have been studied.

Efforts to justify a sanctuary based on an insistence that humpbacks will not survive without it create two concerns.

One is the implicit accusation that user groups– commercial fishing, whale watching, recreational boaters– are driving the whales away, showing no concern for their long term survival.

"We've been among the whales biggest champions," argues Jim Coon, president of Maui Commercial Boat Owners Association (McBoat).

"We have supported whale watching guidelines, provide funding for ongoing research, and educate our passengers about the whales and their marine environment. Hawaii already has some of the strictest whale watching regulations in the country, and to claim the whales are not recovering under the present conditions is downright irresponsible."

A second concern is that a sanctuary justified by a perception that current protection efforts aren't working may lead to further regulations, which will reduce everyone's access to the state's near shore waters.

Charlie Maxwell is a native Hawaiian, and has been a Hawaiian rights advocate for nearly a quarter of a century. Now Charlie has his own radio program, and tries constantly to put the issues of Maui in a balanced perspective.

Maxwell is concerned that a humpback whale sanctuary will do little to protect whales, but lead to increased regulations that will interfere with na-

Continued on page 30 ▸

m's oceans with a single step.

But whether these suggested steps are followed, or another agenda entirely is developed, I believe strongly that in order to be legitimate the components of Maui's equation must be these: Environment/Economy • Culture/Open Space.

The question is, can we make them add up to a solution? Because there is far more at stake here for Maui than just the potential for more visitors from a new market segment.

If we can make the equation work, I believe we may have found a vehicle for balancing the needs of Environment and Economy for Maui's long term future. If we can't, then it may send a chilling signal about prospects for that future.

The time has come to find out.

WHALES

Continued from page 21

tive Hawaiian uses of the ocean.

"We need a program based on research and education, not regulation and restriction. If people could see and learn from how native Hawaiians used the ocean, we wouldn't need all kinds of restrictions that prevent our ways of living from the ocean that go back centuries."

Maxwell's call for more research and education is echoed by Kim Roberts who, with her husband Blaine, owns and operates Lahaina Divers.

Kim is the Maui representative for the Tourism and Ocean Recreation Council of Hawaii (TORCH), a statewide lobbying group for boat owners. Three years ago Kim started a coral reef conservation group called "Malama Kai," and has been working to educate divers about the need to protect and conserve coral areas and to establish an artificial reef off West Maui.

"Most appear to equate sanctuary with regulation, not research and education."

"When we look at the prospect of a sanctuary here, in some ways we're excited, and in other ways we're pretty ambivalent," explains Roberts.

"We're excited because we look to their sanctuaries and we see a lot of effort put into research and education. On the other hand, we're ambivalent because in Hawaii there's been a history of things going down without much control or input from the user groups. All we ever see is increasing levels of enforcement and regulation, even when it's not needed."

While the state may well be correct in its belief that single species sanctuary will be more readily accepted by residents of Hawaii, the process by which other resources may be included at some future date needs to be clearly defined.

One major reason is the growing sense that species other than humpback whales are in immediate need of attention.

"I've fished in these water for years," reports Jung.

"When you fish for a living, you learn to constantly watch the ocean for signs of change. It's obvious to anyone who spends a lot of time on the water that there are more serious problems we need to attend to besides whales. That algae problem, for example, is a five-alarm fire. The issue of shark control is something we need to put some major thought into right away. Coastal runoff and marine debris are destroying our near shore water quality.

"A large sanctuary based only on humpback whale protection will just lead to more rules to make life more difficult for commercial operators," warns Roberts. "We need to find ways to constructively address some of the problems out there. Degradation of coral reefs is a big one, and we need to develop some clear priorities for enhancing and protecting the reefs and the species that live in them."

It is clear that the bulk of the work lies ahead. A major issue that needs to be addressed is the difference in direction between the Office of State Planning and the Sanctuaries and Reserves Division. Without unity of vision in what the sanctuary should be, those agencies will surely end up working at cross purposes, and any opportunity to protect Hawaii's marine resources will be lost. However, an even more important consideration is the need to ensure that the people of Hawaii play a major role in determining the nature of the sanctuary.

Over and over, one hears the distrust in the voices of those who stand to be most directly affected by the sanctuary designation.

"Although I am fully in favor of doing more to protect the ocean, I'm not sure I favor a sanctuary," says Jung.

"We are the users on the water, and the people in Washington who run the sanctuary program are not. They have no active involvement on the water, and historically allow very little input from the people on site. I'm worried that a federally administered marine sanctuary will just lead to more empire-building, and bureaucracy run amok. We need to have some assurance that this thing will be run at the state level, be based on scientific study, and allow local input."

Both the Office of State Planning and the Sanctuaries and Reserves Division appear keen to solicit input from the public.

At the same time however, there remains the important task of educating the public about exactly what options exist and what a sanctuary can accomplish.

The question that gets asked over and over again is "What will a humpback whale sanctuary do that isn't already possible under current state and federal regulations?"

Most observers appear to equate sanctuary with regulation, rather than with research and education.

However sanctuary legislation emphasizes research and education, and the Hawaiian Islands Humpback Whale National Marine Sanctuary mandates that a primary focus of a sanctuary management plan will "facilitate all public and private uses of the Sanctuary consistent with the primary objective of the protection of humpback whales and their habitat."

"Our two fold challenge," observes Sanctuaries staff member Steve Olson, "is to reach consensus with the state on defining the sanctuary parameters and to educate the public about the ability of a sanctuary to accommodate a wide range of uses. In other words, to manage through education rather than 'in your face' enforcement."

Margaret Cummiskey, of U.S. Senator Dan Inouye's office agrees — "Education is the key. We've got to let people know what to expect."

Senator Inouye and Representative Abercrombie have done an admirable job of moving the sanctuary forward to the point of designation.

The next 18 months will provide many opportunities for all parties to express their concerns.

It is important the people of Hawaii take full advantage of these opportunities. While Congress has indeed drawn the lines, and it remains for the residents of the nation's only island state to fill in the blanks.

Paul H. Forestell is director of Research and Education for the Maui-based Pacific Whale Foundation. He received his Ph.D. from the University of Hawaii. Dr. Forestell has conducted studies of whales and dolphins throughout the Pacific since 1976. He has advised government agencies and commercial operators in Hawaii, Australia, and Japan concerning programs to ensure the recovery and protection of marine mammals.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Brian Henderson
President, Maalaea Yacht Marina A.O.A.O.
Rural Route 1, Box 377
Wailuku, Hawaii 96793-9502

Dear Mr. Henderson:

Thank you for your letter of comment dated January 15, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments:

a. The location of the three condominiums is now included on Figure 2a of the final SEIS. The draft and final SEIS indicate in Paragraph 4.8 that adjacent land to the east along the shore is designated for multi-family use and contains a series of condominiums.

b. The east mole will have no different effect on the condominiums than does Old Maalaea Road and the parking areas which front each of the condominiums.

c. The modest expansion of the harbor is not expected to have any affect on the air quality of the area. The strong winds will blow any exhaust fumes out to sea. The berths along the east mole are expected to contain recreational boats, not commercial boats. The commercial activity will take place generally in the same location as it now does.

d. The beach to the east of the east breakwater is not likely to be affected by the harbor expansion. The present east breakwater is not a walkway; in fact walking on the breakwater is prohibited.

e. Although there may be some negative effect on occupancy in the closest condominiums during construction, once construction is completed, property values are likely to increase rather than decrease.

f. The State of Hawaii claims all submerged lands and all lands seaward of the high tide line throughout the State. In addition, Executive Order No. 02605 dated June 3, 1972 assigns the filled and underwater areas, adjacent to the harbor, to the Department of Transportation as an addition to Ma'alaea Harbor, and the State of Hawaii was granted the littoral rights of the Maalaea Yacht Marina Condominium by deed dated October 29, 1958. Your attorney may contact our Office of Counsel, Mr. Steven Stomber or Ms. Patricia Billington, telephone number 438-9972, for other pertinent references.

g. The construction contractor will be required to prepare a blasting plan approved by the Corps Contracting Officer prior to doing any blasting. The plan will contain precautions to assure no damage is done to the adjacent buildings.

h. Paragraphs 5.2.3e of the draft SEIS and 5.10.4e of the final SEIS state the mitigation for blasting effects on turtles. For your information, there is no "colony" of Hawksbill turtles in Maalaea Bay. Several years ago, there was an isolated instance of a Hawksbill nesting somewhere in the bay. There are no suitable areas adjacent to the harbor for nesting activity. The proposed harbor improvement project will have no impact on Hawksbill turtles. The National Marine Fisheries Service concurred in this determination.

i. There are no provisions of the Hawaiian Islands Humpback Whale National Marine Sanctuary which will affect the proposed project.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213
TEL (310) 980-4000; FAX (310) 980-4018

January 19, 1991 F/SWO23:JJN

District Engineer
U.S. Army Engineer District, Honolulu
ATTN: CEPOD-ED-PV/Lennan
Building 230
Fort Shafter, Hawaii 96858-5440

Dear Sir:

The following comments relate to the Draft Supplemental Environmental Impact Statement (DSEIS), Maalaea Harbor For Light-Draft Vessels, Maui, Hawaii.

The purpose of the proposed project is to provide needed improvements to Maalaea Harbor. Though seven alternative harbor improvement plans have been considered, a preferred alternative has not been designated. This needs resolution in the DSEIS.

The DSEIS does not adequately address potential project impacts on nearshore fishery resources and their habitats. Apparently a detailed quantitative field study on the distribution and abundance of reef fishes and invertebrates within the proposed project site is planned, which will satisfy requirements of the Fish and Wildlife Coordination Act. Results of this study should be incorporated in the DSEIS. A description of the marine environment and biota along each of the proposed entrance channel alignments should be included as well.

The National Marine Fisheries Service conducted and concluded Section 7 consultation under the Endangered Species Act. A non-jeopardy Biological Opinion with conservation recommendations was issued for the project on July 23, 1990. It is included in Appendix A of the DSEIS.

Should you have questions regarding these comments, please contact Mr. John Naughton at 2570 Dole St., Room 105, Honolulu, Hawaii 96822-2396; (808)955-8831.

Sincerely,

Gary Matlock

Gary Matlock, Ph.D.
Acting Regional Director

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Gary Matlock, Ph.D.
Acting Director, Southwest Region
National Marine Fisheries Service
501 West Ocean Boulevard. Suite 4200
Long Beach, California 90802-4018

Dear Dr. Matlock:

Thank you for your letter of comment dated January 19, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments.

a. A preferred alternative was not identified in the draft SEIS; however, one has been designated in the final SEIS.

b. The U.S. Fish and Wildlife Service had not performed a detailed survey of the project site at the time the draft SEIS was prepared. The survey has now been performed, and the draft Fish and Wildlife Coordination Act report is included in Appendix B of the final SEIS and summarized in Chapter 4, Affected Environment, and Chapter 5, Environmental Consequences.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

U.S. Department of Transportation
United States Coast Guard

Commander (dpl)
Fourteenth Coast Guard District
Prince Kalanianaole Fed Bldg
300 Ala Moana Blvd
Honolulu, HI 96850-4982
Phone: (808) 541-2124

11000

JUN 17 1993

U.S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV/Lennan
Building T-1
Fort Shafter, Hawaii 96825-5440

Gentlemen:

This letter is in response to your request for comments on the Supplemental Environmental Impact Statement (EIS) for Maalaea Harbor for Light-Draft Vessels Maui, Hawaii.

We have several comments regarding clarification of our current and future operational activities in Maalaea Harbor. We have no comments on any technical analysis presented in the Supplemental EIS.

First, this EIS is an adjunct to previous efforts which date back to 1980. As the supplemental reports indicates, there have been some changes in the assumptions to the project, so too have there been changes in the scope of Coast Guard operations in the area. When the original study was undertaken, the Coast Guard had a 95 foot patrol boat homeported in Maalaea Harbor; presently we operate a small boat station operation there employing a rigid hull inflatable boat. Our search and rescue operations are dynamic in nature; we constantly analyze our operations and resource mix to make sure we are able to respond adequately to demographic shifts, changes in maritime commerce activities, and changes in search and rescue technology in the areas where we operate. In short, we strive to remain flexible in the deployment of our limited resources in order to best meet those changing needs.

Second, we believe the supplemental EIS implies a condition we are not able to validate at this time. Specifically, the EIS indicates that an engineering constraint in the development of the alternatives for the harbor project is the need to accommodate a Coast Guard 110 foot patrol boat. It is true that if the preferred alternative design does not make allowances for the necessary operating parameters for the 110' cutter, it would preclude us from placing one there in the future. However, we are not in a position to let the final selection of the engineering alternate dictate that we place a 110' cutter in Maalaea Harbor. The determination of which Coast Guard resource is the proper one for Maui is based on the analysis of the

historical search and rescue data for the area and the projection of future maritime trends, not because there is adequate pier space for any given type of craft.

We use a systems approach in that our resources are located throughout the Hawaiian Islands in such a way as to complement each other and to provide redundancies. Frankly, our current mix and location of resources works extremely well.

In conclusion, it appears that the preferred alternative would minimally accommodate a 110' cutter. However, this is based solely on the drawings and it is impossible to predict other natural or mechanical limiting factors at this time. This in no way should be considered as a commitment on the part of the Coast Guard to place one there in the future. Finally, an alternative should not be ruled out solely on the basis of whether it can accommodate a 110 foot Coast Guard patrol boat.

You may contact Captain R. Mattingly or Lieutenant Commander C. Quedens of my Search and Rescue Branch at (808) 541-2310 should you have any questions or need more information.

Sincerely,

J. H. Donahue
J. H. DONAHUE
Chief of Staff

Copy: State of Hawaii, Dept. of Transportation, Harbors Division
Commander, Coast Guard Group, Honolulu
Officer in Charge, Coast Guard Station, Maui

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Captain R. Mattingly
Search and Rescue Branch
Fourteenth Coast Guard District
300 Ala Moana Boulevard
Honolulu, Hawaii 96850-4982

Dear Captain Mattingly:

Thank you for your letter of comment dated January 19, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments concerning Coast Guard activities at Ma'alaea Harbor are noted, and appropriate statements in the SEIS have been changed. Because the Maui boating public is concerned with safety in relation to the Coast Guard's capability on Maui, Coast Guard flexibility at Ma'alaea Harbor was a consideration in selecting the preferred alternative. It was not the major factor, but was considered along with other factors in making the selection. Your comments and this response are reproduced in Appendix C of the final SEIS.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL

BRIAN J. J. CHOY
Director

January 19, 1993

Mr. Rex Johnson, Director
Department of Transportation
State of Hawaii
869 Punchbowl Street
Honolulu, Hawaii 96813-5097

Attention: Mr. Randal Leong

Dear Mr. Johnson:

SUBJECT: SUPPLEMENTAL DRAFT EIS FOR THE MAALAEA HARBOR FOR LIGHT DRAFT VESSELS, MAUI, HAWAII

We have completed our review of the subject document and have several comments. Please include the following information when resubmitting the Final Supplemental EIS for this project, as required by §11-200-17 Hawaii Administrative Rules:

- Statement of the relationship of the proposed action to land use plans, policies and controls for the affected area [§11-200-17(h)];
- Relationship between local short term uses of humanity's environment and the maintenance and enhancement of long term productivity [§11-200-17(j)];
- Irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented [§11-200-17(k)];
- Probable adverse environmental effects which cannot be avoided [§11-200-17(l)]; and
- Mitigation measures proposed to reduce significant, unavoidable, adverse impacts to insignificant levels, including the basis for considering these levels acceptable [§11-200-17(m)].

Please include copies of all substantive comment letters and responses in the Final Supplemental EIS. Letters of no comment need not be reproduced in the Final, however, all persons, organizations, and public agencies who have commented on the Draft Supplemental EIS (no comment letters included) shall be listed in the Final pursuant to §11-200-18.

If you have any questions, please call Margaret Wilson at 586-4185. Thank you.

Sincerely,

Brian J.J. Choy
Director

c: ✓U.S. Army Engineer District, Honolulu

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Brian J.J. Choy, Director
State of Hawaii
Office of Environmental Quality Control
220 South King Street
Honolulu, Hawaii 96813

Dear Mr. Choy:

Thank you for your letter of comment dated January 19, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for the Ma'alaea Harbor for Light-draft Vessels. Your letter and this response are included in Appendix C of the final SEIS. The responses below follow the order of your specific comments.

a. The relationship of the proposed action to land use plans, policies and controls for the affected area is discussed in paragraph 5.14 of the final SEIS.

b. The relationship between local short term uses of humanity's environment and the maintenance and enhancement of long term productivity is discussed in paragraph 5.16 of the final SEIS.

c. Irreversible and irretrievable commitments of resources that would be involved in the proposed action are discussed in paragraph 5.17 of the final SEIS.

d. Probable adverse environmental effects which cannot be avoided are discussed in paragraph 5.18 of the final SEIS.

e. Mitigation measures are listed in paragraph 5.19 of the final SEIS.

f. Letters with no substantive comments are listed in paragraph 7.5 of the final SEIS. Letters with substantive comments are listed in paragraph 7.6 and reproduced along with the responses in Appendix C.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

LINDA CROCKETT LINGLE
Mayor
TELEPHONE 243-7855

OFFICE OF THE MAYOR
COUNTY OF MAUI
WAILUKU, MAUI, HAWAII 96793

January 20, 1993

Mr. Kisuk Cheung, P.E.
Director of Engineering
Planning Division
DEPARTMENT OF THE ARMY
U.S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

Subject: Joint Federal and State of Hawaii Draft Supplemental Environmental Impact Statement for the Maalaea Harbor for Light-Draft Vessels

The Maui County Department of Planning and Public Works have reviewed the draft and commented as per the attached letters. The comments of the Planning Department are extensive and need to be addressed in the final impact statement. County permits will be required for portions of the project mauka of the shoreline and I suggest your staff contact the Department of Planning for details regarding these permits.

Sincerely,

LINDA CROCKETT LINGLE
Mayor, County of Maui

LCL:NGP:ecq
Enclosures
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LINDA CROCKETT LINGLE
Mayor
GEORGE N. KAYA
Director
CHARLES JENCKS
Deputy Director

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
LAND USE AND CODES ADMINISTRATION
250 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

AARON SHINMOTO, P.E.
Land Use and Codes Administration
EASSIE MILLER, P.E.
Wastewater Reclamation Division
RALPH NAGAMINE, P.E.
Engineering Division
BRIAN HASHIRO, P.E.
Solid Waste Division
MELVIN HIPOLITO
Highways Division

January 14, 1993

MEMO TO: Nolan G. Perreira, Executive Assistant

F R O M: George N. Kaya, Director of Public Works

SUBJECT: SUPPLEMENTAL EIS FOR MAALAEA HARBOR FOR LIGHT DRAFT VESSELS

We have reviewed the subject EIS and offer the following comments:

1. That the project is subject to coastal flooding, as such, said project shall conform to the Chapter 19.62 of the Maui County Code, pertaining to flood hazard districts.
2. That the material from the dredging operation may not be accepted at the county landfill. The contractor shall contact the Solid Waste Management Division for further information.
3. That due to the increase of the berthing facilities, what provisions are proposed for additional parking?

GNA:MAALAEA

xc: Engineering Division
Solid Waste Division
Wastewater Reclamation Division
luca

LINDA CROCKETT LINGLE
Mayor

BRIAN W. MISKAE
Planning Director

COUNTY OF MAUI
PLANNING DEPARTMENT
250 S. HIGH STREET
WAILUKU, MAUI, HAWAII 96793

MEMORANDUM

To: Nolan Perreira
Via: Linda Crockett Lingle, Mayor
From: Brian Miskae, Planning Director
Date: January 14, 1993

Re: Comments on Draft Supplemental Environmental Impact Statement for Maalaea Harbor for Light-Draft Vessels.

Dear Sirs:

We have reviewed the above referenced document. We concur that there is a need to improve this small boat harbor to both accommodate pent up demand for slips and improve its navigational qualities. Additionally, the Department offers the following comments and suggest that the related analysis be included in the final document.

Surfing Impacts:

The Department recognizes the importance of protecting existing surfing sites and supports the selection of an alternative that produces the least impacts on this activity.

The document is fairly clear and goes to great lengths in its analysis of impacts to the surfing breaks with regard to each of the alternatives. This analysis, however, is somewhat limited to the immediate effects of construction on the individual breaks and should also include some analysis of the long term effects of each of the alternatives. It seems to this Department that the construction of the original breakwater may have contributed to the creation of Buzzes 1, 2 and 3, and Off-the-wall through sand attenuation and accumulation. If indeed this is the case, this pattern could be used to project the long term effects of each alternative on the surfing sites. This same analysis could project the effects of the alternatives on nearby shorelines with regard to possible erosion.

Similarly, if the existing breaks were created by the construction of the original harbor breakwaters, the document should explore the possible creation of new breaks under each of the alternatives.

Finally, the document should select a preferred alternative with regard to surfing impacts.

Ancillary Impacts

As previously stated, we concur that improvements are needed to accommodate the already existing demand for harbor facilities. The document does not, however, address the impacts associated with increased use of the area by boat owners and tourists. As the capacity of the harbor increases, it is logical to assume that there would be a corresponding increase in activities particularly as it related to the tourist industry such as fishing, whale watching, trips to Molokini, etc. The traffic study projects some increases in the number of vehicles using the area and proposes some mitigation, but there should be some analysis related to increased demand for other services at the harbor. These services would include, but not be limited to, freshwater consumption (uses include human consumption, boat washing, and landscape watering), sewage production, solid waste generation, etc.

Growth Inducement

Further, because of the increased intensity of use at the harbor, the area becomes more of a focal point of ocean related activities for the island and it seems likely that there would be an increased pressure towards the urbanization of lands around the harbor area. The likelihood of this occurrence should be analyzed.

Traffic Impacts

The traffic study supports a conclusion that there would be minimal impacts with regard to traffic generation and bases its trip generation on the ITE manual's "per berth" rate. We feel that using this method may provide inaccurate calculations for several reasons.

Just as trip generation varies with different land uses, the same could be assumed for different levels of use for various types of slips or types of vessels. Since the harbor already has a significant number of tourist oriented vessels, it stands to reason that this number would increase proportionately with the construction of new slips. Since the profitability of commercial tour operations may depend on maximizing the number of passengers relative to a given vessel size, we feel that these uses may have significantly different trip generation rates than other types of boating activities such as pleasure boating or commercial fishing. This could result in a significantly higher number of trips generated though there are a limited number of new slips.

Similarly, trip generation would vary with the size as well as use of vessel. If the final design selected by DLNR is based primarily to accommodate small pleasure craft, the trip generation rate may be applicable in some portions of the analysis. If, however, the harbor is designed to accommodate larger commercial vessels, the per berth generation factor not is applicable at all. Larger vessels, designed for tours, diving trips, sunset cruises, etc., still only use one berth but carry more people. This results in a projection that estimates 2.96 trips per day for a vessel that may be carrying upwards of one hundred persons. This not only provides an inaccuracy for the individual boat, but also on a harbor wide scale as very few berths accommodating larger vessels (each projecting only 2.96 trips) would generate large numbers of trips.

It also stands to reason that the ITE generation tables may not be applicable in this case for the Hawaiian Islands since so much of our economy and ocean oriented uses are based on tourism and not on the simple ownership of pleasure craft.

As an alternative method of analysis, we suggest a "per use" projection based on designs and the accommodation of different size and number of commercial vessels.

The traffic study is also limited to impacts on nearby intersections. It should also address circulation within the immediate harbor area, particularly with regard to adequate parking.

Permitting

Since not all of the proposed facilities are in submerged lands, portions of the project falls within the County 's jurisdiction under CZM regulations. Because of this, the State would have to apply for an SMA permit for the portions mauka of the shoreline.

Impacts to Humpback Whales

We concur with the conclusions that human intrusion into calving grounds is detrimental to the species. It is also noted that the presence of this endangered species is a special attraction to the tourism industry. We would like to see the document explore the implementation of a mitigation program to lessen the impacts of present and increased use and frequency of ocean craft within this very important whale habitat. One suggestion in addition to the recommendations in the documents report could be to limit the number of vessels licensed for whale watching.

If you have any questions regarding these comments, please contact William Spence of my staff.

Very truly yours,

Brian Miskae
Planning Director

cc: B. Miskae
C. Jencks
W. Spence

LINDA CROCKETT LINGLE
Mayor
TELEPHONE 243-7855

OFFICE OF THE MAYOR
COUNTY OF MAUI
WAILUKU, MAUI, HAWAII 96793

January 22, 1993

Mr. Kisuk Cheung, P.E.
Director of Engineering
Planning Division
DEPARTMENT OF THE ARMY
U.S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

Subject: Supplemental EIS for Maalaea Harbor for Light Draft Vessels

Please add the attached letter to Maui County's comments relating to the subject supplemental EIS.

I apologize for any inconvenience this late submittal may have caused you.

Sincerely,

NOLAN G. PERREIRA
Executive Assistant

NGP:ecq
Enclosure
cc: Mayor Linda Crockett Lingle
George Kaya, Director of Public Works

c:\letter\366

LINDA CROCKETT LINGLE
Mayor
GEORGE N. KAYA
Director
CHARLES JENCKS
Deputy Director

COUNTY OF MAUI
DEPARTMENT OF PUBLIC WORKS
LAND USE AND CODES ADMINISTRATION
250 SOUTH HIGH STREET
WAILUKU, MAUI, HAWAII 96793

AARON SHINMOTO, P.E.
Land Use and Codes Administration
EASSIE MILLER, P.E.
Wastewater Reclamation Division
RALPH NAGAMINE, P.E.
Engineering Division
BRIAN HASHIRO, P.E.
Solid Waste Division
MELVIN HIPOLITO
Highways Division

January 19, 1993

MEMO TO: Nolan G. Perreira, Executive Assistant

F R O M: George N. Kaya, Director of Public Works

SUBJECT: SUPPLEMENTAL EIS FOR MAALAEA HARBOR FOR LIGHT DRAFT VESSELS

We are amending our January 14, 1992 comments on the subject EIS with the following:

4. The submitted traffic impact study assumes that the State D.O.T.'s island wide highway improvements would be constructed prior to the subject project and therefore this report is inadequate. The applicant shall revise the traffic impact study to include road improvements mitigating the projects's impacts assuming no State highway improvements are installed.

5. Specific improvements that should be implemented with expansion is to upgrade the Old Maalaea Road (north) and Maalaea Wharf access road to 12 feet wide lanes with 4 feet wide paved shoulders so large trailer boat, bicycle and pedestrian traffic can be easily accommodated. Also, approaches to Honoapiilani Highway should include separate left and right turn lanes with wide throat openings to receive trailer boat turning movements.

If you have any questions regarding this memorandum, please call Lloyd Lee at 243-7745.

FC

xc: Engineering Division

SW/A:MAALAEA

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Linda Crockett Lingle, Mayor
County of Maui
Wailuku, Hawaii 96793

Dear Mayor Lingle:

Thank you for your letters of comment dated January 20, and January 22, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. The comments of the Departments of Planning and Public Works were considered during selection of the preferred alternative, and their comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of the detailed comments of each Department.

a. **Public Works Department**

(1) The proposed project will not increase or decrease the coastal flooding in the project area, and the project will comply with the appropriate Federal, State of Hawaii and County of Maui laws and regulations pertaining to flood plain management.

(2) The Solid Waste Management Division has been contacted concerning upland disposal. However, all of the dredged material will be used as fill for new harbor features, and no upland disposal is expected.

(3) The proposed project includes a large number of new parking spaces as part of the infrastructure improvements.

(4) The timing of the State's portion of the project, improvement of the infrastructure, is such that the highway improvements planned by DOT will likely be in place before the infrastructure development is complete. However, the State sponsor proposes some road improvements to be constructed if the highway improvements planned by the DOT are not implemented in the envisioned time frame.

(5) The specific improvements you recommended have been included in DOT's master plan for highway improvements in the Ma'alaea area.

b. Planning Department

(1) Surfing Impacts. The FSEIS and appended surf site study (Appendix E) predict both the immediate and longer term effects on the surf sites to the extent engineering analysis would allow.

(a) The existing surf breaks were not created by the existing harbor structures. There is no attenuation or accumulation of sand. The breaks exist because of the topography of the hard reef flat adjacent to the harbor.

(b) See comment 1 above.

(c) The final SEIS indicates both a recommended alternative and an environmentally preferred alternative. Surf sites were considered in the selection of both alternatives.

(2) Ancillary Impacts: Although the number of boats berthed at Ma'alaea Harbor will double, this increase is not expected to have significant environmental effects. Many of the boats are now trailered, and use the resources, and the infrastructure improvements are expected to have the capacity to handle the increased berths. For example, sewage treatment capability will be improved and will include pump-out facilities, so that sewage handling will be improved over the current condition. DLNR Division of Boating and Ocean Recreation intends to limit the number of commercial permits allowed at Ma'alaea, and DLNR Aquatics Resources Division is presently developing regulations for the use of Molokini, so that even with increased boats in the harbor, there will likely be less pressure on Molokini. Ma'alaea Harbor does not now have a solid waste problem, and it is not likely that an increase in the number of boats will create one, since the governing regulations are now, and will continue to be, enforced.

(3) Growth Inducement: The addition of 130 +/- boats in Ma'alaea Harbor does not appear to be a significant reason for increased urbanization, especially since many of the boats are either trailered or moored elsewhere. It is projected that increased development will occur in the Ma'alaea area whether or not the harbor improvements are developed.

(4) Traffic Impacts

(a) A revised traffic impact analysis utilizes information presented in the Maui Long-Range Highway Planning Study, historic traffic count information collected by the Hawaii Department of Transportation, and projected traffic volumes from the proposed Ma'alaea Triangle Development to estimate future traffic conditions without the proposed harbor expansion. Assumptions included:

(1) Traffic volumes were estimated to increase by 2.9 percent per year, on an average annual basis;

(2) Left-turn movements at the southern intersection of Old Ma'alaea Road and Honoapiilani Highway would be diverted to the intersection Ma'alaea Wharf Access Road and Honoapiilani Highway; and

(3) The Department of Transportation would implement a policy that requires commercial passenger vessels with 25 or more passengers to provide bus or van service to and from the harbor.

(b) Trip generation was recalculated based on the types, uses, and sizes of the expected vessel makeup, as well as the expected number of passengers and employees. Section 4.13 describes the existing and future without-project traffic conditions, section 5.13 identifies impacts of the proposed harbor expansion on traffic, and section 5.19 discusses potential mitigation measures for project impacts.

(5) Permitting: An SMA application is in progress by the State Department of Transportation, as agent for DLNR, Division of Boating and Ocean Recreation. The final SEIS discusses the proposed projects and their relationships to the CZM program.

(6) Impacts to Humpback Whales: The National Marine Fisheries Service (NMFS) has established rules governing the approach to the whales, but the rules apply to all boaters, whether commercial whale watchers or recreational boaters. Permits are issued by NMFS for research under the provisions of the Endangered Species Act. The final SEIS incorporates the mitigation measures required by the NMFS for potential impacts to the whales.

Sincerely,

M. Bruce Elliott
Lieutenant Colonel, U.S. Army
District Engineer

MARK A. MASSARA
SURFRIDER FOUNDATION LEGAL OFFICE
1642 Great Highway
San Francisco, California 94122
#415-665-7008
Fax #415-665-9008

District Engineer
U.S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV/Lennan
Building 230
Fort Shafter, Hawaii 96858-5440

January 20, 1993

Dear District Engineer:

The following are comments submitted by the Surfrider Foundation on the joint Federal and State of Hawaii Draft Supplemental Environmental Impact Statement ("DSEIS") for the Maalaea Harbor.

I. RECREATIONAL AND ENVIRONMENTAL AMENITIES AT MAALAEA REQUIRE PROTECTION.

A. SURFING AT MAALAEA IS A PROTECTED ACTIVITY.

As the DSEIS recognizes, in order for this project to be found consistent with the Coastal Zone Management Act (CZMA) it must be consistent with the State of Hawaii's coastal use policies.

With respect to recreational resources, the Corps is to "protect coastal resources uniquely suited for recreational activities that cannot be provided in other areas" and must provide for "replacement of coastal resources having significant recreational value, including but not limited to surfing sites and sandy beaches, when such resources will be unavoidably damaged by development." DSEIS, Determination of Federal Consistency, page 1.

There are at least five separate surfing areas located at Maalaea. Two of the sites, Maalaea Pipeline and Off-the-wall, are considered to be extremely valuable surf venues. They are valuable because they are unique. Maalaea Pipeline is considered one of the best surf spots on the planet, and surfers travel from all over the world to ride its waves. The DSEIS recognizes the importance of Maalaea & Off-the-wall, and acknowledges the uniqueness and value of these locations. DSEIS, Assessment of Recreational Surfing Sites, Sept. 1992. In short, these important surfing resources <u>cannot</u> be replaced and must instead be protected from impacts associated with the project.

B. ENVIRONMENTAL RESOURCES AT MAALAEA ARE PROTECTED.

The same Federal Consistency Determination policies which protect surfing activities at Maalaea also protect environmental resources. Specifically, the coral reef habitat and the Humpback whale are protected environmental resources.

The policies which govern the project state the project must "minimize disruption or degradation of coastal water ecosystems by effective regulation of...channelization" and "preserve valuable coastal ecosystems...."

Thus, in determining which alternative is most appropriate for the project the Corps should be guided by the foregoing policies in attempting to protect surfing and environmental resources.

II. ONLY CONSTRUCTION OF AN INTERIOR MOLE PROTECTS SURFING RESOURCES.

Of all the alternatives discussed (except the "no project" alternative), only construction of an interior mole adequately protects surfing and other existing recreational activities.

Besides the interior mole, the Corps considered construction of a 450 foot extension of the East breakwater (alt. 1); 555 foot extension to the South breakwater (alt. 2); 600 foot extension to South breakwater (alt. 3); and 675 foot extension to East breakwater (alt.4).

Each of the four alternatives has direct, severe, permanent negative impacts on at least one surf site. Alternative 1 literally runs rocks into the surf area at Buzzes #2 and will severely impact (by wave refraction) both Off-the-wall (some rocks will actually be located in the surfing area) and Buzzes #3.

Alternative 2 directly and negatively impacts the Maalaea Pipeline in a variety of ways (rocks, boat traffic, wave refraction, etc) and should not even be considered. In addition, alternative 2 will negatively impact Buzzes #1 & #2 and Off-the-wall.

Alternative 3 is similarly unacceptable due to placement of rocks right in surf spots at Off-the-wall and Buzzes #2. These two surf spots will literally disappear from this alternative. A rock revetment will exist where Buzzes #2 currently exists and Off-the-wall will be located in the harbor entrance channel. However, because of alternative 3's jetty configuration, it is nearly impossible that ridable waves could be produced within the channel.

Alternative 4 completely destroys Buzzes #2 (rocks in lineup) and would severely and detrimentally impact Buzzes #1 & #3 and Off-the-wall.

Modifications to alternative 3 as proposed by Moffatt & Nichol are similarly unacceptable because they will result in the complete destruction of Off-the-wall.

Of all the alternatives, Moffatt & Nichol's proposal to eliminate breakwater extensions and construct an interior mole (alt. 5) is the only surf sensitive choice. It is also the only choice which is consistent with the goal of expansion of Maalaea and protection of surfing resources located around Maalaea. Alternative 5 is the only choice which protects recreation as required by the CZMA.

III. CONSTRUCTION OF AN INTERIOR MOLE PROTECTS THE ENVIRONMENT.

The report on Humpback Whales by Forestell & Brown demonstrates that boating traffic has direct negative impacts on Humpback Whales, particularly calfs.

Because whales are often sited within 50 meters of the existing breakwaters, any construction, reconfiguration or extension of the breakwaters has direct negative impacts on whales.

Of all the alternatives, construction of an interior mole will least impact whales. Construction of an interior mole along with other measures (speed limits etc.) proposed by Forestell & Brown will provide the most effective mitigation measures to reduce negative impacts to the Humpback Whale population.

In addition, the United States Department of the Interior, Fish and Wildlife Service, by letter dated April 21, 1992, has determined that dredging activities associated with construction of new or extended breakwaters would have direct and secondary negative impacts on the coral reef community. The negative impacts will reverberate through the coral reef community and severally impact the entire habitat. Fish and Wildlife specifically endorses construction of a stub breakwater inside the existing harbor as a way to significantly reduce impacts to the coral reef habitat at the project site.

Construction of the interior mole is the only alternative which complies with NEPA's goal of reducing environmental impacts from the project. Specifically, the interior mole will protect existing coral reef habitat by eliminating the need to extend existing breakwaters (and take additional coral reef area) and

will minimize impacts to the Humpback Whale population. The interior mole is also consistent with the CZMA's goal of protection of coastal resources.

IV. CONCLUSION.

Thus, construction of an interior mole at Maalaea Harbor is the only alternative contained in the Corps DSEIS which protects both environmental and recreational resources at Maalaea. Only the mole will result in compliance and consistency with the CZMA; only the mole will result in compliance with NEPA. All the other alternatives have been determined to result in direct negative impacts to both surfing and environmental resources in the area.

We hope the Corps will recognize the overriding superiority of the mole and pursue it as the best environmental alternative available for the project.

If you have any questions regarding our comments, please do not hesitate to contact us.

Sincerely,

Mark A. Massara

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Mark A. Massara
Surfrider Foundation Legal Office
1642 Great Highway
San Francisco, California 94122

Dear Mr. Massara:

Thank you for your letter of comment dated January 20, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments.

a. No impacts to the Ma'alaea Pipeline are expected as a result of the selected preferred alternative, although the surf break known as "Off-the-Wall" will be destroyed. It has been determined that the impacts to surf sites cannot be avoided; however, modifications to the project design have minimized those impacts to the extent practicable. Consistency with the Coastal Zone Management Act will be determined by the State.

b. The Biological Opinion of the National Marine Fisheries Service (NMFS) indicated that the proposed improvement project, with the recommended mitigation, would have a less severe adverse impact on humpback whales than does the present situation. The Corps and State of Hawaii intend to adopt the recommendations of the NMFS. The coral reef habitat which will be destroyed by the breakwater extension and dredging the new entrance channel will be partially replaced by habitat provided by the new breakwater. The sides of the new channel and the armor stone of the breakwater will provide some new vertical relief habitat. Only the absolute minimum of habitat will be destroyed, consistent with providing the most cost effective protection for harbor users.

c. Your comments concerning the effects on the five surf sites from the various alternatives are noted. These impacts were shown in Figures 15 thru 19 of the draft SEIS, and are also shown in Figures 24 thru 27 and discussed in Section 5.12.1 of the final SEIS. The proposed project design has been modified to avoid and minimize impacts to the surf sites to the extent practicable.

d. Alternative Plan 6 (Figure 10, draft SEIS and Figure 15, final SEIS) is not a feasible alternative. This design is not acceptable from a navigation safety standpoint. During large-wave conditions, boats entering the harbor would be subjected to undiminished waves directly on their sterns and would have to turn broadside to these waves to enter the protected portion of the harbor. In addition, the configuration of the harbor under alternative 6 would result in severe oscillation within the harbor, with resulting safety and property damage problems.

Also under Alternative Plan 6, expansion inland would be very expensive due to land acquisition (estimated $10 million adjacent land purchase price). This alternative had to be eliminated because it does not meet the purposes of the project to improve navigation conditions and reduce vessel damage and because it is not feasible from an engineering and economic standpoint. Alternative Plan 6 is discussed in sections 3.4 and 3.5 of the final SEIS.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

COMMENTS
ON
DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
FOR
MAALAEA HARBOR FOR LIGHT DRAFT VESSELS
MAUI, HAWAII

6, Jan, 21

COMMENTOR: **NAME:** Rich Gallagher
STREET: 1795 S. Kihei Rd Suite 1001
CITY Kihei Maui Ha 96753

COMMENTS:

Alternate #3 with the modification to route traffic/parking shifting to the west gets my vote for being the most practible solution.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Hugh Gallagher
1295 South Kihei Road
Suite 1001
Kihei, Hawaii 96753

Dear Mr. Gallagher:

Thank you for your letter of comments dated January 21, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

25 JAN 1993
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Ron Gammie, Past President
Maalaea Community Association
R R 1 Box 453
Wailuku, Hi. 96793

January 21, 1993

James T. Muratsuchi
Lieutenant Colonel, U.S. Army
District Engineer
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hi. 96858-5440

Re: Draft Supplemental Environmental Impact Statement for Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii.

Dear Colonel:

We have encountered a very definite concern on the part of condominium owners to the east of the existing harbor east breakwater. The concern is with the seawalls which were built years ago to supplement the rock walls of earlier times.

If the proposed harbor breakwater changes will effect and damage those walls it could be very expensive to the property owners and the public as well since there are public access right of ways between some of the condos.

The Draft Supplemental Environmental Impact Statement for Maalaea Harbor for Light-Draft Vessels, as distributed in November 1992 did not address this concern. While the Maalaea Community Association has previously commented, January 6, 1993, on the Draft EIS, we wish to have this concern addressed in the final EIS as well.

Very truly yours,

Ron Gammie

Ron Gammie, Past President

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. Ron Gammie, Past President
Ma'alaea Community Association
Rural Route 1, Box 453
Wailuku, Hawaii 96793

Dear Mr. Gammie:

Thank you for your letter of comment dated January 21, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS.

It appears there is no east flowing long-shore current in the vicinity of Ma'alaea Harbor. The proposed modifications to the harbor will not intensify or otherwise significantly change the long-shore currents in the area. There is no reason to believe that the harbor modifications will have any effect on the seawalls east of the east breakwater. However, direct wave action may tend to scour and undermine the seawalls, because of the way waves reflect off the vertical faces of seawalls. Maintenance of the seawalls is the responsibility of the landowners.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

25 JAN 1993	
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Ma'alaea Small Boat Harbor

Supplemental Environmental Impact Statement

James T. Muratsuchi
Lieutenant Colonel U. S. Army
District Engineer
U.S. Army Engineer District Honolulu
Building 230
Fort Shafter 96858-5440

Dear Sir:

One of the dilemmas today at Ma'alaea Harbor is that we do not know how to keep the waters of the harbor and the surrounding ocean pure enough so that the life-sustaining marine organisms continue to evolve naturally.

We have also been unable to keep Ka Poli Spring, Ma'alaea's natural source of fresh water, functioning and pure.

The Harbor as it is presently configured has destroyed the sandy beach where children once played, altered surf sites that may have been used for 1,000 years, removed the heiau where Hawaiians worshiped, eliminated the sources of food collected by native people. Harbor users have polluted the surrounding waters of not only of Ma'alaea Bay with sewage, chemical and petroleum products, but also have damaged the reefs, commercialized, over used, and degraded the precious resources at Molokini.

Ka Poli Park has been severely impacted by the harbor.

The shells of the immediate area and Ma'alaea Bay in general have suffered heavily from harbor construction and impacts of subsequent harbor users.

Noise pollution from boat operators is an ongoing problem.

Traffic congestion is severe.

The well-being of our environment and and our island community is at stake.

Please address these issues related to both the social and the natural environment in your Final Environmental Impact Statement (FEIS).

All projects which are related to Ma'alaea Harbor expansion must be integrated into your FEIS.

Please examine the impact to
- Native Hawaiian rights
- the total bay because the boats use the entire bay, Molokini
- Kaho'olawe
- the fishery resources
- shells
- limu
- turtles
- surf sites
- surfers

the community.

No harbor projects, excepting specific solutions to the sewage and fuel problems, should commence until the completion and approval of the FEIS.

No land use designations on the state or county community plans shall be changed. Land Use Commission or County Planning Commission hearings regarding Ma'alaea Harbor shall not be held until the FEIS is completed and approved.

Natural environment

AIR

Please show: how will the air not be increasingly poisoned by the smoke, odors, dust, fumes, chemicals and other pollutants from the increase in boats, service vehicles to the boats, buses and cars using the harbor?

Please provide: baseline data on the state of present air pollution in the harbor.

Please provide: information on what steps are being taken to correct the present problem.

How long will correction take?

How much will it cost (environmental, medical, household, business, etc.)?

Who will pay the bill?

WATER

Please account for the present state of Ka Poli Spring.

How will Ka Poli Spring not be further impacted by the proposed development?

Please provide a baseline study of the state of water in the harbor, a number of places in Ma'alaea Bay, Molokini, and Kaho'olawe.

How will harbor and Ma'alaea Bay's waters not be increasingly poisoned by the proposed development?

Who will monitor water quality?

What will the cost of monitoring be? Who will pay?

MALACOLOGY

An inventory needs to be made of shells in the harbor area found prior to 1952 when the harbor was built.

An inventory needs to be made of shells present in Ma'alaea Bay.

The impact of proposed expansion on present and future shell populations needs to be analyzed.

Please examine all alternatives to disruption of the life cycle of

25 JAN 1993
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ED-P

January 22, 1993

James T. Haratsuchi
Lieutenant Colonel U. S. Army
District Engineer
U. S. Army Engineer District Honolulu
Building 230
Fort Shafter, Honolulu, O'ahu 96858-5440

The Protect Ma'alaea Coalition would like the Final Environmental Impact Statement (FEIS) for Ma'alaea Small Boat Harbor to give primary consideration to public safety.

The FEIS should assure that construction be limited to what is vital and necessary to assure public safety, protect or against storm surge, protect in property and human life.

The FEIS should assure protection of the fragile littoral and bay environment.

Native Hawaiian rights shall be defined and assured by any action suggested by the FEIS.

All littoral and marine resources (including microscopic life forms, coral, fish, marine mammals, limu, mollusks, echinoderms, fleshy algae, and coralline algae) shall be documented and assured continual protection, conservation and preservation in perpetuity by the FEIS.

The carrying capacity of Ma'alaea Bay, Molokini's waters and Kaho'olawe's waters shall be established by the FEIS. The correlation between the proposed number of boats and the carrying capacity of the Bay and surrounding islands' waters shall be specified in the FEIS.

shells.

Mitigation plans need to be submitted to deal with shell life.

ALL OTHER MARINE LIFE FORMS

Fish, coral, the range of marine mammals, turtles, plankton, limu, microscopic creatures and other life forms in Ma'alaea Bay must be inventoried, the impact of harbor expansion on them analyzed, and alternatives to harbor expansion considered. Mitigation measures must be designed.

An independent study of the endangered Humpback whale needs to be made by scientists who are not operating a commercial business from Ma'alaea Harbor, so no appearance of conflict of interest exists.

Aloha,

Lesley Ann Bruce
January 22, 1993

RR 1 Box 120 Apt. 120
Wailuku, Maui.
Hawaii 96793.

Fishermen who fish for a living shall be given priority in the awarding of boat slips.

Assurance of limitation of commercial expansion and commercial exploitation of the fragile natural resources must be in place before harbor improvements are undertaken.

The FEIS shall assure preservation and/or restoration of surf sites.

Native Hawaiian spiritual and cultural resources impacted by past or present harbor construction shall be documented, preserved and/or restored.

The FEIS shall assure that native Hawaiian resources are not impacted at Ma'alaea.

The State Department of Transportation shall work with other state agencies to remove alien plants and ungulates from upland ceded lands surrounding Ma'alaea to stop siltation of Ma'alaea Bay.

Upland ceded lands shall be seeded and reforested with native Hawaiian vegetation.

Fields between Ma'alaea Bay and Mauna Kahalawai shall be seeded and reforested with native Hawaiian vegetation to stop agricultural pollution of Ma'alaea Bay.

Sewage pump out facilities must be constructed immediately and be strictly regulated to stop the continual pollution of Ma'alaea Bay.

Land transportation and traffic impacts must be studied to assure public safety.

Inside and Outside construction at the harbor must both be presented in the FEIS to give total information on impacts, alternatives and mitigative measures. The federal improvements cannot be separated from the state improvements. Every aspect of proposed construction must be included in the FEIS.

Estimates of how many boats can move simultaneously within the harbor must be included. Estimated of how many boats can exit and enter the harbor in a given amount of time must be included.

Suggested plans for precautions during natural disasters, and how the proposed plan provides for public safety need to be included.

The state and federal officials shall include native Hawaiians on all Citizens Advisory Committees dealing with harbor issues.

The state and federal officials shall include all other interested parties on all Citizens Advisory Committees dealing with harbor issues.

Such Committee meetings shall be publicly noticed.

Timetables of proposed improvements must include information on when the state plans to file a condemnation proceeding against owners of Milowai, Ma'alaea Yacht Marina and Ma'alaea Mermaid to gain a construction easement and terminate their littoral rights. Such timetables shall be included in the FEIS.

The FEIS must delineate estimates of what these court proceedings will cost the state. Such costs shall be incorporated into the cost of the harbor.

The FEIS must delineate estimates of costs of a construction easement.

The FEIS must delineate estimates of costs of termination of littoral rights and include these in the cost of the harbor.

The FEIS shall include expansion of landing ramps to assure total access of Coast Guard vessels when other boats are being hauled out.

The FEIS shall verify the number of tourist operations at the harbor.

The FEIS shall verify the number of commercial fishermen.

The FEIS shall verify the number of subsistance fishermen.

The FEIS shall verify the number of recreational boaters.

Thank you for your inclusion of these issues in your Final Environmental Impact Statement for Ma'alaea Small Boat Harbor.

Very truly yours,

Lesley Ann Bruce

Protect Ma'alaea Coalition
Lesley Ann Bruce, Treasurer

RR 1 Box 388 Apt. 120
Ma'alaea Beach Road
Wailuku, Maui, HI 96793

January 22, 1993

James T. Maratsuchi
Lieutenant Colonel U.S. Army
District Engineer
U.S. Army Engineer District Honolulu
Building 230
Fort Shafter, Honolulu, O'ahu 96858-5440

Dear Sir:

Attached is "Ma'alaea Harbor Conceptual Layout" from the SEIS.

Please note that the parking lot at the left is laid out on what is a gulch with vertical sides.

This land, KaPoli Park is needed as park land at Ma'alaea by Maui's people.

Please examine alternative locations in your Final Environmental Impact Statement for Ma'alaea Small Boat Harbor.

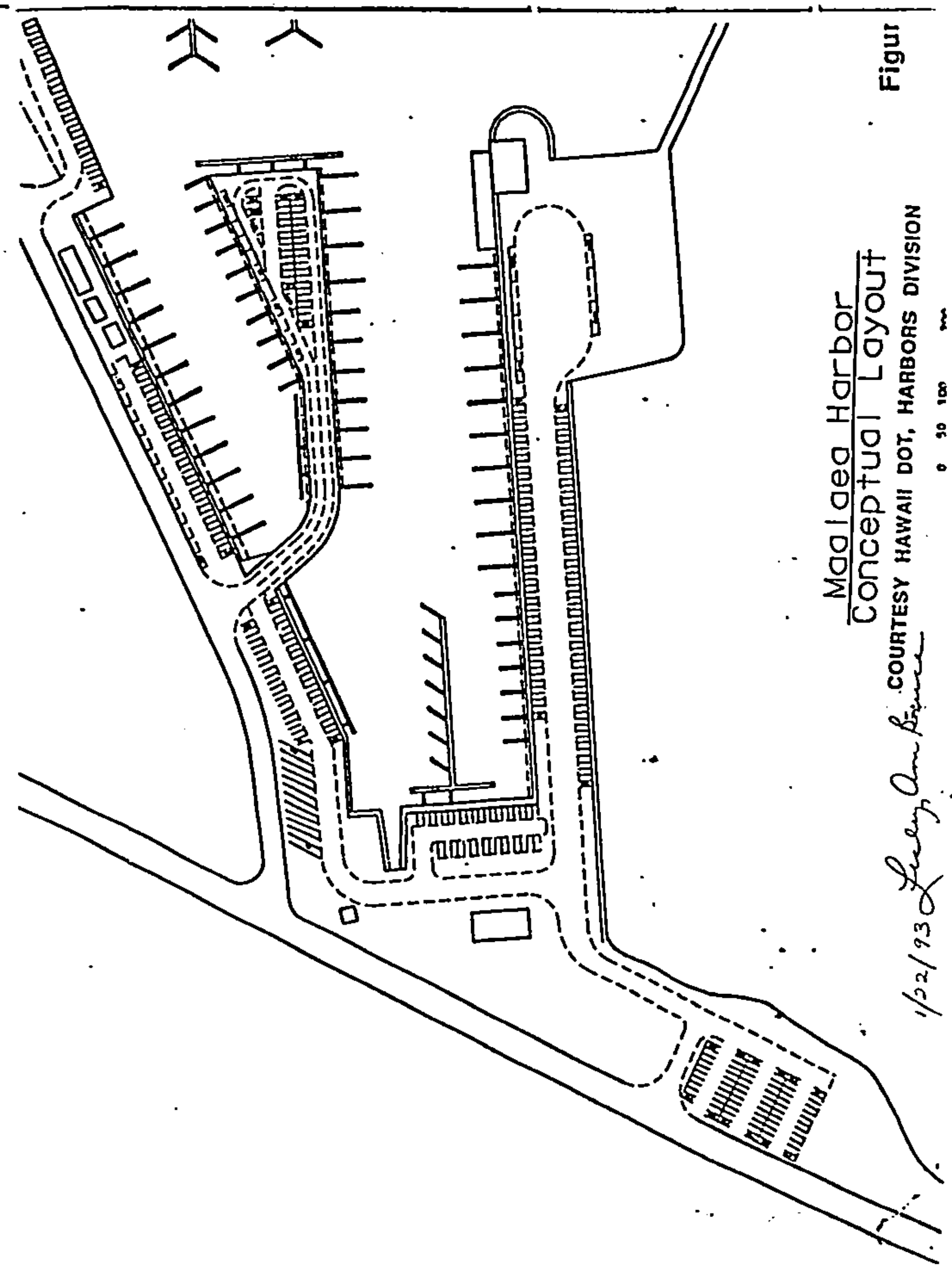
Please include a consideration of the Ma'alaea Triangle, or a portion of it for parking, since this parcel on the mauka side of Ma'alaea Road (on which the Jinsha Shrine is located, and the rest of the 18 acres) is for sale.

Thank you for your consideration.

Sincerely,

Lesley Ann Bruce

R.R. #1 Box 388, Apt. 120
Ma'alaea Beach Road
Wailuku, Maui HI 96793



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1/22/93 Lesley Ann Bruce

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Lesley Ann Bruce, Treasurer
Protect Maalaea Coalition
Rural Route 1, Box 388, Apartment 120
Wailuku, Maui, Hawaii 96793

Dear Ms. Bruce:

Thank you for your letter dated January 22, 1993 commenting on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. The following paragraphs follow the order of your specific comments:

a. The main purpose of this project is to provide improvements to Ma'alaea Harbor to reduce surge in the harbor and navigation hazards. The extension of the south breakwater provides protection from southerly swells and waves, which the present configuration does not. Although the *safety* of boaters is the major consideration, other important considerations are involved, such as convenience and efficiency of the operations.

b. In addition to providing design changes necessary for public safety, protection against surge, protection of property and human life, the project will also provide infrastructure improvements such as sewage pump-out facilities, water, electricity, and parking.

c. The FSEIS discusses the potential effects of the proposed project and where necessary describes mitigation measures to avoid, minimize or compensate for those effects. See section 5-19 of the FSEIS for details.

d. The harbor improvement project is not expected to have any effect on Native Hawaiian rights.

e. Aquatic resources of the area are addressed in more detail in Chapter 4 and by the U.S. Fish and Wildlife Service report in Appendix A, to assist in making a reasonable assessment of project effects.

f. The carrying capacity of the waters of Ma'alaea Bay, Molokini and Kaho'olawe would be very difficult if not impossible to determine, and would vary with the activity. Much of the activity in these waters is non-consumptive, so that the carrying capacity is almost unlimited. Many of the boats which will be berthed in the harbor are presently moored it local waters, or trailered, and currently operate in the bay and adjacent waters. Until berths are actually assigned, there is no way to determine how many new boats will be operating in these waters, so that even if a carrying capacity could be determined, there would be no way to correlate the carrying capacity with the harbor improvements. However, the anticipated effects of the proposed action on the physical, biological and social conditions are described in the FSEIS.

g. This issue is beyond the scope of the FSEIS, which is to assess the effects of the proposed action and alternatives. The Division of Boating and Ocean Recreation, State of Hawaii Department of Land and Natural Resources, determines the priority in awarding slips. The priority does not consider occupation. Fishermen will not be given priority based on their occupation.

h. As described in section 5-19 of the FSEIS, mitigation measures to offset adverse effects will be implemented either prior to or concurrently with project construction. There will be an expansion of commercial activity with the expansion of the harbor.

i. Design modifications have been made in order to avoid, to the extent practicable impacts to surf sites. In addition, mitigation measures to compensate for the unavoidable effects are being studied. The expected effects of the project on the surf breaks adjacent to the harbor were identified in Chapter 5 of the draft SEIS and are again identified in Chapter 5 of the FSEIS.

j. There will be no additional cultural resources material included in the FSEIS. As stated in the draft SEIS, there are no man-made remains of Native Hawaiian cultural resources in the harbor area except the two stone artifacts in front of Buzz's restaurant. The harbor improvements will have no effect on those artifacts. The State of Hawaii Historic Preservation Officer (SHPO) has concurred with the Corps' determination that the harbor improvement project will have no effect on historic properties.

k. There are no Native Hawaiian resources other than those identified in the draft SEIS known to exist in the area of potential effect. The SHPO has concurred with the Corps' determination that the harbor improvement project will have no effect on historic properties.

l. These items are not appropriate for inclusion in this project SEIS. The harbor improvements will have no effect on these areas, nor will the areas have an effect on the harbor, after completion of the project, which will be different from the present effect.

m. Sewage pump out facilities are an integral part of the infrastructure improvements which the State of Hawaii sponsor will provide as funds become available. As shown in Table 2 of the FSEIS, these facilities are scheduled to be completed prior to the construction of the additional berths.

n. Land transportation and traffic impacts were studied and the results included in the draft SEIS. As appropriate, additional information has been included in the FSEIS.

o. Information concerning both the Federal portion of the project and the State of Hawaii portion were included in the draft SEIS. Not every aspect of the proposed construction can be included in the SEIS. It is a planning document, and cannot contain the level of detail which the construction plans and specifications contain. The final SEIS contains the level of detail sufficient to assess the effects of the project on the significant resources of the area. Additional environmental documentation may be prepared by the State in the future for some of their planned improvements.

p. The number of boats which can move within the harbor at one time, or exit or enter in a given amount of time does not appear to be related to any effect of the improvement project on significant environmental resources, and has not been included in the final SEIS. However, DBOR may have information concerning its criteria for harbor development.

q. Operational plans for the harbor, unless directly related to an environmental impact, are not required to be included in the SEIS. Harbor operational plans may be obtained from the Ma'alaea Harbor Master or from the Division of Boating and Ocean Recreation of the Department of Land and Natural Resources. The proposed action is not expected to affect natural disasters; therefore, this issue is not included in the FSEIS.

r. There is no Citizens Advisory Committee dealing with harbor issues. There is a Boating Advisory Group which meets monthly with the Regional Boating Manager to discuss matters dealing with harbors and launch ramps, and is commonly referred to as a "users group." These meetings are open to the public. There have been other meetings held with the general public and interested groups as stated in Chapter 7 of the draft SEIS.

s. Condemnation proceedings against owners of Milowai, Ma'alaea Yacht Marina and Ma'alaea Mermaid are not being considered at this time. It is not believed that legal action to obtain a construction easement is required, and the State of Hawaii already possesses the littorial rights for the real estate abutting the area where harbor improvements will be constructed.

t. The expansion of launch ramps is not part of the present improvements planned for Ma'alaea Harbor.

u. This information was contained in the draft SEIS, Appendix F, Economic Analysis, and is contained in the same appendix of the FSEIS.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Lesley Ann Bruce
Rural Route, Box 388, Apartment 120
Wailuku, Maui, Hawaii 96793

Dear Ms. Bruce:

Thank you for your letter dated January 22, 1993 commenting on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. The following paragraphs follow the order of your specific comments.

a. Although the waters in Ma'alaea Harbor are frequently turbid, there is no evidence to indicate that the harbor has contributed to the decline of aquatic resources in Ma'alaea Bay. The Hawaii Department of Health is currently leading a study to determine the causes of water quality degradation due to algae blooms and recommend corrective measures.

b. Your comment regarding Ka Poli Spring is noted; however, whether the spring was functioning at the time of original harbor construction is not known. Because the spring would not be affected by the proposed project, it has not been addressed in the final SEIS.

c. The Corps is not aware of any information which would indicate that the harbor has caused damage to resources in the surrounding area. The final SEIS describes the environment as it exists today, since this baseline environment is what may be affected by the project.

d. The area you refer to as Ka Poli Park is actually unimproved, vacant land owned by the State of Hawaii and under the control of the Department of Land and Natural Resources, Division of Boating and Ocean Recreation (DBOR). Although the Kihei/Makena Community Plan identifies that area for a park, discussions with the County Parks Department indicated they had no current plans to improve the area. DBOR is developing tentative plans to use the area for parking, and to provide some park-type amenities.

e. There is evidence that mollusks have declined throughout Ma'alaea Bay, but there is no evidence suggesting the harbor is to blame. Rather, the Hawaiian Shell News of November 1977 speculates that the "blight" was caused by "sewage and waste water from the recent "bloom" of developments along the shore."

f. There seems to be some difference of opinion among residents of the area. Some speak of the peace and tranquility of the area, while others complain of the noise from the boats. In general, the noise made by the wind is the dominate sound around the harbor. If there is excessive noise early in the morning or late at night, the harbor master or Harbor Patrol should be contacted to take enforcement action.

g. There is traffic congestion in, and approaching, the harbor at times. A study of the traffic was performed and results reported in the draft and final SEIS.

h. Your comment is noted: however, this project will have very little environmental impact, and certainly the well-being of the environment and community of Maui is not contingent upon this project.

i. Social issues, if any, are addressed in the context of the environmental effect that caused the social impact.

j. Information concerning both the Federal portion of the project and the State of Hawaii portion were included in the draft SEIS. Not every aspect of the proposed construction can be included in the SEIS. It is a planning document, and cannot contain the level of detail which the construction plans and specifications contain. The final SEIS contains the level of detail sufficient to assess the effects of the project on the significant resources of the area.

k. The harbor improvement project is not expected to have any effect on Native Hawaiian rights.

l. Much of the activity in these waters is non-consumptive, so that the increase in the number of boats berthed in Ma'alaea Harbor is not expected to have a significant impact on the resources of Ma'alaea Bay. Many of the boats which will be berthed in the harbor are presently moored in local waters, or trailered, and currently operate in the bay and adjacent waters.

m. Aquatic resources of the area are addressed in more detail in Chapter 4 and the report of the U.S. Fish and Wildlife Service in Appendix A, so that a reasonable assessment of project effects can be made.

n. The harbor improvements are not expected to have a significant effect on marine turtles. A Biological Opinion was received from the National Marine Fisheries Service (NMFS) and included in the draft and final SEIS. Later correspondence between the Corps and NMFS concerning hawksbill turtles and Hawaiian monk seals is also included in the final SEIS.

o. The impact on surfing was well documented in the draft SEIS and is again documented in the final SEIS.

p. There are some harbor improvements which have been previously approved and are not connected with the present project, such as paving and restriping parking areas. These improvements will not be included in the SEIS.

q. There are no plans at present to request land use changes; however, if such action is taken in the future, it may be independent of the harbor improvement project.

r. Air quality is good at Ma'alaea. The State of Hawaii Department of Health does not monitor air quality there, because there is no indication of an air quality problem.

s. There is presently no spring in the immediate harbor area. If Ka Poli Spring was flowing at the time the harbor was built, it was likely destroyed during harbor construction.

t. Ka Poli Spring no longer exists as a functioning spring at the harbor, and therefore cannot be impacted by the improvements to the harbor.

u. (See sub paragraph e.) The harbor improvements are not expected to have an effect on the mollusks of Ma'alaea Bay. There is evidence that mollusks have declined throughout Ma'alaea Bay, but there is no evidence suggesting the harbor is to blame. No additional effort will be expended on molluska research for this project.

v. Aquatic resources of the area are now identified in sufficient detail so that a reasonable assessment of project effects can be made.

w. The National Marine Fisheries Service rendered a Biological Opinion before the report by the Pacific Whale Foundation was prepared. The report is a compilation of data the Foundation has gathered over several years, and was provided for information to the public and decision makers. The data in the report had nothing to do with the decision by NMFS concerning the effects of the project on humpback whales. Another study of humpback whales is not needed for this project.

Sincerely,

Ray H. Jyo, P.E. for
Director Engineering

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Lesley Ann Bruce
Rural Route 1, Box 388, Apartment 120
Wailuku, Maui, Hawaii 96793

Dear Ms. Bruce:

Thank you for your letter dated January 22, 1993 commenting on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. The following paragraphs follow the order of your specific comments:

a. The parking lot layout shown in the parcel of land you have identified as *Ka Poli Park* is a conceptual plan only. It is not intended to be a detailed site design. Both the Corps and the Department of Land and Natural Resources, Division of Boating and Ocean Recreation are aware of the gulch which passes through the area. During the detailed design, provisions will be made for crossing the gulch if required.

b. As stated in the draft and final SEIS, the land you identify as Ka Poli Park is part of Ma'alaea Harbor, and will be used for harbor purposes. The Division of Boating and Ocean Recreation is tentatively planning to add park-type amenities among the parking areas if it is decided to use this area for parking.

c. Alternative locations for Ma'alaea Small Boat Harbor have not been considered in detail. The cost and environmental effects of developing a harbor in a new location would be much greater than for the proposed improvements to the present harbor. Creation of a new harbor also conflicts with federal and State policies regarding coastal zone management.

d. One of the General Partners of the Ma'alaea Triangle Partnership was contacted, and he stated that the Partnership is not actively trying to sell the property, but that the Partnership would consider an offer if one was made. He declined to state a price at which they would seriously consider selling the property; however, the property is appraised at over $10 million for tax purposes. A price in this range makes this purchase not practicable for the State sponsor.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

25 JAN 1993	
HED	TDY
DHED	TB 1/25
SECY	✓
CLK-TYP	✓
ED-P	

Maalaea Banyans
190 Hauoli St.
Maalaea Harbor HI 96793
January 22, 1993

James T. Muratsuchi
Lieutenant Colonel U.S. Army
District Engineer
U.S. Army Engineer District Honolulu
Building 230
Fort Shafter HI 96858-5440

Dear Sir:

Regarding the Environmental Impact Statement for Ma'alaea Small Boat Harbor I would like to respectfully request that you address the preservation of Kapoli Park at the Harbor.

Also, please address the effect of the change in harbor configuration on the sand at the small beach park at the end of Hauoli St.

Thank you for your consideration.

Sincerely,

Regina M. Finnegan

Regina M. Finnegan

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Regina M. Finnegan
Maalaea Banyans
190 Houoli Street
Maalaea Harbor, Hawaii 96793

Dear Ms. Finnegan:

Thank you for your letter of comment dated January 22, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments:

a. The unimproved area you identify as Kapoli Park is part of the Ma'alaea Harbor and will be used for harbor purposes as stated in both the draft and final SEIS. The Department of Land and Natural Resources, Boating and Ocean Recreation Division, is tentatively planning to use that area for parking, with some park-like features included.

b. The change in harbor configuration is not expected to have any effect on the sand at the small beach park at the end of Hauoli Street.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

University of Hawaii at Manoa

Environmental Center
A Unit of Water Resources Research Center
Crawford 317 • 2550 Campus Road • Honolulu, Hawaii 96822
Telephone (808) 956-7361

January 29, 1993
RE:0618
REVISED

Governor, State of Hawaii
c/o Office of Environmental of Quality Control
220 South King Street, Suite 400
Honolulu, Hawaii 96813

Dear Governor:

Draft Supplemental Environmental Impact Statement (SEIS)
Maalaea Harbor for Light-Draft Vessels
(Joint State/NEPA Draft EIS and Addendum)
Wailuku, Maui

The Honolulu District of the U.S. Army Corps of Engineers, sponsored by the State of Hawaii, Department of Transportation, Harbors Division is proposing to improve the existing light-draft harbor at Maalaea, Maui. At this time a preferred alternative has not been selected. As funds are provided by the Hawaii State legislature, the local sponsor (DOT) will incrementally provide: 1) an interior revetted mole and a berthing area 8 feet deep adjacent to the existing eastbreakwater; 2) parking, water, electricity, fuel and restroom facilities; and 3) an increase of approximately 130 berths. Negative impacts are expected to occur to surf sites, traffic, and biological resources including endangered species.

The Environmental Center has reviewed the referenced document with the assistance of Jon Matsuoka, School of Social Work; Paul Ekern, (Emeritus) Water Resources Research Center; and Alex Buttaro, Environmental Center.

General Comments

The Draft SEIS for the Maalaea Harbor improvements contains a number of very thorough and well designed appendices that cover most, if not all, the technical issues relative to the potential impacts of the proposed Harbor modifications. What is not so easy to discern from the body of the Draft SEIS is the interaction between these various issues and the community at large. It would be helpful if the Final SEIS would expand on the material presented in Chapter 5, Environmental Consequences (Environmental Impacts of the Proposed Action) and discuss, at least in summary form, the relationships of the various impacts and issues presented in the Appendices to the affected community.

Affected Environment

Since the wind direction is such a key factor in the wave characteristics of the surf sites, it is important that a full discussion of the wind patterns be included in the Final SEIS. In this regard, a discussion of the changing offshore-onshore sea breeze pattern between day and night should be included. Figure 11 page 18 is cited as adapted from Moffatt and Nichol August 1992. The same figure is included in Appendix A of Appendix E (fig. 2-4) as from Walker, 1974. It would probably be more appropriate if the original citation were carried for both figures, i.e. Walker, 1974.

Hurricane "Iniki" created significant changes in the nearshore bottom topography on the west coast of Oahu and in some coastal areas off Lanai. Have there been any measurements of the nearshore bottom topography around Maalaea Bay since "Iniki" that might modify the present plans, operations or impacts of the alternative harbor designs?

Most of the proposed alternatives would significantly modify the present physical characteristics of the Harbor. They would add or remove breakwaters and revetted moles or alter depths and widths of the entrance channel. There is no indication in the present document if the effects of these changes on tsunami run-up in the harbor or adjacent shoreline have been evaluated. If the tsunami hazard has not been examined relative to these physical modifications, we would suggest that such computations be made or the appropriate computer models run so that the results can be considered in the final design of the harbor.

Threatened and Endangered Species (Section 5.2.3)

We note that Maalaea Bay is one of two areas designated by the National Marine Fisheries Service (NMFS) for more strict approach limits to Humpback Whales (300 vs. 100 yards). It is apparent from the Draft SEIS that while many studies have been undertaken relative to the ecology and behavior of the Whales, many unanswered questions remain. Thus, it seems appropriate for the NMFS and the state to be conservative in their management of this coastal water area. In this regard, what criteria will be used by DOT or DLNR to implement the various recommendations put forth by NMFS (page 26) to mitigate adverse effects of this project on the Humpback Whales?

Socio-economic Issues

Hawaii's Coastal Zone Management (CZM) program requires that any agency action that damages or destroys surfing sites must also provide replacement or adequate monetary compensation. Section 205A-2(c)(1)(B), HRS, states that the State of Hawaii's CZM policy seeks to:

Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by: ...(ii) Requiring replacement of coastal resources having significant recreational value, including but not limited to surfing sites and sandy beaches, when such resources will unavoidably be damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable....

1) To what extent will the proposed project comply with the cited CZM policy?

2) If non-compliance with Section 205A-2(c)(1)(B) is expected, the Final SEIS should include the rationale for such a decision.

Our reviewers noted that the socio-economic issues were discussed throughout the various appendices. No separate social impact assessment (SIA) was included. We understand that previous environmental documents pertinent to this project may have addressed some of these issues. If an SIA was conducted previously then a summary of the findings should be included in this document. If not, the Final SEIS should include a summary discussion of the social implications of this action on the communities affected. For example, can some estimates be made of the relative importance of the Maalaea surf sites to the surfing community as compared to other sites on Maui?

Alternatives

Given the importance of the surfing sites to the local community and the significance of Maalaea Bay to the Humpback Whales, it appears that expansion of the present harbor will result in permanent, long term and unmitigatable impacts. With this in mind, it seems essential that a greater discussion of alternative sites be included in the Final SEIS or that the rationale for non-address of alternative sites be provided.

Thank you for your time and consideration of our comments.

Sincerely,

Jacquelin N. Miller

Jacquelin N. Miller
Associate Environmental Coordinator

cc: OEQC
Randal Ioong, DOT
William Lennan, COE
Roger Fujioka
Paul Ekern
Jon Matsuoka
Alex Buttaro

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Jacquelin N. Miller,
Associate Environmental Coordinator
The Environmental Center
University of Hawaii at Manoa
2550 Campus Road, Crawford 317
Honolulu, Hawaii 96822

Dear Ms. Miller:

Thank you for your letter of comment dated January 29, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments:

General Comments

The final SEIS presents expanded summaries of the technical studies and other information contained in the appendices. These summaries include brief descriptions of study purpose, assumptions, evaluation and project impacts.

Affected Environment

The discussion of wind patterns in the project area has been expanded. We did not feel it was necessary to distinguish between day and night wind patterns with respect to effects on surfing sites, since the waves are not wind-driven. The citation for Figure 11 has been changed as you requested.

No measurements of the nearshore bottom topography have been completed since Hurricane Iniki. However, no observable changes are known that would affect the project design, construction, or operation.

In-house analysis of the effectiveness of each alternative plan on existing surge and navigation conditions indicates that the proposed modifications would have no effect on tsunami run-up.

Threatened and Endangered Species

The Department of Land and Natural Resources, the agency now responsible for small boat harbors, has agreed to the mitigation measures recommended by the National Marine Fisheries Service. Exact details of the mitigation will be developed during coordination between the two agencies, with input from the Corps as appropriate.

Socioeconomics

Compliance with the Coastal Zone Management policies of the State will be determined by the state after release of this final SEIS. Section 5.14 presents the conclusions that the proposed action would be consistent with most of the policies of the CZM, but that it would be unavoidably be inconsistent with other policies and objectives. The proposed navigation improvements would destroy one surf site and modify another in an unknown way. Potential measures to mitigate those effects are being considered and are listed in the final section of Chapter 5, Environmental Consequences. Requirements for mitigation of the surf sites will be determined during further coordination with the State's Coastal Zone Management Office.

A separate Social Impact Assessment was not conducted for this project, since in general, social impact assessments are not required by either NEPA or HRS 343 rules. Socioeconomic impacts have been identified to the extent that physical effects would indirectly cause social effects (air quality, water quality, loss of recreation sites, etc.).

Alternatives

A complete discussion of alternatives considered in detail and those eliminated from further consideration is presented in Chapter 3, Alternatives. Alternative locations for a harbor were not considered feasible because of cost and the virtual certainty of significant environmental effects. All reasonable alternatives for reducing navigation and surge problems within the harbor were considered. Those that were not feasible because of engineering or economic factors were eliminated.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Affairs
600 Harrison Street, Suite 515
San Francisco, California 94107-1376

ER 92/1122

February 1, 1993

Lieutenant Colonel James T. Muratsuchi
District Engineer
U.S. Army Engineer District, Honolulu
Attention: CEPOD-ED-PV/Lennan
Building 230
Fort Shafter, HI 96858-5440

Re: Draft Supplemental Environmental Impact Statement for Maalaea Harbor For Light-Draft Vessels, Maui, Hawaii (ER #92/1122)

Dear Lieutenant Colonel Muratsuchi:

The U.S. Fish and Wildlife Service (Service) has reviewed the November 1992 Draft Supplemental Environmental Impact Statement (DSEIS) for the Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii. The following comments are provided for your consideration pursuant to the National Environmental Policy Act of 1969, as amended, (42 U.S.C. 4321 et seq), the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and other authorities mandating Service concern for environmental values.

The DSEIS does not address potential adverse impacts to aquatic resources from the proposed project construction which the Service provided in our Planning Aid Letter (PAL) dated April 21, 1991. The DSEIS also lacks information on potential mitigation measures to offset losses to reef flat communities in the proposed project area.

The Service's PAL specifically states that dredging associated with the proposed project will result in the direct loss of habitat for corals, other macroinvertebrates, fishes, and benthic algae. The PAL addressed secondary impacts to reef corals from increased levels of suspended sediments and turbidity generated by the dredging and from the dewatering of the dredged spoils. Initial recommendations for mitigation including the construction of a large shallow-water artificial reef and the perpetual protection and management of additional reef-platform habitats within Maalaea Bay were also presented in the Service's PAL.

The Pacific Islands Office will complete quantitative studies of the aquatic resources at the proposed project site and will prepare the Service's draft Coordination Act Report under the authority of and in accordance with the provisions of Section 2(b) of the Fish and Wildlife Coordination Act (draft 2(b) Report) during Fiscal Year 1993.

The Service will evaluate all of the proposed alternatives discussed in the DSEIS and provide further information in our draft 2(b) Report on how each alternative will directly impact aquatic resources in the project area. The Service will make specific recommendations for a project alternative which avoids or minimizes adverse impacts to these resources and will recommend appropriate mitigation measures to offset any unavoidable resource losses associated with the proposed project. Service recommendations to protect important aquatic resources in the project area should be given full consideration in the Final EIS for the proposed project.

We appreciate the opportunity to provide these comments.

Sincerely,

Patricia Sanderson Port
Regional Environmental Officer

cc:
Director, OEA w/original incoming
Regional Director, FWS, Portland
FWS, Pacific Islands Office (Evans)

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Ms. Patricia Sanderson Port
Regional Environmental Officer
U.S. Department of the Interior
600 Harrison Street
San Francisco, California 94107-1376

Dear Ms. Port:

Thank you for your letter of comment dated February 1, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light Draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your detailed comments:

a. The final SEIS incorporates the evaluations and conclusions provided in the Fish and Wildlife Service's draft Fish and Wildlife Coordination Act Report (contained in Appendix A of the final SEIS) and other studies related to marine resources. These evaluations and conclusions address impacts to coral habitat, macro invertebrates, fishes, benthic algae, and other marine organisms. Recommended mitigation measures have also been included in a section at the end of the Environmental Consequences chapter.

b. The final SEIS responds to the Fish and Wildlife Service's requests in its draft Fish and Wildlife Coordination Act Report for additional information concerning Alternative 6. The final Fish and Wildlife Coordination Act Report can now be completed.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

1. PH
2. PV

In reply, please refer to:

February 1, 1993

92-429/epo

Mr. Kisuk Cheung, P.E.
Director of Engineering
U.S. Army Engineer District, Honolulu
Attention: CEPOD-ED-PV/Lennan
Building 230
Fort Shafter, HI 96858-5440

Dear Mr. Cheung:

Subject: Draft Supplemental Environmental Impact Statement (DSEIS) for Maalaea Harbor for Light Draft Vessels
Maui, Hawaii
TMK: 3-6-01,2, 34, 43, 49, 50 and
TMK: 3-8-14, 28, 31

Thank you for allowing us to review and comment on the subject document. We have the following comments to offer:

Wastewater Branch

The subject project is located in the critical wastewater disposal area as determined by the Maui County Wastewater Advisory Committee. No new cesspools will be allowed in the subject area.

The DSEIS does not address at all the wastewater disposal facilities. The Department of Health is very concerned about the added wastes from the additional berths/boats/people on the existing cesspools. We are also very concerned about the lack of pump-out facilities available for the boats to use to empty their wastewater holding tanks.

For your information the Department of Health's recently amended Administrative Rules, Chapter 11-62, "Wastewater Systems", require the upgrading of existing cesspools when public facilities are renovated. New or upgraded wastewater disposal facilities should be constructed concurrently with the construction of the new harbor facilities. All wastewater plans must conform to applicable provisions of Chapter 11-62.

The Department of Health will refrain from any specific comments on wastewater disposal at this time, until wastewater generation is discussed in a redraft environmental impact statement which should be submitted to the Department of Health for review.

If you have any questions on this matter, please contact Ms. Lori Kajiwara of the Wastewater Branch at 586-4290.

Water Pollution

The construction associated with the proposed project may require a Section 401 Water Quality Certification (WQC). The Army Corps of Engineers, Operations Division should be contacted as soon as possible in order to determine if a Section 401 WQC is applicable to this project.

The final EIS should provide more detail regarding the anticipated impacts to the marine environment associated with the construction activity of the project. The discussion should detail the best management practices to be applied to eliminate or minimize impacts to the marine environment.

If you have any questions on this matter, please contact Mr. Mark Tomomitsu of the Clean Water Branch at 586-4309.

Underground Storage Tanks

Chapter 2 of the document (page 5) makes reference to the present infrastructure being inadequate and lacking fueling facilities and specifies that the "local sponsor" will be making these improvements in the future. If the "local sponsor" will be installing underground storage tanks for these fueling facilities, then the "sponsor" should be made aware that there are design, installation, and notification requirements relating to underground tanks, and they are found in 40 Code of federal Regulations Part 280, Subpart B. In addition, should any project improvement activities result in the discovery of abandoned underground tanks or potential releases from underground tanks, then such events should be reported to the Underground Storage Tank Section at 586-4228 and response actions taken to clean up the release. Finally, the "sponsor" should be informed that the local fire authority may have additional local requirements regarding underground tanks.

If there are any comments regarding this matter, please contact Ms. Kim Savage of the Underground Storage Tank Section of the Solid and Hazardous Waste Branch at 586-4228.

Very truly yours,

JOHN C. LEWIN, M.D.
Director of Health

c: Director of Transportation
Wastewater Branch
Clean Water Branch
Solid and Hazardous Waste Branch
Maui District Health Office

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

John C. Lewin, M.D.
Director of Health
P.O. Box 3378
Honolulu, Hawaii 96801

Dear Dr. Lewin:

Thank you for your letter of comment dated February 1, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments:

a. The Department of Transportation has had for some time a plan to upgrade the sewage treatment facilities at Ma'alaea Harbor, to include pump-out facilities. Funding has already been received to design the modifications; however, detailed design has not yet been completed. The design will comply with the applicable provisions of Chapter 11-62, and the plans will be coordinated with the Department of Health.

b. A Section 401 Water Quality Certification will be requested for this project, and we intend to work closely with the Department of Health to assure compliance with applicable State water quality standards.

c. The final SEIS presents an expanded discussion of the existing marine resources and the potential effects of the proposed federal and State projects. In addition, the final section of the Environmental Consequences chapter discusses mitigation measures that have already been incorporated into the project design and those that could potentially be employed. In addition, best management practices will be included in the contractor's environmental protection plan, which is required by the contract specifications.

d. The Department of Land and Natural Resources, Division of Boating and Ocean Recreation, the local sponsor of this project, has been informed of your concern for underground storage tanks and will coordinate with your staff as necessary.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
P.O. BOX 1109
WAILUKU, MAUI, HAWAII 96793-7109

February 11, 1993

U.S. Army Engineer District, Honolulu
Attn: CEPOD-ED-PV/Lennan
Building T-1
Fort Shafter, Hawaii 96825-5440

Re: Supplemental Environmental Impact Statement for Maalaea Harbor for Light-Draft Vessels; Maui, Hawaii

Dear Mr. Lennan,

The Supplemental Environmental Impact Statement does not address water consumption, or other issues pertaining to water infrastructure. The increase in harbor utilization will generate both primary and secondary increases in water consumption. These impacts should be addressed. If these items were addressed in the 1980 or 1982 documents, such analysis is likely outdated.

The applicant should be made aware that water for construction & other uses, both for land based portions of this project and land based improvements related to this project, may not be available until new sources have been developed to service the area. The project may require substantial system improvements.

Drought & salt tolerant plants should be utilized in landscaped portions of this project.

Sincerely,

for David Craddick
Director

elk

"By Water All Things Find Life"

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

Planning Division

Mr. David Craddick, Director
Department of Water Supply
County of Maui
P.O. Box 1109
Wailuku, Hawaii 96793-7109

Dear Mr. Craddick:

Thank you for your letter of comment dated February 11, 1993 on the draft Supplemental Environmental Impact Statement (SEIS) for Ma'alaea Harbor for Light-draft Vessels, Maui, Hawaii. Your comments were considered during selection of the preferred alternative, and your comments and this response are reproduced in Appendix C of the final SEIS. The responses below follow the order of your comments.

a. Thank you for pointing out our failure to address water consumption in the draft SEIS. The issue is addressed in Chapters 4 and 5 of the final SEIS.

b. As you suggested, drought and salt tolerant plants will likely be used in landscaped portions of this project. Every effort will be made to use native Hawaiian plants.

Sincerely,

Ray H. Jyo, P.E.
Director of Engineering

APPENDIX D

TRAFFIC STUDY

Traffic Impact Study, Maalaea Harbor Expansion, Maalaea, Maui, Hawaii

FINAL

REVISED
TRAFFIC IMPACT STUDY

MAALAEA HARBOR EXPANSION

Maalaea, Maui

Prepared for:
State of Hawaii
Department of Transportation
Harbors Division

Prepared by:
Parsons Brinckerhoff
Quade & Douglas, Inc.

May 17, 1994

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TRAFFIC IMPACT STUDY
MAALAEA HARBOR EXPANSION

INTRODUCTION

The State of Hawaii, Department of Land & Natural Resources, Division of Boating and Ocean Recreation, plans to expand the harbor facilities at the Maalaea Harbor on the Island on Maui. The project will encompass the addition of 130 berths, fueling facilities, sewage improvements, comfort station and additional parking. This study addresses the traffic impacts of the proposed Maalaea Harbor expansion. Descriptions of existing conditions and future conditions, with and without project generated traffic, are included for the average weekday morning (A.M.) and afternoon (P.M.) peak hours. Mitigative measures, where appropriate, are also included.

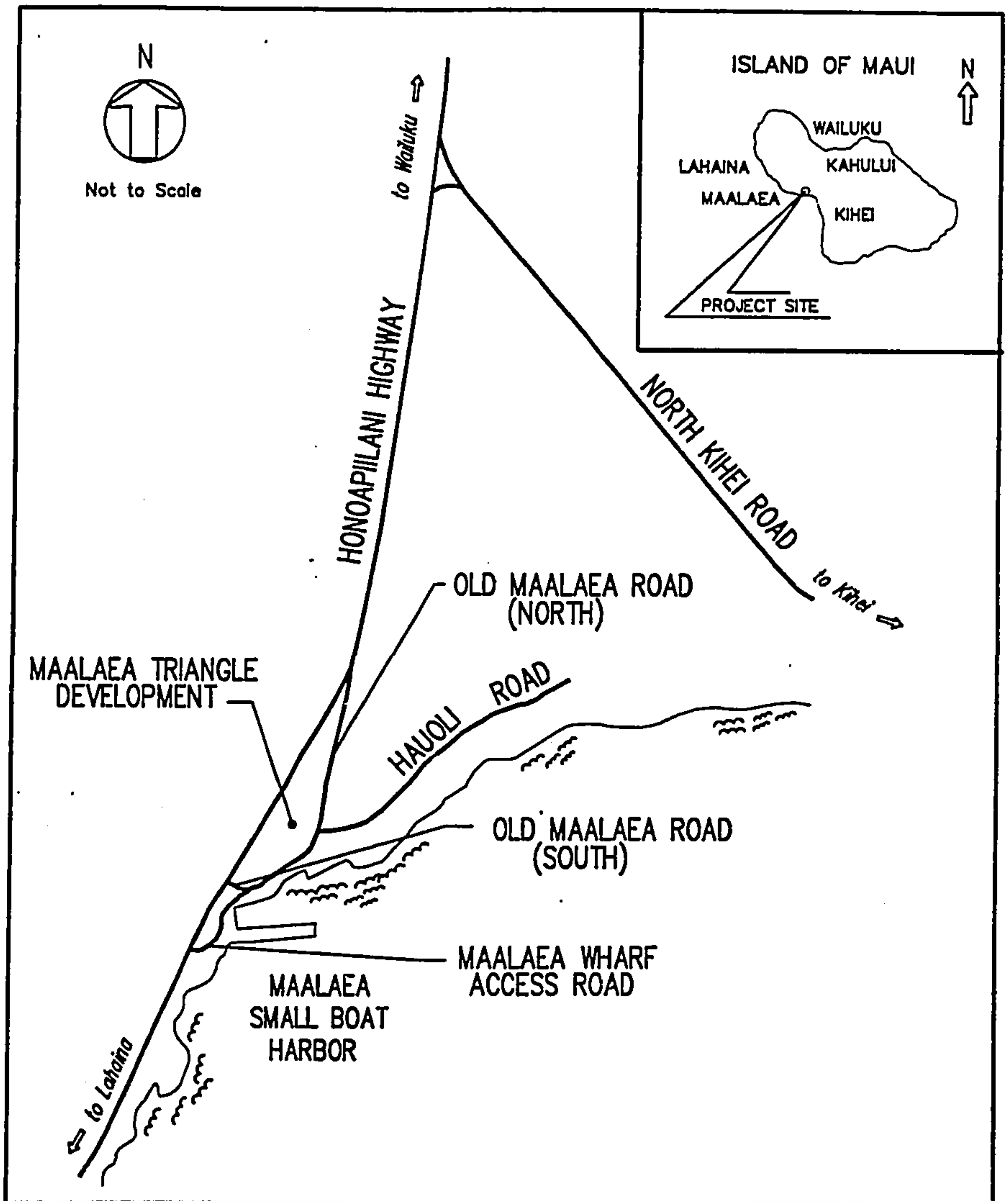
EXISTING CONDITIONS

Maalaea Harbor is located on the southwest shore of the Island of Maui, Hawaii. Situated between the two inactive volcanoes of East and West Maui, it is approximately seven miles south of the County seat of Wailuku and eight miles south of the commercial and business center of Kahului. The harbor is on the western shoreline of Maalaea Bay. Figure 1 shows the location of the proposed project and the surrounding roadway. Currently, Maalaea Harbor consists of approximately 90 berths and a boat launching ramp for use by commercial as well as private vessels.

Roadway System

Honoapiilani Highway is a two-lane state highway providing the only improved highway connection between Central and West Maui. In the vicinity of the proposed project, the posted speed limit is 45 miles per hour.

Old Maalaea Road, a two-lane road providing access to the Maalaea area, intersects Honoapiilani Highway at two locations, approximately 3,000 feet apart. The northern intersection meets the highway at an acute angle, and only turns to or from the Wailuku direction are permitted. Northbound traffic wishing to enter the highway from Old



Parsons Brinckerhoff

LOCATION MAP

Figure 1

4/28/94

Maalaea Road is controlled by a stop sign. A dedicated left-turn lane is provided for left-turns from Honoapiilani Highway entering Old Maalaea Road.

At the unsignalized southern intersection, Old Maalaea Road forms a T-intersection with Honoapiilani Highway. At this intersection, a shared left/right-turn lane is provided for traffic exiting Maalaea Harbor.

At the unsignalized intersection of Maalaea Wharf Access Road and Honoapiilani Highway, located approximately 700 feet south of the Old Maalaea Road's southern intersection, a shared left/right-turn lane is provided for traffic exiting Maalaea Harbor.

Hauoli Road, a two-lane road providing access to the residential area of Maalaea, intersects Old Maalaea Road forming a T-intersection located approximately 1,000 feet south of the northern Old Maalaea Road intersection with Honoapiilani Highway. A shared left/right-turn lane is provided on Hauoli Road at its intersection with Old Maalaea Road.

24-Hour Traffic Counts

24-hour traffic counts were conducted from June 13, 1991 through June 21, 1991. Vehicle approach and departure volumes were taken at several locations and are summarized in Appendix A. During this period, the average daily traffic utilizing Honoapiilani Highway was found to be slightly under 21,000 vehicles per day. From the 24-hour counts, the morning peak was found to be from 6:45 to 7:45 a.m. and the afternoon peak hour found to be from 4:00 to 5:00 p.m. Table 1 summarizes the variations in peak hour volumes for each day of the week along Honoapiilani Highway. Figure 2 graphs the variations in the peak hour volumes versus time of day for each work day along Honoapiilani Highway.

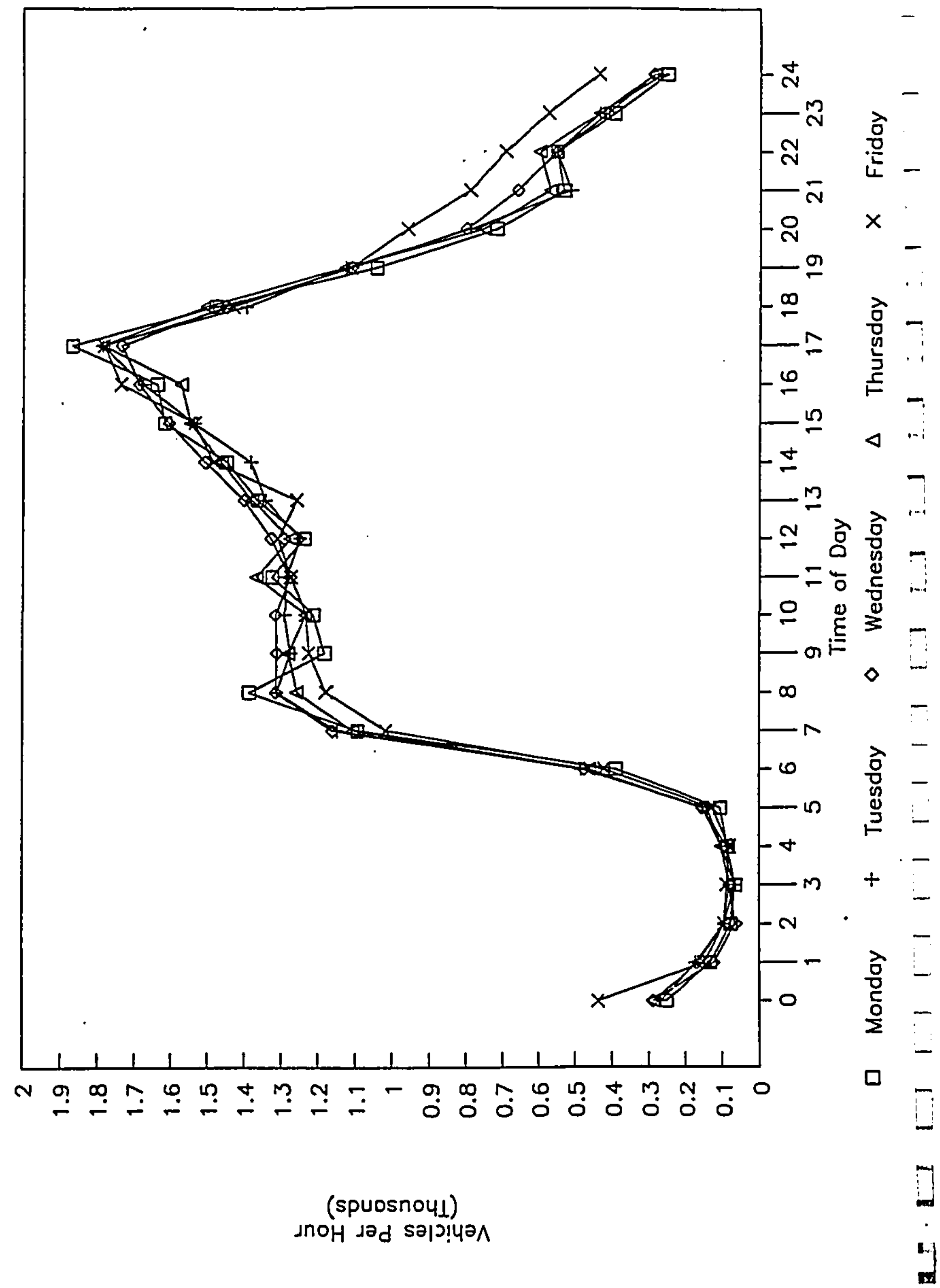
Table 1: Honoapiilani Highway Peak Hour Volumes

DAY OF WEEK	A.M.	P.M.
Sunday	1328	1427
Monday	1441	1867
Tuesday	1320	1819
Wednesday	1338	1763
Thursday	1297	1785
Friday	1224	1838
Saturday	1365	1552

Figure 2

Honoapiilani Highway

Existing 24-Hour Traffic Count



Turning Movement Counts

Existing turning movements counts were also taken in August 1991 at the intersection of Old Maalaea Road with Hauoli Road and at the intersections of Honoapiilani Highway with Maalaea Wharf Access Road, Old Maalaea Road northern intersection, and Old Maalaea Road southern intersection. The morning peak hour occurred from 6:45 - 7:45 a.m. and the afternoon peak was from 4:00 - 5:00 p.m. Summaries of the manual turning movement counts are attached in Appendix B. Existing peak hour volumes are shown in Figure 3.

The unsignalized intersections methodology outlined in the 1985 Highway Capacity Manual[1] was used to evaluate operating conditions at critical intersections. Operating conditions are expressed as qualitative measures known as levels-of-service (LOS). These levels-of-service are designated from A to F, with LOS A representing the best operating conditions and LOS F the worst. Levels-of-service criteria are identified in Appendix C.

At the intersection of Honoapiilani Highway and the Maalaea Wharf Access Road the left-turn movement from Honoapiilani Highway experiences LOS A during the A.M. peak hour and LOS B during the P.M. peak hour. Traffic using the shared left/right-turn lane exiting Maalaea Harbor experiences LOS D and LOS E during the A.M. and P.M. peak hours respectively.

At the southern intersection of Old Maalaea Road and Honoapiilani Highway, the left-turn movement from the highway into Maalaea Harbor operates at LOS A during the A.M. peak hour and at LOS B during the P.M. peak hour. Traffic using the shared left/right-turn lane exiting Maalaea Harbor experiences LOS D and LOS E during the A.M. and P.M. peak hour respectively.

At the northern intersection of Old Maalaea Road and Honoapiilani Highway, the left-turn movement from the highway onto Old Maalaea Road currently experiences LOS A and LOS C during the A.M. and P.M. peak hour respectively. The right-turn movement exiting Maalaea Harbor experiences LOS A during the A.M. peak hour and LOS C during the P.M. peak hour.

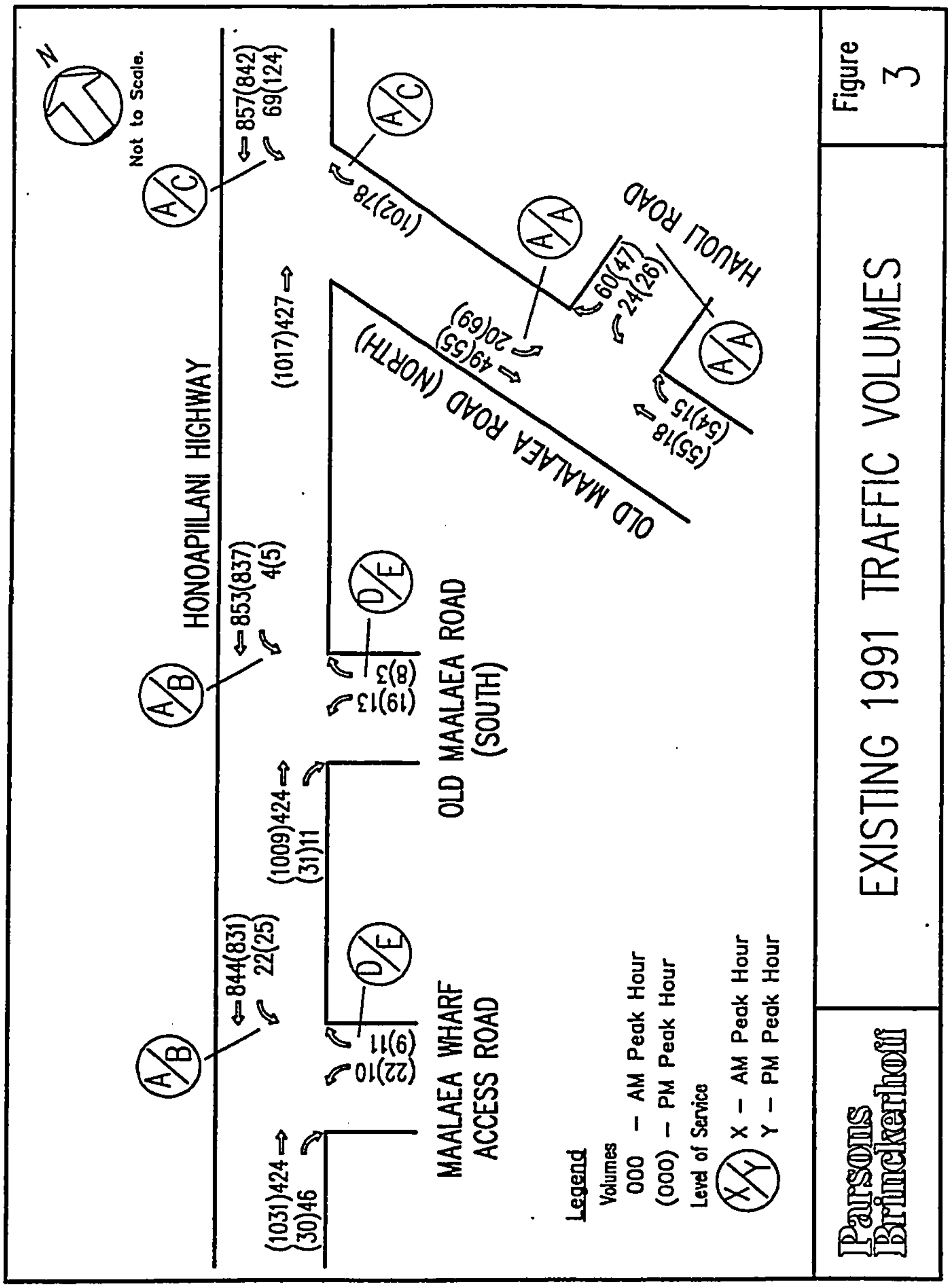


Figure 3

EXISTING 1991 TRAFFIC VOLUMES

4/28/94

At the intersection of Old Maalaea Road and Hauoli Road, all movements operate at LOS A during both the A.M. and P.M. peak hours.

Two-lane highway capacity analysis; as outlined in the 1985 Highway Capacity Manual; indicates that Honoapiilani Highway, both north and south of Maalaea Harbor, operates at LOS E during the A.M. peak hour and P.M. peak hour. Table 2 summarizes the existing operating conditions.

Table 2: Existing Level-of-Service

	A.M.	P.M.
UNSIGNALIZED INTERSECTION		
Honoapiilani Hwy./Maalaea Wharf Access Rd.		
Honoapiilani Hwy. Lt.	A	B
Maalaea Wharf Access Rd. shared Lt./Rt.	D	E
Honoapiilani Hwy./Old Maalaea Rd. southern		
Honoapiilani Hwy. Lt.	A	B
Old Maalaea Rd. shared Lt./Rt.	D	E
Honoapiilani Hwy./Old Maalaea Rd. northern		
Honoapiilani Hwy. Lt.	A	C
Old Maalaea Rd. Rt.	A	C
Old Maalaea Rd./Hauoli Rd.		
Old Maalaea Rd. Lt.	A	A
Hauoli Rd. shared Lt./Rt.	A	A
TWO-LANE HIGHWAY		
Honoapiilani Highway		
South of Maalaea	E	E
North of Maalaea	E	E

FUTURE TRAFFIC CONDITIONS WITHOUT PROJECT

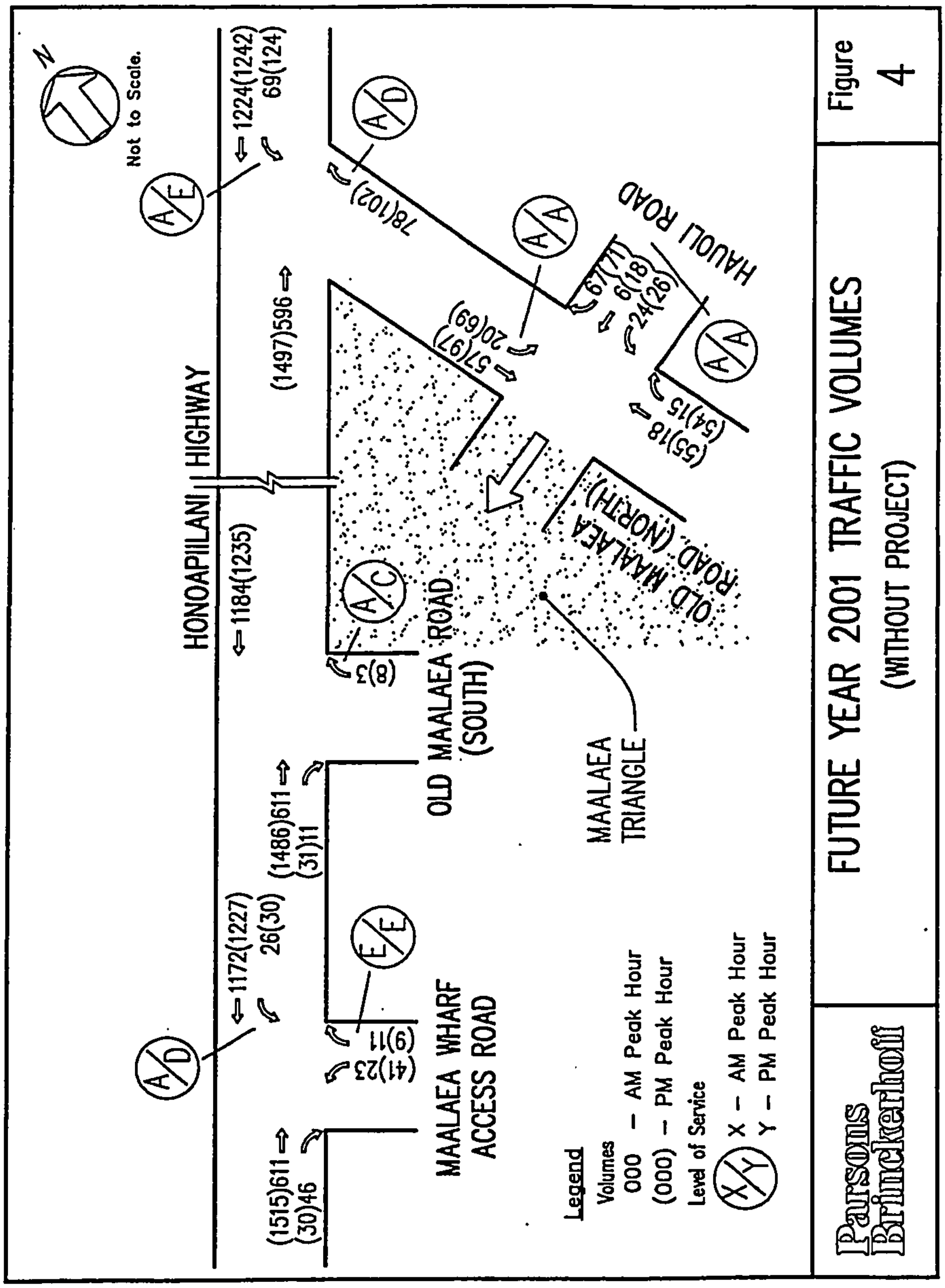
Future traffic conditions refer to the year 2001, when completion of the harbor expansion is expected. Future traffic volumes for year 2001 without project conditions were based on information presented in the following: Maui Long-Range Highway Planning Study[2] and historic traffic count information collected by the State of Hawaii, Department of Transportation, Highways Division. Traffic volumes along Honoapiilani Highway in the vicinity of Maalaea Harbor was estimated to increase by an average annual growth rate of 2.9 percent per year. In addition to the growth rate, traffic volumes from the Maalaea Triangle Development[3] was also added to the roadway network. The Maalaea Triangle development consists of a 170,000 square-foot shopping center located north of Maalaea Harbor, between Honoapiilani Highway and Old Maalaea Road. The Maalaea Triangle development is expected to be completed and occupied by the year 1995. Figure 4 shows the traffic volumes for year 2001 without project conditions.

Based on discussions with the State of Hawaii, Department of Transportation Highways Division, left-turn movements at the southern intersection of Old Maalaea Road and Honoapiilani Highway would be restricted due to its close proximity to the intersection of Maalaea Wharf Access Road and Honoapiilani Highway and poor sight distance. Therefore, subsequent analyses for future year 2001 conditions were performed assuming that all left-turn traffic at the intersection of Old Maalaea Road (south) and Honoapiilani Highway would be diverted to the intersection of Maalaea Wharf Access Road and Honoapiilani Highway.

Unsignalized intersection analysis shows that the left-turn movement at the intersection of Maalaea Wharf Access Road and Honoapiilani Highway is expected to continue to operate at LOS A during the A.M. peak hour. During the P.M. peak hour, the left-turn movement from the highway is anticipated to approach LOS D conditions. Traffic using the shared left/right-lane exiting the harbor is expected to experience at LOS E during both the A.M. and P.M. peak hours.

At the southern intersection of Old Maalaea Road and Honoapiilani Highway, the right-turn movement on Old Maalaea Road (south) is expected to operate at LOS A during the A.M. peak hour and LOS C during the P.M. peak hour.

At the northern intersection of Old Maalaea Road and Honoapiilani Highway, vehicles turning left from the highway onto Old Maalaea Road are anticipated to operate at LOS A during the A.M. peak hour and LOS E during the P.M. peak hour. Right turning vehicles exiting Old Maalaea Road is expected to continue to operate at LOS A during the A.M. peak hour. During the P.M. peak hour, the right-turn movement exiting Old Maalaea Road is expected to operate at LOS D.



Not to Scale.
N
HONOAPIILANI HIGHWAY
1224(1242)
69(124)
1184(1235)
1172(1227)
26(30)
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20(69)
57(97)
67(71)
6(18)
24(26)
(54)15
(55)18
HAUOLI ROAD
OLD MAALAEA ROAD (NORTH)
OLD MAALAEA ROAD (SOUTH)
MAALAEA WHARF ACCESS ROAD
MAALAEA TRIANGLE
Legend
Volumes
000 – AM Peak Hour
(000) – PM Peak Hour
Level of Service
X – AM Peak Hour
Y – PM Peak Hour
Parsons Brinckerhoff
FUTURE YEAR 2001 TRAFFIC VOLUMES
(WITHOUT PROJECT)
Figure
4
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At the intersection of Old Maalaea Road and Hauoli Road, all movements are anticipated to continue to operate at LOS A during both peak hours.

Two-lane highway capacity analysis reveals that Honoapiilani Highway, both north and south of Maalaea Harbor, is anticipated to experience over-capacity conditions during the P.M. peak hour and would operate at LOS E during the A.M. peak hour.

PROJECT TRAFFIC

The proposed expansion project would provide additional facilities for vessels using the Maalaea Harbor. The project would increase the total number of berths from the existing 90 berths to a total of 220 berths. Based upon the Economic Analysis for Maalaea Harbor[4] conducted by the Army Corps of Engineers, up to 37 berths out of the additional 130 proposed berths could be used by commercial passenger vessels on the Maalaea Harbor waiting list. Other improvements proposed with the Maalaea Harbor Expansion Project include; an extension of the existing southern breakwater, construction of a "Center Mole", construction of an "East Mole", a wharf for fueling, paved parking areas, sewage system improvements, and additional comfort stations.

In conjunction with the proposed expansion of Maalaea Harbor, the State of Hawaii, Department of Land & Natural Resources, Division of Boating and Ocean Recreation is proposing to implement a policy change that requires commercial passenger vessels with 25 or more passengers to provide bus or van service to and from the harbor. The proposed change in policy would affect approximately 15 existing commercial passenger vessels with 25 or more passengers. This policy change would assist in reducing traffic into and out of Maalaea Harbor as well as reducing the demand for parking stalls.

Trip Generation

Traffic generation estimates the number of trips attracted or produced by the project. Distribution and assignment determines the origins and destinations of these trips and assigns the estimated project traffic to the roadway network.

Commercial passenger vessels on the Maalaea Harbor waiting list are separated into three categories: trailered or moored along the coast (12 vessels), at other harbors

(4 vessels) and not yet acquired (21 vessels). These commercial passenger vessels are comprised of three size ranges. The first type of vessels ranges in the size from 60-feet to 100-feet and is usually used for Dinner Cruises of approximately 150 passengers. The second type of vessels is in the 40-feet to 60-feet size range and is typically used for Large Sight-Seeing cruises carrying about 50 passengers. The third type of vessels is commonly called "Six-Pack" vessels because it generally carries 6 passengers. Six-Pack vessels are generally under 40 feet in size and are usually used for specialty sightseeing such as scuba diving.

Based upon the Economic Analysis for Maalaea Harbor, the 12 vessels trailered or along the coast and the 4 vessels at other harbors are assumed to be all Six-Pack type vessels. Of the 21 vessels that are not yet acquired, 12 are assumed to be Six-Pack vessels, 8 are assumed to be Large Sight-Seeing vessels and 1 is assumed to be a Dinner Cruise vessel. Therefore, new commercial passenger vessels would be comprised of 28 Six-Pack vessels, 8 Large Sight-Seeing vessels, and 1 Dinner Cruise vessel.

Trip generation for the commercial passenger vessels for the Maalaea Harbor Expansion Project was based upon an average 70% passenger occupancy per vessel. As previously mentioned, the proposed policy change will require commercial passenger vessels with 25 passengers or more to provide bus or van service. The trip generation for vessels with 25 passenger or more was, therefore, based on a split of 40% of the passengers use cars and 60% of the passengers use vans or buses. It was also assumed that passenger cars would have an occupancy rate of 2.5 people per vehicle.

Trip generation for the crew of the commercial passengers vessels was based upon a crew size of two (2) for the Six-Pack, five (5) for the Large Sight-Seeing, and eight (8) for the Dinner Cruise vessels. Each crew member was assumed to travel by themselves and would generate on average two trips during the peak hour. Table 3 shows the trips generated by the proposed commercial passenger vessels for the Maalaea Harbor Expansion Project.

Table 3: Trip Generation (Additional Commercial Passenger Vessels)

Land Use (Parameter)	Quantity (vessels)	A.M. Peak Hour ENTER (vph)	A.M. Peak Hour EXIT (vph)	P.M. Peak Hour ENTER (vph)	P.M. Peak Hour EXIT (vph)
Six Pack	28	91	10	10	91
Large Sight-Seeing	8	87	10	10	87
Dinner Cruise	1	24	3	3	24
Total	37	202	23	23	202

Note:
vph = vehicles per hour

Trip generation for the remaining new berths, non-commercial passenger vessels, was estimated using statistical information published in Trip Generation[5] Fifth Edition, by the Institute of Transportation Engineers (ITE). Trip Generation is a statistical compilation of traffic data from various sources estimating the number of trips that may be generated by a specific land use. The marina land use category identified in Trip Generation was used for this project. Trip generation for the proposed project is based upon 93 new berths. Table 4 shows the trip generation rates used for non-commercial passenger vessels, while Table 5 summarizes the trips generated by the Maalaea Harbor Expansion Project due to non-commercial passenger vessels.

Table 4: Trip Rates (Non-Commercial Passenger)

Land Use (Parameter)	A.M. Peak Hour Trip Rate	A.M. Peak Hour % Enter	P.M. Peak Hour Trip Rate	P.M. Peak Hour % Enter
Maalaea Harbor Expansion Marina (93 berths)	0.170	64%	0.210	51%

Table 5: Traffic Generation (Non-Commercial Passenger)

Land Use (Parameter)	A.M. Peak Hour ENTER (vph)	A.M. Peak Hour EXIT (vph)	P.M. Peak Hour ENTER (vph)	P.M. Peak Hour EXIT (vph)
Maalaea Harbor Expansion Marina (93 berths)	10	6	10	10

Note:
vph = vehicles per hour

The proposed change in policy requiring commercial passenger vessels with 25 or more passengers to provide van or bus service applies to existing commercial passenger vessel operators. Estimates of the reduction of traffic anticipated by the change in policy are based on the assumption for the commercial passenger vessels stated earlier. Table 6 summarizes the trips reduced due to the policy change. Table 7 summarizes the net traffic increase attributable to the proposed expansion and policy change of the Maalaea Harbor.

Table 6: Traffic Reduction Due To Policy Change

	A.M. Peak Hour		P.M. Peak Hour	
Vessel	ENTER (vph)	EXIT (vph)	ENTER (vph)	EXIT (vph)
Existing Commercial Passenger	108	12	12	108

Table 7: Net Traffic Increase

	A.M. Peak Hour		P.M. Peak Hour	
Vessels	ENTER (vph)	EXIT (vph)	ENTER (vph)	EXIT (vph)
Commercial Passenger	+202	+23	+23	+202
Non-Commercial Passenger	+10	+6	+10	+10
Existing Commercial Passenger	<-108>	<-12>	<-12>	<-108>
NET TRIPS	104	17	21	104

Trip Distribution/Traffic Assignment

All traffic generated by the harbor expansion project was assumed to leave the harbor through one of the three existing intersections.

Trip distribution of the net increase in project generated traffic was based on existing traffic distribution patterns. Traffic headed toward West Maui was assigned to the Maalaea Wharf Access Road intersection. Trips headed toward Wailuku, Kihei and Kahului were assigned to the Old Maalaea Road northern and southern intersections and the Maalaea Wharf Access Road intersections. Table 8 summarizes the trip distribution for the proposed project and Figure 5 shows the assignment of traffic generated by the Maalaea Harbor Expansion Project.

Table 8: Trip Distribution

Intersection W/ Honoapiilani Hwy.	To/From Kaanapaili		To/From Wailuku		
	Wharf Access Rd.	Old Maalaea Rd. Southern	Wharf Access Rd.	Old Maalaea Rd. Southern	Old Maalaea Rd. Northern
A.M. Peak Hour					
IN	44	9	39	0	12
OUT	7	0	7	0	3
P.M. Peak Hour					
IN	4	6	6	0	5
OUT	37	0	55	6	6

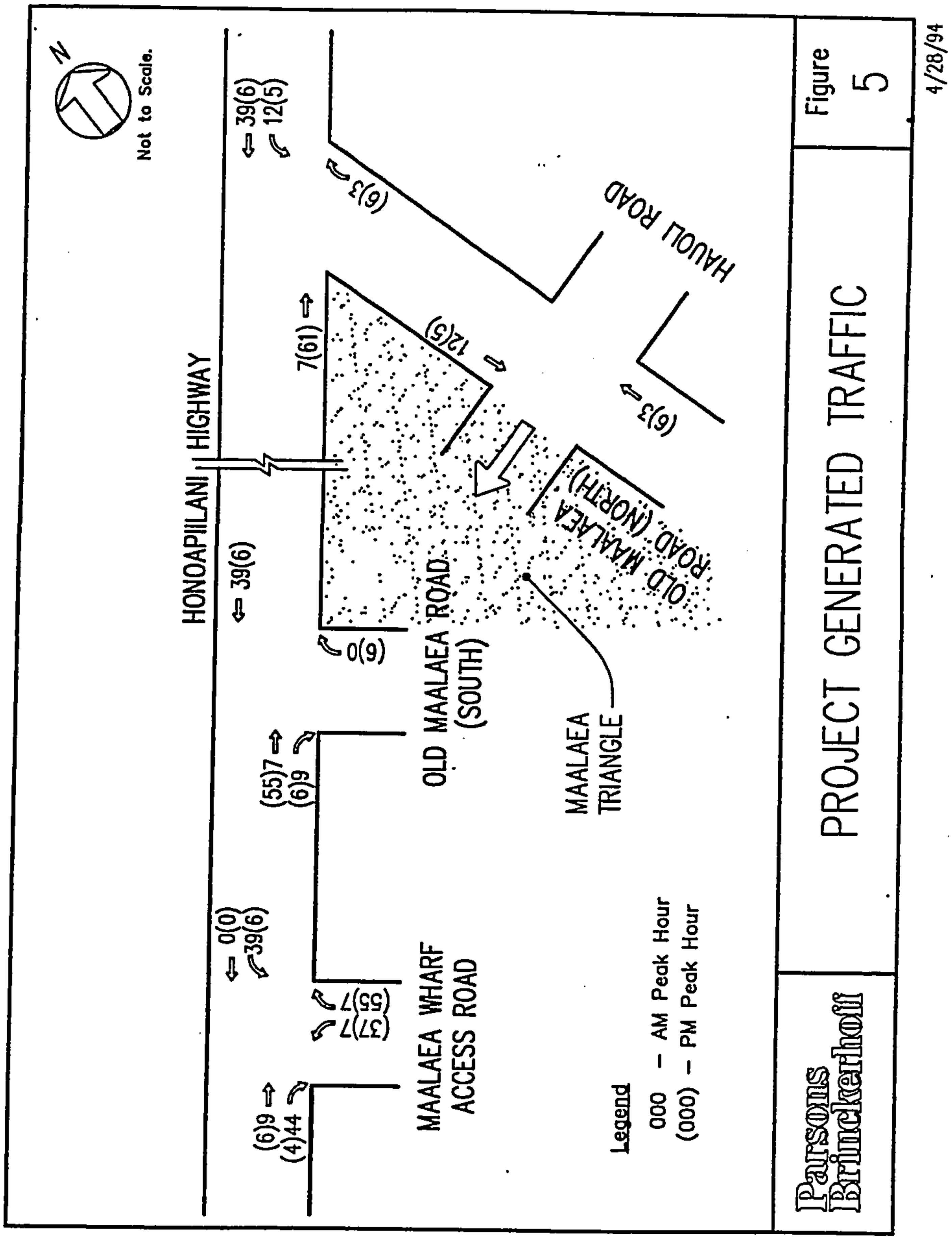
PROJECT IMPACTS

Traffic generated by the Maalaea Harbor Expansion Project was added to the Base Year 2001 traffic volumes (without project). Future year 2001 with project traffic conditions are shown in Figure 6. The results of the intersection analysis are summarized below.

Unsignalized intersection analysis shows that the left-turn movement at the intersection of Maalaea Wharf Access Road and Honoapiilani Highway is anticipated to continue to operate at LOS A during the A.M. peak hour. During the P.M. peak hour, vehicles turning left from the highway is expected to continue to operate at LOS D conditions. Traffic using the shared left/right-lane exiting the harbor is expected to operate at LOS E and LOS F during the A.M. peak hour and the P.M. peak hour respectively.

At the southern unsignalized intersection of Old Maalaea Road and Honoapiilani Highway, the right-turn movement out of Maalaea Harbor would operate at LOS A during the A.M. peak hour and at LOS D during the P.M. peak hour.

The left-turn movement from Honoapiilani Highway onto Old Maalaea Road North is expected to continue to operate at LOS A during the A.M. peak hour and LOS E during the P.M. peak hour with the proposed project. The right-turn movement from Old Maalaea


Not to Scale.
N
HONOAPIILANI HIGHWAY
HAUOLI ROAD
OLD MAALAEA ROAD (NORTH)
OLD MAALAEA ROAD (SOUTH)
MAALAEA TRIANGLE
MAALAEA WHARF ACCESS ROAD
39(6)
12(5)
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39(6)
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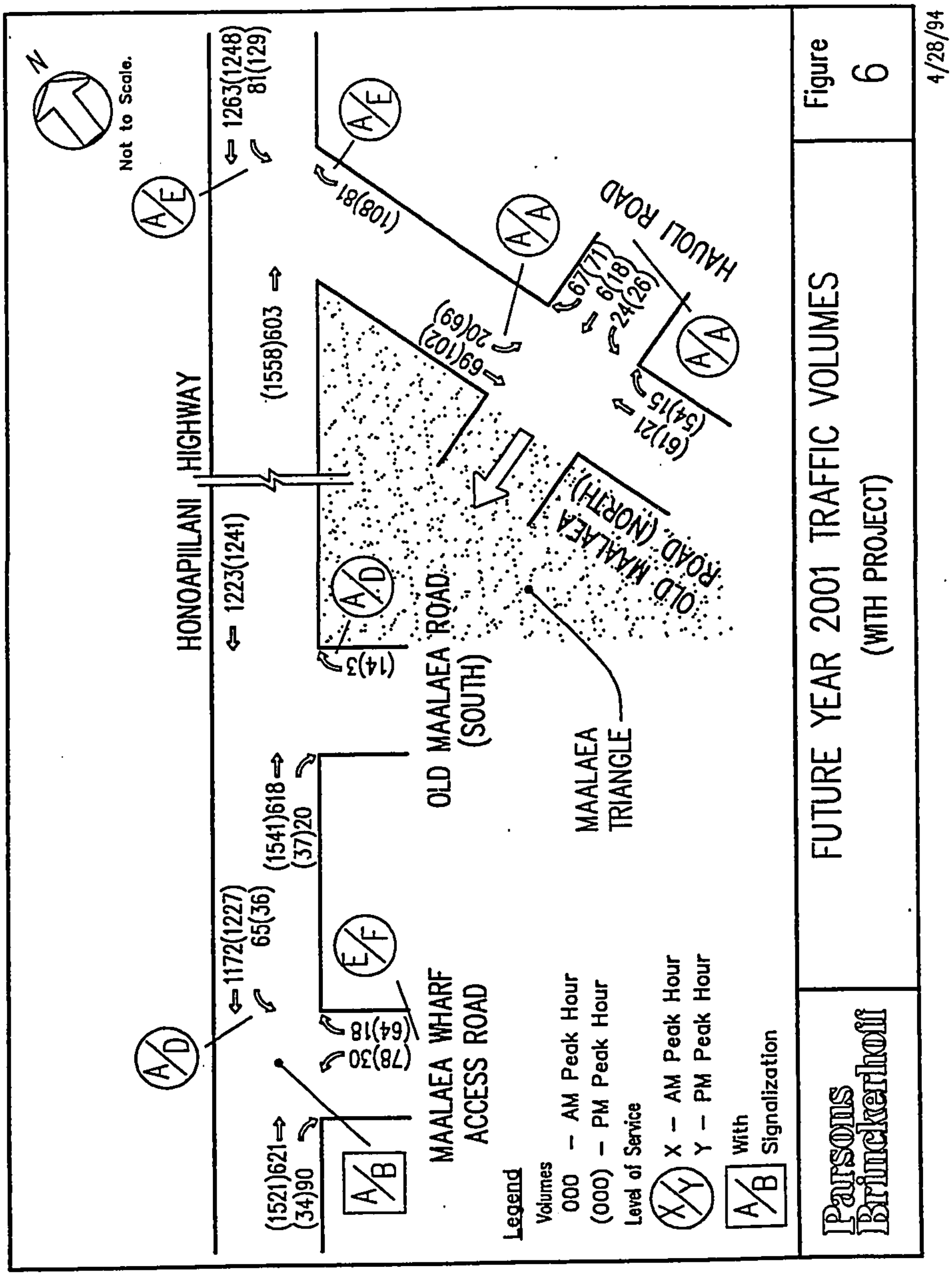
Legend
000 – AM Peak Hour
(000) – PM Peak Hour
Parsons Brinckerhoff
PROJECT GENERATED TRAFFIC
Figure
5
4/28/94


FUTURE YEAR 2001 TRAFFIC VOLUMES
(WITH PROJECT)
Figure
6
4/28/94
Parsons Brinckerhoff
Not to Scale.
N
HONOAPIILANI HIGHWAY
HAUOLI ROAD
OLD MAALAEA ROAD (NORTH)
OLD MAALAEA ROAD (SOUTH)
MAALAEA TRIANGLE
MAALAEA WHARF ACCESS ROAD
1263(1248)
81(129)
(108)81
67(71)
6(18)
24(26)
20(69)
69(102)
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65(36)
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(78)30
(1521)621
(34)90
Legend
Volumes
000 – AM Peak Hour
(000) – PM Peak Hour
Level of Service
X – AM Peak Hour
Y – PM Peak Hour
With Signalization

Road North onto Honoapiilani Highway would continue to operate at LOS A during the A.M. peak hour and LOS E during the P.M. peak hour with the proposed project.

All movements at the unsignalized intersection of Old Maalaea Road and Hauoli Road will continue to operate at LOS A during both peak hours with the proposed project.

Table 9 displays a comparison of the peak hour level-of-service during the A.M. and P.M. peak hour for the existing, year 2001 without project and year 2001 with project scenario.

Table 9: Unsignalized Intersection Analysis (2-lane Honoapiilani Hwy.)

Study Intersection	EXISTING A.M.	EXISTING P.M.	FUTURE W/O PROJECT. A.M.	FUTURE W/O PROJECT. P.M.	FUTURE W/ PROJECT A.M.	FUTURE W/ PROJECT P.M.
Honoapiilani Highway / Maalaea Wharf Access Road						
Honoapiilani Highway						
Southbound LT	A	B	A	D	A	D
Maalaea Wharf Access Rd.						
Westbound LT/RT	D	E	E	E	E	F
Honoapiilani Highway / Old Maalaea Road - South						
Honoapiilani Highway						
Southbound LT	A	B	n/a	n/a	n/a	n/a
Old Maalaea Road - South						
Westbound LT/RT	D	E	n/a	n/a	n/a	n/a
Westbound RT	n/a	n/a	A	C	A	D
Honoapiilani Highway / Old Maalaea Road - North						
Honoapiilani Highway						
Southbound LT	A	C	A	E	A	E
Old Maalaea Road - North						
Westbound RT	A	C	A	D	A	E
Old Maalaea Road - North / Hauoli Street						
Old Maalaea Road - North						
Southbound LT	A	A	A	A	A	A
Hauoli Street						
Westbound LT/RT	A	A	n/a	n/a	n/a	n/a
Westbound LT/TH/RT	n/a	n/a	A	A	A	A

Note:
n/a = not applicable, LT = left-turn, RT = right-turn, LT/RT = shared left-turn and right-turn
LT/TH/RT = shared left-turn, through and right-turn

One of the recommended improvements identified in the Maui Long-Range Highway Planning Study is to improve Honoapiilani Highway to four-lanes with left-turning bays. This would improve existing operating conditions on Honoapiilani Highway in the vicinity of Maalaea Harbor. Table 10 summarizes the roadway capacity levels-of-service for Honoapiilani Highway. Table 11 shows the level-of-service at the study intersections with 4-lanes along Honoapiilani Highway.

Table 10: Highway Capacity Analysis

	FUTURE W/O PROJECT.		FUTURE W/ PROJECT	
Roadway Section	A.M.	P.M.	A.M.	P.M.
Two-Lane Honoapiilani Highway				
South of Maalaea	E	F	E	F
North of Maalaea	E	F	E	F
Four-Lane Honoapiilani Highway				
South of Maalaea	B	C	B	C
North of Maalaea	B	C	B	C

Table 11: Unsignalized Intersection Analysis (4-lane Honoapiilani Hwy.)

	FUTURE W/O PROJECT.		FUTURE W/ PROJECT	
Study Intersection	A.M.	P.M.	A.M.	P.M.
Honoapiilani Highway / Maalaea Wharf Access Road				
Honoapiilani Highway				
Southbound LT	A	D	A	D
Maalaea Wharf Access Rd.				
Westbound LT/RT	E	E	E	F
Honoapiilani Highway / Old Maalaea Road - South				
Old Maalaea Road - South				
Westbound RT	A	A	A	A
Honoapiilani Highway / Old Maalaea Road - North				
Honoapiilani Highway				
Southbound LT	A	E	A	E
Old Maalaea Road - North				
Westbound RT	A	A	A	B

Note:
LT = left-turn, RT = right-turn, LT/RT = shared left-turn and right-turn

A review of the of the traffic signal warrants in the Manual on Uniform Traffic Control Devices[6] indicates that the intersection of Maalaea Wharf Access Road and Honoapiilani Highway meets Warrant 11, Peak Hour Volume. Furthermore, there would be increase bus and van service as well as the steep grades at the intersection. Additionally, vehicles exiting Maalaea Wharf Access Road are expected to experience long to extreme delays, LOS E to LOS F.

With Honoapiilani Highway widened to 4-lanes and signalization at its intersection with Maalaea Wharf Access Road, motorists exiting Maalaea Wharf Access Road are expected to experience short delays, LOS B, during both the A.M. and P.M. peak hours. The northbound and southbound approach along Honoapiilani Highway are anticipated to experience little delays, LOS A, during the A.M. peak hour and average delays or better, LOS B to LOS C, during the P.M. peak hour. Table 12 shows a comparison of the overall intersection level-of-service for the signalized intersection of Honoapiilani Highway and Maalaea Wharf Access Road during the A.M. and P.M. peak hour for year 2001 without project and year 2001 with project scenario.

Table 12: Signalized Intersection Analysis (4-lane Honoapiilani Hwy.)

	FUTURE W/O PROJECT.		FUTURE W/ PROJECT	
	A.M.	P.M.	A.M.	P.M.
Study Intersection				
Honoapiilani Highway / Maalaea Wharf Access Road	A	B	A	B

RECOMMENDATIONS AND CONCLUSIONS

The Maui Long-Range Highway Planning Study has previously identified that Honoapiilani Highway requires widening to four-lanes. The additional lanes along Honoapiilani Highway would be required even without the Maalaea Harbor Expansion Project. Intersection analysis shows that the additional lanes along Honoapiilani Highway increases the capacity of the highway and improves the level-of-service for the right-turn movements exiting Old Maalaea Road at its northern and southern intersection with Honoapiilani Highway. However, left-turning vehicles entering and exiting Maalaea Wharf Access Road are still expected to experience long to extreme delays, LOS D to LOS F. Additionally, with the increased bus and van service and the existing steep grades at this intersection, it is recommend that the intersection of Maalaea Wharf Access Road and Honoapiilani Highway be signalized.

The following additional improvements are recommended to accommodate the additional traffic due to the proposed Maalaea Harbor Expansion:

- Provide a dedicated left-turn lane and deceleration lane on Honoapiilani Highway at the Wharf Access Road intersection.
- Provide separate left-turn and right-turn lanes on Maalaea Wharf Access Road for egress at the intersection of Honoapiilani Highway and Maalaea Wharf Access Road.
- Adopt a policy requiring commercial passenger vessels with a capacity of 25 or more passengers to provide bus and van service.
- Provide additional parking to existing Maalaea Harbor.

With these improvements the roadway system would have adequate capacity to accommodate the traffic generated by the proposed expansion project.

REFERENCES

1. Transportation Research Board, National Research Council, Highway Capacity Manual, Special Report 209, Washington, D.C. 1985.

2. State of Hawaii, Department of Transportation, County of Maui, Department of Public Works, Department of Planning, Maui Long-Range Highway Planning Study, Island-Wide Plan, Final Report, Honolulu, Hawaii, May 1991.

3. Parsons Brinckerhoff Quade & Douglas, Inc., Final Traffic Impact Study Maalaea Triangle, January 1994

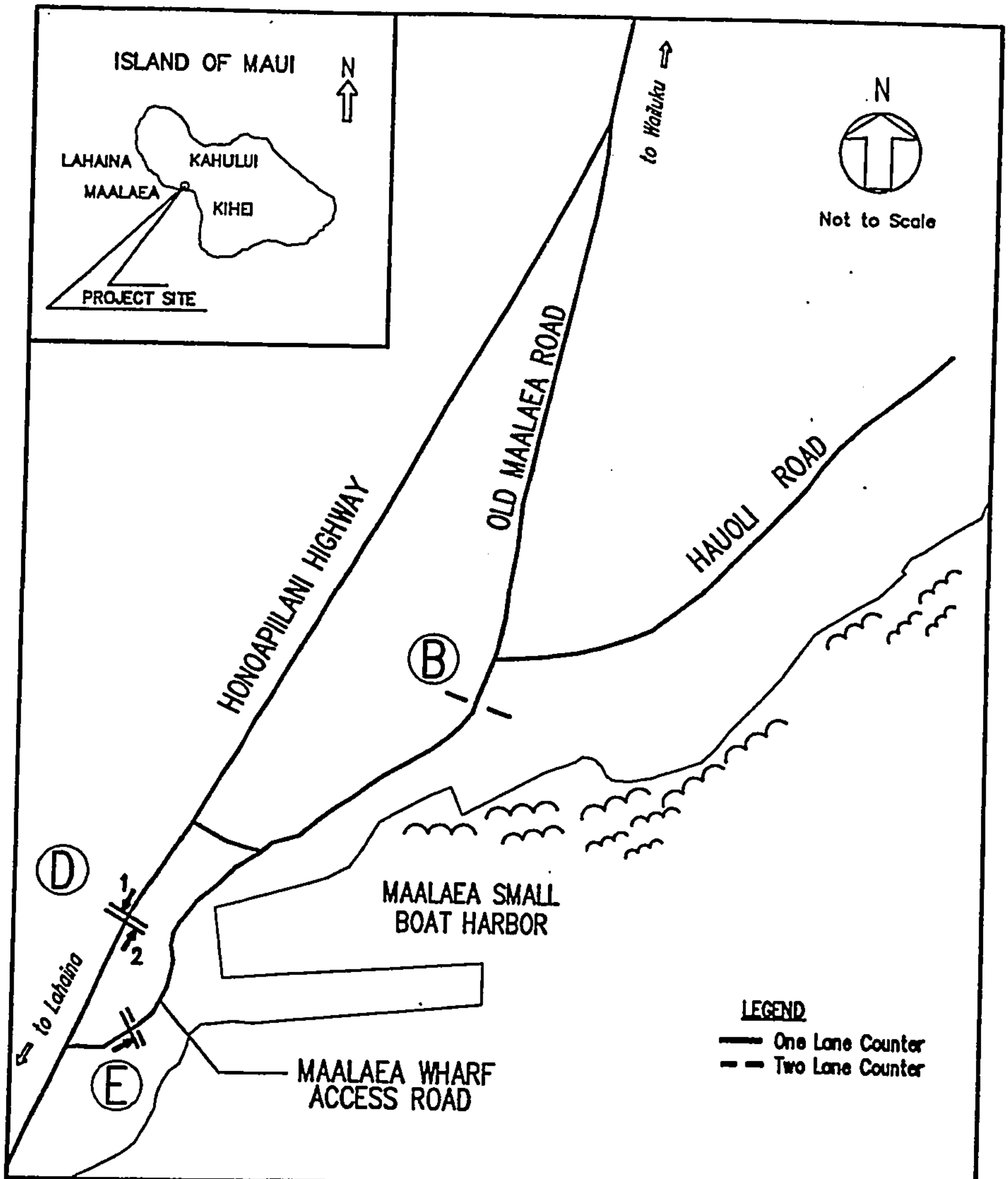
4. United States Army Corps of Engineering, Maalaea Small Boat Harbor, Economic Analysis, Honolulu, Hawaii, November 1992.

5. Institute of Transportation Engineers, Trip Generation, Fifth Edition, Washington, D.C. 1991.

6. U.S. Department of Transportation, Federal Highways Administration, Manual on Uniform Traffic Control Devices for Streets and Highways, Washington, D.C. 1988.

APPENDIX A

24-HOUR TRAFFIC COUNTS



Parsons Brinckerhoff

24-HOUR TRAFFIC COUNT

9/12/91

SUNDAY 6/16/91

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	1	1	9	6:00-6:15	0	17	17	46	12:00-12:15	0	56	56	147	18:00-18:15	0	21	21	101
0:15-0:30	0	1	1	7	6:15-6:30	0	26	26	68	12:15-12:30	0	41	41	153	18:15-18:30	0	29	29	102
0:30-0:45	0	4	4	9	6:30-6:45	0	16	16	72	12:30-12:45	0	59	59	185	18:30-18:45	0	18	18	89
0:45-1:00	0	0	0	6	6:45-7:00	0	28	28	87	12:45-13:00	0	48	48	204	18:45-19:00	0	17	17	85
1:00-1:15	0	4	4	9	7:00-7:15	0	14	14	84	13:00-13:15	0	58	58	206	19:00-19:15	0	22	22	86
1:15-1:30	0	0	0	8	7:15-7:30	0	13	13	71	13:15-13:30	0	46	46	211	19:15-19:30	0	21	21	78
1:30-1:45	0	2	2	6	7:30-7:45	0	13	13	68	13:30-13:45	0	45	45	197	19:30-19:45	0	28	28	88
1:45-2:00	0	2	2	8	7:45-8:00	0	21	21	61	13:45-14:00	0	45	45	194	19:45-20:00	0	16	16	87
2:00-2:15	0	3	3	7	8:00-8:15	0	19	19	66	14:00-14:15	0	43	43	179	20:00-20:15	0	18	18	83
2:15-2:30	0	2	2	9	8:15-8:30	0	29	29	82	14:15-14:30	0	39	39	172	20:15-20:30	0	11	11	73
2:30-2:45	0	0	0	7	8:30-8:45	0	11	11	80	14:30-14:45	0	35	35	162	20:30-20:45	0	9	9	54
2:45-3:00	0	0	0	5	8:45-9:00	0	26	26	85	14:45-15:00	0	40	40	157	20:45-21:00	0	9	9	47
3:00-3:15	0	4	4	6	9:00-9:15	0	22	22	88	15:00-15:15	0	35	35	149	21:00-21:15	0	7	7	36
3:15-3:30	0	1	1	5	9:15-9:30	0	25	25	84	15:15-15:30	0	30	30	140	21:15-21:30	0	10	10	35
3:30-3:45	0	1	1	6	9:30-9:45	0	21	21	94	15:30-15:45	0	41	41	146	21:30-21:45	0	7	7	33
3:45-4:00	0	0	0	6	9:45-10:00	0	19	19	87	15:45-16:00	0	45	45	151	21:45-22:00	0	7	7	31
4:00-4:15	0	1	1	3	10:00-10:15	0	33	33	98	16:00-16:15	0	37	37	153	22:00-22:15	0	9	9	33
4:15-4:30	0	0	0	2	10:15-10:30	0	21	21	94	16:15-16:30	0	31	31	154	22:15-22:30	0	5	5	28
4:30-4:45	0	0	0	1	10:30-10:45	0	24	24	97	16:30-16:45	0	24	24	137	22:30-22:45	0	4	4	25
4:45-5:00	0	3	3	4	10:45-11:00	0	37	37	115	16:45-17:00	0	34	34	126	22:45-23:00	0	5	5	23
5:00-5:15	0	2	2	5	11:00-11:15	0	33	33	115	17:00-17:15	0	32	32	121	23:00-23:15	0	6	6	20
5:15-5:30	0	4	4	9	11:15-11:30	0	35	35	129	17:15-17:30	0	28	28	118	23:15-23:30	0	3	3	18
5:30-5:45	0	12	12	21	11:30-11:45	0	27	27	132	17:30-17:45	0	31	31	125	23:30-23:45	0	2	2	16
5:45-6:00	0	13	13	31	11:45-12:00	0	29	29	124	17:45-18:00	0	21	21	112	23:45-24:00	0	3	3	14

MONDAY 6/17/91

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	3	3	12	6:00-6:15	0	19	19	52	12:00-12:15	0	41	41	129	18:00-18:15	0	33	33	150
0:15-0:30	0	1	1	11	6:15-6:30	0	17	17	67	12:15-12:30	0	36	36	139	18:15-18:30	0	38	38	153
0:30-0:45	0	0	0	9	6:30-6:45	0	30	30	87	12:30-12:45	0	62	62	164	18:30-18:45	0	31	31	141
0:45-1:00	0	1	1	5	6:45-7:00	0	30	30	96	12:45-13:00	0	54	54	193	18:45-19:00	0	26	26	128
1:00-1:15	0	0	0	2	7:00-7:15	0	14	14	91	13:00-13:15	0	37	37	189	19:00-19:15	0	32	32	127
1:15-1:30	0	0	0	1	7:15-7:30	0	16	16	90	13:15-13:30	0	35	35	188	19:15-19:30	0	26	26	115
1:30-1:45	0	0	0	1	7:30-7:45	0	17	17	77	13:30-13:45	0	36	36	162	19:30-19:45	0	29	29	113
1:45-2:00	0	0	0	0	7:45-8:00	0	12	12	59	13:45-14:00	0	41	41	149	19:45-20:00	0	21	21	108
2:00-2:15	0	1	1	1	8:00-8:15	0	12	12	57	14:00-14:15	0	41	41	153	20:00-20:15	0	11	11	87
2:15-2:30	0	0	0	1	8:15-8:30	0	15	15	56	14:15-14:30	0	33	33	151	20:15-20:30	0	16	16	77
2:30-2:45	0	0	0	1	8:30-8:45	0	12	12	51	14:30-14:45	0	52	52	167	20:30-20:45	0	15	15	63
2:45-3:00	0	0	0	1	8:45-9:00	0	18	18	57	14:45-15:00	0	42	42	168	20:45-21:00	0	10	10	52
3:00-3:15	0	0	0	0	9:00-9:15	0	16	16	61	15:00-15:15	0	51	51	178	21:00-21:15	0	11	11	52
3:15-3:30	0	2	2	2	9:15-9:30	0	14	14	60	15:15-15:30	0	35	35	180	21:15-21:30	0	9	9	45
3:30-3:45	0	1	1	3	9:30-9:45	0	22	22	70	15:30-15:45	0	44	44	172	21:30-21:45	0	11	11	41
3:45-4:00	0	0	0	3	9:45-10:00	0	27	27	79	15:45-16:00	0	39	39	169	21:45-22:00	0	2	2	33
4:00-4:15	0	0	0	3	10:00-10:15	0	20	20	83	16:00-16:15	0	35	35	153	22:00-22:15	0	7	7	29
4:15-4:30	0	0	0	1	10:15-10:30	0	24	24	93	16:15-16:30	0	54	54	172	22:15-22:30	0	8	8	28
4:30-4:45	0	2	2	2	10:30-10:45	0	36	36	107	16:30-16:45	0	38	38	166	22:30-22:45	0	7	7	24
4:45-5:00	0	1	1	3	10:45-11:00	0	28	28	108	16:45-17:00	0	49	49	176	22:45-23:00	0	8	8	30
5:00-5:15	0	3	3	6	11:00-11:15	0	33	33	121	17:00-17:15	0	46	46	187	23:00-23:15	0	6	6	29
5:15-5:30	0	2	2	8	11:15-11:30	0	26	26	123	17:15-17:30	0	35	35	168	23:15-23:30	0	2	2	23
5:30-5:45	0	10	10	16	11:30-11:45	0	37	37	124	17:30-17:45	0	43	43	173	23:30-23:45	0	2	2	18
5:45-6:00	0	21	21	36	11:45-12:00	0	25	25	121	17:45-18:00	0	39	39	163	23:45-24:00	0	5	5	15

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	3	3	18	6:00-6:15	0	20	20	78	12:00-12:15	0	70	70	256	18:00-18:15	0	69	69	307
0:15-0:30	0	7	7	18	6:15-6:30	0	30	30	97	12:15-12:30	0	80	80	270	18:15-18:30	0	53	53	272
0:30-0:45	0	2	2	16	6:30-6:45	0	41	41	121	12:30-12:45	0	82	82	281	18:30-18:45	0	46	46	240
0:45-1:00	0	2	2	14	6:45-7:00	0	37	37	128	12:45-13:00	0	62	62	294	18:45-19:00	0	59	59	227
1:00-1:15	0	1	1	12	7:00-7:15	0	44	44	152	13:00-13:15	0	75	75	299	19:00-19:15	0	45	45	203
1:15-1:30	0	1	1	6	7:15-7:30	0	29	29	151	13:15-13:30	0	68	68	287	19:15-19:30	0	37	37	187
1:30-1:45	0	3	3	7	7:30-7:45	0	35	35	145	13:30-13:45	0	76	76	281	19:30-19:45	0	28	28	169
1:45-2:00	0	0	0	5	7:45-8:00	0	23	23	131	13:45-14:00	0	77	77	296	19:45-20:00	0	20	20	130
2:00-2:15	0	6	6	10	8:00-8:15	0	35	35	122	14:00-14:15	0	97	97	318	20:00-20:15	0	16	16	101
2:15-2:30	0	0	0	9	8:15-8:30	0	45	45	138	14:15-14:30	0	59	59	309	20:15-20:30	0	25	25	89
2:30-2:45	0	0	0	6	8:30-8:45	0	50	50	153	14:30-14:45	0	70	70	303	20:30-20:45	0	19	19	80
2:45-3:00	0	1	1	7	8:45-9:00	0	39	39	169	14:45-15:00	0	62	62	288	20:45-21:00	0	12	12	72
3:00-3:15	0	2	2	3	9:00-9:15	0	50	50	184	15:00-15:15	0	71	71	262	21:00-21:15	0	10	10	66
3:15-3:30	0	0	0	3	9:15-9:30	0	45	45	184	15:15-15:30	0	68	68	271	21:15-21:30	0	9	9	50
3:30-3:45	0	0	0	3	9:30-9:45	0	57	57	191	15:30-15:45	0	76	76	277	21:30-21:45	0	9	9	40
3:45-4:00	0	1	1	3	9:45-10:00	0	37	37	189	15:45-16:00	0	60	60	275	21:45-22:00	0	11	11	39
4:00-4:15	0	0	0	1	10:00-10:15	0	54	54	193	16:00-16:15	0	78	78	282	22:00-22:15	0	11	11	40
4:15-4:30	0	1	1	2	10:15-10:30	0	47	47	195	16:15-16:30	0	100	100	314	22:15-22:30	0	14	14	45
4:30-4:45	0	0	0	2	10:30-10:45	0	48	48	186	16:30-16:45	0	88	88	326	22:30-22:45	0	5	5	41
4:45-5:00	0	3	3	4	10:45-11:00	0	60	60	209	16:45-17:00	0	98	98	364	22:45-23:00	0	8	8	38
5:00-5:15	0	6	6	10	11:00-11:15	0	56	56	211	17:00-17:15	0	86	86	372	23:00-23:15	0	7	7	34
5:15-5:30	0	11	11	20	11:15-11:30	0	66	66	230	17:15-17:30	0	88	88	360	23:15-23:30	0	7	7	27
5:30-5:45	0	17	17	37	11:30-11:45	0	71	71	253	17:30-17:45	0	78	78	350	23:30-23:45	0	4	4	26
5:45-6:00	0	30	30	64	11:45-12:00	0	49	49	242	17:45-18:00	0	72	72	324	23:45-24:00	0	4	4	22

WEDNESDAY 6/19/91

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	1	1	10	6:00-6:15	0	37	37	118	12:00-12:15	0	42	42	210	18:00-18:15	0	56	56	248
0:15-0:30	0	3	3	9	6:15-6:30	0	39	39	142	12:15-12:30	0	47	47	188	18:15-18:30	0	63	63	226
0:30-0:45	0	0	0	6	6:30-6:45	0	48	48	158	12:30-12:45	0	65	65	202	18:30-18:45	0	45	45	217
0:45-1:00	0	0	0	4	6:45-7:00	0	48	48	172	12:45-13:00	0	73	73	227	18:45-19:00	0	57	57	221
1:00-1:15	0	0	0	3	7:00-7:15	0	25	25	160	13:00-13:15	0	73	73	258	19:00-19:15	0	44	44	209
1:15-1:30	0	2	2	2	7:15-7:30	0	31	31	152	13:15-13:30	0	50	50	261	19:15-19:30	0	20	20	166
1:30-1:45	0	0	0	2	7:30-7:45	0	36	36	140	13:30-13:45	0	60	60	256	19:30-19:45	0	38	38	159
1:45-2:00	0	1	1	3	7:45-8:00	0	33	33	125	13:45-14:00	0	60	60	243	19:45-20:00	0	24	24	126
2:00-2:15	0	3	3	6	8:00-8:15	0	37	37	137	14:00-14:15	0	49	49	219	20:00-20:15	0	21	21	103
2:15-2:30	0	1	1	5	8:15-8:30	0	30	30	136	14:15-14:30	0	44	44	213	20:15-20:30	0	11	11	94
2:30-2:45	0	2	2	7	8:30-8:45	0	38	38	138	14:30-14:45	0	50	50	203	20:30-20:45	0	26	26	82
2:45-3:00	0	1	1	7	8:45-9:00	0	45	45	150	14:45-15:00	0	51	51	194	20:45-21:00	0	20	20	78
3:00-3:15	0	0	0	4	9:00-9:15	0	45	45	158	15:00-15:15	0	48	48	193	21:00-21:15	0	9	9	66
3:15-3:30	0	0	0	3	9:15-9:30	0	45	45	173	15:15-15:30	0	52	52	201	21:15-21:30	0	11	11	66
3:30-3:45	0	0	0	1	9:30-9:45	0	29	29	164	15:30-15:45	0	57	57	208	21:30-21:45	0	12	12	52
3:45-4:00	0	1	1	1	9:45-10:00	0	49	49	168	15:45-16:00	0	58	58	215	21:45-22:00	0	11	11	43
4:00-4:15	0	0	0	1	10:00-10:15	0	37	37	160	16:00-16:15	0	91	91	258	22:00-22:15	0	13	13	47
4:15-4:30	0	0	0	1	10:15-10:30	0	46	46	161	16:15-16:30	0	73	73	279	22:15-22:30	0	9	9	45
4:30-4:45	0	1	1	2	10:30-10:45	0	53	53	185	16:30-16:45	0	76	76	298	22:30-22:45	0	8	8	41
4:45-5:00	0	7	7	8	10:45-11:00	0	56	56	192	16:45-17:00	0	71	71	311	22:45-23:00	0	9	9	39
5:00-5:15	0	10	10	18	11:00-11:15	0	47	47	202	17:00-17:15	0	69	69	289	23:00-23:15	0	8	8	34
5:15-5:30	0	15	15	33	11:15-11:30	0	69	69	225	17:15-17:30	0	85	85	301	23:15-23:30	0	4	4	29
5:30-5:45	0	32	32	64	11:30-11:45	0	51	51	223	17:30-17:45	0	54	54	279	23:30-23:45	0	3	3	24
5:45-6:00	0	34	34	91	11:45-12:00	0	48	48	215	17:45-18:00	0	53	53	261	23:45-24:00	0	2	2	17

THURSDAY 6/20/91

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	5	5	16	6:00-6:15	0	21	21	74	12:00-12:15	0	50	50	195	18:00-18:15	0	30	30	141
0:15-0:30	0	5	5	16	6:15-6:30	0	32	32	99	12:15-12:30	0	50	50	187	18:15-18:30	0	25	25	126
0:30-0:45	0	1	1	13	6:30-6:45	0	40	40	119	12:30-12:45	0	44	44	184	18:30-18:45	0	25	25	113
0:45-1:00	0	1	1	12	6:45-7:00	0	33	33	126	12:45-13:00	0	60	60	204	18:45-19:00	0	31	31	111
1:00-1:15	0	3	3	10	7:00-7:15	0	21	21	126	13:00-13:15	0	53	53	207	19:00-19:15	0	24	24	105
1:15-1:30	0	0	0	5	7:15-7:30	0	38	38	132	13:15-13:30	0	43	43	200	19:15-19:30	0	21	21	101
1:30-1:45	0	0	0	4	7:30-7:45	0	10	10	102	13:30-13:45	0	45	45	201	19:30-19:45	0	19	19	95
1:45-2:00	0	1	1	4	7:45-8:00	0	22	22	91	13:45-14:00	0	48	48	189	19:45-20:00	0	17	17	81
2:00-2:15	0	0	0	1	8:00-8:15	0	23	23	93	14:00-14:15	0	35	35	171	20:00-20:15	0	15	15	72
2:15-2:30	0	0	0	1	8:15-8:30	0	28	28	83	14:15-14:30	0	33	33	161	20:15-20:30	0	18	18	69
2:30-2:45	0	0	0	1	8:30-8:45	0	27	27	100	14:30-14:45	0	31	31	147	20:30-20:45	0	15	15	65
2:45-3:00	0	1	1	1	8:45-9:00	0	26	26	104	14:45-15:00	0	46	46	145	20:45-21:00	0	7	7	55
3:00-3:15	0	0	0	1	9:00-9:15	0	30	30	111	15:00-15:15	0	35	35	145	21:00-21:15	0	16	16	56
3:15-3:30	0	0	0	1	9:15-9:30	0	25	25	108	15:15-15:30	0	42	42	154	21:15-21:30	0	7	7	45
3:30-3:45	0	2	2	3	9:30-9:45	0	25	25	106	15:30-15:45	0	50	50	173	21:30-21:45	0	7	7	37
3:45-4:00	0	2	2	4	9:45-10:00	0	33	33	113	15:45-16:00	0	37	37	164	21:45-22:00	0	11	11	41
4:00-4:15	0	1	1	5	10:00-10:15	0	42	42	125	16:00-16:15	0	51	51	180	22:00-22:15	0	7	7	32
4:15-4:30	0	1	1	6	10:15-10:30	0	32	32	132	16:15-16:30	0	50	50	188	22:15-22:30	0	7	7	32
4:30-4:45	0	0	0	4	10:30-10:45	0	39	39	146	16:30-16:45	0	43	43	181	22:30-22:45	0	12	12	37
4:45-5:00	0	5	5	7	10:45-11:00	0	48	48	161	16:45-17:00	0	49	49	193	22:45-23:00	0	9	9	35
5:00-5:15	0	2	2	8	11:00-11:15	0	40	40	159	17:00-17:15	0	53	53	195	23:00-23:15	0	10	10	38
5:15-5:30	0	7	7	14	11:15-11:30	0	58	58	185	17:15-17:30	0	40	40	185	23:15-23:30	0	5	5	36
5:30-5:45	0	20	20	34	11:30-11:45	0	47	47	193	17:30-17:45	0	38	38	180	23:30-23:45	0	4	4	28
5:45-6:00	0	26	26	55	11:45-12:00	0	40	40	185	17:45-18:00	0	33	33	164	23:45-24:00	0	2	2	21

FRIDAY 6/21/91

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	2	2	2	6:00-6:15	0	14	14	54	12:00-12:15	0	0	0	0	18:00-18:15	0	0	0	0
0:15-0:30	0	0	0	2	6:15-6:30	0	26	26	75	12:15-12:30	0	0	0	0	18:15-18:30	0	0	0	0
0:30-0:45	0	2	2	4	6:30-6:45	0	35	35	93	12:30-12:45	0	0	0	0	18:30-18:45	0	0	0	0
0:45-1:00	0	3	3	7	6:45-7:00	0	37	37	112	12:45-13:00	0	0	0	0	18:45-19:00	0	0	0	0
1:00-1:15	0	4	4	9	7:00-7:15	0	26	26	124	13:00-13:15	0	0	0	0	19:00-19:15	0	0	0	0
1:15-1:30	0	0	0	9	7:15-7:30	0	25	25	123	13:15-13:30	0	0	0	0	19:15-19:30	0	0	0	0
1:30-1:45	0	0	0	7	7:30-7:45	0	21	21	109	13:30-13:45	0	0	0	0	19:30-19:45	0	0	0	0
1:45-2:00	0	5	5	9	7:45-8:00	0	13	13	85	13:45-14:00	0	0	0	0	19:45-20:00	0	0	0	0
2:00-2:15	0	1	1	6	8:00-8:15	0	20	20	79	14:00-14:15	0	0	0	0	20:00-20:15	0	0	0	0
2:15-2:30	0	0	0	6	8:15-8:30	0	24	24	78	14:15-14:30	0	0	0	0	20:15-20:30	0	0	0	0
2:30-2:45	0	0	0	6	8:30-8:45	0	13	13	70	14:30-14:45	0	0	0	0	20:30-20:45	0	0	0	0
2:45-3:00	0	1	1	2	8:45-9:00	0	25	25	82	14:45-15:00	0	0	0	0	20:45-21:00	0	0	0	0
3:00-3:15	0	1	1	2	9:00-9:15	0	19	19	81	15:00-15:15	0	0	0	0	21:00-21:15	0	0	0	0
3:15-3:30	0	0	0	2	9:15-9:30	0	26	26	83	15:15-15:30	0	0	0	0	21:15-21:30	0	0	0	0
3:30-3:45	0	0	0	2	9:30-9:45	0	19	19	89	15:30-15:45	0	0	0	0	21:30-21:45	0	0	0	0
3:45-4:00	0	0	0	1	9:45-10:00	0	34	34	98	15:45-16:00	0	0	0	0	21:45-22:00	0	0	0	0
4:00-4:15	0	1	1	1	10:00-10:15	0	32	32	111	16:00-16:15	0	0	0	0	22:00-22:15	0	0	0	0
4:15-4:30	0	0	0	1	10:15-10:30	0	-32	-32	53	16:15-16:30	0	0	0	0	22:15-22:30	0	0	0	0
4:30-4:45	0	1	1	2	10:30-10:45	0	0	0	34	16:30-16:45	0	0	0	0	22:30-22:45	0	0	0	0
4:45-5:00	0	0	0	2	10:45-11:00	0	0	0	0	16:45-17:00	0	0	0	0	22:45-23:00	0	0	0	0
5:00-5:15	0	8	8	9	11:00-11:15	0	0	0	-32	17:00-17:15	0	0	0	0	23:00-23:15	0	0	0	0
5:15-5:30	0	5	5	14	11:15-11:30	0	0	0	0	17:15-17:30	0	0	0	0	23:15-23:30	0	0	0	0
5:30-5:45	0	17	17	30	11:30-11:45	0	0	0	0	17:30-17:45	0	0	0	0	23:30-23:45	0	0	0	0
5:45-6:00	0	18	18	48	11:45-12:00	0	0	0	0	17:45-18:00	0	0	0	0	23:45-24:00	0	0	0	0

SATURDAY 6/15/91

MAALAEA ROAD (NORTH) LOCATION B

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	9	9	30	6:00-6:15	0	20	20	57	12:00-12:15	0	32	32	131	18:00-18:15	0	19	19	114
0:15-0:30	0	3	3	24	6:15-6:30	0	14	14	68	12:15-12:30	0	33	33	134	18:15-18:30	0	23	23	105
0:30-0:45	0	3	3	22	6:30-6:45	0	26	26	81	12:30-12:45	0	40	40	134	18:30-18:45	0	18	18	91
0:45-1:00	0	0	0	15	6:45-7:00	0	31	31	91	12:45-13:00	0	45	45	150	18:45-19:00	0	24	24	84
1:00-1:15	0	1	1	7	7:00-7:15	0	13	13	84	13:00-13:15	0	47	47	165	19:00-19:15	0	25	25	90
1:15-1:30	0	2	2	6	7:15-7:30	0	19	19	89	13:15-13:30	0	42	42	174	19:15-19:30	0	24	24	91
1:30-1:45	0	1	1	4	7:30-7:45	0	17	17	80	13:30-13:45	0	48	48	182	19:30-19:45	0	29	29	102
1:45-2:00	0	1	1	5	7:45-8:00	0	16	16	65	13:45-14:00	0	29	29	166	19:45-20:00	0	20	20	98
2:00-2:15	0	0	0	4	8:00-8:15	0	16	16	68	14:00-14:15	0	22	22	141	20:00-20:15	0	17	17	90
2:15-2:30	0	2	2	4	8:15-8:30	0	26	26	75	14:15-14:30	0	35	35	134	20:15-20:30	0	12	12	78
2:30-2:45	0	2	2	5	8:30-8:45	0	20	20	78	14:30-14:45	0	36	36	122	20:30-20:45	0	16	16	65
2:45-3:00	0	2	2	6	8:45-9:00	0	22	22	84	14:45-15:00	0	26	26	119	20:45-21:00	0	10	10	55
3:00-3:15	0	1	1	7	9:00-9:15	0	25	25	93	15:00-15:15	0	32	32	129	21:00-21:15	0	16	16	54
3:15-3:30	0	1	1	6	9:15-9:30	0	10	10	77	15:15-15:30	0	45	45	139	21:15-21:30	0	12	12	54
3:30-3:45	0	4	4	8	9:30-9:45	0	19	19	76	15:30-15:45	0	36	36	139	21:30-21:45	0	12	12	50
3:45-4:00	0	1	1	7	9:45-10:00	0	20	20	74	15:45-16:00	0	27	27	140	21:45-22:00	0	8	8	48
4:00-4:15	0	0	0	6	10:00-10:15	0	27	27	76	16:00-16:15	0	34	34	142	22:00-22:15	0	12	12	44
4:15-4:30	0	0	0	5	10:15-10:30	0	29	29	95	16:15-16:30	0	47	47	144	22:15-22:30	0	11	11	43
4:30-4:45	0	1	1	2	10:30-10:45	0	32	32	108	16:30-16:45	0	33	33	141	22:30-22:45	0	18	18	49
4:45-5:00	0	7	7	8	10:45-11:00	0	28	28	116	16:45-17:00	0	29	29	143	22:45-23:00	0	12	12	53
5:00-5:15	0	3	3	11	11:00-11:15	0	24	24	113	17:00-17:15	0	36	36	145	23:00-23:15	0	9	9	50
5:15-5:30	0	3	3	14	11:15-11:30	0	30	30	114	17:15-17:30	0	32	32	130	23:15-23:30	0	9	9	48
5:30-5:45	0	13	13	26	11:30-11:45	0	40	40	122	17:30-17:45	0	32	32	129	23:30-23:45	0	5	5	35
5:45-6:00	0	21	21	40	11:45-12:00	0	29	29	123	17:45-18:00	0	31	31	131	23:45-24:00	0	7	7	30

SUNDAY 6/16/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	24	63	87	268	6:00-6:15	74	27	101	296	12:00-12:15	155	187	342	1364	18:00-18:15	112	182	294	1243
0:15-0:30	19	60	79	274	6:15-6:30	94	34	128	368	12:15-12:30	147	167	314	1337	18:15-18:30	154	129	283	1201
0:30-0:45	16	44	60	268	6:30-6:45	144	50	194	491	12:30-12:45	186	159	345	1350	18:30-18:45	147	150	297	1180
0:45-1:00	11	33	44	270	6:45-7:00	134	41	175	598	12:45-13:00	160	170	330	1331	18:45-19:00	109	115	224	1098
1:00-1:15	11	40	51	234	7:00-7:15	165	47	212	709	13:00-13:15	188	145	333	1322	19:00-19:15	144	105	249	1053
1:15-1:30	10	21	31	186	7:15-7:30	160	60	220	801	13:15-13:30	195	148	343	1351	19:15-19:30	103	112	215	985
1:30-1:45	10	30	40	166	7:30-7:45	129	83	212	819	13:30-13:45	172	172	344	1350	19:30-19:45	87	110	197	885
1:45-2:00	14	28	42	164	7:45-8:00	119	70	189	833	13:45-14:00	179	140	319	1339	19:45-20:00	83	122	205	866
2:00-2:15	8	26	34	147	8:00-8:15	97	84	181	802	14:00-14:15	198	159	357	1363	20:00-20:15	84	109	193	810
2:15-2:30	7	25	32	148	8:15-8:30	128	95	223	805	14:15-14:30	201	164	365	1385	20:15-20:30	56	94	150	745
2:30-2:45	6	22	28	136	8:30-8:45	122	105	227	820	14:30-14:45	209	177	386	1427	20:30-20:45	72	80	152	700
2:45-3:00	6	17	23	117	8:45-9:00	127	101	228	859	14:45-15:00	163	129	292	1400	20:45-21:00	78	89	167	662
3:00-3:15	5	32	37	120	9:00-9:15	121	108	229	907	15:00-15:15	196	147	343	1386	21:00-21:15	66	92	158	627
3:15-3:30	7	18	25	113	9:15-9:30	121	116	237	921	15:15-15:30	210	149	359	1380	21:15-21:30	44	115	159	636
3:30-3:45	5	23	28	113	9:30-9:45	116	133	249	943	15:30-15:45	215	199	414	1408	21:30-21:45	53	92	145	629
3:45-4:00	4	27	31	121	9:45-10:00	118	147	265	980	15:45-16:00	186	167	353	1469	21:45-22:00	36	93	129	591
4:00-4:15	13	23	36	120	10:00-10:15	133	135	268	1019	16:00-16:15	180	173	353	1479	22:00-22:15	44	70	114	547
4:15-4:30	20	12	32	127	10:15-10:30	136	161	297	1079	16:15-16:30	164	213	377	1497	22:15-22:30	43	86	129	517
4:30-4:45	14	18	32	131	10:30-10:45	85	129	214	1044	16:30-16:45	180	253	433	1516	22:30-22:45	32	90	122	494
4:45-5:00	16	14	30	130	10:45-11:00	131	156	287	1066	16:45-17:00	142	162	304	1467	22:45-23:00	23	98	121	486
5:00-5:15	18	5	23	117	11:00-11:15	152	154	306	1104	17:00-17:15	154	162	316	1430	23:00-23:15	14	64	78	450
5:15-5:30	33	23	56	141	11:15-11:30	159	182	341	1148	17:15-17:30	141	184	325	1378	23:15-23:30	18	55	73	394
5:30-5:45	44	27	71	180	11:30-11:45	149	183	332	1266	17:30-17:45	138	180	318	1263	23:30-23:45	7	59	66	338
5:45-6:00	38	30	68	218	11:45-12:00	181	168	349	1328	17:45-18:00	143	163	306	1265	23:45-24:00	13	29	42	259

MONDAY 6/17/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	7	37	44	225	6:00-6:15	111	59	170	500	12:00-12:15	172	161	333	1309	18:00-18:15	137	165	302	1390
0:15-0:30	4	24	28	169	6:15-6:30	185	90	275	693	12:15-12:30	189	149	338	1288	18:15-18:30	145	132	277	1258
0:30-0:45	4	31	35	151	6:30-6:45	191	90	281	865	12:30-12:45	186	170	356	1317	18:30-18:45	130	111	241	1147
0:45-1:00	8	16	24	131	6:45-7:00	290	76	366	1092	12:45-13:00	185	153	338	1365	18:45-19:00	110	112	222	1042
1:00-1:15	6	15	21	108	7:00-7:15	307	97	404	1326	13:00-13:15	184	149	333	1365	19:00-19:15	93	103	196	936
1:15-1:30	2	10	12	92	7:15-7:30	230	110	340	1391	13:15-13:30	196	130	326	1353	19:15-19:30	95	89	184	843
1:30-1:45	7	12	19	76	7:30-7:45	222	109	331	1441	13:30-13:45	210	189	399	1396	19:30-19:45	76	83	159	761
1:45-2:00	11	13	24	76	7:45-8:00	176	135	311	1386	13:45-14:00	212	177	389	1447	19:45-20:00	75	102	177	716
2:00-2:15	4	12	16	71	8:00-8:15	144	139	283	1265	14:00-14:15	233	181	414	1528	20:00-20:15	56	91	147	667
2:15-2:30	3	9	12	71	8:15-8:30	158	125	283	1208	14:15-14:30	234	184	418	1620	20:15-20:30	68	83	151	634
2:30-2:45	6	11	17	69	8:30-8:45	163	121	284	1161	14:30-14:45	200	199	399	1620	20:30-20:45	48	70	118	593
2:45-3:00	7	13	20	65	8:45-9:00	164	167	331	1181	14:45-15:00	235	150	385	1616	20:45-21:00	50	65	115	531
3:00-3:15	5	8	13	62	9:00-9:15	140	141	281	1179	15:00-15:15	211	180	391	1593	21:00-21:15	62	98	160	544
3:15-3:30	8	27	35	85	9:15-9:30	121	141	262	1158	15:15-15:30	219	152	371	1546	21:15-21:30	52	89	141	534
3:30-3:45	9	12	21	89	9:30-9:45	154	186	340	1214	15:30-15:45	216	228	444	1591	21:30-21:45	68	79	147	563
3:45-4:00	7	8	15	84	9:45-10:00	160	168	328	1211	15:45-16:00	219	212	431	1637	21:45-22:00	34	69	103	551
4:00-4:15	7	8	15	86	10:00-10:15	133	181	314	1244	16:00-16:15	216	215	431	1677	22:00-22:15	39	70	109	500
4:15-4:30	27	3	30	81	10:15-10:30	141	186	327	1309	16:15-16:30	243	229	472	1778	22:15-22:30	28	77	105	464
4:30-4:45	16	5	21	81	10:30-10:45	166	194	360	1329	16:30-16:45	234	297	531	1865	22:30-22:45	24	89	113	430
4:45-5:00	34	5	39	105	10:45-11:00	138	186	324	1325	16:45-17:00	208	225	433	1867	22:45-23:00	7	59	66	393
5:00-5:15	38	20	58	148	11:00-11:15	123	138	261	1272	17:00-17:15	172	216	388	1824	23:00-23:15	13	58	71	355
5:15-5:30	56	26	82	200	11:15-11:30	168	191	359	1304	17:15-17:30	173	236	409	1761	23:15-23:30	15	69	84	334
5:30-5:45	61	48	109	288	11:30-11:45	161	166	327	1271	17:30-17:45	141	211	352	1582	23:30-23:45	12	41	53	274
5:45-6:00	90	49	139	388	11:45-12:00	135	155	290	1237	17:45-18:00	133	194	327	1476	23:45-24:00	7	37	44	252

TUESDAY 6/18/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	15	27	42	247	6:00-6:15	171	69	240	651	12:00-12:15	174	155	329	1285	18:00-18:15	144	169	313	1350
0:15-0:30	11	42	53	221	6:15-6:30	214	75	289	862	12:15-12:30	170	174	344	1334	18:15-18:30	149	151	300	1279
0:30-0:45	8	33	41	188	6:30-6:45	212	101	313	1035	12:30-12:45	176	179	355	1346	18:30-18:45	127	147	274	1218
0:45-1:00	12	23	35	171	6:45-7:00	229	76	305	1147	12:45-13:00	172	143	315	1343	18:45-19:00	116	122	238	1125
1:00-1:15	6	23	29	158	7:00-7:15	221	84	305	1212	13:00-13:15	169	132	301	1315	19:00-19:15	129	97	226	1038
1:15-1:30	9	19	28	133	7:15-7:30	243	111	354	1277	13:15-13:30	177	142	319	1290	19:15-19:30	103	114	217	955
1:30-1:45	2	12	14	106	7:30-7:45	224	132	356	1320	13:30-13:45	182	192	374	1309	19:30-19:45	71	113	184	865
1:45-2:00	4	18	22	93	7:45-8:00	148	148	296	1311	13:45-14:00	203	186	389	1383	19:45-20:00	71	90	161	788
2:00-2:15	8	2	10	74	8:00-8:15	188	124	312	1318	14:00-14:15	183	165	348	1430	20:00-20:15	48	82	130	692
2:15-2:30	7	14	21	67	8:15-8:30	182	144	326	1290	14:15-14:30	201	169	370	1481	20:15-20:30	65	80	145	620
2:30-2:45	5	6	11	64	8:30-8:45	202	140	342	1276	14:30-14:45	211	215	426	1533	20:30-20:45	59	72	131	567
2:45-3:00	6	17	23	65	8:45-9:00	154	141	295	1275	14:45-15:00	212	180	392	1536	20:45-21:00	39	66	105	511
3:00-3:15	2	18	20	75	9:00-9:15	182	164	346	1309	15:00-15:15	205	176	381	1569	21:00-21:15	55	89	144	525
3:15-3:30	9	17	26	80	9:15-9:30	143	172	315	1298	15:15-15:30	220	166	386	1585	21:15-21:30	66	55	121	501
3:30-3:45	15	19	34	103	9:30-9:45	139	185	324	1280	15:30-15:45	204	223	427	1586	21:30-21:45	50	87	137	507
3:45-4:00	8	12	20	100	9:45-10:00	142	163	305	1290	15:45-16:00	233	248	481	1675	21:45-22:00	53	95	148	550
4:00-4:15	25	7	32	112	10:00-10:15	132	179	311	1255	16:00-16:15	199	231	430	1724	22:00-22:15	25	62	87	493
4:15-4:30	24	3	27	113	10:15-10:30	177	208	385	1325	16:15-16:30	235	214	449	1787	22:15-22:30	36	98	134	506
4:30-4:45	30	6	36	115	10:30-10:45	123	162	285	1286	16:30-16:45	194	265	459	1819	22:30-22:45	32	94	126	495
4:45-5:00	37	8	45	140	10:45-11:00	135	170	305	1286	16:45-17:00	205	244	449	1787	22:45-23:00	23	65	88	435
5:00-5:15	54	18	72	180	11:00-11:15	140	153	293	1268	17:00-17:15	148	209	357	1714	23:00-23:15	15	45	60	408
5:15-5:30	59	19	78	231	11:15-11:30	149	146	295	1178	17:15-17:30	165	206	371	1636	23:15-23:30	25	54	79	353
5:30-5:45	93	47	140	335	11:30-11:45	168	175	343	1236	17:30-17:45	152	183	335	1512	23:30-23:45	15	59	74	301
5:45-6:00	138	55	193	483	11:45-12:00	140	178	318	1249	17:45-18:00	149	182	331	1394	23:45-24:00	8	44	52	265

WEDNESDAY 6/19/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	15	28	43	254
0:15-0:30	7	19	26	185
0:30-0:45	2	31	33	155
0:45-1:00	4	16	20	122
1:00-1:15	5	8	13	92
1:15-1:30	5	26	31	97
1:30-1:45	3	10	13	77
1:45-2:00	2	5	7	64
2:00-2:15	5	12	17	68
2:15-2:30	8	13	21	58
2:30-2:45	6	15	21	66
2:45-3:00	6	15	21	80
3:00-3:15	8	10	18	81
3:15-3:30	4	25	29	89
3:30-3:45	3	14	17	85
3:45-4:00	10	14	24	88
4:00-4:15	13	7	20	90
4:15-4:30	36	5	41	102
4:30-4:45	39	7	46	131
4:45-5:00	40	6	46	153
5:00-5:15	46	7	53	186
5:15-5:30	76	29	105	250
5:30-5:45	99	-29	70	274
5:45-6:00	132	114	246	474

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
6:00-6:15	194	63	257	678
6:15-6:30	204	90	294	867
6:30-6:45	204	99	303	1100
6:45-7:00	230	76	306	1160
7:00-7:15	231	129	360	1263
7:15-7:30	205	121	326	1295
7:30-7:45	214	132	346	1338
7:45-8:00	181	101	282	1314
8:00-8:15	182	125	307	1261
8:15-8:30	182	137	319	1254
8:30-8:45	171	174	345	1253
8:45-9:00	158	181	339	1310
9:00-9:15	182	162	344	1347
9:15-9:30	157	163	320	1348
9:30-9:45	165	148	313	1316
9:45-10:00	137	199	336	1313
10:00-10:15	135	143	278	1247
10:15-10:30	139	200	339	1266
10:30-10:45	114	224	338	1291
10:45-11:00	138	183	321	1276
11:00-11:15	170	168	338	1336
11:15-11:30	149	183	332	1329
11:30-11:45	154	183	337	1328
11:45-12:00	154	166	320	1327

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
12:00-12:15	148	149	297	1286
12:15-12:30	190	180	370	1324
12:30-12:45	191	171	362	1349
12:45-13:00	198	173	371	1400
13:00-13:15	203	183	386	1489
13:15-13:30	206	164	370	1489
13:30-13:45	182	161	343	1470
13:45-14:00	226	182	408	1507
14:00-14:15	231	165	396	1517
14:15-14:30	206	189	395	1542
14:30-14:45	192	203	395	1594
14:45-15:00	215	204	419	1605
15:00-15:15	229	175	404	1613
15:15-15:30	231	190	421	1639
15:30-15:45	215	192	407	1651
15:45-16:00	228	226	454	1686
16:00-16:15	212	249	461	1743
16:15-16:30	221	220	441	1763
16:30-16:45	178	215	393	1749
16:45-17:00	192	246	438	1733
17:00-17:15	163	214	377	1649
17:15-17:30	160	213	373	1581
17:30-17:45	147	228	375	1563
17:45-18:00	137	189	326	1451

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
18:00-18:15	134	154	288	1362
18:15-18:30	129	155	284	1273
18:30-18:45	125	144	269	1167
18:45-19:00	134	134	268	1109
19:00-19:15	119	101	220	1041
19:15-19:30	111	76	187	944
19:30-19:45	83	109	192	867
19:45-20:00	80	120	200	799
20:00-20:15	80	106	186	765
20:15-20:30	67	71	138	716
20:30-20:45	63	84	147	671
20:45-21:00	105	83	188	659
21:00-21:15	59	76	135	608
21:15-21:30	52	72	124	594
21:30-21:45	68	100	168	615
21:45-22:00	37	86	123	550
22:00-22:15	35	79	114	529
22:15-22:30	27	60	87	492
22:30-22:45	31	74	105	429
22:45-23:00	21	85	106	412
23:00-23:15	11	66	77	375
23:15-23:30	18	77	95	383
23:30-23:45	16	47	63	341
23:45-24:00	5	48	53	288

THURSDAY 6/20/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	15	43	58	262	6:00-6:15	160	66	226	616	12:00-12:15	180	157	337	1290	18:00-18:15	154	140	294	1395
0:15-0:30	6	42	48	214	6:15-6:30	204	79	283	810	12:15-12:30	182	182	364	1309	18:15-18:30	148	146	294	1295
0:30-0:45	8	25	33	185	6:30-6:45	197	96	293	968	12:30-12:45	175	166	341	1335	18:30-18:45	139	139	278	1224
0:45-1:00	7	18	25	164	6:45-7:00	228	76	304	1106	12:45-13:00	177	161	338	1380	18:45-19:00	134	127	261	1127
1:00-1:15	7	13	20	126	7:00-7:15	225	108	333	1213	13:00-13:15	178	156	334	1377	19:00-19:15	118	99	217	1050
1:15-1:30	7	21	28	106	7:15-7:30	229	118	347	1277	13:15-13:30	227	135	362	1375	19:15-19:30	75	94	169	925
1:30-1:45	10	12	22	95	7:30-7:45	200	113	313	1297	13:30-13:45	215	185	400	1434	19:30-19:45	98	102	200	847
1:45-2:00	6	18	24	94	7:45-8:00	155	109	264	1257	13:45-14:00	213	153	366	1462	19:45-20:00	78	89	167	753
2:00-2:15	8	14	22	96	8:00-8:15	151	154	305	1229	14:00-14:15	197	210	407	1535	20:00-20:15	80	79	159	695
2:15-2:30	7	7	14	82	8:15-8:30	200	136	336	1218	14:15-14:30	199	154	353	1526	20:15-20:30	62	80	142	668
2:30-2:45	4	12	16	76	8:30-8:45	178	150	328	1233	14:30-14:45	204	219	423	1549	20:30-20:45	84	62	146	614
2:45-3:00	7	20	27	79	8:45-9:00	153	158	311	1280	14:45-15:00	192	171	363	1546	20:45-21:00	51	72	123	570
3:00-3:15	5	18	23	80	9:00-9:15	148	158	306	1281	15:00-15:15	182	186	368	1507	21:00-21:15	66	90	156	567
3:15-3:30	5	29	34	100	9:15-9:30	144	136	280	1225	15:15-15:30	199	192	391	1545	21:15-21:30	65	109	174	599
3:30-3:45	9	14	23	107	9:30-9:45	162	171	333	1230	15:30-15:45	173	222	395	1517	21:30-21:45	72	97	169	622
3:45-4:00	8	14	22	102	9:45-10:00	146	169	315	1234	15:45-16:00	187	231	418	1572	21:45-22:00	37	62	99	598
4:00-4:15	16	7	23	102	10:00-10:15	145	185	330	1258	16:00-16:15	202	236	438	1642	22:00-22:15	23	79	102	544
4:15-4:30	34	9	43	111	10:15-10:30	173	164	337	1315	16:15-16:30	197	240	437	1688	22:15-22:30	37	82	119	489
4:30-4:45	41	5	46	134	10:30-10:45	137	190	327	1309	16:30-16:45	208	278	486	1779	22:30-22:45	31	78	109	429
4:45-5:00	29	11	40	152	10:45-11:00	186	187	373	1367	16:45-17:00	176	248	424	1785	22:45-23:00	24	81	105	435
5:00-5:15	54	17	71	200	11:00-11:15	164	158	322	1359	17:00-17:15	182	219	401	1748	23:00-23:15	14	68	82	415
5:15-5:30	76	13	89	246	11:15-11:30	160	185	345	1367	17:15-17:30	159	235	394	1705	23:15-23:30	15	81	96	392
5:30-5:45	86	49	135	335	11:30-11:45	132	183	315	1355	17:30-17:45	157	192	349	1568	23:30-23:45	10	52	62	345
5:45-6:00	110	56	166	461	11:45-12:00	147	146	293	1275	17:45-18:00	141	217	358	1502	23:45-24:00	11	35	46	286

FRIDAY 6/14/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	14	19	33	340
0:15-0:30	5	40	45	260
0:30-0:45	16	26	42	204
0:45-1:00	9	19	28	148
1:00-1:15	11	22	33	148
1:15-1:30	8	15	23	126
1:30-1:45	7	10	17	101
1:45-2:00	10	11	21	94
2:00-2:15	9	9	18	79
2:15-2:30	6	17	23	79
2:30-2:45	4	15	19	81
2:45-3:00	6	20	26	86
3:00-3:15	6	11	17	85
3:15-3:30	9	18	27	89
3:30-3:45	1	14	15	85
3:45-4:00	13	8	21	80
4:00-4:15	12	14	26	89
4:15-4:30	28	4	32	94
4:30-4:45	23	6	29	108
4:45-5:00	32	7	39	126
5:00-5:15	45	19	64	164
5:15-5:30	44	36	80	212
5:30-5:45	66	53	119	302
5:45-6:00	100	57	157	420

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
6:00-6:15	157	64	221	577
6:15-6:30	171	69	240	737
6:30-6:45	199	99	298	916
6:45-7:00	189	68	257	1016
7:00-7:15	192	95	287	1082
7:15-7:30	200	104	304	1146
7:30-7:45	208	91	299	1147
7:45-8:00	185	103	288	1178
8:00-8:15	181	137	318	1209
8:15-8:30	176	117	293	1198
8:30-8:45	177	128	305	1204
8:45-9:00	156	152	308	1224
9:00-9:15	145	144	289	1195
9:15-9:30	151	180	331	1233
9:30-9:45	117	181	298	1226
9:45-10:00	160	156	316	1234
10:00-10:15	125	148	273	1218
10:15-10:30	158	177	335	1222
10:30-10:45	169	178	347	1271
10:45-11:00	139	181	320	1275
11:00-11:15	132	185	317	1319
11:15-11:30	167	178	345	1329
11:30-11:45	145	179	324	1306
11:45-12:00	157	165	322	1308

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
12:00-12:15	142	138	280	1271
12:15-12:30	176	155	331	1257
12:30-12:45	165	156	321	1254
12:45-13:00	174	152	326	1258
13:00-13:15	185	162	347	1325
13:15-13:30	199	134	333	1327
13:30-13:45	211	189	400	1406
13:45-14:00	212	191	403	1483
14:00-14:15	195	146	341	1477
14:15-14:30	209	191	400	1544
14:30-14:45	197	214	411	1555
14:45-15:00	201	182	383	1535
15:00-15:15	203	215	418	1612
15:15-15:30	209	220	429	1641
15:30-15:45	203	212	415	1645
15:45-16:00	230	243	473	1735
16:00-16:15	204	239	443	1760
16:15-16:30	217	202	419	1750
16:30-16:45	201	302	503	1838
16:45-17:00	167	251	418	1783
17:00-17:15	174	206	380	1720
17:15-17:30	163	225	388	1689
17:30-17:45	164	176	340	1526
17:45-18:00	153	169	322	1430

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
18:00-18:15	139	157	296	1346
18:15-18:30	142	123	265	1223
18:30-18:45	189	121	310	1193
18:45-19:00	141	99	240	1111
19:00-19:15	161	123	284	1099
19:15-19:30	146	101	247	1081
19:30-19:45	121	91	212	983
19:45-20:00	123	93	216	959
20:00-20:15	137	93	230	905
20:15-20:30	89	78	167	825
20:30-20:45	107	72	179	792
20:45-21:00	90	123	213	789
21:00-21:15	93	82	175	734
21:15-21:30	80	92	172	739
21:30-21:45	78	102	180	740
21:45-22:00	68	98	166	693
22:00-22:15	43	87	130	648
22:15-22:30	58	110	168	644
22:30-22:45	44	98	142	606
22:45-23:00	42	92	134	574
23:00-23:15	32	98	130	574
23:15-23:30	28	97	125	531
23:30-23:45	13	85	98	487
23:45-24:00	20	64	84	437

SATURDAY 6/15/91

HONOAPIILANI HIGHWAY

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	27	76	103	385
0:15-0:30	22	49	71	335
0:30-0:45	10	42	52	285
0:45-1:00	8	23	31	257
1:00-1:15	10	27	37	191
1:15-1:30	8	35	43	163
1:30-1:45	4	19	23	134
1:45-2:00	12	18	30	133
2:00-2:15	12	17	29	125
2:15-2:30	12	30	42	124
2:30-2:45	9	18	27	128
2:45-3:00	4	20	24	122
3:00-3:15	7	29	36	129
3:15-3:30	2	31	33	120
3:30-3:45	14	23	37	130
3:45-4:00	14	26	40	146
4:00-4:15	12	16	28	138
4:15-4:30	31	10	41	146
4:30-4:45	15	10	25	134
4:45-5:00	16	11	27	121
5:00-5:15	20	15	35	128
5:15-5:30	51	19	70	157
5:30-5:45	61	43	104	236
5:45-6:00	58	45	103	312

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
6:00-6:15	102	42	144	421
6:15-6:30	111	59	170	521
6:30-6:45	110	60	170	587
6:45-7:00	143	76	219	703
7:00-7:15	130	66	196	755
7:15-7:30	127	85	212	797
7:30-7:45	140	68	208	835
7:45-8:00	77	86	163	779
8:00-8:15	86	115	201	784
8:15-8:30	139	128	267	839
8:30-8:45	135	167	302	933
8:45-9:00	97	140	237	1007
9:00-9:15	120	155	275	1081
9:15-9:30	124	147	271	1085
9:30-9:45	124	164	288	1071
9:45-10:00	167	176	343	1177
10:00-10:15	132	172	304	1206
10:15-10:30	123	193	316	1251
10:30-10:45	138	215	353	1316
10:45-11:00	140	200	340	1313
11:00-11:15	154	202	356	1365
11:15-11:30	150	159	309	1358
11:30-11:45	153	206	359	1364
11:45-12:00	155	149	304	1328

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
12:00-12:15	175	159	334	1306
12:15-12:30	195	127	322	1319
12:30-12:45	188	163	351	1311
12:45-13:00	154	125	279	1286
13:00-13:15	180	162	342	1294
13:15-13:30	196	145	341	1313
13:30-13:45	203	262	465	1427
13:45-14:00	192	131	323	1471
14:00-14:15	223	150	373	1502
14:15-14:30	243	148	391	1552
14:30-14:45	202	164	366	1453
14:45-15:00	207	143	350	1480
15:00-15:15	219	115	334	1441
15:15-15:30	207	152	359	1409
15:30-15:45	195	182	377	1420
15:45-16:00	198	131	329	1399
16:00-16:15	170	130	300	1365
16:15-16:30	188	135	323	1329
16:30-16:45	182	242	424	1376
16:45-17:00	184	144	328	1375
17:00-17:15	157	144	301	1376
17:15-17:30	148	146	294	1347
17:30-17:45	152	160	312	1235
17:45-18:00	159	149	308	1215

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
18:00-18:15	165	157	322	1236
18:15-18:30	174	112	286	1228
18:30-18:45	146	100	246	1162
18:45-19:00	149	102	251	1105
19:00-19:15	170	87	257	1040
19:15-19:30	138	78	216	970
19:30-19:45	127	114	241	965
19:45-20:00	99	90	189	903
20:00-20:15	67	87	154	800
20:15-20:30	98	69	167	751
20:30-20:45	80	84	164	674
20:45-21:00	73	92	165	650
21:00-21:15	70	110	180	676
21:15-21:30	71	99	170	679
21:30-21:45	55	90	145	660
21:45-22:00	72	101	173	668
22:00-22:15	61	84	145	633
22:15-22:30	63	103	166	629
22:30-22:45	45	100	145	629
22:45-23:00	43	87	130	586
23:00-23:15	27	85	112	553
23:15-23:30	32	89	121	508
23:30-23:45	32	70	102	465
23:45-24:00	19	40	59	394

MONDAY 6/17/91

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	0	0	2	6:00-6:15	0	5	5	17	12:00-12:15	0	16	16	76	18:00-18:15	0	18	18	80
0:15-0:30	0	0	0	1	6:15-6:30	0	17	17	33	12:15-12:30	0	29	29	92	18:15-18:30	0	21	21	75
0:30-0:45	0	0	0	1	6:30-6:45	0	33	33	58	12:30-12:45	0	50	50	121	18:30-18:45	0	21	21	81
0:45-1:00	0	0	0	0	6:45-7:00	0	46	46	101	12:45-13:00	0	25	25	120	18:45-19:00	0	12	12	72
1:00-1:15	0	0	0	0	7:00-7:15	0	28	28	124	13:00-13:15	0	19	19	123	19:00-19:15	0	16	16	70
1:15-1:30	0	0	0	0	7:15-7:30	0	11	11	118	13:15-13:30	0	17	17	111	19:15-19:30	0	10	10	59
1:30-1:45	0	0	0	0	7:30-7:45	0	3	3	88	13:30-13:45	0	29	29	90	19:30-19:45	0	20	20	58
1:45-2:00	0	0	0	0	7:45-8:00	0	7	7	49	13:45-14:00	0	23	23	88	19:45-20:00	0	16	16	62
2:00-2:15	0	0	0	0	8:00-8:15	0	1	1	22	14:00-14:15	0	17	17	86	20:00-20:15	0	2	2	48
2:15-2:30	0	0	0	0	8:15-8:30	0	4	4	15	14:15-14:30	0	20	20	89	20:15-20:30	0	7	7	45
2:30-2:45	0	0	0	0	8:30-8:45	0	6	6	18	14:30-14:45	0	15	15	75	20:30-20:45	0	8	8	33
2:45-3:00	0	0	0	0	8:45-9:00	0	7	7	18	14:45-15:00	0	27	27	79	20:45-21:00	0	9	9	26
3:00-3:15	0	0	0	0	9:00-9:15	0	5	5	22	15:00-15:15	0	20	20	82	21:00-21:15	0	6	6	30
3:15-3:30	0	0	0	0	9:15-9:30	0	6	6	24	15:15-15:30	0	20	20	82	21:15-21:30	0	3	3	26
3:30-3:45	0	0	0	0	9:30-9:45	0	5	5	23	15:30-15:45	0	25	25	92	21:30-21:45	0	5	5	23
3:45-4:00	0	0	0	0	9:45-10:00	0	10	10	26	15:45-16:00	0	24	24	89	21:45-22:00	0	1	1	15
4:00-4:15	0	0	0	0	10:00-10:15	0	4	4	25	16:00-16:15	0	21	21	90	22:00-22:15	0	4	4	13
4:15-4:30	0	0	0	0	10:15-10:30	0	16	16	35	16:15-16:30	0	31	31	101	22:15-22:30	0	3	3	13
4:30-4:45	0	2	2	2	10:30-10:45	0	22	22	52	16:30-16:45	0	24	24	100	22:30-22:45	0	5	5	13
4:45-5:00	0	0	0	2	10:45-11:00	0	12	12	54	16:45-17:00	0	32	32	108	22:45-23:00	0	1	1	13
5:00-5:15	0	3	3	5	11:00-11:15	0	11	11	61	17:00-17:15	0	33	33	120	23:00-23:15	0	7	7	16
5:15-5:30	0	1	1	6	11:15-11:30	0	13	13	58	17:15-17:30	0	26	26	115	23:15-23:30	0	1	1	14
5:30-5:45	0	8	8	12	11:30-11:45	0	21	21	57	17:30-17:45	0	15	15	106	23:30-23:45	0	0	0	9
5:45-6:00	0	3	3	15	11:45-12:00	0	26	26	71	17:45-18:00	0	21	21	95	23:45-24:00	0	1	1	9

TUESDAY 6/18/91

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	0	0	10	6:00-6:15	0	0	0	0	12:00-12:15	0	71	71	191	18:00-18:15	0	30	30	117
0:15-0:30	0	3	3	9	6:15-6:30	0	0	0	0	12:15-12:30	0	60	60	212	18:15-18:30	0	24	24	101
0:30-0:45	0	2	2	5	6:30-6:45	0	0	0	0	12:30-12:45	0	47	47	213	18:30-18:45	0	29	29	100
0:45-1:00	0	1	1	6	6:45-7:00	0	39	39	39	12:45-13:00	0	36	36	214	18:45-19:00	0	25	25	108
1:00-1:15	0	0	0	6	7:00-7:15	0	41	41	80	13:00-13:15	0	36	36	179	19:00-19:15	0	21	21	99
1:15-1:30	0	1	1	4	7:15-7:30	0	10	10	90	13:15-13:30	0	37	37	156	19:15-19:30	0	20	20	95
1:30-1:45	0	1	1	3	7:30-7:45	0	15	15	105	13:30-13:45	0	43	43	152	19:30-19:45	0	29	29	95
1:45-2:00	0	0	0	2	7:45-8:00	0	12	12	78	13:45-14:00	0	37	37	153	19:45-20:00	0	9	9	79
2:00-2:15	0	1	1	3	8:00-8:15	0	13	13	50	14:00-14:15	0	36	36	153	20:00-20:15	0	8	8	66
2:15-2:30	0	0	0	2	8:15-8:30	0	24	24	64	14:15-14:30	0	37	37	153	20:15-20:30	0	4	4	50
2:30-2:45	0	0	0	1	8:30-8:45	0	14	14	63	14:30-14:45	0	35	35	145	20:30-20:45	0	5	5	26
2:45-3:00	0	1	1	2	8:45-9:00	0	20	20	71	14:45-15:00	0	30	30	138	20:45-21:00	0	2	2	19
3:00-3:15	0	1	1	2	9:00-9:15	0	28	28	86	15:00-15:15	0	25	25	127	21:00-21:15	0	1	1	12
3:15-3:30	0	1	1	3	9:15-9:30	0	24	24	86	15:15-15:30	0	45	45	135	21:15-21:30	0	3	3	11
3:30-3:45	0	0	0	3	9:30-9:45	0	23	23	95	15:30-15:45	0	28	28	128	21:30-21:45	0	5	5	11
3:45-4:00	0	1	1	3	9:45-10:00	0	22	22	97	15:45-16:00	0	41	41	139	21:45-22:00	0	1	1	10
4:00-4:15	0	0	0	2	10:00-10:15	0	24	24	93	16:00-16:15	0	41	41	155	22:00-22:15	0	3	3	12
4:15-4:30	0	2	2	3	10:15-10:30	0	26	26	95	16:15-16:30	0	47	47	157	22:15-22:30	0	2	2	11
4:30-4:45	0	4	4	7	10:30-10:45	0	21	21	93	16:30-16:45	0	45	45	174	22:30-22:45	0	6	6	12
4:45-5:00	0	0	0	6	10:45-11:00	0	37	37	108	16:45-17:00	0	61	61	194	22:45-23:00	0	4	4	15
5:00-5:15	0	0	0	6	11:00-11:15	0	33	33	117	17:00-17:15	0	50	50	203	23:00-23:15	0	4	4	16
5:15-5:30	0	0	0	4	11:15-11:30	0	39	39	130	17:15-17:30	0	40	40	196	23:15-23:30	0	4	4	18
5:30-5:45	0	0	0	0	11:30-11:45	0	46	46	155	17:30-17:45	0	30	30	181	23:30-23:45	0	6	6	18
5:45-6:00	0	0	0	0	11:45-12:00	0	35	35	153	17:45-18:00	0	17	17	137	23:45-24:00	0	0	0	14

WEDNESDAY 6/19/91

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	0	0	-1	6:00-6:15	0	21	21	52	12:00-12:15	0	37	37	137	18:00-18:15	0	26	26	123
0:15-0:30	0	1	1	-3	6:15-6:30	0	44	44	89	12:15-12:30	0	30	30	124	18:15-18:30	0	28	28	115
0:30-0:45	0	1	1	-2	6:30-6:45	0	60	60	138	12:30-12:45	0	58	58	152	18:30-18:45	0	24	24	104
0:45-1:00	0	0	0	2	6:45-7:00	0	59	59	184	12:45-13:00	0	37	37	162	18:45-19:00	0	22	22	100
1:00-1:15	0	0	0	2	7:00-7:15	0	27	27	190	13:00-13:15	0	49	49	174	19:00-19:15	0	15	15	89
1:15-1:30	0	0	0	1	7:15-7:30	0	12	12	158	13:15-13:30	0	34	34	178	19:15-19:30	0	21	21	82
1:30-1:45	0	0	0	0	7:30-7:45	0	12	12	110	13:30-13:45	0	37	37	157	19:30-19:45	0	22	22	80
1:45-2:00	0	0	0	0	7:45-8:00	0	16	16	67	13:45-14:00	0	37	37	157	19:45-20:00	0	15	15	73
2:00-2:15	0	0	0	0	8:00-8:15	0	13	13	53	14:00-14:15	0	38	38	146	20:00-20:15	0	6	6	64
2:15-2:30	0	1	1	1	8:15-8:30	0	17	17	58	14:15-14:30	0	30	30	142	20:15-20:30	0	7	7	50
2:30-2:45	0	1	1	2	8:30-8:45	0	20	20	66	14:30-14:45	0	29	29	134	20:30-20:45	0	11	11	39
2:45-3:00	0	0	0	2	8:45-9:00	0	20	20	70	14:45-15:00	0	32	32	129	20:45-21:00	0	1	1	25
3:00-3:15	0	0	0	2	9:00-9:15	0	13	13	70	15:00-15:15	0	36	36	127	21:00-21:15	0	9	9	28
3:15-3:30	0	0	0	1	9:15-9:30	0	17	17	70	15:15-15:30	0	40	40	137	21:15-21:30	0	6	6	27
3:30-3:45	0	0	0	0	9:30-9:45	0	17	17	67	15:30-15:45	0	37	37	145	21:30-21:45	0	5	5	21
3:45-4:00	0	0	0	0	9:45-10:00	0	20	20	67	15:45-16:00	0	33	33	146	21:45-22:00	0	4	4	24
4:00-4:15	0	0	0	0	10:00-10:15	0	31	31	85	16:00-16:15	0	28	28	138	22:00-22:15	0	4	4	19
4:15-4:30	0	0	0	0	10:15-10:30	0	25	25	93	16:15-16:30	0	25	25	123	22:15-22:30	0	0	0	13
4:30-4:45	0	0	0	0	10:30-10:45	0	26	26	102	16:30-16:45	0	36	36	122	22:30-22:45	0	1	1	9
4:45-5:00	0	1	1	1	10:45-11:00	0	29	29	111	16:45-17:00	0	25	25	114	22:45-23:00	0	2	2	7
5:00-5:15	0	12	12	13	11:00-11:15	0	26	26	106	17:00-17:15	0	33	33	119	23:00-23:15	0	4	4	7
5:15-5:30	0	7	7	20	11:15-11:30	0	43	43	124	17:15-17:30	0	36	36	130	23:15-23:30	0	3	3	10
5:30-5:45	0	11	11	31	11:30-11:45	0	30	30	128	17:30-17:45	0	35	35	129	23:30-23:45	0	0	0	9
5:45-6:00	0	13	13	43	11:45-12:00	0	27	27	126	17:45-18:00	0	26	26	130	23:45-24:00	0	-4	-4	3

THURSDAY 6/20/91

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	0	0	8
0:15-0:30	0	3	3	6
0:30-0:45	0	2	2	7
0:45-1:00	0	1	1	6
1:00-1:15	0	1	1	7
1:15-1:30	0	0	0	4
1:30-1:45	0	0	0	2
1:45-2:00	0	1	1	2
2:00-2:15	0	2	2	3
2:15-2:30	0	0	0	3
2:30-2:45	0	0	0	3
2:45-3:00	0	0	0	2
3:00-3:15	0	0	0	0
3:15-3:30	0	1	1	1
3:30-3:45	0	0	0	1
3:45-4:00	0	0	0	1
4:00-4:15	0	0	0	1
4:15-4:30	0	0	0	0
4:30-4:45	0	1	1	1
4:45-5:00	0	1	1	2
5:00-5:15	0	3	3	5
5:15-5:30	0	4	4	9
5:30-5:45	0	1	1	9
5:45-6:00	0	9	9	17

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
6:00-6:15	0	10	10	24
6:15-6:30	0	29	29	49
6:30-6:45	0	66	66	114
6:45-7:00	0	40	40	145
7:00-7:15	0	27	27	162
7:15-7:30	0	19	19	152
7:30-7:45	0	11	11	97
7:45-8:00	0	7	7	64
8:00-8:15	0	10	10	47
8:15-8:30	0	18	18	46
8:30-8:45	0	7	7	42
8:45-9:00	0	8	8	43
9:00-9:15	0	14	14	47
9:15-9:30	0	18	18	47
9:30-9:45	0	7	7	47
9:45-10:00	0	15	15	54
10:00-10:15	0	11	11	51
10:15-10:30	0	18	18	51
10:30-10:45	0	12	12	56
10:45-11:00	0	27	27	68
11:00-11:15	0	13	13	70
11:15-11:30	0	59	59	111
11:30-11:45	0	21	21	120
11:45-12:00	0	31	31	124

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
12:00-12:15	0	34	34	145
12:15-12:30	0	25	25	111
12:30-12:45	0	43	43	133
12:45-13:00	0	28	28	130
13:00-13:15	0	25	25	121
13:15-13:30	0	24	24	120
13:30-13:45	0	21	21	98
13:45-14:00	0	28	28	98
14:00-14:15	0	28	28	101
14:15-14:30	0	18	18	95
14:30-14:45	0	20	20	94
14:45-15:00	0	21	21	87
15:00-15:15	0	30	30	89
15:15-15:30	0	22	22	93
15:30-15:45	0	16	16	89
15:45-16:00	0	14	14	82
16:00-16:15	0	18	18	70
16:15-16:30	0	30	30	78
16:30-16:45	0	21	21	83
16:45-17:00	0	24	24	93
17:00-17:15	0	39	39	114
17:15-17:30	0	22	22	106
17:30-17:45	0	27	27	112
17:45-18:00	0	24	24	112

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
18:00-18:15	0	12	12	85
18:15-18:30	0	13	13	76
18:30-18:45	0	16	16	65
18:45-19:00	0	8	8	49
19:00-19:15	0	31	31	68
19:15-19:30	0	16	16	71
19:30-19:45	0	8	8	63
19:45-20:00	0	11	11	66
20:00-20:15	0	7	7	42
20:15-20:30	0	8	8	34
20:30-20:45	0	4	4	30
20:45-21:00	0	3	3	22
21:00-21:15	0	6	6	21
21:15-21:30	0	1	1	14
21:30-21:45	0	4	4	14
21:45-22:00	0	2	2	13
22:00-22:15	0	5	5	12
22:15-22:30	0	4	4	15
22:30-22:45	0	5	5	16
22:45-23:00	0	2	2	16
23:00-23:15	0	6	6	17
23:15-23:30	0	5	5	18
23:30-23:45	0	1	1	14
23:45-24:00	0	2	2	14

FRIDAY 6/14/91

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	2	2	10	6:00-6:15	0	12	12	23	12:00-12:15	0	33	33	98	18:00-18:15	0	6	6	36
0:15-0:30	0	0	0	7	6:15-6:30	0	26	26	48	12:15-12:30	0	37	37	102	18:15-18:30	0	8	8	30
0:30-0:45	0	1	1	7	6:30-6:45	0	65	65	111	12:30-12:45	0	49	49	138	18:30-18:45	0	8	8	30
0:45-1:00	0	0	0	3	6:45-7:00	0	43	43	146	12:45-13:00	0	27	27	146	18:45-19:00	0	6	6	28
1:00-1:15	0	0	0	1	7:00-7:15	0	26	26	160	13:00-13:15	0	23	23	136	19:00-19:15	0	6	6	28
1:15-1:30	0	1	1	2	7:15-7:30	0	7	7	141	13:15-13:30	0	19	19	118	19:15-19:30	0	8	8	28
1:30-1:45	0	1	1	2	7:30-7:45	0	4	4	80	13:30-13:45	0	18	18	87	19:30-19:45	0	7	7	27
1:45-2:00	0	3	3	5	7:45-8:00	0	9	9	46	13:45-14:00	0	18	18	78	19:45-20:00	0	18	18	39
2:00-2:15	0	1	1	6	8:00-8:15	0	6	6	26	14:00-14:15	0	13	13	68	20:00-20:15	0	9	9	42
2:15-2:30	0	0	0	5	8:15-8:30	0	11	11	30	14:15-14:30	0	23	23	72	20:15-20:30	0	7	7	41
2:30-2:45	0	0	0	4	8:30-8:45	0	4	4	30	14:30-14:45	0	17	17	71	20:30-20:45	0	6	6	40
2:45-3:00	0	0	0	1	8:45-9:00	0	7	7	28	14:45-15:00	0	15	15	68	20:45-21:00	0	8	8	30
3:00-3:15	0	0	0	0	9:00-9:15	0	7	7	29	15:00-15:15	0	15	15	70	21:00-21:15	0	11	11	32
3:15-3:30	0	0	0	0	9:15-9:30	0	4	4	22	15:15-15:30	0	9	9	56	21:15-21:30	0	5	5	30
3:30-3:45	0	0	0	0	9:30-9:45	0	11	11	29	15:30-15:45	0	13	13	52	21:30-21:45	0	12	12	36
3:45-4:00	0	1	1	1	9:45-10:00	0	13	13	35	15:45-16:00	0	20	20	57	21:45-22:00	0	12	12	40
4:00-4:15	0	1	1	2	10:00-10:15	0	11	11	39	16:00-16:15	0	12	12	54	22:00-22:15	0	7	7	36
4:15-4:30	0	0	0	2	10:15-10:30	0	11	11	46	16:15-16:30	0	10	10	55	22:15-22:30	0	6	6	37
4:30-4:45	0	0	0	2	10:30-10:45	0	18	18	53	16:30-16:45	0	20	20	62	22:30-22:45	0	5	5	30
4:45-5:00	0	5	5	6	10:45-11:00	0	9	9	49	16:45-17:00	0	20	20	62	22:45-23:00	0	4	4	22
5:00-5:15	0	0	0	5	11:00-11:15	0	13	13	51	17:00-17:15	0	22	22	72	23:00-23:15	0	5	5	20
5:15-5:30	0	1	1	6	11:15-11:30	0	33	33	73	17:15-17:30	0	14	14	76	23:15-23:30	0	3	3	17
5:30-5:45	0	2	2	8	11:30-11:45	0	13	13	68	17:30-17:45	0	8	8	64	23:30-23:45	0	1	1	13
5:45-6:00	0	8	8	11	11:45-12:00	0	19	19	78	17:45-18:00	0	8	8	52	23:45-24:00	0	4	4	13

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4	TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00–0:15	0	2	2	8	6:00–6:15	0	6	6	26	12:00–12:15	0	24	24	91	18:00–18:15	0	12	12	57
0:15–0:30	0	1	1	7	6:15–6:30	0	24	24	49	12:15–12:30	0	28	28	103	18:15–18:30	0	10	10	50
0:30–0:45	0	0	0	4	6:30–6:45	0	50	50	89	12:30–12:45	0	42	42	114	18:30–18:45	0	7	7	42
0:45–1:00	0	0	0	3	6:45–7:00	0	28	28	108	12:45–13:00	0	22	22	116	18:45–19:00	0	7	7	36
1:00–1:15	0	1	1	2	7:00–7:15	0	18	18	120	13:00–13:15	0	21	21	113	19:00–19:15	0	9	9	33
1:15–1:30	0	0	0	1	7:15–7:30	0	5	5	101	13:15–13:30	0	23	23	108	19:15–19:30	0	1	1	24
1:30–1:45	0	1	1	2	7:30–7:45	0	10	10	61	13:30–13:45	0	14	14	80	19:30–19:45	0	17	17	34
1:45–2:00	0	0	0	2	7:45–8:00	0	5	5	38	13:45–14:00	0	14	14	72	19:45–20:00	0	7	7	34
2:00–2:15	0	1	1	2	8:00–8:15	0	1	1	21	14:00–14:15	0	14	14	65	20:00–20:15	0	9	9	34
2:15–2:30	0	0	0	2	8:15–8:30	0	10	10	26	14:15–14:30	0	9	9	51	20:15–20:30	0	6	6	39
2:30–2:45	0	1	1	2	8:30–8:45	0	4	4	20	14:30–14:45	0	14	14	51	20:30–20:45	0	5	5	27
2:45–3:00	0	3	3	5	8:45–9:00	0	3	3	18	14:45–15:00	0	10	10	47	20:45–21:00	0	7	7	27
3:00–3:15	0	2	2	6	9:00–9:15	0	4	4	21	15:00–15:15	0	7	7	40	21:00–21:15	0	8	8	26
3:15–3:30	0	1	1	7	9:15–9:30	0	3	3	14	15:15–15:30	0	17	17	48	21:15–21:30	0	8	8	28
3:30–3:45	0	1	1	7	9:30–9:45	0	7	7	17	15:30–15:45	0	17	17	51	21:30–21:45	0	3	3	26
3:45–4:00	0	0	0	4	9:45–10:00	0	7	7	21	15:45–16:00	0	22	22	63	21:45–22:00	0	5	5	24
4:00–4:15	0	0	0	2	10:00–10:15	0	12	12	29	16:00–16:15	0	8	8	64	22:00–22:15	0	9	9	25
4:15–4:30	0	0	0	1	10:15–10:30	0	13	13	39	16:15–16:30	0	13	13	60	22:15–22:30	0	6	6	23
4:30–4:45	0	0	0	0	10:30–10:45	0	14	14	46	16:30–16:45	0	17	17	60	22:30–22:45	0	9	9	29
4:45–5:00	0	2	2	2	10:45–11:00	0	10	10	49	16:45–17:00	0	10	10	48	22:45–23:00	0	9	9	33
5:00–5:15	0	2	2	4	11:00–11:15	0	7	7	44	17:00–17:15	0	19	19	59	23:00–23:15	0	5	5	29
5:15–5:30	0	1	1	5	11:15–11:30	0	16	16	47	17:15–17:30	0	17	17	63	23:15–23:30	0	2	2	25
5:30–5:45	0	10	10	15	11:30–11:45	0	31	31	64	17:30–17:45	0	15	15	61	23:30–23:45	0	3	3	19
5:45–6:00	0	9	9	22	11:45–12:00	0	20	20	74	17:45–18:00	0	13	13	64	23:45–24:00	0	1	1	11

SUNDAY 6/16/91

MAALAEA WHARF ENTRANCE LOCATION E

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
0:00-0:15	0	0	0	7
0:15-0:30	0	2	2	9
0:30-0:45	0	2	2	9
0:45-1:00	0	1	1	5
1:00-1:15	0	1	1	6
1:15-1:30	0	0	0	4
1:30-1:45	0	2	2	4
1:45-2:00	0	1	1	4
2:00-2:15	0	0	0	3
2:15-2:30	0	0	0	3
2:30-2:45	0	0	0	1
2:45-3:00	0	0	0	0
3:00-3:15	0	1	1	1
3:15-3:30	0	1	1	2
3:30-3:45	0	2	2	4
3:45-4:00	0	3	3	7
4:00-4:15	0	0	0	6
4:15-4:30	0	0	0	5
4:30-4:45	0	0	0	3
4:45-5:00	0	0	0	0
5:00-5:15	0	2	2	2
5:15-5:30	0	2	2	4
5:30-5:45	0	1	1	5
5:45-6:00	0	7	7	12

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
6:00-6:15	0	3	3	13
6:15-6:30	0	21	21	32
6:30-6:45	0	50	50	81
6:45-7:00	0	34	34	108
7:00-7:15	0	22	22	127
7:15-7:30	0	10	10	116
7:30-7:45	0	5	5	71
7:45-8:00	0	4	4	41
8:00-8:15	0	3	3	22
8:15-8:30	0	5	5	17
8:30-8:45	0	10	10	22
8:45-9:00	0	6	6	24
9:00-9:15	0	7	7	28
9:15-9:30	0	2	2	25
9:30-9:45	0	6	6	21
9:45-10:00	0	5	5	20
10:00-10:15	0	8	8	21
10:15-10:30	0	11	11	30
10:30-10:45	0	12	12	36
10:45-11:00	0	14	14	45
11:00-11:15	0	17	17	54
11:15-11:30	0	16	16	59
11:30-11:45	0	37	37	84
11:45-12:00	0	21	21	91

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
12:00-12:15	0	25	25	99
12:15-12:30	0	32	32	115
12:30-12:45	0	21	21	99
12:45-13:00	0	45	45	123
13:00-13:15	0	25	25	123
13:15-13:30	0	27	27	118
13:30-13:45	0	14	14	111
13:45-14:00	0	20	20	86
14:00-14:15	0	21	21	82
14:15-14:30	0	23	23	78
14:30-14:45	0	19	19	83
14:45-15:00	0	19	19	82
15:00-15:15	0	21	21	82
15:15-15:30	0	14	14	73
15:30-15:45	0	27	27	81
15:45-16:00	0	11	11	73
16:00-16:15	0	23	23	75
16:15-16:30	0	16	16	77
16:30-16:45	0	22	22	72
16:45-17:00	0	22	22	83
17:00-17:15	0	10	10	70
17:15-17:30	0	19	19	73
17:30-17:45	0	13	13	64
17:45-18:00	0	12	12	54

TIME	MOV 1	MOV 2	TOTAL	TOTAL 4
18:00-18:15	0	15	15	59
18:15-18:30	0	13	13	53
18:30-18:45	0	12	12	52
18:45-19:00	0	5	5	45
19:00-19:15	0	5	5	35
19:15-19:30	0	9	9	31
19:30-19:45	0	8	8	27
19:45-20:00	0	12	12	34
20:00-20:15	0	5	5	34
20:15-20:30	0	7	7	32
20:30-20:45	0	7	7	31
20:45-21:00	0	9	9	28
21:00-21:15	0	3	3	26
21:15-21:30	0	8	8	27
21:30-21:45	0	4	4	24
21:45-22:00	0	3	3	18
22:00-22:15	0	1	1	16
22:15-22:30	0	2	2	10
22:30-22:45	0	2	2	8
22:45-23:00	0	9	9	14
23:00-23:15	0	1	1	14
23:15-23:30	0	0	0	12
23:30-23:45	0	2	2	12
23:45-24:00	0	5	5	8

APPENDIX B

MANUAL TRAFFIC COUNTS

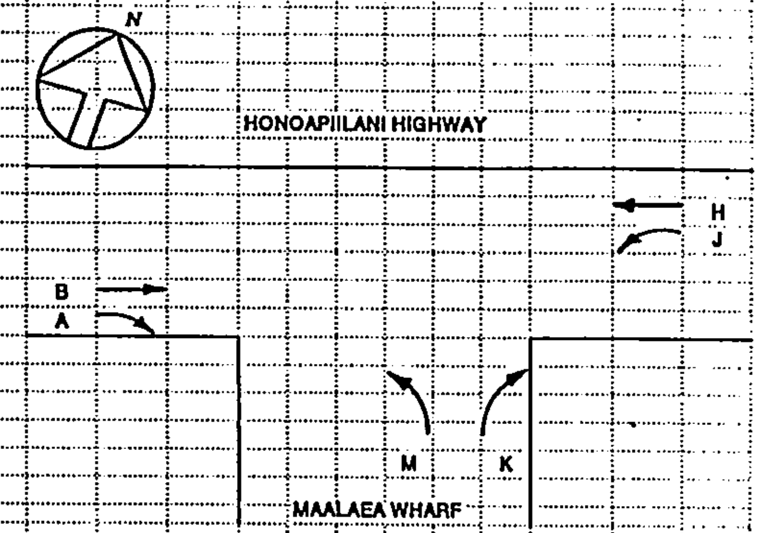
NAME: MAALAEA WHARF

LOCATION: HONOAPIILANI HWY/MAALAEA WHARF

DATE: JULY 18,1991

BY: WMH

File Name: HHMW_AM



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
6:00-6:15 AM	5	63					7	164		1		0
-6:30	29	143					20	362		1		2
-6:45	57	244					34	537		2		4
-7:00	80	320					48	748		2		6
-7:15	98	405					54	950		4		9
-7:30	103	523					56	1184		9		14
-7:45	103	668					56	1381		12		15
-8:00	107	777					61	1547		14		16
-8:15	107	886					62	1722		15		18
-8:30	111	1009					63	1915		17		18
-8:45	113	1142					65	2104		19		19
-9:00 AM	116	1279					66	2262		21		20

COUNT VOLUMES

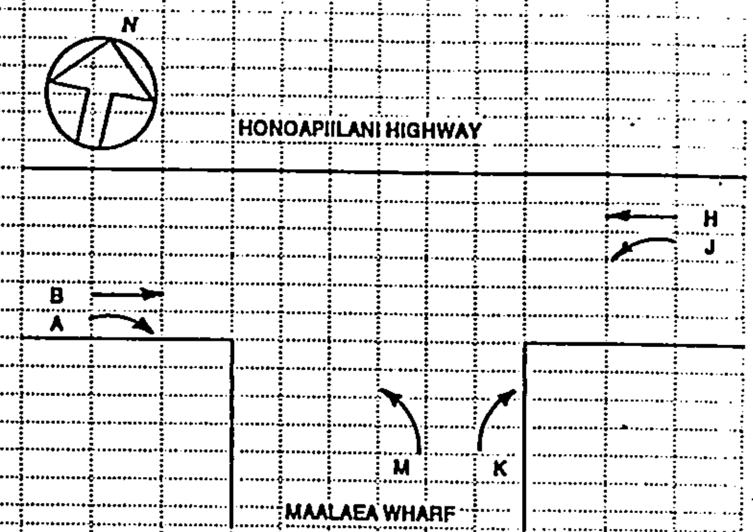
TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
6:00-6:15 AM	5	63	0	0	0	0	7	164	0	1	0	0	240	
-6:30	24	80	0	0	0	0	13	198	0	0	0	2	317	
-6:45	28	101	0	0	0	0	14	175	0	1	0	2	321	
-7:00	23	76	0	0	0	0	14	211	0	0	0	2	326	1204
-7:15	18	85	0	0	0	0	6	202	0	2	0	3	316	1280
-7:30	5	118	0	0	0	0	2	234	0	5	0	5	369	1332
-7:45	0	145	0	0	0	0	0	197	0	3	0	1	346	1357 *
-8:00	4	109	0	0	0	0	5	166	0	2	0	1	287	1318
-8:15	0	109	0	0	0	0	1	175	0	1	0	2	288	1290
-8:30	4	123	0	0	0	0	1	193	0	2	0	0	323	1244
-8:45	2	133	0	0	0	0	2	189	0	2	0	1	329	1227
-9:00 AM	3	137	0	0	0	0	1	158	0	2	0	1	302	1242
6:00-9:00 TOTAL	116	1279	0	0	0	0	66	2262	0	21	0	20	3764	
6:45-7:45 HOUR	46	424	0	0	0	0	22	844	0	10	0	11	1357	

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
6:00-6:15 AM	68	0	171	1	12	63	0	165
-6:30	104	0	211	2	37	82	0	198
-6:45	129	0	189	3	42	103	0	176
-7:00	99	0	225	2	37	78	0	211
-7:15	103	0	208	5	24	88	0	204
-7:30	123	0	236	10	7	123	0	239
-7:45	145	0	197	4	0	146	0	200
-8:00	113	0	171	3	9	110	0	168
-8:15	109	0	176	3	1	111	0	176
-8:30	127	0	194	2	5	123	0	195
-8:45	135	0	191	3	4	134	0	191
-9:00 AM	140	0	159	3	4	138	0	160
6:00-9:00 TOTAL	1395	0	2328	41	182	1299	0	2283
6:45-7:45 HOUR	470	0	866	21	68	435	0	854

NAME: MAALAEA WHARF
LOCATION: HONOAPIILANI HWY/MAALAEA WHARF
DATE: JULY 17, 1991
BY: WMH

File Name: HHMW_PM



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
3:00-3:15 PM	6	141					2	181		5		9
-3:30	15	332					4	406		7		13
-3:45	23	508					6	601		10		14
-4:00	33	735					11	788		16		18
-4:15	40	955					13	993		25		21
-4:30	45	1168					20	1217		26		23
-4:45	51	1491					30	1419		30		24
-5:00	63	1766					36	1619		38		27
-5:15	73	2001					41	1791		44		30
-5:30	82	2214					46	1964		48		34
-5:45	88	2430					47	2127		51		39
-6:00 PM	94	2595					49	2305		54		46

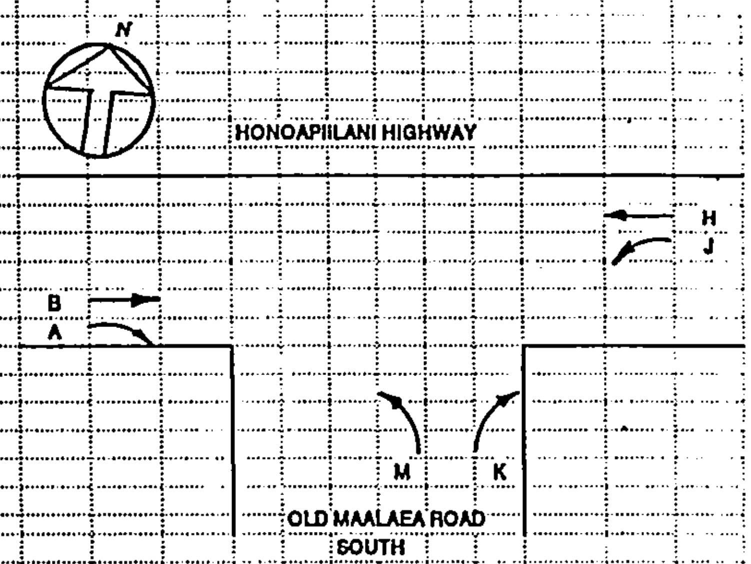
COUNT VOLUMES

TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
3:00-3:15 PM	6	141	0	0	0	0	2	181	0	5	0	9	344	
-3:30	9	191	0	0	0	0	2	225	0	2	0	4	433	
-3:45	8	176	0	0	0	0	2	195	0	3	0	1	385	
-4:00	10	227	0	0	0	0	5	187	0	6	0	4	439	1601
-4:15	7	220	0	0	0	0	2	205	0	9	0	3	446	1703
-4:30	5	213	0	0	0	0	7	224	0	1	0	2	452	1722
-4:45	6	323	0	0	0	0	10	202	0	4	0	1	546	1883
-5:00	12	275	0	0	0	0	6	200	0	8	0	3	504	1948
-5:15	10	235	0	0	0	0	5	172	0	6	0	3	431	1933
-5:30	9	213	0	0	0	0	5	173	0	4	0	4	408	1889
-5:45	6	216	0	0	0	0	1	163	0	3	0	5	394	1737
-6:00 PM	6	165	0	0	0	0	2	178	0	3	0	7	361	1594
3:00-6:00 TOTAL	94	2595	0	0	0	0	49	2305	0	54	0	46	5143	
4:00-5:00 HOUR	30	1031	0	0	0	0	25	831	0	22	0	9	1948	

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
3:00-3:15 PM	147	0	183	14	8	150	0	186
-3:30	200	0	227	6	11	195	0	227
-3:45	184	0	197	4	10	177	0	198
-4:00	237	0	192	10	15	231	0	193
-4:15	227	0	207	12	9	223	0	214
-4:30	218	0	231	3	12	215	0	225
-4:45	329	0	212	5	16	324	0	206
-5:00	287	0	206	11	18	278	0	208
-5:15	245	0	177	9	15	238	0	178
-5:30	222	0	178	8	14	217	0	177
-5:45	222	0	164	8	7	221	0	166
-6:00 PM	171	0	180	10	8	172	0	181
3:00-6:00 TOTAL	2689	0	2354	100	143	2641	0	2359
4:00-5:00 HOUR	1061	0	856	31	55	1040	0	853

NAME:	MAALAEA WHARF	File Name:	HHOMW_AM
LOCATION:	HONOAPIILANI HWY/OLD MAALAEA ROAD SOUTH		
DATE:	JULY 18,1991		
BY:	KKN		



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
6:00–6:15 AM	4	59					0	169		2		0
–6:30	14	131					3	376		6		2
–6:45	21	227					4	563		8		2
–7:00	28	298					6	785		11		2
–7:15	30	384					7	989		15		3
–7:30	32	505					8	1222		18		4
–7:45	32	651					8	1410		21		5
–8:00	33	760					8	1578		30		5
–8:15	35	869					8	1746		38		5
–8:30	36	991					8	1930		48		5
–8:45	37	1124					8	2118		51		6
–9:00 AM	39	1260					8	2273		55		7

COUNT VOLUMES

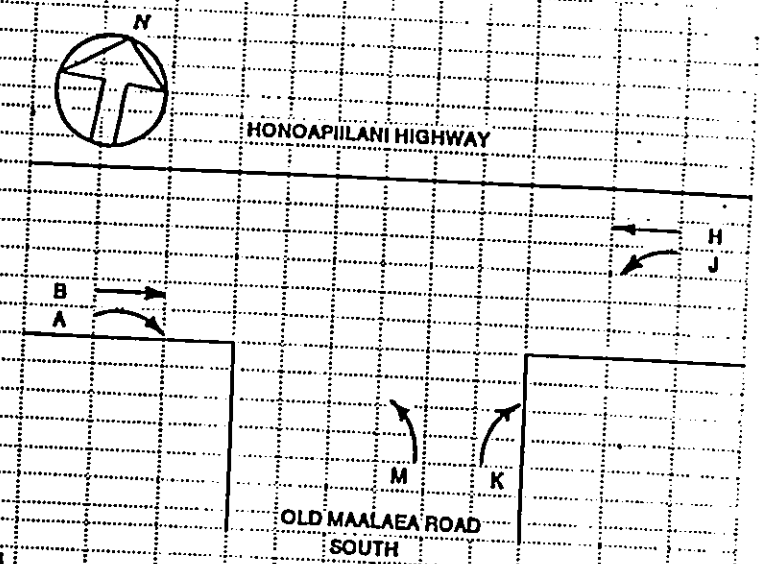
TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
6:00–6:15 AM	4	59	0	0	0	0	0	169	0	2	0	0	234	
–6:30	10	72	0	0	0	0	3	207	0	4	0	2	298	
–6:45	7	96	0	0	0	0	1	187	0	2	0	0	293	
–7:00	7	71	0	0	0	0	2	222	0	3	0	0	305	1130
–7:15	2	86	0	0	0	0	1	204	0	4	0	1	298	1194
–7:30	2	121	0	0	0	0	1	233	0	3	0	1	361	1257
–7:45	0	146	0	0	0	0	0	194	0	3	0	1	344	1308 *
–8:00	1	109	0	0	0	0	0	162	0	9	0	0	281	1284
–8:15	2	109	0	0	0	0	0	168	0	8	0	0	287	1273
–8:30	1	122	0	0	0	0	0	184	0	10	0	0	317	1229
–8:45	1	133	0	0	0	0	0	188	0	3	0	1	326	1211
–9:00 AM	2	136	0	0	0	0	0	155	0	4	0	1	298	1228
6:00–9:00 TOTAL	39	1260	0	0	0	0	8	2273	0	55	0	7	3642	
6:45–7:45 HOUR	11	424	0	0	0	0	4	853	0	13	0	3	1308	

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
6:00–6:15 AM	63	0	169	2	4	59	0	171
–6:30	82	0	210	6	13	74	0	211
–6:45	103	0	188	2	8	96	0	189
–7:00	78	0	224	3	9	71	0	225
–7:15	88	0	205	5	3	87	0	208
–7:30	123	0	234	4	3	122	0	236
–7:45	146	0	194	4	0	147	0	197
–8:00	110	0	162	9	1	109	0	171
–8:15	111	0	168	8	2	109	0	176
–8:30	123	0	184	10	1	122	0	194
–8:45	134	0	188	4	1	134	0	191
–9:00 AM	138	0	155	5	2	137	0	159
6:00–9:00 TOTAL	1299	0	2281	62	47	1267	0	2328
6:45–7:45 HOUR	435	0	857	16	15	427	0	866

NAME:	MAALAEA WHARF
LOCATION:	HONOAPIILANI HWY/OLD MAALAEA ROAD SOUTH
DATE:	JULY 17, 1991
BY:	KKN

File Name: HHOMW_PM



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
3:00–3:15 PM	4	146					0	181		2		1
–3:30	11	334					0	404		6		1
–3:45	14	508					0	596		11		2
–4:00	22	731					0	785		14		5
–4:15	25	951					1	986		20		10
–4:30	32	1159					1	1212		25		11
–4:45	41	1474					2	1418		31		12
–5:00	53	1740					5	1622		33		13
–5:15	61	1970					7	1795		37		14
–5:30	65	2183					9	1970		40		14
–5:45	76	2393					9	2131		43		15
–6:00 PM	79	2562					10	2299		55		15

COUNT VOLUMES

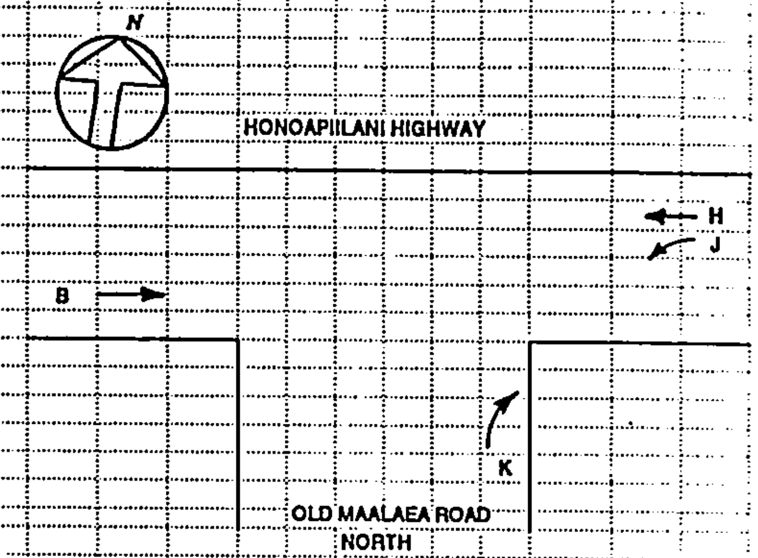
TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
3:00–3:15 PM	4	146	0	0	0	0	0	181	0	2	0	1	334	
–3:30	7	188	0	0	0	0	0	223	0	4	0	0	422	
–3:45	3	174	0	0	0	0	0	192	0	5	0	1	375	
–4:00	8	223	0	0	0	0	0	189	0	3	0	3	426	1557
–4:15	3	220	0	0	0	0	1	201	0	6	0	5	436	1659
–4:30	7	208	0	0	0	0	0	226	0	5	0	1	447	1684
–4:45	9	315	0	0	0	0	1	206	0	6	0	1	538	1847
–5:00	12	266	0	0	0	0	3	204	0	2	0	1	488	1909
–5:15	8	230	0	0	0	0	2	173	0	4	0	1	418	1891
–5:30	4	213	0	0	0	0	2	175	0	3	0	0	397	1841
–5:45	11	210	0	0	0	0	0	161	0	3	0	1	386	1689
–6:00 PM	3	169	0	0	0	0	1	168	0	12	0	0	353	1554
3:00–6:00 TOTAL	79	2562	0	0	0	0	10	2299	0	55	0	15	5020	
4:00–5:00 HOUR	31	1009	0	0	0	0	5	837	0	19	0	8	1909	

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
3:00–3:15 PM	150	0	181	3	4	147	0	183
–3:30	195	0	223	4	7	188	0	227
–3:45	177	0	192	6	3	175	0	197
–4:00	231	0	189	6	8	226	0	192
–4:15	223	0	202	11	4	225	0	207
–4:30	215	0	226	6	7	209	0	231
–4:45	324	0	207	7	10	316	0	212
–5:00	278	0	207	3	15	267	0	206
–5:15	238	0	175	5	10	231	0	177
–5:30	217	0	177	3	6	213	0	178
–5:45	221	0	161	4	11	211	0	164
–6:00 PM	172	0	169	12	4	169	0	180
3:00–6:00 TOTAL	2641	0	2309	70	89	2577	0	2354
4:00–5:00 HOUR	1040	0	842	27	36	1017	0	858

NAME: MAALAEA WHARF
LOCATION: HONOAPIILANI HWY/OLD MAALAEA WHARF NORTH
DATE: JULY 18,1991
BY:

File Name: HHMWN_AM



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
6:00-6:15 AM		59					14	169				10
-6:30		133					24	379				14
-6:45		229					47	567				34
-7:00		300					65	791				50
-7:15		387					84	996				66
-7:30		509					103	1230				92
-7:45		656					116	1424				112
-8:00		765					134	1586				131
-8:15		874					156	1754				147
-8:30		996					168	1938				164
-8:45		1130					177	2126				190
-9:00 AM		1267					190	2281				211

COUNT VOLUMES

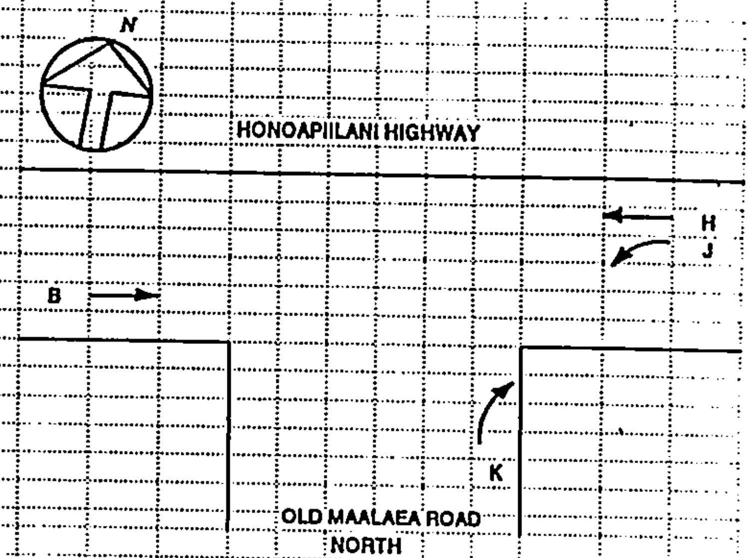
TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
6:00-6:15 AM	0	59	0	0	0	0	14	169	0	0	0	10	252	
-6:30	0	74	0	0	0	0	10	210	0	0	0	4	298	
-6:45	0	96	0	0	0	0	23	188	0	0	0	20	327	
-7:00	0	71	0	0	0	0	18	224	0	0	0	16	329	1206
-7:15	0	87	0	0	0	0	19	205	0	0	0	16	327	1281
-7:30	0	122	0	0	0	0	19	234	0	0	0	26	401	1384
-7:45	0	147	0	0	0	0	13	194	0	0	0	20	374	1431 *
-8:00	0	109	0	0	0	0	18	162	0	0	0	19	308	1410
-8:15	0	109	0	0	0	0	22	168	0	0	0	16	315	1398
-8:30	0	122	0	0	0	0	12	184	0	0	0	17	335	1332
-8:45	0	134	0	0	0	0	9	188	0	0	0	26	357	1315
-9:00 AM	0	137	0	0	0	0	13	155	0	0	0	21	326	1333
6:00-9:00 TOTAL	0	1267	0	0	0	0	190	2281	0	0	0	211	3949	
6:45-7:45 HOUR	0	427	0	0	0	0	69	857	0	0	0	78	1431	

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
6:00-6:15 AM	59	0	183	10	14	69	0	169
-6:30	74	0	220	4	10	78	0	210
-6:45	96	0	211	20	23	116	0	188
-7:00	71	0	242	16	18	87	0	224
-7:15	87	0	224	16	19	103	0	205
-7:30	122	0	253	26	19	148	0	234
-7:45	147	0	207	20	13	167	0	194
-8:00	109	0	180	19	18	128	0	162
-8:15	109	0	190	16	22	125	0	168
-8:30	122	0	196	17	12	139	0	184
-8:45	134	0	197	26	9	160	0	188
-9:00 AM	137	0	168	21	13	158	0	155
6:00-9.00 TOTAL	1267	0	2471	211	190	1478	0	2281
6:45-7:45 HOUR	427	0	926	78	69	505	0	857

NAME: MAALAEA WHARF
LOCATION: HONOAPIILANI HWY/OLD MAALAEA WHARF NORTH
DATE: JULY 17, 1991
BY:

File Name: HHMWN_PM



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
3:00–3:15 PM		147					18	181				31
–3:30		335					45	404				60
–3:45		510					70	596				81
–4:00		736					103	785				111
–4:15		961					130	987				142
–4:30		1170					162	1213				162
–4:45		1486					190	1420				186
–5:00		1753					227	1627				213
–5:15		1984					268	1802				242
–5:30		2197					297	1979				258
–5:45		2408					330	2140				290
–6:00 PM		2577					359	2309				316

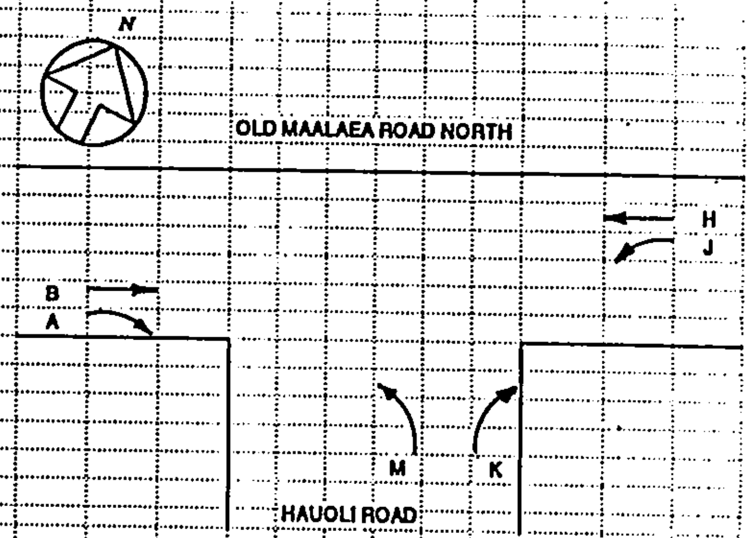
COUNT VOLUMES

TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
3:00–3:15 PM	0	147	0	0	0	0	18	181	0	0	0	31	377	
–3:30	0	188	0	0	0	0	27	223	0	0	0	29	467	
–3:45	0	175	0	0	0	0	25	192	0	0	0	21	413	
–4:00	0	226	0	0	0	0	33	189	0	0	0	30	478	1735
–4:15	0	225	0	0	0	0	27	202	0	0	0	31	485	1843
–4:30	0	209	0	0	0	0	32	226	0	0	0	20	487	1863
–4:45	0	316	0	0	0	0	28	207	0	0	0	24	575	2025
–5:00	0	267	0	0	0	0	37	207	0	0	0	27	538	2085 •
–5:15	0	231	0	0	0	0	41	175	0	0	0	29	476	2076
–5:30	0	213	0	0	0	0	29	177	0	0	0	16	435	2024
–5:45	0	211	0	0	0	0	33	161	0	0	0	32	437	1886
–6:00 PM	0	169	0	0	0	0	29	169	0	0	0	26	393	1741
3:00–6:00 TOTAL	0	2577	0	0	0	0	359	2309	0	0	0	316	5561	
4:00–5:00 HOUR	0	1017	0	0	0	0	124	842	0	0	0	102	2085	

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
3:00–3:15 PM	147	0	199	31	18	178	0	181
–3:30	188	0	250	29	27	217	0	223
–3:45	175	0	217	21	25	196	0	192
–4:00	226	0	222	30	33	256	0	189
–4:15	225	0	229	31	27	256	0	202
–4:30	209	0	258	20	32	229	0	226
–4:45	316	0	235	24	28	340	0	207
–5:00	267	0	244	27	37	294	0	207
–5:15	231	0	216	29	41	260	0	175
–5:30	213	0	206	16	29	229	0	177
–5:45	211	0	194	32	33	243	0	161
–6:00 PM	169	0	198	26	29	195	0	169
3:00–6:00 TOTAL	2577	0	2668	316	359	2893	0	2309
4:00–5:00 HOUR	1017	0	966	102	124	1119	0	842

NAME:	MAALAEA WHARF	File Name:	MRHR_AM
LOCATION:	OLD MAALAEA ROAD NORTH/HAUOLI ROAD		
DATE:	JULY 18,1991		
BY:	JYM		



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
6:00–6:15 AM	0	1					3	11		0		9
–6:30	1	1					5	19		4		13
–6:45	1	4					6	41		14		30
–7:00	3	10					13	52		18		40
–7:15	4	15					18	66		26		51
–7:30	13	21					25	78		35		71
–7:45	16	22					26	90		38		90
–8:00	19	24					35	99		43		107
–8:15	22	25					47	109		47		122
–8:30	24	29					52	116		54		135
–8:45	27	31					55	122		62		159
–9:00 AM	29	38					63	127		66		173

COUNT VOLUMES

TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
6:00–6:15 AM	0	1	0	0	0	0	3	11	0	0	0	9	24	
–6:30	1	0	0	0	0	0	2	8	0	4	0	4	19	
–6:45	0	3	0	0	0	0	1	22	0	10	0	17	53	
–7:00	2	6	0	0	0	0	7	11	0	4	0	10	40	136
–7:15	1	5	0	0	0	0	5	14	0	8	0	11	44	156
–7:30	9	6	0	0	0	0	7	12	0	9	0	20	63	200
–7:45	3	1	0	0	0	0	1	12	0	3	0	19	39	186 *
–8:00	3	2	0	0	0	0	9	9	0	5	0	17	45	191
–8:15	3	1	0	0	0	0	12	10	0	4	0	15	45	192
–8:30	2	4	0	0	0	0	5	7	0	7	0	13	38	167
–8:45	3	2	0	0	0	0	3	6	0	8	0	24	46	174
–9:00 AM	2	7	0	0	0	0	8	5	0	4	0	14	40	169
6:00–9:00 TOTAL	29	38	0	0	0	0	63	127	0	66	0	173	496	
6:45–7:45 HOUR	15	18	0	0	0	0	20	49	0	24	0	60	186	

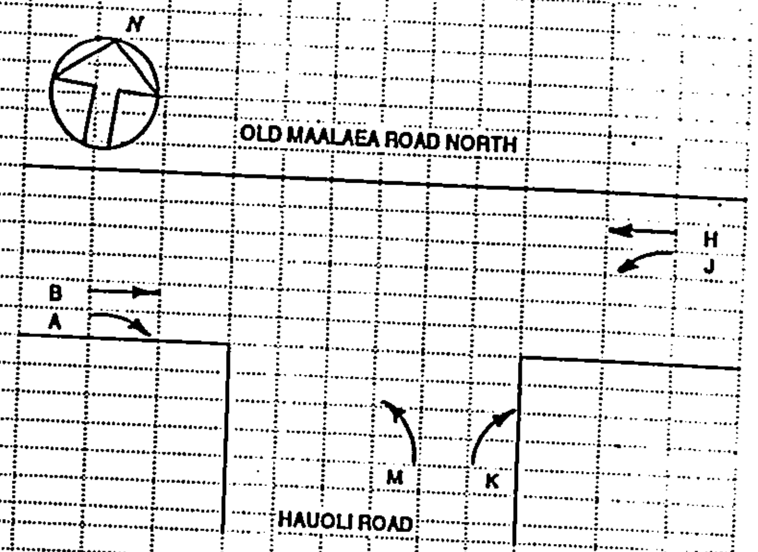
Note: Peak hour is calculated by the highest combined volume traveling through all counted intersections.

APPROACH/DEPARTURE VOLUMES

	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
6:00–6:15 AM	1	0	14	9	3	10	0	11
–6:30	1	0	10	8	3	4	0	12
–6:45	3	0	23	27	1	20	0	32
–7:00	8	0	18	14	9	16	0	15
–7:15	6	0	19	19	6	16	0	22
–7:30	15	0	19	29	16	26	0	21
–7:45	4	0	13	22	4	20	0	15
–8:00	5	0	18	22	12	19	0	14
–8:15	4	0	22	19	15	16	0	14
–8:30	6	0	12	20	7	17	0	14
–8:45	5	0	9	32	6	26	0	14
–9:00 AM	9	0	13	18	10	21	0	9
6:00–9:00 TOTAL	67	0	190	239	92	211	0	193
6:45–7:45 HOUR	33	0	69	84	35	78	0	73

NAME: MAALAEA WHARF
LOCATION: OLD MAALAEA ROAD NORTH/HAUOLI ROAD
DATE: JULY 17, 1991
BY: JYM

File Name: MRHR_PM



COUNT READINGS

TIME	A	B	C	D	E	F	J	H	G	M	L	K
3:00–3:15 PM	9	18					12	6		6		13
–3:30	13	38					27	18		9		22
–3:45	23	51					41	29		15		30
–4:00	26	76					61	42		21		35
–4:15	39	94					76	54		31		48
–4:30	54	103					92	70		40		59
–4:45	63	113					106	84		44		73
–5:00	80	131					130	97		47		82
–5:15	97	142					160	108		54		100
–5:30	104	149					178	119		59		109
–5:45	117	164					202	128		66		126
–6:00 PM	123	175					224	135		72		141

COUNT VOLUMES

TIME	A	B	C	D	E	F	J	H	G	M	L	K	TOTAL	TOT4
3:00–3:15 PM	9	18	0	0	0	0	12	6	0	6	0	13	64	
–3:30	4	20	0	0	0	0	15	12	0	3	0	9	63	
–3:45	10	13	0	0	0	0	14	11	0	6	0	8	62	
–4:00	3	25	0	0	0	0	20	13	0	6	0	5	72	261
–4:15	13	18	0	0	0	0	15	12	0	10	0	13	81	278
–4:30	15	9	0	0	0	0	16	16	0	9	0	11	76	291
–4:45	9	10	0	0	0	0	14	14	0	4	0	14	65	294
–5:00	17	18	0	0	0	0	24	13	0	3	0	9	84	308 *
–5:15	17	11	0	0	0	0	30	11	0	7	0	18	94	319
–5:30	7	7	0	0	0	0	18	11	0	5	0	9	57	300
–5:45	13	15	0	0	0	0	24	9	0	7	0	17	85	320
–6:00 PM	6	11	0	0	0	0	22	7	0	6	0	15	67	303
3:00–6:00 TOTAL	123	175	0	0	0	0	224	135	0	72	0	141	870	
4:00–5:00 HOUR	54	55	0	0	0	0	69	55	0	26	0	47	308	

Note: Peak hour is calculated by the highest combined volume traveling through all counted intersections.

APPROACH/DEPARTURE VOLUMES

TIME	ABC	DEF	GHJ	KLM	AEJ	BFK	CGL	DHM
3:00–3:15 PM	27	0	18	19	21	31	0	12
–3:30	24	0	27	12	19	29	0	15
–3:45	23	0	25	14	24	21	0	17
–4:00	28	0	33	11	23	30	0	19
–4:15	31	0	27	23	28	31	0	22
–4:30	24	0	32	20	31	20	0	25
–4:45	19	0	28	18	23	24	0	18
–5:00	35	0	37	12	41	27	0	10
–5:15	28	0	41	25	47	29	0	18
–5:30	14	0	29	14	25	16	0	16
–5:45	28	0	33	24	37	32	0	16
–6:00 PM	17	0	29	21	28	26	0	13
3:00–6:00 TOTAL	298	0	359	213	347	316	0	207
4:00–5:00 HOUR	109	0	124	73	123	102	0	81

APPENDIX C

LEVEL-OF-SERVICE DEFINITIONS

APPENDIX C

The Highway Capacity Manual defines six Levels of Service, labelled A through F, from best to worst conditions. Levels of Service for signalized and unsignalized intersections are defined in terms of average user delays. Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time.

Unsignalized Intersections

For unsignalized intersections, the Highway Capacity Manual evaluates gaps in the major street traffic flow and calculates available gaps for left turns across oncoming traffic and for the left and right turns onto the major roadway from the minor street.

LEVEL OF SERVICE A:	Little or no delay.
LEVEL OF SERVICE B:	Short traffic delays.
LEVEL OF SERVICE C:	Average traffic delays.
LEVEL OF SERVICE D:	Long traffic delays.
LEVEL OF SERVICE E:	Very long traffic delays.
LEVEL OF SERVICE F:	Demand volume exceeds capacity, resulting in extreme delays with queuing that may cause severe congestion and affect other movements at the intersection.

Two -Lane Highways

LEVEL OF SERVICE A:	Average speed on the two-lane highway would approach 60 miles per hour. Passing demand is well below passing capacity and platooning of three or more vehicles are rare.
LEVEL OF SERVICE B:	Average speed on the two-lane highway would approach 55 miles per hour. Platooning is common as passing demand approaches passing capacity.
LEVEL OF SERVICE C:	Average speed on the tow-lane highway would approach 52 mph on level terrain. Long platoons can be expected.
LEVEL OF SERVICE D:	Speeds of 50 mph can still be maintained under ideal conditons. The opposing traffic streams of a two-lane highway operate separately as passing approaches zero.

LEVEL OF SERVICE E:	Speeds under 50 mph would be realized. Passing on two-lane highways is virtually impossible and platooning becomes intense where there are slow moving vehicles of other interruptions.
LEVEL OF SERVICE F:	Traffic demands exceeds the capacity of the highway.

APPENDIX E

SURF SITE ANALYSIS

Assessment of Recreational Surfing Activities, Maalaea Small Boat Harbor

Appendix A - Maalaea Harbor Evaluation of Project Impacts on Surf Sites
Appendix B - Assessment of Recreational Surfing Sites, Maalaea Small Boat Harbor, Maalaea, Maui, Hawaii

ASSESSMENT OF RECREATIONAL SURFING ACTIVITIES
MAALAEA SMALL BOAT HARBOR

Prepared for:

U.S. Army Corps of Engineers
Contract No. DACW83-91-D-0016

Prepared by:

Belt Collins & Associates

September 1992

Editors Note:

The alternative numbers contained in this report on Surfing Activities are different than those in the text of the Supplemental EIS. Cross reference key follows.

SEIS alternative	Report alternative
1968 Authorized Plan	Alternative No. 2
1980 Appproved Plan	Alternative No. 3
Alternative Plan 1	Not evaluated
Alternative Plan 2	Not evaluated
Alternative Plan 3	Not evaluated
Alternative Plan 4	Alternative No. 4
Alternative Plan 5	Modification to Alternative No. 3
Alternative Plan 6	Alternative No. 5

Alternative No. 1 is an early version of Alternative Plan 4, which is not included in the SEIS

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FIGURES

TABLES

APPENDICES

1. INTRODUCTION

The purpose of this study is to evaluate the potential impacts of Maalaea harbor improvement alternatives on adjacent surfing sites. Specifically, the location of recreational surfing breaks in the area will be identified in relation to existing structures and landmarks. The potential impacts of the proposed external harbor improvements on the identified surfing site characterization parameters will be estimated. Modifications to existing and proposed alternative harbor structures to mitigate the effects on surf breaks will be discussed.

This study has the effect of essentially assessing the relative merit of one surfing site compared to another. This has been done as explicitly as possible and with knowledge that such an evaluation is subjective. It is very important to note that all of Maui's surfing sites are important. The ratio of the number of surfing areas to the size of Maui's population is low and Maui has the fewest surfing sites per mile of shoreline of all the major islands of Hawaii (Clark, 1992). Maui's population is increasing, as is the surfing and bodyboarding populations. The comparison of the surf sites within the Maalaea Harbor area was conducted solely for the purpose of providing information to minimize impacts associated with the proposed harbor improvement alternatives.

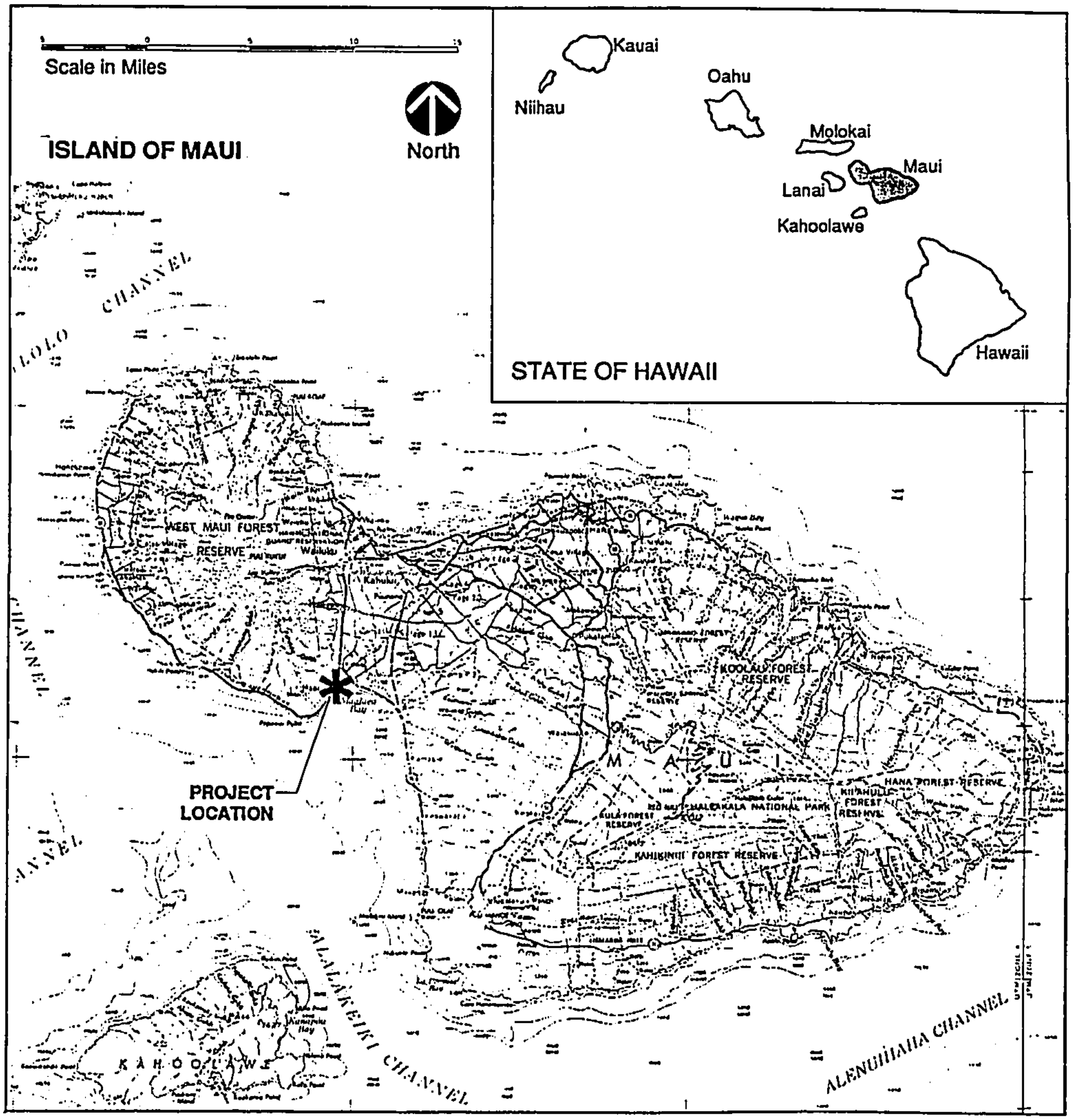
As proposed in "Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii," the U.S. Army Corps of Engineers (COE) plans to modify Maalaea Harbor, Maui, Hawaii. These modifications are directed at reducing navigational hazards, reducing wave action in the harbor basin, expanding the existing berthing space, and increasing attendant facilities. The potential modifications include a combination of the extension of the existing breakwaters, removal of part of the existing breakwaters, and the addition of revetments to the breakwater extensions. Four harbor improvement alternatives have been proposed by the COE.

2. METHODOLOGY

Both technical analyses and personal interviews with experts and local surfers were conducted in order to identify and characterize the surf sites and determine the impacts of the proposed modifications. The technical analyses, including wave refraction analysis, wave statistic analysis, aerial photograph analysis, and evaluation of proposed project improvements on the surf sites, were conducted by Sea Engineering and its subconsultant, Moffat & Nichol, Engineers; their report is included as Appendix A. Personal interviews and identification of the surf sites were conducted by John Clark, Ocean Recreation Consultant. This report is included as Appendix B. In order to facilitate the determination of the overall impacts of each of the proposed alternatives, the impacts on various characteristics of each surf site were combined with the relative significance of the sites themselves. From this, a direct evaluation can be made among the impacts of four harbor improvement alternatives.

3. SITE DESCRIPTION

Maalaea Harbor is located on the southwest shore of Maui, approximately seven miles south of Wailuku, between McGregor Point to the west and Kihei to the east (see Figure 1). The shoreline of Maalaea Bay is characterized by a long narrow coral-sand beach



Source: U.S. Geological Survey, 1974

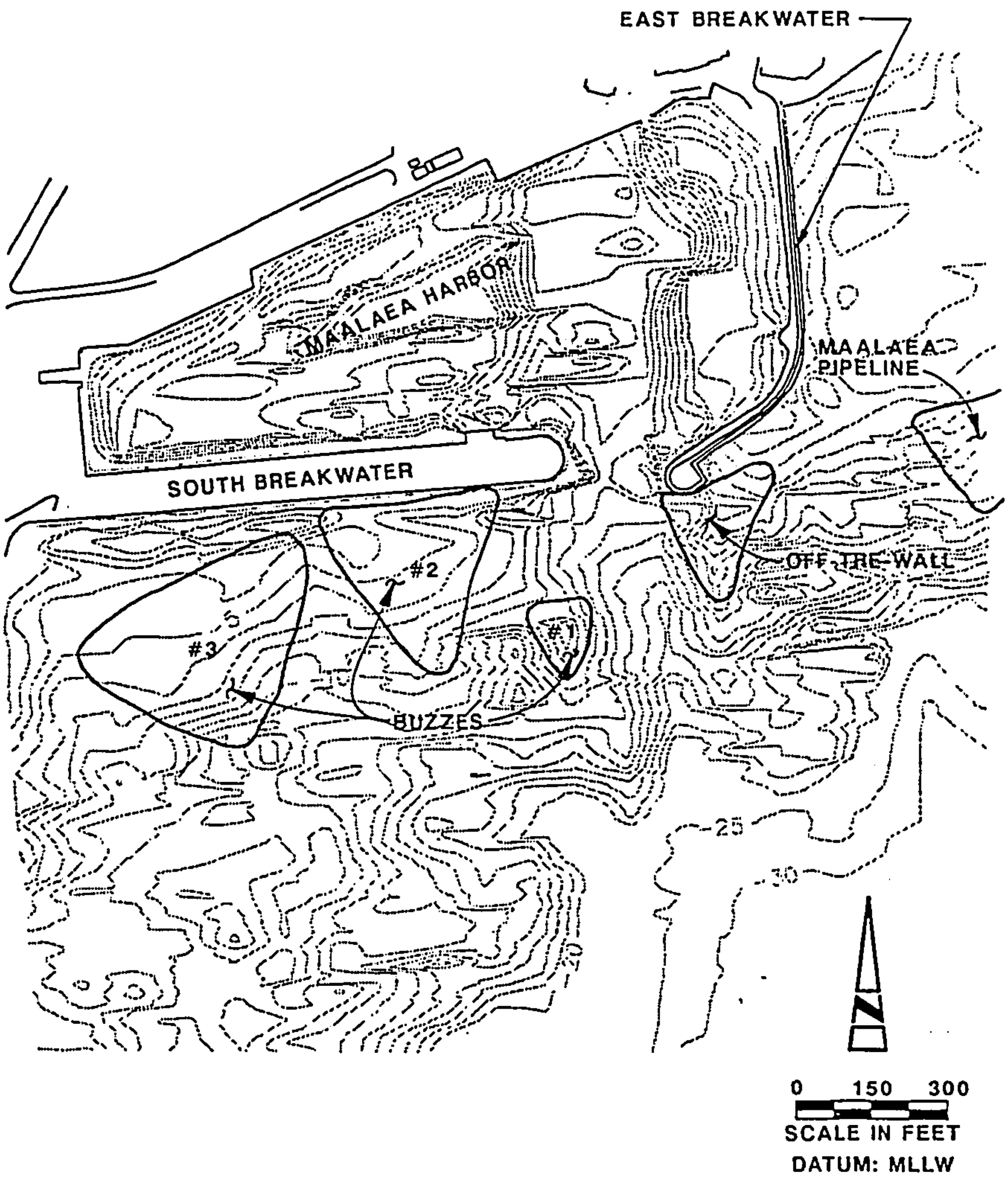
Figure 1
Location Map

approximately four miles long and averages between 75 and 100 feet in width. Maalaea Harbor is located at the extreme west end of this beach. The nearshore bottom along most of the beach is predominantly sandy with scattered patches of rock. A coralline reef extends approximately 1,000 feet offshore in the vicinity of the harbor. The islands of Kahoolawe and Lanai are approximately 15 miles to the south, and 20 miles to the west respectively (see Figure 2).

Figure 2. Aerial view of Maalaea Small Boat Harbor. View is to the southwest.
Photo credit: Erik Aeder

4. IDENTIFICATION OF SURF SITES

A total of five different surfing sites were identified within the Maalaea Harbor project area. These locations, from east to west, are Maalaea Pipeline, Off-the-Wall, Buzz's No. 1, Buzz's No. 2, and Buzz's No. 3 (see Figure 3). (A complete description of these sites can be found in both Appendices A and B.) Each of these sites varies with respect to both surfing conditions and density of use.



Source: Moffat & Nichol, Engineers
Maalaea Harbor, Evaluation of Project Impacts on Surf Sites, 1992

Figure 3
Surfing Sites

Maalaea Pipeline offers what may be one of the longest rides in the world. Surfers from around the world come to surf the site when it is breaking at six feet or greater (see Figure 4). *Surfer Magazine* has ranked it as one of the ten best waves in the world (Clark, 1992). Under normal conditions the wave breaks in four different sections with each section having as many as 15 to 20 surfers in the lineup. As many as 80 surfers can be found at the break at one time. The site can be ridden by bodyboarders when the break is small.

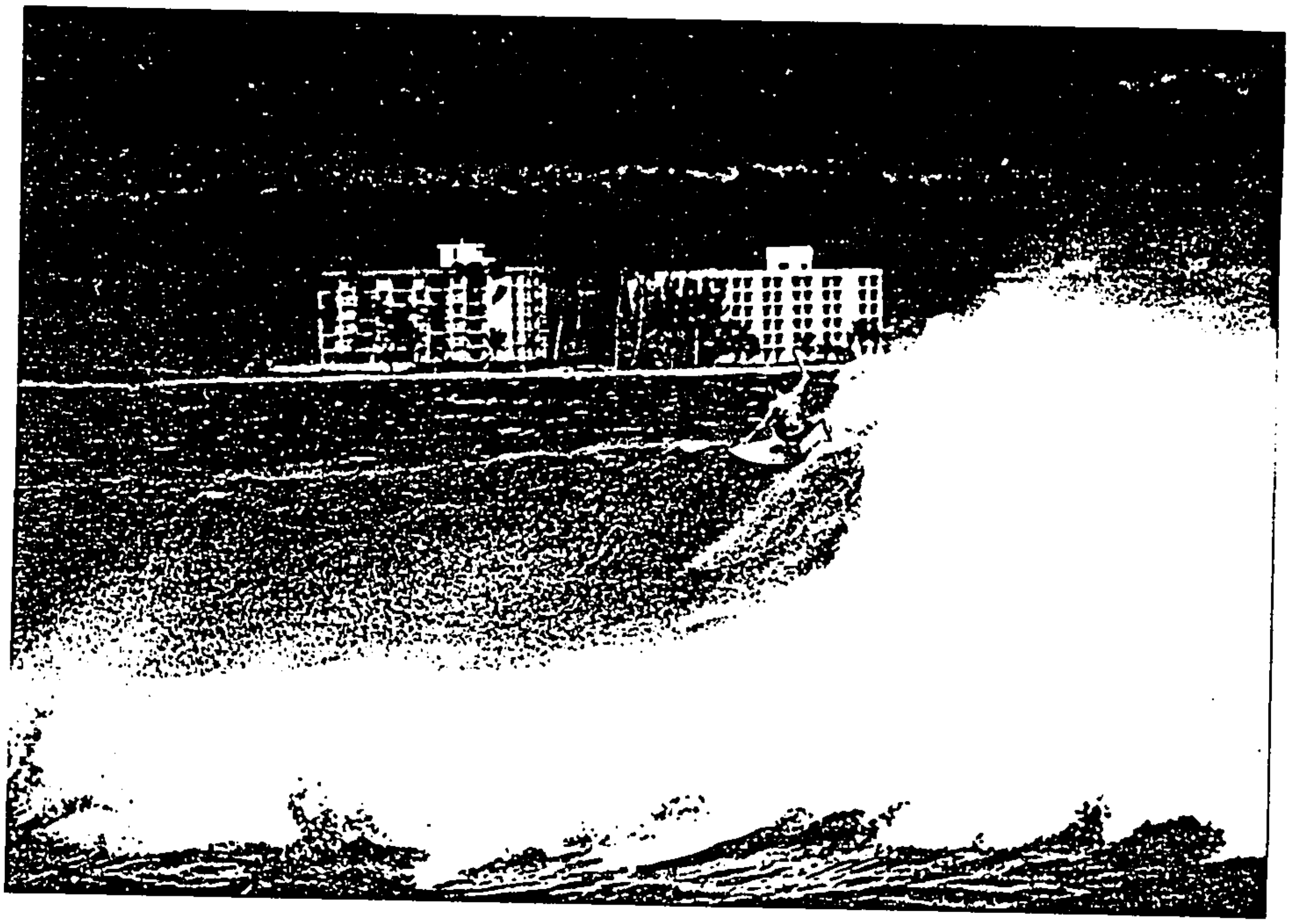


Figure 4. Owl Chapman performing a cutback off the top of a six-foot Pipeline wave
Photo credit: Steve Wilkings

Off-the-Wall is located off the end of the east breakwater and is just east of the entrance channel to the harbor (see Figures 5 and 6). This site is utilized by both bodyboarders and surfers when wave heights are at least two to three feet. Bodyboarders tend to use the site more when wave heights are small as they are able to maneuver closer to the wall (east breakwater). The left ride at this site is considered to be an excellent plunging wave. This site has experienced up to 15 surfers at a time in the lineup.

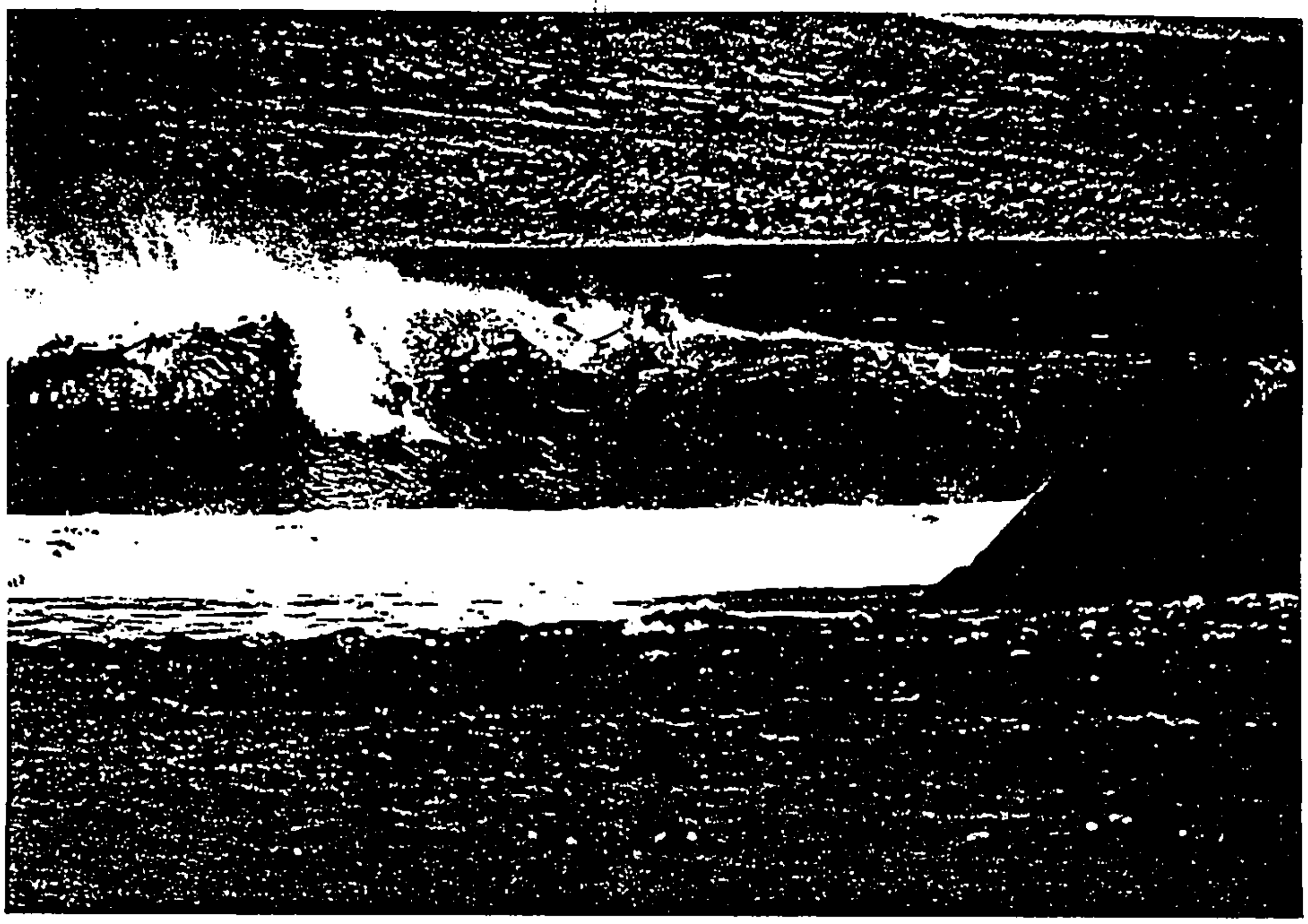


Figure 5. Surfer taking off at Off-the-Wall.
East breakwater located to the right.
Photo credit: Erik Aeder

Immediately west of the entrance channel and south of the south breakwater is Buzz's No. 1. This site is characterized as a high surf, deep water break that is rarely ridden. When this site is breaking, it is ridden by both bodyboarders and surfers. No more than six surfers normally utilize the site at one time.

Buzz's No. 2 is located just west of Buzz's No. 1. The breaking range is from 2 to 12 feet and these waves are normally spilling. This is one of the more popular sites in the harbor area as it is utilized by up to 50 surfers when it is breaking. Both beginning and intermediate level surfers as well as body boarders use the site, depending on wave conditions. Because of its popularity with surfers of a broad skill range, Buzz's No. 2 is considered one of the more important surf sites in the south Maui area.

Smaller more poorly-shaped waves characterize Buzz's No. 3, which is immediately west of Buzz's No. 2. This site is ridden almost exclusively by body boarders and generally by no more than 10 to 15 at one time.

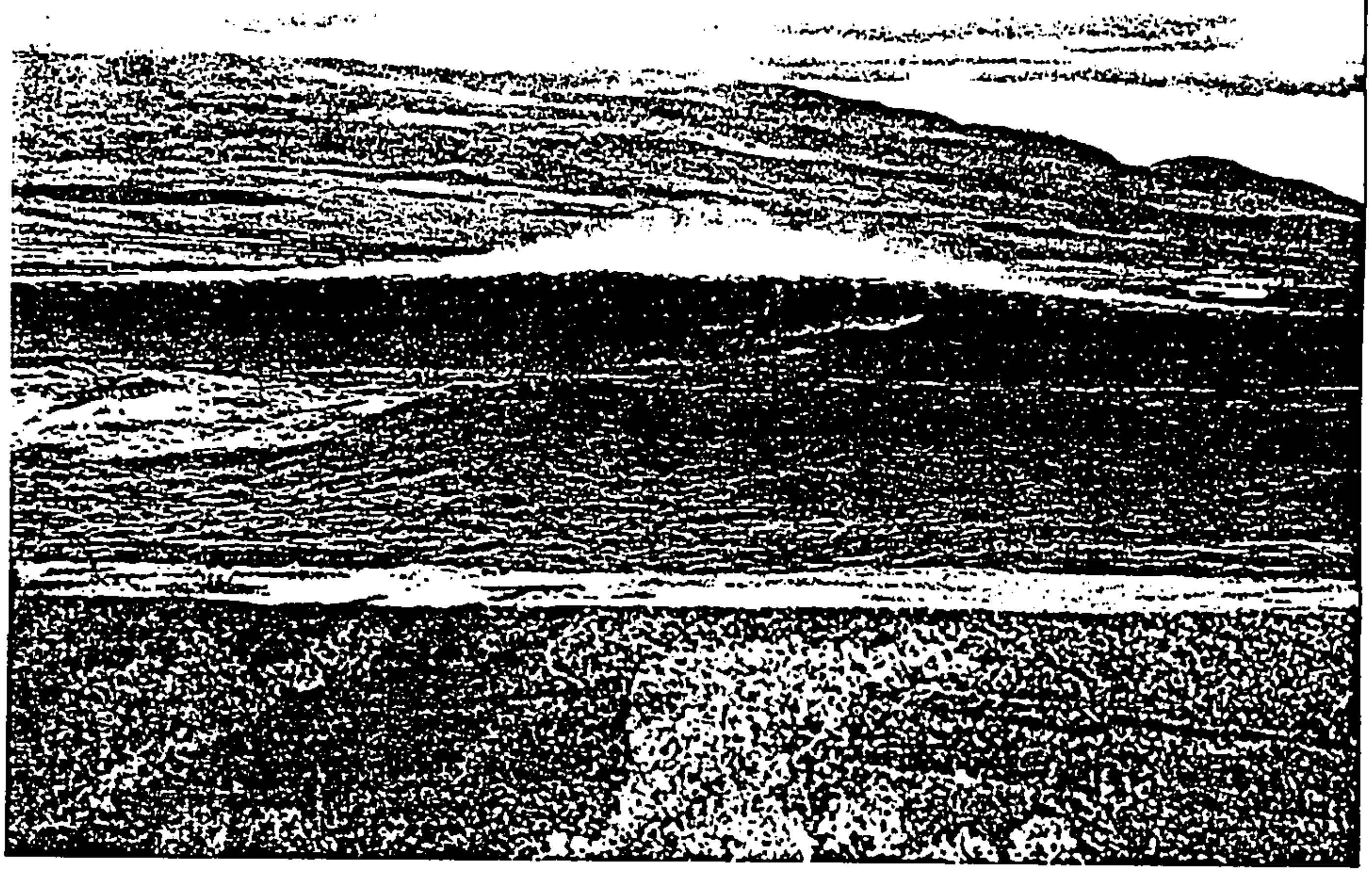


Figure 6. View of Off-the-Wall from the east breakwater.
Photo credit: Erik Aeder

5. CHARACTERIZATION OF THE SURF SITES

The relative significance of the surf sites found in the Maalaea Harbor area were characterized by evaluating the sites with respect to several parameters. These parameters include surfing quality, frequency of use, density of use, uniqueness, required surfing skills, and percentage of time surfable conditions occur at the site.

1) Surfing quality refers to the break's wave size, speed, shape or type, and peel angle (Moffat and Nichol 1992). The length of the ride provided by the break is also taken into account.

2) Frequency of use is simply an estimate of how often the site is used.

3) Density of use pertains to the number of surfers that can normally utilize the site at a given time, including those in the lineup and those paddling out to the site.

4) The uniqueness of a site is determined by the number of sites in the same general area that have similar characteristics.

5) The diversity of abilities of surfers that can utilize the site under various wave conditions determines the range of skills required.

6) The percentage of time surfable conditions exist refers to the relative proportion of time conditions at the site are favorable for surfing.

The surfing sites are described within each parameter below. Table 1 provides a summary of this information.

5.1 Quality of the Breaks

Maalaea Pipeline, Off-the-Wall, and Buzz's No. 2 experience high quality waves. Maalaea Pipeline is likely the most significant break of the group. Buzz's No. 1 and Buzz's No. 3, when compared to the other sites, are of lesser quality due to shorter ride length, poorly-shaped waves, smaller range of peel angles, or inconsistent break location (Clark, 1992; Moffat and Nichol, 1992).

5.2 Frequency of Use

The frequency of use pattern for the sites follows closely with the quality of the breaks. Therefore, both Buzz's No. 3 and Buzz's No. 1 are surfed less frequently. The three remaining sites are considered to be utilized frequently (Clark, 1992).

5.3 Density of Use

Approximately 80 surfers can utilize Maalaea Pipeline and nearly 40 can surf Buzz's No. 2. Either of these two sites can support more surfers than the remaining three sites combined. Off-the-Wall and Buzz's No. 3 normally have approximately 15 riders each. Buzz's No. 1, with the lowest density of use, is not normally utilized by more than six surfers at any one time (Clark, 1992; Moffat and Nichol, 1992).

5.4 Uniqueness

Maalaea Pipeline is a very unique surfing site as it has been classified as the fastest right-hand breaking wave in the world. It offers one of the longest rides in Hawaii (Clark, 1992). With the exception of Maalaea Pipeline, Off-the-Wall is unique in that it is one of the few hollow, plunging waves in the area. All three Buzz's locations are similar to other sites located in the area. However, Buzz's No. 2 may be considered a unique break due to the consistency of the peak there (Clark, 1992).

SITES / PARAMETERS	Maalaea Pipeline	Off-the-Wall	Buzz's No. 1	Buzz's No. 2	Buzz's No. 3
quality of the waves	peel angle = 30-60 degrees breaker heights = 3 to 12 feet type = hollow plunging	peel angle = 30-80 degrees breaker heights = 3 to 12 feet type = hollow plunging	peel angle = 40-80 degrees breaker heights = 3 to 12 feet type = spilling/plunging	peel angle = 30-80 degrees breaker heights = 2 to 12 feet type = spilling	peel angle = 35-60 degrees breaker heights = 2 to 12 feet type = gently spilling
frequency of use	high	high	moderate	high	moderate
density of use	80	15	6	40	15
uniqueness	unique	unique	similar sites in the area	unique characteristics	similar sites in the area
ability level	beginners to experts	beginners to experts and bodyboarders	beginners to experts	beginners to intermediate and bodyboarders	beginners and bodyboarders
frequency of surfable conditions	55%	52%	21%	46%	53%

Table 1
Site Parameters

5.5 Range of Skills Required

Maalaea Pipeline, Off-the Wall, and Buzz's No. 2 all attract surfers of nearly all surfing abilities. Maalaea Pipeline attracts both bodyboarders and board surfers, however, the board surfers tend to dominate the site when the waves exceed four feet. Beginning and intermediate level surfers often surf the east end of the break. When the waves are breaking at six feet or greater, expert surfers come from all over the state of Hawaii to surf the site. Off-the-Wall is also utilized by both bodyboarders and board surfers. Bodyboarders typically use the site more when the break is less than three feet and therefore closer to the east breakwater. Buzz's No. 1 is used by both bodyboarders and board surfers when it is breaking. Buzz's No. 2 is similar to Off-the-Wall in that bodyboarders primarily use the site when the break is less than three feet. As the waves at this site increase, board surfers make up approximately half of the surfers using the site. Both beginning and intermediate level surfers utilize the site, depending on the conditions of the break. Buzz's No. 3 is normally ridden by only bodyboarders (Clark, 1992; Moffat and Nichol, 1992).

5.6 Estimates of the Frequency of Surfable Conditions

In determining the percentage of time (hours) surfable conditions occur at each of the sites, surfable wave criteria included a breaker height of greater than one foot. This information was based on oceanographic parameters. Additionally, the waves must have been plunging or spilling, and the peel angles between 30 and 90 degrees. Maalaea Pipeline, Off-the-Wall, and Buzz's No. 3 all had surfable conditions slightly more than 50 percent of the time. Buzz's No. 2 was surfable approximately 47 percent of the time and Buzz's No. 3 was surfable approximately 20 percent of the time (Moffat and Nichol, 1992). (See Appendix A for further information on wave statistic analysis.)

6. EVALUATION OF THE PROJECT IMPACTS ON THE SURF SITES

Four alternatives to the current marina entrance configuration were provided by the U.S. Army Corps of Engineers for evaluation by this study. The four harbor improvement alternatives are designated as Alternative No. 1, 2, 3, and 4. The alternatives are:

1) a 450-foot extension to the east breakwater and removal of approximately 300 feet of the south breakwater (see Figure 7),

2) a 555-foot extension to the south breakwater and removal of approximately 650 feet of the east breakwater (see Figure 8),

3) a 600-foot extension of the south breakwater including a revetment and removal of approximately 75 feet from the east breakwater (see Figure 9), and

4) a 675-foot extension to the east breakwater and of approximately 300 feet from the south breakwater (see Figure 10).

Each alternative has the potential to affect the surf sites in a number of ways. The site may be physically encroached upon or destroyed by the proposed extension of, or attachment of a revetment to one of the currently existing breakwaters. The entrance channel associated with the alteration of the breakwaters may directly encroach the site as well. Wave reflection caused by the breakwater extensions and/or revetments may negatively impact the breaking location or the face of the incident waves. Boat traffic entering and exiting the entrance channel may infringe upon the lineup, creating a safety hazard. Wakes from boat traffic may also spoil the face of the surfing waves. On-shore site-access impacts may also occur as a result of harbor alterations.

6.1 Impact of Alternative No. 1

The first alternative, which incorporates a 450-foot extension to the east breakwater and the removal of 300 feet from the south breakwater, would result in the entrance channel completely destroying Buzz's No. 2. Both Buzz's No. 1 and Off-the-Wall would have their left rides shortened due to the extension of the east breakwater. Both of these sites will also experience wave reflection from the east breakwater extension (Moffat and Nichol, 1992). (See Figure 7.)

6.2 Impact of Alternative No. 2

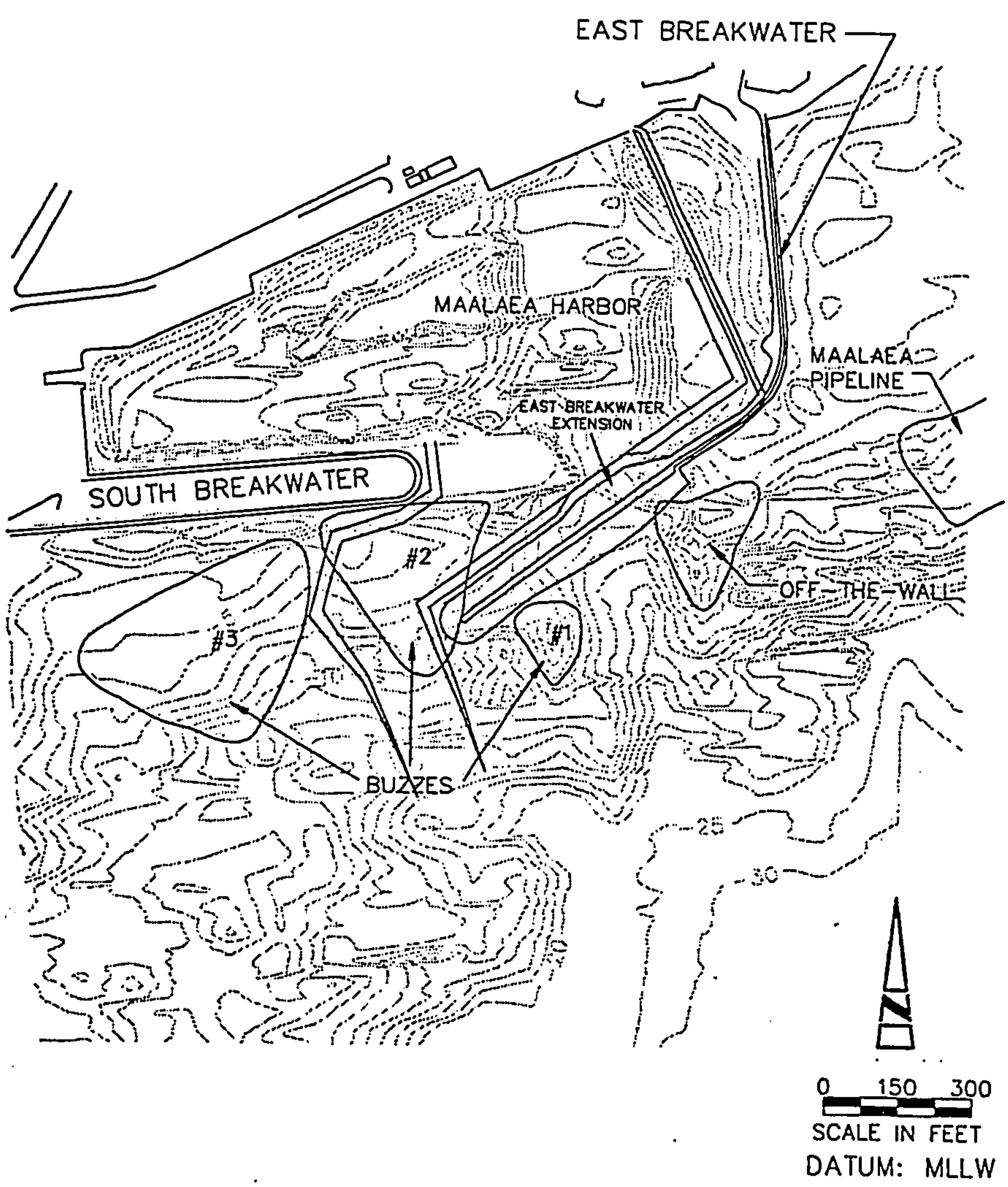
By extending the south breakwater 555 feet and removing 650 feet from the east breakwater in Alternative No. 2, the entrance channel will directly encroach the west side of the Maalaea Pipeline surf site. Boat traffic may impact wave conditions and will reduce the size of the take-off area for the remaining right ride at the site. Off-the-Wall and Buzz's No. 2 will have their right rides impacted by the south breakwater extension. The reflection of waves off this structure may also impact these two sites (Moffat and Nichol, 1992). (See Figure 8.)

6.3 Impact of Alternative No. 3

The 600-foot south breakwater extension and revetment and proposed entrance channel associated with Alternative No. 3 would completely destroy Off-the-Wall. Buzz's No. 1 and No. 2 would have their right rides reduced. Wave reflection caused by the extension of the south breakwater would impact the left ride at Buzz's No. 2. Consequently, this entire site would be destroyed as well. The take-off area for Maalaea Pipeline would be adversely affected by boat traffic entering and leaving the harbor channel (Moffat and Nichol, 1992). (See Figure 9.)

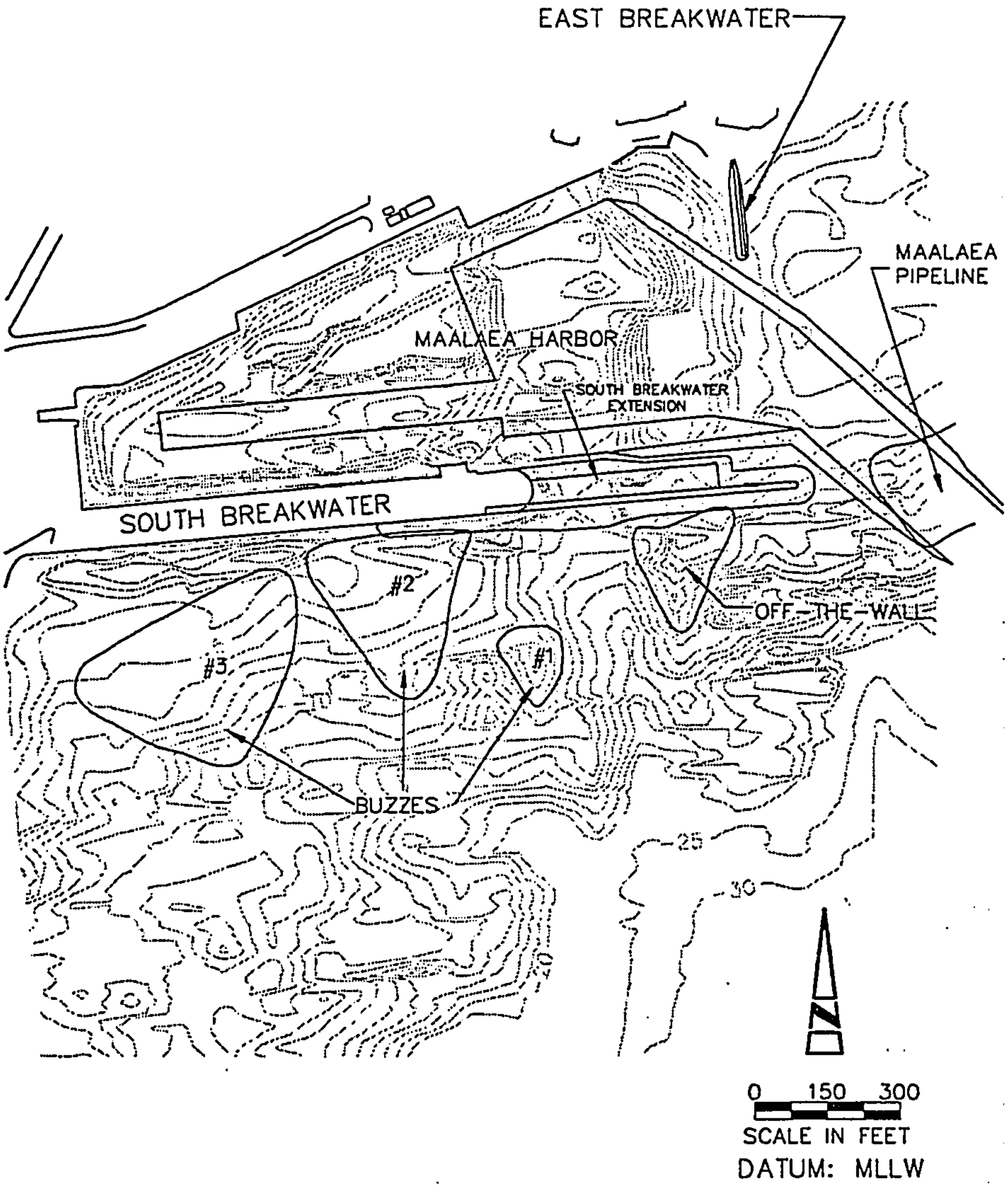
6.4 Impact of Alternative No. 4

Alternative No. 4 would result in the complete destruction of Buzz's No. 2 due to the 675-foot extension of the east breakwater and placement of the entrance channel. The entrance channel location would destroy the right ride at Buzz's No. 3 and waves from boat traffic associated with the harbor may impact the left ride. Buzz's No. 1 and Off-the-Wall will have their left rides impacted from wave reflection off the east breakwater extension (Moffat and Nichol, 1992). (See Figure 10.)



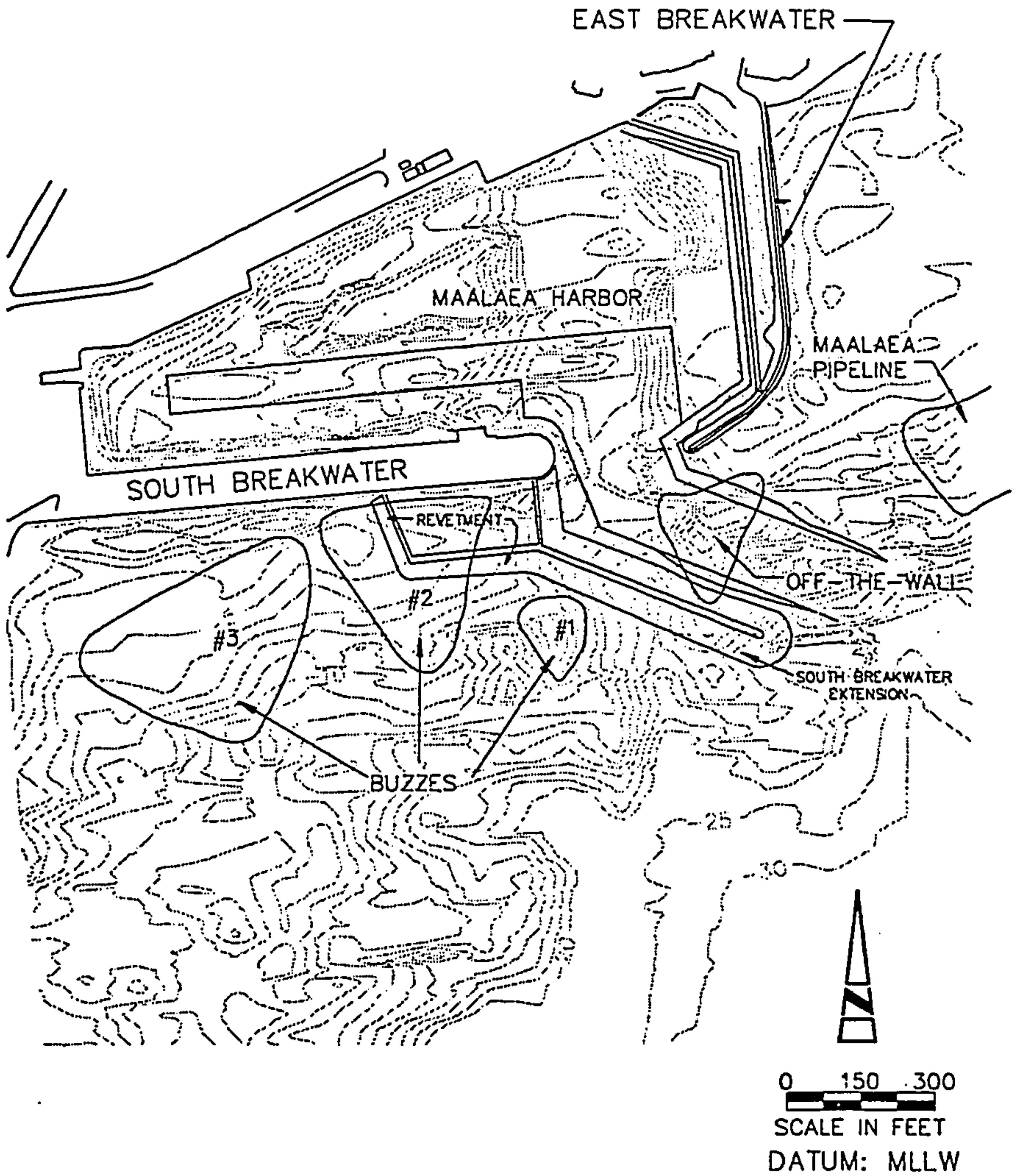
Source: Moffat & Nichol, Engineers
Maalaea Harbor, Evaluation of Project Impacts on Surf Sites, 1992

Figure 7
Alternative No. 1



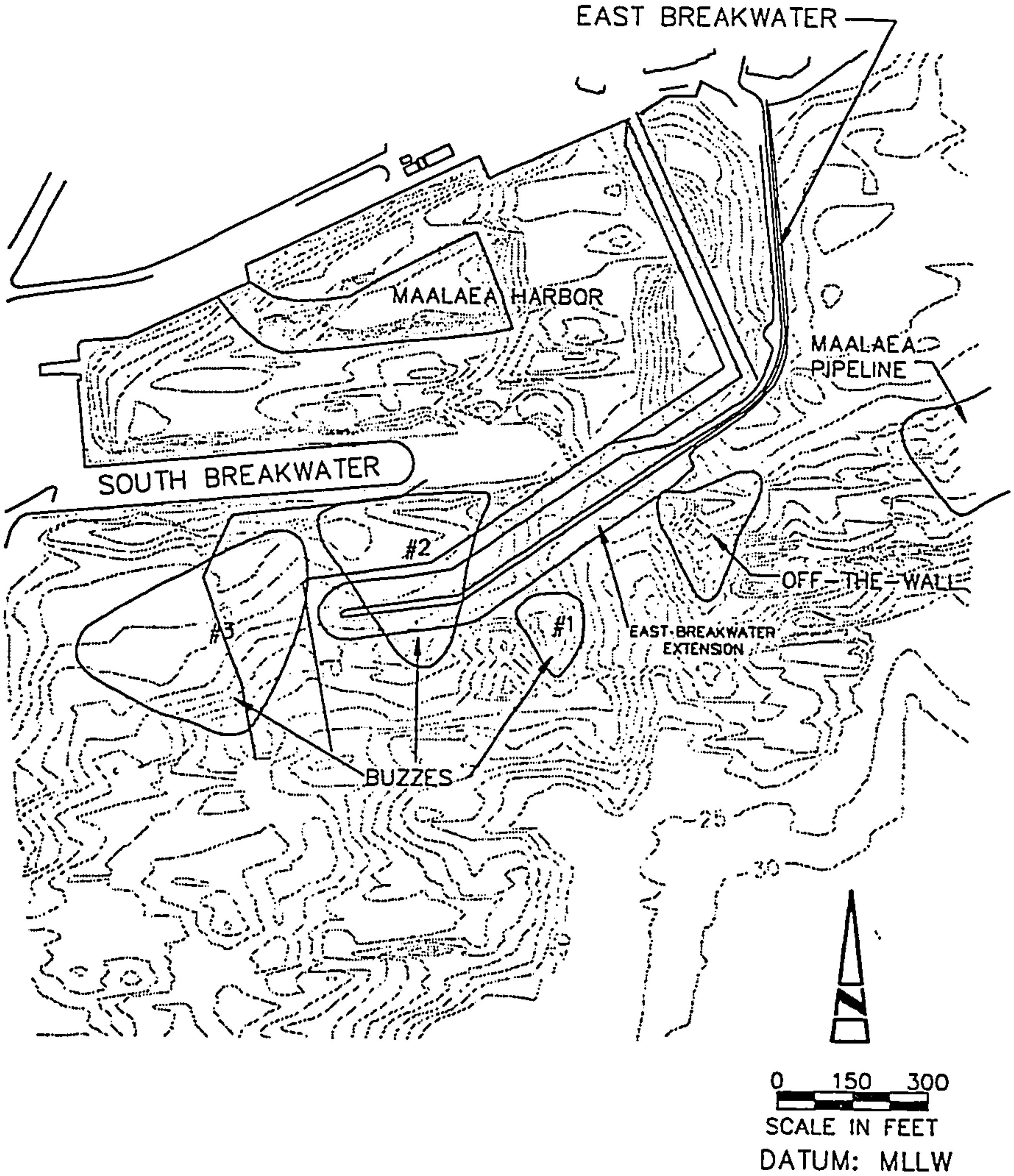
Source: Moffat & Nichol, Engineers
Maalaea Harbor, Evaluation of Project Impacts on Surf Sites, 1992

Figure 8
Alternative No. 2



Source: Moffat & Nichol, Engineers
Maalaea Harbor, Evaluation of Project Impacts on Surf Sites, 1992

Figure 9
Alternative No. 3



Source: Moffat & Nichol, Engineers
Maalaea Harbor, Evaluation of Project Impacts on Surf Sites, 1992

Figure 10
Alternative No. 4

7. EVALUATION OF EFFECTS ON SURFING SITES IN THE HARBOR AREA FROM HARBOR IMPROVEMENT ALTERNATIVES

The following summary combines the effect of each of the proposed harbor improvement alternatives on each of the parameters used to determine the significance of each of the sites. By characterizing each of the sites with respect to these parameters, a comparison can be made between the surfing impacts of the improvement alternatives. A summary of the impacted parameters for each alternative is located in Table 2.

7.1 Alternative No. 1

Alternative No. 1 will affect three surfing locations. Specifically, it would result in the complete destruction of Buzz's No. 2. The surfing quality of this site, as well as its uniqueness, are considered to be high. This site normally experiences surfable conditions approximately 46 percent of the time. The frequency of use of this particular site is high and coupled with the high density of use (approximately 40 surfers) by individuals of various surfing abilities, results in its being a very important surfing location (Moffat and Nichol, 1992). Sites in the area with characteristics similar to the site that would be lost include Mudflats, Loading Zone, and Kealia (Clark, 1992).

Two other sites would be affected, but not completely lost. Off-the-Wall, is considered to be a high quality site, and the other, Buzz's No. 1, is of less significance when compared to the other sites. Part of Off-the-Wall would be lost due to direct encroachment and wave reflection (Moffat and Nichol, 1992). The percent of time surfable conditions exist at the sites would probably not be reduced, but the surfing quality would be decreased. Due to the infrequency of the break at Buzz's No. 1, the result, due to the decrease in surfing quality because of wave reflection, is less significant compared to the other losses associated with this alternative.

7.2 Alternative No. 2

While no surfing locations would be completely destroyed, three sites would be adversely affected by Alternative No. 2 (Moffat and Nichol, 1992). The most significant site in the Harbor area, Maalaea Pipeline, would suffer from the direct encroachment of the entrance channel. This would result in the loss of the left ride and part of the take-off area (Moffat and Nichol, 1992). The loss of the take-off area could shorten the right ride, which is one of the primary factors contributing to the uniqueness of the site. The percent of time this site experiences surfable conditions should not be affected, though boat traffic will likely generate waves which may affect the quality of incident waves for the site (Moffat and Nichol, 1992). The frequency of use should not be changed by these alterations. However, the density of use for the site, which currently is very high, would obviously be reduced or dangerous conditions, mixing vessel traffic and surfers in the lineup, could result. Assuming that the proposed channel area would only impinge on the western most take-off area, approximately 20 surfers would presumably be displaced. This would affect a wide range of surfers, most notably the expert level surfers who are attracted to the site because of the long, fast right ride that the site currently provides. No sites in the area have characteristics similar to that of Maalaea Pipeline.

SITES / ALTERNATIVES	Maalaea Pipeline	Off-the-Wall	Buzz's No. 1	Buzz's No. 2	Buzz's No. 3
Alternative No. 1	none	reduction in quality of the waves	reduction in quality of the waves	complete loss of the site	slight reduction in quality of the waves
Alternative No. 2	reduction in the qualtiy of the waves, decrease in density of use, alteration of uniqueness	reduction in the quality of the waves	none	reduction in the quality of the waves	none
Alternative No. 3	decrease in density of use (related to safety concerns in take off area)	complete loss of the site	reduction in the quality of the waves	complete loss of the site	none
Alternative No. 4	reduction in the quality of the waves	reduction in the quality of the waves	none	complete loss of the site	reduction in the quality of the waves, decrease in density of use
Modification to Alternative No. 3	none	complete loss of the site	reduction in the quality of the waves	reduction in the quality of the waves	none
Alternative No. 5	none	none	none	none	none

[white] no impacts

[light shading] one or more parameters impacted

[dark shading] site completely lost

Table 2
Site Alternatives

Two additional surf sites, Off-the-Wall and Buzz's No. 2, will have their right rides shortened from the extension of the south breakwater (Moffat and Nichol, 1992). Except for surfing quality, the surfing site parameters at these sites should remain constant.

7.3 Alternative No. 3

Alternative No. 3 will have impacts on four sites. The destruction of two surf sites, Off-the-Wall and Buzz's No. 2, would result from this alternative. These are significant surfing sites. Both sites are relatively unique with respect to the types of surfing conditions they offer. The two combined provide for a wide range of surfing abilities. Additionally, both locations experience surfing conditions a relatively high percentage of the time (Moffat and Nichol, 1992). The frequency of use of the sites is also considered to be high. The two sites together can handle approximately 60 surfers at any one time (Clark, 1991; Moffat and Nichol, 1992). Because of these last three factors (high percentage of surfable conditions, high frequency of use, and high density of use), the subsequent total loss of these two sites would result in a major impact on surfing opportunities at Maalaea.

In addition to the loss of Off-the-Wall and Buzz's No. 2, two of the three remaining sites would also be affected. Buzz's No. 1 would experience wave reflection from the extension of the south breakwater (Moffat and Nichol, 1992). This site is infrequently used owing to its low percentage of surfable conditions. The number of surfers using the site, when it is breaking, is relatively small.

The other site adversely affected, but not destroyed by the improvements planned in Alternative No. 3, is Maalaea Pipeline. Boat traffic will potentially pass through the west take-off area for this site. The proximity of boats entering and leaving the harbor to surfers waiting in the take-off area will cause safety problems (Moffat and Nichol, 1992). It is doubtful that any other parameters of this site will be affected.

The only site not adversely affected by Alternative No. 3 is Buzz's No. 3 which is almost exclusively a bodyboarding site and is normally used by less than 15 individuals at a time. Sites in the area with similar characteristics to those destroyed include Mudflats, Loading Zone, and Kealia. None, however, are considered to be hard, spilling-wave sites such as Off-the-Wall.

7.4 Alternative No. 4

The modifications proposed in this alternative impact four of the five surfing locations. This alternative would completely destroy Buzz's No. 2 and directly encroach upon Buzz's No. 3 (Moffat and Nichol, 1992). Approximately 40 surfers of various abilities will be displaced. The right ride at Buzz's No. 3 will also be eliminated. Both the number and diversity of surfers impacted due to the loss of this part of the break, again is less than Alternative No. 2. The left side ride will also see the effects of the larger boat traffic entering and leaving the harbor in the form of cross-waves (Moffat and Nichol, 1992).

Other sites affected include Buzz's No. 1 and Off-the-Wall. Buzz's No. 1 will be impacted primarily by way of wave reflection of the east breakwater extension. The ride may also be cut short due to the proximity of this extension (Moffat and Nichol, 1992). Off-the-Wall will experience wave reflections for the same reason, however the consequences of impacts to this site will be greater due to the high quality of the ride at this site.

8. MODIFICATIONS TO EXISTING AND PROPOSED HARBOR STRUCTURES TO MITIGATE THE EFFECTS ON SURF BREAKS

Two alternative modifications to the existing and proposed harbor structures were developed by Moffat and Nichol and are included in Appendix A. One alternative involved a modification of the proposed Alternative No. 3. This modification would eliminate the revetment that would be attached to the existing south breakwater. This would eliminate the direct encroachment into Buzz's No. 2. Additionally, the realignment of the proposed south breakwater extension would eliminate some of the safety concerns associated with boats using the harbor channel and surfers in the take-off area at Maalaea Pipeline (Moffat and Nichol, 1992). (See Figure 11.)

An additional alternative, suggested in the Moffat and Nichol report, deals with interior modifications of the Harbor, specifically the construction of an interior mole. This structure would be attached to the south breakwater and would reduce wave energy entering the harbor. In order to create additional berthing space, interior expansion of the harbor would be necessary. This alternative would have no direct impact on the previously identified surfing breaks (Moffat and Nichol, 1992). (See Figure 12.)

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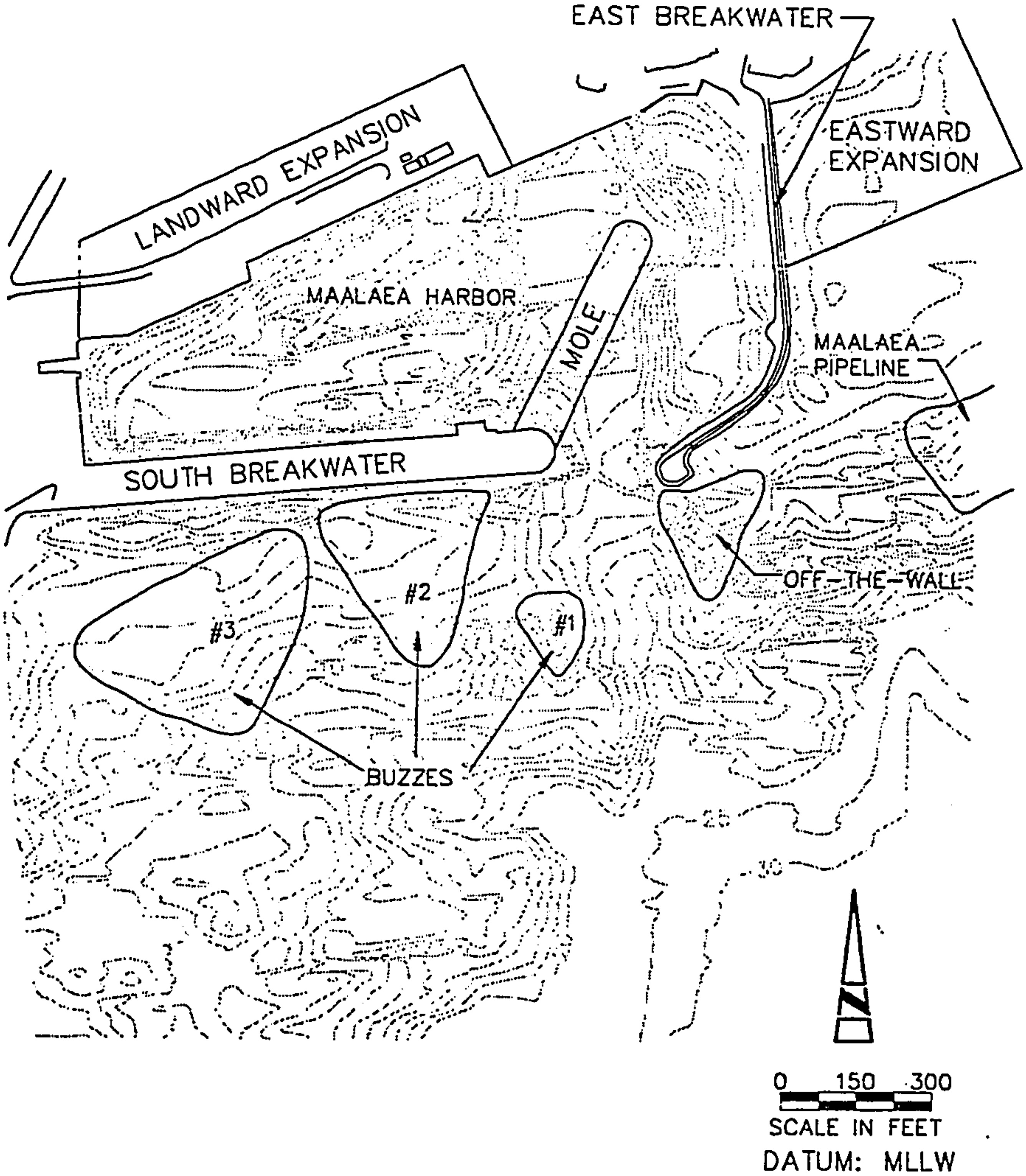

Source: Moffat & Nichol, Engineers
Maalaea Harbor, Evaluation of Project Impacts on Surf Sites, 1992

Figure 12
Alternative No. 5

APPENDIX A

MAALAEA HARBOR

EVALUATION OF PROJECT IMPACTS ON SURF SITES

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CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (COE) proposes to modify Maalaea Harbor, Maui, Hawaii. These modifications, presented in "Maalaea Harbor for Light-Draft Vessels, Maui, Hawaii - General Design Memorandum No. 1" (1980), are aimed at reducing wave action in the harbor basin, expanding the berthing space, reducing navigational hazards, and increasing attendant facilities. Possible modifications might include extension of the existing south breakwater, widening and deepening of the entrance channel, increasing the turning basin within the harbor, and removal or partial removal of the east breakwater. However, the location of nearby surfing sites place constraints on the location of additional harbor structures.

Surfing is recognized as an integral element of the overall Maalaea Harbor Improvement Plan. Several surf sites have been identified in the vicinity of the existing breakwater and harbor entrance. An important consideration in modifying the entrance channel is to minimize the potential impacts of the project features on surf sites. The purpose of this study is to prepare an assessment of parameters related to recreational surfing activities in the vicinity of Maalaea Harbor.

Identification of a surf site requires the definition of the characteristics and boundaries of surfing activity at the site under the range of expected wave, wind and tidal conditions. The identification process comprises both technical analyses and interviews with experts and local surfers. Technical evaluation consists of analyses of bathymetry and wave conditions, review of aerial photographs, and field observations to identify characteristics and boundaries of the surf sites. This report addresses these technical aspects of surf site identification. Interviews with experts and local surfers, also used in surf site identification, are essential in gaining insight concerning the usage and range of surfable waves.

Specific Scope of Work items included:

1. Review existing available information pertinent to the project.

2. Conduct site investigation to aid in locating the existing surf breaks relative to existing and proposed harbor structures and to examine the bottom characteristics and reef formation.

3. Conduct the following coastal engineering analysis of the surf sites:

   a. deepwater wave climate summary, wave refraction and shoaling analysis, and breaking characteristics;

   b. outline surf sites under various wave conditions;

   c. analyze potential impacts of existing harbor structures and proposed harbor improvements on the surf breaks; and

   d. identify possible modifications to existing and proposed harbor structures to mitigate effects on surf breaks.

4. Summarize findings and recommendations in a report.

2.0 SITE DESCRIPTION

2.1 General

Maalaea Harbor is located on the southwest shore of Maui approximately seven miles south of Wailuku between McGregor Point to the west and Kihei to the east. The shoreline of Maalaea Bay is characterized by a long narrow coral-sand beach, and Maalaea Harbor is located at the extreme west end of this beach. A coralline reef extends approximately 1,000 feet offshore in the vicinity of the harbor. The project site location is shown in Figure 2-1. The islands of Kahoolawe and Lanai are approximately 15 miles to the south, and 20 miles to the west respectively.

Two surf areas in the vicinity of the project site were identified in the U.S. Army Corps of Engineers (1980) General Design Memorandum No. 1 as shown in Figure 2-2. Area No. 1 is the world renowned "Maalaea Pipeline." Although prime surfing waves at this site do not occur frequently, they have been acclaimed by professional surfers among the best surfing waves in the world. Area No. 2, previously called "Off-the-Wall," is another popular surfing site.

2.2 Site Visit Observations

During the November 1991 site visit, light tradewinds prevailed with a 1- to 2-foot surf from the south. Site observations, as well as discussions with local surfers were recorded during the survey. Local surfers gave verbal descriptions of the characteristics of each site under various conditions. The sites were identified and marked directly onto a detailed bathymetric chart. Take off areas, entry points, and riding areas were verbally confirmed.

The primary surfing waves are southern swell that pass between Maui and Kahoolawe. Local surfers suggest that a southwest or a western swell may wrap around Kahoolawe and contribute to surfing conditions at Maalaea. One frequent surfer at Maalaea confirmed that the waves from the south are the principle source of surf waves.

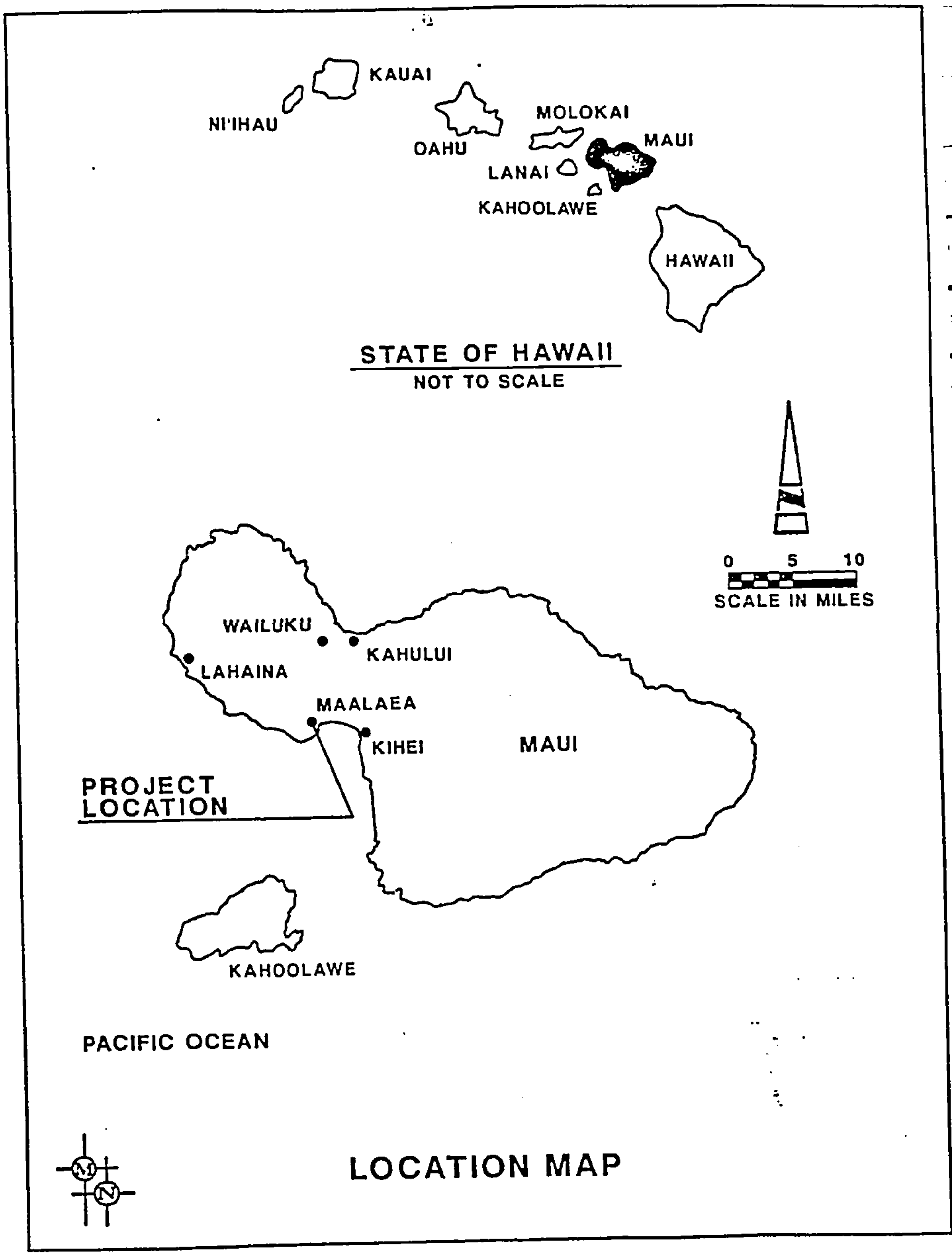
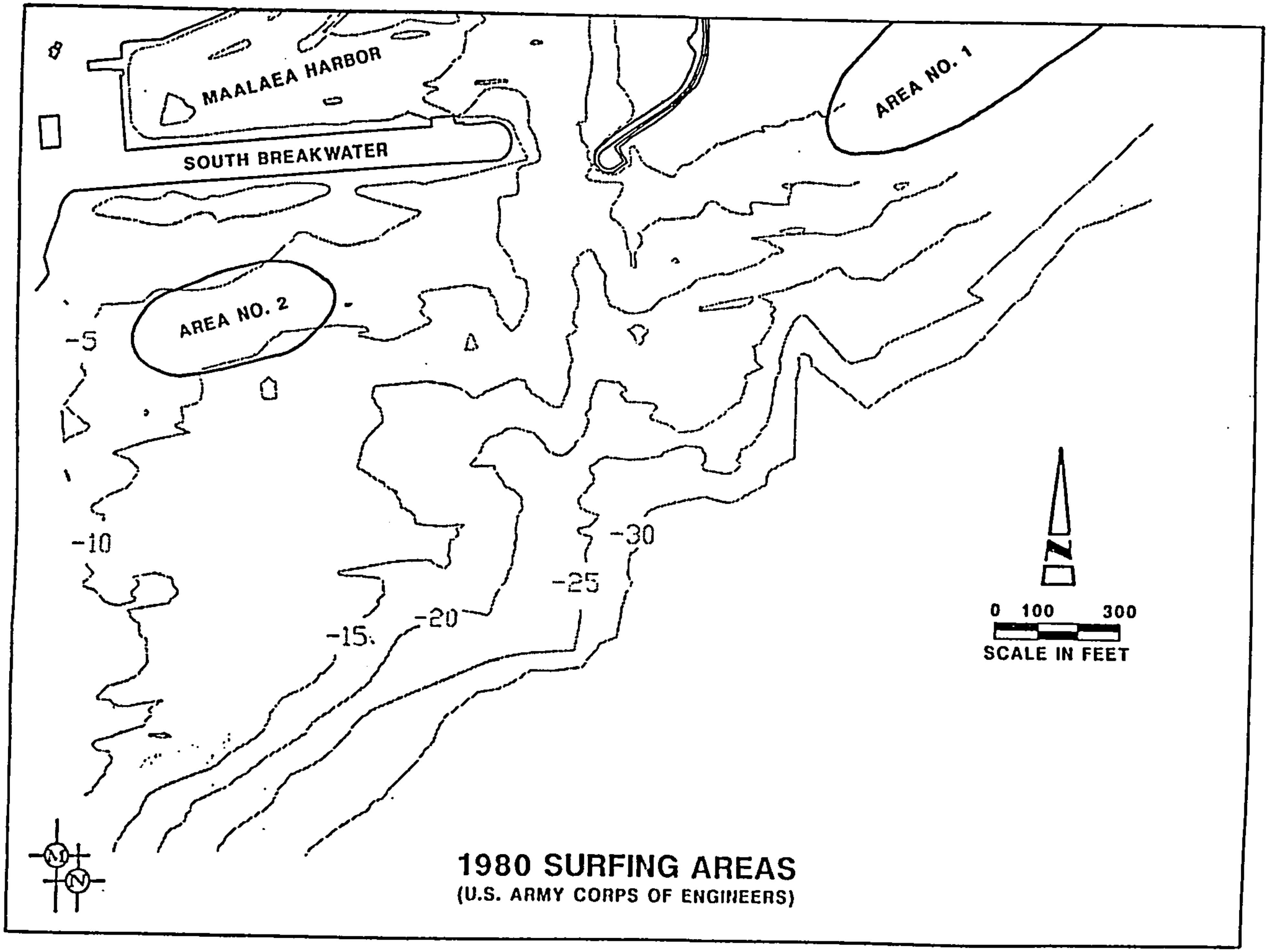

KAUAI
NI'IHAU
OAHU
MOLOKAI
MAUI
LANAI
KAHOOLAWE
HAWAII
STATE OF HAWAII
NOT TO SCALE
0 5 10
SCALE IN MILES
WAILUKU
KAHULUI
LAHAINA
MAALAEA
KIHEI
MAUI
PROJECT LOCATION
KAHOOLAWE
PACIFIC OCEAN
LOCATION MAP

FIGURE 2-1



1980 SURFING AREAS
(U.S. ARMY CORPS OF ENGINEERS)

FIGURE 2-2

It was firmly stated that there are no discernable strong rip currents near the east breakwater. The currents identified on the Corps of Engineers, (1980) plan were perhaps wind currents.

Surfers enter the water from the east breakwater, the harbor entrance, or through a small channel along the east breakwater.

The prevailing wind condition was offshore from the trades. The wind on the east side of the harbor has a strong longshore component blowing toward the west, but still offshore. On the west side of the harbor the local hills tend to deflect the wind and it blows more directly offshore.

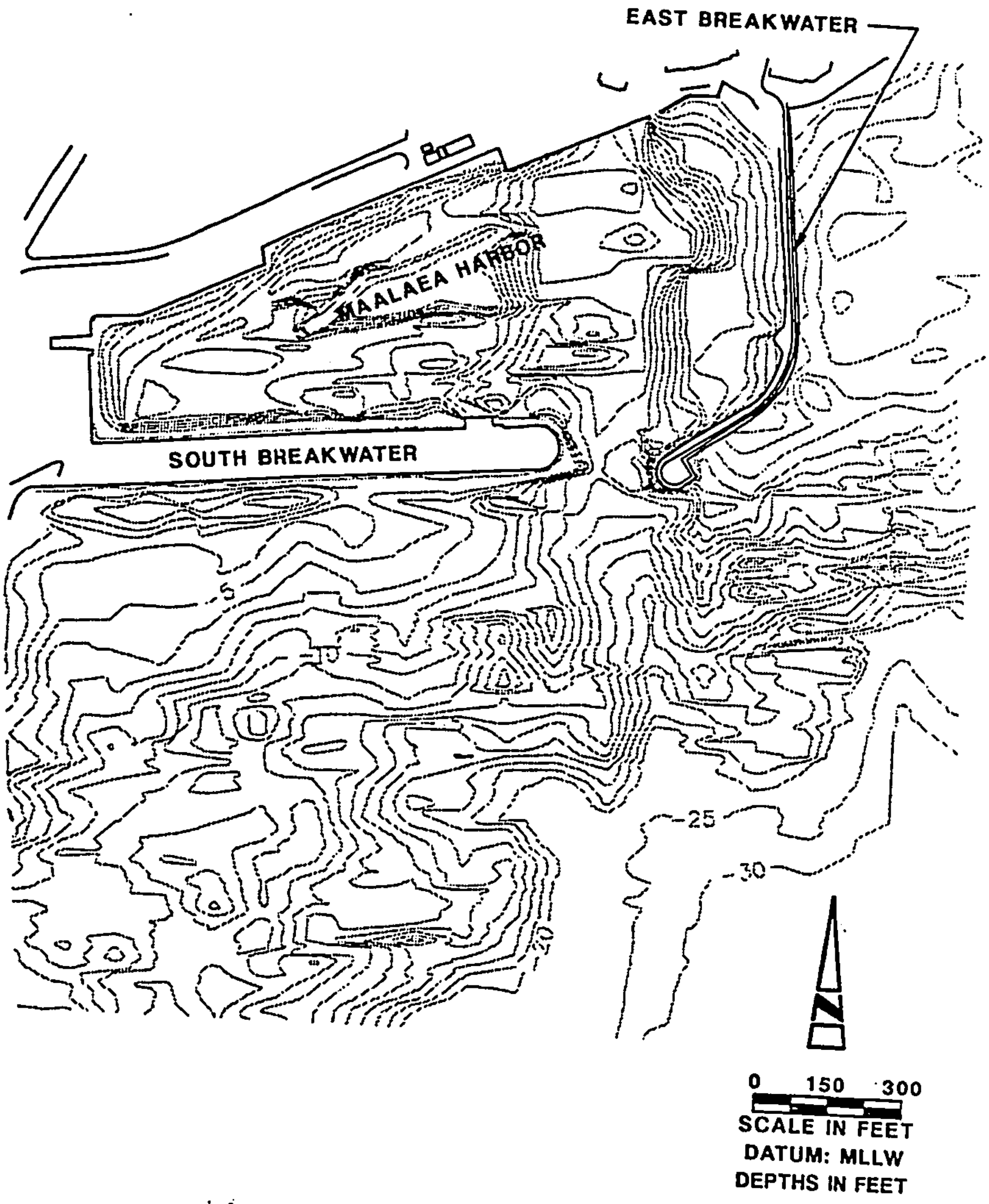
The investigators snorkeled the areas to verify the bottom characteristics and features shown on the bathymetric chart. The bottom is a hard coralline structure with coral heads and small channels. Small pockets of medium sand are dispersed over the reef.

2.3 Bathymetry

Nearshore bathymetry immediately adjacent to the harbor is available from the Maalaea Small Boat Harbor Plans prepared for the COE as shown in Figure 2-3 (R.M. Towill Corp., 1989). The bottom consists of a hard coralline reef with coral heads and small channels. The entrance channel has a fine sandy bottom with a small submerged ridge on either side. Water depths in the entrance channel range from -10 to -20 feet Mean Lower Low Water (MLLW). The water depth of the small ridges are approximately -8 feet, MLLW. The bathymetry immediately adjacent to the south breakwater consists of a broad reef flat approximately two feet below MLLW. This reef flat has a relatively uniform seaward slope of 1:45 (V:H). There is a small trench fronting the western portion of the south breakwater at an approximate depth of seven feet below MLLW. The material from this trench was likely used to construct the south breakwater.

2.4 Tides

The tides in the Hawaiian Islands are semidurinal, with a diurnal inequality. The mean tide range is approximately two feet, and the maximum annual tide range is approximately four feet. Tide data for Maalaea Bay is presented in Table 1.



1989 C.O.E. BATHYMETRY

(SOURCE: R.M. TOWILL CORPORATION, OCTOBER 1989)

FIGURE 2-3

TABLE 1

TIDE LEVELS FOR MAALAEA BAY

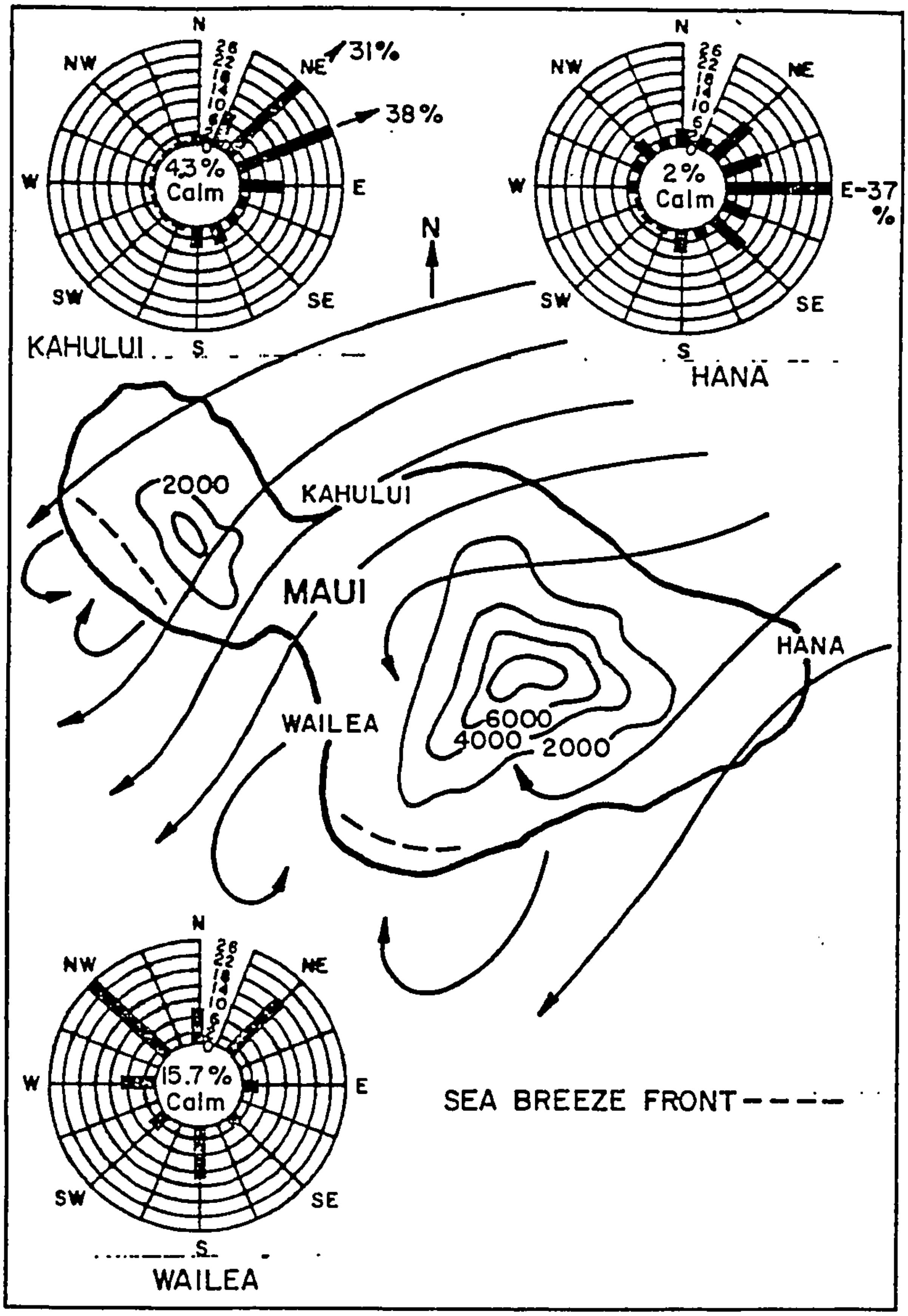
	Feet
Mean Higher High Water (MHHW)	+2.3
Mean High Water (MHW)	+1.8
Mean Tide Level (MTL)	+1.0
Mean Low Water (MLLW)	+0.2
Mean Lower Low Water (MLLW)	0.0

Ref: Maalaea Harbor for Light-Draft Vessels, General Design Memorandum and Final Environmental Impact Statement, COE, 1980.

2.4 Wind

The predominant winds in the vicinity of the Hawaiian Islands are the northeast tradewinds, which occur approximately 75 percent of the year. On Maui the tradewinds are strongly influenced by topographic conditions. At Maalaea Harbor, the northeast trade winds become northerly as they are funneled between the mountains of East and West Maui as shown in Figure 2-4 (Walker, 1974). Trade wind speeds often reach 25 knots at Maalaea.

The winter season is characterized by a weakening of the northeast tradewinds. This weakening results in climatic conditions conducive for the southwesterly Kona winds to occur. The Kona winds are characterized by light and variable winds which persist for a few days to a few weeks at a time. Although Kona storms are capable of generating wind speeds up to 30 knots, the frequency of occurrence is considered small.



FROM WALKER (1974)

TYPICAL TRADE WIND PATTERN ON MAUI

FIGURE 2-4

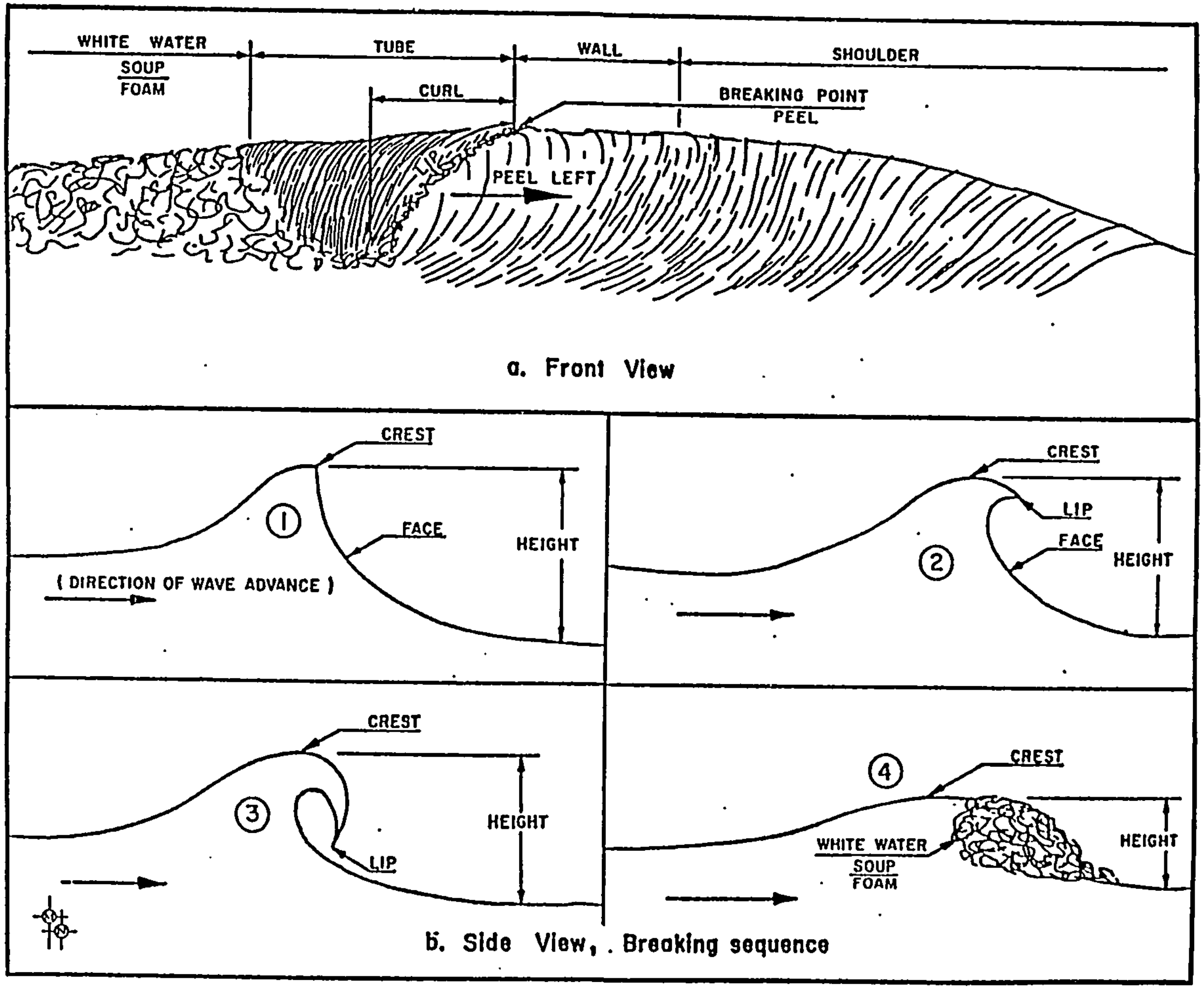
3.0 TECHNICAL ASPECTS OF A SURF SITE

3.1 Technical Description of Surfing Waves

Figure 3-1 illustrates a surfing wave and presents the terminology used in this report. A glossary of surfing terms is included as Appendix C. Surfing waves result from the interaction of waves with the bottom, wind with the waves, and the surfer with the wave. Waves approach from offshore, are transformed by the bottom into breaking conditions and are ridden by surfers. The interaction of the waves with the bottom is the most important factor in distinguishing one site from another. The wind also affects surface conditions and breaking qualities of the waves.

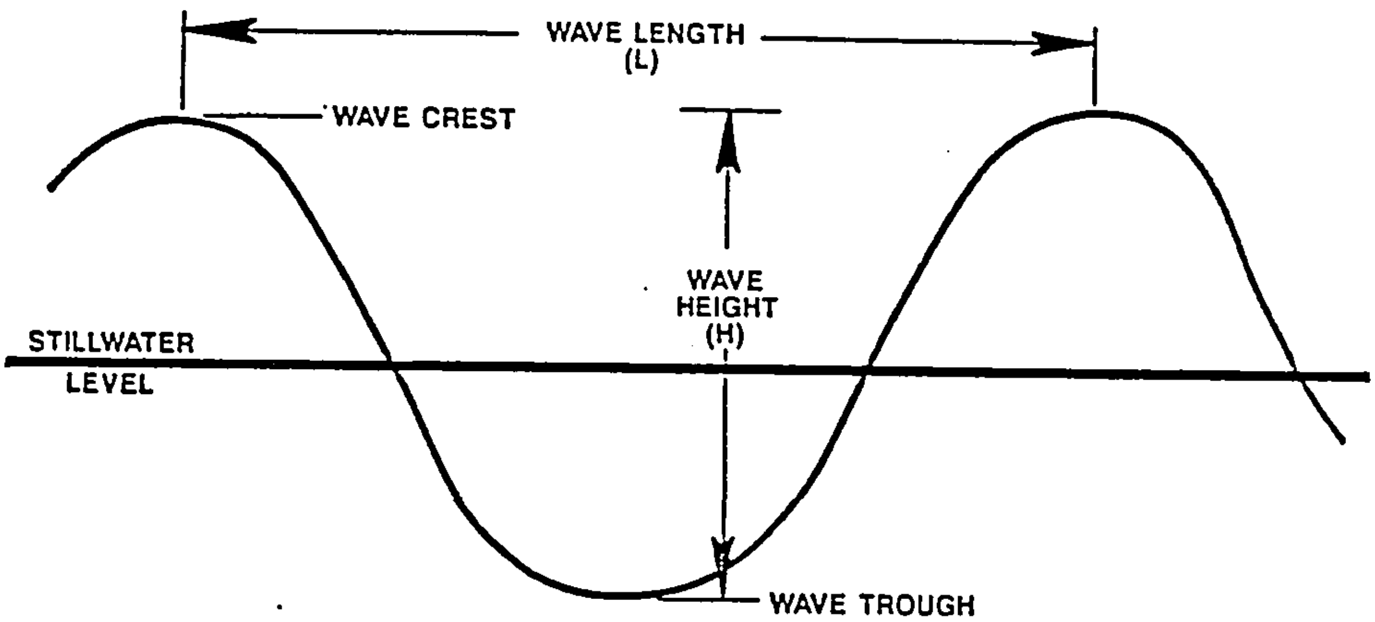
Breaker height, breaker type, and peel angle are all important parameters in the identification of surf site characteristics. The wave height, H, is the most obvious parameter. The wave height is the measure of the vertical distance from the trough of the wave to the crest, as defined in Figure 3-2. Another parameter is the wave length, L, which is the horizontal distance between successive wave crests. The wave period, T, is the time required for successive wave crests to pass a given stationary point.

Breaker type is another important parameter in identifying surf site characteristics. As waves travel toward the beach from deep water into shallower water, they are affected by the bottom conditions. The slope of the bottom, m, in relation to other parameters, such as wave steepness, H/L, and relative depth, d/L, determines the type of breaking conditions that will prevail, thereby determining breaker type. The breaker type may be a gentle spilling, which is characteristic of short-period waves over a gentle slope, or plunging which is characteristic of long-period waves over a steep slope. Figure 3-3 graphically illustrates the breaker types as well as collapsing and surging wave types. Figure 3-4 indicates the breaker type expected to occur on a given seaward beach slope, relative to the breaking wave steepness. Spilling and plunging breakers are the most common surfing waves and are typical of the surfing conditions at Maalaea Harbor.



SURFING WAVE TERMINOLOGY

FIGURE 3-1



WAVE PERIOD (T) IS THE TIME REQUIRED FOR SUCCESSIVE WAVE CRESTS TO PASS A GIVEN STATIONARY POINT

WAVE PARAMETERS

FIGURE 3-2

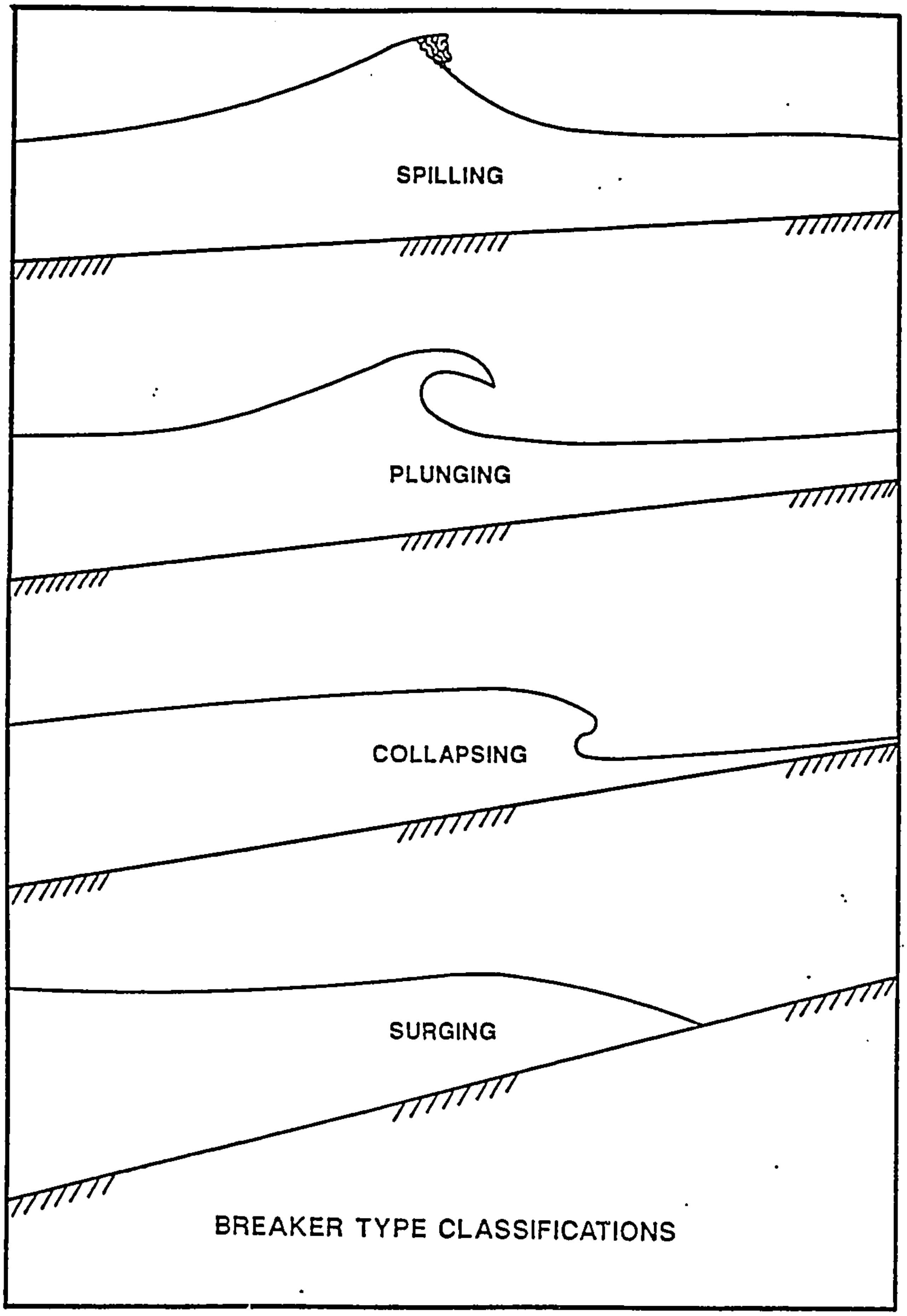
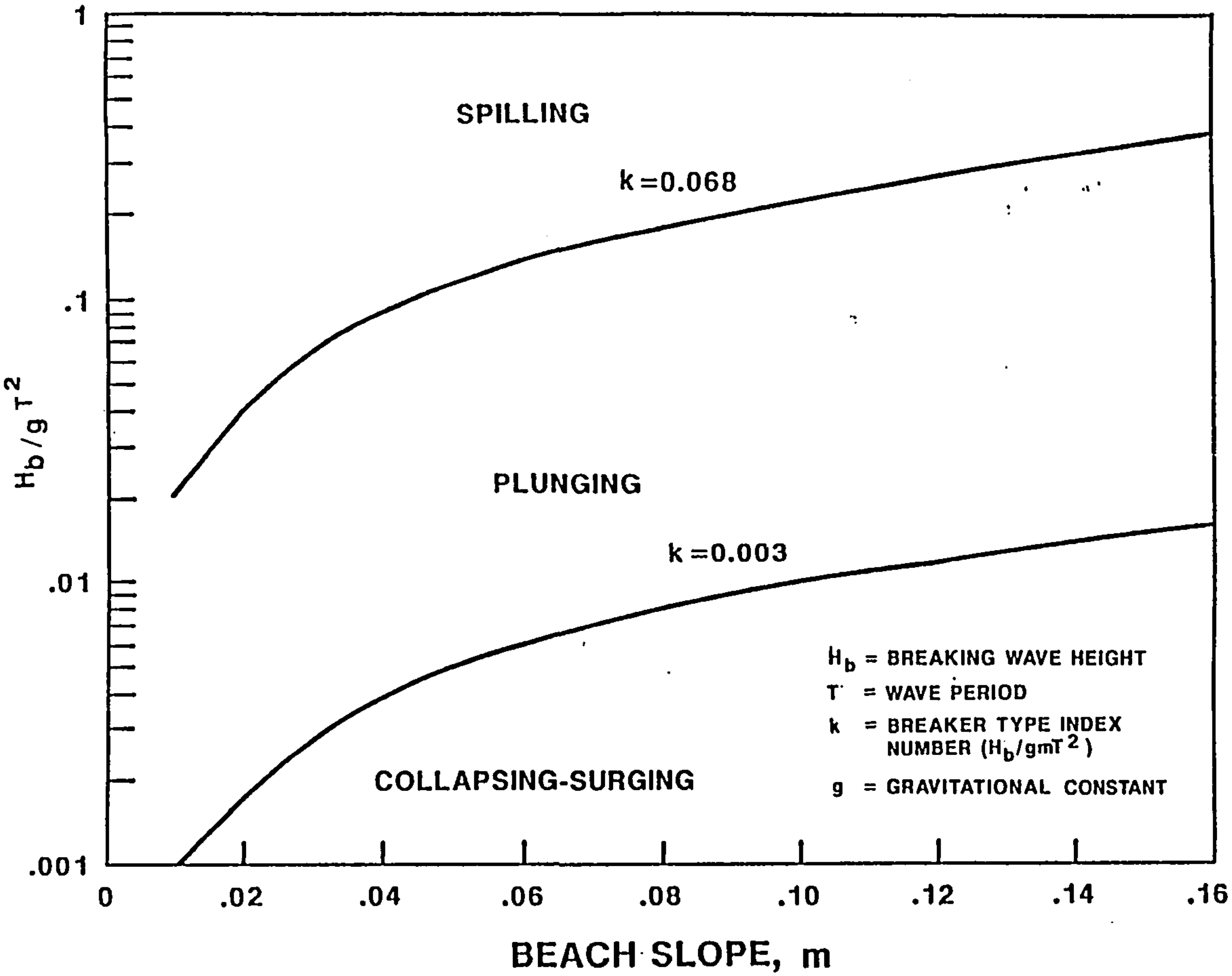

SPILLING
PLUNGING
COLLAPSING
SURGING
BREAKER TYPE CLASSIFICATIONS

FIGURE 3-3



BREAKER TYPE INDEX

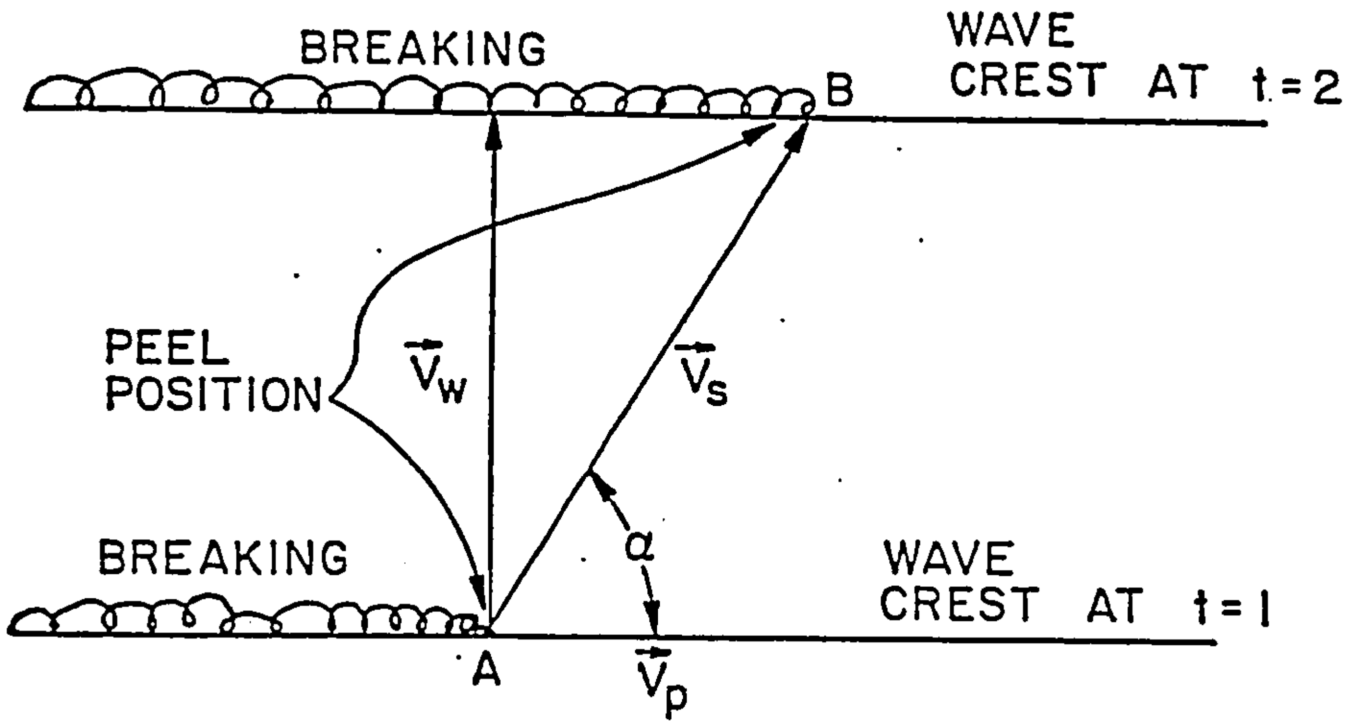
FIGURE 3-4

Peel angle is the third important parameter in identifying surf site characteristics. Surfers are not satisfied with a ride straight in toward shore. They prefer to work the face of the breaking portion of the wave (see Figure 3-1). Figure 3-5 shows a plan view of a wave as it breaks laterally along the crest as the wave propagates toward shore. The peel angle, α, is measured from overhead. Walker (1974) documented a relation between the peel angle and the breaker height to develop a description of surfing waves. This relation which is generally applicable is shown in Figure 3-6. It is desirable for the wave to break at a point and then peel laterally along the crest. The surfer generally rides the wave in the peel region. The ride is terminated at a beach, a structure, a section where the wave stops breaking, or when the surfer desires to get off the wave or wipes out. The peel angle should have a range of 30 to 90 degrees. More acute peel angles are close-out waves; i.e., the wave essentially breaks simultaneously along the crest and is unridable. Waves that progressively break along the crest as they approach shore are highly desirable for surfing and are described as peeling waves. The peel angle is controlled by the angle of the wave crest with the breaker depth. Hence, if the wave propagates directly up a beach slope, it will have a 0-degree peel angle, will close out, and will be unsuitable for surfing unless it is a very gently spilling breaker wherein the white water does not reach the wave trough.

The wind has a profound influence on breaker height and type. Any surfer can attest that a gentle to even strong wind with a component opposing the wave tends to hold the wave up longer and create a smoother surface than a wind with a component in the direction of wave propagation. A component of wind in the direction of wave propagation causes the wave to break prematurely with a lower height and consequently, a lower breaker index. This spoils the surface conditions and is one reason why field experiments may yield lower breaker indices than those obtained from laboratory experiments of wave breaking.

3.2 Surf Site Bathymetry

The characteristics of a surf site depend upon the bathymetry of the ocean bottom. The basic requirement for a desirable surfing wave is for the wave to peak gradually into a breaking condition; gradual peaking results from a

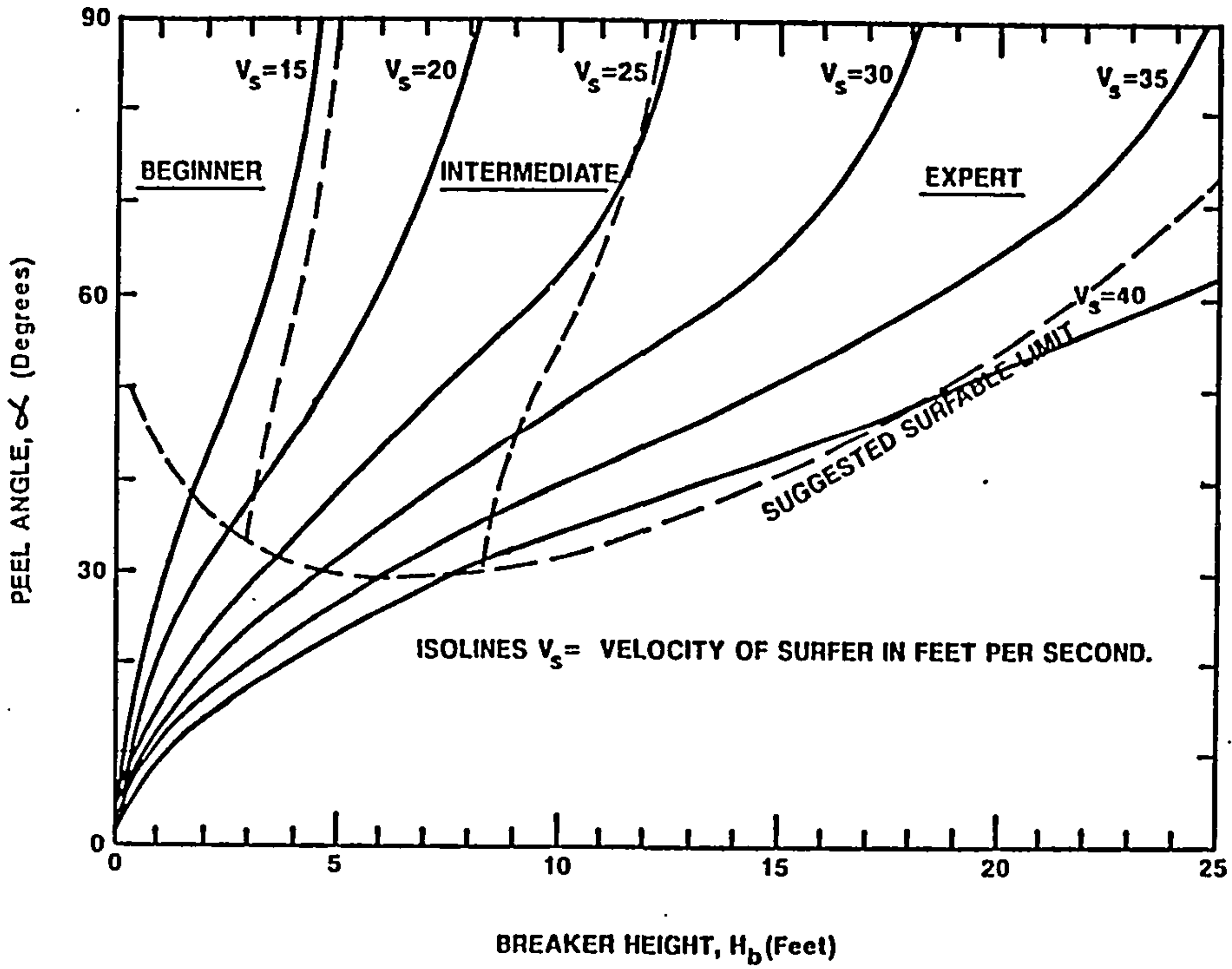


PLAN VIEW

$\vec{V}_W$ = VELOCITY OF WAVE
$\vec{V}_S$ = SURFER VELOCITY
$\vec{V}_P$ = PEEL VELOCITY
α = PEEL ANGLE

PEEL PARAMETERS

FIGURE 3-5



PEEL ANGLE vs. BREAKER HEIGHT

FIGURE 3-6

gradually decreasing water depth. The breaker height, H_b, is in part governed by the wave properties and the bottom slope. As the wave propagates toward shore it eventually increases in height to a point where it becomes unstable and breaks. The breaker index H_b/d_b is a ratio of breaker height to water depth. The breaker index of $H_b/d_b=0.78$ is commonly used as a general guide. For example, a breaker index of 0.78 indicates that a 3-foot wave will break in about 4-feet of water (H_b/d_b = 3 feet/4 feet = 0.75 ≈ 0.78).

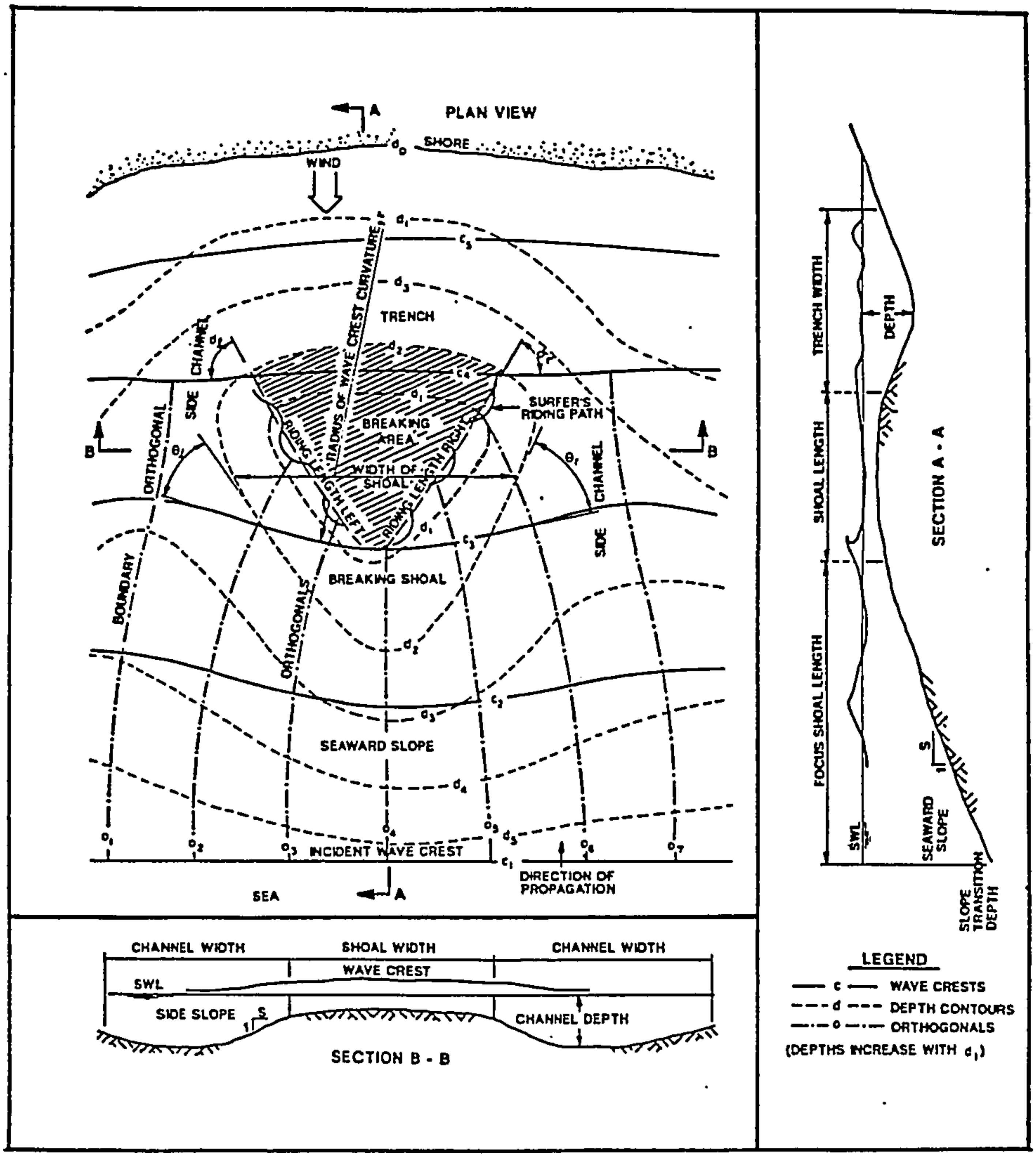
The bottom and boundary configurations that induce surfing waves are different for each site. Prominent bathymetric features that transform incoming waves into desirable surfing waves include a seaward slope, side channels, and a shoal or ridge. These features are discussed in the subsections that follow. Figure 3-7 shows these and other site features.

3.3 Seaward Slope

Wave refraction is defined as the process by which the direction of a wave moving in shallow water at an angle to the depth contours is changed. The part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest line to bend toward alignment with the underwater depth contours. Therefore, a seaward slope in a ridge configuration induces the incoming waves to converge. The primary seaward slope parameters are steepness and orientation in relation to the incoming waves, as well as the plan configuration.

Seaward slope steepness influences breaker height and type. Steeper slopes result in higher breaking waves. For example, a given incoming wave will break with a 25 percent greater height on a 1:10 slope than on a 1:50 slope. Waves also tend to break in a more plunging form for steeper slopes. Most Hawaiian surf sites break in a plunging or spilling-plunging form.

The orientation of the seaward slope in relation to the incoming waves has a significant influence on a surf site. A shoal oriented directly, or nearly directly, into the direction of wave approach will cause more waves to converge, resulting in a greater breaking height, than a shoal oriented at a 45-degree angle to the direction of wave approach. This influence becomes



GENERAL SURF SITE FEATURES

FIGURE 3-7

more pronounced as the shoal extends into deeper water for narrow shoals. Shoals with blunter shapes located in shallow water are not as sensitive to causing waves to converge. The plan configuration of the seaward slope varies considerably from site to site. The seaward slope of most prime Hawaiian surf sites is generally blunt as opposed to having a sharp point protruding seaward.

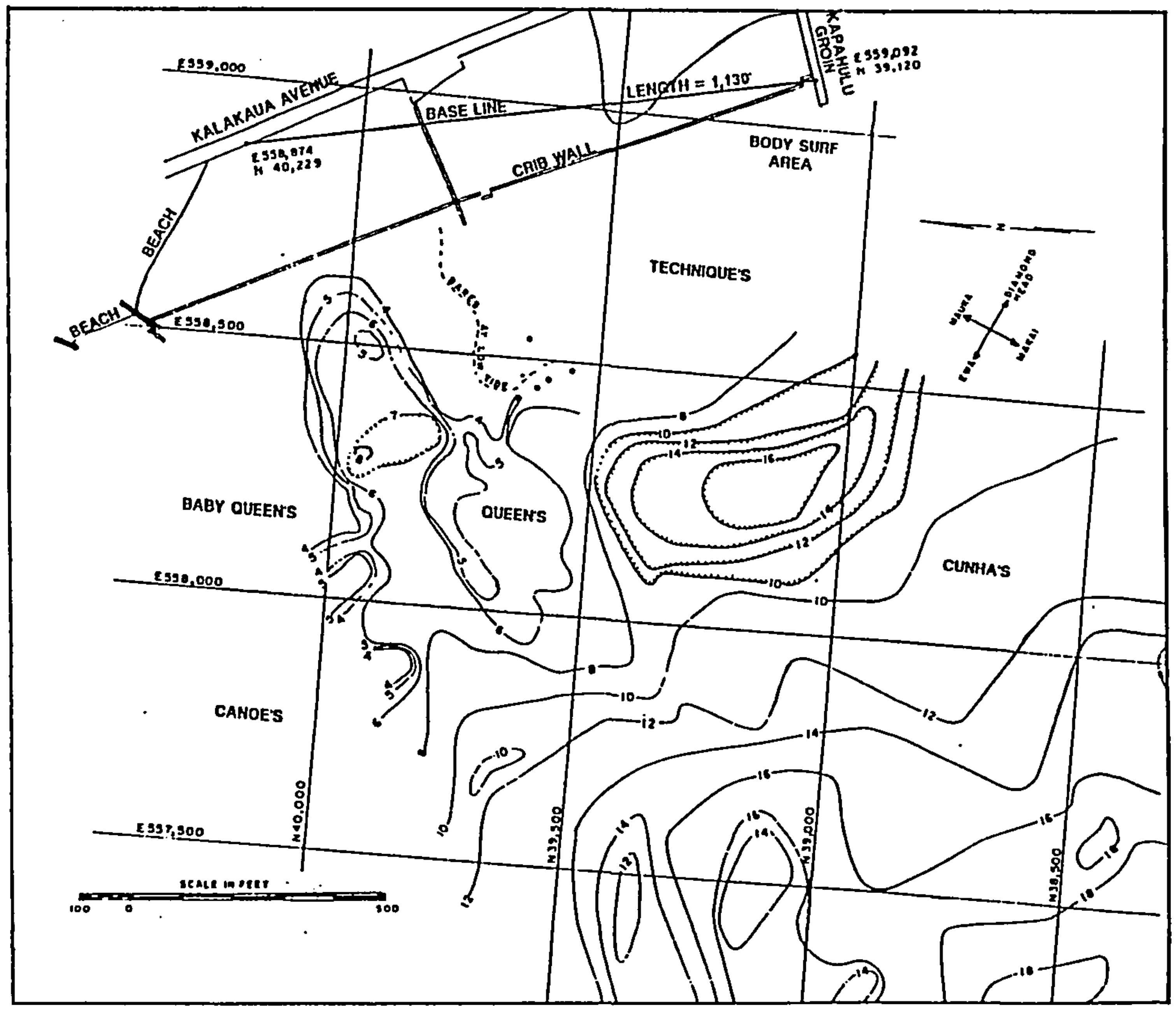
3.4 Side Channels

Depth variations near the breaker zone contribute toward the creation of desirable surfing waves. A surf shoal commonly has a channel on one or both of its sides. Excellent surfing conditions frequently exist on both sides of a natural channel and sometimes alongside a dredged channel. The important side channel parameters are the depth differential relative to the shoal, the width of the channel, and the alignment of the shoal relative to the incident waves.

Side channels perform several important functions in wave transformations. A side channel separates adjacent surf sites from one another, induces a wave-amplitude differential between the non-breaking wave in the channel and the breaking wave over the shoal, and changes wave angle, which subsequently influences peel angle and breaker height. The side channel provides an area for surfers to gain access to and return from the surf site without interfering with other surfers. Rip currents are often found in the side channels which aid surfers in accessing the surf site.

3.5 Shoals

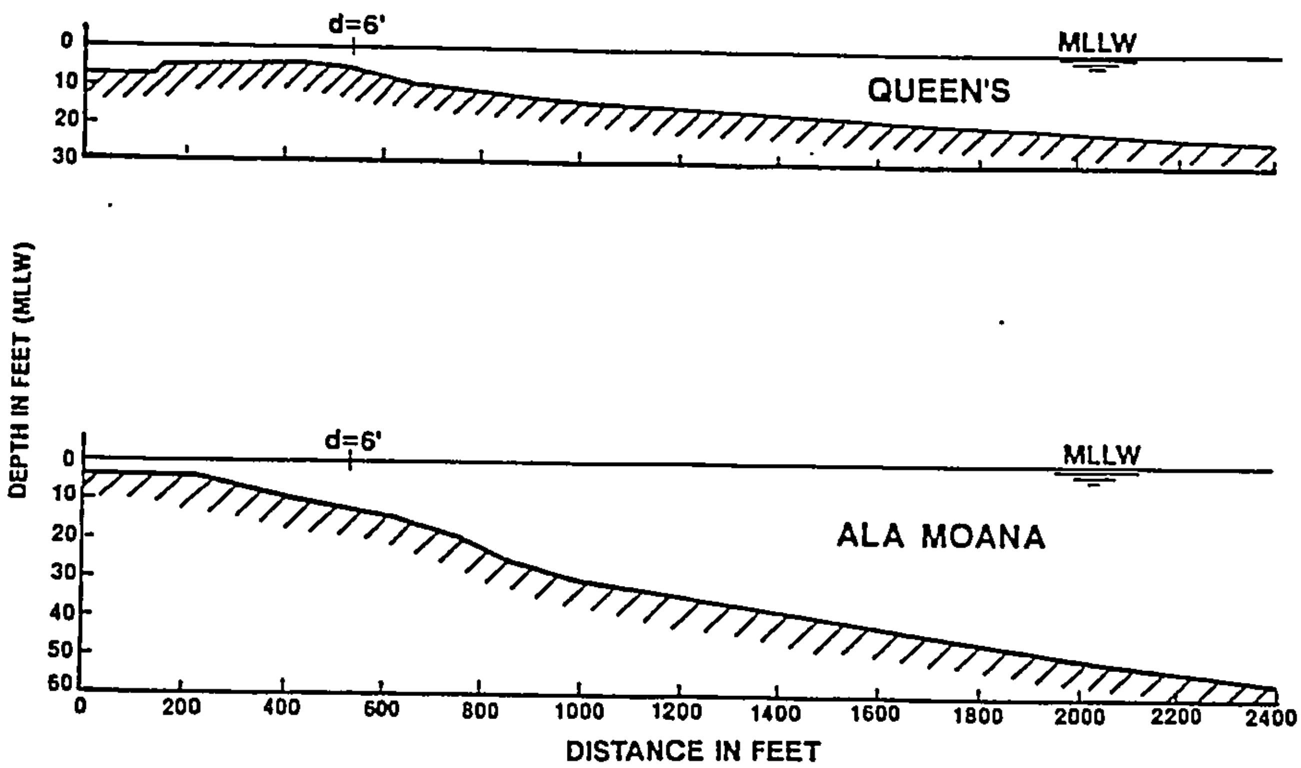
A shoal or a ridge configuration is an extension of the seaward slope and the side channel slopes. A shoal fulfills the breaking-depth criterion such that waves are induced to break farther seaward over the shoal than in adjacent channels. The size, shape, depth, and location of the shoal are the important parameters that determine if an incident wave is transformed into a desirable surfing wave. In general, the shape of a shoal at surf sites is blunt, with contours that run obliquely toward shore.



FROM WALKER (1974)

QUEEN'S BATHYMETRIC CHART

FIGURE 3-8



FROM WALKER (1974)

CROSS SECTIONS THROUGH SELECTED SURF SITES

FIGURE 3-9

The orientation of shoal side contours controls the peel angle. The peel follows the breaking depths and the wave is highest at the initial break. Subsequent breaking along the crest is usually progressively lower as the wave propagates from the initial break. After the initial break, the instability of the breaking wave is transferred laterally, and the wave may break at a lower height than the controlling depth. The wave crest at prime surf sites generally subtends a 30- to 90-degree angle with the bottom contours. Waves with crests at more acute angles are generally too fast to ride and those with crests at more obtuse angles are "back-off" waves, which are generally not considered to have a desirable surfing form. A 50-degree wave crest-to-bottom contour angle appears to be a typical angle found at most desirable surf sites. This leaves leeway for wave-direction variability to allow the site to be useful for surfing under a wide range of wave conditions.

3.6 Physical Description of a Typical Hawaiian Surf Site

Walker (1974) conducted field observations at prime Hawaiian surf sites to study the interactions between the surfer and the wave and between the wave and the bottom. The cited purposes were to determine the characteristics of recreational surfing over Hawaiian reefs and to determine the major parameters that render a surf site desirable. Of primary interest in his study was the correlation between site bathymetry and desirable surfing waves. An understanding of this correlation and of the parameters that create such desirable waves at prime surf sites can be applied to the project site. One surf site studied by Walker (1974) is Queen's; this site, as well as the project site, are both located on a south facing shore of a Hawaiian island.

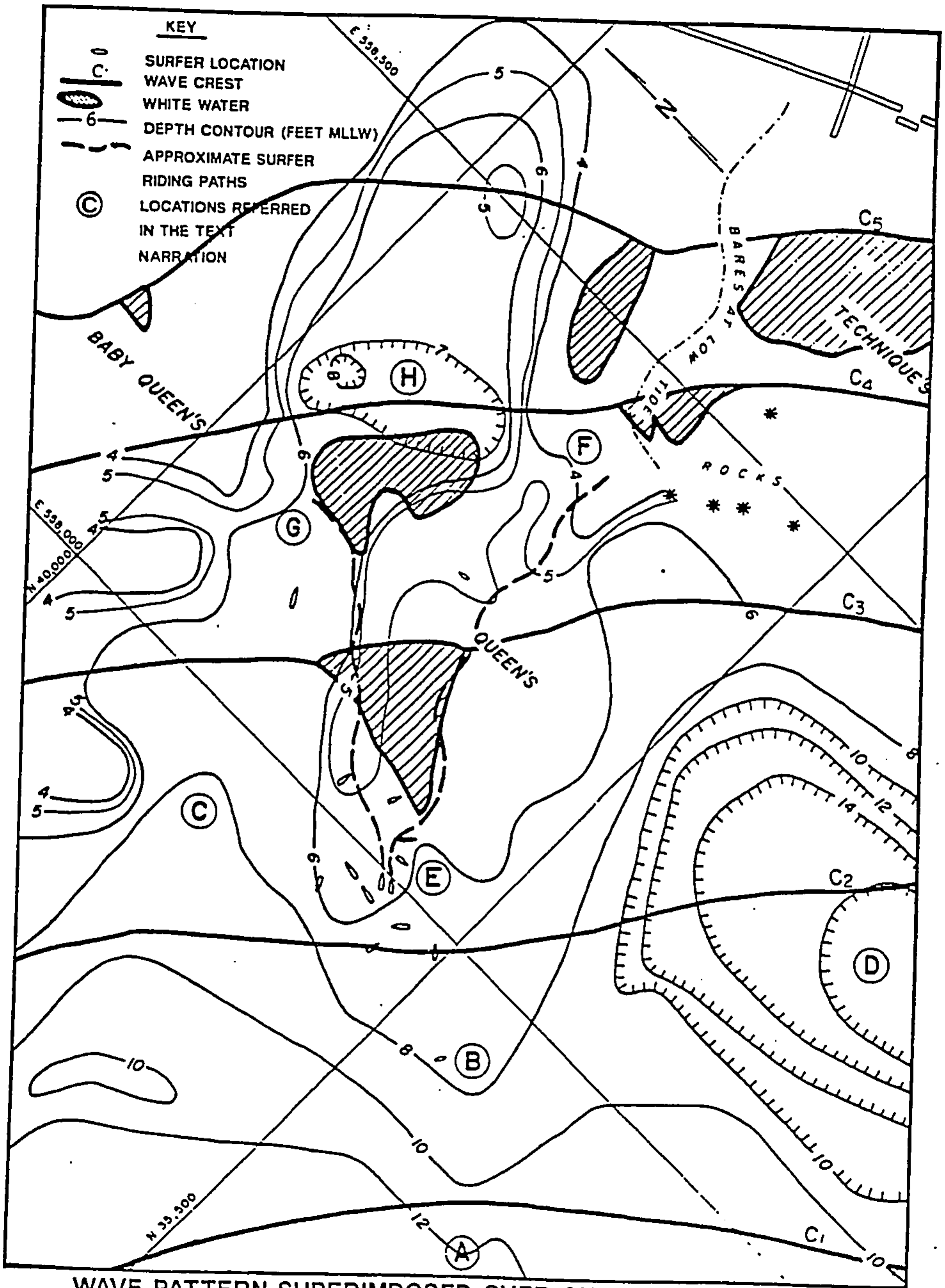
The Queen's surf site is located in Waikiki Bay. The Queen's bathymetric chart, presented in Figure 3-8, shows a 300 foot by 600 foot coral reef shoal. It has a 150 foot wide, 7 foot deep sand-filled channel on the left side and a large 16 foot deep hole on the right side. The shoal is located at the head of a bay that has an average 1:120 slope from the 12 to 45 foot depths. The slopes of the shoal steepen to 1:40 from the 12 to 6 foot depths and then become relatively flat. Figure 3-9 shows a cross section through the center of the shoal.

Queen's is a popular south shore surf site that is surfed by intermediate and skilled surfers year round. The best season is in the summer during the southern swell. The site may be surfed on waves ranging in height from 2 to 8 feet. The site is confined to the shoal when breaking wave heights are 6 feet and under. When the breaker heights are over 6 feet, Queen's may connect with Cunhas to the right and Baby Queen's on the inside left. When breaker heights exceed 8 feet, the site loses its isolated identity, and waves close across the side channel.

A detailed discussion of typical wave transformations and surfer interactions with the wave is given in the narration that follows, wherein a general description of the characteristics of Queen's and surf sites in general is provided. Wave crests and surfer locations on a 4 foot wave, taken from an aerial photograph, were superimposed over a Queen's bathymetric chart, and the results are presented in Figure 3-10. The wave crests are labeled in C_i sequence. The encircled letters pertain to locations in the subsequent narration.

Incoming waves approach the shoal from the southwest. The concave bay shape causes a divergent wave crest, C_1, at the start of the shoal in the 12 foot depth, at position A. At this point, the wave crest is essentially uniform in height. The shallow water depths over the ridge at position B, relative to the depths in side channel C and hole D, concentrate wave energy over the ridge, thereby causing the wave height to increase. The crest line has been transformed to a concave form called a "bowl" by surfers, as shown at crest C_2. The wave is initially picked up by the surfers at the wave peak over ridge E; the locations of several surfers are shown in Figure 3-10 in position E, the take-off area.

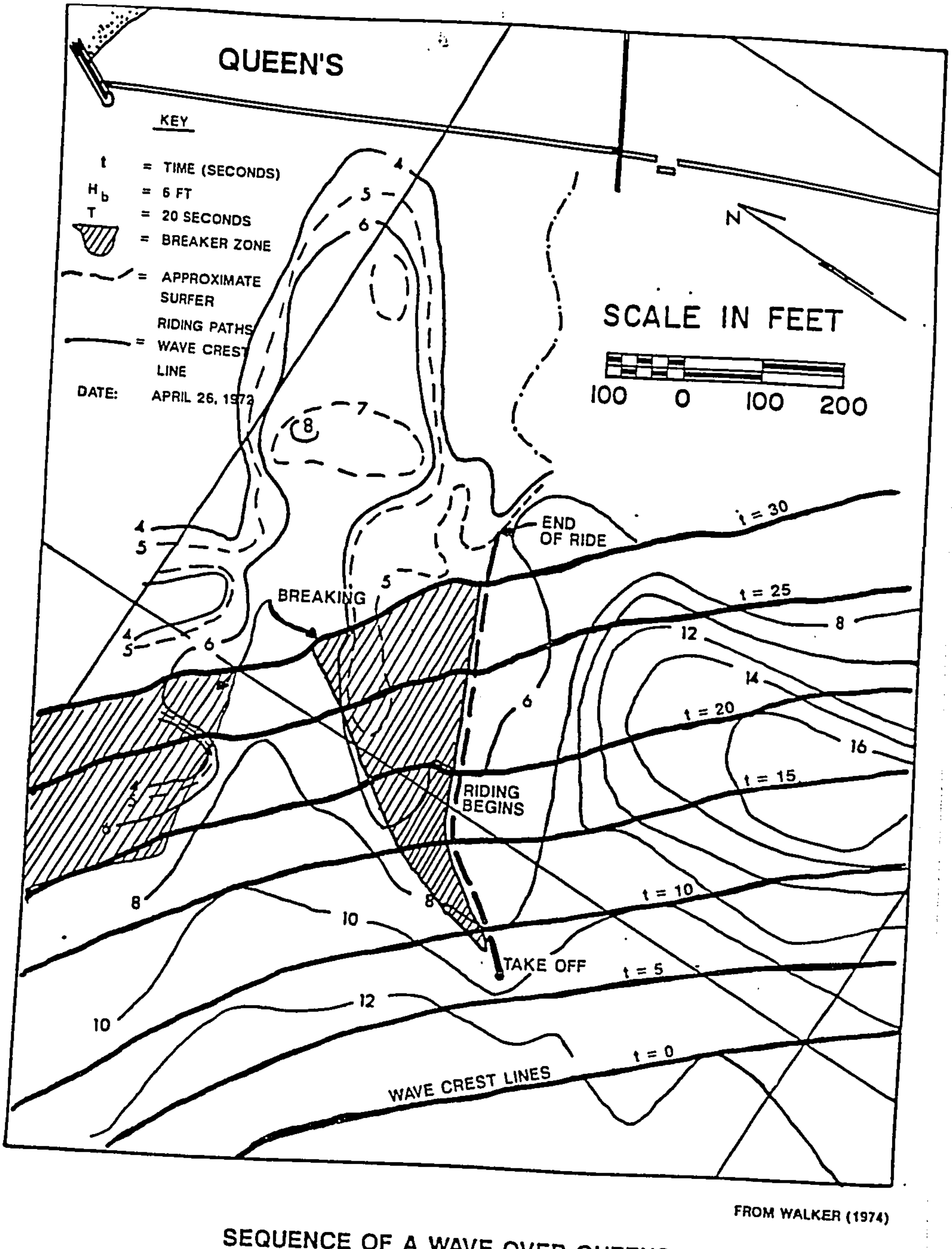
The initial break occurs immediately shoreward of the take-off area, in a plunging-spilling form. The surfer may ride the wave to the right or to the left, depending upon the wave form and his preference. The approximate riding paths are shown in Figure 3-10 by the dashed, wavy lines. The ride to the right generally terminates in front of the rocks, at F. The ride to the left generally terminates in the trench, at H, or in the channel, at G, into the Baby Queen's site.



WAVE PATTERN SUPERIMPOSED OVER QUEEN'S BATHYMETRIC CHART AND SURFER LOCATIONS

FIGURE 3-10

Figure 3-11 illustrates a sequence of breaking waves over Queen's. The breaking wave height, H_b, was 6 feet, the period, T, was 20 seconds and the direction of approach was from the southwest. Crest-lines showing the wave propagating over the shoal are shown on the figure as crosshatched. The path of a surfer is also plotted. The wave was caught well outside the white water region, which starts at T = 15 seconds. The breaking proceeds laterally along the crest, creating a peel angle of 55 degrees to the right and 80 degrees to the left. The deep hole to the right is apparently partially responsible for refracting the wave more on the right than on the left. Also, the orientations of the 5- to 6-foot depth contours relative to the incoming wave direction induces a slightly more acute peel angle to the right than to the left.



FROM WALKER (1974)

SEQUENCE OF A WAVE OVER QUEENS

FIGURE 3-11

4.0 WAVE CONDITIONS

4.1 General

The natural characteristics and behavior of Hawaiian surf are closely associated with wave climate and exposure. Waves approaching the islands may be represented by the following general types (Marine Advisers, Inc., 1964):

1. Northeast Trade Waves - These waves are generated by the northeasterly tradewinds that prevail approximately 75 percent of the year. Northeast trade waves are characterized in deep water by wave heights of up to 20 feet and periods ranging from 5 to 12 seconds. They occur most frequently and are the largest during the months from April through November.

2. Kona Storm Waves - During the winter season, Kona winds generate waves from the south through southwest with characteristics similar to those of trade waves. Kona conditions occur most frequently from November through April. Infrequently, a Kona storm associated with a large low-pressure system generates large storm waves from the southwest.

3. North Pacific Swell - The North Pacific swell, for which the large surf on the north and northwest coasts in Hawaii has become famous, is due to the waves generated from North Pacific extra-tropical cyclones. These large waves have heights in excess of 20 feet and periods ranging from 10 to 15 seconds. The North Pacific cyclones travel eastward and generate waves that approach the northwestern exposed shores of the islands. These waves are most likely to occur from October through April.

4. Southern Hemisphere Swell - This swell is generated in the South Pacific Ocean and the Indian Ocean. Large, extra-tropical storms generate waves and swell that travel 5,000 miles with breaking wave heights ranging up to 10 to 15 feet annually. The wave heights in deep water are 3 to 6 feet, with 14 to 18 second periods. These waves are generally

characterized by rather long wave lengths, and distinct wave groups, and they are independent of the local wind system.

5. Local Storms and Hurricanes - Local storms and hurricanes are infrequent. Tropical storms generated off the coast of Mexico move westward through the equatorial region and occasionally deflect northward toward the Hawaiian Islands. Hurricane Iwa in November 1982, Hurricane Dot in August 1959, and Hurricane Nina in December 1957 are the major hurricanes that have caused damage to the Hawaiian shoreline in the past 40 years.

The project site is located on the leeward side of Maui, on a shoreline with an average azimuth of about 60 degrees. The project site is directly exposed to large waves generated from the south-southeast and clockwise through 185 degrees. The site is also directly exposed to waves generated between 213 degrees through 217 degrees as shown in Figure 4-1.

Kahoolawe partially protects the site from southern swell and the Lanai, Molokai, and west Maui shorelines block waves from the northwest; however, waves with south westerly components can reach the site. Direct wave attack on this shore occurs occasionally, primarily during Kona storms or with a southern swell. As a result, waves at the project site are generally mild.

WAVE EXPOSURE AT MAALAEA

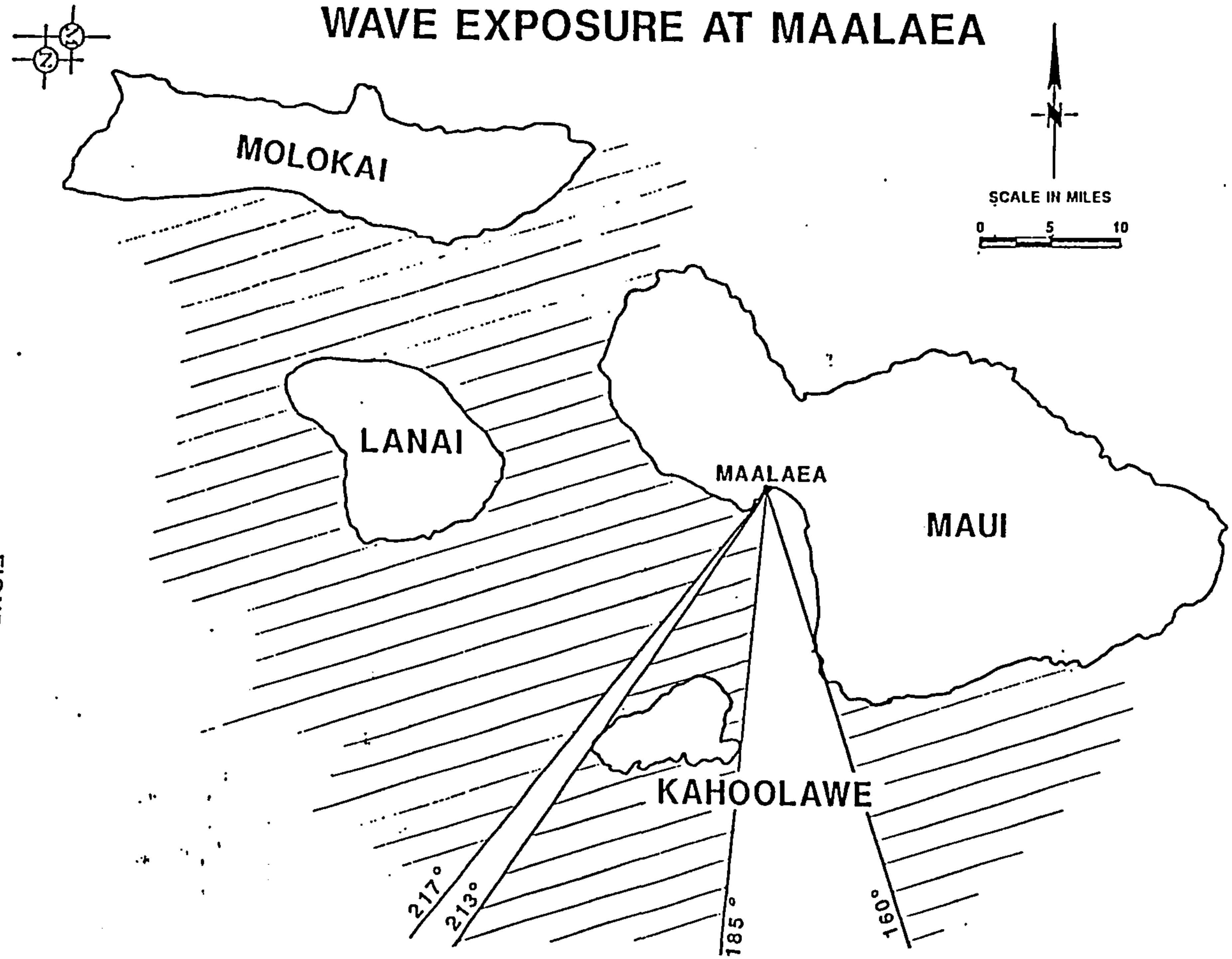


FIGURE 4-1

5.0 METHODOLOGY

5.1 Wave Refraction Analysis

A wave refraction analysis was performed to determine directions of predominant wave approach relative to shoreline orientation. The results were used for the analysis of characterizing potential surf sites at Maalaea Harbor. Wave refraction computations were performed using a numerical model employing linear wave theory described by Headland (1984). A modification was made to the numerical model incorporating a nonlinear shoaling coefficient based on data by Walker (1974).

Deepwater wave refraction diagrams were prepared by using the bathymetry described on the National Oceanic and Atmospheric Administration (NOAA) Chart No. 19340. The deepwater wave refraction diagrams include azimuths from 160 degrees to 235 degrees, and wave periods from 8 to 16 seconds. These waves were refracted from deepwater to a depth of -60 feet, MLLW. Analysis revealed that wave approach at the -60-foot contour ranged from 185 degrees to 215 degrees. Deepwater wave heights up to five feet were considered to be characteristic of the site.

Shallow water wave refraction diagrams were prepared by using the bathymetry described on the U.S. Coast and Geodetic Survey Chart No. 4104, along with the Maalaea Small Boat Harbor bathymetry (Towill, 1989). The shallow water wave refraction analysis incorporated this later range of wave directions to perform detailed refraction from the -60-foot (MLLW) contour to breaking. The azimuth direction of wave approach for shallow waters was 185, 195, 205 and 215 degrees. The numerical model was run using a +1-foot (MLLW) tide to represent an average condition, although tides can play a major role, especially in the smaller waves.

The shallow water refraction diagrams show where the waves are breaking; the peel angles can be measured from the refraction diagrams at each site. The shallow water refraction diagrams are included in Appendix A. Figure 5-1 shows a representative example how each surf site was identified and how the peel angles were obtained based on wave refraction diagrams.

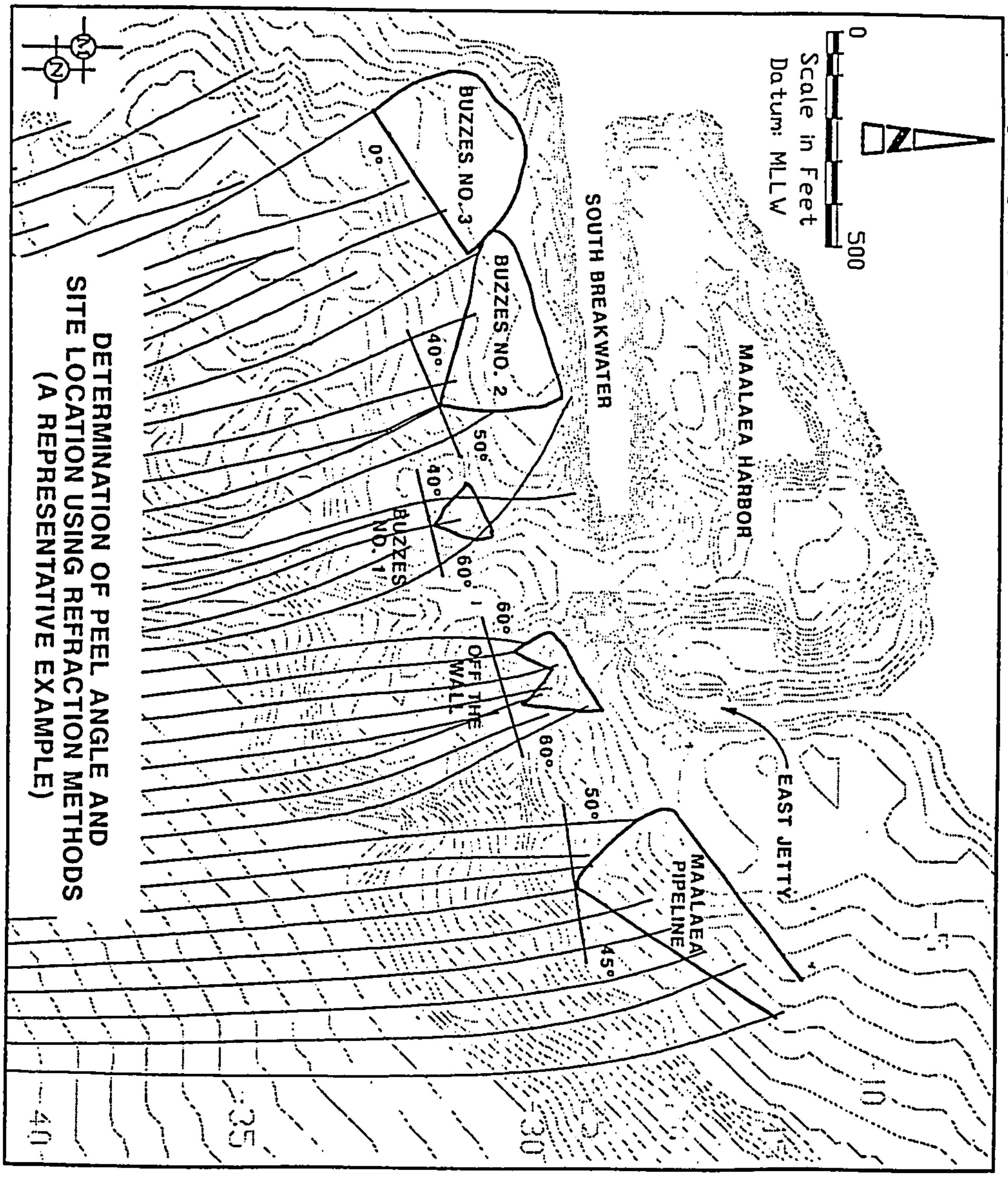

Scale in Feet
0
500
Datum: MLLW
MAALAEA HARBOR
SOUTH BREAKWATER
EAST JETTY
BUZZES NO. 3
BUZZES NO. 2
BUZZES NO. 1
OFF THE WALL
MAALAEA PIPELINE
0°
40°
50°
40°
60°
60°
60°
50°
45°
-10
-30
-35
-40
DETERMINATION OF PEEL ANGLE AND
SITE LOCATION USING REFRACTION METHODS
(A REPRESENTATIVE EXAMPLE)

FIGURE 5-1

5.2 Wave Statistics Analysis

Deepwater wave statistics taken from a wave gage positioned near Waikiki Beach from July 26, 1990 to February 6, 1991 (Noda 1991) along with the wave refraction analysis were used to classify waves at Maalaea as either surfable or nonsurfable. The surfable wave criteria used is a breaker height (H_b) greater than one foot, the wave type had to be either plunging or spilling, and the peel angle had to be greater than 30 degrees and less than 90 degrees. This is a rather broad criteria which does not imply that waves are actually surfed under all of these conditions, but they could be.

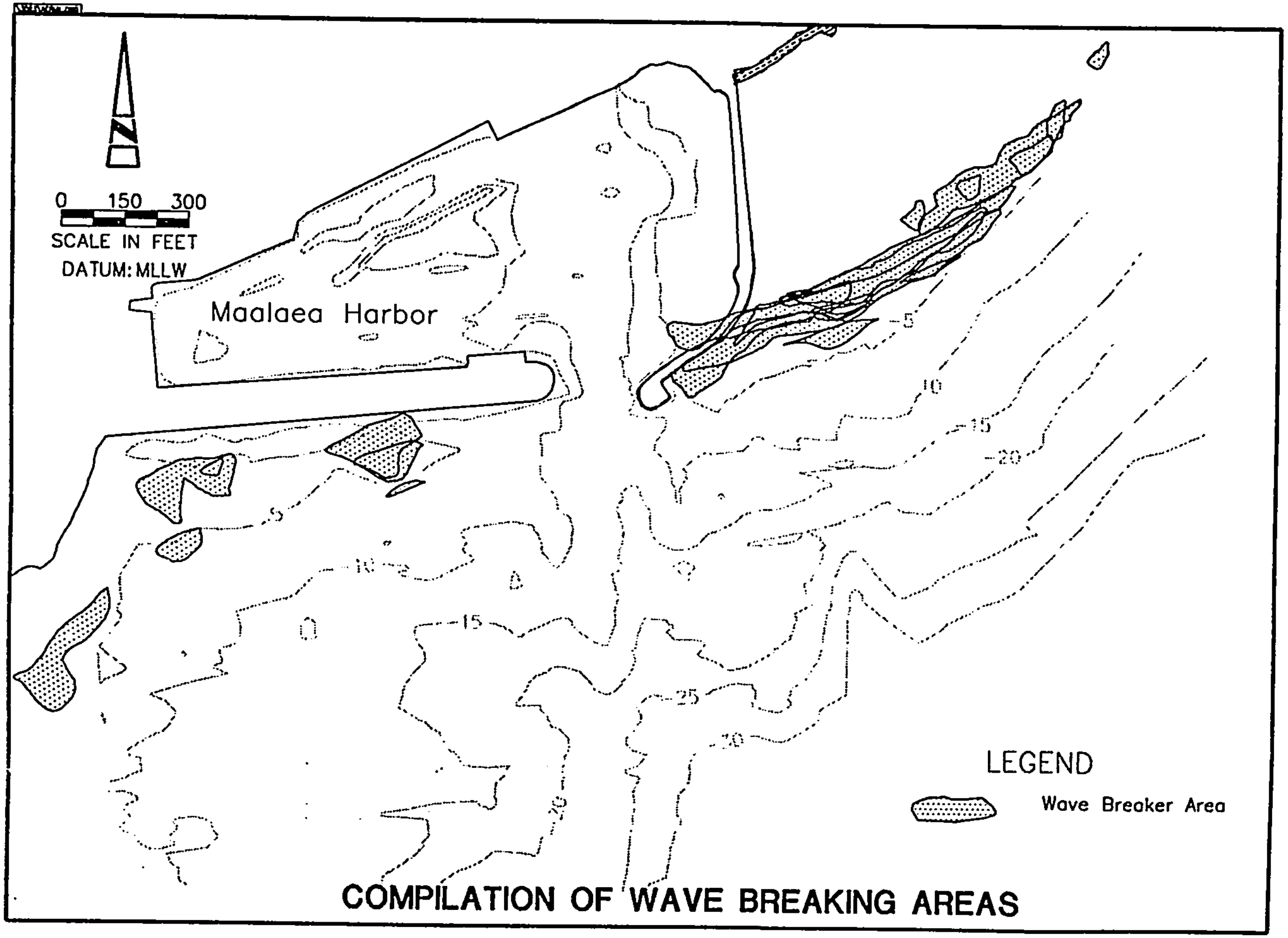
The wave data (Noda 1991) was grouped by either sea conditions, swell conditions, or both. The swell data was used for this analysis, because it is the long period swell that is mostly responsible for surfable wave conditions. The data was presented in two monthly categories from July 26, 1990 to October 26, 1990, and from October 26, 1990 to February 6, 1991. These monthly categories were further subdivided by an azimuth band of 22.5 degree increments. Because some of the azimuth band increments did not fully envelope wave directions pertinent to our project site, a percentage of that wave data was used for the analysis.

Based on measured wave data (Noda 1991), exposure to the site, and shallow water transformations, the waves were refracted to the point of breaking. The data was presented as a percent occurrence in hours per year of breaking conditions given 8760 hours per year and adhering to the above classification of surfable waves. Wherever the wave refraction analysis showed an unsurfable condition for a given deepwater wave condition, those hours were not included as surfable hours.

5.3 Aerial Photograph Analysis

Aerial photographs of the Maalaea Harbor and vicinity were used to evaluate the location of breaking waves and thus the possible location of surfing waves. Sea Engineering, Inc. performed a search of historical aerial photographs from 1949 to the present concentrating on photographs that showed breaking waves, wave crests, and if possible, surfers in the water.

Seven photographs were available, spanning a 38 year period from 1953 to 1991 and includes both summer and winter months. The areas of breaking waves on each photographs were digitized and stored in a CAD file. A numerical algorithm was used to correct for photographic distortions and to rectify them all to the same scale. The breaker zones were then imposed on a digitized base map of the project vicinity. These diagrams are included in Appendix B. Figure 5-2 shows a compilation of the wave breaking areas form all of the photographs.



COMPILATION OF WAVE BREAKING AREAS

FIGURE 5-2

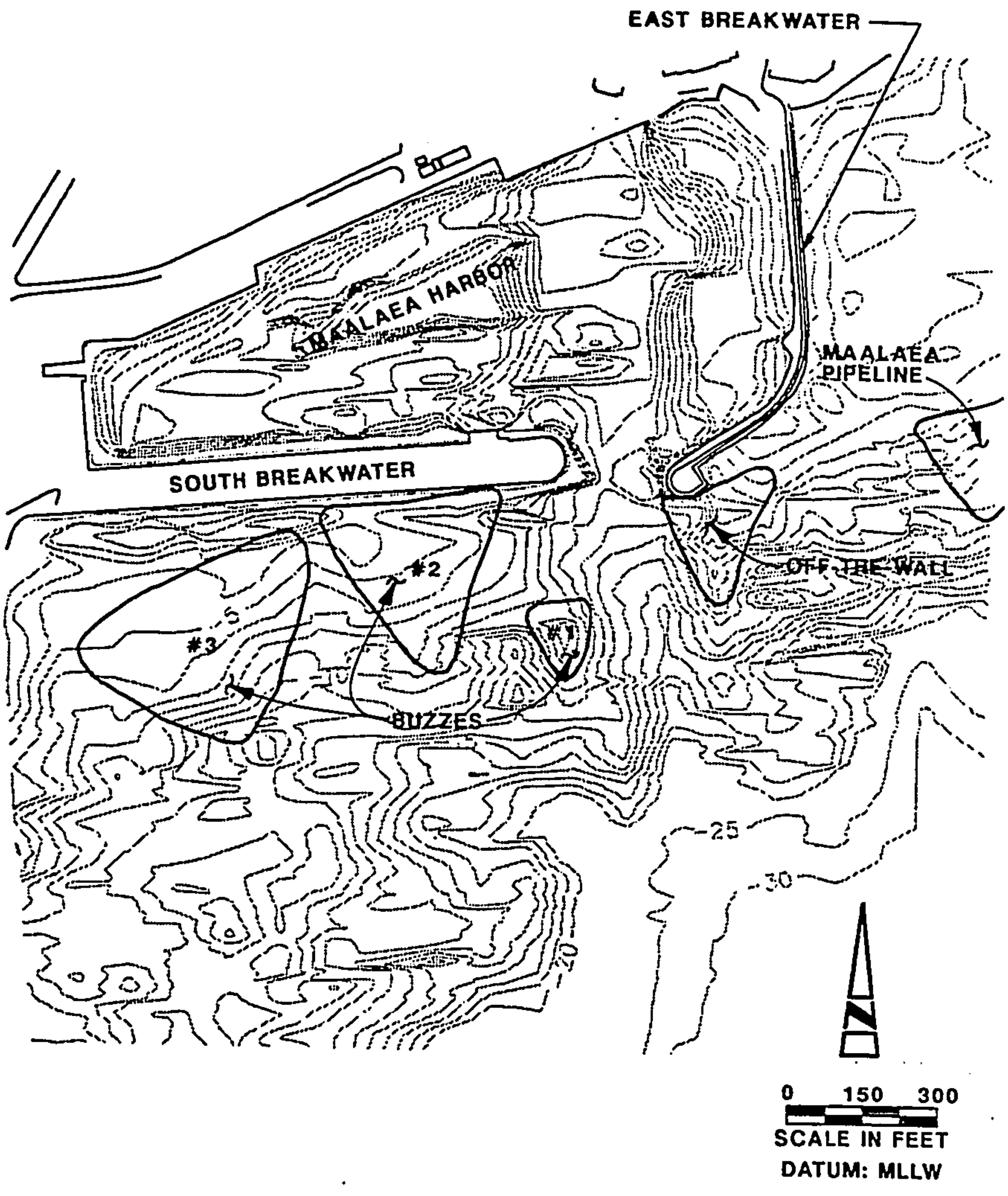
6.0 IDENTIFICATION AND ANALYSIS OF SURF SITES

6.1 Surf Site Identification

Locations of the surfing areas were identified during site observations conducted on November 5-8, 1991. Several local surfers were asked to locate surf sites on a map as shown in Figure 6-1. Five surf sites were identified in the immediate vicinity of the harbor. The locations determined from this 1991 survey were plotted together with the COE (1980) locations as shown in Figure 6-2.

Surf site names are ephemeral at times, and different people have different names for the same sites. The location of the surf sites, rather than the names, are relevant to this report. For example, a surf site located east of the east breakwater has been referred to as "Freight Trains," "Pipeline," "Maalaea Express Rights," or "Maalaea Pipeline." This surf site hereinafter referred to as the "Maalaea Pipeline." The other surf sites identified are "Off the Walls" and "Buzzes." "Sea Flight" is the name of one of the "Buzzes" surf sites to some surfers. "Off the Walls" is on the eastern side of the entrance channel, and "Buzzes" is located on the western side of the entrance channel. "Buzzes" is actually three distinct sites as defined by the bathymetry and local surfers description. "Buzzes No. 1" and "Buzzes No. 2" are located west of the harbor entrance channel. "Buzzes No. 3" is located near the root of the south breakwater.

The surf sites discussed in this section were not identified by direct measurements nor were they observed over a wide range of conditions due to time constraints of the study. However, analysis of aerial photographs, refraction studies, detailed bathymetry, and interviews with local surfers gives a reasonable confidence as to the surf site locations.



LOCAL SURFER SURF SITE SURVEY (1991)

FIGURE 6-1

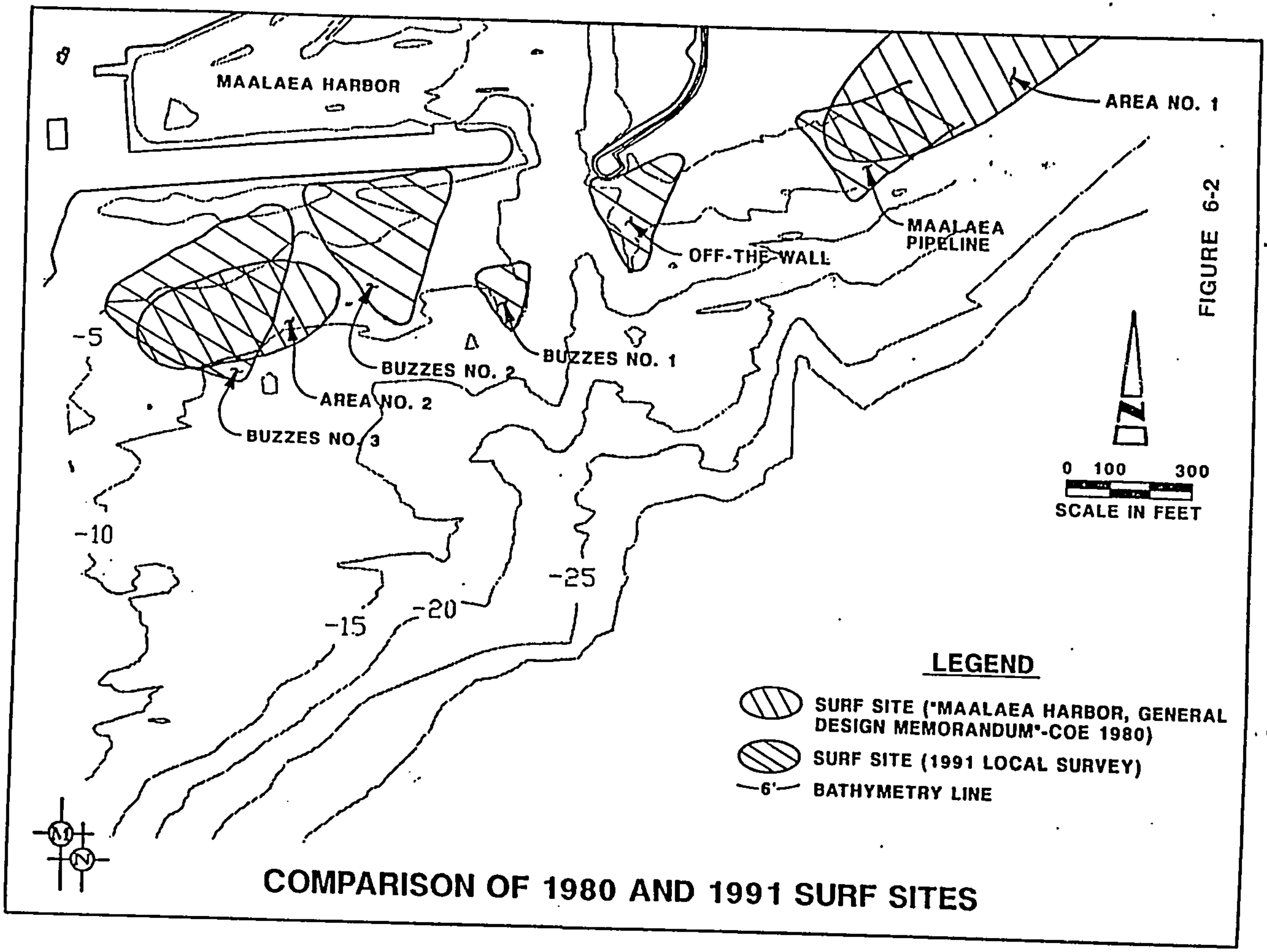


FIGURE 6-2

COMPARISON OF 1980 AND 1991 SURF SITES

6.2 Aerial Photograph Analysis

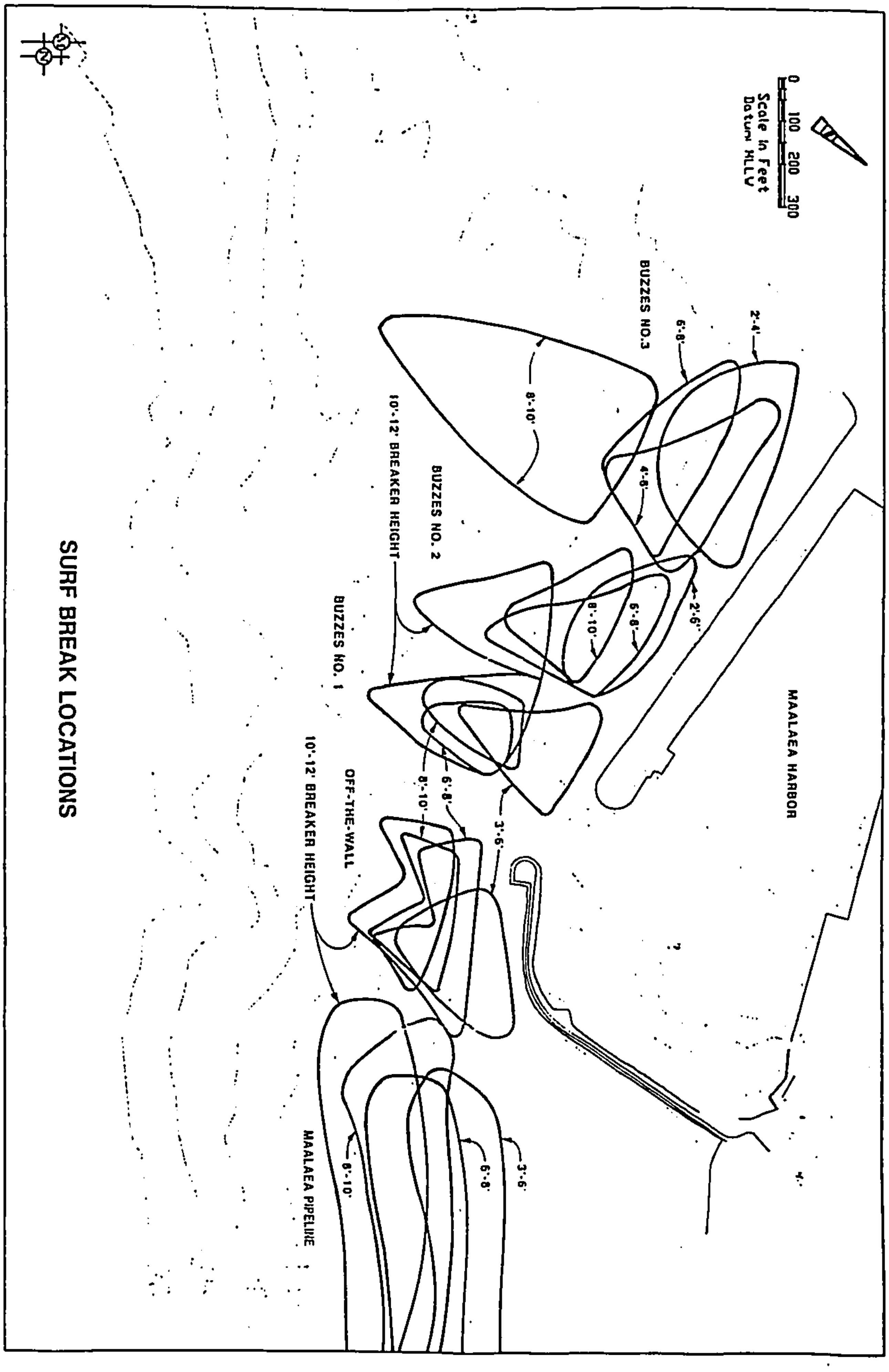
Locations of surfing areas were identified and analyzed by Sea Engineering, Inc. (1991) using aerial photographs as discussed in Section 5.3. Wave breaking zones and wave crests were digitized from aerial photographs and are shown in Appendix B. Harbor construction was initially started in 1952, and the July 1953 photograph shows waves breaking where the east breakwater was later constructed.

The location where the wave begin to break for each surf site area is fairly consistent in all the photographs. The majority of breaking waves occur on the east side of the harbor entrance. However, local sources have indicated that the break on the west side of the entrance channel is more consistent and is frequented by body boarders. No waves are breaking in the harbor entrance channel in any of the photographs, nor is there evidence of surfers. The photographs are not indicative of good surf conditions; the waves are only one to two feet in height.

6.3 Detailed Bathymetry and Wave Refraction Analysis

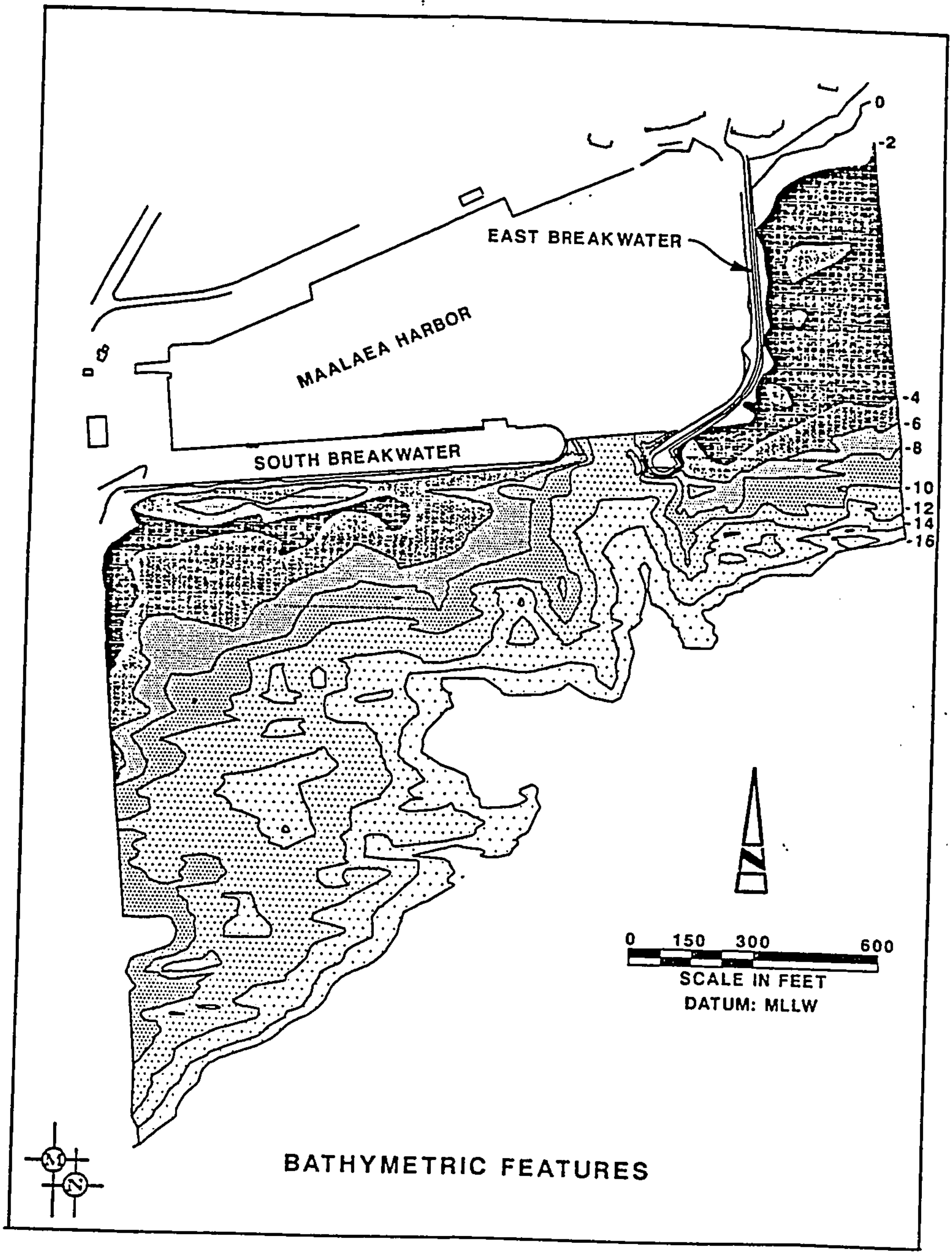
Figure 6-3 identifies the configuration and boundaries of the surf sites at Maalaea Harbor based upon analyses of the detailed site bathymetry and wave transformations. The figure illustrates the configuration and boundaries for a range of breaker heights. The site configurations were determined by identification of blunt shoal contours running obliquely toward shore as illustrated in Figure 6-4 and wave refraction analysis discussed in Section 5.1. The boundaries were determined from the locations at which the depth contours realign with the shoreline.

Cross sections were sketched outside the harbor to show relevant features of the bathymetry at each surf site. Figures 6-5 through 6-8 show the general locations and sections for each surf site.



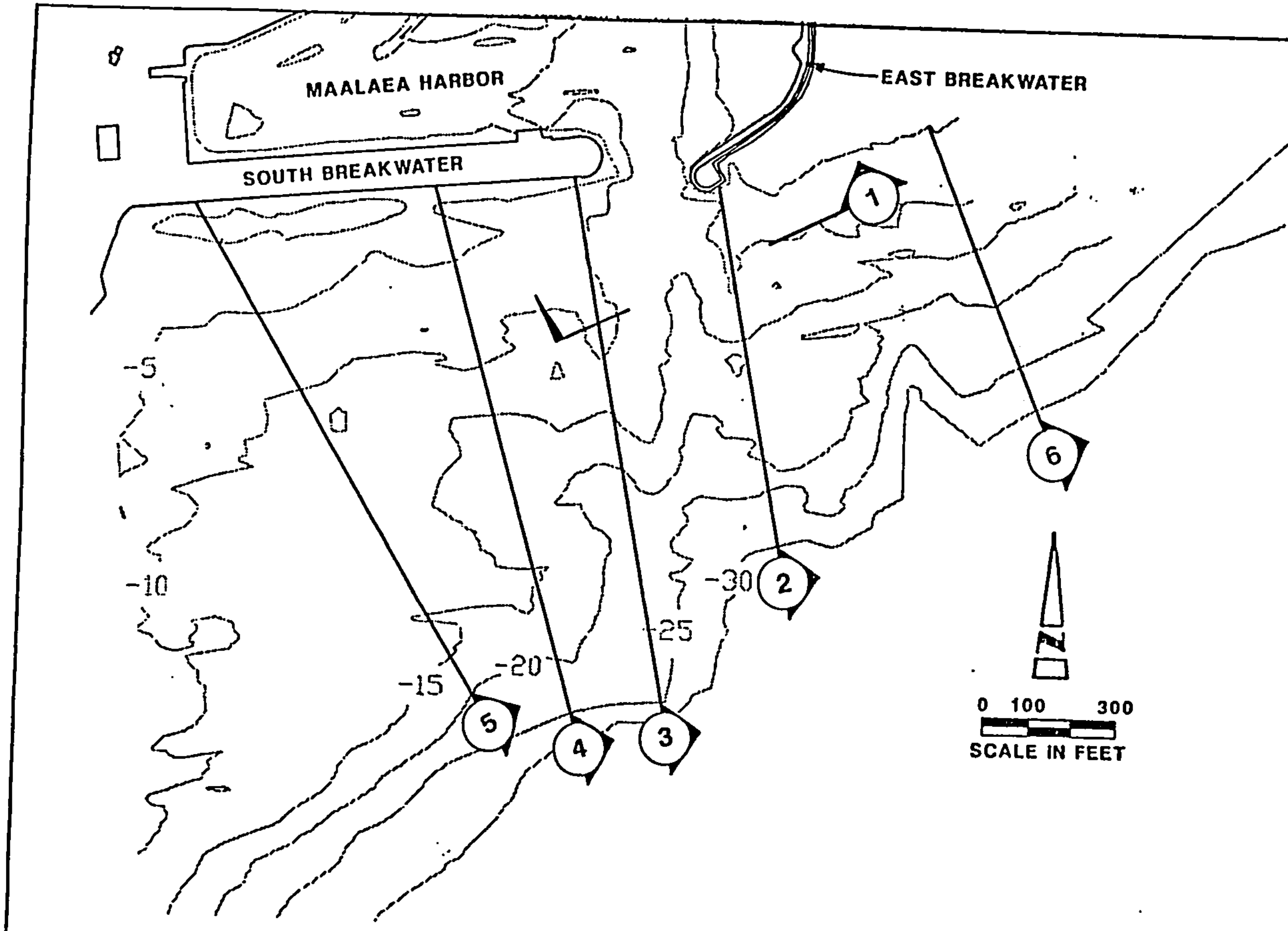
SURF BREAK LOCATIONS
0 100 200 300
Scale in Feet
Datum MLLW
BUZZES NO.3
2'-4'
6'-8'
8'-10'
10'-12' BREAKER HEIGHT
BUZZES NO. 2
4'-6'
2'-6'
6'-8'
8'-10'
MAALAEA HARBOR
BUZZES NO. 1
8'-10'
6'-8'
3'-6'
OFF-THE-WALL
10'-12' BREAKER HEIGHT
MAALAEA PIPELINE
3'-6'
6'-8'
8'-10'

FIGURE 6-3



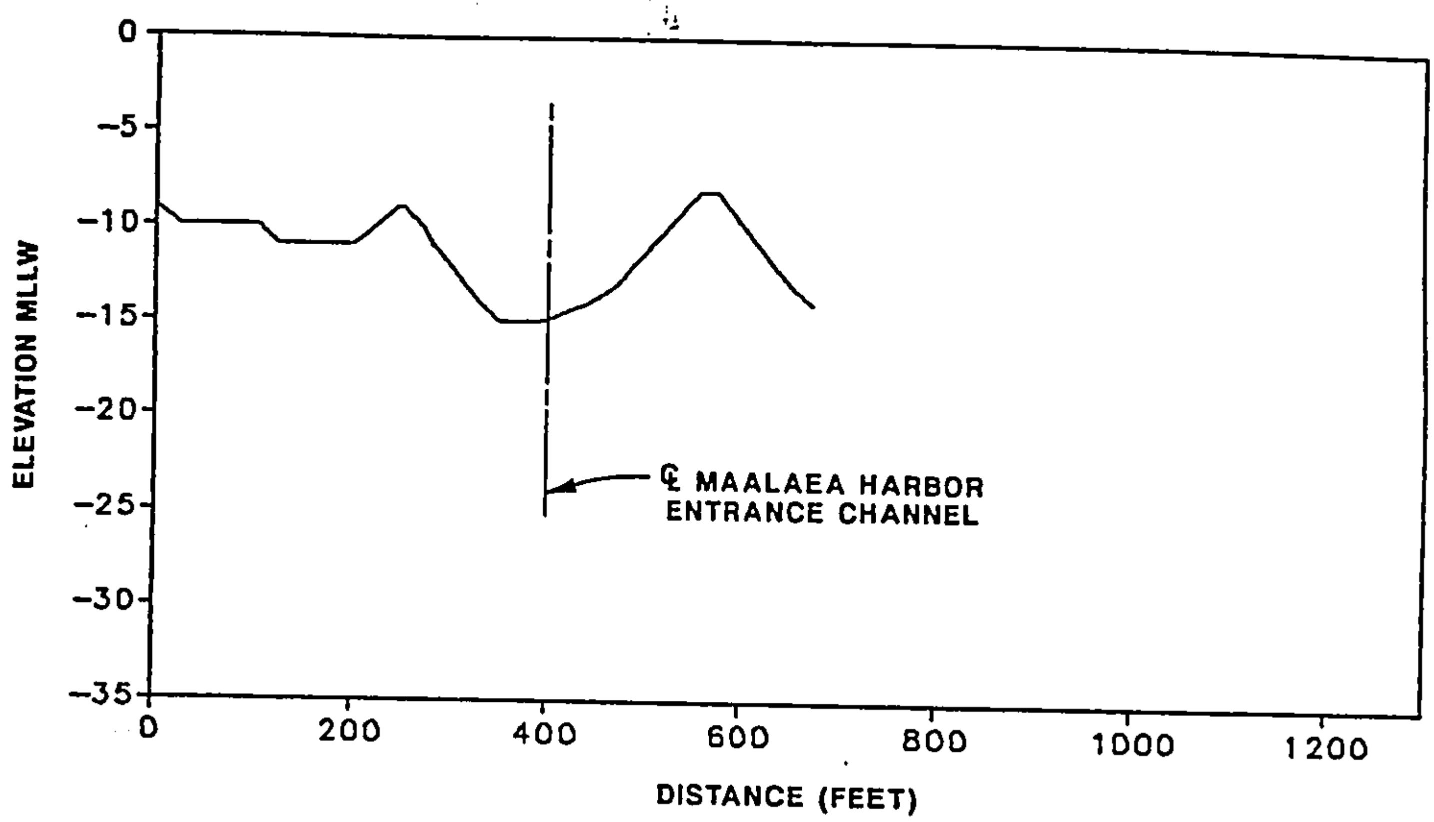
BATHYMETRIC FEATURES

FIGURE 6-4

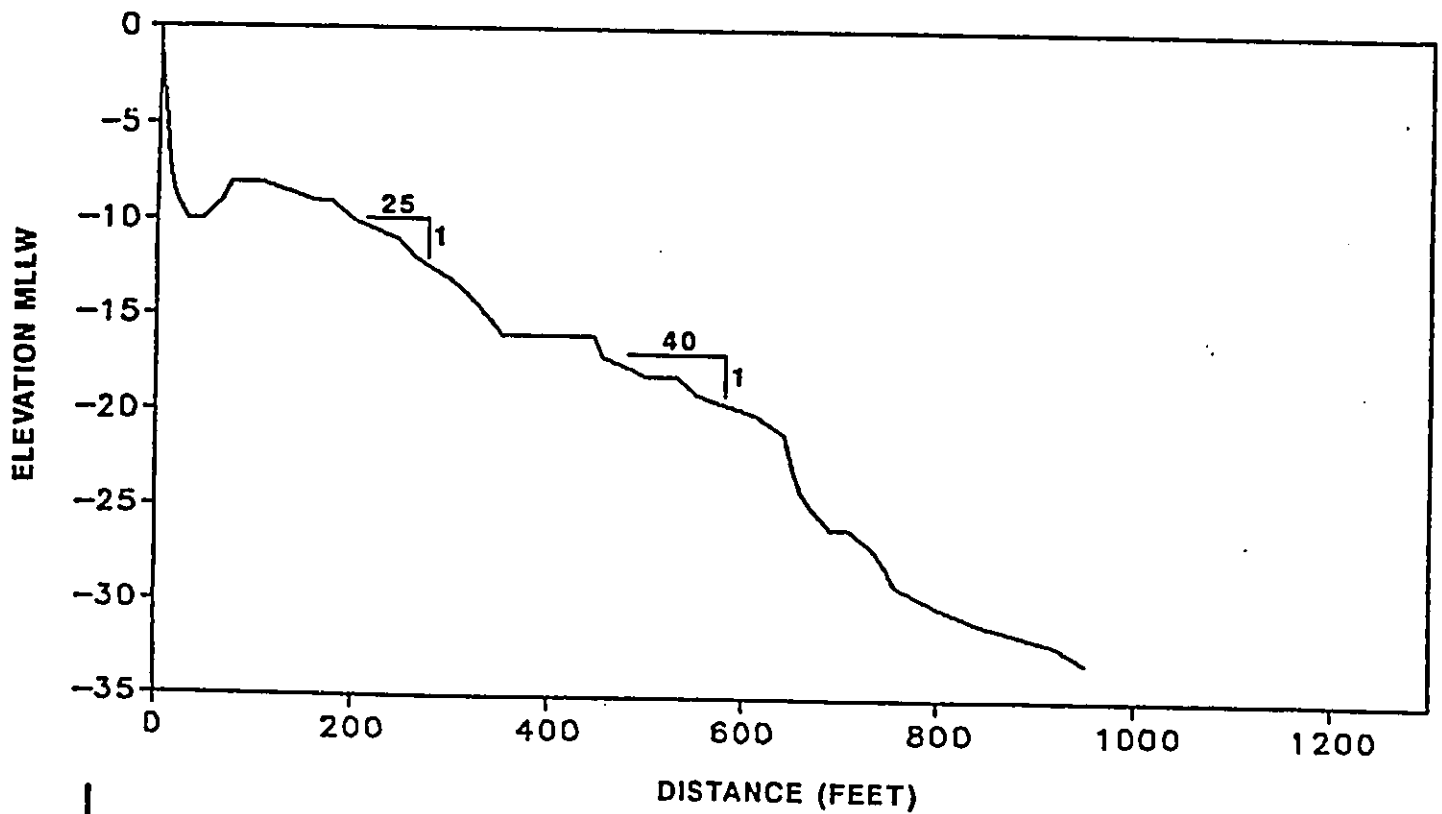


BATHYMETRY SECTION LOCATIONS

FIGURE 6-5

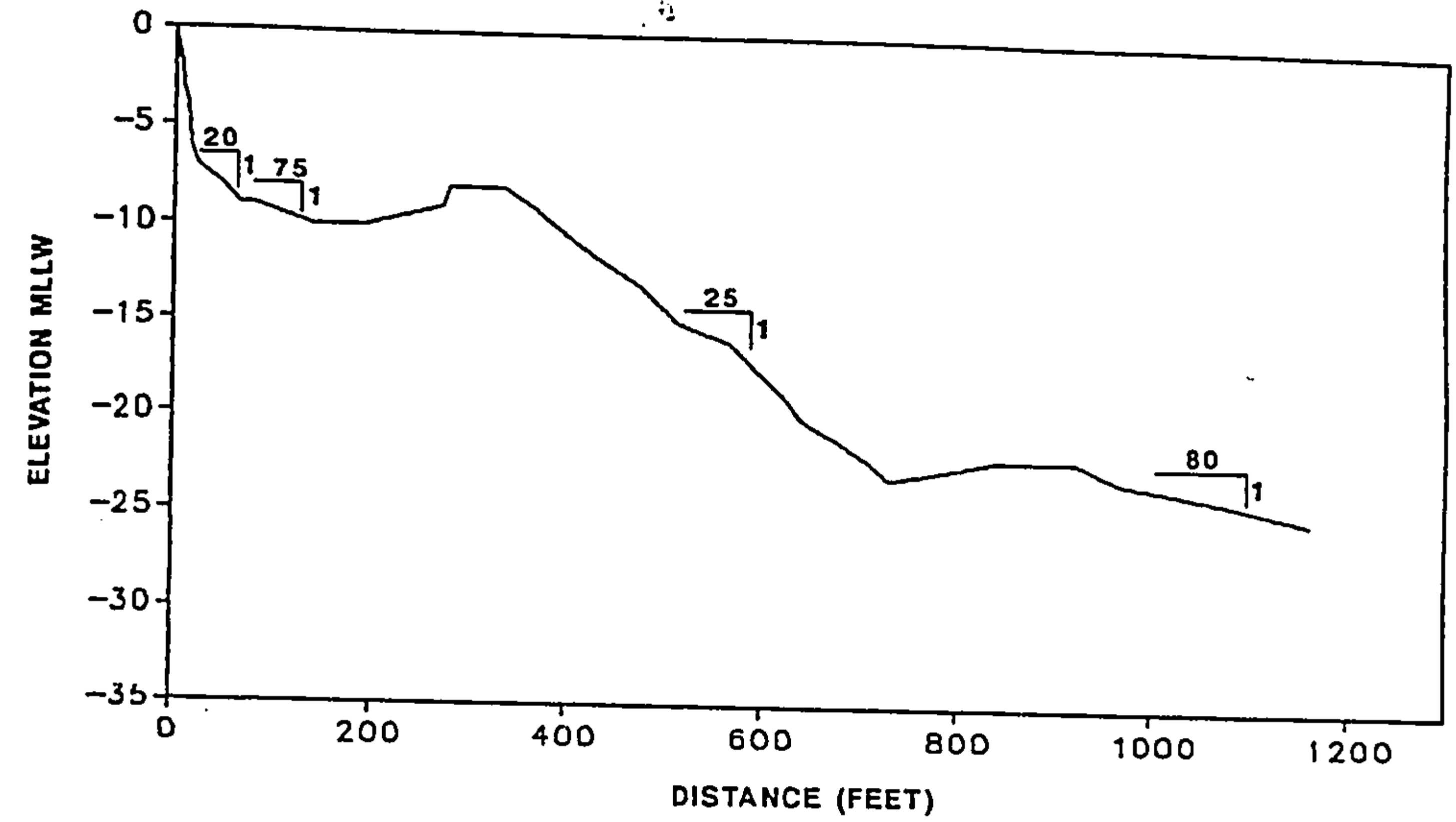


SECTION 1

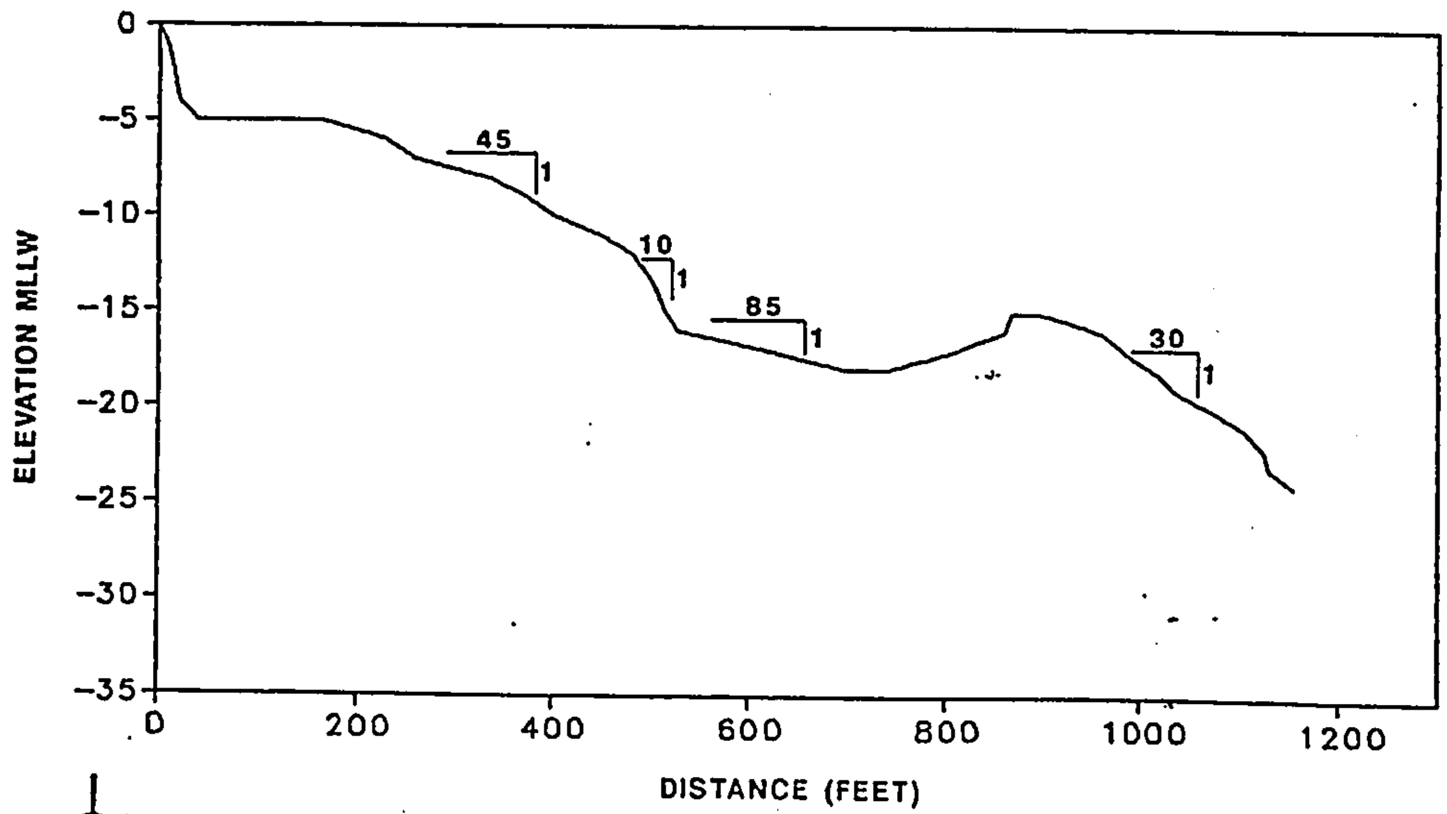


SECTION 2 - OFF-THE-WALL

FIGURE 6-6

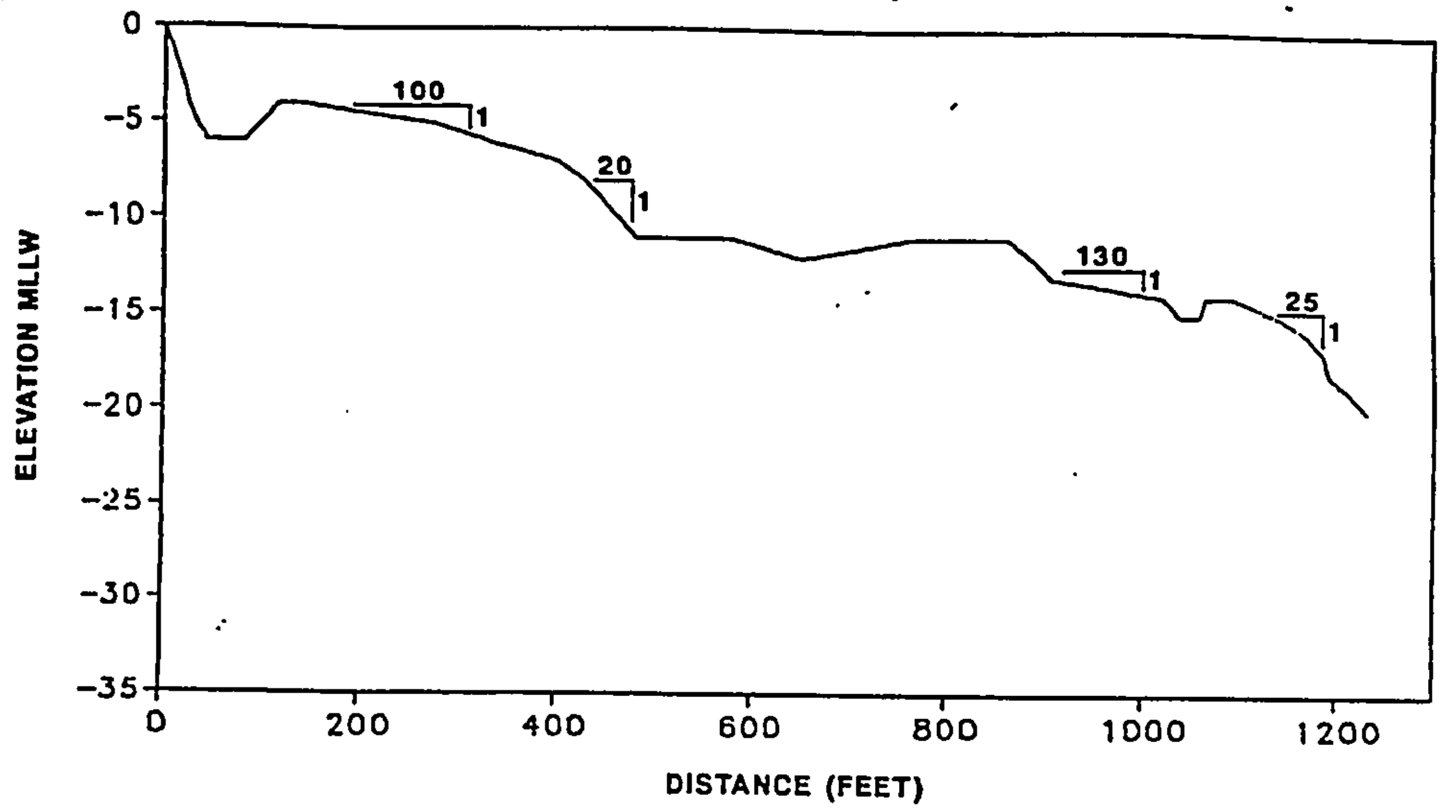


SECTION 3 - BUZZES NO. 1

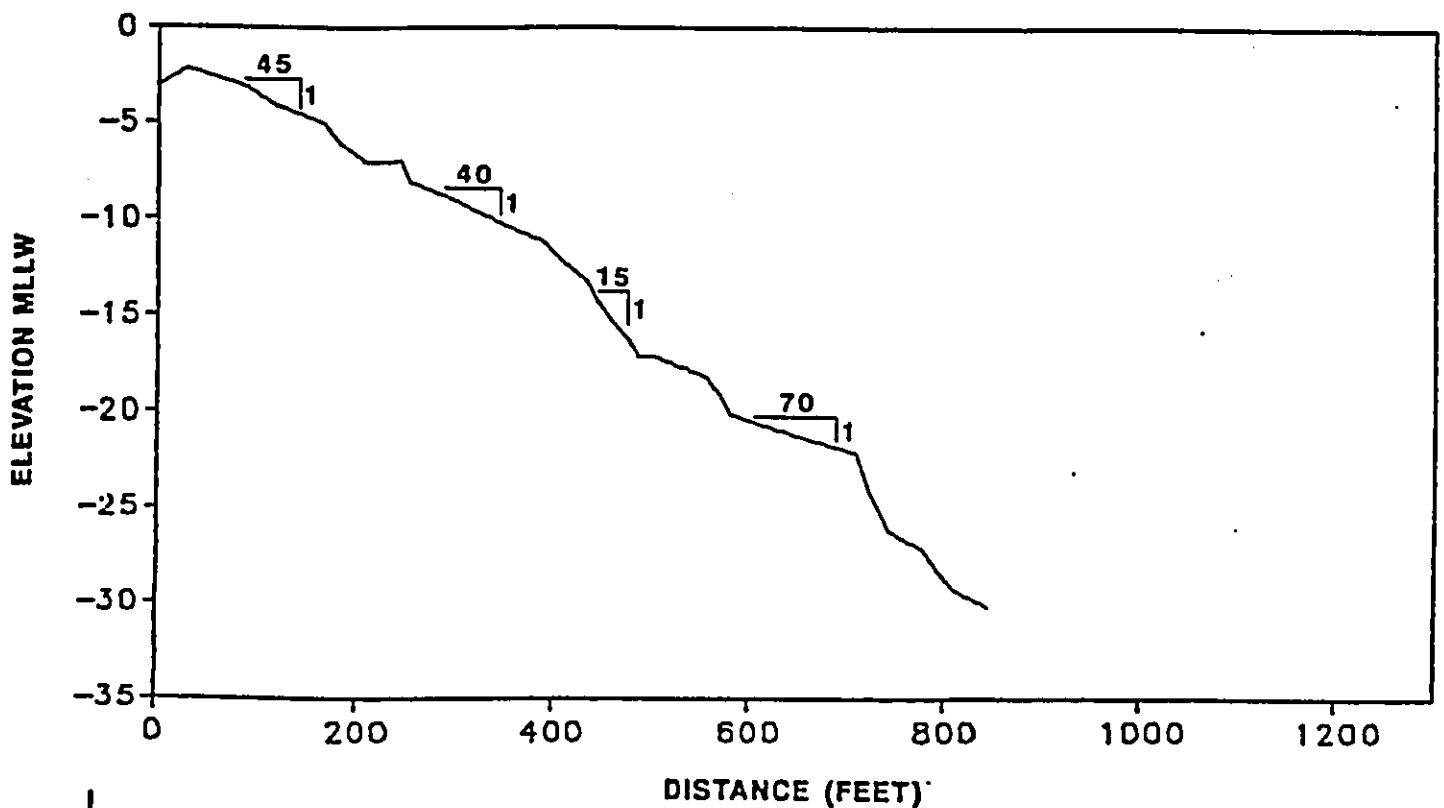


SECTION 4 - BUZZES NO. 2

FIGURE 6-7



SECTION 5 - BUZZES NO. 3



SECTION 6 - MAALAEA PIPELINE

FIGURE 6-8

Off-the-Wall

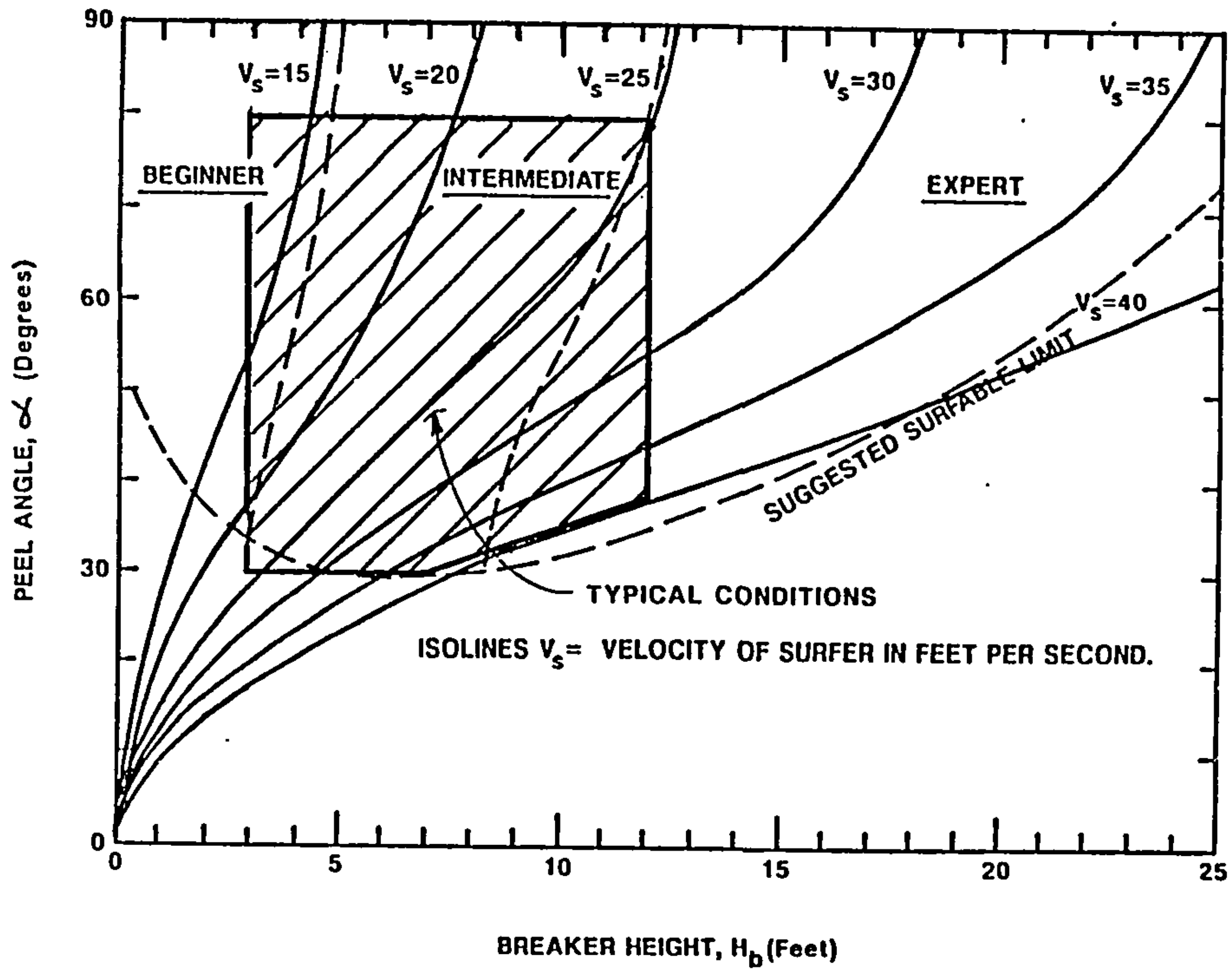
"Off-the-Wall" is located along the entrance channel's eastern edge. Figure 6-3 illustrates that both rights and lefts can be surfed at the "Off-the-Wall" site. The left peel-angle ranges from approximately 40 to 70 degrees and the right peel angle ranges from approximately 30 to 80 degrees. The right ride breaks at 3 to 8 feet with conditions favorable for surfing. The ride terminates near the wall at the head of the east breakwater. The bathymetry suggests a close out near the breakwater. The left follows the entrance channels edge. The greater depth differential creates a well defined breaking area into the harbor entrance. The left ride breaks at 3 to 12 feet with conditions favorable for surfing. The rides are more of a take off and drop, but can be exhilarating on sizable surf near the east breakwater. The site has up to 15 surfers at a time.

A cross section through the "Off-the-Wall" shoal is shown in Figure 6-6. The shoal has an average slope of 1:25 from the 16- to 8-foot depth contours. The breaker types range from plunging to spilling for a typical range of surfing conditions.

Figure 6-3 shows breaking at this site shoal to initiate at the 14-foot depth contour, which would roughly correspond to a 12-foot breaker at MTL. The breaker pattern over the shoal frequently has a notch break. Figure 6-9 illustrates the range of peel angles and breaker heights associated with the "Off-the-Wall" site.

Buzzes No. 1

The bathymetry in the vicinity of "Buzzes No. 1" site, shown in Figure 6-3, illustrates that both lefts and rights can be surfed at this site. The surf break is indicated by a small submerged ridge at the 12- to 8-foot depth contours along the west side of the entrance channel. This ridge induces a range of 6- to 12-foot waves to break. Breaking wave heights ranging from 3 to 6 feet also produce conditions favorable for surfing landward of the ridge during milder wave conditions. The lefts are a short drop and ride. The right can be ridden straight in along the channel edge, but the wave backs



RANGE OF PEEL ANGLES vs. BREAKER HEIGHTS AT OFF-THE-WALL

FIGURE 6-9

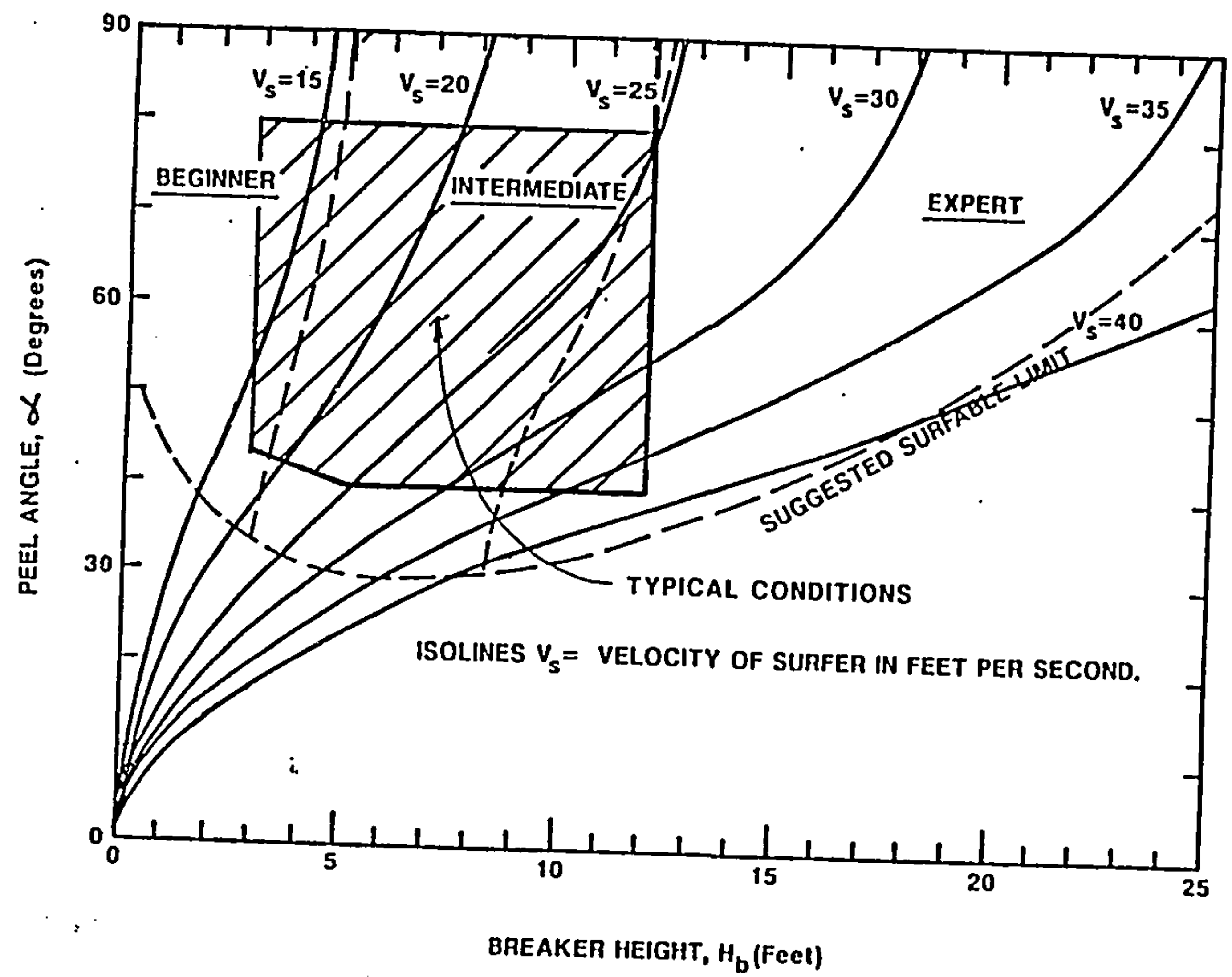
off. A cross section through this ridge is shown in Figure 6-7. The seaward slope of the ridge is about 1:25 (V:H). This steep slope would produce plunging waves for long period waves and mild plunging to spilling waves for shorter period waves of 6 to 8 seconds. Peel angles will range from approximately 40 to 80 degrees, depending upon wave direction. Figure 6-10 illustrates the range of peel angles and breaker heights associated with the "Buzzes No. 1" site.

Buzzes No. 2

Near the middle of the south breakwater, a large, broad ridge creates a spilling wave ranging from 2 to 12 feet in height. Figure 6-3 illustrates that both rights and lefts can be surfed with the lefts exhibiting a more acute peel angle. Larger waves break over a large ridge 400 feet wide from the 13-foot depth to the 7-foot depth. This ridge has contours oblique to shore which could induce left rides for waves ranging from 6 to 12 feet in height. A cross section through this ridge is also shown in Figure 6-15. The slope of the ridge is about 1:45 (V:H). This mild slope would produce spilling waves for short period waves of six to eight seconds and plunging waves for longer period waves. The depth contours shoreward of the 7-foot contour become shore parallel and would result in a close-out section. The occurrence of this larger surf would be infrequent, but has the potential for a ride for intermediate skilled surfers. Peel angles will range from approximately 30 to 80 degrees, depending upon wave direction.

Smaller waves break, from the 7-foot depth contour to shore, over a very broad featureless bathymetry with shore-parallel depth contours. The mild bottom slope continues at 1:45 (V:H) to the 5-foot depth contour, where it flattens out causing ill-defined spilling breakers. The waves can be ridden frequently by body boarders and intermediate skilled board surfers. The site frequently has 30 to 40 people out at a given time, but may have more than 50 surfers. The site is viewed as an important south shore surf area.

Because of the mild slopes at the seaward portion of the nearshore surf break, the area creates a spilling breaker lacking definitive peel properties. Such characteristics are better suited for beginning surfers. The bottom slope from the 6-to 5-foot contour flattens out over regular contours until the



RANGE OF PEEL ANGLES vs. BREAKER HEIGHTS AT BUZZES NO. 1

FIGURE 6-10

south breakwater is reached. A few minor shoulders may be found for short rides in isolated places. The inner surf breaks are being initiated at approximately the 6-foot depth contour, which would roughly correspond to a 5-foot breaker height. Peel angles and breaker heights associated with "Buzzes No. 2" are shown in Figure 6-11.

In summary, "Buzzes No. 2" supports surf ranging from 2 to 12 feet in height with rides to the left. Under the more predominant smaller wave conditions, the surf would be less defined with spilling breakers suitable for beginners over a broad area.

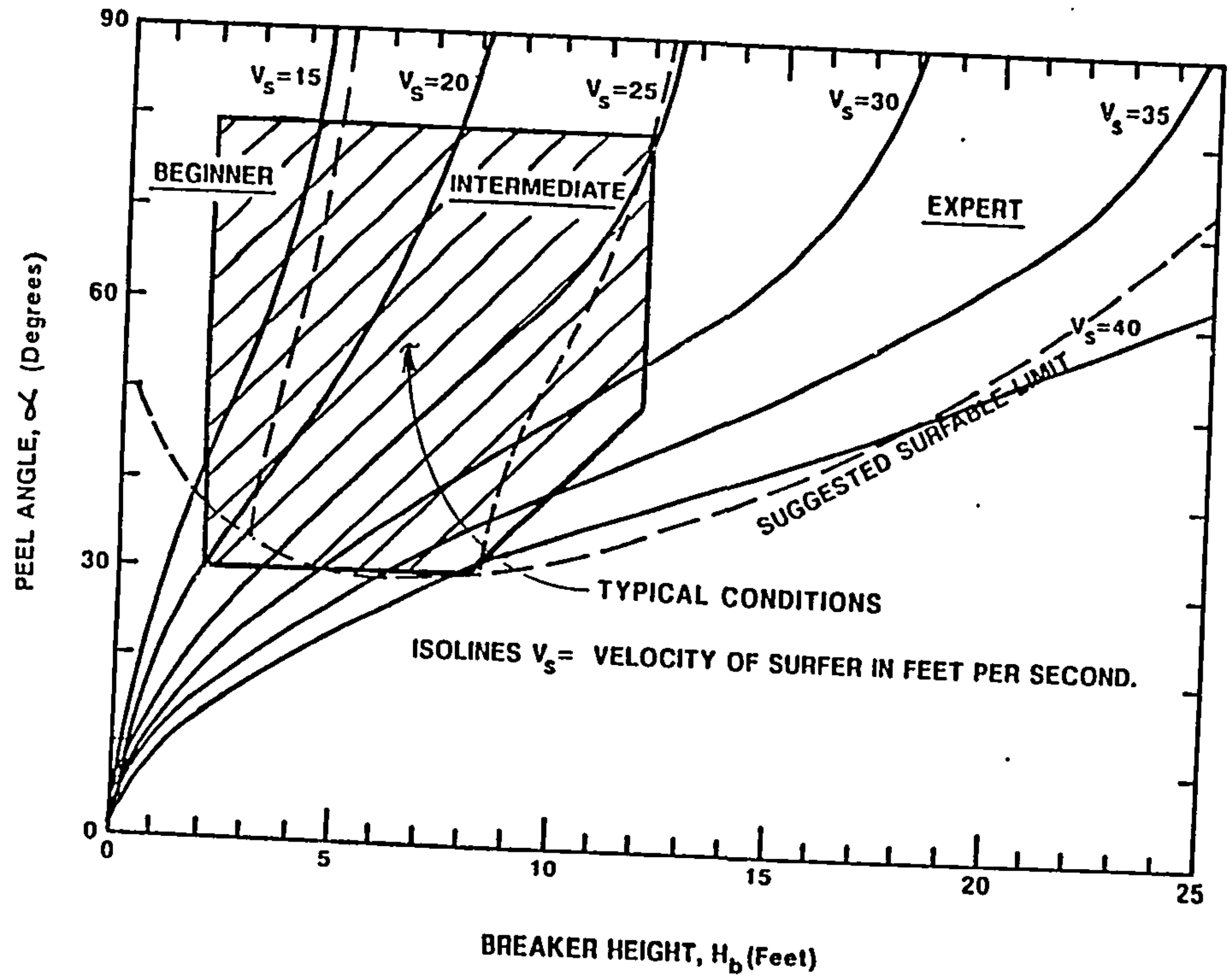
Buzzes No. 3

"Buzzes No. 3", a smaller and less frequently surfed site, is located near the root of the south breakwater. This site has smaller waves and may be about 80 percent the height of "Buzzes No. 2". The wave backs off on the right ride due to a trench along the south breakwater. The site has a gentle spill used by body boarders. Larger waves feather offshore, but seldom break because bottom slope is extremely flat at approximately 1:100 (V:H).

Figure 6-3 illustrates that both rights and lefts can be surfed at the "Buzzes No. 3" site, with the lefts exhibiting a more acute peel angle. The right peel angle is approximately 60 to 80 degrees. The left peel angle is approximately 35 to 60 degrees. The right ride continues until the wave closes out. Figure 6-12 illustrates the range of peel angles and breaker heights associated with this site.

"Maalaea Pipeline"

"Maalaea Pipeline" breaks with conditions favorable to surfing during the summer primarily with waves 3 to 12 feet, however, larger wave heights have been observed at this location. For waves under 4 feet in height, riders can surf short sections of waves before the wave closes out. A short left ride exist toward the east breakwater. When the waves are 6 to 8 feet or greater, a very fast, right ride is produced that surfers can ride for several hundred feet. These waves are a hard plunging type that produce a tube that the surfer can ride through.



RANGE OF PEEL ANGLES vs. BREAKER HEIGHTS AT BUZZES NO. 2

FIGURE 6-11

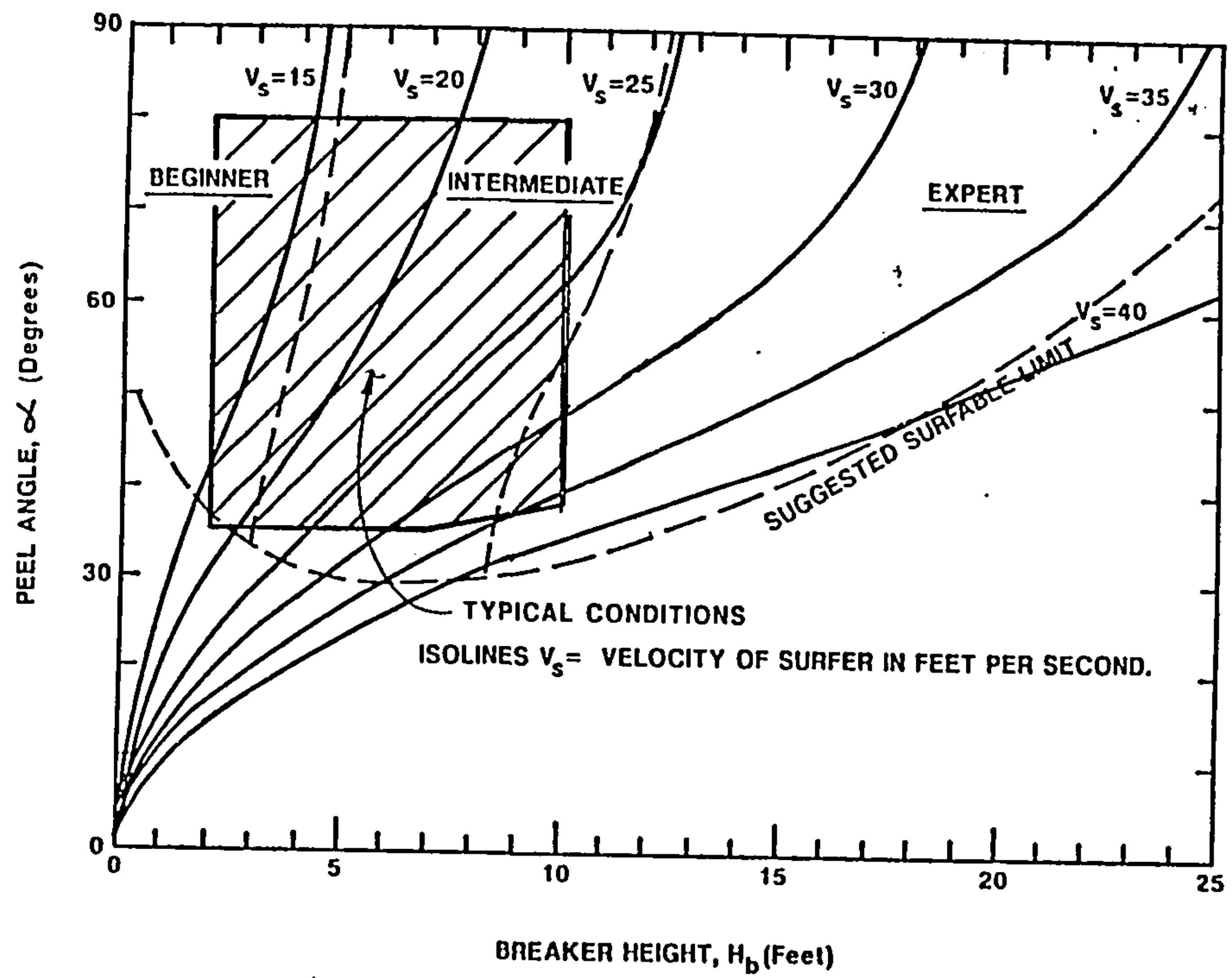


FIGURE 6-12

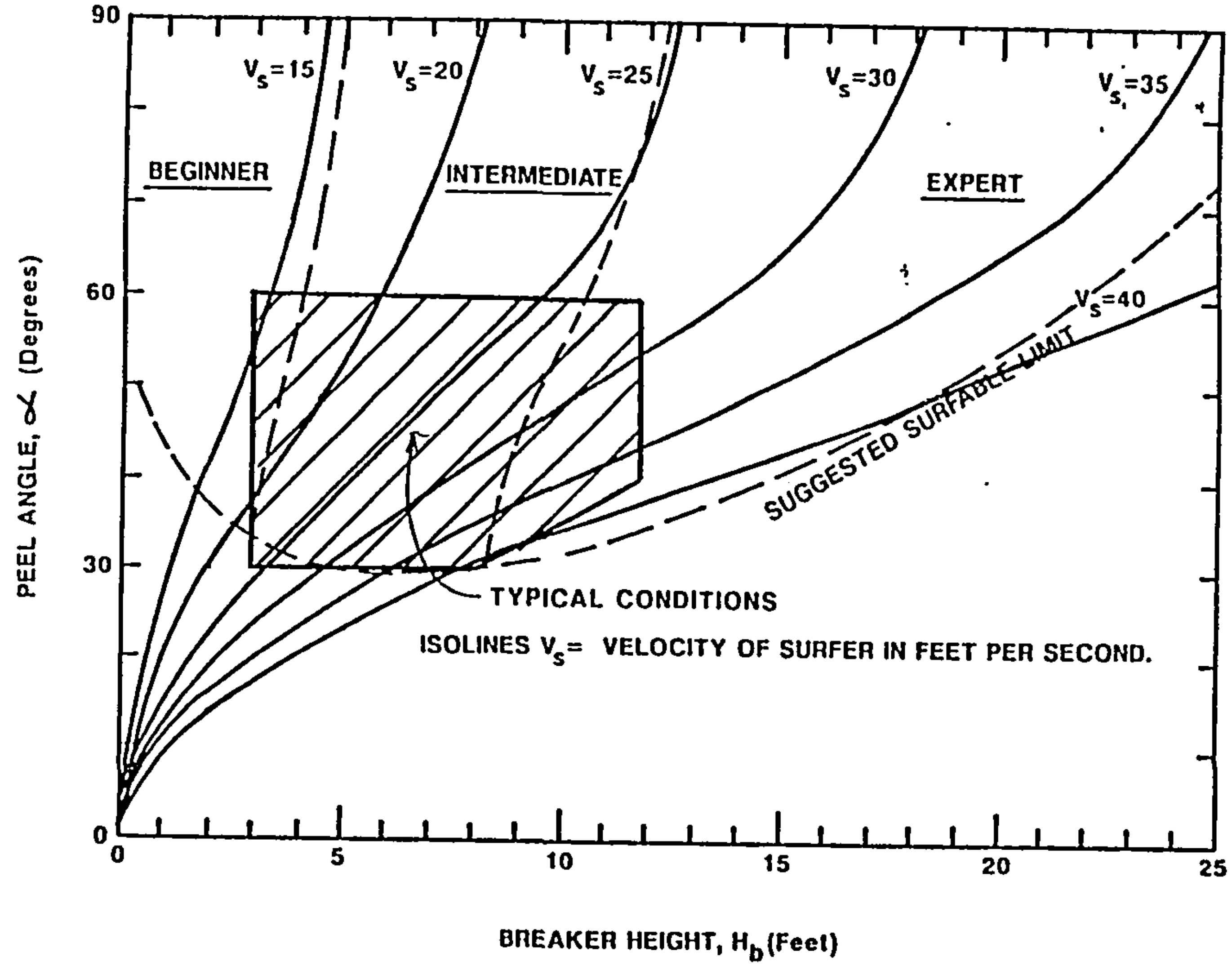
RANGE OF PEEL ANGLES vs. BREAKER HEIGHTS AT BUZZES NO. 3

Figure 6-3 illustrates that both rights and lefts can be surfed at the "Maalaea Pipeline" site, with the rights exhibiting a more acute peel-angle. The surf site boundary and configuration is not complete on the west end due to inadequate bathymetric information. However, it was determined that the approximate bottom slope at this site is 1:40 (V:H).

The right peel-angle is approximately 30 to 60 degrees and the left peel angle is approximately 50 degrees. The right ride continues until the wave closes out. This occurs where the shoal contours realign with the shoreline, thereby causing the peel angle to approach zero degrees. Figure 6-13 illustrates the range of peel angles and breaker heights associated with the "Maalaea Pipeline" site.

6.4 Wave Statistic Analysis

Based on the methodology described in Section 5.2, each surf site was evaluated as being surfable or nonsurfable. Figure 6-14 shows the approximate percentage of time that each surf site is surfable. "Buzzes No. 1" has the lowest surfable percentage of the five sites. This is due to its deep shoal which is at -8 to -12 feet, MLLW. Bathymetry at that depth would require waves in excess of 6 feet in order to break as a surfable wave. The other remaining four sites have bathymetric contours that are generally shallow enough to allow a large percentage of the waves to break.



RANGE OF PEEL ANGLES vs. BREAKER HEIGHTS AT MAALAEA PIPELINE

FIGURE 6-13

Surfable Conditions at Maalaea Harbor
From 26 July 1990 to 6 February 1991

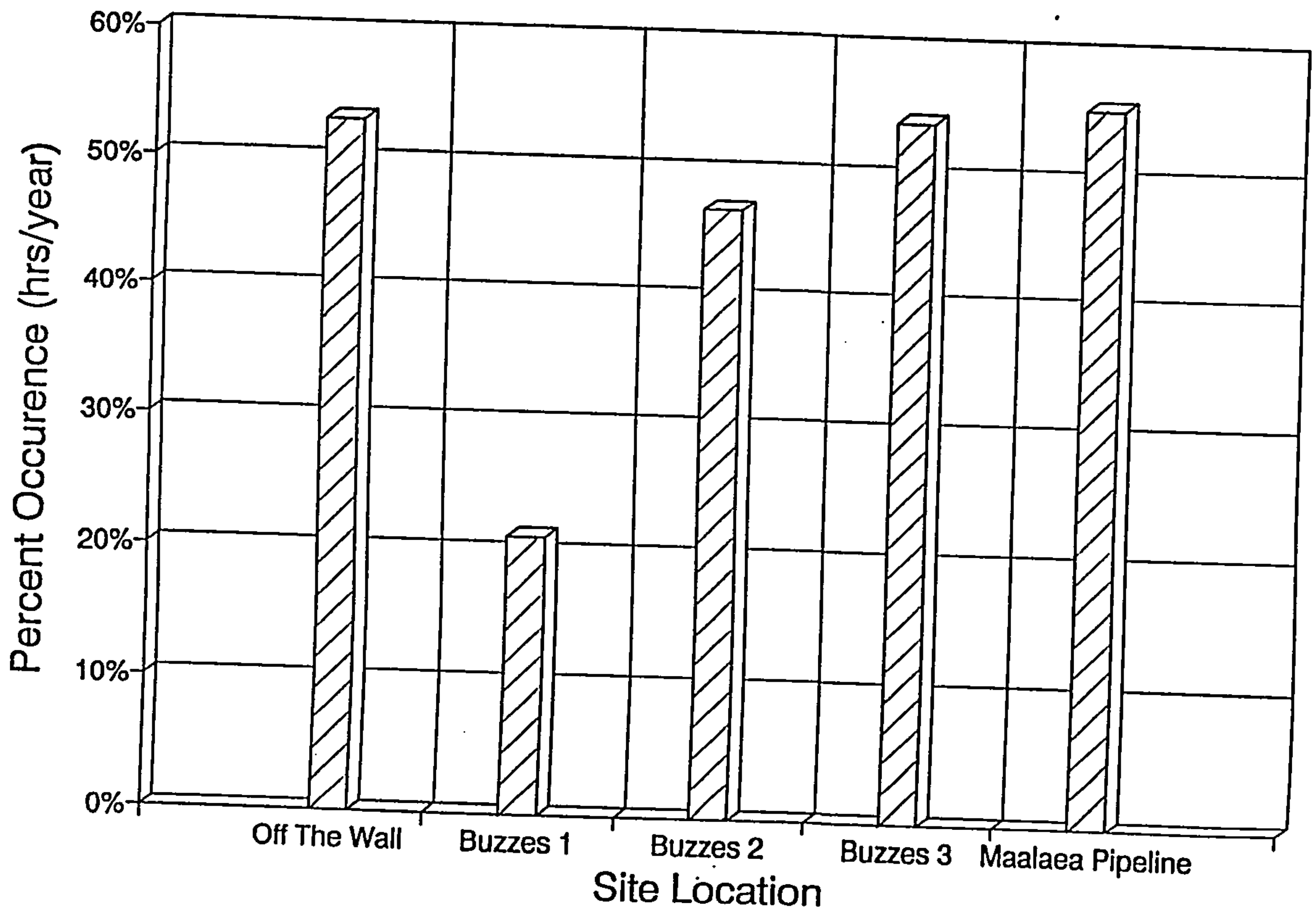


FIGURE 6-14

7.0 EVALUATION OF PROJECT IMPACTS ON SURF SITES

Construction of a marina entrance channel and breakwater may affect surf sites in the following ways:

1. Direct surf site encroachment: Direct encroachment of the channel and/or structures into the surf site (including into surfer access channels).

2. Reflected wave impacts: Reflection of waves from jetty structures into the surf site, thus influencing breaking wave characteristic: The ride of the surfer may be bumpy when encountering a reflected wave and reflection may precipitate premature breaking when the incident and reflected waves become in-phase.

3. Boat-wake impacts: Generation of waves from boat traffic that may enter surfing areas, thereby creating a cross-wave that can spoil the face of a surfing wave.

4. Site-access impacts: Change of onshore access to the surf site.

Although wind has been cited as an important parameter affecting the conditions at a surf site, entrance channel jetties typically have negligible impact upon the wind due to their relatively low, sloped profiles.

Evaluation of each of the four alternative marina entrance configurations considered the aforementioned potential surfing impacts. The four alternative marina entrance configurations are:

1. A 450-foot extension to the east breakwater and removal of approximately 300 feet from the south breakwater;

2. A 555-foot extension to the south breakwater and removal of approximately 650 feet from the east breakwater;

3. A 600-foot extension to the south breakwater with a revetment and removal of approximately 75 feet from the east breakwater; and

4. A 675-foot extension to the east breakwater and removal of approximately 300 feet from the south breakwater.

The existing configuration was evaluated as the "base" condition to which the alternatives were compared.

7.1 Existing Configuration

The "Maalaea Pipeline" surf site as shown in the July 1953 (Appendix B) aerial photograph was identified in this study as being impacted by direct encroachment of the existing harbor structures. Breaking wave heights in this photograph are less than three feet, and are not representative of larger, more surfable waves which tend to break farther offshore from the breakwater.

Waves may be either partially or totally reflected from both natural and manmade barriers. Reflection of waves implies a reflection of wave energy, as opposed to energy dissipation. The amount of wave reflection is controlled by the barrier slope and roughness and by the angle of incidence of the incoming wave. Minor wave reflection occurs off the south and east breakwaters but do not adversely affect surfable conditions at any of the identified surf sites (Clark, 1991).

Boat traffic can generate waves that may enter the "Off-the-Wall" and "Buzzes No. 1" surf sites. These sites may intermittently experience a cross-wave that spoils the face of some of the surfable waves during the passage of larger, fast traveling boats. However, these cross-waves are not noticed at sites farther away from the entrance channel such as "Buzzes No. 3" and "Maalaea Pipeline."

Surfers access the "Maalaea Pipeline" site by swimming through a channel that runs along the length of the east breakwater to a take off area approximately 500 feet east of the breakwater. Access to the "Off-the-Wall" surf site is attained by walking to the head of the east breakwater, climbing down the rocks to the water, and swimming out to the take off area. Access to any of the "Buzzes" surf sites requires walking along the south breakwater, climbing down the rocks to the water, and swimming to the take off spots.

7.2 Alternative No. 1

The "Buzzes No. 2" surf site, as shown in Figure 7-1, will be impacted by direct encroachment of the east breakwater extension. This surf site will be destroyed as a result. The proposed modifications of this alternative will not encroach upon the "Maalaea Pipeline" surf site for the full range of breaker heights at the site. However, the proposed modifications will partially encroach on the left ride at "Off-the-Wall" and "Buzzes No. 1."

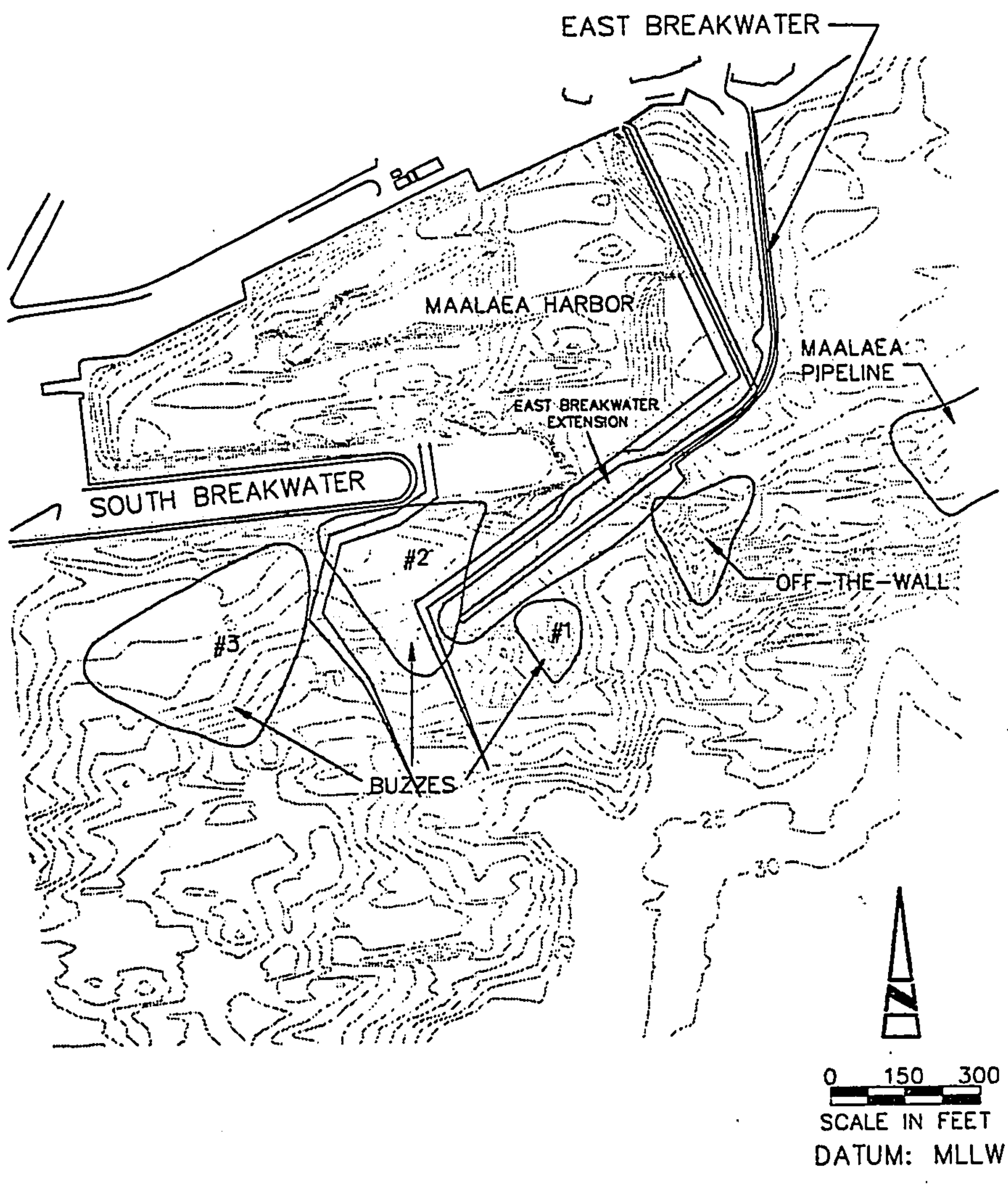
Wave reflection will occur off the proposed east breakwater extension. This will cause the end of the left ride at "Buzzes No. 1" to be impacted. Also, wave reflection will impact the remaining left ride at "Off-the-Wall" that was not already lost by direct encroachment of the east breakwater extension.

Boat traffic can generate waves that may enter the "Buzzes No. 3" surf site. This site may intermittently experience a cross-wave that spoils the face of some of the surfable waves during the passage of larger, fast traveling boats. However, these cross-waves should not impact surf at sites farther away from the entrance channel such as "Off-the-Wall" and "Maalaea Pipeline."

7.3 Alternative No. 2

The "Maalaea Pipeline" surf site, as shown in Figure 7-2, will be impacted by direct encroachment of the south breakwater extension. This surf site will suffer a direct loss of the left ride and also loss of some primary take off locations closest to the east breakwater. The extension of the south breakwater will partially encroach on the end of the right rides for both the "Off-the-Wall" and "Buzzes No. 2" surf sites.

Minor wave reflection will occur off the south breakwater extension to enter "Buzzes No. 1" and change the conditions at "Off-the-Wall."



MAALAEA HARBOR

ALTERNATIVE NO. 1

FIGURE 7-1

Boat traffic can generate waves that may enter the remainder of "Maalaea Pipeline" surf site. This site may intermittently experience a cross-wave that spoils the face of some of the surfable waves during the passage of larger, fast traveling boats. However, these cross-waves should not have greater impacts than the other identified surf sites that presently occur.

The south breakwater extension will alter surf site access to "Off-the-Wall" and possibly to "Maalaea Pipeline." Boating will directly encroach on the take off locations at "Maalaea Pipeline" and create an unacceptable condition for both boaters and surfers.

7.4 Alternative No. 3

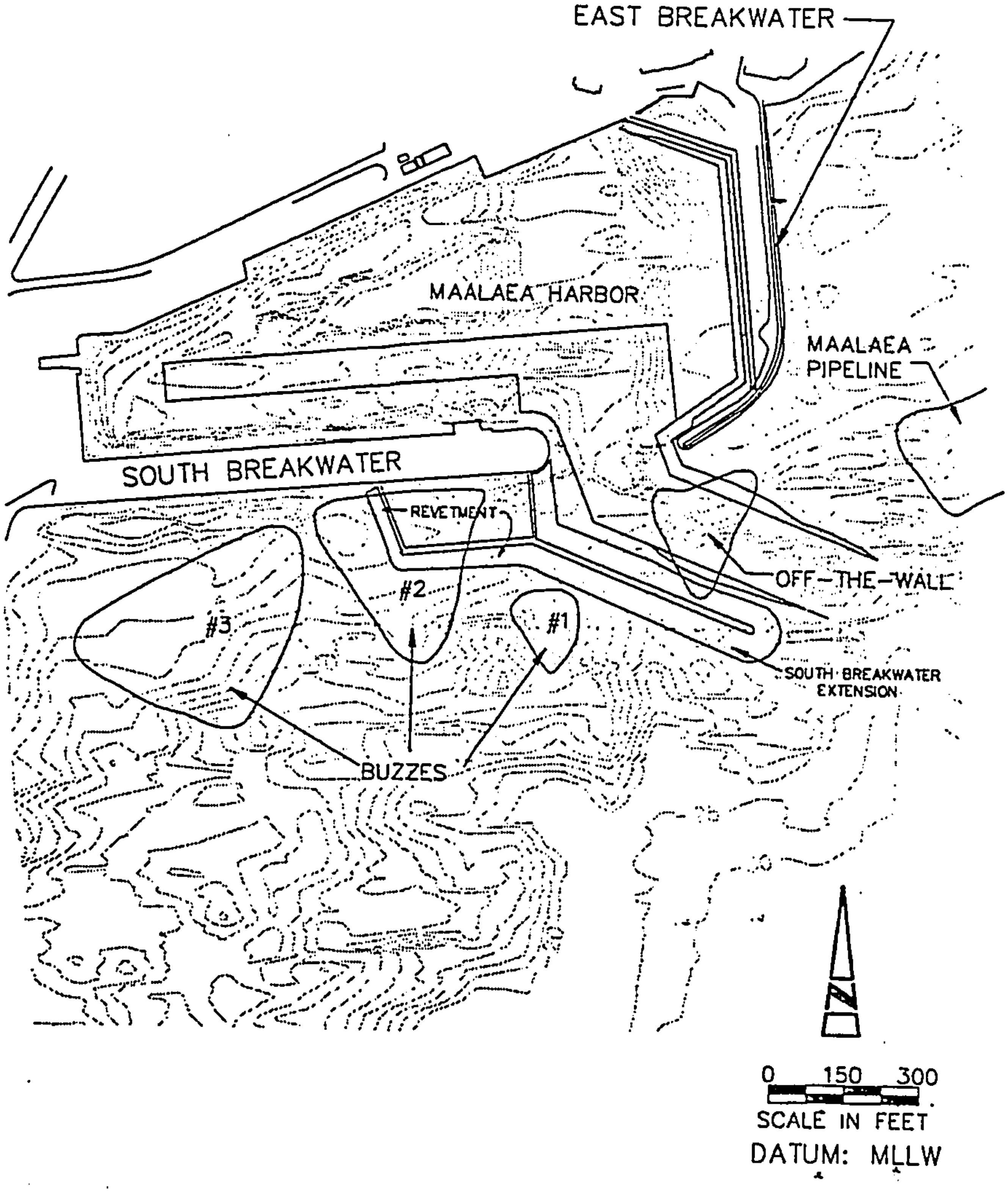
The "Off-the-Wall" and "Buzzes No. 2" surf sites, as shown in Figure 7-3, will be impacted by direct encroachment by the proposed modifications of the south and east breakwaters. These surf sites will be destroyed as a result. The proposed modifications of this alternative will not encroach upon the "Maalaea Pipeline" and "Buzzes No. 3" surf sites.

Wave reflection will occur off the proposed extension of the south breakwater. This will result in a partial to complete loss of the "Buzzes No. 1" surf site. Also, the remaining left ride that may exist at "Buzzes No. 2" will be impacted by wave reflection thereby resulting in a complete loss of this surf site as well.

Boat traffic should have no adverse impacts on "Buzzes No. 3" but boat traffic will pass through the "Maalaea Pipeline" take off area. The close proximity of boaters to peaking waves is a broaching condition and the closeness of surfers to boaters would pose a general safety concern.

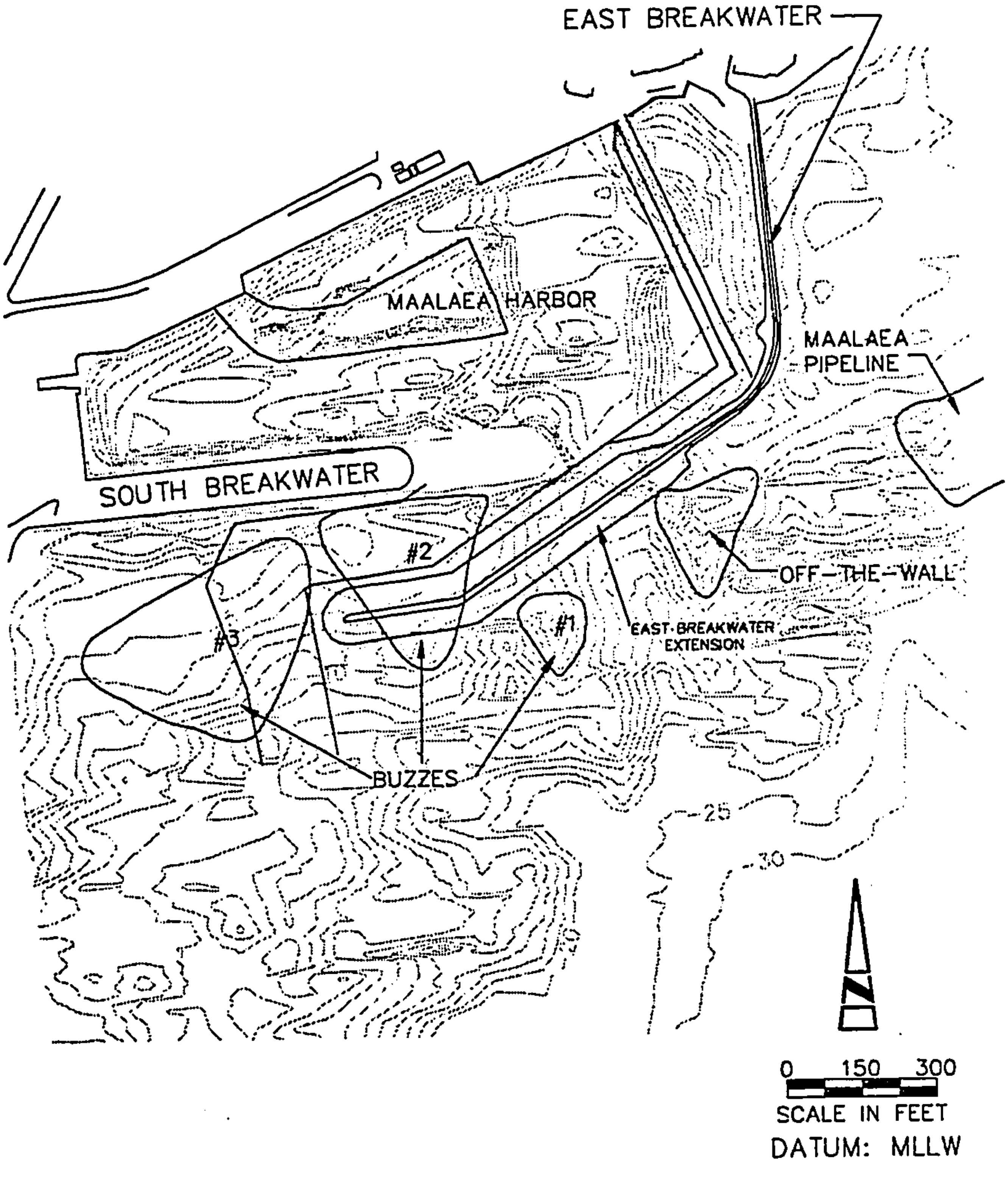
7.5 Alternative No. 4

The "Buzzes No. 2" and "Buzzes No. 3" surf sites, as shown in Figure 7-4, will be impacted by direct encroachment of the east breakwater extension. "Buzzes No. 2" will be destroyed as a result. "Buzzes No. 3" will be partially lost on the right ride. The proposed modifications will not directly encroach upon the "Maalaea Pipeline," but will shorten the ride at "Buzzes No. 1."



MAALAEA HARBOR
ALTERNATIVE NO. 3

FIGURE 7-3



MAALAEA HARBOR
ALTERNATIVE NO. 4

FIGURE 7-4

Wave reflection will occur off of the east breakwater extension. This will impact the left rides at both the "Off-the-Wall" and "Buzzes No. 1" surf sites. Wave reflection will not affect the "Maalaea Pipeline" and the left ride at "Buzzes No. 3."

Boat traffic can generate waves that may enter the remainder of "Buzzes No. 3" surf site. This site may intermittently experience a cross-wave that spoils the face of some of the surfable waves during the passage of larger, fast traveling boats. However, these cross-waves should not impact the other identified surf sites. Boat traffic should have no adverse impacts on "Buzzes No. 1," "Off-the-Wall," and "Maalaea Pipeline" surf sites.

8.0 ALTERNATIVES CONSIDERED FOR IMPACT MITIGATION

Alternatives have been considered for the mitigation of impacts on surf sites due to construction of each of the proposed alternative harbor configurations. The purpose of the breakwater extensions and entrance channel reconfiguration is to reduce wave energy in the harbor to protect existing berthing areas and allow for additional berthing areas.

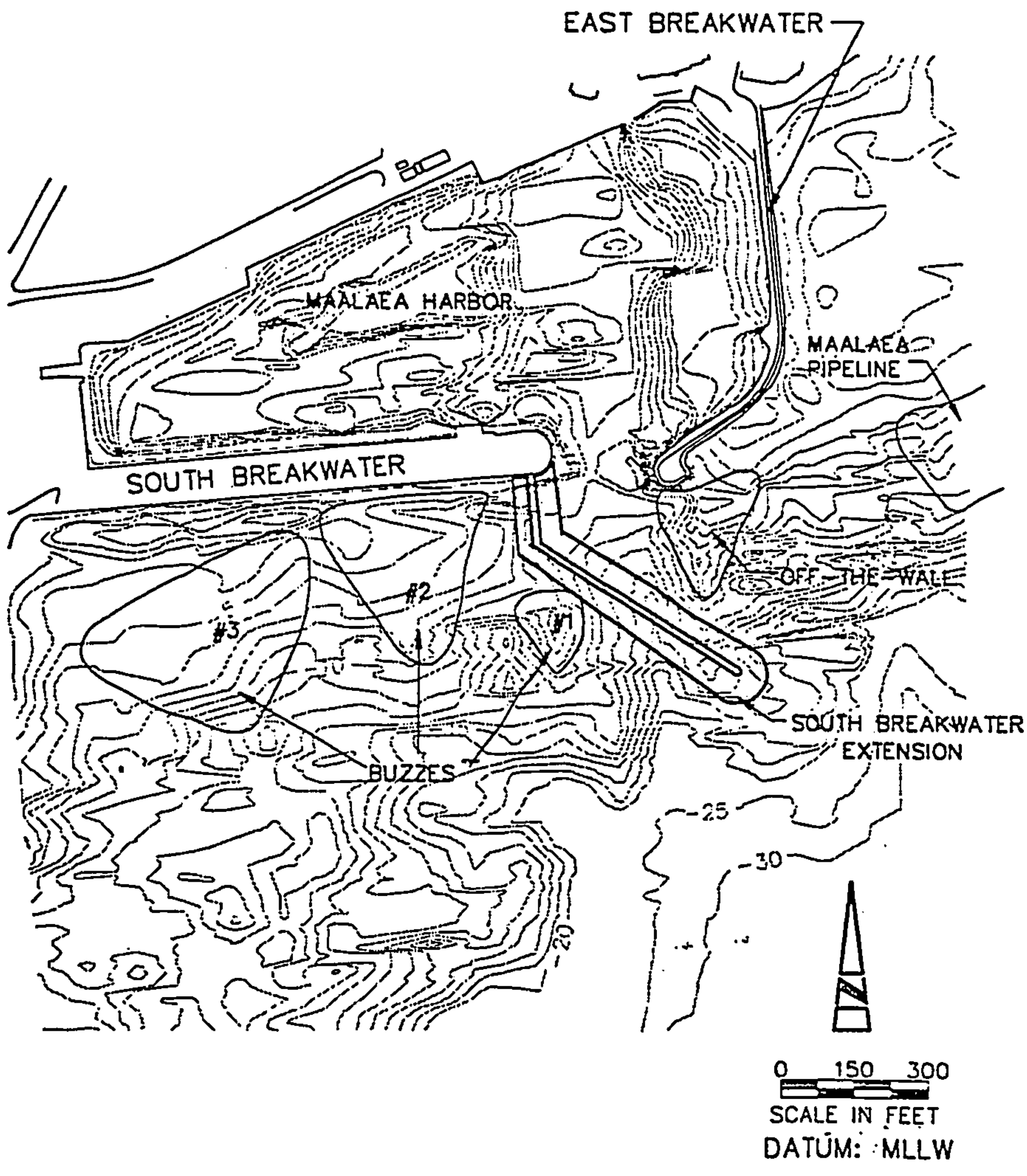
Five surf sites were identified along the project reach, based upon a 1991 surf site survey and a refraction analysis. From west to east the identified sites are, "Buzzes No. 3," "Buzzes No. 2," "Buzzes No. 1," "Off-the-Wall," and "Maalaea Pipeline." The following paragraphs identify possible modifications to the existing and proposed harbor configuration alternatives.

8.1 Modification to Alternative No. 3

Much of the direct surf site encroachment by the south breakwater extension on the "Buzzes No. 2" surf site is due to the revetment connecting the south breakwater to the south breakwater extension. If this revetment were eliminated then this surf site would not be directly impacted, although it may still be indirectly impacted by wave reflections off the breakwater extension. Minor realignment of the south breakwater as shown in Figure 8-1 could reduce direct boat traffic impacts at the "Maalaea Pipeline" take off areas, however, the "Off-the-Wall" surf site will still be completely destroyed due to the south breakwater extension. An interior mole could also be provided to further reduce wave energy in the harbor.

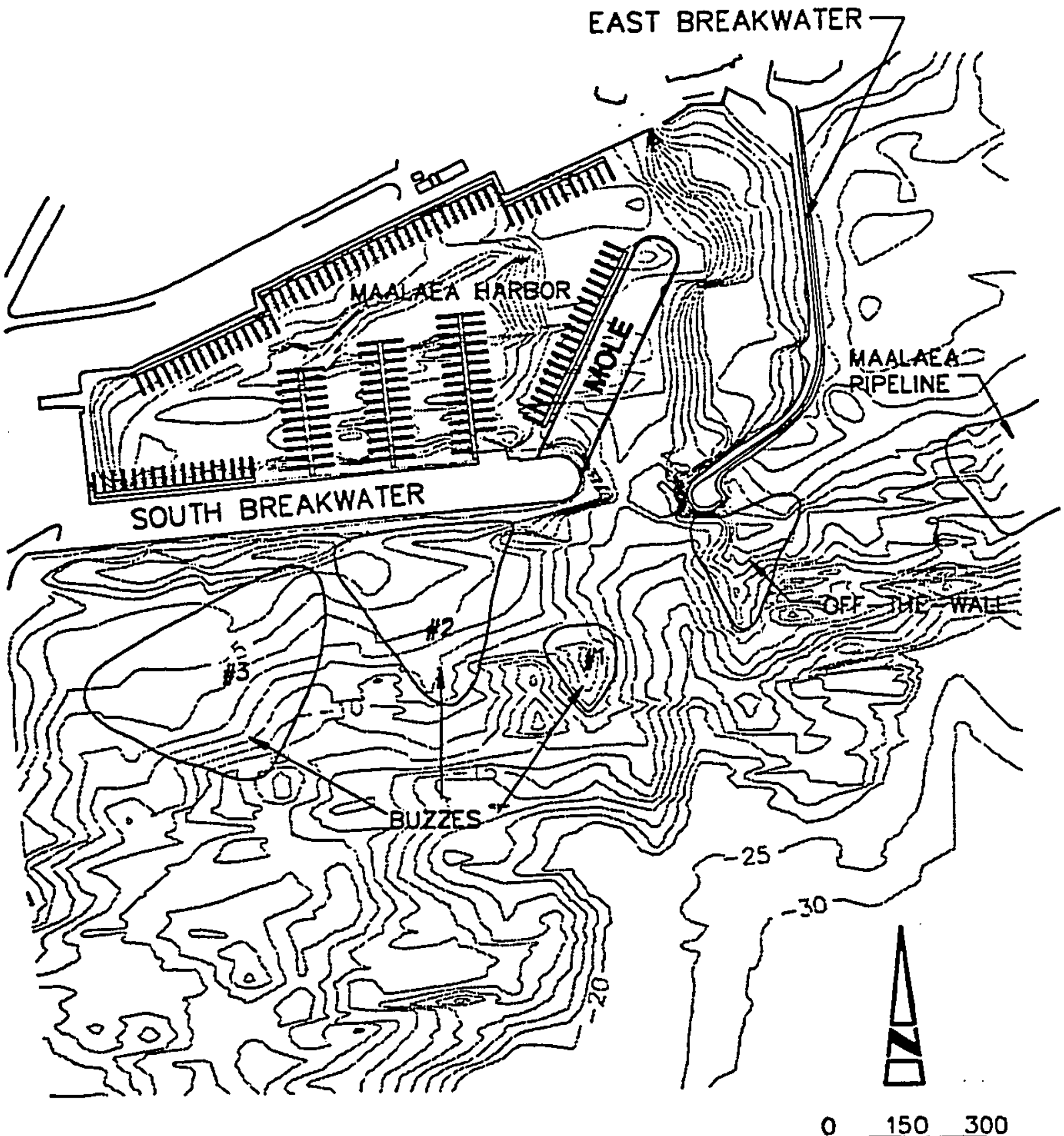
8.2 Eliminate Breakwater Extensions - Alternative No. 5

The most direct measure to reduce impacts of the marina entrance channel on all surf sites is to keep its present seaward configuration. An interior mole could be constructed off the south breakwater to reduce wave energy within the harbor as shown in Figure 8-2. This alternative provides for additional berthing areas on the leeward side of the mole. Due to the added protection provided by the mole, berthing along the south breakwater could be extended



MAALAEA HARBOR
MODIFICATION TO ALTERNATIVE NO. 3

FIGURE 8-1



NOTE: MARINA SLIPS ARE SCHEMATICALLY SHOWN FOR POSSIBLE EXPANSION OF HARBOR. FEASIBILITY AND OPTIMIZATION OF SLIP LAYOUT FOR THIS MARINA CONFIGURATION SHOULD BE CONDUCTED.

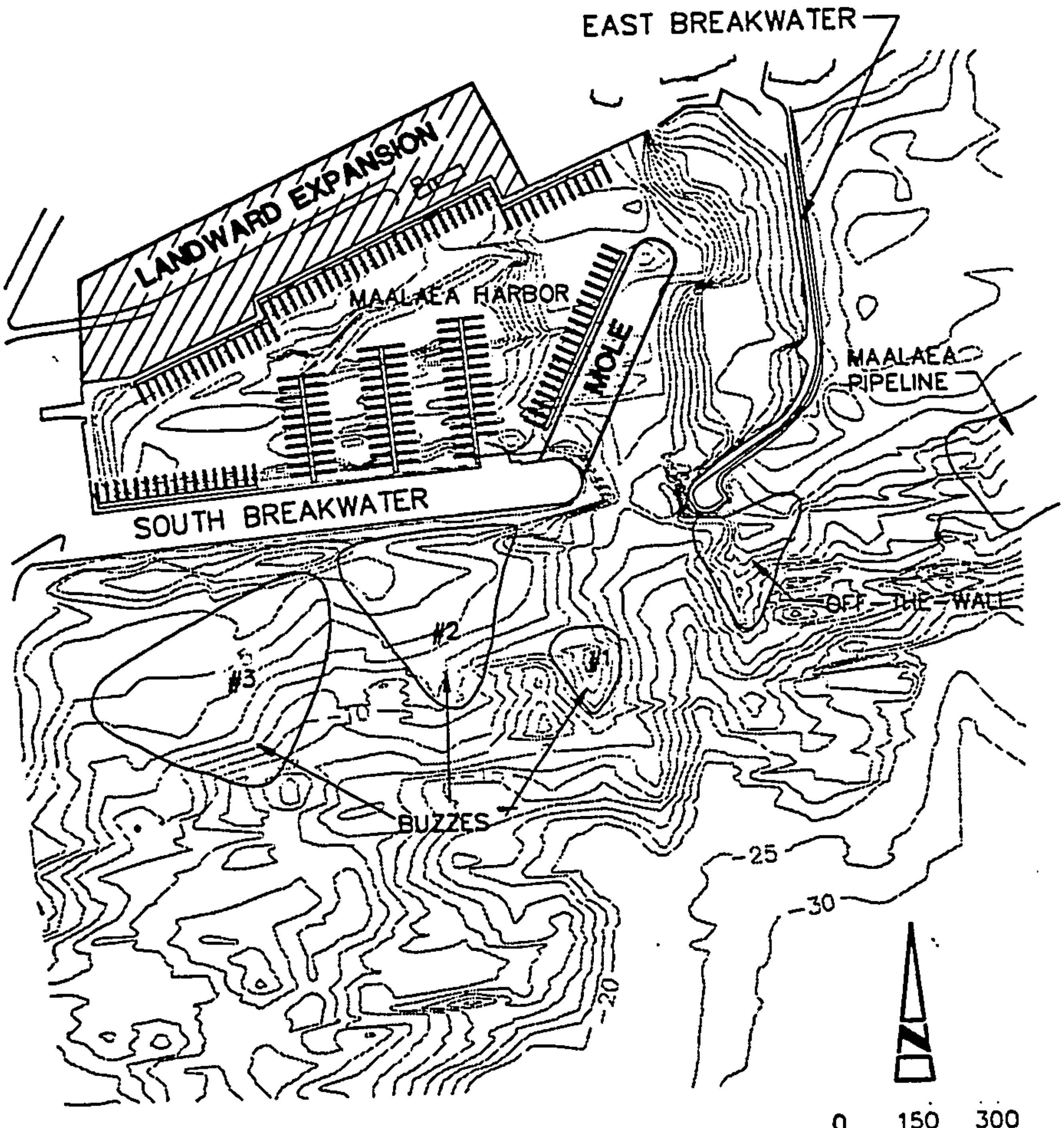
MAALAEA HARBOR

ALTERNATIVE NO. 5A

FIGURE 8-2

farther into the harbor. These additional berthing areas are conceptually shown in Figure 8-2. Dredging of the entrance channel and interior harbor may be required to facilitate these modifications. This alternative is completely free of any surf site impacts.

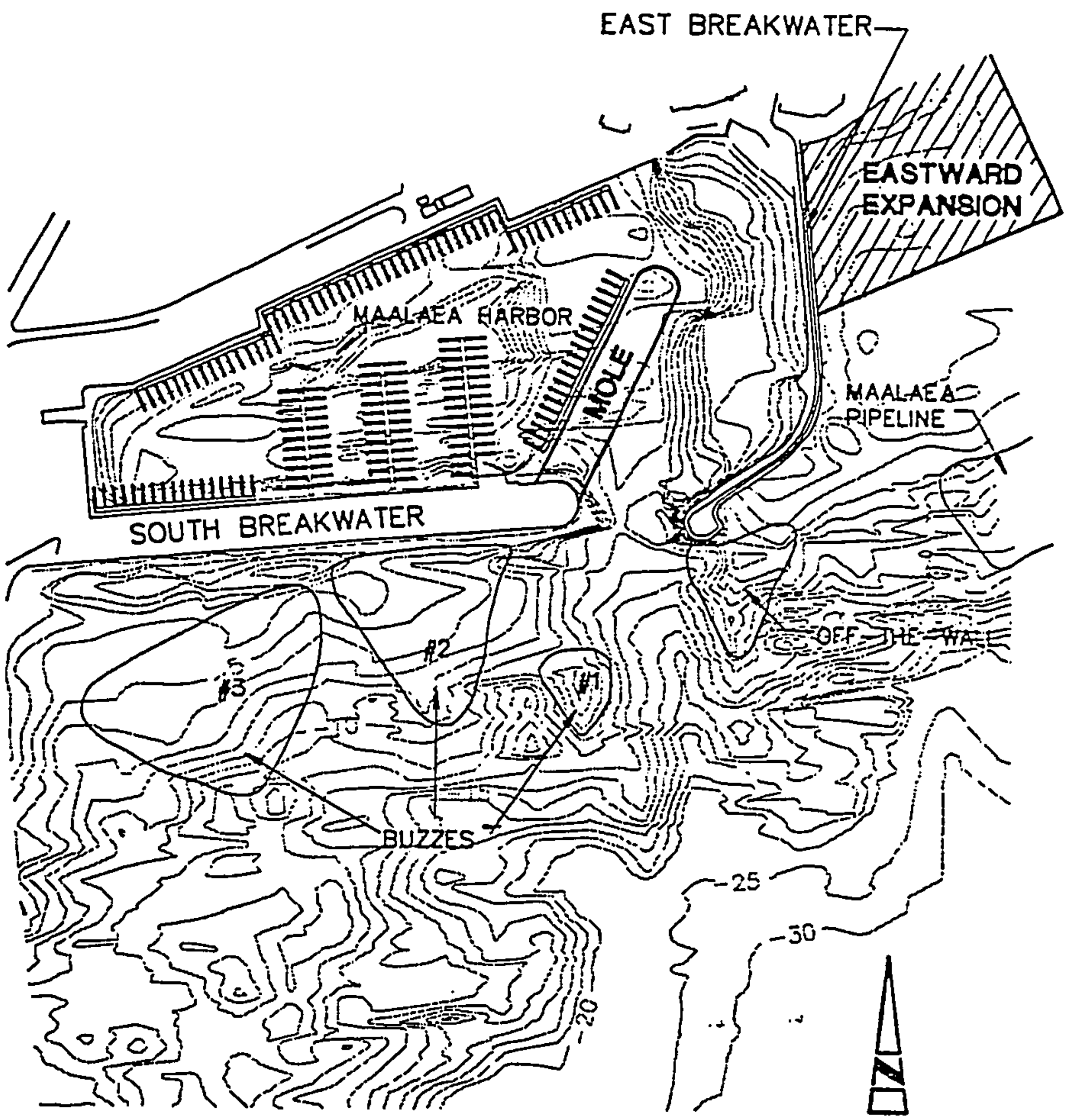
To mitigate for the lost berthing area caused by the construction of the interior mole, interior expansion of the harbor would allow for lost berthing space. Landward expansion of the harbor shown in Figure 8-3 would require extensive land redevelopment. Eastward expansion of the harbor shown in Figure 8-4 would have a direct impact to the adjacent beaches. These alternatives would require further detailed studies to determine their feasibility.



NOTE: MARINA SLIPS ARE SCHEMATICALLY SHOWN FOR POSSIBLE EXPANSION OF HARBOR. FEASIBILITY AND OPTIMIZATION OF SLIP LAYOUT FOR THIS MARINA CONFIGURATION SHOULD BE CONDUCTED.

MAALAEA HARBOR
ALTERNATIVE NO. 5B

FIGURE 8-3



NOTE: MARINA SLIPS ARE SCHEMATICALLY SHOWN FOR POSSIBLE EXPANSION OF HARBOR. FEASIBILITY AND OPTIMIZATION OF SLIP LAYOUT FOR THIS MARINA CONFIGURATION SHOULD BE CONDUCTED.

MAALAEA HARBOR

ALTERNATIVE NO. 5C

FIGURE 8-4

9.0 SUMMARY OF FINDINGS

The U.S. Army Corps of Engineers (COE) proposes to modify Maalaea Harbor. This study identified and evaluated nearby surf sites and the potential impacts of the modifications. Alternatives to minimize the impacts are presented and discussed.

Hawaiian surf is closely associated with wave conditions and exposure. Waves approaching the island may be represented by Northeast Trade waves, Kona Storm waves, North Pacific swell, Southern Hemisphere swell, and local storms and hurricanes. The project site is located on the leeward side of Maui and is directly exposed to large waves generated from the south, primarily during Kona storms or with a southern swell.

Five surf sites were identified along the project reach and are, from west to east, "Buzzes No. 3," "Buzzes No. 2," "Buzzes No. 1," "Off-the-Wall," and "Maalaea Pipeline." Detailed bathymetry and wave refraction analysis revealed the location of breaker heights ranging from 2 to 12 feet in the vicinity of Maalaea Harbor. Aerial photograph analysis revealed the location of breaker heights of one to two feet in the vicinity of Maalaea Harbor. The aerial photographs did not show the larger surfing waves for which the area is known and therefore do not typify the breaker zones for surfing waves.

"Buzzes No. 3" is a smaller and less frequently surfed site located near the root of the south breakwater. Larger waves feather offshore but seldom break because the bottom slope is extremely flat. This site has a gently spilling wave and is used mostly by body boarders.

"Buzzes No. 2" may support infrequent larger surf from 4 to 12 feet with rides to the left. This site is located near the middle of the south breakwater and is defined by a large, broad ridge creating spilling waves more suitable for body boarders and beginner surfers.

"Buzzes No. 1" is located along the west side of the entrance channel and is defined by a small, submerged ridge. Bathymetry at that depth would require waves in excess of 6 feet in order to break as a surfable wave. Therefore, this site is seldom used by surfers and is only surfable during the infrequent, larger wave conditions.

"Off-the-Wall" is located along the entrance channel's eastern edge. Breaking wave heights ranging from 3 to 12 feet produce conditions favorable for surfing. The rides are more of a take off and drop, but can be exhilarating on sizable surf near the east breakwater.

"Maalaea Pipeline" is located approximately 500 feet east of the channel entrance. This site breaks with conditions favorable to surfing with wave heights ranging from 3 to 12 feet and larger. These waves are a hard plunging type that produce a very fast, right ride tube for several hundred feet.

The four alternative harbor entrance configurations presented by the COE to help reduce wave energy in the harbor are:

1. A 450-foot extension to the east breakwater and removal of approximately 300 feet from the south breakwater;

2. A 555-foot extension to the south breakwater and removal of approximately 650 feet from the east breakwater;

3. A 600-foot extension to the south breakwater with a revetment and removal of approximately 75 feet from the east breakwater; and

4. A 675-foot extension to the east breakwater and removal of approximately 300 feet from the south breakwater.

Extending the east breakwater, as described in Alternatives No. 1 and 4, will directly impact the "Buzzes No. 2," "Buzzes No. 1," and "Off-the-Wall" surf sites. Extending the south breakwater, as described in Alternatives No. 2 and 3, will directly impact "Buzzes No. 2," and "Off-the-Wall" and indirectly impact "Buzzes No. 1."

Modifications to Alternative No. 3 were considered to minimize impacts on the existing surf sites. Modifications to the other three alternatives to minimize impacts on the existing surf sites were not considered feasible or beneficial to the overall project. Eliminating the revetment for Alternative No. 3 would reduce direct impacts to "Buzzes No. 2" although it may still be impacted by wave reflection. Also, minor realignment of the south breakwater extension could reduce direct impact on the "Off-the-Wall" surf site. An interior mole could also be provided to further reduce wave energy in the harbor.

A fifth alternative was presented that eliminates the breakwater extensions and provides an interior mole. This alternative does not produce any surf site impacts and provides increased wave protection for the harbor interior. Interior expansion of the harbor would allow for additional berthing space, either towards the north or east.

10.0 REFERENCES

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APPENDIX A

WAVE REFRACTION DIAGRAMS

WAVE REFRACTION DIAGRAM INDEX

The refraction diagrams presented in Appendix A are for the shallow water conditions only. Shallow water wave refraction diagrams were prepared based upon the results of the deepwater wave refraction analysis. These waves were refracted from the -60-foot MLLW contour to breaking conditions and include wave directions from 185 to 215 degrees with wave periods ranging from 8 to 16 seconds.

MAALAEA REFRACTION

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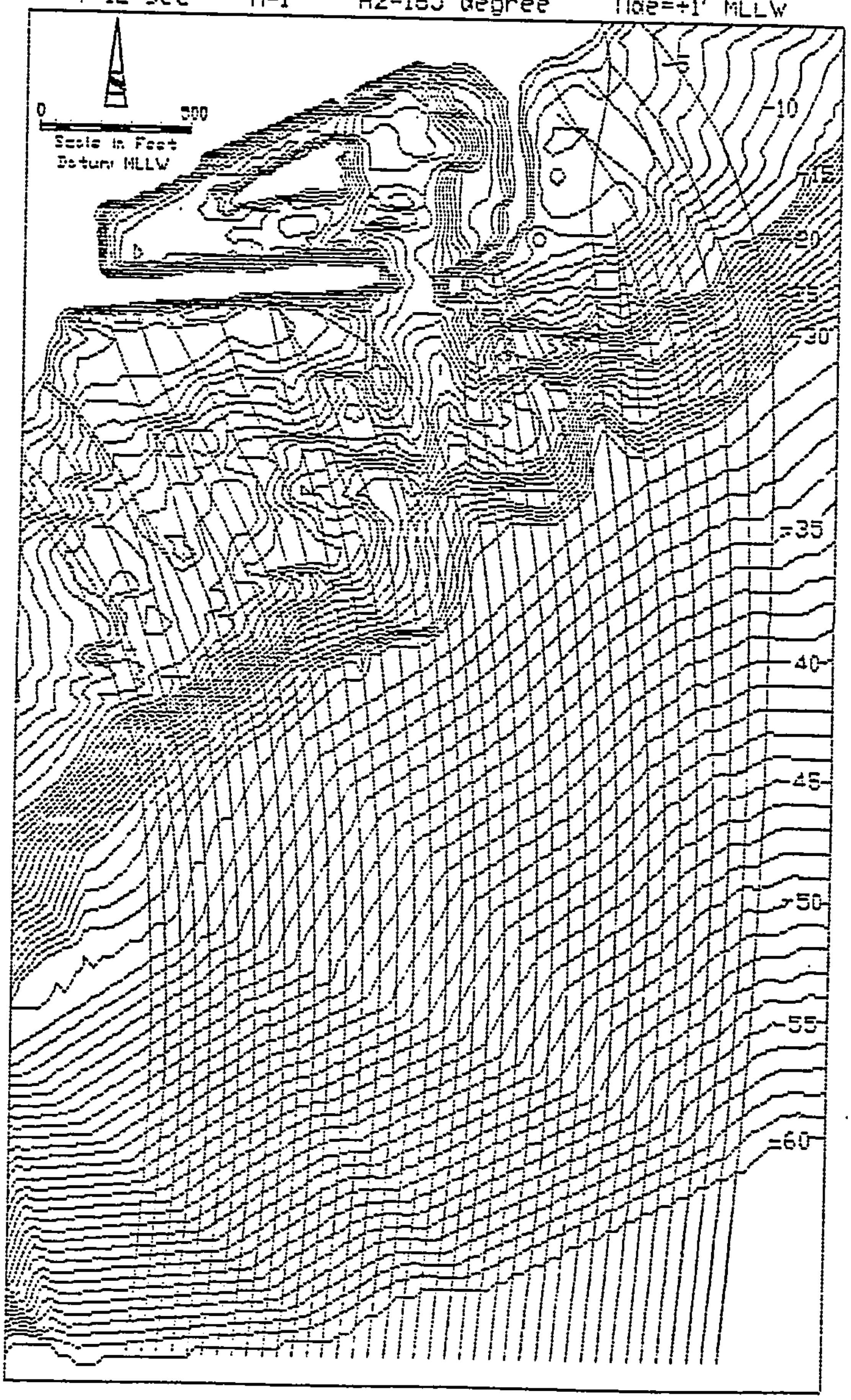

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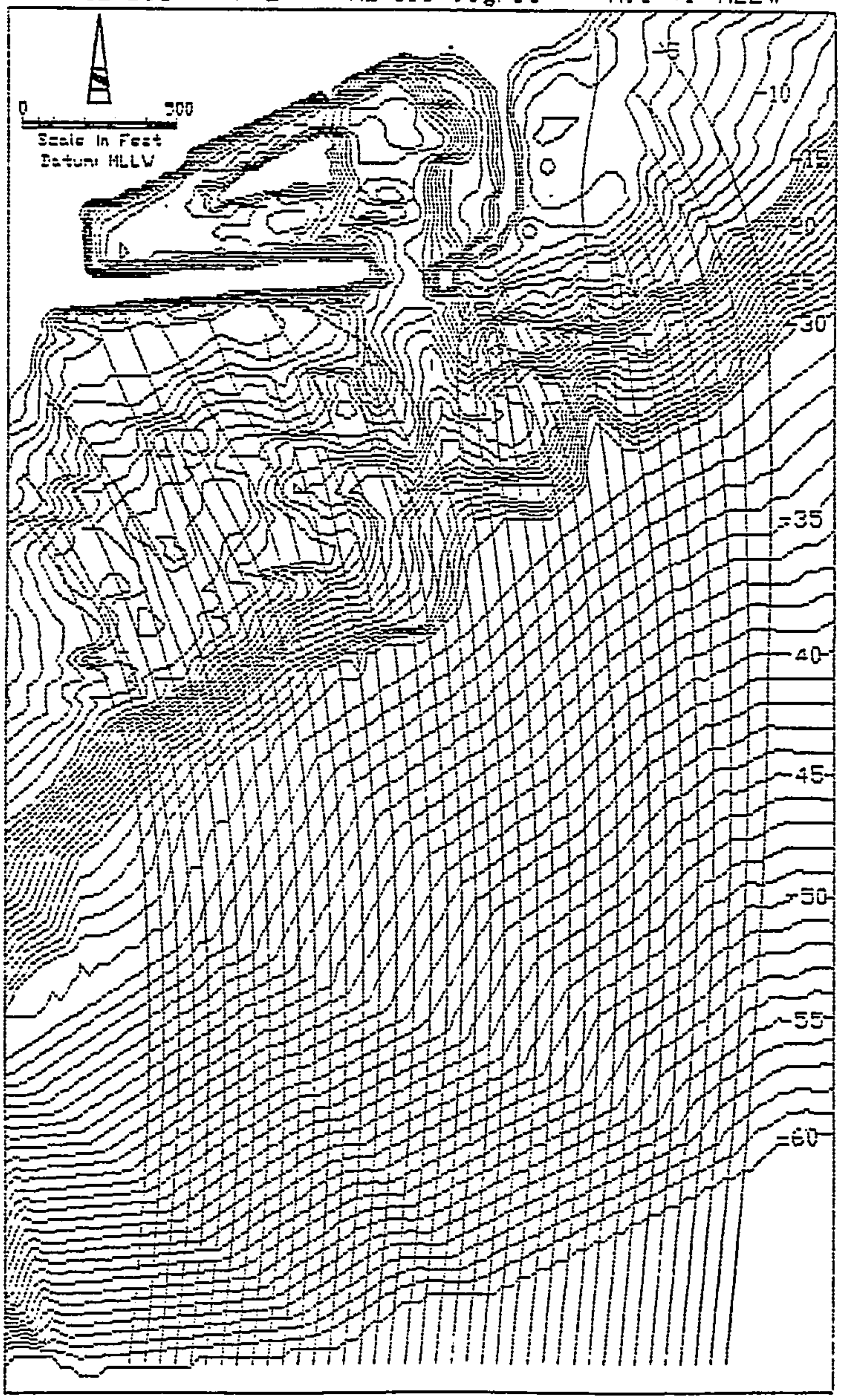

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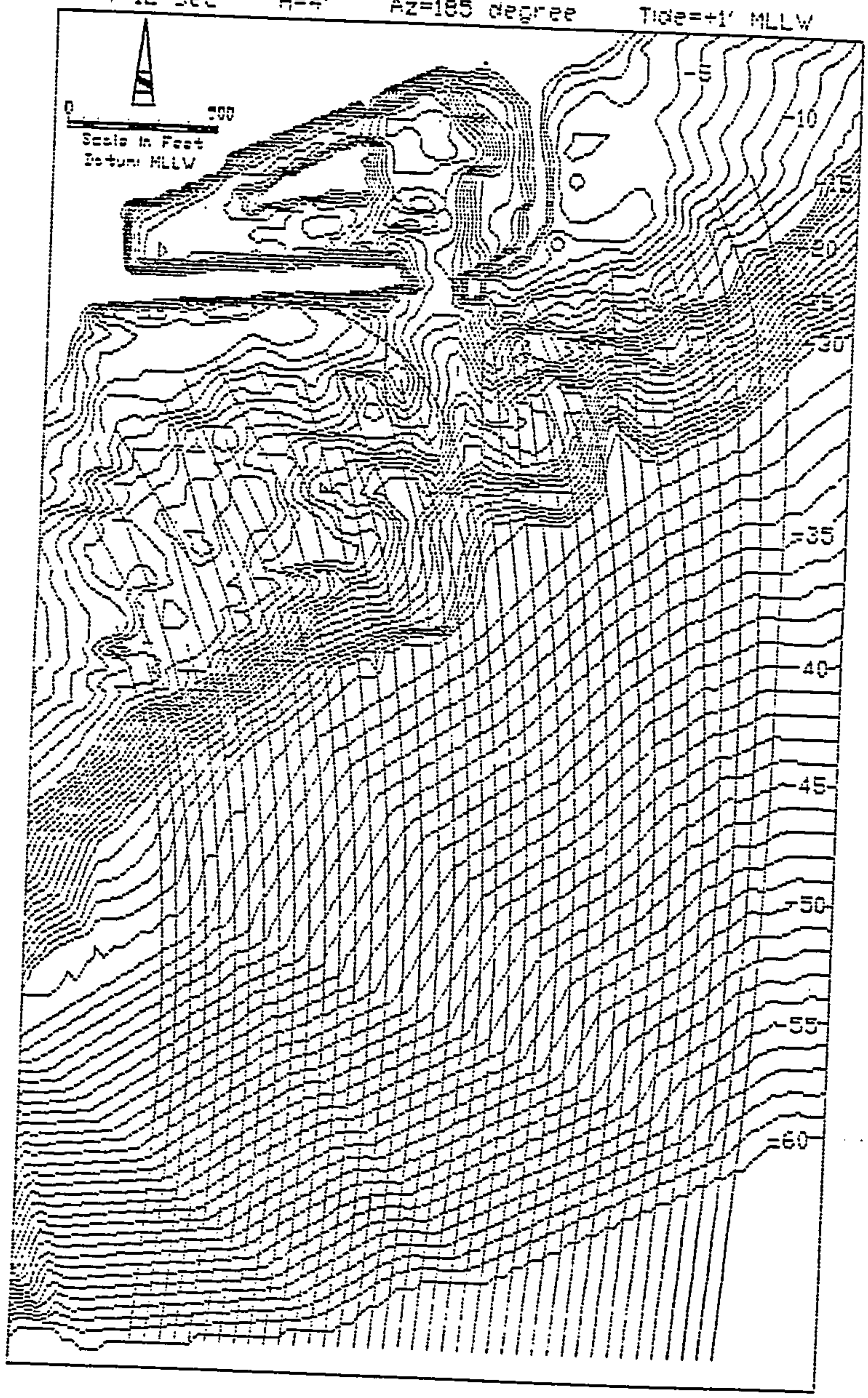
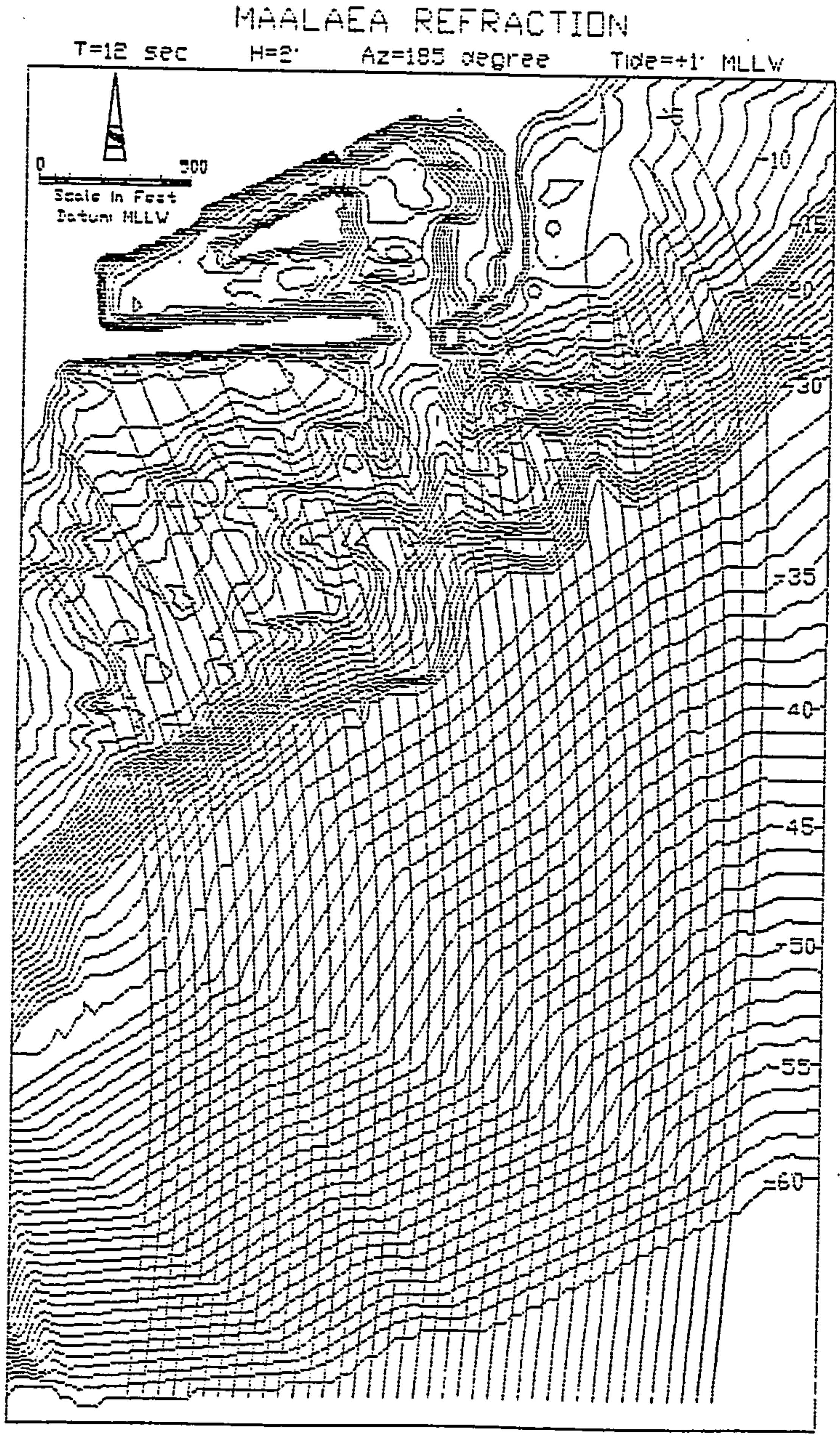


CORRECTION

THE PRECEDING DOCUMENT(S) HAS
BEEN REPHOTOGRAPHED TO ASSURE
LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING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Az=185 degree
Tide=+1' MLLW
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Scale in Feet
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-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60

MAALAEA REFRACTION

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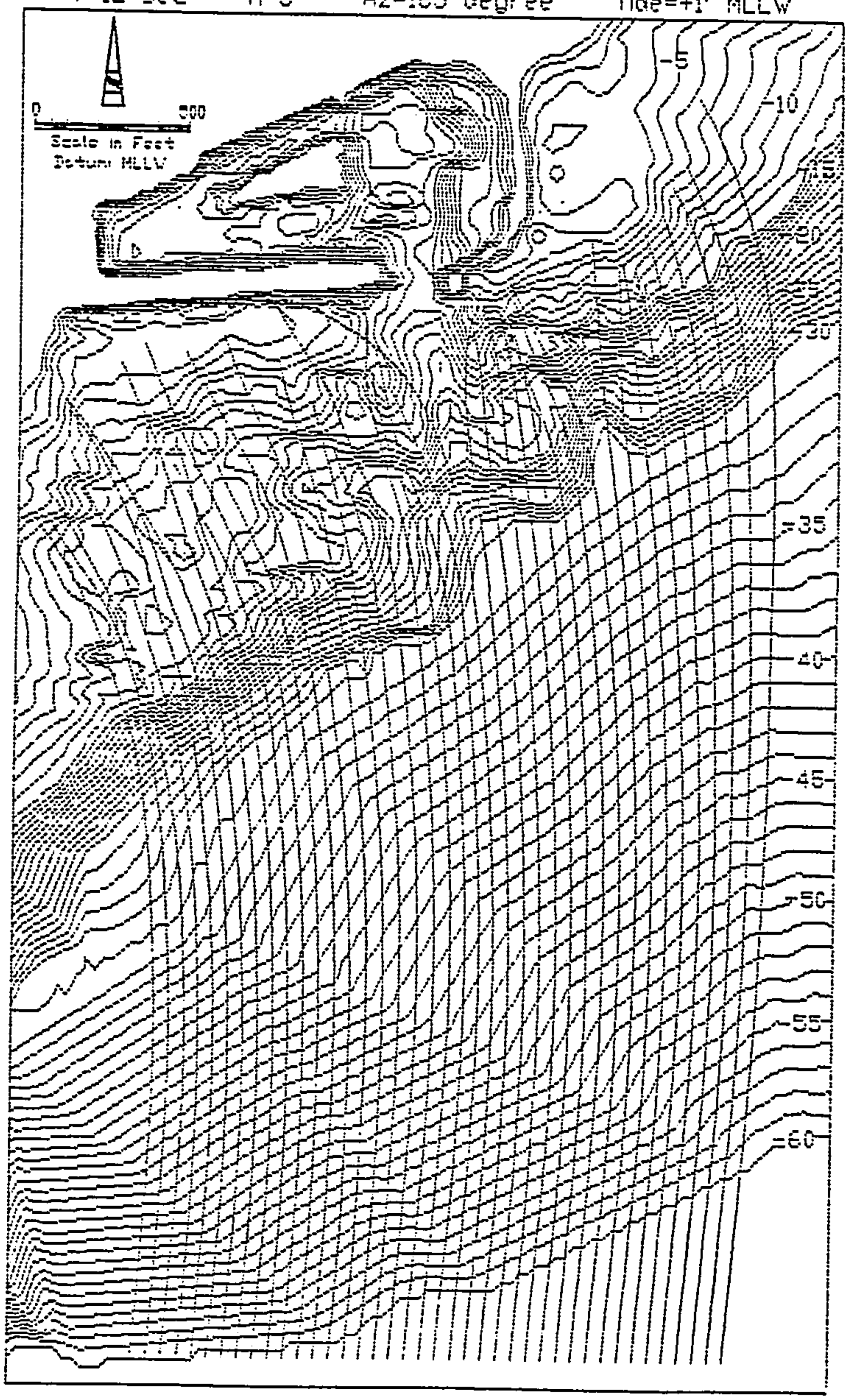

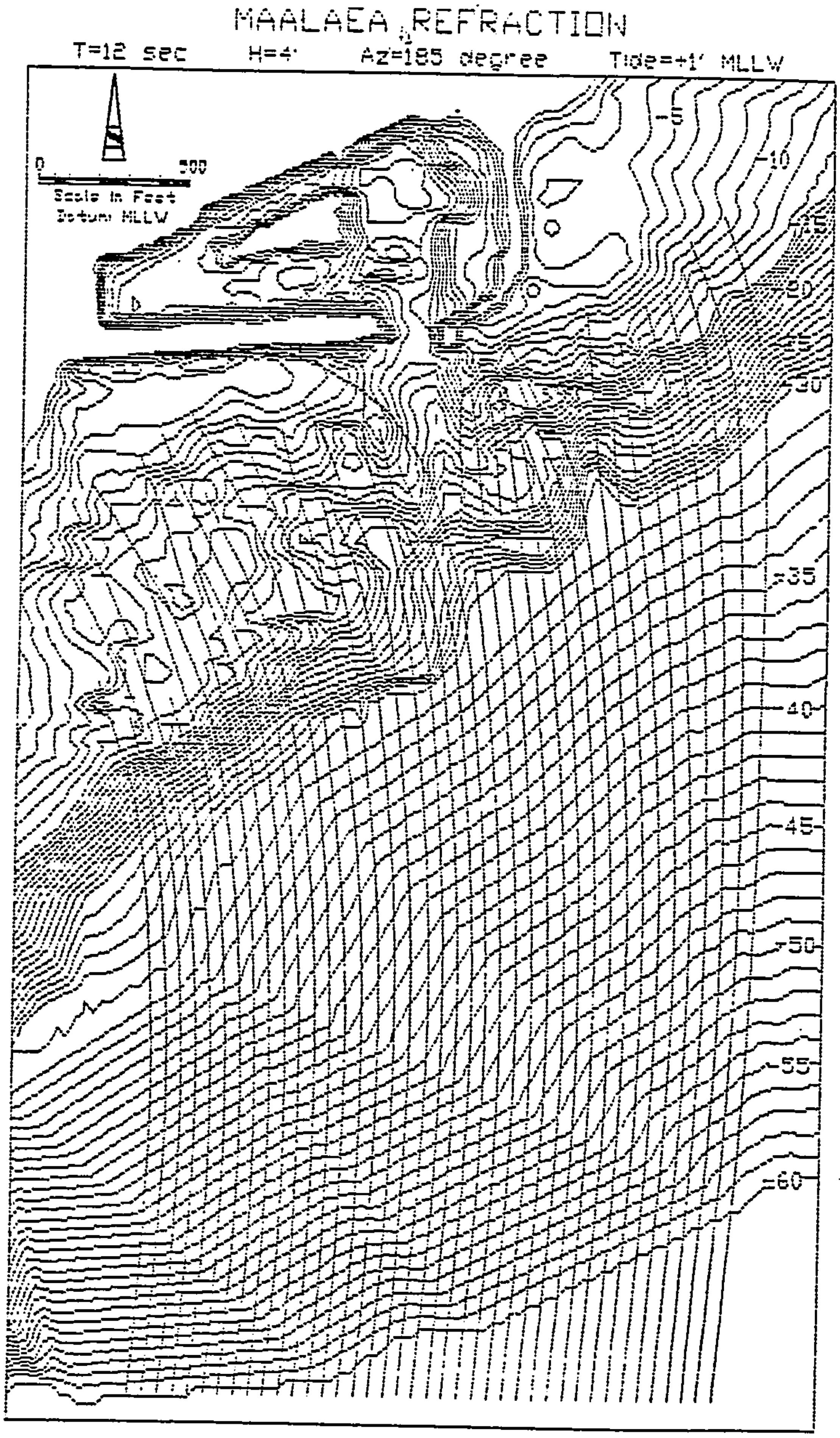
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Az=185 degree
Tide=+1' MLLW
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Scale in Feet
Datum: MLLW
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-15
-20
-25
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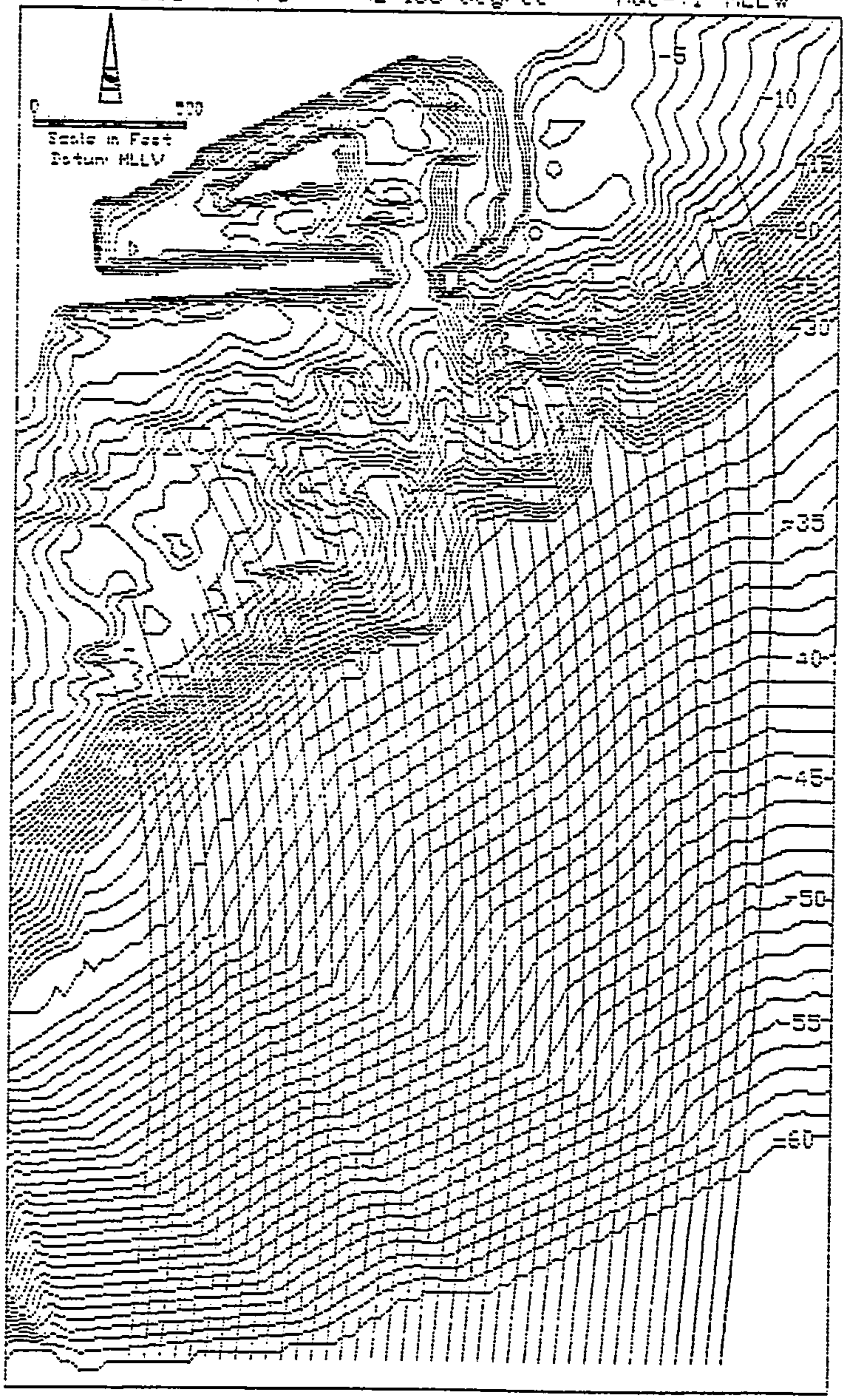
-60

MAALAEA REFRACTION

T=12 sec H=5' Az=185 degree Tide=+1' MLLW



MAALAEA REFRACTION

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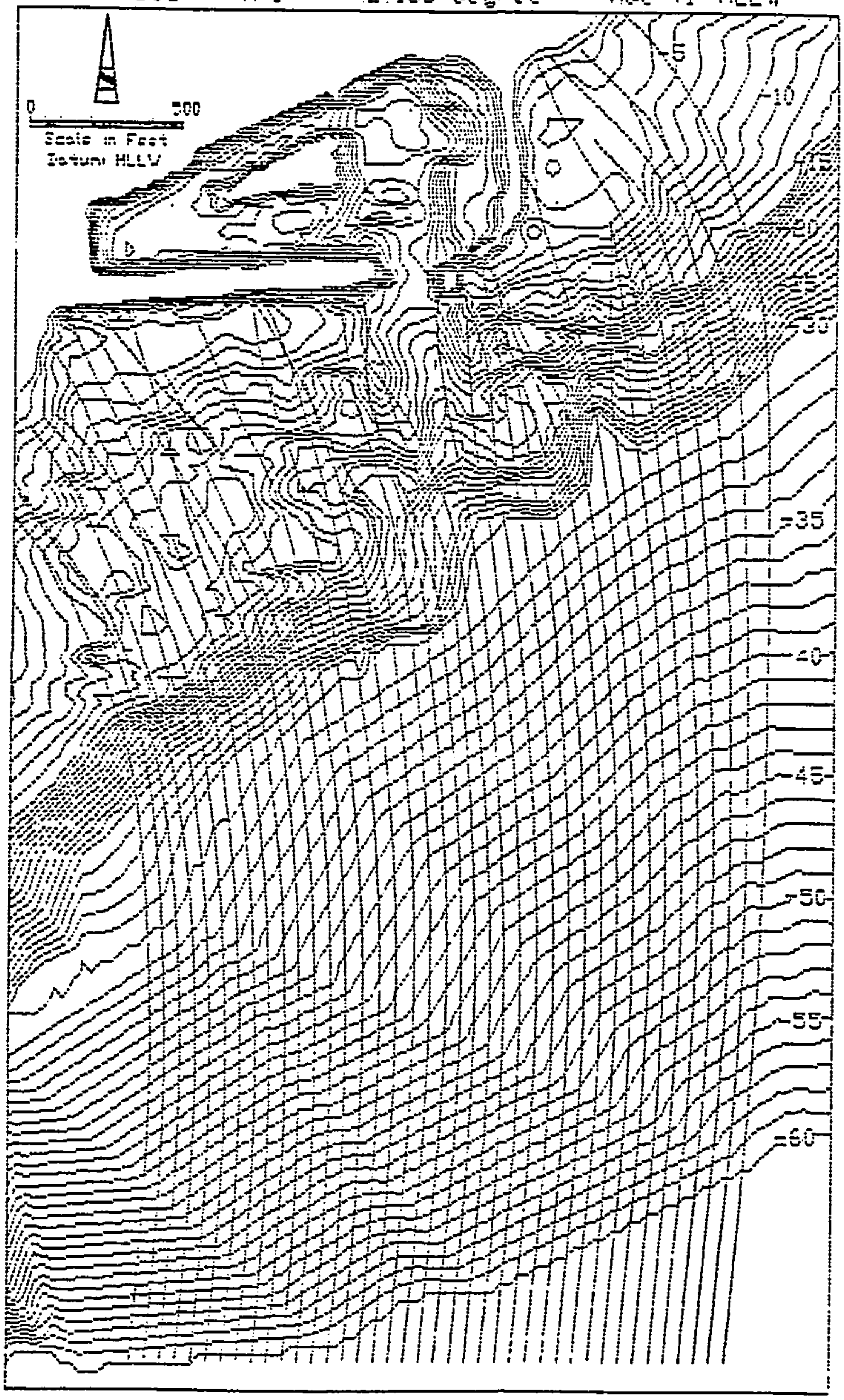

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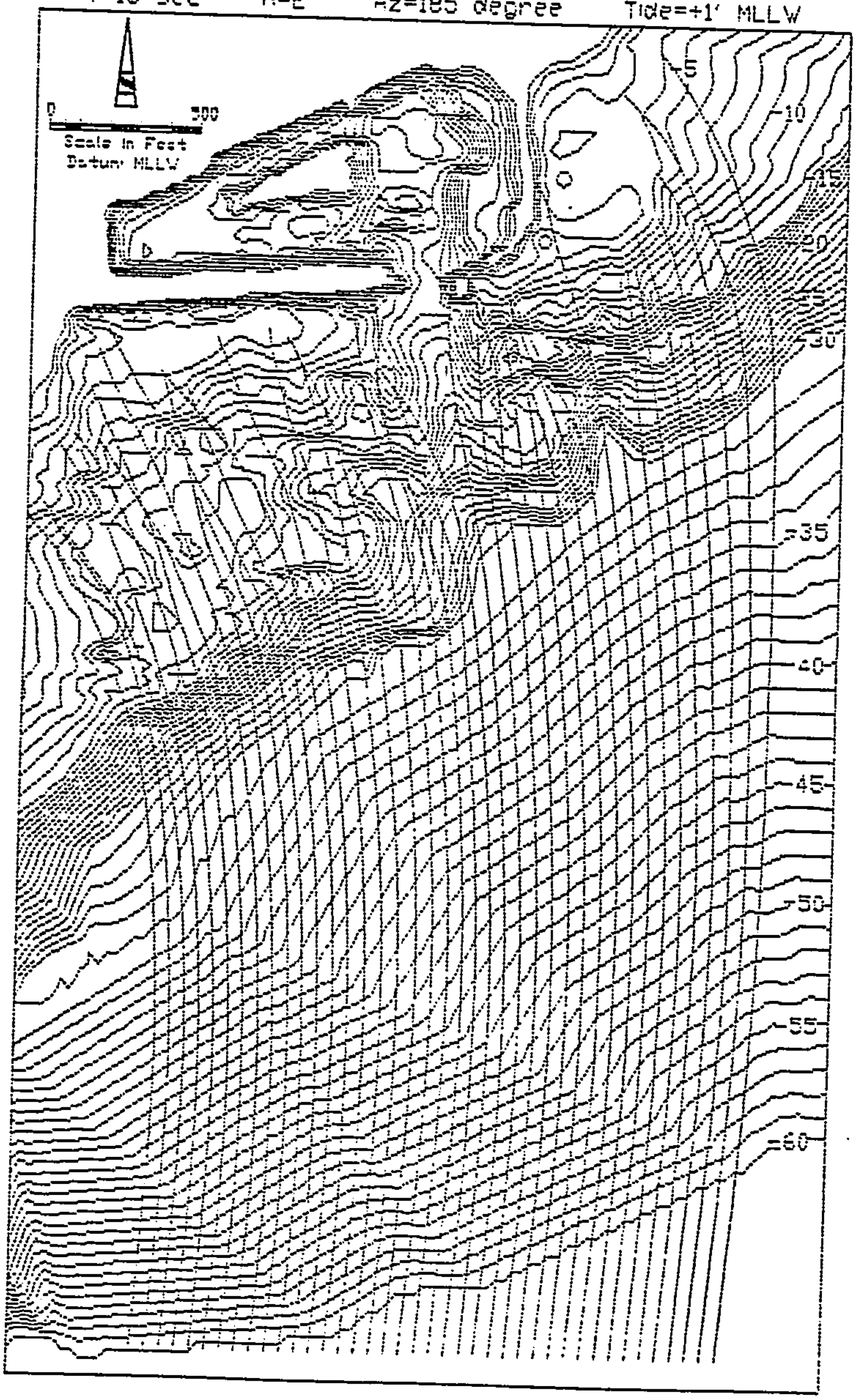

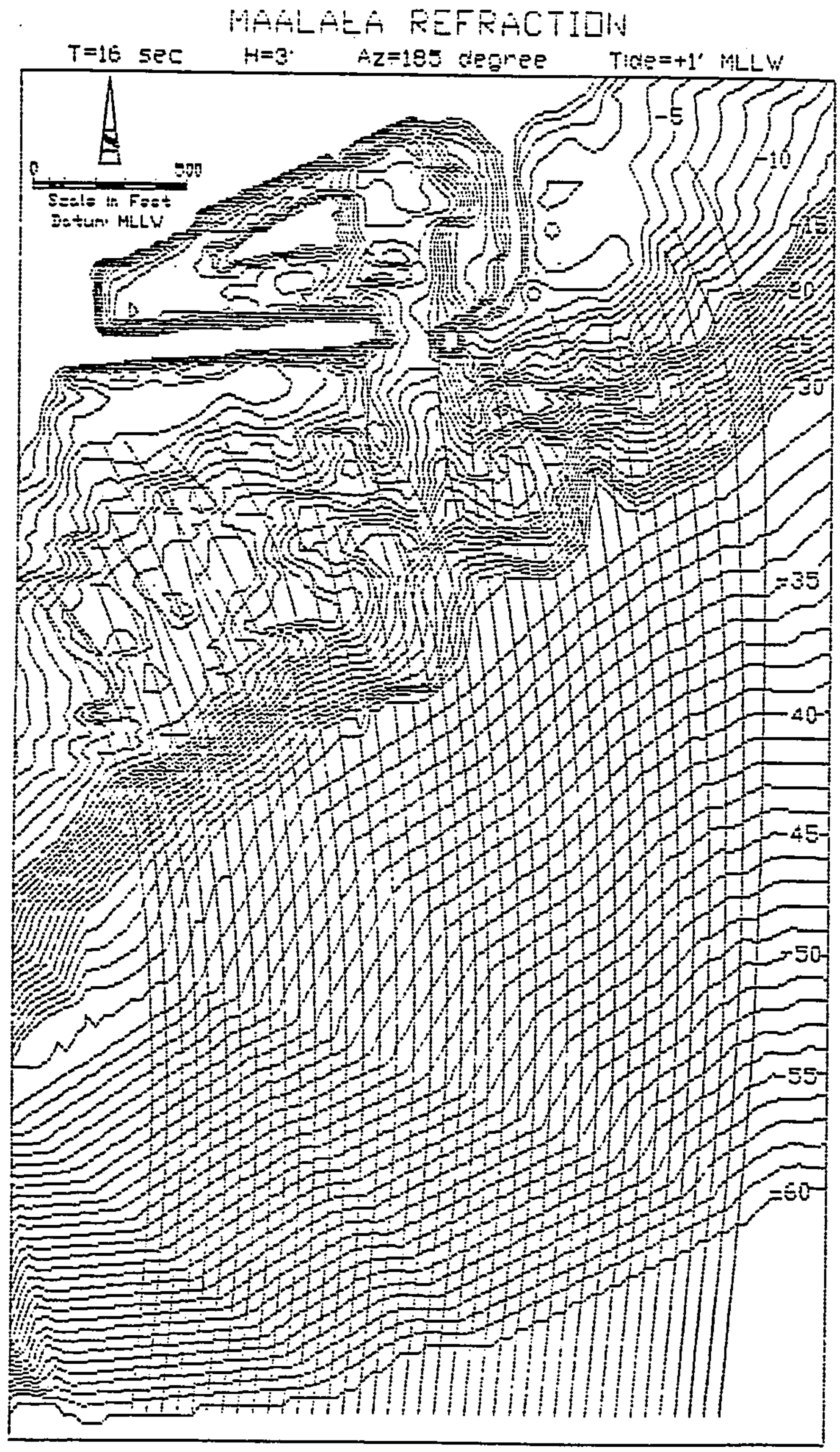
MAALAEA REFRACTION
T=16 sec H=3' Az=185 degree Tide=+1' MLLW
0
500
Scale in Feet
Datum: MLLW
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-20
-25
-30
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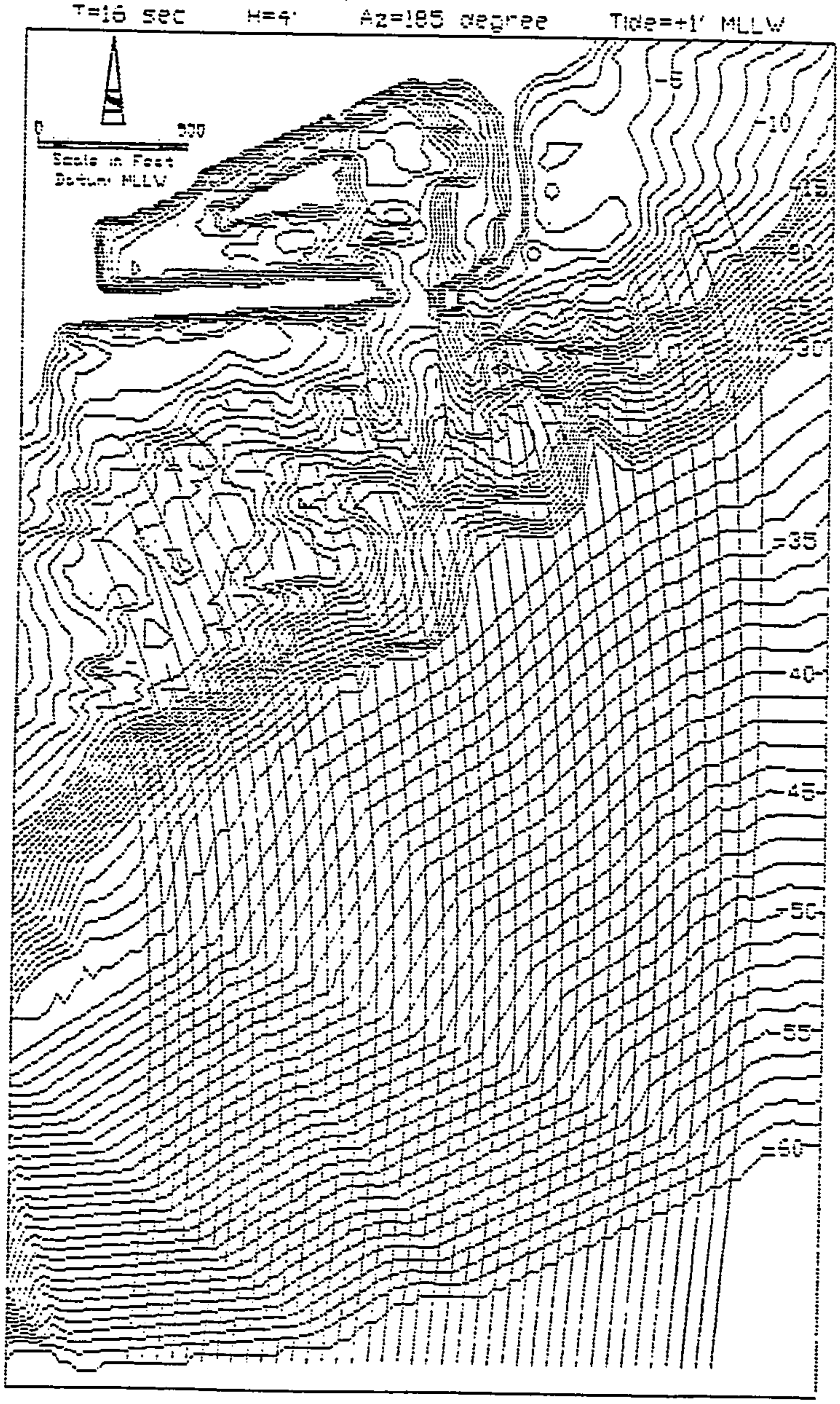
MAALAEA REFRACTION

T=16 sec   H=4'   Az=185 degree   Tide=+1' MLLW



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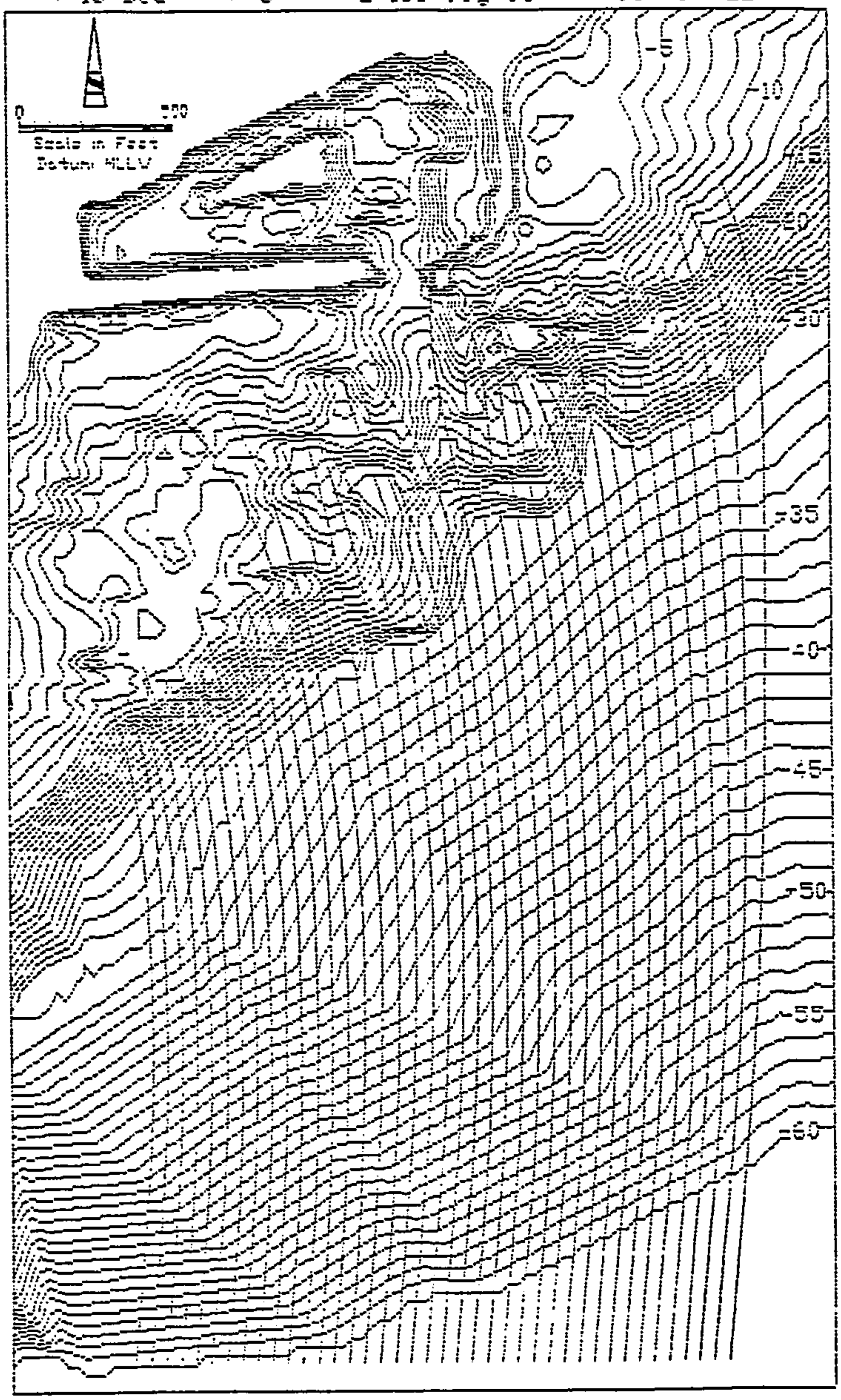

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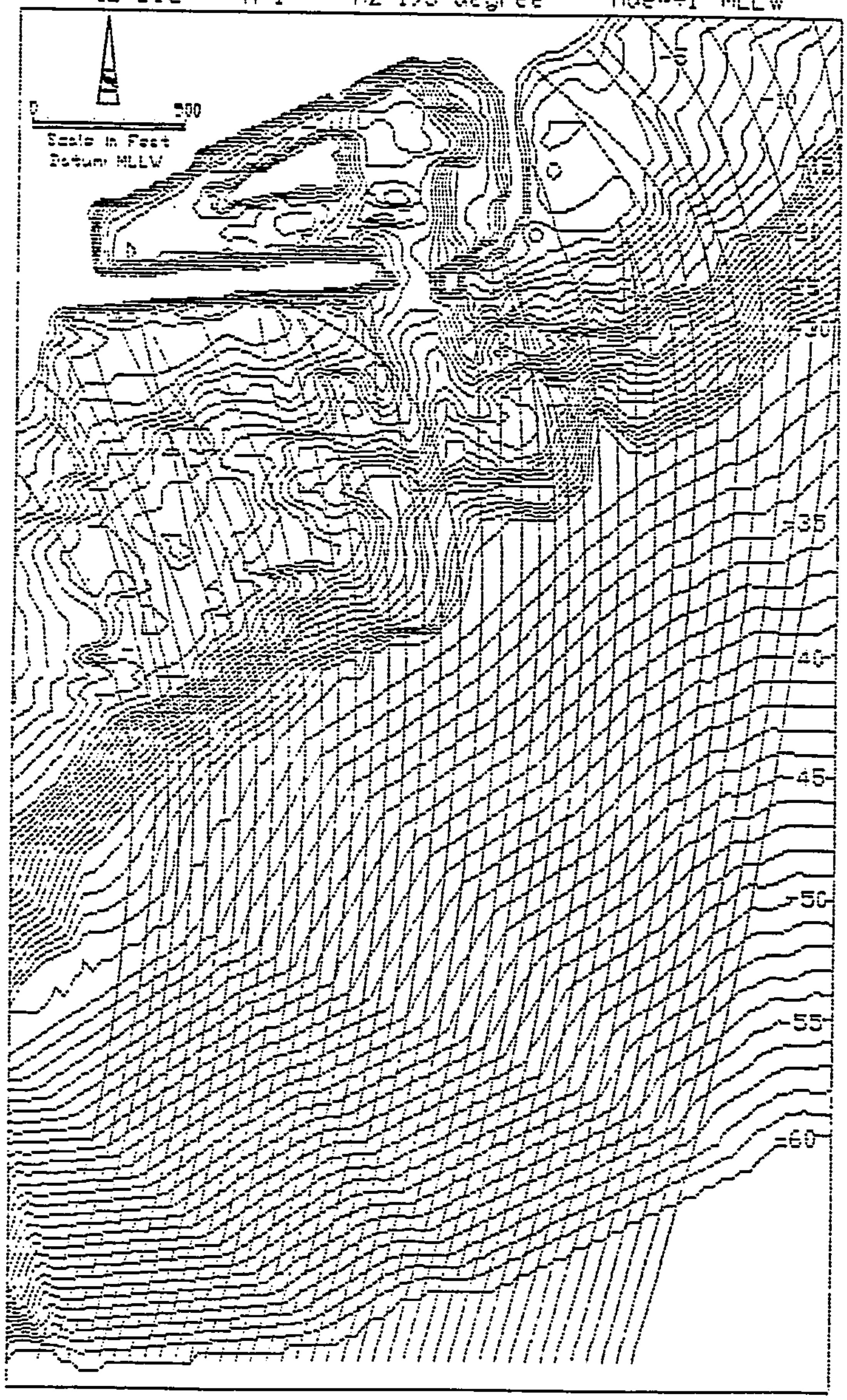
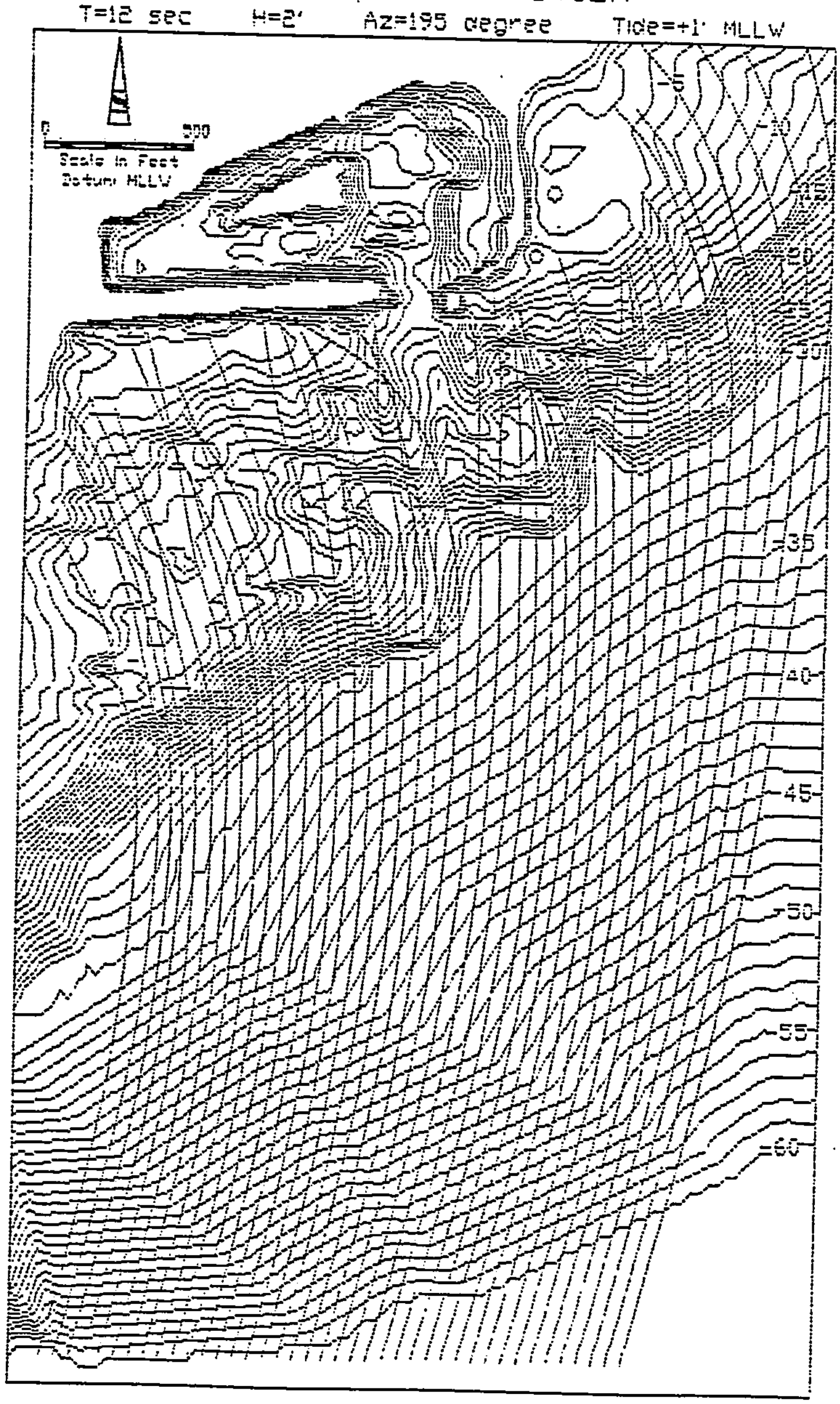


MAALAEA REFRACTION

T=12 sec   H=2'   Az=195 degree   Tide=+1' MLLW



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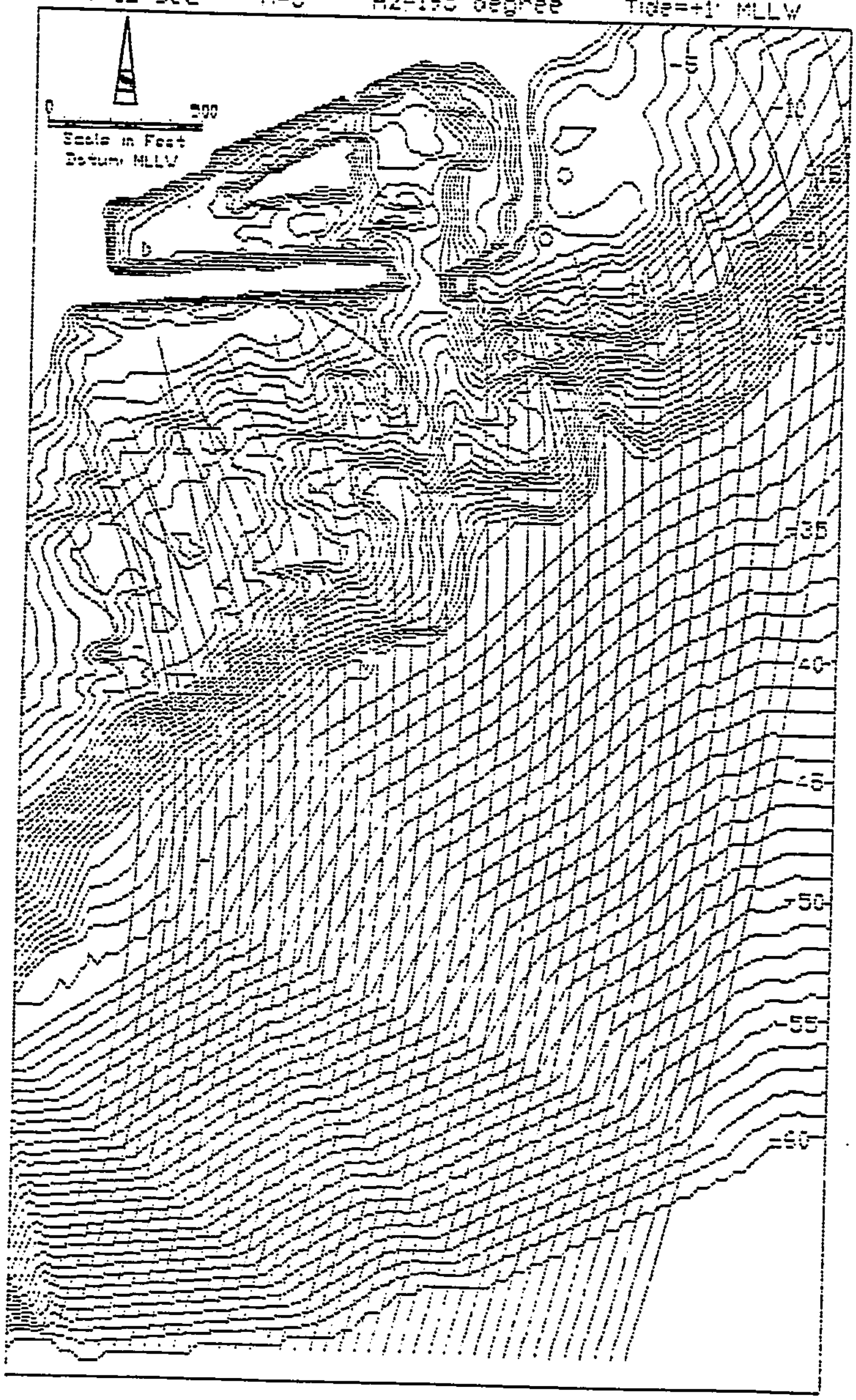

MAALAEA REFRACTION

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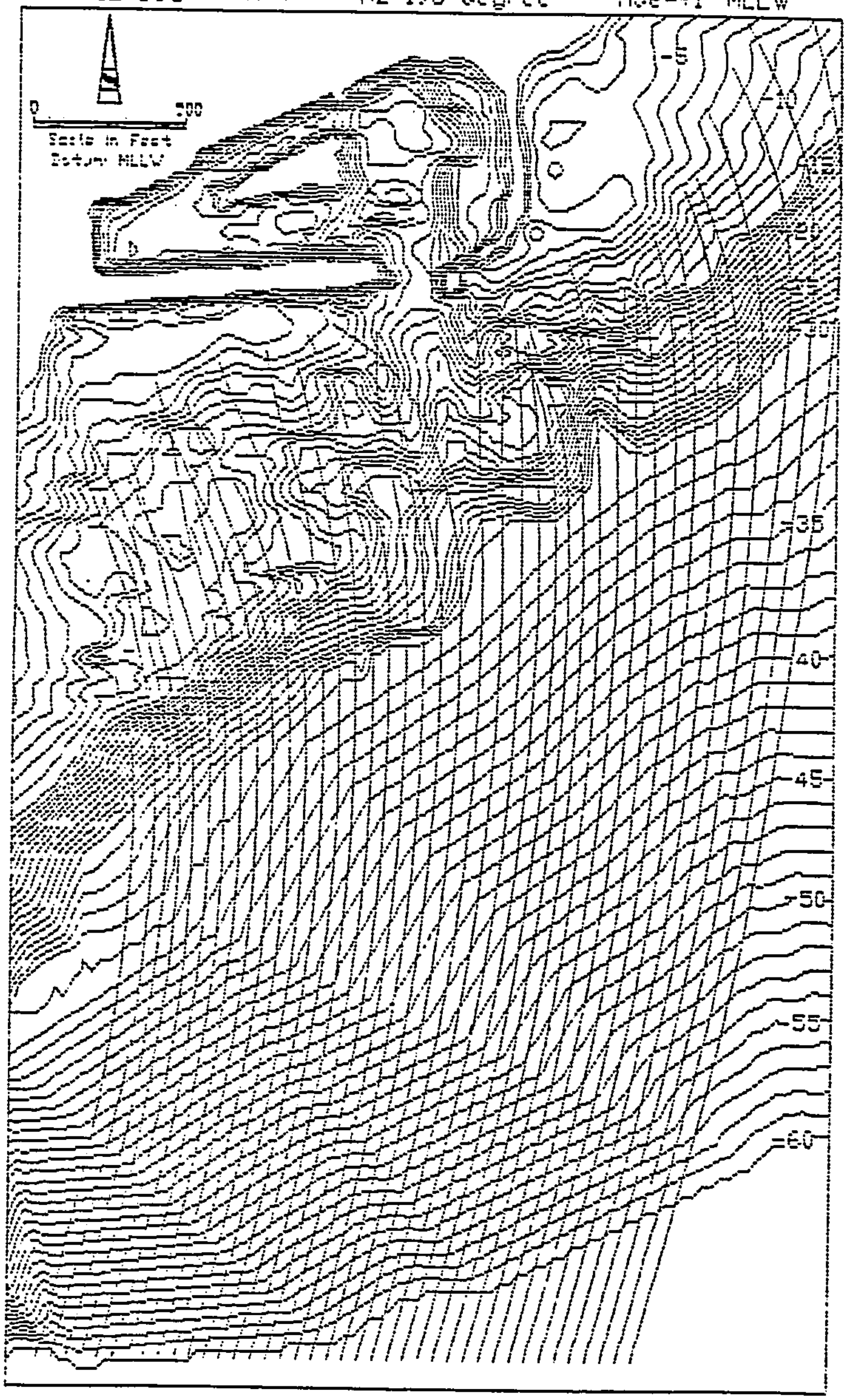

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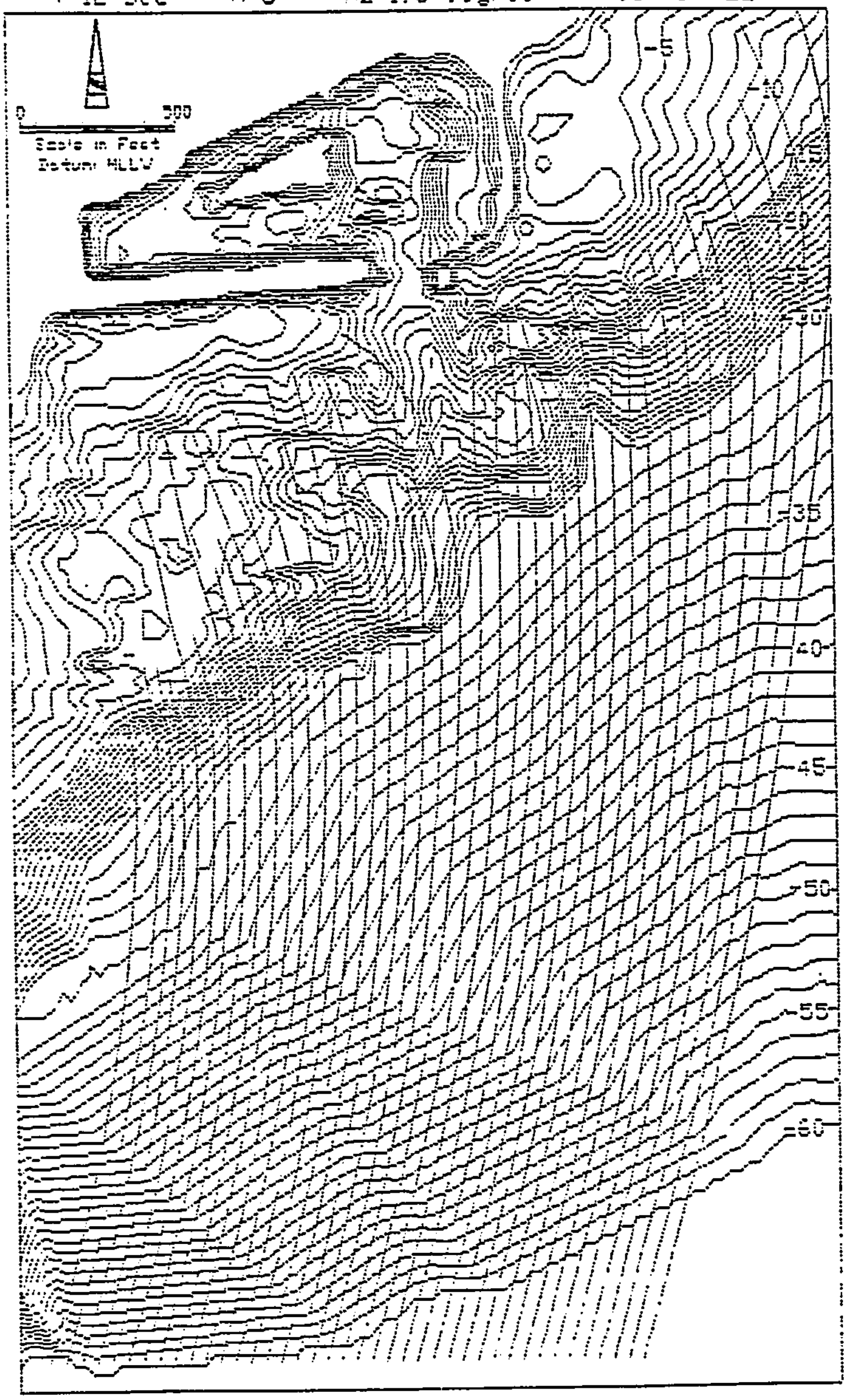

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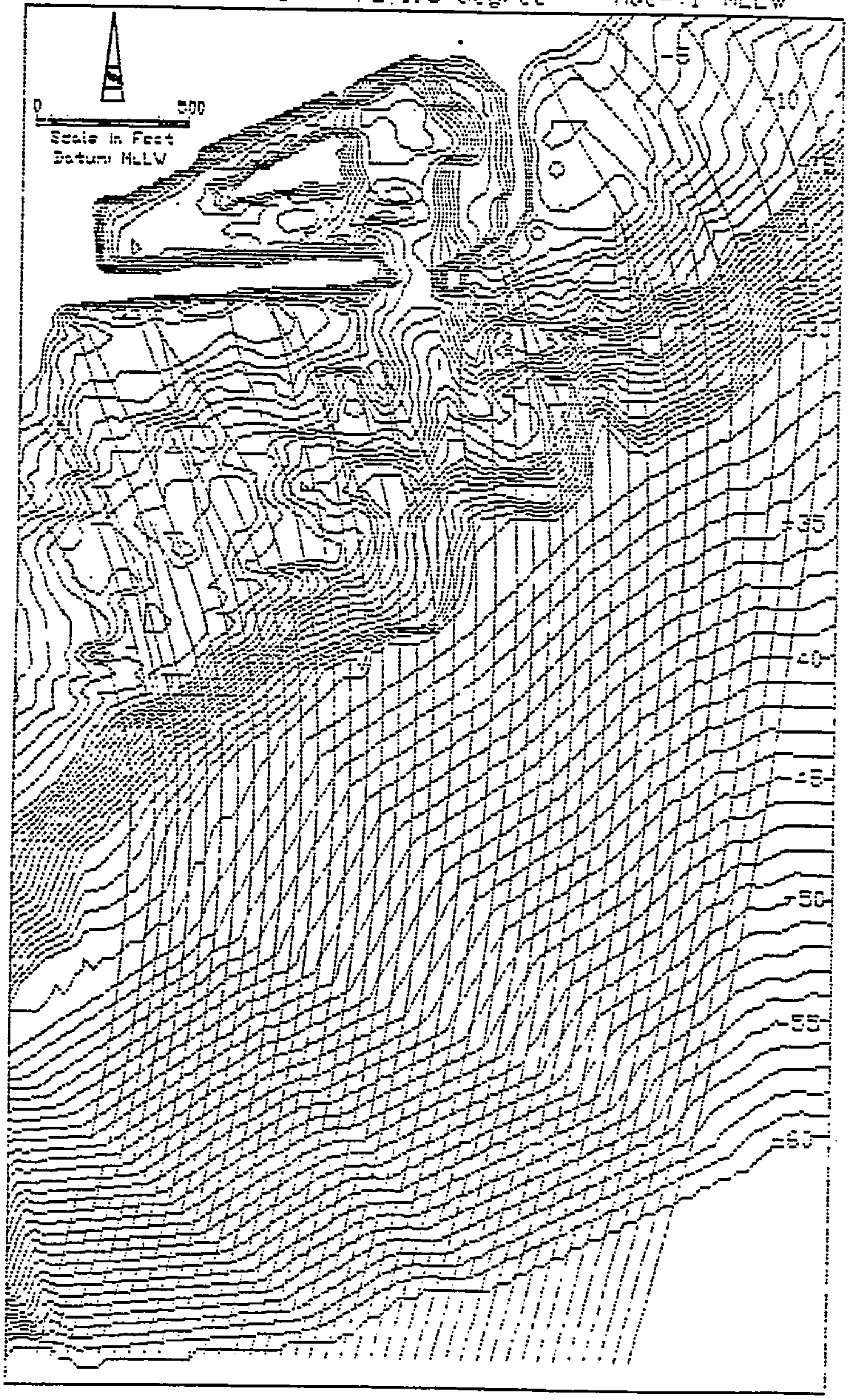

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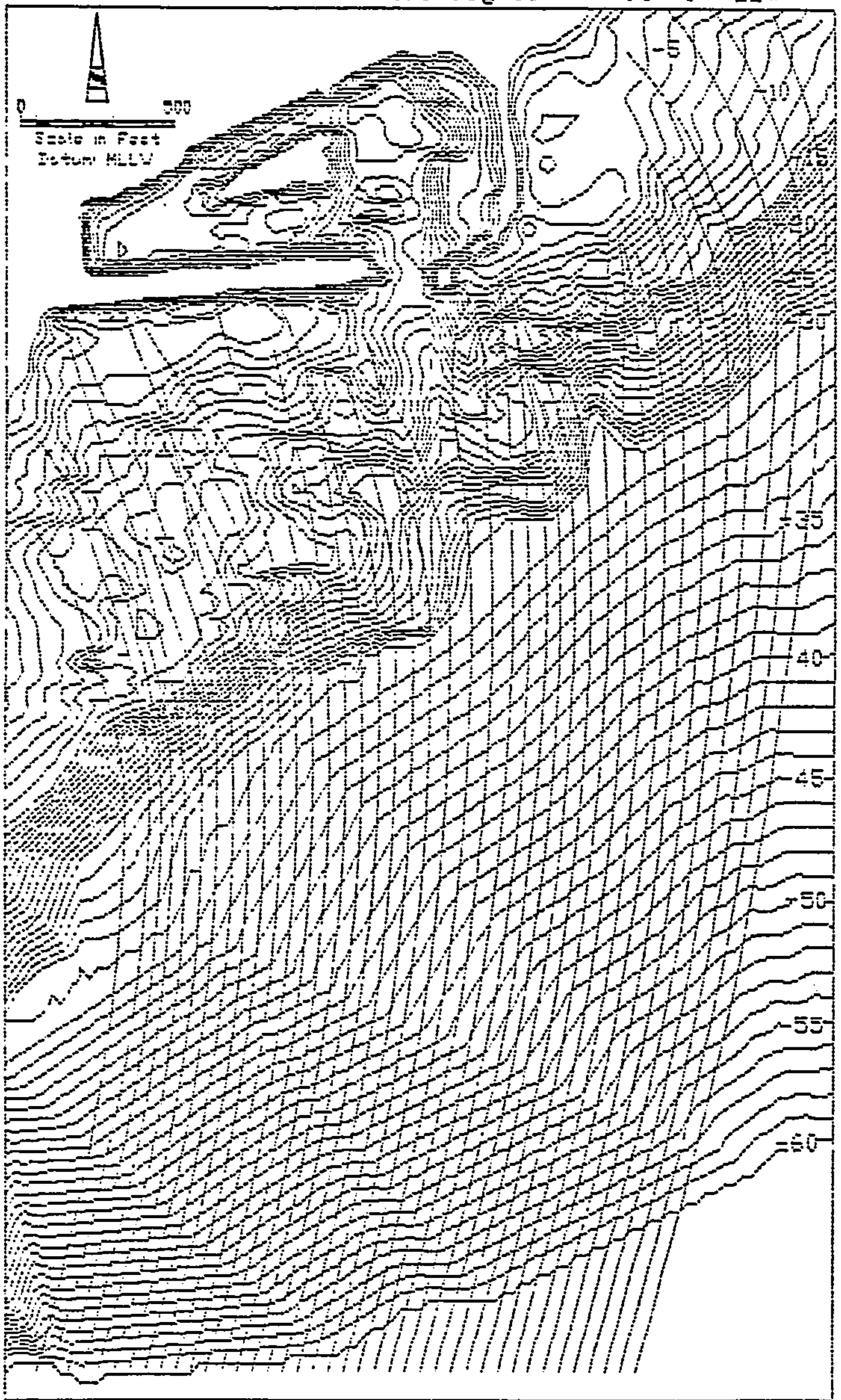

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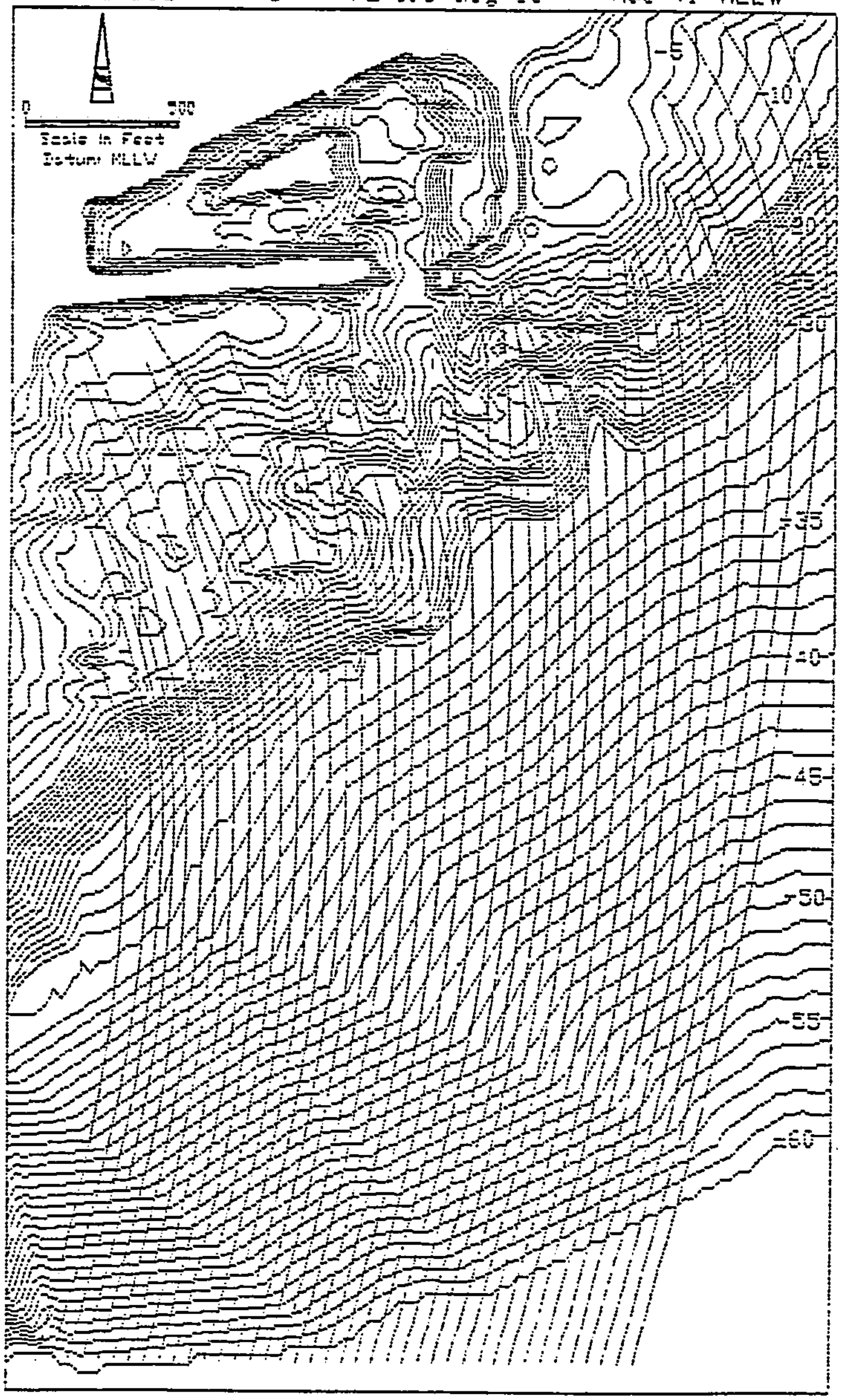

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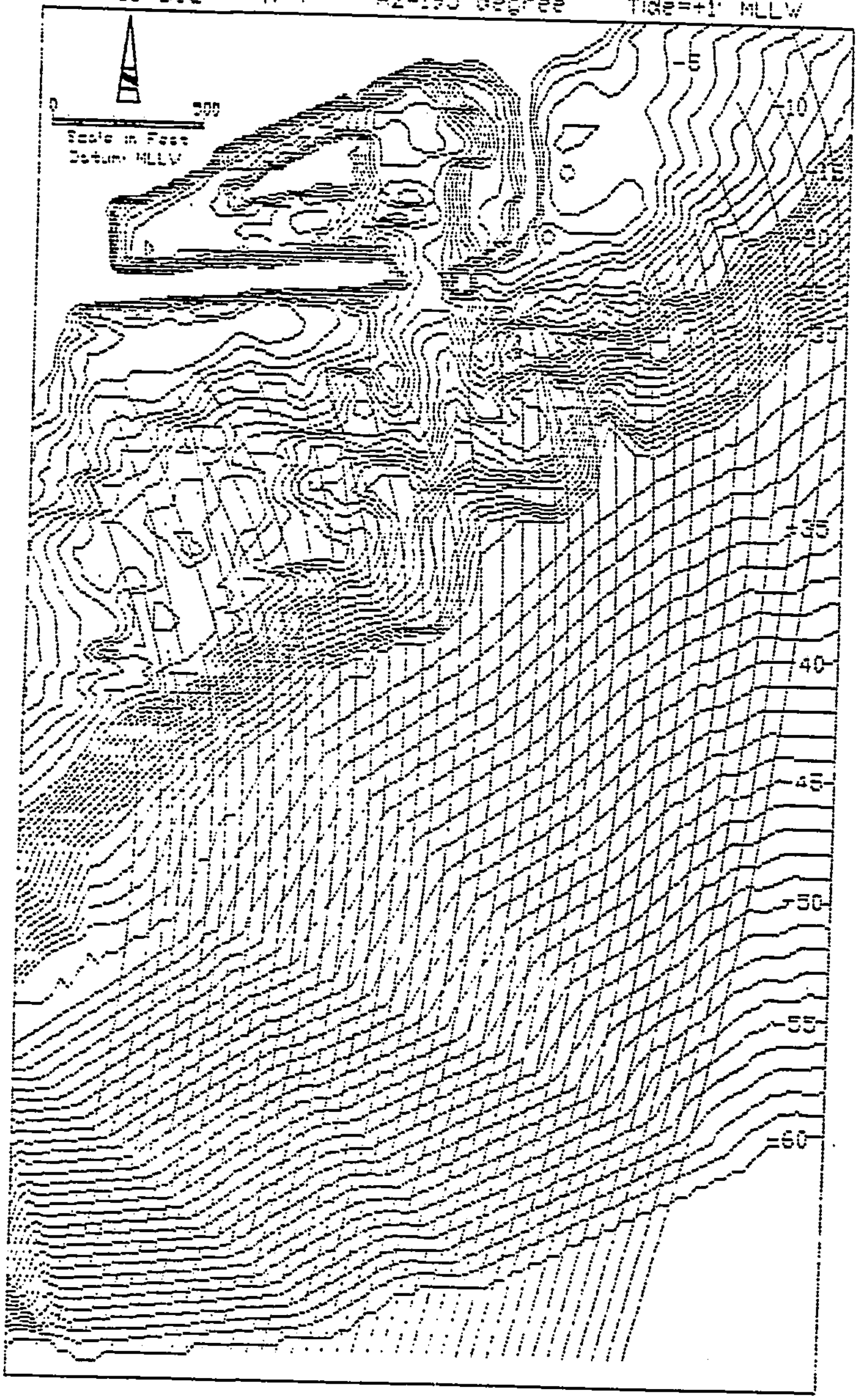

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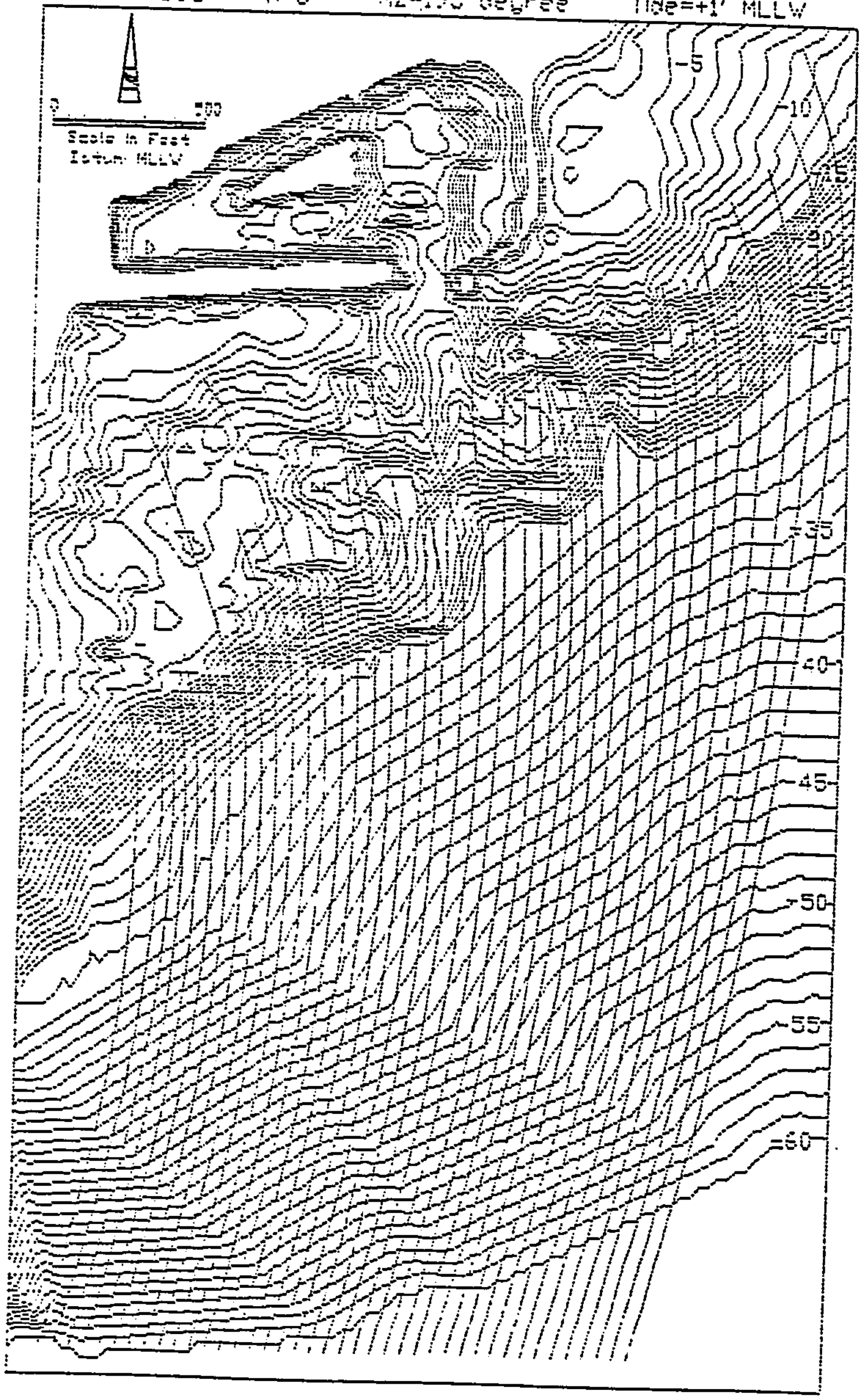

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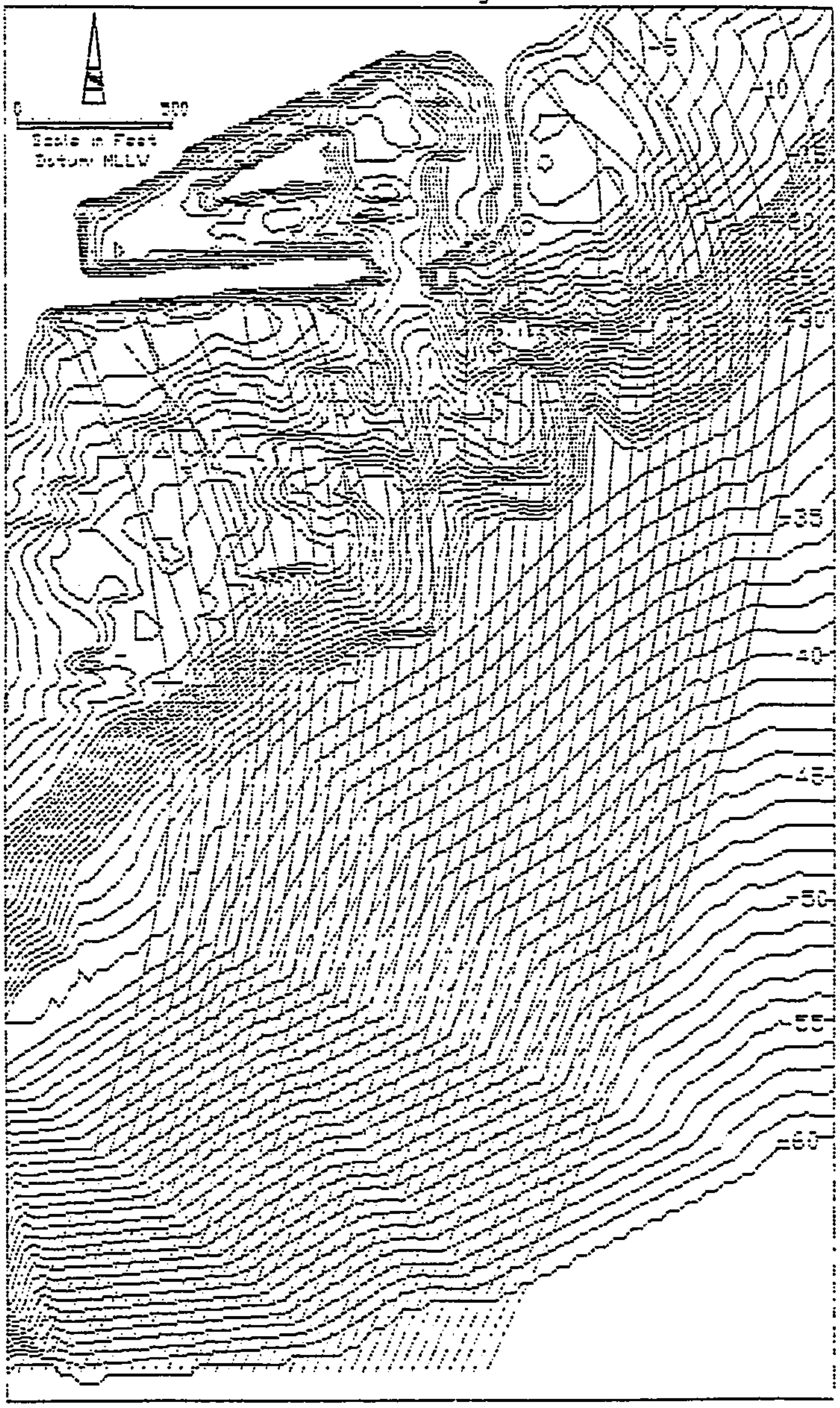

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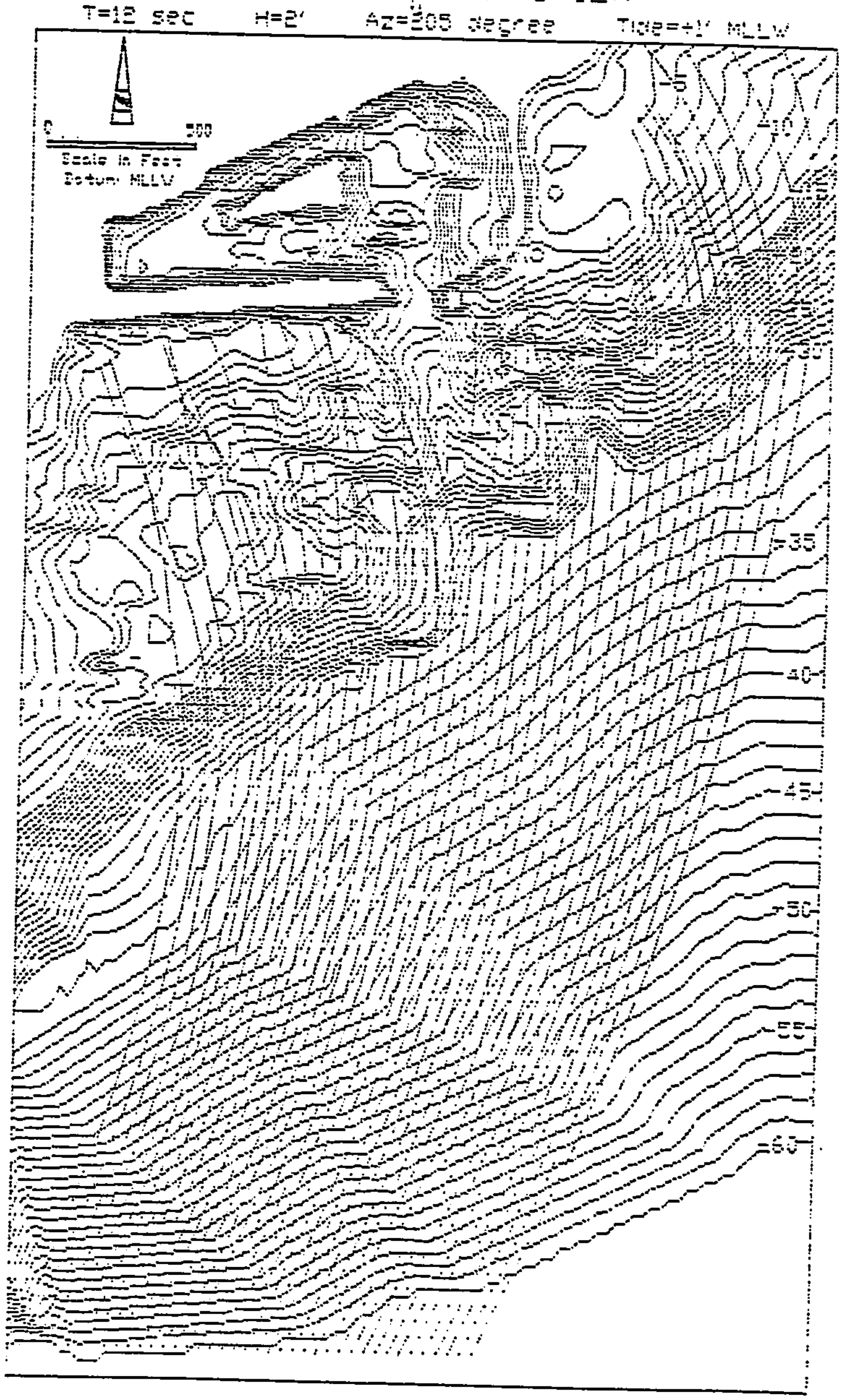

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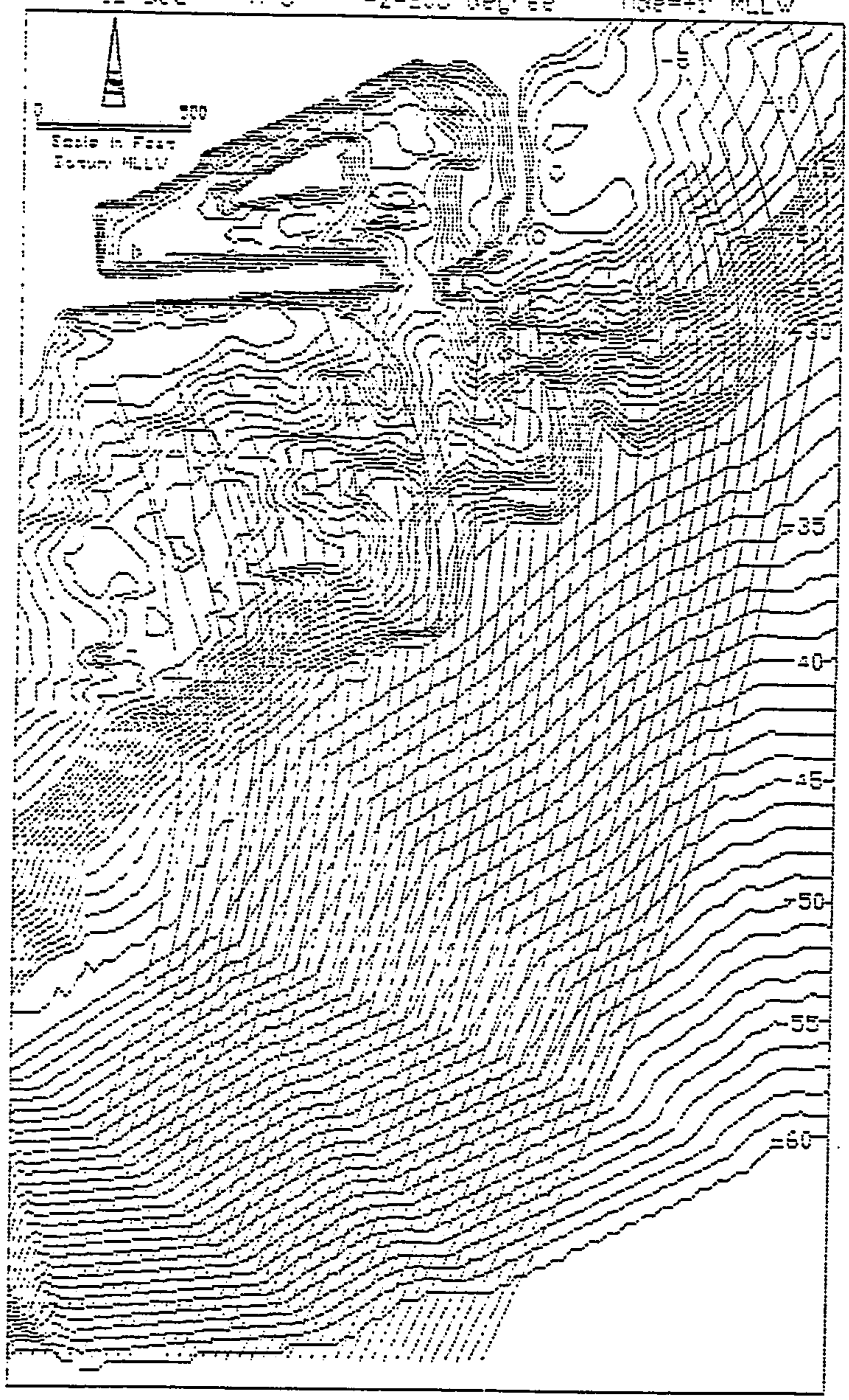

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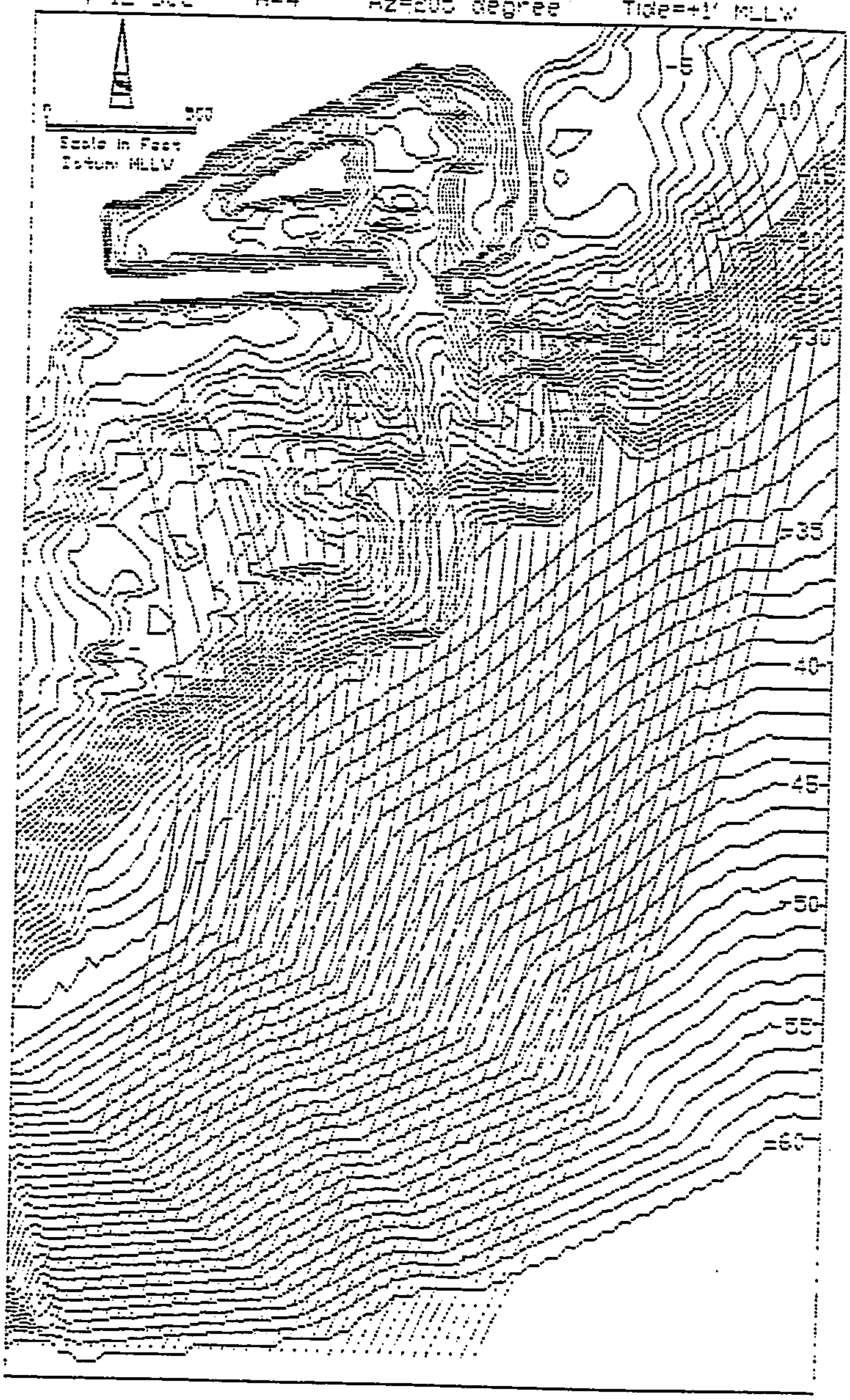

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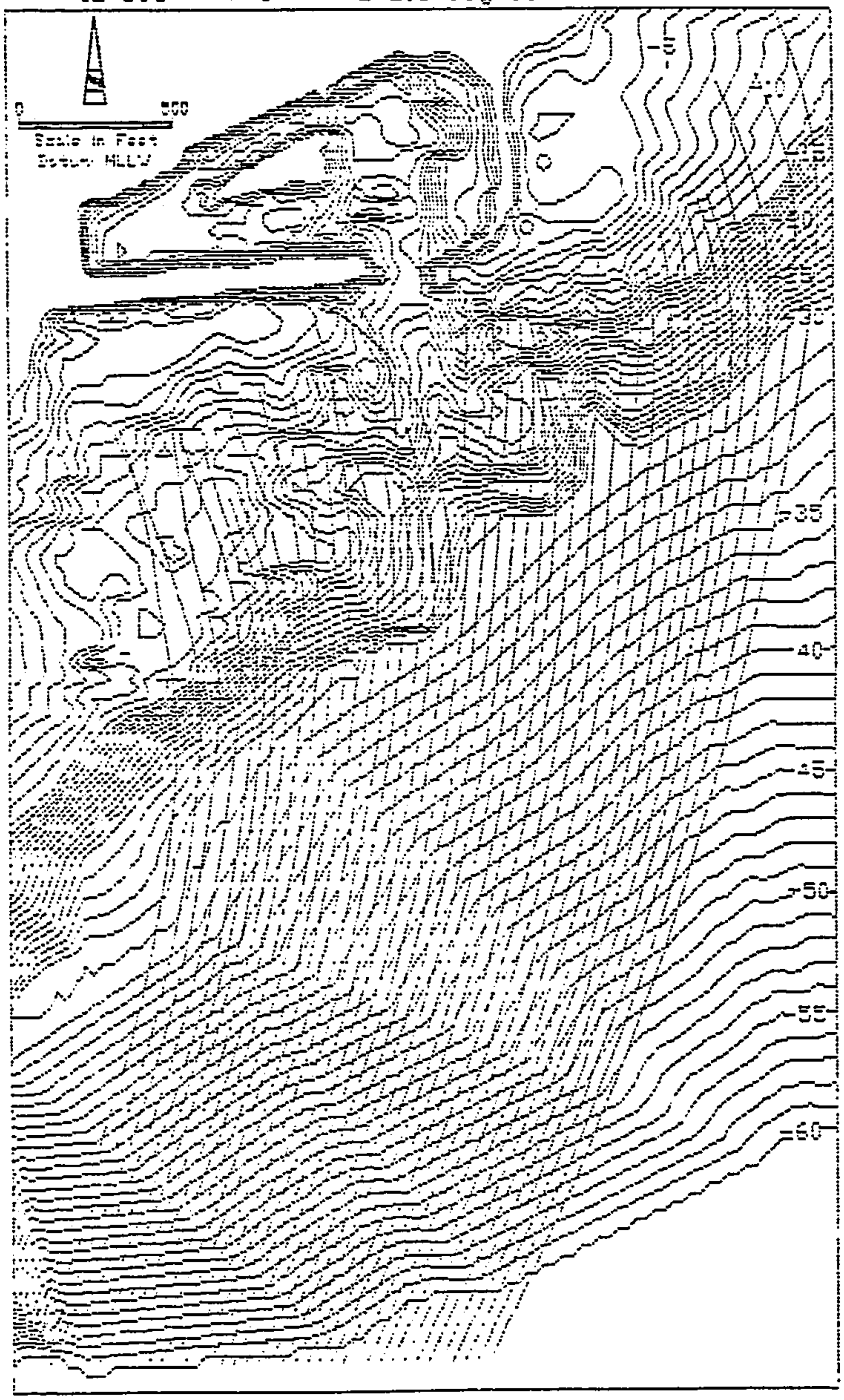

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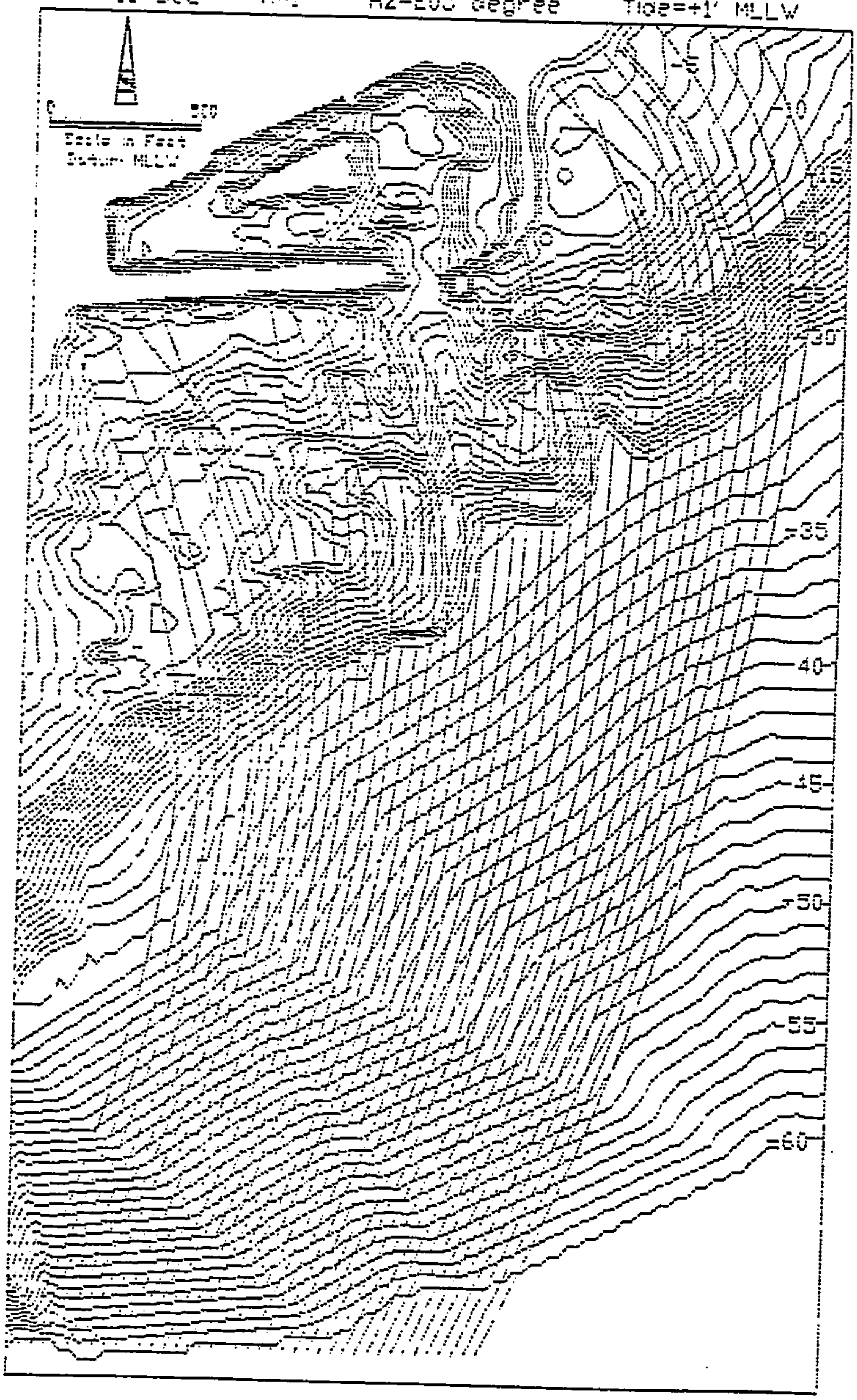

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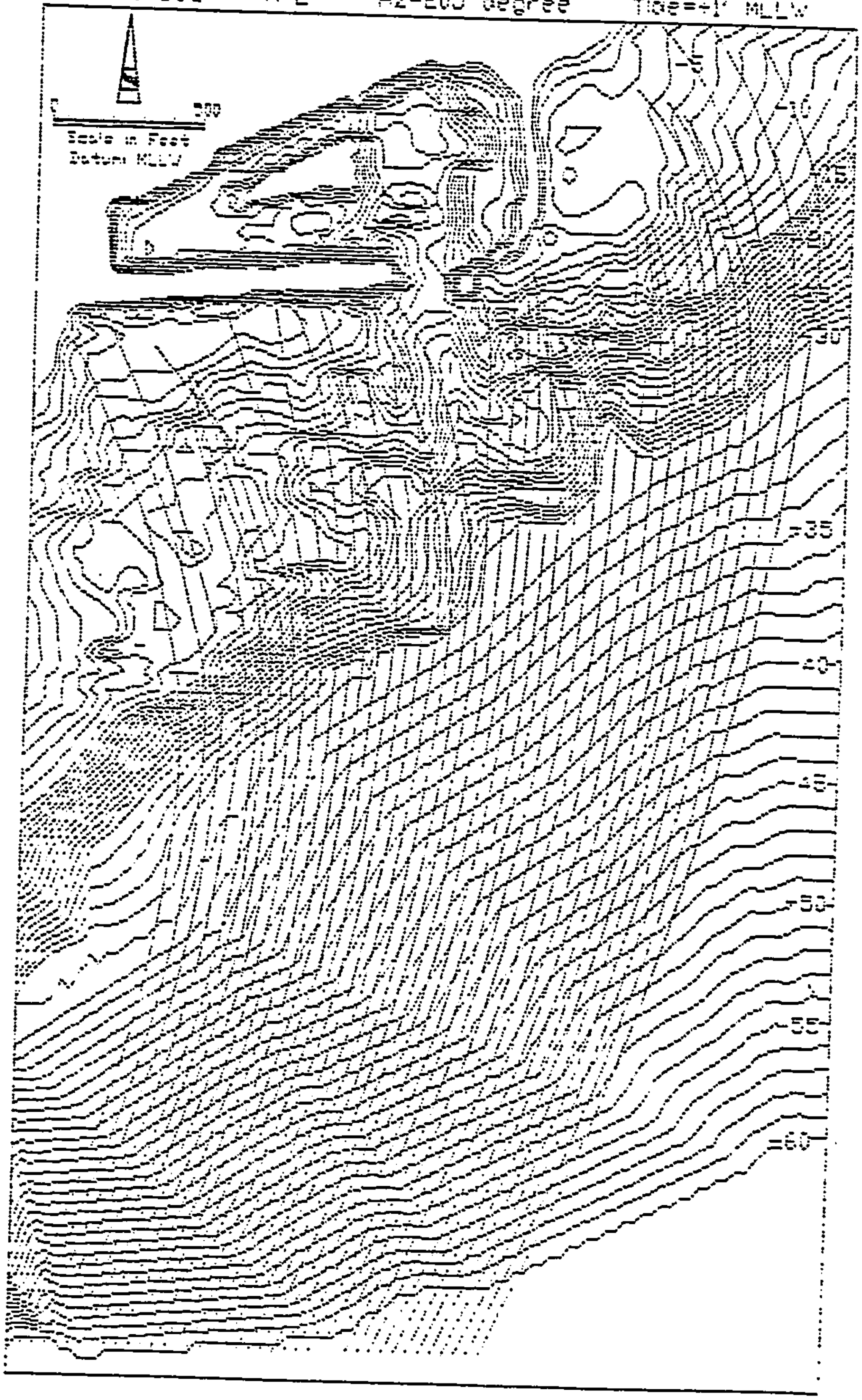

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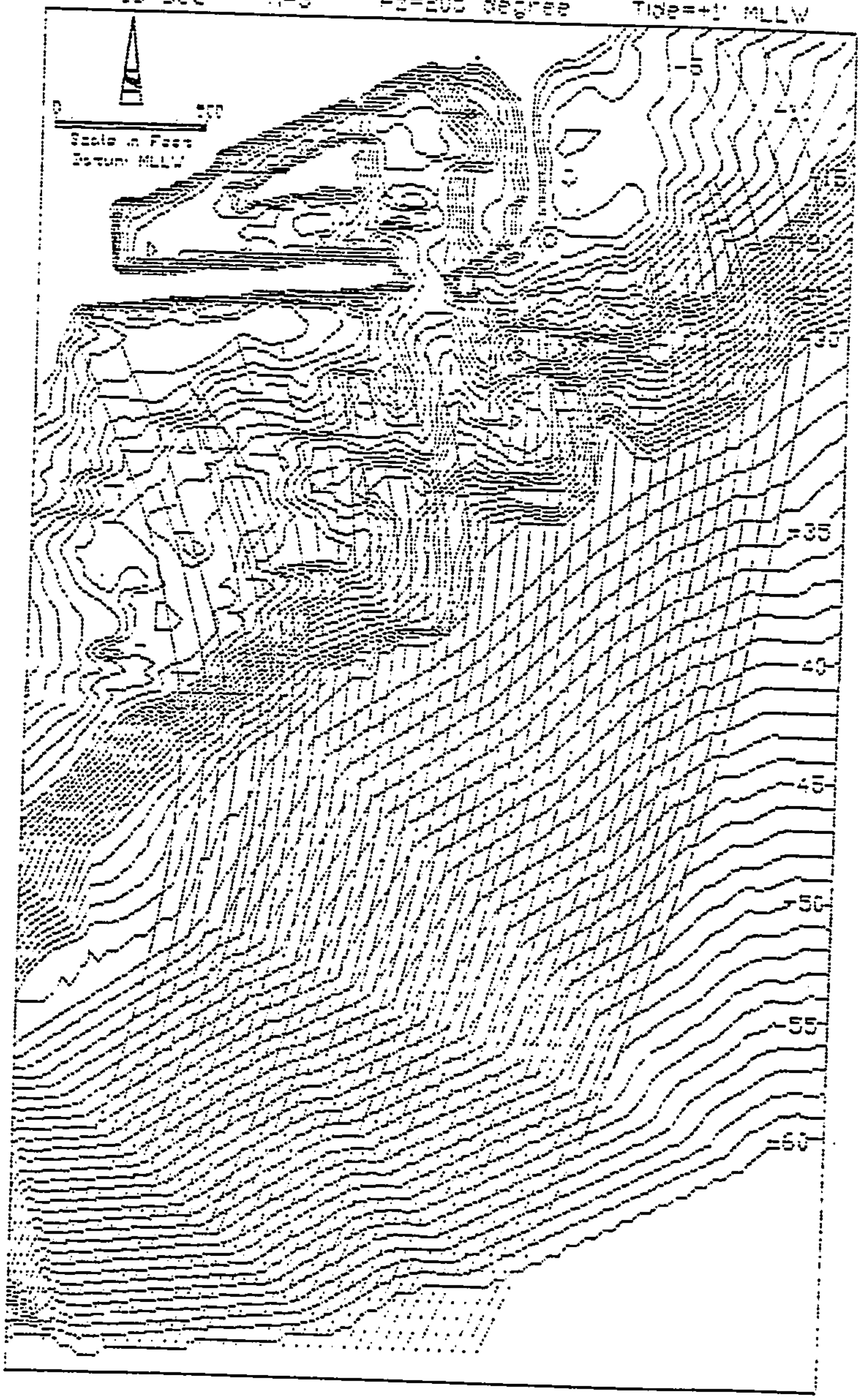

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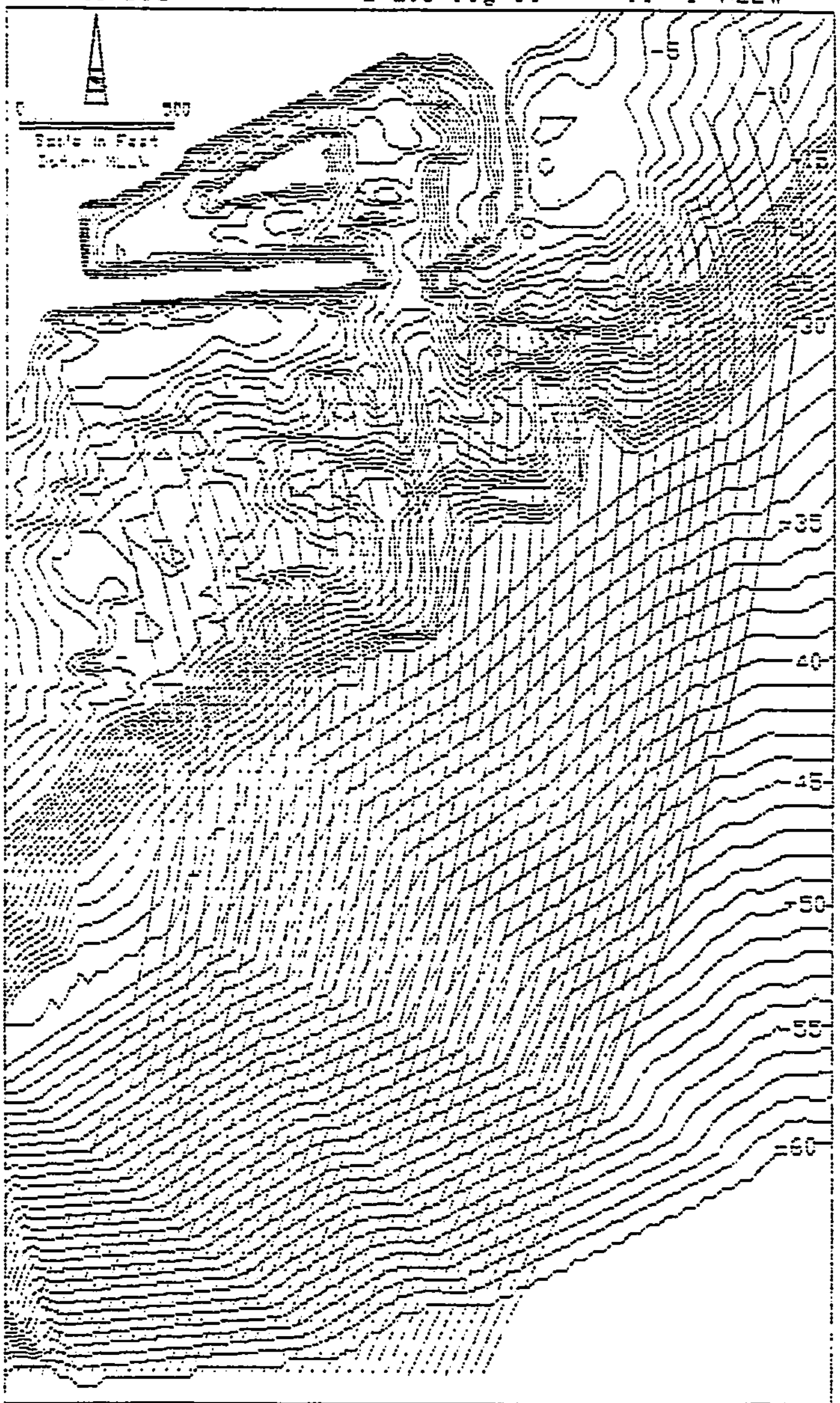

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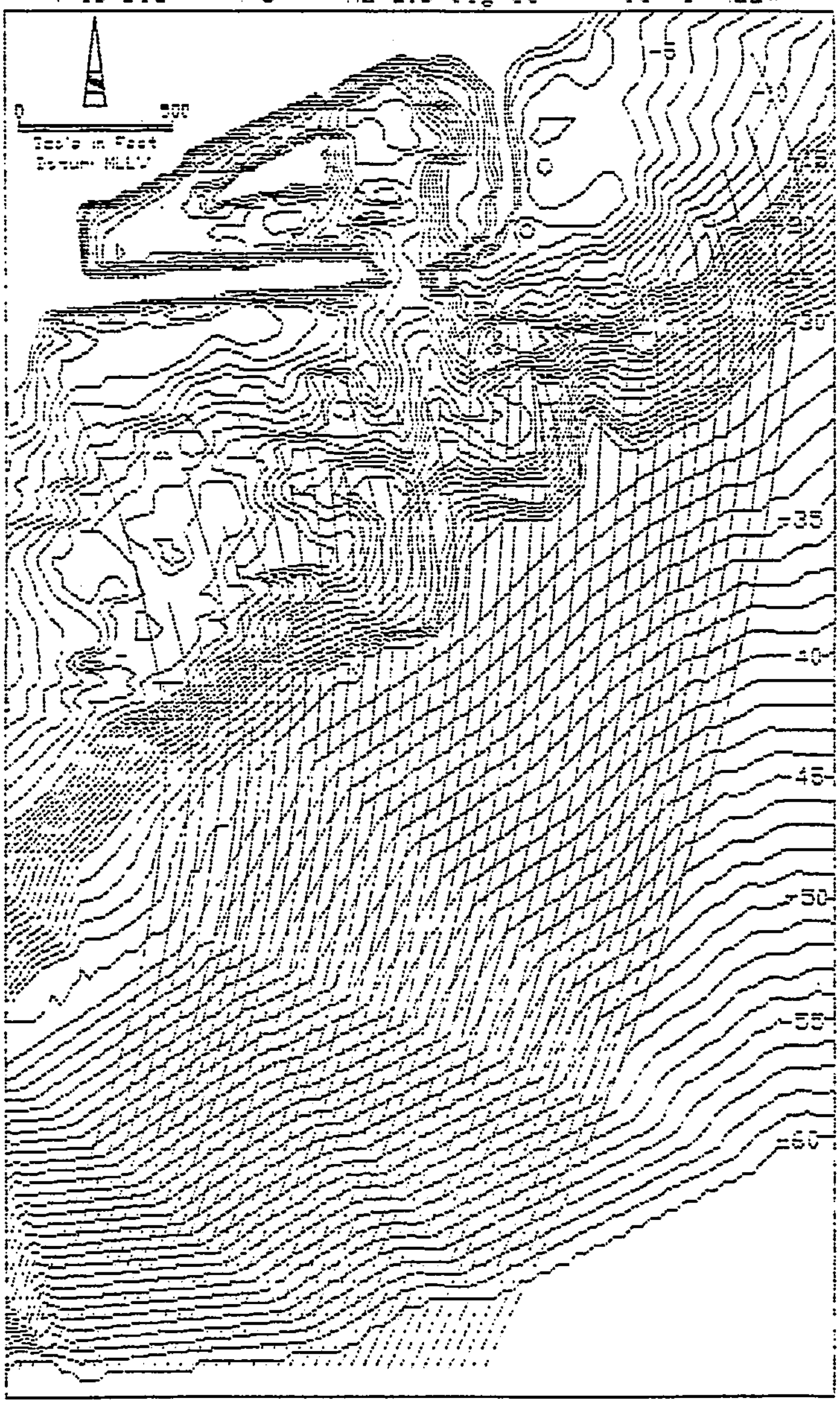

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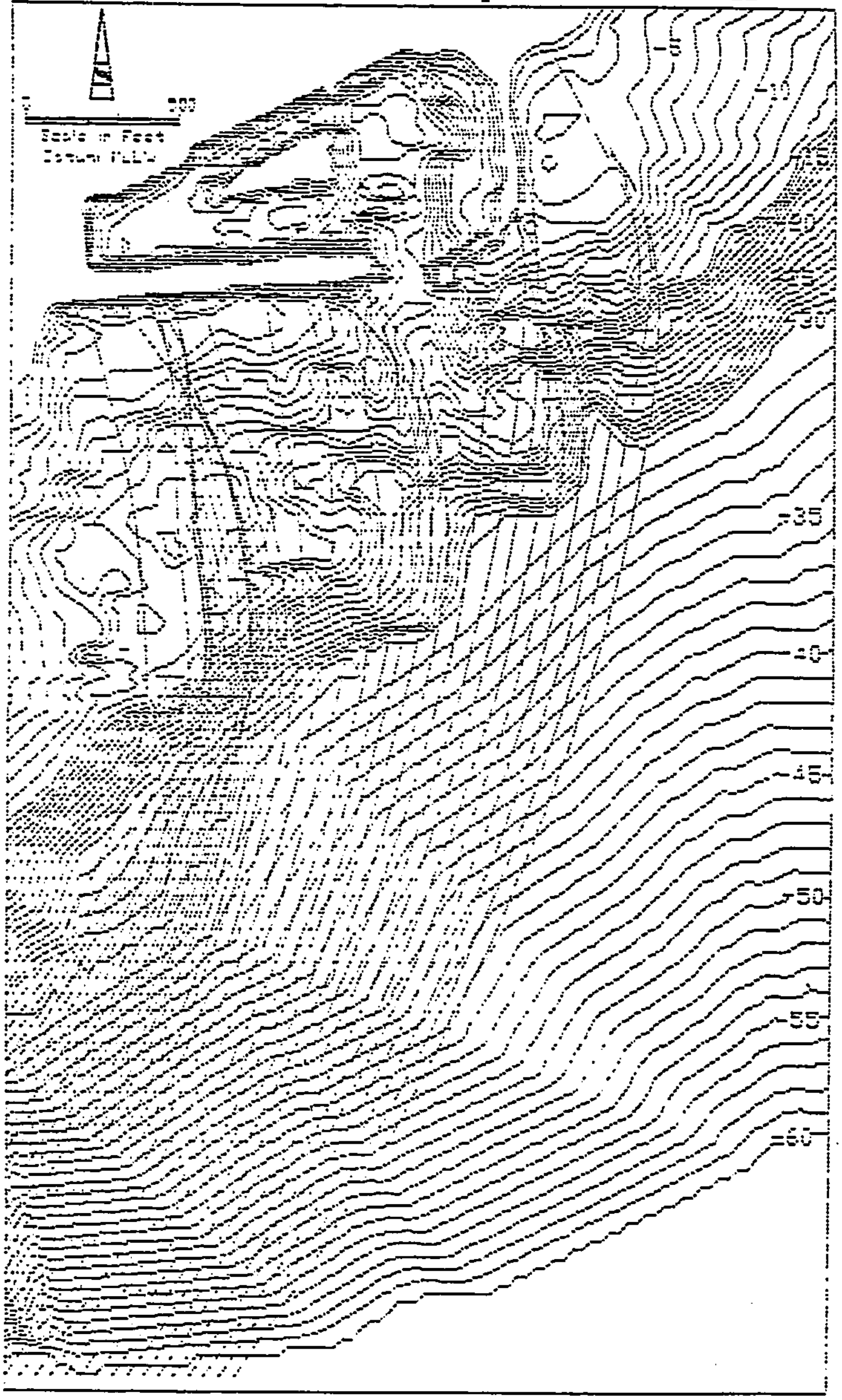

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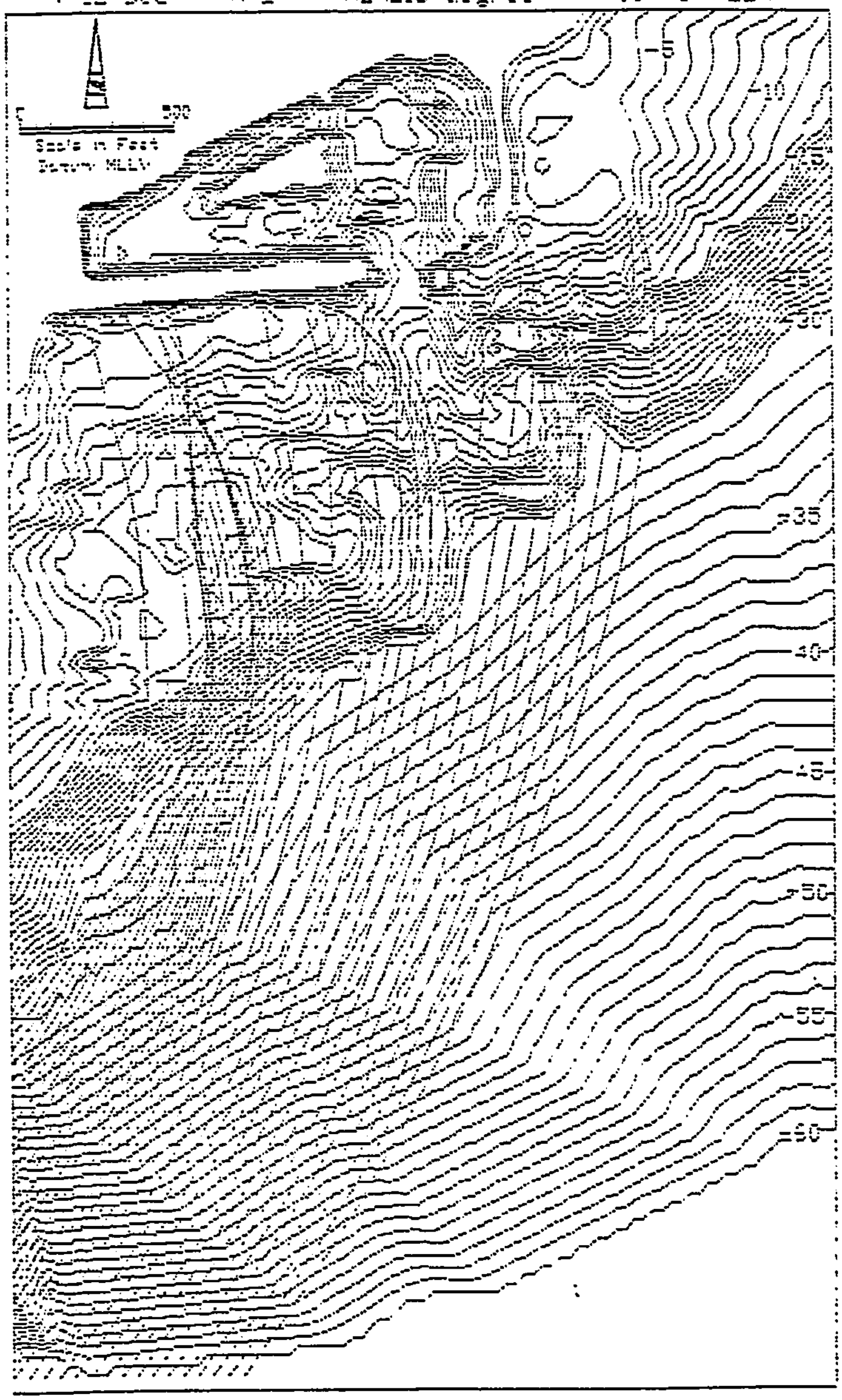

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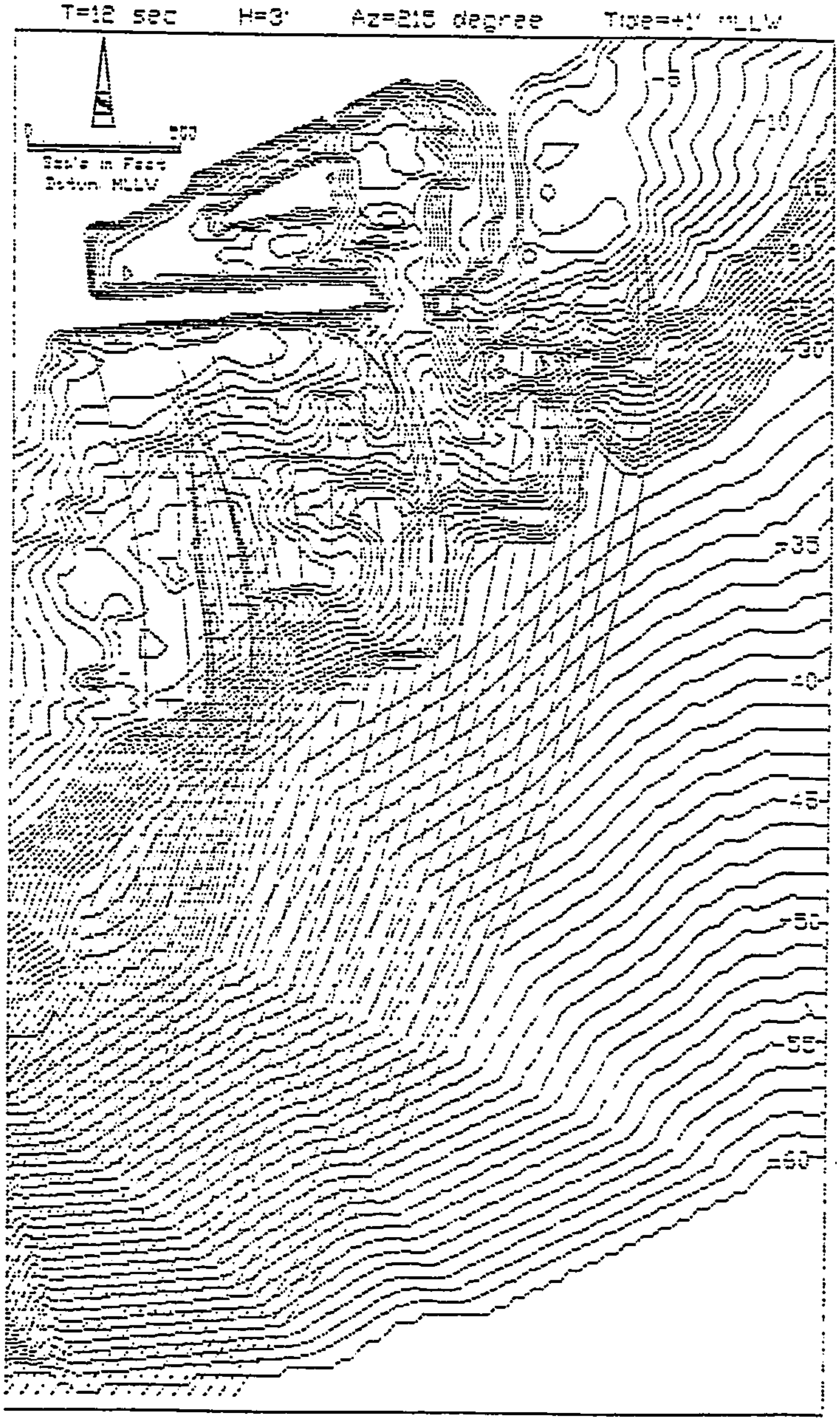

MAALAEA REFRACTION

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MAALAEA REFRACTION

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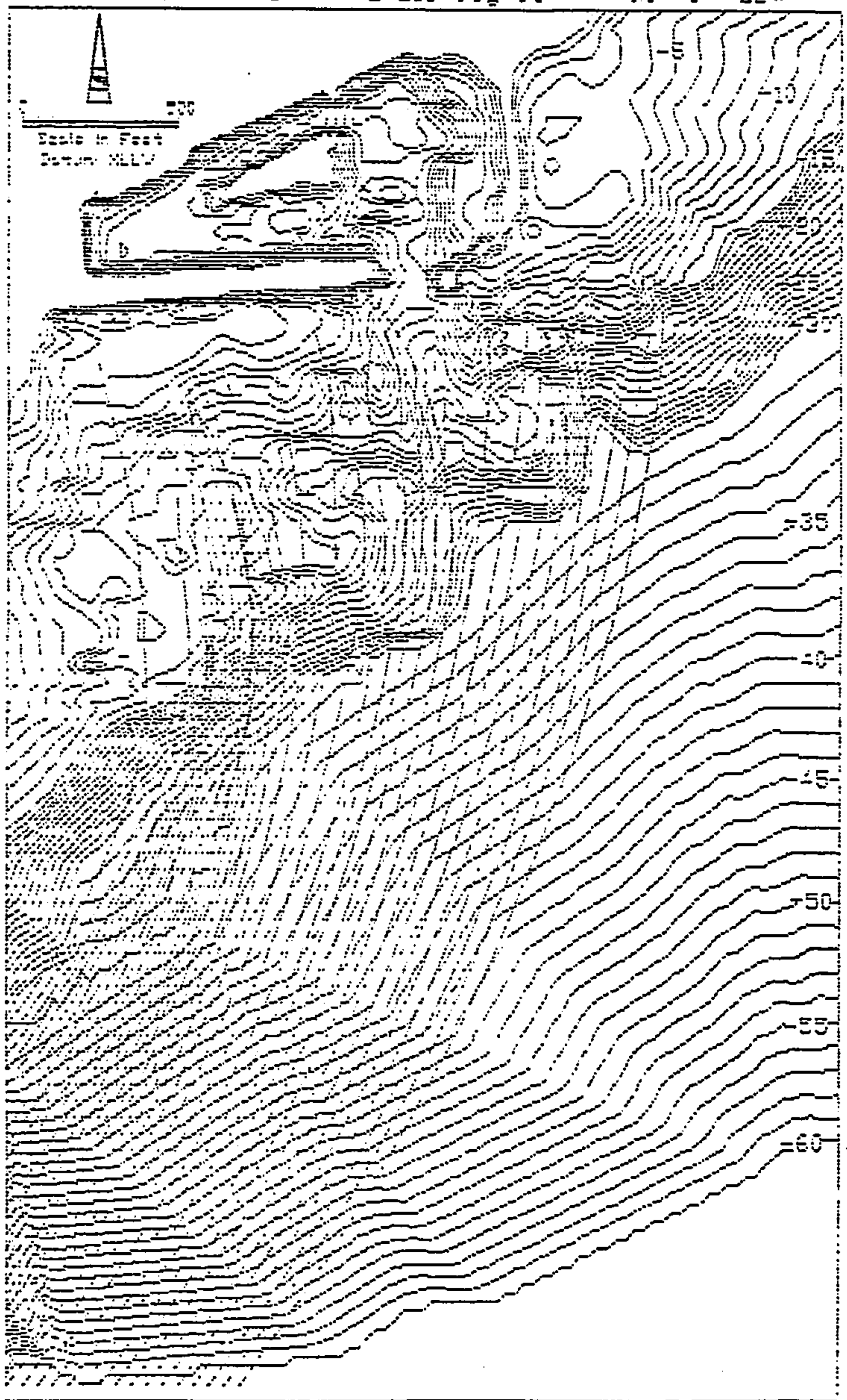

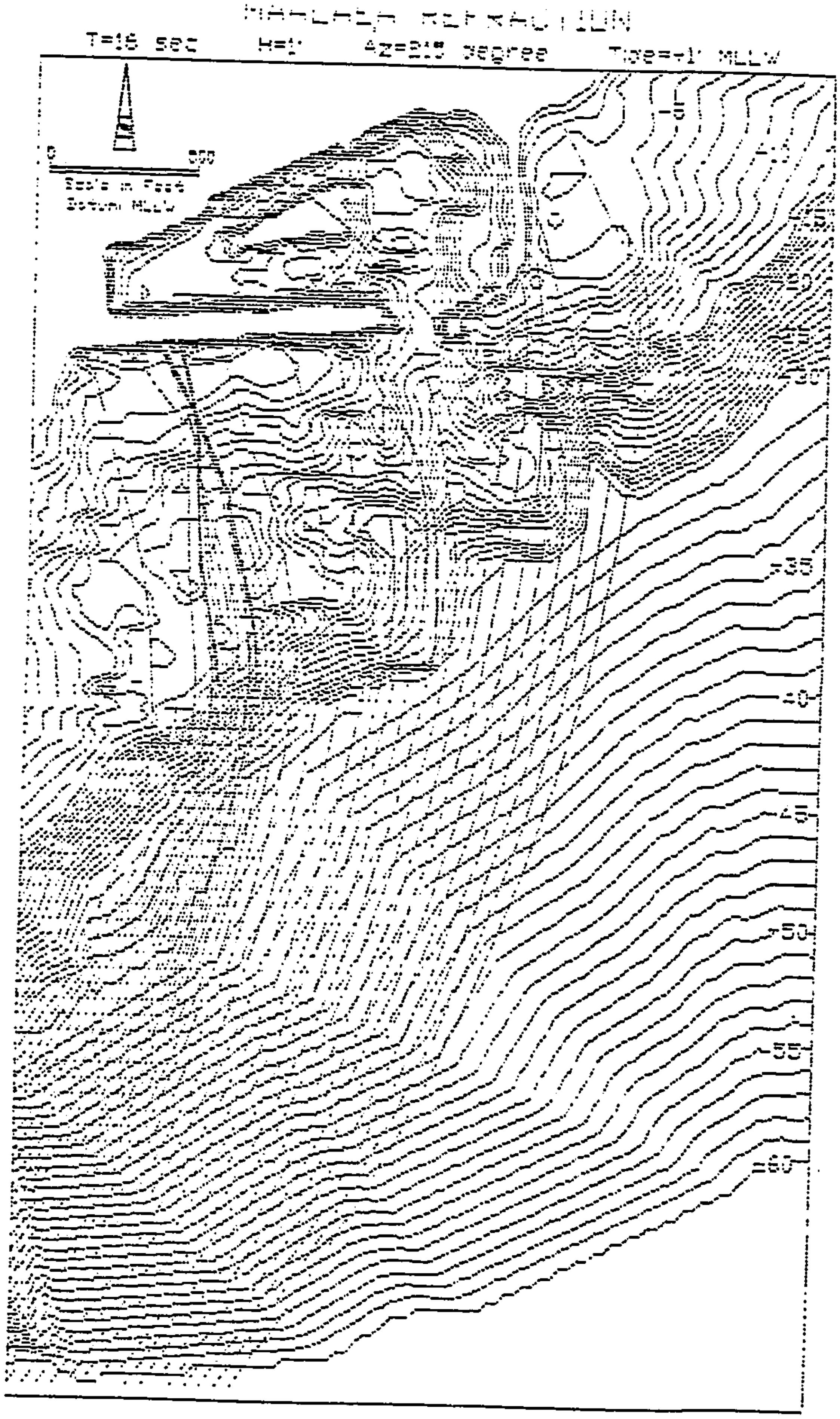
sec
Scale in Feet
Datum MLLW
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MAALAEA REFRACTION

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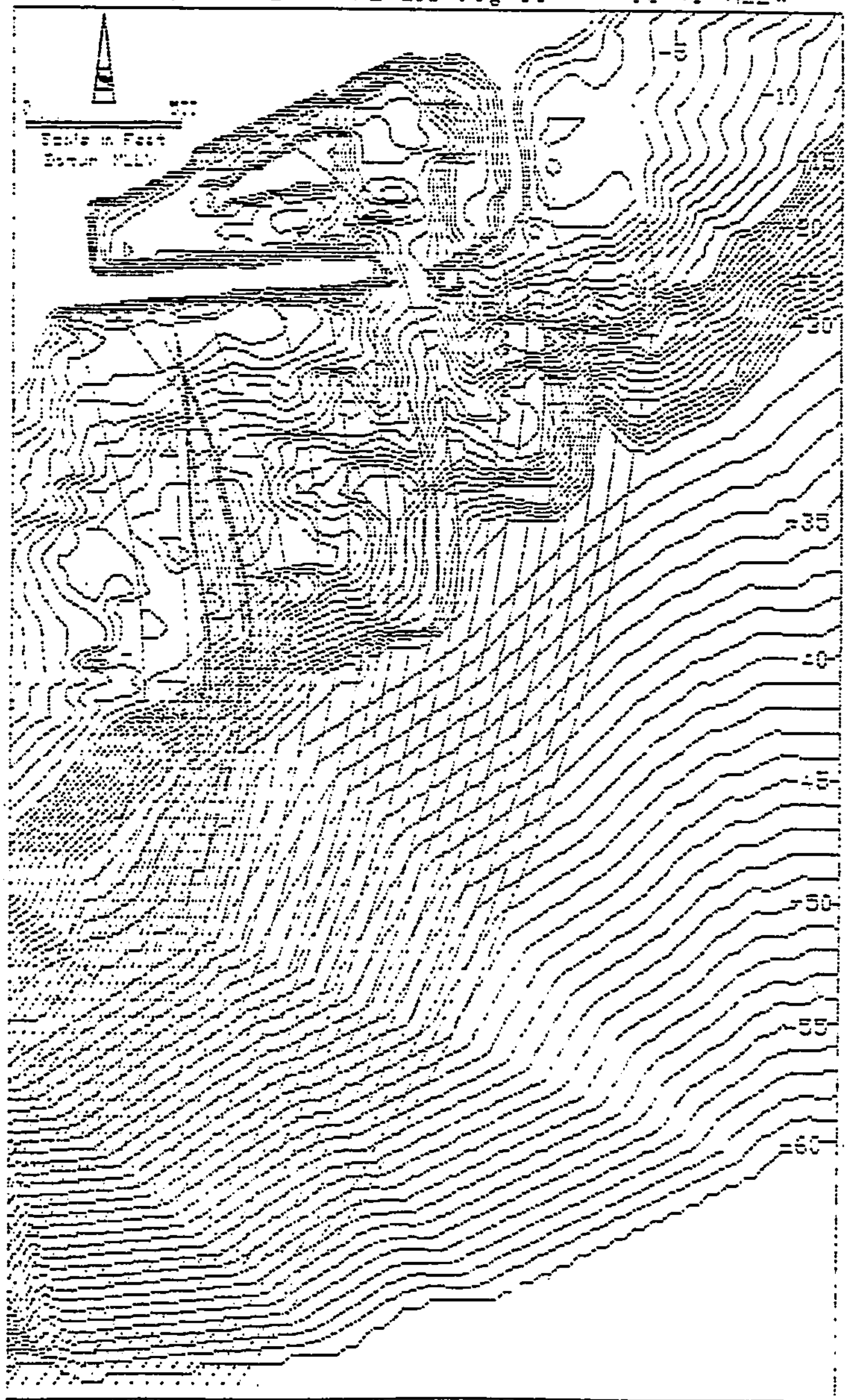

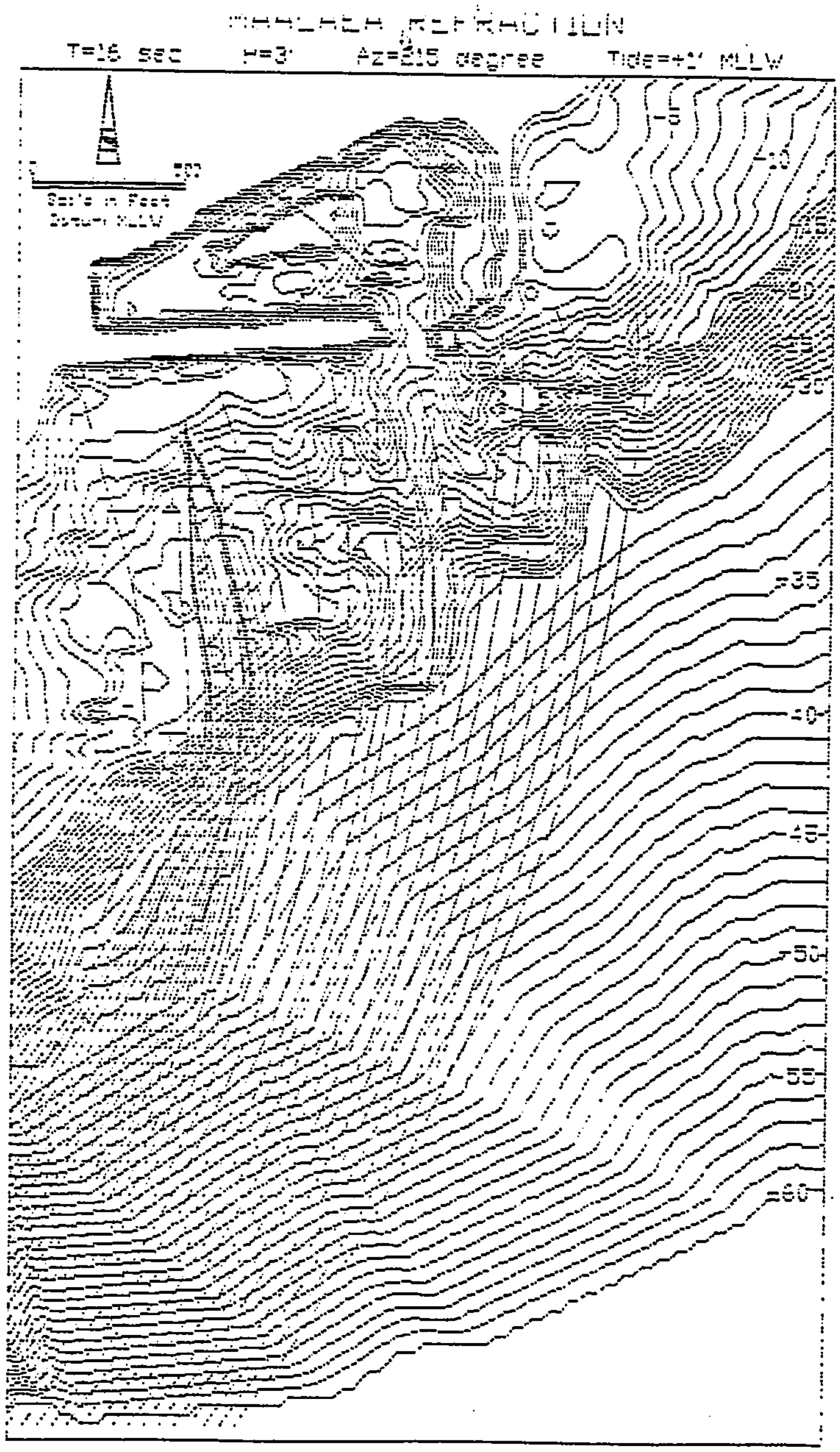
MAALAEA REFRACTION
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Scale in Feet
Datum MLLW
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MAALAEA REFRACTION

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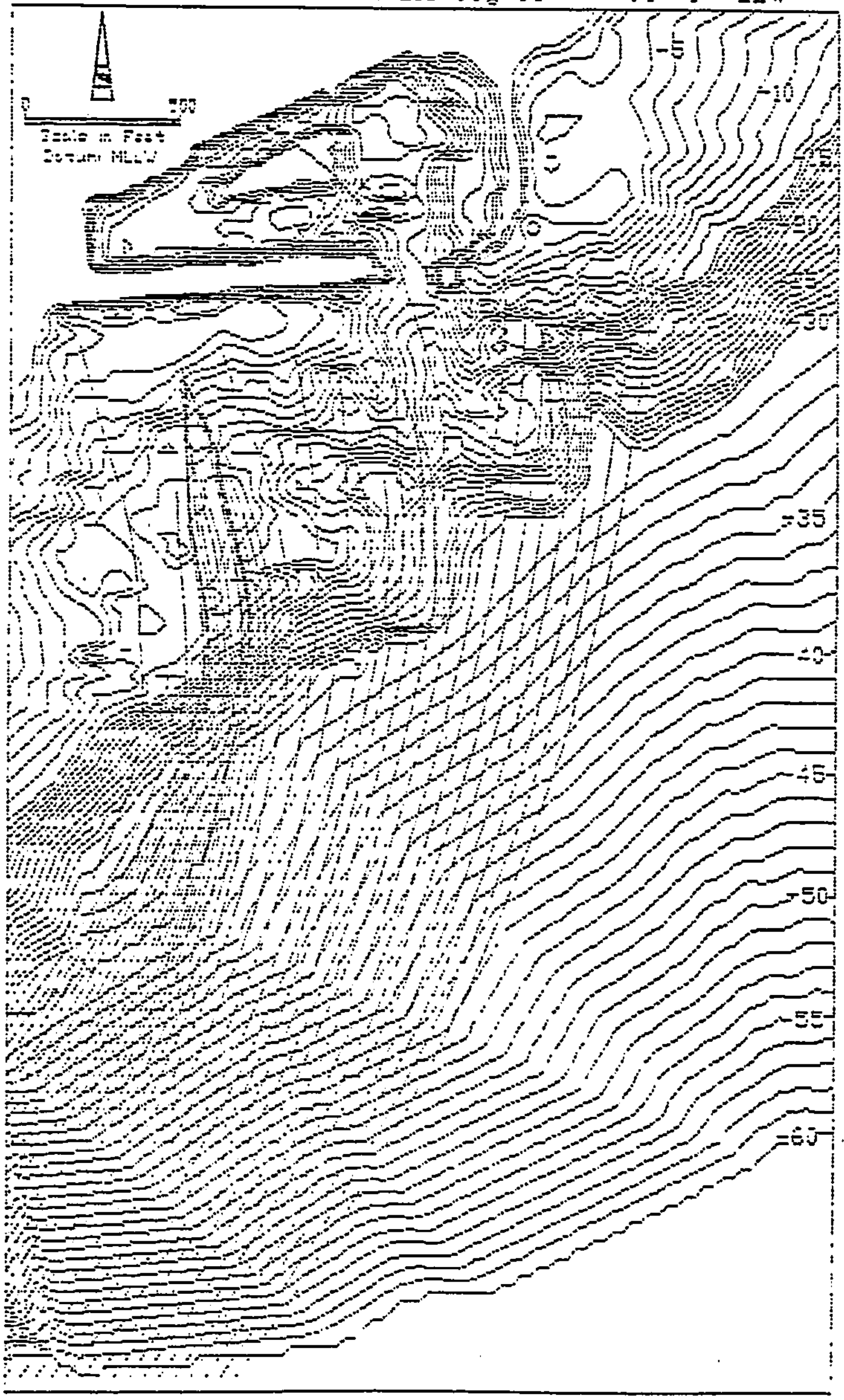

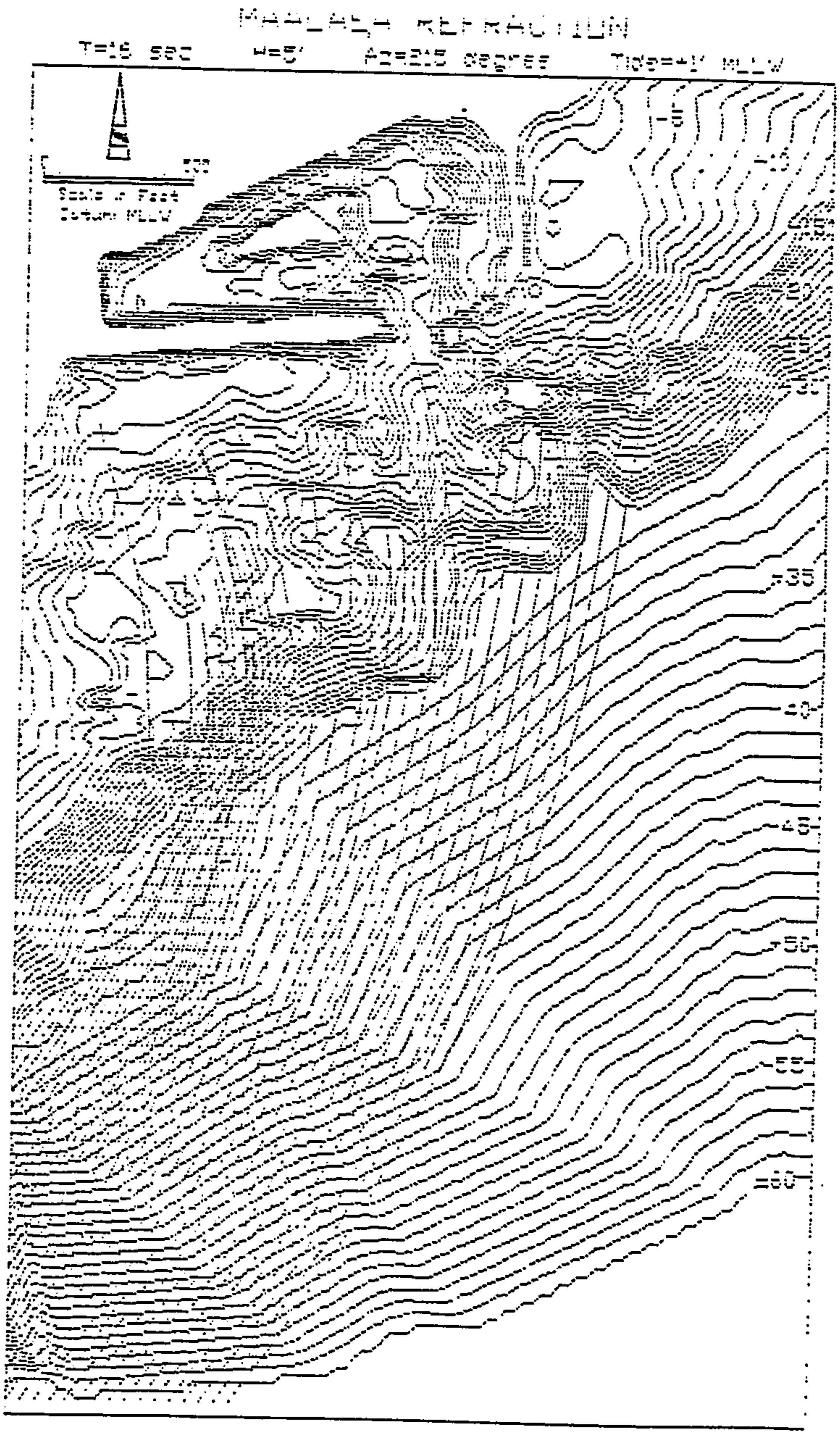
MAALAEA REFRACTION
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Scale in Feet
Datum: MLLW
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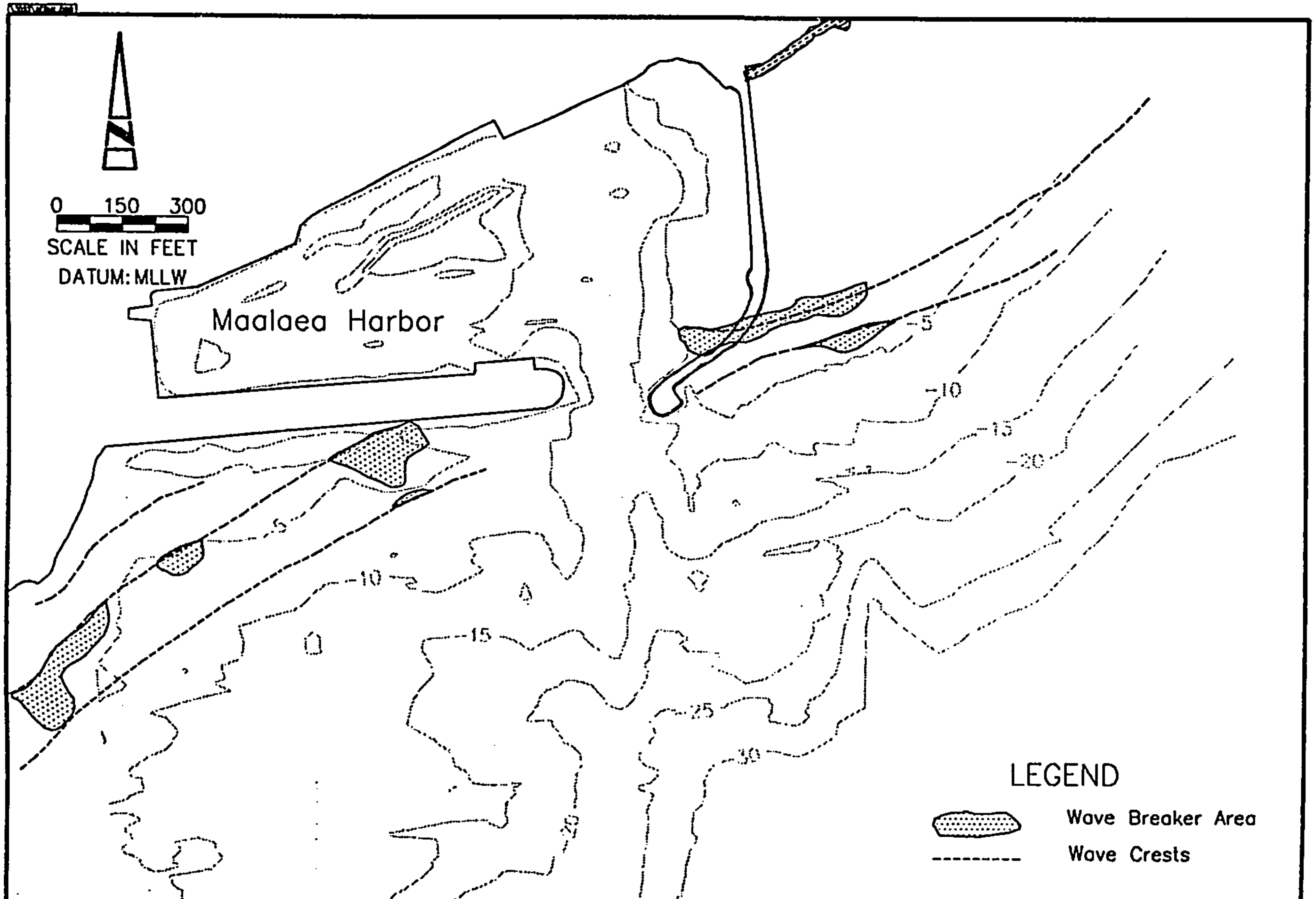
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60

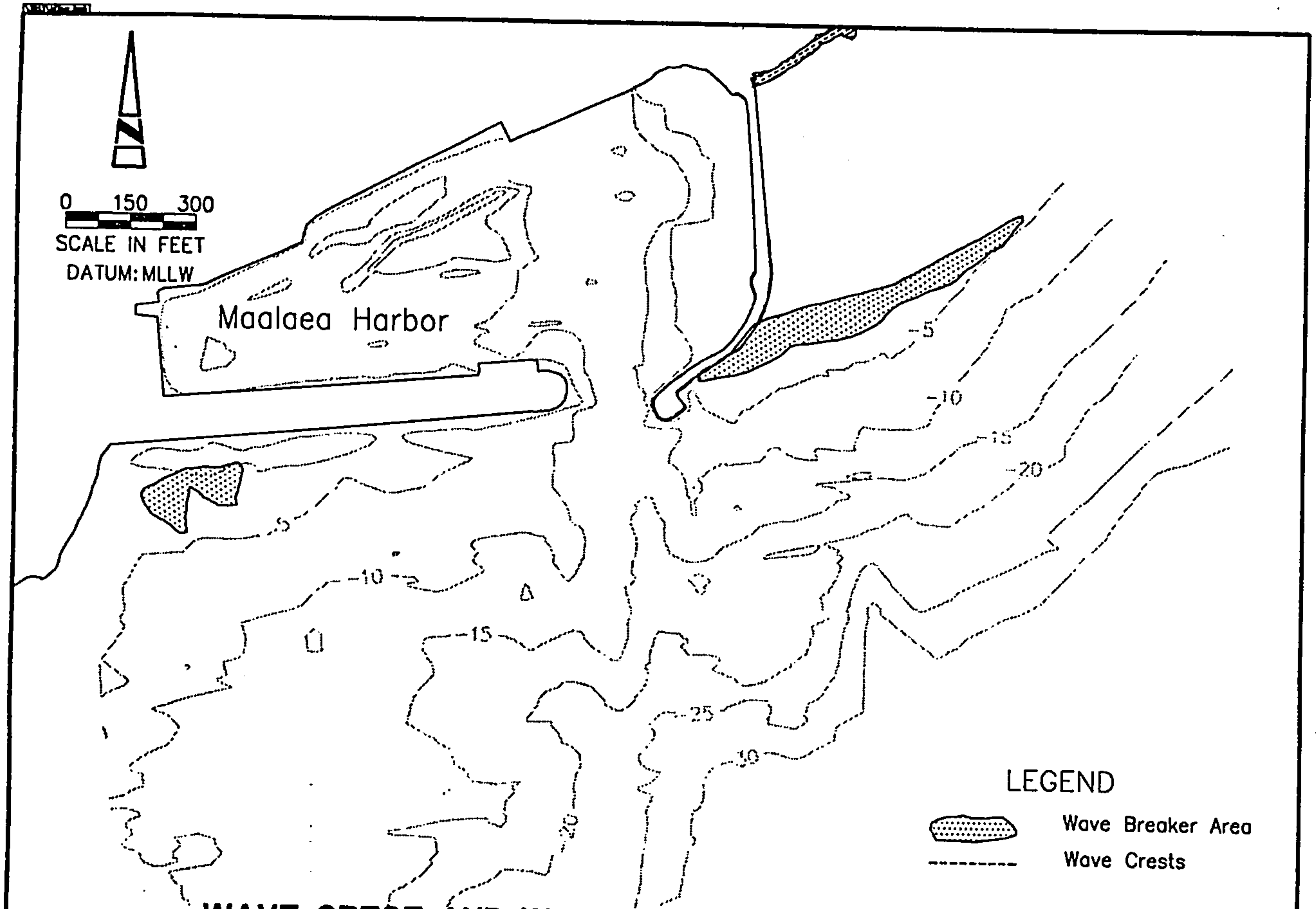
APPENDIX B

AERIAL PHOTOGRAPH DIAGRAMS

Aerial Photograph Diagram Index



WAVE CREST AND WAVE BREAKING AREAS-JULY 11, 1953



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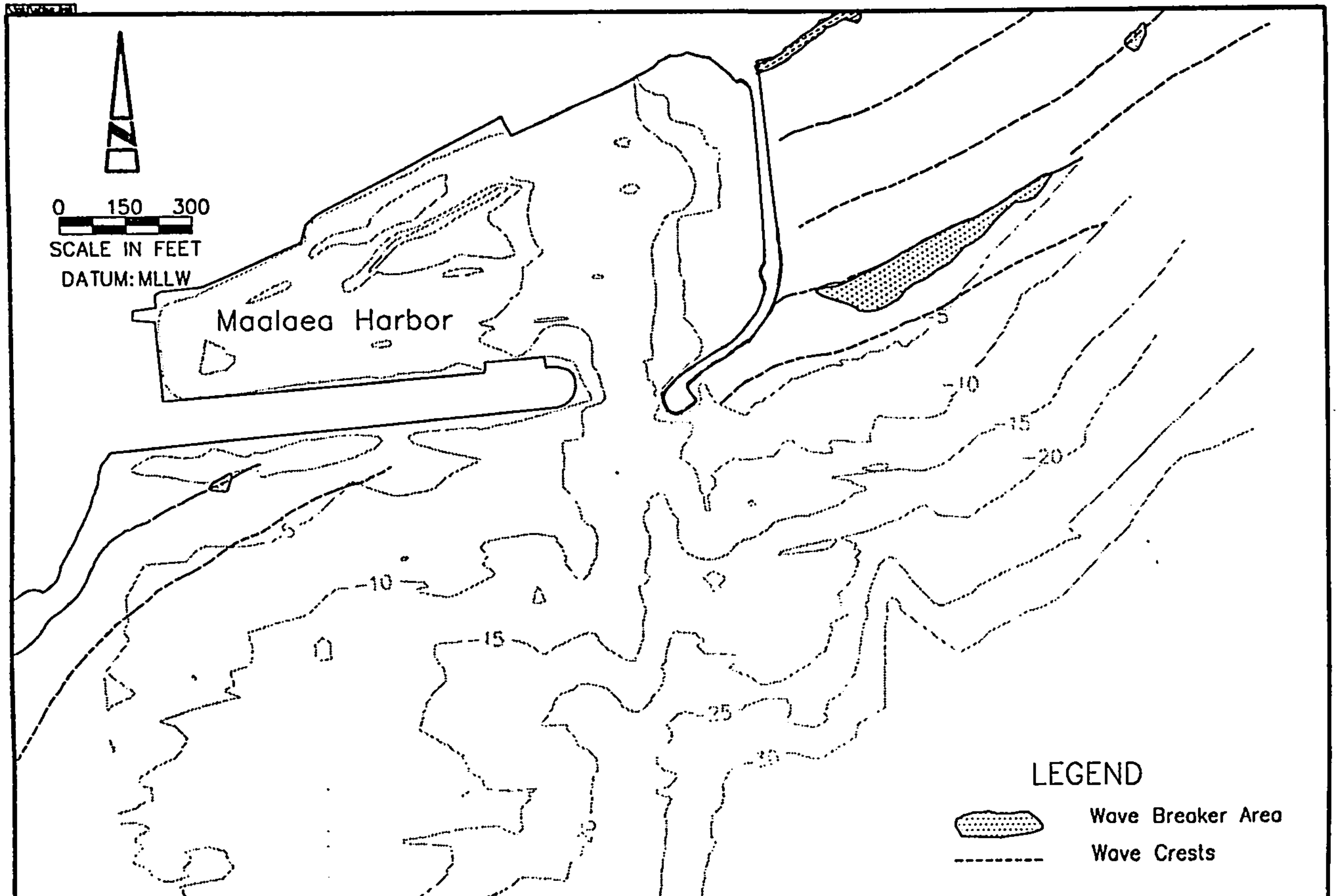

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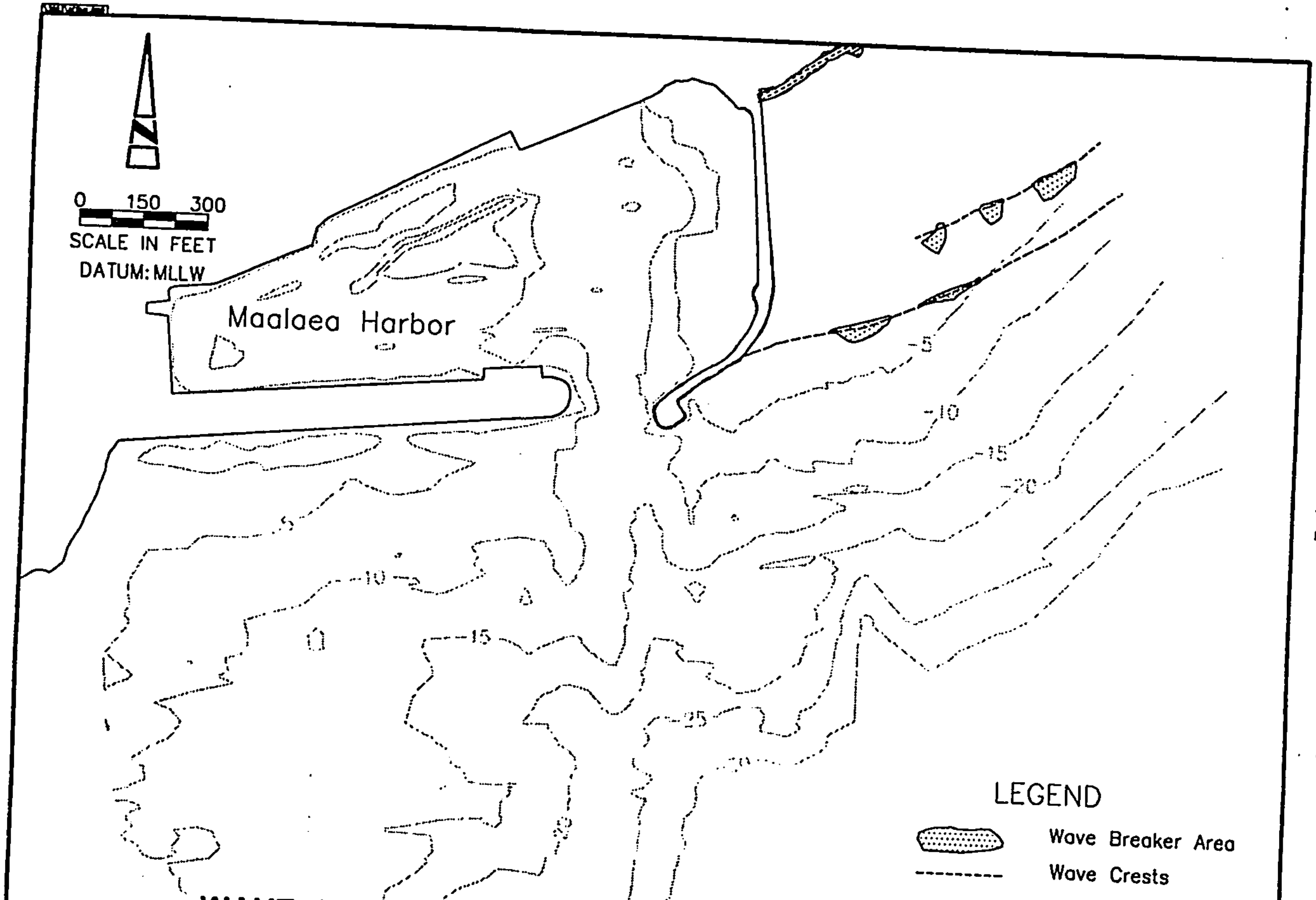

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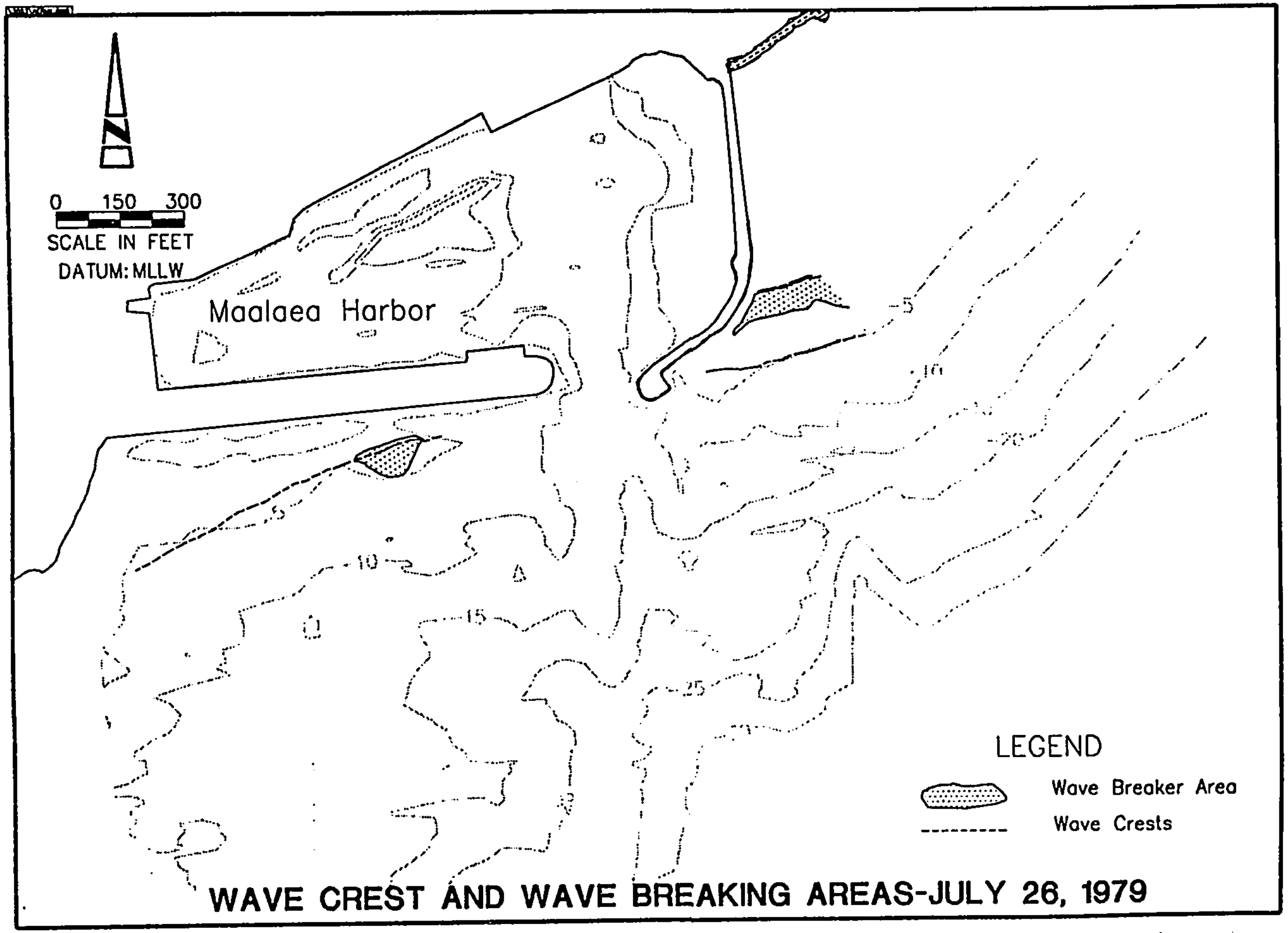

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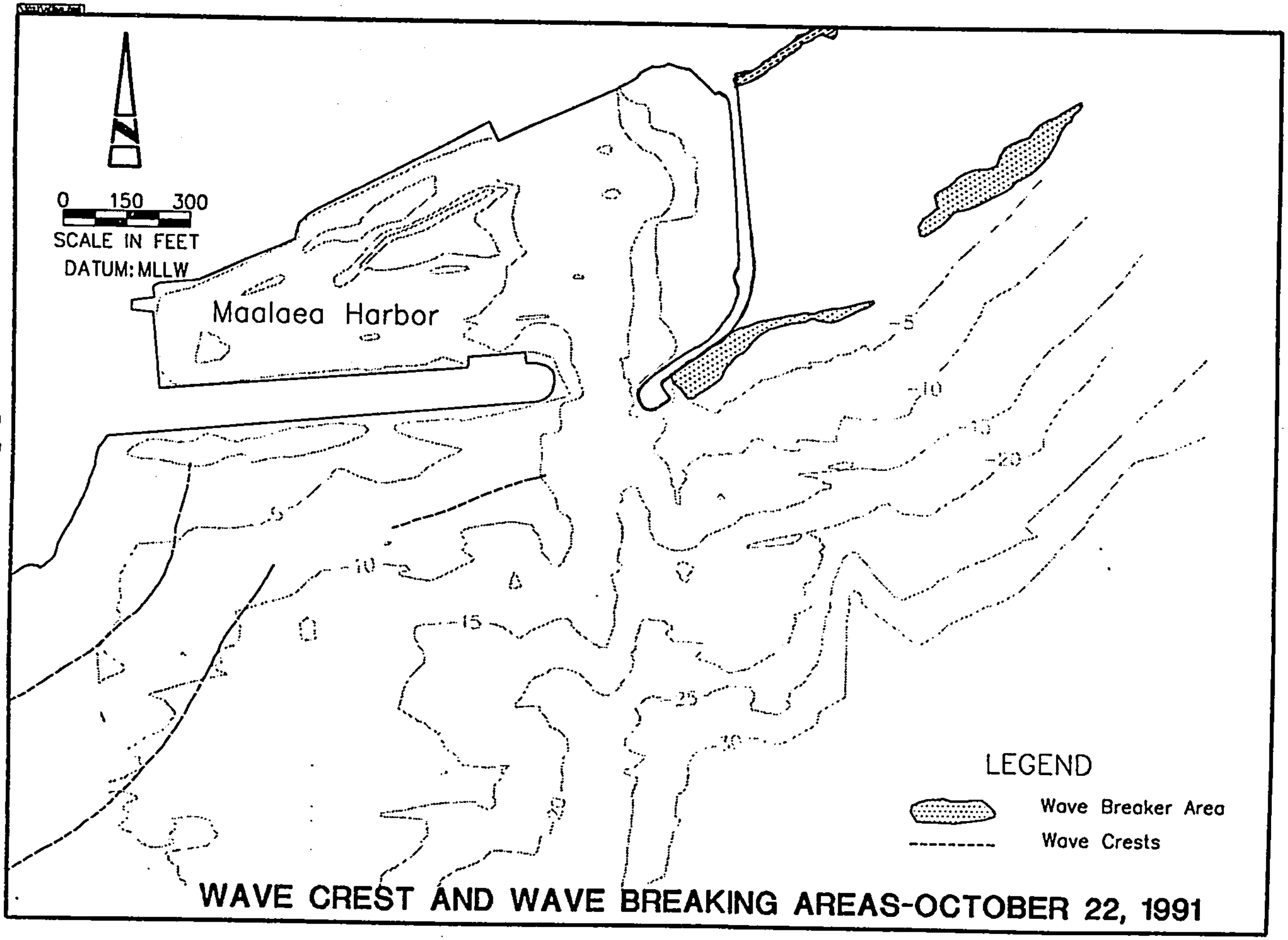

WAVE CREST AND WAVE BREAKING AREAS-OCTOBER 22, 1991

APPENDIX C GLOSSARY OF SURFING TERMS

Back-off - The termination of the broken wave's white water due to the wave's movement over an inshore trench or deep, diverging orthogonals, or a loss of wave energy caused by wave movement over a long, shallow reef. A breaking wave having an obtuse peel-angle.

Blown-out - A rough, choppy surface condition caused by a wind blowing with sufficient velocity to spoil the waves for surfing. If often implies a surface caused by a component of following wind.

Board surfing - Surfing in which a surfboard is utilized by the surfer.

Body surfing - Surfing in which no extra equipment, except possibly swim fins, are utilized by the surfer.

Bowl - A wave whose crest line is concave in the direction of wave advance due to converging orthogonals.

Break - The surf riding area; the breaking area.

Breaking area - That area outlined by the initial breaking point, the peel-lines, and shoreward limit of advance of the white water.

Channel break - A surf site adjacent to an easily distinguishable natural or man-made channel.

Close-out - A long section of the wave crest that breaks instantly. A section of a wave in which the peel-rate exceed the maximum speed of the surfer. A distinguishable section in which the peel-angle equals zero. Short, fast sections that a surfer is able to ride under would not be considered a "close-out."

Curl - That portion of the breaking wave between the breaking point and the point where the wave lip has touched the wave face. On a plunging wave, this curl region is very distinct, while on a spilling wave, this region is vague and often indistinguishable from the rest of the wave.

Face - See "Waveface."

Mat surfing - Surfing in which an inflatable mat is utilized by the surfer.

Mushy - A breaker form similar to that of a spilling wave; often associated with a blown-out condition.

Peak	- An easily distinguishable high point along a wave's crest line. It usually occurs just prior to a wave's initial breaking point.
Peel	- The wave's breaking point. A peel is said to peel right or left, depending upon the lateral direction the breaking point moves when viewed facing the direction of wave advance.
Peel-angle	- The included angle between the peel-line and a line tangent to the crest-line at the breaking point.
Peel-line	- The path described by the breaking point along the bottom as the wave proceeds shoreward. The outside boundary of the white water seen in aerial photographs very nearly describes the peel-line.
Peel-off	- See "peel."
Peel-rate	- The lateral rate of movement along the crest line. The peel-rate is classified as fast or slow based upon its relationship to a surfer's maximum speed.
Point surf	- A surf site adjacent to a point of land or promontory.
Riding distance	- The distance traveled from the surfer's take-off point to the end of his ride.
Section	- A distinguishable portion of a breaking wave where the peel-rate is fairly constant. Sections of breaking waves are classified as fast or slow, depending upon the peel-rate.
Shore-break	- A surf site very close to shore. Shore breaks usually have short rides that terminate at or near the beach.
Site line-up	- A marker or a series of markers, either natural or artificial used by surfers to position themselves in the proper take-off areas for a particular surf site.
Soup	- The turbulent region of the broken wave distinguished by the boiling white water or foam.
Surf site	- An area where surfers participate in the sport of surf riding on natural ocean waves. A surf site includes the take-off, riding, board-recovery, rider-return, and access areas.
Surfing	- The sport of utilizing a water wave to propel an individual. It can be likened to an individual sliding down a hill as the hill moves forward.
Surf shoal	- An area of the ocean bottom contoured so that waves break over it in a favorable surfing form.

Take-off area - The region of a surf site where surfers catch waves. It usually occurs just seaward of the initial breaking point.

Tube - That portion of the breaking wave between the breaking point and the point where the white water defines the fully broken wave. For a plunging breaker, the tube area becomes greater as the peel-angle decreases.

Wall - A nearly vertical wave face. A wave is often said to be "walling up" as its forward face approaches the vertical.

Wave crest - The highest point of a wave.

Wave crest-line - The lateral line described by the wave crest at any instant in time. Wave patterns are distinguished by crest-lines in aerial photographs.

Wave face - The water surface in front of the wave's crest. In most cases for surfing waves, the face is the water surface from the wave crest forward to the point where the water surface is nearly horizontal.

Wave height - The vertical distance from the preceding trough to the following wave crest. In the surf zone, wave height is usually estimated vertically from the point where the water surface is horizontal to the following wave's crest.

Wave line-up - The relationship between the wave's direction of advance and its breaking characteristics at a particular surf site. A good wave line-up implies that the direction of the wave advance corresponds well with the bottom topography at the particular surf site and results in well-formed surfing waves.

Wave lip - The wave's upper leading edge in the curl region.

Wave shoulder - That surfable portion of the wave outside the white water, curl, and wall regions; usually considered the safe riding area for a surfer. On waves with a long "wall" area, the wave shoulder begins after the wall ends.

Wave steepness - In traditional engineering terms it is the ratio of wave height to wave length (H/L). To the surfer, it refers to the attitude or slope of the wave's face. A steep wave would be one with a nearly vertical wave face.

White water - See "soup."

Wipe out - To fall off a surfboard.

APPENDIX B

ASSESSMENT OF RECREATIONAL SURFING SITES
MAALAEA SMALL BOAT HARBOR
MAALAEA, MAUI, HAWAII

Prepared for

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September 1992

1.0 INTRODUCTION

1.1 Purpose.

This surfing site survey was undertaken to provide background information for the Pacific Ocean Division, U.S. Army Corps of Engineers. The information is intended to assist them in addressing environmental and social concerns regarding proposed navigational improvements to Maalaea Boat Harbor.

1.2 Scope.

The scope of work included:

1. Observing surfing conditions and existing interferences.
2. Interviewing local surfers.
3. Identifying the potential population of recreational surfers affected by the project improvements.
4. Assisting other consultants in comparing anecdotal information with data analyses regarding:

   a. Plotting surfing sites from historical aerial photographs.
   b. Outlining the locations of surf sites under various wave conditions.
   c. Analyzing potential impacts of harbor structures upon breaks including both direct and indirect encroachment.

1.4 Survey Methodology.

Anecdotal information for this survey was gathered from interviews and sites visits with: Ben Bland and Elden Chang, Maui surfers who are members of the Hawaiian Island Surfing Society; Robert Jensen, a Maui surfer and former professional bodyboarder; Tom Stone, a big wave surfer and former Maui resident, now a City and County of Honolulu lifeguard; Joe Tiepel, a Honolulu surfer and bodyboarder and owner of the Surf News Network, and surfing photographers Erik Aeder of Maui and Steve Wilkings of Honolulu. Material for this report was also gathered from a standard literary search of appropriate books and periodicals. These are listed in the References section.

2.0 Physical Conditions.

2.1 Maalaea Bay and Beach.

Maalaea Boat Harbor, the project site, is located in the western corner of Maalaea Bay. South of the harbor the shoreline consists of low to medium high sea cliffs, while east of the harbor the shoreline is a low vertical seawall fronting the condominiums and then a continuous white sand beach. The beach is approximately four miles long, averages 75 to 100 feet in width, and is backed by low dunes. According to Moberly and Chamberlain, " Sediment-filled salt ponds, now lithified, form the backshore." Some of these ponds are intermittently flooded during the winter and spring. Kealia Pond behind the north end of the beach is a permanent body of water although its size varies seasonally.

The nearshore bottom along most of the beach is predominantly sandy with scattered patches of rock. Well developed coral reefs are concentrated in the west end of the bay on either side of the harbor's entrance channel. Live corals, invertebrates, crustaceans, gastropods and fish populations are abundant on these reefs.

2.2 Swell Directions

Maalaea Bay faces directly south, so most of the surf at the surfing sites in the bay is generated by storms in the Southern Hemisphere, South Pacific low pressure areas. The swells from these storms arrive in Hawaii during the summer months and produce Hawaii's "summer surf." This surf may appear as early as April and as late as September, but is most prevalent during May, June, July, and August. Wave heights of 4 to 6 feet are common during a summer swell, and occasionally heights of 10 feet or greater occur.

Tropical storms (winds of 35 to 64 knots), hurricanes (winds of 65 knots or greater) and Kona (southerly) storms also generate surf in Maalaea Bay, but surf from these sources is infrequent. Tropical storms and hurricanes usually occur during the summer months while Kona storms usually occur during the winter and spring months. The size and ridability of the surf generated by these storms depends on the intensity, location, and duration of the storms.

In order for a south swell to reach Maalaea Bay, it must clear the islands to the south of Maui. A direct south swell apparently passes the Big Island and comes through the Alalakeiki Channel between Maui and Kahoolawe, while southwest swells reach the bay through the Kealaikahiki Channel between Kahoolawe and Lanai. The Big Island apparently blocks most swells from the southeast. Not all south swells that strike the Hawaiian Islands, therefore, produce good surfing waves in Maalaea Bay, and it appears that those swells arriving from due south and to a lesser extent from the southwest produce the best surfing waves. Almost any south swell, however, will generate surf at most of the surfing sites within the bay, and all of these sites are surfed when waves heights are two feet or greater.

2.21 Regional Winds

In Hawaiian waters strong, gusty trade winds blow from a northeasterly direction and prevail throughout most of the year, especially during the summer months. From June through August, the trades prevail over 90 percent of the time and often have direct impacts on local surfing sites. Although Maalaea Bay is not in the direct path of the trade winds, it is affected by them.

Maui consists of two major volcanoes, West Maui and Haleakala or East Maui. When lavas from Haleakala banked against the already existing West Maui volcano, a broad, gently sloping plain, the Maui Isthmus, was formed, connecting the two volcanoes. The trade winds blow into the northern side of the isthmus with great force, evidenced by the extensive, 200' high sand dunes found near Kahului Harbor. Although Maalaea Bay is on the southern side of the isthmus, the trade winds striking the northern side are funneled through the gap between East and West Maui and accelerate as they cross the isthmus. These accelerated winds strike Maalaea Bay with great force and directly impact the surfing sites in the bay.

For the majority of the surfing sites, including the Maalaea Pipeline, the wind blows directly into the face of the breaking waves. This "holds up" the waves, making them more difficult to catch. Surfers must paddle longer and harder on their initial take-off to overcome the force of the wind blowing against them. The wind also agitates the surface of the ocean and the face of the waves by creating chop, short broken waves. Chop presents surfers with a rough wave face rather than the preferable smooth wave face and often inhibits the ride, causing bumpy rides and falls. The Maalaea winds occasionally are forceful enough to discourage surfers from surfing. Generally, the winds tend to be lighter in the early mornings and late afternoons and heaviest at midday and in the early afternoons. Many surfers take advantage of this phenomenon by surfing either early or late in the day and avoiding the midday winds.

The best surf in Maalaea Bay, surf generated by south swells, occurs during the summer months when the trade winds are also most prevalent. As a result, high surf and strong offshore winds often occur concurrently.

2.3 Surfing Sites Within the Project Area.

Three surfing sites are located within the Maalaea Harbor project area: the Maalaea Pipeline, Off-the-Wall, and Buzz's. They are identified on the map by name.

2.31. Maalaea Pipeline.

<u>Location</u>. The Maalaea Pipeline or the Pipeline is also sometimes called Maalaea or Maalaeas. The break is located on the reef offshore the east breakwater and extends east fronting the condominiums in Maalaea Village. The break was named the Maalaea Pipeline because waves forming on the shallow reef are often hollow as they plunge forward. To a surfer in the water

looking into these waves as they break, each wave can be imagined to resemble a pipeline. This is the same phenomenon that lead to the naming of the world famous Banzai Pipeline on Oahu's North Shore.

Access. The Maalaea Pipeline is accessed primarily from the shoreline inshore of the east breakwater. Surfers park at the harbor and walk on the breakwater until it begins to curve toward the entrance channel. At that point they climb down the breakwater and paddle out to the lineup through a small channel between the Pipeline and Off-the-Wall. The breakwater access is used when surf heights are under six feet. Surf heights over six feet close out the entry channel. During periods of high surf the Pipeline is accessed from the entire shoreline fronting the condominiums through several public rights-of-way and from Haycraft Park at the end of the paved road. Surfers reach the surfing site from these accesses by paddling around the east end of the break.

Characteristics. Surfers characterize surfing breaks by the direction in which they ride the wave, either to their left or to their right. A wave that peels to their left is called a left slide or simply a left, while a wave that peels to their right is called a right slide or simply a right. The Maalaea Pipeline is a steep, hollow, plunging right that offers one of the longest rides in the Hawaiian Islands and possibly in the world. For this reason the break is recognized by surfers around the world as a surfing site of international significance. Surfer Magazine (established in 1960) has ranked it as one of the ten best waves in the world and the fastest breaking right in the world.

The initial take-off point of the Maalaea Pipeline is offshore the east breakwater, approximately five hundred feet east of the entrance channel. The distance of the initial take-off point from the breakwater varies, depending on the size of the swell, moving inland and closer to the breakwater during smaller surf and moving seaward and farther away from the breakwater during larger surf. On a day when the waves are six feet or higher and striking the reef at just the right angle, an expert surfer on a fast board can ride the entire length of the wave from the initial take-off point to the end of the wave. Under ordinary conditions, however, especially when wave heights are six feet or smaller, the waves tend to form at least four sections, each of which breaks so fast that most surfers cannot complete the entire ride if they catch the wave at the initial take-off point. Under ordinary conditions, each section will usually have its own take-off point. For this reason there are often at least four groups of surfers spread along the entire length of the lineup with one group at each take-off site.

Expert surfers have ridden the Pipeline at wave heights of ten feet and greater. They note that even during periods of high wave heights, the break does not close out and can hold any sized wave. High surf apparently does not break across or close out the entrance channel.

The Pipeline is normally a long, straight wave, and only begins to wrap or curve shoreward in its last section. The last section is known to some surfers as Corners and attracts surfers of novice and intermediate abilities who are not as adept at completing a wave from the inner sections and occasionally bodyboarders.

Currents. There are no significant rip currents in the vicinity of the Maalaea Pipeline during periods of high surf. The major water movement is a lateral drift to the east along the front of the breakwater. Waves striking the breakwater are normally reflected to the east, creating a lateral drift as they flow along the breakwater and over the shallow reef (as shallow as one foot at low tide in some places). This drift dissipates as the water depth over the reef deepens beyond the breakwater.

Reflected Waves. Reflected waves from incoming surf striking the breakwater and returning seaward are common inshore of the Pipeline. These waves often interface with the whitewater of incoming waves, but normally do not interfere with the riding face of the waves in the lineup. Some interference on the wave faces may occur when the waves are small, 2-3 feet, and the lineup is in close to the breakwater. Some surfers suggest that lower tides seems to mitigate some of the deflection and produce a hollower wave. Some surfers enjoy riding an incoming wave that intersects with a reflected wave. They feel that the reflected wave produces an additional peak on the incoming wave and accelerates its breaking speed.

Winds. The Maalaea winds can be a factor in surfing the Pipeline successfully. From mid-morning to late afternoon the winds are often very strong, sometime blowing across the waves from the east or blowing directly offshore. When the winds are exceptionally strong, they prevent surfers and bodyboarders from making a quick take-off, thereby lessening the opportunity for completing a ride.

Users. The Maalaea Pipeline is ridden by both surfers and bodyboarders, but is considered to be primarily a surfing site. Most bodyboarders do not attain the speed that a surfer does across the face of a wave, and sustained speed is a key element in completing a ride at this break. Bodyboarders tend to ride the first section at the initial take-off site when the waves are 4 feet or smaller. As the surf increases in size and becomes more difficult for the bodyboarders to complete a ride, they usually relocate to other breaks such as Buzz's or Mudflats. As the surf increases in size, it also attracts more surfers, making it harder for the bodyboarders to get a wave. Surfboards are more mobile in the water than bodyboards, so as the number of surfers increases, the wave opportunities for bodyboarders decreases.

On a good day of sizable surf (4-6 feet) each section of the Maalaea Pipeline may have 15-20 surfers. With approximately four sections in the lineup, there may be as many as 80 surfers at this break. This is consistent with other breaks that have multiple sections such as Laniakea on Oahu's North Shore.

When the Maalaea Pipeline is breaking at six feet or greater, surfers come from all over the island to ride it. Surfers also come from neighbor islands, primarily from Oahu, specifically to surf this site. There is so much interest in this break beyond Hawaii that a surfing photographer from Oahu recalled one summer when he had been instructed by a surfing magazine to drop everything and fly to Maui whenever the Pipeline was breaking. The magazine not only paid for his expenses, but the expenses of four professional surfers that he was told to take on the trip with him.

2.32 Off-the-Wall.

Location. Off-the-Wall is located on the shallow reef offshore the end of the east breakwater and is situated between the Maalaea Pipeline and the entrance channel. It is called Off-the-Wall because it breaks immediately offshore the breakwater which is "the wall."

Access. Off-the-Wall is accessed from the shoreline inshore of the east breakwater. Surfers park at the harbor and walk on the breakwater until it begins to curve toward the entrance channel. At that point they climb down the breakwater and paddle out to the lineup through a small channel between the Pipeline and Off-the-Wall.

Surfers also access Off-the-Wall by paddling through the harbor and out the entrance channel and by paddling across the entrance channel from Buzz's.

Characteristics. Off-the-Wall is both a left and a right that is surfed when waves heights are two feet or greater. The initial take-off site is directly offshore the end of the east breakwater. The rights are usually of shorter duration than the lefts and tend to merge and close out with the Pipeline when surf heights reach six feet or greater. The lefts are considered to be an excellent steep, hollow, plunging wave, that end at the edge of the entrance channel.

Currents. There are no significant rip currents in the vicinity of Off-the-Wall during periods of high surf. The major water movement is along the front of the breakwater. Waves striking the breakwater are normally reflected to the east, creating a lateral drift as they flow along the breakwater and over the shallow reef (as shallow as one foot at low tide in some places). This drift dissipates as the water depth over the reef deepens beyond the breakwater. Waves that end in the entrance channel are quickly dissipated by the deep water, producing no currents in the channel.

Reflected Waves. Reflected waves from incoming surf striking the breakwater and returning seaward are common inshore of Off-the-Wall. These waves often interface with the whitewater of incoming waves, but normally do not interfere with the riding face of the waves in the lineup. Some interference on the wave faces may occur when the waves are small, 2-3 feet, and the lineup is in close to the breakwater.

Winds. The Maalaea winds can be a factor in surfing Off-the-Wall successfully. From mid-morning to late afternoon the winds are often very strong, sometime blowing across the waves from the east or blowing directly offshore. When the winds are exceptionally strong, they prevent surfers and bodyboarders from making a quick take-off, thereby lessening the opportunity for completing a ride.

Users. Off-the-Wall is ridden by both surfers and bodyboarders. Because of the site's proximity to the breakwater, it tends to be ridden on smaller days primarily by bodyboarders who can maneuver closer to the breakwater than surfers. Surfers ride it on bigger days (over three feet) when the opportunities for avoiding contact with the breakwater are improved as the lineup moves farther offshore.

2.33. Buzz's.

Location. Buzz's or Buzz's Wharf is named for Buzz's Wharf, a restaurant which is located at Maalaea Harbor between the west end of the boat basin and Honoapiilani Highway. The restaurant is the most prominent landmark inshore of the break.

Access. Buzz's is accessed by climbing across the boulders of the south breakwater and jumping into the ocean. Surfers and bodyboarders compete for parking with other harbor users alongside the access road on top of the breakwater and near the restaurant.

Characteristics. Buzz's is located on the reef fronting the south breakwater between the entrance channel and the restaurant. While the site has only one name, Buzz's is actually a series of three smaller, individual breaks situated offshore the breakwater. These breaks produce good surfing waves on both south and southwest swells.

The first break is situated offshore the former SeaFlight terminal building at the end of the breakwater. This break is considered to be a high surf, deep water break and is rarely ridden. It is both a right into the entrance channel and a left towards the breakwater. It only breaks when wave heights are six feet or greater.

The second break is the most popular and consistent peak, and the break that most surfers identify as Buzz's. Located midway between the end of the south breakwater and the restaurant, it is both a left and a right, although the left is the longer and more preferred ride. Waves at this site are usually spilling rather than plunging waves and terminate on the breakwater.

The third break is located offshore from the end of the boat basin and is both a left and a right. Waves here tend to be smaller and more poorly-shaped than waves at the second break to the east, and the peak often shifts rather than breaking in one consistent place. Waves at the third break normally terminate before they reach the breakwater. During periods of high surf the second and third breaks may connect.

Currents. There are no significant rip currents in the vicinity of Buzz's during periods of high surf. The major water movement is along the front of the breakwater. Waves striking the breakwater are normally reflected to the southwest, creating a lateral drift as they flow along the breakwater and over the shallow reef. This current dissipates as it flows toward the restaurant and enters deeper water.

Reflected Waves. Reflected waves from incoming surf striking the breakwater and returning seaward are common inshore of Buzz's, at all three breaks. These waves often interface with the whitewater of incoming waves, but normally do not interfere with the riding face of the waves in the lineup. Some interference on the wave faces may occur when the waves are small, 2-3 feet, and the lineup is in close to the breakwater. Many bodyboarders enjoy the interaction between the incoming and reflected waves and feel that it enhances their rides.

Winds. The Maalaea winds seem to be less of a factor in surfing at Buzz's than at other sites to the east of the entrance channel. Buzz's seems to get more offshore than sideshore winds, and therefore better wave conditions. Some surfers attribute this to Buzz's proximity to the mountain ridge on the southwest side of Honoapiilani Highway. They feel the mountain ridge helps to channel the wind in an offshore direction.

Users. The first break at Buzz's is ridden by both surfers and bodyboarders, although infrequently by both. This break rarely attracts more than six surfers and/or bodyboarders.

The second or main break at Buzz's is regarded as both a surfing and bodyboarding site, but tends to be used more by bodyboarders. When waves are small (one to three feet), bodyboarders are the primary users. When waves are medium height or higher (four feet or higher), the wave-riding population is usually fifty percent or less surfers and fifty percent or more bodyboarders. This break will attract from 20 to 30 surfers/bodyboarders.

The third break is regarded as a smaller, more secondary break and is ridden almost exclusively by bodyboarders. Usually there are no more than 10 to 15 riders. The Maui Fire Department occasionally uses this site for surf rescue training.

Buzz's is an important summer surfing site to the population centers of Kahului and Wailuku. It is one of the few good south shore sites that is easily accessible to central Maui. The majority of the other south shore sites are on the Lahaina-side of the island, a long distance from the island's two largest cities. Buzz's also offers a gentler, spilling-type of wave that breaks close to shore which is ideal for beginning and intermediate bodyboarders.

All of Maui's surfing sites have become very important in recent years. The island has comparatively fewer surfing sites per mile of shoreline than do the other major islands, while the surfing/bodyboarding population has increased considerably with the island's population and with the general interest in these sports, especially bodyboarding. Many windsurfers also seem to be taking up either surfing or bodyboarding to improve their wave riding skills and to keep in the water during periods of poor wind conditions.

2.4 Surfing Sites Outside of the Project Area.

Seven surfing sites are located outside of the Maalaea Harbor project area, but within Maalaea Bay between McGregor Point and Kealia Pond: McGregor Point, Little Cape St. Francis, Haywood's Lot, Mudflats, Loading Zone, Hole-in-the-Wall and Kealia.

2.41. McGregor Point.

Location. McGregor Point is the site of McGregor Landing, a former inter island steamer landing. The landing was named in the late 1800s for Daniel McGregor, a sea captain who was apparently the first to discover that large sailing vessels could anchor safely adjacent to the point. A navigational light is situated on top of the point, so the surfing site is also called Lighthouse by some surfers.

Access. The break is accessed by parking on the access road to the navigational light, climbing down the medium high sea cliffs and jumping off the rocks into the ocean. Surfers exit the ocean the same way- by climbing over the rocks.

Characteristics. McGregor Point is a deep water point break that only breaks on larger south swells. Waves usually have to be 4 feet or higher to break there. The break is a right that offers longer rides the bigger it gets. It does not close out no matter what the size of the south swell.

Users. It is ridden by both surfers and bodyboarders. On a good day 25-30 people may be in the water.

2.42. Little Cape St. Francis

Location. Little Cape St. Francis, also known as The Cliffs, is located below a small residential community on the low sea cliffs at the western end of Maalaea Bay. Cape St. Francis is the name of a surfing break in Africa that was introduced to the surfing world in the movie The Endless Summer in the 1960s. Maui surfers apparently adopted the name and applied it to this break. Both the African and Maui sites are rights that are breaking over a shallow reef offshore a rocky point.

Access. The break is accessed primarily through several sites in the residential community, but some surfers park at Maalaea Harbor and paddle to the site.

Characteristics. This break is actually a series of peaks and sections that form on a shallow reef. It is surfed when wave heights are two feet or higher. Waves here are normally small and of poor quality for surfing.

Users. This break is surfed infrequently, and usually only by longboard riders, surfers who ride on boards approximately nine feet or longer. This break rarely attracts more than six surfers.

2.43. Haywood's Lot.

Location. Haywood's Lot is located offshore the swimming pool of the Island Sands condominium in Maalaea Village. It was named for the Fred Haywood family, the former owners of the condominium property.

Access. It is accessed through a public right-of-way between the Island Sands and Maalaea Harbor.

Characteristics. This break is both a left and a right that is a spilling wave. It is considered to be a secondary break.

Users. This break is ridden by both surfers and bodyboarders of beginning to intermediate ability, including longboard surfers, and may attract 15-20 riders.

2.44. Mudflats.

Location. Mudflats is located offshore the east end of Maalaea Village, just beyond the end of the paved road. It is named for the mudflats that comprise the unimproved backshore. An old drainage pipe protected by a low rock jetty extends into the ocean here, and the surfing break is located immediately to the east of the jetty.

Access. Mudflats is accessed through Haycraft Park, a small community beach park at the end of the paved road. The park was developed and landscaped by Kenny Haycraft and his brother-in-law Vern Johnson who adopted the site in 1985 as part of the county's Adopt-a-Park Program. Haycraft now lives on the Big Island, and the park is maintained by Johnson. The county has improved the park with paved parking and a shower.

Characteristics. Mudflats is actually a series of at least five different peaks that extend down the beach towards Kealia. There are both lefts and a rights with both plunging and spilling waves, depending on the site, the size of the swell, and the tide.

Users. These breaks are ridden by both surfers and bodyboarders of beginning to expert ability, and may attract 15-20 riders per peak.

2.45. Loading Zone

Location. Loading Zone is located offshore the east end of Maalaea Village, just beyond the end of the paved road. It fronts a high, vertical concrete wall in the backshore.

Access. Loading Zone is accessed through Haycraft Park at the end of the paved road or over the dirt roads in the backshore of Maalaea Beach.

Characteristics. Loading Zone is a spilling, shorebreak wave that breaks over a shallow sandbar.

Users. This break is ridden by both surfers and bodyboarders of beginning to expert ability, and may attract 10-15 riders.

2.46. Kealia

Location. Kealia is located offshore Kealia Pond at the east end of Maalaea Beach. It takes its name from the pond.

Access. The break is accessed over the secondary roads in the backshore of Maalaea Beach.

Characteristics. Like Mudflats, Kealia is a series of several smaller breaks, usually consisting of spilling, shorebreak waves. These breaks are considered to be secondary surfing sites.

Users. These breaks are ridden by both surfers and bodyboarders of beginning to expert ability, and many attract 10-15 riders. These sites are surfed much less frequently than the sites at the southwest end of the bay.

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APPENDIX F

ECONOMIC ANALYSIS

Maalaea Small Boat Harbor Economic Analysis

MAALAEA SMALL BOAT HARBOR

ECONOMIC ANALYSIS

1. EXISTING HARBOR AND FLEET. The State of Hawaii currently maintains mooring spaces for ninety (90) craft at Maalaea Small Boat Harbor. The harbor basin is subject to surge problems that prevent the full utilization of the available 11.3 acres of dredged water area. The Maui Boating Advisory Group and the Harbors Division of the State Department of Transportation have developed a master berthing plan that will allow an increase in berthing capacity to 220 moored craft after the harbor wave and surge problems are eliminated. The distribution of vessels by type of use is shown in Table 1.

TABLE 1. MAALAEA SMALL CRAFT
EXISTING FLEET AND WAITING LIST CRAFT BY TYPE OF USE

		WAITING LIST CRAFT			
TYPE CRAFT	IN HARBOR	TRAILERED OR ALONG COAST	NOW AT OTHER HARBOR	NOT YET ACQUIRED	TOTAL
Recreation	25	9	8	53	95
Subsistence Fishing	13	3	3	-	19
Commercial Fishing	15	2	2	3	22
Charter Fishing		3	1	6	-
	37 1/				84
Commercial Passenger	-	12	4	21	-
TOTAL:	90	29	18	83	220

1/ Breakdown between charter fishing and other commercial passenger vessels not readily available for currently moored craft.

2. HARBOR WAITING LISTS. The State Harbors Division Maui District Office a waiting list for mooring slips at Maalaea Harbor. At the present time 328 applications for boat slips are on file with the Maui District. Each application requires the payment of an annual renewal fee. An additional waiting list is maintained for applicants for commercial permits that are required for any passenger-carrying operation utilizing facilities of the State of Hawaii. The commercial passenger-carrying permits for Maalaea Harbor are limited by the State boating regulations to a maximum of 30 percent of the available mooring space at the facility. Craft on the waiting list that are now in Maalaea Harbor but which only desire a better slip have been eliminated from this analysis. The net valid waiting list craft total 130. Of these 29 are now trailered craft or moored along the coast, 18 are now in another harbor, and 83 have not been acquired yet. The planned 220 craft capacity for Maalaea Harbor will not satisfy the total current demand for mooring space at the facility. As a result, the harbor will be at maximum capacity upon completion of the federal and nonfederal improvements.

3. PRESENT AND NEAR TERM COMMUNITY STRUCTURE. Maui's economy is based almost completely on its tourist industry and sugar plantations, with pineapple, diversified agriculture, and cattle ranching playing lesser roles. Maalaea Harbor is located approximately seven miles south of the adjacent communities of Wailuku and Kahului, the urban and commercial hub of Maui Island. Maui's sole deep draft harbor is located at Kahului. Two major resort communities have developed on the Island: Lahaina - Kaanapali, located on the west end of the Maui and extending from Lahaina town north approximately ten (10) miles; and Kihei - Wailea, extending from Kihei village south about ten (10) miles. Kihei lies approximately four (4) miles east of Maalaea Harbor. The population of the Island was estimated to be 88,100 in mid-1989. About 8 percent of the workers are employed in agriculture and food processing. Some 15 percent are employed by the hotels while another 15 percent are employed in other services. The government employs some 11 percent while finance, trade and transportation account for 37 percent of the jobs. The island has approximately 15,000 hotel rooms. The Kihei - Wailea resort area has 5,200 rooms and the Lahaina - Kaanapali resort area has 8,800 rooms. The Wailuku - Kahului area has about 500 rooms. Both the Kihei - Wailea and the Wailuku - Kahului areas are tributary to Maalaea Harbor.

4. COMMERCIAL PASSENGER CRAFT

a. General. As shown in Table 1, commercial passenger craft on the waiting list are split into three categories; trailered or along coast (12); at other harbors (4); and not yet acquired (83). These commercial passenger craft also fall into three different size clusters. The 60- to 100-foot long craft generally carry about 150 passengers and are typically used to provide dinner cruises. The 40- to 60-foot vessels generally carry about 50 passengers and are usually engaged in sightseeing cruises. The commercial passenger craft under 40 feet generally carry 6 passengers (called "6-pack" vessels) and are usually engaged in specialty sightseeing or action cruises such as scuba diving.

b. Trailered or Along Coast. Those commercial passenger craft on the waiting list that are presently trailered or moored along the coast are assumed to be all "6-pack" type craft, due to problems in trailering craft longer than 30 to 35 feet. It is likely that boat operators mooring their vessels along the coast are reluctant to commit to investing in larger craft due to the hazards of open coast mooring. In addition, the logistics of getting larger number of passengers between the shore and the craft are difficult along an open shore. These conditions will bias the vessel operations toward a smaller number of passengers per craft. Existing Maui District records indicate that a number of craft moored along the open coast are in the 40- to 60-foot range. However, for benefit analysis these will all be categorized as "6-pack" vessels.

c. At Other Harbors. The commercial passenger craft on the Maui District waiting list that are presently berthed at other harbors are also considered to be "6-pack" type craft. This is based on the observation that owners of larger craft holding slips in other harbors are likely to be reluctant to give up those slips. The other harbor in this case will be Lahaina Harbor (the only other small craft harbor on Maui). Larger vessels at Lahaina harbor slips are considered to have an inside track in a "seller market" for tour boat customers. The smaller craft may be more flexible about changing harbors and so for benefit calculations these "other harbor" vessels are also assumed to be "6-pack" operations.

d. Not Yet Acquired. Commercial passenger craft listed on the waiting list that have not yet been acquired total 21 craft. If they were categorized by their stated size into "Dinner Cruise," "Large Sightseeing" and "6-Pack" groups there would be 1 "Dinner Cruise" type vessel, 8 "Large Sightseeing" vessels and 27 "6-pack" vessels. Based on the number of hotel rooms in the tributary area for Maalaea Harbor, and the usual ratio of one typical dinner cruise operation for each 2,000 to 3,000 rooms, two "Dinner Cruise" type vessels are expected at this harbor. However, constraints on available maneuvering room for large vessels in combination with planned restrictions on issuance of future commercial permits for Maalaea Harbor will likely prevent successful operation of additional dinner cruises from the facility. The waiting list shows one application for a passenger craft in the over 70-foot size that has not yet been acquired. The 8 craft shown on the waiting list in the 60 to 69-foot size are considered to be "large sightseeing" vessels, not "dinner cruise" vessels as their size would indicate. Similarly, the 14 craft under 60 feet in length are categorized as "6-Pack" vessels.

5. WITH PROJECT ECONOMIC BENEFITS. Table 2 shows the estimated navigation benefits for the added users of Maalaea Harbor. No additional benefits are calculated for the existing users of Maalaea Harbor. The benefits are shown by type of craft use and by present craft location. Total average annual benefits are $1,198,000.

6. NET REVENUE BY USE TYPE.

a. Commercial Passenger - Dinner Cruise. A Sea Grant study (UNIHI-SEAGRANT-ME-84-02) in 1984 indicated that a typical multi-function (food and entertainment) 149 person seating capacity catamaran on Oahu (55% occupancy) yields net revenue of $215,159 (1992 price level), based on 32,780 passengers per year and an average fare of $34. The study also indicated that approximately one of these dinner cruise craft could be supported for every 2,000 to 3,000 hotel rooms on Oahu. On this basis, the Maalaea tributary area will support 2 of these operations. It is estimated in the 1984 Sea Grant study that about one out of three visitors to Maui takes a tour boat ride of some kind. Of these, 11 percent are dinner cruise customers. This would indicate a total of some 300,000 dinner cruise passenger per year, currently, or about 9 dinner cruise craft handling 32,780 passengers each year, or about one per every 1,600 hotel rooms. Although the Kihei-Wailea area will support at least one dinner cruise vessel for every 2,500 hotel rooms or 2 such craft handling 32,780 passengers each per year, no benefits are computed for Maalaea due to planned restrictions on vessel size and commercial passenger operations at the harbor.

b. Charter Fishing. Based on a 1984 National Marine Fisheries Study of charter fishing (ADMIN RPT H-84-6C "NOT FOR PUBLICATION"), the per craft annual revenue for charter fishing craft for Maui will average $13,899 (1992 price level). The state-wide average reported days spent charter fishing was 133. The distribution of reported charter fishing trips was found to be bimodal, suggesting a delineation between part-time and full-time charter fishing operations. By dividing the sample into two groups (greater or less than 133 trips) the assumed part-time charter fishing operations made in 67 trips per year, while the assumed full-time operations made 208 trips per year. As the reported Maui average was 227 trips per year, it would appear that the Maui-based charter fishing craft are mostly full time operations.

c. Commercial Passenger - Large Sightseeing. No studies are available that document net revenue for a "typical" large commercial passenger sightseeing boat for either Maui or the State of Hawaii. The benefits accruing to these craft are estimated by assuming that the per-passenger revenue generated is proportional to the average of the per-passenger revenues generated by dinner cruise craft and charter fishing craft, respectively. A net revenue figure of $67,579 is projected for large sightseeing vessels. (1992 price level) is used to estimate the benefits accruing to these craft. Those "Commercial Passenger - Large Sightseeing" craft that are moored along the coast now are estimated to yield only half the net revenue increase from being able to have an adequate mooring space in the proposed new harbor.

d. Commercial Passenger - "6-Pack". These craft have a passenger capacity of six people just like the charter fishing craft. For this reason they are assumed to have the same net revenue generating capacity as a charter fishing craft, which is $13,899 (1992 price level) per year. As estimated for the "Commercial Passenger-Large Sightseeing" craft moored along the coast, those "6-Pack" craft moored along the coast are also estimated to yield only half the net revenue ($6,950 in 1992 price level) increase from being able to have an adequate mooring space in the proposed new harbor.

e. Commercial Fishing. The benefits per commercial fishing craft are based on a 1985 survey of Maui boaters by the Corps of Engineers using the contingent valuation method, for a West Maui facility. This survey covered those commercial fishing craft (among other types of craft) that are now trailered or along the coast or in another harbor. This contingent valuation (CV) value for commercial fisherman was $1,306 according to the 1985 survey factored to 1992 prices. A study of commercial fishing made for a navigation facility at Kahului Harbor indicated that net revenues for full time commercial fishing craft on Maui with a full resource constraint scenario were $10,707 (1992 price level) per year. The same study indicated, also, that every 1.8 commercial fishing craft were equivalent to one full time commercial fishing operation. The commercial fishing craft on the waiting list that will be new craft and those from other harbors were adjusted to full time fishing craft (number in parenthesis) and the benefits computed using a net return of $10,707 (1992 price level) per year. Those craft coming from another harbor are assumed to be replaced in kind at that other harbor (i.e. with a new commercial fishing craft).

f. Recreation Craft. Benefits per craft are estimated by using the West Maui contingent valuation survey results. The CV benefit per craft owner wanting a harbor mooring was estimated to be $2,584 (1992 price level) for West Maui. For the number of craft involved it was decided that a separate contingent valuation survey would not be warranted for Maalaea specifically and that the West Maui value is a reasonable substitute.

g. Subsistence Fishing Craft. The benefits for subsistence fishing craft are also derived from the West Maui contingent valuation survey and are $1,462 (1992 price level) per year.

7. UNCERTAINTIES.

a. General. The applicability of the West Maui contingent valuation survey to a site just on the border of the West Maui area might be questioned. However, for the categories where these values are used for benefits, the number of craft are small and the project feasibility is not significantly affected by these benefits. Actually, the values estimated are for harbor facilities for craft that already exist (probably on a trailer or moored along the coast). For new craft, the benefits would probably be considerably higher, but these future owners were not surveyed. The benefits for those new recreation craft, new other miscellaneous craft and new subsistence fishing craft are probably understated. This conclusion is further supported by the commercial fishing craft example, where an alternate analysis of net income was available. The benefit categories that do have a significant impact on the project feasibility are the new commercial passenger dinner cruise and the commercial passenger-large sightseeing craft. These are discussed below.

b. Commercial Passenger-Dinner Cruise. The estimate of the number of these type operations out of Maalaea is discussed above in items "4.a", "4.d" and "6.a". The demand for dinner cruise craft from Oahu and the Maui historical experience would seem to indicate that there is demand for two of these dinner cruise operations at Maalaea. One dinner cruise operates at Maalaea presently.

c. Commercial Passenger - Large Sightseeing Craft. These are discussed in items "4.a", "4.d" and "6.c" above. The 1984 survey (Sea Grant survey described above) of tour boats indicated that there were about 15 craft of this type serving Maui in 1983. Fourteen of these were based in Lahaina. It is estimated that most of the demand was generated by the Lahaina resort area. Two thirds of the island's hotel rooms were there then, and also, the Kihei and Wailuku - Kahului areas are both almost an hour travel time way from Lahaina. For the 7,785 units in the Lahaina area, there was one large sightseeing craft per 556 hotel rooms. Eight craft are used for benefit analysis.

d. Other Facility Development. In the early 1970's the Corps studied the feasibility of enlarging the Lahaina Small Boat Harbor or building a new facility in the nearby area. No sites in Lahaina were acceptable to the area residents for historical preservation or social impact reasons. An apparently acceptable West Maui site was identified at Olowalu but was found to be economically infeasible under Corps evaluation criteria. Concerns were also raised regarding the Olowalu site's impact on the endangered humpback whale. Private developers have contemplated building a harbor near the Olowalu site. Because of environmental, social and cultural sensitivities, it is probably best to rate the building of this private facility as having only a fair probability of becoming reality. The Corps contingent valuation study indicated that there would be approximately 150 existing boaters willing to pay $200 or more a month for mooring in West Maui. About 40 percent of these craft are recreation craft. The waiting list at Maalaea indicates there are approximately half again as many potential new owners wanting mooring space in a new harbor. Depending upon the size of any private marina developed in the West Maui area, demand for mooring at Maalaea could be reduced accordingly. Plans for this private facility were likely formulated with the full knowledge that the Corps and State may be close to initiating construction on the Maalaea Harbor. The private developers have apparently estimated that there is sufficient excess demand to make the development of an additional West Maui marina viable even with the upgraded Maalaea Harbor in place.

e. The benefits shown on Table 2 are only for the 130 valid waiting list craft. There are a total of 215 craft on the valid waiting list. By the time modifications are completed, the harbor will be filled and there will still be a waiting list for the excess demand for slips at Maalaea Harbor. The total average annual benefits is $1,198,000.

TABLE 2. MAALAEA SMALL CRAFT NAVIGATION BENEFITS

	ADDITIONAL MOORED CRAFT 1)			NET REVENUE PER CRAFT			BENEFITS		
CRAFT USE TYPE	FROM ALONG COAST OR TRAILER	FROM OTHER HARBOR	NEW CRAFT	FROM ALONG COAST OR TRAILER	FROM OTHER HARBOR	NEW CRAFT	FROM ALONG COAST OR TRAILER	FROM OTHER HARBOR	NEW CRAFT
Recreation	9	8	53	$2,584	$2,584	$2,584	$23,256	$20,672	$136,952
Subsistence Fishing	3	3	0	$1,462	$1,462		$4,386	$4,386	
Commercial Fishing 1/	2 (1)	2 (6)	3	$1,369	$10,707		$2,738	$21,414	$19,273
Charter Fishing	3	1	6	$6,950	$13,899	$13,899	$20,850	$13,899	$83,394
Commercial Passenger-Dinner	0	0	0		$205,304	$205,304			
Commercial Passenger-Large Sightseeing	0	0 (10)	8			$65,809		$526,472	
Commercial Passenger-6-Pack	12	3	14	$6,950	$13,899	$13,899	$83,400	$41,697	$194,586
Total	29	17	84				$134,630	$628,540	$434,205

TOTAL AVERAGE ANNUAL BENEFITS $1,197,375
ROUNDED $1,198,000

1) Number of craft in parenthesis are equivalent craft estimates used for benefit computation.

APPENDIX G

ENGINEERING DESIGN

Engineering Design

Wave Response of Proposed Improvements to the Small Boat Harbor at Maalaea, Maui, Hawaii

Wave Response of Proposed Improvement Plan 6 to the Small Boat Harbor at Maalaea, Maui, Hawaii

ENGINEERING DESIGN

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ENGINEERING DESIGN

1. GENERAL CRITERIA

a. DESIGN REFERENCES.

(1) U.S. Army Coastal Engineering Research Center. Automated Coastal Engineering System. Version 1.06. December 1990.

(2) U.S. Army Coastal Engineering Research Center. Coastal Engineering Technical Notes.

(3) U.S. Army Coastal Engineering Research Center. Shore Protection Manual. 1984.

(4) U.S. Army Coastal Engineering Research Center. Pacific Coast Hindcast Deepwater Wave Information Study. WIS Report 14. March 1986.

(5) U.S. Army Corps of Engineers. Hydraulic Design of Small Boat Harbors. Engineer Manual 1110-2-1615. September 1984.

(6) U.S. Army Corps of Engineers. Design of Coastal Revetments, Seawalls and Bulkheads. Engineer Manual 1110-2-1614. April 1985.

(7) U.S. Army Corps of Engineers. Hydraulic Design of Deep Draft Navigation Projects. Engineer Manual 1110-2-1613. April 1983.

b. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing navigational improvement plans for Maalaea Harbor, Maui, Hawaii.

(1) Harbor improvements should provide safe navigation and protection for the design vessel;

(2) The improvements should include a turning basin adequate for maneuvering of the design vessel and suitable berthing areas;

(3) The entrance channel should be of adequate depth and width to safely permit navigation by the design vessel;

(4) Protective structures should be designed to withstand the most severe combination of weather and sea conditions that are reasonably characteristic of the study area.

2. SITE LOCATION

a. MAALAEA BAY. Maalaea Harbor is located on the southwest shoreline of the island of Maui, about 7 miles south of the county seat of Wailuku. The shoreline of Maalaea Bay is part of an isthmus connecting two large inactive volcanos which form the geologically older West Maui and the more recent East Maui. The shoreline of Maalaea Bay is characterized by a long narrow coral-sand beach which attracts many tourist from around the world. Maalaea Harbor is located at the extreme west end of this beach.

b. MAALAEA HARBOR. Maalaea Harbor was first developed by the Territory of Hawaii in 1952. The project was modified in 1955, 1959, and 1979 to its present configuration. The existing facility consists of a 90-foot wide, 12-foot deep entrance channel; a 1,000-foot long, 90-foot wide breakwater and mole structure on the south side of the basin; an 870-foot long breakwater on the east side of the basin; a 300-foot long, and 50-foot wide paved wharf on the north side of the basin. The dredged basin area is approximately 11.3 acres. The present useable capacity of Maalaea Harbor is 89 vessels. The only small craft haulout and repair facility on the island of Maui is located at the west end of the harbor. The one lane haulout ramp also serves as a trailer boat launching ramp.

3. TIDES AND CURRENTS

a. TIDES. Design tide planes for Maalaea Bay are based on a composite of data from the Oluwalu (Latitude 20° 48.7' North; Longitude 156° 37.6' West) and Makena (Latitude 20° 39.4' North; Longitude 156° 26.7' West) stations from the U.S. Coast and Geodetic Survey and are referenced to Mean Lower Low Water (MLLW) datum. All elevations in this report are referenced to MLLW datum.

	Tide (Feet)
Highest Tide (Estimated)	3.5
Mean Higher High Water	2.30
Mean High Water	1.80
Half Tide Level	1.00
Mean Low Water	0.20
Mean Lower Low Water	0.00
Lowest Tide (Estimated)	-1.0

b. CURRENTS. Currents near Maalaea Harbor are dominated by the southwest setting, tradewind generated surface current. Current speed is estimated to be typically less than 1 knot under normal tradewind conditions and does not cause navigation problems. Significant wave-generated rip currents may exist when high waves are breaking, but this phenomenon has not been documented. Tidal currents in Maalaea Bay are weak and insignificant with regard to navigation considerations.

4. WAVE CLIMATE

Waves arriving at Maalaea Bay are generated in the south through southwest sectors of the Pacific Ocean. Four primary wave types affect the study area. These four types are (a) southern swell, (b) "Kona" storm waves, (c) tsunamis, and (d) hurricanes.

Southern Swell. Southern swell is generated in the southern hemisphere, most frequently during the Antarctic winter months between April and November. After travelling 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 from 14 and 22 seconds with heights generally 1 to 4 feet. On rare occasions, the southern swell produces waves at Maalaea Harbor which exceed 10 feet, rendering the existing entrance channel unsafe for navigation and causing severe surge within the harbor basin. In any year, southern swell may occur about 50 percent of the time.

"Kona" Storms. Kona storm waves generally approach Maalaea from the south or south-southwest. These storms may generate waves which can adversely affect the existing harbor. Periods usually range from 8 to 10 seconds, with heights of 10 to 15 feet. In any year, Kona storms may occur several times or not at all. They most frequently occur during the winter months.

Tsunami. Tsunami are impulse-generated waves caused by catastrophic geological occurrences within an ocean basin. Adverse impacts resulting from location in the tsunami flood zone include the risks of destruction of property and loss of life.

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 speed 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 1978 at least fourteen tropical storms or hurricanes have intruded within 500 miles of the state. So far, most of the threatening storms have weakened before reaching the islands and their effects have been minimal in most cases. Hurricane effects in the Hawaiian waters generally occur during the summer months. Recorded passages of hurricanes near the Hawaiian Islands occurred in 1950 (Hurricane Hiki), 1957 (Hurricane Della), 1978 (Hurricane Fico), 1982 (Hurricane Iwa), and 1992 (Hurricane Iniki).

5. WAVE DATA

Long-term directional wave data for the study area is not available. Existing data from the U.S. Army Coastal Engineering Research Center's (CERC) Pacific Coast Hindcast Deepwater Wave Information Study (WIS-14, 1986) for the Hawaiian Islands is not applicable for Maalaea Bay because it contains no data from southern approaches.

6. DESIGN STORM PARAMETERS

Design storm parameters applicable to Maalaea Bay are based upon data obtained from "Hurricane Vulnerability Study for Honolulu, Hawaii and Vicinity" (HED, 1985). Parameters of a model Hawaiian hurricane with a southeast approach were developed by Paul Haraguchi utilizing the characteristics of Hurricanes Dot and Iwa.

Maximum Sustained Wind Speed, U (knots)	62.0
Forward Speed, V_f (knots)	20.0
Radius of Maximum Winds, R (nm)	10.0
Drop in Pressure, $(p_n - p_o)$ (inches H_g)	1.0

7. WATER LEVELS AND WAVE HEIGHTS

a. GENERAL. Components of the design stillwater level (d_{swl}) are astronomical tide, storm surge due to reduced atmospheric pressure and wind stress, and wave setup.

$$d_{swl} = s_a + s_p + s_s + s_w$$

b. s_a WATER LEVEL RISE DUE TO ASTRONOMICAL TIDE.

Assume s_a = Mean Higher High Water = 2.3'

c. s_p WATER LEVEL RISE DUE TO REDUCED ATMOSPHERIC PRESSURE.

$$s_p = 1.14\,(p_n - p_o)\,(1 - e^{-R/r})$$ Eq 3-85 SPM, 1977

Where $(p_n - p_o)$ = central pressure reduction
R = radius of maximum winds
r = radius of storm passage from computation point

Using the model hurricane characteristics:

Maximum sustained winds	= 62.0 knots
Forward Speed (V_f)	= 20.0 knots
Radius of Maximum Winds	= 10.0 nm
Drop in Sea Level Pressure (Δ_p)	= 1.0 in-H_g

Use: r = 20.0 nm
$\Delta_p = (p_n - p_o) = 1.0$ in-H_g
$s_p = 1.14\,(1.0 \text{ in-}H_g)\,(1 - e^{-10/20}) = 0.7$ feet

d. s_s WATER LEVEL RISE DUE TO WIND STRESS. Wind stress effects are small for the Hawaiian islands, as deep water extends extremely close to the shoreline. The water level rise due to wind stress (s_s) is computed over a specified wind fetch:

$$s_s = \Sigma s_i = \frac{(540\ k\ U_r^2\ \Delta x)}{d_{mean}}$$

Where
s_i = incremental water surface rise
k = wind stress constant = 3×10^{-6}
U_r = max. sustained wind speed = 62.0 kt
d_{mean} = mean depth over increment
Δx = incremental horizontal distance
x = fetch distance under consideration

For this computation, d_{mean} is simplified as the arithmetic average of the water depths between discrete distance increments, including tidal and atmospheric pressure effects.

Therefore, the water depth (d) at a specified location is represented as the sum of the mean sea level depth (d_{msl}) obtained from existing U.S. Coast and Geodetic Survey bathymetry charts, plus the tidal and atmospheric pressure effects:

$$d = d_{msl} + s_a + s_p$$
$$= d_{msl} + 2.3' + 0.7' = d_{msl} + 3.0'$$

x (nm)	Δx (nm)	d (ft)	d_{mean} (ft)	$540\ k\ U_r^2$	s_i (ft)	Σs_i (ft)
4.10		180+3.0				
	2.70		183.00	6.23	0.090	0.090
1.40		180+3.0				
	0.14		153.00	6.23	0.010	0.100
1.26		120+3.0				
	0.73		93.00	6.23	0.050	0.150
0.53		60+3.0				
	0.39		48.00	6.23	0.050	0.200
0.14		30+3.0				
	0.09		27.00	6.23	0.020	0.220
0.05		18+3.0				
	0.01		18.00	6.23	0.003	0.223
0.04		12+3.0				
	0.04		7.50	6.23	0.033	0.256
0						

$s_s = \Sigma s_i = 0.256'$; Use $s_s = 0.30'$

e. s_w WATER LEVEL RISE DUE TO WAVE SETUP. Wave setup may be defined as that elevation of the mean water level caused by wave action alone. Wave setup is calculated by Goda's method included in ACES Version 1.06:

$$\frac{d\eta}{dx} = -1/(\eta + h)\ \frac{d}{dx}\left[\frac{1}{8} H^2_{rms} \left(0.5 + \frac{2kh}{\sinh 2kh}\right)\right]$$

Where:

$\frac{d\eta}{dx}$ = *set-up gradient*

H_{rms} = statistical root mean square wave height
x = offshore-onshore distance
η = wave setup
k = wave number = $2\pi/L$
L = wavelength
h = water depth of interest

Let $d_s = d_{mllw} + s_a + s_p + s_s$

= 15.0' + 2.3' + 0.7' + 0.3'

= 18.3'

Where d_{mllw} = average depth at point of computation

By applying the Goda wave transformation routine contained in ACES Version 1.06 the computed wave setup (s_w) is:

s_w = 0.17'; use 0.2'

f. d_{swl} DESIGN STILLWATER LEVEL.

$d_{swl} = s_a + s_p + s_s + s_w$

= 2.3 + 0.7 + 0.3 + 0.2

= 3.5 feet

For conservatism, the computed stillwater level utilized in the original General Design Memorandum is adopted where:

$d_{swl} = s_a + s_p + s_s + s_w$

= 2.5 + 0.5 + 0.5 + 0.5

= 4.0 feet

g. d_s DESIGN WATER DEPTH AT STRUCTURE TOE. The design water depth at the structure toe is comprised of the average depth for the specified location relative to MLLW, plus the storm water level superelevation (d_{swl}).

	Location	Mean Depth (MLLW)	Design Depth d_s (MLLW)
①	Baseline "A" Head	16.0	20.0
②	Baseline "A" Sta 5+00	12.0	16.0
③	Baseline "A" Sta 3+80	15.0	15.0
④	Baseline "B" Sta 3+00	6.0	10.0
⑤	Baseline "B" Sta 1+40	3.5	7.5
⑥	Baseline "A" Sta 0+50	-	-
⑦	Baseline "A" Sta 0+50 (ext)	6.0	10.0

h. DESIGN WAVE HEIGHT. The design breaking wave height, H_b is a function of water depth, bottom slope, and the incident wave height and period (steepness). Large storm waves will break offshore at the outer edge of the shallow reef flat and then reform and continue shoreward as smaller waves. From Figure 7-4, SPM, the design breaking wave height is given as a dimensionless relationship between relative depth (H_b/d_s), nearshore slope (m), and wave steepness (d_s/gT^2). For areas where the nearshore slope is flat ($m = 0.0$):

$H_b = 0.78\,d_b$ = breaker height

Where:

d_b = breaking depth
g = gravitational acceleration = 32.2 ft/sec²
T = wave period

8. DESIGN VESSELS

Design vessel dimensions are based upon (a) the largest vessel expected to use the harbor and (b) a typical medium-sized vessel expected to use the harbor most frequently.

The length dimension for the larger design vessel is representative of the known dimensions of the U.S. Coast Guard cutter which would be stationed at Maalaea Harbor. The dimensions for the large design vessel are:

a. Length: 110 feet
b. Beam: 24 feet
c. Draft: 5.5 feet

The dimensions of a typical medium-sized vessel expected to use the harbor most frequently are estimated to be:

a. Length: 55 feet
b. Beam: 12 feet
c. Draft: 4 feet

DESIGN WAVE HEIGHTS

LOCATION	BOTTOM SLOPE (SEC)	AVERAGE DEPTH (FT)	SWL (FT)	d_s DESIGN DEPTH (FT)	DESIGN PERIOD (SEC)	d_s/gT^2	h_b/d_s	DESIGN BREAKING WAVE (FT)
Head "A"	0.000	16.0	4.0	20.0	12	0.0043	0.78	15.6
Sta 5+00 "A"	0.030	12.0	4.0	16.0	12	0.0035	1.03	16.5
					18	0.0015	1.07	17.1
Sta 3+80 "A"	0.020	15.0	4.0	19.0	12	0.0041	0.93	17.7
					18	0.0018	0.97	18.4
Sta 3+00 "B"	0.030	6.0	4.0	10.0	12	0.0022	1.06	10.6
					18	0.0010	1.10	11.0
Sta 1+40 "B"	0.014	3.5	4.0	7.5	12	0.0016	0.92	6.9
Sta 0+50 "A"	-	-	-	-	12	-		-
Sta 0+50 "A"	0.013	6.0	4.0	10.0	12	0.0022	0.90	9.0

9. CHANNEL AND BASIN DIMENSIONS

a. CHANNEL DEPTH.

The design channel depth incorporates allowances for vessel draft and squat, wave conditions and safety clearances.

Loaded Draft of Design Vessel	7.5 feet
Expected Low Tide Below MLLW	0.5 feet
Vessel Squat at 5 knots	1.0 feet
Pitch and Roll Due to Wave Action	4.0 feet
Bottom Clearance	2.0 feet
Total Channel Depth	15.0 feet

Channel depth is reduced to 12.0 feet in the lee of the protective structures.

b. CHANNEL WIDTH.

The required minimum channel width is based on assuming concurrent passage of large and medium sized design vessels. Channel width element allowances shown as a percentage of the vessel beam and assume poor vessel controllability based upon strong cross-winds presented by the prevailing northeasterly trade winds and a following sea during design wave conditions.

	Factor	Beam	Width
Bank Clearance (large)	0.6	24	14.4
Maneuvering Lane (large)	2.0	24	48.0
Vessel Clearance (large)	0.8	24	19.2
Maneuvering Lane (medium)	2.0	12	24.0
Bank Clearance (medium)	0.6	12	7.2
Total Minimum Channel Width			112.8
Design Channel Width			Use 150 feet

c. TURNING BASIN.

Basin dimension calculations are limited to the verification of the adequacy of the existing turning basin, as the dimensions are already fixed for the existing facility. The width of the turning basin is 1.8 times the length of the large design vessel and 3.6 times the length of the medium design vessel. The length of the turning basin is 2.9 times the length of the large design vessel and 5.8 times the length of the medium design vessel. The total turning basin area is 1.7 acres.

10. STRUCTURE LAYER DESIGN

a. COVER LAYER STABILITY. The revetment cover layer size was calculated using the Hudson stability formula (SPM Equation 7-116) as incorporated into the Automated Coastal Engineering System (ACES), Version 1.06 microcomputer software:

$$W = \frac{w_r H_b^3}{K_D (S_r - 1)^3 \cot\theta}$$

Where :

W = Design armor unit weight (lbs)
w_r = Unit weight = 156 lb/cu. ft. (Basalt)
= 145 lb/cu. ft. (Concrete)
H_b = Design wave height
K_D = Empirical stability coefficients
S_r = Specific gravity of stone relative to sea water = 2.44

$\cot\theta$ = Cotangent of the angle between the structure slope and horizontal = 2.0

The underlayer stone size is generally based on one - tenth to one - fifteenth of the design stone size. The computed underlayer stone size is 50 to 150 pounds. A synthetic geotextile will be used as a filter layer to prevent the migration of the fine materials through the structures.

b. LAYER THICKNESS. Armor layer thickness is computed as follows (SPM Equation 7-121):

$$t = k_\Delta \, n \, [W / w_r]^{1/3}$$

where :

t = armor layer thickness
k_Δ = layer coefficient
= 1.00 for rough, irregular quarrystone
= 1.03 for dolos
n = number of units in layer = 2
W = design armor weights:
12,000 pounds for dolos
16,000 pounds for breakwater trunk
6,000 pounds for revetted mole
3,000 pounds for revetted mole
w_r = unit weight of armor unit = 156 pcf (stone)
= 145 pcf (concrete)

DESIGN WAVE HEIGHT AND ARMOR UNIT STABILITY ANALYSIS

LOCATION	BOTTOM SLOPE	AVERAGE DEPTH	d_s DESIGN DEPTH	DESIGN PERIOD	h_b/d_s	DESIGN BREAKING WAVE	STABILITY COEFF.	ARMOR WEIGHT (TONS)	SIZE RANGE LOW LIMIT	SIZE RANGE HIGH LIMIT
Head "A"	0.000	16.0	20.0	12	0.78	15.6	10.8	5.92	6.00	6.00
Sta 5+00 "A"	0.030	12.0	16.0	12	1.03	16.5	12.6	6.00	6.00	6.00
				18	1.07	17.1	14.0	6.01	6.00	6.00
Sta 3+80 "A"	0.020	15.0	19.0	12	0.93	17.7	15.6	5.98	6.00	6.00
				18	0.97	18.4	17.5	5.99	6.00	6.00
Sta 3+00 "B"	0.030	6.0	10.0	12	1.06	10.6	2.0	7.61	5.71	9.51
				18	1.10	11.0	2.0	8.50	6.38	10.63
Sta 1+40 "B"	0.014	3.5	7.5	12	0.92	6.9	1.6	2.62	1.97	3.28
Sta 0+50 "A"	-	-	-	12	-		2.0	1.38	1.04	1.72
Sta 0+50 "A"	0.013	6.0	10.0	12	0.90	9.0	2.8	3.33	2.50	4.16

c. Number of Units per Area. The number of armor units required for unit area of the structure face is given by:

$$N_r/A = n\,k_\Delta\,(1 - P/100)\,(w_r/W)^{2/3}$$

Where:

k_Δ	= layer coefficient
	= 1.00 for rough, irregular quarrystone
	= 1.03 for dolos
n	= number of units in layer = 2
P	= porosity = 37 percent (quarrystone)
	= 52 percent (dolos)
W	= design armor weights:
w_r	= unit weight of armor unit = 156 pcf (stone)
	= 145 pcf (concrete)

11. PROTECTIVE STRUCTURES DESIGN

The east breakwater modification includes removal of about 80 feet of the head of the existing structure to allow for the alignment of the new entrance channel. The rebuilt breakwater head will utilize armor stone from the removed portion. Two layers of stone larger than 3 tons are required at a slope of 1.0 vertical on 1.5 horizontal, assuming maximum breaking wave conditions.

Also included in the east breakwater modification is the addition of a revetted mole on the interior side of the existing structure. The 500 to 800 pound armor stone was designed for a breaking 4-foot high wave. The crest elevation of the existing structure between Station 4+50 and Station 6+00 was checked for overtopping and found to be subject to wave splash under some conditions. Historically, the structure has been subject to occasional minor overtopping during high wave conditions. However, no modification to the east breakwater crest elevation has been provided because construction of the south breakwater extension is expected to reduce the frequency of these minor overtopping occurrences at the east breakwater.

12. SUBSURFACE CONDITIONS.

Subsurface investigations consisting of 7 borings were conducted for the preparation of the General Design Memorandum in April and May 1980 and are considered to remain valid for this analysis. The borings found that a lightly cemented coral limestone breccia crest, approximately one foot thick, covers most of the bottom adjacent to the existing harbor structures. Unconsolidated clastic marine sediments with coral sands, gravels, cobbles and boulders underlie the surface crust. Clay, silt and sand from terrigenous sources cover the floor of the existing harbor basin. Two of the borings in the inner harbor show reddish-brown clay below the coral limestone sediments.

13. DREDGING.

Conventional dredging equipment such as heavy duty backhoes, clamshells, and hydraulic cutter heads should be able to remove the crust layer and underlying coral rubble without blasting. However, isolated spot blasting may be required to initiate excavation. Excavation slopes of 1 vertical to 3 horizontal are expected to be stable. Bench width of 20 feet from the top of the excavated slope to the toe of the protective structure should provide for sufficient structural stability including an allowance for additional slope flattening due to scour.

Blasting will not likely be permitted between 1 December and 31 May when humpback whales are likely to be in Maalaea Bay. In addition, blasting operations will be halted if turtles are sighted within the project area.

14. CONSTRUCTION MATERIALS.

Primary construction materials will consist of basalt stone and concrete. These materials and their availability are as follows:

Stone construction material can be obtained from three commercial quarries on Maui. Bulk, saturated, surface dry specific gravity ranges from 2.6 to 3.0. The three quarries are Ameron HC&D, Limited (Puunene Quarry), Camp 6 (Old Railroad Quarry, Puunene) and Maui Concrete and Aggregates (Waikapu Quarry). Rock outcrops exposed along Highway 30 between Maalaea and Lahaina, and field stone at various locations on Maui are potential sources of stone. Piles of fieldstone resulting from land clearing operations by sugar companies are located on hillsides between Maalaea and Lahaina, north of Maalaea Bay in the vicinity of the Old Puunene Airport, and west of Highway 30 between Maalaea and Wailuku. Arrangements for obtaining stones from the above locations will be the responsibility of the construction contractor. A nominal charge (royalty) may be assessed by the sugar companies for rock removed from their fields. Prior contacts with sugar company representatives indicated that selective borrowing of individual rock pieces would not be permitted; i.e. the entire stockpile must be removed.

Approximately 8,000 cubic yards of concrete will be required for construction of dolos armor units and the rib cap on the main breakwater. Compressive strength of 5,000 psi (water-cement ratio of 0.40) will be required for the concrete. Type II cement will be specified due to seawater exposure conditions. Cement conforming to ASTM C-150, Type II is produced by manufacturers on Oahu Island, Kaiser Cement and Gypsum Corporation and Hawaiian Cement Corporation. Concrete coarse aggregate (basalt) conforming to ASTM C-33 is available at both Concrete Industries and Maui Concrete and Aggregate in maximum nominal sizes of 3.4-inch, 1-inch, and 2-1/2 inches. In addition, 1-1/2 inch maximum nominal size aggregate is available at Concrete Industries. Bulk, saturated, surface-dry specific gravity averages about 2.70, and absorption is about 3.2, for concrete aggregate obtained from Maui Concrete and Aggregate. Aggregate obtained from concrete Industries would have an average bulk, saturated, surface-dry specific gravity of 2.80 and absorption of about 2.8. Concrete aggregates produced by these two suppliers have been used on various Corps of Engineers flood control and breakwater rehabilitation projects on the island of Maui.

15. SAND MOVEMENT AND SHOALING.

Underwater reconnaissance of the harbor area indicates that relatively small quantities of sand are present on the surface of the limestone reef down to depths of about 15 feet, where more sand is present. Based on shoaling rates within the mouth of the existing harbor, developed from information from the State Harbors Division, and estimates of maintenance dredging requirements for the authorized plan, a revised estimate for the plans shown in this report was developed. Maintenance dredging requirements for the plans in this report are higher than the authorized plan requirements because the structure extends into deeper water and will tend to intercept littoral drift. The resulting shoaling is expected to occur primarily in the entrance channel in the lee of the breakwater extension. Shoaling within the harbor basin is expected to continue at about its present rate due to continuing deposition of terrigenous sediments which arrive via the four storm drains which enter into the basin. Periodic maintenance dredging of the areas adjacent to each of the drains will be the major requirement within the basin. It is estimated that approximately 1,000 cubic yards every 10 years will be added to the existing non-federal dredging requirement, due to the creation of the new berthing area adjacent to the existing east breakwater. Federal dredging is estimated to be approximately 8,000 cubic yards every 10 years.

Miscellaneous Paper CERC-93-4
July 1993

Wave Response of Proposed Improvements to the Small Boat Harbor at Maalaea, Maui, Hawaii

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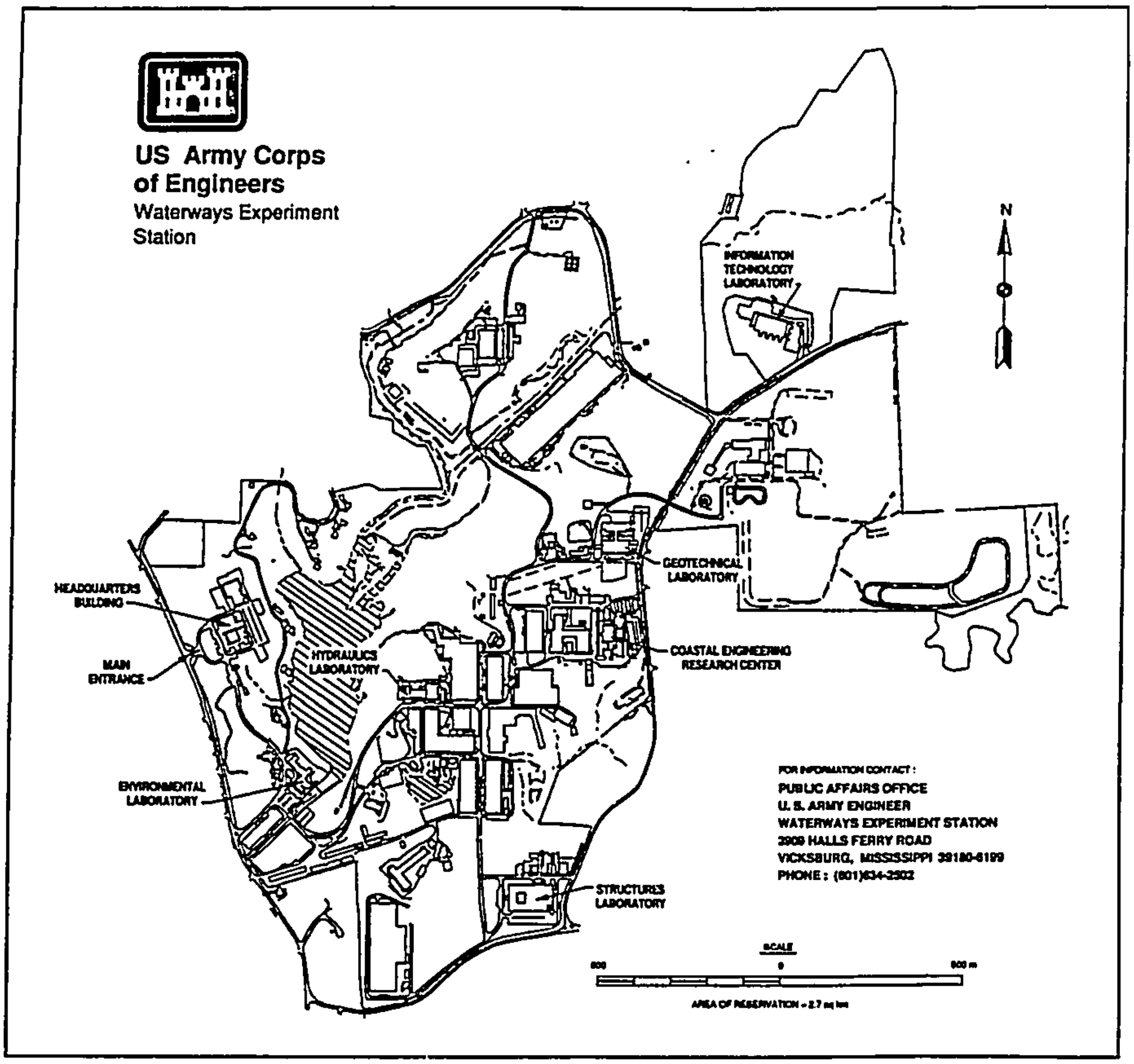
Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000



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Contents

Preface

This study was authorized by the US Army Engineer Division, Pacific Ocean (POD), and was conducted by personnel of the Coastal Oceanography Branch (COB), Research Division (RD), Coastal Engineering Research Center (CERC), of the U.S. Army Engineer Waterways Experiment Station (WES). The first study phase was conducted during the period June 1990 - September 1991. The second phase (Plans 1a and 1b) was conducted during October through December 1992. Messrs. George Young and Stanley Boc, POD, oversaw progress of the study.

This report was prepared by Ms. Linda S. Lillycrop, Mr. Steven M. Bratos, Dr. Edward F. Thompson, and Ms. Panola Rivers, COB, under the direct supervision of Dr. Martin C. Miller, Chief, COB, and Mr. H. Lee Butler, Chief, RD. The report was prepared under the general supervision of Mr. Charles C. Calhoun, Jr., Assistant Director, CERC, and Dr. James R. Houston, Director, CERC.

The assistance of Dr. Robert E. Jensen, RD, and Mr. Paul D. Farrar, COB, is deeply appreciated. Messrs. Antonio Baptista, and Paul Turner, Oregon Graduate Institute (OGI), developed grid generation software and assisted in implementation of the software used in this study.

At the time of preparation of this report, Dr. Robert W. Whalin was Director of WES. COL Leonard G. Hassell, EN was Commander.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	13,277.1	square meters
degrees (angle)	0.01745329	radian
feet	0.3048	meters
mile (US Statute)	1.6093	kilometers
nautical mile	1.852	kilometers
pounds	2.2046	kilograms

Editors Note:

The alternative numbers contained in this report on Wave Response are different than those in the text of the Supplemental EIS. Cross reference key follows.

SEIS alternative	Report alternative
1968 Authorized Plan	Not evaluated
1980 Appproved Plan	Proposed Plan 1
Alternative Plan 1	Not evaluated
Alternative Plan 2	Not evaluated
Alternative Plan 3	Not evaluated
Alternative Plan 4	Proposed Plan 3
Alternative Plan 5	Not evaluated
Alternative Plan 6	Not evaluated

Proposed Plan 2 is an early version of Alternative Plan 4, which is not included in the SEIS.

Proposed Plan 1a is the same as the 1980 approved plan, except the south breakwater extension is rotated clockwise 7 degrees. This angle corresponds to that of Alternative Plan 5

Proposed Plan 1b is the same as the 1980 Approved Plan, with a vertical bulkhead instead of a sloping rock face on the central mole.

1 Introduction

Background

At the request of the U.S. Army Engineer Division, Pacific Ocean (POD), a numerical model wave response study of proposed improvements to Maalaea small boat harbor was conducted by the U.S. Army Engineer Waterways Experiment Station's (WES's) Coastal Engineering Research Center (CERC). The study was conducted to determine an optimal design plan of improvement which would provide the harbor with adequate protection from the incident wave climate. The existing harbor facility consists of an entrance channel, turning basin, two protective breakwaters, 93 berths, a haulout and launching ramp, and a 100,000-lb[1] capacity cold storage plant. Following evaluation of the existing harbor, five proposed design plans of improvement were investigated.

Study Location

Maalaea small boat harbor is located on the southwest coast of the island of Maui, HI, the second-largest island in the Hawaiian chain. The harbor is approximately 7 miles south of the County seat in Wailuku and approximately 8 miles south of the commercial and business center of Kahului (Figure 1).

The shoreline of Maalaea Bay is part of an isthmus connecting two inactive volcanos which form west and east Maui. The shoreline is characterized by a long narrow coral-sand beach and includes the world-renowned Maalaea Pipeline surfing area. Maalaea Harbor is located at the extreme west end of this beach.

Maalaea Harbor was first developed by the Territory of Hawaii in 1952. The harbor was modified in 1955, 1959, and to the present configuration in 1979 (Figure 2). The existing facility consists of a 90-ft-wide, 12-ft-deep

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[1] A table of factors for converting non-SI units of measurement to SI units is presented on page v.

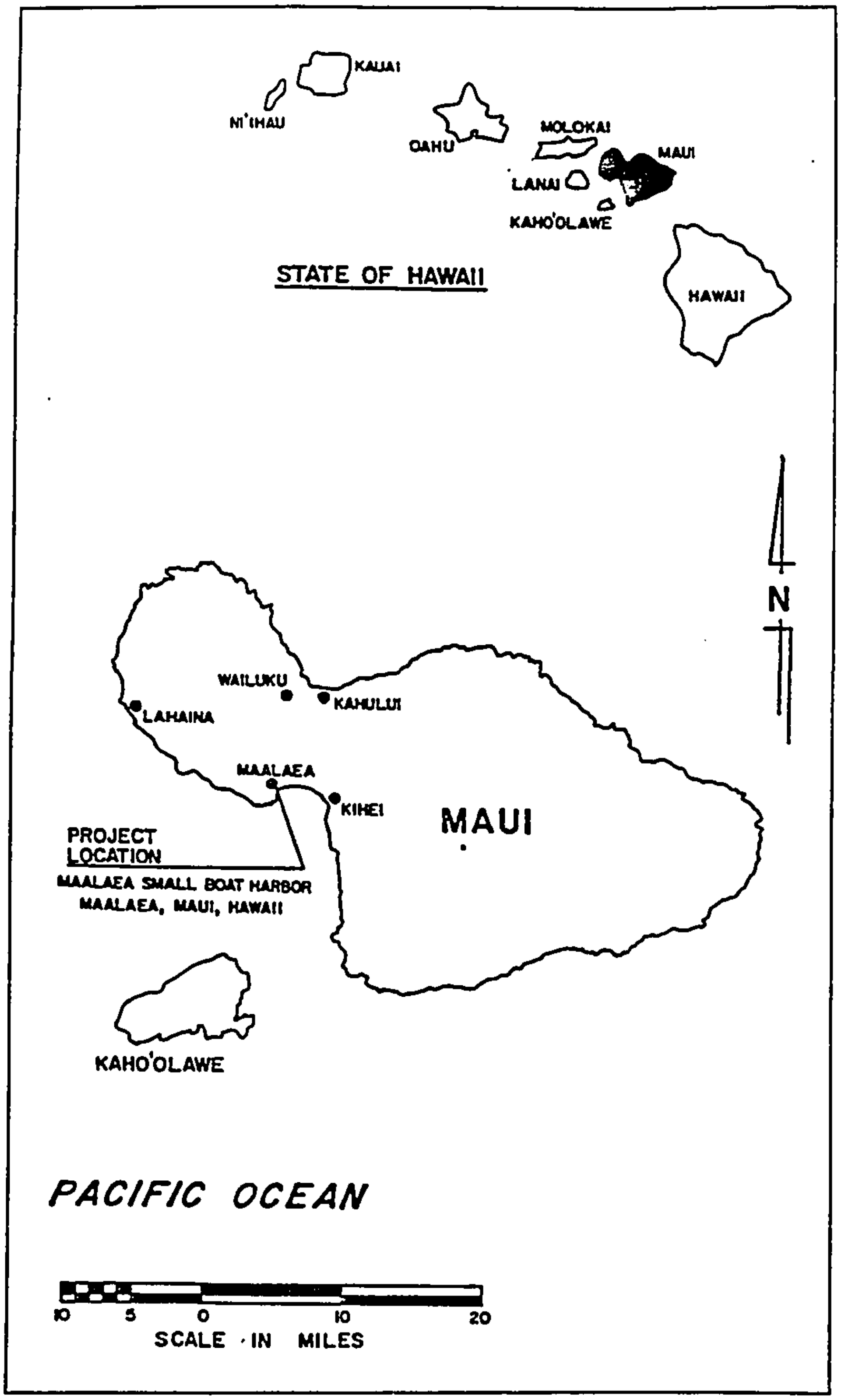

Figure 1. Study location

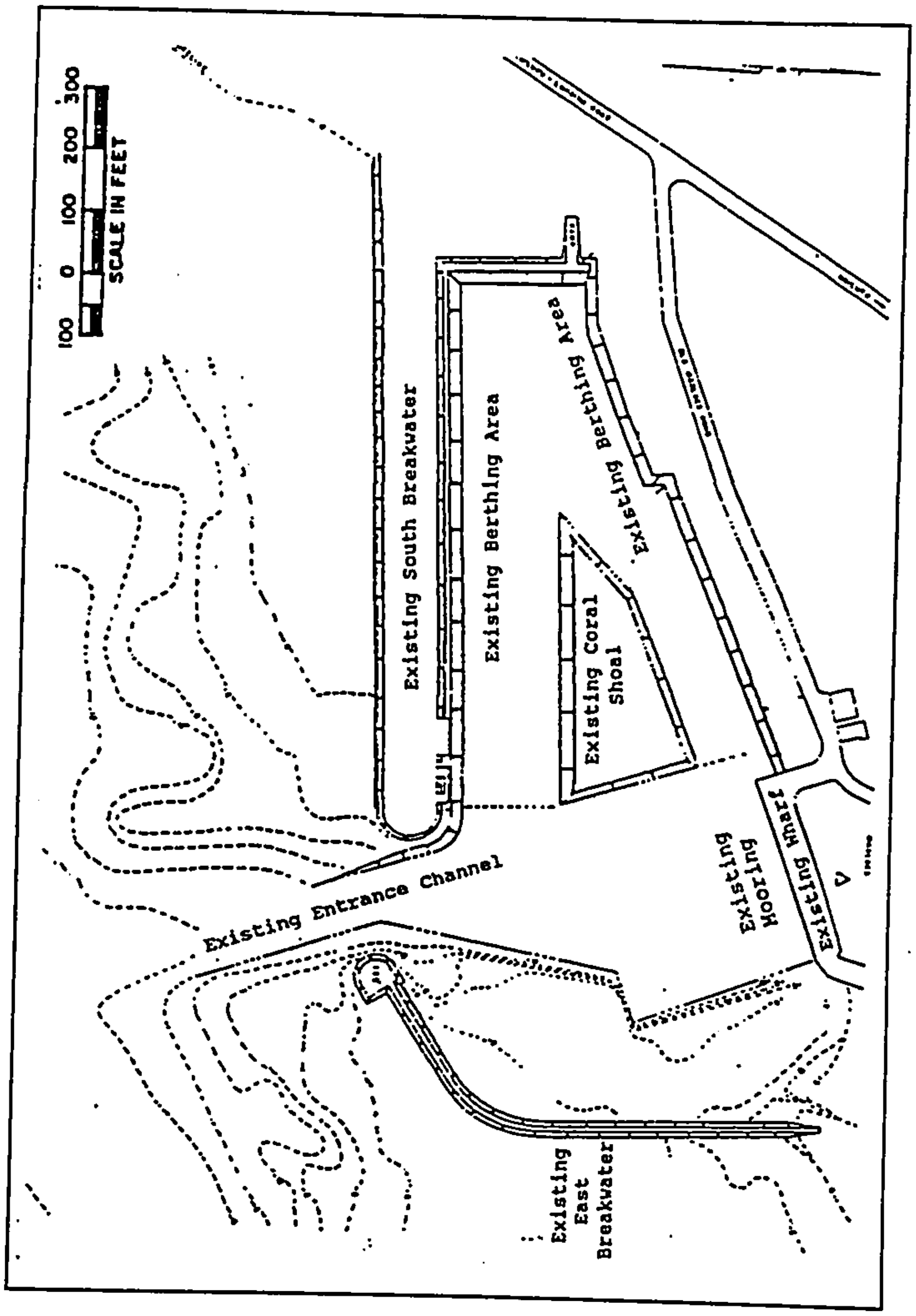

Figure 2. Existing plan

entrance channel; an 11.3 acre dredged basin; a 100-ft-long, 90-ft-wide breakwater and revetment on the south side of the basin; an 870-ft-long breakwater on the east side of the basin; and a 300-ft-long, 50-ft-wide paved wharf on the north side of the basin. The capacity of the harbor is limited to 93 small craft due to hazardous conditions. A 100,000-lb-capacity cold storage plant was constructed for use by commercial fishermen operating out of Maalaea Harbor. A launching ramp is located at the west end of the harbor basin. A U.S. Coast Guard cutter is stationed at Maalaea Harbor.

Maalaea Harbor experiences problems which include severe harbor surge, entrance channel navigation difficulties, and inadequate harbor facilities. The surge results from the existing configuration and alignment of the harbor entrance, which allow direct wave propagation through the channel opening. Surge problems cause navigational hazards and prevent safe berthing in some portions of the harbor.

Proposed improvements to Maalaea harbor are limited by several constraints. The most significant is that the harbor site is fixed and alternate sites can not be considered. Constraints mandated by harbor users and local surfers include: (a) the existing breakwater structures must remain intact and changes to the structures must be additive; (b) construction of modifications must be accomplished without serious interruption of harbor navigation; and (c) additional structures must not extend beyond the present eastern harbor boundary in order to avoid impacts on the surfing area outside the harbor. In early 1980, a hydraulic model study was conducted at WES to investigate the stability of various breakwater cross sections considered in the proposed plans of improvement. Details of the study are provided in Carver and Markle (1981). The General Design Memorandum (GDM) for Maalaea Harbor for Light-Draft Vessels (U.S. Army Engineer District, Honolulu 1980) contains a record of the research and planning which led to proposed design improvements, Plan 1 (Figure 3).

Plan 1 will provide berthing facilities for approximately 310 small craft, and includes the following improvements:

a. A 620-ft-long extension to the existing south breakwater.

b. An additional 400-ft-long revetment on the seaward side of the existing south breakwater.

c. A 610-ft-long entrance channel, varying in width from 150 to 180 ft, and varying in depth from 12 to 15 ft.

d. A 1.7-acre, 12-ft-deep turning basin.

e. Removal of 80 ft from the existing east breakwater head.

f. A 50-ft-wide, 720-ft-long interior revetment adjacent to the existing east breakwater.

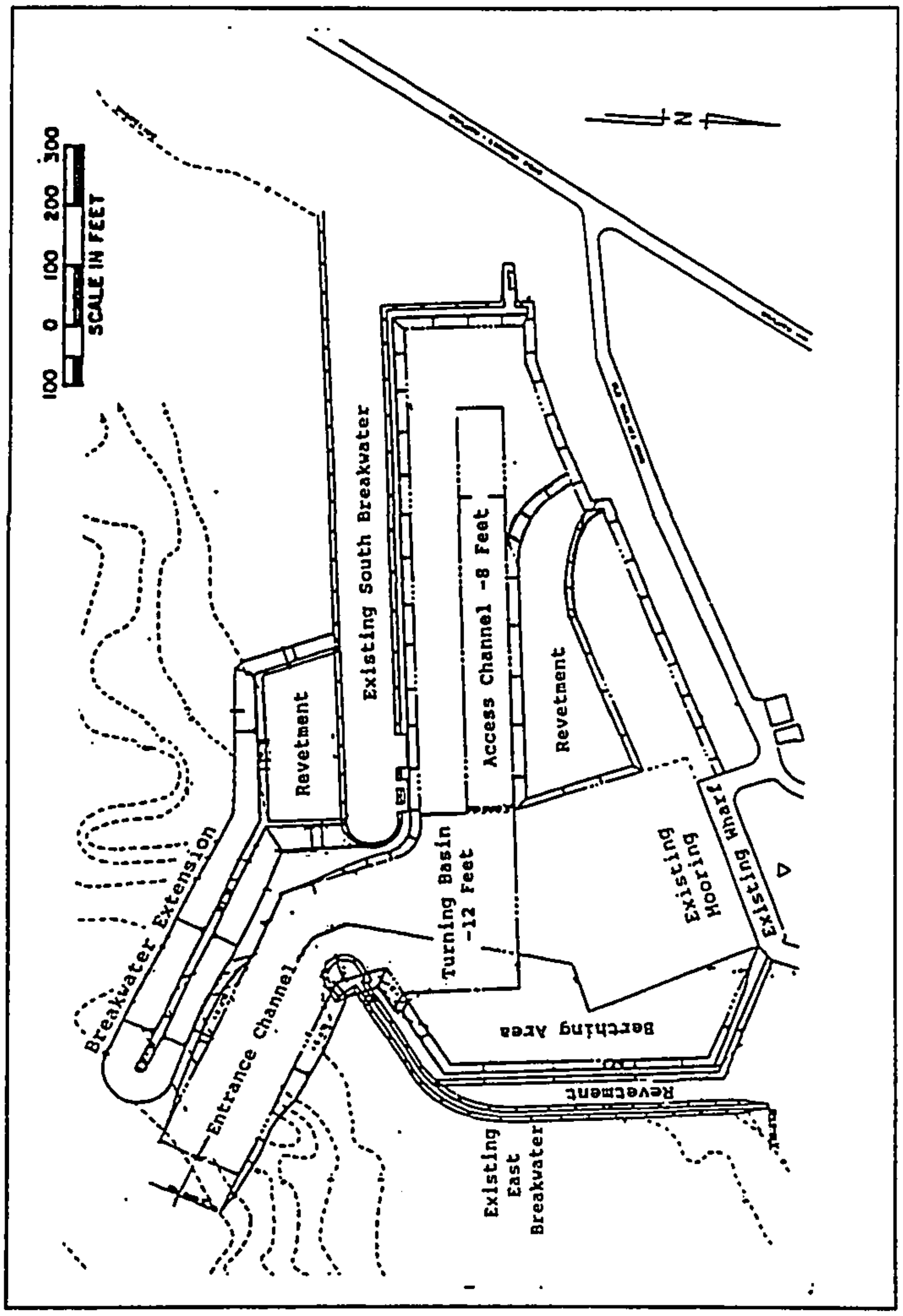

Figure 3. Proposed Plan 1

g. An 8-ft-deep berthing area adjacent to the existing east breakwater.

h. A 570-ft-long interior revetment varying in width from 50 to 170 ft.

Plan 2 (Figure 4) redirects the entrance channel to the west and includes the following improvements:

a. Removal of 300 ft from the existing south breakwater tip.

b. A 610-ft-long 15-ft-deep entrance channel, varying in width from 150 to 200 ft, and varying in depth from 12 to 15 ft.

c. A 1.7-acre, 12-ft-deep turning basin.

d. Removal of 80 ft from the existing east breakwater head.

e. A 600-ft-long extension to the existing east breakwater.

f. A 50-ft-wide, 600-ft-long interior revetment adjacent to the existing east breakwater.

g. An 8-ft-deep berthing area adjacent to the existing east breakwater.

h. *A 570-ft-long interior revetment varying in width from 50 to 170 ft.*

Plan 3 (Figure 5) includes the same improvements as Plan 2 with the exception of an additional extension to the existing east breakwater. The 600-ft-long extension will continue an additional 250 ft towards the west.

Two additional plans were considered in the second phase of this study (Figure 6). They are modifications of Plan 1. Plan 1a is the same as Plan 1 except the new south breakwater extension and entrance channel are rotated clockwise 7 deg. Plan 1b is identical to Plan 1a except a vertical sheet-pile bulkhead replaces the revetment along the east side of the center mole.

Headquarters, U.S. Army Corps of Engineers (HQUSACE) and POD established the following study objectives: Verify that the proposed harbor design improvements meet the criteria that wave heights not exceed 1 ft in berthing areas and 2 ft in the entrance and access channels and turning basin more than approximately 10 percent of the time per year. Develop a final design plan that satisfies the locals to the harbor and adjacent areas. To accomplish these objectives, the HARBD numerical harbor wave response model (Chen and Houston 1987) developed at CERC was used to test the existing harbor configuration and proposed Plans 1, 2, and 3. The existing configuration was tested to establish harbor response to waves for existing conditions. The three proposed plans were tested since the final design plan must meet the aforementioned constraints. Subsequently, POD requested testing of the two modifications to Plan 1 (Plans 1a and 1b). The proposed plans will hereafter be referred to as "Plan 1", Plan 2", "Plan 3", "Plan 1a", and "Plan 1b."

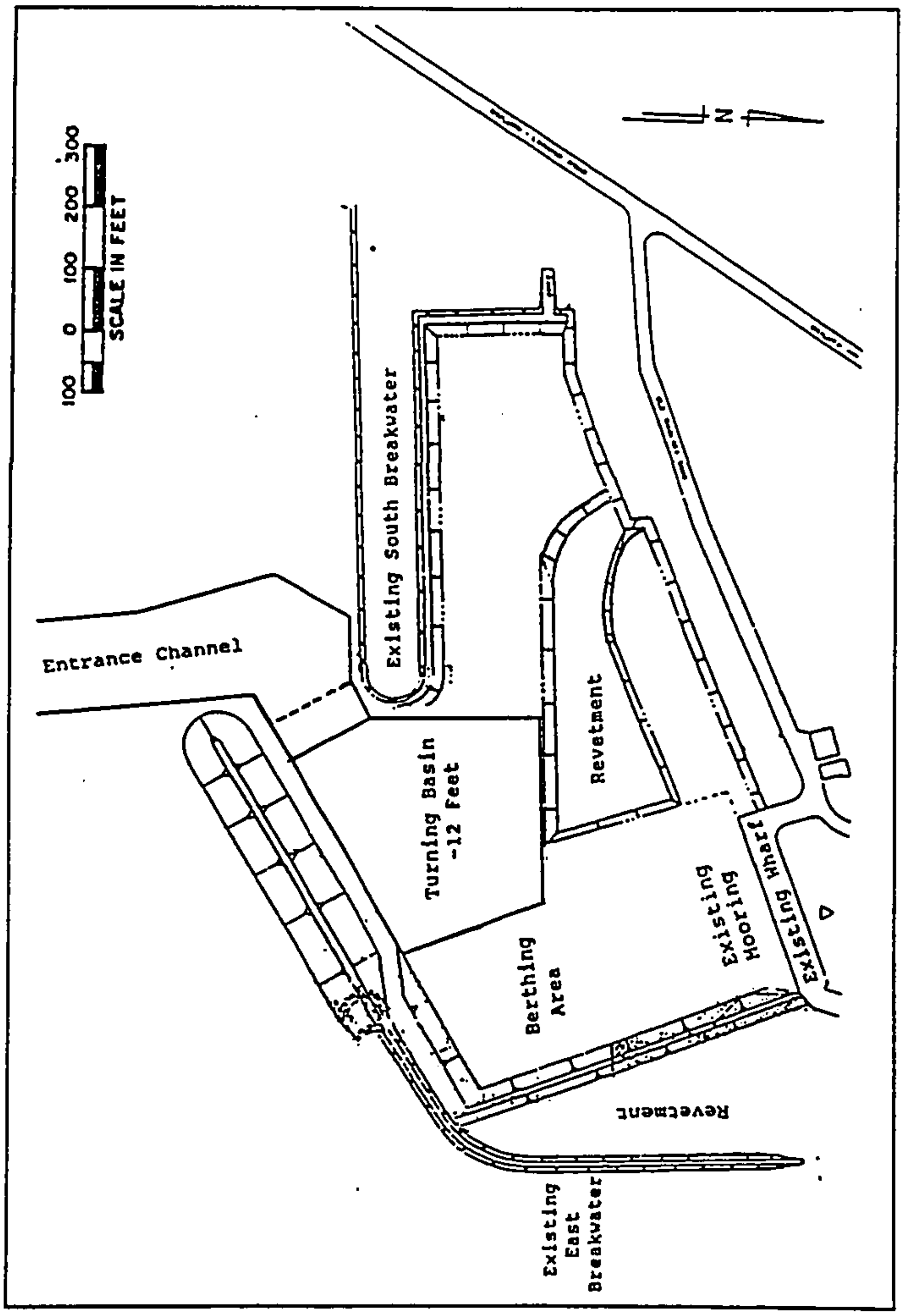

Figure 4. Proposed Plan 2

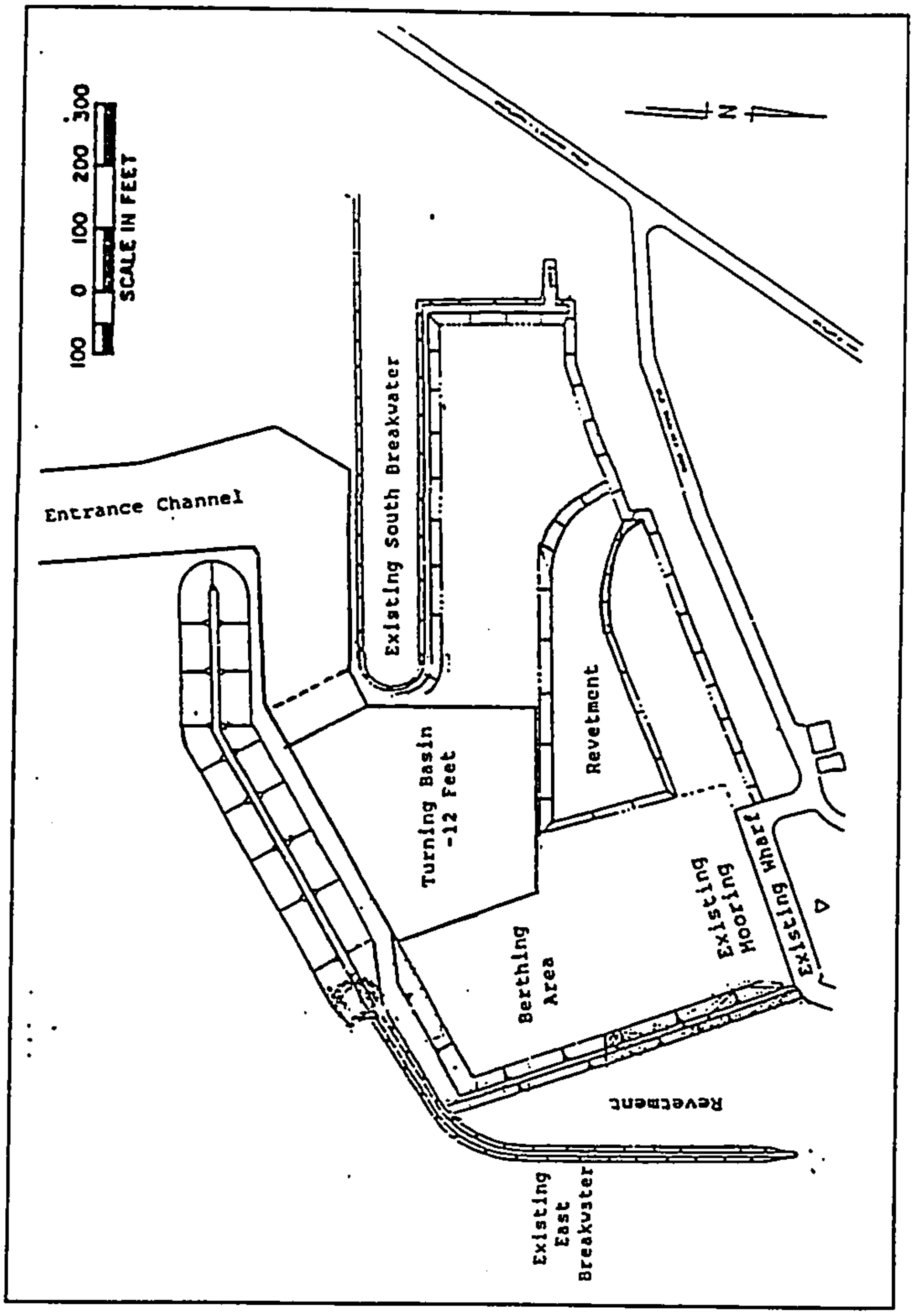

Figure 5. Proposed Plan 3

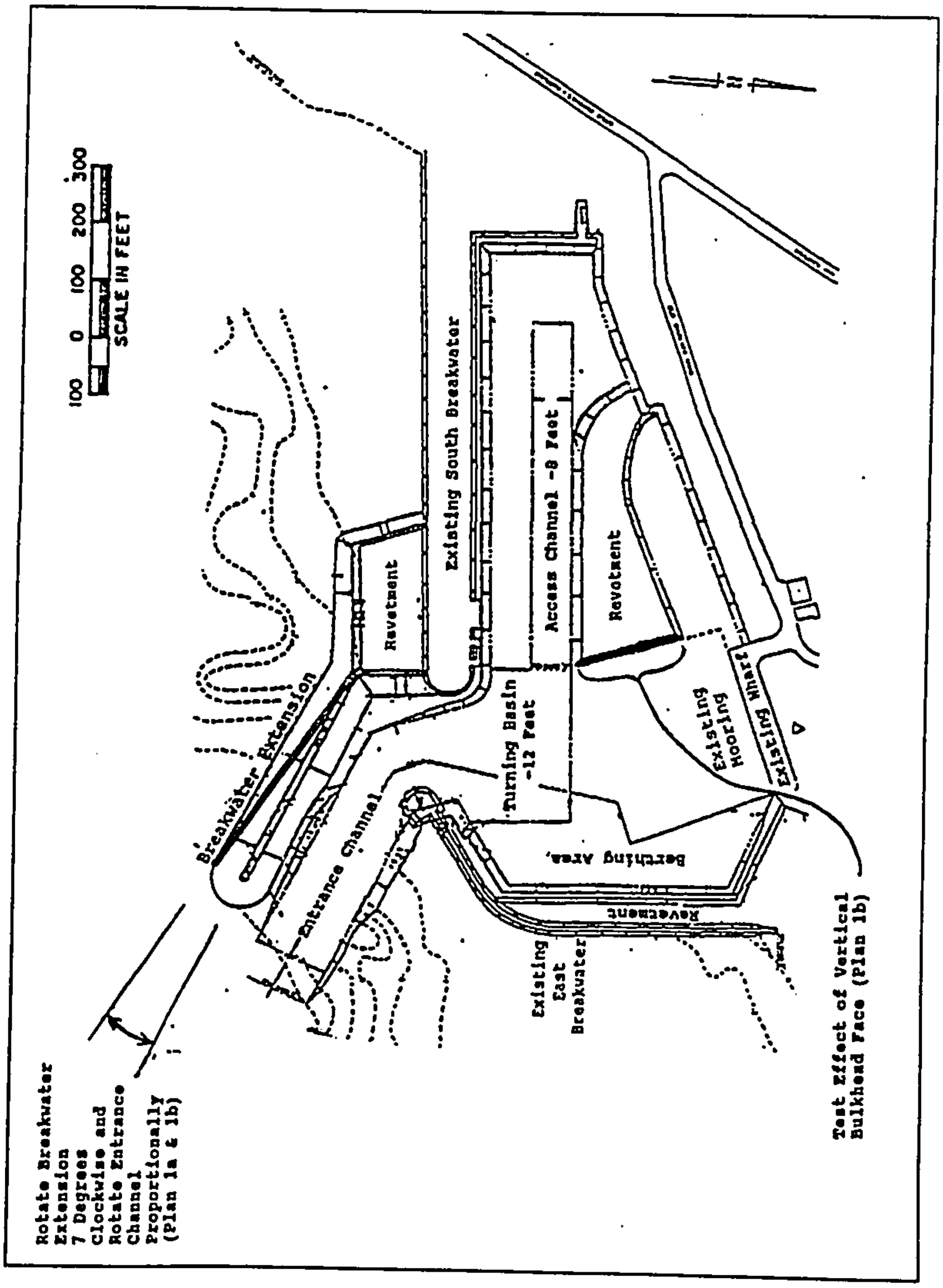

Figure 6. Proposed Plan 1a and 1b

Modeling Approach

Both numerical and physical modeling were considered for this study. Physical modeling has the advantages of providing more complete, reliable results for this particular study and would allow more comprehensive optimization of the project design. However, since the proposed design plans are considerably different, the physical model would cost significantly more and take longer to complete than the numerical model approach. The assumptions inherent in the numerical modeling approach are as follows:

No wave transmission or overtopping of structures.
Structure crest elevations will not be tested or optimized.
No wave-wave or wave-current interaction.
No wave breaking effects.
Diffraction around the structure ends will be represented by diffraction around a blunt vertical wall with a specified reflection coefficient.

Within limits of the assumptions, the numerical modeling approach can be expected to give a reasonable assessment of the proposed plans. This approach was selected because POD's allowable time and study funds were limited and design alternatives for this particular project were extensive. The procedure of this study is described in the following paragraphs.

The deepwater wave conditions for the southwest coast of the island of Maui were established from the Monitoring Completed Coastal Projects (MCCP) (US Army Corps of Engineers (USACE) 1987) measurements taken at Barbers Point Harbor, Oahu, HI. The percent occurrences of the deepwater conditions were calculated to later determine the percent occurrence of the wave heights inside the harbor. The method to establish the deepwater conditions is presented in Chapter 2 of this report, "Deepwater Wave Conditions."

The deepwater waves were transformed to the Maalaea Harbor vicinity through application of the SHALWV numerical model (Hughes and Jensen 1986). SHALWV simulates growth, decay, propagation, shoaling, refraction, and sheltering of a directional wave spectrum over arbitrary bathymetry. The SHALWV model was chosen due to its ability to include effects pertinent to this study such as: (a) simulation over an extensive area, (b) large depth gradients along the grid boundaries, (c) input along two grid boundaries, (d) wave refraction and diffraction around islands, and (e) the ability to model refined areas through subgrids. The SHALWV model is presented in Chapter 3 of this report, "Wave Transformation Modeling."

The resulting wave conditions of SHALWV were then used as input to HARBD to determine the wave response inside the harbor. HARBD is a steady state finite element model that calculates linear wave oscillations in harbors of arbitrary configuration and variable bathymetry. The effects of bottom friction and boundary absorption (reflection) are included. Through application of HARBD, the resulting wave heights in the harbor entrance and access channels, turning basin, and berthing areas were determined and the percent occurrence of those conditions were calculated using the results of both the SHALWV and HARBD models. The HARBD model and details and results of the procedures are presented in Chapter 4 of this report, "Wave Response Modeling."

2 Deepwater Wave Conditions

Maalaea small boat harbor is affected primarily by wave conditions resulting from southern swell and "Kona", or low pressure systems, storm waves arriving from south or south-southwest. Sources of wave information for the Hawaiian Islands and particularly for use at the Maalaea Harbor vicinity are extremely limited.

Possible sources of wave information in the Hawaiian Islands include (Figure 7): the Wave Information Studies (WIS) deepwater hindcasts for the Pacific coast which include seven stations around the Hawaiian Islands (Corson, et al. 1986); the deepwater buoy, Station 51001 (Gilhousen, et al. 1986), operated by the National Oceanic and Atmospheric Administration's National Data Buoy Center (NDBC); the Summary of Synoptic Meteorological Observations (U.S. Naval Weather Service Command 1976) climatological summaries of shipboard wave observations; and the Monitoring Completed Coastal Projects (MCCP) Program of the US Army Corps of Engineers (USACE 1987) slope array at Barbers Point, Oahu.

Of the available data sources in the Hawaiian Islands, the wave measurements from the MCCP slope array at Barbers Point, Oahu, are the only directional data that have exposures representative of the coast relevant to Maalaea. Although Barbers Point is on a different island than Maalaea, the coastline orientation and southern exposure are similar at the two sites.

Deepwater Wave Climate

Offshore wave climate at the Maalaea harbor site was estimated using the MCCP Barbers Point slope array measurements. Although data sources are limited, the percent occurrence of significant wave height, peak spectral period, and direction are adequately represented in the Barbers Point data. These data include effects of southern swell, which is an important factor relevant to the Maalaea harbor site.

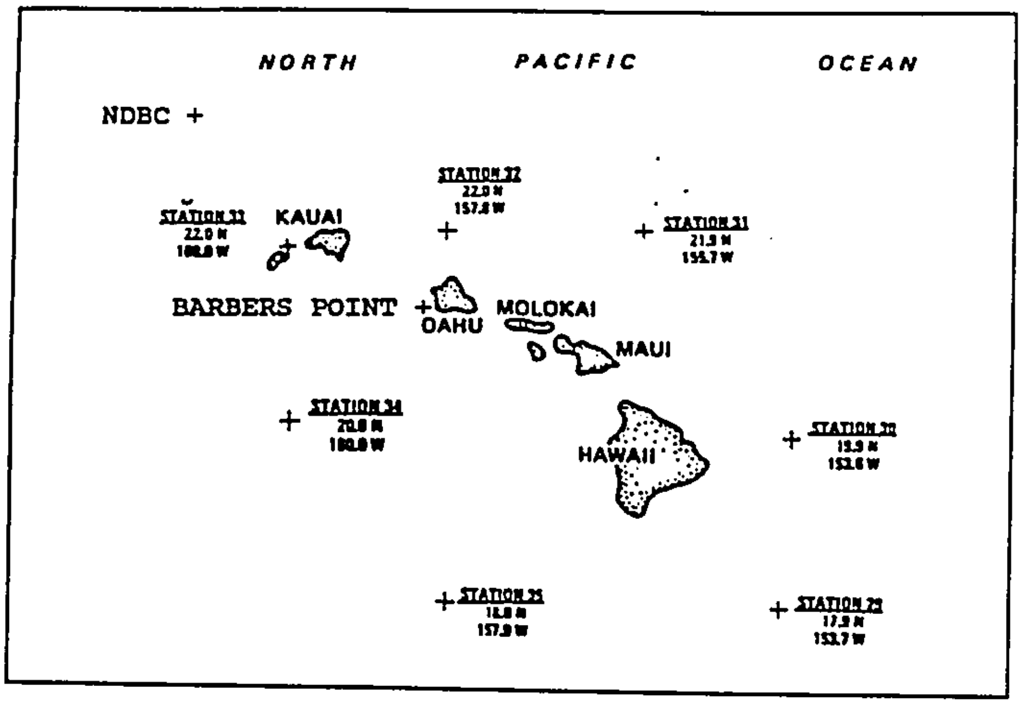

Figure 7. Sources of wave information in the Hawaiian Islands

Maalaea harbor is exposed to a sector of wave angles from about the 135.0- to 270.0-deg azimuth. MCCP measurements within this sector were taken as part of the deepwater climate at Maalaea. Measurements outside this sector were not used because the harbor is sheltered by land from those directions.

The MCCP Barbers Point measurements represent a general wave climate for a southwest-facing coast. Therefore, measurements taken during various intervals over the period from July 1986 through August 1990 were compiled to obtain a data set representative of one complete year. The measurements were then "unrefracted" from 28 ft to an approximate 1,300-ft depth to transfer the data set to an appropriate location fronting Maalaea. This process was accomplished through application of an Automated Coastal Engineering System (ACES) code which implements Snell's Law. Bottom contours were assumed straight and parallel. The percent occurrences from each direction in the exposed sector were then compiled and are given in Appendix A and summarized by direction in Table 1 at the end of the text of this report. The compiled percent occurrence of height, period, and direction are considered as the best possible representation of the deepwater wave climate for Maalaea Harbor. The percent occurrence of waves corresponding to Table 1 is shown in Figure 8.

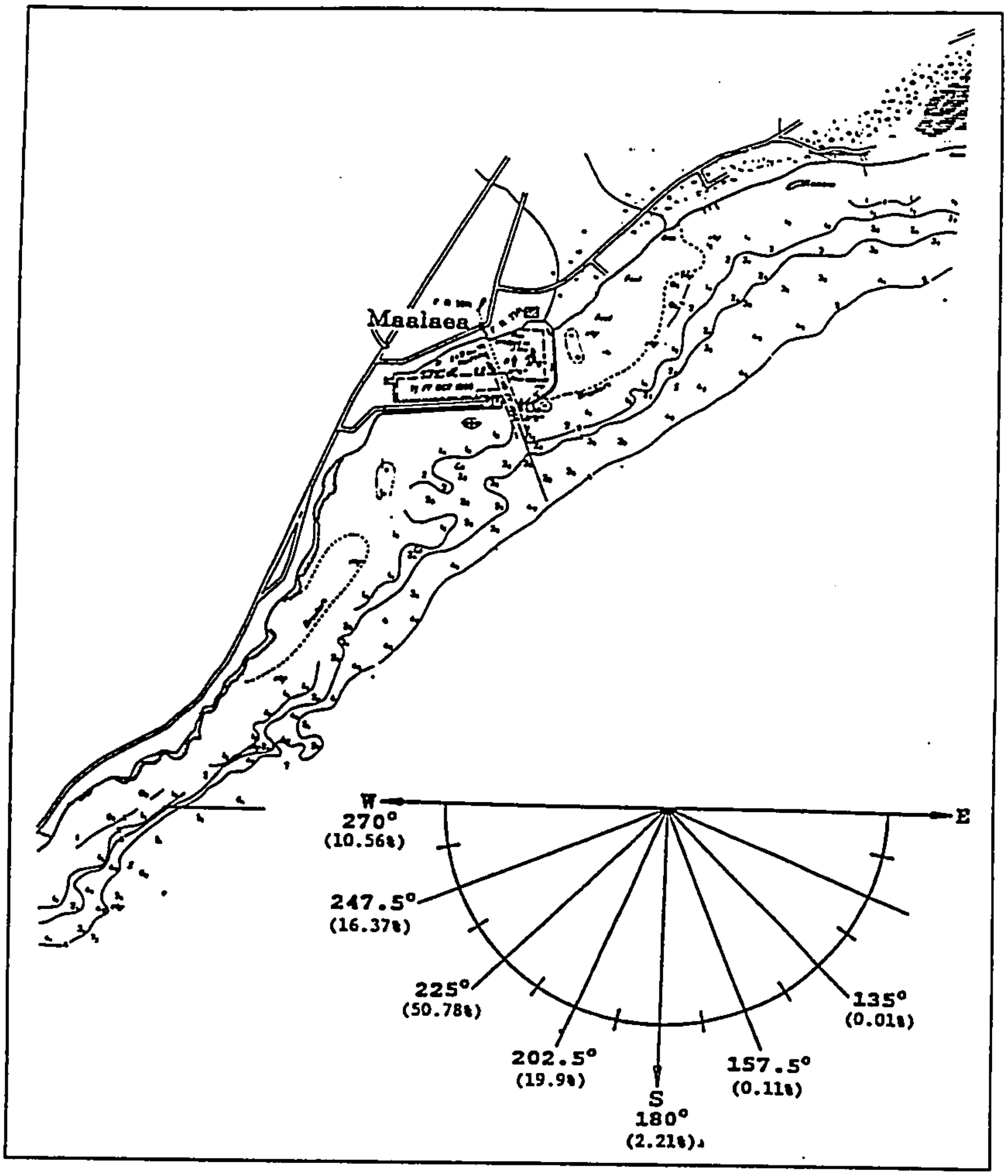

Figure 8. Percent occurrence of deepwater wave conditions by direction

3 Wave Transformation Modeling

Wave Transformation Model

Once the deepwater wave conditions are established, it is necessary to transform the waves shoreward to the Maalaea vicinity. This was accomplished using the numerical wave model SHALWV (Jensen, Vincent, and Abel 1987). SHALWV numerically simulates growth, decay, propagation, shoaling, refraction, and sheltering of a directional wave spectrum over arbitrary bathymetry. The modeled spectra are represented as fully two-dimensional spectra in discrete frequency and direction bands. The model is time-dependent and is most often used to simulate time-varying wave and wind conditions. SHALWV was chosen to transform waves to the Maalaea vicinity due to the sizable extent of the grid required to include the island of Kahoolawe. For this application, winds are not used; therefore, no wave growth occurs and wave input is held constant for each wave condition. The fetch of the modeled area is approximately 20 miles, therefore the effect of local winds is limited to higher frequencies. Although some differences in the distribution of wave energy in frequency and direction can be expected with the introduction of local winds, only extreme conditions will contribute significantly. Holding the wave conditions constant, in this case for 5 hr, neglects changes in regional winds and waves on a smaller time scale. This is a limitation of the measured data, which was collected in 6-hr increments.

The model is based on the solution of the inhomogeneous energy balance equation solved with finite-difference methods using square grid cells to describe the bathymetry and wind field. The field equation represents wind and wave growth, refraction, shoaling, nonlinear wave-wave interactions, high frequency energy dissipation, wave bottom interactions, and decomposition of the energy into wind-sea and swell wave components. The maximum time-step interval is determined from the following Courant number stability criterion which is based on grid size and water depth:

$$\frac{\Delta L}{\Delta t} > C_g(f^*)$$

where

ΔL = length of grid cell
Δt = computational time step
C_g = group velocity associated with lowest frequency at the deepest grid point
f = lowest spectral frequency

The Courant number criterion insures that wave energy does not propagate more than one grid cell during a time step (Hughes and Jensen 1986).

Wave Transformation Simulation

The SHALWV model uses a rectangular, uniformly spaced, finite difference grid that extends over the general area of interest. If necessary, the model allows additional subgrids that are used to resolve complex bathymetry in areas of interest. The main grid used in this study, shown in Figure 9, has 50 cells alongshore (positive x-axis directed east) and 42 cells across-shore (positive y-axis directed north). The grid has square cells of about 3,000 ft in the x and y directions. This grid covered the region of interest including Maalaea Bay and important sheltering features such as the island of Kahoolawe and McGregor Point. Waves were input along the x or y axis depending on the direction being modeled.

In order to resolve the bathymetry near Maalaea Harbor, a higher resolution subgrid of Maalaea Bay was included in the modeling effort. The extent of the subgrid is outlined in Figure 9. The subgrid consists of 35 alongshore and 31 across-shore square grid cells with about 750-ft sides. The resolution of the subgrid is approximately four times greater than the main grid. Wave output at the interface between the subgrid and the HARBD outer boundary were used as input to HARBD.

SHALWV transformation estimates were performed from a depth of approximately 1,300 ft at the offshore boundary to approximately 30 ft at the HARBD outer boundary (Maalaea harbor). Representative period-direction combinations were selected from the modified slope array data for input to SHALWV. Direction bands modeled were 22.5 deg and centered about the 135.0-, 157.5-, 180.0-, 202.5-, 225.0-, 247.5-, and 270.0-deg azimuth, as shown in Figure 9. Peak periods ranged from 9 to 20 sec and selected wave heights ranged from 3 to 8 ft based on shoaling estimates which would exceed the maximum 1- and 2-ft wave height criterion discussed in Chapter 4.

The wave conditions input to SHALWV and the corresponding transformed wave height and direction are given in Table 2 at the end of this text. Figures 10 through 16 are plots of wave direction vectors that show representative wave refraction from the SHALWV main grid input boundary, (x or y axis), to the subgrid boundary in the Maalaea Harbor vicinity. Each figure shows resulting wave direction vectors from input conditions of an 8-ft wave height,

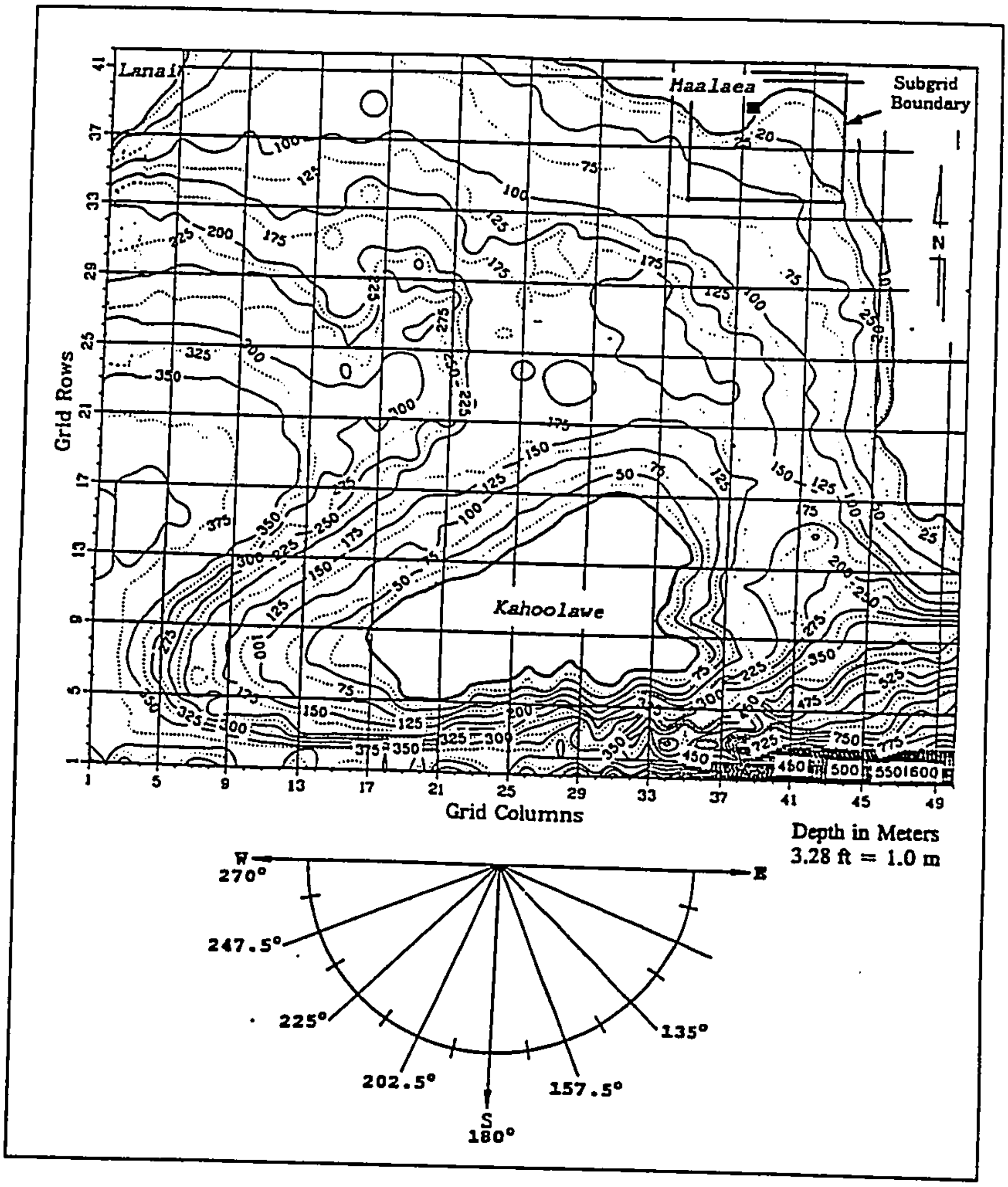

Figure 9. Maalaea SHALWV grid and bathymetry

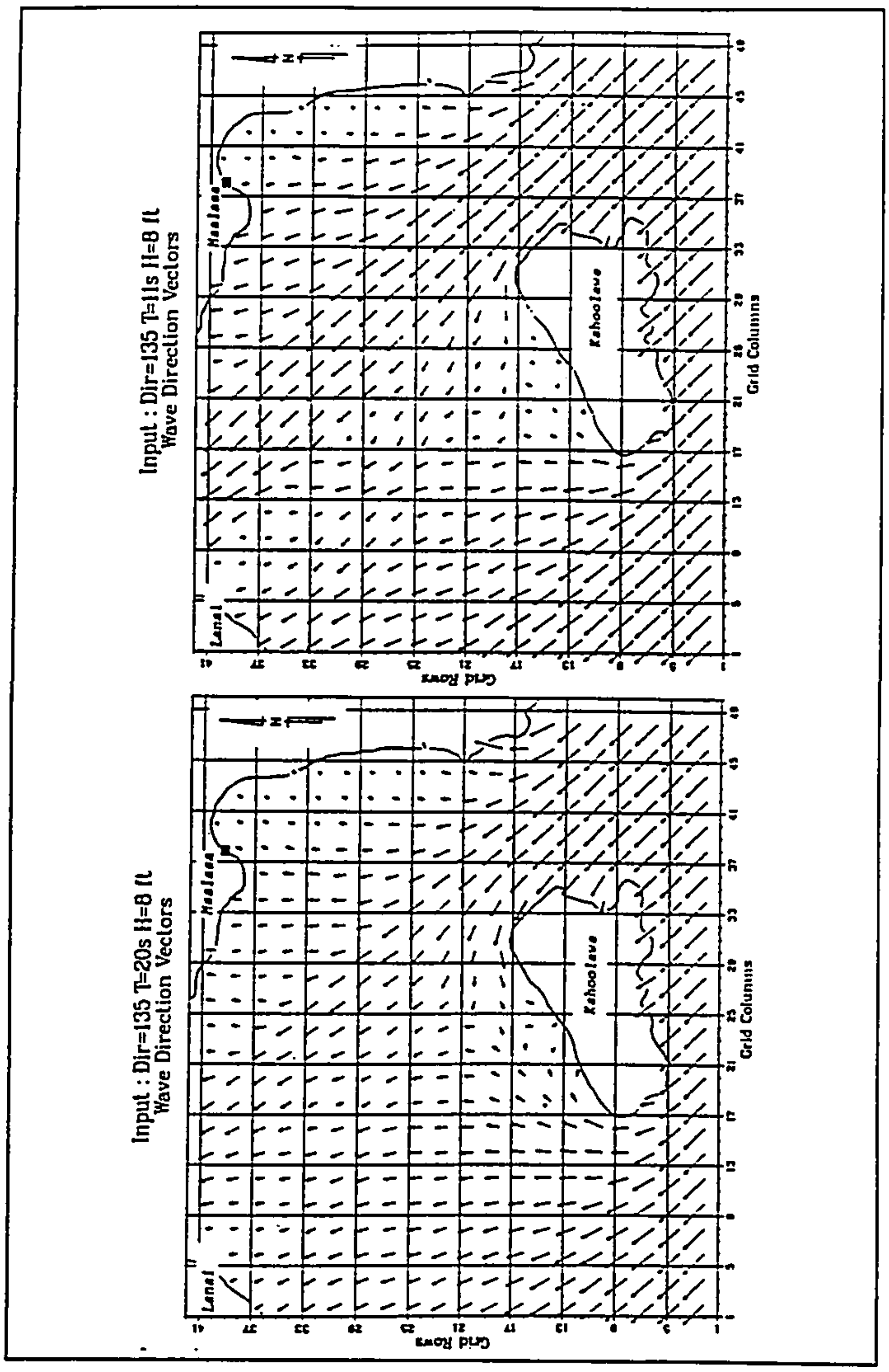

Figure 10. Wave direction vectors for 135.0 deg

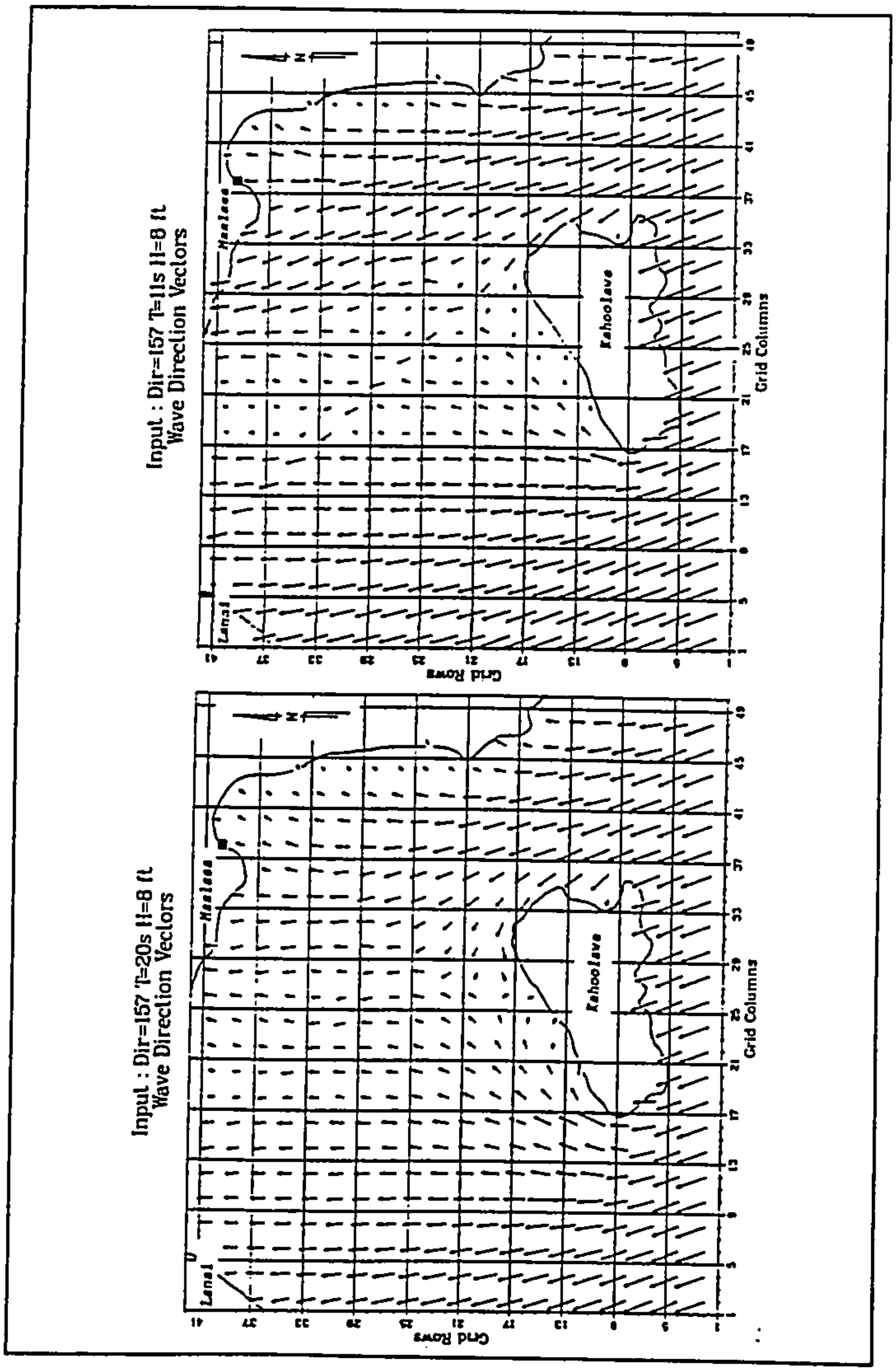

Figure 11. Wave direction vectors for 157.5 deg

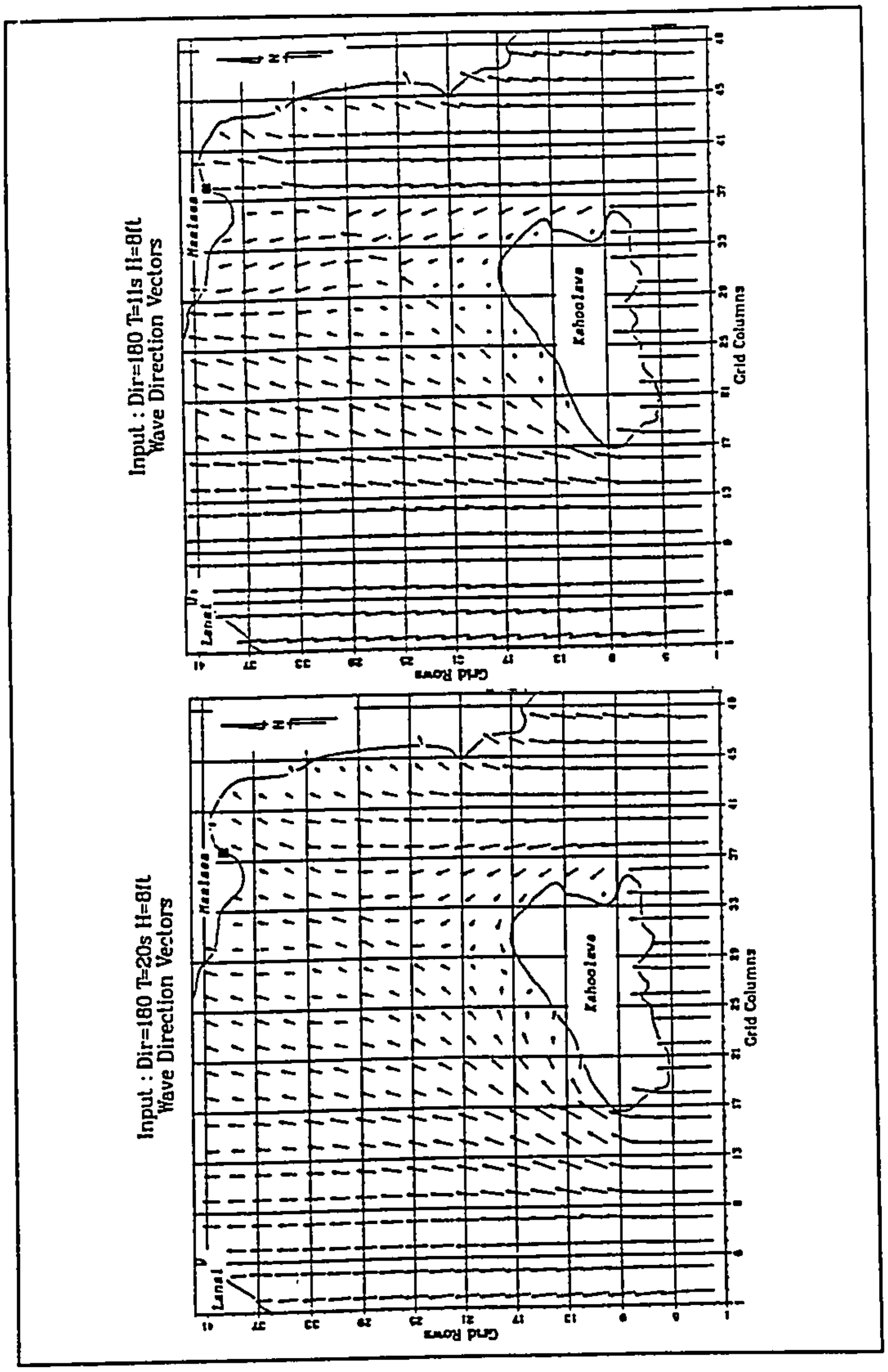

Figure 12. Wave direction vectors for 180.0 deg

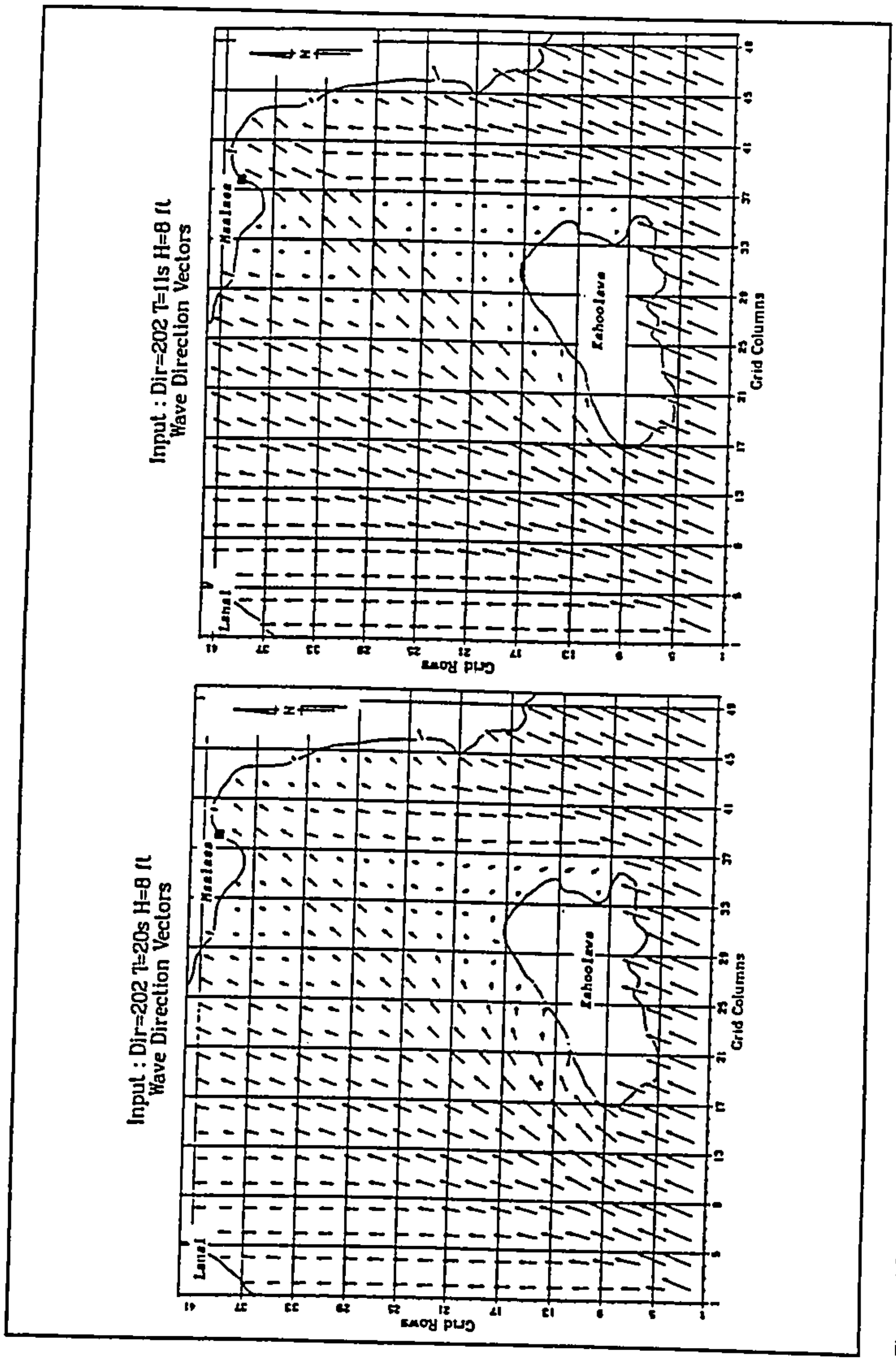

Figure 13. Wave direction vectors for 202.5 deg

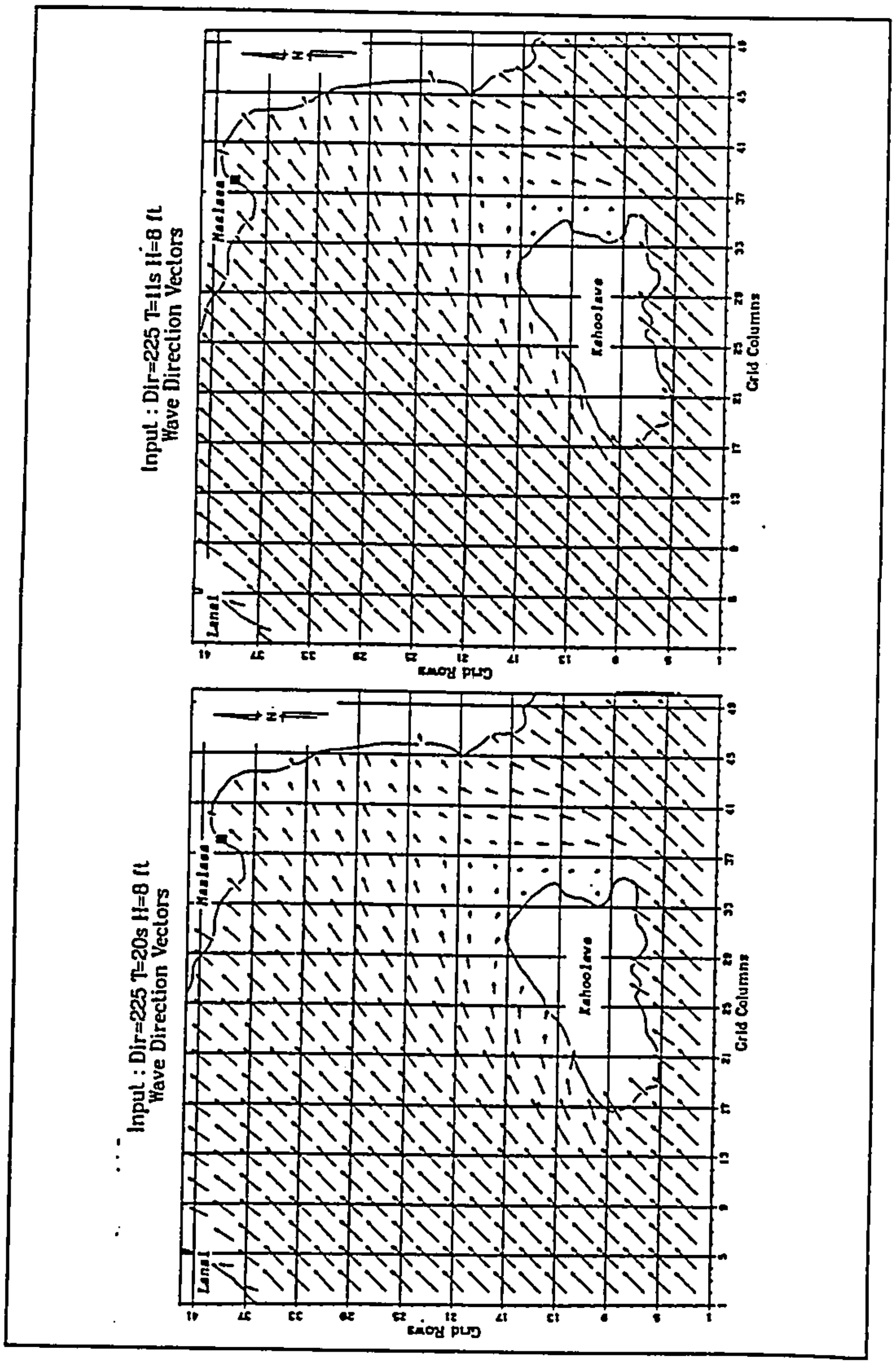

Figure 14. Wave direction vectors for 225.0 deg

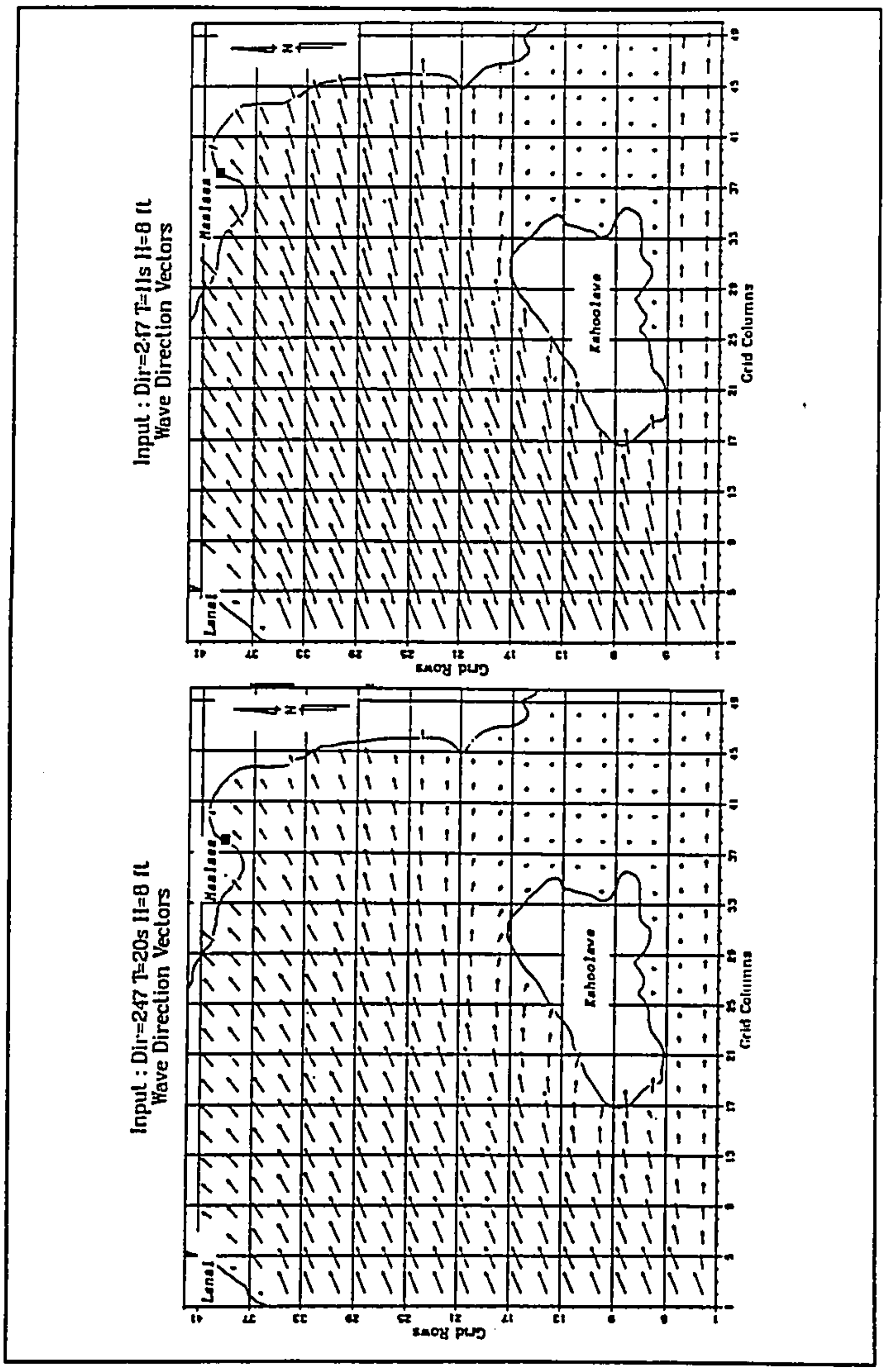

Figure 15. Wave direction vectors for 247.5 deg

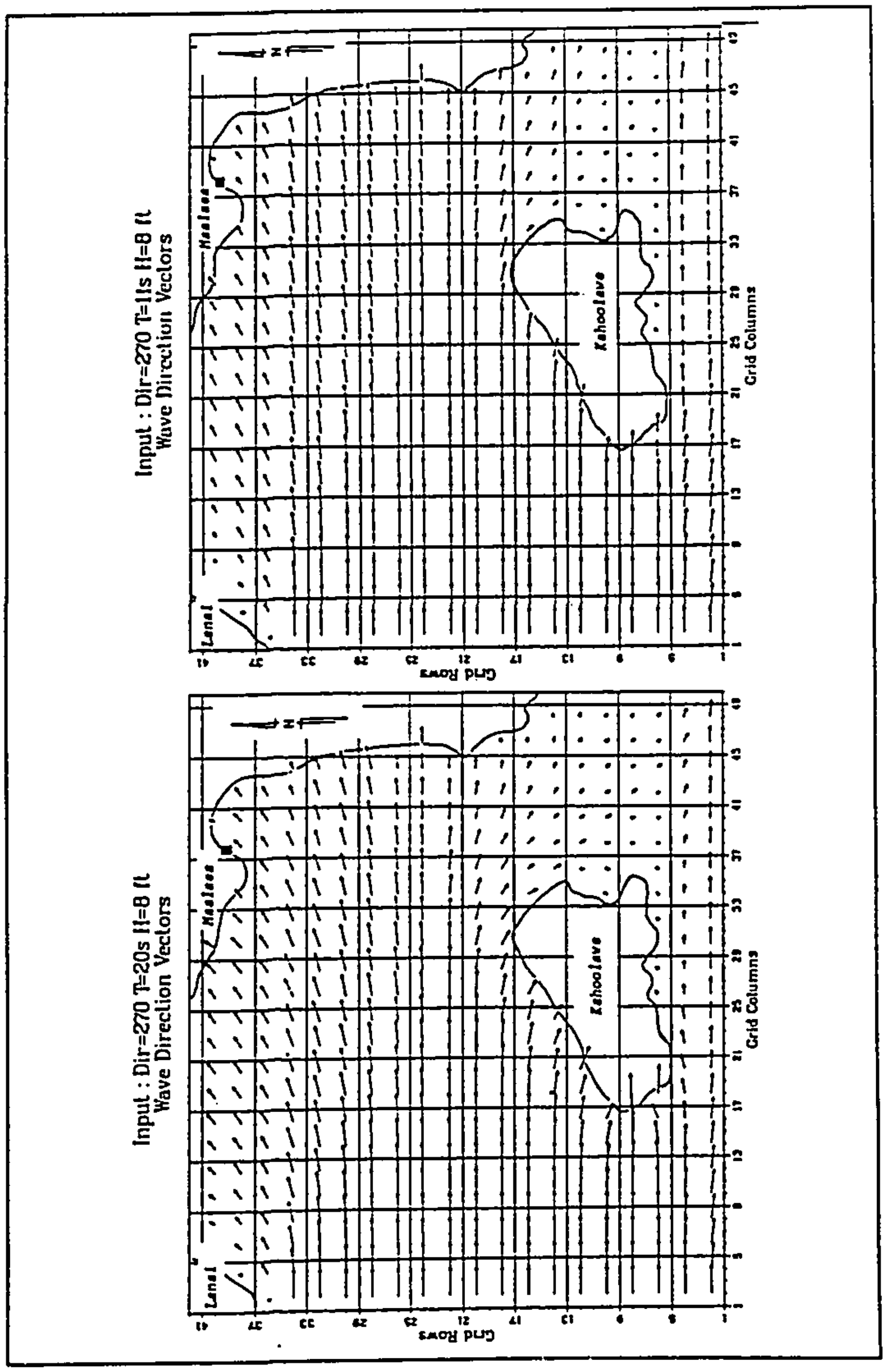

Figure 16. Wave direction vectors for 270.0 deg

an 11- and 20-sec wave period, and wave directions ranging from the 135.0- to 270.0-deg azimuth. The length and direction of the vectors represent the relative wave height and direction, respectively, for each grid point.

These plots show that waves coming from 247.5, 225.0, 202.5, and 180.0 deg produce the most wave energy at the Maalaea Harbor vicinity. Also, the shorter wave periods (11 sec) result in a higher percentage of energy reaching the harbor area than the longer period (20-sec) waves. Waves coming from 247.5 and 225.0 deg travel in nearly straight line paths to the harbor area, resulting in a shoaling dominant transformation process. Waves from 202.5 deg begin refracting toward the island of Kahoolawe on the east and west sides, which results in wave refraction focusing toward the harbor vicinity. Note that the effects of wave diffraction around the island of Kahoolawe are not included in the simulation. These effects do not significantly affect the wave energy reaching the harbor area for wave periods of 20 sec or less, since the distance between the island and the harbor area (12.5 miles) is much greater than 20 wavelengths (7.8 miles for a 20-sec wave). Waves coming from 180.0 deg travel through Alalakeiki Channel and are parallel to the bottom contours in Maalaea Bay. This results in another direct approach of wave energy into the harbor vicinity.

Given the percent occurrence of waves from the directions between 135.0 and 270.0 deg, (Figure 8), the most significant wave directions are 247.5 (16.37 percent), 225.0 (50.78 percent), and 202.5 (19.9 percent) deg. The percent occurrence of waves coming from 180.0 deg is 2.2 percent, and from 157.5 and 135.0 deg is less than 1 percent. Therefore, the frequency of waves affecting the harbor from these directions will be minimal.

4 Harbor Wave Response Modeling

Harbor Wave Response Model

The numerical model HARBD (Chen and Houston 1987) was used to simulate the wave response at Maalaea small boat harbor, Maui, Hawaii. HARBD is a steady state hybrid finite element model that calculates linear wave oscillations in harbors of arbitrary configuration and variable bathymetry. The model is advantageous over other numerical harbor models since bottom friction and boundary reflection are included. The bottom friction is assumed to be proportional to flow velocity with a phase difference. The boundary absorption is based on a formulation similar to that in the impedance condition in acoustics and is expressed in terms of wave number ($2\pi/L$ where L is the wavelength) and reflection coefficient of the boundary. The result is that HARBD predicts wave amplitudes that are more realistic than those from previous models (Chen and Houston 1987). HARBD was originally developed for harbor oscillations (long-period waves), and the general formulation was adapted for wind waves (short-period waves) by Houston (1981).

The model has been tested and compared with known analytical solutions for a number of cases and the results are excellent (Chen 1984, and Chen and Houston 1987). It has been applied in the design or modification of Agat Harbor, Guam (Farrar and Chen 1987); Kawaihae Harbor, Hawaii, Hawaii (Lillycrop, Bratos, and Thompson 1990); and Barbers Point Harbor, Oahu, Hawaii (Durham 1978). The model was instrumental in studying the effects of entrance channel dredging at Morro Bay Harbor, California (Kaihatu, Lillycrop, and Thompson 1989), and analyzing harbor resonance at Los Angeles-Long Beach Harbor California (Sargent 1989). The model was used to plan wave protection at Fisherman's Wharf, San Francisco, California (Bottin, Sargent, and Mize 1985); Green Harbor, Massachusetts (Weishar and Aubrey 1986); Los Angeles-Long Beach Harbor, California (Houston 1976); and to estimate the wave conditions in Indiana Harbor, Indiana during a study of sediment disposal alternatives (Clausner and Abel 1986). HARBD was compared to laboratory data collected from the physical model study of Barcelona Harbor, Buffalo, New York (Crawford and Chen 1988) with encouraging results. The predictions of HARBD are currently under further comparison with prototype and physical model data collected from recent studies of Barbers Point Harbor, Oahu, Hawaii.

HARBD uses a hybrid element method in which a finite element solution in the interior region of the harbor is matched to an analytical solution in the exterior region. In the interior region, HARBD allows arbitrary bathymetry, (i.e., shallow, intermediate, and deepwater waves), variable configuration, and the effects of bottom friction and boundary reflection.

In model formulation for arbitrary depth water waves, the water domain is divided into near and semi-infinite far regions. The near region is bounded by an artificial 180 deg semi-circular boundary outside the harbor and includes the interior harbor and all marine structures and bathymetry of interest. The far region is an infinite semicircular ring shape bounded by the near region and the coastlines. The region extends to infinity in all horizontal directions. The semi-infinite far region is assumed to have a constant water depth and no bottom friction (Chen and Houston 1987). The finite near region, which contains the area of interest, is subdivided into a mesh of triangular shaped elements. The length of the sides of each element is determined from the desired grid resolution and design wave parameters. The water depth and bottom friction coefficient are specified for each element, and a reflection coefficient is assigned to each element on the solid boundaries. The model requires a wave period and direction as input. The solution consists of an amplification factor (i.e., the ratio of the wave height to the incident wave height) and a corresponding phase angle for the entire near region. The phase angle is of little importance to the present study.

The governing partial differential equation is derived through application of linear wave theory to the continuity and momentum equations. This also assumes all dependent variables are periodic in time with angular frequency ω. These steps yield the following generalized Helmholtz equation (Chen 1986) in which the velocity potential ϕ is solved:

$$\nabla(\lambda c c_g \nabla\phi) + \frac{c c_g}{c}\omega^2\phi = 0 \tag{2}$$

where

∇ = horizontal gradient operator
λ = complex bottom friction factor
c = wave phase velocity = (ω/κ)
c_g = wave group velocity = $[c/2\{1 + (2\kappa h/\sinh 2\kappa h)\}]$
κ = wave number, $(2\pi/L)$, where L = wavelength
ω = angular frequency
ϕ = velocity potential
h = water depth

The wave number is obtained from the dispersion relation.

$$\omega^2 = g\kappa \tanh(\kappa h) \tag{3}$$

where g = acceleration due to gravity

The complex bottom friction factor λ is assumed proportional to the maximum velocity at the bottom and is defined as:

$$\lambda = \frac{1}{1 + \frac{i\beta a_o}{h \sinh \kappa h} \exp(i\gamma)} \tag{4}$$

where

β = dimensionless bottom friction coefficient that varies spatially
a_o = incident wave amplitude
γ = phase shift between stress and flow velocity
i = $(-1)^{1/2}$

The effects of bottom friction do not necessarily need to be included in the general solution. This is accomplished by setting $\beta = 0$, which results in $\lambda = 1$, and Equation 1 reduces to an expression which excludes bottom friction.

For the absorptive boundary condition along the solid harbor boundaries, the model adopts the impedance condition used in acoustics in terms of the boundary reflection coefficient K_r expressed as:

$$\frac{\partial \phi}{\partial n} - \alpha \phi = 0 \tag{5}$$

with

$$\alpha = i\kappa \frac{1 - K_r}{1 + K_r} \tag{6}$$

where

α = dimensional coefficient related to the boundary reflection
n = unit-normal vector directed outward from the fluid domain

Similar to the friction coefficient, when $K_r = 1$, then $\alpha = 0$ and Equation 5 reduces to a zero velocity potential normal to the boundary (Sargent 1989). This infers a perfectly reflecting boundary condition.

A conventional finite element approximation is used in the near region, and an analytical solution with unknown coefficients is used to describe the semi-infinite far region. Conditions in the near and far regions must be matched along the artificial semicircle boundary. This requirement is met by HARBD routines which automatically match the solutions using the stationarity of a functional, to a series of Hankel Functions which give the solution for the infinite region (Farrar and Chen 1987). The hybrid element numerical techniques used in the formulation are discussed in greater detail in Chen and Mei (1974).

The HARBD model is intended to simulate waves that can be adequately described by the mild slope equation (Equation 2). Model accuracy decreases as wave conditions approach those outside the validity of this governing equation. HARBD does not simulate nonlinear processes such as wave breaking, wave transformation and overtopping of structures, and wave current interaction; however, the model predicts wave heights accurately if these processes are not dominant. Since nonlinear processes naturally occur in the prototype, care and consideration of the effects must be taken in interpretation of results.

Finite Element Grids

Finite element grids generated for the Existing Plan and Plans 1, 2, and 3 are shown in Figures 17 through 20, respectively. The grid used for both Plans 1a and 1b is shown in Figure 21. All grids cover approximately the same interior harbor areas, however, coverage of the offshore area is variable. In order to model areas pertinent to each plan, the Existing and Plans 1, 1a, and 1b include the offshore area eastward, while Plans 2 and 3 include the offshore area westward. The radius of the semicircular boundary is approximately 800 ft for the existing and Plan 1, 1a, and 1b grids, and approximately 700 ft for the Plan 2 and 3 grids. The radial distance is designed to include the entrance channel and allow enough area to include possible modifications.

Total numbers of elements (triangles), nodes (triangular corners), and boundary elements are:

Existing:	7,146 elements, 3,752 nodes, 252 boundary elements
Plan 1:	6,765 elements, 3,613 nodes, 356 boundary elements
Plan 2:	7,866 elements, 4,176 nodes, 353 boundary elements
Plan 3:	7,911 elements, 4,215 nodes, 386 boundary elements
Plans 1a,1b:	6,810 elements, 3,636 nodes, 357 boundary elements

Each grid was designed with a grid resolution of approximately six elements per wavelength, based on an 8-sec wave period and a basin depth of 8 ft.

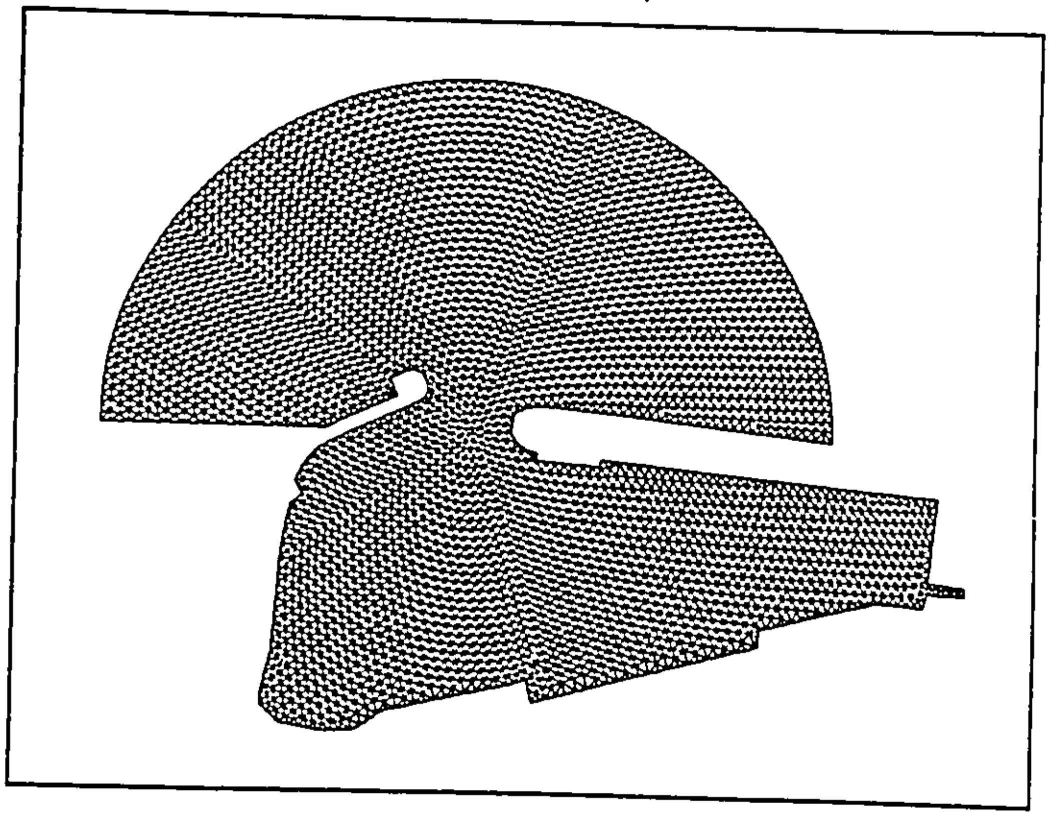

Figure 17. Finite element grid for Existing Plan

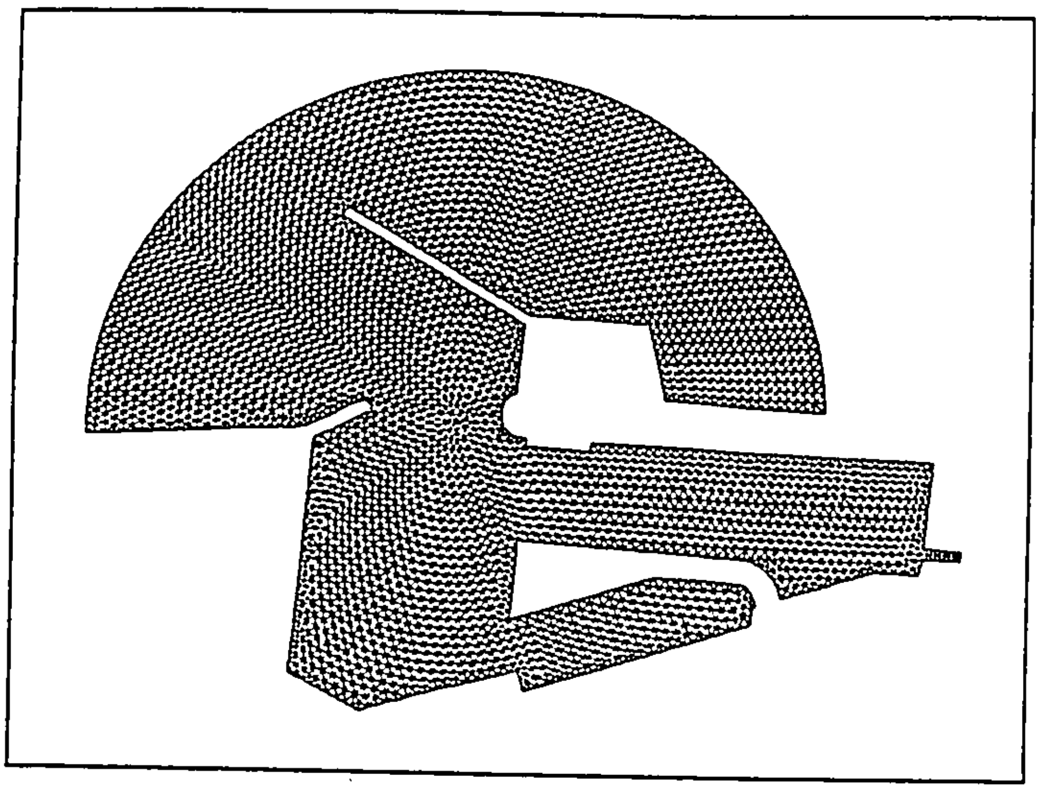

Figure 18. Finite element grid for Plan 1

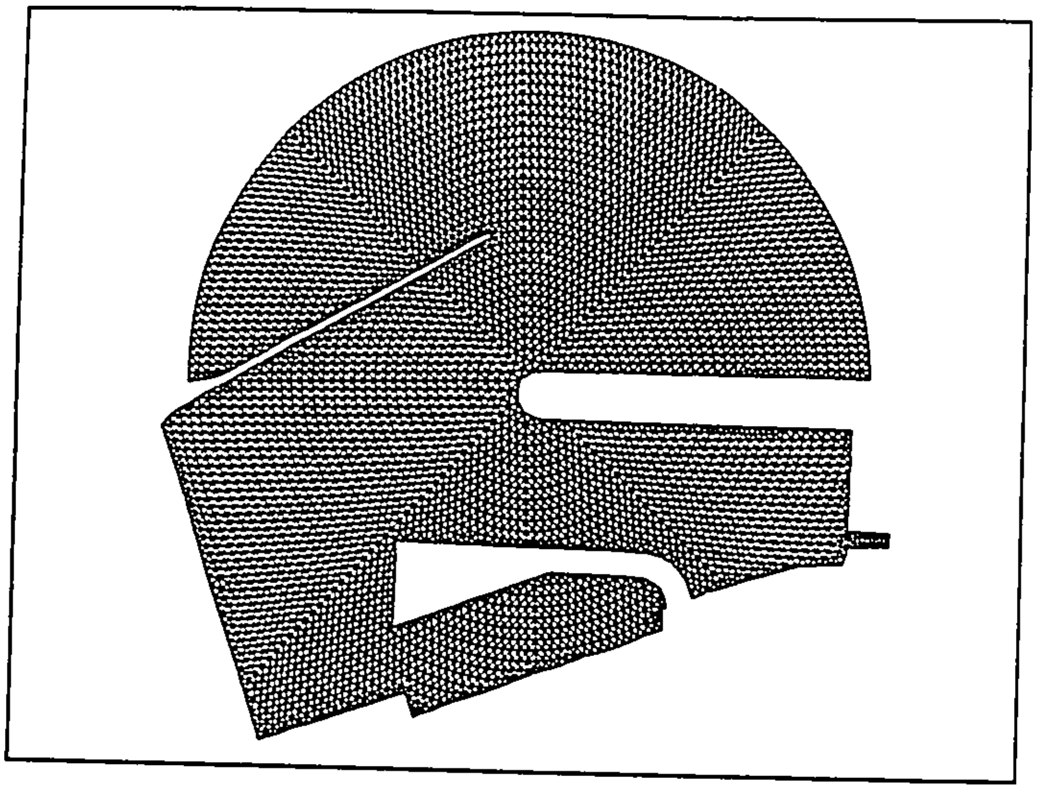

Figure 19. Finite element grid for Plan 2

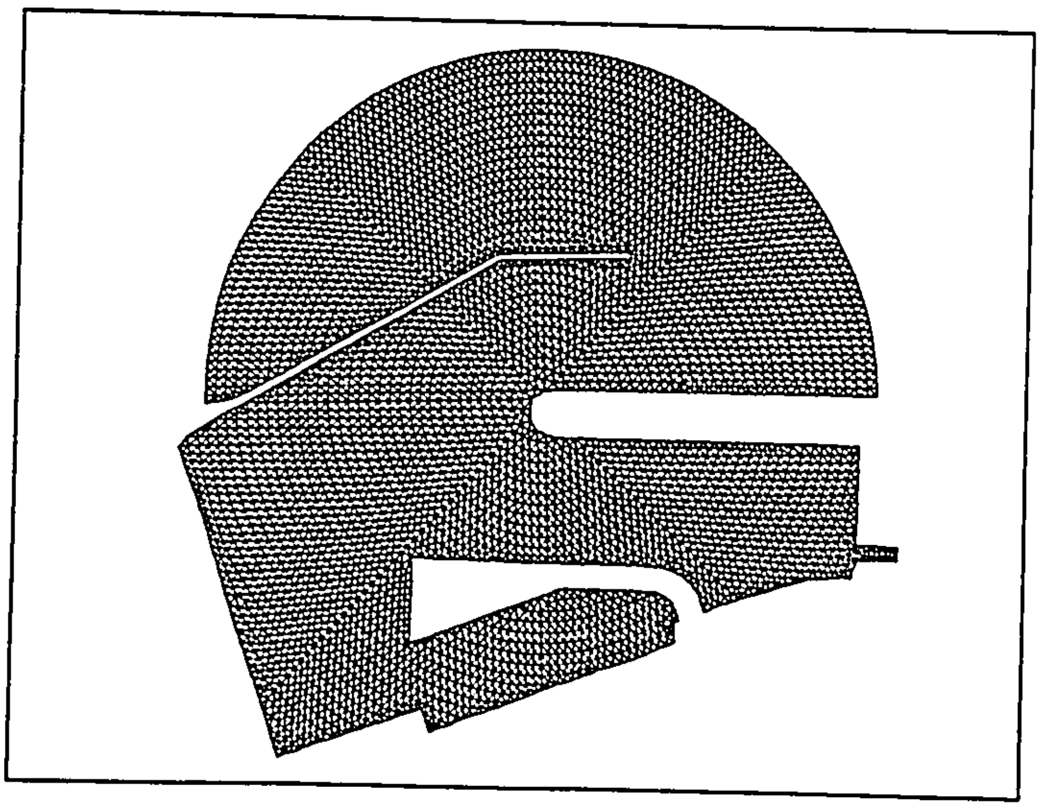

Figure 20. Finite element grid for Plan 3

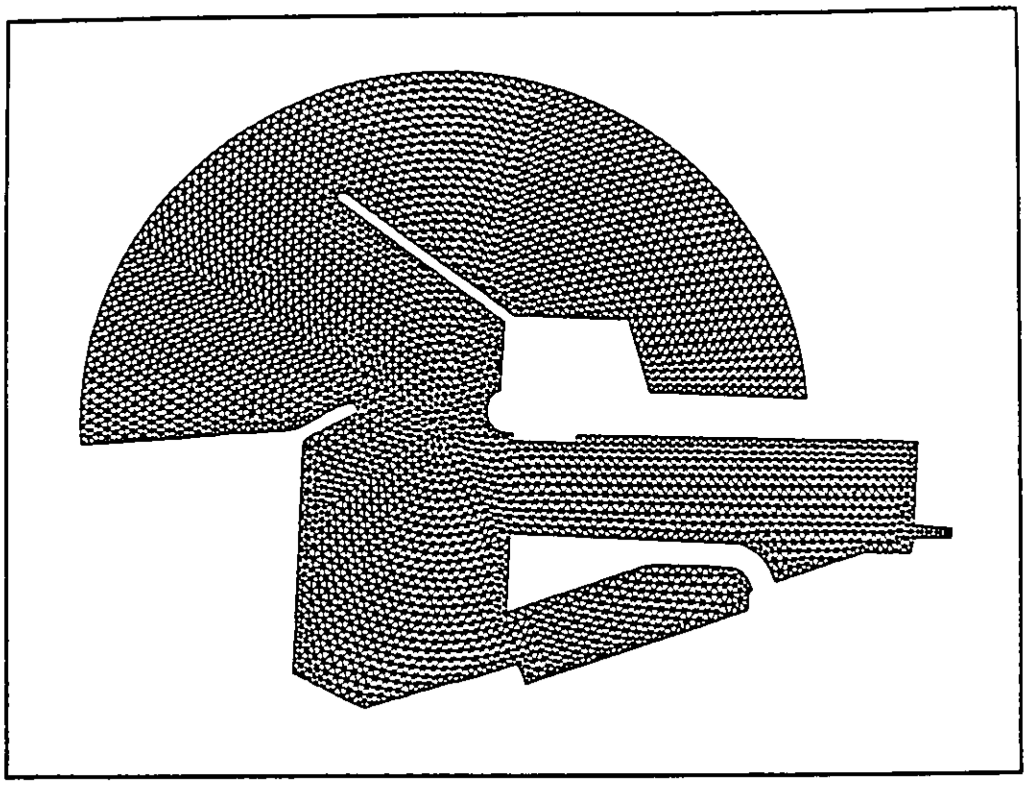

Figure 21. Finite element grid for Plans 1a and 1b

The grid bathymetry was obtained from POD hydrographic surveys taken in 1989. The design still-water level (swl) was used for all tests. Boundary reflection coefficients of the interior harbor walls were calculated using methods in the *Shore Protection Manual* (SPM 1984), and were refined upon recommendation from POD. The assigned reflection coefficients for the existing structures were 0.40 for the 1:2-sloped seaward and harbor sides of the south breakwater and along the west and north walls of the harbor basin, 1.0 for the paved wharf, and 0.35 for the 1:2-sloped seaward and harbor sides of the east breakwaters. For Plan 1, the reflection coefficients for the structural improvements were 0.25 for the 1:2-sloped south breakwater extension and seaward side revetment and 0.35 for the 1:1.5-sloped interior revetments along the existing east breakwater and at the center of the harbor basin. For the structural improvements of Plan 2, the reflection coefficients were 0.25 for the 1:2-sloped east breakwater extension and 0.35 for the 1:1.5-sloped interior revetments as in Plan 1. The additional 250-ft-long 1:2-sloped east breakwater extension in Plan 3 was assigned a reflection coefficient of 0.25. Reflection coefficients in Plan 1a were the same as in Plan 1. Plan 1b differed from Plan 1a in that the reflection coefficient along the east face of the center mole was set to 1.00. The open boundary along the east diameter of the semicircle was fully transmissive. The bottom friction factor β was set at 0.05 since the entire bottom was sandy (Kaihatu, Lillycrop, and Thompson 1989).

The grids for this study were generated through application of automated finite element grid generation software developed at the Oregon Graduate

Institute (OGI) by Dr. Antonio M. Baptista and Mr. Paul J. Turner. This procedure for automated HARBD grid generation was an original WES application.

Harbor Wave Response Simulation

To establish the wave climate incident to Maalaea harbor, a total of 187 deepwater wave height, period, and direction combinations were input to the SHALWV model and transformed to the Maalaea harbor vicinity. The selected SHALWV output locations and their relation to Maalaea Harbor were given previously in Chapter 3 of this report. Deepwater wave characteristics and the resulting transformed wave conditions are given in Table 2. To determine wave heights throughout the harbor, the resulting SHALWV wave heights were multiplied with the HARBD amplification factors corresponding to each deepwater condition. The 187 wave height, period, and direction combinations were tested for the Existing Plan and Plans 1, 2, 3, 1a, and 1b. All simulations were run on the WES CRAY Y-MP supercomputing facilities.

Output "basins" were selected for each plan tested to determine wave response throughout the harbor. A basin is an area consisting of a specified number of elements from which the mean value of the results of those elements is calculated. Sixteen output basin locations were selected for the Existing Plan, 23 for Plans 1, 2, 1a, and 1b, and 24 for Plan 3. The locations were selected in areas of interest for safe navigation and mooring by CERC and POD, and are shown for each plan tested in Figures 22 through 25. For the Existing and Plans 1, 2, and 3, basins 1 through 3, 1 through 5, 1 through 6, and 2 through 7, respectively, are located throughout the harbor entrance and access channels and turning basin with a 2-ft maximum wave height criterion. Basins 3 through 16, 6 through 23, 7 through 23, and 8 through 24, respectively, are located in the harbor berthing areas with a 1 ft maximum wave height criterion. Basin locations and numbers in Plans 1a and 1b are identical to those in Plan 1. The resulting HARBD amplification factors at these basins for each deepwater wave condition were saved and tabulated for each plan (Tables 3 through 44).

The percent occurrence of wave heights exceeding 1 ft in the berthing areas and 2 ft in the entrance and access channels and turning basin were calculated for the Existing and Plans 1, 2, 3, 1a, and 1b. The procedure to calculate the percent occurrence of wave heights exceeding the 1-ft maximum criterion is as follows. The largest HARBD amplification factor of the basins located in the 1-ft maximum wave height criterion areas (berthing areas), was selected for each deepwater wave condition. The selected HARBD amplification factors were then multiplied by the transformed wave heights from SHALWV corresponding to each deepwater wave period and direction with a wave height of 3 ft. If the resulting SHALWV-HARBD wave height does not exceed 1 ft, the largest HARBD amplification was then multiplied by the transformed SHALWV wave height corresponding to the deepwater wave conditions with a wave height of 4 ft. The iterative process continued until the resulting wave height exceeded the maximum 1 ft wave height criterion or

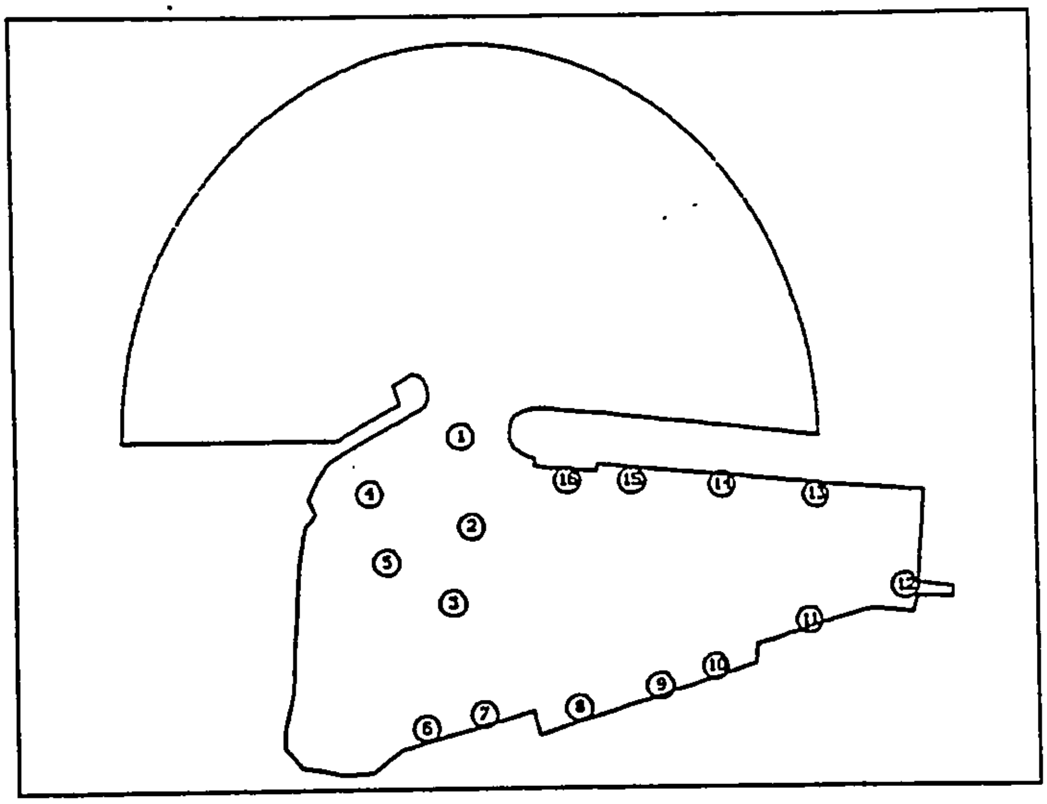

Figure 22. Output basin locations for Existing Plan

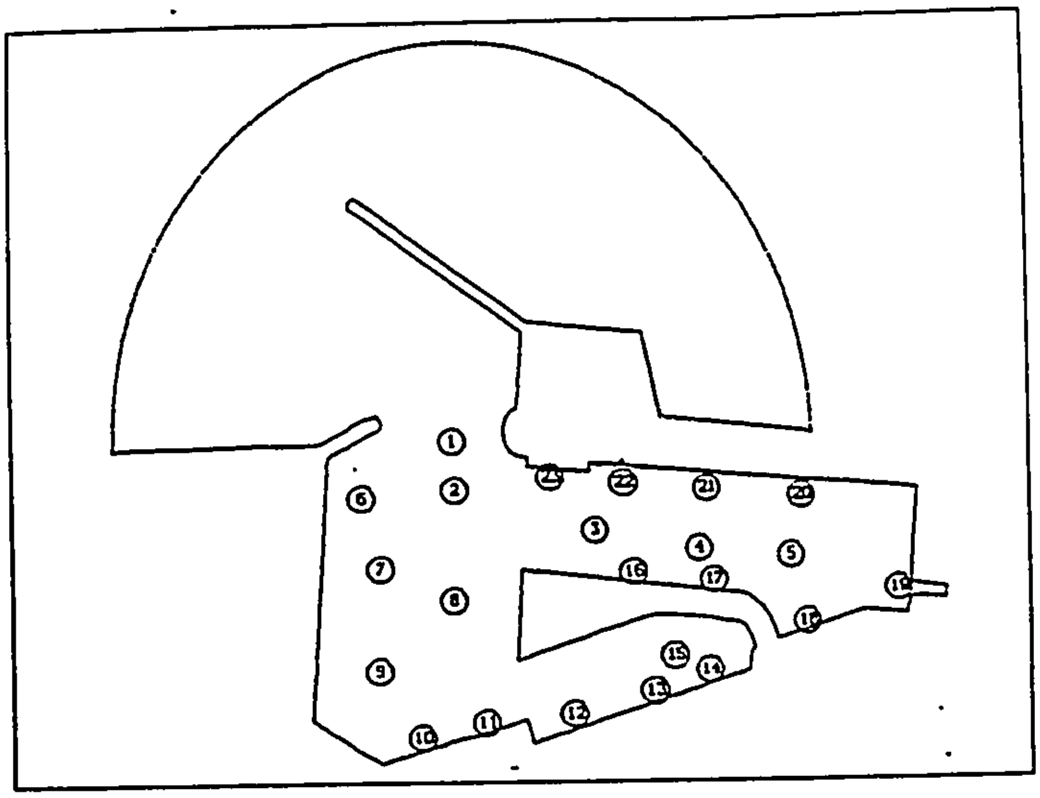

Figure 23. Output basin locations for Plans 1, 1a, and 1b

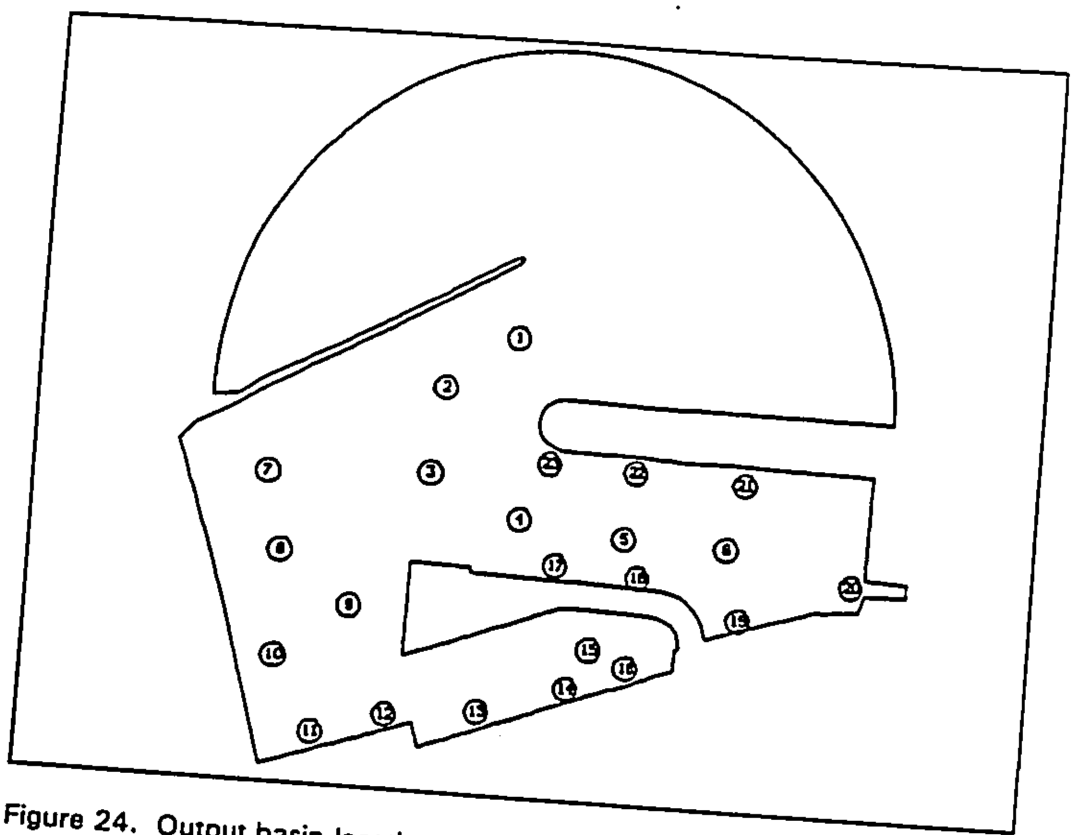

Figure 24. Output basin locations for Plan 2

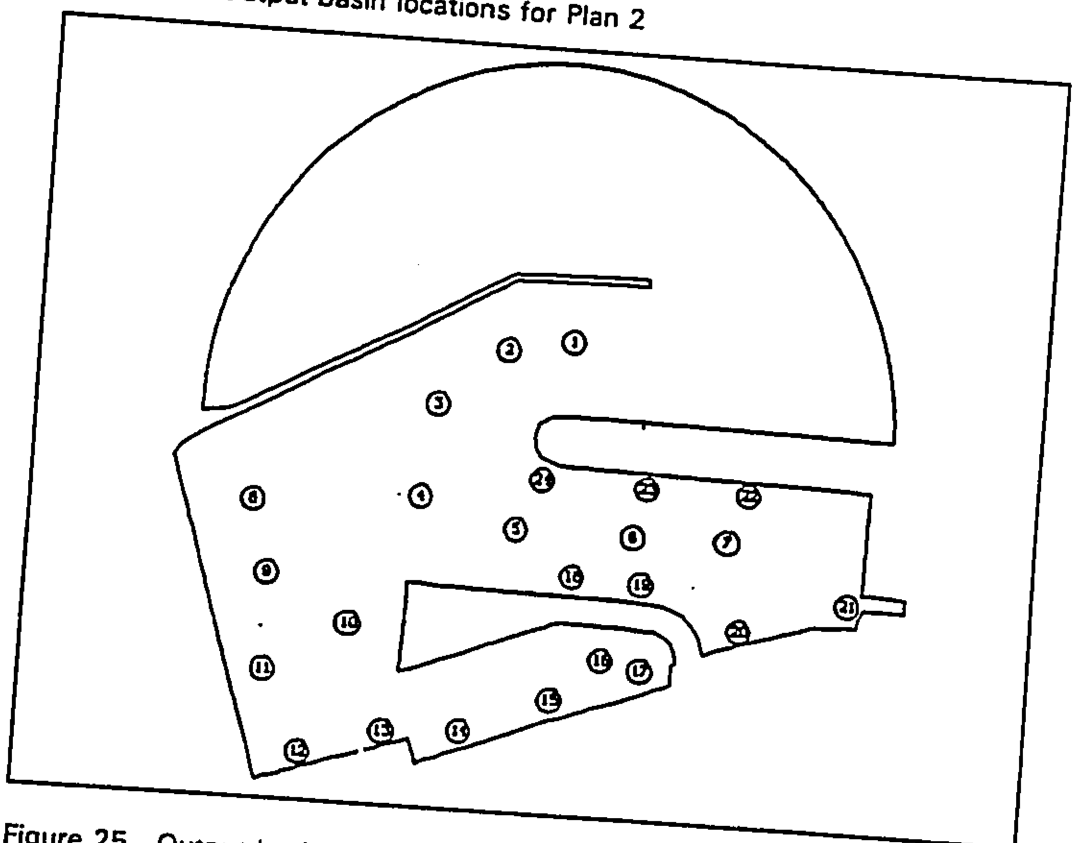

Figure 25. Output basin locations for Plan 3

the deepwater wave height exceeded 9 ft. The percent occurrence of wave heights exceeding 9 ft was included in all tabulations since the incremental deepwater wave heights greater than 9 ft could not be defined. The percent occurrence of those resulting wave heights which exceeded 1 ft were then tabulated from the percent occurrence tables for the deepwater wave conditions. The same procedure was used to calculate the percent occurrence of wave heights exceeding the maximum 2-ft criterion for those basins located in the harbor entrance and access channels and turning basin. As expected, wave heights from the Existing Plan are largest. Wave heights from Plan 2 exceed those of Plans 1 and 3, and wave heights from Plan 3 are lowest overall.

The above-mentioned procedure can be followed to calculate the resulting HARBD-SHALWV wave height at a specific output location of the Existing or Plans 1, 2, 3, 1a, and 1b for a specified deepwater wave period, direction, and height. Tabulations of these results are not included in the text due to the substantial amount of data involved.

Tables 45 through 50 are tabulations of the HARBD-SHALWV wave heights initially exceeding the HQUSACE criterion for each deepwater wave direction. The deepwater wave period, exceeding wave height, deepwater wave height, HARBD amplification factor, SHALWV wave height, and basin in which they occurred are given for the 1- and 2-ft maximum criteria for the Existing and Plans 1, 2, 3, 1a, and 1b. For the Existing Plan, Table 45 shows that the wave heights initially exceeding the maximum 1 ft criterion berthing areas (basins 3 through 16) were caused by a 9-sec wave from 247.5 deg, a 13-sec wave from directions of 157.5 and 225.0 deg, a 15-sec wave from 202.5 deg, and a 17-sec wave from 180.0 deg. The exceeding wave heights from directions of 157.5, 180.0, 202.5, and 247.5 deg occurred in basin 4 and the wave from 225.0 deg occurred in basin 9. Referring to Figure 22, basin 4 is located just inside the entrance toward the eastern side of the harbor and basin 9 is located along the northern wall. Wave heights exceeding the 2-ft maximum criterion turning basin and entrance channel (basins 1 and 2) resulted from a 9-sec wave from directions of 225.0 and 247.5 deg, a 15-sec wave from 180.0 deg, and a 17-sec wave from 202.5 deg. These waves occurred at the harbor entrance in basin 1.

In evaluating Table 46 for Plan 1, the wave heights initially exceeding the 1-ft criterion in the berthing areas (basins 6 through 23) are caused by a 13-sec wave from 180.0 deg and a 15-sec wave from 225.0 deg. The wave from 180.0 deg occurred in basin 11, located along the existing wharf, and the 225.0-deg wave occurred in basin 8, located east of the interior revetment. The maximum 2-ft wave height criterion was not exceeded for Plan 1.

Wave conditions initially exceeding the maximum 1-ft criterion berthing areas for Plan 2 (basins 7 through 23) include: an 11-sec wave from 157.5 deg, occurring along the south breakwater in basin 23; a 20-sec wave from 180.0 deg in basin 8; and a 20-sec wave from 202.5 deg and an 11-sec wave from 225.0 deg, both occurring in basin 7. Basins 7 and 8 are located near the east breakwater. Wave heights initially exceeding the 2-ft maximum criterion channels and turning basin include: an 11-sec wave from 157.5 deg;

a 20-sec wave from 180.0 deg and 202.5 deg; and a 9-sec wave from 225.0 deg. These waves all occurred in basin 1 located at the harbor entrance.

As shown in Table 48, none of the deepwater wave conditions resulted in wave heights exceeding the maximum 1- and 2-ft criteria for Plan 3, however, the percent occurrence of wave heights greater than 9 ft was included in the tabulations for this plan.

For Plan 1a, wave heights exceeded the 1-ft berthing area criterion for many of the shorter wave periods with directions from 180 deg to 247.5 deg (Table 49). In most cases, the exceedance occurred at basin 11, located along the existing wharf. The 9-sec waves caused exceedances at basins 6 and 8, located near the east breakwater. The 2-ft criterion was exceeded at basin 1 for 9 sec periods from 202.5 deg and 225.0 deg and for 11-sec periods from 225.0 deg.

The 1-ft criterion was exceeded for Plan 1b for many of the shorter periods with directions between 157.5 deg and 247.5 deg (Table 50). The exceedances generally occurred at basin 11, though basins 6 and 7 also appeared. The 2-ft criterion was exceeded at basin 1 for 9-sec waves from 202.5 deg and 225.0 deg and 11-sec waves from 225.0 deg.

The percent occurrence of wave heights exceeding the maximum 1- and 2-ft criteria more than approximately 10 percent of the time were calculated using the percent occurrence tables of deepwater conditions and HARBD-SHALWV wave height results for all plans. These results are given in Tables 51 through 62 and illustrated in Figures 26 through 31. Although wave breaking was not taken into account in Tables 51 through 62, the higher wave heights would most likely have broken over the reef, thus reducing wave heights in the harbor. In evaluating the resulting percent occurrence tables (Tables 51 through 62) and Figures 26 through 31, it is apparent that waves approaching from the southeast (135.0- to 157.0-deg) directions are insignificant in comparison to waves approaching from the south to west (180.0- to 270.0-deg) directions.

The percentage of wave heights exceeding the maximum 1 ft and 2 ft criteria for the Existing and Plans 1, 2, 3, 1a, and 1b are summarized in Table 63, along with the HQUSACE criteria. These values are conservative since they represent basins with the largest wave heights occurring in the harbor for each deepwater wave condition. The Existing Plan and Plans 2 and 1b allow one or both of the HQUSACE criteria of wave heights greater than 1 and 2 ft more than 10 percent of the time per year to be exceeded. However, Plans 1 and 1a, which include structural modification to the east, and Plan 3, which includes structural modification toward the west, satisfy the HQUSACE criteria for providing adequate protection inside the harbor. Although Plan 1a satisfies the 1 ft berthing area criterion, the results indicate that basin 11, along the existing wharf, may be marginally acceptable.

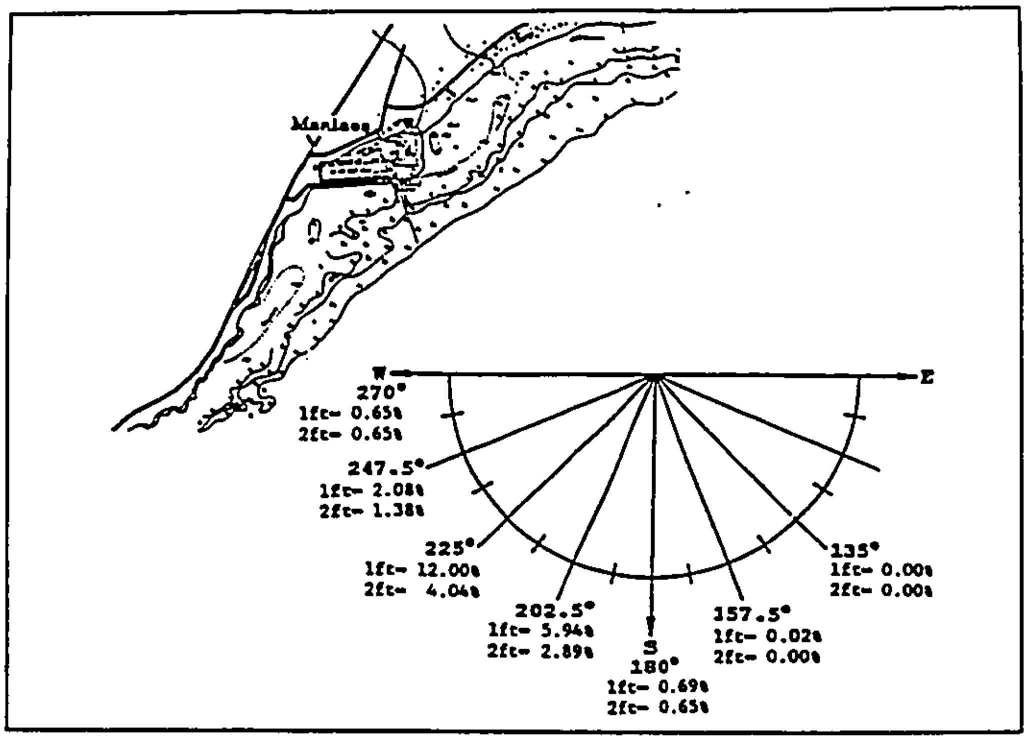

Figure 26. Existing Plan - Percent occurrence of wave heights exceeding 1- and 2-ft criteria

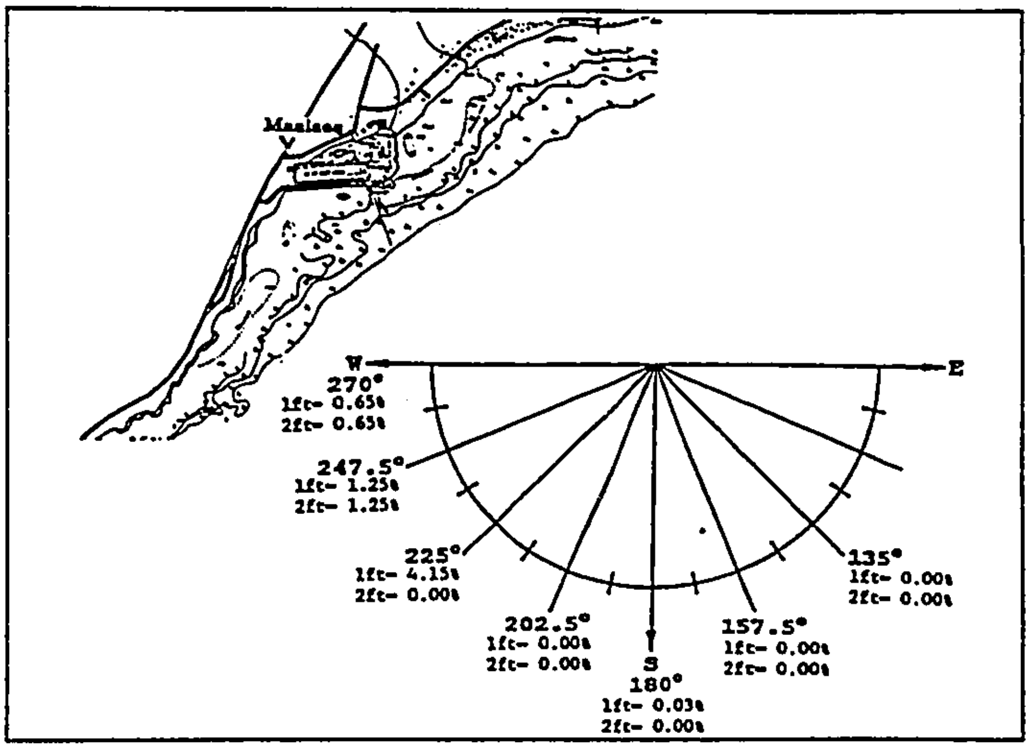

Figure 27. Plan 1 - Percent occurrence of wave heights exceeding 1- and 2-ft criteria

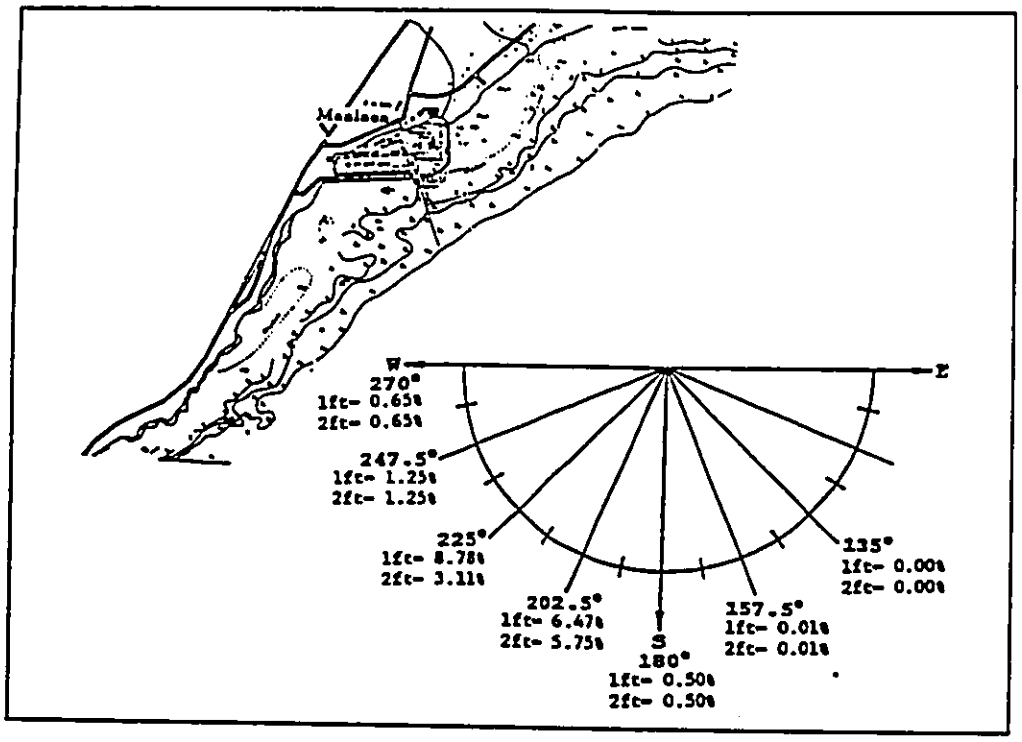

Figure 28. Plan 2 - Percent occurrence of wave heights exceeding 1- and 2-ft criteria

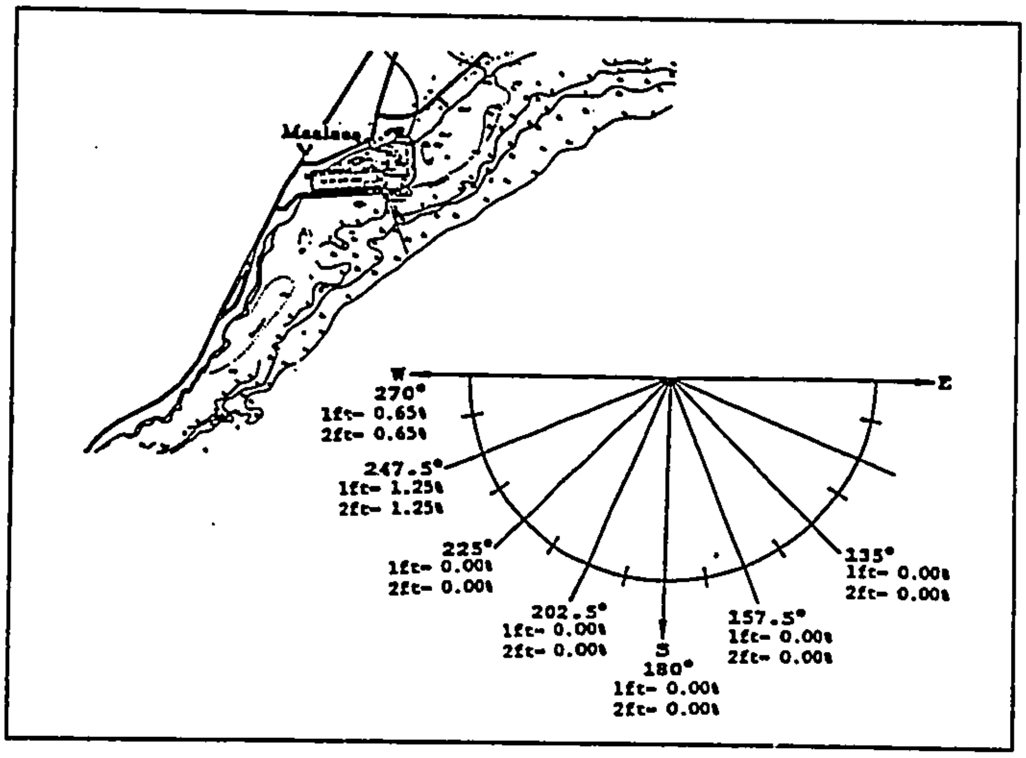

Figure 29. Plan 3 - Percent occurrence of wave heights exceeding 1- and 2-ft criteria

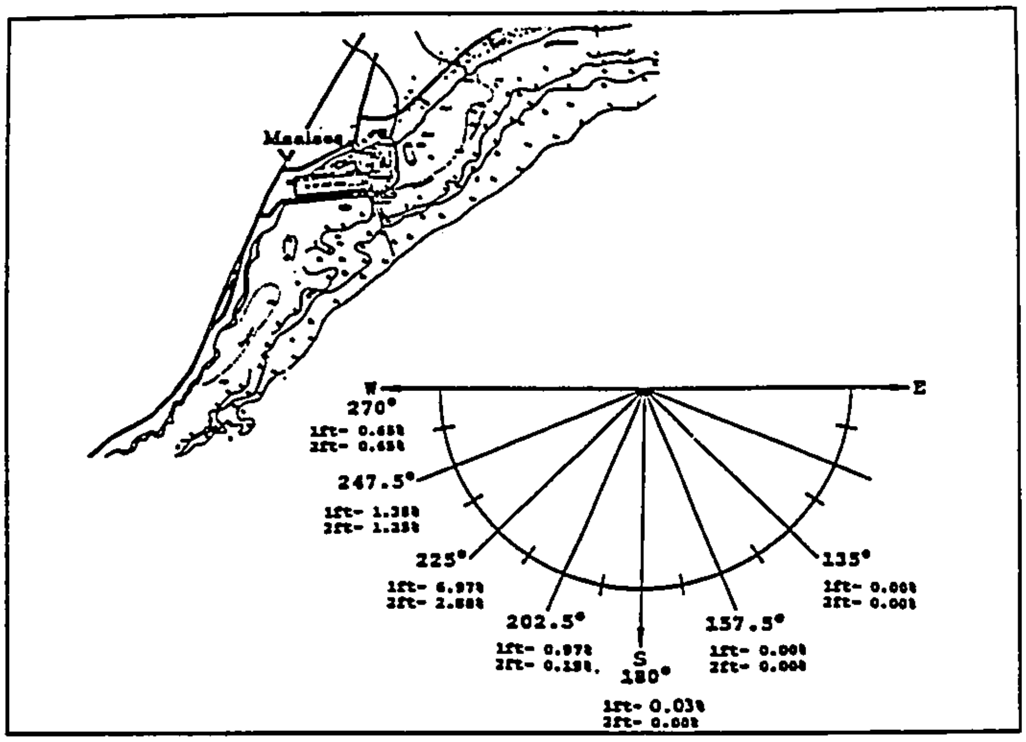

Figure 30. Plan 1a - Percent occurrence of wave heights exceeding 1- and 2-ft criteria

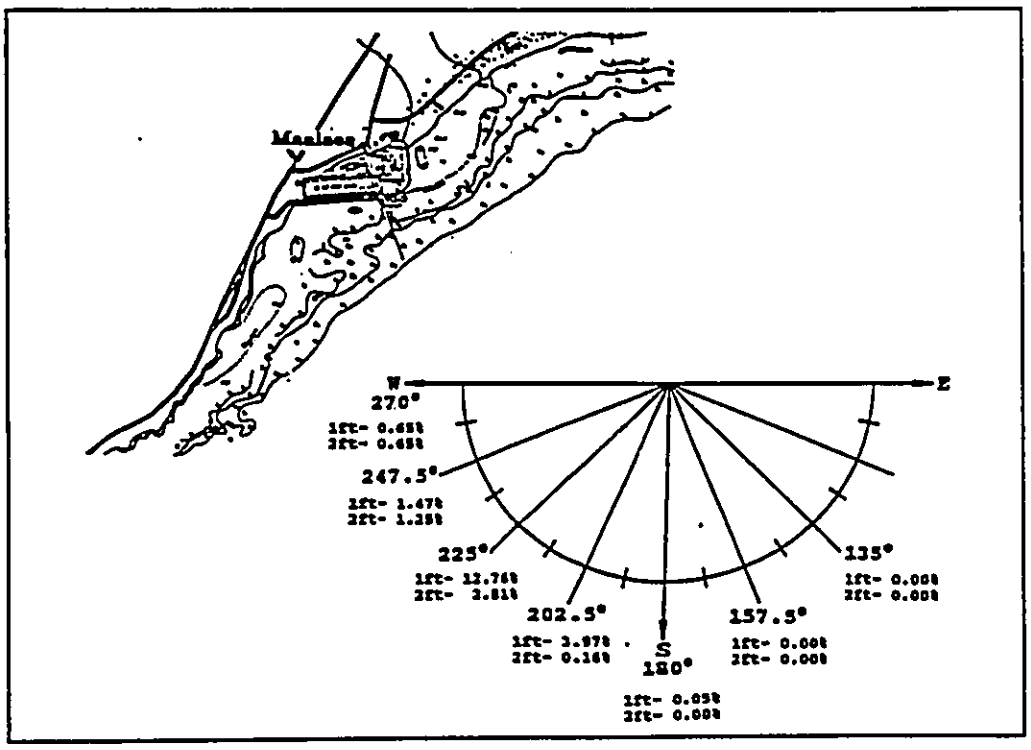

Figure 31. Plan 1b - Percent occurrence of wave heights exceeding 1- and 2-ft criteria

5 Conclusions

The numerical model studies and results described in this report should be seen in light of the following considerations:

a. The deepwater waves were based on measurements from MCCP data collected at Barbers Point, Oahu. Availability of incident wave data at the Maalaea Harbor vicinity would improve the validity of the overall results.

b. The revised SPM reflection coefficients were based on estimates from POD and were not reevaluated. Research in this area continues at CERC for better guidance.

c. The following assumptions were made in the implementation of the HARBD numerical model used in this study: (1) The model does not consider wave transmission through the breakwater, overtopping of structures, and wave breaking effects in the entrance channel. (2) Structure crest elevations were not tested or optimized. (3) Currents and nonlinear effects were neglected. (4) Diffraction around the structure ends was represented by diffraction around a blunt vertical wall with specified reflection coefficients. If wave transmission through the breakwater and overtopping of structures did occur in the harbor, the increased energy would result in larger wave heights than predicted. The presence of wave currents and breaking would increase hazardous navigation; however, wave breaking would reduce the energy in the harbor and result in lower wave heights than predicted. The primary effects which must be considered within a harbor such as Maalaea are wave refraction, diffraction, and dissipation effects, for which the model has been well verified.

d. The HARBD model uses monochromatic waves only.

e. The resulting percent occurrence of wave heights exceeding the 1- and 2-ft criteria is based on incident significant wave heights $H_{1/3}$. The use of H_{10} or H_1 would increase the incident wave heights by approximately 27 and 67 percent, respectively. Therefore, resulting wave heights inside the harbor would increase, and the percent occurrence of wave heights exceeding the 1- and 2-ft wave height criteria would increase.

Based on the results of this study, the following conclusions were reached:

a. The Existing Plan is unsatisfactory in providing the harbor with adequate protection against the incident wave climate.

b. The POD plan based on the GDM (Plan 1), which is directed toward the east, is satisfactory relative to the HQUSACE design criteria for protecting the harbor from the incident wave climate. Plan 1 is a recommended alternative.

c. Plan 2, which is directed toward the west, will not protect the harbor adequately from the deepwater waves from directions between south and west.

d. Plan 3, a modification to Plan 2, provides adequate protection from the incident wave climate since the additional east breakwater extension overlaps the existing south breakwater and permits very low energy inside the harbor. This plan is also a recommended alternative.

e. Plan 1a, similar to Plan 1, satisfies the HQUSACE design criteria. However, harbor performance relative to the criteria may be marginal in a few berthing locations, particularly along the existing wharf. Plan 1a is considered an acceptable alternative. It has an advantage relative to Plan 1 in that the south breakwater extension is farther west and may be less likely to affect the Maalaea Pipeline surfing area East of the harbor.

f. Plan 1b, with vertical sheet-pile bulkheads along the east face of the center mole, satisfies the criterion for entrance channel protection but fails to provide adequate protection of some of the more exposed harbor areas. Plan 1b is not recommended.

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Table 1
Percent Occurrence of Wave Heights Versus Direction

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
0.00-1.00	0.00	0.00	0.01	0.02	0.02	0.02	0.00	0.07
1.01-2.00	•	0.03	0.91	3.97	4.32	1.33	0.28	10.84
2.01-3.00	•	0.07	0.86	5.34	11.05	4.16	2.04	23.52
3.01-4.00	0.00	0.01	0.28	4.26	11.60	3.81	2.24	22.20
4.01-5.00	0.00	0.00	0.04	2.28	8.63	2.28	1.88	15.11
5.01-6.00	0.00	0.00	0.02	1.13	5.14	1.52	0.77	8.58
6.01-7.00	0.00	0.00	•	1.81	3.38	0.96	1.22	7.37
7.01-8.00	0.00	0.00	0.09	0.96	3.64	0.83	0.82	6.34
8.01-9.00	0.00	0.00	0.00	0.19	3.00	0.21	0.66	4.06
9.01 +	0.00	0.00	0.00	0.00	0.00	1.25	0.65	1.90
TOTAL	0.01	0.11	2.21	19.96	50.78	16.37	10.56	100.0

Table 2
SHALWV Offshore and Transformed Wave Conditions

Deepwater			Transformed	
Period (sec)	Height (ft)	Direction (deg)	Direction (deg)	Height (ft)
9	3.00	135.0	160.0	0.91
1	3.00	135.0	162.0	0.81
3	3.00	135.0	166.0	0.75
15	3.00	135.0	170.0	0.73
17	3.00	135.0	173.0	0.69
20	3.00	135.0	175.0	0.69
9	3.00	157.5	168.0	1.62
11	3.00	157.5	170.0	1.48
13	3.00	157.5	171.0	1.73
15	3.00	157.5	173.0	1.26
17	3.00	157.5	174.0	1.16
20	3.00	157.5	175.0	1.07
9	3.00	180.0	176.0	1.72
11	3.00	180.0	176.0	1.62
13	3.00	180.0	177.0	1.57
15	3.00	180.0	177.0	1.45
17	3.00	180.0	177.0	1.38
20	3.00	180.0	177.0	1.23
9	3.00	202.5	180.0	1.19
11	3.00	202.5	179.0	1.13
13	3.00	202.5	178.0	1.10
15	3.00	202.5	178.0	1.00
17	3.00	202.5	178.0	0.94
20	3.00	202.5	177.0	0.84
9	3.00	225.0	193.0	0.88
11	3.00	225.0	191.0	0.84
13	3.00	225.0	189.0	0.78
15	3.00	225.0	188.0	0.75
17	3.00	225.0	186.0	0.69
20	3.00	225.0	184.0	0.69
9	3.00	247.5	199.0	0.53
11	3.00	247.5	194.0	0.53
13	3.00	247.5	191.0	0.56
15	3.00	247.5	189.0	0.56
17	3.00	247.5	187.0	0.59
20	3.00	247.5	186.0	0.62
9	3.00	270.0	198.0	0.40
11	3.00	270.0	193.0	0.40
13	3.00	270.0	191.0	0.43
15	3.00	270.0	189.0	0.46
17	3.00	270.0	187.0	0.49
20	3.00	270.0	186.0	0.49

(Sheet 1 of 5)

Table 2 (Continued)

Deepwater			Transformed	
Period (sec)	Height (ft)	Direction (deg)	Direction (deg)	Height (ft)
9	4.00	135.0	160.0	1.16
11	4.00	135.0	162.0	1.03
13	4.00	135.0	166.0	0.94
15	4.00	135.0	170.0	0.91
17	4.00	135.0	173.0	0.88
20	4.00	135.0	175.0	0.84
9	4.00	157.5	168.0	2.03
11	4.00	157.5	170.0	1.74
13	4.00	157.5	171.0	1.68
15	4.00	157.5	173.0	1.58
17	4.00	157.5	174.0	1.52
20	4.00	157.5	175.0	1.36
9	4.00	180.0	176.0	2.22
11	4.00	180.0	176.0	2.13
13	4.00	180.0	177.0	2.04
15	4.00	180.0	177.0	1.91
17	4.00	180.0	177.0	1.75
20	4.00	180.0	177.0	1.61
9	4.00	202.5	183.0	1.69
11	4.00	202.5	182.0	1.64
13	4.00	202.5	181.0	1.48
15	4.00	202.5	181.0	1.48
17	4.00	202.5	181.0	1.41
20	4.00	202.5	180.0	1.26
9	4.00	225.0	198.0	1.45
11	4.00	225.0	195.0	1.35
13	4.00	225.0	193.0	1.29
15	4.00	225.0	192.0	1.19
17	4.00	225.0	190.0	1.13
20	4.00	225.0	188.0	1.05
9	4.00	247.5	203.0	0.78
11	4.00	247.5	198.0	0.81
13	4.00	247.5	195.0	0.88
15	4.00	247.5	192.0	0.91
17	4.00	247.5	191.0	0.94
20	4.00	247.5	190.0	1.00
9	4.00	270.0	202.0	0.59
11	4.00	270.0	197.0	0.62
13	4.00	270.0	194.0	0.69
15	4.00	270.0	192.0	0.72
17	4.00	270.0	191.0	0.78
20	4.00	270.0	189.0	0.81

Table 2 (Continued)				
Deepwater			**Transformed**	
Period (sec)	**Height (ft)**	**Direction (deg)**	**Direction (deg)**	**Height (ft)**
9	5.00	135.0	160.0	1.32
11	5.00	135.0	162.0	1.49
13	5.00	135.0	166.0	1.10
15	5.00	135.0	170.0	1.03
17	5.00	135.0	173.0	1.00
20	5.00	135.0	175.0	0.97
9	5.00	157.5	168.0	2.38
11	5.00	157.5	170.0	2.15
13	5.00	157.5	171.0	1.97
15	5.00	157.5	173.0	.86
17	5.00	157.5	174.0	1.73
20	5.00	157.5	175.0	1.57
9	5.00	180.0	176.0	2.62
11	5.00	180.0	176.0	2.51
13	5.00	180.0	177.0	2.37
15	5.00	180.0	177.0	2.13
17	5.00	180.0	177.0	2.18
20	5.00	180.0	177.0	1.84
9	5.00	202.5	183.0	2.04
11	5.00	202.5	182.0	1.86
13	5.00	202.5	181.0	1.80
15	5.00	202.5	181.0	1.67
17	5.00	202.5	181.0	1.57
20	5.00	202.5	180.0	1.37
9	5.00	225.0	198.0	1.64
11	5.00	225.0	195.0	1.54
13	5.00	225.0	193.0	1.44
15	5.00	225.0	192.0	1.38
17	5.00	225.0	190.0	1.29
20	5.00	225.0	188.0	1.19
9	5.00	247.5	203.0	0.91
11	5.00	247.5	198.0	0.94
13	5.00	247.5	195.0	1.00
15	5.00	247.5	192.0	1.03
17	5.00	247.5	191.0	1.08
20	5.00	247.5	190.0	1.13
9	5.00	270.0	202.0	0.65
11	5.00	270.0	197.0	0.73
13	5.00	270.0	194.0	0.73
15	5.00	270.0	192.0	0.84
17	5.00	270.0	191.0	0.88
20	5.00	270.0	189.0	0.94

(Sheet 3 of 5)

Table 2 (Continued)				
Offshore			Transformed	
Period (sec)	Height (ft)	Direction (deg)	Direction (deg)	Height (ft)
9	6.00	180.0	176.0	3.13
20	6.00	180.0	177.0	2.24
9	6.00	202.5	183.0	2.29
13	6.00	202.5	181.0	2.17
15	6.00	202.5	181.0	2.04
20	6.00	202.5	180.0	1.70
9	6.00	225.0	198.0	1.97
11	6.00	225.0	195.0	1.83
13	6.00	225.0	193.0	1.74
15	6.00	225.0	192.0	1.64
17	6.00	225.0	190.0	1.54
20	6.00	225.0	188.0	1.44
9	6.00	247.5	203.0	1.07
11	6.00	247.5	198.0	1.13
13	6.00	247.5	195.0	1.16
15	6.00	247.5	192.0	1.23
17	6.00	247.5	191.0	1.29
20	6.00	247.5	190.0	1.35
9	6.00	270.0	202.0	0.78
11	6.00	270.0	197.0	0.84
13	6.00	270.0	194.0	0.94
15	6.00	270.0	192.0	1.00
17	6.00	270.0	191.0	1.03
20	6.00	270.0	189.0	1.08
9	7.00	202.5	183.0	2.75
13	7.00	202.5	181.0	2.46
15	7.00	202.5	181.0	2.34
20	7.00	202.5	180.0	2.01
9	7.00	225.0	198.0	2.34
11	7.00	225.0	195.0	2.17
13	7.00	225.0	193.0	2.04
15	7.00	225.0	192.0	1.92
17	7.00	225.0	190.0	1.81
20	7.00	225.0	188.0	1.67
9	7.00	247.5	203.0	1.25
11	7.00	247.5	198.0	1.29
13	7.00	247.5	195.0	1.38
15	7.00	247.5	192.0	1.45
17	7.00	247.5	191.0	1.48
20	7.00	247.5	190.0	1.54
9	7.00	270.0	202.0	0.91
11	7.00	270.0	197.0	1.00

(Sheet 4 of 5)

Table 2 (Concluded)

Offshore			Transformed	
Period (sec)	Height (ft)	Direction (deg)	Direction (deg)	Height (ft)
13	7.00	270.0	194.0	1.10
15	7.00	270.0	192.0	1.16
17	7.00	270.0	191.0	1.19
20	7.00	270.0	189.0	1.29
13	8.00	225.0	194.0	1.80
15	8.00	225.0	192.0	2.20
17	8.00	225.0	190.0	2.05
20	8.00	225.0	188.0	1.89
9	8.00	247.5	202.0	1.64
11	8.00	247.5	198.0	1.45
13	8.00	247.5	195.0	1.57
15	8.00	247.5	192.0	1.64
17	8.00	247.5	191.0	1.70
20	8.00	247.5	190.0	1.77
9	8.00	270.0	202.0	1.03
11	8.00	270.0	197.0	1.13
13	8.00	270.0	194.0	1.23
15	8.00	270.0	192.0	1.32
17	8.00	270.0	191.0	1.38
20	8.00	270.0	189.0	1.45
15	9.00	225.0	192.0	2.43
17	9.00	225.0	190.0	2.31
20	9.00	225.0	188.0	2.14
9	9.00	247.5	202.0	1.64
11	9.00	247.5	198.0	1.64
13	9.00	247.5	195.0	1.73
15	9.00	247.5	192.0	1.84
17	9.00	247.5	191.0	1.89
20	9.00	247.5	190.0	1.99
9	9.00	270.0	202.0	1.23
11	9.00	270.0	197.0	1.26
13	9.00	270.0	194.0	1.38
15	9.00	270.0	192.0	1.44
17	9.00	270.0	191.0	1.54
20	9.00	270.0	189.0	1.63

(Sheet 5 of 5)

Table 3
HARBD Wave Amplification Factors
Existing Plan Wave Angle = 135.0 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	1.78	1.05	0.93	1.14	0.36	1.14
2	0.94	0.50	0.41	0.66	0.27	0.71
3	0.93	0.38	0.30	0.35	0.16	0.48
4	1.09	0.90	0.73	0.79	0.21	0.59
5	1.30	0.65	0.44	0.80	0.17	0.46
6	0.47	0.41	0.25	0.46	0.15	0.51
7	0.64	0.34	0.34	0.73	0.23	0.48
8	0.12	0.15	0.12	0.34	0.15	0.36
9	0.22	0.03	0.20	0.54	0.15	0.41
0	0.08	0.06	0.20	0.38	0.12	0.17
1	0.04	0.06	0.04	0.16	0.06	0.03
2	0.01	0.03	0.03	0.09	0.03	0.05
3	0.01	0.03	0.02	0.11	0.08	0.16
4	0.04	0.02	0.09	0.08	0.08	0.23
5	0.15	0.06	0.16	0.21	0.07	0.28
6	0.09	0.11	0.21	0.40	0.11	0.33

Table 4
HARBD Wave Amplification Factors
Existing Plan, Wave Angle = 157.5 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.65	1.08	0.67	1.20	0.65	0.61
2	0.18	0.78	0.37	0.74	0.42	0.41
3	0.14	0.44	0.30	0.39	0.22	0.26
4	1.20	0.77	0.59	0.81	0.40	0.24
5	0.56	0.83	0.36	0.76	0.45	0.24
6	0.10	0.39	0.24	0.53	0.25	0.25
7	0.12	0.57	0.28	0.77	0.44	0.32
8	0.10	0.18	0.12	0.35	0.24	0.23
9	0.21	0.39	0.17	0.60	0.31	0.24
0	0.14	0.17	0.11	0.42	0.25	0.14
1	0.07	0.06	0.01	0.16	0.12	0.06
2	0.02	0.02	0.01	0.09	0.06	0.04
3	0.04	0.06	0.03	0.07	0.14	0.11
4	0.13	0.12	0.06	0.07	0.12	0.15
5	0.08	0.23	0.07	0.27	0.13	0.07
6	0.09	0.11	0.05	0.47	0.18	0.16

Table 5 HARBD Wave Amplification Factors Existing Plan, Wave Angle = 180.0 deg						
	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.18	0.44	0.44	1.40	1.50	0.11
2	0.27	0.04	0.18	0.78	0.62	0.09
3	0.16	0.04	0.14	0.41	0.33	0.05
4	0.15	0.42	0.47	0.86	0.79	0.06
5	0.14	0.17	0.15	0.67	0.70	0.04
6	0.18	0.02	0.07	0.53	0.41	0.05
7	0.20	0.02	0.18	0.76	0.69	0.07
8	0.10	0.03	0.10	0.31	0.35	0.05
9	0.17	0.06	0.22	0.54	0.58	0.05
0	0.08	0.04	0.17	0.39	0.42	0.04
1	0.05	0.03	0.03	0.12	0.18	0.02
2	0.01	0.01	0.02	0.08	0.10	0.01
3	0.01	0.02	0.05	0.04	0.14	0.03
4	0.09	0.03	0.12	0.07	0.13	0.03
5	0.07	0.04	0.17	0.27	0.22	0.02
6	0.08	0.06	0.15	0.42	0.42	0.04

Table 6 HARBD Wave Amplification Factors Existing Plan, Wave Angle = 202.5 deg						
	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.45	1.24	0.81	0.62	1.45	0.10
2	0.07	0.43	0.52	0.24	0.61	0.08
3	0.04	0.50	0.44	0.17	0.32	0.05
4	0.12	0.75	0.70	0.47	0.78	0.05
5	0.12	0.64	0.26	0.31	0.68	0.04
6	0.02	0.32	0.25	0.19	0.40	0.04
7	0.08	0.38	0.44	0.16	0.68	0.07
8	0.08	0.20	0.24	0.06	0.34	0.05
9	0.28	0.27	0.56	0.05	0.58	0.05
10	0.20	0.18	0.38	0.02	0.42	0.04
11	0.11	0.13	0.12	0.02	0.18	0.02
12	0.02	0.03	0.03	0.01	0.10	0.01
13	0.07	0.08	0.13	0.03	0.14	0.02
14	0.16	0.16	0.28	0.01	0.13	0.03
15	0.14	0.16	0.33	0.03	0.22	0.02
16	0.25	0.17	0.26	0.06	0.42	0.03

Table 7
HARBD Wave Amplification Factors
Existing Plan, Wave Angle = 225.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	1.39	0.29	0.85	0.50	0.76	0.87
2	0.68	0.32	0.60	0.57	0.48	0.56
3	0.43	0.41	0.50	0.35	0.24	0.38
4	0.90	0.33	0.42	0.29	0.46	0.41
5	0.39	0.32	0.26	0.36	0.46	0.34
6	0.47	0.26	0.29	0.35	0.31	0.40
7	0.57	0.34	0.47	0.47	0.57	0.39
8	0.35	0.14	0.26	0.24	0.28	0.29
9	0.76	0.28	0.56	0.45	0.50	0.34
10	0.50	0.17	0.36	0.29	0.36	0.15
11	0.26	0.14	0.11	0.06	0.16	0.02
12	0.05	0.03	0.03	0.03	0.09	0.04
13	0.15	0.09	0.13	0.09	0.12	0.13
14	0.45	0.11	0.27	0.18	0.12	0.19
15	0.39	0.12	0.31	0.29	0.21	0.24
16	0.53	0.29	0.24	0.26	0.37	0.28

Table 8
HARBD Wave Amplification Factors
Existing Plan, Wave Angle = 247.5 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	1.26	0.72	0.63	0.77	0.51	0.80
2	0.87	0.46	0.66	0.46	0.40	0.53
3	0.60	0.41	0.41	0.24	0.24	0.35
4	0.89	0.56	0.20	0.46	0.19	0.37
5	0.53	0.37	0.37	0.48	0.26	0.31
6	0.64	0.27	0.38	0.30	0.22	0.38
7	0.70	0.32	0.56	0.51	0.35	0.36
8	0.39	0.17	0.27	0.26	0.23	0.27
9	0.69	0.24	0.52	0.45	0.24	0.32
0	0.43	0.09	0.35	0.32	0.18	0.14
11	0.22	0.06	0.06	0.14	0.09	0.02
12	0.05	0.02	0.04	0.08	0.05	0.04
13	0.12	0.04	0.10	0.11	0.12	0.12
14	0.40	0.07	0.20	0.10	0.13	0.18
15	0.35	0.10	0.33	0.18	0.10	0.22
16	0.40	0.12	0.30	0.33	0.16	0.26

Table 9
HARBD Wave Amplification Factors
Existing Plan, Wave Angle = 270.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	1.21	0.89	0.63	0.77	0.51	0.79
2	0.73	0.59	0.66	0.46	0.41	0.52
3	0.38	0.50	0.41	0.24	0.24	0.35
4	0.62	0.50	0.20	0.46	0.19	0.36
5	0.76	0.31	0.37	0.48	0.26	0.30
6	0.35	0.29	0.38	0.30	0.22	0.37
7	0.51	0.45	0.56	0.51	0.35	0.36
8	0.15	0.28	0.27	0.26	0.23	0.27
9	0.37	0.50	0.52	0.45	0.24	0.32
10	0.24	0.32	0.35	0.32	0.18	0.14
11	0.12	0.10	0.06	0.14	0.09	0.02
12	0.03	0.02	0.04	0.08	0.05	0.04
13	0.10	0.11	0.10	0.11	0.12	0.12
14	0.10	0.24	0.20	0.10	0.13	0.18
15	0.22	0.27	0.33	0.18	0.10	0.22
16	0.21	0.18	0.30	0.33	0.16	0.26

Table 10
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 135.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.38	0.31	0.38	0.33	0.40	0.14
2	0.31	0.26	0.22	0.33	0.29	0.13
3	0.12	0.13	0.16	0.16	0.23	0.06
4	0.06	0.07	0.10	0.10	0.13	0.03
5	0.04	0.04	0.06	0.06	0.07	0.02
6	0.24	0.13	0.13	0.36	0.31	0.09
7	0.17	0.14	0.14	0.30	0.36	0.09
8	0.19	0.16	0.23	0.13	0.16	0.10
9	0.13	0.07	0.13	0.23	0.26	0.08
10	0.16	0.11	0.15	0.24	0.31	0.14
11	0.18	0.19	0.24	0.25	0.38	0.14
12	0.05	0.04	0.08	0.06	0.13	0.06
13	0.02	0.02	0.03	0.02	0.05	0.02
14	0.01	0.01	0.02	0.01	0.03	0.02
15	0.01	*	0.01	0.01	0.03	0.02
16	0.14	0.13	0.18	0.17	0.22	0.05
17	0.08	0.08	0.09	0.10	0.11	0.03
18	0.04	0.04	0.06	0.05	0.07	0.01
19	0.02	0.02	0.03	0.02	0.03	0.02
20	0.01	0.03	0.06	0.08	0.14	0.03
21	0.02	0.03	0.07	0.08	0.14	0.04
22	0.06	0.06	0.10	0.09	0.13	0.05
23	0.14	0.10	0.20	0.22	0.21	0.07

* Wave amplitude is below significance for tabulation.

Table 11
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 157.5 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.14	0.57	0.61	0.21	0.43	0.32
2	0.15	0.31	0.43	0.19	0.40	0.20
3	0.03	0.20	0.28	0.10	0.25	0.17
4	0.02	0.10	0.17	0.06	0.15	0.09
5	0.01	0.07	0.11	0.04	0.08	0.05
6	0.11	0.11	0.38	0.17	0.51	0.13
7	0.11	0.11	0.14	0.16	0.47	0.21
8	0.11	0.11	0.41	0.10	0.12	0.15
9	0.09	0.09	0.23	0.13	0.31	0.18
10	0.10	0.10	0.18	0.13	0.33	0.25
11	0.10	0.10	0.42	0.13	0.42	0.27
12	0.03	0.03	0.14	0.03	0.13	0.10
13	0.01	0.01	0.05	0.01	0.05	0.04
14	*	*	0.03	*	0.03	0.03
15	0.01	0.01	0.02	*	0.03	0.03
16	0.04	0.04	0.31	0.10	0.26	0.15
17	0.02	0.02	0.15	0.06	0.14	0.08
18	0.01	0.01	0.10	0.03	0.08	0.05
19	0.01	0.01	0.06	0.01	0.03	0.03
20	0.01	0.01	0.10	0.05	0.14	0.11
21	*	*	0.11	0.05	0.13	0.11
22	0.01	0.16	0.17	0.07	0.10	0.11
23	0.03	0.23	0.31	0.14	0.25	0.18

* Wave amplitude is below significance for tabulation.

Table 12
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 180.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.23	0.56	0.63	0.22	0.24	0.37
2	0.07	0.29	0.45	0.13	0.23	0.27
3	0.13	0.22	0.29	0.12	0.12	0.22
4	0.07	0.12	0.18	0.07	0.07	0.12
5	0.04	0.09	0.12	0.04	0.04	0.07
6	0.10	0.09	0.41	0.04	0.27	0.29
7	0.10	0.21	0.36	0.04	0.23	0.33
8	0.05	0.17	0.42	0.07	0.10	0.14
9	0.06	0.06	0.24	0.04	0.17	0.24
10	0.07	0.09	0.18	0.07	0.17	0.28
11	0.05	0.29	0.43	0.11	0.18	0.35
12	0.01	0.06	0.14	0.03	0.04	0.12
13	0.01	0.02	0.05	0.01	0.02	0.05
14	*	0.01	0.03	*	0.01	0.03
15	*	0.01	0.02	*	0.01	0.03
16	0.13	0.26	0.32	0.12	0.12	0.20
17	0.07	0.13	0.16	0.06	0.07	0.10
18	0.03	0.05	0.10	0.03	0.03	0.06
19	0.02	0.05	0.06	0.02	0.01	0.03
20	0.02	0.06	0.10	0.05	0.06	0.13
21	0.03	0.05	0.12	0.05	0.06	0.13
22	0.06	0.13	0.18	0.08	0.07	0.12
23	0.14	0.26	0.33	0.15	0.16	0.20

* Wave amplitude is below significance for tabulation.

Table 13
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 202.5 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.51	0.44	0.50	0.69	0.16	0.37
2	0.29	0.24	0.44	0.40	0.13	0.27
3	0.25	0.18	0.24	0.30	0.09	0.22
4	0.13	0.11	0.15	0.18	0.05	0.12
5	0.08	0.08	0.10	0.11	0.03	0.07
6	0.09	0.08	0.41	0.25	0.15	0.29
7	0.06	0.13	0.35	0.28	0.13	0.33
8	0.15	0.17	0.34	0.39	0.05	0.14
9	0.04	0.06	0.20	0.23	0.09	0.24
10	0.02	0.09	0.08	0.24	0.08	0.28
11	0.18	0.29	0.36	0.39	0.10	0.35
12	0.05	0.06	0.11	0.13	0.02	0.12
13	0.02	0.02	0.03	0.05	0.01	0.05
14	0.01	0.01	0.02	0.03	*	0.03
15	*	0.01	0.01	0.02	*	0.03
16	0.26	0.26	0.26	0.32	0.09	0.20
17	0.15	0.13	0.13	0.17	0.05	0.10
18	0.07	0.05	0.08	0.10	0.02	0.06
19	0.04	0.05	0.05	0.06	0.01	0.03
20	0.04	0.06	0.08	0.11	0.04	0.13
21	0.05	0.05	0.10	0.12	0.04	0.13
22	0.11	0.13	0.14	0.17	0.05	0.12
23	0.24	0.26	0.23	0.35	0.12	0.20

Table 14
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 225.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.68	0.68	0.56	0.77	0.36	0.27
2	0.54	0.46	0.52	0.48	0.32	0.25
3	0.31	0.35	0.27	0.33	0.19	0.15
4	0.17	0.15	0.17	0.20	0.12	0.09
5	0.10	0.10	0.11	0.12	0.07	0.05
6	0.22	0.18	0.53	0.34	0.32	0.10
7	0.30	0.36	0.43	0.36	0.26	0.11
8	0.38	0.30	0.42	0.47	0.12	0.18
9	0.12	0.14	0.25	0.30	0.20	0.11
10	0.17	0.10	0.10	0.29	0.21	0.22
11	0.42	0.36	0.44	0.45	0.26	0.24
12	0.09	0.09	0.13	0.15	0.06	0.11
13	0.05	0.02	0.04	0.06	0.02	0.05
14	0.02	0.01	0.03	0.04	0.01	0.03
15	0.01	0.01	0.02	0.02	0.01	0.04
16	0.32	0.28	0.29	0.35	0.19	0.14
17	0.18	0.13	0.14	0.19	0.11	0.07
18	0.08	0.06	0.09	0.11	0.05	0.03
19	0.05	0.06	0.06	0.06	0.02	0.05
20	0.06	0.07	0.09	0.12	0.10	0.09
21	0.05	0.06	0.11	0.14	0.09	0.12
22	0.13	0.12	0.15	0.19	0.11	0.12
23	0.27	0.25	0.25	0.38	0.26	0.20

Table 15
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 247.5 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.78	0.48	0.74	0.35	0.47	0.26
2	0.65	0.44	0.46	0.32	0.34	0.25
3	0.32	0.23	0.32	0.19	0.27	0.15
4	0.18	0.15	0.19	0.11	0.15	0.09
5	0.11	0.09	0.12	0.07	0.08	0.05
6	0.27	0.43	0.33	0.33	0.40	0.10
7	0.42	0.36	0.35	0.27	0.46	0.10
8	0.50	0.35	0.45	0.12	0.18	0.17
9	0.19	0.21	0.29	0.20	0.32	0.10
10	0.25	0.09	0.28	0.21	0.36	0.22
11	0.54	0.37	0.44	0.25	0.45	0.24
12	0.11	0.11	0.14	0.06	0.16	0.11
13	0.06	0.04	0.06	0.02	0.06	0.04
14	0.02	0.02	0.03	0.01	0.04	0.03
15	0.01	0.01	0.02	0.01	0.04	0.04
16	0.34	0.25	0.34	0.19	0.25	0.14
17	0.19	0.13	0.18	0.11	0.12	0.07
18	0.08	0.07	0.11	0.05	0.08	0.03
19	0.06	0.05	0.06	0.02	0.04	0.05
20	0.06	0.08	0.12	0.09	0.16	0.09
21	0.05	0.09	0.13	0.09	0.16	0.11
22	0.12	0.13	0.18	0.11	0.15	0.12
23	0.28	0.21	0.36	0.25	0.23	0.20

Table 16
HARBD Wave Amplification Factors
Plan 1, Wave Angle = 270.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.62	0.47	0.75	0.35	0.47	0.26
2	0.40	0.44	0.46	0.32	0.34	0.25
3	0.21	0.23	0.32	0.19	0.27	0.15
4	0.11	0.15	0.19	0.11	0.15	0.09
5	0.08	0.09	0.12	0.07	0.08	0.05
6	0.47	0.44	0.33	0.33	0.40	0.10
7	0.28	0.36	0.35	0.27	0.46	0.10
8	0.27	0.35	0.45	0.12	0.18	0.17
9	0.11	0.21	0.29	0.20	0.32	0.10
10	0.27	0.09	0.28	0.21	0.36	0.22
11	0.54	0.37	0.44	0.25	0.45	0.24
12	0.10	0.11	0.14	0.06	0.16	0.11
13	0.03	0.04	0.06	0.02	0.06	0.04
14	0.02	0.02	0.03	0.01	0.04	0.03
15	0.01	0.01	0.02	0.01	0.04	0.04
16	0.28	0.25	0.34	0.19	0.25	0.14
17	0.13	0.13	0.18	0.11	0.12	0.07
18	0.06	0.07	0.11	0.05	0.08	0.03
19	0.05	0.05	0.06	0.02	0.04	0.05
20	0.06	0.08	0.12	0.09	0.16	0.09
21	0.04	0.09	0.13	0.09	0.16	0.11
22	0.18	0.13	0.18	0.11	0.15	0.12
23	0.28	0.21	0.36	0.25	0.23	0.20

Table 17
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 135.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	1.07	1.35	1.32	0.94	0.94	0.46
2	0.77	0.89	0.71	0.59	0.61	0.32
3	0.47	0.64	0.83	0.31	0.76	0.23
4	0.15	0.33	0.84	0.30	0.41	0.15
5	0.09	0.21	0.23	0.13	0.15	0.08
6	0.03	0.07	0.09	0.06	0.19	0.06
7	0.65	0.68	0.69	0.50	0.38	0.24
8	0.39	0.59	0.56	0.25	0.56	0.18
9	0.21	0.31	0.32	0.30	0.40	0.17
10	0.29	0.29	0.39	0.17	0.31	0.09
11	0.21	0.28	0.28	0.18	0.25	0.11
12	0.12	0.20	0.32	0.05	0.35	0.12
13	0.02	0.05	0.01	0.04	0.14	0.07
14	0.02	0.01	0.01	0.02	0.05	0.03
15	*	0.01	0.01	0.01	0.04	0.03
16	0.01	0.01	0.01	0.01	0.03	0.02
17	0.13	0.31	0.68	0.02	0.38	0.18
18	0.09	0.21	0.45	0.15	0.22	0.14
19	0.03	0.12	0.20	0.09	0.15	0.10
20	0.02	0.08	0.19	0.06	0.16	0.12
21	0.02	0.09	0.11	0.09	0.10	0.06
22	0.06	0.10	0.26	0.05	0.22	0.17
23	0.18	0.34	0.81	0.33	0.31	0.32

* Wave amplitude is below significance for tabulation.

Table 18
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 157.5 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	1.59	1.20	0.46	0.83	0.78	1.00
2	1.06	0.85	0.32	0.49	0.54	0.67
3	0.79	0.85	0.23	0.33	0.57	0.70
4	0.71	0.65	0.15	0.25	0.33	0.43
5	0.28	0.19	0.08	0.07	0.09	0.22
6	0.14	0.08	0.06	0.08	0.15	0.20
7	0.47	0.74	0.24	0.27	0.22	0.52
8	0.50	0.53	0.18	0.33	0.40	0.55
9	0.54	0.35	0.17	0.14	0.25	0.43
10	0.33	0.34	0.09	0.18	0.21	0.29
11	0.40	0.26	0.11	0.11	0.15	0.27
12	0.18	0.25	0.63	0.17	0.22	0.35
13	0.09	0.02	0.07	0.03	0.07	0.17
14	0.03	0.02	0.03	0.01	0.03	0.06
15	0.01	0.01	0.03	0.01	0.02	0.06
16	0.01	0.01	0.02	*	0.01	0.04
17	0.57	0.51	0.18	0.19	0.29	0.40
18	0.27	0.39	0.14	0.11	0.17	0.24
19	0.13	0.19	0.10	0.06	0.10	0.19
20	0.13	0.14	0.12	0.08	0.12	0.23
21	0.22	0.12	0.06	0.04	0.07	0.15
22	0.17	0.22	0.17	0.16	0.20	0.31
23	0.64	0.70	0.32	0.13	0.27	0.47

* Wave amplitude is below significance for tabulation.

Table 19
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 180.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	1.56	1.45	1.16	0.21	0.94	0.91
2	1.27	1.04	0.60	0.16	0.62	0.67
3	0.62	0.85	0.39	0.07	0.75	0.35
4	0.49	0.56	0.38	0.08	0.41	0.15
5	0.16	0.16	0.10	0.02	0.15	0.12
6	0.07	0.06	0.09	0.03	0.19	0.04
7	0.68	0.91	0.51	0.08	0.38	0.61
8	0.45	0.56	0.45	0.07	0.31	0.56
9	0.55	0.35	0.18	0.02	0.40	0.14
10	0.30	0.35	0.26	0.02	0.30	0.19
11	0.35	0.25	0.17	0.01	0.25	0.14
12	0.07	0.26	0.24	0.02	0.35	0.08
13	0.08	0.02	0.03	*	0.14	0.02
14	0.03	0.02	0.01	*	0.05	0.01
15	0.01	0.01	*	*	0.04	*
16	0.02	0.01	*	*	0.03	*
17	0.34	0.44	0.29	0.07	0.38	0.15
18	0.22	0.32	0.17	0.04	0.21	0.11
19	0.09	0.16	0.08	0.02	0.15	0.04
20	0.07	0.12	0.11	0.03	0.16	0.03
21	0.14	0.10	0.04	0.01	0.10	0.03
22	0.11	0.18	0.18	0.05	0.22	0.08
23	0.49	0.59	0.19	0.05	0.30	0.23

* Wave amplitude is below significance for tabulation.

Table 20
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 202.5 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.76	0.66	1.55	0.20	0.77	1.51
2	0.46	0.55	0.86	0.17	0.53	1.05
3	0.18	0.46	0.69	0.10	0.61	0.41
4	0.38	0.26	0.62	0.11	0.31	0.24
5	0.18	0.09	0.15	0.02	0.11	0.21
6	0.08	0.04	0.06	0.04	0.14	0.08
7	0.26	0.54	0.80	0.08	0.32	0.80
8	0.11	0.31	0.56	0.08	0.47	0.50
9	0.22	0.24	0.28	0.03	0.33	0.20
10	0.11	0.18	0.36	0.03	0.25	0.25
11	0.14	0.15	0.25	0.02	0.21	0.22
12	0.04	0.11	0.30	0.03	0.28	0.14
13	0.03	0.02	0.02	0.01	0.11	0.03
14	0.01	0.01	0.01	*	0.04	0.01
15	*	*	*	*	0.03	*
16	*	*	*	*	0.03	*
17	0.27	0.19	0.49	0.08	0.29	0.24
18	0.20	0.15	0.32	0.05	0.16	0.18
19	0.12	0.08	0.13	0.02	0.11	0.13
20	0.08	0.05	0.13	0.03	0.12	0.08
21	0.12	0.06	0.07	0.01	0.07	0.10
22	0.08	0.09	0.17	0.06	0.16	0.12
23	0.51	0.26	0.56	0.07	0.22	0.34

* Wave amplitude is below significance for tabulation.

Table 21
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 225.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.87	0.94	0.35	0.77	0.20	0.48
2	0.71	0.58	0.19	0.60	0.13	0.42
3	0.38	0.45	0.06	0.53	0.15	0.22
4	0.13	0.29	0.13	0.39	0.13	0.42
5	0.07	0.11	0.03	0.10	0.07	0.33
6	0.03	0.05	0.01	0.15	0.05	0.12
7	0.56	0.50	0.18	0.23	0.11	0.37
8	0.43	0.31	0.08	0.40	0.09	0.18
9	0.17	0.25	0.04	0.20	0.10	0.16
10	0.21	0.19	0.06	0.21	0.04	0.15
11	0.18	0.15	0.04	0.14	0.06	0.18
12	0.13	0.11	0.06	0.21	0.07	0.10
13	0.02	0.02	0.01	0.04	0.04	0.02
14	0.01	0.01	*	0.02	0.02	*
15	*	0.01	*	0.01	0.02	*
16	*	0.01	*	0.01	0.01	*
17	0.11	0.21	0.10	0.31	0.15	0.41
18	0.08	0.18	0.07	0.18	0.11	0.29
19	0.04	0.10	0.03	0.09	0.08	0.19
20	0.03	0.06	0.03	0.13	0.09	0.12
21	0.03	0.07	0.01	0.07	0.04	0.16
22	0.03	0.11	0.04	0.25	0.13	0.20
23	0.11	0.30	0.11	0.25	0.26	0.59

* Wave amplitude is below significance for tabulation.

Table 22
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 247.5 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.74	0.94	0.13	0.92	0.55	0.30
2	0.61	0.54	0.03	0.69	0.38	0.21
3	0.36	0.34	0.11	0.60	0.43	0.18
4	0.12	0.18	0.15	0.42	0.22	0.15
5	0.07	0.05	0.04	0.10	0.08	0.08
6	0.02	0.02	0.12	0.16	0.10	0.05
7	0.44	0.53	0.01	0.27	0.22	0.16
8	0.38	0.25	0.05	0.46	0.33	0.13
9	0.17	0.17	0.05	0.24	0.24	0.12
10	0.20	0.13	0.06	0.25	0.19	0.06
11	0.18	0.10	0.04	0.16	0.15	0.07
12	0.12	0.07	0.05	0.25	0.21	0.08
13	0.02	0.02	*	0.05	0.08	0.05
14	0.01	0.01	*	0.02	0.03	0.02
15	*	*	*	0.01	0.03	0.02
16	*	0.01	*	0.01	0.02	0.02
17	0.10	0.12	0.12	0.33	0.20	0.18
18	0.07	0.09	0.08	0.19	0.11	0.13
19	0.03	0.04	0.04	0.10	0.08	0.09
20	0.02	0.03	0.03	0.14	0.08	0.11
21	0.03	0.03	0.21	0.08	0.05	0.05
22	0.04	0.05	0.05	0.27	0.11	0.15
23	0.12	0.14	0.14	0.27	0.15	0.30

* Wave amplitude is below significance for tabulation.

Table 23
HARBD Wave Amplification Factors
Plan 2, Wave Angle = 270.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.67	0.77	0.13	0.92	0.55	0.32
2	0.36	0.49	0.05	0.69	0.38	0.23
3	0.28	0.44	0.11	0.60	0.43	0.19
4	0.31	0.32	0.15	0.42	0.22	0.16
5	0.13	0.12	0.04	0.10	0.08	0.08
6	0.06	0.06	0.02	0.16	0.10	0.06
7	0.19	0.45	0.01	0.27	0.22	0.18
8	0.17	0.27	0.05	0.46	0.33	0.14
9	0.18	0.25	0.05	0.24	0.24	0.13
10	0.11	0.19	0.06	0.25	0.19	0.06
11	0.13	0.16	0.04	0.16	0.15	0.08
12	0.07	0.12	0.05	0.25	0.21	0.09
13	0.03	0.02	*	0.05	0.08	0.05
14	0.01	0.01	*	0.02	0.03	0.02
15	*	0.01	*	0.01	0.03	0.02
16	*	0.01	*	0.01	0.02	0.02
17	0.25	0.24	0.12	0.33	0.20	0.18
18	0.13	0.20	0.08	0.19	0.11	0.14
19	0.06	0.11	0.04	0.10	0.08	0.10
20	0.06	0.07	0.03	0.14	0.08	0.11
21	0.10	0.08	0.02	0.08	0.05	0.05
22	0.06	0.13	0.05	0.27	0.11	0.16
23	0.29	0.36	0.14	0.27	0.15	0.31

* Wave amplitude is below significance for tabulation.

Table 24
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 135.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.58	0.67	0.49	0.42	0.25	0.14
2	0.34	0.31	0.31	0.27	0.14	0.09
3	0.16	0.17	0.14	0.16	0.09	0.05
4	0.12	0.17	0.12	0.14	0.08	0.03
5	0.11	0.09	0.12	0.12	0.06	0.03
6	0.05	0.05	0.03	0.02	0.01	0.01
7	0.03	0.03	0.01	0.02	0.01	0.01
8	0.08	0.10	0.08	0.08	0.07	0.04
9	0.10	0.11	0.09	0.09	0.06	0.02
10	0.05	0.08	0.04	0.05	0.04	0.02
11	0.08	0.06	0.06	0.05	0.03	0.01
12	0.06	0.08	0.04	0.03	0.02	0.01
13	0.03	0.07	0.04	0.05	0.03	0.01
14	0.01	0.02	*	0.01	0.01	0.01
15	*	*	*	*	*	*
16	*	*	0.21	*	0.11	*
17	*	*	*	*	*	*
18	0.08	0.07	0.07	0.06	0.04	0.02
19	0.05	0.04	0.04	0.03	0.02	0.01
20	0.03	0.02	0.02	0.01	0.01	0.01
21	0.02	0.01	0.01	0.01	0.01	0.01
22	0.02	0.02	0.01	0.01	0.01	0.01
23	0.05	0.02	0.04	0.05	0.03	0.01
24	0.15	0.11	0.11	0.08	0.05	0.04

* Wave amplitude is below significance for tabulation.

Table 25
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 157.5 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.42	0.25	0.37	0.37	0.35	0.07
2	0.23	0.08	0.25	0.24	0.21	0.05
3	0.15	0.56	0.13	0.14	0.13	0.03
4	0.12	0.05	0.11	0.12	0.12	0.03
5	0.08	0.04	0.08	0.11	0.10	0.02
6	0.04	0.02	0.03	0.02	0.02	0.01
7	0.02	0.01	*	0.02	0.02	0.01
8	0.08	0.03	0.07	0.06	0.08	0.03
9	0.09	0.02	0.08	0.08	0.08	0.02
10	0.05	0.04	0.05	0.04	0.05	0.01
11	0.07	0.02	0.04	0.05	0.04	0.01
12	0.06	0.03	0.03	0.03	0.03	0.01
13	0.03	0.02	0.03	0.05	0.05	0.01
14	0.01	0.01	*	0.01	0.01	0.01
15	*	*	*	*	*	*
16	*	*	*	*	*	*
17	*	*	*	*	*	*
18	0.06	0.02	0.05	0.06	0.05	0.01
19	0.04	0.01	0.03	0.03	0.03	0.01
20	0.02	0.01	0.01	0.01	0.01	*
21	0.01	0.01	0.01	0.01	0.01	*
22	0.01	0.01	0.01	0.01	0.01	*
23	0.04	0.01	0.02	0.04	0.04	0.01
24	0.11	0.04	0.08	0.07	0.07	0.02

* Wave amplitude is below significance for tabulation.

Table 26
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 180.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.51	0.26	0.13	0.28	0.35	0.16
2	0.35	0.17	0.10	0.19	0.22	0.09
3	0.18	0.12	0.05	0.11	0.14	0.06
4	0.15	0.08	0.04	0.10	0.12	0.06
5	0.09	0.07	0.02	0.09	0.10	0.04
6	0.05	0.04	0.01	0.02	0.02	0.01
7	0.03	0.02	*	0.01	0.02	0.01
8	0.10	0.08	0.03	0.05	0.07	0.05
9	0.11	0.05	0.03	0.07	0.08	0.04
10	0.07	0.06	0.01	0.03	0.04	0.03
11	0.06	0.04	0.01	0.04	0.04	0.02
12	0.08	0.04	0.01	0.03	0.03	0.02
13	0.06	0.02	0.01	0.04	0.04	0.02
14	0.01	0.01	*	*	0.01	0.01
15	*	*	*	*	*	*
16	*	*	*	*	*	*
17	*	*	*	*	*	*
18	0.07	0.04	0.01	0.05	0.05	0.03
19	0.04	0.02	0.01	0.03	0.03	0.02
20	0.02	0.01	*	0.01	0.01	0.01
21	0.01	0.01	*	0.01	0.01	0.01
22	0.03	0.02	*	0.05	0.01	0.01
23	0.04	0.02	*	0.05	0.04	0.02
24	0.12	0.08	0.02	*	0.07	0.03

* Wave amplitude is below significance for tabulation.

Table 27
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 202.5 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.18	0.21	0.05	0.23	0.32	0.06
2	0.13	0.19	0.04	0.16	0.20	0.04
3	0.05	0.10	0.03	0.10	0.13	0.03
4	0.05	0.08	0.01	0.09	0.11	0.03
5	0.02	0.06	*	0.08	0.09	0.02
6	0.01	0.03	*	0.03	0.02	*
7	0.01	0.01	*	*	0.02	*
8	0.03	0.09	0.02	0.06	0.06	0.02
9	0.03	0.05	0.01	0.07	0.07	0.02
10	0.02	0.06	0.01	0.03	0.04	0.01
11	0.02	0.03	0.01	0.04	0.04	0.01
12	0.02	0.03	*	0.03	0.03	0.01
13	0.02	0.01	*	0.03	0.04	0.01
14	*	0.01	*	*	0.01	*
15	*	*	*	*	*	*
16	*	*	*	*	*	*
17	*	*	0.49	*	*	*
18	0.02	0.04	*	0.05	0.05	0.01
19	0.01	0.03	*	0.03	0.03	*
20	*	0.01	*	0.01	0.01	*
21	*	0.01	*	0.01	0.01	*
22	0.01	0.02	*	0.01	0.01	*
23	0.01	0.01	*	0.03	0.04	0.01
24	0.03	0.07	0.01	0.08	0.06	0.01

* Wave amplitude is below significance for tabulation.

Table 28
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 225.0

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.14	0.32	0.28	0.16	0.14	0.25
2	0.14	0.25	0.16	0.11	0.09	0.17
3	0.07	0.11	0.07	0.09	0.06	0.11
4	0.07	0.09	0.09	0.07	0.05	0.07
5	0.04	0.07	0.08	0.07	0.04	0.05
6	0.02	0.03	0.03	0.02	0.01	0.02
7	0.01	0.01	*	*	0.01	0.01
8	0.04	0.09	0.06	0.05	0.03	0.08
9	0.04	0.06	0.06	0.06	0.03	0.05
10	0.03	0.07	0.04	0.03	0.02	0.04
11	0.03	0.04	0.03	0.03	0.02	0.03
12	0.03	0.04	0.03	0.02	0.02	0.03
13	0.03	0.01	0.01	0.02	0.02	0.03
14	0.01	0.01	0.01	*	*	0.02
15	*	*	*	*	*	0.01
16	*	*	*	*	*	0.01
17	*	*	*	*	*	*
18	0.03	0.04	0.04	0.04	0.02	0.04
19	0.02	0.03	0.03	0.02	0.01	0.03
20	0.01	0.01	0.01	0.01	0.01	0.02
21	0.01	0.01	0.01	0.01	0.01	0.01
22	0.01	0.02	0.02	0.01	0.01	0.01
23	0.01	0.02	0.02	0.02	0.02	0.03
24	0.05	0.08	0.09	0.07	0.03	0.08

* Wave amplitude is below significance for tabulation.

Table 29
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 247.4 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.22	0.29	0.09	0.05	0.24	0.24
2	0.16	0.17	0.05	0.05	0.11	0.17
3	0.16	0.07	0.06	0.03	0.06	0.11
4	0.07	0.09	0.05	0.02	0.06	0.07
5	0.03	0.08	0.04	0.02	0.05	0.05
6	0.02	0.03	0.01	*	0.01	0.02
7	0.01	0.01	*	*	0.01	0.01
8	0.04	0.06	0.03	0.01	0.05	0.08
9	0.05	0.06	0.04	0.02	0.04	0.05
10	0.03	0.04	0.02	*	0.03	0.04
11	0.03	0.03	0.02	0.01	0.02	0.03
12	0.04	0.03	0.01	0.01	0.02	0.03
13	0.03	0.01	0.01	0.09	0.02	0.03
14	0.01	0.01	*	*	0.01	0.02
15	*	*	*	*	*	0.01
16	*	*	*	*	*	0.01
17	*	*	*	*	*	*
18	0.03	0.04	0.03	0.01	0.03	0.04
19	0.01	0.03	0.02	0.01	0.02	0.03
20	0.01	0.01	0.01	*	0.01	0.02
21	0.01	0.01	*	*	0.01	0.01
22	0.01	0.02	0.01	*	0.01	0.01
23	0.01	0.02	0.01	0.01	0.02	0.03
24	0.05	0.08	0.04	0.01	0.04	0.08

* Wave amplitude is below significance for tabulation.

Table 30
HARBD Wave Amplification Factors
Plan 3, Wave Angle = 270.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.27	0.30	0.09	0.05	0.24	0.24
2	0.27	0.18	0.05	0.05	0.11	0.17
3	0.16	0.07	0.06	0.03	0.06	0.11
4	0.10	0.10	0.05	0.02	0.06	0.07
5	0.06	0.08	0.04	0.02	0.05	0.05
6	0.04	0.03	0.02	*	0.01	0.02
7	0.02	0.01	*	*	0.01	0.01
8	0.09	0.07	0.04	0.01	0.05	0.08
9	0.06	0.06	0.04	0.02	0.04	0.05
10	0.07	0.05	0.02	0.01	0.03	0.04
11	0.04	0.03	0.02	0.01	0.02	0.03
12	0.05	0.03	0.01	0.01	0.02	0.03
13	0.03	0.02	0.02	0.01	0.02	0.03
14	0.02	0.01	*	*	0.01	0.02
15	*	*	*	*	*	0.01
16	*	*	*	*	*	0.01
17	*	*	*	*	*	*
18	0.04	0.05	0.03	0.01	0.03	0.04
19	0.03	0.03	0.02	0.01	0.02	0.03
20	0.01	0.01	0.01	*	0.01	0.02
21	0.01	0.01	*	*	0.01	0.01
22	0.02	0.02	0.01	*	0.01	0.01
23	0.02	0.03	0.02	0.01	0.02	0.03
24	0.08	0.09	0.05	0.01	0.04	0.08

* Wave amplitude is below significance for tabulation.

Table 31
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 135.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.52	0.41	0.44	0.10	0.29	0.20
2	0.41	0.28	0.27	0.08	0.26	0.18
3	0.16	0.11	0.19	0.05	0.14	0.09
4	0.09	0.05	0.10	0.03	0.07	0.04
5	0.05	0.03	0.06	0.01	0.04	0.02
6	0.29	0.28	0.13	0.12	0.19	0.06
7	0.21	0.19	0.23	0.11	0.21	0.06
8	0.31	0.21	0.29	0.05	0.15	0.13
9	0.17	0.17	0.13	0.10	0.21	0.06
10	0.16	0.09	0.24	0.08	0.25	0.15
11	0.31	0.21	0.33	0.10	0.28	0.17
12	0.05	0.06	0.06	0.03	0.10	0.06
13	0.03	0.02	0.02	0.01	0.04	0.02
14	0.01	0.01	0.01	0.01	0.02	0.01
15	0.01	*	0.01	*	0.02	0.02
16	0.18	0.10	0.19	0.05	0.13	0.07
17	0.10	0.06	0.09	0.03	0.06	0.03
18	0.05	0.02	0.05	0.01	0.03	0.01
19	0.03	0.01	0.02	*	0.01	0.01
20	0.01	0.02	0.06	0.02	0.06	0.04
21	0.04	0.03	0.08	0.02	0.07	0.05
22	0.11	0.07	0.12	0.03	0.08	0.06
23	0.17	0.10	0.19	0.05	0.13	0.10

* Wave amplitude is below significance for tabulation.

Table 32
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 157.5 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.47	0.41	0.48	0.21	0.19	0.35
2	0.39	0.30	0.36	0.11	0.21	0.22
3	0.11	0.11	0.19	0.10	0.10	0.15
4	0.06	0.06	0.11	0.06	0.05	0.07
5	0.03	0.04	0.07	0.03	0.03	0.04
6	0.32	0.27	0.33	0.10	0.21	0.12
7	0.26	0.25	0.45	0.09	0.21	0.14
8	0.34	0.15	0.38	0.04	0.12	0.14
9	0.21	0.21	0.18	0.07	0.19	0.16
10	0.18	0.12	0.31	0.05	0.17	0.25
11	0.32	0.26	0.35	0.11	0.23	0.27
12	0.05	0.06	0.08	0.03	0.08	0.09
13	0.03	0.03	0.02	0.01	0.03	0.03
14	0.01	0.02	0.02	*	0.01	0.02
15	0.02	0.01	0.01	*	0.01	0.02
16	0.12	0.15	0.20	0.10	0.09	0.13
17	0.07	0.07	0.10	0.05	0.05	0.06
18	0.03	0.02	0.05	0.02	0.02	0.03
19	0.02	0.02	0.03	0.01	0.01	0.01
20	0.01	0.03	0.06	0.03	*	0.07
21	0.02	0.03	0.07	0.04	0.05	0.08
22	0.08	0.10	0.11	0.07	0.05	0.09
23	0.11	0.16	0.16	0.15	0.08	0.14

* Wave amplitude is below significance for tabulation.

Table 33
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 180.0 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.52	0.70	0.50	0.46	0.17	0.28
2	0.32	0.44	0.37	0.30	0.09	0.24
3	0.20	0.21	0.20	0.18	0.09	0.13
4	0.10	0.12	0.12	0.10	0.05	0.07
5	0.06	0.08	0.07	0.06	0.03	0.04
6	0.14	0.19	0.35	0.12	0.04	0.18
7	0.16	0.32	0.48	0.09	0.03	0.20
8	0.20	0.25	0.39	0.18	0.03	0.14
9	0.12	0.24	0.19	0.15	0.01	0.20
10	0.06	0.23	0.31	0.19	0.03	0.23
11	0.18	0.45	0.36	0.31	0.10	0.27
12	0.06	0.07	0.08	0.06	0.03	0.10
13	0.03	0.03	0.03	0.02	0.01	0.03
14	0.01	0.02	0.02	0.01	0.01	0.02
15	*	0.01	0.01	0.01	*	0.02
16	0.21	0.27	0.21	0.18	0.09	0.13
17	0.12	0.12	0.10	0.09	0.05	0.06
18	0.04	0.05	0.05	0.05	0.02	0.03
19	0.03	0.04	0.03	0.02	0.01	0.01
20	0.03	0.06	0.06	0.06	0.03	0.06
21	0.05	0.04	0.08	0.08	0.04	0.07
22	0.13	0.13	0.12	0.15	0.05	0.08
23	0.21	0.26	0.17	0.29	0.12	0.13

* Wave-amplitude is below significance for tabulation.

Table 34
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 202.5 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.89	0.88	0.51	0.58	0.28	0.27
2	0.64	0.62	0.37	0.41	0.17	0.24
3	0.31	0.28	0.20	0.22	0.11	0.13
4	0.15	0.16	0.12	0.12	0.07	0.07
5	0.08	0.11	0.07	0.07	0.04	0.04
6	0.33	0.16	0.35	0.21	0.11	0.18
7	0.41	0.36	0.48	0.15	0.08	0.20
8	0.48	0.31	0.39	0.26	0.08	0.14
9	0.32	0.19	0.19	0.24	0.10	0.20
10	0.16	0.24	0.31	0.29	0.11	0.23
11	0.43	0.45	0.36	0.42	0.20	0.27
12	0.13	0.08	0.08	0.09	0.06	0.09
13	0.05	0.01	0.03	0.03	0.02	0.03
14	0.02	0.01	0.02	0.01	0.01	0.02
15	0.01	0.01	0.01	0.01	0.01	0.02
16	0.32	0.32	0.21	0.22	0.12	0.12
17	0.18	0.15	0.10	0.11	0.06	0.06
18	0.07	0.06	0.05	0.05	0.03	0.03
19	0.04	0.05	0.03	0.02	0.01	0.01
20	0.05	0.08	0.06	0.07	0.04	0.06
21	0.07	0.08	0.08	0.09	0.05	0.07
22	0.19	0.16	0.12	0.18	0.07	0.07
23	0.31	0.29	0.18	0.36	0.17	0.12

* Wave amplitude is below significance for tabulation.

Table 35
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 225.0 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.94	0.97	0.61	0.61	0.44	0.30
2	0.82	0.81	0.46	0.43	0.30	0.29
3	0.26	0.29	0.24	0.24	0.16	0.14
4	0.13	0.18	0.13	0.13	0.10	0.07
5	0.07	0.11	0.08	0.08	0.05	0.03
6	0.56	0.32	0.34	0.30	0.25	0.11
7	0.66	0.57	0.43	0.43	0.20	0.09
8	0.70	0.42	0.48	0.48	0.15	0.19
9	0.51	0.31	0.24	0.24	0.22	0.08
10	0.25	0.38	0.38	0.39	0.22	0.21
11	0.60	0.60	0.51	0.51	0.36	0.26
12	0.19	0.11	0.09	0.09	0.11	0.10
13	0.07	0.02	0.02	0.02	0.04	0.03
14	0.02	0.01	0.01	0.01	0.02	0.02
15	0.01	0.01	0.01	0.01	0.02	0.03
16	0.28	0.34	0.24	0.23	0.17	0.12
17	0.16	0.16	0.12	0.12	0.09	0.06
18	0.06	0.07	0.06	0.06	0.04	0.02
19	0.03	0.06	0.03	0.03	0.02	0.02
20	0.04	0.08	0.08	0.08	0.06	0.06
21	0.05	0.09	0.11	0.11	0.06	0.09
22	0.16	0.16	0.17	0.17	0.08	0.11
23	0.26	0.28	0.27	0.27	0.23	0.17

Wave amplitude is below significance for tabulation.

Table 36
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 247.5 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.74	0.60	0.61	0.44	0.25	0.30
2	0.71	0.64	0.43	0.31	0.22	0.30
3	0.13	0.25	0.24	0.16	0.11	0.15
4	0.06	0.14	0.13	0.10	0.06	0.07
5	0.03	0.09	0.08	0.05	0.03	0.03
6	0.62	0.37	0.29	0.25	0.19	0.12
7	0.51	0.48	0.43	0.20	0.21	0.09
8	0.51	0.39	0.48	0.15	0.13	0.20
9	0.44	0.19	0.24	0.22	0.19	0.08
10	0.23	0.30	0.39	0.22	0.21	0.21
11	0.49	0.40	0.51	0.36	0.25	0.26
12	0.16	0.10	0.09	0.11	0.09	0.10
13	0.06	0.02	0.02	0.04	0.03	0.03
14	0.02	0.01	0.01	0.02	0.02	0.02
15	0.01	0.01	0.01	0.02	0.02	0.03
16	0.17	0.27	0.24	0.17	0.10	0.12
17	0.08	0.12	0.12	0.09	0.05	0.06
18	0.03	0.06	0.06	0.04	0.02	0.03
19	0.02	0.04	0.03	0.02	0.01	0.02
20	0.02	0.07	0.08	0.06	0.05	0.07
21	0.02	0.08	0.11	0.07	0.06	0.09
22	0.10	0.15	0.17	0.08	0.06	0.11
23	0.10	0.26	0.28	0.23	0.10	0.18

Wave amplitude is below significance for tabulation.

Table 37
HARBD Wave Amplification Factors
Plan 1a, Wave Angle = 270.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.80	0.53	0.61	0.44	0.25	0.30
2	0.74	0.52	0.43	0.31	0.22	0.30
3	0.15	0.22	0.24	0.16	0.11	0.15
4	0.07	0.13	0.13	0.10	0.06	0.07
5	0.04	0.08	0.08	0.05	0.03	0.03
6	0.63	0.36	0.29	0.25	0.19	0.12
7	0.52	0.47	0.43	0.20	0.21	0.09
8	0.53	0.38	0.48	0.15	0.13	0.20
9	0.45	0.18	0.24	0.22	0.19	0.08
10	0.24	0.29	0.38	0.22	0.21	0.21
11	0.51	0.35	0.51	0.36	0.25	0.26
12	0.16	0.09	0.09	0.11	0.09	0.10
13	0.06	0.03	0.02	0.04	0.03	0.03
14	0.02	0.02	0.01	0.02	0.02	0.02
15	0.01	0.01	0.01	0.02	0.02	0.03
16	0.18	0.24	0.24	0.17	0.10	0.13
17	0.09	0.11	0.12	0.09	0.05	0.06
18	0.03	0.05	0.06	0.04	0.02	0.03
19	0.02	0.04	0.03	0.02	0.01	0.02
20	0.03	0.06	0.08	0.06	0.05	0.07
21	0.03	0.08	0.11	0.07	0.06	0.09
22	0.12	0.13	0.17	0.08	0.06	0.11
23	0.11	0.22	0.28	0.23	0.10	0.18

* Wave amplitude is below significance for tabulation.

Table 38
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 135.0 deg

Basin	Wave Period, sec					
	9	11	13	15	17	20
1	0.54	0.40	0.44	0.09	0.29	0.20
2	0.45	0.27	0.25	0.09	0.24	0.18
3	0.15	0.11	0.17	0.05	0.14	0.09
4	0.09	0.05	0.10	0.03	0.07	0.04
5	0.05	0.03	0.06	0.02	0.04	0.02
6	0.29	0.28	0.13	0.11	0.22	0.06
7	0.20	0.19	0.28	0.10	0.22	0.08
8	0.30	0.22	0.31	0.08	0.09	0.13
9	0.09	0.22	0.12	0.11	0.22	0.05
10	0.19	0.04	0.24	0.05	0.26	0.16
11	0.32	0.26	0.44	0.11	0.37	0.21
12	0.06	0.07	0.09	0.03	0.13	0.08
13	0.04	0.03	0.03	0.01	0.04	0.03
14	0.01	0.01	0.02	0.01	0.02	0.02
15	0.02	0.01	0.01	*	0.02	0.02
16	0.17	0.10	0.18	0.05	0.13	0.07
17	0.10	0.06	0.09	0.03	0.07	0.03
18	0.04	0.02	0.04	0.01	0.03	0.02
19	0.02	0.01	0.02	*	0.01	0.01
20	0.01	0.02	0.05	0.02	0.06	0.04
21	0.03	0.03	0.07	0.02	0.08	0.05
22	0.11	0.07	0.12	0.03	0.08	0.07
23	0.17	0.10	0.20	0.05	0.11	0.12

* Wave amplitude is below significance for tabulation.

Table 39
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 157.5 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.48	0.42	0.47	0.21	0.18	0.37
2	0.42	0.31	0.35	0.11	0.21	0.21
3	0.10	0.12	0.17	0.10	0.09	0.16
4	0.05	0.05	0.10	0.06	0.05	0.08
5	0.03	0.04	0.06	0.03	0.03	0.04
6	0.32	0.30	0.35	0.09	0.25	0.12
7	0.24	0.26	0.52	0.08	0.17	0.18
8	0.32	0.18	0.38	0.07	0.13	0.09
9	0.11	0.28	0.18	0.08	0.21	0.15
10	0.22	0.06	0.25	0.06	0.15	0.28
11	0.33	0.32	0.46	0.14	0.29	0.35
12	0.06	0.09	0.11	0.03	0.10	0.12
13	0.04	0.04	0.04	0.01	0.03	0.04
14	0.01	0.02	0.02	*	0.02	0.02
15	0.02	0.02	0.01	*	0.01	0.02
16	0.12	0.15	0.19	0.10	0.09	0.14
17	0.07	0.07	0.09	0.05	0.04	0.07
18	0.03	0.02	0.04	0.02	0.02	0.03
19	0.01	0.02	0.03	0.01	0.01	0.01
20	0.01	0.03	0.05	0.03	0.04	0.07
21	0.02	0.03	0.06	0.04	0.05	0.09
22	0.09	0.11	0.11	0.07	0.04	0.10
23	0.11	0.16	0.17	0.15	0.06	0.15

* Wave amplitude is below significance for tabulation.

Table 40
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 180.0 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.50	0.69	0.49	0.47	0.18	0.28
2	0.29	0.42	0.36	0.31	0.10	0.23
3	0.21	0.20	0.18	0.18	0.09	0.14
4	0.10	0.11	0.10	0.10	0.05	0.07
5	0.06	0.08	0.06	0.06	0.03	0.04
6	0.14	0.22	0.37	0.12	0.04	0.21
7	0.16	0.33	0.54	0.11	0.04	0.21
8	0.22	0.26	0.40	0.20	0.05	0.09
9	0.16	0.32	0.20	0.14	0.02	0.21
10	0.09	0.11	0.23	0.21	0.06	0.25
11	0.28	0.56	0.48	0.39	0.13	0.35
12	0.07	0.10	0.12	0.08	0.04	0.12
13	0.04	0.04	0.04	0.02	0.01	0.04
14	0.01	0.03	0.02	0.01	0.01	0.02
15	0.01	0.02	0.01	*	*	0.02
16	0.20	0.26	0.19	0.19	0.09	0.13
17	0.12	0.11	0.09	0.09	0.05	0.06
18	0.05	0.04	0.05	0.05	0.02	0.03
19	0.03	0.04	0.03	0.02	0.01	0.01
20	0.03	0.05	0.05	0.06	0.03	0.06
21	0.05	0.04	0.07	0.08	0.04	0.07
22	0.13	0.14	0.12	0.15	0.05	0.08
23	0.21	0.27	0.18	0.31	0.12	0.11

* Wave amplitude is below significance for tabulation.

Table 41
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 202.5 deg

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.85	0.91	0.50	0.59	0.28	0.28
2	0.58	0.64	0.36	0.42	0.18	0.23
3	0.33	0.28	0.18	0.21	0.11	0.14
4	0.16	0.17	0.11	0.12	0.07	0.07*
5	0.09	0.11	0.06	0.07	0.04	0.03
6	0.34	0.15	0.37	0.19	0.12	0.21
7	0.43	0.39	0.55	0.15	0.07	0.21
8	0.51	0.36	0.40	0.29	0.09	0.09
9	0.39	0.27	0.20	0.23	0.10	0.21
10	0.17	0.09	0.22	0.30	0.13	0.25
11	0.60	0.59	0.48	0.52	0.25	0.35
12	0.16	0.11	0.12	0.10	0.07	0.12
13	0.08	0.03	0.04	0.03	0.02	0.04
14	0.03	0.02	0.02	0.01	0.01	0.02
15	0.02	0.02	0.02	0.01	0.01	0.02
16	0.31	0.32	0.19	0.22	0.12	0.12
17	0.19	0.15	0.09	0.11	0.06	0.06
18	0.07	0.06	0.05	0.06	0.03	0.03
19	0.04	0.05	0.03	0.03	0.01	0.01
20	0.05	0.08	0.05	0.07	0.04	0.06
21	0.08	0.08	0.07	0.09	0.05	0.07
22	0.20	0.15	0.12	0.18	0.07	0.08
23	0.32	0.27	0.19	0.38	0.18	0.11

* Wave amplitude is below significance for tabulation.

Table 42
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 225.0

Basin	Wave Period, sec 9	11	13	15	17	20
1	0.89	1.02	0.61	0.61	0.45	0.31
2	0.75	0.83	0.50	0.39	0.32	0.29
3	0.30	0.30	0.22	0.22	0.16	0.14
4	0.14	0.18	0.12	0.12	0.10	0.07
5	0.07	0.12	0.07	0.07	0.05	0.03
6	0.58	0.30	0.33	0.32	0.26	0.10
7	0.69	0.61	0.50	0.51	0.16	0.13
8	0.72	0.49	0.51	0.51	0.18	0.18
9	0.57	0.39	0.23	0.23	0.23	0.06
10	0.21	0.18	0.32	0.33	0.21	0.23
11	0.79	0.77	0.66	0.66	0.43	0.33
12	0.22	0.14	0.13	0.13	0.12	0.13
13	0.11	0.04	0.04	0.04	0.04	0.04
14	0.04	0.03	0.03	0.03	0.02	0.03
15	0.02	0.02	0.02	0.02	0.01	0.03
16	0.27	0.35	0.23	0.23	0.18	0.12
17	0.16	0.16	0.11	0.11	0.09	0.06
18	0.06	0.07	0.06	0.06	0.04	0.03
19	0.04	0.06	0.03	0.03	0.02	0.02
20	0.04	0.08	0.07	0.07	0.06	0.06
21	0.06	0.09	0.10	0.10	0.06	0.09
22	0.17	0.15	0.16	0.16	0.08	0.11
23	0.27	0.26	0.29	0.29	0.24	0.20

* Wave amplitude is below significance for tabulation.

Table 43
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 247.5 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.74	0.58	0.62	0.45	0.25	0.31
2	0.71	0.70	0.39	0.33	0.21	0.30
3	0.14	0.25	0.22	0.16	0.12	0.14
4	0.05	0.14	0.13	0.10	0.06	0.07
5	0.02	0.09	0.07	0.05	0.03	0.03
6	0.62	0.36	0.31	0.26	0.22	0.10
7	0.50	0.52	0.50	0.16	0.21	0.13
8	0.55	0.40	0.51	0.18	0.09	0.18
9	0.53	0.23	0.23	0.23	0.21	0.06
10	0.15	0.17	0.33	0.21	0.22	0.23
11	0.62	0.55	0.66	0.43	0.33	0.33
12	0.18	0.13	0.13	0.12	0.11	0.13
13	0.08	0.03	0.04	0.04	0.04	0.04
14	0.03	0.02	0.03	0.02	0.02	0.03
15	0.02	0.01	0.02	0.01	0.02	0.04
16	0.15	0.26	0.23	0.18	0.11	0.12
17	0.08	0.12	0.11	0.09	0.05	0.06
18	0.02	0.06	0.06	0.04	0.02	0.03
19	0.01	0.04	0.03	0.02	0.01	0.02
20	0.02	0.07	0.07	0.06	0.05	0.06
21	0.03	0.09	0.10	0.06	0.06	0.09
22	0.11	0.18	0.16	0.08	0.07	0.12
23	0.10	0.27	0.29	0.24	0.09	0.21

Wave amplitude is below significance for tabulation.

Table 44
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 270.0 deg

	Wave Period, sec					
Basin	9	11	13	15	17	20
1	0.79	0.51	0.61	0.45	0.25	0.31
2	0.74	0.56	0.39	0.33	0.21	0.30
3	0.15	0.21	0.22	0.16	0.12	0.14
4	0.06	0.12	0.12	0.10	0.06	0.07
5	0.04	0.07	0.07	0.05	0.03	0.03
6	0.63	0.36	0.31	0.26	0.22	0.10
7	0.50	0.52	0.50	0.16	0.21	0.13
8	0.57	0.38	0.51	0.18	0.09	0.18
9	0.55	0.21	0.23	0.23	0.21	0.06
10	0.15	0.17	0.33	0.21	0.22	0.23
11	0.64	0.48	0.66	0.43	0.33	0.33
12	0.19	0.12	0.13	0.12	0.11	0.13
13	0.08	0.03	0.04	0.04	0.04	0.04
14	0.03	0.02	0.03	0.02	0.02	0.03
15	0.02	0.01	0.02	0.01	0.02	0.04
16	0.17	0.23	0.23	0.18	0.11	0.12
17	0.09	0.10	0.11	0.09	0.05	0.06
18	0.03	0.05	0.06	0.04	0.02	0.03
19	0.02	0.03	0.03	0.02	0.01	0.02
20	0.02	0.06	0.07	0.06	0.05	0.06
21	0.03	0.08	0.10	0.06	0.06	0.09
22	0.12	0.16	0.16	0.08	0.07	0.12
23	0.12	0.24	0.29	0.24	0.09	0.21

Wave amplitude is below significance for tabulation.

Table 44
HARBD Wave Amplification Factors
Plan 1b, Wave Angle = 270.0 deg

Wave Period, sec						
Basin	9	11	13	15	17	20
1	0.79	0.51	0.61	0.45	0.25	0.31
2	0.74	0.56	0.39	0.33	0.21	0.30
3	0.15	0.21	0.22	0.16	0.12	0.14
4	0.06	0.12	0.12	0.10	0.06	0.07
5	0.04	0.07	0.07	0.05	0.03	0.03
6	0.63	0.36	0.31	0.26	0.22	0.10
7	0.50	0.52	0.50	0.16	0.21	0.13
8	0.57	0.38	0.51	0.18	0.09	0.18
9	0.55	0.21	0.23	0.23	0.21	0.06
10	0.15	0.17	0.33	0.21	0.22	0.23
11	0.64	0.48	0.66	0.43	0.33	0.33
12	0.19	0.12	0.13	0.12	0.11	0.13
13	0.08	0.03	0.04	0.04	0.04	0.04
14	0.03	0.02	0.03	0.02	0.02	0.03
15	0.02	0.01	0.02	0.01	0.02	0.04
16	0.17	0.23	0.23	0.18	0.11	0.12
17	0.09	0.10	0.11	0.09	0.05	0.06
18	0.03	0.05	0.06	0.04	0.02	0.03
19	0.02	0.03	0.03	0.02	0.01	0.02
20	0.02	0.06	0.07	0.06	0.05	0.06
21	0.03	0.08	0.10	0.06	0.06	0.09
22	0.12	0.16	0.16	0.08	0.07	0.12
23	0.12	0.24	0.29	0.24	0.09	0.21

* Wave amplitude is below significance for tabulation.

Table 45
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria*
(Deepwater Wave Conditions)

Direction (deg)	Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. factor	SHALWV Height (ft)	Basin Num. #
Existing Plan - 1 ft Criteria						
135.0	*					
157.5	13 15	1.02 1.06	3.00 4.00	0.59 0.66	1.73 1.56	4 4
180.0	13 15 17	1.11 1.10 1.09	5.00 3.00 3.00	0.47 0.76 0.79	2.37 1.45 1.38	4 7 4
202.5	11 13 15 17	1.05 1.08 1.02 1.10	4.00 4.00 6.00 4.00	0.64 0.70 0.47 0.78	1.64 1.55 2.04 1.41	5 4 4 4
225.0	9 13 15 17	1.09 1.01 1.03 1.04	4.00 6.00 8.00 7.00	0.76 0.58 0.47 0.57	1.45 1.74 2.20 1.81	9 9 7 7
247.5	9	1.11	7.00	0.89	1.25	4
270.0	*					
Existing Plan - 2 ft Criteria						
135.0	*					
157.5	*					
180.0	15 17	2.02 2.07	3.00 3.00	1.40 1.50	1.45 1.38	1 1
202.5	11 17	2.05 2.04	4.00 4.00	1.24 1.45	1.64 1.41	1 1
225.0	9	2.01	4.00	1.39	1.45	1
247.5	9	2.07	8.00	1.26	1.64	1
270.0*						

* Deepwater wave heights between 1-9 ft do not exceed HQUSACE criteria for this condition.

Table 46
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria*
(Deepwater Wave Conditions)

Direction (deg)	Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. factor	SHALWV Height (ft)	Basin Num. #
Proposed Plan 1 - 1 ft Criteria						
135.0	*					
157.5	*					
180.0	13	1.01	5.00	0.43	2.37	11
202.5	*					
225.0	13 15	1.08 1.03	7.00 8.00	0.53 0.47	2.04 2.20	6 8
247.5	*					
270.0*						
Proposed Plan 1 - 2 ft Criteria						
135.0	*					
157.5	*					
180.0	*					
202.5	*					
225.0	*					
247.5	*					
270.0	*					

* Deepwater wave heights between 1-9 ft do not exceed HQUSACE criteria for this condition.

Table 47
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria*
(Deepwater Wave Conditions)

Direction (deg)	Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. factor	SHALWV Height (ft)	Basin Num. #
Proposed Plan 2 - 1 ft Criteria						
135.0	*					
157.5	11	1.22	4.00	0.70	1.74	23
180.0	9	1.17	3.00	0.68	1.71	7
	11	1.47	3.00	0.91	1.62	7
	13	1.04	4.00	0.51	2.04	7
	20	1.03	5.00	0.56	1.84	8
202.5	9	1.04	5.00	0.51	2.04	23
	11	1.17	6.00	0.54	2.17	7
	13	1.18	4.00	0.80	1.48	7
	20	1.01	4.00	0.80	1.26	7
225.0	9	1.10	6.00	0.56	1.97	7
	11	1.08	7.00	0.50	2.17	7
247.5	*					
270.0	*					
Proposed Plan 2 - 2 ft Criteria						
135.0	*					
157.5	11	2.09	4.00	1.20	1.74	1
180.0	9	2.68	3.00	1.56	1.72	1
	11	2.35	3.00	1.45	1.62	1
	13	2.37	4.00	1.16	2.04	1
	17	2.05	5.00	0.94	2.18	1
	20	2.04	6.00	0.91	2.24	1
202.5	13	2.29	4.00	1.55	1.48	1
	20	2.07	5.00	1.51	1.37	1
225.0	9	2.03	7.00	0.87	2.34	1
	11	2.04	7.00	0.94	2.17	1
247.5	*					
270.0*						

* Deepwater wave heights between 1-9 ft do not exceed HQUSACE criteria for this condition.

Table 48
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria*
(Deepwater Wave Conditions)

Direction (deg)	Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. factor	SHALWV Height (ft)	Basin Num. #
Proposed Plan 3 - 1 ft Criteria						
135.0	*					
157.5	*					
180.0	*					
202.5	*					
225.0	*					
247.5	*					
270.0	*					
Proposed Plan 3 - 2 ft Criteria						
135.0	*					
157.5	*					
180.0	*					
202.5	*					
225.0	*					
247.5	*					
270.0	*					

* Deepwater wave heights between 1-9 ft do not exceed HQUSACE criteria for this condition.

Table 49
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria*
(Deepwater Wave Conditions)

Direction (deg)	Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. factor	SHALWV Height (ft)	Basin Num. #
Proposed Plan 1a - 1 ft Criteria						
135.0	*					
157.5	*					
180.0	11 13	1.13 1.13	5.00 5.00	0.45 0.48	2.51 2.37	11 7
202.5	9 13 15	1.11 1.03 1.13	6.00 6.00 8.00	0.48 0.48 0.42	2.29 2.17 2.68	8 7 11
225.0	9 11 13 15	1.01 1.10 1.19 1.12	4.00 6.00 8.00 8.00	0.70 0.60 0.51 0.51	1.45 1.83 2.34 2.20	8 11 11 11
247.5	9	1.02	8.00	0.62	1.64	6
270.0	*					
Proposed Plan 1a - 2 ft Criteria						
135.0	*					
157.5	*					
180.0	*					
202.5	9	2.03	6.00	0.89	2.29	1
225.0	9 11	2.19 2.11	7.00 7.00	0.94 0.97	2.34 2.17	1 1
247.5	*					
270.0	*					

* Deepwater wave heights tested do not exceed HQUSACE criteria for this condition.

Table 50
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria*
(Deepwater Wave Conditions)

Direction (deg)	Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. factor	SHALWV Height (ft)	Basin Num. #
Proposed Plan 1b - 1 ft Criteria						
135.0	*					
157.5	13	1.02	5.00	0.52	1.97	7
180.0	11	1.19	4.00	0.56	2.13	11
	13	1.11	4.00	0.55	2.04	7
202.5	9	1.01	4.00	0.60	1.69	11
	11	1.11	5.00	0.60	1.86	11
	13	1.18	6.00	0.55	2.17	7
	15	1.09	5.00	0.65	1.67	11
225.0	9	1.15	4.00	0.79	1.45	11
	11	1.04	4.00	0.77	1.35	11
	13	1.54	8.00	0.66	2.34	11
	15	1.09	6.00	0.66	1.64	11
247.5	9	1.02	8.00	0.62	1.64	6
	13	1.04	8.00	0.67	1.57	11
270.0	*					
Proposed Plan 1b - 2 ft Criteria						
135.0	*					
157.5	*					
180.0	*					
202.5	9	2.33	7.00	0.85	2.75	1
225.0	9	2.08	7.00	0.89	2.34	1
	11	2.21	7.00	1.02	2.17	1
247.5	*					
270.0	*					

* Deepwater wave heights tested do not exceed HQUSACE criteria for this condition.

Table 51
Percent Occurrence of Wave Heights Versus Direction*
Existing Plan - Wave Heights Exceeding 1 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
0.00-1.00	*	*	*	*	*	*	*	0.00
1.01-2.00	*	*	*	*	*	*	*	0.00
2.01-3.00	*	0.01	0.45	*	*	*	*	0.46
3.01-4.00	*	0.01	0.18	1.55	1.02	*	*	2.76
4.01-5.00	*	*	0.03	0.70	0.90	*	*	1.63
5.01-6.00	*	*	0.02	1.05	2.79	*	*	3.86
6.01-7.00	*	*	*	1.68	2.06	0.34	*	4.08
7.01-8.00	*	*	*	0.77	2.89	0.36	*	4.03
8.01-9.00	*	*	*	0.19	2.34	0.13	*	2.66
9.01 +	*	*	*	*	*	1.25	0.65	1.90
TOTAL	0.00	0.02	0.69	5.94	12.00	2.08	0.65	21.38

* *Percent occurrence is below significance for tabulation.*

Table 52
Percent Occurrence of Wave Heights Versus Direction*
Existing Plan - Wave Heights Exceeding 2 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
0.00-1.00	*	*	*	*	*	*	*	0.00
1.01-2.00	*	*	*	*	*	*	*	0.00
2.01-3.00	*	*	0.45	*	*	*	*	0.45
3.01-4.00	*	*	0.18	1.18	1.02	*	*	2.38
4.01-5.00	*	*	*	0.61	0.90	*	*	1.51
5.01-6.00	*	*	0.02	0.21	0.49	*	*	0.72
6.01-7.00	*	*	*	0.63	0.34	*	*	0.97
7.01-8.00	*	*	*	0.26	0.41	*	*	0.77
8.01-9.00	*	*	*	*	0.88	0.13	*	1.01
9.01 +	*	*	*	*	*	1.25	0.65	1.68
TOTAL	0.00	0.00	0.65	2.89	4.04	1.38	0.65	9.61

* Percent occurrence is below significance for tabulation.

Table 53
Percent Occurrence of Wave Heights Versus Direction*
Plan 1 - Wave Heights Exceeding 1 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
3.01-4.00	*	*	*	*	*	*	*	0.00
4.01-5.00	*	*	0.03	*	*	*	*	0.03
5.01-6.00	*	*	*	*	*	*	*	0.00
6.01-7.00	*	*	*	*	1.42	*	*	1.42
7.01-8.00	*	*	*	*	1.74	*	*	1.74
8.01-9.00	*	*	*	*	0.99	*	*	0.99
9.01+	*	*	*	*	*	1.25	0.65	1.90
TOTAL	0.00	0.00	0.03	0.00	4.15	1.25	0.65	6.08

* Percent occurrence is below significance for tabulation.

Table 54
Percent Occurrence of Wave Heights Versus Direction*
Plan 1 - Wave Heights Exceeding 2 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	*	*	*	*	*	*	*	0.00
3.01-4.00	*	*	*	*	*	*	*	0.00
4.01-5.00	*	*	*	*	*	*	*	0.00
5.01-6.00	*	*	*	*	*	*	*	0.00
6.01-7.00	*	*	*	*	*	*	*	0.00
7.01-8.00	*	*	*	*	*	*	*	0.00
8.01-9.00	*	*	*	*	*	*	*	0.00
9.01+	*	*	*	*	*	1.25	0.65	1.90
TOTAL	0.00	0.00	0.00	0.00	0.00	1.25	0.65	1.90

* Percent occurrence is below significance for tabulation.

Table 55
Percent Occurrence of Wave Heights Versus Direction*
Plan 2 - Wave Heights Exceeding 1 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	.	.	0.32	.	.	.	.	0.32
3.01-4.00	.	0.01	0.06	2.09	.	.	.	2.16
4.01-5.00	.	.	0.03	1.40	.	.	.	1.43
5.01-6.00	.	.	.	0.91	2.79	.	.	3.70
6.01-7.00	.	.	*	1.18	1.91	.	.	3.09
7.01-8.00	.	.	0.09	0.70	2.11	.	.	2.90
8.01-9.00	.	.	.	0.19	1.97	.	.	2.16
9.01+	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.01	0.50	6.47	8.78	1.25	0.65	17.66

* Percent occurrence is below significance for tabulation.

Table 56
Percent Occurrence of Wave Heights Versus Direction*
Plan 2 - Wave Heights Exceeding 2 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	.	.	0.32	.	.	.	.	0.32
3.01-4.00	.	0.01	0.06	2.09	.	.	.	2.16
4.01-5.00	.	.	0.03	1.26	.	.	.	1.29
5.01-6.00	.	.	.	0.66	.	.	.	0.66
6.01-7.00	.	.	*	1.04	0.50	.	.	1.54
7.01-8.00	.	.	0.09	0.51	1.09	.	.	1.69
8.01-9.00	.	.	.	0.19	1.52	.	.	1.71
9.01+	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.01	0.50	5.75	3.11	1.25	0.65	11.27

* Percent occurrence is below significance for tabulation.

Table 57
Percent Occurrence of Wave Heights Versus Direction*
Plan 3 - Wave Heights Exceeding 1 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	.	.	.	.	.	.	.	0.00
3.01-4.00	.	.	.	.	.	.	.	0.00
4.01-5.00	.	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	.	.	.	.	0.00
6.01-7.00	.	.	.	.	.	.	.	0.00
7.01-8.00	.	.	.	.	.	.	.	0.00
8.01-9.00	.	.	.	.	.	.	.	0.00
9.01 +	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.00	0.00	0.00	1.25	0.65	1.90

* Percent occurrence is below significance for tabulation.

Table 58
Percent Occurrence of Wave Heights Versus Direction*
Plan 3 - Wave Heights Exceeding 2 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	.	.	.	.	.	.	.	0.00
3.01-4.00	.	.	.	.	.	.	.	0.00
4.01-5.00	.	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	.	.	.	.	0.00
6.01-7.00	.	.	.	.	.	.	.	0.00
7.01-8.00	.	.	.	.	.	.	.	0.00
8.01-9.00	.	.	.	.	.	.	.	0.00
9.01 +	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.00	0.00	0.00	1.25	0.65	1.90

* Percent occurrence is below significance for tabulation.

Table 59
Percent Occurrence of Wave Heights Versus Direction*
Plan 1a - Wave Heights Exceeding 1 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
3.01-4.00	.	.	.	.	.	.	.	0.00
4.01-5.00	.	.	0.03	.	0.89	.	.	0.92
5.01-6.00	.	.	.	0.10	1.32	.	.	1.42
6.01-7.00	.	.	.	0.08	0.49	.	.	0.58
7.01-8.00	.	.	.	0.59	1.75	.	.	2.34
8.01-9.00	.	.	.	0.19	2.51	0.13	.	2.84
9.01+	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.03	0.97	6.97	1.38	0.65	10.00

* Percent occurrence is below significance for tabulation.

Table 60
*Percent Occurrence of Wave Heights Versus Direction**
Plan 1a - Wave Heights Exceeding 2 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	.	.	.	.	.	.	.	0.00
3.01-4.00	.	.	.	.	.	.	.	0.00
4.01-5.00	.	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	0.01	.	.	.	0.01
6.01-7.00	.	.	.	0.08	0.27	.	.	0.35
7.01-8.00	.	.	.	0.09	1.09	.	.	1.18
8.01-9.00	.	.	.	.	1.52	.	.	1.52
9.01+	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.00	0.19	2.88	1.25	0.65	4.96

* Percent occurrence is below significance for tabulation.

Table 61
Percent Occurrence of Wave Heights Versus Direction*
Plan 1b - Wave Heights Exceeding 1 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
3.01-4.00	.	.	0.02	.	0.88	.	.	0.90
4.01-5.00	.	.	0.03	1.15	2.53	.	.	3.71
5.01-6.00	.	.	.	0.90	2.36	.	.	3.26
6.01-7.00	.	.	.	1.12	1.64	.	.	2.77
7.01-8.00	.	.	.	0.59	2.83	0.07	.	3.50
8.01-9.00	.	.	.	0.19	2.51	0.14	.	2.85
9.01 +	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.05	3.96	12.76	1.47	0.65	18.89

* Percent occurrence is below significance for tabulation.

Table 62
Percent Occurrence of Wave Heights Versus Direction*
Plan 1b - Wave Heights Exceeding 2 ft

Wave Height ft	Wave Direction, deg (from which waves approach)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
2.01-3.00	.	.	.	.	.	.	.	0.00
3.01-4.00	.	.	.	.	.	.	.	0.00
4.01-5.00	.	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	.	.	.	.	0.00
6.01-7.00	.	.	.	0.07	0.20	.	.	0.27
7.01-8.00	.	.	.	0.09	1.09	.	.	1.18
8.01-9.00	.	.	.	.	1.52	.	.	1.52
9.01 +	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.00	0.16	2.81	1.25	0.65	4.87

* Percent occurrence is below significance for tabulation.

Table 63
Summary of Percent Occurrence of Wave Heights

Location	Percent of Time Criterion is Exceeded						
	HQUSACE Criterion	Existing	Plan 1	Plan 2	Plan 3	Plan 1a	Plan 1b
Berthing areas (1 ft criterion)	< 10.0	21.4	6.1	17.7	2.0	10.0	18.9
Entrance Channel (2 ft criterion)	< 10.0	9.6	2.0	11.3	2.0	5.0	4.9

Appendix A
Offshore Wave Climate Percent Occurrence Tables

Table A-1
Percent Occurrence of Height and Period by Direction
Wave Direction = 135.0 deg (from which waves approach)

Wave Height ft	Peak Period (sec)						
	9	11	13	15	17	20	Total
0.00-1.00	.	.	.	.	.	.	0.00
1.01-2.00	.	.	.	.	*	*	*
2.01-3.00	.	.	.	.	*	.	*
3.01-4.00	.	.	.	.	.	.	0.00
4.01-5.00	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	.	.	.	0.00
6.01-7.00	.	.	.	.	.	.	0.00
7.01-8.00	.	.	.	.	.	.	0.00
8.01-9.00	.	.	.	.	.	.	0.00
9.01 +	.	.	.	.	.	.	0.00
Total	0.00	0.00	0.00	0.00	*	*	0.01

* Percent occurrence is below table resolution.

Table A-2
Percent Occurrence of Height and Period by Direction
Wave Direction = 157.5 deg (from which waves approach)

Wave Height ft	Peak Period (sec)						
	9	11	13	15	17	20	Total
0.00-1.00	.	.	.	.	.	.	0.00
1.01-2.00	.	.	.	*	0.01	0.02	0.03
2.01-3.00	.	.	0.03	0.01	0.03	*	0.07
3.01-4.00	.	.	0.01	.	.	.	0.01
4.01-5.00	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	.	.	.	0.00
6.01-7.00	.	.	.	.	.	.	0.00
7.01-8.00	.	.	.	.	.	.	0.00
8.01-9.00	.	.	.	.	.	.	0.00
9.01 +	.	.	.	.	.	.	0.00
Total	0.00	0.00	0.04	0.01	0.04	0.02	0.11

* Percent occurrence is below table resolution.

Table A-3
Percent Occurrence of Height and Period by Direction
Wave Direction = 180.0 deg (from which waves approach)

Wave Height ft	Peak Period (sec) 9	11	13	15	17	20	Total
0.00-1.00	.	.	.	•	•	0.01	0.01
1.01-2.00	0.01	0.02	0.03	0.14	0.52	0.19	0.91
2.01-3.00	0.09	0.16	0.07	0.06	0.39	0.09	0.86
3.01-4.00	0.03	0.02	.	•	0.18	0.04	0.28
4.01-5.00	.	.	0.03	.	•	•	0.04
5.01-6.00	.	.	.	.	0.02	.	0.02
6.01-7.00	.	.	.	.	.	•	•
7.01-8.00	0.09	.	.	.	•	.	0.09
8.01-9.00	.	.	.	.	.	.	0.00
9.01+	.	.	.	.	.	.	0.00
Total	0.22	0.20	0.13	0.21	1.12	0.33	2.21

* Percent occurrence is below table resolution.

Table A-4
Percent Occurrence of Height and Period by Direction
Wave Direction = 202.5 deg (from which waves approach)

Wave Height ft	Peak Period (sec) 9	11	13	15	17	20	Total
2.01-3.00	1.18	0.66	0.51	1.70	0.90	0.39	5.34
3.01-4.00	0.47	0.07	0.37	2.09	1.12	0.14	4.26
4.01-5.00	0.15	.	0.10	1.25	0.61	0.17	2.28
5.01-6.00	0.07	.	0.18	0.66	0.21	•	1.13
6.01-7.00	0.08	.	.	1.04	0.63	0.06	1.81
7.01-8.00	0.09	.	.	0.50	0.26	0.11	0.96
8.01-9.00	.	.	.	0.19	.	.	0.19
9.01+	.	.	.	.	.	.	0.00
Total	2.32	0.80	1.53	9.25	4.76	1.30	19.96

* Percent occurrence is below table resolution.

Table A-5
Percent Occurrence of Height and Period by Direction
Wave Direction = 225.0 deg (from which waves approach)

Wave Height ft	Peak Period (sec)						
	9	11	13	15	17	20	Total
2.01-3.00	1.46	2.92	4.31	1.46	0.84	0.06	11.05
3.01-4.00	1.02	2.37	5.44	2.05	0.68	0.04	11.60
4.01-5.00	0.90	1.63	2.82	1.98	1.24	0.06	8.63
5.01-6.00	0.49	1.39	2.30	0.81	0.15	*	5.14
6.01-7.00	0.34	0.16	1.41	1.15	0.30	0.02	3.38
7.01-8.00	0.41	0.68	1.02	0.73	0.73	0.07	3.64
8.01-9.00	0.88	0.64	0.45	0.54	0.48	0.01	3.00
9.01+	.	.	.	.	.	.	0.00
Total	6.32	10.90	19.38	9.32	4.56	0.30	50.78

* Percent occurrence is below table resolution.

Table A-6
Percent Occurrence of Height and Period by Direction
Wave Direction = 247.5 deg (from which waves approach)

Wave Height ft	Peak Period (sec)						
	9	11	13	15	17	20	Total
2.01-3.00	0.73	2.22	0.78	0.31	0.08	0.04	4.16
3.01-4.00	0.64	1.87	0.69	0.51	0.08	0.02	3.81
4.01-5.00	0.35	1.22	0.38	0.31	0.01	0.01	2.28
5.01-6.00	0.55	0.68	0.06	0.17	0.05	0.01	1.52
6.01-7.00	0.34	0.41	.	0.18	0.03	*	0.96
7.01-8.00	0.36	0.28	0.17	*	0.01	.	0.83
8.01-9.00	0.13	0.07	0.01	.	.	.	0.21
9.01+	1.12	0.06	.	0.07	.	*	1.25
Total	4.40	7.52	2.43	1.63	0.29	0.10	16.37

* Percent occurrence is below table resolution.

Table A-7
Percent Occurrence of Height and Period by Direction
Wave Direction = 270.0 deg (from which waves approach)

Wave Height ft	Peak Period (sec)						
	9	11	13	15	17	20	Total
2.01-3.00	0.39	0.86	0.60	0.16	0.02	•	2.04
3.01-4.00	0.47	0.88	0.80	0.04	0.03	0.02	2.24
4.01-5.00	0.11	1.03	0.61	0.12	•	•	1.88
5.01-6.00	0.31	0.32	0.11	0.03	.	•	0.77
6.01-7.00	0.07	0.53	0.51	0.10	•	•	1.22
7.01-8.00	0.17	0.19	0.44	0.02	.	.	0.82
8.01-9.00	0.12	0.54	.	.	.	.	0.66
9.01 +	.	0.22	0.32	.09	.02	.	0.65
Total	1.66	4.72	3.48	0.57	0.09	0.04	10.56

* Percent occurrence is below table resolution.

Appendix B
Notation

a	Wave amplitude function
a_o	Incident wave amplitude
c	Wave celerity
c_g	Group celerity
g	Gravitational acceleration
H	Wave height
h	Water depth
i	imaginary unit = $(-1)^{1/2}$
K_r	Reflection coefficient
κ	Wave number = $2\pi/L$
L	Wavelength
n	Independent variable in the direction of the unit vector
s	Wave phase function
T	Wave period
x	Horizontal coordinate
y	Horizontal coordinate
α	Reflective component of absorbing boundary
β	Dimensionless bottom friction coefficient
γ	Phase difference between bottom friction and flow velocity
θ	Wave approach angle
λ	Complex bottom friction factor
π	3.14159..................
ω	Radian wave frequency, intrinsic wave frequency
ϕ	Velocity potential
∂	Partial differentiation
∇	Gradient operator in two dimensions = $(\partial/\partial x + \partial/\partial y)$

Draft Miscellaneous Paper CERC-94-xx
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Wave Response of Proposed Improvement Plan 6 to the Small Boat Harbor at Maalaea, Maui, Hawaii

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DRAFT

Prepared for U.S. Army Engineer Division, Pacific Ocean

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Preface

This study was authorized by the US Army Engineer Division, Pacific Ocean (POD), and was conducted by personnel of the Coastal Oceanography Branch (COB), Research Division (RD), Coastal Engineering Research Center (CERC), of the US Army Engineer Waterways Experiment Station (WES). The study was conducted during the period April through May 1994. Mr. Stanley Boc, POD, oversaw progress of the study.

This report was prepared by Dr. Edward F. Thompson, Hydraulic Engineer, COB; and Ms. Lori L. Hadley, Hydraulic Engineer, COB. The work was performed under the direct supervision of Dr. Martin C. Miller, Chief, COB, and Mr. H. Lee Butler, Chief, RD, and under the general supervision of Mr. Charles C. Calhoun, Jr., Assistant Director, CERC, and Dr. James R. Houston, Director, CERC.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors,
Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radian
feet	0.3048	meters
mile (US Statute)	1.6093	Kilometers
nautical mile	1.852	kilometers

1 Introduction

Background

At the request of the US Army Engineer Division, Pacific Ocean (POD), a numerical model wave response study of proposed improvement Plan 6 to Maalaea small boat harbor was conducted by the U.S. Army Engineer Waterways Experiment Station's (USAEWES) Coastal Engineering Research Center (CERC). The study was conducted as an extension of an earlier study to assess the wave response of various alternative modification plans for the harbor (Lillycrop et al. 1993). This report is focussed on the suggested alternative Plan 6 for modifying the existing harbor. Plan 6 was not considered in the earlier study. Information provided in the earlier report is referenced in this report but generally not repeated. Thus, for example, detailed descriptions of the existing harbor and the numerical model must be obtained from the report by Lillycrop et al. (1993).

Study Location

Maalaea small boat harbor is located on the southwest coast of the island of Maui, HI, the second largest island in the Hawaiian chain. The harbor is approximately 7 miles south of the County seat in Wailuku and approximately 8 miles south of the commercial and business center of Kahului (Figure 1).

Harbor space on Maui is much in demand. Maalaea small boat harbor contains 93 berths. Wave energy penetrates inside the harbor sufficiently often and with enough energy that the harbor is regarded as having a "surge" problem. A larger, more protected small boat harbor at Maalaea would help satisfy the demand for tranquil berthing space.

The shoreline of Maalaea Bay is part of an isthmus connecting two inactive volcanos which form west and east Maui. The shoreline is characterized by a long narrow coral-sand beach. The area is also known among surfers as the Maalaea Pipeline because of an infrequent, but world class breaking wave condition. Maalaea Harbor is located at the extreme west end of this beach. Several lesser surfing spots are also located near the harbor. There is concern that changes at Maalaea small boat harbor may impact nearby surfing areas.

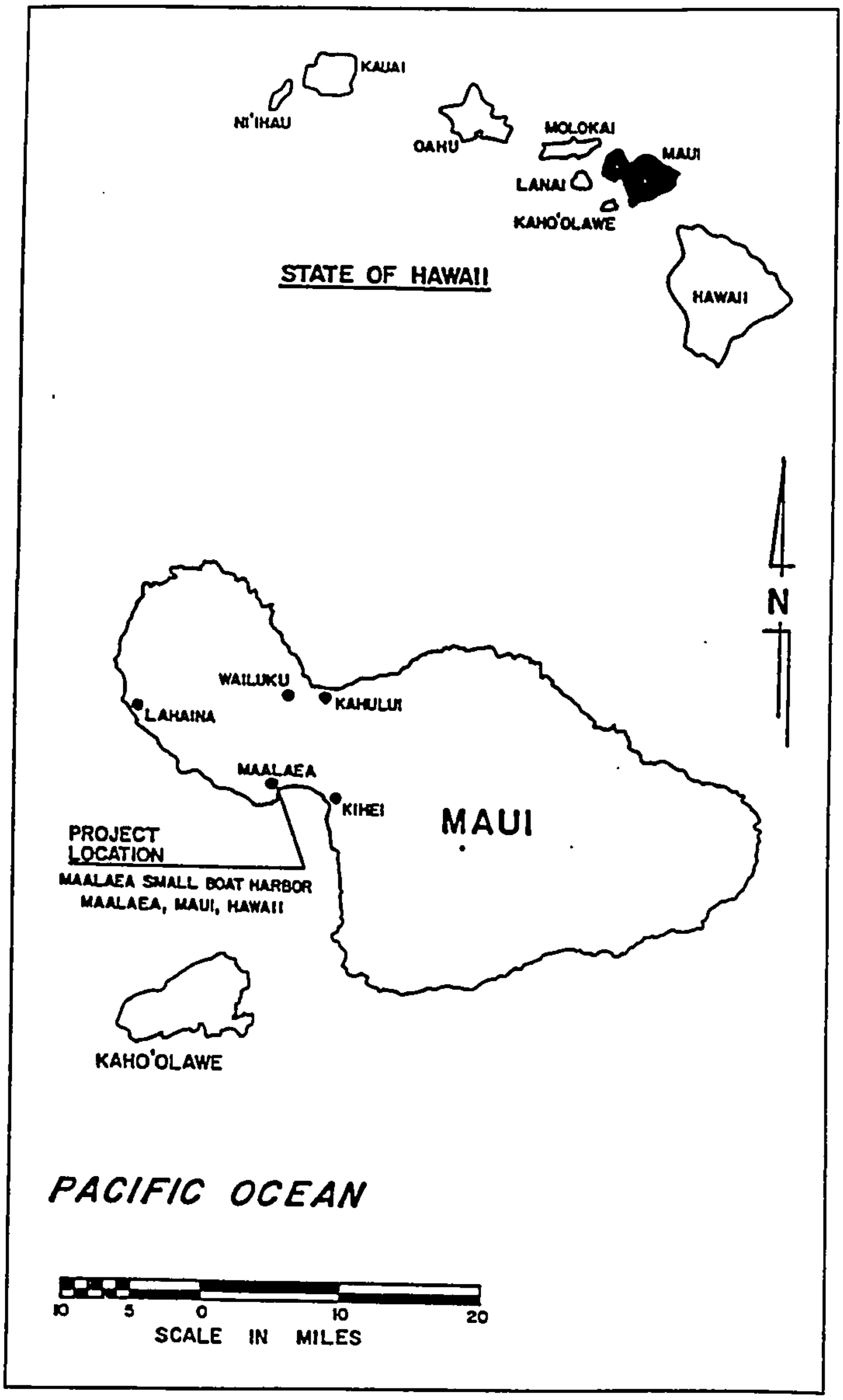

Figure 1. Study location

The existing harbor configuration is shown in Figure 2. Plan 6 (Figure 3) would provide a more protected harbor area without new structures *exterior* to the existing harbor. Its disadvantages include lack of needed new mooring space and a possibly difficult entrance channel section confined between two rock-faced structures. Plan 6 includes the following improvements:

a. Addition of a 95 ft wide, 500 ft long mole extending from the east end of the existing south breakwater into the harbor.

b. A 610 ft long entrance channel, varying in width from 150 to 200 ft, and varying in depth from 12 to 15 ft (not shown in Figure 3).

c. A 570 ft long interior revetment varying in width from 50 to 170 ft.

Study objectives of the Headquarters, US Army Corps of Engineers (HQUSACE) and POD were to test the proposed harbor design improvements against the criteria that wind wave and swell wave heights not exceed 1 ft in berthing areas and 2 ft in the entrance and access channels and turning basin more than approximately 10 percent of the time per year. Another objective was to assess the potential for harbor oscillations in Plan 6 relative to the existing harbor. To accomplish these objectives, the HARBD numerical harbor wave response model (Chen and Houston 1987) developed at CERC was used.

Modeling Approach

Both numerical and physical modeling were originally considered for study of alternative modifications to Maalaea small boat harbor. As discussed by Lillycrop et al. (1993), the numerical modeling approach was chosen to assess the variety of proposed alternatives. Assumptions inherent in the numerical modeling approach are as follows:

- no wave transmission or overtopping of structures,
- structure crest elevations will not be tested or optimized,
- no wave-wave or wave-current interaction,
- no wave breaking effects,
- diffraction around the structure ends is represented by diffraction around a blunt vertical wall with specified reflection coefficient,
- energy losses at constricted entrances are not explicitly included.

Within the limits of the assumptions, the numerical modeling approach can be expected to give a reasonable assessment of the proposed plans.

The procedures used to develop incident wind wave and swell information for the harbor response model are described by Lillycrop et al. (1993). The HARBD model and finite element grid used are briefly presented in Chapter 2. Results for wind waves and swell are given in Chapter 3. Harbor oscillation results for both the existing harbor and Plan 6 are given in Chapter 4. Conclusions are summarized in Chapter 5.

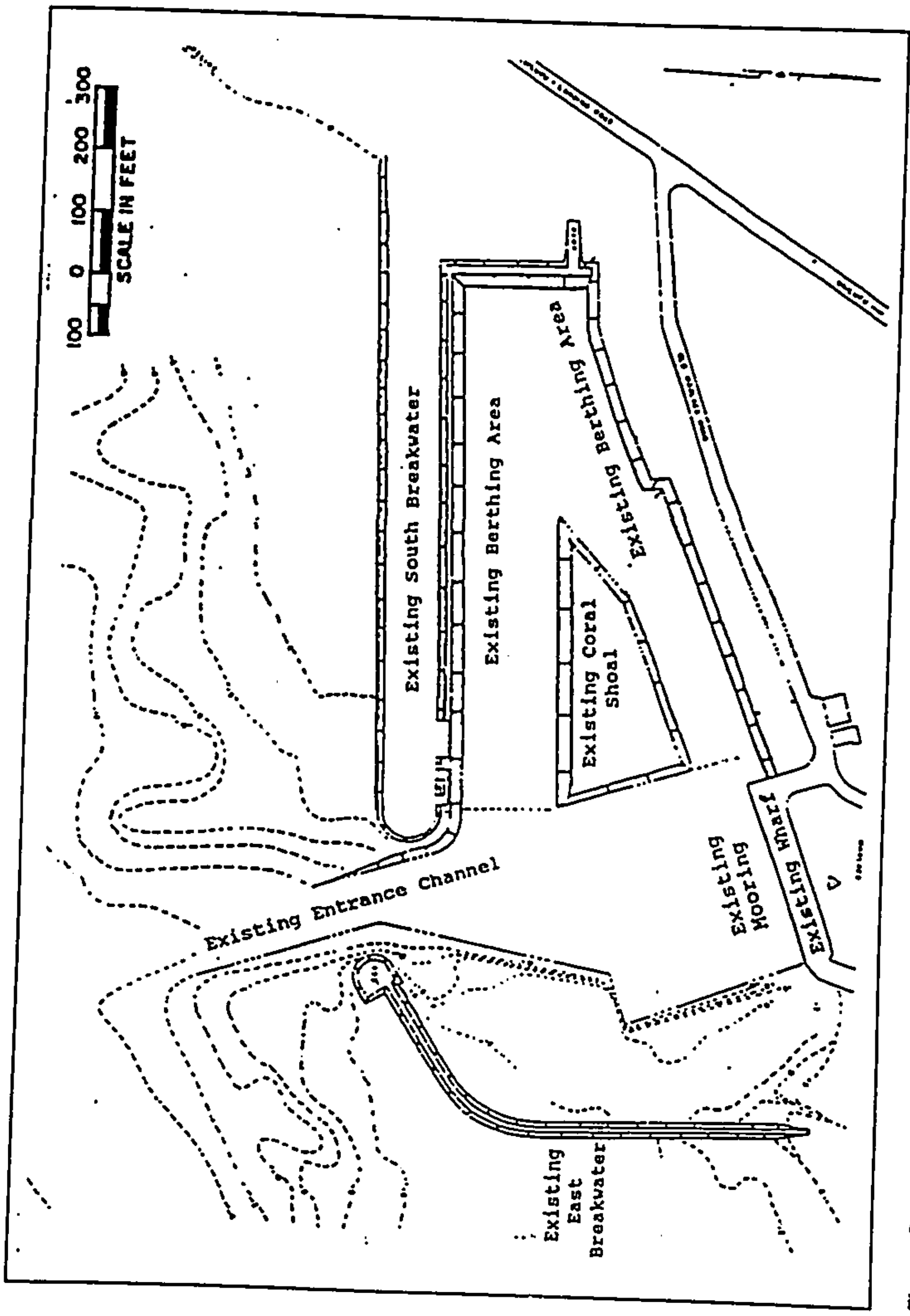

Figure 2. Existing plan

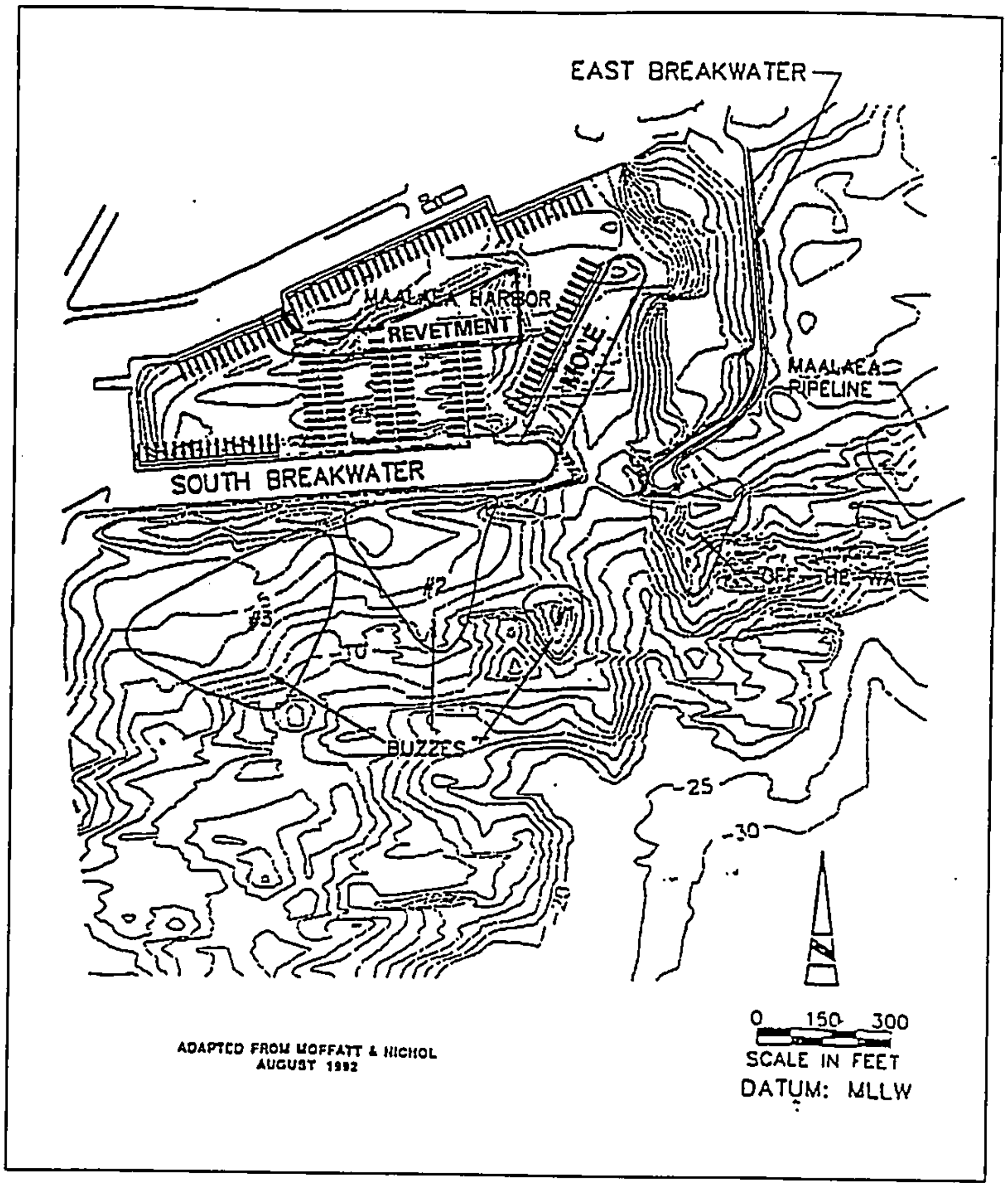

Figure 3. Proposed Plan 6

2 Numerical Model

The numerical model HARBD is a steady state hybrid element model (Chen and Houston 1987, Chen 1986, Lillycrop 1993). The model is described in the earlier report on Maalaea small boat harbor (Lillycrop et al. 1993). An overview of the model and its applications is also available in Thompson and Hadley (1994).

A finite element grid was developed to represent Plan 6 by modifying the grid used previously for the existing harbor (Figure 4). The new mole and interior revetted area were added and bathymetry was modified to give a 15-ft deep entrance channel. The channel depth transitions to 12 ft near the existing wharf. Grid characteristics are summarized in Table 1. The grid manipulation software was developed by Turner and Baptista (1993).

Table 1
Grid Size, Plan 6

Item	Size
Number of Elements	6747
Number of Nodes	3603
Number of Solid Boundary Nodes	353
Number of Semicircle Boundary Nodes	105
Length of Typical Element	20 ft

Reflection coefficients along solid boundaries are the same as those used previously for the existing harbor for the boundaries common to both plans. Reflection coefficients along the new boundaries introduced in Plan 6 were estimated as 0.5 along the new mole and 0.35 along the interior revetment (Figure 5). Other parameter values used in the model are summarized in Table 2.

Different parameters are used for the harbor oscillation tests. The reflection coefficient was set to 1.0 for all boundaries, since long waves

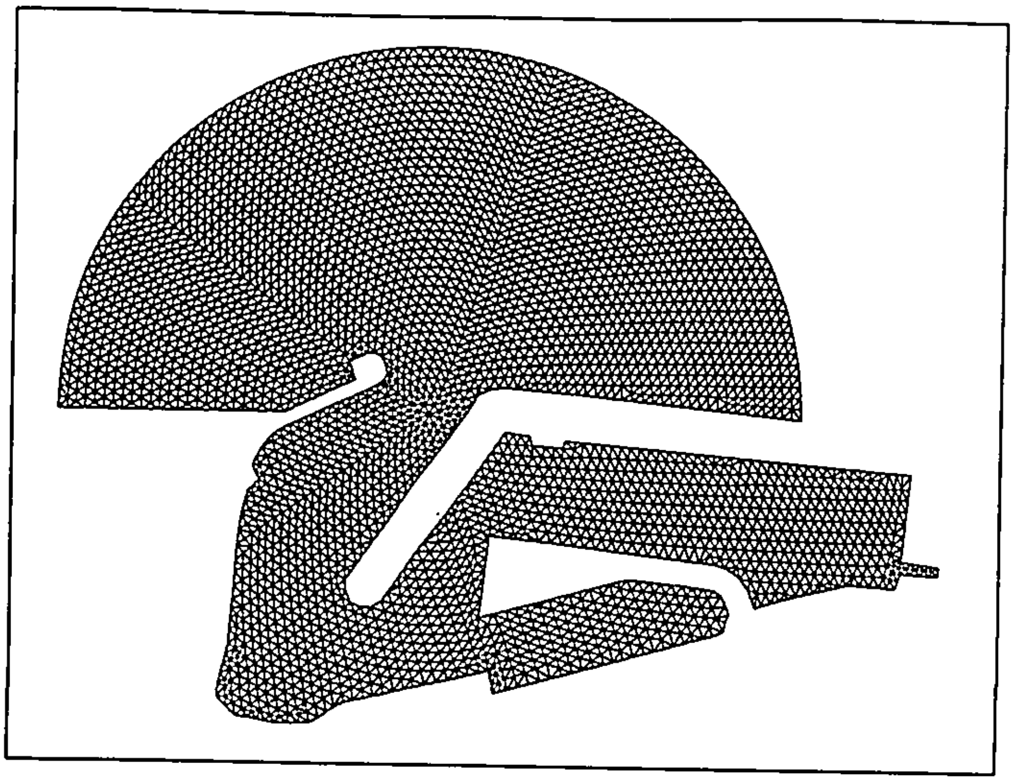

Figure 4. Finite element grid for Plan 6

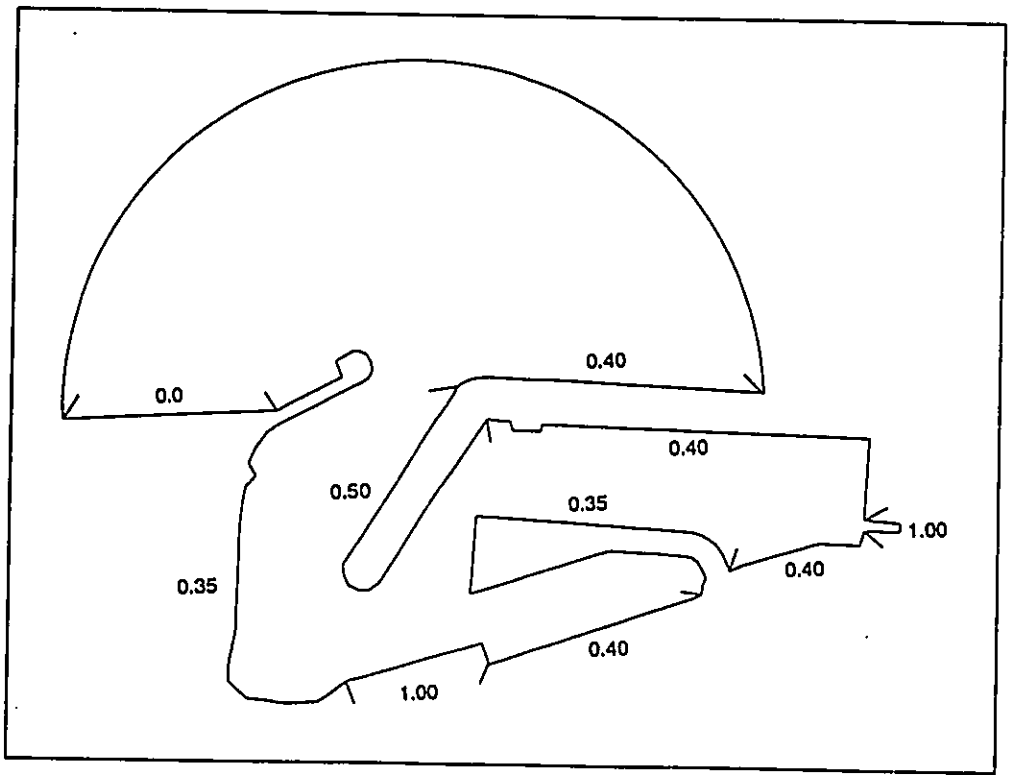

Figure 5. Boundary reflection coefficients for Plan 6

Table 2 Parameter Values Used in HARBD, Plan 6		
Parameter	Value	
	Wind Waves and Swell	Harbor Oscillations
Bottom friction, β	0.0	0.0
Coastline reflection, $K_{r,coast}$	0.1	1.0
Depth in infinite region, h_{inf}	25 ft	25 ft

generally reflect very well from a coastal boundary. Long waves are more affected by bottom friction than short waves, so a value of bottom friction β greater than zero is appropriate. However a default β of zero was used in these tests in which relative differences between the existing harbor and Plan 6 are the primary concern.

3 Harbor Response To Wind Waves and Swell

To establish the wave climate incident to Maalaea harbor, a total of 187 deepwater wave height, period, and direction combinations were input to the SHALWV model (Lillycrop et al. 1993). The SHALWV grid extended beyond the island of Kahoolawe. It allowed estimates of sheltering and shallow water effects on waves between the deepwater, open ocean south of Kahoolawe and the Maalaea harbor area. To determine wave heights in Maalaea harbor, the SHALWV wave heights near the harbor (in the vicinity of the seaward boundary of the HARBD grid) were multiplied with the HARBD amplification factors corresponding to each deepwater condition. The 187 wave height, period, and direction combinations were tested for Plan 6. All simulations were run on the WES CRAY Y-MP supercomputing facilities.

Output "basins" were selected for each plan tested to determine wave response throughout the harbor. A basin is a small cluster of elements over which the HARBD response is averaged to give a more representative output. Eighteen output basin locations were selected for Plan 6. The locations, selected by CERC and POD, are shown in Figure 6. Since the wave height criteria which must be satisfied are different for channel areas than for berthing areas, the basins are designated by area (Table 3). The HARBD amplification factors at these basins for each deepwater wave condition were saved and tabulated (Appendix A).

The percent occurrence of wave heights exceeding 1 ft in the berthing areas and 2 ft in the entrance and access channels and turning basin were calculated for Plan 6. The procedure is identical to that used by Lillycrop et al. (1993).

Table 3
Designation of Output Basin Areas, Plan 6

Area	Basin Numbers
Channel	1-6
Berthing	7-18

Table 4 is a tabulation of the HARBD-SHALWV wave heights initially exceeding the HQUSACE criteria for each deepwater wave direction. The table shows that wave heights

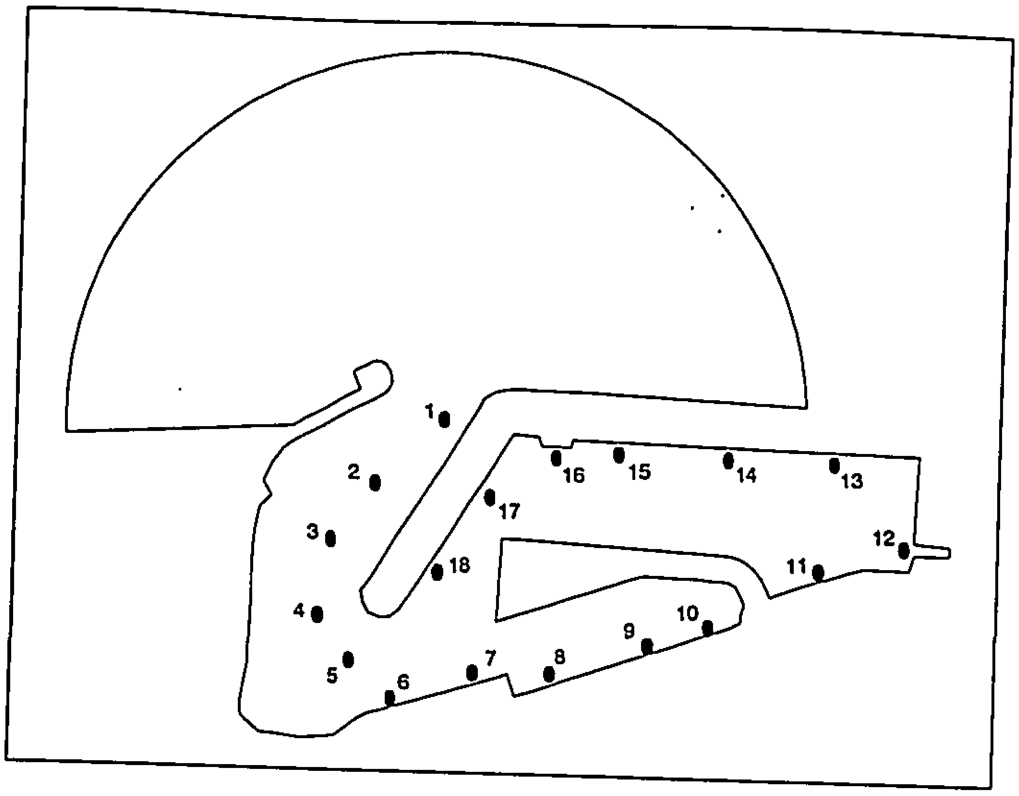

Figure 6. Output basin locations for Plan 6

initially exceeding the maximum 1-ft criterion in berthing areas (basins 7 through 18) did not occur for deepwater incident wave heights of less than 9 ft. Wave heights exceeding the 2 ft maximum criterion in the entrance channel (basins 1-6) resulted from 9-, 13-, and 15-sec waves from 225-deg direction and 17-sec waves from 180-deg direction. These waves occurred at the harbor entrance in basin 1.

The percent occurrence of wave heights exceeding the maximum 1-ft and 2-ft criteria was calculated using the percent occurrence tables of deepwater conditions and HARBD-SHALWV wave height results. These results are given in Tables 5 and 6 and illustrated in Figure 7. Although wave breaking was not taken into account in the tables, the higher wave heights may break over the reef, thus reducing wave heights in the harbor. In evaluating the percent occurrence results, it is apparent that waves approaching from the southeast (135.0 and 157.0 deg) directions are insignificant in comparison to waves approaching from south to west (180.0 to 270.0 deg) directions.

The percentage of wave heights exceeding the maximum 1-ft and 2-ft criteria for the Existing and Plans 1, 2, 3, 1a, 1b, and 6 are summarized in Table 7 along with the HQUSACE criteria. These values are somewhat conservative since they represent basins with the largest wave heights occurring in the harbor for each deepwater wave condition. Plan 6 satisfies the HQUSACE criteria for providing adequate protection in the channel and berthing areas.

Table 4
HARBD-SHALWV Wave Heights Exceeding HQUSACE Criteria, Plan 6

Deepwater Direction (deg az.)	Deepwater Period (sec)	Height (ft)	Deepwater Height (ft)	HARBD Amp. Factor	SHALWV Height (ft)	Basin Number
1-ft Criterion						
135.0	*					
157.5	*					
180.0	*					
202.5	*					
225.0	*					
247.5	*					
270.0	*					
2-ft Criterion						
135.0	*					
157.5	*					
180.0	17	2.04	3.8	1.22	1.68	1
202.5	*					
225.0	9 13 15	2.01 2.31 2.02	4.7 7.0 6.9	1.27 1.13 1.07	1.58 2.04 1.89	1 1 1
247.5	*					
270.0	*					

* Deepwater wave heights between 1-9 ft do not exceed HQUSACE criteria for this condition.

Although Plan 6 is acceptable relative to the usual protection criteria, it may result in unusually hazardous navigation conditions in the confined portion of the channel located between the east breakwater and the proposed new mole. Table 7 indicates the liklihood of encountering wave heights in the channel which exceed the HQUSACE threshold criterion. More detailed information about the distribution of wave height conditions above the threshold in Plan 6 is given in Figure 8. For example, the figure indicates that one percent of the time wave heights at some point in the channel will exceed about 3.3 ft. These conditions are characteristic of output basin 1. More protected areas would generally experience lower wave conditions.

Table 5
Percent Occurrence of Wave Height Versus Direction, Plan 6 - Wave Heights Exceeding 1 ft in Berthing Areas

Deepwater Wave Height ft	Deepwater Wave Direction (deg azimuth)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
3.01-4.00	.	.	.	.	.	.	.	0.00
4.01-5.00	.	.	.	.	.	.	.	0.00
5.01-6.00	.	.	.	.	.	.	.	0.00
6.01-7.00	.	.	.	.	.	.	.	0.00
7.01-8.00	.	.	.	.	.	.	.	0.00
8.01-9.00	.	.	.	.	.	.	.	0.00
9.01+	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.00	0.00	0.00	1.25	0.65	1.90

Table 6
Percent Occurrence of Wave Height Versus Direction, Plan 6 - Wave Heights Exceeding 2 ft in Channel

Deepwater Wave Height ft	Deepwater Wave Direction (deg azimuth)							
	135.0	157.5	180.0	202.5	225.0	247.5	270.0	Total
3.01-4.00	.	.	0.05	.	.	.	.	0.05
4.01-5.00	.	.	.	.	0.36	.	.	0.36
5.01-6.00	.	.	0.02	.	0.49	.	.	0.51
6.01-7.00	.	.	.	.	0.57	.	.	0.57
7.01-8.00	.	.	0.01	.	2.25	.	.	2.26
8.01-9.00	.	.	.	.	1.88	.	.	1.88
9.01+	.	.	.	.	.	1.25	0.65	1.90
TOTAL	0.00	0.00	0.08	0.00	5.54	1.25	0.65	7.52

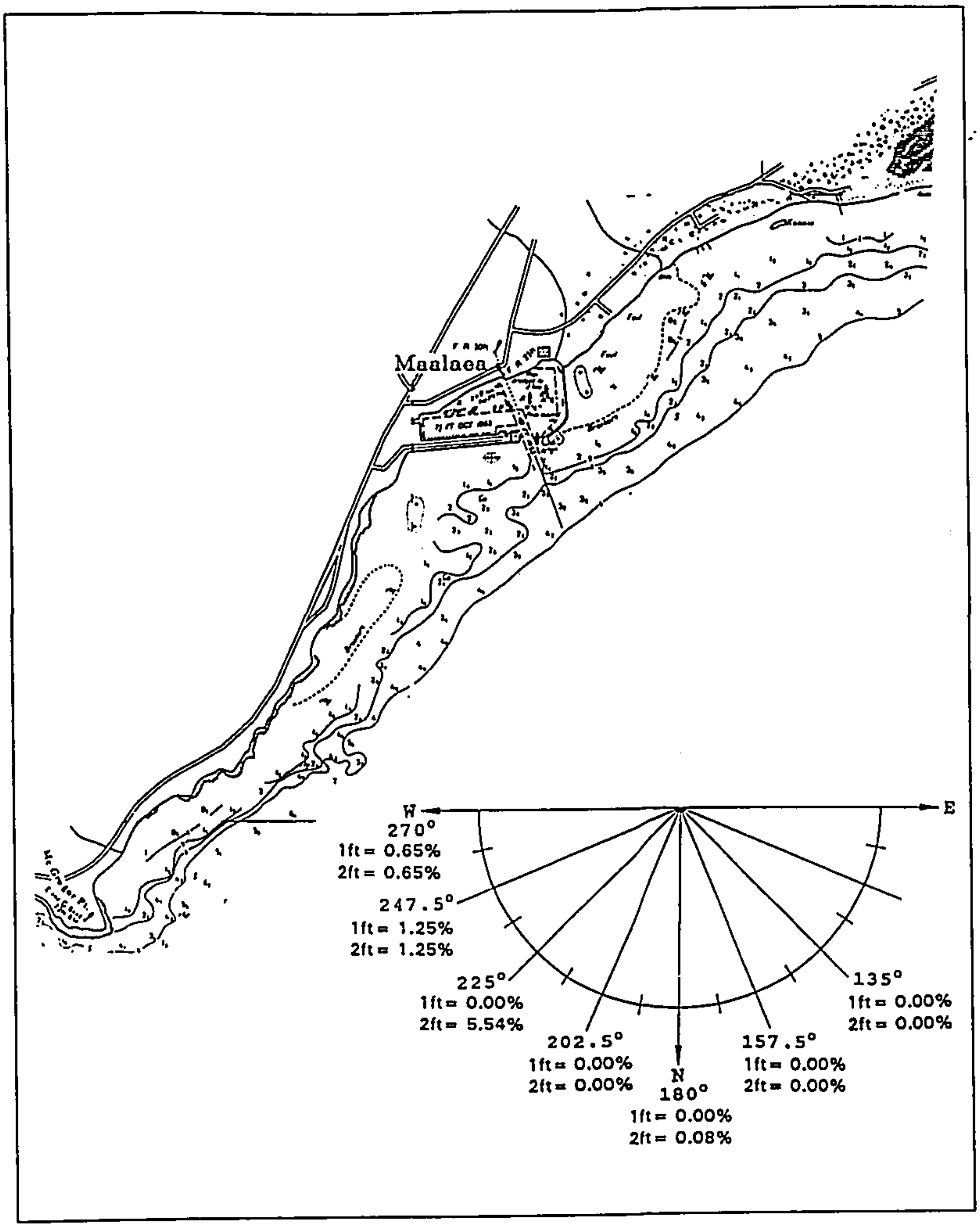

Figure 7. Percent occurrence of wave heights exceeding HQUSACE criteria, Plan 6

Table 7
Summary of Percent Occurrence of Wave Heights

Location	Percent of Time Criterion is Exceeded							
	HQUSACE Criterion	Existing	Plan 1	Plan 2	Plan 3	Plan 1a	Plan 1b	Plan 6
Berthing areas (1 ft criterion)	< 10.0	21.4	6.1	17.7	2.0	10.0	18.9	1.9
Entrance Channel (2 ft criterion)	< 10.0	9.6	2.0	11.3	2.0	5.0	4.9	7.5

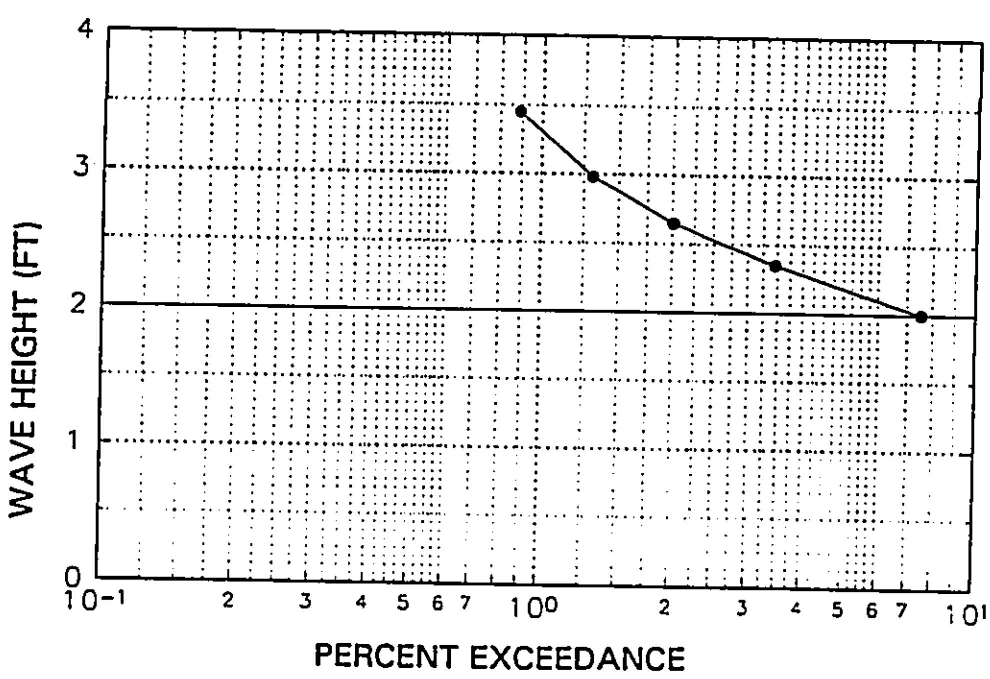

Figure 8. Cumulative distribution of wave heights exceeding HQUSACE criterion in channel, Plan 6

4 Harbor Oscillations

The HARBD numerical model was run for both Plan 6 and the existing plan to investigate the harbor response to wave periods characteristic of harbor oscillations. These tests were included because the "surge" problem reported in the existing harbor may arise in part from a resonant response to long period wave energy impacting the harbor. Harbor oscillations were not considered in the earlier study by Lillycrop et al. (1993).

Incident long wave conditions consisted of wave periods ranging from 20 sec to 180 sec approaching the harbor from directly offshore (central approach direction relative to the HARBD seaward boundary). The increment between successive periods tested, based on frequency, was 0.00020 Hz for the shorter periods to 0.00007 Hz for most of the longer periods.

Amplification factors for Plan 6 and the existing harbor plan are shown by basin in Appendix B. It is important to note that the basin numbers in Appendix B for the existing harbor match the locations shown in Figure 6. Coincident basin locations for the existing harbor and Plan 6 allowed a more straighforward comparison of oscillation characteristics of the two harbor configurations.

Relative to harbor oscillations, the principal difference between Plan 6 and the existing harbor appears to be the addition of new "corner" areas in Plan 6. The corner just west of basin 10 and the corner between basins 16 and 17 both appear to act as antinodes for a number of different resonant oscillation modes, as evidenced by the high amplification factor peaks in Appendix B. Both of these potentially troublesome areas may be desired for berthing facilities. Basin 12, which is an active antinode in the existing harbor, appears to be comparably active in Plan 6, though the resonant frequencies are different.

The amplification factors shown in Appendix B should be viewed as conservatively high for several reasons. Wave reflection coefficient at all solid boundaries was taken as 1.0. Energy losses through a constricted entrance are not explicitly included in the HARBD model (Thompson et al. 1993). Finally, the east breakwater is represented as a solid barrier; but for harbor oscillation wave periods, significant energy may be transmitted through it.

5 Conclusions

The numerical model studies and results described in this report should be seen in light of the following considerations:

a. Deepwater wave estimates are based on measurements in the Monitoring of Completed Coastal Projects program collected at Barbers Point, Oahu. Availability of incident wave data at the Maalaea Harbor vicinity would significantly improve the validity of the overall results.

b. Reflection coefficients were estimated as described by Lillycrop et al. (1993). Research in this area continues at CERC for better guidance.

c. The following assumptions were made in the implementation of the HARBD numerical model used in this study. The model does not consider wave transmission through the breakwater, overtopping of structures, and wave breaking effects in the entrance channel; structure crest elevations were not tested or optimized; currents and nonlinear effects were neglected; and diffraction around the structure ends was represented by diffraction around a blunt vertical wall with specified reflection coefficients. If wave transmission through the breakwater and overtopping of structures did occur in the harbor, the increased energy could result in larger wave heights than predicted. The presence of wave currents and breaking would increase hazardous navigation, however wave breaking would reduce the energy in the harbor and result in lower wave heights than predicted. The primary effects which must be considered within a harbor such as Maalaea are wave refraction, diffraction, and dissipation effects for which the model has been well verified.

d. Energy losses for long period (harbor oscillation) waves passing through a constricted entrance were not explicitly modeled.

e. The HARBD model uses monochromatic waves only.

Based on the results of this study, the following conclusions were reached:

a. Plan 6 is satisfactory in providing the harbor with adequate protection from the incident wind wave and swell climate.

b. Navigation during high wave conditions is potentially more hazardous in Plan 6 relative to other plans because much of the entrance channel is confined between two rock-faced structures.

c. Plan 6 can potentially lead to a significant increase in the amplitude of harbor oscillations by:

- creating more confined corners (which can act as antinodes) in desired berthing areas

- creating a new solid, impermeable eastern boundary for the harbor basin. In the existing harbor, the permeable east breakwater serves as the eastern boundary of the harbor basin.

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Appendix A
HARBD Wave Amplification Factors, Wind Waves and Swell

Table A1
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 135.0 deg

Basin	Deepwater Wave Period, sec					
	9	11	13	15	17	20
1	1.30	0.94	0.51	1.26	0.15	1.07
2	0.98	0.65	0.45	0.71	0.12	0.63
3	0.60	0.35	0.35	0.43	0.07	0.55
4	0.56	0.47	0.22	0.30	0.04	0.23
5	0.34	0.38	0.18	0.14	0.01	0.07
6	0.28	0.22	0.15	0.17	0.01	0.11
7	0.09	0.12	0.16	0.19	0.02	0.01
8	0.10	0.05	0.07	0.10	0.01	0.02
9	0.04	0.04	0.05	0.07	0.01	0.01
10	0.02	0.03	0.03	0.04	*	0.01
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	*	0.01	0.01	*	0.01
14	0.01	0.01	0.02	0.01	*	0.01
15	0.01	0.02	0.02	0.02	*	0.01
16	0.01	0.02	0.03	0.02	*	0.02
17	0.08	0.07	0.12	0.11	0.01	0.04
18	0.08	0.07	0.12	0.11	0.01	0.04

* Wave amplification factor is below significance for tabulation.

Table A2
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 157.5 deg

Basin	Deepwater Wave Period, sec					
	9	11	13	15	17	20
1	0.27	1.06	0.44	1.35	0.76	1.00
2	0.50	0.68	0.40	0.68	0.43	0.57
3	0.25	0.37	0.33	0.44	0.28	0.40
4	0.24	0.52	0.20	0.30	0.18	0.21
5	0.16	0.40	0.16	0.16	0.06	0.04
6	0.13	0.25	0.12	0.18	0.07	0.05
7	0.03	0.14	0.13	0.19	0.11	0.07
8	0.04	0.06	0.06	0.10	0.06	0.05
9	0.02	0.04	0.04	0.06	0.04	0.02
10	0.01	0.03	0.03	0.04	0.02	0.01
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	0.01	0.01	0.01	*	*
14	*	0.02	0.01	0.01	*	0.01
15	*	0.03	0.02	0.02	*	0.01
16	0.01	0.04	0.03	0.03	*	0.01
17	0.04	0.09	0.10	0.12	0.04	0.03
18	0.04	0.09	0.10	0.12	0.04	0.03

* Wave amplification factor is below significance for tabulation.

Table A3
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 180.0 deg

Basin	Deepwater Wave Period, sec					
	9	11	13	15	17	20
1	0.36	0.42	0.14	1.02	1.22	0.20
2	0.11	0.30	0.15	0.53	0.60	0.12
3	0.08	0.22	0.10	0.37	0.39	0.08
4	0.08	0.18	0.08	0.25	0.28	0.04
5	0.06	0.14	0.06	0.16	0.13	0.01
6	0.03	0.09	0.05	0.16	0.15	0.01
7	0.01	0.07	0.05	0.17	0.18	0.02
8	0.01	0.03	0.03	0.08	0.10	0.01
9	0.01	0.02	0.02	0.05	0.06	0.01
10	*	0.01	0.01	0.03	0.03	*
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	*	*	0.01	0.01	*
14	*	0.01	0.01	0.01	0.01	*
15	*	0.01	0.01	0.02	0.02	*
16	*	0.02	0.01	0.03	0.02	*
17	0.01	0.04	0.04	0.11	0.10	0.01
18	0.01	0.04	0.04	0.11	0.10	0.01

* Wave amplification factor is below significance for tabulation.

Table A4
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 202.5 deg

Basin	Deepwater Wave Period, sec					
	9	11	13	15	17	20
1	0.35	0.68	0.61	0.60	1.12	0.32
2	0.15	0.48	0.27	0.39	0.48	0.21
3	0.06	0.41	0.23	0.25	0.33	0.13
4	0.08	0.36	0.09	0.18	0.23	0.08
5	0.08	0.28	0.04	0.13	0.11	0.02
6	0.06	0.18	0.03	0.13	0.13	0.01
7	0.03	0.17	0.04	0.13	0.15	0.03
8	0.01	0.08	0.02	0.06	0.08	0.02
9	0.01	0.05	0.01	0.04	0.05	0.01
10	0.01	0.03	0.01	0.02	0.03	0.01
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	0.01	*	0.01	*	*
14	*	0.02	*	0.01	0.01	*
15	*	0.03	0.01	0.02	0.01	*
16	0.01	0.04	0.01	0.02	0.02	*
17	0.02	0.11	0.03	0.09	0.08	0.01
18	0.02	0.11	0.03	0.09	0.08	0.01

* Wave amplification factor is below significance for tabulation.

Table A5
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 225.0 deg

Basin	Deepwater Wave Period, sec					
	9	11	13	15	17	20
1	1.27	0.72	0.89	1.07	0.95	0.91
2	0.27	0.27	0.44	0.42	0.44	0.47
3	0.23	0.27	0.41	0.39	0.29	0.42
4	0.35	0.23	0.21	0.20	0.21	0.18
5	0.30	0.19	0.15	0.14	0.10	0.05
6	0.19	0.12	0.13	0.12	0.11	0.08
7	0.05	0.12	0.14	0.13	0.13	0.01
8	0.03	0.05	0.07	0.06	0.07	0.01
9	0.03	0.03	0.04	0.04	0.04	0.01
10	0.02	0.02	0.03	0.03	0.03	*
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	0.01	0.01	0.01	*	*
14	*	0.01	0.01	0.01	0.01	0.01
15	0.01	0.02	0.02	0.02	0.01	0.01
16	0.01	0.03	0.03	0.02	0.01	0.01
17	0.04	0.07	0.10	0.09	0.07	0.03
18	0.04	0.07	0.10	0.09	0.07	0.03

* Wave amplification factor is below significance for tabulation.

Table A6
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 247.5 deg

Basin	Deepwater Wave Period, sec					
	9	11	13	15	17	20
1	1.02	0.70	1.15	0.76	0.81	0.96
2	0.42	0.45	0.46	0.37	0.40	0.51
3	0.26	0.39	0.42	0.25	0.26	0.45
4	0.39	0.26	0.22	0.18	0.15	0.19
5	0.31	0.21	0.16	0.08	0.03	0.05
6	0.18	0.15	0.14	0.10	0.02	0.09
7	0.09	0.16	0.15	0.11	0.07	0.01
8	0.04	0.08	0.07	0.06	0.05	0.01
9	0.03	0.05	0.05	0.04	0.02	0.01
10	0.02	0.03	0.03	0.02	0.01	*
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	0.01	0.01	*	*	*
14	0.01	0.02	0.01	0.01	*	0.01
15	0.01	0.03	0.02	0.01	*	0.01
16	0.01	0.04	0.03	0.01	*	0.01
17	0.05	0.11	0.10	0.06	0.02	0.03
18	0.05	0.11	0.10	0.06	0.02	0.03

* Wave amplification factor is below significance for tabulation.

Table A7
HARBD Wave Amplification Factors
Plan 6, Deepwater Wave Direction = 270.0 deg

	Deepwater Wave Period, sec					
Basin	9	11	13	15	17	20
1	1.07	0.88	1.15	0.76	0.81	0.96
2	0.42	0.49	0.46	0.37	0.40	0.52
3	0.26	0.44	0.42	0.25	0.26	0.46
4	0.29	0.28	0.22	0.18	0.15	0.19
5	0.22	0.24	0.16	0.08	0.03	0.05
6	0.18	0.18	0.13	0.10	0.02	0.09
7	0.08	0.19	0.15	0.11	0.07	0.01
8	0.04	0.09	0.07	0.06	0.05	0.01
9	0.03	0.06	0.05	0.04	0.02	0.01
10	0.02	0.04	0.03	0.02	0.01	*
11	*	*	*	*	*	*
12	*	*	*	*	*	*
13	*	0.01	0.01	*	*	*
14	0.01	0.02	0.01	0.01	*	0.01
15	0.01	0.03	0.02	0.01	*	0.01
16	0.01	0.04	0.03	0.01	*	0.01
17	0.05	0.14	0.10	0.06	0.02	0.03
18	0.05	0.14	0.10	0.06	0.02	0.03

* Wave amplification factor is below significance for tabulation.

Appendix B
HARBD Wave Amplification Factors, Harbor Oscillations

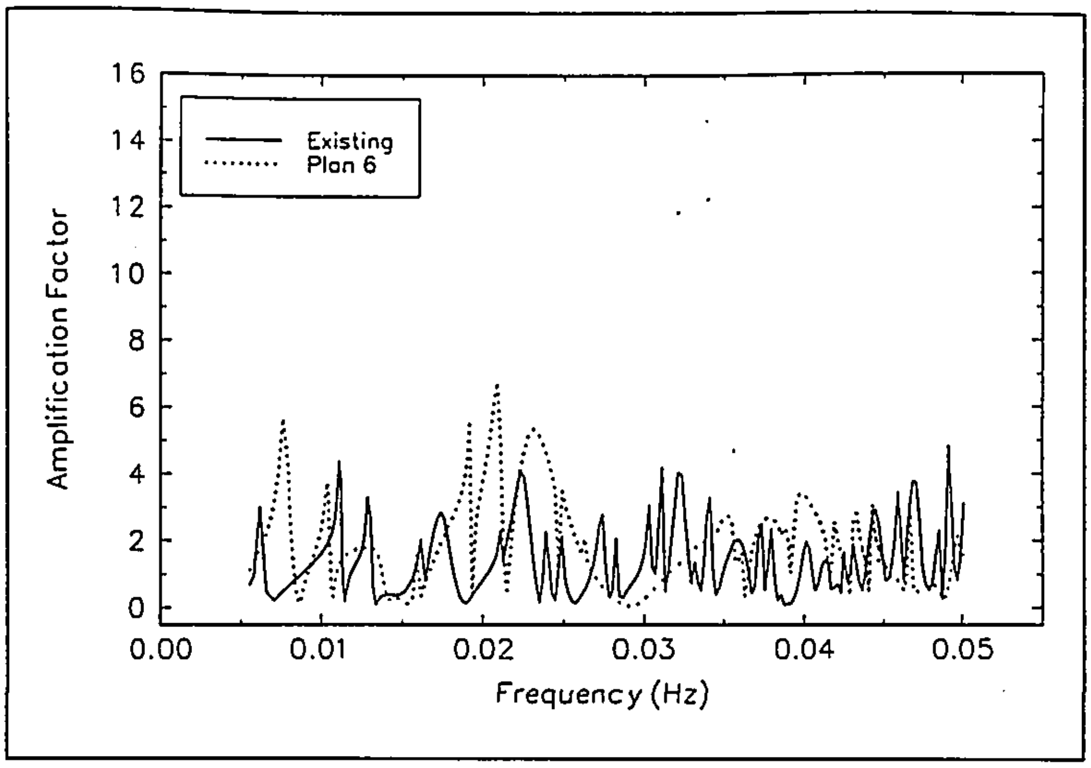

Figure B1. Wave amplification factor, basin 1

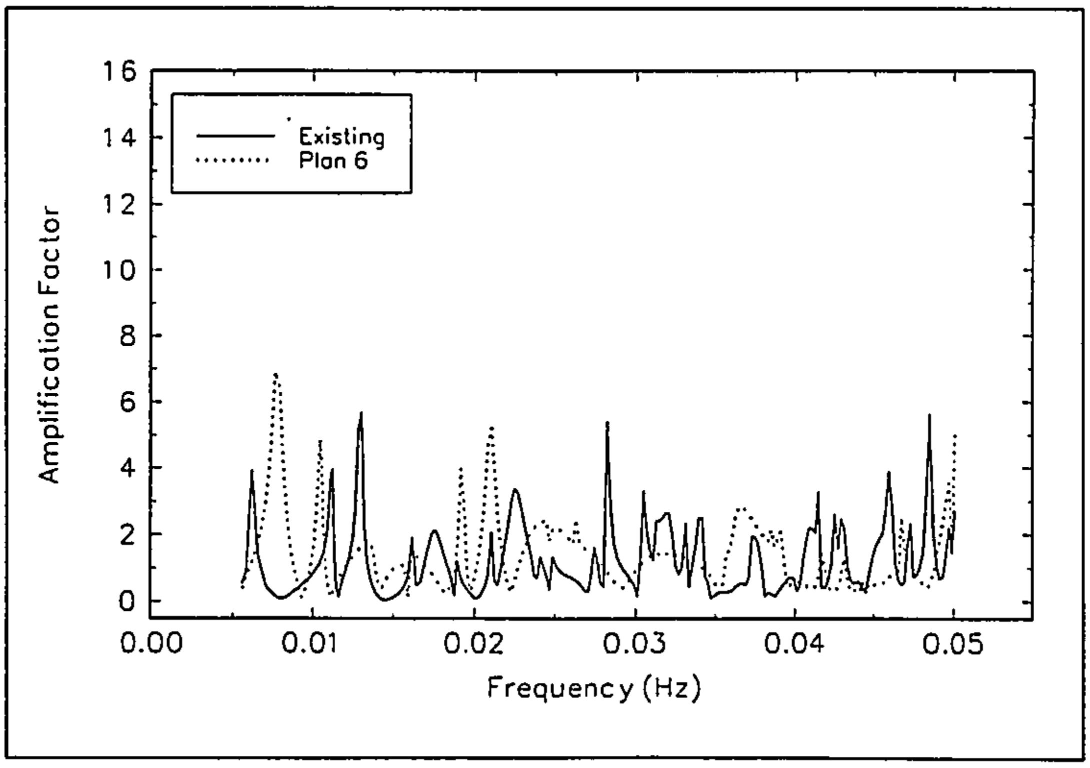

Figure B2. Wave amplification factor, basin 2

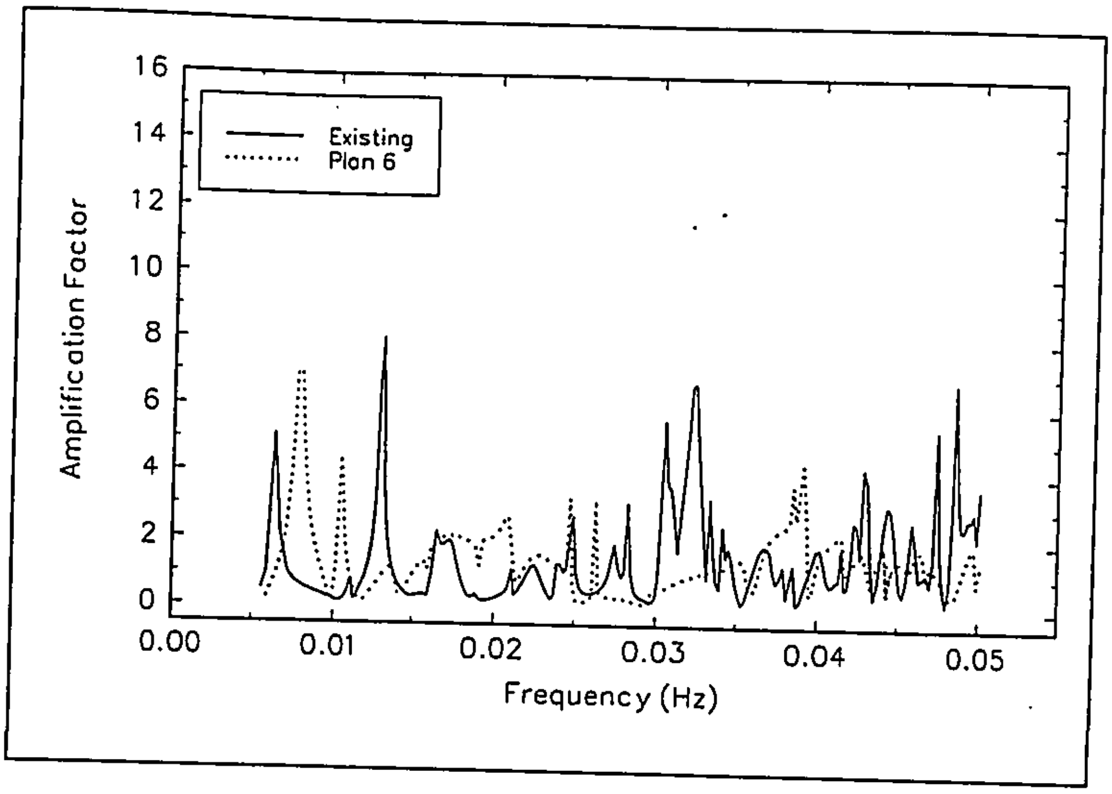

Figure B3. Wave amplification factor, basin 3

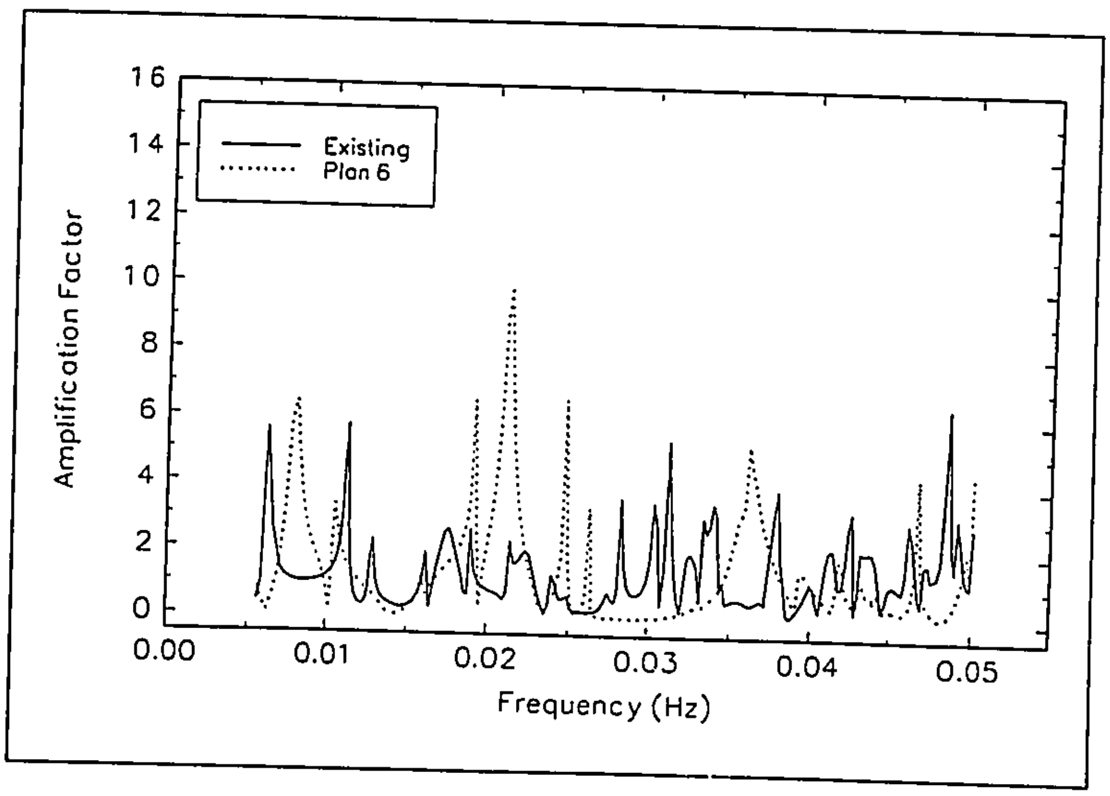

Figure B4. Wave amplification factor, basin 4

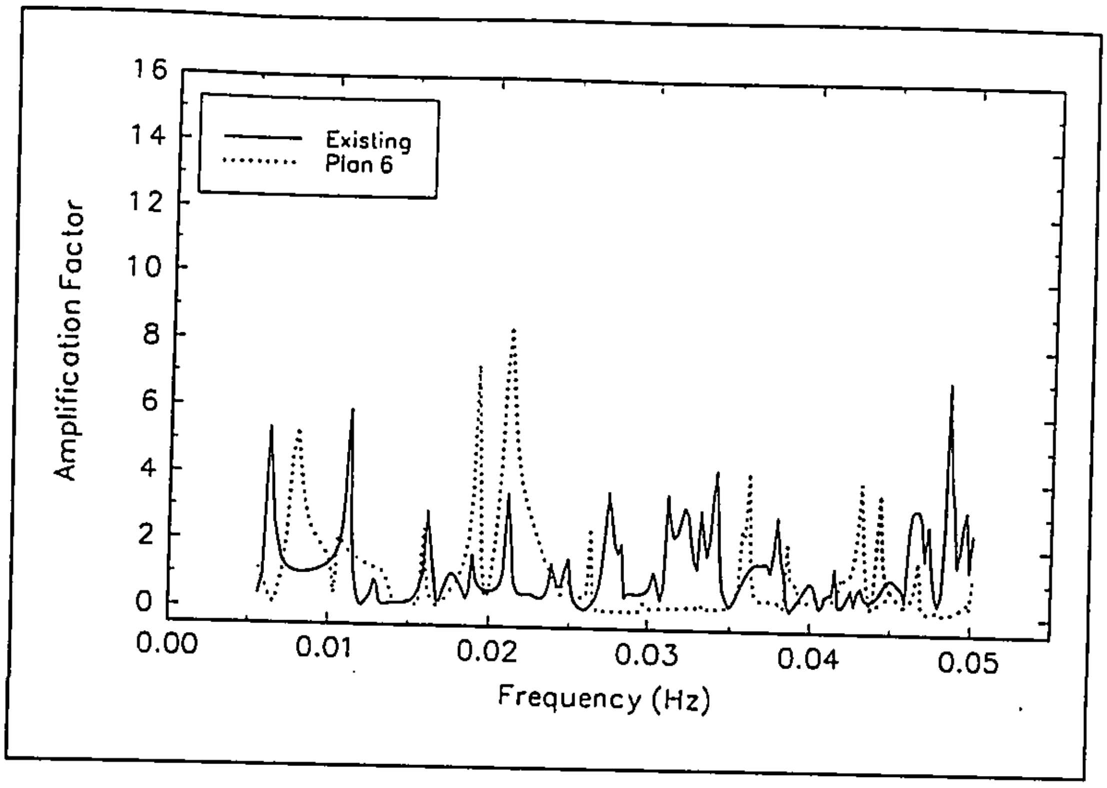

Figure B5. Wave amplification factor, basin 5

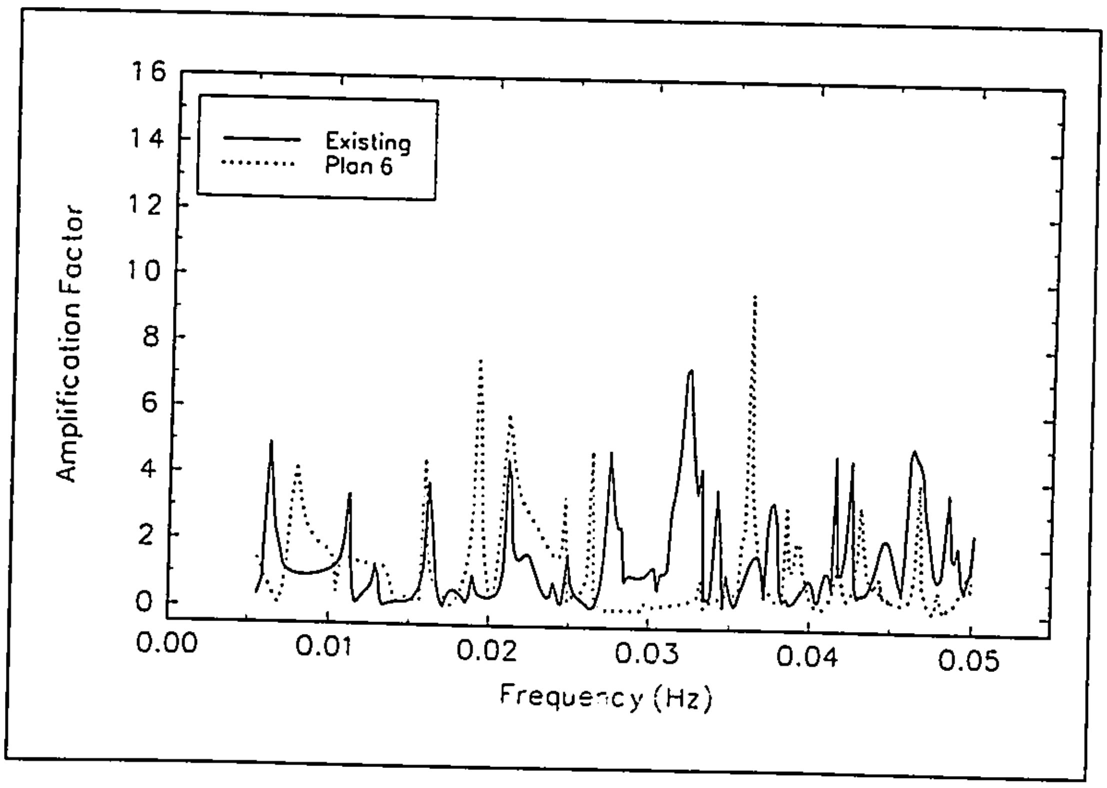

Figure B6. Wave amplification factor, basin 6

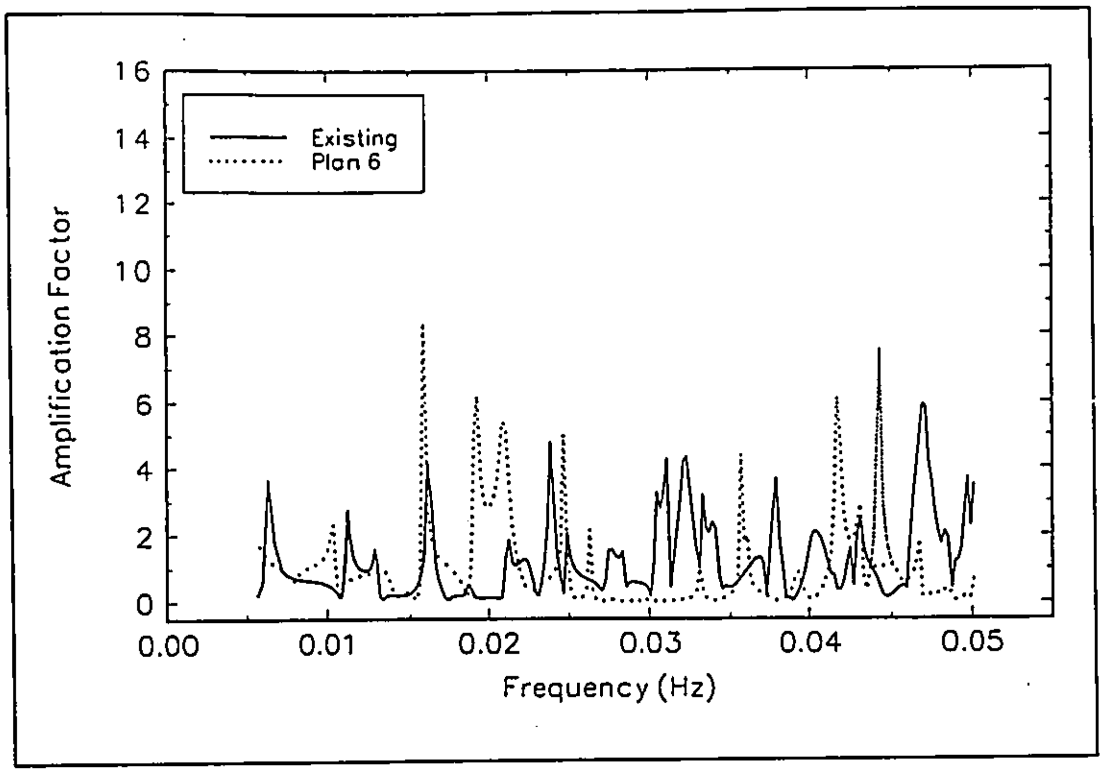

Figure B7. Wave amplification factor, basin 7

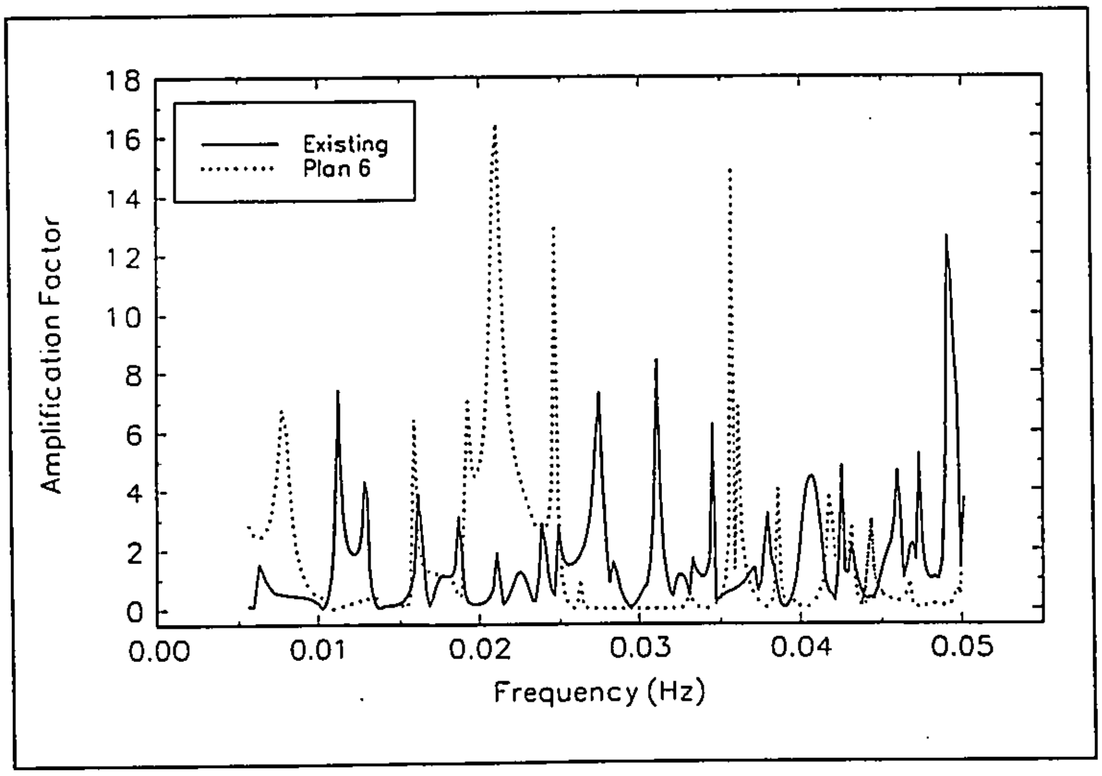

Figure B8. Wave amplification factor, basin 8

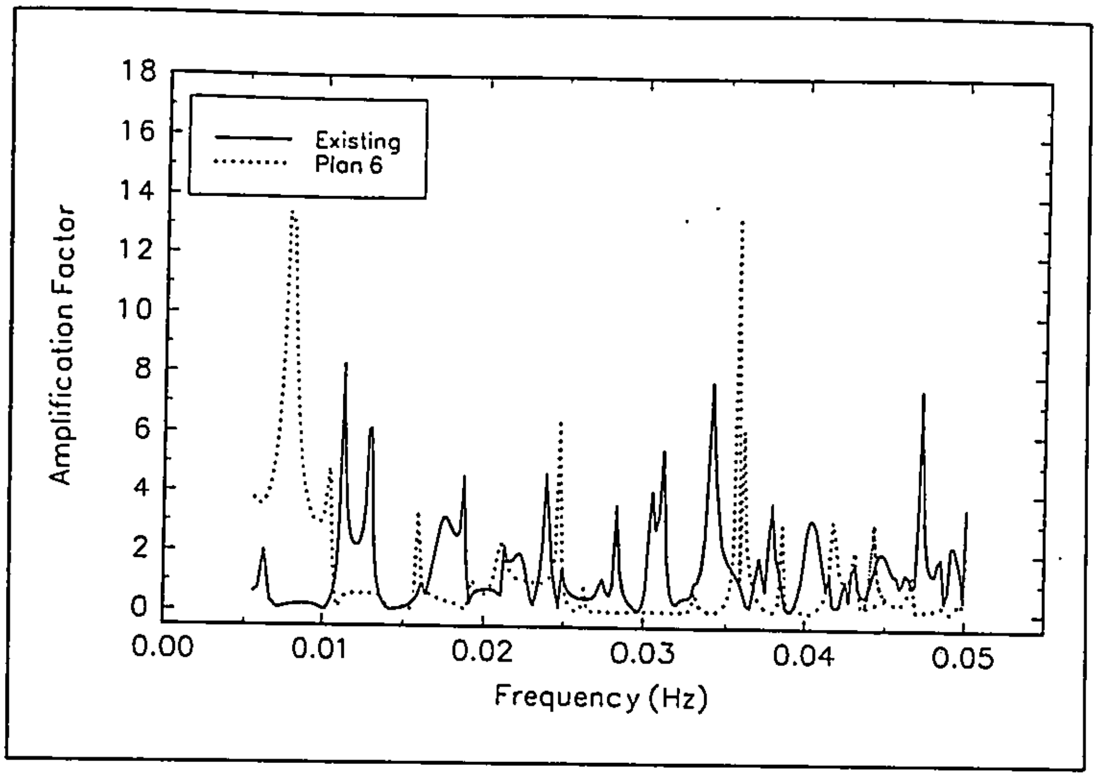

Figure B9. Wave amplification factor, basin 9

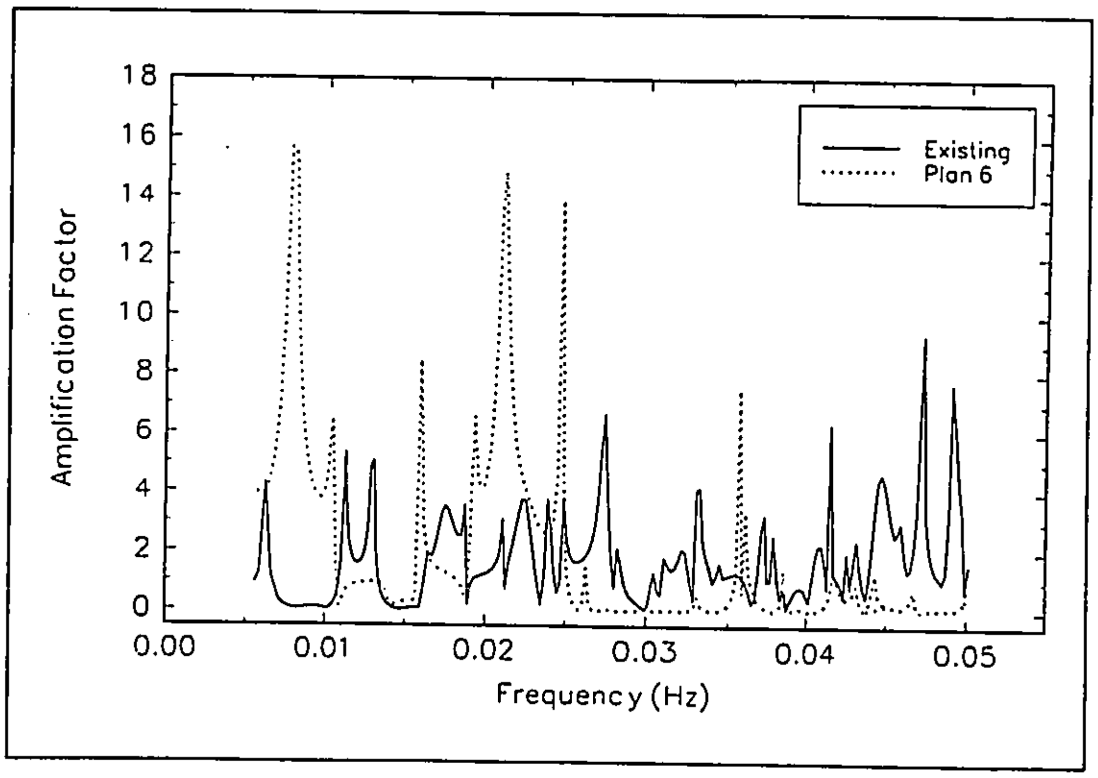

Figure B10. Wave amplification factor, basin 10

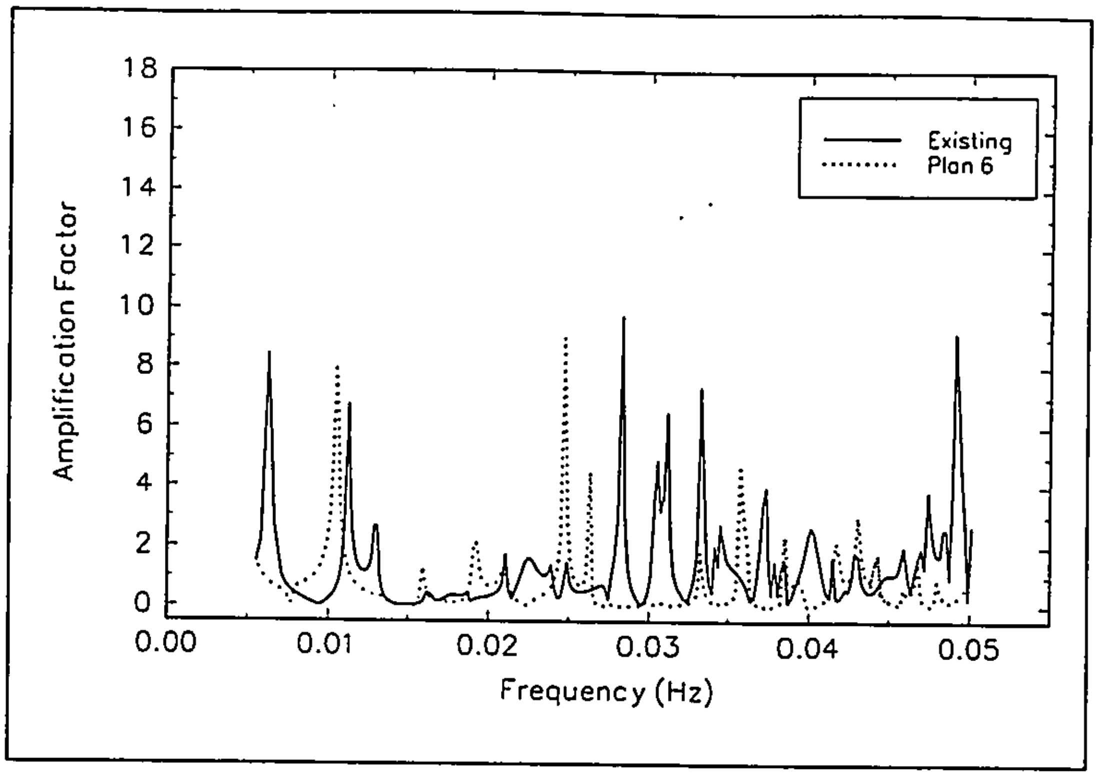

Figure B11. Wave amplification factor, basin 11

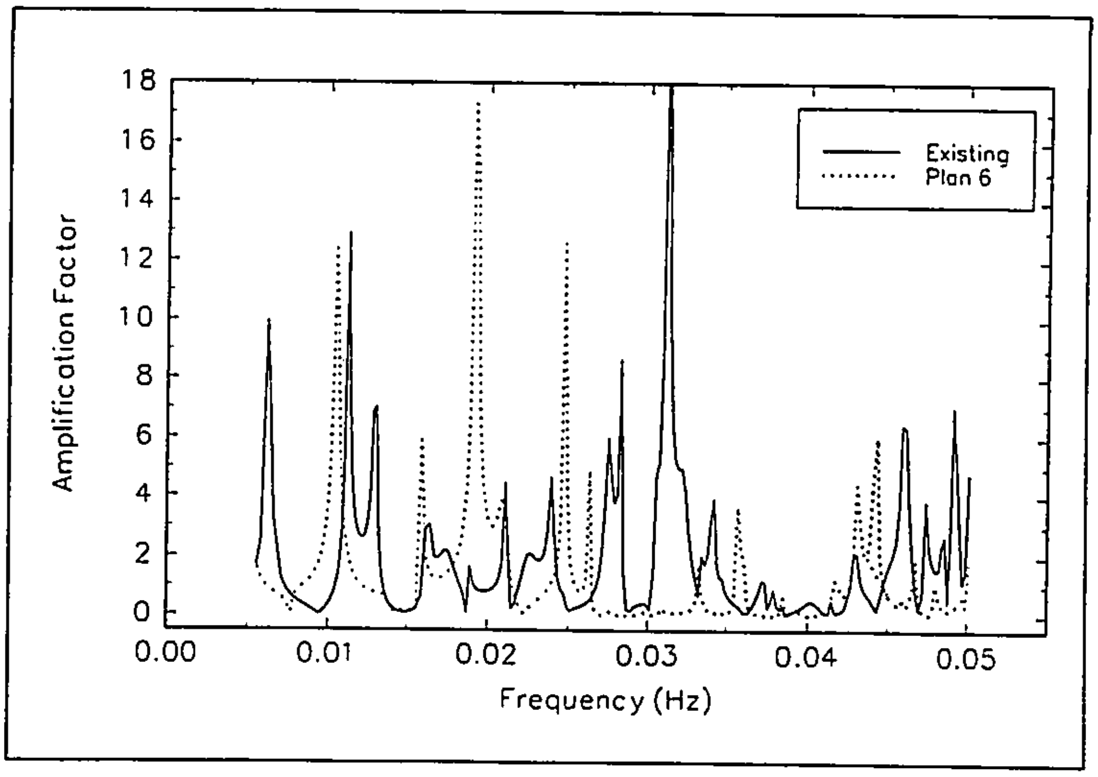

Figure B12. Wave amplification factor, basin 12

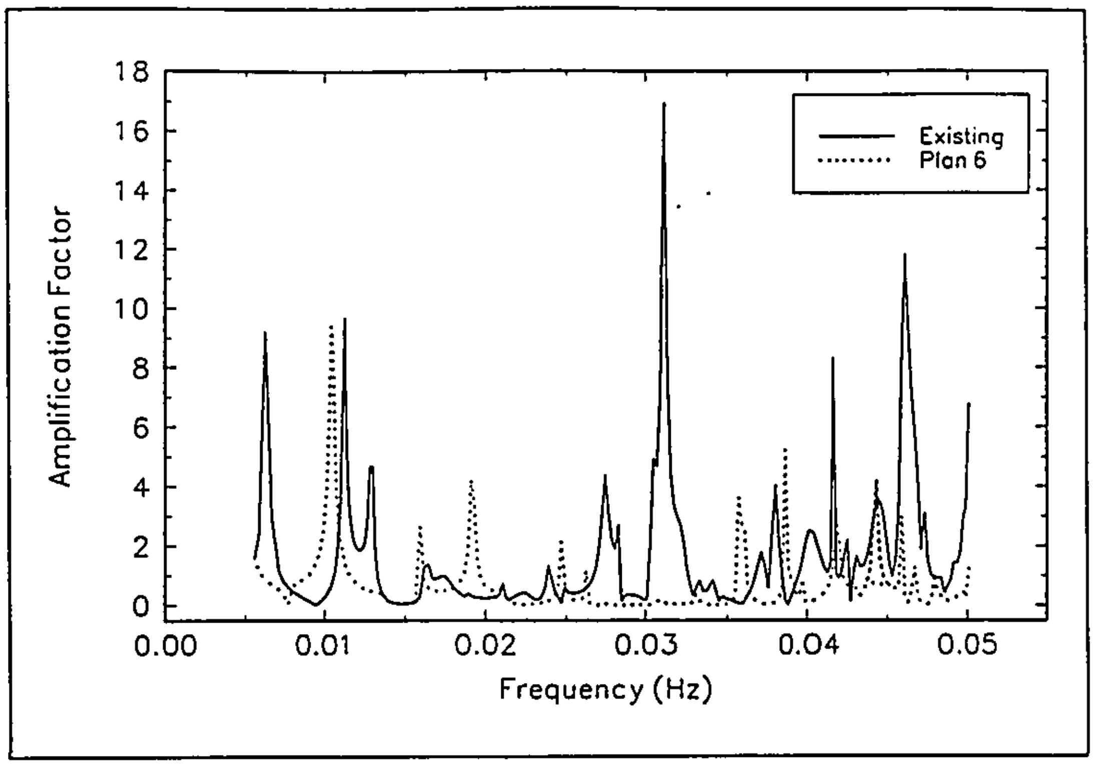

Figure B13. Wave amplification factor, basin 13

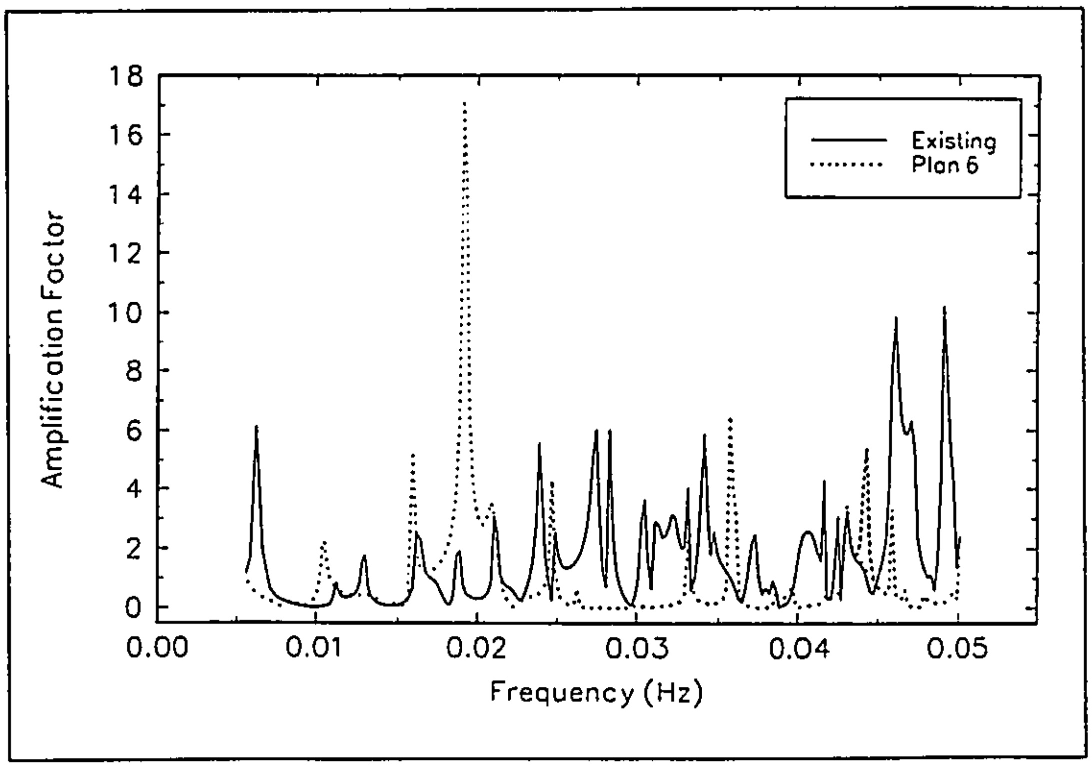

Figure B14. Wave amplification factor, basin 14

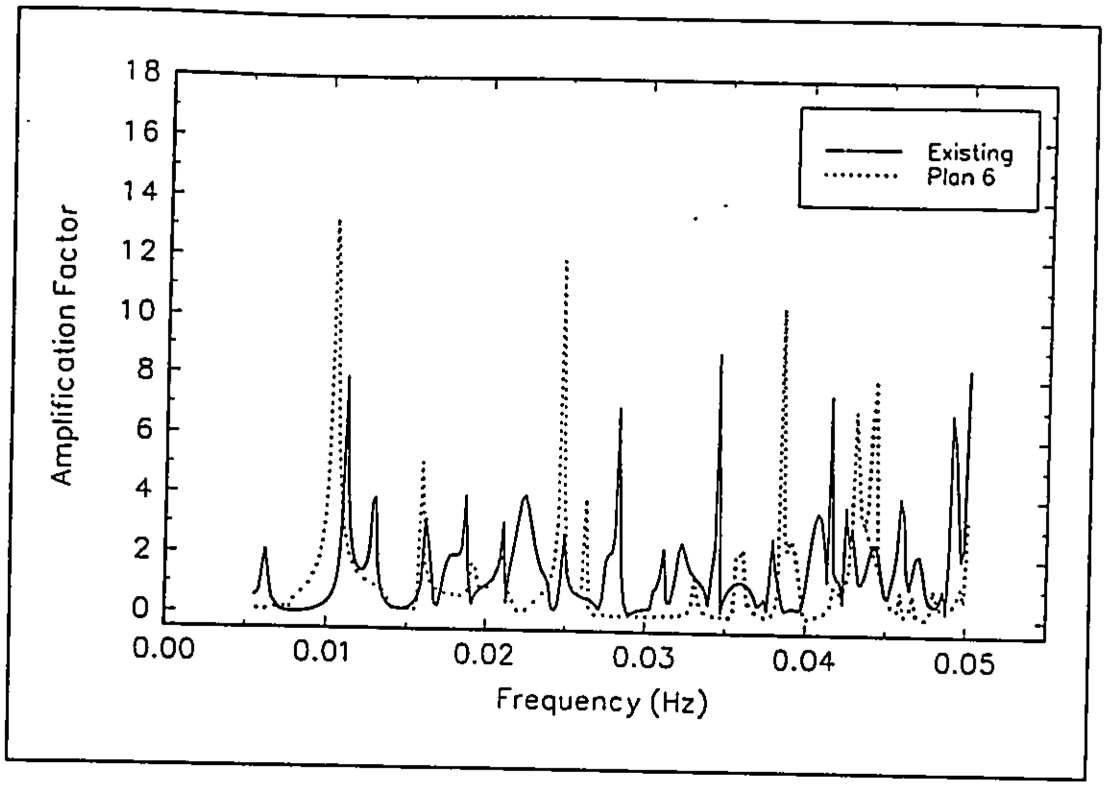

Figure B15. Wave amplification factor, basin 15

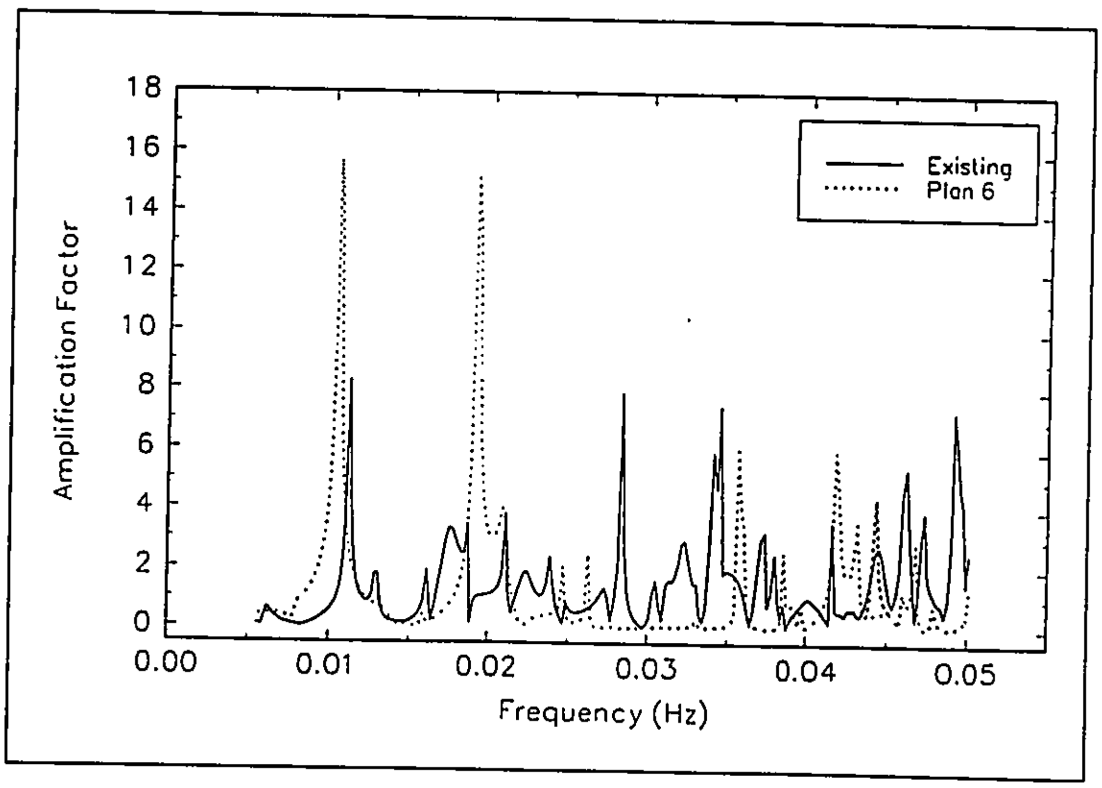

Figure B16. Wave amplification factor, basin 16

APPENDIX H

CULTURAL HISTORY OVERVIEW

A Cultural History Overview of the Kahoma Stream Flood Control Project, Lahaina, Maui, and Ma'alaea Small Boat Harbor Project, Ma'alaea, Maui, Hawaii

A Cultural History Overview of the Kahoma Stream Flood Control Project, Lahaina, Maui, and Ma'alaea Small Boat Harbor Project, Ma'alaea, Maui, Hawaii

By Pauline King Joerger

and Michael W. Kaschko

Prepared for the U.S. Army Corps of Engineers Under

Contract DACW84-79-C-0012

Hawaii Marine Research

125 Merchant Street, Suite 201

Honolulu, Hawaii 96813

INTRODUCTION

The U.S. Army Corps of Engineers, Pacific Ocean Division, requested that Hawaii Marine Research conduct a historical study of the Mala Wharf and Ma'alaea Small Boat Harbor Surfing Site, and an archaeological overview of the recent research near the Mala Wharf area. The intent of this study was to provide sufficient information for the U.S. Army Corps of Engineers to assess the probable impacts of any projects they may initiate in those areas on significant cultural resources. Both areas are evaluated below as to their eligibility for inclusion on the National Register of Historic Places.

This report was prepared from ~~inpoint~~ informant data and existing reports, published or unpublished, in depositories on Oahu and Maui. No archaeological field work was conducted. The area of concern at Mala Wharf is indicated in Figure 1. The Ma'alaea Small Boat Harbor is depicted in Figure 2. Both of these maps were supplied by the Corps of Engineers.

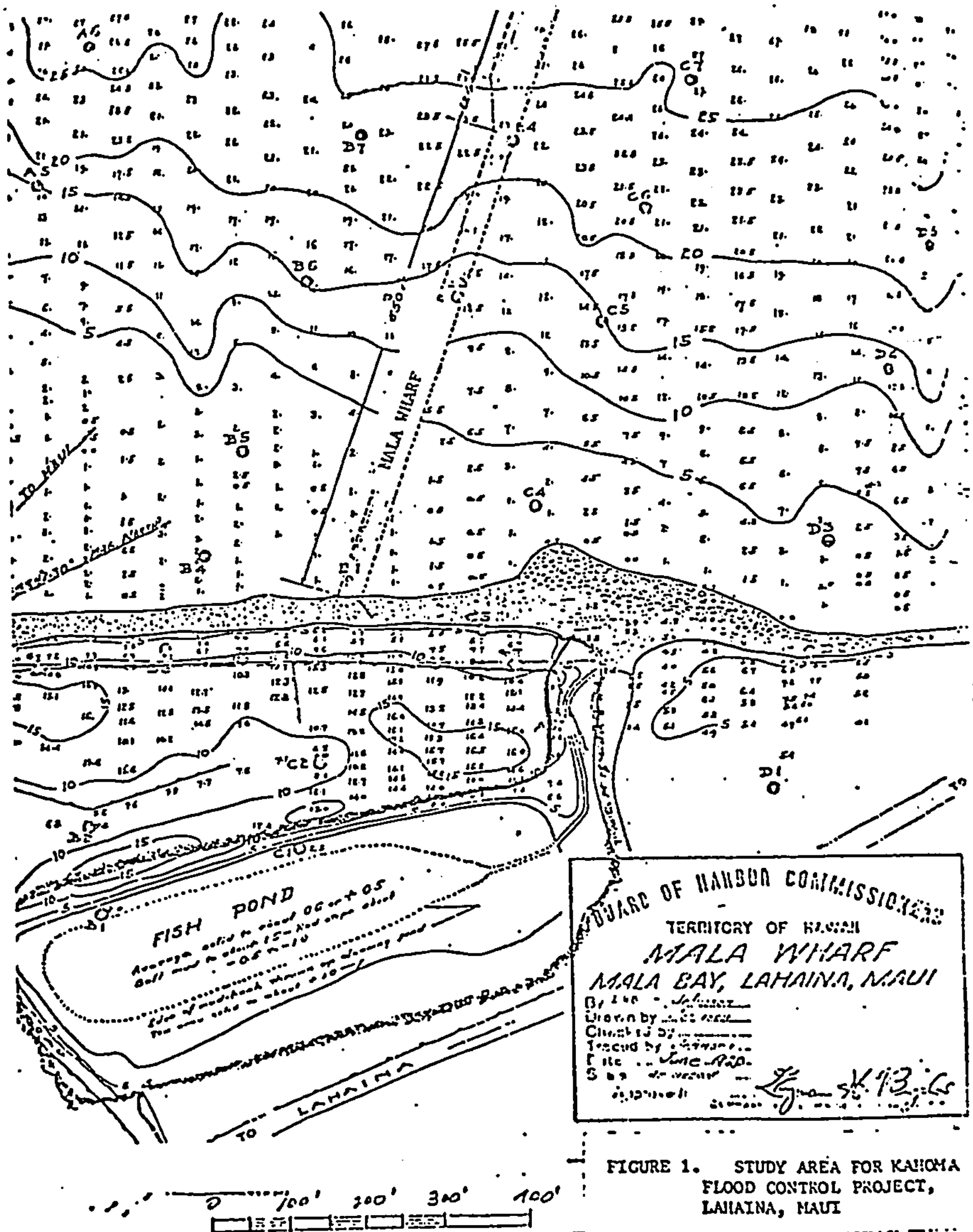

FIGURE 1. STUDY AREA FOR KAHOMA FLOOD CONTROL PROJECT, LAHAINA, MAUI

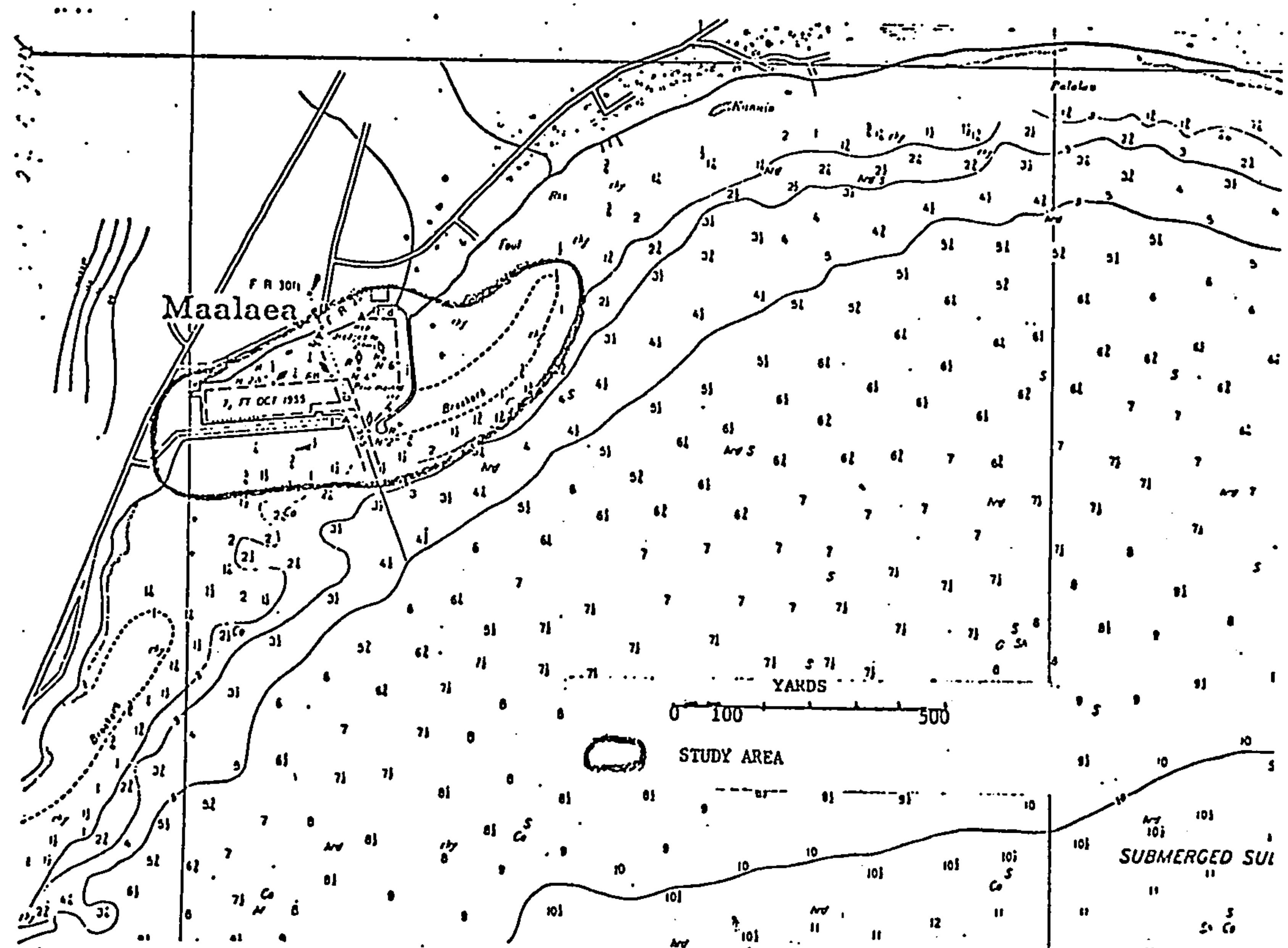

FIGURE 2. MAALAEA SMALL BOAT HARBOR; MAALAEA, ISLAND OF MAUI"

DISCUSSION OF THE SITES

Mala Wharf

Adjacent to Kahoma Stream and bisected by the Mala Wharf approach road are the remains of an inland fishpond called 'Alamihi. Situated in the ahupua'a (ancient land division) of 'Alamihi, the pond may have been named 'Alamihi in historic times and may have had a different name in ancient times. Shortly before Western contact (1778) 'Alamihi was the site of a battle between two great chiefs, Kauhi'aimokuakama and Kamehameha-nui. Kauhi was fighting against the authority of Kamehameha-nui as the high chief of Maui. During the rebellion Kauhi "seized all the food at 'Alamihi ahupua'a." (Kamakau, 1961:73) According to Kamakau, enough food was collected to support the needs of his army for a march across the island (Kamakau, 1961:73).

In the Great Mahale (land division) of 1848 Kamehameha III kept the ahupua'a of 'Alamihi, including the fishpond, as Crown Land (Indices, p. 26; Nahaolelua, Report). Mauka (inland) of the pond and adjacent to it David Malo (c. 1793-1853) a well known Hawaiian historian, was awarded a parcel of land approximately eleven acres in area (Indices, p. 208; LCA No. 3702). Malo's parcel extended from the fishpond mauka and across the Ka'anapali Road. It was reported by Kamakau (c. 1866) that there was a breadfruit tree "on which the first victim of the battle was laid." The tree was "near the house of David Malo" (Kamakau, 1961:73-74). Moreover Inez Ashdown stated that the lower part of Kahoma Stream was in fact called

"Kapa'ulu," or enclosure of breadfruit, and it was from Kapa'ulu that fresh water was fed into 'Alamihi fishpond (Ashdown, Personal Communication).

Thus, 'Alamihi fishpond was part of the important battle in the latter part of the 18th Century between two great chiefs (ali'i nui) and at least one of the breadfruit trees of the area was still standing in the 1860s.

Kamehameha III and Malo were the only two recorded land owners in 'Alamihi ahupua'a for some time.

The fishpond itself was mentioned in government records from time to time. P. Nahaolelua, governor of Maui, reported to the King in 1853 on a survey of the area and referred to the pond and a few coconut trees (Nahaolelua, 1853). Again he reported that he had received six dollars for the fishpond apparently as rent or a fee (Nahaolelua, 1855).

By 1889 Pioneer Mill Company had leased much of the 'Alamihi land including the fishpond for fifteen years. The area was given as nine acres (Iaukea, 1894:79). Until the revolution of 1893 which abrogated monarchy and replaced the Kingdom of Hawaii with a Provisional Government, 'Alamihi fishpond was part of the Crown Lands, the personal property of Kamehameha III and his heir, Kamehameha IV. After 1865 the Crown Lands were administered by a Board of Commissioners of Crown Lands and the income from these lands given to whomever was monarch. 'Alamihi fishpond, then, remained the property of the Hawaiian monarchy and was administered by a government agency.

When the Provisional Government became the Republic of Hawaii in 1894 the Crown Lands became public lands. Thus, in a "Statement of Leases of Public Lands under control of Commissioners of Public Lands as of the date of 31 August 1898," the government of the Republic included the Crown Lands and 'Alamihi fishpond with that of government or public lands (Public Lands Commission, 1898:14). After the Islands were annexed by the United States in 1898, the Commissioner of Public Lands of the Terriotry of Hawaii reported to the Governor that about sixty acres of land and fishponds ~~and~~ consisting of many "small patches and remnants in and about the town of Lahaina" were all that remained of the Lahaina Crown Lands. He placed the value of the acreage at about $6,000.

Interest in the fishpond was evinced early in the 20th Century by the Survey Department of the Territory of Hawaii. In 1908 and 1917 two surveys were made (Figures 3 and 4). The pond was described as being 5.23 acres in the earlier survey. Some changes were made to the pond on the end toward Lahaina town to accomodate a government road. By 1917 the pond had been reduced in size to 4.07 acres.

A more dramatic change occurred in the 1920s with the building of Mala Wharf. That structure was completed in 1922 and the approach road to the wharf cut diagonally across the pond dividing the pond into two roughly equal portions (Figure 5) (Board of Harbor Commissioners, 1922:13-14).

Passenger ships in the inter-island service used Mala for some years. These ships could not moor at the wharf. Instead they anchored in the Bay and transferred passengers in small ship boats to a landing built onto the wharf (Board of Harbor Commissioners, 1923:13). As part of the improvements to the harbor and the surrounding land, the Territory of Hawaii planned to add 13,400 cubic yards of "sanitary fill" to 'Alamihi fishpond. By 1930 the project was completed (Superintendent of Public Works, 1929:20; 1930:23). Mala Wharf was damaged and repaired periodically until 1941 when the Superintendant of Public Works of the Territory of Hawaii reported that no funds were available for work on the wharf. Today Mala Wharf is in a seriously deteriorated state and has been condemned as unsafe.

'Alamihi pond, however, kept the integrity of its name as late as 1953. The year before, the Terriorty of Hawaii had issued a revocable permit to Shizuko Suehiro to use the pond. The next year the pond was described as being 2.417 acres in size (Department of Taxation, n.d.).

Hawaiian fishponds have been described in terms of their construction and location and of their cultural significance as possessions of Hawaiian chiefs. Their function as a source of food supply has also been discussed. 'Alamihi fishpond should first be evaluated in terms of these three aspects: type of pond, food supply, and ownership.

As an inland pond or pu'uone, 'Alamihi probably had at least one 'auwai or ditch that fed or drained the pond (Figure 1). Mrs. Ashdown's information on Kapa'ulu suggests that a feeder ditch may have existed mauka from the mouth of the stream.

In terms of food supply 'Alamihi does not appear to have been particularly productive. In the 19th Century, records of the Crown Lands did not indicate that the monarchs derived a significant income from the pond. A brief review of documents did not indicate that

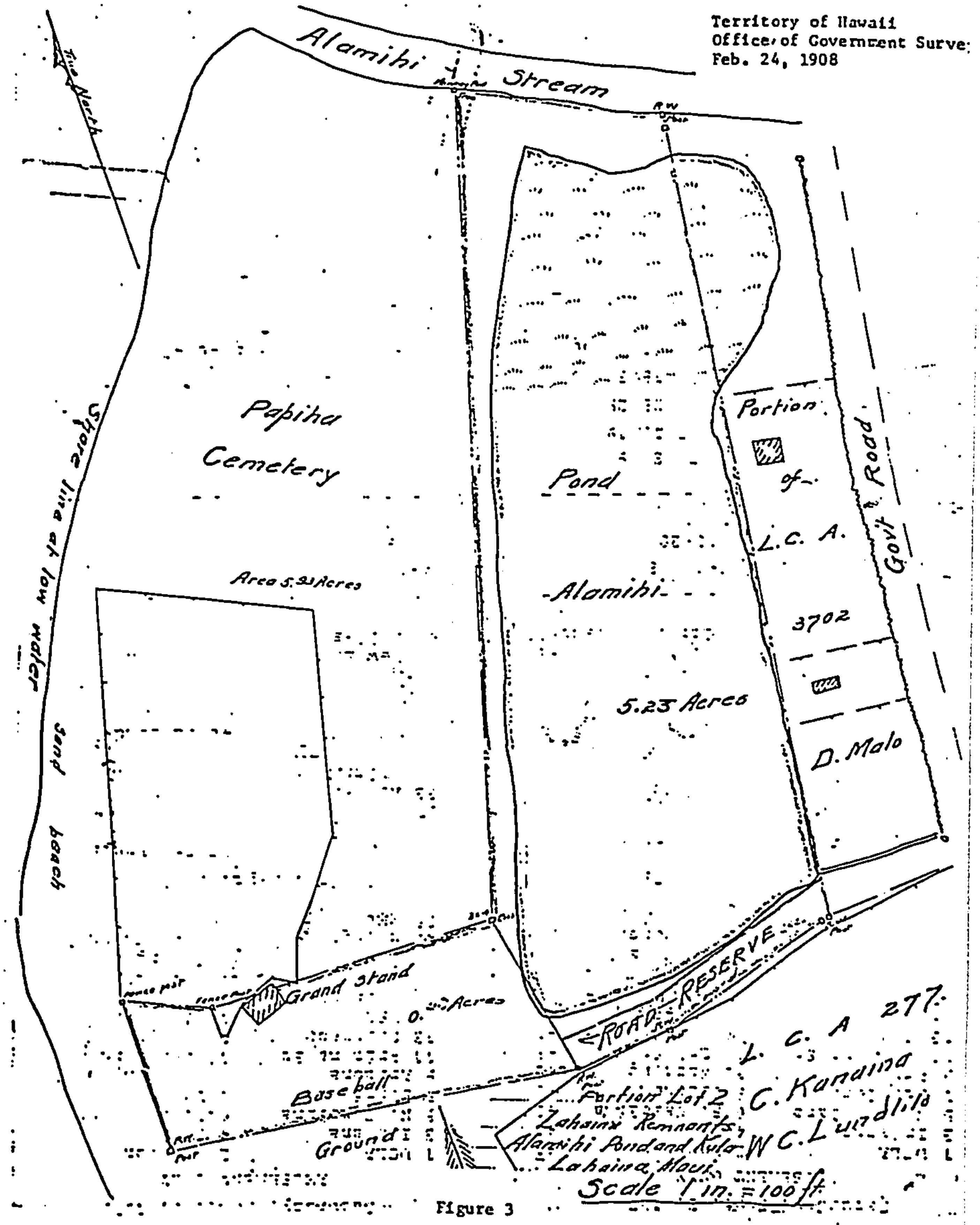
Territory of Hawaii
Office of Government Survey
Feb. 24, 1908
Alamihi Stream
Shore line at low water
Sand beach
Papiha Cemetery
Area 5.93 Acres
Pond
Alamihi
5.23 Acres
Portion of L.C.A. 3702
D. Malo
Gov't Road
Grand stand
Base ball Ground
ROAD RESERVE
L. C. A 277
C. Kanaina
W C. Lunalilo
Portion Lot 2
Lahaina Remnants,
Alamihi Pond and Kula
Lahaina, Maui
Scale 1 in. = 100 ft.

Figure 3

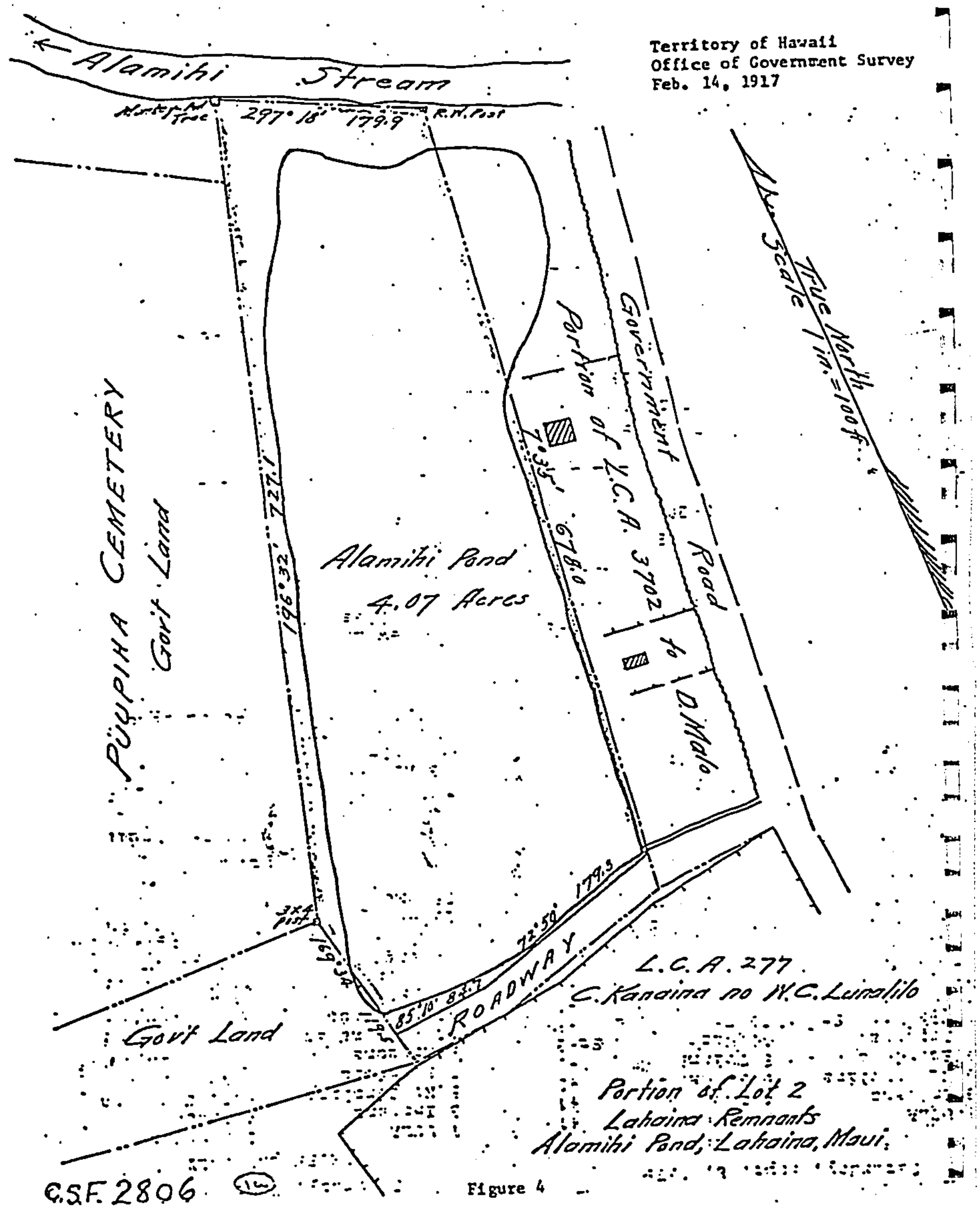
Territory of Hawaii
Office of Government Survey
Feb. 14, 1917
Alamihi Stream
297° 18' 179.9
R.R. Post
True North
Scale 1 in.=100 ft.
Government Road
Portion of L.C.A. 3702 to D. Malo
Püupiha Cemetery
Gov't Land
196° 32' 727.1
Alamihi Pond
4.07 Acres
7° 35' 678.0
3x4 Post
169° 34'
85° 10' 83.7
72° 50' 179.3
ROADWAY
L.C.A. 277
C. Kanaina no W.C. Lunalilo
Gov't Land
Portion of Lot 2
Lahaina Remnants
Alamihi Pond, Lahaina, Maui.
C.S.F. 2806

Figure 4

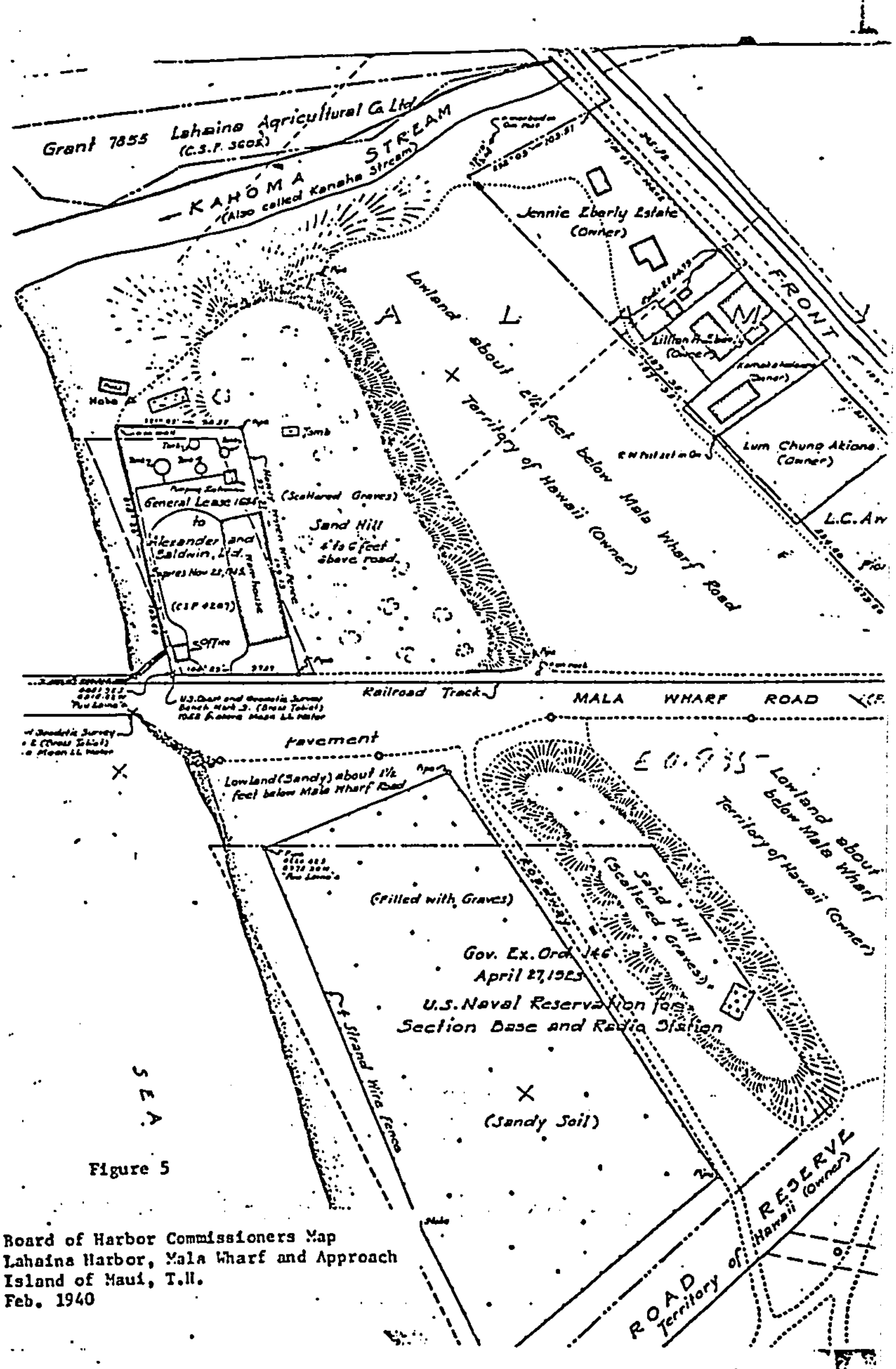

Figure 5

Board of Harbor Commissioners Map
Lahaina Harbor, Mala Wharf and Approach
Island of Maui, T.H.
Feb. 1940

the Hawaiian monarchs depended on 'Alamihi for supply of pond raised fish. It may, however, have been used instead to supply the monarch's retainers with fish. As of 1900 no fishponds on Maui were listed as being used commercially (Cobb, 1902:430-431). Survey maps in 1908 and 1917 show no evidence of an 'auwai and government reports suggest that the pond had become a stagnant or marshy remnant by 1929.

From 1848 to 1893 ownership of the pond and most of the land surrounding it remained with the Hawaiian monarchs. After 1893, the same parcels have belonged to the government of Hawaii. Mala and 'Alamihi have not been districts of high density development. The use of the wharf lasted less than twenty years. Otherwise the area remains a quiet place between Lahaina and Ka'anapali. The changes that have occurred to the pond may have, in fact, preserved it. It would be possible to recover this pu'uone and restore its integrity.

Archaeological Overview. The specific area of study discussed here is the 'Alamihi Fish pond (Tinker, n.d.) and the immediately adjacent bank of Kahoma Stream just North of Lahaina, Maui (See Figure). The fish pond itself has been heavily silted and is now filled with dark organic mud. The remains of a constructed stone 'auwai are visible at the North end of the fishpond entering Kahoma Stream. At least three burials and an imu, all apparently historic, are located within this Northern end of the pond. Mala Road apparently crosses the other end of the fishpond, connecting to the Mala Wharf. On the immediate seaward side of the pond, just behind the beach where the wharf is located, is a large sand berm, on which is situated a historic cemetery. The inland side of the fishpond is in close proximity to the highway to Lahaina.

Previous Research and its Implications. In the last few years the specific area of Kahoma Stream and the Mala Wharf, Lahaina, has been the subject of several archaeological field investigations (Connolly 1974, Sinoto 1975, Davis 1977, Hammatt 1978). In the course of a project ~~primarily involved with the removal of~~ historic burials from the large beach sand berm, the fishpond area adjacent to Kahoma Stream was test excavated to reveal at 80 centimeters depth a black, highly organic, silty muck deposit with abundant land snails included, and more than 50 centimeters thick. The 'auwai of the fishpond adjacent to Kahoma Stream was also examined and test-trenched, exposing its base at least 90 centimeters below the present surface. The presence of a typical fishpond sediment combined with the 'auwai structure confirmed the identification of the area as a former active fishpond (Hammatt 1978:16).

In addition to their relevance to the reconstruction of the ancient environment (in this case especially throught the analysis of land snails), fishponds may also preserve other valuable archaeological remains. Excavations have recently revealed preserved wood artifacts included within fishpond sediments at Kualoa Regional Park, Oahu (Personal Communication, Clark and Connolly). Similar materials could be present in part of the sediments filling the Kahoma Stream fishpond, in particular if a habitation site was located nearby.

The possibility of sub-surface cultural deposits being present immedidately adjacent to the fishpond appears to be good. Sinoto

(1975:2) notes:

> On the basis of the site type and its proximity to a fishpond, freshwater stream, and coastal area (similarities to known significant Hawaiian sites such as 018-Bellows Beach, Al-3-Halawa Valley on Molokai, Mokapu Burial Ground), there are suffieient grounds to suspect the subsurface presence of potentially significant archaeological remains.

During the removal of historic burials from the large sand berm, three test trenches were excavated revealing a buried surface showing soil development. This buried soil was from 10 to 30 centimeters thick and at a depth of 60 to 120 centimeters from surface. In two of the test trenches this layer contained pre-historic cultural material including charcoal fragments, shell midden, and basalt flakes (Hammatt, 1978:14).

> In both cases, the layers are thin and relatively indistinct. However, there is adequate reason to suspect that buried cultural layers may be located in other portions of the Mala locality, particularly in the low-lying areas.
>
> (Hammatt, 1978:15)

A total of 90 human burials have been removed from the sand berm area. Three of these have been identified as prehistoric flexed burials and the remainder as historic. An estimated 135 undisturbed burials still remain in the sand berm area (Hammatt, 1978:6). Within the fishpond itself there are apparently at least three burials and one possible imu (Sinoto, 1975). The burial removal operation demonstrated that there are a large number of burials in this area without any surface indications of their presence.

In addition to the above, there is also the possibility of buried habitation deposits being located in the banks of Kahoma

Stream adjacent to the coast line. A substantial prehistoric occupation deposit, covered by stream alluvium and thus undetectable from the surface, was excavated in Mohinahina Gulch, along the west main coastline north of the project area (Griffin and Lovelace, 1977). The presence of a similar site may be possible in the sediments adjacent to Kahoma Stream in this area in the vicinity of the beach.

Ma'alaea Small Boat Harbor

Ma'alaea Bay has had an important place in Hawaiian history as a stop over or transit place for travelers. One recorded event told by Kamakau was the procession which took the remains of the chief Kakaulike by canoe to Ma'alaea and then by land to Wailuku and Iao Valley (Kamakau, 1961:69). Other references in the writings of travelers were made to their arrival by canoe or small boat at Ma'alaea. At the end of the 19th Century a pier extended out from the shore into the sea. (Figure 6).

By 1902 this pier was in a "condition of extreme dilapidation" (Superintendent of Public Works, 1902:78-79). For reasons which were not stated, the Superintendent of Public Works of the Territory of Hawaii did not believe that Ma'alaea was suitable for the construction of a wharf. Instead he made plans for the Territory to build one near McGregor's Point (1902:78-79, 1903:-, 1904:11, 1905:5-6; Maui News). The project was finally abandoned in 1906 (Maui News, 1906).

During World War II Ma'alaea Bay was used by the 4th and 5th Marine Divisions in joint ship-to-shore rehearsals before the 1945 battle of Iwo Jima (Allen, 1950:190). Ma'alaea was also used for amphibious landing practice (Allen 1950:190).

By the 1950s modern construction of a small boat harbor was begun (Board of Harbor Commissioners, 1951:9, 1952:8, 1953:8). By March of 1953 a breakwater and dredging were completed (Figure 5). By 1958 a second breakwater was constructed. On maps and drawings these are designated as the west breakwater and the east breakwater (Hill, 1979:1).

In 1975 Pacific Sea Transportation, Ltd., began its interisland ferry service with the use of hydrofoils. The first boat, the Kamehameha, arrived at Ma'alaea and docked at a SeaFlite terminal which the company had constructed near the west breakwater (Department of Transportation, 1975:18, 20). SeaFlite continued to operate its ferry until the end of 1977.

The small boat harbor has been used as a mooring place for commercial fishing boats, charter boats and pleasure craft. The Coast Guard cutter Cape Newagen, a search and rescue vessel, is based at the barbor. There is a waiting list for mooring space at the harbor. In 1974 fifty boats were on the list. By 1975 the number had increased to one hundred and thirty-one (Department of Transportation, 1974:27, 1975:23).

Captain Percy A. Lilly, Jr. (Personal Communication), noted that Ma'alaea dry dock was used extensively. The small boat harbor would continue to be used, he felt, for small operations of commercial fishermen, charter boats and private vessels.

An interesting cultural attribute has become associated with Ma'alaea Small Boat Harbor and its breakwaters. Two areas in front of the jetty at Ma'alaea harbor and at Ma'alaea reef on the Kihei side of the harbor have been described as surfing areas (Facilities Manual, 1975:151-152).

While both areas are used today, it is off the west and east breakwaters where the experienced and expert surfers ride the waves. It is, however, off the east breakwater where "the best, fastest, and most beautiful tubes in the world" exist, according to John Severson, editor of Surfer magazine (Hill, 1979:8). Thus, changes in the entrance to the harbor would alter this surfing site and, perhaps, destroy it.

It appears that the most remarkable surfing site at Ma'alaea is a modern one and possibly a site created by the construction of the breakwaters of the harbor.

A quick review of the works on surfing in the Hawaiian Collection at Hamilton Library did not identify Ma'alaea as an important surfing site in the first half of the 20th Century. Similarly, a review of the articles on surfing in Paradise of the Pacific brought about the same result. Maps showing ancient and modern surfing sites did not include Ma'alaea (Finney, 1959:48 passim). Residents of Maui, when questioned, stated that they remembered surfing at Ma'alaea every weekend and all summer about thirty years ago. With further questioning it became apparent that the most commonly used surfing area was at the reef on the Kihei side of the harbor.

Surfing and Hawaii have an ancient partnership. Surfboard riding was common and a popular sport in pre-historic Hawaii. It diffused throughout Oceania, was developed in Eastern Polynesia and most highly refined in the Hawaiian Islands, reaching the level of development of a "cultural peak" (Finney, 1959:21-23).

For various reasons, the sport declined in importance in Hawaii in the 19th Century. Early in the 20th Century, it was revived again and the center of surfing activity was at Waikiki Beach. Between 1911 and 1959 the sport grew, developed and changed. (Finney, 1959:74-76). It also spread out from Hawaii to California, Australia, Peru, New Zealand, South Africa, Israel, France and Tahiti. Innovations in board construction and surfing techniques have developed in some of these new surfing centers and were soon adopted in others.

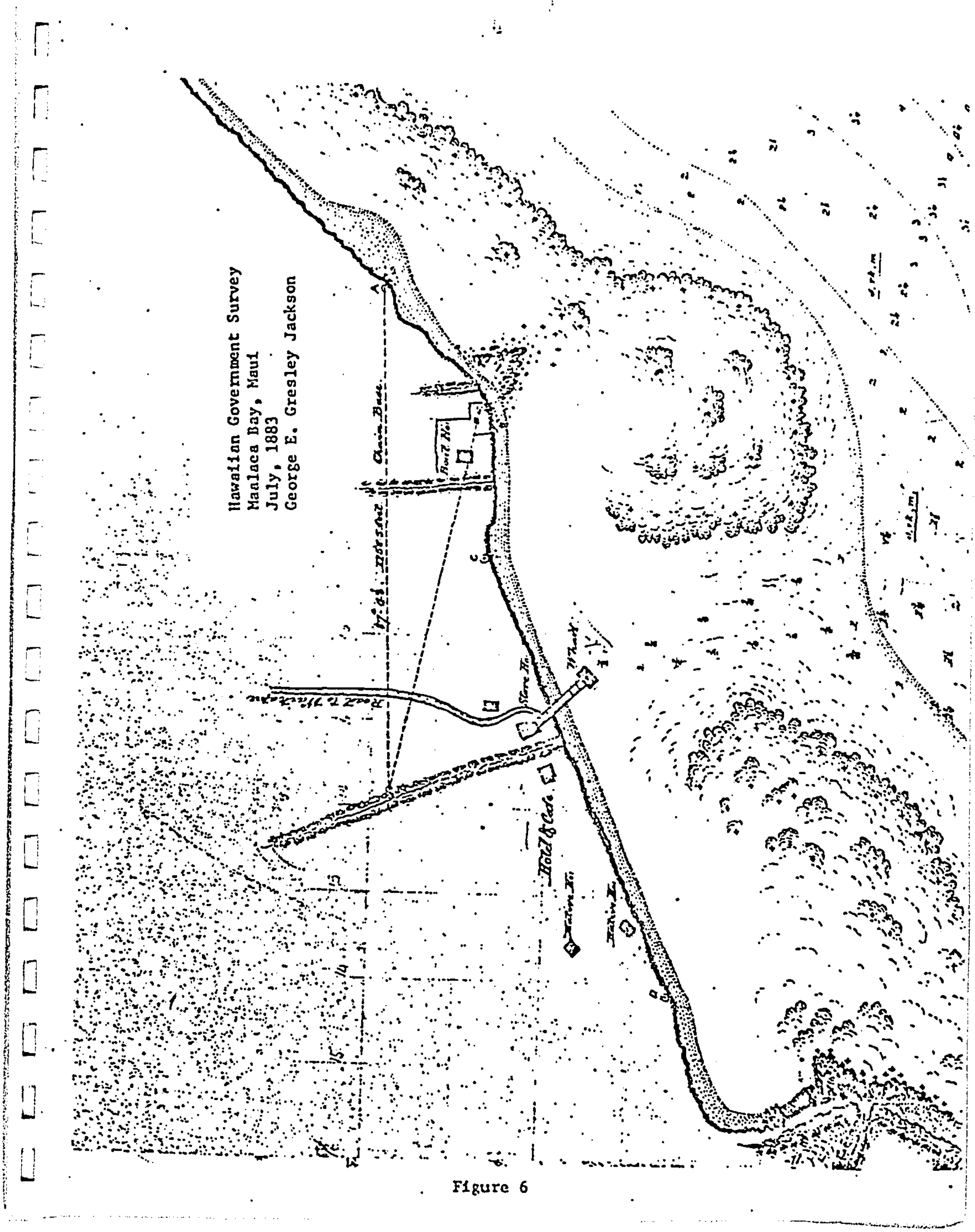
Hawaiian Government Survey
Maalaea Bay, Maui
July, 1883
George E. Gresley Jackson

Figure 6

EVALUATIONS OF ELIGIBILITY AND RECOMMENDATIONS

Ma'alaea Small Boat Harbor Surfing Site

It does not appear from our investigations that Ma'alaea Small Boat Harbor is eligible for inclusion on the National Register of Historic Places. The currently used surfing site immediately adjacent to the harbor has probably become popular within the last fifteen years and as such it is not now, nor has it been in the past, a site important in Hawaii's history in terms of the criteria detailed in 36 C.F.R. 63. Further Ma'alaea Small Boat Harbor as a whole has not been a significant part of Hawaii's Maritime Activities.

Mala Wharf

Because of its association with an important historical figure (David Malo) and its likelihood to yield information important to the prehistory of Hawaii, it is our opinion that the fishpond is eligible for inclusion on the National Register of Historic Places. Our review of recent research in the area strongly indicates that there are significant sub-surface cultural deposits present within and immediately adjacent to the 'Alamihi Fishpond area.

Enough physical evidence exists to establish that significant sub-surface prehistoric cultural remains are probably present within and immediately surrounding the 'Alamihi Fishpond at Kahoma Stream.

The presence of a fishpond here is significant almost by definition. The prehistoric political and economic importance of fishponds and aquaculture has been increasingly emphasized in recent research (Summers, 1964, Kikuchi, 1973, Apple and Kikuchi 1975). Because of the ~~prehistorical~~ political and economic importance traditionally associated with the Lahaina area, both historically and prehistorically, this fishpond is significant in terms of its probable association with those cultural developments.

Depending on the scope and location of the flood control project construction, it is possible that this work could disturb and/or destroy significant archaeological remains of several kinds, including:

1. The fishpond itself and its sediment fill possibly containing valuable preserved materials including land snails, and the associated structural remains adjacent to Kahoma Stream.
2. Sub-surface prehistoric occupation deposits located around the perimeter of the fishpond and bank of Kahoma Stream, and possibly associated with its operation.
3. Human burials both historic and prehistoric located in and around the large sand berm, including some within the fishpond.

Recommendations

To determine in detail the nature of the significant cultural resources which would be affected by the flood control project, it would be necessary to conduct a systematic sub-surface testing program. This would be designed to examine the specific area to be disturbed by construction activities in order to identify the nature, extent, and concentration of the archaeological remains present. For the fishpond in particular, Hammatt states:

> The existence of the fishpond mauka of the graveyard is confirmed and this area should be more fully evaluated archaeologically before it is disturbed. This evaluation would include subsurface mapping of the extent of the fishpond bottom sediments as well as coring of bottom sediments for the purpose of documenting micro-flora and fauna assemblages for reconstructing the age and environmental history of the fishpond. (1978:19).

Until the infomation produced by such a testing procedure is available for analysis, it is not possible to make specific determinations regarding the preservation and/or salvage actions appropriate to prevent damage to cultural resources present in the area.

REFERENCES

The material gathered for this project was accumulated by standard historical research methods. Important depositories on Oahu and Maui were visited, two and a half days were spent on Maui when both subject areas were inspected, informants were interviewed and a bibliography was collected.

The depositories used were the Archives of Hawaii; the Hawaiian Collection, Hamilton Library, University of Hawaii; Bernice P. Bishop Museum Library; State of Hawaii Survey Office; Maui Historical Society; Kahului Public Library; Makawao Public Library, Wailuku Public Library and Lahaina Resortation Foundation. While not all depositories yielded pertinent information, at least on unexpected source was found at Makawao Public Library where Mrs. Gail Bartholomew had prepared an index of the Maui News from 1900 through 1930.

Two government officials were interviewed: Mr. Jeffrey Chang, Planner, Planning Department, County of Maui; and Captain Percy A. Lilly, Jr., District Manager, Maui, Water Transportation Facilities Division, Department of Transportation, State of Hawaii.

Informants were interviewed. They were, Mrs. Inez Ashdown who formerly served as a Maui County historic preservation advisor and Mrs. Pika Walker. The latter was asked to inquire of residents of the Mala Wharf and 'Alamihi area in regard to their knowledge of the fishpond.

About one quarter of the bibliography compiled proved useful as citations. The bibliography included printed works, manuscript and unprinted material, newspapers and periodicals, maps and photographs.

Printed works included, in the main, standard works on a subject. For example, on fishponds, Hawaiian Fishponds (Summers, 1964) was used for background information. The annual reports of the Superintendent of Public Works and the Board of Harbor Commissioners of the Territory of Hawaii and the Department of Transportation of the State of Hawaii were used to follow the sequence of construction at Mala and Ma'alaea. Hawaii's War Years, 1941-1945 (Allen, 1950), was the major reference for World War II material.

Newspapers and periodicals were used where indexes exist. Thus, the Honolulu Star Bulletin and Honolulu Advertiser were checked for the period 1929 through 1978; Paradise of the Pacific and Hawaiian Annual and Almanac and Maui News from 1900 through 1923. Single or individual articles were used when found in files or scrapbooks. For example, an article in Hawaii Coastal Zone News was an important source.

Among the manuscript and unprinted material used were land records in the State Department of Taxation, the Survey Division of the State Department of Accounting and General Services, and the Bureau of Conveyances and Land Management of the State Department of Land and Natural Resources. Archives of Hawaii documents were used extensively. The Master of Arts thesis of Ben R. Finney, "Hawaiian Surfing, A Study of Cultural Change," was an important source in regard to ancient and modern surfing.

The maps that illustrate this report were found at the Archives of Hawaii and the Survey Division of the Department of Accounting and General Services, State of Hawaii.

Photographs were looked for at the Archives of Hawaii, the Maui Historical Society, the Kahului and Makawao Public Libraries, and in various issues of <u>Paradise of the Pacific</u>. No photographs were found which would illustrate the subject matter of this report.

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