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JOHN WAIHEE
GOVERNOR

August 23, 1990

The Honorable Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
Honolulu, Hawaii 96813

Dear Mr. Callejo:

Based upon the recommendation of your office, I am pleased to accept the Final Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project 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 whether the action described therein should be allowed to proceed. My acceptance of the statement is an affirmation of the adequacy of that statement under applicable laws and does not constitute an endorsement of the proposed action.

When the decision is made regarding the proposed action itself, I expect the proposing agency to weigh carefully whether the societal benefits justify the environmental impacts which will likely occur. These impacts are adequately described in the statement, and, together with the comments made by reviewers, provide a useful analysis of the proposed action.

With kindest regards,

Sincerely,

JOHN WAIHEE

cc: Dr. Bruce S. Anderson

SEP 2 3 1990

KAWAINUI MARSH
FLOOD DAMAGE MITIGATION PROJECT

M & E Pacific, Inc.
Consulting Engineers

1990-06-OA-FEIS- KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT

FINAL

ENVIRONMENTAL IMPACT STATEMENT

KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT

PREPARED FOR

The City and County of Honolulu
Division of Engineering
Department of Public Works

Sam Callejo
Director and Chief Engineer

PREPARED BY

M&E Pacific, Inc.
Engineers and Architects
1001 Bishop Street
Honolulu, Hawaii 96813

JUNE 1990

FINAL
ENVIRONMENTAL IMPACT STATEMENT

PROJECT:	KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT
LOCATION:	KAWAINUI MARSH, KAILUA, OAHU
PROPOSING AGENCY:	CITY & COUNTY OF HONOLULU DEPARTMENT OF PUBLIC WORKS
ACCEPTING AUTHORITY	MAYOR, CITY & COUNTY OF HONOLULU GOVERNOR, STATE OF HAWAII
CONSULTANT:	M&E PACIFIC, INC. PAUAHI TOWER, SUITE 500 1001 BISHOP STREET HONOLULU, HI 96813 (808) 521 3051 CONTACT PERSON: JAMES DEXTER

SUMMARY

The City and County of Honolulu proposes to implement a plan to increase the ability of Kawainui Marsh to distribute and store stormwater runoff in order to reduce the potential for flooding in Coconut Grove. The purpose of this action is to meet or exceed the design objective of 3,000 acre-feet of flood storage capacity established for the original Corps of Engineers' project. This action is proposed as an alternative to the construction of a channel through the marsh.

The proposed action is a modification of the proposal in the Draft Environmental Impact Statement. The basic elements of the revised plan are:

a) Opening approximately 10,000 linear feet of waterway which will create approximately 10 acres of open water to distribute flood water more efficiently within the interior of the marsh;

b) Clearing vegetation and sediment from existing ponds to provide approximately 20 acres of open water to enhance flow into the waterways and reduce the presence of floating material which could block flow and impede flood water distribution;

c) Construction of a processing and handling area for the materials removed in order to maintain the elements completed in a) and b) above in a functioning condition.

There are several differences in the revised plan. The waterway alignments have been changed to follow as much as possible the abandoned agricultural canals within the marsh and their size has been increased (but no change in proposed depth) to improve flood water distribution. The waterways have been shortened; they extend only to the central areas of the marsh and not to Oneawa Canal. The low flow weir within the marsh on the emergency ditch, the levee modifications and overflow system as well as changes to the Kaelepulu drainage system have been deleted. Corps of Engineers' studies will address proposed changes to the levee and outlet. City and County of Honolulu proposals to clean Kaelepulu Stream will be addressed by separate study.

The estimated first cost of construction is $4,112,000. This assumes the material removed from the marsh must be disposed in a landfill. Efforts are ongoing to identify alternative means to recycle this material, but additional time is required to complete all the necessary technical and administrative details. Maintenance equipment is expected to cost between $458,000 to $704,000.

The waterways will be constructed by a combination of mechanical equipment removal, blasting, and application of chemicals to control new vegetation growth. The unused landfill (portion adjacent to the model airplane field) will be converted into a processing area for green vegetation, peat and sediment. The drying beds will be sealed to reduce potential for leachate through the old landfill material. The materials will be processed and treated to control odors and acidity, and dried to meet federal and state regulations for landfill disposal.

Coordination of the construction and maintenance work with fish and wildlife, and historic preservation agencies will be required in the construction contract documents. Public notification will be provided before any use of explosives is authorized. All required permits will be obtained prior to the initiation of work.

The principal environmental short-term impacts of the proposed action are reduction in flood stages at the upstream end of the marsh which will reduce but not eliminate the possibility of flooding Coconut Grove, financial costs associated with the construction and maintenance contract, and effects during the construction. Construction impacts include noise, dust, and suspended sediment in the immediate area of the dredging and vegetation removal operations. All work will be conducted in order to comply with federal and local regulations, and monitoring will be included as a requirement to verify compliance. If off-site disposal of marsh material becomes feasible, i.e. other than Kapaa landfill, truck traffic using public roads will be a minor impact. The magnitude of the additional trucking volume is expected to be less than five trailer truckloads per day emanating from the quarry road.

In the long-term, the principal impacts, in addition to the short-term impacts, are related to the hydrologic impacts on productivity in the wetland. These effects are characterized as changes in fauna species composition and distribution, micro-scale changes in plant species composition within the waterways and ponds due to vegetation removal, detritus production and peat accumulation within the waterways, and nutrient cycling and availability. Depth to the substrata is not expected to be significantly altered by removal of vegetation and shallow dredging of sediments in the ponds. The mass nutrient balance, in terms of total nutrient input and output, will not be significantly altered by the proposed action because the circulation rate will change by a period measured in terms of hours which is so small in comparison to the annual growing season that the overall net productivity changes are difficult if not impossible to measure on a scale as large as the marsh.

The unresolved issues include completion of the long-term plan for flood control between the Corps of Engineers, State of Hawaii and the City and County of Honolulu, and development of a long-term management plan to integrate flood control activities with other natural and cultural resource objectives. Ongoing study by the Corps of Engineers is targeted to address the former issue. Items that should be included in the latter issue are controlling the sediment and nutrient inputs into the marsh, and management of long-term primary productivity as it affects not only flood control plans but ecological succession, and manipulation of water levels for natural resource management. Future studies should emphasize better understanding of the biological interrelationships with environmental inputs such as water, nutrients and sediment.

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SECTION ONE

INTRODUCTION

I Purpose and Need for Action

The City and County of Honolulu proposes to implement a plan to increase the ability of Kawainui Marsh to distribute and store stormwater runoff in order to reduce the potential for downstream flooding. This plan has been revised since originally presented in the Draft Environmental Impact Statement (DEIS). The plan would prevent floodwater from entering homes in the Coconut Grove area if there were a repeat flood such as occurred on New Year's Eve, 1988. The plan, however, is not capable of preventing flood for all possible events, if elements were to occur differently, for example, more rainfall in a shorter period, or antecendent marsh levels were higher.

Kawainui Marsh is the largest remaining wetland in the State of Hawaii. The marsh is a habitat for four endangered Hawaiian waterbird species and contains important archaeological artifacts. Part of the marsh is listed on the National Register of Historic Places. It also acts as a nutrient and sediment sink protecting the waters of Kailua Bay. The marsh, the surrounding area, and important landmarks are shown in Figure 1-1.

A major function of the marsh is that of a flood basin protecting portions of Kailua. The dense wetland vegetation within the marsh inhibits the movement of flood water into the interior portion, and can result in water surface elevations that during severe floods will exceed the crest of the Federal levee. Heavy rains during the winter rainy season bring increased risk of excess runoff with increased flood potential. There have been over twenty floods since the turn of the century which have inundated areas bordering the marsh. The most recent flood occurred on December 31, 1987-January 1, 1988. Damage in the community of Coconut Grove from that flood is estimated at $10,000,000 (Aiona, 1989).

In the aftermath of the New Year's Eve, 1988 flooding on Oahu, Federal, State, and City emergency declarations were proclaimed to authorize certain public actions to provide relief and reduce the imminent threat of additional danger. Vegetation was removed from the marsh (west) side of the Federal flood control levee. The levee crest was raised approximately one foot of gravel material.

The emergency actions taken to date have prevented water levels in the marsh from remaining high so that subsequent storm runoff can be more readily stored. However, the emergency measures have not improved distribution of floodwater within the marsh. The existing flood protection project does not meet City and County storm drainage standards and there is still the need for additional measures to reduce the risk of future flooding and the potential for subsequent damage.

II Project History

As noted above, flood waters from Kawainui Marsh have overflowed from the present boundary of the marsh on at least twenty occasions since the turn of the century. Following major floods in 1921, 1951, and 1965, public agencies reviewed and revised plans and took new actions to prevent flood damage. Partly as a result of the 1951 flood, the Territory of Hawaii initiated a pilot project to drain Kawainui Marsh to Kailua Bay. After the 1965 flood, the Federal portion of the project was completed.

The flcod of December 31, 1987 - January 1, 1988 set in motion another review (by government agencies, concerned interest groups, and individual citizens) of the flood damage prevention measures which exist and additional measures that could be implemented to reduce the risk of another event and attendant consequences. The U.S. Army Engineer District, Honolulu (HED) evaluated several emergency alternatives for improving the flood control features of the Federal Project. They recommended the excavation of a channel approximately 8,000 feet long and 200 feet wide through the center of Kawainui Marsh with an invert elevation of -5 feet from the Oneawa canal to the Maunawili side of the marsh.

An environmental assessment of this proposed action was prepared by HED and the City and County of Honolulu, Department of Public Works, and a notice of preparation of an environmental impact statement was published in the Office of Environmental Quality (OEQC) Bulletin on September 8, 1988. Sixty letters providing comments on the proposed action were received during the 30-day review and consultation period. The proposed action was also discussed at one public information meeting on August 10, 1988.

As a result of the comments and suggestions provided by reviewers and special studies conducted since September, 1988, the proposed action has changed significantly. The planned improvements to Kawainui Marsh described in the following section of this document consist of several actions which emphasize prevention and management measures to improve the water retention capabilities of the marsh and yet recognize the wetland's ecological and environmental attributes.

The recommended action is sufficiently different from that previously proposed for a new environmental impact statement to be prepared. An interagency briefing was provided for Federal, State, and City and County agencies on

June 14, 1989. A public informational meeting on the proposed action was held in Kailua on July 13, 1989. An environmental assessment and notice of intent to prepare an environmental impact statement was filed with OEQC on July 18, 1989 and published in the OEQC Bulletin on September 8, 1989.

The City and County was notified by the Honolulu District Engineer, U.S. Army Corps of Engineers (COE), by letter dated July 11, 1989 that certain aspects of the proposed plan associated with levee modifications would require the approval of the Assistant Secretary of the Army for Civil Works. Aspects of the plan dealing with opening waterways to create habitat for fish and wildlife and flood storage were supported by the COE.

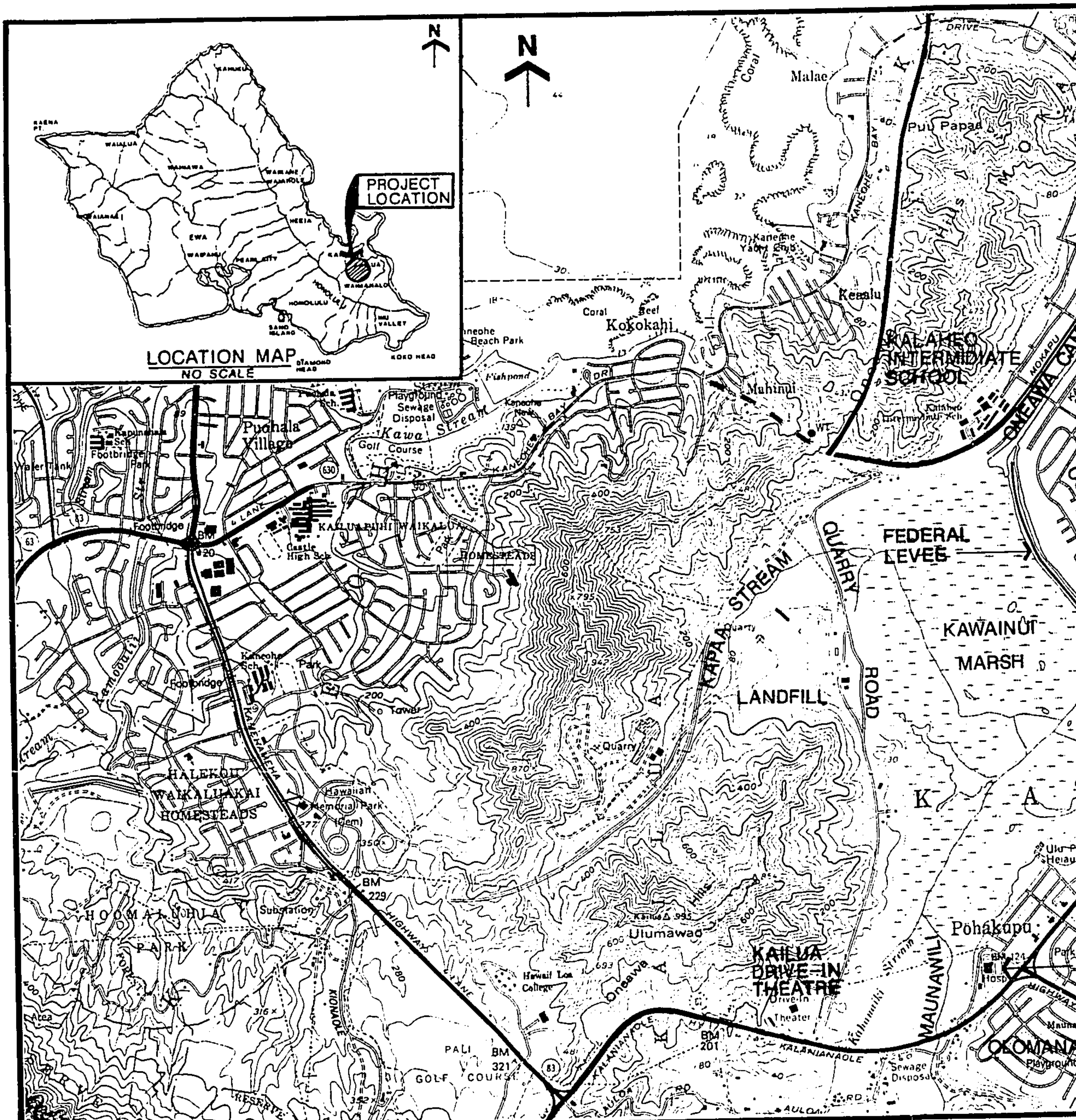
The COE was unable to support the analyses and conclusions reached with respect to modifications to the federal flood control levee. As a result, elements associated with the existing federal project were excluded from further study by the City and County, and efforts were concentrated on increasing the flood capacity by opening waterways and preserving the existing resources of the marsh.

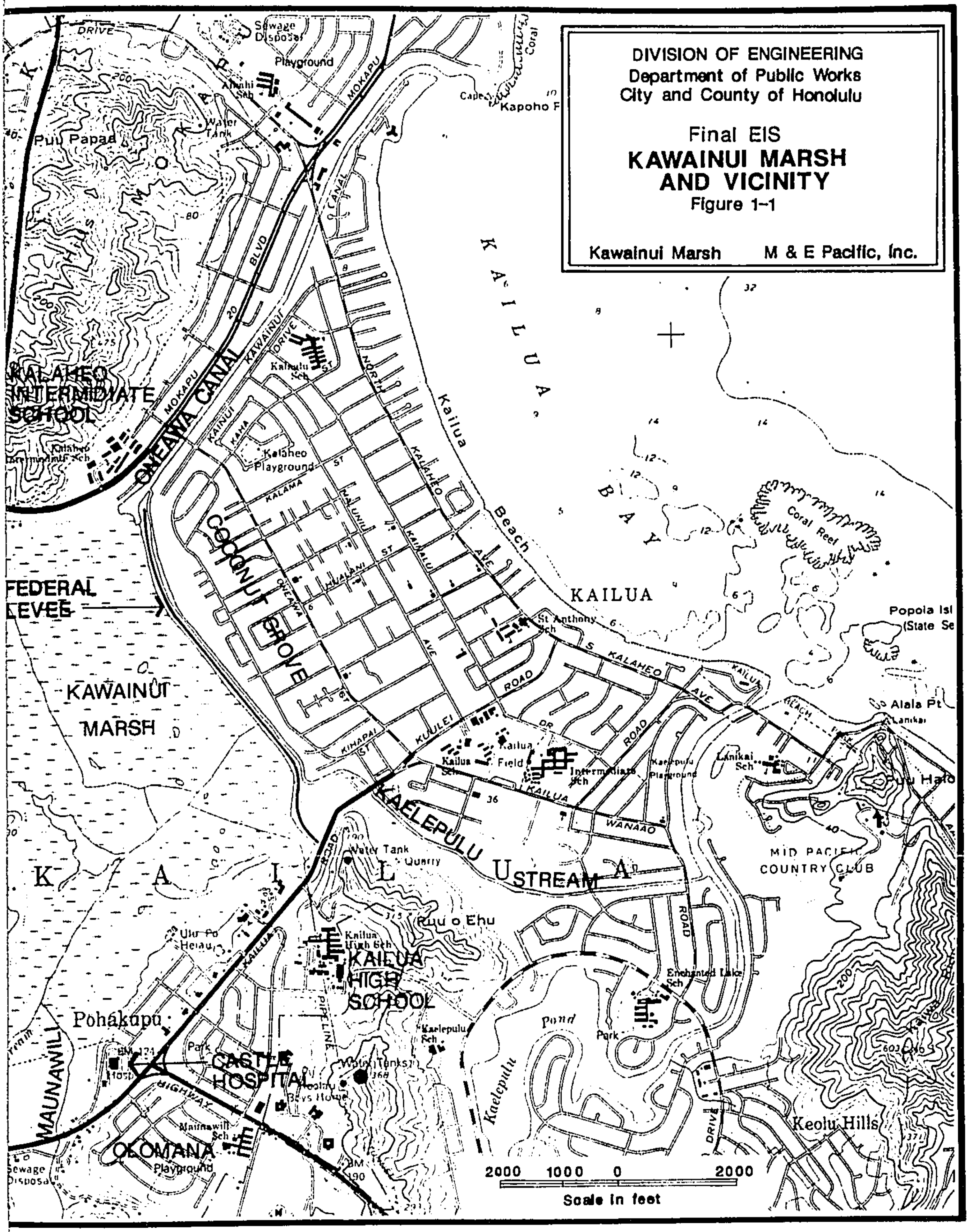
The COE initiated a Reconnaissance Report in September 1989 to determine if a federal interest existed in pursuing modifications to the federally constructed flood control project. The purpose of the Reconnaissance Report was to: 1) reevaluate the Kawainui Marsh federal flood control project following the flooding of Coconut Grove on January 1, 1988, 2) establish a federal interest in needed project modifications, and 3) identify a willing and capable project sponsor to cost-share feasibility/design studies and subsequent project modification.

On December 21, 1989, the COE and the City and County signed an intergovernmental cost-sharing agreement for a Feasibility Study. The Feasibility Study would be accomplished under Section 205 of the Flood Control Act of 1948, as amended, to determine how best to restore and continue flood protection to the residents of Coconut Grove. Matching federal and City and County funds were made available to pursue a flood control solution. The cost for this study, to be shared on a 50/50 basis, is estimated at $400,000 plus a 25% contingency for a total of $500,000. Based on this amount, the maximum cost-share to the City is $250,000.

The costs associated with the agreement are for the study as mentioned above and the construction of improvements. Under the Water Resources Act of 1986, $5,000,000.00 is available for the improvements. The City's total cost would not be less than 25%.

The signing of the agreement now creates a renewed partnership between the City and the COE. Both government agencies are working together with the public toward a common goal of providing flood protection for Coconut Grove. The information and analyses developed by the City and County are being utilized wherever possible by the COE to avoid duplication of efforts.


LOCATION MAP
NO SCALE
PROJECT LOCATION
N
KAILUA DRIVE-IN THEATRE
FEDERAL LEVEE
KAWAINUI MARSH
LANDFILL
QUARRY ROAD
KAPAA STREAM
KALAHEO INTERMEDIATE SCHOOL
Puohala Village
Kawa Stream
Golf Course
Kokokahi
Malae
Keaalu
Mahinui
Ulumawao
Pohakupu
MAUNAWILI
KALANIANAOLE
HALEKOU WAIKALUAKAI HOMESTEADS
HOOMALUHIA PARK
Hawaiian Memorial Park
Hawaii Loa College
KAILUAPUHI WAIKALUA HOMESTEADS
Castle High Sch
Kaneohe Yacht Club
Kaneohe Beach Park
PALI GOLF COURSE
KIONAOLE
HIGHWAY
Substation
Quarry



DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu

Final EIS
KAWAINUI MARSH AND VICINITY
Figure 1-1

Kawainui Marsh M & E Pacific, Inc.

SECTION TWO

DESCRIPTION OF THE PROPOSED ACTION

I Description of the Existing Federal Project

The following is excerpted from the U.S. Army Corps of Engineers' historical review of the existing Federal project (Corps of Engineers, 1988):

> "The Kawainui Marsh flood control project was first described in House Document No. 214, Eighty-first Congress, first session. It was authorized by Section 204 of the Flood Control Act approved 17 May 1950. The original plan recommended in the project document provided for an unlined, tidewater outlet channel (Oneawa canal), 9525 feet long, 105 feet wide on the bottom, side slopes of two horizontal to one vertical, and an average of 13 feet deep in the main portion and a concrete and timber control structure 350 feet wide at the inlet to the canal.
>
> The actual project as completed in 1966 includes a 6,850 foot long earthen levee with a maximum crest elevation of 9.5 feet, separating the marsh from Coconut Grove residential area, and a 9,470 foot long Oneawa outlet canal running east from the northern end of the marsh into Kailua Bay. The control structure was never built."

The existing project is shown in Figure 2-1. The pertinent data related to the Federal project, as shown in the Design Memorandum (U.S. Army Corps of Engineers, 1957) is shown in Table 2-1. Key design parameters to note on this table include the levee freeboard, i.e the vertical difference between the water surface and the crest, (3.15 feet), the maximum stage at the upstream end of the Oneawa outlet canal (6.7 feet) at 7350 cubic feet per second (cfs) design outflow, elevation of the crown (top) of levee (10.5 feet), and the side slope horizontal to vertical ratio (3:1). As-built drawings of the U.S. Army Corps of Engineers (1966) show material from the levee foundation excavation was placed along the edge of the marsh, resulting in a final levee grade of approximately 9.5 feet.

II Emergency Improvements

In the aftermath of the New Year's Eve 1988 flooding, the City and County of Honolulu took measures to reduce the threat of subsequent flooding to the residential and business areas of Coconut Grove. The City requested and received an exemption from the Special Management Area Ordinance and CDUA process under the emergency clauses to permit removal of vegetation from the marsh side of the Federal levee. In addition to the removal of

Table 2-1

Pertinent Data From Corps of Engineers Design Report (Kawainui)

1. Drainage area	11.2	sq.mi.
2. Hydrologic and hydraulic data		
Design flood, second-feet inflow to swamp	18,100	
Maximum flood of record		
Date	26-27 March 1951	
Discharge, second-feet inflow to swamp	12,300	
Standard project flood, second-feet inflow to swamp	18,100	
Channel capacity, second-feet outflow from swamp	7,350	
Freeboard for design flood		
Channel (minimum above design water surface)	2.0	feet
Swamp levee (minimum above design water surface)	3.15	feet
Velocity of flow, design flood		
Maximum	6.9	feet/second
Minimum	3.9	feet/second
Maximum stage at upper end of channel	6.7	feet, MSL
Maximum swamp stage	7.35	feet, MSL
3. Definite project plan		
Channel		
Length	9,465	feet
Depth	14 - 10	feet
Bottom width	110 & 80	feet
Invert elevation		
Station 0+00	-8.0	feet, MSL
Station 90+00	-6.2	feet, MSL
Station 94+65	-0.2	feet, MSL
Slope of channel invert		
Station 0+00 to 90+00	0.02	%
Station 90+00 to 94+65	1.20	%
Elevation of top of banks	6.0 to 10.5	feet,MSL
Side slopes		
Shoreline to Station 16+00		
Horizontal to vertical	2:1	
Station 18+00 to 94+65		
Horizontal to vertical	3:1	
Bank stabilization	Riprap	
Control structure		
Trapezoidal weir with trapezoidal cross-section and manually operated slide gates		
Length (crest)	262	feet
Width (crest)	4	inches
Crest height	3.0	feet, MSL
Flap gates with auxiliary manual control	8 - 24	inches
Culvert with flap gate which has auxiliary manual control	1 - 24	inches
Levee		
Compacted earth fill		
Combined length	6,340	feet
Height (above base)	0 - 16	feet
Elevation of crown	10.5	feet, MSL
Crown width	10	feet
Side slopes	3:1	
Relocation		
Power lines	3	

vegetation, a compacted base course layer was added to the crest (top) of the levee during the emergency repair work. This has provided some measure of additional freeboard (the vertical difference between the levee and the top of the channel bank) but, because of the permeability of this material (crushed gravel), its effectiveness for prolonged high water levels in the marsh is uncertain.

The principal emergency measure, vegetation removal, resulted in the creation of a new ditch that was effective in keeping water levels below critical stages. The plan of this action is shown in Figure 2-2. Note that a strip of vegetation between 45 to 65 feet of material was removed. Survey sections taken in March 1989, approximately one year after this emergency work, indicate that between 40 to 60 feet of open waterway still exists within the area of the vegetation removal.

The removal of the vegetation was accompanied by the removal of the soil mass bound together in the matrix of roots and decaying vegetation beneath the surface. The survey sections are shown in Appendix A, Section 5. They also show soft sediments generally two feet in depth between levee stations 2+00 and 29+00 resting above the firm bottom. Sediment testing described in Appendix B indicates the sources of this material are predominantly the original material that formed the substrate beneath the former vegetation and soft underlying sediments exposed on the side of the excavation (when vegetation was removed) that has sloughed into the waterway. Although there is sediment in the waterway, it has not impaired its ability to reduce excessive water levels in the marsh. Evidence in support of this statement is presented in Appendix A, Section 4.

A major test of the effectiveness of vegetation removal occurred during April 1989 when a five day storm resulted in 15.7 inches of rainfall at the National Weather Service (NWS) rain gage station No. 787.1 in Maunawili Valley. During the peak twenty-four hour period when data were available, 8.4 inches of rainfall occurred at this station. This was the largest rainstorm since the New Year's Eve flood.

Water level recorders installed in the marsh for the environmental assessment monitored the stages during a portion of this period. Data obtained from these recorders indicated the peak water level elevations at the upstream end of the marsh exceeded 10 feet (msl) and were estimated at 7.7 feet near the edge of the marsh adjacent to the levee. At the time of the peak levels in the marsh, the water level recorders at the Oneawa outlet canal recorded water levels that were only slightly above tidewater levels. Although the retention of floodwater at the upper end of the marsh has not been greatly affected by the emergency actions to date, the ditch has reduced water levels between storms and prevented the marsh level from remaining high so that subsequent storm runoff can be more readily stored.

III Risk Assessment

The analysis of the probability of future floods exceeding the existing levee (contained in Appendix A, Section 4) indicates that the emergency actions to date are not sufficient to prevent flooding to Coconut Grove as specified by the City and County of Honolulu Storm Drainage Standards (Department of Public Works, 1988). For areas larger than 100 acres and all streams, the 100-year recurrence interval flood is the standard which, expressed in probability terms, is a flood with a one percent annual chance of being equalled or exceeded. The estimated probability of marsh flood levels exceeding an elevation of 10.3 feet, the existing elevation at levee station 7+00, is between two to four percent annually. (Levee stationing begins at the Kailua Road end of the levee.)

The purpose of the project is to reduce the economic losses associated with the overflow of flood water into the homes and businesses adjoining the marsh. There were an estimated $10,000,000 in losses in Coconut Grove from the New Year's Eve 1988 flood. The proposed project will reduce damage to homes and businesses from a repeat occurrence of this flood. However, the project will not prevent flood damage from the most extreme floods theoretically possible. None of the alternatives considered can guarantee complete freedom from future flood damage.

Given the above risk assessment, action to reduce the level of risk is being initiated by the City and County of Honolulu. The proposed action will incorporate attainable design criteria of the City and County of Honolulu and will be funded by City and State of Hawaii appropriations.

IV Description of the Proposed Project

The proposed plan consists of opening waterways into the interior of Kawainui Marsh in order to increase the capability of the marsh to distribute and store stormwater runoff, removing vegetation and sediment from previous ponds that provide detention basins and water bird habitat, and constructing a processing facility for materials handling to facilitate long-term maintenance.

The reasons that this plan was selected instead of other alternatives identified in Section 5 are:

a) the proposed action is believed to be the most consistent with the Kawainui Marsh Resource Management Plan (DPED, 1983);
b) the effects upon the existing wetland communities are less disruptive;
c) the estimated construction time is the least; and
d) the plan elements are flexible to permit revisions during the design, for example, changes to the waterway alignments due to environmental concerns.

The plan elements are as follows:

Open new waterways. The purpose of creating the new waterways is to meet or exceed the design objective of providing 3,000 acre-feet of flood storage capacity between the marsh and the top of the levee, the basis for the design of the Oneawa canal/levee size established for the original U.S. Army Corps of Engineers' project (U.S. Army Corps of Engineers, 1957). The present circulation of flood water within the marsh is restricted due to the flow resistance caused by the vegetation.

Water levels recorded on gages during recent floods and hydraulic model studies described in Appendix A, Section 4, point to the fact that the marsh drains from the upstream end of the City and County emergency ditch. The present circulation of flood water within the marsh interior is restricted due to the flow resistance created by the friction and physical obstruction of the marsh vegetation. Evidence cited for this in Appendix A, Section 4, shows a change of approximately one foot in only 1000 feet between the upstream end of the City and County ditch and a gage located in the interior. Rather than moving swiftly into the interior, the water is stored at the upstream end until the height exceeds the top of the levee.

Removing vegetation from the ponds that have been formed over years of flood activity will improve the transport of water debouching from Maunawili and Kahanaiki Streams directly into the proposed waterways. It will also enable maintenance equipment to remove sediment that has accumulated in these ponds over many years. The ponds are bordered for the most part by floating mats of California grass (*Brachiaria mutica*) and honohono grass (*Commelina diffusa*). The presence of the ponds is due more to the absence of vegetation at the water table surface than the presence of soil or rock sides to hold water. In the short-term, making the ponds deeper below the water table would mean they will presumably be filled with water at the start of the design flood and thus not provide additional retention storage. The normal water level in these ponds is between approximately 3 to 4 feet, mean sea level (msl). During the design storm condition, it was assumed this water level had already risen to 5 feet msl *before* the start of the design flood. This is a reasonable assumption because a flood of design proportions is likely to have been preceded by weeks of heavy rains which partially filled the marsh. There are some practical limits as to how high antecendent levels will rise, however, that are discussed in Appendix A.

Increasing the size of the ponds may have some habitat, recreational or aesthetic value but it has marginal significance for flood control because the bordering vegetation is normally buoyant and thus will rise as the water level rises. In other words, the floating vegetation doesn't reduce storage in the short time frame of flood events, but it certainly restricts movement of water to portions of the marsh where it can be stored below the elevation of the levee. Therefore clearing the ponds, particularly of troublesome water hyacinth (*E. crassipes*) is planned to reduce clogging in the channels. Over the long-term time frame of marsh evolution, infilling by terrigenous sediment and organic decomposition will raise the soil surface above the saturation level which will raise long-term flood levels. Maintenance may help to prolong existing water levels.

Opening waterways into the interior will decrease the time for internal distribution of flood water and will reduce storage at the upper end of the marsh. This will result in lower flood levels at the upstream end next to the levee. Traditional hydrologic methods based upon reservoir routing analysis ignore the friction that occurs from water flowing through vegetation. The studies described in Appendix A, Section 4 show this friction requires additional energy to force water to the outlet. The additional energy requirement is created by higher water levels at the upstream end which also results in the overtopping of the levee. To reduce this resistance, approximately 10,000 lineal feet of additional waterway length will be created. When this is added to the existing emergency ditch (between the proposed weir and the upstream end), there will be a total of 15,500 lineal feet of waterway created. Assuming the average waterway width of the new waterway is 50 feet, this will provide 10 acres of additional open water.

Three means are proposed to open waterways: 1) mechanical removal; 2) explosives to blow apart the vegetation mat, and 3) herbicides.

The initial method of vegetative removal will be to place explosives in holes set below the top of the mat. These holes will be a few feet apart along the proposed waterway alignment. The elevation of the bottom of the charge will vary. Where peat deposits are deep, charges will be set deep to excavate the material which will otherwise fill in the newly formed waterway; where submerged vegetation occurs at shallow depth, charge depth will be minimized. The range of placement is expected to vary between 5 to 15 feet below the surface.

The hydraulic analysis of the waterways assumes the sediments have a maximum elevation of +2 feet, msl. The charges are required to be set sufficiently below this level to allow for some loose sediments to slough into the bottom of the excavation without filling the excavation above 2.0 feet, msl after the initial displacement of vegetation and soil by the blast. Sufficient clearance must be provided to allow for operation of the maintenance equipment barges which will have a draft of approximately 18 inches.

Mechanical means will be used to remove vegetation from waterways in close proximity to the residential areas, sensitive water bird habitat, and some portions of the waterway in the northwest corner near the model airplane field where the mat is not as dense. The exact type of machinery will depend upon the type of bids received and their evaluation by the City and County of Honolulu for the construction and maintenance contract. In general, it is recommended that the machinery be equipped with attachments that can pull up the roots of plants rather than merely cut and spray the vegetation. This is to reduce the propagation potential of the cuttings and also to reduce the accumulation of sediments.

If locally procured equipment is selected, it is envisioned that conventional cranes could tractor on top of planking on segmented barges along the waterways and, using a claw, remove vegetation and load it into a barge behind it. A floating suction pump will follow behind this crane to suction loose sediment that falls from the vegetation as it is removed. The depth required for the equipment to float through the marsh by this procedure is sufficient to create the depth of waterway required according to the hydraulic analysis. If specialized aquatic plant harvesters are procured from the mainland, manufacturers should provide additional attachments for loading the vegetation onto barges as well as basic equipment for removal. Ideally, the equipment should include a rototiller to root out plants, a rake or claw to draw the material to the barge, a clam bucket to remove sediment and vegetation into small material barges, and a dredge pump for maintenance dredging.

The top width of these waterways will be approximately 50 feet wide, though the edges will be irregular. Assuming the marsh level is 3.5 feet, msl, the depth of the waterways after construction will be a minimum of one and one-half feet. The maximum will depend upon the existing bottom which can be much greater than one and one-half feet in depth once the floating mat is removed.

The alignment will be generally as shown on Figure 2-3. Two considerations affecting waterway alignment are potential effects on waterbird habitat and on archaeological artifacts. Fortunately, the waterway alignments do not need to be linear and can vary several hundred feet without significantly varying the results from a hydraulic engineering standpoint.

Portions of the waterway alignments closest to the endangered waterbird habitat have been inspected by the U.S. Fish and Wildlife Service (USFWS) personnel to determine if any significant nesting areas are at risk. None were identified.

Given known archaeological resources in other portions of the marsh not encompassed by the waterways, it was potentially possible that adverse effects might occur. To identify these potential effects, additional soil sediment samples were taken along the alignments prior to construction for the purpose of identifying areas of concern and changing the alignments as necessary. The types of analyses were determined in consultation with the State Historic Preservation Office (SHPO) and performed by qualified archaeologists. As a result of the investigation, no significant impacts to archaeological features are expected. However, as a precaution, an archaeologist will be present during explosives work and all work halted if any indication to the contrary develops. SHPO will be consulted to determine mitigative actions.

→ Water hyacinth at the waterway inlets pose a threat because the plants can be dislodged by floods, as was witnessed during the flood in 1988, and can close the inlets. Another concern is that propagules will overgrow the water surface before maintenance equipment can be mobilized. Applications of herbicide are proposed. Three brand names are identified in Appendix B, Section 5 that are considered safe for application. One includes the herbicide Rodeo which has been approved once before (aerial application in 1988) for use in the marsh. The first proposed application will be with Rodeo. It will be broadcast by helicopter over the proposed waterway alignment including the open water ponds to the south of the inlets prior to the initiation of blasting. The second application will be made from a boat after the waterways are opened.

There are a number of other methods available to manage the vegetation of Kawainui Marsh. These include the use of fire, grazing, and other biological and other chemical control methods. These are discussed and evaluated in Appendix B, Section 5. They require further research and public discussion, however, and may be appropriate in long-term resource management plans.

Maintenance facility and operation plan. The maintenance of the waterways and the ponds at the upstream end of the marsh is an important portion of the proposed action. Preferred waterway maintenance methods in order of priority are 1) mechanical harvesting, 2) chemical control, and 3) excavation using explosives. The proposed action requires continuous maintenance by floating equipment to harvest new vegetation growth, floating peat deposits, and sediment deposits. Besides the two initial applications of herbicide glyphosate (tradename for product containing this chemical is Rodeo) to control water hyacinth and other vegetation types in the new waterways, additional yearly applications may be required to control extraordinary growth areas that exceed the removal capacity of the mechanical equipment. The period during which these additional applications might be made and studied for possible adverse effects is two years after the initial application. During permitted months, in order to clear waterways in which peat has been dislodged and blocks flow paths, additional blasting may be requested using the environmental permit process (SMA and CDUA).

Vegetation that grows in the waterways and ponds after initial construction will be removed by mechanical means and barged to the handling/dewatering area shown on Figure 2-3. The exact type of equipment depends upon the contractor's bid for the project. Each bidder will have to comply with the technical specifications of the contract. These will include minimum waterway area to be cleared and alignment, periods of operation, environmental safeguards including procedures in the event buried items of archaeological significance are unearthed, removal and disposal of green vegetation, peat and sediment, and water quality monitoring.

The operation plan for the waterways will encourage the removal of vegetation from existing ponds and new waterways to the winter season. Floating vegetation is to be taken to the disposal area. Sediment removal is to be encouraged in the summer season within open water areas to reduce the possibility of destroying nests hidden in vegetation. Coordination with fish and wildlife personnel will be required to identify nesting sites and schedule operational areas in order to minimize disturbance during nesting. Spraying will be conducted in the early spring when plant activity results in new shoots and carbohydrate levels in the stem-bases is low.

Materials removed from the marsh will be handled differently depending upon their characteristics. Sediments will be pumped from transport barges or temporary pipelines into drying beds. Drying beds will be lined to limit the amount of percolation into the unconsolidated landfill material in order to reduce the potential for leachate problems. Additional testing (described in Appendix B) done on the soil sediments along the proposed alignments did not identify potential pollution problems due to metals in the return waters decanted from the sediment drying basins. Periodic testing during the first two years of operations will be part of the contract specifications.

Green vegetation may be utilized by private commercial firms as an additive to anaerobic digesters to provide bulking and nutrient supplements. Vegetation needs to be drained and compacted to facilitate transportation off the site on public roads; however, dewatering is not essential and in fact detrimental in terms of the value of the final byproducts. Handling facilities will be required to provide for this type of vegetation. When conditions require disposal of the material in a landfill, special drying of this material will be provided in drying beds that are also used for soil sediment during the summer.

Peat and sediment must be dried to at least 40 percent solids by weight for disposal in the landfill. The material will be dried with the residue green harvest in drying beds to allow sufficient time for this dewatering to take place and to stabilize the organic decomposition once the material is exposed to aerobic conditions.

V Project Costs

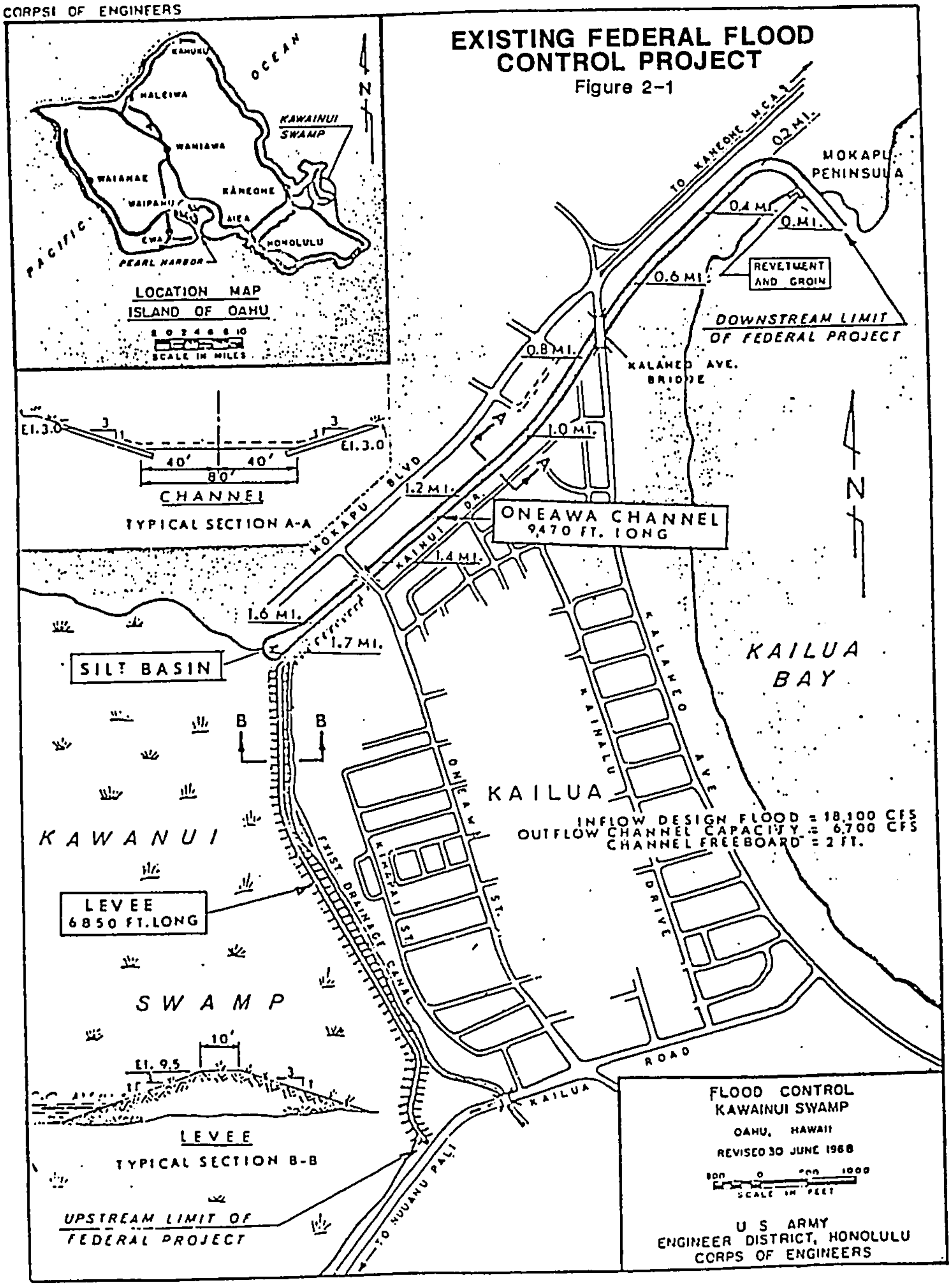
Total construction costs for all of the proposed action elements are estimated at approximately $4,112,000, including herbicide application. The costs are shown in Table 2-2. Appendix A, Section 12 provides a detailed basis for the cost estimates. In addition, this section provides two estimates from suppliers of aquatic plant control equipment of the costs to maintain the proposed waterways.

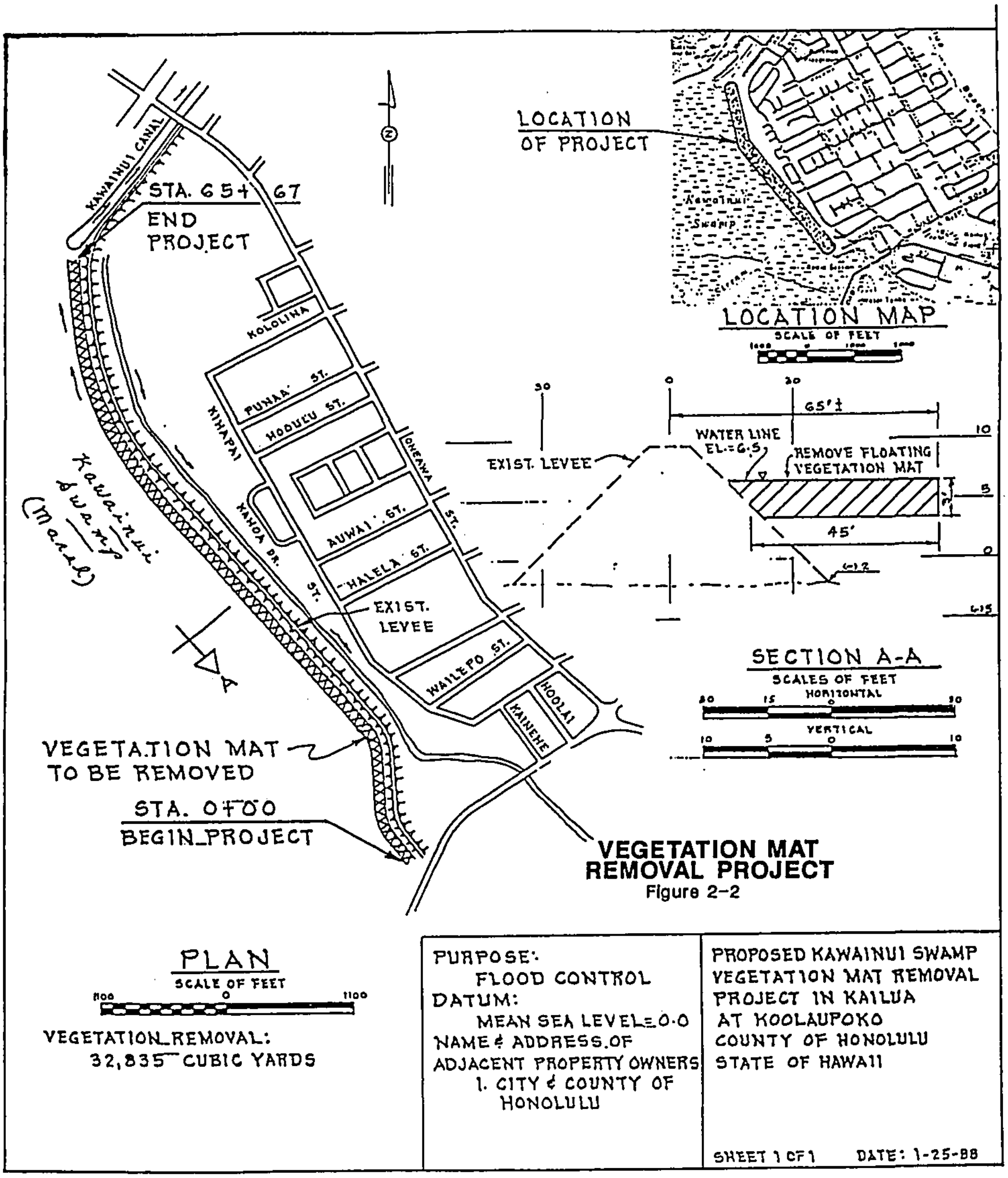
The equipment purchase costs range from $457,900 to $704,100 approximately; the latter costs being based upon a more realistic estimate of the removal requirements. This cost would have to be amortized over the life of the maintenance contract along with other contractor costs including labor, profit, and performance bonding.

Table 2-2

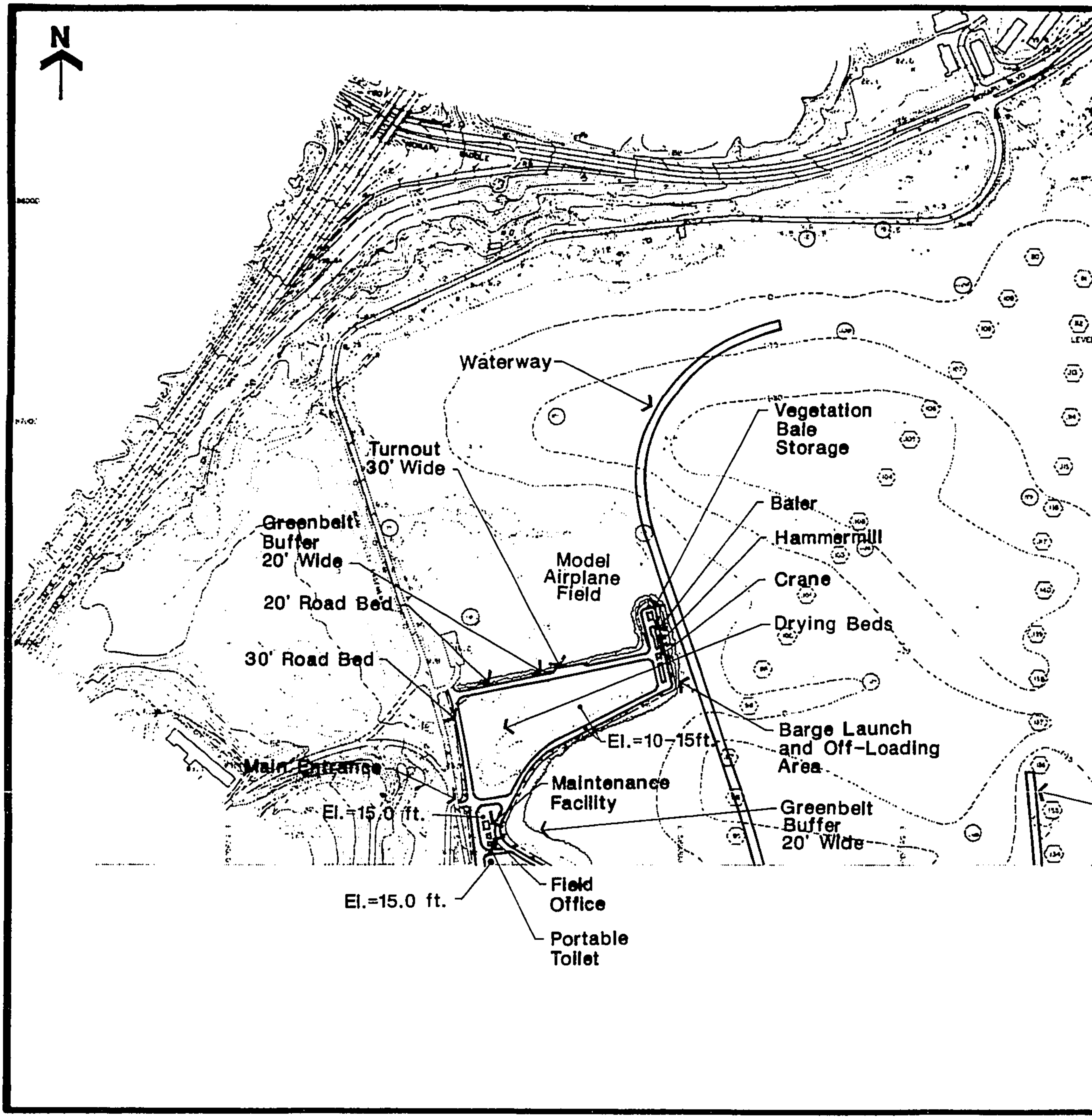
Proposed Action Construction Costs
July 1991 Price Level

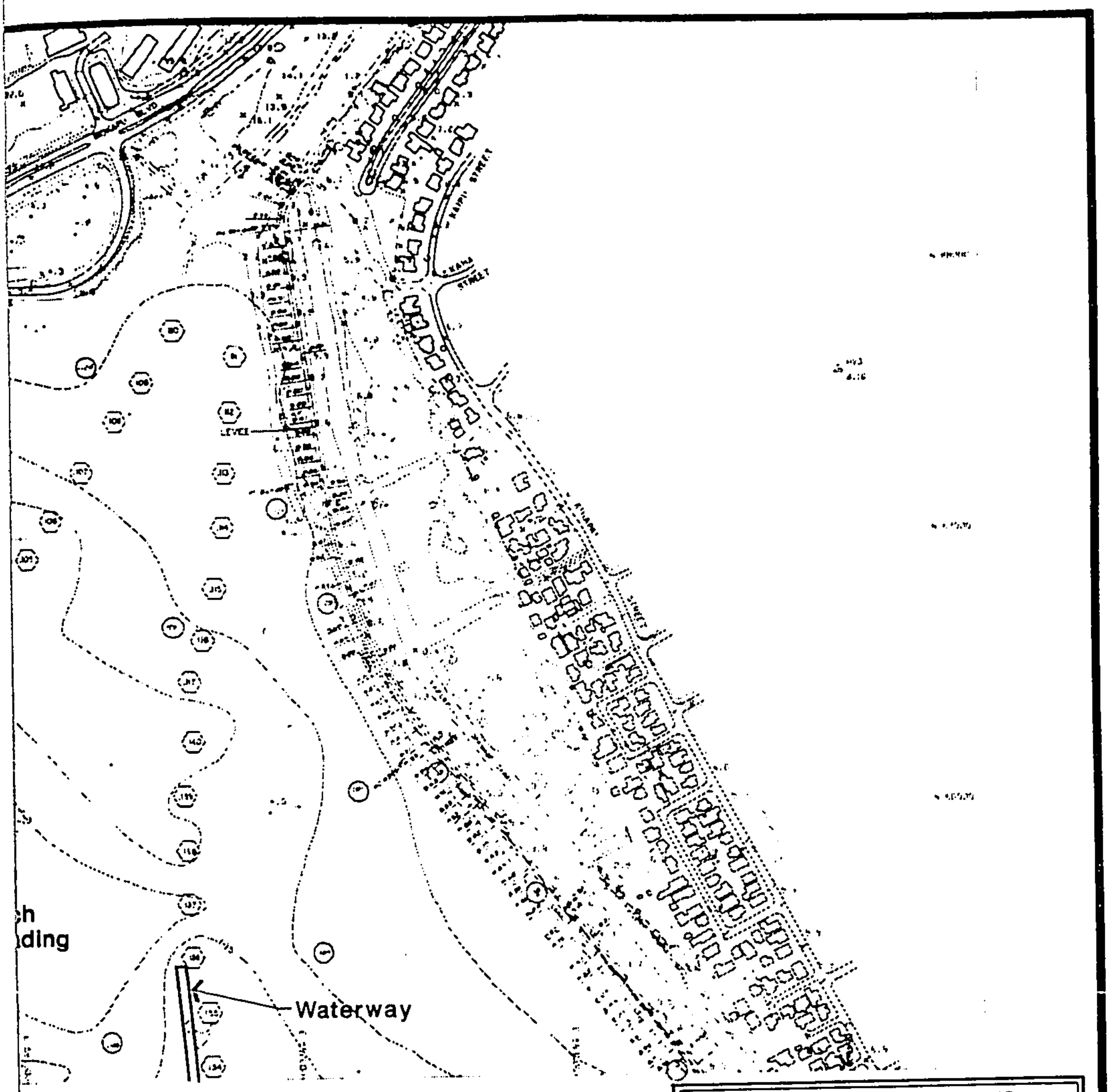
Item	Description	Material	Sub-contractor	Labor	Equipment	Total
100	Mobilization	$ 18,884		$ 24,676	$ 9,072	$ 52,632
200	Processing Fac.-Utilities/Roads	658,915	184,248	203,174	58,675	1,105,012
300	Processing Fac.-Vegetation Handling	287,325		53,491	14,741	355,557
400	Processing Fac.-Sediment	2,099,575	3,820	109,064	29,036	2,241,495
500	Channel Clearing	78,850		221,350	47,500	347,700
Total		$3,143,549	$188,060	$611,755	$159,024	$4,102,396


CORPS OF ENGINEERS
EXISTING FEDERAL FLOOD CONTROL PROJECT
Figure 2-1
LOCATION MAP
ISLAND OF OAHU
SCALE IN MILES
OCEAN
PACIFIC
KAHUKU
HALEIWA
WAHIAWA
WAIANAE
WAIPAHU
KANEOHE
AIEA
EWA
HONOLULU
PEARL HARBOR
KAWAINUI SWAMP
CHANNEL
TYPICAL SECTION A-A
El. 3.0
40'
80'
MOKAPU PENINSULA
TO KANEOHE M.C.A.S.
REVETMENT AND GROIN
DOWNSTREAM LIMIT OF FEDERAL PROJECT
KALAHEO AVE. BRIDGE
0.2 MI.
0.4 MI.
0.6 MI.
0.8 MI.
1.0 MI.
1.2 MI.
1.4 MI.
1.6 MI.
1.7 MI.
MOKAPU BLVD
KAINUI DR.
ONEAWA CHANNEL
9,470 FT. LONG
KAILUA BAY
SILT BASIN
KAILUA
KAWANUI
SWAMP
INFLOW DESIGN FLOOD = 18,100 CFS
OUTFLOW CHANNEL CAPACITY = 6,700 CFS
CHANNEL FREEBOARD = 2 FT.
KALAHEO AVE
KAINALU DRIVE
ONEAWA ST.
KIHAPAI ST.
EXIST. DRAINAGE CANAL
LEVEE
6850 FT. LONG
El. 9.5
10'
LEVEE
TYPICAL SECTION B-B
UPSTREAM LIMIT OF FEDERAL PROJECT
TO NUUANU PALI
KAILUA ROAD
FLOOD CONTROL
KAWAINUI SWAMP
OAHU, HAWAII
REVISED 30 JUNE 1968
SCALE IN FEET
U S ARMY
ENGINEER DISTRICT, HONOLULU
CORPS OF ENGINEERS



VEGETATION MAT REMOVAL PROJECT
Figure 2-2


N
Waterway
Turnout
30' Wide
Vegetation
Bale
Storage
Baler
Greenbelt
Buffer
20' Wide
Hammermill
Model
Airplane
Field
Crane
20' Road Bed
Drying Beds
30' Road Bed
Barge Launch
and Off-Loading
Area
El.=10-15ft.
Main Entrance
Maintenance
Facility
El.=15.0 ft.
Greenbelt
Buffer
20' Wide
El.=15.0 ft.
Field
Office
Portable
Toilet

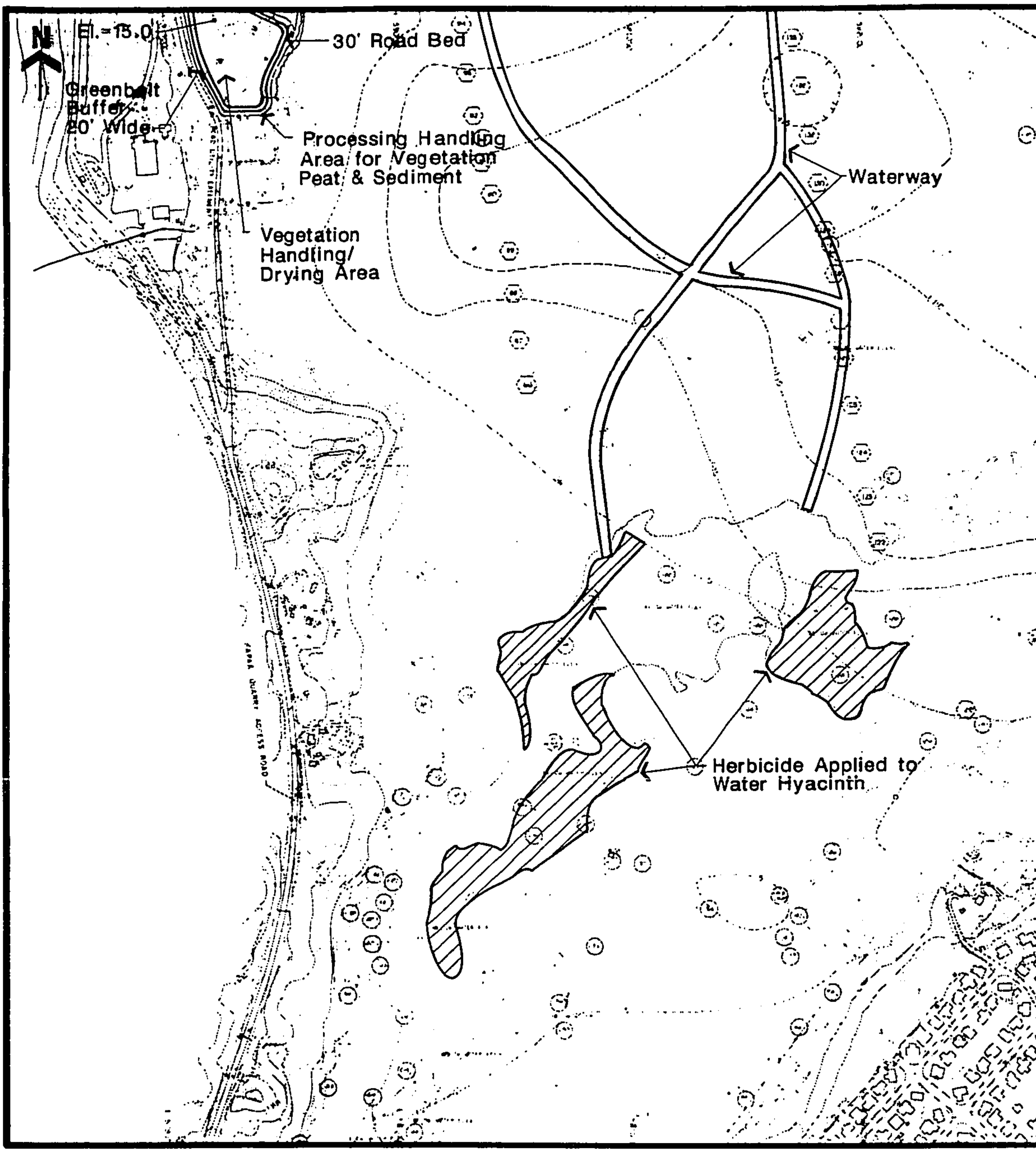


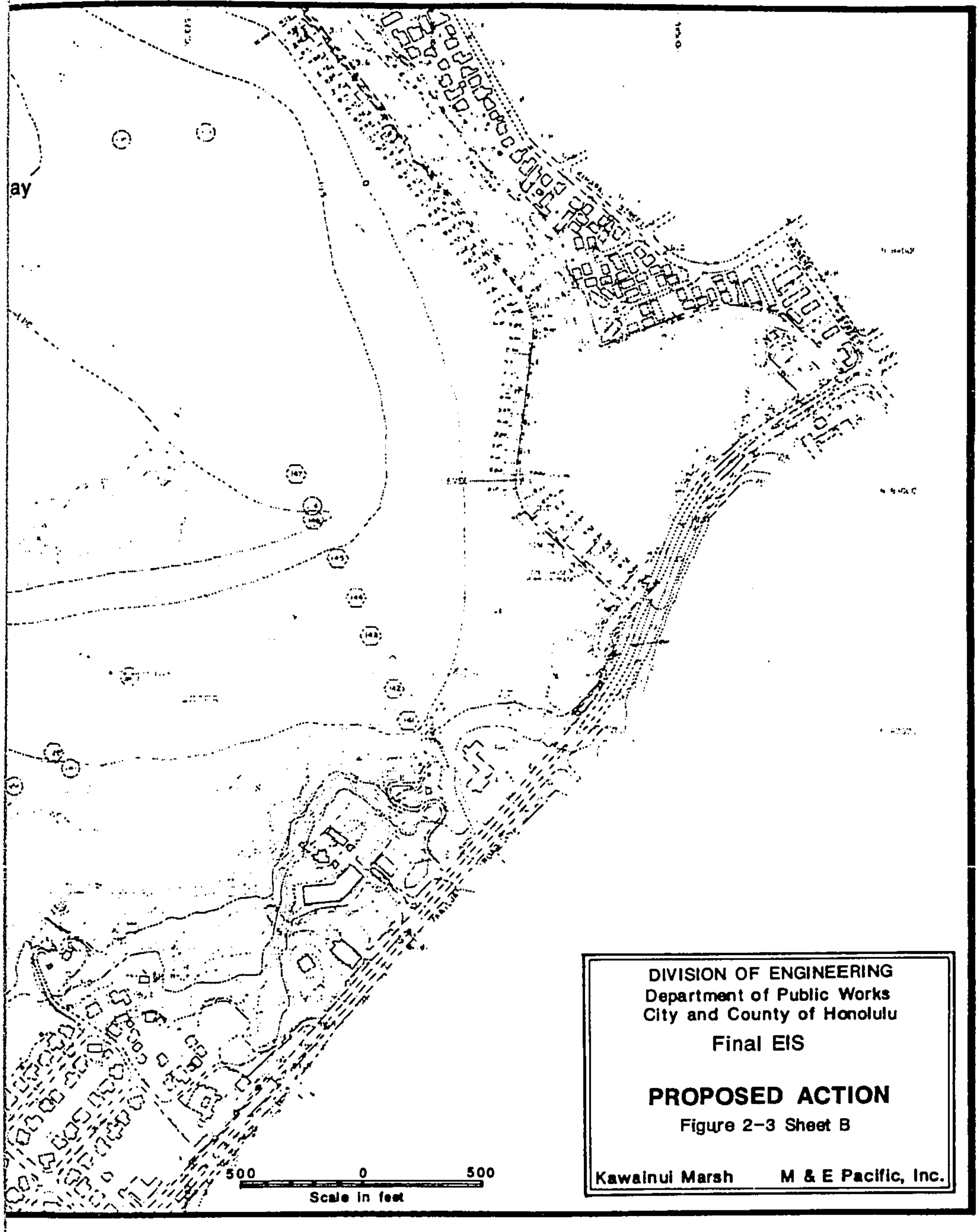
500 0 500
Scale in feet

DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu
Final EIS

PROPOSED ACTION
Figure 2-3 Sheet A

Kawainui Marsh M & E Pacific, Inc.


El.=15.0
30' Road Bed
Greenbelt Buffer 20' Wide
Processing Handling Area for Vegetation Peat & Sediment
Vegetation Handling/ Drying Area
Waterway
Herbicide Applied to Water Hyacinth



DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu
Final EIS

PROPOSED ACTION

Figure 2-3 Sheet B

Kawainui Marsh M & E Pacific, Inc.

SECTION THREE

DESCRIPTION OF THE ENVIRONMENT

I Human Environment

Overview

Kawainui Marsh is the largest remaining wetland in the State of Hawaii. Located at the base of the Ko'olau Mountains on the Island of Oahu, it consists of approximately one thousand acres. The marsh contains resource values beyond the open vistas it affords between sea and mountain. It is the habitat for a diversity of organisms that include four endangered Hawaiian waterbird species, and is the site of early Hawaiian fishponds and wetland agriculture. It serves as a flood retention basin for protecting Kailua Town and as a nutrient and sediment sink to protect the waters of Kailua Bay. It also provides recreational and educational potential for the people of Oahu and the state.

Kawainui Marsh was once a marine embayment open to the sea until about 2,800 years ago when the Kailua sand barrier first began to form. It is believed that the entire area of Kawainui Marsh was and remained a large lagoon until about 400-500 years ago when infilling of the peripheral portion of the marsh began. It is bordered on the west and north by the Kapaa and Kalaheo sanitary landfills and the Ameron rock quarry, on the south and southeast by Kalanianaole Highway/Kailua Road, and on the east by the residential area of Coconut Grove.

Kawainui Marsh has evolved, is influenced by, and derives much of its value in the context of the growth, development and urbanization of Oahu (Figure 3-1). Kawainui is a predominant feature in the environment of the Kailua area and the overall Koolaupoku district of windward Oahu. The population in this area alone has grown from 5,258 in 1930, to 92,219 in 1970, to 114,000+ in 1985 (Hawaii Data Book, 1988). The focus of the marsh has changed significantly from the early documented times as an abundant producer of fish and agriculture crops to the current need for flood control and historic/biological protection.

Coconut Grove is the most prominent urban feature in the project area, and the area most susceptible to flooding. It lies directly east of Kawainui Marsh, between the marsh and Kailua Bay. The community measures approximately one and a half miles long in a north-south axis and slightly less than a mile wide in an east-west axis. The houses are built on low-lying coral sands derived from dune formations along the coast that were leveled to construct house lots. The houses closest to the marsh generally are in soggy, less permeable soil with higher organic content at slightly lower elevations compared to more seaward portions of Coconut Grove.

Castle Memorial Hospital is the most prominent landmark in the Pohakupu-Olomana urban subdivisions clustered around the intersection of Kalanianaole Highway and Kailua Road to the south of the marsh. This area is at a higher elevation than Coconut Grove and is not affected by the level of water in the marsh.

A third urban area lies outside of the marsh but has considerable effect upon it. This is Maunawili subdivision, located in Maunawili Valley south and up-gradient of the marsh. This valley is drained by the two streams that flow into the marsh, Kahanaiki and Maunawili. A golf course is under construction in the area.

In addition to increased residential growth, industrial use of the area has contributed to the current status of the marsh. Over the years as many as four sewage treatment plants have discharged effluent directly into Kawainui. Only one, the Maunawili Estates subdivision station upstream from the marsh, is still in operation. There is also an active land quarry and rock crusher adjacent to the marsh and for years there was a large auto junk yard in operation along the northern edge of the marsh. The City and County has also used the area as a landfill since the early 1960s mostly to accommodate the population growth on windward Oahu.

Within the overall planning area of the marsh there are also other established facilities such as churches, a model airplane field, single family dwellings, a hospital and YMCA. Land use and zoning are shown on Figure 3-2. At present these uses of the land are not considered incompatible with the overall goals to increase the flood control of the marsh while preserving the unique characteristics of Kawainui (RMP, 1983).

The State of Hawaii is in the process of purchasing a parcel of land at the southeast corner of the marsh known as the "ITT parcel" (see Figure 3-2) and, through the State Department of Land and Natural Resources (DLNR), develop it as an interpretive nature center for the marsh. The 1983 state-sponsored Kawainui Resource Management Plan identified Oneawa canal as a potentially valuable recreational boating resource and suggested expanding the estuary recreational boating activities. Ultimately, non-motorized boating for educational purposes may be deemed compatible with the wildlife and waterfowl aspects of the marsh and utilize any open waterway or channel through the marsh as an opportunity for people to learn more about the marsh in a controlled manner.

Kawainui has many special facets and uses. High among these features is its use by the public for passive recreation, research and education. A current example of public use is the guided educational tours of the marsh, using both local and mainland resource experts, that are regularly conducted by the Kawai Nui Heritage Foundation. A comprehensive educational source book, slide show and video have been developed which highlight the evolution, cultural significance, wetland values, flora, fauna and ethnobotanical features of the area. In addition, numerous neighbors of the marsh take walks, jog and conduct incidental nature study along its boundaries.

Aesthetics

Kawainui Marsh is the most substantial aesthetic resource in the project area. The wide and flat expanses of diverse wetland plants, isolated stands of paperbark trees, and elevated forested fringe provide a dramatic foreground view plane for the spectacular foothills and steep volcanic slopes to the west. It also affords visual diversity from the prominent urban character of the lands to the east and north of it when viewed from vantage points to the south and west.

The primary aesthetic considerations currently focus on the areas surrounding the marsh basin. The wilderness character of the marsh should be promoted through rehabilitation, landscaping and management. The drive-in theater, the landfill operation, the auto junkyard and other urban uses of the surrounding lands are identified as being incompatible with the visual qualities and natural area aesthetic appeal of the marsh.

Historical Perspective

There is evidence that Kawainui Marsh was once a bay open to the Pacific Ocean. The ancestral Kawainui Bay of some 4,000 to 6,000 years ago became a lagoon somewhere between the third and sixth century A.D. The early Hawaiians may have accelerated Kawainui's evolution from lagoon to marsh through the construction of fish ponds and taro walls to impede the flow and ebb of both fresh and sea waters through the lagoon. While the walls of the fish pond have not been located, further research could add to the mounting evidence of the presence of the early Hawaiians and their habitation and manipulation of this environment.

Taro farming was carried out on the higher areas. Portions of the marsh that were once used for taro cultivation are presently covered by *Brachiaria* (California grass). The area now covered by the bulrush population was probably open water kept that way by massive efforts each year to remove the vegetation. The drainage system was such that water first entered the upper taro patches, flowed into the fishpond, through the lower taro patches, and into Kaelepulu Pond. When the lower taro patches dried, the water was diverted directly into

Kaelepulu Pond and out to the ocean. This provided a natural wastewater treatment system for the culture of fish, and also afforded the growth of a source of plant starch for domestic consumption. Once the waters reached Kaelepulu Pond, they were probably brackish. This elevated salinity (brackishness) was encouraged where the fishpond(s) lay by the sea, by keeping the mouths of the streams cleaned to allow saltwater intrusion of the fishponds.

In 1851, the present Enchanted Lakes (Kaelepulu Pond) was still a fishpond with an open connection to the sea (Smith, 1978). With the disruption of Hawaiian society after the arrival of the Europeans, the fishponds were one of the first things to disappear because of a lack of maintenance. Taro and dryland (kula) farming, however, continued above and below the marsh. There existed still a substantial body of open water in the marsh which at one time had an area of 180 ha (445 acres), corresponding with some of the area now covered in peat, since this peat probably formed in the lake body after its abandonment as a fishpond.

Active anthropogenic management of the marsh waters began with fish farming and continued with the marsh being used as a source for irrigation water. Between the years 1860 to 1876, rice farming began on the windward side of Oahu with the conversion of former taro lands to rice pond fields. Weirs were constructed to prevent the intrusion of seawater; thus, the area became a freshwater environment, with the marsh now serving as a reservoir for irrigation waters.

In 1878, the Waimanalo sugar plantation was established, drawing irrigation water from the marsh through a weir downstream of Kailua Road on Kaelepulu Stream. Until 1950, the marsh was dammed during the winter to conserve water. In 1926, the Kaneohe Ranch planted *Brachiaria mutica* as pasturage for cattle, and utilized the fresh water to maintain the grass. Rice farming ceased to be important between 1900 and 1934.

Cultural Resources

Kawainui, the Kailua area, and the Koolaupoku district are significant in the history of the Hawaiian people. The area contained an extensive system of taro patches and was well known because of its large fishpond. Figure 3-3 shows the location of significant archaeological and historic sites that are known at this time. Archaeological studies have identified a number of significant sites in the Kawainui Marsh area (Table 3-1). Some of these sites have been recommended for preservation and others for salvage excavations. The sites recommended for preservation require protection and maintenance for continuing public use.

TABLE 3-1

KAWAINUI MARSH ARCHAEOLOGICAL SITES

as noted on map

Bishop Museum site no.	Clark (1980b & c)	Cordy (1977 & 78)	Ewart & Tuggle	State site number (HPO)	Site description	Site Name TMK Owner
50-Oa-G6-32	cluster 1	site 1	site 1	80-11-2022	series of terraces from marsh edge up edge of slope, a long retaining wall upslope, ruins of a historic house, a spring excavation yielded charcoal dates in the range of A.D. 353-655 and A.D. 529-965. Artifact found on surface.	Kawainui Terraces 2022 TMK 4-2-13:38 Henry Wong
"	" 2	" 2	" 2	3957	9 dryland agricultural terraces, 20 mounds, small c-shaped structures, walls, a walled depression, remains of a historic structure; surface artifact recovered	Kawainui Agricultural Complex 3957 TMK 4-2-13:38 Henry Wong
"	" 3	" 3	----	3958	terraces, walls, 38+m long and 28+m long	Kukanono Terraces 3958 TMK 4-2-13:31 or 38 Henry Wong or YMCA

50-Oa-G6-32	cluster 4	site 3	site 3	3959	26 mounds, 19 dryland agricultural terraces, linear walls, one 53m+ long, a historic house foundation, a prehistoric basalt mirros found on surface and other prehistoric basalt artifacts, large boulder grindstone; historic artifacts; date ranges from A.D. 1362 + 70 to A.D. 1742 + 70	Miomio Agricultural and Habitation Complex TMK 4-2-13:38 Henry Wong
"	" 5	" 5	——	3960	a large lo'i c. 40 x 30m, a stone and earthen platform, a stone-lined channel 10m long, stone mounds	Pohakupu Agricultural Cluster 3960 TMK 4-2-13:38 Henry Wong
"	" 6	" 6	——	3961	stone mounds, a stone-edged canal, terraces, retaining walls	Kukanono Cluster 3961 TMK 4-2-13:38 Henry Wong
50-Oa-G6-34	cluster 7	——	site 4	2024	mounds, wall remnants, a terrace	Makalii Slope C;ister 2024 TMK 4-2-13:10 Iolani School
"	" 8	——	" 5	3962	3 historic buildings	Makalii Historic Site 3962 TMK 4-2-13:10 Iolani School

50-Oa-G6-34	cluster 9	----	site 6	3963	earthen mounds	Makalii Mounds 3963 TMK 4-2-13:10 Iolani School
50-Oa-G6-33	cluster 10	----	----	2023	12 features: retaining walls, L-shaped alignment of rocks, terraces, a road-bed, a level terrace or platform; surface artifacts; excavation yielded radiocarbon date of the 8th century and volcanic glass dates were supportive: A.D. 780 and 900	Kawainui Cluster 2023 TMK 4-2-13:10 Iolani School
"	" 11	----	----	2023	2 retaining walls	Kawainui Cluster 2023 TMK 4-2-13:10 Iolani School
50-Oa-G6-36	cluster 12	----	----	2026	a large agricultural terrace: 65m long along marsh edge in a NE-SW direction, 14m SE-NW; walls single-course high; rusting crane 80m n of site	Kapaloa Agricultural Terrace 2026 TMK 4-2-13:10 Iolani School
"	----	----	site 7	3965	low stone terrace perpendicular to stone wall; abut at SE corner	Pohakea Terrace 3965 TMK 4-2-13:10 Iolani School
"	----	----	" 8	3964	recently abandoned house	Kaeleuli House Site TMK 4-2-15:06
"	----	----	" 9	3964	recently abandoned house	Michael Baldwin Tr. etal

50-Oa-G6-37	cluster 15	----	----	2027	stone-walled enclosures, linear pile of rocks, terraces, surface artifacts	Kukanono Habitation Site 2027 TMK 4-2-13:38 Henry Wong
50-Oa-G6-38	cluster 14	----	----	2028	2 walls which meet at a right angle; one runs along an old road bed; behind Castle Memorial Hospital; probably historic	Ulukahiki Walls 2028 TMK 4-2-06:4 Or 7 Castle Memorial Hospital
50-Oa-G6-39	cluster 13	site 7	----	2029	large agricultural complex of rectangular fields, probable water channel; excavation yielded basaltic glass date A.D. 1738 + 34 years as well as large taro root stains and taro pollen	Kawainui Marsh Site 7 TMK 4-2-13, 14, 16, 06 Various owners
50-Oa-G6-40	Wheeler 1981			2030	excavation exposed a truncated cultural layer under modern fill and overlying beach sand producing prehistoric artifacts. Dates obtained were between A.D. 1374 to 1630	Kihapai Occupation Site 2030 TMK 4-3-57:65 City & County
50-Oa-G6-41	Athens 1983			2031	evidence for prehistoric occupation were many surface artifacts; corrected carbon dates range A.D. 1240-1385	Kawainui Slope Site 2031 TMK 4-2-13:38 Henry Wong

Legends associated with Kawainui Marsh include: "Menehune," a legendary people who accomplish great works at night; a "mo'o," guardian spirit of the fishpond who took the shape of a lizard; and the "makalei," a supernatural, fish-attracting tree.

Kawainui is significant for an understanding of prehistoric Polynesian migration, settlement and cultural development as well as for learning more of the Hawaiian natural and cultural history (Kelly, 1981).

A portion of Kawainui Marsh was determined eligible for inclusion on the State and National Register of Historic Places in 1979. The marsh as a whole was a significant prehistoric occupation area as evidenced by Hawaiian legend, extensive agricultural systems, ceremonial sites, burial sites, and habitation areas. Two adjacent large Hawaiian heiau (stone platform temples), Ulupo and Pahukini, are on the National Register of Historic Places. The agricultural site cluster below Ulupo Heiau which lies immediately adjacent to the marsh has been called possibly the earliest agricultural field dated in the islands thus far.

Archaeological and geological studies show the marsh to have been a marine embayment within the prehistoric period. Aerial photographs taken in 1940 document the presence of several hundred small taro pond fields (lo'i) in the narrow, southern portion of the present marsh. Under the Hawaiian irrigation-drainage system, water from Maunawili and Kahanaiki Streams passed through the upper lo'i carrying organic nutrients into other Kawainui taro fields. Houses and upland gardens (kula) were concentrated along the Kukanono-Maunawili slope and on the rise between Maunawili and Kahanaiki Streams (Cordy, 1977). A series of berms or narrow roadways are seen traversing the marsh in old aerial photographs. Remnants of some of these berms, perhaps used to gain access for agricultural use of the marsh, may remain to this day. Unusual alignments of paperbark trees (*Melaleuca*) may mark the location of some elevated berms.

For the most part, archaeological survey work in the marsh has been limited to surface surveys. Many of the extensive cultural and archaeological resources including the buried agricultural fields that contain a stratigraphic record of the human land use in the marsh lie below the surface. An intensive sediment coring study has been undertaken in an attempt to determine what effect the proposed project will have on archaeological resources. This study was coordinated with and reviewed by Dr. Joyce Bath of the State Historic Preservation Office. Ten core samples were taken at 1000-foot intervals along the proposed waterway alignments. The analysis of samples from these cores will provide chronological, paleo vegetation and sedimentary information on the subsurface environment to be impacted by blasting. The analysis will include C14-dating, lead isotope dating, clay mineralogy organic matter percent and pollen analysis. In addition, marine shells have been collected for identification and heavy metal analysis was conducted. The work allows for a comprehensive interpretation of the paleoenvironment of the marsh although its primary purpose is to assess archaeological impact of the proposed channel construction. Contract specifications have been prepared in draft form that address data recovery during construction.

Archaeologists have covered the area on foot during the coring field work. The environment varies from open water to heavily vegetated marsh, with a vegetation mat floating on 10-15 feet of water. No archaeological features were observed. A report on the results of this archaeological survey and early analyses of the core samples is included in Appendix B, Section 6.

The State Historic Preservation Office will continue to be consulted as work progresses. In the event that any unanticipated sites or remains are discovered, work will be stopped until SHPO has been notified and can assess the potential impacts of the project.

Because the proposed action will occur outside of the area that is eligible for inclusion on the State and National Register of Historic Places and will not utilize federal funds or require a federal permit, compliance with Section 106 of the National Historic Preservation Act is not applicable.

Land Ownership

The City and County of Honolulu owns approximately 750 acres of the marsh interior, while the periphery is state and privately owned. The largest private periphery landowner is Harold L.K. Castle (Kaneohe Ranch Co., Ltd.) and the second largest is Henry H. Wong. Figure 3-4 shows land ownership status in the marsh.

The State of Hawaii has acquired or has in condemnation approximately 182 acres scattered around the marsh and has identified another 65 acres to be acquired in the future. For all discussions concerning flood-control, the City and County has both ownership and responsibility.

A primary conclusion of the Resource Management Plan is that existing land ownership patterns and controls would make broad multi-resource management most difficult. The Plan recommends that all private lands adjacent to the marsh basin that have cultural and natural significance be acquired by the state. Similarly, the study recommended that county-owned lands within the basin be exchanged for other lands owned by the state. This exchange of lands between the two levels of government requires supporting legislation.

There have been many attempts to implement the recommendations of the Plan by turning over control and responsibility to the state. The major obstacle has been over the issue of flood control management. While the state has consistently been in favor of accepting jurisdiction over wildlife, environmental and cultural resource management of the marsh, it did not want to be the lead agency for flood control (Pers. Comm., Ron Walker).

In its 1990 session, the State Legislature enacted Senate Bill 3127 which transfers all of the city-owned land in Kawainui Marsh, except for the community park area, to the State once the City and the Army Corps of Engineers have completed all pending flood control projects to the satisfaction of the Department of Land and Natural Resources. The bill provides further that the State will enter into any required operation or maintenance agreements with the Corps at the time of transfer. Pending the completion of the transfer, the state and the city are to enter into a management lease, license agreement or other appropriate vehicle to enable DLNR to "manage the economic, ecological and cultural resources of Kawainui Marsh as provided in the 1983 Kawainui Marsh resource management plan." The bill is pending approval by the Governor. The state plans to continue to acquire as much of the appropriate land as possible adjacent to the marsh proper on the three sides cornering on and opposite the Coconut Grove area for resource management.

II Physical Environment

Geology

Maunawili Valley is part of the remnant of the volcanic dome, the Ko'olau Range, which constitutes the eastern three-fourths of the island of Oahu. The precipitous cliffs, or palis, have slopes between 45 to 85 degrees; above 1500 feet the slopes are about 60 degrees. The highest points along the crestline within the study area are in excess of 2000 feet. The trend of the cliffs coincides with the rift zone that occurred along the flanks of the active volcano which ended during the late Pleistocene and Recent Periods. Summarizing from Takasaki, et al, (1969):

> "The main Koolau rift zone and caldera are principal structural features. The rift zone, described by Stearns and MacDonald (1946, p. 14) as the locus of repeated fissure eruptions, occupies most of the windward area. The rift zone of an active volcano consists of a narrow zone of fissures and a line of cinder and spatter cones. Where erosion has exposed rift zones of extinct volcanoes to considerable depth, the zones are marked by numerous parallel or nearly parallel dikes. Where the dikes are numerous and closely spaced, the term dike complex is applicable. The dikes, and especially the dike complex of the Ko'olau Volcanic Series, exercise much control over the occurrence and movement of groundwater in the study area."

The principal stratigraphic units are the lava flows, dikes and breccia of the Ko'olau Volcanic Series and the Kailua Volcanic Series from the Pliocene Period; the Honolulu Volcanic Series from the Pleistocene Period; and alluvium and calcareous sedimentary material from the Recent Period (see Figure 3-5). Noteworthy to this document is the statement describing the coarse breccia that outcrops as the ridge between Kawainui Marsh and Kaneohe Bay and nearby to the south along Ulumawao Ridge. The breccia is not jointed and is well cemented. Takasaki, et al (1969) note the water-bearing properties of these breccia depend upon the degree of cementation. Where they are moderately to well cemented, yields are low. Thus the ridges surrounding the Kawainui Marsh drainage may not provide significant opportunities for groundwater movement between hydrologic divides. The lava flows of the Honolulu Volcanic Series are generally less permeable than the Ko'olau Volcanic Series. Where the former occurs overlaying the latter, such as shown in Maunawili Valley, they restrict the upward movement of groundwater. Thus at the edges of these rock assemblages springs may occur. Historical accounts document the occurrence of a spring at the Ulupo Heiau which is shown at the edges of the Honolulu stratigraphic unit.

Lava flows of the Ko'olau Series form the high ridges along the southwestern side and together with rock from the Kailua Volcanic Series make up the prominent volcanic ridges on the southeastern and northwestern sides of Maunawili Valley. Scattered through the valley are pyroclastic and basaltic lava flows of the Honolulu Volcanic Series. The younger alluvium underlying the lower part of the stream valleys consists primarily of silt and clay soil.

The soil conditions within the marsh vary considerably with depth from the surface. Borings taken in the marsh (Dames and Moore, 1961) indicate that a thick blanket of roots and peat overlay this area. This report indicated the organic material has a dry density of about 7 pounds per cubic foot and contains over 800 percent moisture relative to dry weight. Beneath the peat, two types of silt were encountered. One organic silt had a dry density of 17 to 50 pounds per cubic foot with moisture contents that varied at that time (1961) from 100 to 300 percent. This material, like the peat is very compressible. A fairly compressible gray marine deposit of silt with sea shells was encountered with dry densities ranging from 40 to 75 pounds per cubic foot and moisture contents from 40 to 120 percent. The geologic formation underlying the marsh has been identified (Stearns, 1938) as unconsolidated calcareous marine sediments, chiefly cream colored and light tan, which consist of very permeable beach sand of grains of worn coral, coralline algae, and shells with appreciable amounts of foraminifera and other marine organisms.

Hydrology

Tropical air circulation in the central North Pacific Ocean results in the most prominent feature of the climate, the trade-wind flow in a general east to west direction. The dominance of the trades with the influence of terrain give the unique climate character to the study area. Under trade-wind conditions the air is moist at elevations below the 4000-5000 feet temperature inversion layer. Below this elevation, the temperature decreases from the surface to the inversion layer where the sudden increase in temperature restricts the vertical movement of air resulting in cloud development. The clouds form chiefly along the mountains where the incoming trade-wind air is crowded together as it is forced up over the crest. The perpendicular orientation of the Ko'olau Range to the general direction of tradewind movement enhances the cloud formation and the associated rainfall pattern. Elevations within the study area range from sea level to in excess of 2000 feet. Solar insolation is estimated to range from to 300 to 375 calories per square centimeter in the upper watershed area of Maunawili Valley to Kawainui Marsh, respectively.

Spatial and temporal distributions of rainfall are pronounced in the Kawainui study area. In general, the orographic effect of the Ko'olau Range produces the most intense rainfall in the study area nearest the ridgeline's summit. The result of the strong uplifting of tradewinds is a maximum precipitation point for the Island of Oahu just slightly leeward of the crest. Rainfall patterns for individual storms also reflect this topographic influence. The annual rainfall cycle is generally recognized by climatologists as wet period, October to April (7 months) and dry period from May to November (5 months). Mean annual rainfall over the Maunawili drainage basin is estimated (Takasaki, et al, 1969) at 86 inches.

The rainfall in the upper watershed area exceeds the annual rate of evapotranspiration; in the lower watershed areas of the study, the reverse situation occurs. The average water yield of 5.7 mgd for the entire valley (approximately 8.8 cfs) includes ground-water as well as surface components. Estimated firm inflow to the marsh is on the same order of magnitude as the estimate for high rate of evapotranspiration. Thus the sensitivity of the marsh to droughts has to be considered in planning flood damage reduction. The ratio of evaporation to rainfall is calculated to be 0.89 which would be closer to the condition for the marsh than for the Maunawili tributary area. Based on a map of potential evaporation for Oahu (Ekern and Chang, 1985), approximately 70 inches of evaporation may be possible annually in the vicinity of Kawainui Marsh. The significance of the potential evapotranspiration is that water management planning must take into consideration the possibility that inflow may be of the same magnitude as evapotranspiration during low flow periods such during the dry season. Mitigation measures may be required, depending upon the type of flood damage reduction measures, to maintain minimum water levels.

Groundwater escaping from the marsh toward Kaelepulu Stream is another potential loss in the water budget of the marsh, but the relative magnitude of this loss is believed much less than evapotranspiration (see Appendix A, Section 1).

Flood flows originating in Maunawili Valley have been recorded from about the beginning of the 1900s. A partial tabulation of significant historical floods is shown in Table 3-2. Figure 3-6 shows the extent of flood hazards in the vicinity of the marsh and actual areas of inundation experienced in Coconut Grove during the New Year's Eve, 1988 flood.

The inflow hydrographs of 1988 New Year's Eve storm and the storms during April 4 to 9, 1989 for Kawainui Marsh were simulated by using the Nash-Muskingum method of routing the rainfall excess over effective drainage basins (see Appendix A, Section 2). The summaries for Maunawili and Kahanaiki watersheds are shown in Tables A-15, A-16 and A-17 of Appendix A.

The significance of the flood hydrology study is that reasonably accurate inflows were developed to study the effects of both large and moderate floods. Furthermore, it was learned that the time lag between peak rainfall and the flood peak is relatively short, less than two hours. The implication for flood plain management purposes is that flood warning plans have very little potential for flood damage reduction; they can serve to alert residents to move to higher elevations, but only if the warnings are specific as to the onset of the hazard and distributed in sufficient time.

Flow through the marsh is difficult to quantify because of inaccessibility and calculation complexities related to the multi-dimensional nature of the circulation patterns within the marsh. The irregular combination of thick mats of marsh plants and open-water areas complicates the prediction of water surface elevations, currents and flows throughout the marsh. Traditional hydrologic flood routing methods fail to reproduce the hydraulic characteristics of the marsh. Travel time through the marsh greatly affects the storage and hydraulic characteristics of the marsh. A finite element model of the marsh was developed to predict flow rate, direction and water level.

The significant findings of this contemporary study are: 1) the extremely thick growth of marsh plants creates hydraulic head losses through the marsh due to friction and physical obstruction, 2) associated with this resistance to flow is an increase in travel time of the water through the marsh with the result that more storage of the inflowing water occurs in the upper (southern) end of the marsh, and 3) tidal influence is not an important effect on the observed elevations of the water level throughout the majority of the marsh. Evidence to support these conclusions is presented in more detail in Appendix A, Section 4.

The results of the simulation using the finite element model of the 25-, 50-, 100-year, New Year's Eve 1988, and standard project floods (U.S. Army Corps of

Table 3-2

Tabulation of Historical Flood Data

Year	24-hour recorded rainfall (1)	Approximate marsh stage in feet above mean (2) sea level	Flood classification	References
1902	11.70	9.0	major	hearsay
1904	12.50	9.5	major	hearsay
1907	7.88	7.0	medium	hearsay
1908	8.75	8.0	medium	hearsay
1914	10.97	8.5	medium	newspaper &
1916	7.95	7.0	medium	inhabitants
1917	8.46	7.0	medium	newspaper
1918	7.73	6.5	medium	inhabitants
1921	20.15	10.0	major	newspaper & inhabitants
1924	8.00	7.0	medium	inhabitants
1927	7.08	6.0	minor	newspaper
1930	6.82	6.0	minor	newspaper & inhabitants
1932	7.51	6.5	medium	inhabitants
1939	9.56	6.4	medium	inhabitants
1940	10.48	7.3	medium	inhabitants
1951	15.25	8.6	major	U.S. Army Corps of Engineers
1963	-	-	major	DOWALD
1965	-	-	major	DOWALD
1977	-	-	medium	-
1985	-	-	medium	-
1988	22.39	9.5	major	DOWALD
1989	11.08	7.7	minor	City & County

Notes: 1. Rainfall at Maunawili Ranch 1902-1951 and at Maunawili HSPA 1963-1989.
2. Elevations before 1939 estimated; recorded since 1939 at edge of marsh (Coconut

References: Historical Study of Kawainui Marsh Area, Island of Oahu. Marion Kelly and Barry Nakamura, Bishop Museum, Prepared for DPED, Nov. 1981.

Engineers' design flood for the Kawainui Marsh levee) are shown in Figures A-24 through A-34 of Appendix A in terms of the flood hydrograph and computed water levels in the marsh adjoining the levee. The significance of the simulations is that they indicate the probability that the existing levee (approximately 10.0 feet (msl) elevation) would be just overtopped by a flood with an annual chance of being equalled or exceeded of four percent, i.e. a 25-year flood.

Sedimentation and Water Quality

Water quality sampling and analysis conducted for the environmental impact statement preparation confirmed previous trends reported (AECOS, 1982) concerning nutrient and suspended solids removal by the marsh, showed a reduction in the nutrient mass loading due to the removal of sewage treatment plant discharges, and identified levels of heavy metals bound in the sediments. Mineral nutrients are inorganic substances that a plant requires. They can be broken down into two groups, on the basis of their concentrations in plants; the macronutrient (elements that are required in large amounts) and the micronutrient (those required in very small amounts, or trace amounts). These terms reflect the relative requirements of plants for example the chloride ion (Cl^-) is required in such minute quantities that they defy measurement, yet photosynthesis can not occur without it. The availability of these nutrients are controlled by various parameters such as soil composition, and pH. The significance of the test results are discussed in the following paragraphs.

Measurements taken of nutrients indicate the process of uptake by plants in the marsh, loss to sediments, and to the atmosphere remove over 90 percent of the inflowing nitrogenous and phosphoric nutrient loading. The amount of suspended solids removal is a smaller proportion of the total input. Appendix B, Section 2 provides comparative values between 1981 and 1989 which show the wet weather flow from Maunawili and Kahanaiki Streams to be more similar at present in terms of nutrient loading than in the past. While the total input of these nutrients has been reduced, the amount available in the soils is still significant.

Soil texture is very important in the retention of these different nutrients. The texture, and particle size determine the ability of soil to retain minerals and water. The optimum soil structure is called loam, and consist of 30-50% sand (particles >0.02 mm), 30-40% silt (particles >0.02-0.002 mm), and 10-25% clay (particles <0.002 mm). Clay particles provide a reservoir of cations for the plant. The majority of the fine sediments are silt and clay size. Appendix B, Section 2 provides results of grain size analysis at various locations. At various points on the crystalline lattice of these particles, there is an excess of negative charge, where cations can be bound and thus held against the leaching action of percolating soil water. Whereas the principally negatively charged ions are leached out of the soil more rapidly than cations because they do not adhere to clay particles.

Acidity or alkalinity of soil effects the availability of inorganic nutrients and heavy metals. The pH of the soil determines the fertility of the soil. The optimum pH ranges from 5-7. At lower pH levels valuable positive ions no longer adhere to negative clay and organic particles. They are replaced by hydrogen ions and tend to leach out of the soil.

Sediment sample analysis indicated the marsh has trapped heavy metals, particularly copper, chromium, iron, nickel, and zinc. The sediments indicate a heavier burden in the upstream end of the marsh. The sediments also contain a vast supply of nutrients. Many of the mineral nutrients are made available through intricate biogeochemical cycles where the primary movers of the respective cycles are mainly the microorganisms of the soil that act as decomposers or reducers. The most complex cycle is the nitrogen cycle. Unlike carbon and oxygen, nitrogen is chemically unreactive.

The three principal stages in this process are (1) ammoniafication, (2) nitrification, and (3) assimilation.

The first step in the nitrogen cycle is called ammoniafication and is accomplished by microorganisms using the protein and the amino acids from dead organic material, for the formation of their own proteins and release excess nitrogen in the form of ammonium ions ($NH4^{+}$). The ammonia produced by ammoniafication is dissolved in the water.

The second step is called nitrification where ammonia is oxidized in an energy producing process in which bacteria use this energy to oxidize ammonia to nitrite ions ($NO2^{-}$). Nitrite is toxic to higher plants, but it rarely accumulates in the soil. Due to the speed in which nitrite is oxidized to nitrate under most soil conditions, nitrate is the form in which almost all nitrogen is absorbed by plants, although ammonium can also be directly utilized by plants.

Assimilation is the process in which the plant converts the nitrate ion back into its original form of ammonia. In contrast to the reverse reaction nitrification, assimilation requires energy. The ammonium ions formed in this process are thus transferred to carbon containing compounds to produce amino acids and other nitrogenous organic compounds needed by the plant.

The nitrogen is also bound in the soil through numerous bacteria called denitrifiers. These bacteria use nitrate or nitrite as electron acceptors in their respiratory activities. The nitrates or nitrites are important to strict anaerobes, because they are completely unable to use oxygen. Denitrifiers grow best in poorly aerated soil similar to those found in Kawainui Marsh. Nitrogen fixers, like blue-green algae, fix this deficiency by converting atmospheric nitrogen (N2) to NH3, which can be used in the nitrification step.

Compared to nitrogen, the amount of phosphorus required by plants is relatively small. Of all the elements for which the earth's crust is the primary reservoir, phosphorus is the most likely to limit plant growth. Plants use phosphorus in the form of inorganic phosphates where phosphorus enters the roots of plants as soluble anions for the production of many familiar cellular substances that function in photosynthesis and respiration. In freshwater, phosphorus and calcium may lie bound in the bottom sediments for long periods of time until agitation occurs.

The marsh sediments and present nutrient loadings are capable of sustaining future productivity levels of the marsh vegetation that will not be significantly altered. Management of the marsh for various beneficial purposes to man and enhancement of ecological attributes must cope with this aspect of the marsh environment. In addition, the marsh has accumulated various heavy metals, which is not unusual in comparison to sediments in other watersheds on Oahu, nonetheless require special attention when dealing with the removal of these sediments.

Appendix B, Section 5 presents estimates of the amount of sedimentation into the marsh from terrigenous and natural decomposition processes. The available information on the life history of the marsh, the sediment analyses, and extrapolation of sediment transport relationships from similar windward watersheds, indicate that the decay of plant materials in the marsh has had a more significant impact upon deposition in the marsh. The natural succession of the marsh is believed to be toward a wooded bog with attendant increases in average water level over the long term as peat building continues.

Ocean and Estuarine Characteristics

Oneawa Channel discharges into the northern end of Kailua Bay. The bay is an open bight exposed to the northeast trade-winds. The diurnal tidal cycle range between mean lower low water and mean higher high water is 1.8 feet. Under extreme tidal range the fluctuation is 4.0 feet. The northern part of the bay is generally free from fringing reefs and the outlet has not experienced the buildup of sandbars since the construction of the outlet in 1967.

Wind and wave climate effect the nearshore water levels and circulation patterns. Wave data indicate that 64 percent of waves for the northern coasts of Hawaiian water are from the northeasterly and easterly directions. To the north of the outlet channel, the bottom consist primarily of coral ledge and lava rock which provides very little source of littoral drift material. As a result of the predominant wave pattern in the area of the channel outlet which produces littoral currents in a southeasterly direction form the outlet mouth very little deposition at the mouth occurs. Soundings made of the channel in April 1988 by Wagner, Hohns, and Engilis (1988) indicated very little additional deposition in the channel had occurred since construction. Further toward Kailua Beach park, however, a study by Noda and Associates (1977) found that for the summer season, long term erosive transport can be toward Kaneohe. Drift card studies cited in Appendix B, Section 4 show surface drift to be from the north to south in an on-shore direction during the winter months.

Tradewinds prevalent through April to September dominate the local wave climate. The strong steady winds blowing over long open fetches of open ocean generate deepwater waves that have typical periods of 6 to 8 seconds and heights of 4 to 10 feet. The North Pacific swell is generated most often in the winter months and has typical periods of 10 to 16 seconds and heights 5 to 15 feet. Other waves may effect the bay but arrive less frequently such as local storm and hurricane waves. The waves that reach the outlet area are different from deepwater offshore waves having been transformed by processes of refraction, diffraction, shoaling, and breaking. Wave heights measured on the reef adjacent to Popoia Island during June through August 1977 averaged 2.5 feet. Average wave heights at Kailua Beach Park shoreline were less than 1 foot with an average period of 7 seconds during the same period (U.S. Army Corps of Engineers, 1977).

The waters of the bay are Class A coastal waters. There are multiple uses of the bay which is a popular recreational area for swimming, fishing, sailing, surfing, wind-surfing, skin-diving and water-skiing. Kailua Beach Park at the southern end of the bay is located at the mouth of Kaelepulu Stream. This stream originates on the Coconut Grove side of the levee adjacent to Kawainui Marsh. Both this stream and Oneawa Channel exhibit tidal characteristics.

Water quality samples taken in the City and County ditch do not indicate high salinity in this channel. The presence of ledges within the ditch (high points on the profile) inhibit the intrusion of salt water during the tidal exchange cycle. Additional data on estuarine factors are contained in Appendix B, Section 4.

III Biological Environment

Vegetation

The Hawaiians used Kawainui as an active freshwater fishpond believed (Smith, 1978) to be 445 acres in area. Later during the late 1800s rice cultivation was introduced and, as early as the 1890s, cattle grazing began to dominate the upland area. Water was diverted from the marsh for agricultural purposes. Weirs were constructed over the years to prevent seawater from intruding into the marsh.

Siltation, effluent discharge, and flood control measures occurred in the basin. Since the time of that the Hawaiians stopped using the marsh for food gathering (and perhaps earlier) wetland vegetation has occupied the majority of the basin most of which now consists of a bog, with layers of plants, roots and peat floating over water.

Vegetation in Kawainui Marsh is not managed except for grazing along selected upper edges of the marsh (See Figure 3-7). California grass (*Brachiaria mutica*) interspersed with honohono (*Commelina diffusa*), water hyacinth (*Eichornia crassipes*), arrowhead (*Sagittaria sagittaefolia*), scattered stands of cattail (*Typha angustata*), and a bulrush community consisting primarily of bulrush (*Scirpus californicus*), sawgrass (*Cladium leptostachyum*) and taro patch fern (*Cyclosorus interruptus*) are the dominant forms of vegetation. The grass grows on fine alluvial clays which are constantly damp in the higher portions of the marsh and on the substrate created by dead vegetation in lower portions of the marsh. It forms thick, dense floating mats that can support the weight of a man and animals while covering small ponds. The character of the vegetation in Kawainui Marsh has been influenced by changes in nutrient levels, water levels, fire, and the introduction of exotic plants. Smith (1978) provides a more detailed account of the effect of these perturbations upon vegetation communities.

Kawainui Marsh may be divided into two major types of vegetation communities. In the ponding basin is a bulrush/sawgrass marsh with floating mats of live vegetation and peat deposition. In the drier parts toward the south and west is found a bog meadow of California grass, resting on mineral soil and detritus rather than peat. Both communities are stream fed.

The bulrush community consists primarily of *Scirpus californicus*, the California bulrush. This community is basically an aquatic community with diversity; Smith (1978) identified 18 species of plants. Thick mats of roots and living material are formed which, through the decomposition (incomplete decay of vegetation matter) process, form mats of peat. These floating mats produced by emergent aquatic plants provide a pseudo-terrestrial environment supporting plants which are not typically wetland plants such as the paperbark (*Melaleuca leucadendra*), and wild sugarcane (*Saccharum spontaneum*). These non-aquatic plants are rooted in the mats of *Scirpus* and *Cladium* which are floating on a slurry of organic mud.

The second most dominant plant species is the *Cladium leptostachyum*, sawgrass. *Cladium* also forms thin floating mats, but never does form a firm sod. A subspecies, *C. jamaicense*, is a colonizer of the floating mats. Pure stands of sawgrass form transition zones between the bulrush and open grass communities.

Other plants in the bulrush community include the taro patch fern (*Cyclosorus interruptus*) found throughout the area existing on the mats of emergent vegetation. This plant is typically found in marshy areas such as abandoned taro patches. Cattails (*Typha latifolia*) occur in the bulrush community. Arrowhead (*Sagittaria sagittaefolia*) is found near the large open water pond at the southern end of the bulrush community.

The second community is dominated by California grass (*Brachiaria mutica*) and is located in the upper, mountainward portion of the marsh on alluvial soils. It has extremely low species diversity (6 species). Where it occurs, few others do, due its extremely high productivity rates (Smith, 1978). *Brachiaria* is an important grass in lowland pastures. This grass also forms very dense mats of living material. No peat is found in the grass community. The living plants are underlain by a thin layer of litter and soil.

The grass community is interspersed with honohono grass (*Commelina diffusa*). California grass in general, is located around the southeastern and southwestern perimeter of the marsh. The central area is dominated by the *Scirpus*. The surface of the emergency (flood control) canal is sporadically covered with "water lettuce" (*Pistia stratiotes*).

Water hyacinth, *E. crassipes*, exists on the surface and edges of the open water areas covering an approximately 27-acre area. This plant is rapidly encroaching on the open water. *E. crassipes* poses the mos serious threat to the waterbird habitat. Until 1978, this plant was located merely on the periphery of the main pond and not considered to be a pest plant. Since then, *E. crassipes* mats have been spreading out onto the main pond from the periphery. Water hyacinth does provide a food source for some waterbirds. The Hawaiian coot may feed on leaves and flowers occasionally. The extensive coverage of the open water areas by water hyacinth reduces the availability of preferred foods of the endangered waterbirds and migratory waterfowl. The vegetation cover reduces light penetration, inhibiting underwater plant growth. Plant decomposition decreases the oxygen available to aquatic life, gradually decreasing the pond depth through accumulation of organic matter on the bottom.

The upper slopes of the marsh are wooded, mainly with koa haole (*Leucaena leucocephala*), guava (*Psidium guajava*), Chinese banyan (*Ficus microcarpa*) and monkey pod (*Samanea saman*). See Appendix B for a list of plant species occurring in marsh. No endangered plant species have been observed.

The water hyacinth causes greater rates of water loss through evapotranspiration at a rate faster than water in the pond (see Appendix B, Section 5). The combination of increased water loss with the accumulation of organic material on the bottom results in the acceleration of the succession process, with the resultant permanent loss of open water habitat.

Water hyacinth is an efficient "secondary treatment" system. It is capable of removing high levels of biochemical oxygen demand (BOD), suspended solids, metals and nitrogen (Reed, et. al. 1988). It thus plays a valuable role in the treatment of influent waters to the marsh which helps to compensate for its reputation as a "pest" species. Resource management strategies can be developed to include the water hyacinth in a beneficial role.

Avifauna

Four endangered Hawaiian waterbird species nest, feed, rest and breed in Kawainui Marsh: Hawaiian Stilt (*Himantopu mexicanus knudsenii*), Hawaiian Coot (*Fulica americana alai*), Hawaiian Gallinule (*Gallinula chloropus sandvicensis*), and Hawaiian Duck (*Anas wyvilliana*). In addition, the Black-crowned Night Heron, the Great Frigatebird, and a variety of seasonally migratory waterfowl are prevalent in the marsh. The marsh (see Figure 3-7) has been declared a major and essential habitat for the endangered species by the Hawaii Waterbird Recovery Team. However, its importance is based primarily on the potential for substantial habitat improvement and not on its recent condition. Vegetation growth has reduced valuable open waterbird habitat and degraded the marsh.

Although no wetland habitat has yet been designated as critical habitat for endangered species, the *Hawaiian Waterbirds Recovery Plan*, (U.S. Fish and Wildlife Service, 1985) designated the marsh as essential habitat to the recovery efforts of these waterbirds. Although habitat in the marsh was steadily degraded during the past two decades due to the infilling and occlusion of open waters habitat, the marsh can be restored to important functions for endangered waterbirds. Historical use and past distribution of waterfowl has been described and documented by Shallenberger (1977) and Conant (1981). The present status of waterbird use in the marsh is summarized by an unpublished report from the Division of Forestry and Wildlife, DLNR (Engilis, 1988).

The intent of the report cited above is to document the effect of the New Year's Day flood on the marsh's waterbirds. It notes that the flood had a

> ". . . profound positive effect on the native waterbirds. . . [the] small resident population of all four species of Hawaiian waterbirds . . .responded favorably to conditions created by the New Year's Day flood.
>
> The flood effectively cleared and moved floating vegetation creating 75 acres of open water . . .and edge habitat (see Figure 3-7). The flood also scoured the delta region of the Maunawili and Kahanaiki Streams creating flooded fields, meandering channels, and open mudflats. The water level in the marsh was estimated at +4.5 feet (above mean sea level). By late March, water levels began to receded and edge vegetation, including California

grass and water hyacinth, began to grow. A warm May, June and July enhanced this growth and large tracts of open water became overgrown.

All of the waterbirds seemed to prefer a shallow water/mud and vegetation interface. In February-March this interface was located in the delta region and nearly all of the waterbirds were concentrated in this area. However, by late May to July this interface increased in the center of the main pond. The majority of resident birds responded by shifting their activities to this section.

However, some individuals of stilt and gallinule remained in the delta. Stilts and Koloa were documented on several occasions feeding in the city and county emergency channel. Coots were also documented in Hamakua and Oneawa canals. Nesting was documented for all four species of endangered waterbirds. Migratory birds (waterfowl and shorebirds) also utilized the open water and mudflats created after the flood."

Engilis describes the 1988 status of the endangered birds as follows:

"*Hawaiian Duck (Koloa)*. Permanent resident in small numbers: restricted to open waterways, ponds and channels. Most activity was in the delta and main pond areas. One adult with three young were seen in the main pond in late June. In March, four pairs were observed in courtship flight in the delta. Very few Koloa are recorded annually along the windward coast of Oahu. For this reason, the 10-12 birds that can be regularly seen in Kawainui represent the largest known concentration on windward Oahu.

Hawaiian Gallinule. Permanent resident in good numbers in open waterways, channels, and dense marsh vegetation. The actual number of resident gallinule in Kawainui Marsh may never be known due to their secretive behavior. Documented as many as 35 birds, in late June, around the main pond's emergent vegetation. One adult with two young were seen in late July. The significant number of gallinules in Kawainui makes it a primary colonizing source for this species on the windward coast.

Hawaiian Coot. Permanent resident as long as open water is present. Can occur in large numbers (20) if optimal flooded conditions exist. In Kawainui, prefers the open water of the main pond and delta, but can also be seen in Hamakua Canal and upper Oneawa Canal. One adult with one young was seen in late June. Hawaiian Coot is local on Oahu and the population at Kawainui is important as a colonizing source for the windward portion of the island.

Hawaiian Stilt. Permanent resident in small numbers as long as shallow open water with mudflats exist. The stilt responded well to the flood. The usual 3-4 birds that occur in the delta were soon joined by other stilt (presumably from nearby Nuupia Ponds). Three nests were documented this season. One pair successfully reared one young: nesting began in March. Two other pairs were incubating eggs on the large exposed mudflat in the center of the main pond in late July. The high waters resulting from tropical storm Gilma inundated these nests in August. Stilts were frequently documented feeding along the city and county channel. The approximately 12 stilts residing at Kawainui represent a small percentage occurring along the windward coast. The 130+ nesting at nearby Nuupia Ponds is one of the largest concentrations in the state."

The ecological and endangered importance of these waterbirds also has impact on any project being planned for the marsh as the waterbirds fall under the jurisdiction of USFWS management regulations.

Problems which limit existing and potential waterbird use include: vegetation/ aquatic weed encroachment into valuable open water areas, human disturbance, predation, fluctuating water levels, limited access to food, public attitudes, and sedimentation.

The sensitivity of these areas for waterbirds is also important when considering public and recreational uses of the marsh. High sensitivity areas should be viewed from a distance and not used for active recreation, thereby reserving these areas for stringent waterbird protection. Development of walkways, observation points or other low-impact methods using the low and medium sensitivity areas could make Kawainui a unique educational, conservation and recreational resource.

The fast land areas of the marsh especially near the confluence of the Maunawili and Kahanaiki Streams provide pasture for ungulates with pressures of overgrazing. These cattle are also known to graze into the more ruet marshy areas where the Hawaiian duck (Koloa) rest, nest and feed with the potential for trampling active nests.

At least four other mammalian predators have access to the marsh with potentially serious consequence to the endangered waterbirds and their nests. These include the mongoose, rats, cats and dogs.

The primary recommendations for improving the habitat of the marsh for endangered and other waterbirds focus on increasing the amount of open water available and the control of vegetation which competes for this water space. The Kawainui Resource Management Plan recommends increasing the open water areas, in stages, up to 150 acres, at the same time controlling the water hyacinth, water lilies, cattails and California grass. A review of available data all document the compatibility of such goals with the goals of this project.

The birds should be left undisturbed during the peak nesting seasons and any work done in the marsh should minimize the impact at this time. Although the breeding/nesting season occurs year round, March through September is the period of peak nesting. Because this coincides with the dry season, when construction is most favorable, it will be difficult to avoid all impacts during the nesting season. These impacts can be minimized, however, by observing the following priorities:

1) waterway clearing (with explosives) should be scheduled for the period October through February,

2) maintenance sediment removal scheduled for the dry season, May through September, and

3) maintenance vegetation removal scheduled for part of the wet season, October through February, when it will interfere with nesting the least.

Other Fauna

The open waterways are nearly always eutrophic and are dominated by exotic warm water species such as tilapia and mosquitofish. Freshwater turtles occur in the Hamakua Drive canal; however, their existence in Kawainui Marsh has not been well documented.

The lower Maunawili and Kahanaiki Streams are dominated by exotic fish species: Chinese catfish, Cuban limia, swordtails, smallmouth bass and koi. Louisiana crayfish, as well as frogs, toads, and snails are also found.

Cuban limia, reticulated guppy, mosquitofish, and tilapia may be periodically reintroduced to Kawainui Marsh by the State Department of Health Vector Control Branch as required for mosquito control after flooding.

The Oneawa Channel and the immediate upstream portion of the marsh adjacent to the channel is presently an estuarine habitat with potential value for recreational fishing (aholehole, mullet, barracuda, o'opu, lizard fish).

The head of the canal is the most productive aquatic habitat with respect to fishery resources. Itinerant marine and estuarine species frequent the canal including o'opu, o'ophu-hue, awa, lizardfish, papio, oio, kaku, iao, uouoa, 'amaama, aaolehole, upapalu, aaole crab, hapa crab, Samoan crab, opae'oeha'a, opae lolo, and Tahitian prawn. The removal of rooted vegetation will substantially increase the availability of the marsh as a habitat for native stream species.

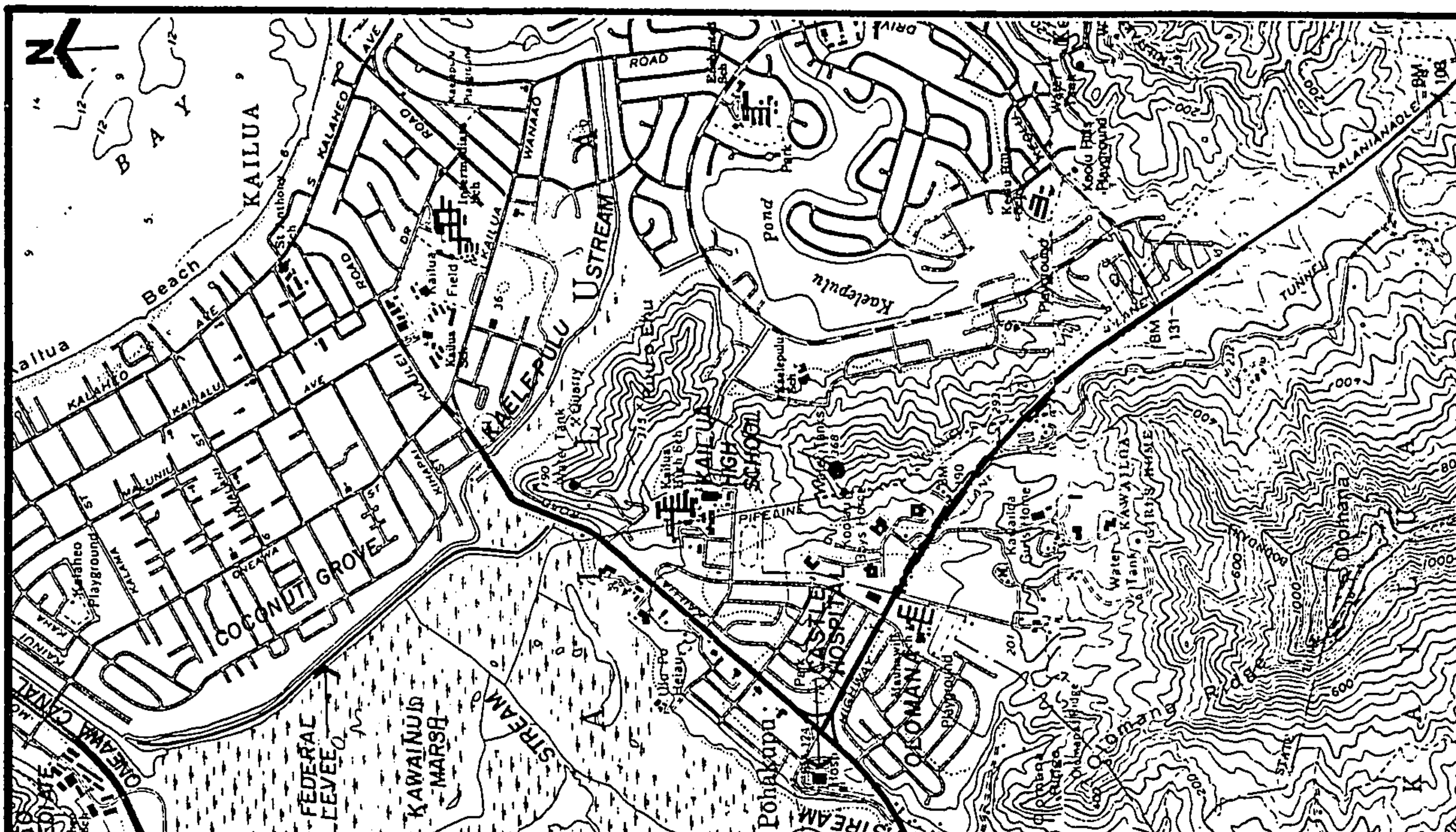
An abundant invertebrate species in the central marsh is *Physa* existing above and below the water surface. These snails are apparently a secondary host for a bird parasite (*schistosome*) which infests the marsh. Mongoose are thought to be the primary predators of the avian life in the marsh. Feral dogs and cats are also found, as well as rats and mice. Cattle and horses graze in the upper parts of the marsh.

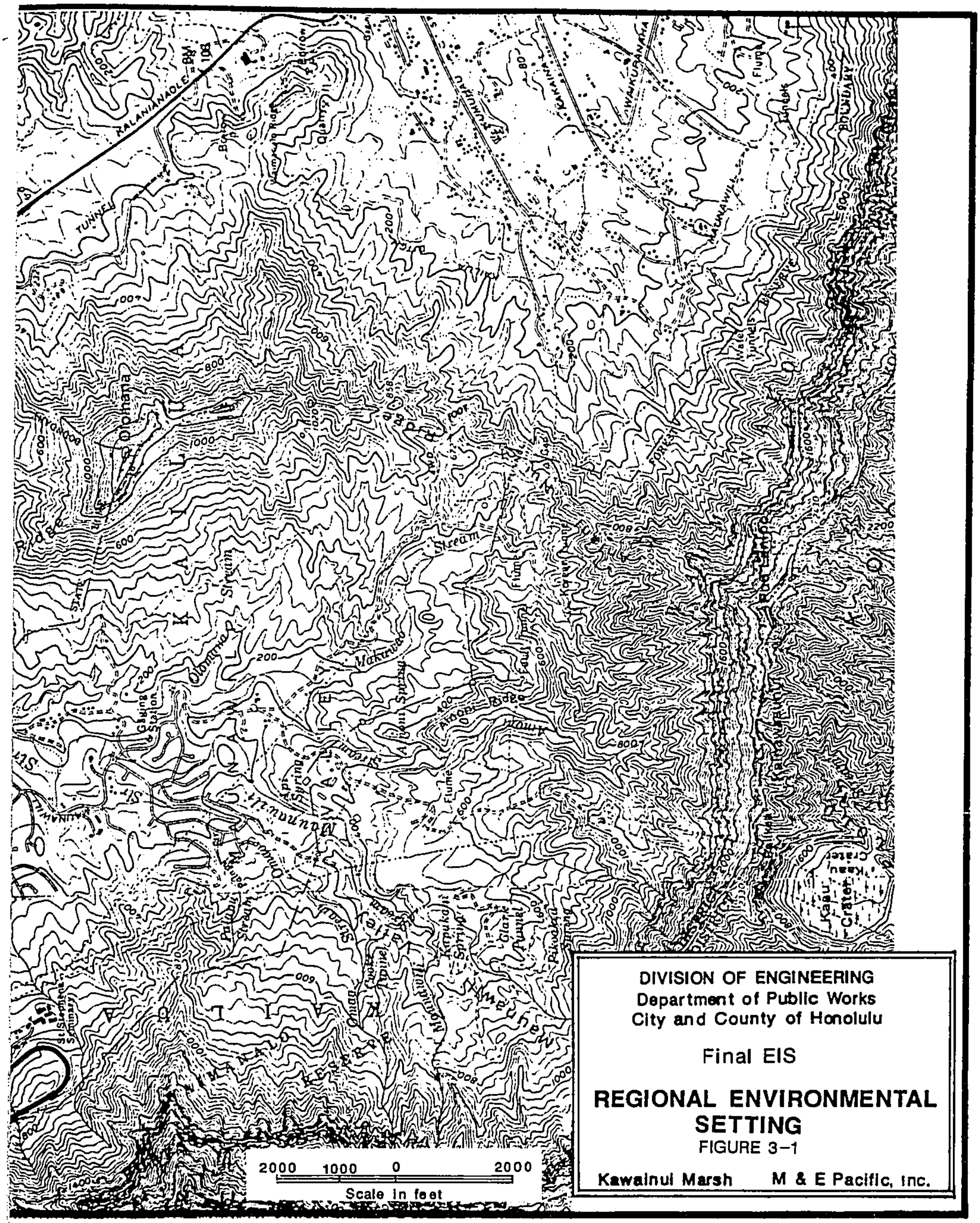
TABLE 3-3

Characteristics of Waterbirds in Kawainui Marsh

BREED	HABITAT/NESTING	FEEDING	PREDATORS
HAWAIIAN STILT *Himantopus mexicanus knudseni*	Nest in or close to fresh or brackish water ponds, mud-flats, marshlands	Seek food in low-lands habitats, mudflats, settling basins, marshes, reservoirs, etc.	Eggs & young, by mongoose, dogs, cats, rats and cattle egrets
	Nest constructed in scrape in the ground, but maybe made of debris/vegetation lined with pebbles, twigs, and debris	Eat: polychaete worms, crabs, aquatic insects, small fishes	
	Clutch - 4 eggs 24-26 days incubation Nest: March-July Breed: Feb-Aug		
HAWAIIAN COOT *Fulica americana alai*	Prefer open water, fresh, brackish or, rarely, saline: need deeper water because builds nest on large floating aquatic vegetation anchored to emer-gent vegetation	Feed close to nesting sites	
		Eat: seeds and green parts of aquatic plants, invertebrates, tadpoles, and small fish	Mongoose, cats, dogs, possibly rats, largemouth bass and herons, man
	Clutch - 4-10 eggs, avg. 5-6, 22 days incubation Peak Nest: Apr-June		
HAWAIIAN GALLINULE (moorhen) *Gallinula chloropus sandvicensis*	Freshwater ponds, marshes, streams ditches	Algae, seeds, grasses, aquatic insects, variety of mollusks	
	Nests are incon-spicuous in emergent vegetation on folded reeds		Mongoose, cats, dogs, possibly bass and heron, man
	Clutch - 6-9, avg. 5-6, 22 days incubation Peak Nest: Apr-June		

BREED	HABITAT/NESTING	FEEDING	PREDATORS
HAWAIIAN DUCK *Anas wyvilliana*	Taro patches, reservoirs, drainage ditches, flooded fields Clutch: 8 eggs 28 days incubation Nest: Dec-May Nests on the ground near water	Eat: Snails, earthworms, dragon flies, algae, leaf parts and seeds seeds of a variety of wetland plants, mollusks, etc.; opportunistic feeders	Mongoose, dogs, pigs, cats, rats Young eaten by bullfrogs and bass, Mynas and owls Poaching for sport or food by man
BLACK-CROWNED NIGHT HERONS *Nycticorax Nycticorax hoactli*	Ponds, marshes, lagoons, tide pools Bulky nests of twigs and sticks in trees Clutch: 2-4 eggs Breed: May-June	Eat: Crustaceans, fish, frogs, mice, insects, and chicks of other birds	Mongoose, dog, cats, bats


KAILUA
BAY
Kailua Beach
COCONUT GROVE
FEDERAL LEVEE
KAWAINUI MARSH
QUARRY
ROAD
KAILUA HIGH SCHOOL
CASTLE HOSPITAL
OLOMANA
MAUNAWILI
STREAM
LANDFILL
Kaelepulu
Pond
Maunawili
Olomana



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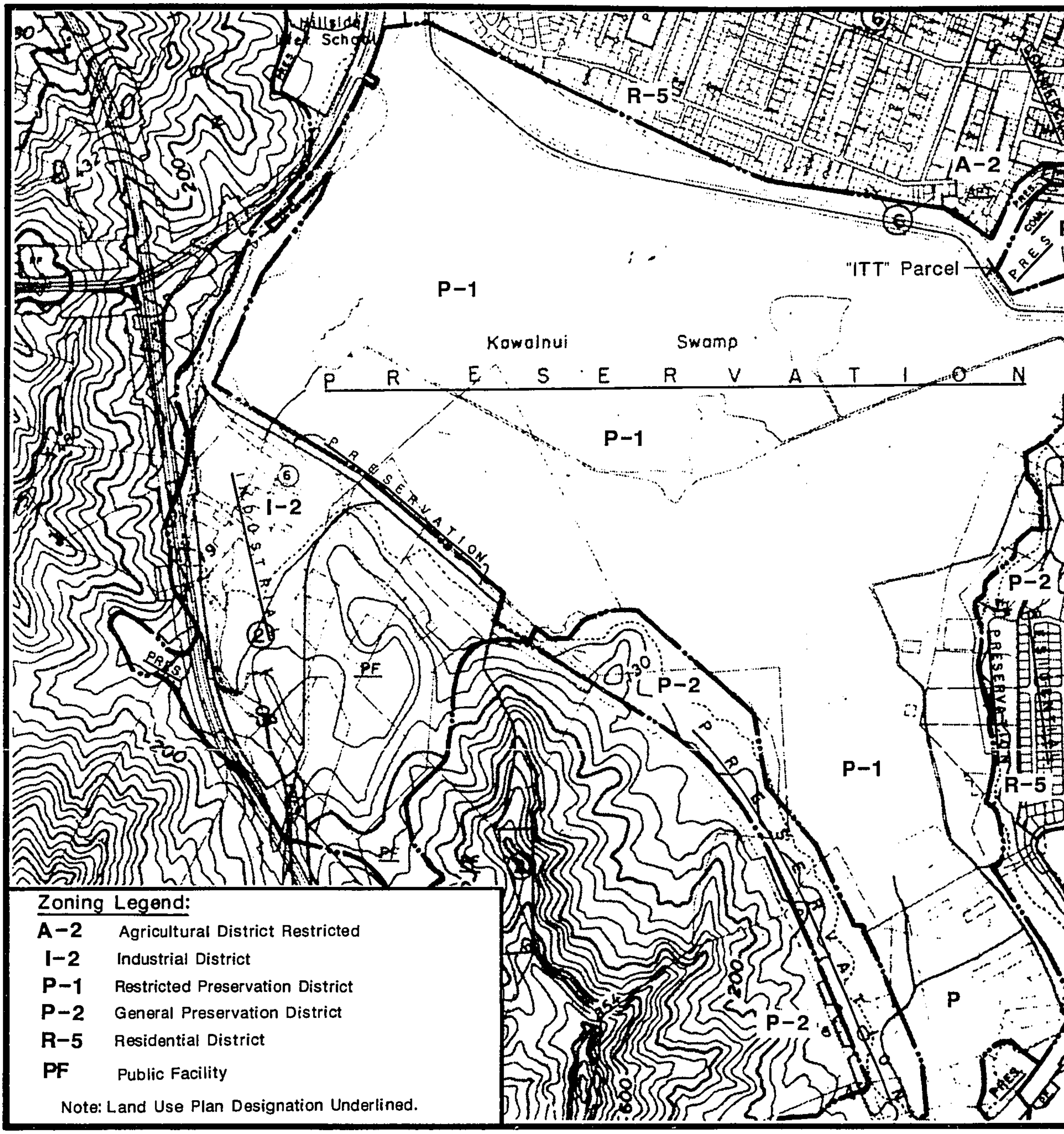
REGIONAL ENVIRONMENTAL SETTING

FIGURE 3-1

Kawainui Marsh M & E Pacific, Inc.

DOCUMENT CAPTURED AS RECEIVED



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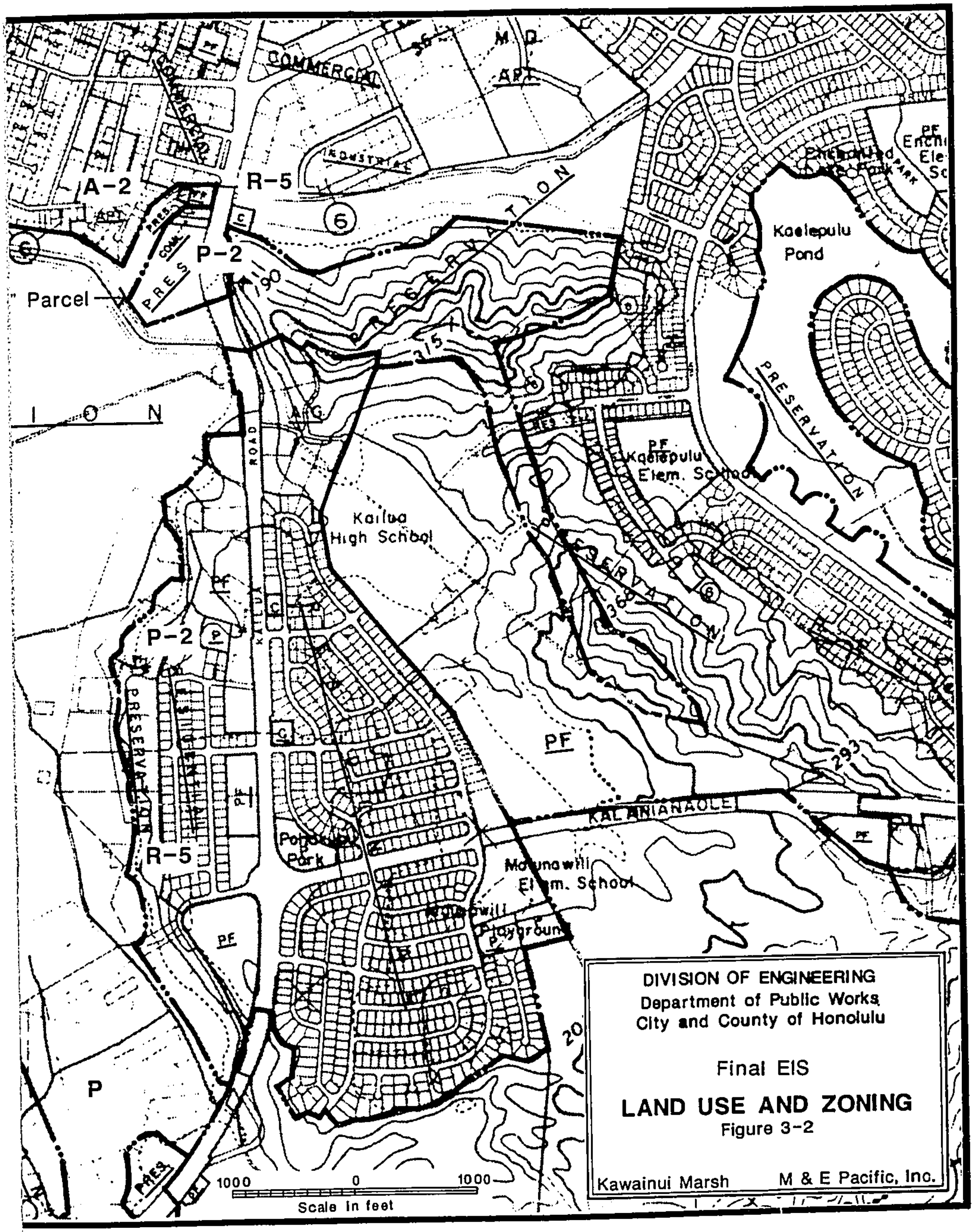
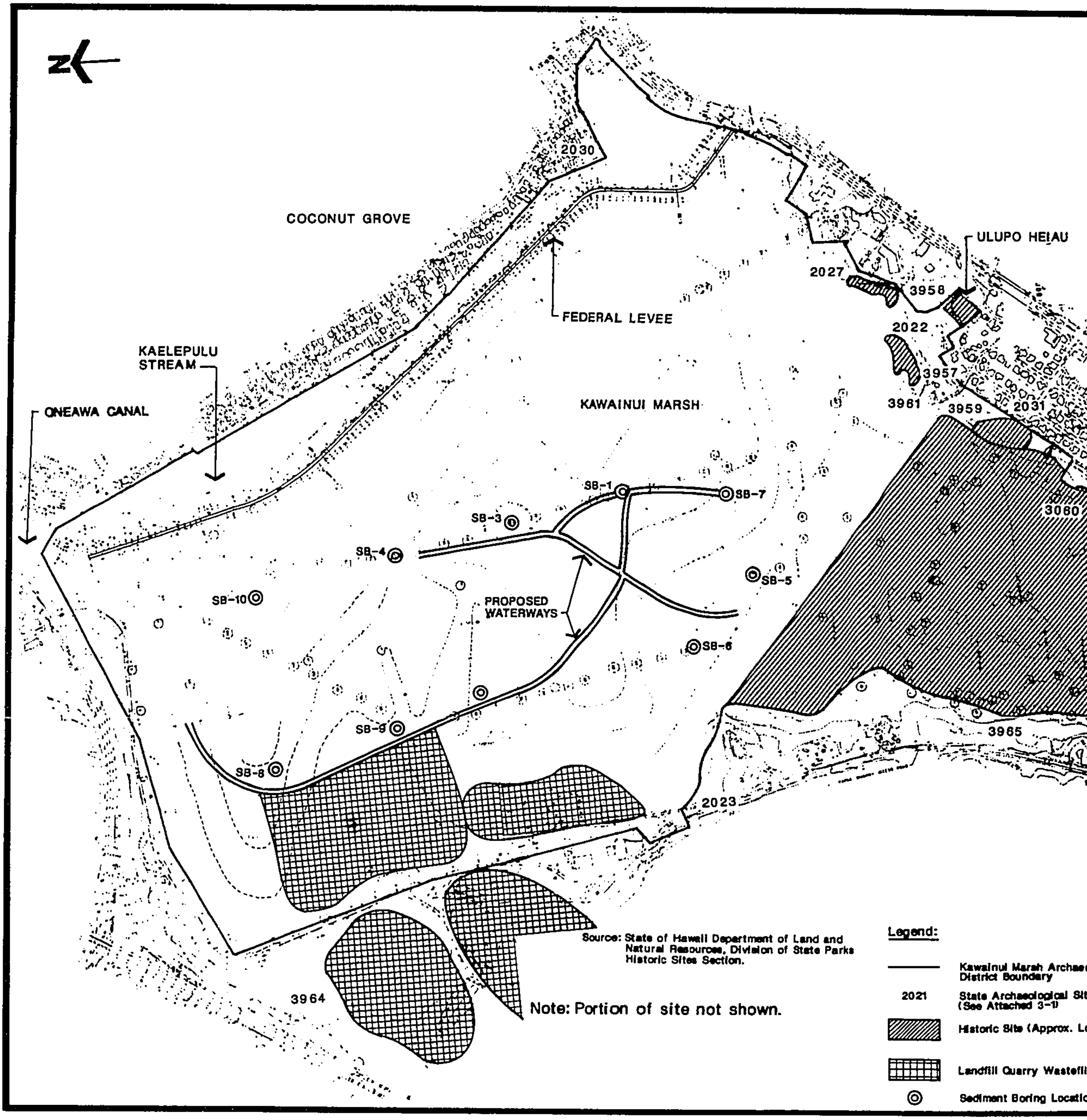
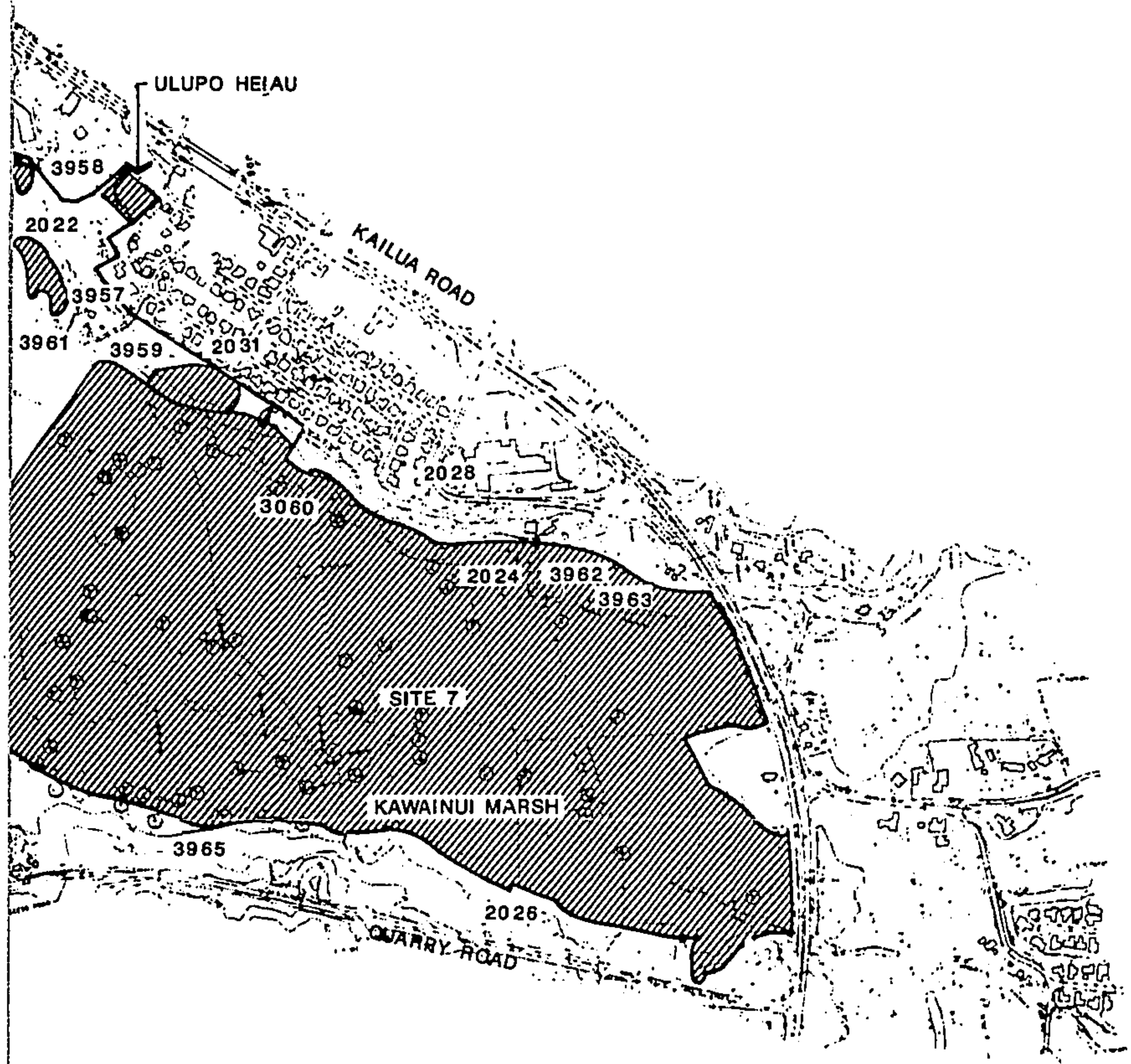



N
COCONUT GROVE
2030
FEDERAL LEVEE
KAELEPULU STREAM
ONEAWA CANAL
KAWAINUI MARSH
ULUPO HEIAU
2027
3958
2022
3957
3961
3959
2031
3060
SB-1
SB-7
SB-3
SB-4
SB-5
SB-10
PROPOSED WATERWAYS
SB-6
SB-9
SB-8
3965
2023
3964
Source: State of Hawaii Department of Land and Natural Resources, Division of State Parks Historic Sites Section.
Note: Portion of site not shown.
Legend:
2021

DOCUMENT CAPTURED AS RECEIVED



Legend:

- Kawainui Marsh Archaeological District Boundary
- 2021 — State Archaeological Site (See Attached 3-1)
- Historic Site (Approx. Location)
- Landfill Quarry Wastefill
- ◎ Sediment Boring Locations

500 0 500
Scale in feet

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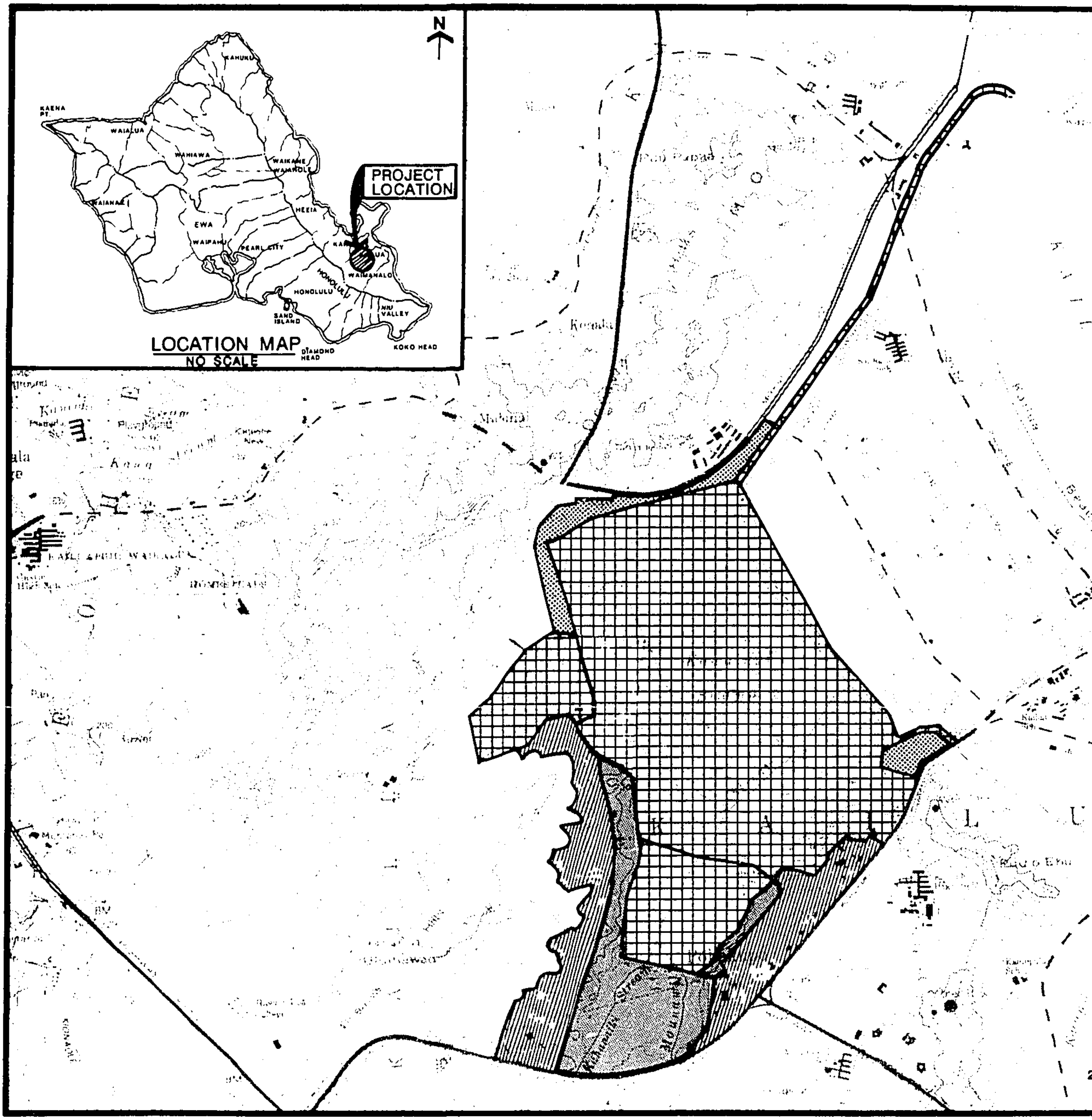
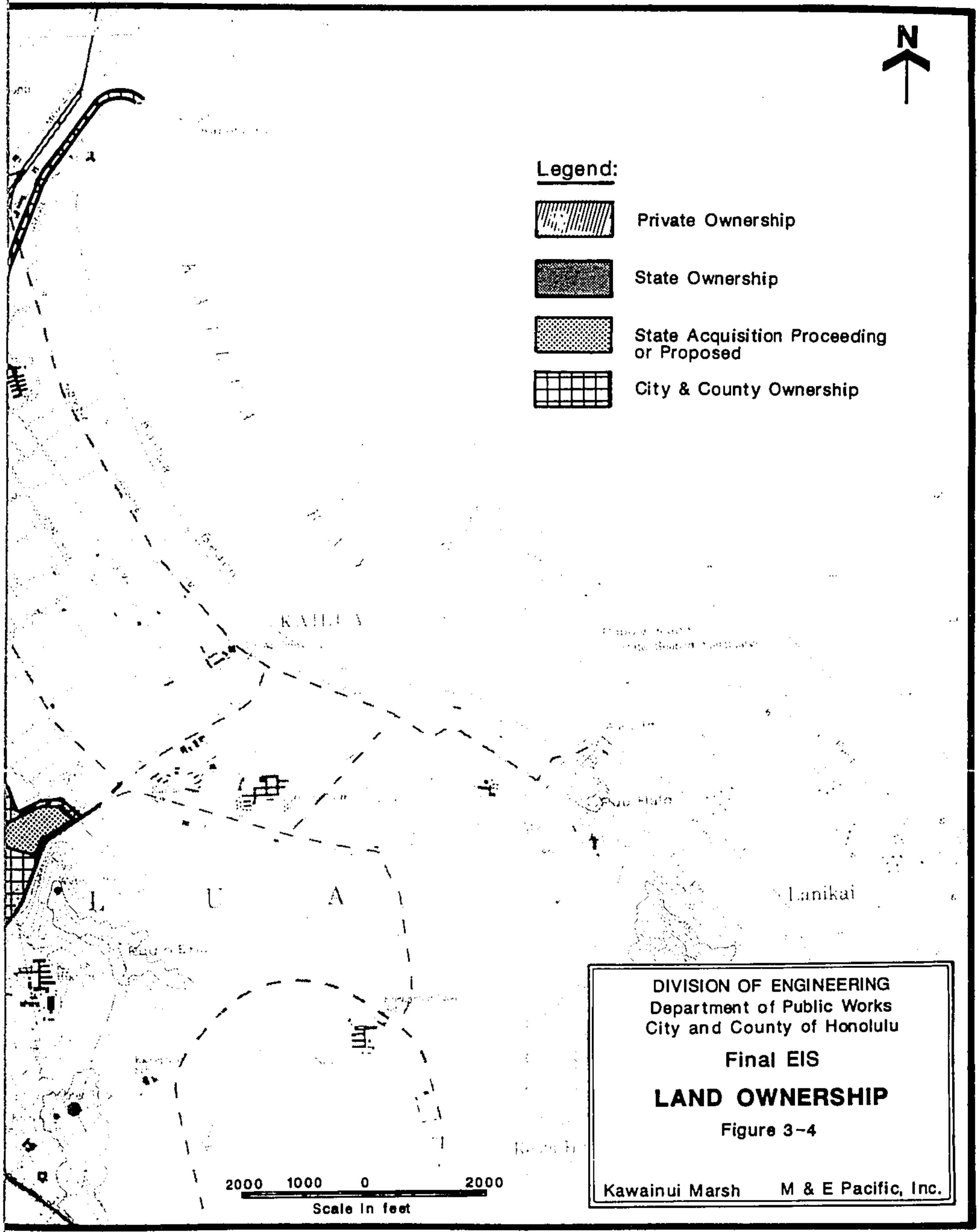
ARCHAEOLOGICAL RESOURCES
Figure 3-3

Kawainui Marsh — M & E Pacific, Inc.


N
KAHUKU
KAENA PT.
WAIALUA
WAHIAWA
WAIKANE
WAIAHOLE
PROJECT LOCATION
WAIANAE
EWA
HEEIA
WAIPAHU
PEARL CITY
WAIMANALO
HONOLULU
SAND ISLAND
NIU VALLEY
DIAMOND HEAD
KOKO HEAD
LOCATION MAP
NO SCALE


N
Legend:
Private Ownership
State Ownership
State Acquisition Proceeding or Proposed
City & County Ownership
KAILUA
L U A
Lanikai
2000 1000 0 2000
Scale in feet
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LAND OWNERSHIP
Figure 3-4
Kawainui Marsh
M & E Pacific, Inc.

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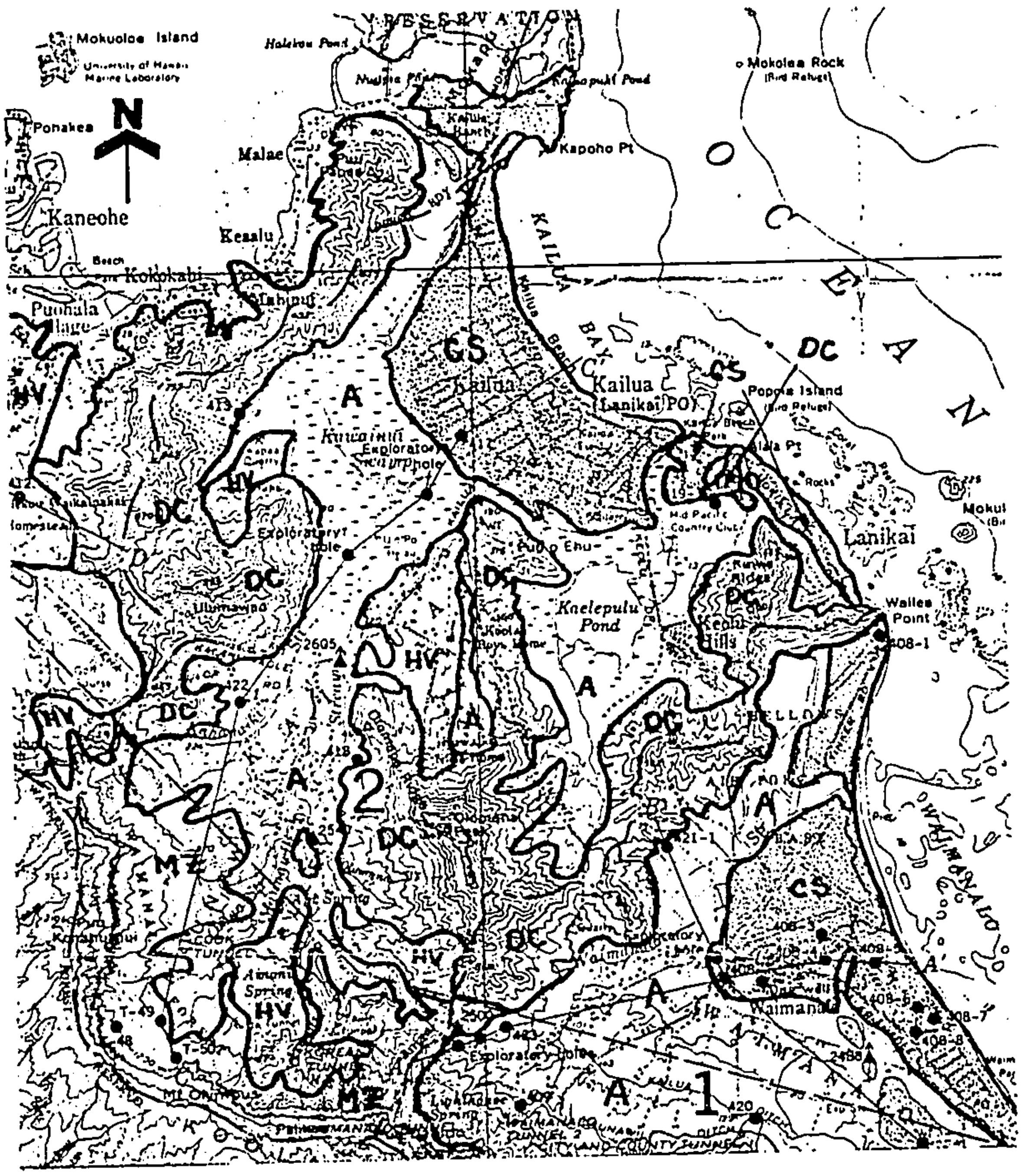
STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT



GENERALIZED GEOLOGIC MAP OF WINDWARD OAHU, HAWAII SHOWING LOCATION OF SELECTED DATA SITES

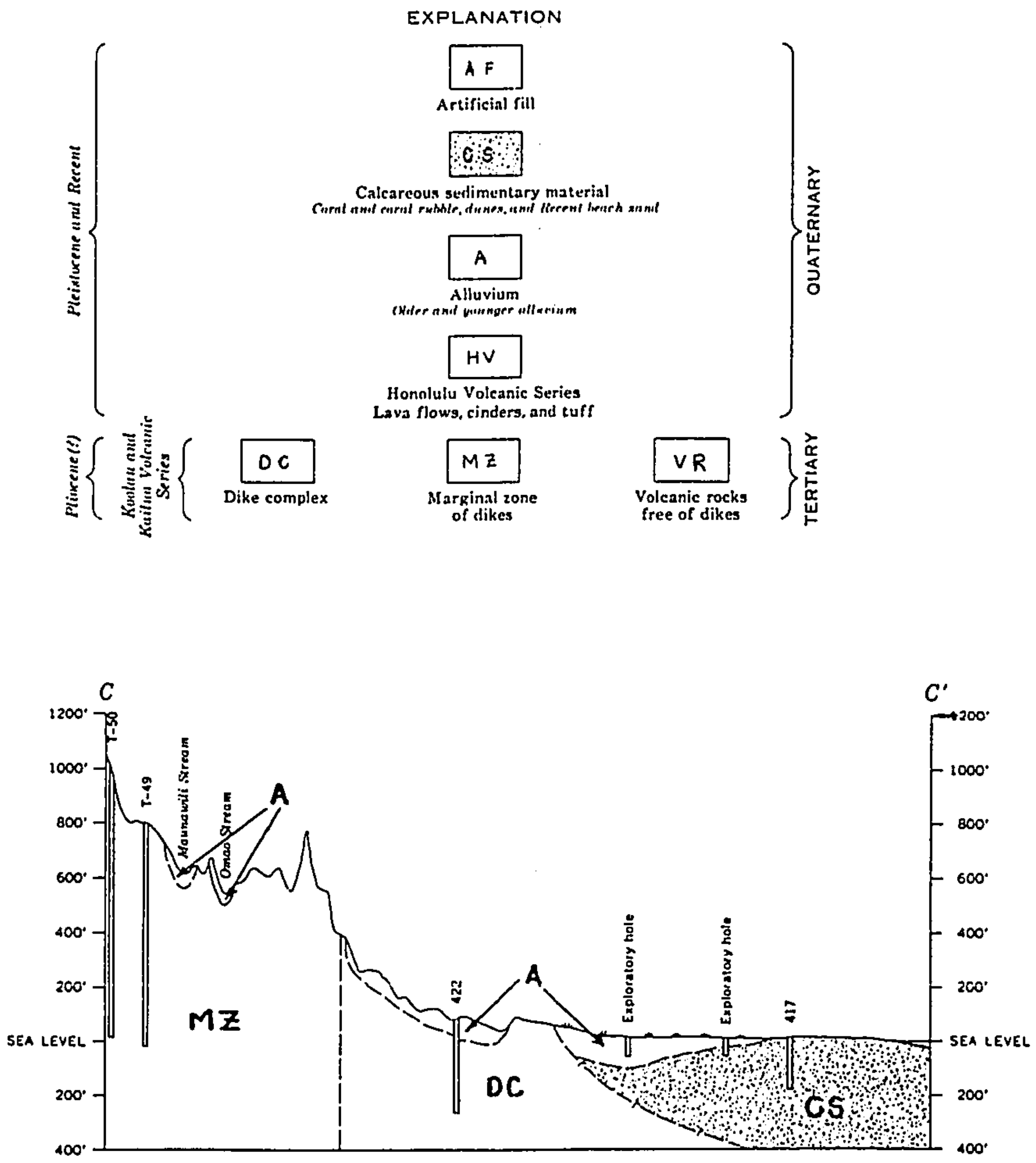
SCALE 1:62 500

1 ½ 0 1 2 3 4 MILES

1 .5 0 1 2 3 4 KILOMETERS

CONTOUR INTERVAL 80 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES IN FEET—DATUM IS MEAN LOWER LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 2 FEET

Reference: Water Resourc
Hawaii, Geolog
Paper 1894 by
G.T Hirashima,



ference: Water Resources of Windward Oahu
Hawaii, Geological Survey Water Supply
Paper 1894 by K.J. Takasaki,
G.T Hirashima, and E.P. Lubke, 1969

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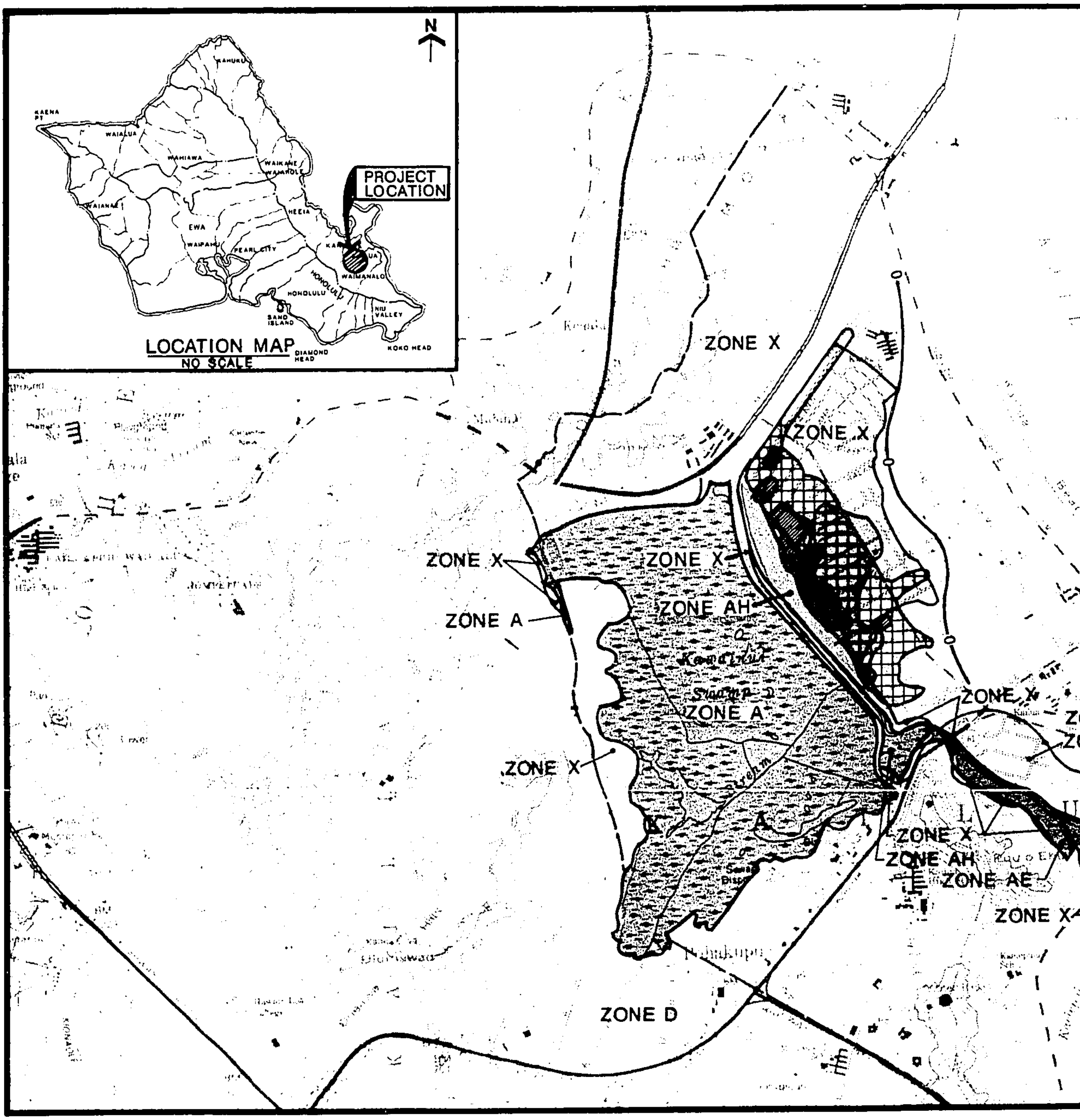
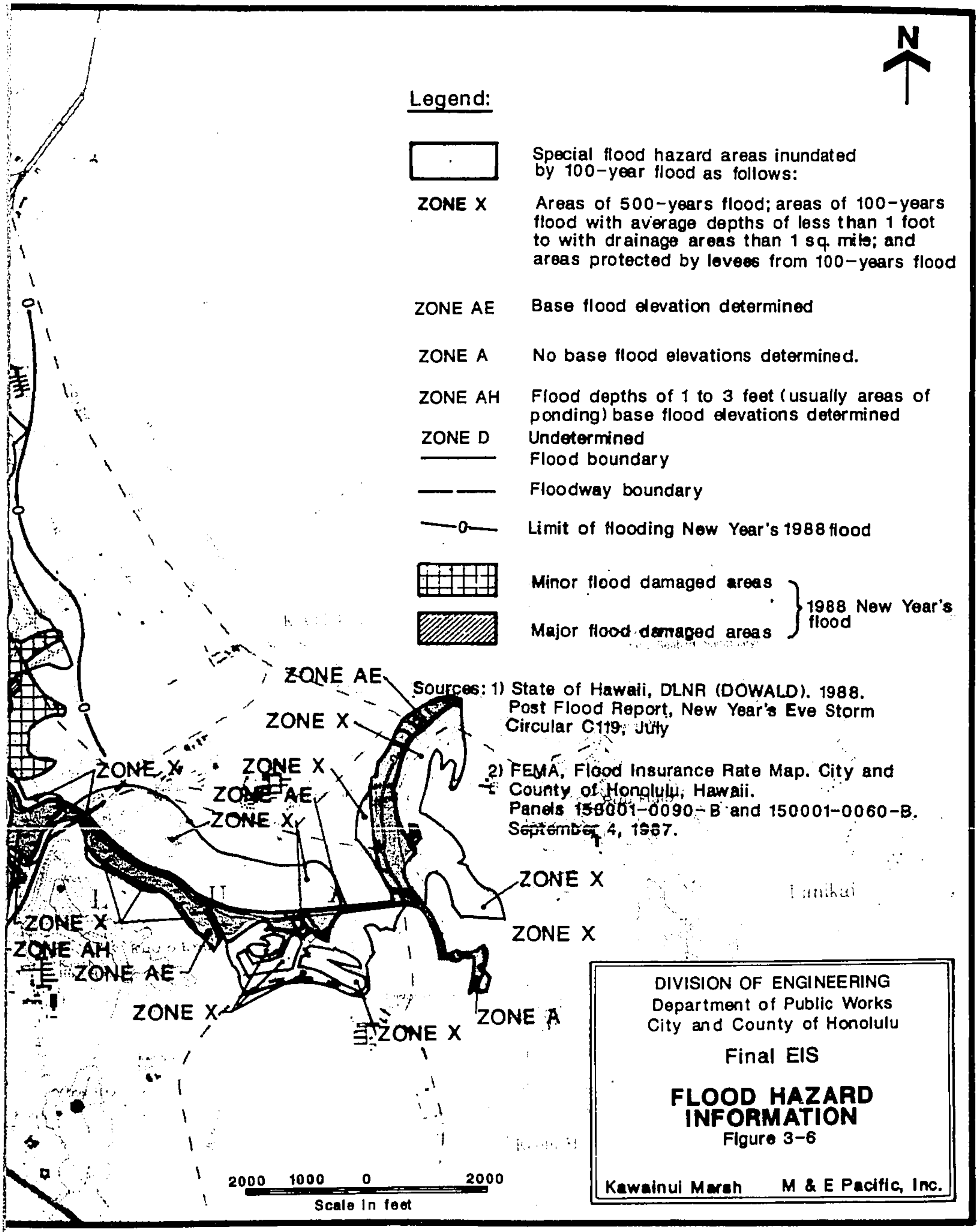
GENERALIZED GEOLOGICAL MAP

Figure 3-5

Kawainui Marsh M & E Pacific, Inc.



N
PROJECT LOCATION
KAHUKU
KAENA PT
WAIALUA
WAHIAWA
WAIANAE
EWA
WAIPAHU
PEARL CITY
HEEIA
WAIMANALO
HONOLULU
SAND ISLAND
NIU VALLEY
DIAMOND HEAD
KOKO HEAD
LOCATION MAP
NO SCALE
ZONE X
ZONE X
ZONE X
ZONE X
ZONE AH
ZONE A
ZONE A
ZONE X
ZONE X
ZONE X
ZONE AH
ZONE AE
ZONE X
ZONE D


N
Legend:
Special flood hazard areas inundated by 100-year flood as follows:
ZONE X
Areas of 500-years flood; areas of 100-years flood with average depths of less than 1 foot to with drainage areas than 1 sq. mile; and areas protected by levees from 100-years flood
ZONE AE
Base flood elevation determined
ZONE A
No base flood elevations determined.
ZONE AH
Flood depths of 1 to 3 feet (usually areas of ponding) base flood elevations determined
ZONE D
Undetermined
Flood boundary
Floodway boundary
Limit of flooding New Year's 1988 flood
Minor flood damaged areas
Major flood damaged areas
1988 New Year's flood
Sources: 1) State of Hawaii, DLNR (DOWALD). 1988. Post Flood Report, New Year's Eve Storm Circular C119, July
2) FEMA, Flood Insurance Rate Map. City and County of Honolulu, Hawaii. Panels 150001-0090-B and 150001-0060-B. September 4, 1987.
ZONE AE
ZONE X
ZONE X
ZONE X
ZONE AE
ZONE X
ZONE X
ZONE X
ZONE X
ZONE AH
ZONE AE
ZONE X
ZONE X
ZONE A
2000 1000 0 2000
Scale in feet
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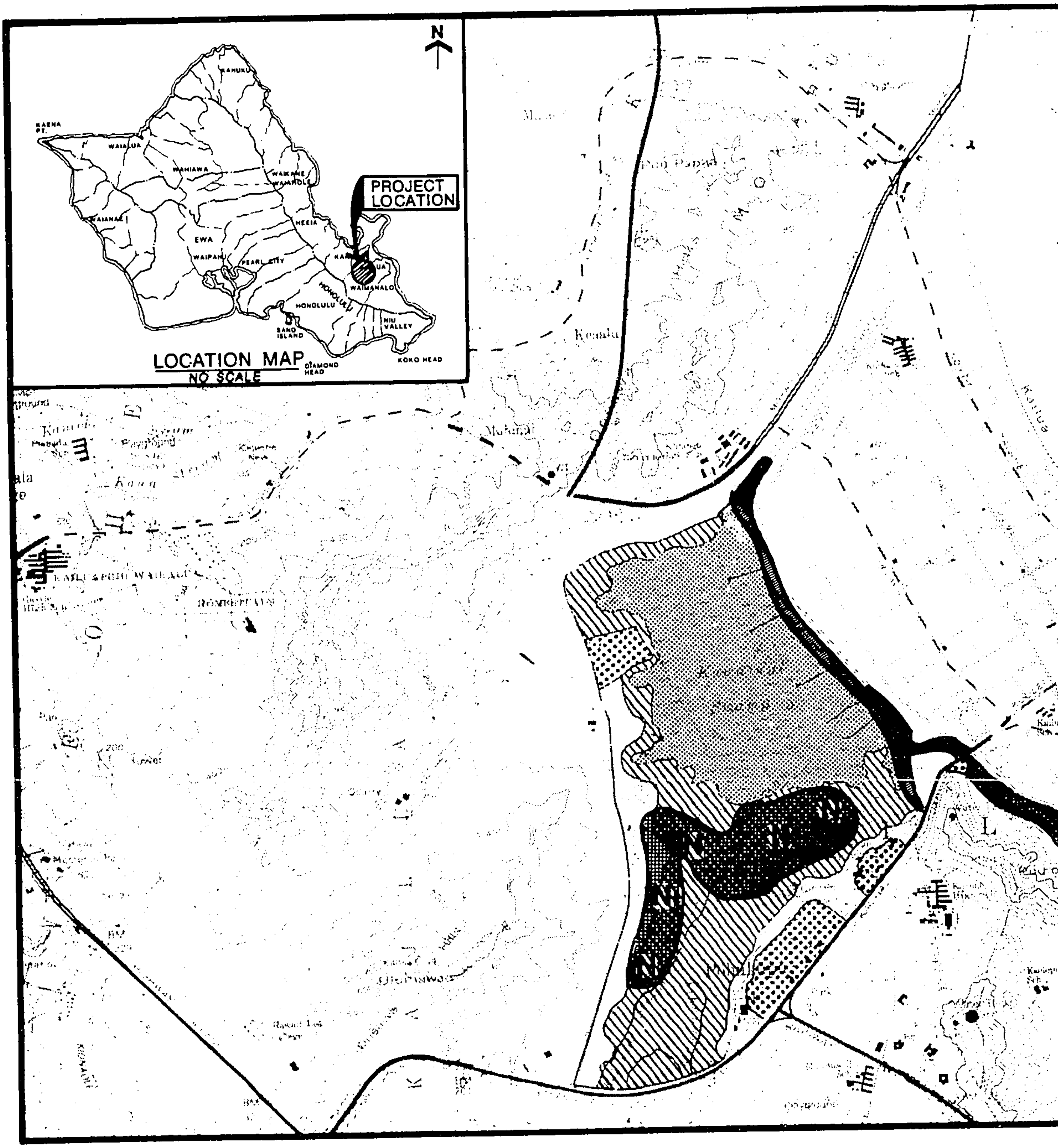
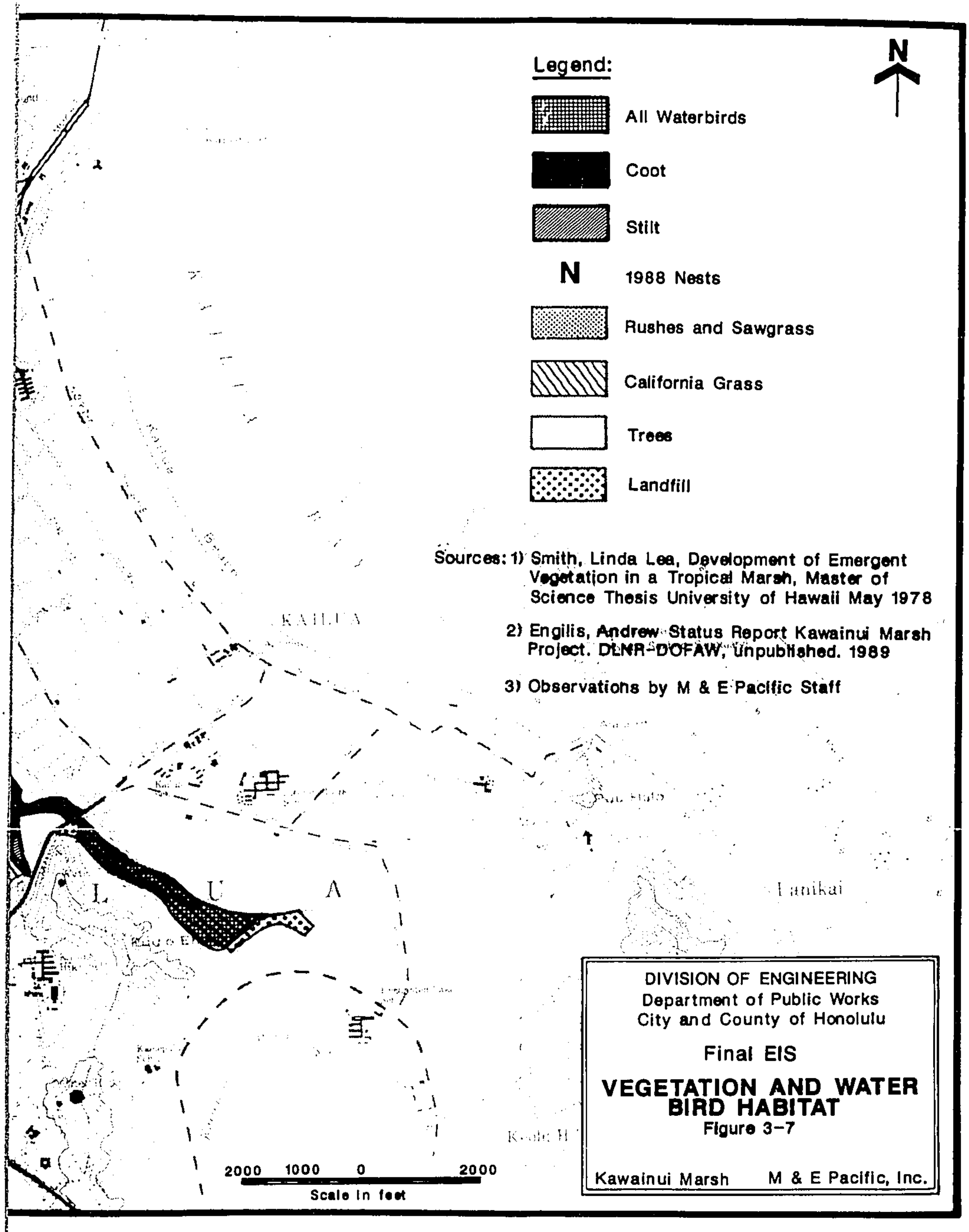
FLOOD HAZARD INFORMATION
Figure 3-6
Kawainui Marsh
M & E Pacific, Inc.


N
KAHUKU
KAENA PT.
WAIALUA
WAHIAWA
WAIKANE
WAIAHOLE
PROJECT LOCATION
KANEOHE
HEEIA
WAIANAE
EWA
WAIPAHU
PEARL CITY
WAIMANALO
HONOLULU
SAND ISLAND
NIU VALLEY
DIAMOND HEAD
KOKO HEAD
LOCATION MAP
NO SCALE
Kawainui Swamp


Legend:
All Waterbirds
Coot
Stilt
N 1988 Nests
Rushes and Sawgrass
California Grass
Trees
Landfill
N
Sources: 1) Smith, Linda Lea, Development of Emergent Vegetation in a Tropical Marsh, Master of Science Thesis University of Hawaii May 1978
2) Engilis, Andrew Status Report Kawainui Marsh Project. DLNR-DOFAW, Unpublished. 1989
3) Observations by M & E Pacific Staff
KAILUA
L U A
Lanikai
2000 1000 0 2000
Scale in feet
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VEGETATION AND WATER BIRD HABITAT
Figure 3-7
Kawainui Marsh
M & E Pacific, Inc.

SECTION FOUR

PROBABLE IMPACTS OF THE PROPOSED ACTION AND MITIGATION MEASURES

I Impact Assessment

Figure 4-1 shows a map depicting environmental constraints and factors. The relationships between the action and the following descriptions of impacts are more understandable when viewed in the context of these factors.

In Section 5 the effects of alternatives are compared in Table 5-1. These effects are categorized as short-term, lasting for the period of construction, and long-term, lasting beyond the initial construction period.

II Short-term Impacts and Monitoring

The openings through the interior of the marsh will have a detrimental effect upon the plant ecology in these areas. The negative short-term environmental impacts of this alternative include the temporary disturbance of the waterbird habitat near the points where the waterways connect with existing habitat areas, the permanent destruction of vegetation and substrate along the alignments (a relatively minor portion of the total wetland), the noise associated with the construction and maintenance activities, and higher flood water levels within the northern end of the marsh which will affect traffic on the quarry road. Additional open water created by these actions will have a positive impact by reducing flood stages at the upstream end of the marsh and by providing additional area for waterbird habitat. No requirement is foreseen at this time for mitigation of the effects of actions to open waterways. All of the proposed actions will be subject to the soil erosion/sedimentation, noise control, and water quality ordinances and construction plans will address these concerns.

Close coordination with fish and wildlife agencies will be required in the contract specifications. Final alignments of the waterways will be field checked prior to construction to determine whether any bird nests occur and monitored before maintenance work is undertaken. The alignments can be altered prior to construction since the effectiveness of these alignments depends not on linearity but upon hydraulic connectivity. Both the alignment of the waterways and the timing of the applications of herbicide will be coordinated with DLNR and USFWS prior to implementation in order to optimize improvements to waterbird habitat and minimize negative impacts on nesting wildfowl.

Monitoring during the construction phase of the project will include water level changes, waterbird activities, water quality, noise levels, seismic effects, vegetation pattern changes, and archaeological oversight. These will document the effects of the proposed plan including unforeseen impacts that may require mitigative action. Additional tests of the use of explosives will be done prior to full scale implementation. Prior to the use of explosives, the public will be notified as to the scheduled times. U.S. Fish and Wildlife Service and DLNR will be consulted. An archaeologist will be present and oversee results of explosives effects.

III Long-term Impacts

Ecological. The objective of the project is to improve circulation during floods within the interface between the bottom zone of the existing peat mat and the top of the levee without destroying the hydrologic balance of the marsh. This will not alter the the natural succession of the wetland, but will insure that the role of the marsh as a flood retention facility is maintained.

One potential long-term negative technical impact is the possibility that one or more of these newly constructed waterways may be obstructed by either shifting or by the dislodging and clogging of the waterway by other vegetation such as water hyacinth. Another long-term negative impact is the cost of the improvement; including both the construction and maintenance cost. However, the order of magnitude of the construction cost of this alternative is considerably less than other alternatives. Reliable estimates of long-term maintenance costs for these alternatives are not available.

The major effects of the waterway openings relative to long-term primary productivity of the wetland are related to the hydrology of the areas affected by the waterway openings. These effects are characterized as changes in species composition, net primary productivity, detritus production, organic accumulation, and nutrient cycling and availability.

Depth to the substrate along the waterways is not expected to be significantly altered by the removal of vegetation. However the open waterways will be subject to ecological succession from different types of vegetation than presently occupy these alignments. For example, the water hyacinth, *E. crassipes,* will have opportunities to increase their area expanse and coverage when high flow dislodges propagules upstream. Although it is planned to control this growth by harvesting and herbicide, fringe areas in these waterways will continue to be dominated and result in a change in the species composition. Depth to the substrate in the existing ponds will be increased during dredging activities.

Additional depths of water anticipated with the waterway openings in the interior of the marsh will not significantly alter the distribution of the present species composition of plants. Migration of invertebrates, fish, amphibians and avifauna along the waterways is expected.

Although the mass nutrient balance, in terms of total nutrient input and outflow, will not be significantly altered by the proposed action, the cycling of nutrients will be affected in the proposed waterways. The supply of dissolved forms of nutrients will be facilitated during floods into the central portion of the marsh. The duration of such short-term impacts will be in hours -- less than a day. In the time period of days, at the present, circulation is such that the inflowing water is distributed throughout the marsh. Consequently, the duration of such short-term events will be so small in comparison to the annual growing season that there will be no significant increase in net overall productivity.

The land adjacent to the model airplane field that will be used for deposition of sediments and vegetation from maintenance operations will not be usable for other uses such as recreation.

Social. The social and economic effect of the project will be primarily a reduction of the disruption caused by floods to the daily lives of the residents and business operators in the flood prone areas adjacent to the marsh. The improvement in circulation will also mean that inundation of low portions of the quarry road will occur more swiftly during the rain storms than presently occurs. The depth of the water will be comparable to what is presently experienced because the flood wave merely translates faster into the marsh. In general, there will be less social and economic disruption with the proposed action than presently occurs.

IV Relationship Between Short Term Uses Of Environment and Maintenance and Enhancement of Long Term Productivity

The major effects summarized above of the waterway openings relative to long-term productivity are related to the hydrology of the areas effected by the waterway openings. These effects are characterized as changes in species composition, net primary productivity, organic accumulation, and nutrient cycling and availability.

Species composition and abundance of flora will be relatively less affected than will the composition and abundance of fauna. Fauna, particularly endangered waterbirds, are presently severely restricted in distribution throughout the marsh. The waterways will increase habitat for feeding, nesting, and loafing. The food web will be altered in subtle ways along the alignments. Additional open water provides breeding areas for mosquitos and other invertebrates. However, it also allows the migration of fish in what is presently impenetrable areas of the wetland. Due to the size of the wetland presently dominated by vegetation, the approximately 10 acres of additional waterway is an important improvement of productivity of one part of the environment at a modest sacrifice of the floral environment.

Proposed changes in water distribution will reduce the magnitude of water level excursions in the upstream end of the marsh but not eliminate a fluctuating water level necessary to sustain the ecosystem in the central and major portion. Without providing direct routes to the outlet that might cause short-circuiting of water, the waterways provide a more seasonally stable, yet moderately fluctuating water level for nesting as well as feeding. With a seasonally stable habitat, and additional open water feeding areas, waterfowl should experience a significant improvement in productivity.

The time effect of this improved circulation can be measured in hours which, in terms of vegetation productivity, detritus accumulation, and peat deposition, has minor effect upon present rates. This aspect of biologic succession due to waterway construction seems unalterable. Maintenance activities will remove sediment deposition and vegetation and floating peat accumulation; however, in the context of the entire waterway and pond area maintained, this affects less than five percent of the marsh.

The effects of hydrology on the decomposition rates based on one literature reference (Mitsch and Gosselink, 1986) is unclear. They note a study that concluded that it cannot be assumed that the increased frequency or duration of flooding will necessarily increase or decrease decomposition rates. Given the above conclusions concerning the nutrient cycling and net productivity changes, the conclusion is that the effects upon organic accumulation and deposition from the proposed action will be minor when compared to the context of the entire marsh.

The design philosophy underlying the proposed action is an attempt to design with nature instead of trying to overcome it. Its elements are each small in scale, some are flexible in terms of location in the event additional impacts are identified during construction, where possible it can complement previous planning recommendations, and the plan preserves options for future efforts to develop an overall master plan. For example, it recognizes that the circulation/storage capability of Kawainui Marsh can be increased without significantly altering the landscape in such a way that adverse changes to the wetland could result. In the long term, increasing the range of flowing waters within the marsh may help in efforts to reestablish early succession plant communities although it is too early to predict how successful opening waterways will be in attaining the goal of prolonging the life of the wetland.

The plan provides the opportunity for some of the objectives of the Kawainui Marsh Resource Management Plan (DPED, 1983) to be implemented, specifically, additional open water habitat, moats for predator control, and the potential for passive recreational access to the marsh for ecological education purposes. Also, it avoids impacts in known areas of archaeological resources and offers possibilities for future plans. One possibility for future study is incorporating fish ponds in the proposed educational/inter-pretive center site adjoining Kaelepulu Stream.

There is no question that the flexibility provided by the proposed plan of action has an attached cost. In the short term there will be productivity changes in the location of the waterways which will require an annual expenditure of public monies to maintain. It will require additional research and evaluation of topics that are not well documented enough for basic management decisions. For example, there has been only one net productivity study of the marsh and that did not include below ground production. Yet any decisions concerning long-term design for components of a plan for flood protection, for example, outlet capacity or levee height, will also require this data. A plan such as this, unlike a traditional structural quick-fix solution, requires commitment to ongoing planning and coordination. This is an unresolved issue discussed in Part VI of this section.

V Irreversible and Irretrievable Commitments of Resources

Because of the limited magnitude and scope of each of the measures included in the proposed action, none is considered irreversible. Assuming that reversals in the proposed action will not take place, the irretrievable resource commitments include the materials, energy and labor to construct the improvements, the loss of small amounts of wetland vegetation and possible changes in plant species. Monetary costs cannot be placed upon all of these commitments. The construction costs for the proposed action elements are estimated as follows:

Mobilization & Contractor Storage -	$ 53,000
Construct Vegetation/Sediment Processing & Handling Facility -	3,701,000
Open Waterways -	348,000
Herbicide application -	10,000
Total	$ 4,112,000

VI Unresolved Issues

The major issue which will affect the successful implementation of the proposed plan is coordination among agencies that have different primary functions and responsibilities for the marsh. Under current regulatory controls, all three levels of government have direct regulatory authority within and around the marsh. There is also a clear geographic overlap of authority.

The vast array of government responsibilities in resource management have not been coordinated nor enforced systematically. There is a need to provide a centralized coordinative mechanism through which consistent protection, enhancement, and use of the marsh resources can be assured.

Legislation was passed during the 1990 session of the State Legislature to address this problem. It provides for the transfer of all of the city-owned land in Kawainui Marsh, except for the community park area, to the State once the City and the Army Corps of Engineers have completed all pending flood control projects to the satisfaction of the Department of Land and Natural Resources.

A second issue that affects the long-term management of the marsh is the problem of controlling the inputs of nutrients and sediment into the marsh. Although this has been identified as an issue, no specific proposals have been identified to address the problem. Stringent enforcement of existing erosion and sedimentation control ordinances has potential only to the limits to which the existing criteria may be applied. There is at present no existing statutes which would limit the release of nutrients, from the application of fertilizers, for example, that may be contributing to excessive productivity in the marsh. Sufficient information is not available to determine the relative effects of different sources and the measures that are required above what already is required by existing statutes and ordinances to develop appropriate legislation that would rectify any shortcomings in the existing system.

The third major unresolved issue is what is the best set of management measures required for long-term control of the vegetation in the marsh. This must be addressed in the context of plans for other functions of the marsh including the cultural resource studies and educational development possibilities, the endangered waterbird sanctuary plans, and recreational and aesthetic concerns of the community. A broader agenda than flood control is required to obtain the data and viewpoints to formulate a long term plan. Some possibilities for long term vegetation control noted in Appendix B, Section 5 are controversial and have significant impacts. For example, biological controls such as additional grazing pressure and fire that have the best prospect for being cost effect and capable of use throughout relatively large areas of the marsh require a lot of research, planning, engineering, and public discussion. Several iterations of ideas may have to be scrapped and new alternatives formulated until a satisfactory approach becomes evident.

As the largest single wetland in Hawaii, the maintenance (and enhancement where possible) of the ecological attributes of Kawainui Marsh should be one of the keystones of any management scenario adopted. Consideration should be given to biweekly monitoring of the entire perimeter of the wetlands to note and report any unlicensed filling or other alteration of the wetlands. Indiscriminate dumping of fill, metal debris, or other materials would result in a significant degradation of the ecological attributes of this wetlands areas. Any fill discovered should be immediately removed and a wetlands restoration plan initiated to facilitate recovery of the wetlands to the prefill status. Consequently an enforceable, implementable management and monitoring plan must be considered for any future wetlands scenarios that may relate to flood attenuation.

A fluctuating water level is one of the key components of productive wetland ecosystems. The key is to have the area become neither too wet, nor too dry. Consequently, management of the water level within the wetlands during normal periods of precipitation and flow is as critical as management of water levels during periods of severe flooding.

Three important lessons about the design and implementation of flood control measures in the marsh learned by comparing the data developed in this report and the original design for the flood control project are:

1) manipulation of the hydrologic outlet of the marsh can work to the detriment of flood protection by raising water levels and altering circulation patterns with the possibility of affecting net productivity;

2) this productivity, in the form of dense growths of vegetation creates a marked difference in flood water levels that will be observed between the upstream and downstream ends of the marsh with the attendant risk of overflow into the adjoining community; and

3) the vegetation decomposition is itself a significant component of sedimentation and infilling of the hydrologic basin and requires consideration relative to future water levels.

These lessons were incorporated into the proposed action. Actions which would lead to major modifications of the marsh outlet at Oneawa canal have been avoided until such time as a more complete understanding of the linkages between the hydrology and productivity are developed. During the interim, presumably the Corps of Engineers' study will address alternatives for providing outlet capacity that does not exceed the downstream Oneawa canal capacity nor flood Coconut Grove. In an emergency, the natural outlet (Kaelepulu Stream) was identified for providing relief. The preliminary design analysis of the proposed action considered the sensitivity of outlet capacity to increased water levels in the marsh prior to the beginning of major floods. However, the long-term accumulation of sediments due to the enormous amount of biomass created annually by the marsh will not be solved by the harvesting or chemical control measures recommended as part of the proposed action. The reason is that these measures do not reach the majority of the areas where this production is taking place.


HAWAIIAN STILT (Himantopus mexicanus knudseni)


HAWAIIAN DUCK (Anas wyvilliana)


HAWAIIAN GALLINULE (Gallinula chloropus sandvicensis)


HAWAIIAN COOT (Fulica americana alai)

APPENDIX A

ENGINEERING STUDIES

SECTION 1. General Climatic Setting

Tropical air circulation in the central North Pacific Ocean results in the most prominent feature of the climate--the tradewind flow in a general east to west direction. The prevailing winds provide a continuous influx of relatively warm moist air that provides the abundant rainfall in the region. The dominance of the trades with the influence of terrain result in the unique climate of the study area. Wind direction frequencies are shown below:

Directions	January %	August %
NNE to E	50	90
ESE to S	19	4
SSW to W	10	<1
WNW to N	20	3
Calm	2	1

Under tradewind conditions the air is moist at elevations below the 4000-5000 feet temperature inversion layer. Below this elevation, the temperature decreases from the surface to the inversion layer where the sudden increase in temperature restricts the vertical movement of air resulting in cloud development. The clouds form chiefly along the mountains where the incoming trade-wind air is crowded together as it is forced up over the crest. The perpendicular orientation of the Ko'olau Range to the general direction of tradewind movement enhances the cloud formation and the associated rainfall pattern.

Elevations within the study area range from sea level to in excess of 2000 feet. The lower elevations, particularly Kawainui Marsh, receive greater amounts of solar energy than the higher elevations. Solar insolation is estimated to range from up to 300 calories per square centimeter in the upper watershed area of Maunawili Valley to 375 calories per square centimeter in Kawainui Marsh. Solar energy affects the evapotranspiration rates which in turn effect the hydrologic budget.

The climate is also characterized by a two-season year consisting of a cooler and wetter winter period and a warmer, drier summer period. The annual rainfall cycle is generally recognized by climatologists as a wet period, October to April (7 months) and dry period from May to November (5 months). Mean annual rainfall over the Maunawili drainage basin is estimated (Takasaki, et al, 1969) at 86 inches.

Due to the latitude of the area, 21 degrees, 20 minutes north latitude, mild and fairly uniform temperatures occur throughout the year. In Honolulu, the warmest month is August with an average temperature of 78.4 degrees F; the coldest month is February, at 71.9 degrees F. At elevations below 5000 feet, the daily range in temperature is between 8 and 20 degrees F.

Spatial and temporal distributions of rainfall are pronounced in the Kawainui study area. In general, the orographic effect of the Ko'olau Range produces the most intense rainfall nearest the summit. The result of the strong uplifting of tradewinds is a maximum precipitation point for Oahu just slightly leeward of the crest. Rainfall patterns for individual storms reflect this topographic influence.

The spatial and temporal distribution of rainfall can be observed from the comparison of recorded data at three rainfall stations summarized in Table A-1. The location of these stations is shown on Figure A-1. As the table shows, annual rainfall at the edge of Kawainui Marsh from Station 791 (Kailua Camp) was 47 percent (40.64/85.76 = 0.47) of the long-term average annual rainfall at Station 787.1 (Maunawili). In addition, the table shows that between 70 to 81 percent of the annual rainfall occurs in the winter period (months of October through April).

The significance of the annual rainfall pattern is that the majority of the water yield of the hydrologic basin surrounding Kawainui originates in the winter months at upper elevations. The existence of the wetland requires the inundation of floodwater during the winter months when the rainfall in the upper watershed area exceeds the annual rate of evapotranspiration. During the dry season, flow into the marsh may not be sufficient to compensate for evapotranspiration losses.

Table A-2 shows the pan evaporation observations from two weather stations. Comparing this table to previous rainfall values (Table A-1) for comparable stations, the reversal in rainfall/evaporation dominance can be seen.

Takasaki, et al, (1969) estimated a hydrologic budget in terms of million gallons per day for two portions of the basin (areas shown in square miles) as follows:

BASIN	AREA	RAINFALL	ET	WATER YIELD	ET/RAINFALL
Maunawili Subbasin	6.7	27.6	14.1	13.4	0.51
Maunawili Valley	18.0	52.2	46.5	5.7	0.89

The ratio of evaporation to rainfall is calculated to be 0.89 which would be closer to the condition for the marsh than for the Maunawili tributary area. A map of potential evaporation for Oahu (Ekern and Chang, 1985) indicates that approximately 70 inches of evaporation may be possible annually in the vicinity of Kawainui Marsh. Assuming that the monthly distribution is similar to Station 795.1 (Waimanalo Experiment), a potential evapotranspiration loss of approximately 0.7 feet is possible in the peak month of June; during the month of December, 0.35 feet is possible. Evapotranspiration from a tall rough crop surface will vary from the potential depending on such factors as crop growth stage and the availability of water. For example, the ratio of crop to pan evaporation for sugar cane varies between 0.40 to 1.01 during the first five months from germination to full canopy. The rate of evapotranspiration for sedges in the marsh can be expected to be similar to rates for sugar cane. These large amounts of evapotranspiration are important to the water balance in the marsh because significant decreases in water level may be possible during periods of extreme drought. Taking the numbers cited above, this may amount to 0.7 feet over one month which may be converted to an average flow rate of 8.7 cubic feet per second (5.61 mgd) based on a marsh area of 740 acres (740 acres x 0.7 feet /30 days x 0.504). The significance of the potential evapotranspiration is that water management planning must take into consideration the possibility that inflow may not match outflow plus losses such as evapotranspiration during the dry season. Mitigation measures will be required to maintain minimum water levels for alternatives which drain the marsh, i.e. lower water levels during the wet season.

Table A-1
Mean Rainfall at Selected Stations

Name	State No.	Elev Ft., MSL	INCHES Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Maunawili NWS	787.10	410	10.30	6.75	9.09	8.15	7.10	4.02	5.50	4.95	4.13	6.63	8.54	10.69	85.76
Hawaii Youth	790.00	155	6.90	4.52	7.22	4.02	3.12	1.72	2.15	2.54	1.91	4.17	5.27	6.83	53.66
Maunawili Circle	790.60	110	8.85	6.63	2.09	4.36	5.34	3.04	3.74	4.49	3.32	5.73	7.10	9.48	73.13
Waimanalo Experiment	795.10	60	8.03	4.84	6.01	3.94	3.08	1.33	1.56	1.99	1.52	3.82	5.30	7.37	49.30
Kailua Camp	791.00	35	6.24	4.21	5.11	4.52	2.38	1.17	1.40	1.60	1.99	3.90	3.86	4.95	40.64

Table A-2
Mean Pan Evaporation at Selected Stations

Name	Elev	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						INCHES								
Maunawili [787.1]	410	3.35	3.47	4.4	4.05	4.44	4.53	4.7	4.51	4.67	4.12	3.26	3.26	48.41
Waimanalo Exper [795.1]	60	4.13	4.13	5.41	5.97	7.15	8.75	8.45	7.47	7.3	6.45	4.33	4.05	66.89

The average water yield of 5.7 mgd for the entire valley (approximately 8.8 cfs) includes ground-water as well as surface components. The groundwater component of flow of some windward streams can be significant. Takasaki, et al, (1969) noted that for Waihee Stream the groundwater component ranged from 82 to 95 percent, averaging 90 percent of the total flow hydrograph. The gain in streamflow can be dramatic in some streams depending upon geologic conditions making predictions of streamflow uncertain. Groundwater movement into the stream channels along their course is very important to sustaining inflow to the wetland.

Groundwater escaping from the marsh toward Kaelepulu Stream is another potential loss in the water budget of the marsh, but the relative magnitude of this loss is believed much less than evapotranspiration. Data that indicate there is a groundwater hydraulic connection between the marsh and Kaelepulu Stream (which is tidal) were obtained during the water level data collection program described in Section 4. A harmonic motion closely corresponding to the approximately 25-hour spring tidal cycle was detected in recorders close to the levee during periods of low water levels in the marsh. During periods of large inflow and higher levels, this periodic motion was masked by larger storm-induced water level changes. The cycles could not be explained by evapotranspiration losses as the downward movement in water level did not correlate with daylight hours.

Groundwater movement from the marsh toward Coconut Grove was considered as a possible source of flooding in an earlier study (U.S. Geological Survey, 1971) and discounted as a significant flood source. However, the study noted that the "inner canal" (Kaelepulu Stream) is generally at a lower hydraulic gradient than the marsh and hence the possibility exists that groundwater flux exists between the marsh and Kaelepulu Stream. The U.S. Army Corps of Engineers' Design Memorandum (1957) estimated the permeability of both the foundation materials and the borrow materials used to construct the levee at 10 feet/day. Using the following equation from Chow (1964) the range in this groundwater movement was estimated:

$$q = \left[\frac{K}{2x}\right](h^2 - h_o^2)$$

where q = discharge per unit width
x = distance between two water bodies
h = head at lower water body
h_o = head at upper water body
k = coefficient of permeability

Assuming 6000 feet of levee, and the distance between the marsh and Kaelepulu Stream to be 125 feet, the flow rate varies according to the following:

marsh water level, ft. (msl)	mgd
3	0.010
5.2	0.064

The average level of Kaelepulu Stream was assumed to be 2.4 feet. At these levels, groundwater movement out of the marsh through the levee is not significant relative to the average daily inflow.

Figure A-2 shows an estimate of the percent of time the combined inflow from Kahanaiki and Maunawili streams is equaled or exceeded. It also indicates the magnitude for average daily inflow from these streams is less than 10 mgd excluding diversions due to Maunawili ditch.

The latter were estimated by Takasaki, et al, (1969) at approximately 2 mgd. Based on Figure A-22, the average daily flow from Kapaa watershed is estimated at approximately 3 mgd, and the flow equalled or exceeded 90 percent of the time is approximately 1.6 mgd. The amount of inflow into the marsh available 99.99 percent of the time is estimated as 1.4 mgd, based on the following methodology: 1) the total inflow from the three principal tributaries (Figure A-2) is estimated to be 3 mgd (4.6 cfs), and 2) the total amount of the Maunawili ditch diversion could be no more than the 99.99 percent flow for Makawao Stream or 1.6 mgd (2.5 cfs), leaving a net of 1.4 mgd (2.1 cfs). The median inflow from the two upstream tributaries would be approximately 7 mgd (10 cfs), without considering the upstream diversion which would reduce this estimate. The significance of these numbers is that they are the same order of magnitude as the estimate for the high rate of evapotranspiration. Thus the sensitivity of the marsh to droughts has to be considered in planning flood damage reduction measures. A balance must be sought when managing water levels to provide levels high enough to preserve important ecological functions.

In addition to merely maintaining water levels, the effects of circulation must be considered when assessing flood damage reduction measures. The literature on wetlands (Mitsch and Gosselink, 1986) indicates net biomass production is directly related to the openness of the wetland to hydrological fluxes. Wetlands in stagnant water have low productivities while wetlands open to flooding have higher productivities. One of the wetland management objectives (Department of Planning and Economic Development, 1983) is to reestablish waterbird habitat. One action that supports this policy is creating open water habitat. This means arresting the changes taking place in the interior of the marsh by increasing water circulation to enhance early succession plants such as sedges. Aerial photographs of the marsh (Appendix B, Section 1) show definite patterns of vegetation have predominated for the past 45 years. For example, the predominance of California grass (*Brachiaria mutica*) which has greater nutrient requirements than sawgrass (*Cladium leptostachyum*) may be the result of the historic circulation patterns. The flow pattern now favors the southeastern corner of the marsh where California grass is dominant. It is interesting to note that this area has avoided colonization by more terrestrial plant types. The opening of new water circulation routes within areas now inhabited by terrestrial plant species may be a strategy to inhibit the succession of the marsh from a wetland to meadow ecosystem. This needs further study by natural resource managers to determine the scale and location where desired results can be achieved. However, if new waterways can be created as part of the flood control program, a photographic baseline to begin monitoring changes in vegetation patterns is needed.

SECTION 2. Flood Hydrology

Climatologists classify atmospheric disturbances having the potential to produce storms with major flood producing proportions into four major types. (1) Cold front storms. These pass during the winter season, and typically are spotty, with several inches falling in some areas and only fractions falling in others. Several of these storms (6-8) may occur on Oahu each year. (2) Kona storms. These are also winter features which are more widespread and prolonged. Normally there are one or two such storms in a season. In March 1958 such a storm produced 17.4 inches of rainfall in downtown Honolulu, in a 24-hour period. (3) Hurricanes and tropical storms. These are relatively rare in Hawaii, and are most likely to occur during the last half of the year. Hurricane Iwa in November 1982 produced between 2 to 4-inches of rainfall in a 24-hour period. (4) Upper level lows. These are storms associated with low pressure areas well developed in the upper atmosphere (as opposed to near sea level). Intense and widespread rain accompanies these types of storms. They are similar to Kona storms; however, surface winds may be from almost any direction. The storm of May 1965 and the New Year's Eve storm of 1988 were this type.

Because of the significance of the New Year's 1988 storm to subsequent flood events at Kawainui Marsh, an in-depth study of that flood's hydrology was made. In addition, a comparable evaluation was made of a more moderate event that occurred in April 1989. The details of this study are explained in the following paragraphs.

Essential data used in the study of flood hydrographs are:

1. A 24-hr rainfall isohyetal map of the 1988 New Year's Eve storm for southeastern Oahu;

2. Rainfall and streamflow data recorded during the 1988 New Year's Eve storm as well as storms during April 4 to 9, 1989; and

3. Basic watershed characteristics of Maunawili (5.45 sq. mi.), Kahanaiki (1.91 sq.mi.) and Kapaa (1.17 sq. mi.) watersheds (Figure A-3).

Data of the 24-hr (7:00 a.m., 31 December 1987 to 7:00 a.m., 1 January 1988) rainfall isohyetal map of 1988 New Year's Eve flood for southeastern Oahu became available in March of 1988 and was subsequently revised and published. This map is the result of an analysis of 1988 New Year's Eve rainfall data by the Division of Water and Land Development, Department of Land and Natural Resources (DOWALD, 1988). Rainfall data and the copy of the paper tapes at gage No. 787.1 as well as streamflow data at gage No. 2540 (Makawao stream) for storms during April 4 to 9, 1989 were obtained. Based on the data in the DOWALD report, the 24-hr average rainfall of 1988 New Year's Eve storm for Makawao, Maunawili, Kahanaiki, and Kapaa watersheds were calculated (Tables A-3 to A-6 and Figure A-4). Using Makawao watersheds as the basis, rainfall distribution correction factors for Maunawili, Kahanaiki and Kapaa watersheds were also obtained (Table A-7), and the storm rainfall was adjusted by the appropriate rainfall distribution correction factor. Furthermore, at Maunawili rain gage No. 787.1, 15.7 inches of rainfall from 4:00 p.m. to 10:00 p.m. on 31 December 1987 were recorded. Unfortunately, the rainfall recorder stopped after 10:00 p.m.. However, as indicated in a nearby rain gage (No. 794.3), the rain storm continued for several hours (until 1:00 a.m., 1 January 1988). It is, therefore, reasonable to extend the rainfall at Maunawili (gage 787.1) for at least two more hours (i.e until 12:00 a.m). By trail and error of matching measured direct runoff hydrograph at Makawao stream gage (No. 2540), 1.8 and 0.9 inches of rainfall were estimated at the Maunawili rain station for 11:00 p.m. and the last hour of 1987. By means of the same technique, rainfall data for April 8-9 storm were also extended from 1:45 a.m. to 6:30 a.m., April 9, 1989.

Table A-3 Calculation of the 24-hr Average Rainfall of 1987 New Year's Eve Storm Over Makawao Watershed

Sub-Region (1)	Sub-Area (sq.mi.) (2)	Estimated Regional Rainfall (inches) (3)	**Rainfall Volume (sq.mi.-inches) (4)
A_1	Ø.555	25	13.88
A_2	Ø.9Ø7	22.5	2Ø.41
A_3	Ø.558	17.5	9.77
Total	2.Ø2 *	Total	44.Ø6

24-hr average rainfall for Makawao Watershed
=(44.Ø6/2.Ø2) = 21.8 inches

* Published area of Makawao Watershed is 2.Ø4 sq. mi (USGS, 1988).
  % of error = (2.Ø2 - 2.Ø4) / 2.Ø4 = -1.Ø%

** Col (4) = Col (2) times Col (3).

Table A-4 Calculation of the 24-hr Average Rainfall of 1987 New Year's Eve Storm Over Maunawili Watershed (including Makawao Watershed)

Sub-Region (1)	Sub-Area (sq.mi.) (2)	Estimated Regional Rainfall (inches) (3)	**Rainfall Volume (sq.mi.-inches) (4)
A_1	1.52	25	38.ØØ
A_2	1.97	22.5	44.33
A_3	1.24	17.5	21.7Ø
A_4	Ø.61	12.5	7.63
Total	5.34 *	Total	111.66

24-hr average rainfall for Maunawili Watershed
=(111.66 / 5.34) = 2Ø.9 inches

* Area of Maunawili Watershed is 5.45 sq.mi.

% of error = (5.34 - 5.45) / 5.45 = -2.Ø %

** Col (4) = Col (2) times Col (3).

Table A-5 : Calculation of the 24-hr Average Rainfall of 1987 New Year's Eve Storm Over Kahanaiki Watershed

Sub-Region (1)	Sub-Area (sq.mi.) (2)	Estimated Regional Rainfall (inches) (3)	**Rainfall Volume (sq.mi.-inches) (4)
A_1	Ø.33	25	8.25
A_2	Ø.35	22.5	7.88
A_3	Ø.94	17.5	16.45
A_4	Ø.24	12.5	3.ØØ
Total	1.86 *	Total	35.58

24-hr average rainfall for Kahanaiki Watershed
=(35.58/1.86) = 19.1 inches

* Area of Kahanaiki Watershed is 1.91 sq. mi.

% of error = (1.86 - 1.91) / 1.91 = -2.6%

** Col (4) = Col (2) times Col (3).

Table A-6 Calculation of the 24-hr Average Rainfall of 1987 New Year's Eve Storm Over Quarry Watershed

Sub-Region (1)	Sub-Area (sq.mi.) (2)	Estimated Regional Rainfall (inches) (3)	**Rainfall Volume (sq.mi.-inches) (4)
A_1	Ø.14	17.5	2.45
A_2	1.Ø5	12.5	13.13
Total	1.19 *	Total	15.58

24-hr average rainfall for Quarry Watershed
=(15.58 / 1.19) = 13.1 inches

* Area of Quarry Watershed is 1.17 sq.mi.
  % of error = (1.19 - 1.17) / 1.17 = 1.7 %

** Col (4) = Col (2) times Col (3).

Table A-7 **Summary of 1987 New Year's Eve Storm 24-hr Average Rainfall and Rainfall Distribution Correction Factors for Makawao, Maunawili (including Makawao), Kahanaiki and Quarry Watersheds**

Watershed (1)	24-hr Average Rainfall (inches) (2)	Area Used in calculating Col (2) (sq.mi.) (3)	Area Used in this report (sq.mi.) (4)	*Rainfall Distribution Correction Factor (5)
Makawao (Base Watershed)	21.8	2.02	2.04	1
Maunawili (including Makawao)	20.9	5.34	5.45	0.96
Kahanaiki	19.1	1.86	1.91	0.88
Quarry	13.1	1.19	1.17	0.60

* Col (5) = Col (2) / 21.8 inches.

The inflow hydrograph for the 740-acre marsh may be estimated by using the Nash-Muskingum routing of rainfall excess (Nash, 1959). The Nash-Muskingum routing equation can be expressed as:

$$O2 = Co\ I2 + C1\ I1 + C2\ O1 \text{ ---------------------(1)}$$

where

O2, O1 = Outflow rates for time intervals 2 and 1, respectively

I2. I1 = Inflow rates for time intervals 2 and 1, respectively

Co, C1, C2 = Muskingum coefficients, and

$$C2 = e^{-dt/k} \text{ ---------------------------------(2)}$$

$$C1 = (K/dt)\ (1-C2) + 1 \text{ --------------------(3)}$$

$$Co = -\ (k/dt)\ (1-C2) + 1 \text{ -------------------(4)}$$

where

dt = Time increment

k = Muskingum Storage Constant

A 30-minute time increment was adopted in this study.

The Muskingum storage constant K for the contributing drainage basins (Maunawili, Kahanaiki and Kapaa) were obtained from Figure A-5, which was derived from a previous study by Wu (1969).

Based on the method described above, direct runoffs from Makawao, Kahanaiki and Kapaa watersheds, for the 1988 New Year's Eve storm and storms during April 4 to 9, 1989 were simulated. Complete results for each watershed are on file, however, due to the volume of data, only results for the 1988 and 1989 storms for Makawao and Maunawili are shown in Tables A-8 through A-13.

The streamflow data recorded at Makawao stream (gage No. 2540) during 1988 New Year's Eve storm (Col. (9) of Table A-8 and storm during April 4 to 9, 1989 (Col (8) of Tables A-10, A-12, and A-13 were used to verify the validity of rainfall-runoff relationship. A spectrum of runoff coefficients were considered for various storms. Through the Nash-Muskingum routing of rainfall excess and the comparison of the simulated and recorded direct runoff hydrographs at Makawao watershed, it was decided that runoff coefficients varied from 45% to 55% should be used in this study. The Corps of Engineers used 65% runoff coefficient in their recent studies of the New Year's Eve flood (USACE, 1988a and 1988b).

As indicated in Table A-14, the runoff coefficients used were adequately calibrated through the available rainfall and streamflow data at Makawao watershed. The 8.2% error in Table A-14 for 1988 New Year's Eve storm is attributed to the conservative assumption made that no rainfall was measured in the beginning hours of 1988 New Year's Day. It is the same reason that caused the undesirable simulation result, as indicated in Figure A-6, after the last hour of 1987.

Table A-8 **Muskingum Method of Simulating 1987 New Year's Eve Storm Direct Runoff Hydrograph at Makawao Watershed (Stream Gage No. 2540), Oahu**

Time (1)	Interval (30 min) (2)	Total Rainfall (in/30 min) (3)	** Total Rainfall (cfs) (4)	*** 100% Outflow (cfs) (5)	55% Outflow (cfs) (6)	**** Outflow Volume (acre-ft) (7)	Corrected Time (8)	***** USGS Stream-flow Data (cfs) (9)	**** Stream-flow Volume (acre-ft) (10)
31/12/87 4:00 p.m.	0	0	0	0	0	0	31/12/87 5:00 p.m.	0	
4:30	1	0.1	263	97	53	2.2	5:30	0	
5:00	2	0.8	2106	880	484	20.0	6:00	418	17.3
5:30	3	0.5	1316	1364	750	31.0	6:30	640	26.4
6:00	4	1.3	3423	2109	1160	47.9	7:00	1670	69.0
6:30	5	1.3	3423	2939	1616	66.8	7:30	1220	50.4
7:00	6	1.7	4476	3632	1998	82.6	8:00	1170	48.3
7:30	7	1.5	3949	3971	2184	90.2	8:30	1960	81.0
8:00	8	1.9	5003	4345	2390	98.8	9:00	2250	93.0
8:30	9	1.9	5003	4761	2619	108.2	9:30	2040	84.3
9:00	10	2.1	5529	5108	2809	116.1	10:00	2350	97.1
9:30	11	1.6	4213	4890	2690	111.2	10:30	2630	118.4
							10:45	3100	
10:00	12	1.0	2633	3881	2135	88.2	11:00	2690	111.2
10:30	13	1.3 *	3423	3383	1861	76.9	11:30	2590	107.0
11:00	14	0.5 *	1316	2633	1448	59.8	12:00	1380	57.0
11:30	15	0.8 *	2106	2091	1150	47.5	1/1/88 0:30 a.m.	1740	71.9
12:00	16	0.1 *	263	1422	782	32.3	1:00	1810	74.8
1/ 1/88 0:30 a.m.	17	0 *	0	593	326	13.5	1:30	1820	75.2
1:00	18			218	120	5.0	2:00	274	11.3
1:30	19			80	44	1.8	2:30	67	2.8
2:00	20			30	17	0.7	3:00	20	0.8
2:30	21			11	6	0.2	3:30	52	2.1
3:00	22			4	2	0.1	4:00		
3:30	23			1.5	1		4:30		
					Total	1101.0		Total	1199.3

* Estimated

** Col (4) = Col (3) (in/30 min.) (ft/12in) (min/60sec) (2.04 sq.mi.) [(5280ft)(5280ft)/sq.mi.]
= Col (3) (2633 cfs); Makawao Watershed Area = 2.04 sq.mi.

*** Solution of Equation (1), with C0 = 0.368, C1 = 0.264, C2 = 0.368 and Muskingum K = 0.50 hr (Figure A-5)

**** Cols (7) and (10) are direct runoff volumes corresponding to Cols (6) and (9), respectively.

***** Data obtained from DOWALD (1988).

Table A-9

Muskingum Method of Simulating 1987 New Year's Eve Storm Direct Runoff Hydrograph at Maunawili Watershed, Oahu

Time (1)	Interval (30 min) (2)	Total Rainfall (in/30 min) (3)	** Adjusted Total Rainfall (in/30 min) (4)	*** Total Rainfall (cfs) (5)	**** Rainfall Excess (cfs) (6)	***** Outflow (cfs) (7)	Corrected Time (8)
31/12/87 4:00 p.m.	0	0	0	0	0	0	31/12/87 5:00 p.m.
4:30	1	0.1	0.1	703	387	58	5:30
5:00	2	0.8	0.77	5416	2979	536	6:00
5:30	3	0.5	0.48	3376	1857	1053	6:30
6:00	4	1.3	1.25	8793	4836	1722	7:00
6:30	5	1.3	1.25	8793	4836	2594	7:30
7:00	6	1.7	1.63	11466	6306	3441	8:00
7:30	7	1.5	1.44	10129	5571	4134	8:30
8:00	8	1.9	1.82	12802	7041	4756	9:00
8:30	9	1.9	1.82	12802	7041	5396	9:30
9:00	10	2.1	2.02	14209	7815	5971	10:00
9:30	11	1.6	1.54	10833	5958	6210	10:30
10:00	12	1.0	0.96	6753	3714	5805	11:00
10:30	13	1.3 *	1.25	8793	4836	5387	11:30
11:00	14	0.5 *	0.48	3376	1857	4789	12:00
11:30	15	0.8 *	0.77	5416	2979	4135	1/1/88 0:30 a.m.
12:00	16	0.1 *	0.10	703	387	3426	1:00
1/ 1/88 0:30 a.m.	17	0 *	0	0	0	2517	1:30
1:00	18					1812	2:00
1:30	19					1305	2:30
2:00	20					940	3:00
2:30	21					677	3:30
3:00	22					487	4:00
3:30	23					351	4:30
						253	5:00
						182	5:30
						131	6:00
						94	6:30
						68	7:00

* Estimated

** Col (4) = Col (3) times rainfall distribution correction factor (0.96 for Maunawili Watershed - Col (5) of Table A-7).

*** Col (5) = Col (4) (in/30 min) (ft/12 in) (min/60 sec) (5.45 sq.mi.) [(5280 ft) (5280 ft)/ sq.mi.] = Col (4) (7034.13 cfs); Maunawili Watershed Area = 5.45 sq. mi.

**** Col (6) = 55% of Col (5)

***** Solution of Equation (1), with C0 = 0.149, C1 = 0.131, C2 = 0.720 and Muskingum K = 1.52 hr (Figure A-5)

Table A-10 **Muskingum Method of Simulating April 4-5, 1989 Storm Direct Runoff Hydrograph at Makawao Watershed (Stream Gage No. 2540), Oahu**

Time (1)	Interval (30 min) (2)	Total Rainfall (in/30 min) (3)	* Total Rainfall (cfs) (4)	** 100% Outflow (cfs) (5)	45% Outflow (cfs) (6)	*** Outflow Volume (acre-ft) (7)	**** USGS Stream-flow Data (cfs) (8)	*** Streamflow Volume (acre-ft) (9)
APR 4/89 12:00 p.m.	0	0	0	0	0	0	9	0.4
12:30	1	0.1	263	97	44	1.8	9	0.4
1:00	2	0.2	527	299	135	5.6	11	0.5
1:30	3	0.8	2106	1024	461	19.0	533	21.0
2:00	4	0.1	263	1030	464	19.2	185	7.6
2:30	5	0	0	448	202	8.3	81	3.3
3:00	6	0.3	790	456	205	8.5	91	3.8
3:30	7	0.6	1580	959	431	17.8	408	16.9
4:00	8	0	0	770	347	14.3	149	6.2
4:30	9	0.7	1843	962	433	17.9	992	56.2
4:45							1730	
5:00	10	1.3	3423	2100	945	39.0	1520	62.8
5:30	11	0.2	527	1870	842	34.8	342	14.1
6:00	12	0	0	827	372	15.4	169	7.0
6:30	13	0	0	304	137	5.7	101	4.2
7:00	14	0	0	112	50	2.1	76	3.1
7:30	15	0.1	263	138	62	2.6	64	2.6
8:00	16	0	0	120	54	2.2	55	2.3
8:30	17	0.2	527	238	107	4.4	52	2.1
9:00	18	0	0	227	102	4.2	98	4.0
9:30	19	0	0	84	38	1.6	96	4.0
10:00	20	0.1	263	128	58	2.4	62	2.6
10:30	21	0	0	117	53	2.2	49	2.0
11:00	22	0	0	43	19	0.8	50	2.1
11:30	23	0	0	16	7	0.3	45	1.9
12:00	24	0	0	6	3	0.1	38	1.6
					Total	230.2	Total	233.7

* Col (4) = Col (3) (in/30 min.) (ft/12in) (min/60sec) (2.04 sq.mi.) [(5280ft)(5280ft)/sq.mi.]
= Col (3) (2633 cfs); Makawao Watershed Area = 2.04 sq.mi.

** Solution of Equation (1), with C0 = 0.368, C1 = 0.264, C2 = 0.368 and Muskingum K = 0.50 hr (Figure A-5)

*** Col (7) and (9) are direct runoff volumes corresponding to Cols (6) and (8), respectively.

**** Data obtained from USGS (1989).

Table A-11 **Muskingum Method of Simulating April 8, 1989 Storm Direct Runoff Hydrograph at Makawao Watershed (Stream Gage No. 2540), Oahu**

Time (1)		Interval (30 min) (2)	Total Rainfall (in/30 min) (3)	* Total Rainfall (cfs) (4)	** 100% Outflow (cfs) (5)	45% Outflow (cfs) (6)	*** Outflow Volume (acre-ft) (7)	**** USGS Stream-flow Data (cfs) (8)	*** Streamflow Volume (acre-ft) (9)
APR 8/89	0:30 a.m.	0	0	0	0	0	0	17	0.7
	1:00	1	0.2	527	194	87	3.6	21	0.9
	1:30	2	0.1	263	307	138	5.7	39	1.6
	2:00	3	0.3	790	473	213	8.8	81	3.3
	2:30	4	0.3	790	673	303	12.5	296	12.2
	3:00	5	0.2	527	650	293	12.1	230	9.5
	3:30	6	0.3	790	669	301	12.4	326	13.5
	4:00	7	0.1	263	552	248	10.2	163	6.7
	4:30	8	0.1	263	369	166	6.9	161	6.7
	5:00	9	0.2	527	399	180	7.4	172	7.1
	5:30	10	0.1	263	383	172	7.1	155	6.4
	6:00	11	0.1	263	307	138	5.7	145	6.0
	6:30	12	0.2	527	376	169	7.0	149	6.2
	7:00	13	0.2	527	471	212	8.8	178	7.4
	7:30	14	0.1	263	409	184	7.6	146	6.0
	8:00	15	0	0	220	99	4.1	118	4.9
	8:30	16	0.1	263	178	80	3.3	99	4.1
	9:00	17	0	0	135	61	2.5	77	3.2
	9:30	18	0.1	263	146	66	2.7	67	2.8
	10:00	19	0	0	123	55	2.3	115	4.8
	10:30	20	0.2	527	239	108	4.5	132	5.5
	11:00	21	0	0	227	102	4.2	99	4.1
	11:30	22	0	0	84	38	1.6	76	3.1
	12:00 p.m.	23	0	0	31	14	0.6	69	2.9
	12:30	24	0	0	11	5	0.2	60	2.5
	1:00	25	0	0	4	2	0.1	86	3.6
						Total	141.9	Total	135.7

* Col (4) = Col (3) (in/30 min.) (ft/12in) (min/60sec) (2.04 sq.mi.) [(5280ft)(5280ft)/sq.mi.]
= Col (3) (2633 cfs); Makawao Watershed Area = 2.04 sq.mi

** Solution of Equation (1), with C0 = 0.368, C1 = 0.264, C2 = 0.368 and Muskingum K = 0.50 hr (Figure A-5)

*** Col (7) and (9) are direct runoff volumes corresponding to Col (6) and (8), respectively.

**** Data obtained from USGS (1989).

Table A-12 Muskingum Method of Simulating April 4-5, 1989 Storm Direct Runoff Hydrograph at Maunawili Watershed, Oahu

Time (1)	Interval (30 min) (2)	Total Rainfall (in/30 min) (3)	* Adjusted Total Rainfall (in/30 min) (4)	** Total Rainfall (cfs) (5)	*** Rainfall Excess (cfs) (6)	**** Outflow (cfs) (7)
APR 4/89 12:00 p.m.	0	0	0	0	0	0
12:30	1	0.1	0.1	703	316	47
1:00	2	0.2	0.19	1336	601	165
1:30	3	0.8	0.77	5416	2437	561
2:00	4	0.1	0.1	703	316	770
2:30	5	0	0	0	0	596
3:00	6	0.3	0.29	2040	918	566
3:30	7	0.6	0.58	4079	1836	801
4:00	8	0	0	0	0	817
4:30	9	0.7	0.67	4713	2121	904
5:00	10	1.3	1.25	8793	3957	1518
5:30	11	0.2	0.19	1336	601	1701
6:00	12	0	0	0	0	1303
6:30	13	0	0	0	0	938
7:00	14	0	0	0	0	675
7:30	15	0.1	0.1	703	316	533
8:00	16	0	0	0	0	425
8:30	17	0.2	0.19	1336	601	396
9:00	18	0	0	0	0	364
9:30	19	0	0	0	0	262
10:00	20	0.1	0.1	703	316	236
10:30	21	0	0	0	0	211
11:00	22	0	0	0	0	152
11:30	23	0	0	0	0	109
12:00	24	0	0	0	0	78
APR 5/89 0:30 a.m.	25	0	0	0	0	56
1:00	26	0	0	0	0	40
1:30	27	0	0	0	0	29
2:00	28	0	0	0	0	21

* Col (4) = Col (3) times rainfall distribution correction factor (0.96 for Maunawili Watershed - Col (5) of Table A-7).

** Col (5) = Col (4) (in/30 min) (ft/12 in) (min/60 sec) (5.45 sq.mi.) [(5280 ft) (5280 ft)/ sq.mi.]
= Col (4) (7034.13 cfs); Maunawili Watershed Area = 5.45 sq. mi.

*** Col (6) = 45% of Col (5)

**** Solution of Equation (1), with CO = 0.149, C1 = 0.131, C2 = 0.720 and Muskingum K = 1.52 hr (Figure A-5)

Table A-13 **Muskingum Method of Simulating April 8, 1989 Storm Direct Runoff Hydrograph at Maunawili Watershed, Oahu**

	Time	Interval (30 min)	Total Rainfall (in/30 min)	* Adjusted Total Rainfall (in/30 min)	** Total Rainfall (cfs)	*** Rainfall Excess (cfs)	**** Outflow (cfs)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
APR 8/89	0:30 a.m.	0	0	0	0	0	0
	1:00	1	0.2	0.19	1336	601	90
	1:30	2	0.1	0.1	703	316	191
	2:00	3	0.3	0.29	2040	918	316
	2:30	4	0.3	0.29	2040	918	485
	3:00	5	0.2	0.19	1336	601	559
	3:30	6	0.3	0.29	2040	918	618
	4:00	7	0.1	0.1	703	316	612
	4:30	8	0.1	0.1	703	316	529
	5:00	9	0.2	0.19	1336	601	512
	5:30	10	0.1	0.1	703	316	494
	6:00	11	0.1	0.1	703	316	444
	6:30	12	0.2	0.19	1336	601	451
	7:00	13	0.2	0.19	1336	601	493
	7:30	14	0.1	0.1	703	316	481
	8:00	15	0	0	0	0	388
	8:30	16	0.1	0.1	703	316	326
	9:00	17	0	0	0	0	276
	9:30	18	0.1	0.1	703	316	246
	10:00	19	0	0	0	0	219
	10:30	20	0.2	0.19	1336	601	247
	11:00	21	0	0	0	0	257
	11:30	22	0	0	0	0	185
	12:00 p.m.	23	0	0	0	0	133
	12:30	24	0	0	0	0	96
	1:00	25	0	0	0	0	69
	1:30	26	0	0	0	0	50
	2:00	27	0	0	0	0	36
	2:30	28	0	0	0	0	26

* Col (4) = Col (3) times rainfall distribution correction factor (0.96 for Maunawili Watershed - Col (5) of Table A-7).

** Col (5) = Col (4) (in/30 min) (ft/12 in) (min/60 sec) (5.45 sq.mi.) [(5280 ft) (5280 ft)/ sq.mi.]
= Col (4) (7034.13 cfs); Maunawili Watershed Area = 5.45 sq. mi.

*** Col (6) = 45% of Col (5)

**** Solution of Equation (1), with C0 = 0.149, C1 = 0.131, C2 = 0.720 and Muskingum K = 1.52 hr (Figure A-5)

Table A-14 **Comparisons of Simulated Direct Runoff Volumes (in acre-ft) With Values Computed from USGS Streamflow Data for Various Storms at Makawao Watershed (Stream Gage No. 2540), Oahu**

	1987 New Year's Eve Storm		April 4-5, 1989 Storm		April 8, 1989 Storm		April 8-9, 1989 Storm	
	USGS (1)	Simulated (2)	USGS (3)	Simulated (4)	USGS (5)	Simulated (6)	USGS (7)	Simulated (8)
	1199.3	1101.0	233.7	230.2	135.7	141.9	435.8	440.7
% of Error		-8.2%		-1.5%		4.6%		1.1%

Table A-8 shows there is approximately one hour basin time lag observed at Makawao watershed for the New Year's Eve storm [Cols (1), (3), (8) and (9) of Table A-8]. As indicated in Tables A-9, the corrected times imply that the front of direct runoffs from Maunawili and Kahanaiki reached the marsh about 6:00 p.m., 31 December 1987. This estimated time lag seems reasonable since both watersheds have a time of concentration of 1.3 hours (Tinniswood and Lau, 1960). However, a discussion with Mr. Richard Nakahara (USGS, 1989) confirmed that very little time lag existed for the storms during April 4 to 9, 1989. (Figure A-7).

The inflow hydrographs of 1988 New Year's Eve storm and the storms during April 4 to 9, 1989 for Kawainui Marsh were simulated by using the Nash-Muskingum method of routing the rainfall excess over effective drainage basins. The summaries for Maunawili and Kahanaiki watersheds are shown in Tables A-15, A-16 and A-17.

The significance of the flood hydrology study is that reasonably accurate inflows were developed to study the effects of both large and moderate floods. Furthermore, it was learned that the time lag between peak rainfall and the flood peak is relatively short, less than two hours. The implication for flood plain management purposes is that flood warning plans have very little potential for flood damage reduction. They can serve to alert residents to move to higher elevations, but only if the warnings are specific as to the onset of the hazard and broadcast in sufficient time.

Table A-15 Composite Direct Runoff Hydrograph for 1987 New Year's Eve Storm at Maunawili and Kahanaiki Watersheds, Oahu

Corrected Time (1)	Interval (30 min) (2)	Maunawili Runoff (cfs) (3)	Kahanaiki Runoff (cfs) (4)	Composited Runoff (cfs) (5)
31/12/87 5:00 p.m.	0	0	0	0
5:30	1	58	46	104
6:00	2	536	409	945
6:30	3	1053	625	1678
7:00	4	1722	967	2689
7:30	5	2594	1342	3936
8:00	6	3441	1659	5100
8:30	7	4134	1809	5943
9:00	8	4756	1976	6732
9:30	9	5396	2162	7558
10:00	10	5971	2321	8292
10:30	11	6210	2216	8426
11:00	12	5805	1747	7552
11:30	13	5387	1522	6909
12:00	14	4789	1178	5967
1/1/88 0:30 a.m	15	4135	936	5071
1:00	16	3426	631	4057
1:30	17	2517	255	2772
2:00	18	1812	90	1902
2:30	19	1305	32	1337
3:00	20	940	11	951
3:30	21	677	4	681
4:00	22	487	1	488
4:30	23	351	0	351
5:00	24	253		253
5:30	25	182		182
6:00	26	131		131
6:30	27	94		94
7:00	28	68		68

Table A-16 Composite Direct Runoff Hydrograph for April 8, 1989 Storm at Maunawili and Kahanaiki Watersheds, Oahu

Corrected Time (1)		Interval (30 min) (2)	Maunawili Runoff (cfs) (3)	Kahanaiki Runoff (cfs) (4)	Composited Runoff (cfs) (5)
APR 8/89	0:30 a.m.	0	0	0	0
	1:00	1	90	76	166
	1:30	2	191	118	309
	2:00	3	316	178	494
	2:30	4	485	249	734
	3:00	5	559	241	800
	3:30	6	618	248	866
	4:00	7	612	203	815
	4:30	8	529	136	665
	5:00	9	512	151	663
	5:30	10	494	145	639
	6:00	11	444	116	560
	6:30	12	451	144	595
	7:00	13	493	180	673
	7:30	14	481	155	636
	8:00	15	388	82	470
	8:30	16	326	67	393
	9:00	17	276	50	326
	9:30	18	246	56	302
	10:00	19	219	47	266
	10:30	20	247	92	339
	11:00	21	257	86	343
	11:30	22	185	30	215
	12:00 p.m.	23	133	11	144
	12:30	24	96	4	100
	1:00	25	69		69
	1:30	26	50		50
	2:00	27	36		36
	2:30	28	26		26

Table A-17 Composite Direct Runoff Hydrograph for April 8-9, 1989 Storm at Maunawili and Kahanaiki Watersheds, Oahu

Corrected Time (1)		Interval (30 min) (2)	Maunawili Runoff (cfs) (3)	Kahanaiki Runoff (cfs) (4)	Composite Runoff (cfs) (5)
APR 8/89	1:30 p.m.	0	0	0	0
	2:00	1	52	42	94
	2:30	2	136	87	223
	3:00	3	196	103	299
	3:30	4	187	66	253
	4:00	5	187	65	252
	4:30	6	233	95	328
	5:00	7	266	105	371
	5:30	8	290	109	399
	6:00	9	354	152	506
	6:30	10	342	113	455
	7:00	11	346	124	470
	7:30	12	588	309	897
	8:00	13	844	418	1262
	8:30	14	935	385	1320
	9:00	15	1006	386	1392
	9:30	16	1151	458	1609
	10:00	17	1401	597	1998
	10:30	18	1569	621	2190
	11:00	19	1655	613	2268
	11:30	20	1611	513	2124
	12:00 a.m.	21	1393	351	1744
APR 9/89	0:30	22	1242	305	1547
	1:00	23	1180	315	1495
	1:30	24	1135	319	1454
	2:00	25	1103	320	1423
	2:30	26	1127	363	1490
	3:00	27	1139	366	1505
	3:30	28	1053	299	1352
	4:00	29	945	249	1194
	4:30	30	867	232	1099
	5:00	31	764	183	947
	5:30	32	596	94	690
	6:00	33	429	33	462
	6:30	34	309	12	321
	7:00	35	223	4	227
	7:30	36	161		161
	8:00	37	116		116
	8:30	38	84		84
	9:00	39	60		60
	9:30	40	43		43
	10:00	41	31		31
	10:30	42	22		22

SECTION 3. Flood Exceedance Probability

The probability of flood flow being equal to or exceeding specified magnitudes is generally studied in terms of the relative frequency versus the instantaneous peak discharge rate. Where records are available, the statistical properties of flood occurrences may be computed and assumed theoretical probability distributions applied for the purpose of estimating the magnitude of large, infrequent floods that may not have occurred during recorded periods but whose probability of occurrence may be estimated (assuming the probability distributions are valid).

Flood flow data for the Makawao and Maunawili Stream recording gage stations (Figure A-1) were collected from U.S. Geological Survey water records and analyzed using a U.S. Army Corps of Engineers computer program known as HECWRC. This program uses the methods described in the revised "Guidelines for Determining Flood Flow Frequency," Bulletin 17B, WRC, September 1981 for computation of flood frequency assuming the data fit the log-Pearson Type III distribution.

The results of the program are shown in Tables A-18 for Maunawili Stream and Table A-19 for Makawao Stream. The first noteworthy point is that the New Year's 1988 flood was not the largest flood flow magnitude on record. In fact, at Makawao gage it ranked third and was approximately 50 percent of the largest recorded flood magnitude. In terms of exceedance probability, at the Maunawili Stream recording station, the calculated peak flow of 6210 cfs (based upon the previous study [Section 2] of the flood hydrology) falls between the flood magnitude for the 10 percent and 5 percent annual chance of exceedance events. Since the long-term average return period is the reciprocal of the annual percent chance of exceedance, the recurrence intervals (over a very long period of observation) would average between ten to twenty years.

These statistics are somewhat at odds with the historical assessment made by Kelly and Nakamura (1981) who tabulated floods since about the turn of the century. Marsh levels due to floods originating in Maunawili Valley as tabulated were extended as part of this document and are shown in Table A-20. The magnitude of the 1988 New Year's Eve flood exceeded 9.5 feet (msl) which, according to this table, has occurred only three other times this century. This suggests that the 1988 New Year's Eve flood was a more infrequent event than a ten-year flood.

Another acceptable means (U.S. Army Corps of Engineers, 1985) of characterizing flood probability, particularly when the storage of flood runoff is important, is to estimate the relative frequency of flood volume associated with storm events. This type of analysis depends upon the probability of storm duration-intensity relationships and the amount of direct runoff to compute the magnitude of the flood volume. The runoff-volume-probability method is believed more relevant to the task of evaluating the risk of storms exceeding the storage capability of the marsh under existing and alternative future conditions.

The probability of various storm intensities related to the period of the storm's duration has been developed for Oahu. Figures A-8 to A-11 show maps of the 2-, 10-, 50-, and 100- year storm intensities for 24-hour duration. Similar maps for 6-hr, 2-day, 4-day and 7-day events were used to estimate the average rainfall over the watershed for storms with various probabilities of exceedance (average return periods) and various durations. Estimates of total volume of storm runoff were then made on the basis of adjusting rainfall intensities to reflect variations over the individual watersheds and a runoff coefficient of 50 percent. The magnitude of this coefficient is justified in view of the runoff coefficients of between 45 to 55 percent obtained during the development of the flood hydrographs discussed previously.

Table A-18 Sheet A

FINAL RESULTS
-PLOTTING POSITIONS- 2605 MAUNAWILI STREAM AT KAWAINUI MARSH, OAHU

EVENTS ANALYZED: MON	DAY	YEAR	FLOW, CFS	ORDERED EVENTS: RANK	WATER YEAR	FLOW, CFS	WEIBULL PLOT POS
3	5	1958	2550.	1	1951	12300.	.0256
2	13	1959	619.	2	1965	9690.	.0538
3	6	1960	1050.	3	1988	6210.	.0844
1	26	1961	866.	4	1985	4850.	.1150
3	12	1962	836.	5	1977	4630.	.1456
3	12	1963	1560.	6	1966	4100.	.1762
12	12	1963	1040.	7	1980	4050.	.2068
2	4	1965	9690.	8	1971	3880.	.2374
11	14	1965	4100.	9	1968	3720.	.2680
9	16	1967	1750.	10	1981	3640.	.2986
12	18	1967	3720.	11	1979	3380.	.3292
2	1	1969	2360.	12	1958	2550.	.3598
1	26	1970	940.	13	1969	2360.	.3904
11	26	1970	3880.	14	1982	2060.	.4210
1	23	1972	1250.	15	1978	1930.	.4516
2	25	1973	334.	16	1967	1750.	.4822
2	5	1974	1400.	17	1987	1670.	.5128
11	21	1974	1400.	18	1963	1560.	.5434
11	27	1975	1200.	19	1986	1550.	.5740
5	12	1977	4630.	20	1975	1400.	.6046
5	23	1978	1930.	21	1974	1400.	.6352
2	4	1979	3380.	22	1972	1250.	.6658
1	8	1980	4050.	23	1976	1200.	.6964
5	7	1981	3640.	24	1960	1050.	.7270
1	20	1982	2060.	25	1964	1040.	.7577
10	28	1982	400.	26	1970	940.	.7883
3	2	1984	400.	27	1961	866.	.8189
2	14	1985	4850.	28	1962	836.	.8495
9	20	1986	1550.	29	1959	619.	.8801
11	10	1986	1670.	30	1984	400.	.9107
12	31	1987	6210.	31	1983	400.	.9413
3	1	1951	12300.	32	1973	334.	.9719

NOTE- PLOTTING POSITIONS BASED ON HISTORIC PERIOD (H) = 38
NUMBER OF HISTORIC EVENTS PLUS HIGH OUTLIERS (Z) = 1
WEIGHTING FACTOR FOR SYSTEMATIC EVENTS (W) = 1.1935

Table A-18 Sheet B

FINAL RESULTS

~~FREQUENCY CURVE 2605 MAUNAWILI STREAM AT KAWAINUI MARSH, OAHU~~

FLOW, CFS: COMPUTED	FLOW, CFS: EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS: .05 LIMIT	CONFIDENCE LIMITS: .95 LIMIT
22200.	28300.	.002	46000.	13500.
17200.	20700.	.005	33500.	10900.
13900.	16100.	.010	25800.	9110.
11100.	12300.	.020	19400.	7470.
7810.	8360.	.050	12700.	5520.
5720.	5970.	.100	8690.	4190.
3910.	4000.	.200	5540.	2960.
1880.	1880.	.500	2450.	1440.
891.	870.	.800	1180.	629.
601.	574.	.900	821.	395.
433.	403.	.950	615.	266.
233.	200.	.990	360.	124.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	3.2701	HISTORIC EVENTS	1
STANDARD DEVIATION	.3819	HIGH OUTLIERS	0
COMPUTED SKEW	.0084	LOW OUTLIERS	0
GENERALIZED SKEW	-.0500	ZERO OR MISSING	0
ADOPTED SKEW	-.0500	SYSTEMATIC EVENTS	31
		HISTORIC PERIOD	38

Table A-19 Sheet A

FINAL RESULTS
-PLOTTING POSITIONS- 2540 MAKAWAO STREAM AT KAWAINUI MARSH, OAHU,

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	WEIBULL PLOT-POS
3	5	1958	2140.	1	1965	6000.	.0323
1	17	1959	319.	2	1985	3940.	.0645
3	5	1960	681.	3	1988	3100.	.0968
1	26	1961	500.	4	1971	3000.	.1290
5	5	1962	460.	5	1968	2510.	.1613
3	6	1963	2140.	6	1963	2140.	.1935
12	12	1963	665.	7	1958	2140.	.2258
2	4	1965	6000.	8	1977	2060.	.2581
11	13	1965	1920.	9	1966	1920.	.2903
9	16	1967	608.	10	1981	1810.	.3226
12	18	1967	2510.	11	1979	1470.	.3548
2	1	1969	766.	12	1980	1410.	.3871
1	26	1970	596.	13	1974	988.	.4194
11	26	1970	3000.	14	1982	936.	.4516
1	23	1972	362.	15	1969	766.	.4839
2	25	1973	35.	16	1960	681.	.5161
2	5	1974	988.	17	1986	668.	.5484
1	12	1975	286.	18	1964	665.	.5806
11	27	1975	272.	19	1987	612.	.6129
5	12	1977	2060.	20	1967	608.	.6452
2	4	1979	1470.	21	1970	596.	.6774
1	8	1980	1410.	22	1961	500.	.7097
5	7	1981	1810.	23	1962	460.	.7419
1	20	1982	936.	24	1972	362.	.7742
0	0	1982	0.	25	1959	319.	.8065
0	0	1983	0.	26	1975	286.	.8387
2	14	1985	3940.	27	1976	272.	.8710
2	27	1986	668.	28	1973	35.	.9032
11	10	1986	612.	29	1982	0.	.9355
12	31	1987	3100.	30	1983	0.	.9677

Table A-19 Sheet B

FINAL RESULTS

-FREQUENCY CURVE- 2540 MAKAWAO STREAM AT KAWAINUI MARSH, OAHU,

FLOW, CFS COMPUTED	FLOW, CFS EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS .05 LIMIT	CONFIDENCE LIMITS .95 LIMIT
12000.	15500.	.002	25800.	7120.
9200.	11200.	.005	18600.	5700.
7400.	8630.	.010	14200.	4740.
5830.	6540.	.020	10500.	3860.
4070.	4370.	.050	6770.	2830.
2950.	3090.	.100	4580.	2130.
1990.	2040.	.200	2870.	1490.
932.	932.	.500	1230.	705.
432.	421.	.800	577.	299.
287.	274.	.900	399.	185.
205.	190.	.950	296.	122.
108.	92.	.990	171.	56.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.9661	HISTORIC EVENTS	0
STANDARD DEVIATION	.3945	HIGH OUTLIERS	0
COMPUTED SKEW	.1283	LOW OUTLIERS	1
GENERALIZED SKEW	-.0500	ZERO OR MISSING	2
ADOPTED SKEW	-.0500	SYSTEMATIC EVENTS	30

Table A-20
Tabulation of Historical Flood Data

Year	24-hour recorded rainfall (1)	Approximate marsh stage in feet above mean (2) sea level	Flood classification	References
1902	11.70	9.0	major	hearsay
1904	12.50	9.5	major	hearsay
1907	7.88	7.0	medium	hearsay
1908	8.75	8.0	medium	hearsay
1914	10.97	8.5	medium	newspaper &
1916	7.95	7.0	medium	inhabitants
1917	8.46	7.0	medium	newspaper
1918	7.73	6.5	medium	inhabitants
1921	20.15	10.0	major	newspaper & inhabitants
1924	8.00	7.0	medium	inhabitants
1927	7.08	6.0	minor	newspaper
1930	6.82	6.0	minor	newspaper & inhabitants
1932	7.51	6.5	medium	inhabitants
1939	9.56	6.4	medium	inhabitants
1940	10.48	7.3	medium	inhabitants
1951	15.25	8.6	major	U.S. Army Corps of Engineers
1963	-	-	major	DOWALD
1965	-	-	major	DOWALD
1977	-	-	medium	-
1985	-	-	medium	-
1988	22.39	9.5	major	DOWALD
1989	11.08	7.7	minor	City & County

Notes: 1. Rainfall at Maunawili Ranch 1902-1951 and at Maunawili HSPA 1963-1989.
2. Elevations before 1939 estimated; recorded since 1939 at edge of marsh (Coconut

References: Historical Study of Kawainui Marsh Area, Island of Oahu. Marion Kelly and Barry Nakamura, Bishop Museum, Prepared for DPED, Nov. 1981.

Another source corroborating this magnitude for the runoff coefficient is the U.S. Army Corps of Engineers (1957) Kawainui Design Memorandum which estimated the runoff coefficient for the first day of the 1921 (largest recorded) flood to be 48.5 percent and 53 percent for the two day period of the storm. After computing the total runoff volume in units of acre-feet, the volumes were converted to units of cfs-days. The results were then graphed as shown in Figure A-12. In this format, the results of storms of any duration ranging between 50 percent chance to 1 percent annual chance of exceedance can be compared to uniform outflow rates from the marsh to determine the critical duration storms. If it is assumed that the marsh is allowed to become completely full, i.e. the water level is to the top of the existing levee, approximately 10 feet msl, for example, the capacity of the City and County emergency ditch is adequate to convey storm runoff through the marsh for floods with a 1 percent annual chance of exceedance and storm duration greater than two days, ignoring the rest of the outlet capacity from the marsh to Oneawa canal. Obviously, this is not a recommended basis for design because it does not allow for freeboard and uncertainty in data and methods--it is for illustration only. The emergency ditch is not adequate, however, for one percent exceedance storms with shorter durations. This is shown on Figure A-12 by the line of 1700 cfs outflow capacity which intersects the 1 percent chance exceedance curves at the two days duration point. The estimate of 1700 cfs capacity is based on a gradually varied flow water surface profile computed using ditch cross sections taken in March 1989 assuming all flow is confined within the ditch and there is no exchange of flow between the marsh and the ditch. This assumption ignores the flow that would be carried through the marsh toward the outlet when the flood stage exceeds the height of the existing bank on the marsh side and the result is therefore a conservative estimate in this respect.

In comparison to the flood probability based upon maximum rate of discharge, the runoff volume probability from the New Year's Eve 1988 flood, exclusive of the rainfall falling directly on the marsh, exceeds a 1 percent annual chance exceedance. The exact probability could not be estimated because rainfall-intensity-duration data are not available for short durations and probabilities smaller than one percent. The total runoff volume for this storm was estimated at 4113 acre-feet. In comparison, the total runoff for the Standard Project Flood (SPF) used as the basis for design (U.S. Army Corps of Engineers, 1957) is approximately 7,130 acre-feet.

> "The standard project flood represents the flood that can be expected from the most severe combination of meteorologic and hydrologic conditions that are considered *reasonably characteristic of the geographic region* involved, excluding extremely rare combinations." (U.S. Army Corps of Engineers, 1975).

It is usually computed by examining all the major storms in a region and selecting a total rainfall depth and pattern as severe as any but not necessarily the most extreme observed in the region.

The difference between the runoff volume curve and the outflow curve is maximum in the time interval of approximately six hours. This defines the critical storm duration used herein to develop design hydrographs.

Using a six-hour one percent chance exceedance (100-year) volume as a base flood, ratios of other flood volumes to the base flood volume were computed and a semi-log graph of ratio versus recurrence interval developed. From the graph, the 25-year flood volume was interpolated. In order to develop a hydrograph that accounted for antecedent conditions before the onset of these design flood volumes, the computed 24 hour flood volume exceedance curves, were used to adjust hourly flow rates until the hydrograph flow volume for the 9 hourly periods preceding and the following 6 hour peak provided the amount of runoff estimated by the curves for a 24 hour duration event. The peak of the flood hydrograph was estimated by preserving the six hour duration volume but conforming to the shape of the runoff hydrograph assumed by the U.S. Corps of Engineers (1957) to develop the Standard Project Flood (SPF) hydrograph for the Kawainui flood control project. Figure A-83 (Alternative C Section) shows a comparison of the 25-year flood, New Year's Eve 1988 flood, and the SPF. Note the time base of the intense part of the synthesized (25-year flood) runoff hydrographs was six hours, however, as opposed to the five hours used for the SPF. The five hour time base was used in subsequent modelling of the SPF. These hydrographs were used to simulate different magnitudes of floods with various probabilities of exceedance using a numerical model of the marsh described in the next section.

SECTION 4. Water Surface Hydraulic Evaluations

Surface water entering Kawainui Marsh originates from three principal tributaries: Maunawili Stream, Kahanaiki Stream, and a stream originating near Kapaa Quarry. Figure A-13 shows a profile of these streams. The profiles indicate the channel slopes are similar in the lower elevations. Maunawili has a higher overall slope and, due to its larger drainage area, is more significant not only to flood flow production but also to base flow contribution. In terms of the New Year's Eve storm, Maunawili Stream contributed an estimated 70 percent of the runoff volume. Together with Kahanaiki, inflow for water surface calculations was split such that those two streams contributed 90 percent and Kapaa inflow contributed 10 percent.

Flow through the marsh is difficult to quantify because of inaccessibility for survey purposes and calculation complexities related to the multi-dimensional nature of the circulation patterns within the marsh. The irregular combination of thick mats of marsh plants and open-water areas complicates the prediction of water surface elevations, currents and flows throughout the marsh. Traditional hydrologic flood routing methods fail to reproduce the hydraulic characteristics of the marsh. Travel time through the marsh greatly affects the storage and hydraulic characteristics of the marsh. A finite element model of the marsh was developed to predict flow rate, direction and water level.

From a hydraulic perspective the Kawainui Marsh must be treated as a system with a highly variable flow field. Parts of the marsh are relatively shallow and covered with a thick layer of marsh plants. These plants (both macrophytes and phreatophytes) float as thick mats on the water surface and also are rooted firmly to the bottom at various locations. The intent of the marsh finite element utilized in all the model simulations is to account for reduction in flow conveyance capacity due to the marsh vegetation. The model assumes that only a small fraction of the cross section is available for flow conveyance during low inflow periods. As the water level rises, the effective width of the flow area gradually increase as the hydraulic gradient creates flow paths through the marsh (above or below the mat). Above a certain water level the entire width is available for conveyance. This effect was corroborated during field investigations during the April 1989 flood at which time changes in flow were observed as the mat elevation rose.

The most advanced version of computer program RMA-2 (Version No. 4) has been used throughout this study as the two-dimensional hydrodynamic model (King and Roig, 1989). RMA-2 is a numerical model written in Fortran 77 for solution of the two-dimensional shallow water equations. It uses the finite element method to describe the marsh system as an assemblage of triangles and quadrilaterals connected at their vertices and at the mid points of their sides by what are called nodes. The elements are allowed to have variable shapes and sizes, thus permitting accurate representation of complex systems like the Kawainui Marsh. Different Manning's n values may be defined for each element. Thus the variability of the marsh can be accommodated and quickly refined by adding or adjusting the density and characteristics of the numerical network. The non-linear shallow water equations are solved using a fully implicit time integration scheme. This permits relatively long computational time steps. Simple steady state solutions, as well as completely dynamic simulations are possible. Version No. 4 of RMA-2 is the most advanced version and was designed specifically for marsh applications. The new version provides an accurate accounting of flow volume and conveyance as a function of time and changing water surface elevations throughout the marsh. Figure A-14 shows the finite element network developed to represent the physical characteristics and geometric shape of the marsh. The numerical network is composed of approximately 525 elements and 1600 nodes. The numerical network extends from above the confluence of Kahanaiki and Maunawili streams, down to the outlet of the marsh and beyond to Kailua Bay through Oneawa Channel. The closely spaced quadrilaterals and triangles are positioned to define the detail of the open water and non-open water areas, including: (1) the bathymetric detail of the interior to the marsh, (2) the location and shape of the City and County drainage ditch adjacent to the eastern levee, (3) the two tributary inflow locations (one from Kahanaiki and Maunawili Streams and one from Kapaa Stream near the quarry and landfill, (4) the location and shape of the outlet, and (5) the trapezoidal Oneawa Channel that extends 9,500 feet from the outlet end of the marsh into Kailua Bay. The shape and spacing of the elements are designed to provide the detail necessary to simulate the flooding characteristics of Kawainui Marsh.

A series of continuous recording stations was established in the marsh to monitor water level changes. The location of these stations (noted by WL notation) is shown on Figure A-1. During heavy rains over the period between April 4 and April 10, 1989, these recorders collected water level data that was used to check the validity of the marsh model. Two rainfall events were responsible for the rapid fluctuations in water levels, one on April 5 and the other April 9. Much of the data was unusable from the second, larger event because the recorders were submerged, at which point their reference pressures and short-circuiting of the batteries resulted in erroneous readings. However, for the period during the first storm, reliable results were recorded.

Table A-21 compares the findings in terms of water level elevations, mean sea level datum, during the period (refer to Figure A-1 for recorder location). One significant finding is the differences in water levels obtained between WL3 and WL6 of approximately one foot over approximately 1000 feet distance. Field observations during this period confirmed the flow direction was between these two stations which demonstrates the retarding effect that the emergent vegetation has on the flow of surface water through the marsh. The other significant finding was that, at approximately the highest stage recorded during the first event, the stage in the head of Oneawa canal was at its lowest point during the diurnal tidal cycle and approximately six feet lower than the stage in the marsh at the upstream end. This demonstrates the hydraulic movements in the marsh have little relation to the tides in the outlet channel in comparison to the circulation within the marsh itself. A profile of the City and County ditch based on recent surveys along the ditch shows (Appendix A, Section 5) that at station 45+00 near the downstream end of the ditch, the channel bottom elevation is relatively high (elevation 1.3 feet, msl) which creates rapids as low flow drops to sea level. This area of the ditch acts as a hydraulic control because the cross sectional shape controls the quantity of outflow as it passes through a series of shallow pools to Oneawa canal. Along the marsh side of the ditch, the built up bank of sediment and vegetation form another control mechanism which functions to retard lateral flow except where seeps and openings in the bank permit more flow into the emergency ditch. The sediment and vegetation in the marsh outlet area also form another control. It is believed that the normal tidal range does not affect the rate of flow through this area because of its higher elevation. The highest state observed at the USGS gage (2648A) is 2.63 feet, msl.

Figures A-15, A-16 and A-17 compare computed and observed water surface elevations at three different locations in Kawainui Marsh during the April 4-9, 1989 storm event. Figures A-15 and A-16 present the simulated and measured results located at gaging stations KAW2 and KAW3. KAW2 is located in the open water area just downstream from the confluence of Kahanaiki and Maunawili Streams. KAW3 is located in the southeast corner of the marsh. Simulated results compare very well with the measured stages, both in magnitude and phase. At the beginning of the storm, the initial water surface elevation assumed in the model is too high by 2 tenths of a foot. In Figure A-16 there is a gap in recorded data starting late on April 4th and continuing to about 9 a.m. on April 6th. This occurred because gage KAW3 was overtopped for that period of time during the storm.

Table A-21
Comparison of Water Level Data from Kawainui Marsh Recorders
Water Level Elevations in Feet Mean Sea Level

Station	Location	Distance	4/4 1715	4/4 2030	4/8 1030	4/9 O705	4/9 1310	4/12 O600
WL5	Maunawili		15.6	?	?	?1/	16.7	14.0
		4000 ft						
WL2	Pond		6.1	6.1	5.8	?2/	9.3	5.1
		2500 ft						
WL3	Hyacinths		6.0	?	6.4	?	?	6.7
		1000 ft						
WL6	Marsh Edge		5.0	6.7	6.1	?	?	?
		100 ft						
#200	C&C Ditch		4.2	6.1	5.5	7.7	7.1	?
		6000 ft						
WL1	Oneawa		0.02	0.09	-0.54	0.5	0.5	0.02

Notes: 1/ High water mark elevation estimated to be 20.1 ft
2/ High water elevation at this station exceeded 10.0 ft

Refer to Figure 4-1 for locations of recorders.

Figure A-17 shows the simulated stage in the marsh near its outlet into the Oneawa canal (solid line) and the NOAA tidal elevation (from tables adjusted to Kailua Bay) located at the downstream end of the Oneawa canal where it enters into Kailua Bay. Tidal effects are slightly attenuated at the outlet of the marsh (9,500 feet upstream from Kailua Bay) and, as will be shown later, are completely attenuated a short distance into the marsh and up into the City and County emergency ditch.

Figure A-18 presents the inflow and outflow hydrographs, along with the simulated discharge hydrograph located midway down the City and County drainage ditch for the April 4-9, 1989 storm event. The light dashed curve (labeled #2) represents the inflow hydrograph entering the upstream end of the marsh near the confluence of the Kahanaiki and Maunawili Streams, developed in the previous section with an increase in flow to reflect base flow into the marsh, (which is based on recorded data from the leading edge and trailing edge of the observed hydrographs at the upstream gage located on Maunawili Stream at the Pali Hwy.). The effects of direct precipitation falling on the marsh, as well as flows entering from the ungaged Kapaa tributary near the quarry road are included in the simulated results shown in Figure A-18.

Attenuation of the storm's inflow hydrograph is dramatic. Timing of the inflow peaks and the peak outflows are separated by approximately 8-16 hours, depending on the antecedent conditions in the watershed and in the marsh during the event. The maximum outflow is about 50% of the inflow for long duration storms and about 20% for short duration storms (these observations are based on the April 1989 storm event only). The computed flow at location #12 in Figure A-18 is located about midway down the City and County ditch adjacent to the levee. Note that the peak of the outflow hydrograph at #12 in the City and County ditch occurs approximately where it intersects the inflow hydrograph. This indicates that the peak flow into the upstream end of the ditch occurs when the upstream portion of the marsh is near its peak storage for a given inflow. The stage and discharge in the upstream one half of the drainage ditch is closely related to the inflow hydrograph at the upstream end of the marsh. The peak discharge at the outlet end of the marsh (curve #4) is lagged behind the peak inflow hydrograph by varying amounts dependent upon the antecedent inflow and storage conditions in the marsh. During the April 4th event, the lag time was approximately 8 hours. Note that the peak inflow for the April 4th event was larger than the April 9th event, but the peak outflow wis lagged 4 hours longer than the April 9th event. The differences result from the amount of additional rainfall and runoff that occurred on the 7th and 8th just prior to the April 9th event. At low initial stages the marsh is slow to respond and takes a lot of water into storage before it begins to discharge it. Drainage from the marsh initiates at the upstream end of the City and County ditch as the upstream end of the marsh fills and rises. As more and more water enters the marsh it slowly distributes the flows into the central and downstream ends of the marsh toward the outlet. Tidal effects are only discernible near the head of the canal (curve 4) and disappear as one moves up the emergency ditch (curve #12) toward Kailua Road.

The significance is that reductions to the storage at the upstream end are necessary to translate greater quantities of water into the central and downstream portion of the marsh. The reduction in the amount of water stored at the upstream end equates to lower water levels at the upstream end of the levee and reduced probability for overtopping the levee.

Figures A-19, A-20 and A-21 present computed water surface contour plots throughout the marsh at three different times during the April 1989 event. Figure A-19 corresponds to the time of the greatest peak inflow into the marsh that occurred late on April 4th. The majority of the marsh surface is still below 6 feet in elevation. There are steep water surface profiles at the upstream end where Kahanaiki Stream enters and where the Kapaa tributary enters near the quarry road. Figure A-19 also shows that the steepest gradient into the emergency ditch is at the upstream end of the ditch. Because of the slow discharge response characteristics of the marsh, the computed peak discharge in the emergency ditch during the peak of the April 4th inflow was only 200 cfs. Also note that the water surface backs up into the Kapaa tributary near the quarry road. Shallow flooding is often observed there.

Figure A-20 corresponds to the time of the peak inflow that occurred late on April 9th, 1989. The water surface contours are approximately the same as those for the peak occurring on April 4th, except the entire marsh is now approximately one foot higher. Notice that the upper two-thirds of the emergency ditch was now fully draining. Figure A-21 presents the water surface contours for the marsh on the morning of April 9th when the peak outflow into the Oneawa canal occurred. The majority of the marsh surface is at elevation 6.5 to 7.5 feet and the entire length of the emergency drainage ditch was fully draining. The maximum outflow from the April 4th rain occurred approximately 12 hours after the peak inflow and the maximum outflow from the April 9th rain occurred approximately 8 hours after the peak inflow. The figures dramatically show the storage and attenuation characteristics of the marsh and how the discharge from the marsh is very much a function of the antecedent marsh levels and previous inflows.

Figure A-22 is a simulated time history of water surface elevation at various locations in the marsh during the April 4-9, 1989 storm event. Figure A-22 shows water surface time histories at three locations along the emergency ditch, one near the outlet to Oneawa canal, one about midway upstream and one near the upstream end of the channel. At the downstream most location (curve 402), the influence of the tide is evident. At location 474 tidal influences are very small and become evident only at the higher high tides (e. g. at day times 6.67 and 7.67). At location 532, all tidal influences disappear. Curves 474 and 532 are closely in phase with each other with the upstream most location approximately 1.5 feet higher. Once again the effects of the marsh's attenuation are reflected in the slight lag in time to the peaks of curves 474 and 532. The upstream most station peaks approximately 4 hours before the midway station on the April 4th event and approximately 2 hours ahead on the April 9th event.

At low stages within the marsh, circulation patterns are believed to be presently influenced by historical canal building activities. The locations of some canals that were compiled from old maps and sketches and aerial photos of the marsh were plotted on current topographic maps. During field investigations, several of these canal alignments were inspected. Flow was observed following some of these alignments durin; periods between storms. For example, flow was observed in a southerly direction toward the historic outlet in the southeastern corner of the marsh. Flow in the upstream end of the emergency ditch, which is lower than other portions of the marsh, occurs at low marsh levels and recreates historic hydraulic gradients which brought flow toward this end of the marsh. However, during periods of high inflow into the marsh, the circulations patterns become more complex and are governed by the global direction of hydraulic gradients due to characteristics of the marsh vegetation. Figure A-23, based on computer simulation studies of the April 4-9, 1989 storm, shows a major flow path taken along the higher energy gradient direction created between the inflow end of the marsh and the upstream end of the emergency ditch because of the lower ditch level and retarding effect of bulrush/sawgrass vegetation directly to the north, but also shows flow into the interior at lower velocity.

Cross sections of the City and County emergency ditch were taken at locations shown on Figure A-66. The cross sections are shown on Figures A-35 through A-46. These sections were included in the simulation model.

The significance of the model study results include the capability to reproduce water level and flow patterns with reasonable accuracy for the purposes of studying flood damage reduction measures; the verification that the extremely thick growths of marsh plants create hydraulic head losses due to friction and physical obstruction; the high resistance greatly effects the storage capability of the marsh for flood control purposes particularly as a function of antecedent marsh levels (previous inflows); and the influence of tides is not significant in terms of the observed water levels throughout the majority of the marsh.

The RMA-2 model was used to simulate the flows through the marsh of the hypothetical floods developed for different probabilities of annual exceedance. It is assumed that the initial stage in the marsh is 5.2 feet, msl, and overtopping of the levee could occur over the uppermost 1500 feet of levee near Kailua Road. The sensitivity of the results relative to the antecedent marsh level is discussed later in the Alternative C evaluation. It will be shown how these assumptions affect peak stages and outflow rates for the one percent chance exceedance flood. The results of the simulation of the 25-, 50-, 100-year, New Year's Eve 1988, and standard project floods are shown in Figures A-24 through A-34 in terms of the flood hydrograph and computed water levels in the marsh adjoining the levee. The significance of the simulations is that they indicate the probability that the existing levee at approximately 10.0 feet, msl, would be just overtopped by a four percent chance exceedance (25-year) flood.

SECTION 5. Kaelepulu Channel Hydraulic Evaluation

Overflow from Kawainui Marsh and local storm runoff from Coconut Grove is presently drained to the south along the man-made portion (adjoining Coconut Grove) of Kaelepulu Stream through the Enchanted Lakes subdivision to Kailua Bay. The location of 1989 channel surveys of the channel cross sections are presented on Figure A-66 for the portion of the channel adjacent to Coconut Grove. Figures A-47 through A-65 show these cross sections at approximately 300 foot intervals. The entire reach from the upstream end near Oneawa canal to the outlet at Kailua Bay was used to compute water surface profiles for various flow magnitudes. The computer program HEC-2, Water Surface Profiles, developed by the U.S. Army Corps of Engineers was used to perform the computation. The standard-step backwater calculation method is used by this program.

The water surfaces observed at these locations are dependent upon several factors such as the magnitude of local runoff, the tidal cycle, and the condition of the channel at the outlet at Kailua Beach Park. The outlet is often closed off due to a large sand bar that forms at the mouth of the channel, despite attempts by City and County personnel to keep it open. The calculations were performed for two different starting conditions at the outlet to Kailua Bay. One condition was a sea level based upon the mean higher high water estimated at 1.2 feet (msl) and a second condition based upon the highest astronomical tide expected during the 18.6 year tidal cycle, namely 2.2 feet (msl). The water surface profile results of the former condition occur more frequently and are more indicative of existing conditions and hence useful for assessing the potential impacts of alternatives. The water surface profile results of the latter condition are the basis for evaluating alternative plans; this condition is considered conservative as the basis for design since the likelihood that this tide would occur coincidentally with the design flood is remote.

The profile results based upon a starting sea condition of mean higher high water are shown in Figure A-67. These show results for 2-, 10-, and 25-year peak flood flows originating from the Coconut Grove area. The peak flow rates were developed by using the Soil Conservation Service (SCS) unit hydrograph procedure and are shown in Table A-22. The profile results do not include local storm drainage into Kaelepulu Stream downstream of Kailua Road. In general the water surface elevations for the 2-year flood were slightly above two feet (msl) elevation. The profile shows the effect of the sand bar based on its condition at the time of the survey at the outlet to Kailua Bay. Removal of the sand bar by mechanical means or erosion would tend to lower the profiles. On the other hand, additional storm drainage inflows not considered (noted above) would tend to raise the profile, particularly downstream of Coconut Grove. The magnitude of both effects will need further study to quantify.

An important part of the environmental impact statement is the documentation of the economic effects of the proposed action. The traditional benefit/cost method used by the Corps of Engineers and other public agencies is based on reduction in flood damage to estimate benefits of alternatives in order to assist in the selection of the best alternative from the public expenditure viewpoint. A rudimentary calculation was performed as part of this document that captures some (not all) of the losses that would be considered a benefit of the project. The procedure is limited because the amount of the actual (historical) losses is not on public record and was not releasable to the preparers of the DEIS due to the ongoing litigation. The calculation procedure discussed here is based on estimated damages prevented to structures and contents using methods adopted from Corps of Engineers procedures, but does not include all the potential losses such as cleanup costs, losses to automobiles and other possessions outside of buildings, lost wages, medical costs and disaster assistance costs.

Table A-22
Summary of Kaelepulu Stream
Peak Discharges Assuming Existing Conditions
HEC-2 Flow Values for Kaelepulu Stream

X-Section	2-yr	10-yr	25-yr	50-yr	100-yr	SPF**
to 92+87	137.4	238.6	579.8	1,230.6	2,078.6	4,048.4
*			285.0	915.0	1,742.0	3,845.0
48+00	118.9	203.4	256.8	275.0	293.4	203.4
24+00	83.6	147.1	181.3	194.2	207.3	147.1
3+00	14.8	25.2	29.0	30.8	32.8	25.2

Above based on following drainage area A thru G
* Flow added by overflow of existing levee
** Local runoff assumed, based on 10-year storm

Kaelepulu Stream

Drainage Area	A	B	C	D	E	F	G	TOTAL
Area (Acres)	18.2	35.5	19.1	20.2	45.5	38.3	10.6	187.4
Station Flow Added	Oneawa	3+00	24+00	24+00	24+00	48+00	48+00	

A windshield survey of the Coconut Grove community was made to identify existing structures that could be affected by flooding from Kaelepulu Stream. The structures were categorized by their foundation type and location relative to the stream channel. The elevation of the structure was estimated by building type and location on available topographic maps of each community. Two map bases were used: (1) City and County Honolulu Planning Department (one inch equals two hundred feet scale) photogrammetric maps prepared in 1969, and (2) U.S. Army Corps of Engineers (one inch equals two hundred feet scale) topographic maps prepared in 1988. There is an average difference of approximately two feet in elevation between the two map bases at comparable locations within the flood damage survey area. The 1988 Corps of Engineers maps are believed to be more accurate and show streets at lower elevations, however, these maps cover only the area mauka of Kihapai Street, whereas the City maps encompass the entire community. Thus the latter were used for the building survey, but the resulting flood stage damage calculations were adjusted (lowered) to account for the discrepancy.

The majority of houses in the survey area are post and beam construction. Only four units in the list received from the tax office had slab-on-grade foundations. Per the City building code, there must be 12 inches between the floor beam and the ground. The lowest ground elevation on Figure A-66 is approximately 5.0. The elevation of initial damage to buildings around station 24+00 is estimated at 6.0 feet, msl. At the other stations, initial damage elevations are shown on Table A-24.

Stage damage relationships shown in Table A-23 were adopted for the purpose of computing the estimated flood damage to residences. These are hypothetical relationships based on empirical data developed by the Honolulu District of the Corps of Engineers for justification of flood control expenditures to Congress. The flood damage at various stages was computed for two categories, structure and contents. The structure portion was estimated by multiplying the Corps of Engineers percent of structure damage at each increment of flood depth times the value of the house. The assessed value of the structures were obtained from public records provided by the City and County of Honolulu. Content damage was estimated by a similar computation assuming an average value of contents equal to forty percent of the structure and land value. The results are summarized in Table A-24.

The table assumes, based upon the data available, flooding begins to damage structures at approximately 6.0 feet, although the variation cannot be measured at present due to the accuracy of the maps. Yards and roadways would begin to flood at generally the 5 feet, msl, elevation.

Table A-24 shows the results of the damage calculation for various stages of floods. It should be emphasized that this is a hypothetical estimate and does not necessarily account for all actual losses incurred by historical events. It is instructive for the purpose of this document to compare these losses to the order of magnitude of the annual costs associated with each alternative. This shows the relative merit of each alternative when held in comparison to the losses prevented. Inaccuracies in the estimates are handled by sensitivity analysis of the results to corrections in the relative magnitude of the values. Another use of the data is for identifying the stage in the stream at which the majority of damages begin in order to evaluate the size for the components of Alternative C - Storage and Emergency Overflow that are necessary to pass the Standard Project Flood (SPF) excess from the marsh.

Table A-23
Corps of Engineers
Flood Stage-Damage Relationships
Depth Damage Curves Used in Alenaio Flood Control Study *

FT	19.00		5.00																
BT	10.00																		
*	-8.00	-7.00	-5.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
SS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.25	0.30	0.34	0.37	0.39	0.41	0.43	0.45	0.47
SV	0.00	0.00	0.00	0.00	0.00	0.15	0.17	0.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.40	0.51	0.61	0.67	0.72	0.76	0.79	0.81	0.83
CV	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BT	15.00																		
*	-8.00	-7.00	-5.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
SS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.25	0.30	0.34	0.37	0.39	0.41	0.43	0.45	0.47
SV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.43	0.62	0.81	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.40	0.51	0.61	0.67	0.72	0.76	0.79	0.81	0.83
CV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.40	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BT	20.00																		
*	-8.00	-7.00	-5.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
SS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.25	0.30	0.34	0.37	0.39	0.41	0.43	0.45	0.47
SV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.43	0.62	0.81	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.40	0.51	0.61	0.67	0.72	0.76	0.79	0.81	0.83
CV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.40	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BT	25.00																		
*	-8.00	-7.00	-5.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
SS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.25	0.30	0.34	0.37	0.39	0.41	0.43	0.45	0.47
SV	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.13	0.34	0.45	0.54	0.61	0.66	0.71	0.75	0.78	0.81	0.83
CS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.40	0.51	0.61	0.67	0.72	0.76	0.79	0.81	0.83
CV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.66	0.76	0.82	0.87	0.91	0.93	0.94	0.95	0.95
BT	30.00																		
*	-8.00	-7.00	-5.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
SS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.25	0.30	0.34	0.37	0.39	0.41	0.43	0.45	0.47
SV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.43	0.62	0.81	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.40	0.51	0.61	0.67	0.72	0.76	0.79	0.81	0.83
CV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.40	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* Feet of flooding over first floor
Except for non-residential contents

For this set of stage damage relationships, the following curves (from the curves file) were used, except that SS2 was modified to indicate no damages at or below zero elevation:

	Building Type		
	10.00	15,20,30	25.00
SS	SS2	SS2	SS2
SV	INPV	INV	SV2
CS	CS2	CS2	SC2
CV	FEV	FN	CV2

Building Types:
10 wood on post and beam
15 wood on concrete slab
20 wood on block foundation
25 brick or block on concrete slab
30 metal building
35 reinforced concrete

TABLE A-24
COCONUT GROVE FUTURE STRUCTURE/CONTENT FLOOD DAMAGE ESTIMATE (W/O PROPOSED ACTION)

FLOOD STAGE	STATION 3+00			STATION 24+00			STATION 48+00		
	TOTAL STRUCTURE PERCENT DAMAGE	TOTAL CONTENTS PERCENT DAMAGE	TOTAL DAMAGE (DOLLARS)	TOTAL STRUCTURE PERCENT DAMAGE	TOTAL CONTENTS PERCENT DAMAGE	TOTAL DAMAGE (DOLLARS)	TOTAL STRUCTURE PERCENT DAMAGE	TOTAL CONTENTS PERCENT DAMAGE	TOTAL DAMAGE (DOLLARS)
5.0	0	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0	0
6.0	0	0	0	4,494	11,870	16,364	0	0	0
6.5	5,594	12,721	18,315	16,049	35,677	51,726	0	0	0
7.0	70,216	158,697	228,912	57,194	118,507	175,701	21,373	43,344	64,717
7.5	76,053	173,161	249,214	90,327	203,694	294,021	21,373	43,344	64,717
8.0	119,078	267,919	386,997	119,359	280,168	399,526	44,474	71,996	116,471
8.5	176,737	414,091	590,828	169,659	431,270	600,929	71,340	155,067	226,407
9.0	203,105	494,937	698,042	219,223	577,862	797,085	80,926	182,981	263,907
9.5	233,110	591,155	824,265	263,283	714,683	977,966	111,994	237,640	349,633
10.0	254,608	646,854	901,462	293,410	823,826	1,117,236	133,431	303,230	436,661
10.5	269,905	699,395	969,300	318,898	928,979	1,247,877	174,425	407,341	581,766
11.0	273,956	712,980	986,936	356,412	1,051,329	1,407,741	215,190	488,668	703,858

Table A-25 shows the magnitude of flow and expected stage in Kaelepulu Stream under existing conditions based upon the HEC-2 analysis explained previously. The smaller channel cross-section and greater distance to the ocean result in the water level for equivalent low flows being higher in Kaelepulu Stream than Oneawa canal at the present time. The amount of difference depends upon the relative flows in each channel and the tidal cycle. The estimated water surface elevations for three stations upon water surface profiles calculated using the highest astronomical tide of 2.2 feet (msl) as the starting condition are shown is Figure A-68. These stations were used to estimate flood damage to the Coconut Grove community.

Figure A-69 summarizes the estimate of damage - probability relationships in a singular value. This is known as the expected value of annual damage because it is the expected outcomes integrated over the range of percent chance of annual exceedance. It is also referred to as average annual damage. The estimate is approximately $20,750.00. The present worth of this amount for a 25-year period is $162,740 (SPWF = 7.8431 at 12 percent, 25-year period). Another interpretation is that over the long term, the average damage would average out to this amount on a yearly basis.

The total amount of average annual damage cannot be accurately estimated because different magnitude floods result in different consequences depending upon the severity and duration. The cost of floods includes public losses and expenditures. For example, the City and County of Honolulu expended $282,753 in the aftermath of the New Year's Eve 1988 flood for cleanup, removal of damaged property, and levee work. Total losses to businesses and residences in Coconut Grove from this flood are estimated at approximately $10,000,000 (personal conversation, Mr. James Aiona, City Corporation Counsel, 1989). In comparison, Table A-24's estimated total structure and content damage is approximately $2.5 million for a flood stage of 10.0 feet, msl, approximately the stage experienced in this flood. Thus the total event damage in the average annual damage calculation may be an underestimate by at least a factor of 4.0 (10/2.5 = 4.0). Assuming the same proportional underestimate for each level (probability) of flooding, the average annual damage estimate of $20,750 was multiplied by a factor of 4.0 (4.0 x $20,750 = $83,000). The result serves as a sensitivity check on the present worth of expected annual damages. Using the series present worth factor (7.8431), the present worth of the high estimate of annual damage is $650,980. Assuming this is the limit of public expenditure economically justified (again based on benefit/cost principles), a total first cost of flood damage reduction measures above approximately $0.65 million would in theory not be warranted. Annual maintenance costs of waterways have benefits for habitat improvement and therefore inclusion of these costs in benefit cost comparisons should be apportioned.

TABLE A-25
COMPUTED WATER SURFACE ELEVATION (CWSEL) FOR EXISTING CONDITIONS

STATION	PROBABILITY 0.50 (2YR)	0.10 (10YR)	0.04 (25YR)	0.02 (50YR)	0.01 (100YR)	SPF
48+00	2.10	2.58	3.89	5.72	7.31	10.17
24+00	2.18	2.72	3.98	5.75	7.33	10.17
3+00	2.21	2.78	4.01	5.76	7.33	10.17

SECTION 6. Alternatives Evaluation Criteria

Four major alternatives, some with options, were identified and evaluated using appropriate hydrologic engineering methods. Each methodology is explained in the following evaluations. The level of analytical method sophistication varies between alternatives. The simplest methods are usually applied first in any engineering investigation to screen alternatives; using this approach conserves valuable study resources for evaluation of more difficult problems requiring more elaborate methods.

In order to objectively compare the technical performance of each alternative, a set of criteria was developed to determine size requirements of various components of each alternative plan. The basic criteria are set forth below:

1. Design peak inflow - varies between 9800 cfs (100-year flood) and 18,100 cfs (SPF).
2. Design storm - varies between ten percent annual chance of exceedance (10-year) for local drainage to SPF.
3. Antecedent marsh level at onset of design flood- 5.2 feet, msl (average peak marsh level prior to construction of emergency ditch).
4. Levee freeboard - 3.0 feet.
5. Channel freeboard - 2.0 feet.
6. Roughness values for flow calculations - See Table A-26.

The four alternatives being evaluated are described below. They are identified as Alternative A – Channelization, Alternative B - Diversion, Alternative C - Storage and Emergency Outlet, and Alternative D – Channelization/Levee Raise.

The preliminary basis of design for the first three alternatives is shown in Tables A-27, A-28, A-29, and A-30. Two options were considered for Alternative D: 1) levee raise, and 2) combination levee raise and channelization. The results from the RMA-2 model provided the basis for sizing the levee raise in the first aforementioned option. A holdout routing was used in combination with a gradually varied flow profile calculation (see basis for design for Alternative A) to size the second option.

Table A-26 Values of the Roughness Coefficient n
Source: Chow, Ven Te; Open Channel Hydraulics: McGraw Hill, 1959

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

Table A-27
Alternative A
Channelization

Preliminary Basis of Design:
The following two equations are solved by an iterative procedure (the standard step method) to calculate an unknown water surface elevation at a cross section:

$$WS_2 + \frac{\alpha_2 V_2^2}{2g} = WS_1 + \frac{\alpha_1 V_1^2}{2g} + h_e$$

$$h_e = LS_f + C\left(\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right)$$

Where:

WS_1, WS_2	=	water surface elevations at ends of reach
V_1, V_2	=	mean velocities (total discharge/total flow area) at ends of reach
α_1, α_2	=	velocity coefficients for flow at ends of reach
g	=	acceleration of gravity
h_e	=	energy head loss
L	=	discharge-weighted reach length
S_f	=	representative friction slope for reach
C	=	expansion or contraction loss coefficient

Table A-28
Alternative B
Diversion

Preliminary Basis of Design:
Energy Principle:
The specific energy per pound of fluid at any point along a stream line in a conduit, based on the invert as the datum, is given by the equation:

$$H_o = y + h_p + \left(\frac{v^2}{2g}\right)$$

where:

H_o	=	specific energy head
y	=	height above the invert or potential energy
h_p	=	pressure head above the stream line
$v^2/2g$	=	kinetic energy per unit weight (velocity head the stream line)

For solution the specific energy is known at U/S, D/S and Q therefore area of conduit must be determined for open channel flow:

$$H_o = d + \left(\frac{V^2}{2g}\right) = d + \left(\frac{Q^2}{2gA^2}\right)$$

$$Q = \frac{(1.486)A^{5/3}S^{1/2}}{nP^{2/3}}$$

where:

d = depth
Q = flow rate
A = cross-sectional area
P = wetted perimeter
n = coefficient of friction
S = uniform slope of invert

Table A-29
Alternative C
Storage and Emergency Outlet

Preliminary Basis of Design:
The two dimensional depth averaged hydrodynamic model which forms the basic structure for the RMA-2 model has been applied in many estuarial and riverine environments by the U.S. Army Corps of Engineers, state agencies and private consultants with excellent success when tested against field data. It has been extensively documented elsewhere, see for example Norton et al. (1973) and King and Norton (1978), only the governing equations and an outline of the model approximations is presented below.

Governing Equations:
RMA-2V uses the depth averaged Navier Stokes equations modified by the Boussinesq-Reynolds approach to incorporate the effects of turbulence. Eddy viscosity coefficients are used to represent the influence of turbulent energy losses both at super- and sub-grid scales. The program is designed so that a user may input values of these coefficients for as many groups of elements as are required.

The governing equations of this model take the form:
Momentum

$$h\frac{\partial u}{\partial t} + uh\frac{\partial u}{\partial x} + vh\frac{\partial u}{\partial y} + gh\frac{\partial a}{\partial x} + gh\frac{\partial u}{\partial t} - \frac{h\varepsilon_{xx}\partial^2 u}{\rho\ \partial x^2} - \frac{h\varepsilon_{xy}\partial^2 u}{\rho\ \partial y^2} S_{fx} + \tau_x = 0$$

$$h\frac{\partial v}{\partial t} + uh\frac{\partial v}{\partial x} + vh\frac{\partial v}{\partial y} + gh\frac{\partial a}{\partial x} + gh\frac{\partial h}{\partial y} - \frac{h\varepsilon_{yx}\partial^2 v}{\rho\ \partial x^2} - \frac{h\varepsilon_{yy}\partial^2 v}{\rho\ \partial y^2} S_{fy} + \tau_y = 0$$

Continuity

$$\frac{\partial h}{\partial t} + \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} = 0$$

where u and v are the velocity components in the Cartesian directions x and y at time t, h and a are the water depth and bottom elevation, S_{fx} and S_{fy} are non-linear Chezy or Manning representations for the bottom friction loss term, τ_x and τ_y represent the effects of wind stress and Coriolis influences, and ε_{xx}, ε_{xy}, ε_{yx}, and ε_{yy} are the eddy viscosity coefficients.

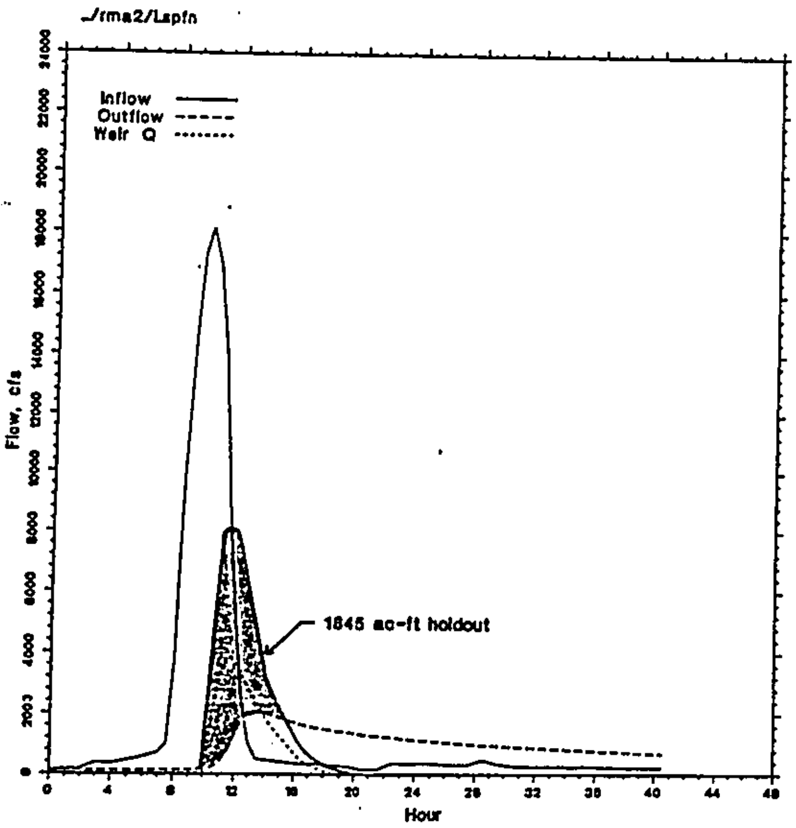
Table A-30
Alternative D
Levee Raise/Channelization

Preliminary Basis of Design:
Muskingum Routing

$$S = K [x I + (1-x) O]$$

where:

S = Storage for channel reach
K = Storage constant
x = Ratio of relative proportion of inflow versus outflow on storage determination
I = Inflow
O = Outflow



Time	Q in	Q out	Weir Q
7.5	1000.	124.	5.
8.0	3880.	127.	5.
8.5	10000.	129.	6.
9.0	14400.	133.	7.
9.5	17200.	138.	10.
10.0	18100.	154.	14.
10.5	16900.	205.	2005.
11.0	13800.	356.	3395.
11.5	8600.	709.	3845.
12.0	4900.	1270.	3698.
12.5	2300.	1756.	3259.
13.0	1000.	1982.	2736.
13.5	500.	2033.	2246.
14.5	440.	1924.	1493.
15.5	385.	1757.	944.
16.5	330.	1619.	424.
17.5	360.	1513.	204.
18.5	275.	1433.	5.
19.5	242.	1364.	4.
20.5	147.	1302.	5.
21.5	156.	1245.	5.
22.5	370.	1195.	5.

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for the Corp's Standard Project Storm Without Levee or Marsh Modifications

SECTION 7. Alternative A - Channelization Evaluation

The basis for the design calculations is shown in Table A-27. A gradually varied flow water surface profile calculation of the type upon which Figure A-73 is based is a conservative estimate in as far as water surface elevations between the inlet and outlet provided the design flow does not exceed 8000 cfs. The channel cross section assumes the entire flow would be conveyed, when in actuality, unless impermeable channel sides were constructed (to the estimated water level), the flow would spread to the sides of the channel. The calculation does not predict water levels from the volume of runoff from a storm such as the SPF whose peak discharge is 18,100 cfs. The difference in flow (18,100 versus 8000 cfs) will result in an increase in storage to attenuate the flow that can pass this size channel. This increase in storage translates into a rise in water surface. (The elevation of the levee raise necessary to protect against this rise is left to the discussion of Alternative D, at which time a channelization plan similar to Alternative A will be evaluated.) Early in the evaluation of alternatives, it was determined that the interior channel alignment did not offer an improvement over an alignment closer to the levee. The limiting factor in the capacity of the marsh to convey water to any channel is the resistance to flow of the marsh near the channel where the water surface is drawn down. The levee alignment has several advantages which include the following:

1. Construction and maintenance would be facilitated by the proximity to the levee.

2. The channel depth could be greater for a given width because the side slope nearest the levee could be much steeper. The channel would have more capacity which would compensate for the increased length because needed water can enter from only one side;

3. There will be less disruption to the marsh environment because the levee channel option is an expansion of an existing ditch.

4. The marsh mat nearest the levee and outlet channel, which is probably the most dense due to consolidation during periods of low water levels, will add to the stability of the marsh side slope and reduce the chance of portions of the mat breaking away and clogging the outlet channel.

5. The middle of the marsh channel would expose large quantities of organic silt to movement into the outlet channel.

The concept for Alternative A is shown in Figures A-74 through A-77. The basis for design shown is adopted from unpublished technical data prepared by the U.S. Army Corps of Engineers. The design assumes that a dredged channel with a cross section as seen in Figure A-76 will be constructed to a depth of - 5.0 feet msl. To maintain water levels in the marsh, an outlet structure (Figure A-75) is proposed to prevent water from draining out of the marsh when the water surface is below 4.0 feet msl. The material taken from the excavation is to be disposed on land adjacent to the marsh next to the model airplane field. Figure A-73 shows the basis for hydraulic feasibility of this plan and the computed water surface profile. Note that based upon a discharge of 8000 cfs, the computed water surface at the upstream end of the marsh exceeds 10 feet, msl. In comparison, Table A-15 estimates the composite peak rate of inflow from the New Year's Eve 1988 storm at the upstream end of the marsh to be 8426 cfs. Thus this plan would divert most of the flow from a comparable storm toward Oneawa canal. Figure A-73 indicates there would be little or no margin of safety between the water surface in the upstream end of the marsh and the present levee elevation of approximately 10 feet. msl. Consequently, to be compared to other alternatives in terms of a design storm, the 100-year design storm was assumed; otherwise this alternative would need to be modified by either enlarging the channel design or providing a higher levee near the upstream end near Kailua Road.

One of the concerns with channelization is that the circulation patterns that preserve the wetland will be changed by this alternative. One way in which the hydrology will be affected will be that the detention time of water within the marsh will be dramatically shortened for Alternative A. The majority of the flood peak for large floods will translate through the marsh in a few hours. For example, assuming an average velocity of flow equal to 5 feet per second, a water particle in the channel could pass through a 6000-foot long channel in 20 minutes. In comparison, Figure A-27 shows the routing for existing conditions. The shorter time over which storage is held with Alternative A means less time is available for water to reach the fringes of the marsh, particularly the eastern edge of the marsh. Over time this will lead to drying of the edges of the marsh and improve conditions for colonization by terrestrial plant species. Another effect of channelization is that relatively frequent floods will be discharged primarily through the channel thus depriving portions of the marsh the flooding needed to maintain the saturated soil conditions favored by wetland plant species. Flooding of the wetland will occur less frequently and, when it does occur, will be shortened. This will have a negative effect upon the wetland plant species. Drying of the marsh also poses a more serious threat from the standpoint of accidental fires that are a hazard to public safety and private property.

An option related to Alternative A is shown on Figure A-77. This is a variation of the channelization method, which is intended to prevent water from flowing toward the levee by building a training dike (levee reveted with stone) as shown on the figure. The concept is based on river training structures where velocities are much greater than occur in the marsh. It would have to be built to the same elevation as the design water surface profile; this is shown on Figure A-73 to be approximately 10+ feet in this area of the marsh. A later discussion of Alternative C will show that flood water will flow around the head of this training structure and equalize the water level adjacent to the levee at least to the same elevation as occurs at the head of the training structure, thus neutralizing its effectiveness. On this basis alone it was dropped from further consideration as being ineffective. In addition, the proposed alignment traverses archaeological sites, and the difficult soil conditions that would be encountered for a foundation for this type of structure would significantly add to the cost of this alternative.

The engineering basis for the cost estimate for this alternative is shown in the cost estimate section at the end of this appendix. The estimate for the low flow control structure was taken from estimates made by the Corps of Engineers. The procedure and quantities for dredging were revised to take advantage of the recent surveys conducted as part of this document to estimate the disposal area requirements and rate of dredge material disposal. It is assumed for this analysis that (based on these surveys) the average thickness of the overlying mat of vegetation is three feet thick and the remainder of the material to elevation -5.0 feet is loose sediments that can be excavated by suction dredging. Probe results indicate a firm bottom along 800 to 1000 feet of this alignment which might require cutter head apparatus. Additional borings are needed to determine the material and its extent. No amount of over dredging was assumed in this calculation although that is the usual procedure to provide a margin of safety against immediate sedimentation which would negate the amount of flow conveyance in the channel design.

SECTION 8. Alternative B - Diversion Evaluation

Diverting flood water around the marsh as shown in Figure A-78 would transport peak flow to Oneawa canal which was designed to safely convey a peak flow of 7350 cfs with approximately 2.0 feet of freeboard. A water surface profile calculation was made using the as-built channel cross-sections that indicated (Figure A-107) 8000 cfs flow wold result in approximately the same design tailwater (6.7 feet, msl) in Oneawa canal. Soundings taken by Wagner, Holms and Englis, 1988, found ". . .the bottom of the channel was generally lower than design grade 4 and the Oneawa Channel was still capable of handling its design flow at the time of the survey."

Considering only the peak flow of 6210 cfs from Maunawili Stream that occurred during the New Year's Eve flood as the basis for the preliminary design shown in Table A-28, Figure A–79 shows 724 cfs per pipe can be conveyed. A total of nine pipes, 12 feet in diameter, (the largest made locally) would be required to transport the peak discharge. The estimated volume of runoff for the New Year's Eve 1988 flood from the other two principal watersheds, Kahanaiki and Kapaa, was 908 and 380 acre-feet, respectively. This volume could be contained within the marsh without overtopping the levee if a diversion were constructed for Maunawili Stream. The accompanying calculation sheets in the cost estimate section show the basis for the size and quantity determination for the diversion and associated structures.

SECTION 9. Alternative C - Storage and Emergency Outlet Evaluation

Introduction

This alternative for flood damage mitigation has three elements that provide for a reduction in the urban damage consequences of flooding without major adverse environmental impacts. These elements are: 1) opening new waterways, 2) protecting the levee from overflows, and 3) providing for the rapid evacuation of overflow water from Kaelepulu Stream into Oneawa outlet canal. These features are shown in Figure A-80.

The previous discussion of marsh hydraulic factors noted that the resistance of the vegetation to flow results in rapid increase in storage at the upstream end, particularly when antecedent marsh levels are relatively low. The purpose of the proposed waterways is increasing the rate that water is stored at the downstream end near Oneawa canal relative to the inflow at the upstream end. This is the central principle of this alternative and why it is designated improvement of storage.

In recent history, the "natural outlet" for the marsh has been at the southeastern corner of the marsh adjoining Kailua Road. This area was also the outlet for the marsh during historic periods when marsh levels were manipulated by Hawaiians for food gathering. In recent times, particularly with the construction of the emergency ditch in 1988, the flow has been observed following the same route primarily as a matter of hydraulic gradient due to the different types of vegetation. As a result, during flood events, the course of least resistance still favors the historical outlet. The likelihood is that future floods will flow toward this area as long as the character of the marsh vegetation remains the same. There is a distinction in vegetation between the southern and northern ends of the marsh. The greater resistance to flow at the northern end and physical differences in elevation increase the concentration of flow toward the southern end of the levee.

An essential element of Alternative C is to plan for the possibility of overflow in the southeastern corner and design features that can safely accept the flood water and redirect it away from the community. To protect the levee, a combination of concrete cap and stone revetment is recommended for the existing levee between stations 0+50 to 14+50, where the flow will concentrate. In order to ensure the overflow occurs where the least negative impact to the rest of the levee and greatest amount of protection can be provided, the levee should be maintained at a grade of 9.0 feet for this 1400 foot distance and raised approximately 2.5 feet for an additional 3000 feet. The amount of levee raise can be reduced slightly as one proceeds toward Oneawa canal. The remaining embankment no longer functions as a levee to prevent water from reaching the Kaelepulu side, but instead separates and channelizes flood flow. Thus the amount of height for freeboard is based upon that for a channel, namely 2 feet.

The existing wetland on the Coconut Grove side of the levee is primarily bulrush (*Scirpus californicus*) and California grass near the edge of the levee. It is proposed to excavate the west bank of Kaelepulu Stream to the level of the existing stream channel invert (bottom) at levee station 14+50 to allow water overflowing the levee to enter the stream and flow north to Oneawa canal. This will also reduce the possibility that water in the wetland (east side of levee) will overtop the bank on the residential side of the stream. This improvement is shown on Figure A-81.

Waterway Hydraulic Analysis

The basis for the preliminary design of Alternative C is the geometric grid shown in Figure A–82. (See Section 4 for an the explanation of the theoretical considerations in the finite element model (RMA-2).) Figure A-82 shows how the geometric network of nodes and elements was modified to simulate the effect of vegetation removal along two principal paths within the marsh and to estimate the magnitude of overflow that would occur for the design storm used by the Corps of Engineers when the levee was originally designed. That design storm is shown in Figure A–83 in comparison to the magnitudes of the New Year's Eve 1988 and 25-year design storm.

The width assumed for both alignments of the proposed waterways was 40 to 50 feet and the bottom elevation assumed was +2 feet, msl. Small deviations (a few hundred feet) from the modeled alignment can be made without changing the predicted hydraulic response of the marsh very much. The channel nearest the levee conveys the most water since it conveys water towards the levee channel while the other channel only allows more flow to storage in the western side of the marsh. A maximum head loss of approximately 1.5 feet was computed in the eastern channel for the New Year's 1988 event as compared to approximately 0.6 feet in the western channel. If there is any flexibility in the widths, it would be better to make the eastern channel (channel closest to levee) wider than the other. The main hydraulic considerations in the alignment of the interior channels are 1) the marsh does not become so fragmented that portions of the mat break away and cause the channels to clog, and 2) the channels are kept at a sufficient distance from the levee and outlet channels so that the mat is not mobilized and forced up against the levee or into the emergency ditch. The maximum computed head difference between the end of the interior channels and the head of the Oneawa Channel is approximately 6 feet. This head difference would result in an average bottom shear stress of 0.56 lb/sq.ft. over a distance of 2000 feet.

Figures A-84 through A-93 show the peak water surface elevations and the peak flow rates that were calculated by the model for the four-, two-, and one-percent chance annual exceedance storms plus the New Year's Eve 1988 and SPF floods. The first three correspond in terms of return periods to the 25-, 50- and 100-year events, respectively. Note that the 25-year event just barely exceeds the overflow crest elevation of 9.0 proposed in this alternative. In essence, the probability of overflow with this alternative would remain approximately the same as with existing conditions. This is due to the effect of improved storage due to the waterway openings simulated by the model.

A sensitivity analysis was conducted of the effect that the assumed antecedent water surface in the marsh has upon the peak stage and peak overflow rate. The marsh model simulation results for Alternative C have assumed the marsh water surface elevation at the beginning of the different design storms to be level and equal to 5.2 feet, msl. This level was adopted as a reasonable estimate after reviewing the data shown in Table A-31. This table shows the peak water levels recorded by a U.S. Geological Survey in the marsh for periods before and after the levee was constructed. The average values for these two periods are 3.7 and 5.2 feet, msl, respectively. The difference between the averages is statistically significant at the 98 percent level as shown in Table A–32. The average peak water level in the marsh has been higher since the construction of the levee and cessation of irrigation withdrawals.

Two additional simulation results are shown in Figures A-94 through A-97. These show the flow hydrographs and stage hydrographs for an assumed starting water surface elevation of 6.2 and 7.2 feet, msl. The latter value is the highest peak water level recorded by the USGS gage prior to its removal from the marsh. The increase in overflow and peak stage observed

Table A-31
Sheet A Kawainui Marsh EIS
30-May-89

Kawainui Canal — Latitude: 21-24'-15"
Crest Gage #2648 — Longitude: 157-45'-26"
Datum: 0.00 feet msl — D. Area: 11.0 sq. mi.

Water Year	Date	Gage Height (ft)	Discharge (csf)
1957	21-Jan-57	4.19	
1958	5-Mar-58	5.16	1640
1959	18-Jan-59	2.30	
1960	3-Aug-60	3.48	
1961			
1962			
1963	15-Apr-63	4.91	750
1964	12-Dec-63	1.91	
1965			
1966			
1967	6-Nov-66	4.19	
1968	18-Dec-67	7.15	
1969	1-Feb-69	6.80	
1970	27-Jan-70	4.54	
1971	26-Nov-70	6.20	
1972	23-Jan-72	5.50	
1973	23-Aug-73	3.65	
1974	2-Feb-74	4.76	
1975	12-Jan-75	5.82	
1976	27-Nov-75	4.02	
1977	30-Jun-77	4.10	
1978	23-May-78	4.60	
1979	20-Feb-79	5.68	

Crest Gage #2648
Datum: 0.00 feet msl

Water Year	Date	Gage Height (ft)	Discharge (csf)
1980	9-Dec-79	2.33	
1981	7-May-81	2.32	
1982	28-Oct-81	2.32	
1983	28-Oct-82	2.31	
1984	13-Dec-83	0.88	
1985	14-Feb-85	2.63	
1986	27-Feb-86	1.93	
1987	end	<1.11	
1988	1-Jan-89	2.49	

Source: U.S. Geological Survey Water Resources Division

Table A-32
Comparison of Pre and Post Levee Construction
Peak Marsh Water Levels
Unpaired t-Test

DF	Unpaired t Value	Probability (1-tail)
17	-2.547	0.0105

Group	Count	Mean	Standard Deviation	Standard Error
1	6	3.658	1.344	0.549
2	13	5.155	1.120	0.311

DF	Unpaired t Value	Probability (2-tail)
17	-2.547	0.0209

Group	Count	Mean	Standard Deviation	Standard Error
1	6	3.658	1.344	0.549
2	13	5.155	1.120	0.311

Note: Group 1 = Pre-Construction
Group 2 = Post-Construction
Based on crest gage data shown for 1957-1979 on Table A-31

within the marsh for a one percent chance annual exceedance (100-year) event is summarized below:

Antecedent Stage (ft)	Increase In Peak Overflow (cfs)	Increase In Peak Marsh Level (ft)
5.2	-	-
6.2	128	0.04
7.2	235	0.08

These values indicate that the amount of increase of overflow at the emergency weir in Alternative C and the resulting peak marsh level are not significantly influenced by the antecedent conditions that would precede a storm of intense proportions such as the 100-year design flood.

Another aspect of the sensitivity study of antecedent conditions is that infilling of the marsh due to biomass decomposition has a small effect in the short-term.

Emergency Overflow Weir

Figures A-98 and A-99 show the simulated currents that would be induced with the emergency overflow weir in the marsh and within the overflow area on the Coconut Grove side of the levee. Note on the marsh figure that the flow curves toward the overflow in a northwest to southeast direction. This is attributed to the hydraulic grade line difference between the weir crest in comparison to the water surface in the marsh and emergency ditch which would be higher due to the confining effect of the levee to prevent overtopping. This phenomenon is also seen in Figure A-93 which shows a decline in the peak water surface in the upstream direction in the vicinity of the weir. Wherever there is a potential energy gradient within the marsh, flow will be induced. Thus, for example, a training levee as proposed as an option in Alternative A would not prevent flow from turning and equalizing the water level in a direction opposed to the main flow because of this potential energy difference.

In order to protect the existing levee from erosion, some form of revetment is recommended as part of this alternative. Figure A-81 shows a preliminary concept that uses reinforced concrete and gabions (wire-filled baskets) to prevent scour. There are many combinations of this type of overflow that would have to be studied during the design in order to arrive at the most cost effective approach. For example, in lieu of gabions, the downstream side of the levee could be replaced with a roller compacted concrete spillway. These types of studies are not possible during the DEIS phase of a project because of resource limitations but the important point to note is that the approach has been shown to be hydraulically feasible, and there is a body of literature which supports the basis for design (Powledge, et al, 1989).

The basis for the design of the emergency overflow is the weir equation:

$$Q = C\,L\,H^{1.5}$$

where Q = the overflow rate in cfs
C = a coefficient
L = length in feet
H = design head in feet

A value of 3.0 was assumed for the weir coefficient on the basis of typical value reported by Powledge et al. (1989) in their study of level crested structures.

The basis for the selection of gabions for the embankment protection is studies performed by the U.S. Bureau of Reclamation (Powledge and Dodge, 1985) that showed

> "gabions have demonstrated the ability to prevent erosion of embankments during flood overflow. Research tests and full scale testing have demonstrated that although gabion wire cells deform under high velocity flows, they prevent erosion of the embankment."

Model studies (Powledge et al, 1989) show (Figure A-71) the type of design proposed herein withstood overtopping for five hours with 8.4 percent loss in the embankment volume. The downstream sideslope of the existing levee will be modified to 4 horizontal to 1 vertical slope. Figure A-70 shows the existing condition of the levee and the approximate location where this slope will extend. The detailed design could be verified by the Corps of Engineers at their Waterways Experiment Station where physical model studies of this nature have been conducted for other projects. For example, this facility model tested the overflow embankments that were constructed for the Arkansas River navigation project. Figure A-72 shows that under certain conditions good grass cover is also an alternative means of reducing erosion. The 1988 flood overflowed the levee for at least 5 hours without major structural damage.

<u>Kaelepulu Stream and Outlet</u>

In order to evacuate flood water rapidly from Kaelepulu Stream before it rises to stages that will inundate residences and businesses, a new outlet structure to Oneawa canal at the northern end of Kaelepulu Stream is recommended. The plan is to construct a reinforced concrete box outlet with a width of 48 feet to maximize the flow capacity of the existing stream channel. Figure A-100 shows a preliminary sketch of the plan; Figure A-101 shows this feature in profile view. The outlet invert is planned to be at -0.5 feet on the upstream (Kaelepulu Stream) side and -1.0 feet msl on the downstream (Oneawa canal) side. These elevations will allow the entry of different aquatic organisms and the water salinity in the stream will become more brackish than at present. Normal water levels will decrease in Kaelepulu Stream by between two to three feet depending on tides and local rainfall. The range will fluctuate with the tidal range observed at the head of the Oneawa canal. However, these lower levels will improve local storm drainage conditions during floods.

Figure A-102 shows the schematic of the stream model geometric grid used for the analysis of three floods: 1) Corps of Engineers Standard Project Flood, 2) New Year's Eve 1988 flood, and 3) a hypothetical 100-year flood. The latter flood frequency is required to meet storm drainage and flood control design criteria according to City and County of Honolulu Standards (Department of Public Works, 1988).

The peak water surface elevations and assumed elevations at which damage to residences and contents begins are summarized below:

Event	Model Node 12	67	72	77	136
SPF	4.4	5.8	6.5	7.2	5.4
NYE 88	3.9	4.8	5.4	5.8	3.4
100-YR	3.3	3.9	4.2	4.5	4.4
DAMAGE		6.5	6.0	7.0	5.0

The locations of these nodes are explained on Table A-33. They are referenced to the cross section locations shown on Figure A-66.

The above summary indicates that the emergency overflow will damage residences and contents during the SPF but not during floods with magnitudes that met or slightly exceeded the City and County.Storm Drainage standards, such as the New Year's Eve, 1988 flood. The summary above does not include the effect of local runoff from the storm drainage system. Local storm drainage design criteria is based upon the 10-year storm, i.e. an annual chance of exceedance of ten percent. If the peak discharge of a ten-year storm from the local Coconut Grove storm drainage system were to discharge at precisely the peak of the water level elevation shown above, the increase in water levels would be approximately 0.2 feet. This assessment is based upon the rating curves shown in Figure A-68 for peak flows of approximately 203 cfs. Local storm runoff peak discharge rates for events with greater return periods, for example a 100-year storm, would be attenuated by local ponding and localized flooding because the local drainage systems are typically not designed to carry runoff of this magnitude.

With regular maintenance proposed as part of this alternative, water surfaces during flood flows can be reduced even further. Adding two feet to the above 100-year flood elevations for freeboard indicates that freeboard requirements can be met in Coconut Grove, but not in the vicinity of Hamakua Drive and Kaelepulu Stream. Furthermore, the elevations calculated in this reach during the SPF indicate that flooding of residences would occur. Note that the flood levels along Kaelepulu Stream would be less under Alternative C than under present conditions if the levee were to overflow, for example the estimated water elevation for the SPF at the Coconut Grove stations above (nodes 67,72,77) is 10.2 feet, msl. Consideration was given to installing a gated weir at the intersection of Kaelepulu Stream and Kailua Road to prevent the flow from rising to damage levels downstream. However, this structure could only prevent flood damages downstream at the expense of increasing flood levels during the Standard Project Flood in the Coconut Grove area. As the analysis indicates that for the City and County standard design, this structure is not required it was deleted from Alternative C at this time.

Another important result of the Kaelepulu Stream model is the water surface elevations predicted at the outlet of the proposed Kaelepulu outlet to Oneawa canal. The peak elevations for the SPF simulation in Oneawa canal (including the flood outflow from Kawainui Marsh) is estimated to be 4.4 feet, msl. This is below the lowest estimated elevation at which residential flooding begins (6.0 feet, msl) in Coconut Grove. It indicates that the the water in the canal will not be higher than homes in Coconut Grove.

The outflow from Kawainui Marsh was considered in the design of the outlet; however, as discussed in Section 4, conditions during the New Year's Eve storm and since then indicate that the outflow from the marsh has only minor impact upon the stage in the head of Oneawa canal. For example, the peak stage at the proposed outlet observed from the New Year's Eve storm was approximately 2.5 feet (msl).

Table A-33

Kawainui Marsh, 100-yr flood, Kaelepulu Stream, Highest Tide 2.2 feet msl

HYDROGRAPH FOR NODE 12

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	-.505	.421	.657	-474.2	9.239	2.239
.50	-.579	.482	.753	-544.1	9.248	2.248
1.00	-.629	.524	.819	-591.9	9.250	2.250
1.50	-.674	.562	.878	-634.6	9.258	2.258
2.00	-.732	.610	.952	-689.5	9.269	2.269
2.50	-.819	.682	1.066	-773.0	9.288	2.288
3.00	-.956	.797	1.244	-905.8	9.321	2.321
3.50	-1.169	.974	1.521	-1114.1	9.378	2.378
4.00	-1.481	1.234	1.928	-1426.6	9.475	2.475
4.50	-1.968	1.640	2.562	-1921.3	9.666	2.666
5.00	-2.521	2.101	3.282	-2543.2	9.923	2.923
5.50	-2.917	2.431	3.798	-3005.5	10.133	3.133
6.00	-3.157	2.631	4.110	-3299.2	10.273	3.273
6.50	-3.261	2.717	4.244	-3429.1	10.344	3.344
7.00	-3.246	2.705	4.226	-3410.0	10.332	3.332
7.50	-3.156	2.630	4.108	-3294.0	10.268	3.268
8.00	-2.968	2.473	3.863	-3059.7	10.142	3.142
8.50	-2.730	2.275	3.553	-2772.5	9.991	2.991
9.00	-2.488	2.073	3.238	-2491.8	9.852	2.852
9.50	-2.264	1.887	2.948	-2241.7	9.737	2.737
10.00	-2.092	1.743	2.723	-2054.2	9.659	2.659

HYDROGRAPH FOR NODE 67

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.151	.015	.151	37.0	4.247	2.247
.50	.167	.017	.168	43.4	4.260	2.260
1.00	.145	.014	.145	37.6	4.265	2.265
1.50	.171	.017	.171	44.5	4.274	2.274
2.00	.207	.021	.208	54.3	4.287	2.287
2.50	.253	.025	.254	66.5	4.309	2.309
3.00	.327	.033	.329	87.1	4.348	2.348
3.50	.452	.045	.454	122.5	4.415	2.415
4.00	.547	.055	.550	153.1	4.539	2.539
4.50	.050	.005	.050	15.0	4.832	2.832
5.00	-.918	-.092	.922	-271.0	5.229	3.229
5.50	-1.375	-.137	1.382	-491.8	5.569	3.569
6.00	-1.703	-.170	1.711	-641.1	5.807	3.807
6.50	-1.836	-.184	1.845	-706.8	5.913	3.913
7.00	-1.801	-.180	1.810	-690.2	5.891	3.891
7.50	-1.654	-.165	1.662	-619.7	5.783	3.783
8.00	-1.428	-.143	1.435	-512.8	5.585	3.585
8.50	-1.037	-.104	1.043	-352.6	5.339	3.339
9.00	-.556	-.056	.559	-179.3	5.114	3.114
9.50	-.068	-.007	.068	-20.9	4.936	2.936
10.00	.263	.026	.265	79.2	4.821	2.821

HYDROGRAPH FOR NODE 72

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.094	.068	.116	33.0	4.242	2.242
.50	.114	.083	.141	40.3	4.257	2.257
1.00	.106	.077	.131	37.3	4.263	2.263
1.50	.117	.085	.144	41.4	4.269	2.269
2.00	.142	.103	.176	50.5	4.281	2.281
2.50	.166	.121	.205	59.4	4.301	2.301
3.00	.207	.150	.256	74.7	4.335	2.335
3.50	.279	.202	.344	102.1	4.391	2.391
4.00	.288	.209	.355	109.2	4.514	2.514
4.50	-.272	-.197	.336	-113.6	4.863	2.863
5.00	-.875	-.635	1.081	-412.4	5.344	3.344
5.50	-1.190	-.862	1.469	-621.2	5.782	3.782
6.00	-1.324	-.950	1.636	-740.5	6.063	4.063
6.50	-1.317	-.955	1.627	-755.7	6.209	4.209
7.00	-1.223	-.890	1.517	-673.0	6.165	4.165
7.50	-1.087	-.789	1.343	-597.9	6.012	4.012
8.00	-.870	-.631	1.075	-451.2	5.752	3.752
8.50	-.564	-.409	.697	-270.5	5.417	3.417
9.00	-.250	-.181	.309	-111.6	5.125	3.125
9.50	.071	.051	.087	27.9	4.922	2.922
10.00	.258	.187	.319	105.8	4.905	2.905

HYDROGRAPH FOR NODE 77

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.076	.050	.092	24.0	4.239	2.239
.50	.096	.064	.115	30.5	4.254	2.254
1.00	.099	.065	.119	31.4	4.261	2.261
1.50	.104	.069	.125	33.1	4.265	2.265
2.00	.124	.082	.148	39.4	4.276	2.276
2.50	.139	.091	.166	44.4	4.295	2.295
3.00	.166	.109	.198	53.4	4.325	2.325
3.50	.214	.141	.256	70.0	4.374	2.374
4.00	.145	.095	.173	49.3	4.510	2.510
4.50	-.647	-.426	.775	-248.9	4.955	2.955
5.00	-1.230	-.810	1.473	-549.6	5.551	3.551
5.50	-1.446	-.952	1.731	-728.6	6.074	4.074
6.00	-1.452	-.956	1.739	-783.6	6.388	4.388
6.50	-1.333	-.878	1.597	-733.4	6.478	4.478
7.00	-1.165	-.768	1.395	-628.8	6.388	4.388
7.50	-.973	-.641	1.165	-502.2	6.182	4.182
8.00	-.668	-.440	.800	-319.6	5.845	3.845
8.50	-.317	-.209	.380	-137.9	5.439	3.439
9.00	-.069	-.045	.083	-27.7	5.118	3.118
9.50	.190	.125	.227	72.0	4.901	2.901
10.00	.300	.198	.360	110.4	4.784	2.784

HYDROGRAPH FOR NODE 136

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.078	.176	.193	16.2	4.205	2.205
.50	.089	.201	.220	18.5	4.208	2.208
1.00	.105	.236	.258	21.7	4.210	2.210
1.50	.122	.275	.301	25.4	4.214	2.214
2.00	.154	.347	.380	32.1	4.222	2.222
2.50	.203	.456	.499	42.3	4.237	2.237
3.00	.267	.600	.657	56.0	4.261	2.261
3.50	.471	1.060	1.160	101.5	4.373	2.373
4.00	.842	1.894	2.073	194.0	4.680	2.680
4.50	1.257	2.829	3.096	321.7	5.196	3.196
5.00	1.567	3.526	3.858	443.6	5.749	3.749
5.50	1.723	3.876	4.242	522.0	6.153	4.153
6.00	1.764	3.969	4.343	552.1	6.356	4.356
6.50	1.719	3.869	4.234	539.6	6.373	4.373
7.00	1.557	3.503	3.834	473.7	6.178	4.178
7.50	1.287	2.895	3.168	365.7	5.771	3.771
8.00	1.015	2.284	2.500	264.3	5.286	3.286
8.50	.800	1.800	1.970	192.2	4.877	2.877
9.00	.632	1.422	1.556	143.0	4.597	2.597
9.50	.514	1.156	1.265	112.4	4.441	2.441
10.00	.446	1.004	1.099	96.0	4.371	2.371

Node	Channel Station
12	Oneawa Canal Station 93+00 (approximate)
67	Kaelepulu Stream Station 3+00
72	Kaelepulu Stream Station 24+00
77	Kaelepulu Stream Station 48+00
136	Kaelepulu Stream Station 68+32 (Hamakua Drive)

Table A-34

Kawainui Marsh, New Years 88 Flood, Kaelepulu Stream, Highest Tide 2.2 feet msl

HYDROGRAPH FOR NODE 12

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	-.396	.330	.515	-370.9	9.223	2.223
.50	-.439	.366	.572	-412.3	9.229	2.229
1.00	-.505	.421	.657	-474.1	9.239	2.239
1.50	-.609	.508	.793	-573.2	9.257	2.257
2.00	-.790	.658	1.028	-746.1	9.295	2.295
2.50	-1.074	.895	1.398	-1022.2	9.364	2.364
3.00	-1.447	1.206	1.884	-1373.5	9.470	2.470
3.50	-1.979	1.649	2.575	-1945.5	9.672	2.672
4.00	-2.676	2.230	3.484	-2724.4	10.013	3.013
4.50	-3.250	2.708	4.230	-3419.1	10.349	3.349
5.00	-3.658	3.048	4.761	-3952.7	10.630	3.630
5.50	-3.906	3.255	5.084	-4297.2	10.822	3.822
6.00	-3.993	3.328	5.198	-4424.1	10.878	3.878
6.50	-3.957	3.298	5.151	-4374.4	10.872	3.872
7.00	-3.726	3.105	4.851	-4051.6	10.695	3.695
7.50	-3.353	2.794	4.365	-3547.8	10.409	3.409
8.00	-3.010	2.508	3.918	-3107.5	10.162	3.162
8.50	-2.643	2.203	3.441	-2670.2	9.936	2.936
9.00	-2.316	1.930	3.015	-2297.4	9.756	2.756
9.50	-2.039	1.699	2.655	-1996.4	9.629	2.629
10.00	-1.849	1.540	2.406	-1795.7	9.556	2.556

HYDROGRAPH FOR NODE 67

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.101	.010	.102	26.0	4.228	2.228
.50	.115	.012	.116	29.7	4.236	2.236
1.00	.141	.014	.141	36.4	4.247	2.247
1.50	.197	.020	.198	51.3	4.269	2.269
2.00	.303	.030	.304	79.8	4.312	2.312
2.50	.465	.047	.467	125.2	4.392	2.392
3.00	.660	.066	.663	183.8	4.519	2.519
3.50	.323	.032	.325	97.2	4.826	2.826
4.00	-.779	-.078	.783	-265.7	5.351	3.351
4.50	-1.648	-.165	1.656	-632.3	5.896	3.896
5.00	-2.237	-.224	2.248	-913.4	6.367	4.367
5.50	-2.605	-.261	2.613	-1168.0	6.687	4.687
6.00	-2.767	-.277	2.781	-1270.8	6.816	4.816
6.50	-2.772	-.277	2.786	-1264.4	6.780	4.780
7.00	-2.634	-.263	2.647	-1142.7	6.512	4.512
7.50	-2.240	-.224	2.251	-888.0	6.056	4.056
8.00	-1.574	-.157	1.582	-570.2	5.627	3.627
8.50	-.994	-.099	.998	-331.8	5.261	3.261
9.00	-.440	-.044	.442	-137.5	4.979	2.979
9.50	.036	.004	.036	10.6	4.789	2.789
10.00	.215	.022	.216	62.5	4.685	2.685

HYDROGRAPH FOR NODE 72

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.067	.048	.082	23.3	4.226	2.226
.50	.079	.057	.098	27.7	4.234	2.234
1.00	.093	.068	.115	32.8	4.244	2.244
1.50	.125	.091	.154	44.1	4.263	2.263
2.00	.184	.133	.227	65.6	4.300	2.300
2.50	.276	.200	.340	100.3	4.367	2.367
3.00	.392	.284	.484	147.1	4.473	2.473
3.50	-.109	-.079	.135	-45.5	4.851	2.851
4.00	-.958	-.694	1.183	-466.4	5.482	3.482
4.50	-1.492	-1.082	1.843	-852.8	6.190	4.190
5.00	-1.775	-1.287	2.192	-1151.5	6.803	4.803
5.50	-1.888	-1.369	2.332	-1321.8	7.175	5.175
6.00	-1.894	-1.373	2.339	-1366.3	7.354	5.354
6.50	-1.823	-1.321	2.251	-1303.2	7.307	5.307
7.00	-1.607	-1.165	1.985	-1081.4	6.959	4.959
7.50	-1.253	-.909	1.548	-750.6	6.411	4.411
8.00	-.848	-.615	1.047	-445.4	5.807	3.807
8.50	-.476	-.345	.587	-223.1	5.327	3.327
9.00	-.128	-.093	.157	-55.2	4.976	2.976
9.50	.135	.098	.167	55.2	4.776	2.776
10.00	.215	.156	.265	85.2	4.678	2.678

HYDROGRAPH FOR NODE 77

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.057	.038	.068	17.9	4.225	2.225
.50	.068	.045	.082	21.5	4.232	2.232
1.00	.080	.053	.096	25.3	4.242	2.242
1.50	.100	.066	.120	31.7	4.258	2.258
2.00	.140	.092	.168	44.7	4.291	2.291
2.50	.200	.132	.240	65.1	4.350	2.350
3.00	.281	.185	.337	93.9	4.443	2.443
3.50	-.547	-.360	.655	-209.0	4.928	2.928
4.00	-1.452	-.956	1.739	-680.4	5.753	3.753
4.50	-1.889	-1.244	2.262	-1071.2	6.624	4.624
5.00	-2.002	-1.319	2.378	-1296.3	7.290	5.290
5.50	-1.990	-1.304	2.371	-1379.1	7.680	5.680
6.00	-1.884	-1.241	2.256	-1343.3	7.810	5.810
6.50	-1.733	-1.141	2.075	-1214.8	7.717	5.717
7.00	-1.363	-.898	1.632	-882.0	7.288	5.288
7.50	-.876	-.577	1.049	-492.0	6.578	4.578
8.00	-.487	-.321	.583	-234.5	5.875	3.875
8.50	-.179	-.118	.214	-75.8	5.334	3.334
9.00	.089	.059	.107	34.4	4.961	2.961
9.50	.223	.147	.267	81.5	4.761	2.761
10.00	.257	.169	.308	91.5	4.664	2.664

HYDROGRAPH FOR NODE 136

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.098	.220	.241	20.3	4.209	2.209
.50	.116	.261	.285	24.0	4.213	2.213
1.00	.132	.296	.324	27.3	4.215	2.215
1.50	.138	.310	.340	28.6	4.216	2.216
2.00	.146	.329	.360	30.4	4.218	2.218
2.50	.164	.369	.403	34.1	4.224	2.224
3.00	.190	.427	.468	39.6	4.232	2.232
3.50	.227	.510	.558	47.4	4.245	2.245
4.00	.303	.682	.746	63.9	4.278	2.278
4.50	.500	1.125	1.231	108.2	4.393	2.393
5.00	.785	1.766	1.933	179.2	4.635	2.635
5.50	1.048	2.359	2.581	255.9	4.958	2.958
6.00	1.208	2.717	2.974	311.6	5.239	3.239
6.50	1.252	2.818	3.084	332.3	5.388	3.388
7.00	1.218	2.740	2.998	323.6	5.397	3.397
7.50	1.136	2.556	2.797	296.5	5.300	3.300
8.00	1.009	2.269	2.483	254.4	5.122	3.122
8.50	.845	1.901	2.080	203.3	4.886	2.886
9.00	.696	1.567	1.714	160.0	4.667	2.667
9.50	.586	1.317	1.442	130.2	4.514	2.514
10.00	.511	1.151	1.259	111.5	4.429	2.429

Table A-35

Kawainui Swamp, COE Standard Project Flood, Back Side of Levee, Highest Tide 2.2

HYDROGRAPH FOR NODE 12

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	-.213	.178	.278	-199.6	9.205	2.205
.50	-.203	.169	.265	-190.3	9.203	2.203
1.00	-.190	.158	.247	-177.8	9.203	2.203
1.50	-.179	.149	.233	-167.6	9.203	2.203
2.00	-.179	.149	.233	-167.2	9.204	2.204
2.50	-.173	.144	.225	-161.4	9.202	2.202
3.00	-.169	.141	.220	-158.5	9.203	2.203
3.50	-.171	.143	.223	-160.2	9.204	2.204
4.00	-.172	.143	.224	-160.9	9.203	2.203
4.50	-.178	.148	.232	-166.6	9.205	2.205
5.00	-.210	.175	.273	-196.3	9.211	2.211
5.50	-.304	.254	.396	-285.4	9.226	2.226
6.00	-.522	.435	.679	-491.4	9.264	2.264
6.50	-1.388	1.157	1.807	-1344.7	9.528	2.529
7.00	-2.768	2.307	3.604	-2848.6	10.121	3.121
7.50	-3.926	3.272	5.111	-4325.7	10.337	3.837
8.00	-4.484	3.738	5.837	-5154.3	11.301	4.301
8.50	-4.592	3.826	5.977	$\boxed{-5332.5}$	11.423	$\boxed{4.423}$
9.00	-4.449	3.708	5.792	-5115.5	11.309	4.309
9.50	-4.061	3.384	5.286	-4534.2	10.983	3.983
10.00	-3.555	2.963	4.628	-3818.6	10.564	3.564
10.50	-3.058	2.548	3.981	-3169.4	10.194	3.194
11.00	-2.626	2.188	3.418	-2649.4	9.921	2.921
11.50	-2.267	1.889	2.951	-2242.9	9.731	2.731
12.00	-1.983	1.652	2.581	-1935.7	9.604	2.604
12.50	-1.785	1.488	2.324	-1730.1	9.531	2.531
13.00	-1.646	1.372	2.143	-1587.7	9.485	2.485
13.50	-1.530	1.275	1.992	-1469.9	9.447	2.447
14.00	-1.430	1.192	1.861	-1369.0	9.416	2.416
14.50	-1.340	1.117	1.745	-1279.7	9.391	2.391
15.00	-1.260	1.050	1.640	-1200.1	9.369	2.369
15.50	-1.187	.989	1.545	-1128.0	9.350	2.350
16.00	-1.119	.933	1.457	-1062.0	9.334	2.334
16.50	-1.061	.884	1.381	-1005.5	9.321	2.321
17.00	-1.011	.843	1.316	-957.1	9.311	2.311
17.50	-.965	.804	1.256	-912.4	9.301	2.301
18.00	-.921	.767	1.198	-869.6	9.292	2.292
18.50	-.878	.732	1.143	-828.7	9.283	2.283

HYDROGRAPH FOR NODE 67

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.037	.004	.037	9.5	4.207	2.207
.50	.022	.002	.022	5.6	4.205	2.205
1.00	.019	.002	.019	4.9	4.204	2.204
1.50	.020	.002	.020	5.1	4.204	2.204
2.00	.024	.002	.024	6.2	4.206	2.206
2.50	.011	.001	.011	2.9	4.204	2.204
3.00	.018	.002	.018	4.6	4.204	2.204
3.50	.024	.002	.024	6.1	4.205	2.205
4.00	.016	.002	.017	4.2	4.205	2.205
4.50	.023	.002	.023	5.9	4.206	2.206
5.00	.044	.004	.044	11.3	4.212	2.212
5.50	.092	.009	.092	23.6	4.229	2.229
6.00	.215	.022	.216	56.0	4.271	2.271
6.50	-1.291	-.129	1.298	-379.1	4.726	2.726
7.00	-2.976	-.298	2.991	-1131.9	5.855	3.855
7.50	-3.717	-.372	3.735	-1775.2	7.033	5.033
8.00	-3.844	-.384	3.863	$\boxed{-2044.2}$	7.654	5.654
8.50	-3.733	-.373	3.752	-2018.2	7.753	$\boxed{5.753}$
9.00	-3.497	-.350	3.514	-1819.1	7.523	5.523
9.50	-3.148	-.315	3.164	-1491.8	6.999	4.999
10.00	-2.574	-.257	2.586	-1075.9	6.321	4.321
10.50	-1.857	-.186	1.866	-684.7	5.709	3.709
11.00	-1.138	-.114	1.143	-379.4	5.255	3.255
11.50	-.492	-.049	.494	-152.5	4.948	2.948
12.00	.001	.000	.001	.3	4.756	2.756
12.50	.199	.020	.199	57.2	4.652	2.652
13.00	.224	.022	.225	63.5	4.587	2.587
13.50	.226	.023	.227	63.2	4.535	2.535
14.00	.228	.023	.229	63.0	4.492	2.492
14.50	.225	.023	.226	61.7	4.457	2.457
15.00	.219	.022	.220	59.5	4.427	2.427
15.50	.211	.021	.212	57.0	4.402	2.402
16.00	.203	.020	.204	54.4	4.380	2.380
16.50	.200	.020	.201	53.5	4.362	2.362
17.00	.197	.020	.198	52.4	4.348	2.343
17.50	.188	.019	.189	49.7	4.334	2.334
18.00	.178	.018	.179	47.0	4.322	2.322
18.50	.170	.017	.171	44.7	4.311	2.311

HYDROGRAPH FOR NODE 72

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.028	.020	.034	9.6	4.207	2.207
.50	.019	.014	.023	6.5	4.205	2.206
1.00	.014	.010	.018	5.0	4.204	2.204
1.50	.014	.010	.018	5.0	4.204	2.204
2.00	.016	.012	.020	5.7	4.205	2.205
2.50	.011	.008	.014	3.9	4.204	2.204
3.00	.012	.008	.014	4.1	4.204	2.204
3.50	.017	.012	.021	5.8	4.205	2.205
4.00	.013	.010	.017	4.6	4.205	2.205
4.50	.015	.011	.018	5.2	4.206	2.206
5.00	.026	.019	.032	9.0	4.212	2.212
5.50	.050	.037	.062	17.6	4.227	2.227
6.00	.118	.085	.145	41.5	4.262	2.262
6.50	-1.549	-1.123	1.914	-687.3	5.102	3.102
7.00	-2.661	-1.929	3.286	-1708.9	6.752	4.752
7.50	-2.711	-1.965	3.348	-2155.1	7.973	5.973
8.00	-2.584	-1.873	3.191	-2231.7	8.513	6.513
8.50	-2.372	-1.720	2.930	-2103.2	8.533	6.533
9.00	-2.152	-1.560	2.658	-1810.9	8.221	6.221
9.50	-1.804	-1.308	2.229	-1340.4	7.594	5.594
10.00	-1.375	-.997	1.698	-883.0	6.753	4.753
10.50	-.945	-.685	1.167	-513.1	5.954	3.954
11.00	-.531	-.385	.656	-250.0	5.342	3.342
11.50	-.159	-.115	.197	-67.9	4.949	2.949
12.00	.111	.080	.137	44.9	4.744	2.744
12.50	.203	.147	.251	80.0	4.645	2.645
13.00	.212	.154	.262	81.9	4.579	2.579
13.50	.206	.149	.254	78.3	4.527	2.527
14.00	.199	.145	.246	75.1	4.465	2.485
14.50	.193	.140	.239	72.0	4.450	2.450
15.00	.184	.134	.228	68.1	4.421	2.421
15.50	.176	.127	.217	64.5	4.396	2.396
16.00	.167	.121	.206	61.0	4.374	2.374
16.50	.161	.117	.199	58.5	4.357	2.357
17.00	.157	.114	.194	56.6	4.343	2.343
17.50	.149	.108	.184	53.8	4.330	2.330
18.00	.141	.102	.175	50.7	4.319	2.319
18.50	.134	.097	.166	48.1	4.308	2.308

Table A-35 (Continued)

Kawainui Swamp, COE Standard Project Flood, Back Side of Levee, Highest Tide 2.2

HYDROGRAPH FOR NODE 77

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.026	.017	.031	8.1	4.207	2.207
.50	.020	.013	.024	6.2	4.206	2.206
1.00	.015	.010	.018	4.6	4.204	2.204
1.50	.013	.009	.016	4.1	4.204	2.204
2.00	.014	.009	.017	4.4	4.205	2.205
2.50	.013	.008	.015	3.9	4.205	2.205
3.00	.011	.007	.013	3.5	4.204	2.204
3.50	.014	.009	.017	4.4	4.205	2.205
4.00	.014	.009	.017	4.3	4.205	2.205
4.50	.013	.009	.016	4.0	4.206	2.206
5.00	.018	.012	.022	5.6	4.211	2.211
5.50	.033	.022	.039	10.3	4.225	2.225
6.00	.077	.051	.092	24.4	4.257	2.257
6.50	-2.542	-1.688	3.048	-1251.6	5.935	3.935
7.00	-3.114	-2.051	3.729	-2226.2	7.825	5.825
7.50	-2.780	-1.831	3.329	-2371.0	8.857	6.857
8.00	-2.534	-1.669	3.035	-2271.2	9.221	7.221
8.50	-2.195	-1.446	2.629	-1950.3	9.110	7.110
9.00	-1.930	-1.271	2.311	-1605.5	8.703	6.703
9.50	-1.422	-.937	1.703	-1033.9	7.920	5.920
10.00	-.911	-.600	1.091	-551.2	6.941	4.941
10.50	-.484	-.319	.580	-241.7	6.032	4.032
11.00	-.168	-.111	.201	-71.4	5.352	3.352
11.50	.066	.044	.079	25.4	4.935	2.935
12.00	.203	.134	.243	73.5	4.729	2.729
12.50	.247	.163	.296	87.0	4.631	2.631
13.00	.243	.160	.291	84.0	4.567	2.567
13.50	.229	.151	.274	78.2	4.516	2.516
14.00	.217	.143	.260	73.2	4.475	2.475
14.50	.206	.136	.247	68.7	4.441	2.441
15.00	.194	.128	.233	64.4	4.413	2.413
15.50	.183	.121	.220	60.3	4.389	2.389
16.00	.173	.114	.207	56.6	4.368	2.368
16.50	.165	.108	.197	53.5	4.351	2.351
17.00	.158	.104	.189	51.0	4.337	2.337
17.50	.150	.099	.180	48.4	4.325	2.325
18.00	.142	.094	.170	45.7	4.314	2.314
18.50	.135	.089	.161	43.2	4.304	2.304

HYDROGRAPH FOR NODE 134

TIME (HR)	X-VEL (FPS)	Y-VEL (FPS)	TOT-VEL (FPS)	FLOW (CFS)	DEPTH (FT)	ELEV (FT)
.00	.044	.099	.108	9.1	4.201	2.201
.50	.038	.086	.094	7.9	4.201	2.201
1.00	.032	.072	.079	6.6	4.200	2.200
1.50	.028	.063	.068	5.8	4.200	2.200
2.00	.028	.064	.070	5.9	4.201	2.201
2.50	.030	.067	.073	6.1	4.201	2.201
3.00	.027	.061	.067	5.6	4.200	2.200
3.50	.027	.062	.067	5.7	4.201	2.201
4.00	.030	.067	.074	6.2	4.201	2.201
4.50	.031	.071	.077	6.5	4.201	2.201
5.00	.040	.090	.098	8.3	4.202	2.202
5.50	.065	.147	.161	13.5	4.206	2.206
6.00	.109	.244	.268	22.5	4.213	2.213
6.50	.838	1.885	2.062	191.6	4.645	2.645
7.00	1.773	3.990	4.367	505.6	5.789	3.789
7.50	2.255	5.074	5.553	762.5	6.866	4.866
8.00	2.323	5.227	5.720	844.3	7.380	5.380
8.50	2.239	5.037	5.512	820.4	7.442	5.442
9.00	2.063	4.641	5.079	734.0	7.226	5.226
9.50	1.766	3.973	4.348	588.6	6.769	4.769
10.00	1.398	3.145	3.441	421.7	6.128	4.128
10.50	1.067	2.402	2.628	297.5	5.469	3.469
11.00	.809	1.821	1.993	196.9	4.940	2.940
11.50	.622	1.399	1.531	140.8	4.599	2.599
12.00	.499	1.123	1.229	108.8	4.428	2.428
12.50	.429	.964	1.055	92.0	4.357	2.357
13.00	.386	.869	.951	82.3	4.326	2.326
13.50	.353	.794	.869	74.8	4.305	2.305
14.00	.325	.730	.799	68.6	4.288	2.288
14.50	.300	.676	.739	63.2	4.275	2.275
15.00	.279	.628	.688	58.7	4.265	2.265
15.50	.261	.586	.641	54.6	4.256	2.256
16.00	.244	.548	.600	51.0	4.249	2.249
16.50	.229	.514	.563	47.8	4.243	2.243
17.00	.216	.486	.532	45.1	4.238	2.238
17.50	.205	.462	.505	42.8	4.235	2.235
18.00	.195	.439	.480	40.6	4.231	2.231
18.50	.185	.416	.455	38.5	4.228	2.228

Widening of Kaelepulu Stream was not considered in the formulation of this alternative because this action requires additional costs for dredging a wider channel. The probability of the Standard Project Flood is relatively small in comparison to flooding due to rainfall direction Coconut Grove, which will severely tax the local drainage system, and the probability of having the highest astronomical tide coincidental to the peak of the SPF is remote. To determine the sensitivity of the results to the tide level, a simulation of the Kaelepulu Stream model was made assuming a high tide coincident with the SPF peak equal to the mean higher high water of 1.2 feet, msl. The results of the simulation are shown below for Kaelepulu Stream.

	Node			
SPF Peak	67	72	77	136
Water Surface	5.5	6.4	7.1	5.3

Thus the water surface would be 0.4, 0.1, and 0.3 feet above the point assumed for structure and content damage at nodes 72, 77, and 136 respectively.

Before the construction of the outlet is completed, the fine grained sediment in the northern end (less than 500-feet distance from levee) will be excavated to prevent its resuspension and deposition in Oneawa canal. The sediment will be placed on an area of fast land on the marsh side of the levee within temporary confinement dikes. The runoff will be allowed back into Oneawa canal after the fine materials have had time to settle. The entire area will be graded after consolidation has taken place and grassed for use as an area for observing the marsh. Silt curtains will be used to reduce the migration of suspended sediments within Kaelepulu Stream during construction.

Kawainui Marsh Low Flow Weir

Figure A-103 shows a cross section of the proposed low flow weir in the emergency ditch superimposed upon cross section "B" which is located as shown on Figure A-80 near the ditch outlet at the head of Oneawa canal. Note that the lowest point for the top of the mat as it extends across the outlet area of the marsh is approximately 3.5 feet, msl. The lowest elevation along the cross section for the firm bottom measured -1.6 feet, msl. Spot elevations of points between cross section "B" and "A" indicate the middle of the throat area is higher in elevation but, due to access problems, a complete ground survey was difficult. These surveys do indicate that the throat area of the outlet is relatively higher and consists of sediment and vegetation which have built the elevations to above sea level. Aerial photographs of this area before construction of the Oneawa outlet canal indicate differences in vegetation and soil type suggesting the area was already higher than the adjoining marsh and thus would act as a major factor in the outflow from the marsh. This provides additional insight as to why the water level measurements taken upstream of this outlet area do not reflect strong diurnal fluctuations in response to the tides. Water flowing through this area has been observed to drop suddenly through the vegetation and soil substrate to a lower (tidal influenced) level. This drop is marked and pronounced where head cutting has eroded chutes and drop offs in the soil sediments. Tidal fluctuations are generally below the crest of these drops which explains why the flow which passes through critical depth at these points cannot be influenced by normal tide patterns. The exception to this is the emergency ditch which has a slightly lower elevation along the invert and thus at very low flows shows water surface fluctuations due to tidal harmonics.

The basis for setting the crest of the low flow weir was the maximum mat elevations observed at this cross section. Crest elevations higher than this will not accomplish the objective of the weir which is to maintain minimum water levels in the marsh. Flow will seep through the unobstructed marsh vegetation to Oneawa canal. Furthermore, raising the overall level of the marsh by constructing a weir across the throat to the quarry road would cause higher elevations to occur during floods than would otherwise be observed. Sediment and vegetation would likely build up on the upstream side of such a weir requiring constant maintenance during flood season. Gated structures have a high risk of snagging floating vegetation. Higher initial water surface elevations require the upstream measures to be more efficient in terms of managing flood water and thus from a flood control standpoint this is self-defeating. For example, as was shown in the sensitivity analysis of the assumed antecedent water levels, higher initial levels cause greater amounts of overflow over the levee during the large floods (100-year return period) and thus place greater flow in the Kaelepulu Stream system. In the case of the levee raise alternative, they will result in greater heights for levee construction.

Geotechnical Analysis

In addition to hydraulic engineering investigations of the emergency overflow, geotechnical investigations were made of the levee. The purpose of this geotechnical study was to evaluate general soil conditions and the stability of the existing Kawainui Marsh levee, particularly under the overflow conditions. This study includes field explorations, laboratory tests, slope stability analysis, and analysis of general guidelines for levee improvements and limitations. The stability analysis for the emergency overflow show the levee to be stable under the design head.

The levee is about 6,400 feet long from the southerly end near Kailua Road to the northerly end near the bank of Kawainui canal (Oneawa stream outlet). The existing levee may be described as follows:

> The levee is about 10 to 12 feet high with a crest width of about 12 feet and side slopes of about 3 horizontal (H):1 vertical (V), both upstream and downstream.
>
> The levee crest was recently widened to about 12 feet by topping with crushed gravel and was generally clear at the time of the explorations.
>
> The marsh-side slope for the southerly third appeared to be surficially eroded and irregular in shape and the northerly two-thirds appeared to be covered with vegetation with fewer signs of erosion.
>
> The Coconut Grove side slope was generally covered with grass. Water was not visible on the surface of this side slope.

From the field observations and laboratory tests results, the soils encountered in the borings drilled from the levee crest may be approximated as follows:

> Surface layers of about 1 to 6 feet of gravel (base course rock) and or stiff, gray and brown, silty clay (MH-CH, CH soils) underlain by dense to medium density, brown or gray, clayey or silty gravel or sand (GC, GM, SC, SM soils) to about 16 to 30 feet depths, followed by loose gray, clayey and silty coral (GC, GM soils) with sand to about 30 to 40 feet, the depths drilled.

Continuous penetration below the bottoms of borings indicated that the loose to medium density materials may extend down to about 40 feet in boring Nos. 2 and 4 and to about 90 feet in boring No. 3.

Water was noted in the drill holes at about 6 to 11 feet depths or at about elevation of 4 feet to -1 feet. A more detailed description of soils encountered in the borings is contained in the boring logs on file. Variation for the soil and groundwater conditions should be expected between borings and in localized areas.

According to the report, "Design Memorandum, Kawainui Swamp, Oahu, Territory of Hawaii," by U.S. Army, Corps of Engineers, 1957, the dimensions and design parameters for the levee were as follows:

1. Levee Dimensions

   Height = 15 ft.
   Crest elevation = 10.5 ft.
   Crest width = 10 ft.
   Side slopes = 3H:1V

2. Maximum water level = Elev. 7.35 ft.

3. Embankment soil parameters

   γ wet = 117 p.c.f.
   Ø = 30°
   c = 0

4. Foundation soil parameters

   γ wet = 111 p.c.f.
   Ø = 30°
   c = 0

5. Seismic coefficient of 0.1 g. for pseudostatic analysis.

Based on these parameters, the stability analysis generally indicated that the factors of safety satisfied the U.S. Army Corps of Engineers recommended values of 1.5 for gravity with seepage and 1.0 for gravity/seepage plus 0.1 g. seismic load.

A slope stability analysis was performed at four selected locations where the subsurface soil parameters and the topographic sections were available. The topographic sections were surveyed in March, 1989.

The method of analysis, loading conditions, shear strength parameters and other assumptions used for the analysis are discussed in the following sections.

Method of Slope Stability Analysis

The computer program used for the slope stability analysis was the "STABL" IBM PC Version 1.2 developed by Design Professionals Management Systems (DPMS). The program generally uses the Modified Bishop Method to obtain the factors of safety for the trial circular failure surfaces.

For each given input data of soil strength and levee geometry, 225 trial circles were analyzed and the coordinates and the factors of safety of the 10 most critical trial circles were printed out.

The most critical trial circles from the analysis are reported in the sections to follow.

Loading Conditions

The following loading conditions were used for the slope stability analysis:

1. Steady seepage without seismic loads.
2. Steady seepage with seismic loads.

The design flood water was assumed to be at elevation 9 feet. The piezometric level through the embankment was assumed to follow a straight line and to exit near the ground surface at the downstream toe.

Because the water level in the marsh cannot be lowered rapidly, the rapid drawdown loading condition is not applicable to this study, and was not considered.

Shear Strength

The laboratory undrained triaxial compression test results for four specimens are summarized as follows:

Sample No.	γWet	c (p.s.f.)	Ø (degree)
2-C	128	100	31
3-D	111	200	43
4-B	117	400	35
4-F	117	700	37

The test results indicated that the shear strength consists of both cohesion and friction. The cohesion ranged from about 100 to 700 p.s.f. and the friction angles from about 31 to 43 degrees. For the stability analysis, two sets of shear strength parameters were used:

Case I: The lowest shear strength value

γ wet = 110 p.c.f., c = 100 p.s.f., Ø = 31°

Case II: The average frictional strength neglecting the cohesion

γ wet = 110 p.c.f., c = 0, Ø = 36°

Seismic Coefficient

The slope stability analysis for seismic loads was performed using a pseudostatic method. This method computes the horizontal and vertical forces in terms of a seismic coefficient times the gravity loads. The U.S. Department of Army Engineering Regulation No. 1110-2-106 was the basis for the seismic coefficient. According to this regulation, the island of Oahu is located in a seismic Zone I with a recommended seismic coefficient of 0.025g. Since the original design document (1957) applied a seismic coefficient of 0.1g for the project, a seismic coefficient of 0.1g was used for this study.

Factors of Safety

The factors of safety for the slope stability analysis of the existing levee are summarized as follows:

Case I: γ wet = 110 p.c.f., c = 100 p.s.f., Ø = 31°

	Factors of Safety			
	Upstream Slope		Downstream Slope	
Section	Gravity/ Seepage	Gravity/ Seepage +EQ (o.1g)	Gravity/ Seepage	Gravity Seepage +EQ (o.1g)
7+00	1.80	1.33	1.22	1.06
18+50	2.08	1.39	1.58	1.18
34+50	2.10	1.45	1.35	1.04
50+00	2.35	1.47	1.38	1.02
F.S. Recommended by U.S. Army Corps of Engineers	1.50	1.00	1.50	1.00

From the above analysis, the factors of safety generally satisfy the recommended values except the downstream slope with the Case II shear strength values. Under this condition, the downstream slopes (Coconut Grove side) at station 7+00, station 34+50 and station 50+00 have factors of safety less than 1.50.

Based on these assumptions, improvements would be needed for the downstream slope to increase the factor of safety to 1.50.

Levee Stability Under Alternative C

The stability of the embankment depends on the slope angle, slope height, water level and shear strength of the embankment and foundation materials. Changes of any of these factors will affect the stability of the slope.

APPENDIX A, SECTION 9

Some methods to increase the slope stability of an existing embankment may be as follows:

1. Lower slope height
2. Lower water level
3. Flatten slope angle
4. Construct buttress fill
5. Construct weighted toe barn

For this project, lowering of the levee height or water level is not desirable for flood control purposes. Therefore the alternatives (3), (4) and (5) were considered, with (3) being selected.

The proposed improvements of the levee generally consist of the following:

1. Sta 0+50 to 14+50

   Lower levee crest of southern portion to elevation 9 feet to allow overflow:

   a. Design flood water: Elevation 10 feet.
   b. Lower crest to elevation 9 feet.
   c. Line crest with 6 inches of concrete.
   d. Construct downstream revetment with gabion or grouted rubble paving.
   e. Flatten downstream slope.
   f. Other assumptions for the stability analyses include:

      (1) Revetment gabion rock: unit weight 140 p.c.f. and Ø = 45°.
      (2) Downstream slope: 4H:1V. An initial trial slope of 3H:1V was analyzed but did not satisfy the recommended factors of safety.

2. Sta 14+50 to 40+00

   Raise levee crest to allow a freeboard of about 2 feet.

   a. Design flood water: Elevation 10 feet at the overflow and gradually lowers to about elevation 7.5 feet near the Kawainui Canal (Oneawa Stream).

   b. Raise the levee as follows:

Station	Raised Crest Elevation
15+00 to 25+00	12.4 ft.
25+00 to 30+00	12.3 ft.
30+00 to 35+00	12.2 ft.
35+00 to 40+00	12.0 ft.

   c. The crest width will remain at 12 feet.

   d. Other assumptions for the stability analyses include:

      (1) Fill materials: unit weight = 125 p.c.f. and Ø = 40°.
      (2) Freeboard: 2 feet.
      (3) Side slopes: 3H:1V.

3. Sta 40+00 to 45+00

   Slope levee crest to existing 10.0 feet grade.

4. Sta 40+00 to 64+00

   Existing levee will remain as existing.

Stability Analysis of the Improved Levee

Based on the proposed improvements, a slope stability analysis was performed. A summary of the factors of safety at selected sections are as follows:

Case II: γwet = 110 p.c.f., c = 0, Ø = 36°

	Factors of Safety			
	Upstream Slope		Downstream Slope	
Section	Gravity/ Seepage	Gravity/ Seepage +EQ (o.1g)	Gravity/ Seepage	Gravity Seepage +EQ (o.1g)
7+00	1.93	1.40	1.53	1.20
18+50	2.17	1.56	1.87	1.47
34+50	2.17	1.57	1.50	1.20
50+00	2.29	1.58	2.17 *	1.61 *
Recommended F.S. U.S. Army Corps of Engineers	1.50	1.00	1.50	1.00

* These values are different from those shown on Page 8, mainly due to the lowered design flood water level. A freeboard of 2 feet was allowed here.

Additional Explorations

The above analyses were based on a preliminary study of four selected locations and soil reconnaissance data. For the actual design of the levee improvements, additional explorations and laboratory testing are recommended to provide more information for additional stability analysis and evaluation. Cost estimates for Alternative C are shown in the last section of Appendix A.

SECTION 10. Alternative D - Levee Raise and Channelization Evaluation

As another way of creating storage, the levee could be raised to reduce the probability of overflow. To examine this alternative further, the marsh model was used to simulate the height that water would rise to in the marsh if no overflow were permitted. Again for this alternative (as for Alternative C) the basis for the preliminary hydraulic design is the RMA-2 model. The Corps of Engineers design storm (SPF) was also used to estimate the height requirements.

Figures A-104 and 105 show the peak flow and water surface calculated by the model for this condition were 2588 cfs and 13.5 feet, msl, respectively. Based on the assumption that the minimum freeboard requirement would be three feet, the levee crest would have to be raised to 16.5 feet, msl, at the upstream end. It would remain essentially level for approximately four thousand feet of length after which it could be gradually lowered to the existing grade at Oneawa canal. The model results also indicate that the peak rate of outflow from the marsh is not expected to reach the magnitude of the original design for Oneawa canal. However, velocities in the "throat area" between the levee and the quarry road at the head of Oneawa canal would exceed velocities recommended by drainage standards for grassed embankments and channels indicating the need to consider additional bank protection from scour.

An alternative based strictly upon raising the levee would have significant negative effects upon the existing wetland on the Coconut Grove side of the levee. Assuming the toe of the existing levee on the marsh side was maintained, the levee raise would extend the Coconut Grove side to the existing bank of Kaelepulu Stream. A portion of the stream would need realignment closer to the residential area or additional foundation protection for the levee would be needed beyond that evaluated herein.

The revised levee improvement includes raising the crest of the existing levee from elevation 10 feet to 17.0 feet, a design water level at 13.5 feet and the embankment widening to be on the downstream (Coconut Grove) side.

A preliminary slope stability analysis was based on the levee section at Station 7+00 and two types of embankment materials with shear strength parameters assumed as follows:

Embankment Type	Embankment Materials	Assumed Shear Strength C (p.s.f.)	Ø
I	Silty sand or gravel (similar to existing embankment) SM or GM soils.	0	31°
II	Clayey silt (MH soils) w/sand and and gravel or SM soil w/>35% fines passing No. 200 sieve.	200	17°

A toe drain should be considered for the improved embankment. The toe drain should be constructed with fairly well-graded gravel or crushed rock with less than about 5% fines passing the No. 200 sieve. Filter materials or filter fabric should be used to separate the embankment fill with the drainage material. This design should be based on the type of fill material to be used in the embankment.

Estimated factors of safety for the two types of embankment materials are summarized as follows:

Embankment Type	Embankment Slope	Factor of Safety: Up Stream Steady Seepage	Factor of Safety: Up Stream Seepage + E.Q.	Factor of Safety: Down Stream S.S.	Factor of Safety: Down Stream S + E.Q.
I	3H:1V	1.7	1.4	1.6	1.2
II	3H:1V	1.8	1.4	1.6	1.2

The embankment section at the existing station 7+00 is shown on Figure A-106.

The preliminary sections are intended for material quantity estimates only. Additional soil explorations of the foundation soils should be made to evaluate the soil conditions for the final design considerations.

Given the finding that the outlet capacity of Oneawa canal would not be exceeded by the outflow if the levee was raised to store the maximum amount of the SPF, a variation of this plan was considered which would raise the levee enough to pass the limiting flow through an enlarged ditch next to the levee. The limiting flow is defined as approximately 8000 cfs or slightly in excess of the Corps of Engineers design flow for Oneawa canal (Figure A-107). This flow was assumed in investigations of Alternative A and therefore it is instructive to adopt the same magnitude for this comparison.

An option studied as part of this alternative is to enlarge the existing emergency ditch to increase flood conveyance which would reduce the storage of floodwater and ultimately require a lower levee. As previously noted, it is not recommended creating a channel large enough to contain the peak discharge of the SPF because this size channel would exceed the design capacity of Oneawa canal. The amount that storage would be reduced by a channel designed to convey only 8000 cfs at the time of maximum discharge was estimated to be 1850 acre-feet (Figure A-108/1). This amount of storage was subtracted from the storage elevation relationship developed for the marsh using the output of the RMA-2 model (Figure A-107/1) to estimate the peak storage of 5450 acre-feet that would result with a channel sized to convey 8000 cfs during the SPF. The corresponding elevation for this storage at station 7+00 is 11.6 feet. Adding three feet freeboard to this elevation resulted in the estimated levee height of 14.6 feet for the levee embankment plus another 0.5 feet of roadway surface material requires a levee crest of 15.1 feet. A levee section at station 7+00 is shown in Figure A-106.

The width of the channel required for this alternative was determined using numerous sets of water surface profile computations with the water surface profile computer program HEC-2. These are based on adjusting the typical 10 horizontal to 1 vertical trapezoidal section until the water surface elevation at the upstream end of the levee (the south end near Kailua Road) reached 11.6 feet msl. This procedure does not reflect the amount of freeboard that would be required and thus an integral part of this alternative would be raising the levee. Based on an invert elevation of 0.0 msl, and assuming that the height of the weir is 3.5 feet in the new ditch, the required bottom width for the channel to convey 8,000 cfs is estimated to be 140 feet. The basis for the weir overflow was calculated as shown in Table A–36. Water surface profiles for this channel/levee raise plan were started at Channel Station 93+00, the rating curve for which is shown in Figure A-107. Figure A-108 shows the resulting water surface profile along the levee.

The plan view of Alternative D is shown in Figure A-109. Cost estimates are contained in the following section.

Table A-36
Rating Curve for Profile of Large Channel

Case	Water Surface Elevation U/S of Crest (feet)	Head on Weir (feet)	Free Discharge (Q [=] cfs)	Estimated Tailwater 93+00 Elev. (feet)
1	4.0	0.5	95.5	2.20
2	4.5	1.0	270	2.30
3	5.0	1.5	496	2.35
4	5.5	2.0	764	2.40
5	6.0	2.5	1,070	2.45
6	6.5	3.0	1,400	2.50
7	7.0	3.5	1,770	2.55
8	7.5	4.0	2,160	2.70
9	8.0	4.5	2,580	3.00

Notes:

1. Basis of Design:
   Q = CLH^(3/2): with C=3.0
   Assume trapezoidal weir with 2-foot wide crest
   Crest elevation = 3.5 feet = average heighest water level prior to levee construction
   Top width = 90 feet (see section)
2. Function of Weir:
   Retard low flows during droughts
   Lower water levels during flood season using slide gates

Section 11. Alternative E - Storage Restoration (Proposed Action)

This alternative is a modification of Alternative C. The basic elements of the plan are

a) Opening approximately 10,000 linear feet of waterway which will create approximately 10 acres of open water to distribute flood water more efficiently within the interior of the marsh;
b) Clearing vegetation and sediment from existing ponds to provide approximately 20 acres of open water to enhance flow into the waterways and reduce the presence of floating material which could block flow and impede flood water distribution;
c) Construction of a processing and handling area for the materials planned for removal in order to maintain the elements completed in a) and b) above in a functioning condition.

Hydraulic evaluation of the plan involved using the numerical model RMA-2 to evaluate the effectiveness of the plan for flood damage mitigation. The theoretical basis for the model is the same as discussed in Section 4 and Section 11. The geometric grid was, however, modified to reflect the proposed waterways and include new survey data. The waterway alignments were based upon the results of test blasting to excavate clearings and additional surveys made to probe the depth of peat deposits along candidate alignments. These results are discussed next.

The findings of the test blasting included:

a) Explosives will create waterways of the shape and dimensions envisioned during the planning of flood control improvements in the DEIS. At the first test site a shallow excavation between 5 to 10 feet, averaging 7.5 feet approximately, was created. The surface dimensions were approximately 47 feet by 33 feet. At the second site, a shallow excavation between 2.5 to 7 feet, averaging approximately 5 feet in depth was created. The surface dimensions were approximately 42 feet by 33 feet. From a vantage point close to the blast, observers could clearly see that most of the material had been thrown from the site and not merely fallen back into the excavation.

b) Large spoil mounds are not created; the mat was disintegrated over a restricted area surrounding the site in the downwind (generally mauka) direction over a few hundred feet from the site. The vegetation mat disintegrated into small pieces generally less than six inches maximum dimension with the largest piece having a maximum dimension of six feet in size. The procedure does not create adjacent spoil mounds which might inhibit lateral dispersion of flood water.

c) Two months after the test blasts, in April 1990, it was observed that material from beneath the excavation had "rebounded," i.e. hydrostatically adjusted to the removal of the overburden. It was also noted that the ejecta from the excavation could not be distinguished from the surrounding vegetation growth.

It is possible to set charges deeper and remove the material from greater depths with the same amount of explosives. For the test purposes, the charges were intentionally set at four feet below the surface to avoid any subsurface impacts while archaeological investigation results were pending. A greater depth would also reduce the sonic impact of explosives. The problem is, however, more closely associated with the alignment route than the type of removal means. Similar problems will result if mechanical equipment removes only the surface material from the original alignments. These alignments had been selected primarily because the route had been probed and therefore construction information was available for construction purposes, and the aerial application of herbicide improved accessibility.

The conclusion from c) above was that there was an advantage to adjusting the alignments to areas which had less disposition and thereby reduce the problems associated with removal of "rebounding" of material after initial excavation. The logical choice for such alignments are those areas where agricultural canals were once maintained because there was less chance for thick vegetation growth to accumulate. Early aerial photography was used to identify the original alignments on present day photogrammetric maps, which in turn were used to plot candidate alignments. These alignments were field verified by probing the thickness of deposits and taking peat cores which were used to identify locations with the smaller amounts of subsurface deposits. These positions were marked with PVC pipe and surveyed for future reference during construction.

Using new alignments surveys, the hydraulic model geometric grid was revised. Because of the deletion of all plan elements adjacent to the levee for this alternative, including the low weir at the outlet of the existing emergency ditch, the alignments were shortened and stopped at least 1000 feet from the outlet. The area between the ends of the waterways and the outlet was surveyed to verify that the marsh vegetation and peat deposits near the outlet are higher in elevation than near the center. Thus the waterways are expected to import flood water into the interior at a faster rate, but the outflow water surface elevation relationship will remain the same as the present condition.

At the upstream end of the waterways, the removal of vegetation and sediment from approximately 20 acres of pond was simulated in the model. The proposed depth for the waterways was used for the minimum assumed depth for the ponds. It was assumed that material will be dredged from these ponds each year according to the contract specifications. The concern was voiced in comments raised about the DEIS that sediment removal should be included in the plan. This was recognized in the formulation of the proposed action by including maintenance provisions for sediment removal from the existing ponds at the southern end of the marsh. The use of the existing ponds is recommended rather than building new sediment basins in an area designated as a historic site and which offers no engineering advantage upstream.

The design objective of Alternative E is to provide a minimum storage capacity of 3000 acre-feet below the top of the levee. The present levee elevation near the Kailua Road end is approximately 10 feet MSL It was assumed for the analysis shown here that any overflow over the levee is limited to the flow which can be conveyed through the marsh and levee erosion is minor. It was also assumed that the water level in the marsh at the beginning of the flood had reached a level of 5.2 feet, MSL, due to antecedent inflow.

The hydraulic effect of waterway clearing operations was simulated by the RMA-2 model using the channel alignments shown in Figure 2-3. The differences in water surface elevations throughout the marsh without and with the interior channels are shown on Figures A-110 and A-111. The estimated effect of the channels for the New Year's Eve 1988 flood is a reduction in stage of approximately 0.5 feet at the upstream end at the time of the peak inflow in the marsh. For lower flood magnitudes, e.g. a hypothetical 50-year flood, the reduction effect will be greater, while for greater flood magnitudes, e.g. a SPF, the effect will be less.

Note that without the channels the 7.0 feet contour line runs through the middle of the marsh; with the channels this contour swings to the north and east toward the outlet. The effect of the channels is to increase the rate of distribution of flood water within the interior. The faster this distribution takes effect, the less water accumulates in storage at the upstream end where it can potentially overtop the levee.

Figure A-112 shows the stage variation at levee station 7+00 which is at the upstream end as shown on Figure A-66 Sheet B. This stage is predicted for the New Year's Eve storm assuming the interior channels are unobstructed. As indicated, the peak stage at the indicated location is 10.5 feet, MSL. Levee overtopping is predicted by the RMA-2 model to occur with the proposed interior channel construction if a repeat of the New Year's Eve 1988 flood were to occur. The depth of overtopping is approximately 0.5 feet. Assuming the levee does not erode, the peak rate of flow is 1280 cfs. Modeling results of Kaelepulu Stream indicated (see Table A-33) that this rate of flow can be conveyed to the south toward Kailua Bay below the stages which might cause damage to adjacent residences along the channel. However, this condition does not meet City and County drainage standards for levee or channel design.

Figure A-113 shows the flood flow hydrographs at the inlet and outlet and the change in storage in the marsh for the New Year's Eve storm event assuming interior channels are unobstructed. Note that before the peak inflow occurs there is approximately 1300 acre-feet of storage in the marsh, assuming the antecedent conditions similar to the New Year's Eve 1988 storm. The peak storage that occurs 2.5 hours after the peak inflow rate is approximately 4500 acre-feet. The difference between the initial and peak storage is 3200 acre-feet, i.e. the amount of flood detention storage provided with this alternative. The amount of storage will be greater if the antecedent level is lower and will be less if the antecedent level is higher, all other factors, including inflow hydrograph shape and volume, remaining the same.

SECTION 12. Basis of Cost Estimates

FILE : IESTA PROJECT K A W A I N U I   M A R S H SHEET 1 OF 10

JOB NO. 10.89 ALT. A - CHANNELIZATION

REV. 0 16-Oct-89

ITEM	DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
ESC & CONTINGENCY = 8.00%		JULY 1990 AWARD											
	SUMMARY TOTAL COST WITH ESC. & CONTINGENCY												
100	MOBILIZATION		LS		110,214		73,602		81,285		220,450		485,551
200	DISPOSAL AREA - SILTATION BASINS												
201	CLEAR & GRUB	12.5	ACRES	3,820	47,750		0	1,336	16,700	494	6,175	5,650	70,625
202	EXCAVATION	79,100	CY	9.00	711,900		0	2.00	158,200	1.00	79,100	12.00	949,200
203	EMBANKMENT	54,700	CY	0.02	1,094		0	1.00	54,700	1.00	54,700	2.02	110,494
204	GRAVEL FILL	2,000	CY	42.00	84,000		0	2.00	4,000	3.00	6,000	47.00	94,000
205	DISPOSAL WIER & BOTTOM SEAL		LS		175,976		0		104,644		1,514		282,134
300	CHANNELIZATION												
301	VEGITATION REMOVAL	377,400	CY	20.00	7,548,000		0	7.00	2,641,800	4.00	1,509,600	31.00	11,699,400
302	DREDGE CHANNEL	342,250	CY	2.00	684,500		0	7.00	2,395,750	5.00	1,711,250	14.00	4,791,500
303	DISPOSAL DREDGED MATERIAL	342,250	CY	27.00	9,240,750		0	1.00	342,250	1.00	342,250	29.00	9,925,250
400	PERM. WIER AT OUTLET		LS		0		378,000		0		0		378,000
	TOTAL COST WITH ESC. & CONTINGENCY				18,604,184		451,602		5,799,329		3,931,039		28,786,154
												CHECK)))	28,786,154

PROJECT CONSTRUCTION TIME 15 MONTHS (ALL DREDGING ON TWO SHIFT BASIS SIX DAYS PER WEEK)

FILE : IESTA PROJECT K A W A I N U I M A R S H

JOB NO. 10.89 ALT. A - CHANNELIZATION REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
SUMMARY TOTAL COST W\O CONTINGENCY												
100 MOBILIZATION		LS		102,050		68,150		75,264		204,120	0	449,584
200 DISPOSAL AREA - SILTATION BASINS												
201 CLEAR & GRUB	12.5	ACRES	3,537	44,214		0	1,237	15,460	457	5,712	5,231	65,386
202 EXCAVATION	79,100	CY	8.65	684,607		0	2.29	181,303	0.86	68,083	11.81	933,993
203 EMBANKMENT	54,700	CY	0.02	988		0	0.60	32,929	0.93	51,054	1.55	84,971
204 GRAVEL FILL	2,000	CY	38.90	77,804		0	1.74	3,472	2.57	5,134	43.20	86,410
205 DISPOSAL WIER & BOTTOM SEAL		LS		162,941		0		96,893		1,401		261,235
300 CHANNELIZATION												
301 VEGITATION REMOVAL	377,400	CY	18.12	6,838,848		0	6.54	2,468,250	3.81	1,437,792	28.47	10,744,890
302 DREDGE CHANNEL	342,250	CY	1.47	502,207		0	6.11	2,089,783	4.57	1,565,596	12.15	4,157,586
303 DISPOSAL DREDGED MATERIAL	342,250	CY	24.58	8,411,432		0	0.55	186,610	0.47	161,392	25.59	8,759,434
400 PERM. WIER AT OUTLET		LS		0		350,000		0		0		350,000
TOTAL COST W\O CONTINGENCY				16,825,090		418,150		5,149,964		3,500,284		25,893,489
											CHECK)))	25,893,489

PROJECT CONSTRUCTION TIME 15 MONTHS (ALL DREDGING ON TWO SHIFT BASIS SIX DAYS PER WEEK)

FILE : 1ESTA PROJECT K A W A I N U I M A R S H SHEET 3 OF 10

ALT. A - CHANNELIZATION REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100 MOBILIZATION												
DREDGE												
140 SHIP TNS	2	EA	18,000	36,000						0	18000.00	36,000
RENT DURING MOB	3	MO							43,000	129,000	43000.00	129,000
HAUL TO JOB	48	HRS	140.00	6,720							140.00	6,720
RIG UP & DOWN	5	DAYS					1680.00	8,400	400.00	2,000	2080.00	10,400
FLEX FLOATS												
TRUCKING	120	HRS	140.00	16,800							140.00	16,800
RIG UP & DOWN	20	DAYS					1680.00	33,600	400.00	8,000	2080.00	41,600
RENT	1	MONTH							2,000	2,000	2000.00	2,000
LAND EQUIPMENT												
TRUCKING	48	HRS	120.00	5,760							120.00	5,760
RIG UP & DOWN	3	DAYS					1680.00	5,040	400.00	1,200	2080.00	6,240
RENT	2	DAYS							1,000	2,000	1000.00	2,000
MISC. PLANT & EQUIPMENT												
TRUCKING	100	HRS	60.00	6,000							60.00	6,000
RIG UP & DOWN	4	DAYS					1680.00	6,720	400.00	1,600	2080.00	8,320
SHEET PILE BULKHEAD	2,000	SF			25.00	50,000					25.00	50,000
SMALL TOOLS & CONSUMABLES 3.00%				1,613								1,613
ITEM DIRECT COST	LS			72,893		50,000		53,760		145,800		322,453
ITEM TOTAL COST			0.00	102,050	0.00	68,150	0.00	75,264	0.00	204,120	0.00	449,584

FILE : IESTA PROJECT K A W A I N U I M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION		QUANITY NUMEER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA - SILTATION BASINS													
201 CLEAR & GRUB		12.50	ACRES										
TYPICAL CREW		12.50	ACRES					883.44	11,043	326.40	4,080	1209.84	15,123
HAUL		125	LOADS	150.00	18,750							150.00	18,750
DISPOSAL FEE		125	LOADS	100.00	12,500							100.00	12,500
SMALL TOOLS & CONSUMABLES	3.00%				331								331
ITEM DIRECT COST		12.5	ACRES		31,581		0		11,043		4,080	3736.34	46,704
ITEM TOTAL COST		12.5	ACRES	3537.10	44,214	0.00	0	1236.82	15,460	456.96	5,712	5230.88	65,386
202 EXCAVATION		79,100	CY										
EXCAVATE & LOAD TRUCKS		79,100	CY					1.25	98,875	0.47	37,177	1.72	136,052
HAUL TO FILL		54,200	CY	1.60	86,720							1.60	86,720
LOAD SURPLUS		24,900	CY					1.23	30,627	0.46	11,454	1.69	42,081
HAUL TO WASTE		24,900	CY	16.00	398,400							16.00	398,400
SMALL TOOLS & CONSUMABLES	3.00%				3,885								3,885
ITEM DIRECT COST		79,100	CY		489,085		0		129,502		48,631	8.43	667,138
ITEM TOTAL COST		79,100	CY	8.65	684,607	0.00	0	2.29	181,303	0.86	68,083	11.81	933,993

FILE : IESTA PROJECT K A W A I N U I M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA - SILTATION BASINS												
203 EMBANKMENT	54,700	CY										
SPREAD & DRESS	54,700	CY					0.25	13,675	0.37	20,057	0.62	33,732
COMPACT - 90%	54,700	CY					0.18	9,846	0.30	16,410	0.48	26,256
SMALL TOOLS & CONSUMABLES 3.00%				706								706
ITEM DIRECT COST	54,700	CY		706		0		23,521		36,467	1.11	60,694
ITEM TOTAL COST	54,700	CY	0.02	988	0.00	0	0.60	32,929	0.93	51,054	1.55	84,971
204 GRAVEL FILL	2,000	CY										
BUY FOB JOB	3,700	TNS	15.00	55,500							15.00	55,500
PLACE & COMPACT	2,000	CY					1.24	2,480	1.83	3,667	3.07	6,147
SMALL TOOLS & CONSUMABLES 3.00%				74								74
ITEM DIRECT COST	2,000	CY		55,574		0		2,480		3,667	30.86	61,721
ITEM TOTAL COST	2,000	CY	38.90	77,804	0.00	0	1.74	3,472	2.57	5,134	43.20	86,410

FILE : IESTA PROJECT K A W A I N U I M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA - SILTATION BASINS												
205 DISPOSAL WIER & BOTTOM SEAL		LS										
BUILD 2 WIERS & FILER BOXES USE 24" RC PIPE FOR WIER USE 2" TIMBER BOXS - 15'X20'												
BUY												
24" RC PIPE	96	LF	16.00	1,536							16.00	1,536
TIMBER	4,000	BF	0.75	3,000							0.75	3,000
3/4" STONE	250	TNS	15.00	3,750							15.00	3,750
INSTALL												
TIMBER BOXES	2	EA					7000.00	14,000	100.00	200	7100.00	14,200
24" RC PIPE	96	LF					18.50	1,776	4.17	400	22.67	2,176
3/4" STONE	170	CY					6.53	1,113	2.35	401	8.88	1,514
SEAL CONFINEMENT AREA												
BUY REINFORCED POLY SHEATING	523,200	SF	0.20	104,640							0.20	104,640
INSTALL SHEATING	436,000	SF					0.12	52,320			0.12	52,320
SMALL TOOLS & CONSUMABLES 5.00%				3,460								3,460
ITEM DIRECT COST	LS			116,386		0		69,209		1,001		186,596
ITEM TOTAL COST	LS		0.00	162,941	0.00	0	0.00	96,893	0.00	1,401	0.00	261,235

FILE : 1ESTA PROJECT K A W A I N U I   M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 CHANNELIZATION													
301 VEGITATION REMOVAL		377,400	CY										
USE CRANE ON SECT BARGE WITH ORANGE PEEL, CLAW/DRAG BUCKETS AND SECT. BARGE FOR MATERIAL													
EXCAVATE FOR FLOTATION		34,000	CY					2.88	97,920	1.90	64,600	4.78	162,520
EXCAVATE MAT		377,400	CY					2.32	875,568	1.53	577,422	3.85	1,452,990
UNLOAD MAT EXCAVATION		377,400	CY					1.00	377,400	0.45	169,830	1.45	547,230
HANDLE & PROCESS		377,400	CY					0.82	309,468	0.33	124,542	1.15	434,010
LOAD OUT MAT MATERIAL		302,000	CY					0.34	102,680	0.30	90,600	0.64	193,280
HAUL TO DISPOSAL		302,000	CY	16.00	4,832,000							16.00	4,832,000
SMALL TOOLS & CONSUMABLES	3.00%				52,891								52,891
ITEM DIRECT COST		377,400	CY		4,884,891		0		1,763,036		1,026,994	20.34	7,674,921
ITEM TOTAL COST		377,400	CY	18.12	6,838,848	0.00	0	6.54	2,468,250	3.81	1,437,792	28.47	10,744,890

FILE :

PROJECT K A W A I N U I M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 CHANNELIZATION												
302 DREDGE CHANNEL	342,250	CY										
NO PAY ITEMS EXC. FOR LOADING BASIN & CHANNEL FROM SILT BASINS TO PERM CHANNEL												
VEG MAT EXC 750 LF	18,000	CY					2.88	51,840	1.90	34,200	4.78	86,040
REMOVE MAT	20,000	CY					2.32	46,400	1.53	30,600	3.85	77,000
UNLOAD BARGE	20,000	CY					1.00	20,000	0.45	9,000	1.45	29,000
DRY & SHRED	20,000	CY					0.82	16,400	0.33	6,600	1.15	23,000
LOAD OUT & HAUL	16,000	CY	16.00	256,000			0.34	5,440	0.30	4,800	16.64	266,240
							########10,000 CY ADDED TO PAY CY					
TEMP ACCESS CHANNEL	10,000	CY										
ASSEMBLE DREDGE PIPE	7,800	LF	0.50	3,900			4.76	37,128	1.17	9,100	6.43	50,128
DISASSEMBLE DREDGE PIPE	7,800	LF					1.46	11,388	0.36	2,800	1.82	14,188
CRANE FOR MAINTANCE	40	SHIFTS							1,000	40,000	1000.00	40,000
MAIN DREDGING												
LEVEE CREW	360,250	CY					1.79	644,848	0.31	111,678	2.10	756,526
DREDGE PIPE CHARGE	360,250	CY	0.15	54,038							0.15	54,038
MAIN DREDGING LABOR & MAINTANCE	360,250	CY					1.83	659,258	1.22	439,505	3.05	1,098,763
DREDGE CHARGE	10	MONTHS							28,000	280,000	28,000	280,000
DREDGE BOOSTER CHARGE	10	MONTHS							15,000	150,000	15,000	150,000
SMALL TOOLS & CONSUMABLES 3.00%				44,781								44,781
ITEM DIRECT COST	342,250	CY		358,719		0		1,492,782		1,110,283	8.68	2,969,784
ITEM TOTAL	342,250	CY	1.47	502,207	0.00	0	6.11	2,089,783	4.57	1,565,596	12.15	4,157,586

FILE : 1ESTA PROJECT K A W A I N U I M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 CHANNELIZATION													
303 DISPOSAL DREDGED MATERIAL		342,250	CY										
NO PAY LOAD OUT		18,000	CY					0.37	6,660	0.32	5,760	0.69	12,420
HAUL		18,000	CY	10.00	180,000							10.00	180,000
DISPOSAL FEE		1,200	LOADS	100.00	120,000							100.00	120,000
PERM. CHANNEL													
LOAD OUT		342,250	CY					0.37	126,633	0.32	109,520	0.69	236,153
HAUL		342,250	CY	10.00	3,422,500							10.00	3,422,500
DISPOSAL FEE		22,817	LOADS	100.00	2,281,667							100.00	2,281,667
SMALL TOOLS & CONSUMABLES	3.00%				3,999								3,999
ITEM DIRECT COST		342,250	CY	17.55	6,008,166		0		133,293		115,280	18.28	6,256,739
ITEM TOTAL COST		342,250	CY	24.58	8,411,432	0.00	0	0.55	186,610	0.47	161,392	25.59	8,759,434

FILE : IESTA PROJECT K A W A I N U I M A R S H
ALT. A - CHANNELIZATION

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
400 PERM. WIER AT OUTLET												
ALLOW C OF E PRELIMINARY DESIGN	1	LS			350000	350,000					350000	350,000
SMALL TOOLS & CONSUMABLES 0.00%				0								0
ITEM DIRECT COST	1	LS		0		350,000		0		0		350,000
ITEM TOTAL COST	1	LS		0		350,000	0.00	0	0.00	0	0.00	350,000

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FILE : 2ESTB   PROJECT K A W A I N U I   M A R S H   SHEET · 1 OF 10

JOB NO. 10.89   ALT. B - PIPE CULVERT DIVERSION   REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
ESC & CONTINGENCY = 27.00%	JULY 1990 AWARD											
SUMMARY TOTAL COST WITH ESC. & CONTINGENCY												
100 MOBILIZATION		LS		952,500		0		158,750		127,000		1,238,250
200 CLEAR & GRUB	60	ACRES	3,900.00	234,000		0	1,582.00	94,920	587.00	35,220	6069.00	364,140
300 CULVERT WORK												
301 RC PIPE	140,000	LF	694.00	97,160,000	14.00	1,960,000	149.00	20,860,000	117.00	16,380,000	974.00	136,360,000
302 MORTAR												
303 EXCAVATION & DISPOSAL	1000000	CY	23.00	23,000,000		0	6.00	6,000,000	5.00	5,000,000	34.00	34,000,000
304 GRANULAR FILL	750,000	CY	40.00	30,000,000		0	13.00	9,750,000	8.00	6,000,000	61.00	45,750,000
SUB-TOTAL DIVISION 300	140,000	LF		150,160,000		1,960,000		36,610,000		27,380,000	1,544	216,110,000
400 CONCRETE WORK												
401 CONC.,FORMS & RESTEEL	1,940	CY	197.00	382,180	159.00	308,460	194.00	376,360	31.00	60,140	581.00	1,127,140
402 EXCAVATION	11,300	CY	12.00	135,600	50.00	565,000	19.00	214,700	7.00	79,100	88.00	994,400
403 GRANULAR FILL	1,500	CY	50.00	75,000		0	16.00	24,000	7.00	10,500	73.00	109,500
SUB-TOTAL DIVISION 400				592,780		873,460		615,060		149,740		2,231,040
500 EROSION CONTROL		LS		234,252		0		400,050		216,916		851,218
TOTAL COST WITH ESC. & CONTINGENCY				152,173,532		2,833,460		37,878,780		27,908,876		220,794,648
											CHECK)))	220,794,648

PROJECT CONSTRUCTION TIME 5 TO 6 YEARS

FILE : 2ESTB PROJECT K A W A I N U I M A R S H

JOB NO. 10.89 ALT. B - PIPE CULVERT DIVERSION

REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
SUMMARY TOTAL COST W\O CONTINGENCY												
100 MOBILIZATION		LS		750,000		0		125,000		100,000		975,000
200 CLEAR & GRUB	60	ACRES	3,070.71	184,243		0	1,246.00	74,760	462.00	27,720	4,778.71	286,723
300 CULVERT WORK												
301 RC PIPE	140,000	LF	546.50	76,510,420	10.90	1,526,560	118	16,464,000	91.88	12,862,500	766.88	107,363,480
302 MORTAR												
303 EXCAVATION & DISPOSAL	1000000	CY	18.35	18,351,200		0	5.04	5,040,000	4.27	4,270,000	27.66	27,661,200
304 GRANULAR FILL	750,000	CY	31.39	23,543,100		0	10.36	7,770,000	5.95	4,462,500	47.70	35,775,600
SUB-TOTAL DIVISION 300	140,000	LF		118,404,720		1,526,560		29,274,000		21,595,000	1,220	170,800,280
400 CONCRETE WORK												
401 CONC.,FORMS & RESTEEL	1,940	CY	155.50	301,675	125.27	243,028	152.87	296,576	24.56	47,653	458.21	888,933
402 EXCAVATION	11,300	CY	9.74	110,080	39.08	441,612	14.74	166,523	5.37	60,691	68.93	778,906
403 GRANULAR FILL	1,500	CY	39.22	58,834			12.43	18,648	5.88	8,820	57.53	86,302
SUB-TOTAL DIVISION 400				470,590		684,640		481,747		117,165		1,754,142
500 EROSION CONTROL		LS		184,450		0		315,000		170,800		670,250
TOTAL W/O CONTINGENCY				119,934,002		2,211,200		30,270,507		22,010,685		174,486,394

CHECK))) 174,486,394

PROJECT CONSTRUCTION TIME 5 TO 6 YEARS

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100 MOBILIZATION												
ALLOW				750,000				125,000		100,000		975,000
200 CLEAR & GRUB	60	ACRES										
TYP CREW	60	ACRES					890.00	53,400	330.00	19,800	1220.00	73,200
HAUL	2,000	LOADS	45.00	90,000							45.00	90,000
DUMP FEE	2,000	LOADS	20.00	40,000							20.00	40,000
SMALL TOOLS & CONSUMABLES 3.00%				1,602								1,602
ITEM DIRECT COST	60	ACRES	2,193	131,602	0.00	0	890	53,400	330	19,800	3,413	204,802
ITEM TOTAL COST	60	ACRES	3,071	184,243	0.00	0	1,246	74,760	462	27,720	4,779	286,723

FPS ENGINEERING ASSOCIATES , INC.

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 CULVERT WORK												
301 RC PIPE	140000	LF										
BUY												
12 FT DIAM. R C PIPE	140,000	LF	350.00	49,000,000							350.00	49,000,000
HAUL PIPE	17,500	PCS	275.00	4,812,500							275.00	4,812,500
INSTALL												
UNLOAD & LOAD OUT	17,500	PCS					88.00	1,540,000	45.00	787,500	133.00	2,327,500
INSTALL PIPE	140,000	LF	0.25	35,000			73.00	10,220,000	60.00	8,400,000	133.25	18,655,000
DIVING SERVICES	140,000	LF			8.00	1,120,000					8.00	1,120,000
PLACING HORSE	LS			450,000								450,000
ESCLATION												
SMALL TOOLS & CONSUMABLES 3.00%				352,800								352,800
ITEM DIRECT COST	140,000	LF		54,650,300		1,120,000		11,760,000		9,187,500		76,717,800
ITEM TOTAL COST	140,000	LF	546.50	76,510,420	10.90	1,526,560	117.60	16,464,000	91.88	12,862,500	766.88	107,363,480

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 CULVERT WORK													
303 EXCAVATION & DISPOSAL		1000000	CY										
EXCAVATION		1000000	CY					1.60	1,600,000	1.75	1,750,000	3.35	3,350,000
OFF LOAD		1000000	CY					1.50	1,500,000	1.10	1,100,000	2.60	2,600,000
LOAD OUT		1000000	CY					0.50	500,000	0.20	200,000	0.70	700,000
HAUL & DISPOSAL		1000000	CY	13.00	13,000,000							13.00	13,000,000
SMALL TOOLS & CONSUMABLES	3.00%				100,000								100,000
ITEM DIRECT COST		1000000	CY		13,100,000		0		3,600,000		3,050,000		19,750,000
ITEM TOTAL COST		1000000	CY	18.35	18,351,200	0.00	0	5.04	5,040,000	4.27	4,270,000	27.66	27,661,200

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

SHEET 6 OF 10
REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 CULVERT WORK												
304 GRANULAR FILL	750,000	CY										
BUY												
GRAVEL	1387500	TNS	10.00	13,875,000							10.00	13,875,000
HAUL	1387500	TNS	2.00	2,775,000							2.00	2,775,000
INSTALL												
LOAD OUT TO RIG	750,000	CY					2.40	1,800,000	1.25	937,500	3.65	2,737,500
PLACE	750,000	CY					3.00	2,250,000	2.50	1,875,000	5.50	4,125,000
COMPACT	187,500	CY					8.00	1,500,000	2.00	375,000	10.00	1,875,000
SMALL TOOLS & CONSUMABLES 3.00%				166,500								166,500
ITEM DIRECT COST	750,000	CY		16,816,500		0		5,550,000		3,187,500		25,554,000
ITEM TOTAL COST	750,000	CY	31.39	23,543,100	0.00	0	10.36	7,770,000	5.95	4,462,500	47.70	35,775,600

FILE : 2ESTB PROJECT **K A W A I N U I   M A R S H**

ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION			QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
401	CONC.,FORMS & RESTEEL		1,940	CY										
INLET														
FORMS	FOOTINGS	3040	3,040	SF	1.00	3,040								
	WALLS	19100	19,100	SF	0.50	9,550			3.50	10,640			4.50	13,680
									4.75	90,725	0.60	11,460	5.85	111,735
RESTEEL		160 #/CY	120,000	LBS			0.75	90,600						
													0.75	90,600
CONCRETE	BUY		1,320	CY	81.00	106,920								
	PLACE		1,200	CY									81.00	106,920
	FINISH WALLS		19,100	SF	0.05	955			18.00	21,600	5.00	6,000	23.00	27,600
	FINISH TROWEL		8,000	SF					0.80	15,280			0.85	16,235
	CURE		1,200	CY	0.40	480			0.65	5,200			0.65	5,200
	PUMP CHARGE		1,200	CY	6.00	7,200			1.50	1,800			1.90	2,280
OUTLET													6.00	7,200
FORMS	FOOTINGS		560	SF	1.00	560								
	WALLS		5,200	SF	0.50	2,600			3.50	1,960			4.50	2,520
									5.00	26,000	0.60	3,120	6.10	31,720
RESTEEL		160 #/CY	94,880	LBS			0.75	71,160						
													0.75	71,160
CONCRETE	BUY	593	593	CY	81.00	48,033								
	PLACE	560	560	CY									81.00	48,033
	FINISH WALLS		5,200	SF	0.05	260			18.00	10,080	5.00	2,800	23.00	12,880
	FINISH TROWEL		6,000	SF					0.80	4,160			0.85	4,420
	CURE		560	CY	0.40	224			0.65	3,900			0.65	3,900
	PUMP CHARGE		593	CY	6.00	3,558			1.50	840			1.90	1,064
													6.00	3,558
DEWATER DURING CONCRETE WORK			1	LS	2500.00	2,500								
SMALL TOOLS & CONSUMABLES		5.00%				9,609					7500.00	7,500	10,000	10,000
														9,609
ITEM DIRECT COST			1,760	CY	111.07	195,489	91.91	161,760	109.20	192,105	17.55	30,880	329.72	580,314
ITEM TOTAL COST			1,940	CY	155.50	301,675	125.27	243,028	152.87	296,576	24.56	47,653	458.21	888,933

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
402 EXCAVATION		11,300	CY										
INLET EXCAVATION		6,130	CY					10.20	62,526	3.75	22,988	13.95	85,514
FINE GRADE SLABS		11,100	SF					0.60	6,660			0.60	6,660
BACKFILL		225	CY					10.00	2,250	3.00	675	13.00	2,925
HAUL & DISPOSAL		6,130	CY	5.00	30,650			0.48	2,942	0.55	3,372	6.03	36,964
OUTLET													
ALLOW FOR SHEETPILE		18,000	SF			18.00	324,000					18.00	324,000
DIVERT STREAM		125	LF	100.00	12,500			130.00	16,250	48.00	6,000	278.00	34,750
EXCAVATE		4,130	CY					5.10	21,063	1.88	7,744	6.98	28,807
FINE GRADE SLABS		7,120	SF					0.60	4,272			0.60	4,272
BACKILL		100	CY	30.00	3,000			10.00	1,000	3.00	300	43.00	4,300
HAUL & DISPOSAL		4,130	CY	7.00	28,910			0.48	1,982	0.55	2,272	8.03	33,164
SMALL TOOLS & CONSUMABLES	3.00%				3,568								3,568
ITEM DIRECT COST		11,300	CY		78,628		324,000		118,945		43,351		564,924
ITEM TOTAL COST		11,300	CY	9.74	110,080	39.08	441,612	14.74	166,523	5.37	60,691	68.93	778,906

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
403 GRANULAR FILL	1,500	CY										
BUY	2,775	TNS	15.00	41,625							15.00	41,625
SPREAD & COMPACT	1,500	CY					8.88	13,320	4.20	6,300	13.08	19,620
SMALL TOOLS & CONSUMABLES 3.00%				400								400
ITEM DIRECT COST	1,500	CY		42,025		0		13,320		6,300		61,645
ITEM TOTAL COST	1,500	CY	39.22	58,834	0.00	0	12.43	18,648	5.88	8,820	57.53	86,302

FPS ENGINEERING ASSOCIATES , INC.

FILE : 2ESTB PROJECT K A W A I N U I M A R S H
ALT. B - PIPE CULVERT DIVERSION

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
500 EROSION CONTROL		LS										
TEMP FILTER BOXES & GROUND SEAL				125,000				75,000		2,000		202,000
TEMP DIKE								150,000		120,000		270,000
SMALL TOOLS & CONSUMABLES 3.00%				6,750								6,750
ITEM DIRECT COST				131,750		0		225,000		122,000		478,750
ITEM TOTAL COST			0.00	184,450	0.00	0	0.00	315,000	0.00	170,000	0.00	670,250

FILE : 3ESTC PROJECT K A W A I N U I M A R S H

JOB NO. 10.89 ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

REV. 0 16-Oct-89

ESC & CONTINGENCY	ITEM DESCRIPTION 8.00% JULY 1990 AWARD	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
	SUMMARY TOTAL COST WITH ESC. & CONTINGENCY												
100	MOBILIZATION		LS		12,802		0		7,403		5,897		26,102
200	CLEAR & GRUB	17	ACRES	511.00	8,687		0	1923.00	32,691	1829.00	31,076	4,262.00	72,454
300	LEVEE MODIFICATIONS												
301	REMOVE/STOCKPILE GRAVEL	1,780	CY	3.00	5,340		0	5.00	8,900	6.00	10,680	14.00	24,920
302	REPLACE GRAVEL	1,750	CY	5.00	8,750		0	5.00	8,750	6.00	10,500	16.00	28,000
303	SCARIFY LEVEE SURFACE	19,360	SY	0.002	39		0	0.06	1,162	0.06	1,162	0.12	2,363
304	EMBANKMENT	26,300	CY	8.00	210,400		0	4.00	105,200	2.00	52,600	14.00	368,200
305	GABIONS	2,200	EA	45.00	99,000		0	5.00	11,000		0	50.00	110,000
306	ROCK FILL - GABIONS	2,300	CY	27.00	62,100		0	15.00	34,500	4.00	9,200	46.00	105,800
307	CONCRETE CAP	550	CY	160.00	88,000		0	175.00	96,250	1.00	550	336.00	184,800
400	OUTLET STRUCTURE												
401	PRECAST BOX CULVERT	168	LF	933.00	156,744		0	232.00	38,976	30.00	5,040	1,195.00	200,760
402	RIP-RAP APRON	200	CY	34.00	6,800		0	16.00	3,200	6.00	1,200	56.00	11,200
403	CONCRETE	400	CY	193.00	77,200	177.00	70,800	403.00	161,200	47.00	18,800	820.00	328,000
404	EXCAVATION	2,500	CY	4.00	10,000		0	15.00	37,500	7.00	17,500	26.00	65,000
405	GRANULAR FILL	750	CY	34.00	25,500		0	17.00	12,750	4.00	3,000	55.00	41,250
501	CONFINEMENT DIKE FINE GRADE	2	ACRES	33.00	76		0	1104.00	2,539	986.00	2,268	2,123.00	4,883
502	GRAVEL MATERIAL	640	CY	29.00	18,560		0	4.00	2,560	3.00	1,920	36.00	23,040
503	DREDGE MATERIAL	50	CY	15.00	750		0	8.00	400	5.00	250	28.00	1,400
600A	OUTLET WEIR (EARTH)												
601A	EXCAVATION	1,000	CY	15.00	15,000		0	8.00	8,000	4.00	4,000	27.00	27,000
602A	CLAY MATERIAL	1,340	CY	12.00	16,080		0	4.00	5,360	2.00	2,680	18.00	24,120
603A	RIP RAP	550	CY	36.00	19,800		0	20.00	11,000	12.00	6,600	68.00	37,400
600B	OUTLET WEIR (CONCRETE)												
601B	EXCAVATION	440	CY	15.00	6,600		0	8.00	3,520	4.00	1,760	27.00	11,880
602B	EMBANKMENT	14	CY	0.00	0		0	12.00	168	2.00	28	14.00	196
603B	CONCRETE, FORMS & RESTEEL	220	CY	148.00	32,560	85.00	18,700	59.00	12,980	11.00	2,420	303.00	66,660
700	CHANNEL BLASTING	10,000	LF	12.00	115,725		0	23.00	226,165	4.00	37,800	39.00	379,690
800	DISPOSAL AREA - SILTATION BASINS		LS		1,020,720		0		338,244		147,489		1,506,453
	TOTAL COST WITH ESC. & CONTINGENCY - EARTH OUTLET WEIR OPTION				1,978,073		70,800		1,153,750		370,212		3,572,835
	*** PROJECT CONSTRUCTION TIME 12 MONTHS									CHECK)))	3,572,835		
	TOTAL COST WITH ESC. & CONTINGENCY - CONC. OUTLET WEIR OPTION				1,966,353		89,500		1,146,058		361,140		3,563,051
	*** PROJECT CONSTRUCTION TIME 12 MONTHS									CHECK)))	3,563,051		

18-Oct-89 FPS ENGINEERING ASSOCIATES , INC.

FILE : 3ESTC PROJECT K A W A I N U I M A R S H

JOB NO. 10.89 ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

REV. 0 16-Oct-89

ITEM	DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
	SUMMARY TOTAL COST W\O CONTINGENCY												
100	MOBILIZATION		LS		11,854		0		6,854		5,460		24,168
200	CLEAR & GRUB	17	ACRES	473.41	8,048		0	1,780.47	30,268	1,692.76	28,777	3,946.65	67,093
300	LEVEE MODIFICATIONS												
301	REMOVE/STOCKPILE GRAVEL	1,780	CY	3.14	5,587		0	4.47	7,952	5.27	9,376	12.87	22,914
302	REPLACE GRAVEL	1,750	CY	4.69	8,203		0	4.54	7,949	5.41	9,468	14.64	25,626
303	SCARIFY LEVEE SURFACE	19,360	SY	0.00	30		0	0.05	997	0.05	1,022	0.11	2,049
304	EMBANKMENT	26,300	CY	7.10	186,726		0	3.33	87,541	1.55	40,740	11.98	315,007
305	GABIONS	2,200	EA	41.58	91,471		0	4.76	10,472		0	46.34	101,943
306	ROCK FILL - GABIONS	2,300	CY	24.99	57,474		0	13.96	32,103	3.53	8,114	42.47	97,692
307	CONCRETE CAP	550	CY	148.54	81,696		0	162.18	89,198	1.27	700	311.99	171,594
400	OUTLET STRUCTURE												
401	PRECAST BOX CULVERT	168	LF	863.75	145,110		0	215.03	36,126	27.33	4,592	1,106.12	185,828
402	RIP-RAP APRON	200	CY	31.81	6,363		0	15.12	3,024	5.60	1,120	52.53	10,507
403	CONCRETE	400	CY	179.13	71,654	163.56	65,424	373.23	149,291	43.30	17,321	759.23	303,690
404	EXCAVATION	2,500	CY	3.90	9,744		0	14.18	35,454	6.41	16,017	24.49	61,215
405	GRANULAR FILL	750	CY	31.39	23,542		0	15.30	11,477	3.89	2,920	50.59	37,940
501	CONFINEMENT DIKE FINE GRADE	2.3	ACRES	30.68	71		0	1,022.61	2,352	913.04	2,100	1,966.33	4,523
502	GRAVEL MATERIAL	640	CY	26.50	16,962		0	3.78	2,419	2.38	1,523	32.66	20,905
503	DREDGE MATERIAL	50	CY	14.21	711		0	7.00	350	4.20	210	25.41	1,271
600A	OUTLET WEIR (EARTH)												
601A	EXCAVATION	1,000	CY	14.21	14,210		0	7.00	7,000	4.16	4,158	25.37	25,368
602A	CLAY MATERIAL	1,340	CY	11.32	15,163		0	3.85	5,159	2.31	3,095	17.48	23,417
603A	RIP RAP	550	CY	33.02	18,160		0	18.76	10,318	11.13	6,122	62.91	34,600
600B	OUTLET WEIR (CONCRETE)												
601B	EXCAVATION	440	CY	13.76	6,056		0	7.00	3,080	4.16	1,830	24.92	10,966
602B	EMBANKMENT	14	CY	0.34	5		0	11.20	157	2.10	29	13.64	191
603B	CONCRETE, FORMS & RESTEEL	220	CY	136.82	30,101	78.99	17,378	54.66	12,025	9.80	2,156	280.27	61,660
700	CHANNEL BLASTING	10,000	LF	10.72	107,152		0	20.94	209,412	3.50	35,000	35.16	351,564
800	DISPOSAL AREA - SILTATION BASINS		LS		970,554		0		330,057		131,384		1,431,995
	TOTAL COST W\O CONTINGENCY - EARTH OUTLET WEIR OPTION				1,850,489		65,424		1,075,773		329,221		3,320,907
	*** PROJECT CONSTRUCTION TIME 12 MONTHS									CHECK)))	3,320,907		
	TOTAL COST W\O CONTINGENCY - CONCRETE OUTLET WEIR OPTION				1,839,119		82,802		1,068,558		319,861		3,310,339
	*** PROJECT CONSTRUCTION TIME 12 MONTHS									CHECK)))	3,310,339		

FILE : 3ESTC PROJECT K A W A I N U I M A R S H SHEET 3 OF 15
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING REV. 0 16-Oct-89

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100 MOBILIZATION													
HAUL EQUIPMENT IN & OUT		64	HRS	100.00	6,400							100.00	6,400
MISC. TRUCKING		32	HRS	60.00	1,920							60.00	1,920
LABOR & EQUIPMENT RIG/RIG DOWN		3	DAYS					1632.00	4,896	300.00	900	1932.00	5,796
STANDBY ON EQUIPMENT		1	LS							3000.00	3,000	3000.00	3,000
SMALL TOOLS & CONSUMABLES	3.00%				147								146.88
ITEM DIRECT COST		1	LS		8,467		0		4,896		3,900		17,263
ITEM TOTAL COST		1	LS	11853.63	11,854	0.00	0	6854.40	6,854	5460.00	5,460	24168.03	24,168

18-Oct-89

FPS ENGINEERING ASSOCIATES, INC.

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 CLEAR & GRUB												
MAIN CREW	17	ACRES					1060.00	18,020	955.00	16,235	2015.00	34,255
DRESS STREAM BANKS	1,800	LF					2.00	3,600	2.40	4,320	4.40	7,920
HAUL TO DISPOSAL 5 LOADS/ACRE	85	LOADS	60.00	5,100							60.00	5,100
SMALL TOOLS & CONSUMABLES 3.00%				649								649
ITEM DIRECT COST	17	ACRES		5,749		0		21,620		20,555		47,924
ITEM TOTAL COST	17	ACRES	473.41	8,048	0.00	0	1780.47	30,268	1692.76	28,777	3946.65	67,093
301 REMOVE/STOCKPILE GRAVEL												
EXCAVATE & DOZE	1,780	CY					3.00	5,340	3.65	6,497	6.65	11,837
WATER	5	DAYS					68.00	340	40.00	200	108.00	540
HAUL TO STOCKPILE	1,700	CY	2.25	3,820							2.25	3,820
SMALL TOOLS & CONSUMABLES 3.00%				170								170
ITEM DIRECT COST	1,780	CY		3,990		0		5,680		6,697		16,367
ITEM TOTAL COST	1,780	CY	3.14	5,587	0.00	0	4.47	7,952	5.27	9,376	12.87	22,914

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
302 REPLACE GRAVEL													
BUY GROUND STORAGE LOSS		135	TNS	13.00	1,755							13.00	1,755
SPREAD & ROLL		1,750	CY					3.05	5,338	3.75	6,563	6.80	11,901
WATER		5	DAYS					68.00	340	40.00	200	108.00	540
HAUL FROM STOCKPILE		1,750	CY	2.25	3,938							2.25	3,938
SMALL TOOLS & CONSUMABLES	3.00%				170								170
ITEM DIRECT COST		1,750	CY		5,863		0		5,678		6,763		18,304
ITEM TOTAL COST		1,750	CY	4.69	8,209	0.00	0	4.54	7,949	5.41	9,468	14.64	25,626
303 SCARIFY LEVEE SURFACE													
DISK		19,360	SY					0.030	576	0.034	650	0.06	1,226
WATER		2	DAYS					68.00	136	40.00	80	108.00	216
SMALL TOOLS & CONSUMABLES	3.00%				21								21
ITEM DIRECT COST		19,360	SY		21		0		712		730		1,463
ITEM TOTAL COST		19,360	SY	0.00	30	0.00	0	0.05	997	0.05	1,022	0.11	2,049

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
304 EMBANKMENT												
BUY & HAUL FILL	26,300	CY	5.00	131,500							5.00	131,500
SPREAD & COMPACT	26,300	CY					1.95	51,285	0.60	15,780	2.55	67,065
ROUGH GRADE	26,300	CY							IN SPREAD & COMPACT			
FINE GRADE SLOPES	150,000	SF					0.06	9,000	0.08	12,000	0.14	21,000
WATER	33	DAYS					68.00	2,244	40.00	1,320	108.00	3,564
SMALL TOOLS & CONSUMABLES 3.00%				1,876								1,876
ITEM DIRECT COST	26,300	CY		133,376		0		62,529		29,100	8.56	225,005
ITEM TOTAL COST	26,300	CY	7.10	186,726	0.00	0	3.33	87,541	1.55	40,740	11.98	315,007
305 GABIONS												
BUY 1.5X3X6 - GALV & PVC COATED FOB JOB	2,200	EA	29.60	65,112							29.60	65,112
SET UP & TIE	2,200	EA					3.40	7,480			3.40	7,480
SMALL TOOLS & CONSUMABLES 3.00%				224								224
ITEM DIRECT COST	2,200	EA		65,336		0		7,480		0	33.10	72,816
ITEM TOTAL COST	2,200	EA	41.58	91,471	0.00	0	4.76	10,472	0.00	0	46.34	101,943

FPS ENGINEERING ASSOCIATES , INC.

18-Oct-89

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
306 ROCK FILL - GABIONS												
BUY ROCK 1.35 TN/CY	3,105	TNS	13.00	40,365							13.00	40,365
PLACE ROCK	2,300	CY					9.97	22,931	2.52	5,796	12.49	28,727
SMALL TOOLS & CONSUMABLES 3.00%				688								688
ITEM DIRECT COST	2,300	CY		41,053		0		22,931		5,796	30.34	69,780
ITEM TOTAL COST	2,300	CY	24.99	57,474	0.00	0	13.96	32,103	3.53	8,114	42.47	97,692
307 CONCRETE CAP												
BUY CONCRETE	550	CY	80.00	44,000							80.00	44,000
MESH	31,050	SF	0.25	7,763							0.25	7,763
INSTALL												
FORMS	9,000	SF	0.40	3,600			3.50	31,500			3.90	35,100
MESH	31,050	SF					0.40	12,420			0.40	12,420
POUR CONCRETE	500	CY					17.00	8,500	1.00	500	18.00	9,000
SLAB FINISH	18,000	SF	0.03	540			0.55	9,900			0.58	10,440
CURE	27,000	SF	0.02	540			0.05	1,393			0.07	1,933
SMALL TOOLS & CONSUMABLES 3.00%				1,911								1,911
ITEM DIRECT COST	550	CY	106.10	58,354		0	115.84	63,713	0.91	500	222.85	122,567
ITEM TOTAL COST	550	CY	148.54	81,696	0.00	0	162.18	89,198	1.27	700	311.99	171,594

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
401 PRECAST BOX CULVERT												
6' X 12 'X 6' LONG - 6.11 CY/LF WT/PC = 25,000 #												
BUY PRECAST SECTION	168	LF	475.00	79,800							475.00	79,800
HAUL PRECAST SECTION	28	EA	330.00	9,240							330.00	9,240
UNLOAD & SET SECTION	28	EA					493.00	13,804	100.00	2,800	593.00	16,604
FORM GROUTED JOINT 165.5 SF/JOINT	24	EA	414.00	9,936			350.00	8,400			764.00	18,336
GROUT JOINT BUY GROUT	26	CY	150.00	3,900							150.00	3,900
PUMP JOINT	24	EA					150.00	3,600	20.00	480	170.00	4,080
SMALL TOOLS & CONSUMABLES 3.00%				774								774
ITEM DIRECT COST	168	LF		103,650		0		25,884		3,280	790.08	132,734
ITEM TOTAL COST	168	LF	863.75	145,110	0.00	0	215.03	36,126	27.33	4,592	1106.12	185,828
402 RIP-RAP APRON												
BUY RIP-RAP	280	TNS	16.00	4,480							16.00	4,480
PLACE RIP-RAP	200	CY					10.80	2,160	4.00	800	14.80	2,960
SMALL TOOLS & CONSUMABLES 3.00%				65								65
ITEM DIRECT COST	200	CY		4,545		0		2,160		800	37.52	7,505
ITEM TOTAL COST	200	CY	31.81	6,363	0.00	0	15.12	3,024	5.60	1,120	52.53	10,507

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
403 CONCRETE												
FORMS												
FOOTINGS	420	SF	1.00	420			3.50	1,470			4.50	1,890
APRON EDGE	688	SF	1.00	688			3.50	2,408			4.50	3,096
WALLS 54 SF/CY	14,958	SF	0.50	7,479			4.75	71,051	0.60	8,975	5.85	87,505
BLOCKOUT	4	EA	50.00	200			140.00	560			190.00	760
RESTEEL 150 #/CY	57,600	LBS			0.75	43,200					0.75	43,200
CONCRETE												
BUY CONCRETE	383	CY	81.00	31,023							81.00	31,023
FINE GRADE	1,100	SF					0.50	550			0.50	550
PLACE FOOTINGS	32	CY					30.00	960	6.00	192	36.00	1,152
APRON	51	CY					25.00	1,275	6.00	306	31.00	1,581
WALLS	277	CY					18.00	4,986	6.00	1,662	24.00	6,648
PUMP CHARGE	383	CY	6.00	2,298							6.00	2,298
FINISH WALLS	14,958	SF	0.05	748			0.80	11,966			0.85	12,714
TROWEL	340	SF	0.00	0			0.75	255			0.75	255
CURE	16,390	SF	0.02	328			0.03	492			0.05	820
SMALL TOOLS & CONSUMABLES 3.00%				2,879								2,879
ITEM DIRECT COST	360	CY	127.95	46,063	120.00	43,200	266.59	95,973	30.93	11,135	545.48	196,371
ITEM TOTAL COST	400	CY	179.13	71,654	163.56	65,424	373.23	149,291	43.30	17,321	759.23	303,690

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
404 EXCAVATION												
EXCAVATE	2,500	CY					2.75	6,883	1.25	3,125	4.00	10,000
BACKFILL	2,100	CY					6.75	14,175	2.25	4,725	9.00	18,900
LOAD OUT	2,500	CY					0.93	2,313	0.78	1,953	1.71	4,266
LOAD STORED BACKFILL MAT'L BACK	2,100	CY	2.00	4,200			0.93	1,953	0.78	1,638	3.71	7,791
HAUL SURPLUS	400	CY	5.00	2,000							5.00	2,000
SMALL TOOLS & CONSUMABLES 3.00%				760								759.72
ITEM DIRECT COST	2,500	CY		6,960		0		25,324		11,441	17.49	43,725
ITEM TOTAL COST	2,500	CY	3.90	9,744	0.00	0	14.18	35,454	6.41	16,017	24.49	61,215
405 GRANULAR FILL												
BUY GRAN. FILL	1,275	TNS	13.00	16,570							13.00	16,570
SPREAD	750	CY					0.93	698	0.78	586	1.71	1,284
COMPACT	750	CY					10.00	7,500	2.00	1,500	12.00	9,000
SMALL TOOLS & CONSUMABLES 3.00%				246								246
ITEM DIRECT COST	750	CY		16,816		0		8,198		2,086	36.13	27,100
ITEM TOTAL COST	750	CY	31.39	23,542	0.00	0	15.30	11,477	3.89	2,920	50.59	37,940

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
501 FINE GRADE													
		11,132	SY					0.15	1,680	0.13	1,500	0.29	3,180
SMALL TOOLS & CONSUMABLES	3.00%				50								50
ITEM DIRECT COST		2.3	ACRES		50		0		1,680		1,500	1484.52	3,230
ITEM TOTAL COST		2.3	ACRES	30.68	71	0.00	0	1022.61	2,352	913.04	2,100	1966.33	4,523
502 GRAVEL MATERIAL													
BUY GRAVEL		832	TNS	14.50	12,064							14.50	12,064
SPREAD & SHAPE		640	CY	0.00	0			2.70	1,728	1.70	1,088	4.40	2,816
SMALL TOOLS & CONSUMABLES	3.00%				52								52
ITEM DIRECT COST		640	CY		12,116		0		1,728		1,088	23.33	14,932
ITEM TOTAL COST		640	CY	26.50	16,962	0.00	0	3.78	2,419	2.38	1,523	32.66	20,905
503 DREDGE MATERIAL													
EXCAVATE, HAUL & DISPOSAL		50	CY	10.00	500			5.00	250	3.00	150	18.00	900
SMALL TOOLS & CONSUMABLES	3.00%				8								8
ITEM DIRECT COST		50	CY		508		0		250		150	18.15	908
ITEM TOTAL COST		50	CY	14.21	711	0.00	0	7.00	350	4.20	210	25.41	1,271

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
600A OUTLET WEIR (EARTH)													
601A EXCAVATION													
EXC & LOAD		1,000	CY					5.00	5,000	2.97	2,970	7.97	7,970
HAUL TO WASTE		1,000	CY	10.00	10,000							10.00	10,000
SMALL TOOLS & CONSUMABLES	3.00%				150								150
ITEM DIRECT COST		1,000	CY		10,150		0		5,000		2,970	18.12	18,120
ITEM TOTAL [illegible]		1,000	CY	14.21	14,210	0.00	0	7.00	7,000	4.16	4,158	25.37	25,368
602A CLAY MATERIAL													
BUY & HAUL CLAY		1,340	CY	8.00	10,720							8.00	10,720
PLACE		1,340	CY					2.75	3,685	1.65	2,211	4.40	5,896
SMALL TOOLS & CONSUMABLES	3.00%				111								111
ITEM DIRECT COST		1,340	CY		10,831		0		3,685		2,211	12.48	16,727
ITEM TOTAL COST		1,340	CY	11.32	15,163	0.00	0	3.85	5,159	2.31	3,095	17.48	23,417
603A RIP RAP													
BUY STONE		750	TNS	17.00	12,750							17.00	12,750
PLACE		550	CY					13.40	7,370	7.95	4,373	21.35	11,743
SMALL TOOLS & CONSUMABLES	3.00%				221								221
ITEM DIRECT COST		550	CY		12,971		0		7,370		4,373	44.93	24,714
ITEM TOTAL COST		550	CY	33.02	18,160	0.00	0	18.76	10,318	11.13	6,122	62.91	34,600

FILE : 3ESTC PROJECT K A W A I N U I M A R S H
ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
600B OUTLET WEIR (CONCRETE)													
601B EXCAVATION													
EXC & LOAD		440	CY					5.00	2,200	2.97	1,307	7.97	3,507
HAUL TO WASTE		426	CY	10.00	4,260							10.00	4,260
SMALL TOOLS & CONSUMABLES	3.00%				66								66
ITEM DIRECT COST		440	CY		4,326		0		2,200		1,307	17.80	7,833
ITEM TOTAL COST		440	CY	13.76	6,056	0.00	0	7.00	3,080	4.16	1,830	24.92	10,966
602B EMBANKMENT													
PLACE & COMPACT		14	CY					8.00	112	1.50	21	9.50	133
SMALL TOOLS & CONSUMABLES	3.00%				3								3
ITEM DIRECT COST		14			3		0		112		21	9.74	136
ITEM TOTAL COST		14	CY	0.34	5	0.00	0	11.20	157	2.10	29	13.64	191

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
600B OUTLET WEIR (CONCRETE)												
603B CONCRETE,FORMS & RESTEEL												
FORMS SLAB	440	SF	2.00	880			5.40	2,376			7.40	3,256
SCREEDS	1,100	SF	0.15	165			0.40	440			0.55	605
RESTEEL 85 #/CY	17,000	LBS			0.75	12,750		0			0.75	12,750
CONCRETE -- BUY	220	CY	83.00	18,260							83.00	18,260
PLACE	220	CY					22.40	4,928	7.00	1,540	29.40	6,468
PUMP CHARGE	220	CY	8.50	1,870							8.50	1,870
FINISH	1,100	SF	0.02	22			0.70	768			0.72	790
CURE	1,540	SF	0.03	46			0.05	77			0.08	123
SMALL TOOLS & CONSUMABLES 3.00%				258								258
ITEM DIRECT COST	220	CY		21,501		12,750		8,589		1,540	201.73	44,380
ITEM TOTAL COST	220	CY	136.82	30,101	78.99	17,378	54.66	12,025	9.80	2,156	280.27	61,660

FILE : 3ESTC PROJECT K A W A I N U I M A R S H

ALT. C - LEVEE MODIFICATION / CHANNEL BLASTING REV. 0 16-Oct-83

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
700 CHANNEL BLASTING												
701 CHANNEL BLASTING												
701 BUY BLASTING MATERIAL												
AUSTIN DITCHING POWDER	12,000	LBS	2.80	33,600							2.80	33,600
'A' CORD - 25 GR.	70	M	115.00	8,050							115.00	8,050
ELECT CAPS	5,200	EA	2.00	10,400							2.00	10,400
PLASTIC PIPE	25,000	LF	0.50	12,500							0.50	12,500
STEMMING MATERIAL	260	TNS	15.00	3,900							15.00	3,900
MAKE UP BLAST STRINGS	5,000	EA					5.62	28,080	0.40	2,000	6.02	30,080
DRILL, LOAD & HOLES	5,000	EA	0.30	1,500			24.30	121,500	4.60	23,000	29.20	146,000
BLASTING BOX & LEADS, METER, ETC.	1	LS	1500.00	1,500							1500.00	1,500
DAY STORAGE MAGAZINES	6	MO	100.00	600							100.00	600
SMALL TOOLS & CONSUMABLES 3.00%				4,487								4,487
ITEM DIRECT COST	10,000	LF		76,537		0		149,580		25,000		251,117
ITEM TOTAL COST	10,000	LF	10.72	107,152	0.00	0	20.94	209,412	3.50	35,000	35.16	351,554

17-Oct-89 FPS ENGINEERING ASSOCIATES , INC.

FILE : 4ESTO1 PROJECT K A W A I N U I M A R S H

JOB NO. 10.89 ALT D LEVEE MODIFICATION OPTION D1 REV. 0 16-Oct-89

ESC & CONTINGENCY = 8.00% JULY 1990 AWARD

SUMMARY TOTAL COST WITH ESC. & CONTINGENCY

ITEM DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100 MOBILIZATION		LS		22,255		0		20,104		20,110		62,469
200 LEVEE MODIFICATION												
201 CLEAR & GRUB	9	ACRES	520	4,680		0	2,208	19,872	2,170	19,530	4898.00	44,082
202 REMOVE GRAVEL CAP	1,420	CY	4.00	5,680		0	5.00	7,100	6.00	8,520	15.00	21,300
203 REPLACE GRAVEL CAP	1,780	CY	9.00	16,020		0	5.00	8,900	6.00	10,680	20.00	35,600
204 SCARIFY SURFACE	44,100	SY	0.002	88		0	0.060	2,646	0.060	2,646	0.12	5,380
205 EXCAVATION FOR TOE	14,220	CY	29.00	412,380		0	7.00	99,540	4.00	56,880	40.00	568,800
206 EMBANKMENT	260,760	CY	11.00	2,868,360		0	2.00	521,520	1.00	260,760	14.00	3,650,640
207 GRAVEL FOR TOE	57,880	CY	34.00	1,967,920		0	7.00	405,160	3.00	173,640	44.00	2,546,720
300 TRAFFIC CONTROL		LS		103,867		0		196,318		16,330		316,515
TOTAL COST WITH ESC. & CONTINGENCY				5,401,250		0		1,281,160		569,096		7,251,506
											CHECK)))	7,251,506

PROJECT CONSTRUCTION TIME 14 MONTHS

FILE : 4ESTD1 PROJECT K A W A I N U I M A R S H SHEET 2 OF 7

JOB NO. 10.89 ALT D LEVEE MODIFICATION OPTION D1 REV. 0 16-Oct-89

ITEM DESCRIPTION		QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	TOTAL	SUB CONTRACT Unit Cost	TOTAL	LABOR Unit Cost	TOTAL	EQUIPMENT Unit Cost	TOTAL	TOTAL COST Unit Cost	TOTAL
SUMMARY TOTAL COST W\O CONTINGENCY													
100 MOBILIZATION			LS		20,606		0		10,614		18,620		57,841
200 LEVEE MODIFICATION													
201	CLEAR & GRUB	9	ACRES	481	4,332		0	2,044	18,396	2,009	18,081	4,534	40,809
202	REMOVE GRAVEL CAP	1,420	CY	3.28	4,661		0	4.54	6,440	5.31	7,536	13.12	18,637
203	REPLACE GRAVEL CAP	1,780	CY	8.40	14,949		0	4.54	8,077	5.41	9,625	18.34	32,651
204	SCARIFY SURFACE	44,100	SY	0.002	69		0	0.05	2,313	0.05	2,353	0.11	4,736
205	EXCAVATION FOR TOE	14,220	CY	27.09	385,283		0	6.37	90,581	4.13	58,729	37.59	534,593
206	EMBANKMENT	260,760	CY	10.20	2,660,621		0	1.63	425,768	1.15	300,261	12.99	3,386,650
207	GRAVEL FOR TOE	57,880	CY	31.83	1,842,454		0	6.10	353,158	2.52	145,858	40.45	2,341,470
300	TRAFFIC CONTROL	1	LS		96,173		0		181,776		15,120		293,069
TOTAL COST W\O CONTINGENCY					5,029,149		0		1,105,124		576,183		6,710,455
												CHECK))	6,710,455

PROJECT CONSTRUCTION TIME 14 MONTHS

FILE : 4ESTD1 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D1

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	TOTAL	SUB CONTRACT Unit Cost	TOTAL	LABOR Unit Cost	TOTAL	EQUIPMENT Unit Cost	TOTAL	TOTAL COST Unit Cost	TOTAL
100 MOBILIZATION													
CLEAR STOCKPILE AREA		4	ACRES	700.00	2,800			2100.00	8,400	2100.00	8,400	4900.00	19,600
HAUL EQUIPMENT IN & OUT		96	HRS	100.00	9,600							100.00	9,600
MISC. TRUCKING		32	HRS	60.00	1,920							60.00	1,920
LABOR & EQUIPMENT RIG/RIG DOWN		3	DAYS					1632.00	4,896	300.00	900	1932.00	5,796
STANDBY ON EQUIPMENT		1	LS							4000.00	4,000	4000.00	4,000
SMALL TOOLS & CONSUMABLES	3.00%				399								399
ITEM DIRECT COST		1	LS		14,719		0		13,296		13,300	41,315	41,315
ITEM TOTAL COST		1	LS	20606.43	20,606	0.00	0	18614.40	18,614	18620.00	18,620	57,841	57,841

FILE : 4ESTD1 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D1

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 LEVEE MODIFICATION													
201 CLEAR & GRUB													
MAIN CREW		9	ACRES					1060.00	9,540	955.00	8,595	2015.00	18,135
DRESS STREAM BANKS		1,800	LF					2.00	3,600	2.40	4,320	4.40	7,920
HAUL TO DISPOSAL 5 LOADS/ACRE		45	LOADS	60.00	2,700							60.00	2,700
SMALL TOOLS & CONSUMABLES	3.00%				394								394
ITEM DIRECT COST		9	ACRES		3,894		0		13,140		12,915	3,239	29,149
ITEM TOTAL COST	....	9	ACRES	481.32	4,332	0.00	0	2044.00	18,396	2009.00	18,081	4,534	40,809
202 REMOVE GRAVEL CAP													
EXCAVATE & DOZE		1,420	CY					3.00	4,260	3.65	5,183	6.65	9,443
WATER		5	DAYS					68.00	340	40.00	200	108.00	540
HAUL TO STOCKPILE		1,420	CY	2.25	3,191							2.25	3,191
SMALL TOOLS & CONSUMABLES	3.00%				138								138
ITEM DIRECT COST		1,420	CY		3,329		0		4,600		5,383	9.37	13,312
ITEM TOTAL COST	....	1,420	CY	3.28	4,661	0.00	0	4.54	6,440	5.31	7,536	13.12	18,637

FILE : 4ESTD1 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D1

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 LEVEE MODIFICATION												
203 REPLACE GRAVEL CAP												
BUY GROUND STORAGE LOSS (1780CY-1420CY=360CY)	500	TNS	13.00	6,500							13.00	6,500
SPREAD & ROLL	1,780	CY					3.05	5,429	3.75	6,675	6.80	12,104
WATER	5	DAYS					68.00	340	40.00	200	108.00	540
HAUL FROM STOCKPILE	1,780	CY	2.25	4,005							2.25	4,005
SMALL TOOLS & CONSUMABLES 3.00%				173								173
ITEM DIRECT COST	1,780	CY		10,678		0		5,769		6,875	13.10	23,322
ITEM TOTAL COST	1,780	CY	8.40	14,949	0.00	0	4.54	8,077	5.41	9,625	18.34	32,651
204 SCARIFY SURFACE												
DISK	44,100	SY					0.030	1,312	0.034	1,481	0.06	2,793
WATER	5	DAYS					68.00	340	40.00	200	108.00	540
SMALL TOOLS & CONSUMABLES 3.00%				50								50
ITEM DIRECT COST	44,100	SY		50		0		1,652		1,681	0.08	3,383
ITEM TOTAL COST	44,100	SY	0.00	69	0.00	0	0.05	2,313	0.05	2,353	0.11	4,736

FILE : 4ESTD1 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D1

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 LEVEE MODIFICATION												
205 EXCAVATION FOR TOE												
EXCAVATION	14,220	CY					3.35	47,637	1.30	18,486	4.65	66,123
LOAD OUT & HAUL TO STOCK PILE	14,220	CY	2.55	36,261			0.90	12,798	1.30	18,486	4.75	67,545
LOAD FROM STOCKPILE TO DISPOSAL	14,220	CY					0.30	4,266	0.35	4,977	0.65	9,243
HAULING	14,220	CY	10.00	142,200							10.00	142,200
DUMP FEE	940	LOADS	100.00	94,000							100.00	94,000
SMALL TOOLS & CONSUMABLES 3.00%				1,941								1,941
ITEM DIRECT COST	14,220	CY		275,202		0		64,701		41,949	26.85	381,852
ITEM TOTAL COST	14,220	CY	27.09	385,283	0.00	0	6.37	90,581	4.13	58,729	37.59	534,593
206 EMBANKMENT												
BUY & HAUL	260,760	CY	7.00	1,825,320							7.00	1,825,320
SPREAD & COMPACT	260,760	CY					1.00	260,760	0.70	182,532	1.70	443,292
LOAD & HAUL FROM STOCKPILE	55,000	CY	1.20	66,000			0.25	13,750	0.35	19,250	1.80	99,000
DRESS SLOPES ABOVE 0.00	423,000	SF					0.07	29,610	0.03	12,690	0.10	42,300
SMALL TOOLS & CONSUMABLES 3.00%				9,124								9,124
ITEM DIRECT COST	260,760	CY		1,900,444		0		304,120		214,472	9.28	2,419,036
ITEM TOTAL COST	260,760	CY	10.20	2,660,621	0.00	0	1.63	425,768	1.15	300,261	12.99	3,386,650

FILE : 4ESTD1 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D1

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 LEVEE MODIFICATION												
207 GRAVEL FOR TOE												
BUY & HAUL (#4 - 1 1/2 TO 3/4)	80,000	TNS	14.00	1,120,000							14.00	1,120,000
LOAD OUT FROM STOCKPILE	57,880	CY	1.25	72,350			0.25	14,470	0.35	20,258	1.85	107,078
PLACE GRAVEL	57,880	CY					3.75	217,050	1.45	83,926	5.20	300,976
FILTER FABRIC - 20% LAPS 6,400 LF 54 SF + 20.00%												
BUY	414,720	SF	0.27	111,974							0.27	111,974
INSTALL	414,720	SF	0.01	4,147			0.05	20,736			0.06	24,883
SMALL TOOLS & CONSUMABLES 3.00%				7,568								7,568
ITEM DIRECT COST	57,880	CY		1,316,039		0		252,256		104,184	28.90	1,672,479
ITEM TOTAL COST	57,880	CY	31.83	1,842,454	0.00	0	6.10	353,158	2.52	145,858	40.45	2,341,470
300 TRAFFIC CONTROL 12 MONTHS												
BARRICADES & LIGHTS	12	MONTHS	600.00	7,200							600.00	7,200
WATER TRUCK	240	DAYS					135.00	32,400	45.00	10,800	180.00	43,200
POLICE	1,920	HRS	30.00	57,600							30.00	57,600
FLAGMEN	480	DAYS					203.00	97,440			203.00	97,440
SMALL TOOLS & CONSUMABLES 3.00%				3,895								3,895
ITEM DIRECT COST	1	LS		68,695		0		129,840		10,800		209,335
ITEM TOTAL COST	1	LS	0.00	96,173	0.00	0	0.00	181,776	0.00	15,120	0.00	293,069

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H SHEET 1 OF 16

JOB NO. 10.89 ALT D LEVEE MODIFICATION OPTION D2 REV. 0 16-Oct-89

	ITEM DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
ESC & CONTINGENCY =	8.00%	JULY 1990 AWARD											
	SUMMARY TOTAL COST WITH ESC. & CONTINGENCY												
100	MOBILIZATION		LS		395,687		73,602		93,623		34,474		597,385
200	DISPOSAL AREA												
201	CLEAR & GRUB	12.5	ACRES	3,820	47,751		0	1,336	16,700	494	6,175	5,650	70,626
202	EXCAVATION	79,100	CY	9.00	711,900		0	2.00	158,200	1.00	79,100	12.00	949,200
203	EMBANKMENT	54,700	CY	0.02	1,094		0	1.00	54,700	1.00	54,700	2.02	110,494
204	GRAVEL	2,000	CY	42.00	84,000		0	2.00	4,000	3.00	6,000	47.00	94,000
205	OUTLET CONTROL		LS		175,976		0		104,644		1,514		282,134
300	LEVEE MODIFICATION												
301	CLEAR & GRUB	9	ACRES	520.00	4,680		0	2,208.00	19,872	2,170.00	19,530	4,898	44,082
302	REMOVE GRAVEL CAP	1,420	CY	3.54	5,030		0	4.83	6,852	5.69	8,079	14.06	19,961
303	REPLACE GRAVEL CAP	1,780	CY	10.00	17,800		0	5.00	8,900	6.00	10,680	21.00	37,380
304	SCARIFY SURFACE	44,100	SY	0.002	72		0	0.05	2,395	0.06	2,481	0.11	4,948
305	EXCAVATION FOR TOE	14,220	CY	29.00	412,380		0	7.00	99,540	4.00	56,880	40.00	568,800
306	EMBANKMENT	63,260	CY	11.00	695,860		0	2.00	126,520	1.00	63,260	14.00	885,640
307	GRAVEL FOR TOE	30,280	CY	36.00	1,090,080		0	7.00	211,960	3.00	90,840	46.00	1,392,880
308	STONE REVETMENT	11,110	CY	38.00	422,180		0	11.00	122,210	5.00	55,550	54.00	599,940
400	DITCH MODIFICATION												
401	VEGITATION REMOVAL	33,590	CY	20.00	671,800		0	8.00	268,720	5.00	167,950	33.00	1,108,470
402	SEDIMENTATION REMOVAL	56,840	CY	25.00	1,421,000		0	7.00	397,880	5.00	284,200	37.00	2,103,080
500	WIER STRUCTURE												
501	EXCAVATION	440	CY	15.00	6,600		0	8.00	3,520	4.00	1,760	27.00	11,880
502	EMBANKMENT	14	CY	0.36	5		0	12.00	168	2.00	28	14.36	201
503	CONCRETE	220	CY	148.00	32,560	85.00	18,700	59.00	12,980	11.00	2,420	303.00	66,660
504	SHEETPILE	135	TNS	1228.00	165,780		0	189.00	25,515	121.00	16,335	1,538.00	207,630
505	COFFERDAM FOR ACCESS	10,550	CY	11.00	116,050		0	2.00	21,100	1.00	10,550	14.00	147,700
506	VEGITATION REMOVAL	4,440	CY	20.00	88,800		0	6.00	26,640	4.00	17,760	30.00	133,200
600	TRAFFIC CONTROL		LS		106,691		0		290,455		14,969		412,115
	TOTAL COST WITH ESC. & CONTINGENCY				6,673,776		92,302		2,077,094		1,005,234		9,848,406
												CHECK)))	9,848,406

PROJECT CONSTRUCTION TIME 15 MONTHS

	ITEM DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
	SUMMARY TOTAL COST W\O CONTINGENCY												
100	MOBILIZATION		LS		366,377		68,150		86,688		31,920		553,135
200	DISPOSAL AREA												
201	CLEAR & GRUB	12.5	ACRES	3,537	44,214		0	1,237	15,460	457	5,712	5,231	65,386
202	EXCAVATION	79,100	CY	8.65	684,607		0	2.29	181,303	0.86	68,083	11.81	933,993
203	EMBANKMENT	54,700	CY	0.02	988		0	0.60	32,929	0.93	51,054	1.55	84,971
204	GRAVEL	2,000	CY	38.90	77,804		0	1.74	3,472	2.57	5,134	43.20	86,410
205	OUTLET CONTROL		LS		162,941		0		96,893		1,401		261,235
300	LEVEE MODIFICATION												
301	CLEAR & GRUB	9	ACRES	481	4,332		0	2,044	18,396	2,009	18,081	4,534	40,809
302	REMOVE GRAVEL CAP	1,420	CY	3.28	4,658		0	4.47	6,345	5.27	7,480	13.02	18,483
303	REPLACE GRAVEL CAP	1,780	CY	9.51	16,933		0	4.54	8,077	5.41	9,625	19.46	34,635
304	SCARIFY SURFACE	44,100	SY	0.002	67		0	0.05	2,218	0.05	2,297	0.10	4,582
305	EXCAVATION FOR TOE	14,220	CY	27.09	385,283		0	6.37	90,581	4.13	58,729	37.59	534,593
306	EMBANKMENT	63,260	CY	10.12	640,187		0	1.90	120,232	1.24	78,226	13.26	838,645
307	GRAVEL FOR TOE	30,280	CY	33.26	1,007,000		0	6.29	190,534	2.52	76,306	42.07	1,273,840
308	STONE REVETMENT	11,110	CY	35.36	392,895		0	9.80	108,879	4.27	47,440	49.43	549,215
400	DITCH MODIFICATION												
401	VEGITATION REMOVAL	33,590	CY	18.88	634,195		0	7.13	239,362	4.46	149,731	30.46	1,023,288
402	SEDIMENTATION REMOVAL	56,840	CY	23.52	1,336,983		0	6.17	350,980	4.24	241,149	33.94	1,929,112
500	WIER STRUCTURE												
501	EXCAVATION	440	CY	13.76	6,056		0	7.00	3,080	4.16	1,830	24.92	10,966
502	EMBANKMENT	14	CY	0.34	5		0	11.20	157	2.10	29	13.64	191
503	CONCRETE	220	CY	136.82	30,101	78.99	17,378	54.66	12,025	9.80	2,156	280.27	61,660
504	SHEETPILE	135	TNS	1,137.35	153,542		0	174.91	23,612	111.98	15,117	1,424.24	192,272
505	COFFERDAM FOR ACCESS	10,550	CY	9.84	103,833		0	1.40	14,770	0.98	10,339	12.22	128,942
506	VEGITATION REMOVAL	4,440	CY	18.09	80,299		0	5.51	24,465	3.29	14,629	26.89	119,392
600	TRAFFIC CONTROL		LS		98,788		0		268,940		13,860		381,588
	TOTAL COST W\O CONTINGENCY				6,232,087		85,528		1,899,398		910,329		9,127,342

PROJECT CONSTRUCTION TIME 15 MONTHS

CHECK))) 9,127,342

FILE : 4ESTD2 PROJECT KAWAINUI MARSH
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 LEVEE MODIFICATION												
301 CLEAR & GRUB												
MAIN CREW	9	ACRES					1060.00	9,540	955.00	8,595	2015.00	18,135
DRESS STREAM BANKS	1,800	LF					2.00	3,600	2.40	4,320	4.40	7,920
HAUL TO DISPOSAL 5 LOADS/ACRE	45	LOADS	60.00	2,700							60.00	2,700
SMALL TOOLS & CONSUMABLES 3.00%				394								394
ITEM DIRECT COST	9	ACRES		3,094		0		13,140		12,915		29,149
ITEM TOTAL COST	9	ACRES	481.32	4,332	0.00	0	2044.00	18,396	2009.00	18,081	4534.32	40,809
302 REMOVE/STOCKPILE GRAVEL												
EXCAVATE & DOZE	1,420	CY					3.00	4,260	3.65	5,183	6.65	9,443
WATER	4	DAYS					68.00	272	40.00	160	108.00	432
HAUL TO STOCKPILE	1,420	CY	2.25	3,191							2.25	3,191
SMALL TOOLS & CONSUMABLES 3.00%				136								136
ITEM DIRECT COST	1,420	CY		3,327		0		4,532		5,343		13,202
ITEM TOTAL COST	1,420	CY	3.28	4,658	0.00	0	4.47	6,345	5.27	7,480	13.02	18,483

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H SHEET 8 OF 16
ALT D LEVEE MODIFICATION OPTION D2 REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 LEVEE MODIFICATION												
303 REPLACE GRAVEL												
BUY GROUND STORAGE LOSS	609	TNS	13.00	7,917							13.00	7,917
SPREAD & ROLL	1,780	CY					3.05	5,429	3.75	6,675	6.80	12,104
WATER	5	DAYS					68.00	340	40.00	200	108.00	540
HAUL FROM STOCKPILE	1,780	CY	2.25	4,005							2.25	4,005
SMALL TOOLS & CONSUMABLES 3.00%				173								173
ITEM DIRECT COST	1,780	CY		12,095		0		5,769		6,875		24,739
ITEM TOTAL COST	1,780	CY	9.51	16,933	0.00	0	4.54	8,077	5.41	9,625	19.46	34,635
304 SCARIFY LEVEE SURFACE												
DISK	44,100	SY					0.030	1,312	0.034	1,481	0.06	2,793
WATER	4	DAYS					68.00	272	40.00	160	108.00	432
SMALL TOOLS & CONSUMABLES 3.00%				48								48
ITEM DIRECT COST	44,100	SY		48		0		1,584		1,641		3,273
ITEM TOTAL COST	44,100	SY	0.00	67	0.00	0	0.05	2,218	0.05	2,297	0.10	4,582

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

SHEET 5 OF 16
REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA												
203 EMBANKMENT	54,700	CY										
SPREAD & DRESS	54,700	CY					0.25	13,675	0.37	20,057	0.62	33,732
COMPACT - 90%	54,700	CY					0.18	9,846	0.30	16,410	0.48	26,256
SMALL TOOLS & CONSUMABLES 3.00%				706								706
ITEM DIRECT COST	54,700	CY		706		0		23,521		36,467	1.11	60,694
ITEM TOTAL COST	54,700	CY	0.02	988	0.00	0	0.60	32,929	0.93	51,054	1.55	84,971
204 GRAVEL FILL	2,000	CY										
BUY FOB JOB	3,700	TNS	15.00	55,500							15.00	55,500
PLACE & COMPACT	2,000	CY					1.24	2,480	1.83	3,667	3.07	6,147
SMALL TOOLS & CONSUMABLES 3.00%				74								74
ITEM DIRECT COST	2,000	CY		55,574		0		2,480		3,667	30.86	61,721
ITEM TOTAL COST	2,000	CY	38.90	77,804	0.00	0	1.74	3,472	2.57	5,134	43.20	86,410

17-Oct-89 FPS ENGINEERING ASSOCIATES , INC.

FILE : 4EST02 PROJECT K A W A I N U I M A R S H SHEET 6 OF 16
ALT D LEVEE MODIFICATION OPTION D2 REV. 0 16-Oct-89

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA												
205 DISPOSAL WIER & BOTTOM SEAL		LS										
BUILD 2 WIERS & FILER BOXES USE 24" RC PIPE FOR WIER USE 2" TIMBER BOXS - 15'X20'												
BUY												
24" RC PIPE	96	LF	16.00	1,536							16.00	1,536
TIMBER	4,000	BF	0.75	3,000							0.75	3,000
3/4" STONE	250	TNS	15.00	3,750							15.00	3,750
INSTALL												
TIMBER BOXES	2	EA					7000.00	14,000	100.00	200	7100.00	14,200
24" RC PIPE	96	LF					18.50	1,776	4.17	400	22.67	2,176
3/4" STONE	170	CY					6.53	1,113	2.35	401	8.88	1,514
SEAL CONFINEMENT AREA												
BUY REINFORCED POLY SHEATING	523,200	SF	0.20	104,640							0.20	104,640
INSTALL SHEATING	436,000	SF					0.12	52,320			0.12	52,320
SMALL TOOLS & CONSUMABLES 5.00%				3,460								3,460
ITEM DIRECT COST	LS			116,386		0		69,289		1,001		186,596
ITEM TOTAL COST	LS		0.00	162,941	0.00	0	0.00	96,893	0.00	1,401	0.00	261,235

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA													
201 CLEAR & GRUB		12.50	ACRES										
TYPICAL CREW		12.50	ACRES					883.44	11,043	326.40	4,080	1209.84	15,123
HAUL		125	LOADS	150.00	18,750							150.00	18,750
DISPOSAL FEE		125	LOADS	100.00	12,500							100.00	12,500
SMALL TOOLS & CONSUMABLES	3.00%				331								331
ITEM DIRECT COST		12.5	ACRES		31,581		0		11,043		4,080	3736.34	46,704
ITEM TOTAL COST		12.5	ACRES	3537.10	44,214	0.00	0	1236.82	15,460	456.96	5,712	5230.88	65,386
202 EXCAVATION		79,100	CY										
EXCAVATE & LOAD TRUCKS		79,100	CY					1.25	98,875	0.47	37,177	1.72	136,052
HAUL TO FILL		54,200	CY	1.60	86,720							1.60	86,720
LOAD SURPLUS		24,900	CY					1.23	30,627	0.46	11,454	1.69	42,081
HAUL TO WASTE		24,900	CY	16.00	398,400							16.00	398,400
SMALL TOOLS & CONSUMABLES	3.00%				3,885								3,885
ITEM DIRECT COST		79,100	CY		489,085		0		129,502		48,631	8.43	667,138
ITEM TOTAL COST		79,100	CY	8.65	684,607	0.00	0	2.29	181,303	0.86	68,083	11.81	933,993

CORRECTION

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

CORRECTION

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FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100 MOBILIZATION													
FLEX FLOATS													
OCEAN FRT		2	EA	75,000	150,000							75,000	150,000
TRUCKING		120	HRS	140.00	16,800							140.00	16,800
RIG UP & DOWN		20	DAYS					1680.00	33,600	400.00	8,000	2080.00	41,600
RENT		1	MONTH							2,000	2,000	2000.00	2,000
LAND EQUIPMENT													
TRUCKING 22 +22	LOADS	352	HRS	120.00	42,240							120.00	42,240
RIG UP & DOWN		10	DAYS					1680.00	16,800	400.00	4,000	2080.00	20,800
RENT		2	DAYS							2,000	4,000	2000.00	4,000
MISC. PLANT & EQUIPMENT													
TRUCKING		100	HRS	60.00	6,000							60.00	6,000
RIG UP & DOWN		4	DAYS					1680.00	6,720	400.00	1,600	2080.00	8,320
OFF LOAD FACILITY - DITCH MODIFICATION													
SHEET PILE BULKHEAD		2,000	SF			25.00	50,000					25.00	50,000
GRAVEL PAD	100 FT X 200 FT	3,200	TNS	14.00	44,800			1.50	4,800	1.00	3,200	16.50	52,800
SMALL TOOLS & CONSUMABLES	3.00%				1,858								1,858
ITEM DIRECT COST		1	LS		261,698		50,000		61,920		22,800	396,418	396,418
ITEM TOTAL COST		1	LS	366,377	366,377	68,150	68,150	86,688	86,688	31920.00	31,920	553,135	553,135

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
200 DISPOSAL AREA												
201 CLEAR & GRUB	12.50	ACRES										
TYPICAL CREW	12.50	ACRES					883.44	11,043	326.40	4,080	1209.84	15,123
HAUL	125	LOADS	150.00	18,750							150.00	18,750
DISPOSAL FEE	125	LOADS	100.00	12,500							100.00	12,500
SMALL TOOLS & CONSUMABLES 3.00%				331								331
ITEM DIRECT COST	12.5	ACRES		31,581		0		11,043		4,080	3736.34	46,784
ITEM TOTAL COST	12.5	ACRES	3537.10	44,214	0.00	0	1236.82	15,460	456.96	5,712	5230.88	65,386
202 EXCAVATION	79,100	CY										
EXCAVATE & LOAD TRUCKS	79,100	CY					1.25	98,875	0.47	37,177	1.72	136,052
HAUL TO FILL	54,200	CY	1.60	86,720							1.60	86,720
LOAD SURPLUS	24,900	CY					1.23	30,627	0.46	11,454	1.69	42,081
HAUL TO WASTE	24,900	CY	16.00	398,400							16.00	398,400
SMALL TOOLS & CONSUMABLES 3.00%				3,885								3,885
ITEM DIRECT COST	79,100	CY		489,805		0		129,502		48,631	8.43	667,138
ITEM TOTAL COST	79,100	CY	8.65	684,607	0.00	0	2.29	181,303	0.86	68,083	11.81	933,993

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 LEVEE MODIFICATION												
305 EXCAVATION FOR TOE												
EXCAVATION	14,220	CY					3.35	47,637	1.30	18,486	4.65	66,123
LOAD OUT & HAUL TO STOCK PILE	14,220	CY	2.55	36,261			0.90	12,798	1.30	18,486	4.75	67,545
LOAD FROM STOCKPILE TO DISPOSAL	14,220	CY					0.30	4,266	0.35	4,977	0.65	9,243
HAULING	14,220	CY	10.00	142,200							10.00	142,200
DUMP FEE	948	LOADS	100.00	94,800							100.00	94,800
SMALL TOOLS & CONSUMABLES 3.00%				1,941								1,941
ITEM DIRECT COST	14,220	CY		275,202		0		64,701		41,949	26.85	381,852
ITEM TOTAL COST	14,220	CY	27.09	385,283	0.00	0	6.37	90,581	4.13	58,729	37.59	534,593
306 EMBANKMENT												
BUY & HAUL	63,620	CY	7.00	445,340							7.00	445,340
SPREAD & COMPACT	63,280	CY					1.00	63,280	0.70	44,296	1.70	107,576
LOAD & HAUL FROM STOCKPILE	7,800	CY	1.20	9,360			0.25	1,950	0.35	2,730	1.80	14,040
DRESS SLOPES ABOVE 0.00	295,000	SF					0.07	20,650	0.03	8,850	0.10	29,500
SMALL TOOLS & CONSUMABLES 3.00%				2,576								2,576
ITEM DIRECT COST	63,260	CY		457,276		0		85,880		55,876	9.47	599,032
ITEM TOTAL COST	63,260	CY	10.12	640,187	0.00	0	1.90	120,232	1.24	78,226	13.26	838,645

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
300 LEVEE MODIFICATION												
307 GRAVEL FOR TOE												
BUY & HAUL (#4 - 1 1/2 TO 3/4) (1.4 TNS/CY)	42,392	TNS	14.00	593,488							14.00	593,488
LOAD OUT FROM STOCKPILE	30,280	CY	1.25	37,850			0.25	7,570	0.35	10,598	1.85	56,018
PLACE GRAVEL	30,280	CY					3.75	113,550	1.45	43,906	5.20	157,456
FILTER FABRIC - 20% LAPS 6,400 LF												
39 SF + 20.00% BUY	299,520	SF	0.27	80,870							0.27	80,870
INSTALL	299,520	SF	0.01	2,995			0.05	14,976			0.06	17,971
SMALL TOOLS & CONSUMABLES 3.00%				4,083								4,083
ITEM DIRECT COST	30,280	CY		719,286		0		136,096		54,584	30.05	903,886
ITEM TOTAL COST	30,280	CY	33.26	1,007,000	0.00	0	6.29	190,534	2.52	76,306	42.07	1,273,840
308 STONE REVETMENT												
BUY & HAUL 1.45 TN/CY	16,110	TNS	16.00	257,752							16.00	257,752
LOAD OUT FROM STOCKPILE	11,110	CY	1.85	20,554			0.35	3,889	0.50	5,555	2.70	29,998
PLACE ARMOR	11,110	CY					6.65	73,882	2.55	28,331	9.20	102,213
SMALL TOOLS & CONSUMABLES 3.00%				2,333								2,333
ITEM DIRECT COST	11,110	CY		280,639		0		77,771		33,886	35.31	392,296
ITEM TOTAL COST	11,110	CY	35.36	392,895	0.00	0	9.80	108,879	4.27	47,440	49.43	549,215

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
400 DITCH MODIFICATION												
401 VEGITATION REMOVAL	33,590	CY										
•USE CRANE ON SECT BARGE WITH ORANGE PEEL, CLAM/DRAG BUCKETS AND SECT. BARGE FOR MATERIAL												
EXCAVATE MAT	33,590	CY					2.40	80,616	1.65	55,424	4.05	136,040
UNLOAD MAT EXCAVATION	33,590	CY					1.31	44,003	0.50	16,795	1.81	60,798
HANDLE & PROCESS	33,590	CY					0.82	27,544	0.33	11,085	1.15	38,629
LOAD OUT MAT MATERIAL	26,872	CY					0.70	18,810	0.88	23,647	1.58	42,457
HAUL TO DISPOSAL	26,872	CY	10.00	268,720							10.00	268,720
DISPOSAL FEE	1,791	LOADS	100.00	179,147							100.00	179,147
SMALL TOOLS & CONSUMABLES 3.00%				5,129								5,129
ITEM DIRECT COST	33,590	CY		452,996		0		170,973		106,951	21.76	730,920
ITEM TOTAL COST	33,590	CY	18.88	634,195	0.00	0	7.13	239,362	4.46	149,731	30.46	1,023,288

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
500 WIER STRUCTURE													
506 VEGITATION REMOVAL													
EXCAVATE MAT		4,440	CY					1.84	8,186	1.33	5,920	3.18	14,106
UNLOAD MAT EXCAVATION		4,440	CY					1.00	4,440	0.45	1,998	1.45	6,438
HANDLE & PROCESS		4,440	CY					0.82	3,641	0.33	1,465	1.15	5,106
LOAD OUT MAT MATERIAL		3,552	CY					0.34	1,208	0.30	1,066	0.64	2,274
HAUL TO DISPOSAL		3,552	CY	16.00	56,832							16.00	56,832
SMALL TOOLS & CONSUMABLES	3.00%				524								524
ITEM DIRECT COST		4,440	CY		57,356		0		17,475		10,449	19.21	85,280
ITEM TOTAL COST		4,440	CY	18.09	80,299	0.00	0	5.51	24,465	3.29	14,629	26.89	119,392

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
. ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
400 DITCH MODIFICATION												
402 SEDIMENTATION REMOVAL	56,840	CY										
EXCAVATION	56,848	CY					2.40	136,435	1.65	93,799	4.05	230,234
OFF LOAD	56,848	CY					1.31	74,471	0.50	28,424	1.81	102,895
LOAD OUT	56,848	CY					0.70	39,794	0.88	50,026	1.58	89,820
HAUL & DISPOSAL	56,848	CY	10.00	568,480							10.00	568,480
DISPOSAL	3,790	LOADS	100.00	378,987							100.00	378,987
SMALL TOOLS & CONSUMABLES 3.00%				7,521								7,521
ITEM DIRECT COST	56,840	CY		954,988		0		250,700		172,249	24.24	1,377,937
ITEM TOTAL COST	56,840	CY	23.52	1,336,983	0.00	0	6.17	350,980	4.24	241,149	33.94	1,929,112

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
500 WIER STRUCTURE												
501 EXCAVATION												
EXC & LOAD	440	CY					5.00	2,200	2.97	1,307	7.97	3,507
HAUL TO WASTE	426	CY	10.00	4,260							10.00	4,260
SMALL TOOLS & CONSUMABLES 3.00%				66								66
ITEM DIRECT COST	440	CY		4,326		0		2,200		1,307	17.80	7,833
ITEM TOTAL.COST	440	CY	13.76	6,056	0.00	0	7.00	3,080	4.16	1,830	24.92	10,966
502 EMBANKMENT												
PLACE & COMPACT	14	CY					8.00	112	1.50	21	9.50	133
SMALL TOOLS & CONSUMABLES 3.00%				3								3
ITEM DIRECT COST	14			3		0		112		21	9.74	136
ITEM TOTAL COST	14	CY	0.34	5	0.00	0	11.20	157	2.10	29	13.64	191

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H SHEET 14 OF 16
ALT D LEVEE MODIFICATION OPTION D2 REV. 0 16-Oct-89

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
500 WIER STRUCTURE													
503 CONCRETE,FORMS & RESTEEL													
FORMS SLAB		440	SF	2.00	880			5.40	2,376			7.40	3,256
SCREEDS		1,100	SF	0.15	165			0.40	440			0.55	605
RESTEEL	85 #/CY	17,000	LBS			0.75	12,750		0			0.75	12,750
CONCRETE BUY		220	CY	83.00	18,260							83.00	18,260
PLACE		220	CY					22.40	4,928	7.00	1,540	29.40	6,468
PUMP CHARGE		220	CY	8.50	1,870							8.50	1,870
FINISH		1,100	SF	0.02	22			0.70	768			0.72	790
CURE		1,540	SF	0.03	46			0.05	77			0.08	123
SMALL TOOLS & CONSUMABLES	3.00%				258								258
ITEM DIRECT COST		220	CY		21,501		12,750		8,589		1,540	201.73	44,380
ITEM TOTAL COST		220	CY	136.82	30,101	78.99	17,378	54.66	12,025	9.80	2,156	280.27	61,660

FPS ENGINEERING ASSOCIATES , INC.

FILE : 4ESTD2 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
500 WIER STRUCTURE												
504 SHEETPILE	1,000	LF										
BUY SHEETPILE - 27 # /SF	270,000	LBS	0.40	108,000							0.40	108,000
TEMPLATE MAT'L	1	LS	500.00	500							500.00	500
PD CONSUMABLES	6,670	LF	0.10	667							0.10	667
UNLOAD SHEETS 135 TNS	135	TNS					10.41	1,405	6.67	900	17.07	2,305
PITCH & DRIVE	667	PCS					23.18	15,461	14.84	9,898	38.02	25,359
SMALL TOOLS & CONSUMABLES 3.00%				506								506
ITEM DIRECT COST	135	TNS		109,673		0		16,866		10,798	1017.31	137,337
ITEM TOTAL COST	135	TNS	1137.35	153,542	0.00	0	174.91	23,612	111.98	15,117	1424.24	192,272
505 COFFERDAM FOR ACCESS												
BUY & HAUL FILL	10,550	CY	7.00	73,850	0.00	0		0	0.00	0	7.00	73,850
SPREAD FILL	10,550	CY					1.00	10,550	0.70	7,385	1.70	17,935
SMALL TOOLS & CONSUMABLES 3.00%				317								317
ITEM DIRECT COST	10,550	CY		74,167		0		10,550		7,385	8.73	92,102
ITEM TOTAL COST	10,550	CY	9.84	103,833	0.00	0	1.40	14,770	0.98	10,339	12.22	128,942

FILE : 4EST02 PROJECT K A W A I N U I M A R S H
ALT D LEVEE MODIFICATION OPTION D2

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
500 WIER STRUCTURE													
506 VEGITATION REMOVAL													
EXCAVATE MAT		4,440	CY					1.84	8,186	1.33	5,920	3.18	14,106
UNLOAD MAT EXCAVATION		4,440	CY					1.00	4,440	0.45	1,998	1.45	6,438
HANDLE & PROCESS		4,440	CY					0.82	3,641	0.33	1,465	1.15	5,106
LOAD OUT MAT MATERIAL		3,552	CY					0.34	1,208	0.30	1,066	0.64	2,274
HAUL TO DISPOSAL		3,552	CY	16.00	56,832							16.00	56,832
SMALL TOOLS & CONSUMABLES	3.00%				524								524
ITEM DIRECT COST		4,440	CY		57,356		0		17,475		10,449	19.21	85,280
ITEM TOTAL COST		4,440	CY	18.09	80,299	0.00	0	5.51	24,465	3.29	14,629	26.89	119,392

13-Jun-90 FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 1 OF 2

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

REV. 0 13-Jun-90

	ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
ESC & CONTINGENCY =	8.00%	JULY 1991 AWARD											
	SHEET 2 FOREWARD				658,915		184,248		203,174		58,675		1,105,012
300	DISPOSAL AREA - VEGITATION HANDLING AREA												
301	HAMMERMILL	1	EA	26,478	26,478			605.00	605	151.00	151	27234.00	27,234
302	BALER	1	EA	41,867	41,867			4,536.00	4,536	1,210.00	1,210	47613.00	47,613
303	BIN WALL - DOCK/RET. WALL	6,120	SF	31.00	189,720			7.00	42,840	2.00	12,240	40.00	244,800
304	GABIONS - 3' X 6 'X 1 1/2'	190	EA	154.00	29,260			29.00	5,510	6.00	1,140	189.00	35,910
400	DISPOSAL AREA												
401	GRAVEL - 12"	12,130	CY	35.00	424,550			3.00	36,390	1.00	12,130	39.00	473,070
402	SAND BED - 18"	18,190	CY	48.00	873,120			3.00	54,570	1.00	18,190	52.00	945,880
403	GEOSYNTH, 36 MILL	36,390	SY	21.00	764,190			0.30	10,917	0.10	3,639	21.40	778,746
404	CONC. PAD 10' X 10' X 6"	14	CY	153.00	2,142			88.00	1,232			241.00	3,374
405	CONTROL GATES W/ CONC.	10	EA	3,464.00	34,640	276.00	2,760	1,681.00	16,810	117.00	1,170	5,538.00	55,380
406	PARSHAL FLUMES 1'-0"	2	EA	2,333.00	4,666			397.00	794			2,730.00	5,460
407	DATA RECORDERS	2	EA	2,314.00	4,628			151.00	302			2,465.00	4,930
408	SILT SCREENS	40	SY	20.00	800			8.00	320	3.00	120	31.00	1,240
409	CM ARCH - 49" X 33"	85	LF	51.00	4,335			95.00	8,075	27.00	2,295	173.00	14,705
410	ARCH HEADWALLS & PADS	2	EA	529.00	1,058	383.00	766	762.00	1,524	5.00	10	1,679.00	3,358
411	CMP 24"	50	LF	78.00	3,900			41.00	2,050	11.00	550	130.00	6,500
412	CMP HEADWALL & PADS	2	EA	215.00	430	147.00	294	378.00	756	2.00	4	742.00	1,484
500	CHANELIZATION												347,700
501	BLASTED CHANNEL	9,500	LF	8.30	78,850			23.30	221,350	5.00	47,500	36.60	
502	MISC CLEARING											NOT INCLUDED	
503	MISC EXCAVATION											NOT INCLUDED	
	TOTAL COST WITH ESC. & CONTINGENCY				3,143,549		188,068		611,755		159,024		4,102,396
												CHECK>>>	4,102,396

PROJECT CONSTRUCTION TIME 12 MONTHS

FPS ENGINEERING ASSOCIATES, INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

REV. 0 13-Jun-90

ESC & CONTINGENCY = 8.00% JULY 1991 AWARD

SUMMARY TOTAL COST WITH ESC. & CONTINGENCY

	ITEM DESCRIPTION	QUANITY NUMBER	QUANITY Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100	MOBILIZATION		LS		18,884				24,676		9,072		52,632
200	DISPOSAL AREA - GENERAL												
201	CLEAR & GRUB	13.7	AC	3,816	52,279			1,204	16,495	1,110	15,207	6,130	83,981
202	EXCAVATION	9,570	CY	0.10	957			3.00	28,710	1.00	9,570	4.10	39,237
203	EMBANKMENT - IMPORTED	17,720	CY	11.00	194,920			4.00	70,880	1.00	17,720	16.00	283,520
204	GRAVEL FILL	7,090	CY	43.00	304,870			5.00	35,450	1.00	7,090	49.00	347,410
205	FENCE - 8 FT CHAIN LINK	4,160	LF			29.00	122,474					29.00	122,474
206	GATE 24' DOUBLE	1	EA			2,650	2,650					2,650	2,650
207	GATE 30' DOUBLE	1	EA			3,240	3,240					3,240	3,240
208	OFFICE - STD DETAIL D-09	1	EA	25,539	25,539			794	794			26,333	26,333
209	MAINT. BLDG - STD DETAIL	1	EA	21,759	21,759			794	794			22,553	22,553
210	STORAGE SHED	800	SF	17	13,600	0.30	240	31	24,800	0.02	16	48.32	38,656
211	PORT. TOILETS	2	EA	4,536	9,072							4,536	9,072
212	WATER LINE 1"	830	LF			29.00	24,070					29.00	24,070
213	HOSE BIB W/4'X4' PAD	1	EA	115	115			53	53			168.00	168
214	FLEX. OFFICE HOOK UP	1	EA	39	39			38	38			77.00	77
215	WATER METER 1"	1	EA	1,383	1,383							1,383.00	1,383
216	TRANSFORMER	1	EA									INCLUDED IN ITEM 218	
217	POWER POLES, 40'	2	EA									INCLUDED IN ITEM 218	
218	POWER LINE	300	LF	50	15,000							50.00	15,000
219	ELECT HOOK UP	2	EA			1,227.00	2,454					1,227	2,454
220	LANDSCAPE - HIBISCUS HEDGE	1,120	LF			26.00	29,120					26.00	29,120
221	MISC. SIGNS		LS		498				484				982
	SUBTOTAL COST WITH ESC. & CONTINGENCY				658,915		184,248		203,174		58,875		1,105,012
												CHECK>>>	1,105,012

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 1 OF 17

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

REV. 0 13-Jun-90

	ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
	SHEET 2 FOREWARD				605,684		172,571		184,724		60,784		1,023,763
300	DISPOSAL AREA - VEGITATION HANDLING AREA												
301	HAMMERMILL	1	EA	24,517	24,517			560.00	560	140.00	140	25,217	25,217
302	BALER	1	EA	38,766	38,766			4,200.00	4,200	1,120.00	1,120	44,086	44,086
303	BIN WALL - DOCK/RET. WALL	6,120	SF	28.66	175,382			6.09	37,271	1.75	10,710	36.50	223,383
304	GABIONS - 3' X 6 'X 1 1/2'	190	EA	142.99	27,167			26.60	5,054	5.53	1,051	175.12	33,273
400	DISPOSAL AREA												
401	GRAVEL - 12"	12,130	CY	32.63	395,800			2.66	32,266	0.69	8,322	35.98	436,388
402	SAND BED - 18"	18,190	CY	44.74	813,817			2.66	48,385	0.69	12,478	48.09	874,681
403	GEOSYNTH, 36 MILL	36,390	SY	19.74	718,506			0.28	10,189	0.07	2,548	20.09	731,243
404	CONC. PAD 10' X 10' X 6"	14	CY	142.05	1,989			81.80	1,145			223.85	3,134
405	CONTRO[illegible]ATES W/ CONC.	10	EA	3,207.20	32,072	255.56	2,556	1,556.80	15,568	108.50	1,085	5,128.07	51,281
406	PARSHAL FLUMES 1'-0"	2	EA	2,160.02	4,320			367.50	735			2,527.52	5,055
407	DATA RECORDERS	2	EA	2,142.70	4,285			140.00	280			2,282.70	4,565
408	SILT SCREENS	40	SY	18.90	756			7.00	280	2.80	112	28.70	1,148
409	CM ARCH - 49" X 33'	85	LF	47.45	4,033			88.20	7,497	24.85	2,113	160.50	13,643
410	ARCH HEADWALLS & PADS	2	EA	490.17	980	354.38	709	705.60	1,411	4.90	10	1,555.05	3,110
411	CMP 24"	50	LF	72.53	3,627			37.80	1,890	10.50	525	120.83	6,042
412	CMP HEADWALL & PADS	2	EA	199.50	399	136.30	273	350.00	700	2.10	4	687.90	1,376
500	CHANELIZATION												
501	BLASTED CHANNEL	9,500	LF	7.69	73,058			21.56	204,820	4.62	43,890	33.87	321,768
502	MISC CLEARING											NOT INCLUDED	
503	MISC EXCAVATION											NOT INCLUDED	
	TOTAL COST WITH ESC. & CONTINGENCY	....			2,925,157		176,108		556,976		144,892		3,803,133
												CHECK)))	3,803,133

FILE : EST690 PROJECT K A W A I N U I M A R S H

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	Unit	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
SUMMARY TOTAL COST W\O CONTINGENCY												
100 MOBILIZATION	LS			17,485				22,848		8,400		48,733
200 DISPOSAL AREA - GENERAL												
201 CLEAR & GRUB	13.7	AC	3,533.45	48,408			1,115.09	15,277	1,027.62	14,078	5,676.17	77,764
202 EXCAVATION	9,570	CY	0.09	880			3.07	29,348	1.32	12,597	4.48	42,826
203 EMBANKMENT - IMPORTED	17,720	CY	10.05	178,130			3.25	57,666	1.18	20,831	14.48	256,627
204 GRAVEL FILL	7,090	CY	39.51	280,129			4.93	34,959	0.69	4,864	45.13	319,952
205 FENCE - 8 FT CHAIN LINK	4,160	LF			27.26	113,402					27.26	113,402
206 GATE 24' DOUBLE	1	EA			2,453.40	2,453					2,453.40	2,453
207 GATE 30' DOUBLE	1	EA			2,999.96	3,000					2,999.96	3,000
208 OFFICE - STD DETAIL D-09	1	EA	23,647	23,647			735.00	735			24,382	24,382
209 MAINT. BLDG - STD DETAIL	1	EA	20,147	20,147			735.00	735			20,882	20,882
210 STORAGE SHED	800	SF	15.71	12,572	0.26	204	28.28	22,624	0.02	14	44.27	35,414
211 PORT. TOILETS	2	EA	4,200.00	8,400							4,200.00	8,400
212 WATER LINE 1"	830	LF			27.26	22,626					27.26	22,626
213 HOSE BIB W/4'X4' PAD	1	EA	106.47	106			49.00	49			155.47	155
214 FLEX. OFFICE HOOK UP	1	EA	36.05	36			35.00	35			71.05	71
215 WATER METER 1"	1	EA	1,281.00	1,281							1,281.00	1,281
216 TRANSFORMER	1	EA									INCLUDED IN ITEM 218	
217 POWER POLES, 40'	2	EA									INCLUDED IN ITEM 218	
218 POWER LINE	300	LF	46.67	14,000							46.67	14,000
219 ELECT HOOK UP	2	EA			1,135.83	3,408					1,135.83	3,408
220 LANDSCAPE - HIBISCUS HEDGE	1,120	LF			24.53	27,478					24.53	27,478
221 MISC. SIGNS	LS		461.44	461			448.00	448			909.44	909
SUBTOTAL TOTAL COST W/O ESC & CONTG.				605,684		172,571		184,724		60,784		1,023,763
											CHECK>>>	1,023,763

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 3 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
100 MOBILIZATION												
HAUL EQUIPMENT IN & OUT	90	HRS	100.00	9,000							100.00	9,000
MISC. TRUCKING	50	HRS	60.00	3,000							60.00	3,000
LABOR & EQUIPMENT RIG/RIG DOWN	10	DAYS					1,632.00	16,320	300.00	3,000	1,932.00	19,320
STANDBY ON EQUIPMENT	1	LS							3000.00	3,000	3,000.00	3,000
SMALL TOOLS & CONSUMABLES 3.00%				490								490
ITEM DIRECT COST				12,490		0		16,320		6,000		34,810
ITEM TOTAL COST			0.00	17,485	0.00	0	0.00	22,848	0.00	8,400	0.00	48,733

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 4 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
201 CLEAR & GRUB													
TYPICAL CREW		13.70	ACRES					796.49	10,912	734.00	10,056	1530.49	20,968
HAUL		137	LOADS	150.00	20,550							150.00	20,550
DISPOSAL FEE		137	LOADS	100.00	13,700							100.00	13,700
SMALL TOOLS & CONSUMABLES	3.00%				327								327
ITEM DIRECT COST		13.7	ACRES		34,577		0		10,912		10,056	4,054.41	55,545
ITEM TOTAL COST		13.7	ACRES	3533.45	48,408	0.00	0	1115.09	15,277	1027.62	14,078	5,676.17	77,764
202 EXCAVATION													
EXCAVATE,HAUL & COMPACT		9,570	CY					1.25	11,963	0.47	4,498	1.72	16,461
FINE GRADE FLOW DITCHES		15,000	SF					0.60	9,000	0.30	4,500	0.90	13,500
SMALL TOOLS & CONSUMABLES	3.00%				629								629
ITEM DIRECT COST		9,570	CY		629		0		20,963		8,998	3.20	30,590
ITEM TOTAL COST		9,570	CY	0.09	880	0.00	0	3.07	29,348	1.32	12,597	4.48	42,828

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 5 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
203 EMBANKMENT - IMPORTED												
SPREAD, COMPACT & DRESS	17,720	CY					2.10	37,212	0.69	12,227	2.79	49,439
FINE GRADE AREA	66,308	SY					0.06	3,978	0.04	2,652	0.10	6,630
BUY FILL	21,000	CY	6.00	126,000							6.00	126,000
SMALL TOOLS & CONSUMABLES 3.00%				1,236								1,236
ITEM DIRECT COST	17,720	CY		127,236		0		41,190		14,879	10.34	183,305
ITEM TOTAL COST	17,720	CY	10.05	178,130	0.00	0	3.25	57,666	1.18	20,831	14.48	256,627
204 GRAVEL FILL												
BUY FOB JOB TN/CY = 1.55	10,990	TNS	15.00	164,843							15.00	164,843
PLACE & COMPACT	7,090	CY					1.90	13,471	0.49	3,474	2.39	16,945
FILTER CLOTH	230,000	SF	0.15	34,500			0.05	11,500			0.20	46,000
SMALL TOOLS & CONSUMABLES 3.00%				749								749
ITEM DIRECT COST	7,090	CY		200,092		0		24,971		3,474	32.23	228,537
ITEM TOTAL COST	7,090	CY	39.51	280,129	0.00	0	4.93	34,959	0.69	4,864	45.13	319,952

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 6 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
205 FENCE - 8 FT CHAIN LINK													
INSTALLED RAILINGS INC		4,160	LF			20.00	83,200					20.00	83,200
SMALL TOOLS & CONSUMABLES	0.00%				0								0
ITEM DIRECT COST		4,160	LF		0		83,200		0		0	20.00	83,200
ITEM TOTAL COST		4,160	LF	0.00	0	27.26	113,402	0.00	0	0.00	0	27.26	113,402
206 GATE 24' DOUBLE													
INSTALLED		1	EA			1,800	1,800					1,800	1,800
SMALL TOOLS & CONSUMABLES	0.00%				0								0
ITEM DIRECT COST		1	EA		0		1,800		0		0		1,800
ITEM TOTAL COST		1	EA	0.00	0	2,453	2,453	0.00	0	0.00	0	2,453	2,453
207 GATE 30' DOUBLE													
INSTALLED		1	EA			2,201	2,201					2,201	2,201
SMALL TOOLS & CONSUMABLES	0.00%				0								0
ITEM DIRECT COST		1	EA		0		2,201		0		0		2,201
ITEM TOTAL COST		1	EA	0.00	0	3,000	3,000	0.00	0	0.00	0	3,000	3,000

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 7 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
208 OFFICE - STD DETAIL D-09												
HAUL IN & OUT	2	EA	450.00	[illegible]							450.00	900
SET UP	1	EA	25.00	25			75.00	75			100.00	100
STAIRS & HANDRAIL	1	EA	250.00	250			450	450			700.00	700
RENT MOKULUA CONSULTS.	24	MO	550.00	13,200							550.00	13,200
FURNITURE	1	LS	2,500.00	2,500								2,500
SMALL TOOLS & CONSUMABLES 3.00%				16								16
ITEM DIRECT COST	1	EA		16,891		0		525		0	17,416	17,416
ITEM TOTAL COST	1	EA	23847.05	23,647	0.00	0	735.00	735	0.00	0	24,382	24,382
209 MAINT. BLDG - STD DETAIL												
HAUL IN & OUT	2	EA	450.00	900							450.00	900
SET UP	1	EA	25.00	25			75.00	75			100.00	100
STAIRS & HANDRAIL	1	EA	250.00	250			450	450			700.00	700
RENT MOKULUA CONSULTS.	24	MO	550.00	13,200							550.00	13,200
SMALL TOOLS & CONSUMABLES 3.00%				16								16
ITEM DIRECT COST	1	EA		14,391		0		525		0	14,916	14,916
ITEM TOTAL COST	1	EA	20147.05	20,147	0.00	0	735.00	735	0.00	0	20,882	20,882

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 8 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
210 STORAGE SHED 20 X 40	800	SF										
FTGS 8 EA	3	CY	110.00	330	50.00	150	40.00	120			200.00	600
WOOD FRAME 3+7	2,000	SF	3.00	6,000			7.00	14,000			10.00	20,000
CORRG SIDE & ROOF	2,000	SF	0.85	1,700			0.80	1,600			1.65	3,300
DOOR 3 X 8	1	EA	0.00	0			150.00	150			150.00	150
DOOR 8 X 8	1	EA	0.00	0			250.00	250			250.00	250
GRAVEL FLOOR	20	CY	23.25	465			2.00	40	0.50	10	25.75	515
SMALL TOOLS & CONSUMABLES 3.00%				485								485
ITEM DIRECT COST	800	SF		8,980		150		16,160		10	31.62	25,300
ITEM TOTAL COST	800	SF	15.71	12,572	0.26	204	28.28	22,624	0.02	14	44.27	35,414
211 PORT. TOILETS	2	EA										
RENT INCL DISPOSAL	48	MONTHS	125.00	6,000							125.00	6,000
SMALL TOOLS & CONSUMABLES 3.00%				0								0
ITEM DIRECT COST	2	EA		6,000		0		0		0	3,000	6,000
ITEM TOTAL COST	2	EA	4200.00	8,400	0.00	0	0.00	0	0.00	0	4,200	8,400
212 WATER LINE 1"												
COMPLETE INCLUDING TRENCH	830	LF			20.00	16,600					20.00	16,600
SMALL TOOLS & CONSUMABLES 3.00%				0								0
ITEM DIRECT COST	830	LF		0		16,600		0		0	20.00	16,600
ITEM TOTAL COST	830	LF	0.00	0	27.26	22,626	0.00	0	0.00	0	27.26	22,626

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
213 HOSE BIB W/4'X4' PAD													
COMPLETE		1	EA	75.00	75			35.00	35			110.00	110
SMALL TOOLS & CONSUMABLES	3.00%				1								1
ITEM DIRECT COST		1	EA		76		0		35		0	111.05	111
ITEM TOTAL COST		1	EA	106.47	106	0.00	0	49.00	49	0.00	0	155.47	155
214 FLEX. OFFICE HOOK UP													
COMPLETE		1	EA	25.00	25			25.00	25			50.00	50
SMALL TOOLS & CONSUMABLES	3.00%				1								1
ITEM DIRECT COST		1	EA		26		0		25		0	50.75	51
ITEM TOTAL COST		1	EA	36.05	36	0.00	0	35.00	35	0.00	0	71.05	71
215 WATER METER 1"													
BOARD OF WS CHARGE		1	EA	915.00	915							915.00	915
SMALL TOOLS & CONSUMABLES	3.00%				0								0
ITEM DIRECT COST		1	EA		915		0		0		0	915.00	915
ITEM TOTAL COST		1	EA	1281.00	1,281	0.00	0	0.00	0	0.00	0	1281.00	1,281
216 TRANSFORMER													
RENT HECO		1	EA									INCLUDED IN ITEM 218	
SMALL TOOLS & CONSUMABLES	0.00%				0								0
ITEM DIRECT COST		1	EA		0		0		0		0	0.00	0
ITEM TOTAL COST		1	EA	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 10 OF 17

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
217 POWER POLES, 40'												
RENT HECO	2	EA									INCLUDED IN ITEM 218	
SMALL TOOLS & CONSUMABLES 0.00%				0								0
ITEM DIRECT COST	2	EA		0		0		0		0	0.00	0
ITEM TOTAL COST	2	EA	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
218 POWER LINE												
HECO CHARGE 300 LF	1	LS	10,000	10,000							10,000	10,000
SMALL TOOLS & CONSUMABLES 0.00%				0								0
ITEM DIRECT COST	300	LF		10,000		0		0		0	33.33	10,000
ITEM TOTAL COST	300	LF	46.67	14,000	0.00	0	0.00	0	0.00	0	46.67	14,000
219 ELECT HOOK UP												
COMPLETE	1	LS		0	2500.00	2,500		0	0.00	0	2500.00	2,500
SMALL TOOLS & CONSUMABLES 3.00%				0								0
ITEM DIRECT COST	3	EA		0		2,500		0		0	833.33	2,500
ITEM TOTAL COST	3	EA	0.00	0	1135.83	3,408	0.00	0	0.00	0	1,135.83	3,408
220 LANDSCAPE - HIBISCUS HEDGE												
COMPLETE 2 FT HEIGH WITH SPRINKLER (GREEN THUMB)	1,120	LF			18.00	20,160					18.00	20,160
SMALL TOOLS & CONSUMABLES 3.00%				0								0
ITEM DIRECT COST	1,120	LF		0		20,160		0		0	18.00	20,160
ITEM TOTAL COST	1,120	LF	0.00	0	24.53	27,478	0.00	0	0.00	0	24.53	27,478

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 11 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
221 MISC. SIGNS												
COMPLETE	8	EA	40.00	320			40.00	320			80.00	640
SMALL TOOLS & CONSUMABLES 3.00%				10								10
ITEM DIRECT COST	1	LS		330		0		320		0	649.60	650
ITEM TOTAL COST	1	LS	461.44	461	0.00	0	448.00	448	0.00	0	909.44	909
301 HAMMERMILL	1	EA										
BUY/SALV (BUY $30,000)	1	EA	15,000	15,000							15,000	15,000
FRT IN	1	EA	1,500.00	1,500							1500.00	1,500
SET UP & DOWN	2	EA	500.00	1,000			1,500.00	400	50.00	100	2050.00	1,500
SMALL TOOLS & CONSUMABLES 3.00%				12								12
ITEM DIRECT COST	1	EA		17,512		0		400		100	18,012	18,012
ITEM TOTAL COST	1	EA	24,517	24,517	0.00	0	560.00	560	140.00	140	25,217	25,217
302 BALER	1	EA										
BUY	1	EA	48,100	48,100							48,100	48,100
SALV	1	EA	24,000	(24,000)							24,000	(24,000)
FRT IN & OUT	2	EA	1,500.00	3,000							1,500	3,000
SET UP & DOWN	2	EA	250.00	500			1,500.00	3,000	400.00	800	2,150.00	4,300
SMALL TOOLS & CONSUMABLES 3.00%				90								90
ITEM DIRECT COST	1	EA		27,690		0		3,000		800	31,490	31,490
ITEM TOTAL COST	1	EA	38766.00	38,766	0.00	0	4200.00	4,200	1120.00	1,120	44,086	44,086

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 12 OF 17
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
303 BIN WALL - DOCK/RET. WALL	6,120	SF										
BUY BIN UNITS ALUMINIZED CONTECH	6,120	SF	16.25	99,450							16.25	99,450
BUY ROCK FILL 1,043 CY	1,564	TNS	16.00	25,024							16.00	25,024
INSTALL WALL - BINS & ROCK	6,120	SF					4.35	26,622	1.25	7,650	5.60	34,272
SMALL TOOLS & CONSUMABLES 3.00%				799								799
ITEM DIRECT COST	6,120	SF		125,273		0		26,622		7,650	26.07	159,545
ITEM TOTAL COST	6,120	SF	28.66	175,382	0.00	0	6.09	37,271	1.75	10,710	36.50	223,363
304 GABIONS - 3' X 6 'X 1 1/2'	190	EA										
CY/UNIT = 1.00 TNS/UNIT 1.40												
BUY GABIONS	190	EA	30.00	5,700							30.00	5,700
BUY ROCK FILL	850	TNS	16.00	13,597							16.00	13,597
INSTALL GABIONS	190	EA					5.00	950			5.00	950
PLACE ROCK FILL	190	CY					14.00	2,660	3.95	751	17.95	3,411
SMALL TOOLS & CONSUMABLES 3.00%				108								108
ITEM DIRECT COST	190	EA		19,405		0		3,610		751	125.09	23,766
ITEM TOTAL COST	190	EA	142.99	27,167	0.00	0	26.60	5,054	5.53	1,051	175.12	33,273
401 GRAVEL - 12"	12,130	CY										
BUY GRAVEL 1.55 TNS/CY	18,802	TNS	15.00	282,023							15.00	282,023
PLACE GRAVEL	12,130	CY					1.90	23,047	0.49	5,944	2.39	28,991
SMALL TOOLS & CONSUMABLES 3.00%				691								691
ITEM DIRECT COST	12,130	CY		282,714		0		23,047		5,944	25.70	311,705
ITEM TOTAL COST	12,130	CY	32.63	395,800	0.00	0	2.66	32,266	0.69	8,322	35.98	436,388

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
402 SAND BED - 18'	18,190	CY										
BUY SAND 1.45 TNS/CY	26,376	TNS	22.00	580,261							22.00	580,261
PLACE SAND	18,190	CY					1.90	34,561	0.49	8,913	2.39	43,474
SMALL TOOLS & CONSUMABLES 3.00%				1,037								1,037
ITEM DIRECT COST	18,190	CY		581,298		0		34,561		8,913	34.35	624,772
ITEM TOTAL COST	18,190	CY	44.74	813,817	0.00	0	2.66	48,385	0.69	12,478	48.09	874,681
403 GEOSYNTH, 80 MILL	36,390	SY										
HYPERLON - WISDOM												
BUY 38 MIL MATERIAL	38,000	SY	13.50	513,000							13.50	513,000
PLACE	36,390	SY					0.20	7,278	0.05	1,820	0.25	9,098
SMALL TOOLS & CONSUMABLES 3.00%				218								218
ITEM DIRECT COST	36,390	SY		513,218		0		7,278		1,820	14.35	522,316
ITEM TOTAL COST	36,390	SY	19.74	718,506	0.00	0	0.28	10,189	0.07	2,548	20.09	731,243
404 CONC. PAD 10' X 10' X 6"	14	CY										
CONCRETE	14	CY	86.00	1,204			25.00	350			111.00	1,554
FORMS	140	SF	0.30	42			2.00	280			2.30	322
MESH	750	SF	0.20	150			0.25	188			0.45	338
SMALL TOOLS & CONSUMABLES 3.00%				25								25
ITEM DIRECT COST	14	CY		1,421		0		818		0	159.90	2,239
ITEM TOTAL COST	14	CY	142.05	1,989	0.00	0	81.80	1,145	0.00	0	223.85	3,134

FILE : EST690 PROJECT K A W A I N U I M A R S H SHEET 14 OF 17

JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E REV. 0 13-Jun-90

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
405 CONTROL GATES W/ CONC.	10	EA										
BUY GATES & SET FRAMES WATERMAN	10	EA	1,800.00	18,000			75.00	750			1875.00	18,750
CONCRETE	25	CY	88.00	2,200			20.00	500	1.00	25	109.00	2,725
FORMS	1,600	SF	0.50	800			4.50	7,200			5.00	8,000
RESTEEL 125 #/CY	3,125	LBS			0.60	1,875					0.60	1,875
TRUCK PRECAST	10	EA	75.00	750							75.00	750
STONE FILL	55	TNS	15.00	825							15.00	825
PLACE PRECAST UNIT	10	EA					267	2,670	75.00	750	342.00	3,420
SMALL TOOLS & CONSUMABLES 3.00%				334								334
ITEM DIRECT COST	10	EA		22,909		1,875		11,120		775	3,667.86	38,679
ITEM TOTAL COST	10	EA	3207.20	32,072	255.56	2,556	1556.80	15,568	108.50	1,085	5,128.07	51,281
406 PARSHAL FLUMES 1'-0"	2	EA										
BUY FLUME BERKLEY	2	EA	1500.00	3,000							1500.00	3,000
BUY & PLACE SAND BAGS	70	EA	1.00	70			7.50	525			8.50	595
SMALL TOOLS & CONSUMABLES 3.00%				16								16
ITEM DIRECT COST	2	EA		3,086		0		525		0	1,805.38	3,611
ITEM TOTAL COST	2	EA	2160.02	4,320	0.00	0	387.50	735	0.00	0	2,527.52	5,055
407 DATA RECORDERS	2	EA										
BUY RECORDER & INSTALL BERKLEY	2	EA	1200.00	2,400			100.00	200			1300.00	2,600
BUY DATA TRANSFER UNIT	1	EA	655.00	655							655.00	655
SMALL TOOLS & CONSUMABLES 3.00%				6								6
ITEM DIRECT COST	2	EA		3,081		0		200		0	1,630.50	3,261
ITEM TOTAL COST	2	EA	2142.70	4,285	0.00	0	140.00	280	0.00	0	2,282.70	4,565

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

ITEM DESCRIPTION		QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
408 SILT SCREENS		40	SY										
BUY & INSTALL		40	SY	13.50	540			5.00	200	2.00	80	20.50	820
SMALL TOOLS & CONSUMABLES	0.00%				0								0
ITEM DIRECT COST		40	SY		540		0		200		80	20.50	820
ITEM TOTAL COST		40	SY	18.90	756	0.00	0	7.00	280	2.80	112	28.70	1,148
409 CM ARCH - 49' X 33'		85	LF										
BUY & INSTALL CONTECH		85	LF	32.00	2,720			63.00	5,355	17.75	1,509	112.75	9,584
SMALL TOOLS & CONSUMABLES	3.00%				161								161
ITEM DIRECT COST		85	LF		2,881		0		5,355		1,509	114.64	9,745
ITEM TOTAL COST		85	LF	47.45	4,033	0.00	0	88.20	7,497	24.85	2,113	160.50	13,643
410 ARCH HEADWALLS & PADS		2	EA										
FORMS		195	SF	0.50	98			4.50	878			5.00	976
CONCRETE		6.5	CY	88.00	572			20.00	130	1.00	7	109.00	709
RESTEEL 100 #/CY		650	LBS			0.80	520					0.80	520
SMALL TOOLS & CONSUMABLES	3.00%				30								30
ITEM DIRECT COST		2	EA		700		520		1,008		7	1,117.62	2,235
ITEM TOTAL COST		2	EA	490.17	980	354.38	709	705.60	1,411	4.90	10	1,555.05	3,110
411 CMP 24"		50	LF										
BUY & INSTALL CONTECH		50	LF	51.00	2,550			27.00	1,350	7.50	375	85.50	4,275
SMALL TOOLS & CONSUMABLES	3.00%				41								41
ITEM DIRECT COST		50	LF		2,591		0		1,350		375	86.31	4,316
ITEM TOTAL COST		50	LF	72.53	3,627	0.00	0	37.80	1,890	10.50	525	120.83	6,042

FILE : EST690 PROJECT K A W A I N U I M A R S H
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION Alternative E

ITEM DESCRIPTION	QUANITY NUMBER	UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
412 CMP HEADWALL & PADS	2	EA										
FORMS	100	SF	0.50	50			4.50	450			5.00	500
CONCRETE	2.5	CY	88.00	220			20.00	50	1.00	3	109.00	273
RESTEEL	250	LBS			0.80	200					0.80	200
SMALL TOOLS & CONSUMABLES 3.00%				15								15
ITEM DIRECT COST	2	EA		285		200		500		3	494.00	988
ITEM TOTAL COST	2	EA	199.50	399	136.30	273	350.00	700	2.10	4	687.90	1,376
501 BLASTED CHANNEL	9,500	LF										
BUY POWDER	110	CWT	300.00	33,000							300.00	33,000
BUY BLASTING CAPS	200	EA	3.00	600							3.00	600
BUY PRIMER CORD	80	MLF	120.00	9,600							120.00	9,600
BUY STEMMING MATERIAL 10 CY	15	TNS	15.00	225							15.00	225
INSTALL & SHOOT	4,750	EA					28.00	133,000	6.00	28,500	34.00	161,500
ALLOW FOR ADDITIONAL SHOTS	475	EA	9.20	4,370			28.00	13,300	6.00	2,850	43.20	20,520
SMALL TOOLS & CONSUMABLES 3.00%				4,389								4,389
ITEM DIRECT COST	9,500	LF		52,184		0		146,300		31,350	24.19	229,834
ITEM TOTAL COST	9,500	LF	7.69	73,058	0.00	0	21.56	204,820	4.62	43,890	33.87	321,768
502 MISC CLEARING												
											NOT INCLUDED	
SMALL TOOLS & CONSUMABLES 0.00%				0								0
ITEM DIRECT COST				0		0		0		0		0
ITEM TOTAL COST			0.00	0	0.00	0	0.00	0	0.00	0	0.00	0

13-Jun-90

FPS ENGINEERING ASSOCIATES , INC.

FILE : EST690 PROJECT K A W A I N U I M A R S H
JOB NO. 18.90 PRELIMINARY ESTIMATE - CHANNEL BLASTING OPTION

Alternative E

ITEM DESCRIPTION		QUANITY NUMBER	QUANITY UNIT	MATERIAL COST Unit Cost	MATERIAL COST TOTAL	SUB CONTRACT Unit Cost	SUB CONTRACT TOTAL	LABOR Unit Cost	LABOR TOTAL	EQUIPMENT Unit Cost	EQUIPMENT TOTAL	TOTAL COST Unit Cost	TOTAL COST TOTAL
503 MISC EXCAVATION												NOT INCLUDED	
SMALL TOOLS & CONSUMABLES	0.00%				0								0
ITEM DIRECT COST					0		0		0		0		0
ITEM TOTAL COST				0.00	0	0.00	0	0.00	0	0.00	0	0.00	0

Aquatics Unlimited

Quality Products for the Aquatic Environment

FAXED 10/6/89

October 6, 1989

James R. Dexter
M & E Pacific, Inc.
Suite 500, Pauahi Tower
1001 Bishop Street
Honolulu, HI 96813-3497

RE: Aquatic Control Machinery For Kawainui Marsh, Kailua Hawaii

Dear Jim:

This letter is a detailed reply to your letter date September 22, 1989.

1) Equipment for Annual Maintenance: From your description of the work to be performed it is our belief that the following equipment would be the most efficient and economical.

Equipment supplied by Aquatics Unlimited:

A) 2 - Aquamog PRX-163s

Specifications

Length	30' 6"
Width (operating)	17' 6"
(shipping)	10' 0"
Weight	18,000 lbs.
Engine	163 hp.
Propulsion	paddle wheel

each PRX-163 equipped with the following attachments:
- Flail Chopper
- Clam Rake
- Clam Bucket
- Rototiller

B) 4 - Aquamog THS-44s (self propelled hopper barge).

Specifications

Length	40' 0"
Width (operating)	10' 0"
(shipping)	10' 0"

2150 Franklin Canyon Rd. • Martinez, CA 94553 • (415) 370-9175
Fax (415) 370-9179

Weight	15,000 lbs.
Engine	44 hp.
Propulsion	paddle wheel
Payload	20,000 lbs.
sediment	8 cubic yards
vegetation	40 cubic yards

C) 1 - TMC-5X4X2.5 (trailer mounted weed compactor).

	Bail Specifications
Length	5' 0"
Width	4' 0"
Height	2' 6"
Weight	2700 lbs.

Equipment obtained from local sources:

D) 1 - 10 to 20 ton truck crane, with 30' *boom minimum.*

E) Dump truck(s)

2) Means of operation:

A) The Aquamog PRX-163, the work horse of the project, would be used for the following tasks.

Flail Chopper: With this attachment any type of vegetation can be cut to a manageable size. The Flail Chopper has the capability of cutting at a wide range of angles and heights. It can cut up to a 6" diameter tree limb.

Clam Rake: With this attachment any cut or loose vegetation can be picked up and deposited into the Aquamog THS-44.

Clam Bucket: With this attachment sediment can be removed and deposited into the Aquamog THS-44.

Rototiller: With this attachment the canals can be periodically rotovated to remove plant root systems from the canal bottom. Thus greatly reducing and preventing future growth.

B) The Aquamog THS-44 would be used as transports for moving material (vegetation or sediment) from the work area to the unloading site. Two THS-44s would work with each PRX-163. This would cut the downtime of the PRX-163 waiting for the THS-44 to return for reloading.

C) The TMC-5X4X2.5 (trailer mounted compactor) can compact vegetation in to a bail. The bail can than be loaded into a dump truck, for on or off site disposal.

D) The truck crane would be used to pick the vegetation off the transports and load it into the compactor. Also used to pick up the bail and load into the dump truck. Sediment would be picked off the transport and loaded directly into the dump truck.

E) The dump truck(s) would be used to transport bails of vegetation, and sediment to the disposal site.

<u>Note:</u> This operating system would be the easiest to implement. It is both efficient and economical. Pumping vegetation and sediment can be accomplished using the **Aquamog PRX-163**. It is our belief that trying to pump, the distances required, would cause too many unneeded complications and costs.

Sediment can be pumped 4000' with a **PRX-163**. For farther distances booster pumps would be needed every 4000'. To pump vegetation a mulch barge would be needed to get the vegetation to a pumpable substance.

<u>3) Compacting Equipment:</u> We recommend having a trailer mounted compactor rather then barge mounted. The reason being that the bails would be much easier to work with on shore than on the water, bails of vegetation 5' X 4' X 2.5' can weigh up to 2700 lbs. Cost and complications would also out weigh the usefulness of a barge mounted compactor.

<u>4) Additional machinery:</u> No additional machinery needed.

<u>5) Transportation requirements:</u> Equipment would be shipped from Oakland, CA to Honolulu, HI by way of container ship. Then transported to the marsh by truck on a flat bed trailer. All 6 Aquamogs could be launched using a 60-ton crane (minimum). Launching would take approximately one full day. The trailer compactor can be positioned using a pick up truck or dump truck. All transportation and launching would be arranged by our office.

<u>6) Equipment prices and other costs:</u>

#	Description	Unit Cost	Total Cost
2	Aquamog PRX-163	139,773.00	279,546.00
4	Aquamog THS-44	65,923.00	267,692.00
1	TMC-5 X 4 X 2.5	48,073.00	48,073.00
2	Flail Chopper	4,140.00	8,280.00
2	Clam Rake	5,505.00	11,010.00
2	Clam Bucket	4,830.00	9,660.00
2	Rototiller	7,935.00	15,870.00
Recommended Spare Parts			15,000.00

Delivery, Installation, Training	49,000.00
Equipment from Aquatics Unlimited:	$704,131.00

NOTE: Set-up for pumping vegetation

#	Description	Unit Cost	Total Cost
2	Aquamog PRX-163	139,773.00	279,546.00
1	TMC-5 X 4 X 2.5	48,073.00	48,073.00
1	Mulch Barge	225,000.00	225,000.00
2	Flail Chopper	4,140.00	8,280.00
2	Clam Rake	5,505.00	11,010.00
2	Clam Bucket	4,830.00	9,660.00
2	Rototiller	7,935.00	15,870.00
2	Dredgehead 8"	22,789.00	45,578.00
12000	Discharge Pipeline	6.76/ft	81,120.00
	Recommended Spare Parts		50,000.00
	Delivery, Installation, Training		69,000.00
	Equipment from Aquatics Unlimited:		$843,137.00

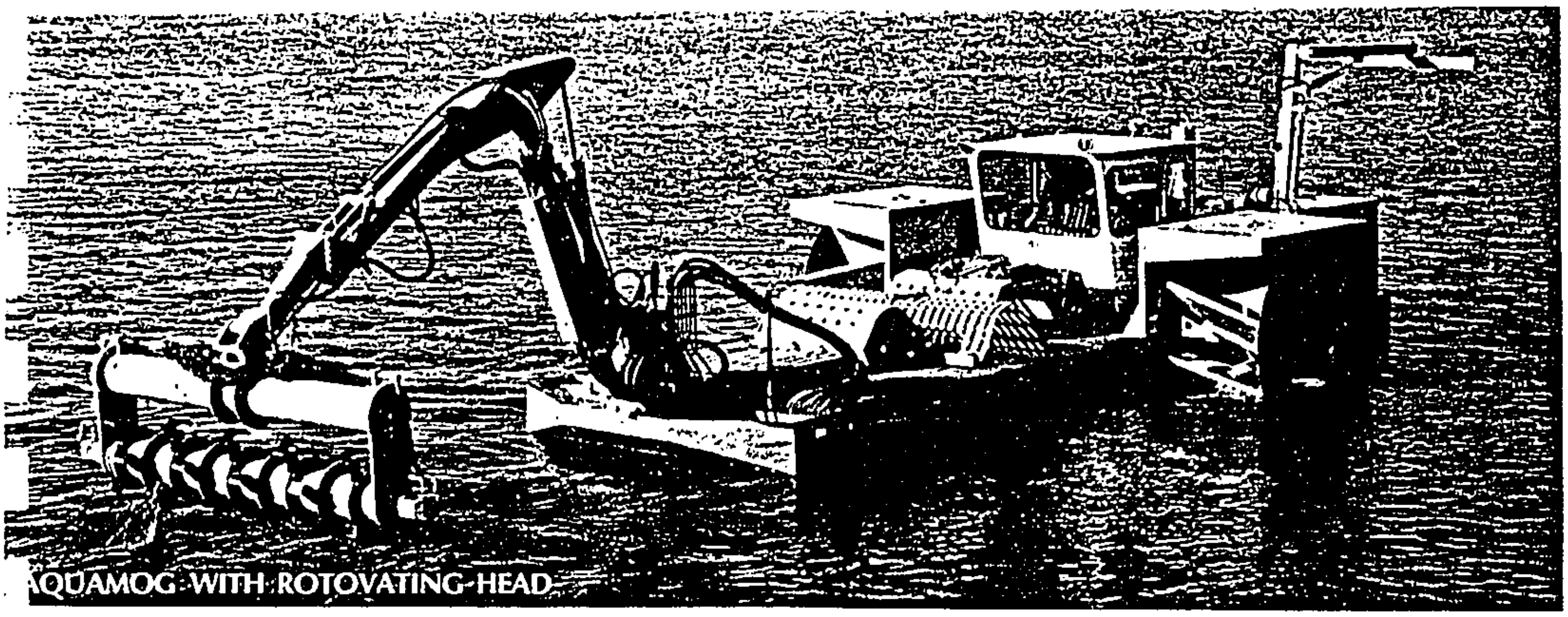
Additional cost would be incurred for dewatering ponds.

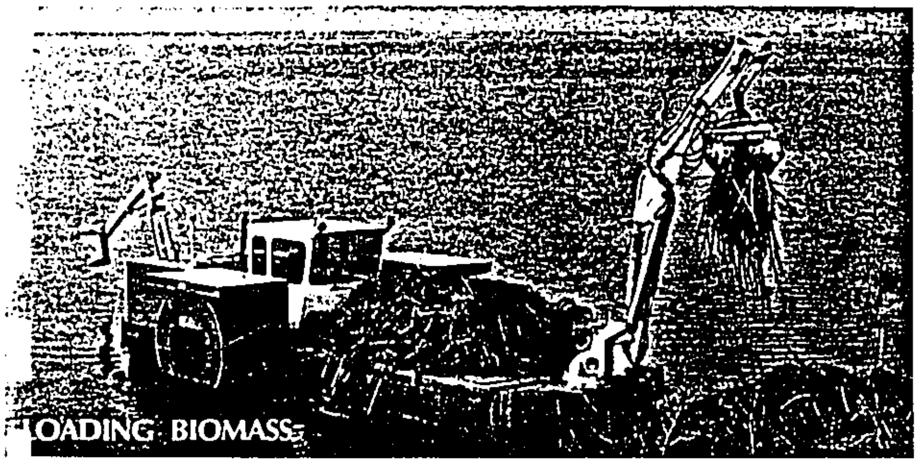
If you have any questions please give us a call. See you in Hawaii October 18.

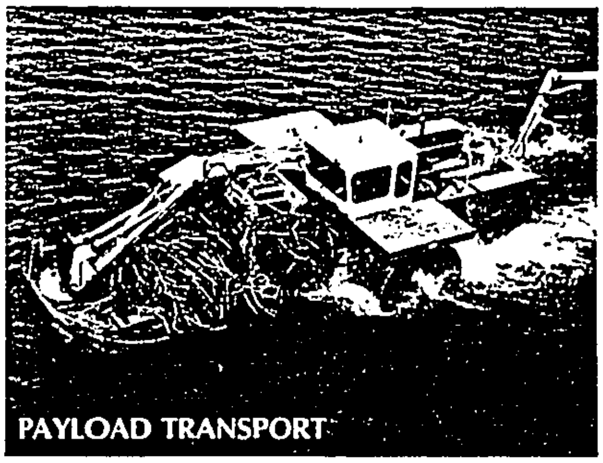
Sincerely,

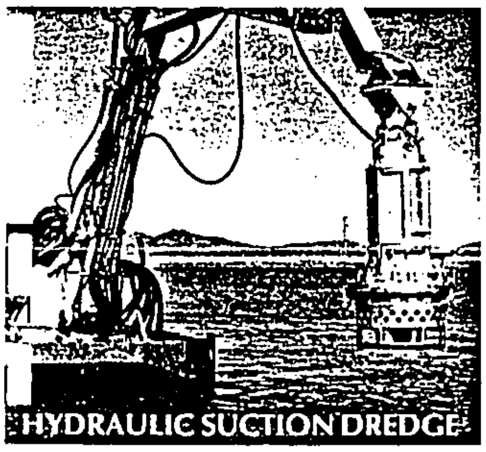
AQUATICS UNLIMITED

David D. McNabb

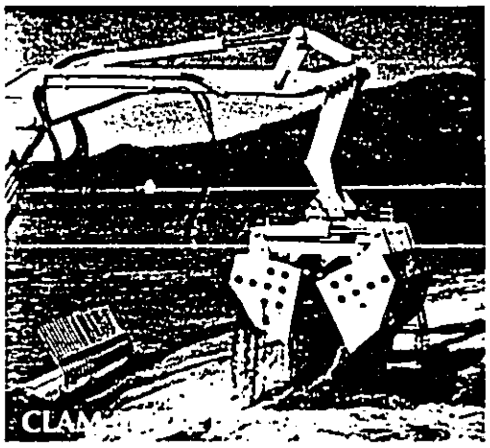

AQUAMOG WITH ROTOVATING HEAD


LOADING BIOMASS


PAYLOAD TRANSPORT


HYDRAULIC SUCTION DREDGE


WEED RAKE


CLA

AI

■ *Aquatics Unlimited*
■ *Aquamog*

MULTI-PURPOSE • MARINE • MAINTENANCE • VESSEL

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WESTERN WATER MANAGEMENT COMPANY

October 20, 1989

Mr. James R. Dexter
M & E Pacific, Inc.
Suite 500, Pauahi Towar
1001 Bishop Street
Honolulu, Hawaii 96813-3497

Re: Aquatic Control Equipment for Kawainui Marsh.

Dear Mr. Dexter:

Thank you for expressing interest in our marsh restoration contract services and equipment sales. Per our telephone conversation, following is information on equipment and operating requirements for both the initial restoration and on going maintenance of Kawainui Marsh.

With regards to the initial restoration requirements of Kawainui Marsh, we have serious doubts as to whether blasting channels is an acceptable restoration technique in this environmentally sensitive area. We would prefer to see a less disruptive mechanical equipment restoration technique employed for the channelization work. For example, our mechanical marsh restoration equipment is well muffeled for noise (less than 80 decimals) and would cause only very localized environmental disruption.

For the initial restoration work, since there is a ready disposal method for the plant biomass, but not for the silt and clay based sedimentation, we propose use of equipment which would minimise the need to transport and dispose sedimentation. Specifically, by utilizing the Cookie Cutter (specifications enclosed) to open the channels, there will be little or no need to transport or dispose of sedimentation. The Cookie Cutter consists of a portable shallow draft work barge propelled by two large multi edged cutters, which for marsh chanellization cut emergent aquatic plant stocks and root mass into small bits which float to the surface. Sedimentation is either thrown clear or sinks to the bottom of the new channel. By making several passes, we can clear sedimentation to the maximum cutting depth of the blades, which is 4½ feet.

To efficiently pick up the floating emergent plant biomass after the Cookie Cutter, we suggest use of an aquatic plant harvester, which can pick up , transport and offload up to 800 cubic feet of material in a matter of minutes. Enclosed is specifications for aquatic plant harvèster models H10-800 and H5-200. If the prospective user of the harvested aquatic plant biomass materail is not equipped to pick up this material at the job site, we can transport it to their location by either dump truck or trailer conveyor.

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In areas where the aquatic plant biomass consists of floating or submersed aquatic plants such as water hyacinth, water lettuce, submersed pond weeds, etc rather than deeply rooted emergents such as bulrush, cattails, or sawgrass, we can use the harvester to directly strip the plant biomass, skipping the Cookie Cutter stage.

Enclosed are aerial photos of the Neary Lagoon restoration project which we performed for the City of Santa Cruz California. The Neary Lagoon project is very similar to Kawainui Marsh in that we utilized a Cookie Cutter/Harvester combination to create much needed flood control channels. Total time to complete Neary Lagoon using the Cookie Cutter/Harvester was 6 weeks, compared to an estimated 5 or 6 months if we had used a floating clam shell or similar equipment. Please feel free to contact Mr. Rudy Quintanar (408)429-3777 of the City of Santa Cruz Department of Parks and Recreation to confirm our equipment's performance in Neary Lagoon.

For Western Water Management to perform the initial channellization as specified in your letter of 9-22-1989, with the Cookie Cutter/Harvester combination, the following would be required:
Personnel: One on site supervisor
One Cookie Cutter operator
One Harvester operator

Optional: One dump truck or trailer conveyor operator(only needed if aquatic plant biomass user is not able to transport material from job site)

Mobilization/demobilization:
Equipment transport to and from Port of Honolulu= $23,000
(two 40' containers or flatracks required each way, plus cost to have container packed and unpacked by union longshoremen)
Intra Island trucking and crane costs= $4,500
Round trip travel costs for personnel= $2,200
Total mobilization/demobilization costs= $29,700

Equipment operation costs:
$275 per hour for both the Cookie Cutter and Harvester, times an estimated maximum of 340 hours = $93,500

Total restoration project costs = $123,200

Optional overland biomass transport cost:
Estd. 340 hours skip loader operation to load dump truck= $20,400
Estd. 340 hours dump truck operation @ $60 per hour= $20,400
Total optional overland biomass transport cost= $40,800

WESTERN WATER MANAGEMENT COMPANY

Please note that we did not include any money in our hourly rate for extraneous overhead items such as bid and performance bonds. To the extent that these sort of items are required in the final contract, the cost will be increased proportionatly.

As you can see from the project cost ($123,200) and time to complete (340 hours), the Cookie Cutter/Harvester combination is by far the most efficient way to complete the initial channellization of Kawainui Marsh.

Cost to purchase a new Cookie Cutter is approximately $147,000 F.O.B. Honolulu. A Cookie Cutter Trailer is an additional $26,400 F.O.B. Honolulu.

Cost to purchase a new United Marine International H10-800 aquatic plant harvester is approximately $122,000 F.O.B. Honolulu.

A smaller UMI H5-200 model harvester is about $55,000 F.O.B. Hono.

Each of the above units of equipment requires one operator each.

If in any of the new channels, you wish to go deeper than 4½' into the sedimentation, we can utilize either a 8" discharge portable hydraulic dredge with one or two booster pumps To go the 12,000' to the disposal area, or we could use our hydrahoe portable bucket dredge and a dump truck.

Of the dredge options, the hydraulic dredge is much quicker and somewhat less expensive to operate the the bucket dredge and dump truck configuration. The hydraulic dredge and operator which we would use is already in Hawaii, so there would be some savings on equipment transportation. Our cost estimate, including mobilization to hydraulically dredge 5,000 cubic yards of sedimentation from the marsh is $57,300 with two booster pumps. Labor requirements for hydraulic dredging are two men, first a leverman to operate the dredge, and a deckhand onshore to handle the discharge pipe, booster pumps, decant pond, etc. Cost for a new 8" discharge hydraulic dredge with ancillory equipment is as follows:

8" discharge portable hydraulic dredge = $120,000
Two Booster pumps @ $30,000 each = $60,000
12,000 feet of 8" discharge pipe = $72,000
300 discharge pipe connectors = $16,500
4 x 40' shipping containers, Oakland/Honolulu = $16,000
Total acqusition cost = $284,500

Bucket dredging and hauling to the disposal site of 5,000 cubic yards of material would have a moderately higher cost than hydraulic dredging, since it is much slower and double handling

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WESTERN WATER MANAGEMENT COMPANY

of the material is required. For bucket dredging, the United Marine International Hydrahoe has 12,000 lbs of on deck storage, and can be off loaded directly into a 5 or 10 cubic yard dump truck for transport to the disposal site. Use of the Hydrahoe requires a leverman on board, and a dump truck operator on shore. Cost of a new hydrahoe with necessary attachments FOB Honolulu is approximately $135,000 and a new 5 cubic yard dump truck purchased locally would be about $20,000 to $25,000.

Either hydraulic or bucket dredging would require the installation of a disposal site liner and cover at an estimated cost of $23,500.
Crew and equipment mobilization = $4,750
(includes two man liner/cover installation crew and materials transportation to job site)
Initial grading = $3,500
22,500 sq ft of 20 mil PVC liner, cost installed = $6,750
Backfill cost = $1,750
18,000 sq ft of 20 mil PVC cover, cost installed = $5,400
Backfill cost = $1,750
Total cost = $23,900

With the proposed use of the Cookie Cutter/Harvester combination to install the original channels, there will be no need to either dredge 5,000 cubic yards of sedimentation, or to build a disposal area for this sedimentation.

For the ongoing maintenance of Kawainui Marsh, there are a number of equipment options. The State of Hawaii could purchase a Cookie Cutter and Harvester, or perhaps just aCookie Cutter alone or a Harvester alone would do the job. A hydraulic dredge and harvester would do the job, but would not be cost effective.

A multi purpose unit such as the United Marine International Hydrahoe would do the job (along with a dump truck). We could sell the State of Hawaii a UMI hydrahoe with a digging bucket, clam bucket, and weed rake for $135,000 FOB Honolulu. With a ancillory dump truck purchased locally, the total Marsh maintenance equipment investment would be $155,000 to $160,000. One man would be required to run the Hydrahoe for perhaps 6 months out of each year to maintain the Marsh at restoration specifcations (maybe 500 hours required annually to bucket dredge 5,000 cubic yards of sedimentation, and another 500 hours for aquatic plant removal) The dump truck with operator would probably be needed about ½ the time that the Hydrahoe is operating. One possiblility for annual labor cost reduction would be to have the same operator for both the Hydrahoe and dump truck.

The following transportation and launching requirements apply to all of the equipment which we have mentioned:

Cookie Cutter: specifications attached.
Transported: Upon it's own trailer, or on standard flat bed trailer.
Launched: By it's own trailer, or by crane.

WESTERN WATER MANAGEMENT COMPANY

H10-800 Aquatic Plant Harvester:
Specifications attached.
Transported: By it's own trailer, or by flatbed trailer.
Launched: By crane.

H5-200 Harvester: Specifications attached.
Transported: By it's own trailer.
Launched: By it's own tr■ailer.

Hydraulic dredge: Specifications available upon request.
Transported: By it's own trailer, or by flatbed trailer.
Launched: By crane

Hydrahoe: Specifications available upon request.
Transported: By flatbed trailer.
Launched: By crane

With regards to your suggestion of use of compacting and bailing equipment for handling aquatic vegetation, United Marine International has and can manufacture custom compacting and bailing features to go with either the Hydrahoe or with H10-800 or H5-200 model harvesters, but compacting of aquatic vegetation is really not neccessary and actually ends up consuming more time and money than it saves. We strongly recommend that you drop the compacting idea.

The United Marine International Hydrahoe is the equivalent of other equipment such as the Aquadozer and Aquamog which you may have looked at. United Marine International has a cost and price advantage over the Aquadozer and Aquamog due to the fact the UMI is the largest manufacturer of harvesters and multipurpose equipment, and owns it's own fabricating equipment. The sellers of the Aquadozer and Aquamog shop out actual manufacture, and as a result the customer pays for two Companies overhead in the equipment prices. If you are interested, I will have United Marine International forward specifications for the Hydrahoe to you and to the State of Hawaii.

I will give you a call next Tuesday to go over this information and answer questions.

Sincerely,

Michael J. Miatech
MJM/ac
enc.

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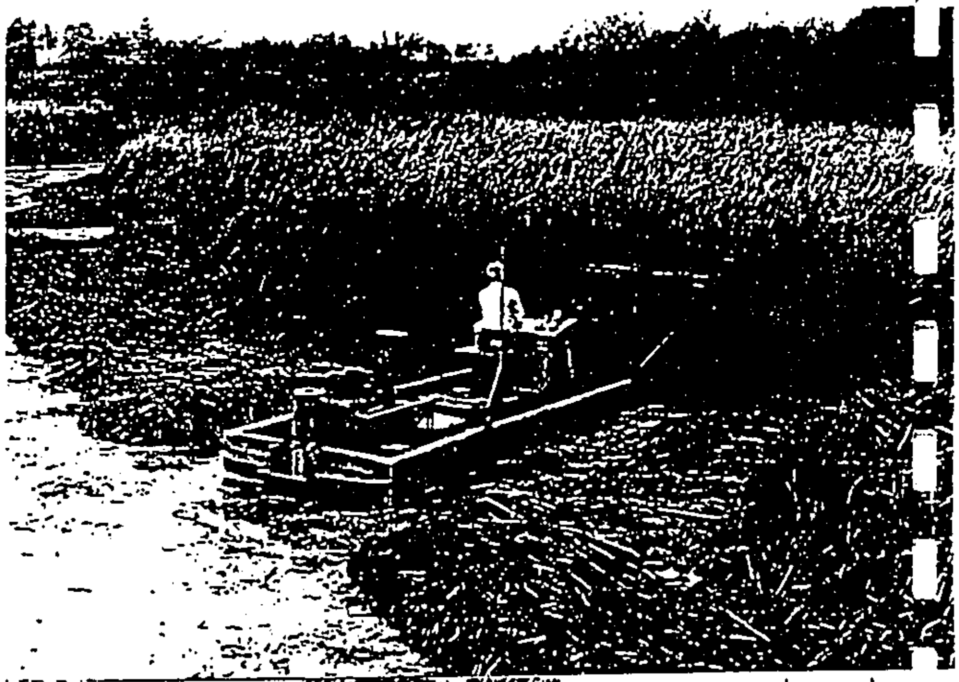
MARSH RESTORATION EQUIPMENT

WESTERN WATER MANAGEMENT COMPANY

Whether the goal is waterfowl habitat improvement, flood control, or increased recreational access, Western Water Management Company has the equipment and expertise to implement solutions. Pictured below is some of the Marsh restoration equipment which we sell and do contract work.

To the right is the Cookie Cutter, which is the only equipment able to handle dense growth of emergent aquatic weeds. The Cookie Cutter can operate in areas where conventional methods such as draglines and clam buckets can not go. With an adjustable cutting depth of up to 4½' the Cookie Cutter can cut below the plants root level, providing long term control.



For removing lighter growth of submersed aquatic weeds, the Aquaquip line of harvesters are ideal. Pictured above is a H10-800 model cleaning up after the Cookie Cutter, with the material hauled off site by the TC-100 Trailer Conveyor.

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WESTERN WATER MANAGEMENT COMPANY

OPTIONS:

1. Available is a specially built Cookie Cutter trailer designed for both on and off road usage. The trailer is self unloading with roller bars to assure ease of launching.
2. A hydraulically mounted winch on the Cookie Cutter itself is offered for reloading or loading on to the trailer.
3. Increasing the Cookie Cutter's cutting depths to 4'6".

COOKIE CUTTER SPECIFICATIONS

GENERAL

Length Overall	27' - 8"	Lifting Pads	Four (with shackles)
Length Hull	24' - 0"	Tie Down Pads	Four
Beam	6' - 0"	Drain Plugs	Two 2" (one each fwd. corner)
Moulded Depth	2' - 6"	Operator's Seat	One vinyl covered (padded) with foot rest
Draft	16"		

ENGINE

General Motors 6-71, N55 Injectors, 174 HP at 1800 RPM, limiting speed governor, engine instrument with low oil pressure and high water temperature alarm. Engine is fresh water keel cooled with rust inhibitor added. 12 volt battery for starting (180 AMP/HR). 100 gallon fuel oil tank with gauge. Custom muffler and aluminum personnel guard. All instruments covered with transparent plexiglas weather shield (removable).

"COOKIE CUTTER" TRANSPORT TRAILER GENERAL SPECIFICATIONS

Overall Length	31' - 4"	Electric Brakes
Bed Length	25'	Breakaway Tilt Frame operated by hydraulic Cylinder and Hand Pump
Overall Width	7' - 10"	Tandem Axles - 15,000 lb. capacity, mounted on Independent Carriage
Bed Width	6' - 6"	Five 12 x 16.5 10 Ply Tires and Wheels
Overall Height	6' - 4" (incl. spare wheel)	
Main Frames	6" x 6" x 20 lb. W.F.I. Beams	

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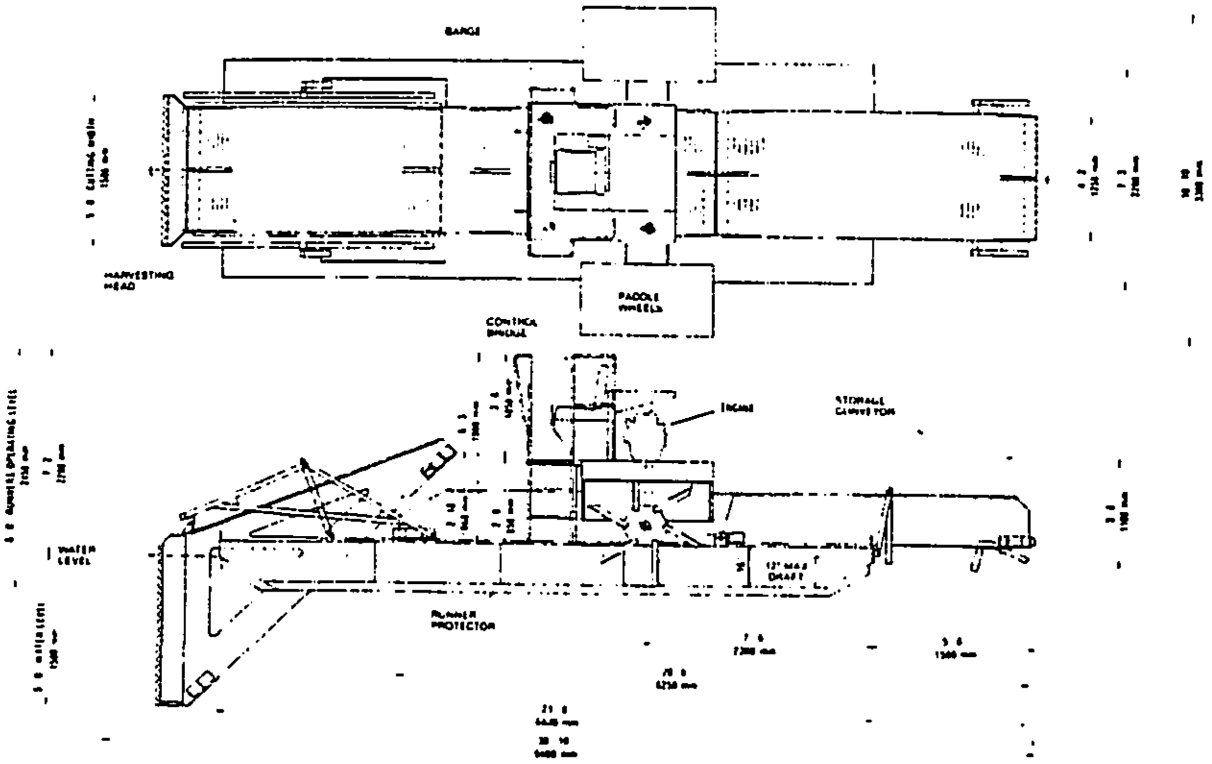
Aquaquip

H5-200 A... ...ic Weed Harvester



AQUATIC WEED HARVESTER SPECIFICATIONS

Dimensions:	Length	30'-6" (9300 mm)
	Width (Shipping)	7'-3" (2200 mm)
	(Operating)	11'-0" (3350 mm)
	Height (Shipping)	8'-0" (2450 mm)
	(Operating)	7'-2" (2200 mm)
	Weight	4950 lbs (2250 kg)
Flotation:	Hull dimensions	21'-0" × 7'-3" × 16" (6400 × 2200 × 400 mm)
	Number of watertight compartments	7
	Draft (Empty)	8" (200 mm)
	(Max. Load)	12" (300 mm)
Power Pack:	Engine	Watercooled diesel 20 hp @ 3000 rpm (15 kW @ 3000 rpm)
	Hydraulic Pump	1
	Hydraulic Reservoir	16 U.S. gallons (60 L)
	Fuel Tank	6 U.S. gallons (23 L)
Harvesting Head:	Cutting Width	5'-0" (1500 mm)
	Cutting Depth	5'-0" (1500 mm)
	Horizontal Knives	Reciprocating 3" (75 mm) stroke (4" opt.) (100 mm)
	Vertical Knives	Same
	Impact Absorption	Swing Suspension
Load Container:	Length (2 conveyors)	20' 6" (6250 mm)
	Width	4' 2" (1300 mm)
	Loading Height	2'-8" (800 mm)
	Maximum Volume	?20 cubic feet (6.3 m³)
	Maximum Weight	3300 lbs (1500 kg)
	Hydraulically adjustable unloading height	0 to 4'-0" (0 to 1200 mm)
	Unloading Time	60 seconds
Propulsion:	Drive	2 paddle wheels, hydraulically driven independently reversible
	Paddle Wheels, diam. × width	48" × 18" (1200 × 450 mm)
	Paddle Wheel Speed	0 to 50 rpm

TRAILER/CONVEYOR SPECIFICATIONS

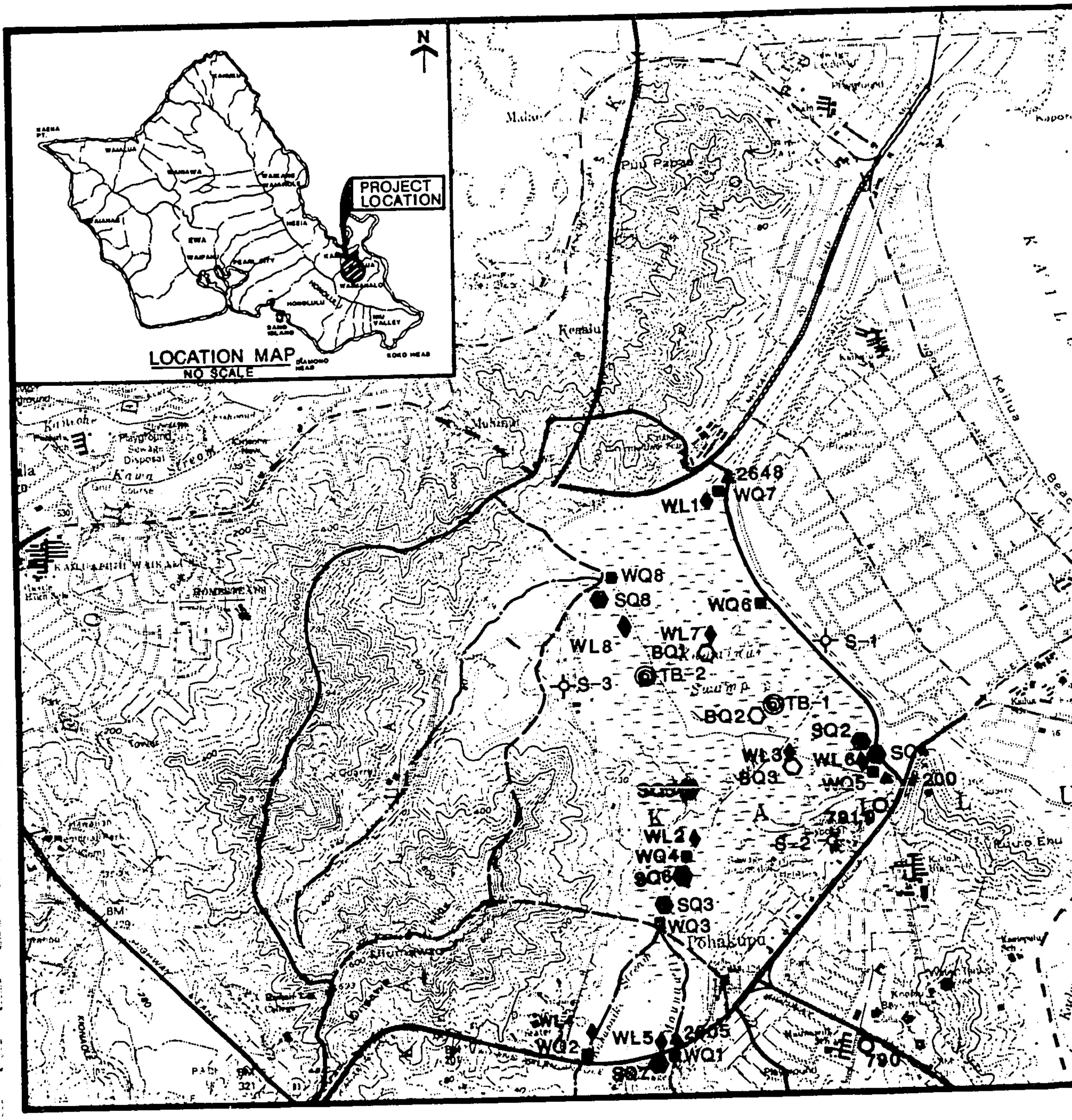
Dimensions:	Length	28'-6" (8700 mm)
	Width	8'-0" (2450 mm)
	Height (Overall)	5'-0" (1500 mm)
	(Deck)	2'-5" (750 mm)
	Weight	1800 lbs (800 kg)
	GVWR	7500 lbs (3400 kg)
	GAWR (Front)	3500 lbs (1600 kg)
	(Rear)	3500 lbs (1600 mm)
	Tire Size	7.00-15 LT
	Rim Size	15" (381 mm)
	Axles	
	Track Center	6'-10" (2100 mm)
	Spring Center	5'-8" (1725 mm)
	Wheel Base	3'-0" (900 mm)
	Brakes	4, 12v electric
	Winch	6000 lbs. pull (27 kN) 12v electric
	Jack	1000 lbs swivel (5 kN)
Conveyor:	Length	18'-6" (5600 mm)
	Width	5'-3" (1600 mm)
	Volume	300 Cubic Feet (8.5 m³)
	Drive	2 hydraulic motors, bi-directional
	Belting	Galvanized flatwire, standard duty
Power Pack:	Engine	Air Cooled gasoline 7.5 hp @ 3200 rpm (5.5 kW @ 3200 rpm)
	Pump	Submersed gear pump
	Filter	Submersed strainer

SHORE CONVEYOR SPECIFICATIONS (Not shown)

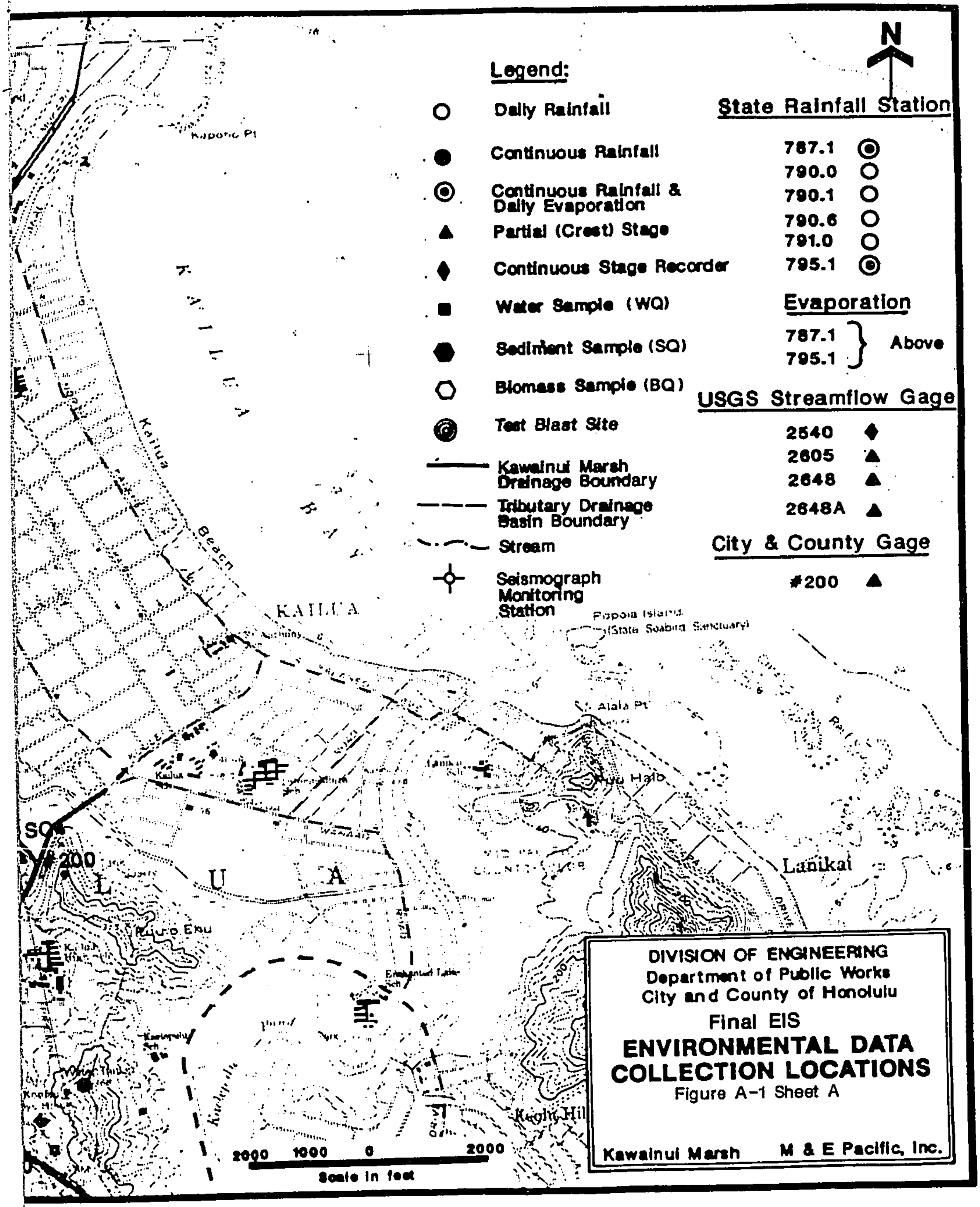
Dimensions:	Length	32'-0" (9750 mm)
	Width (Shipping)	7'-4" (2230 mm)
	(Hopper)	6'-0" (1830 mm)
	Height (Shipping)	10'-0" (3050 mm)
	(Max. Drop Off)	13'-0" (3950 mm)
	Weight	2500 lbs (1150 kg)
	Tires	7.00-15 LT
	Rim Size	15" (381 mm)
Conveyor:	Length	26'-0" (7900 mm)
	Width	4'-2" (1300 mm)
	Belting	Galvanized flat wire, standard duty with cleats
Power Pack:	Standard	Quick disconnect from harvester power pack
	Optional	Air cooled gasoline 18 hp @ 3600 rpm (13.5 kW @ 3600 rpm)
Other:	Drawbar	Used to tow conveyor
	Winch	Used for precision placement of conveyor

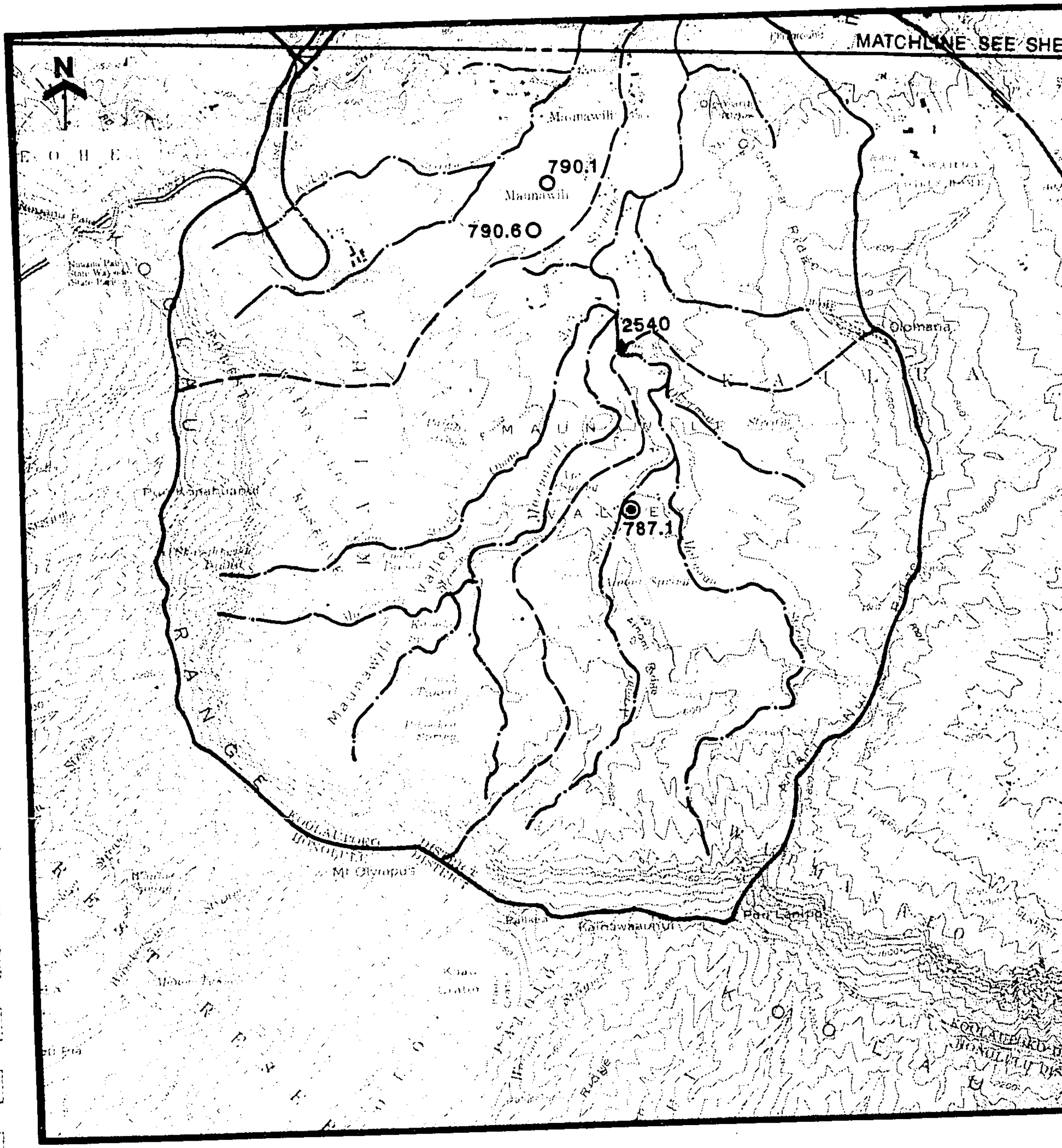
DEALER:

Ma[illegible]
8400 W. [illegible]
Littleton, Colorado 80123
[illegible] 972-[illegible]

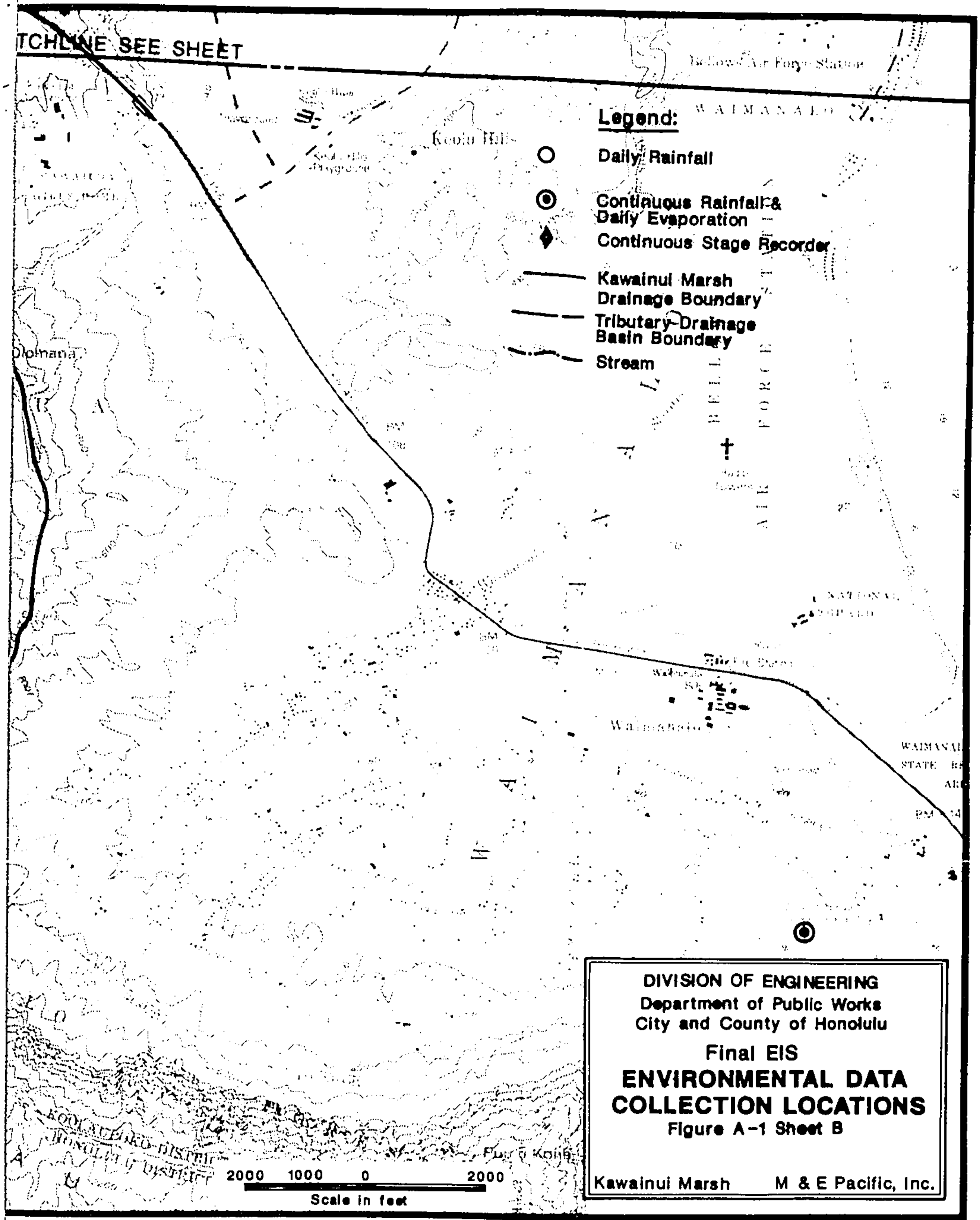


LOCATION MAP
NO SCALE
PROJECT LOCATION
N
Puu Papaa
Kailua
Kawa Stream
WQ8
SQ8
WQ6
WL7
WL8
BQ1
TB-2
S-3
S-1
TB-1
BQ2
SQ2
WL3
WL6
BQ3
WQ5
200
WL1
WQ7
2648
WL2
WQ4
SQ3
WQ3
S-2
WL5
WQ2
WQ1
2605
790


N
Legend:
Daily Rainfall
Continuous Rainfall
Continuous Rainfall & Daily Evaporation
Partial (Crest) Stage
Continuous Stage Recorder
Water Sample (WQ)
Sediment Sample (SQ)
Biomass Sample (BQ)
Test Blast Site
Kawainui Marsh Drainage Boundary
Tributary Drainage Basin Boundary
Stream
Seismograph Monitoring Station
State Rainfall Station
787.1
790.0
790.1
790.6
791.0
795.1
Evaporation
787.1
795.1
Above
USGS Streamflow Gage
2540
2605
2648
2648A
City & County Gage
#200
Kaiwa Pt
KAILUA
Kailua Beach
Popoia Island (State Seabird Sanctuary)
Alala Pt
Lanikai
SQ
#200
Kapoho Pt
2000 1000 0 2000
Scale in feet
DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu
Final EIS
ENVIRONMENTAL DATA COLLECTION LOCATIONS
Figure A-1 Sheet A
Kawainui Marsh
M & E Pacific, Inc.



MATCHLINE SEE SHE
N
790.1
Maunawili
790.6
2540
Olomana
787.1
Mt Olympus
Puu Lanipo
Kainawaauhui



DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu

Final EIS

ENVIRONMENTAL DATA COLLECTION LOCATIONS

Figure A-1 Sheet B

Kawainui Marsh | M & E Pacific, Inc.

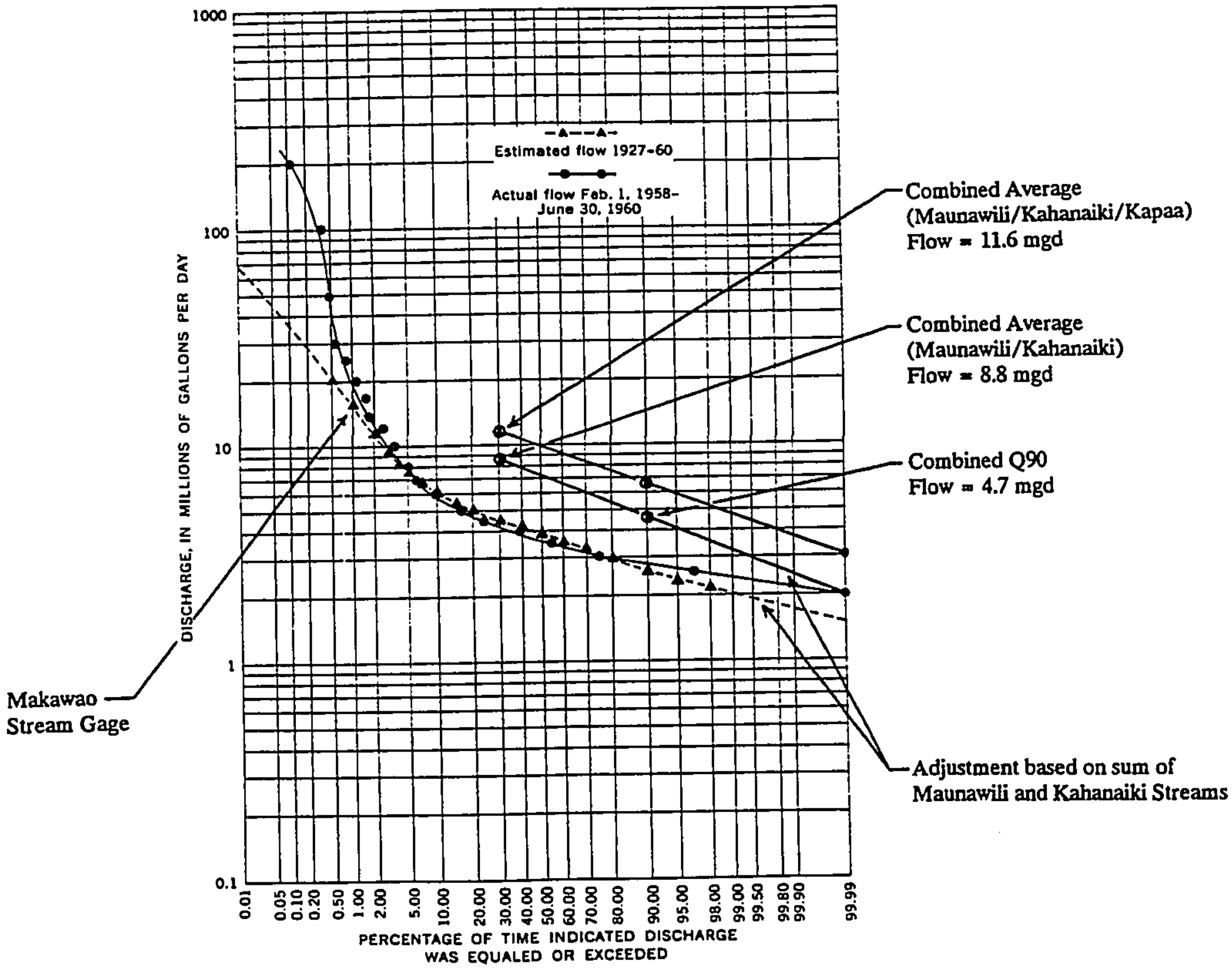


Figure A-2 Approximate Stream Flow Partial Duration Curve for Kawainui Marsh Tributaries (Maunawili/Kahanaiki)

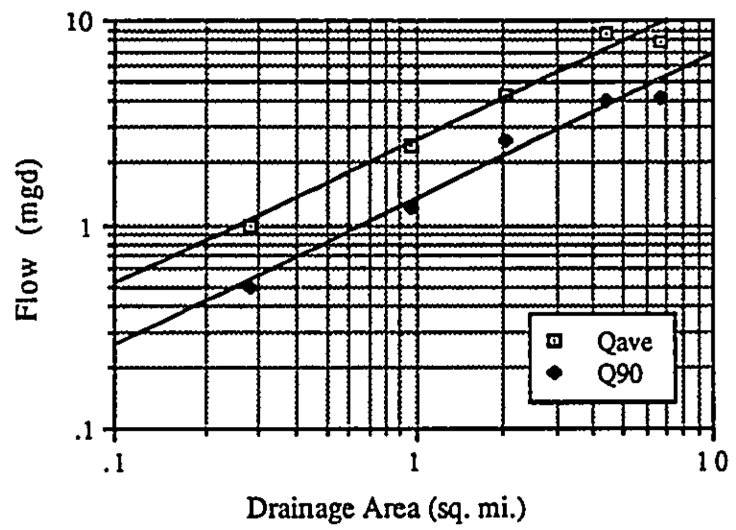
Source: Takasaki, K.J.; Hirashima, G.T.; Lubke, E.R.; Water Resources of Windward Oahu, Hawaii; United States Government Printing Office, Washington: 1969.

Figure A-2/1

Relationship for Q_{ave} and Q_{90}

Stream	Drainage Area DA[=](sq. mi.)	Q_{ave}[1]	Q_{90}[2]
Makawao	2.04	4.3	2.6
Kamooalii	4.38	8.5	4.1
Haiku	0.97	2.4	1.2
Iolekaa	0.28	1.0	0.5
Maunawili	6.74	7.8	4.2

Based on five windward Streams in Kaneohe/Kailua Area



1. $Q_{ave} = (2.5)*DA^{0.70}$ ($R^2 = 0.98$)

2. $Q_{90} = (1.30)*DA^{0.71}$ ($R^2 = 0.97$)

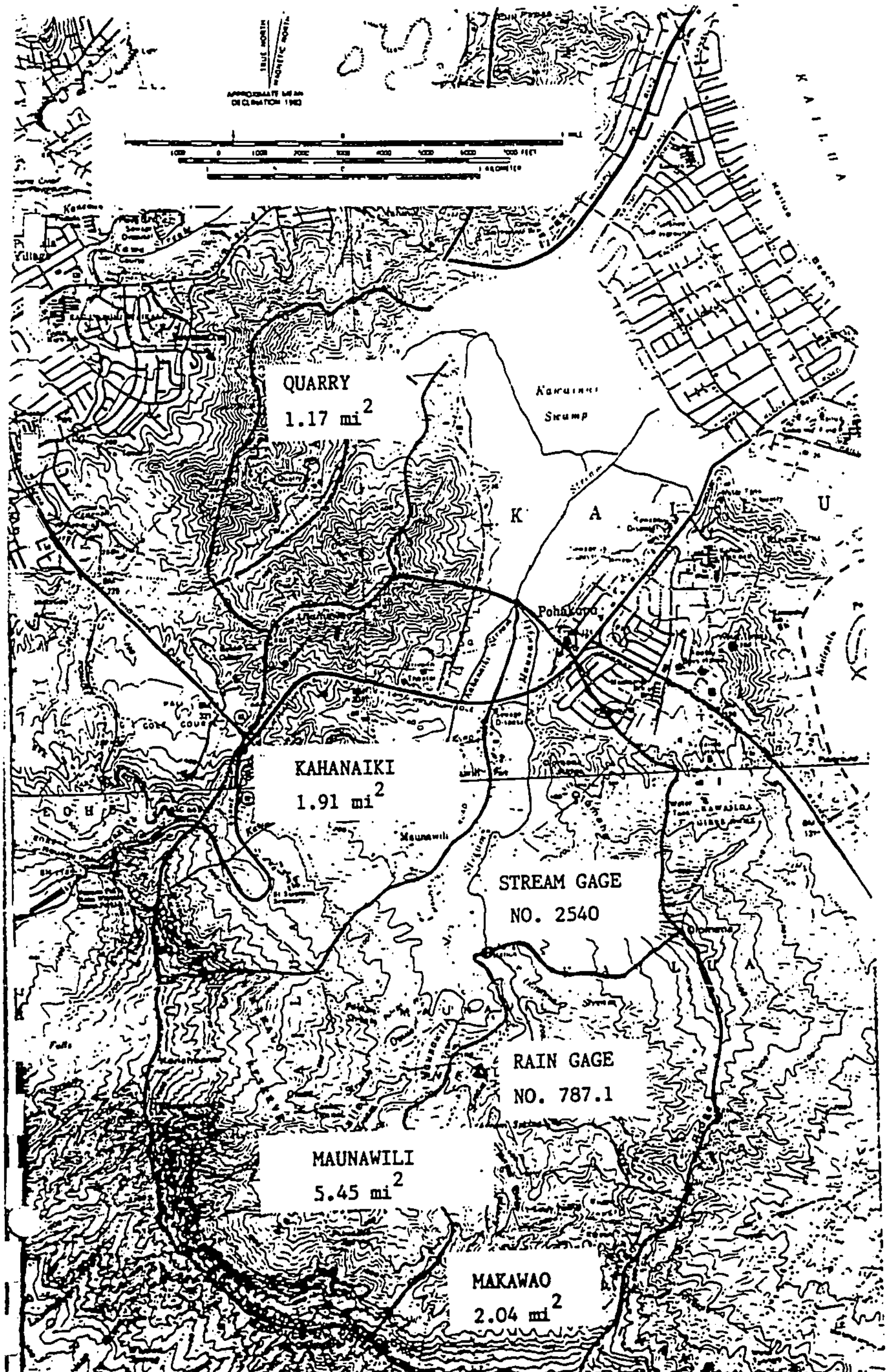


Figure A-3 Locations of Makawao, Maunawili and Kahanaiki Watersheds, Oahu.

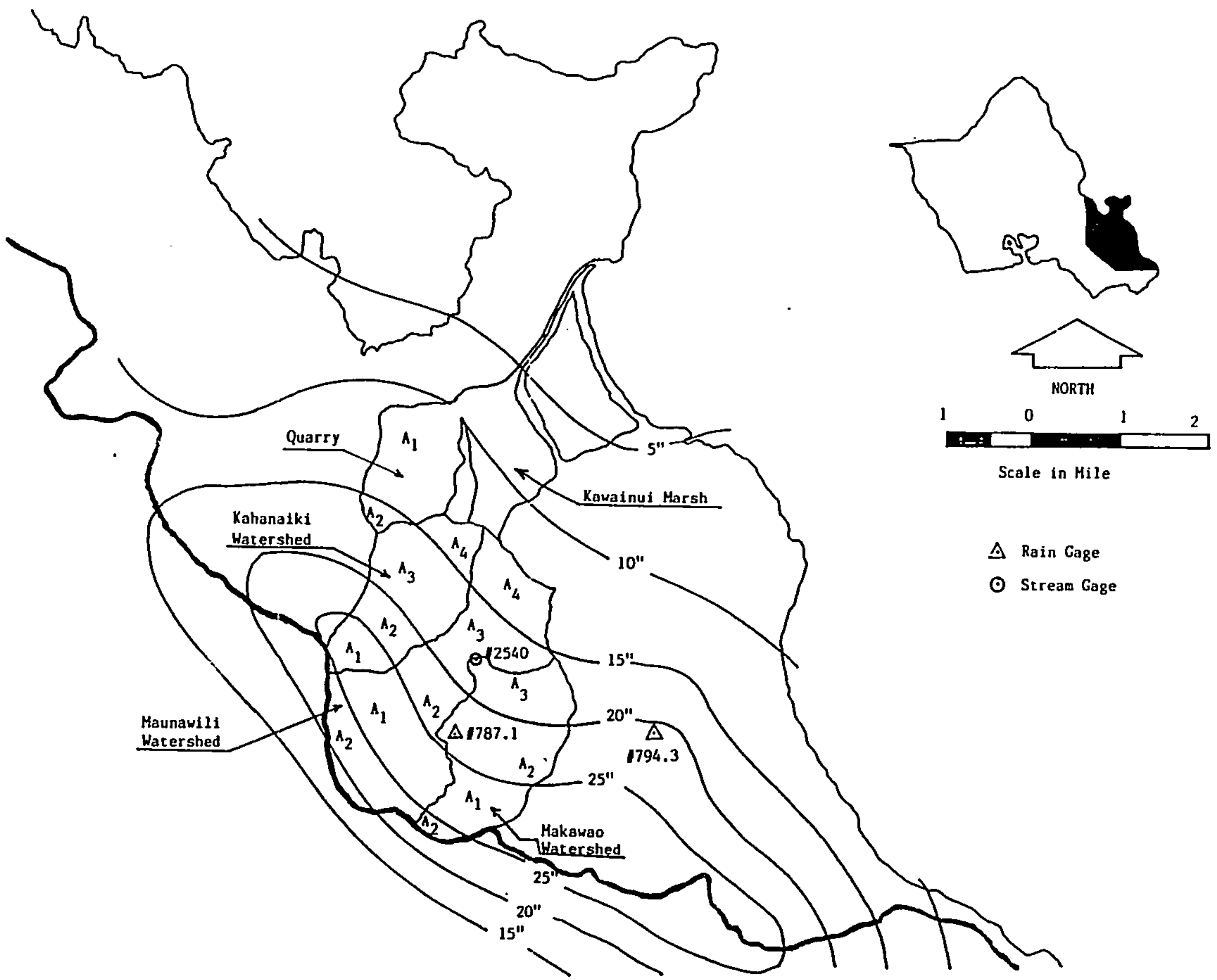


Figure A-4 24-hr (7:00 a.m.,31 Dec 1987 to 7:00 a.m.,1 Jan 1988) Rainfall Isohyetal Map of Kailua, Oahu.

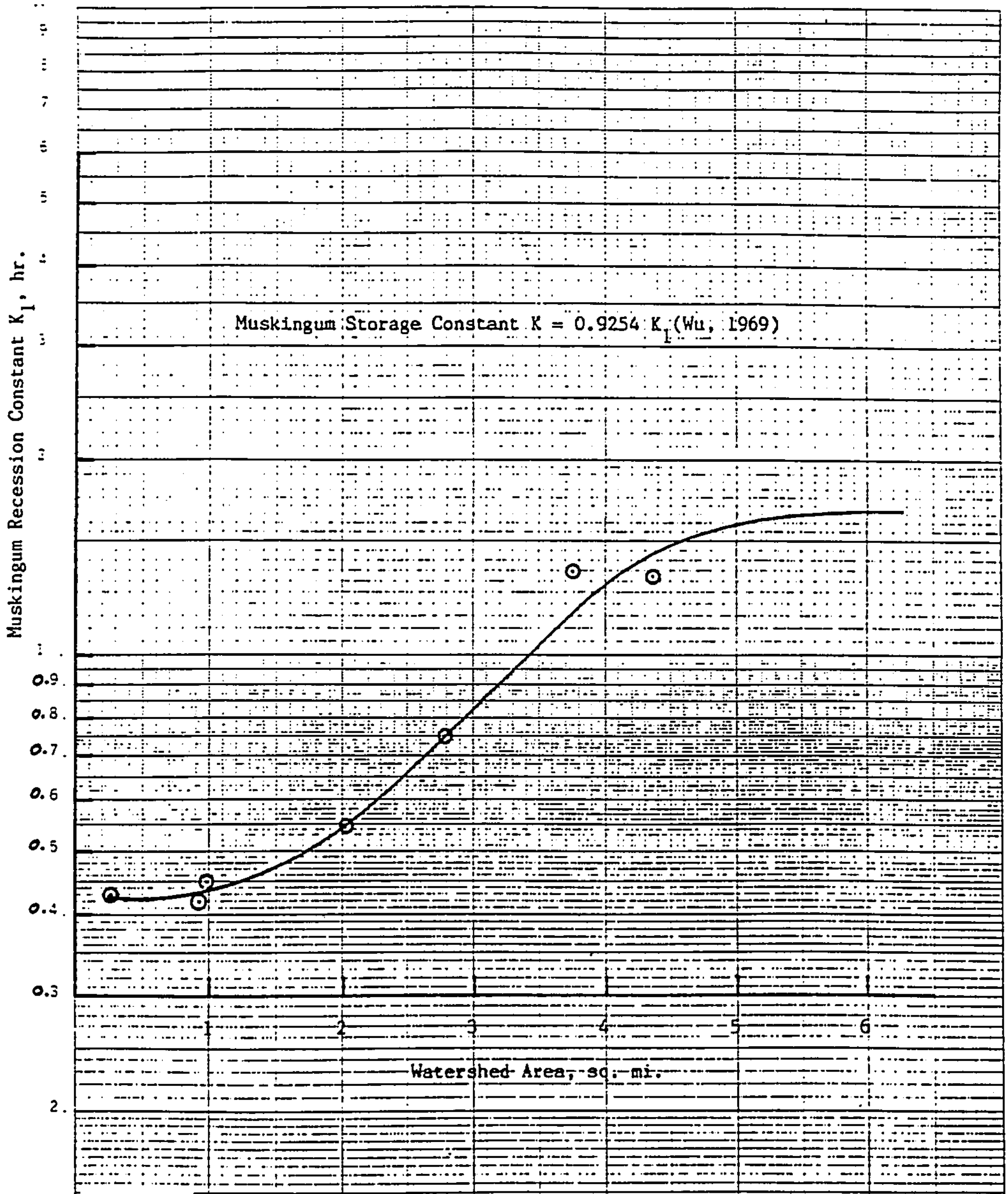


Figure A-5 Watershed Area vs Recession Constant Plot for Windward Watersheds, Oahu.

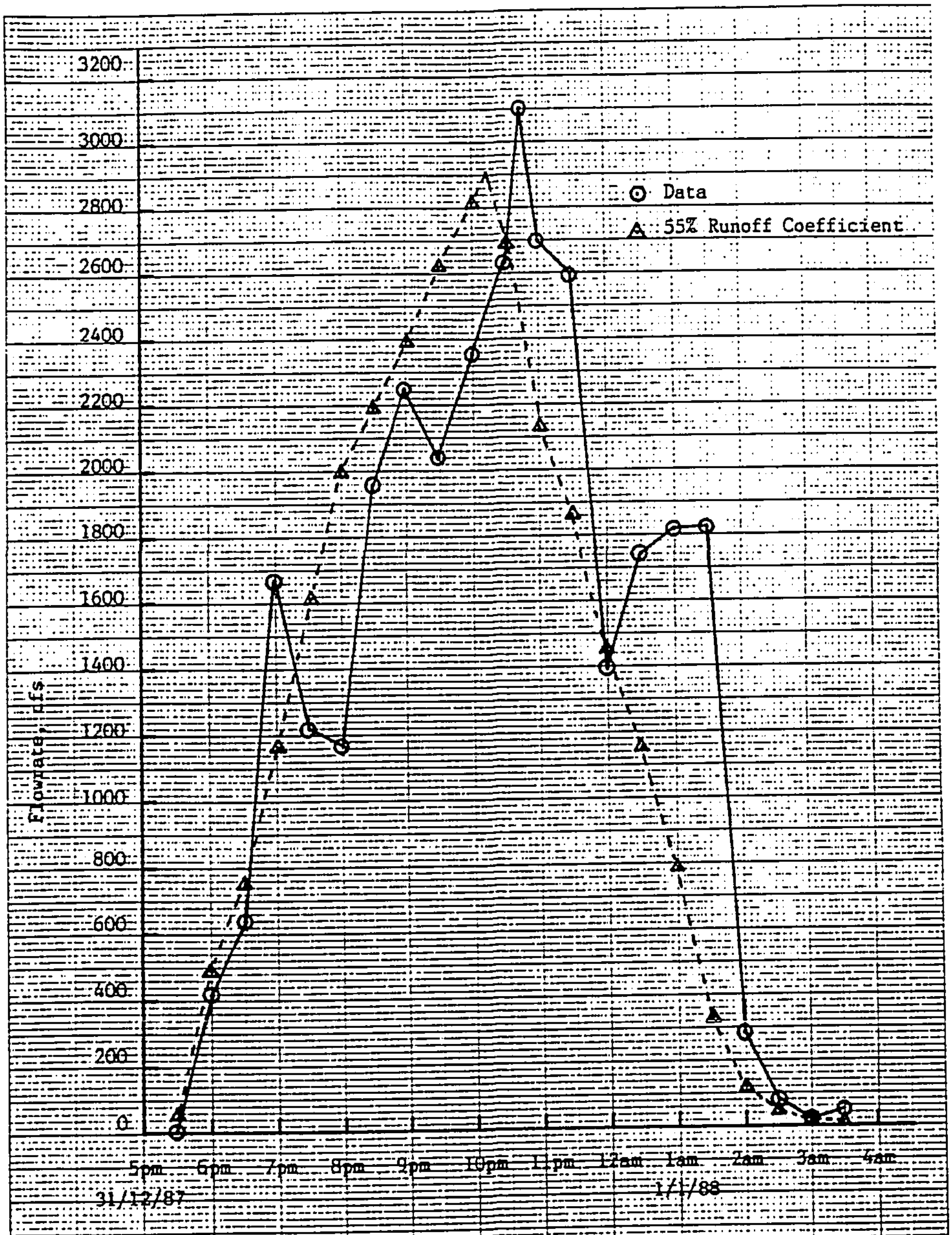


Figure A-6 Muskingum Mehtod of Simulating 1987 New Year's Eve Strom Direct Runoff Hydrograph at Makawao Watershed (Stream Gage No.2540), Oahu.

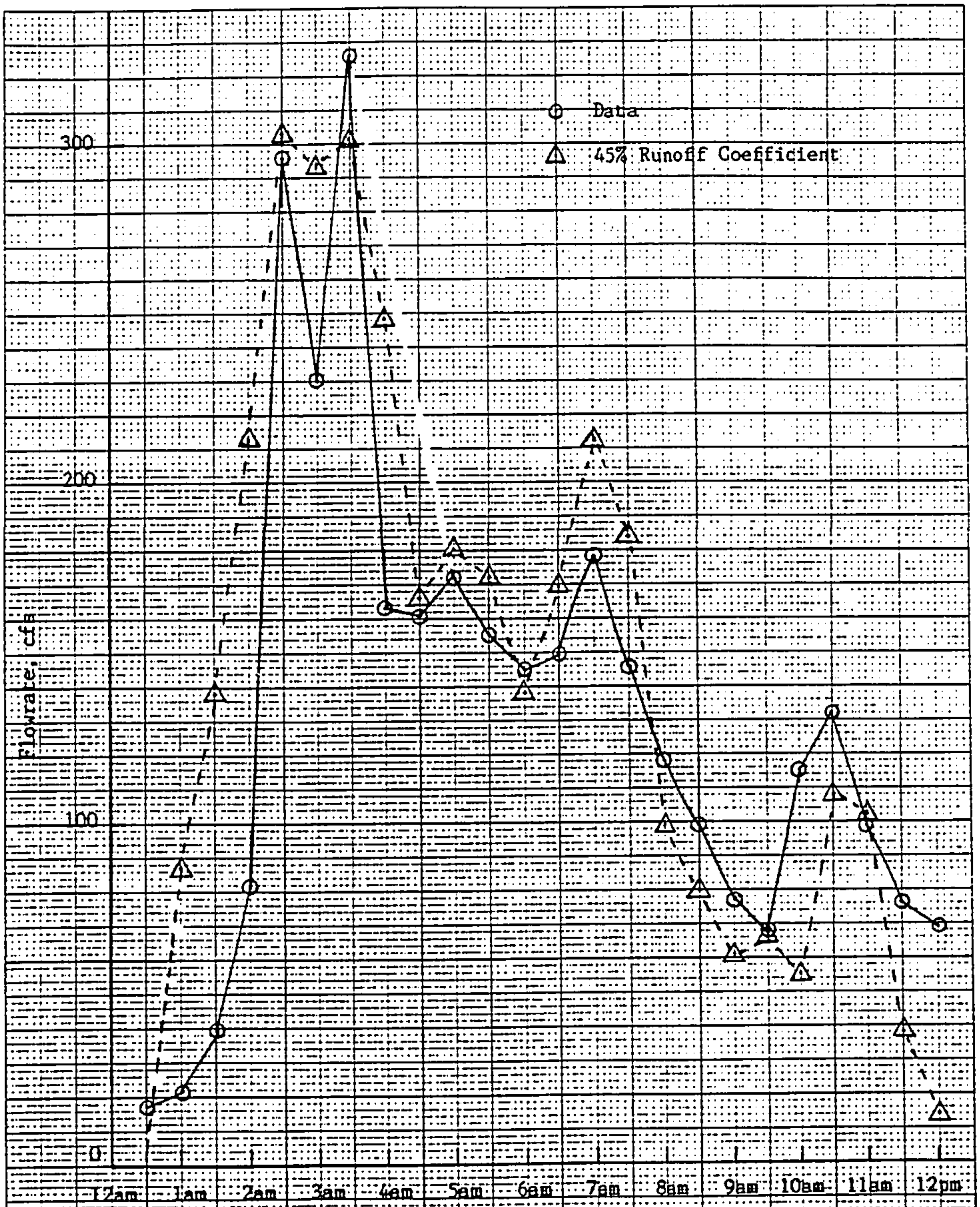


Figure A-7 Muskingum Method of Simulating April 8, 1989 Storm Direct Runoff Hydrograph at Makawao Watershed (Stream Gage NO. 2540), Oahu.

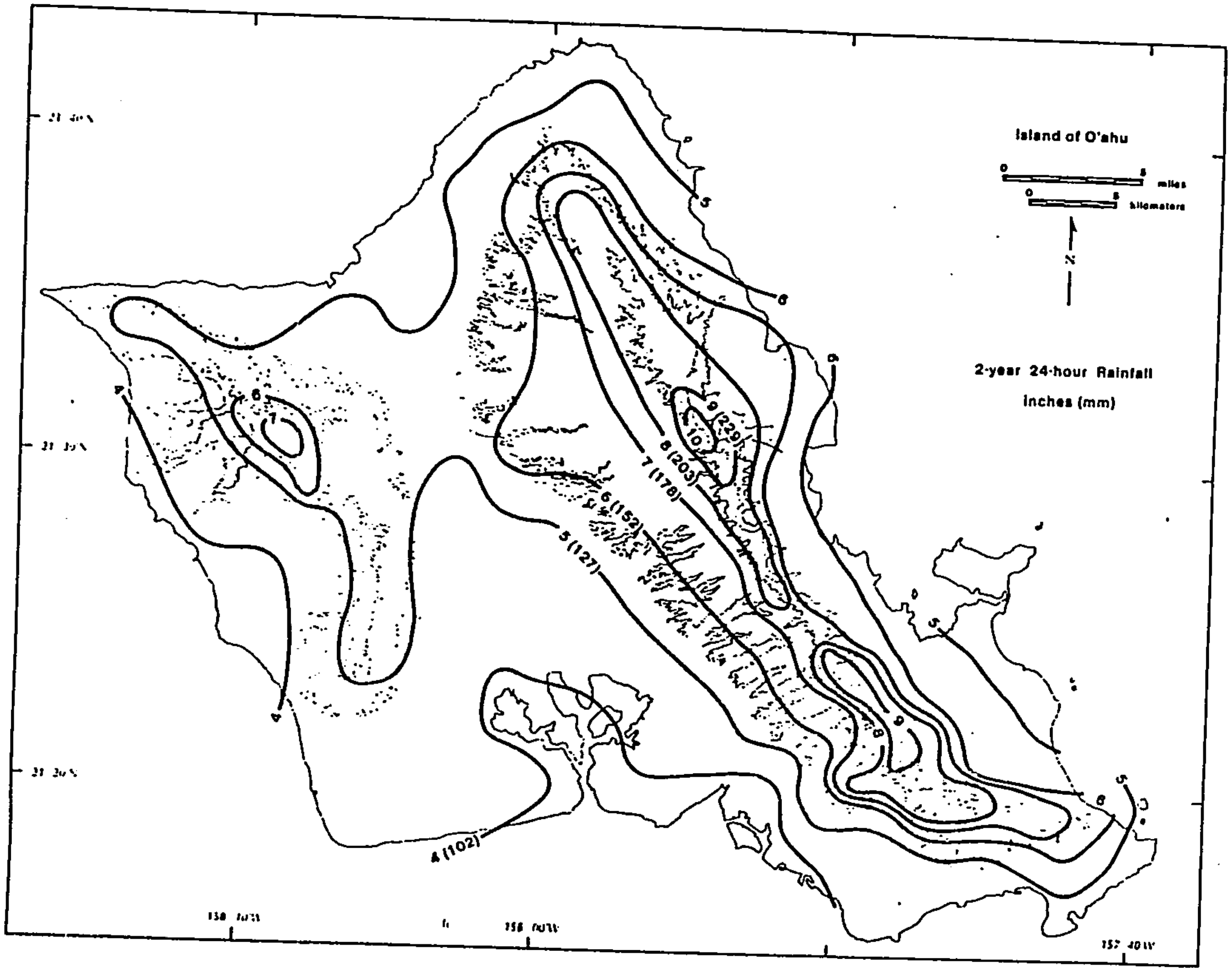


Figure A-8 Map of 2-yr 24-hr rainfall, O'ahu, Hawai'i

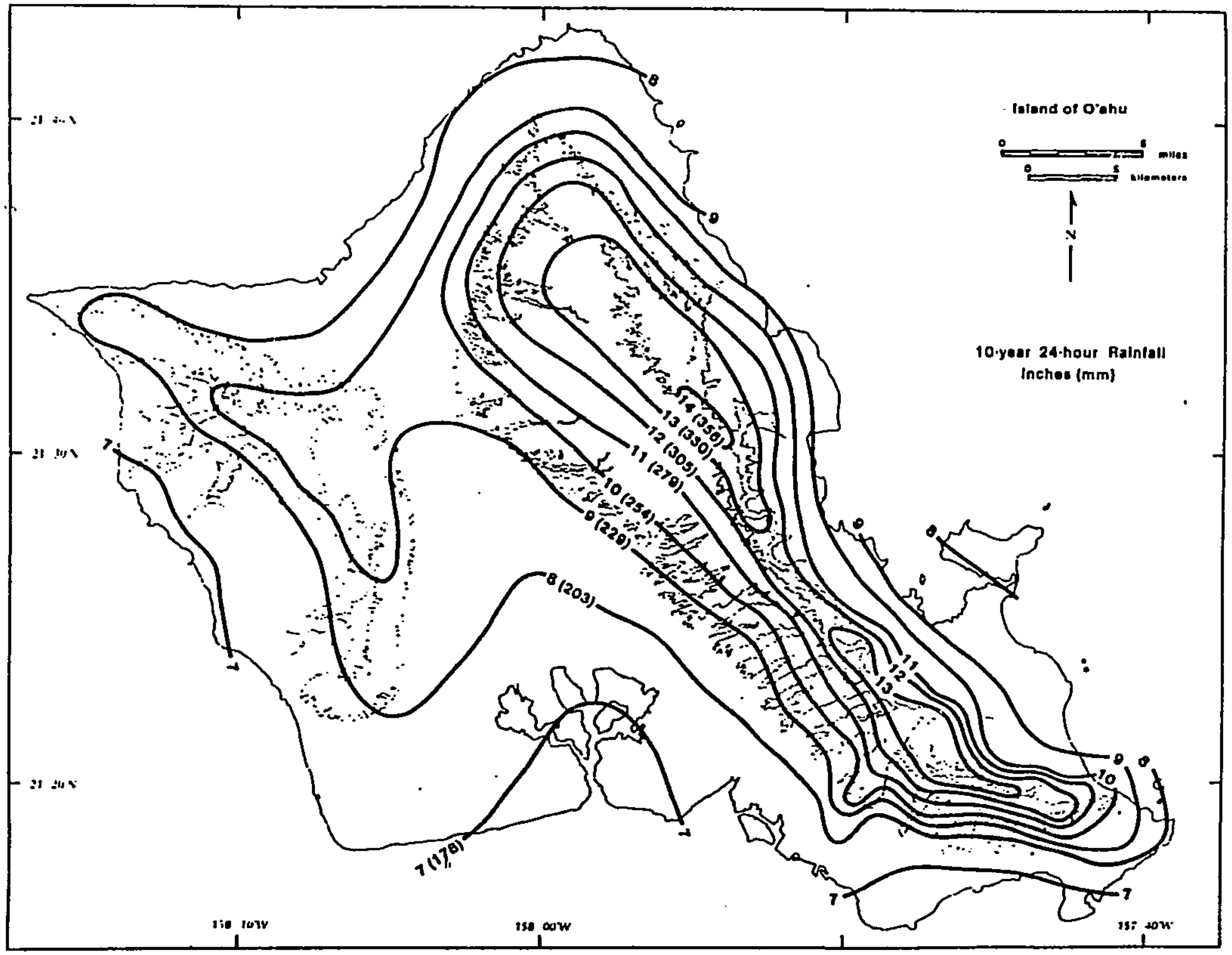


Figure A-9 Map of 10-yr 24-hr rainfall, O'ahu, Hawai'i

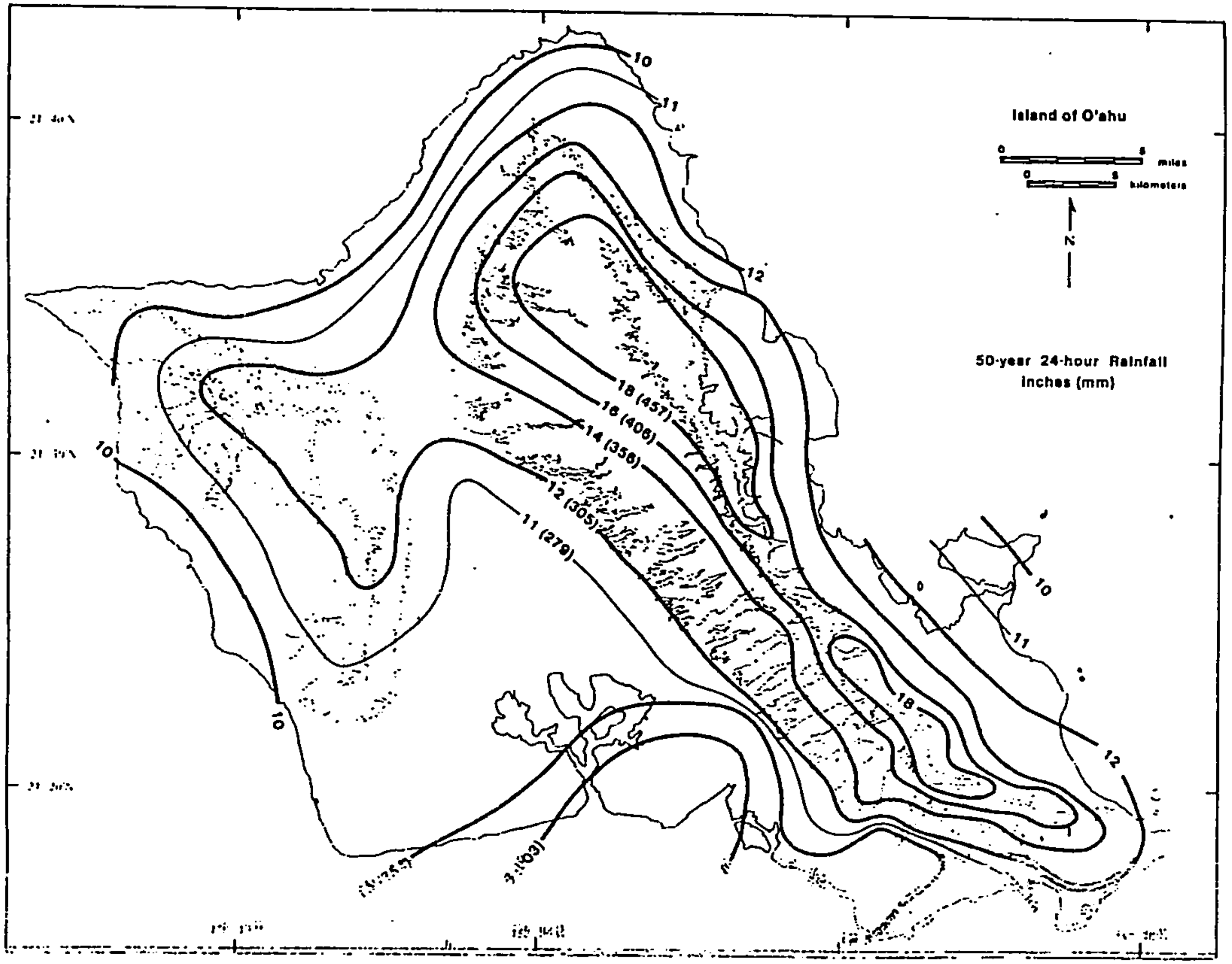


Figure A-10 Map of 50-yr 24-hr rainfall, O'ahu, Hawai'i

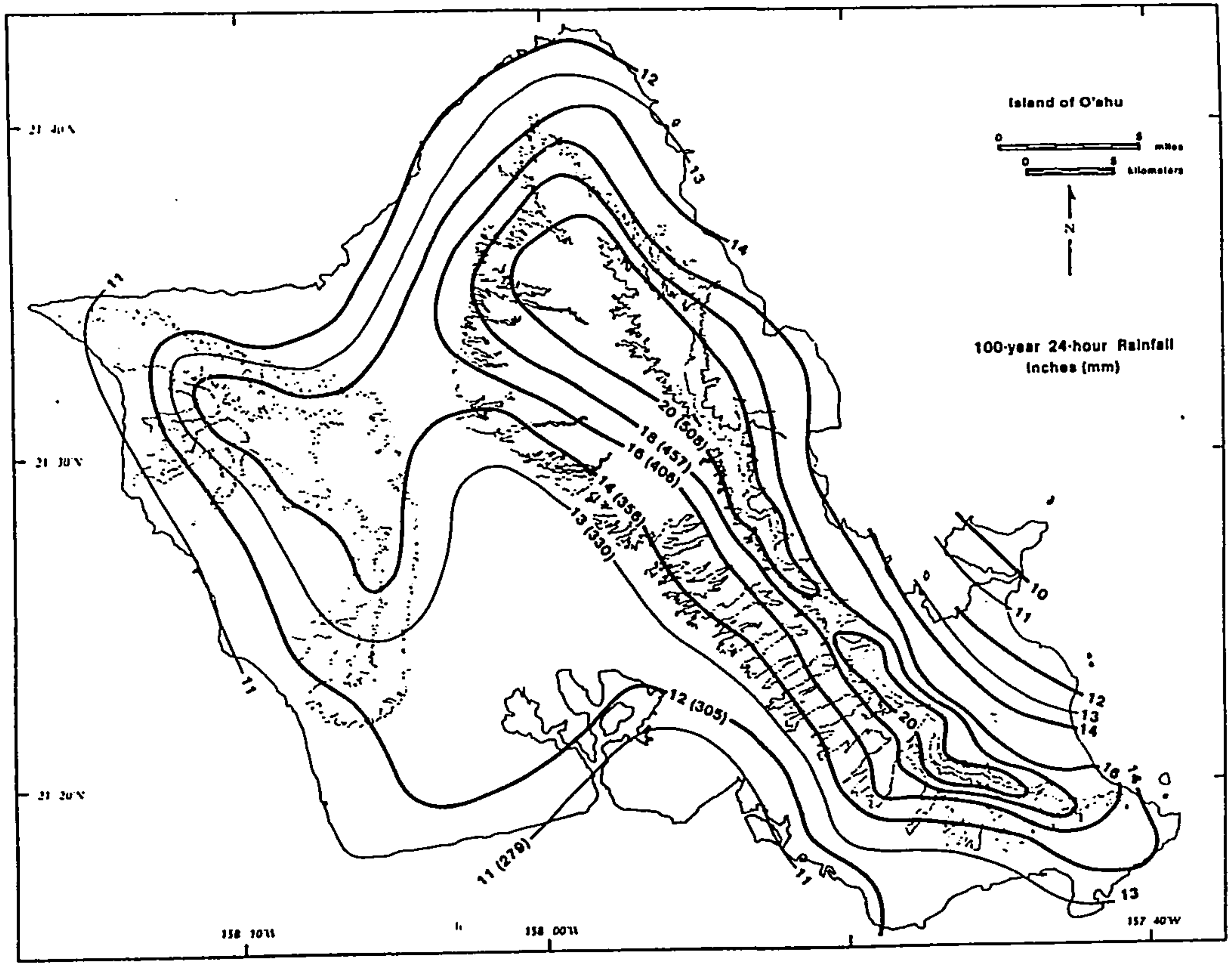
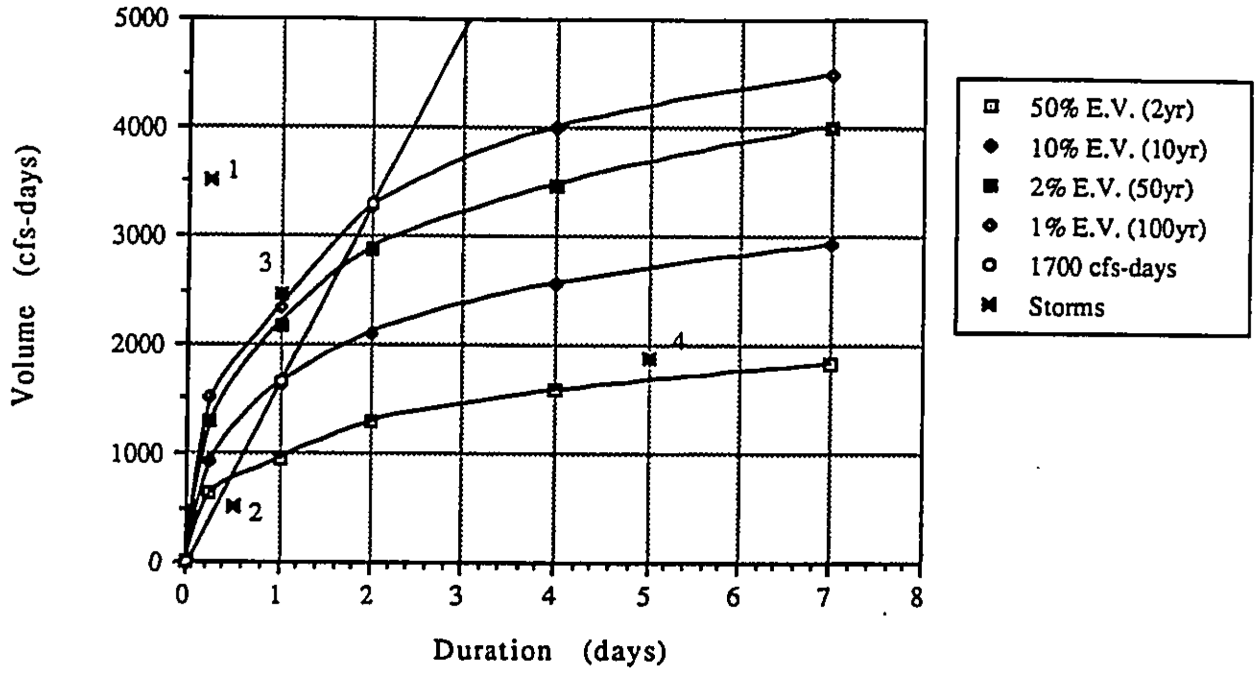


Figure A-11 Map of 100-yr 24-hr rainfall, O'ahu, Hawai'i

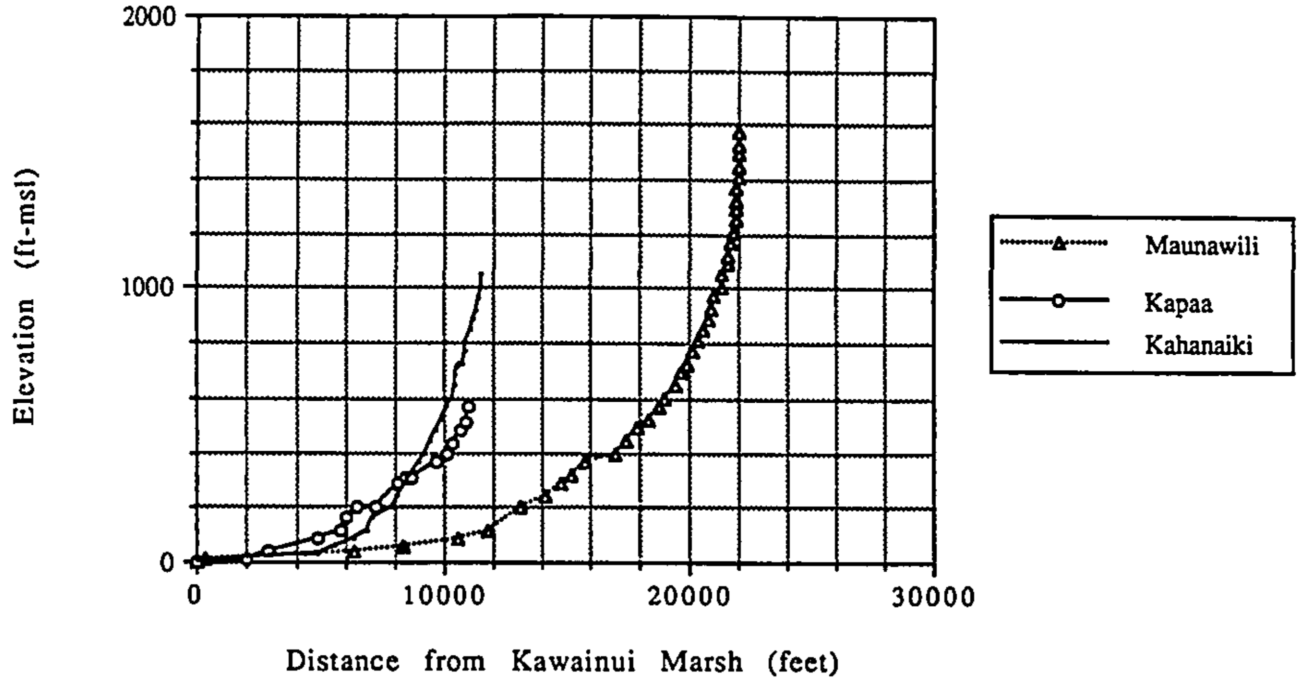
Figure A-12
Kawainui Marsh
Storm Runoff Volume Curves



1. SPF, 3688 cfs-days, 5 hour duration
2. Storm of April 4-5 1989, 5625 cfs-days, 12 hour duration
3. Flood of New Year's 1988, 4375 cfs-days, 1 day duration
4. Storm of April 4-9 1989, 8125 cfs-days, 5 day duration

Figure A-13

Stream Profiles



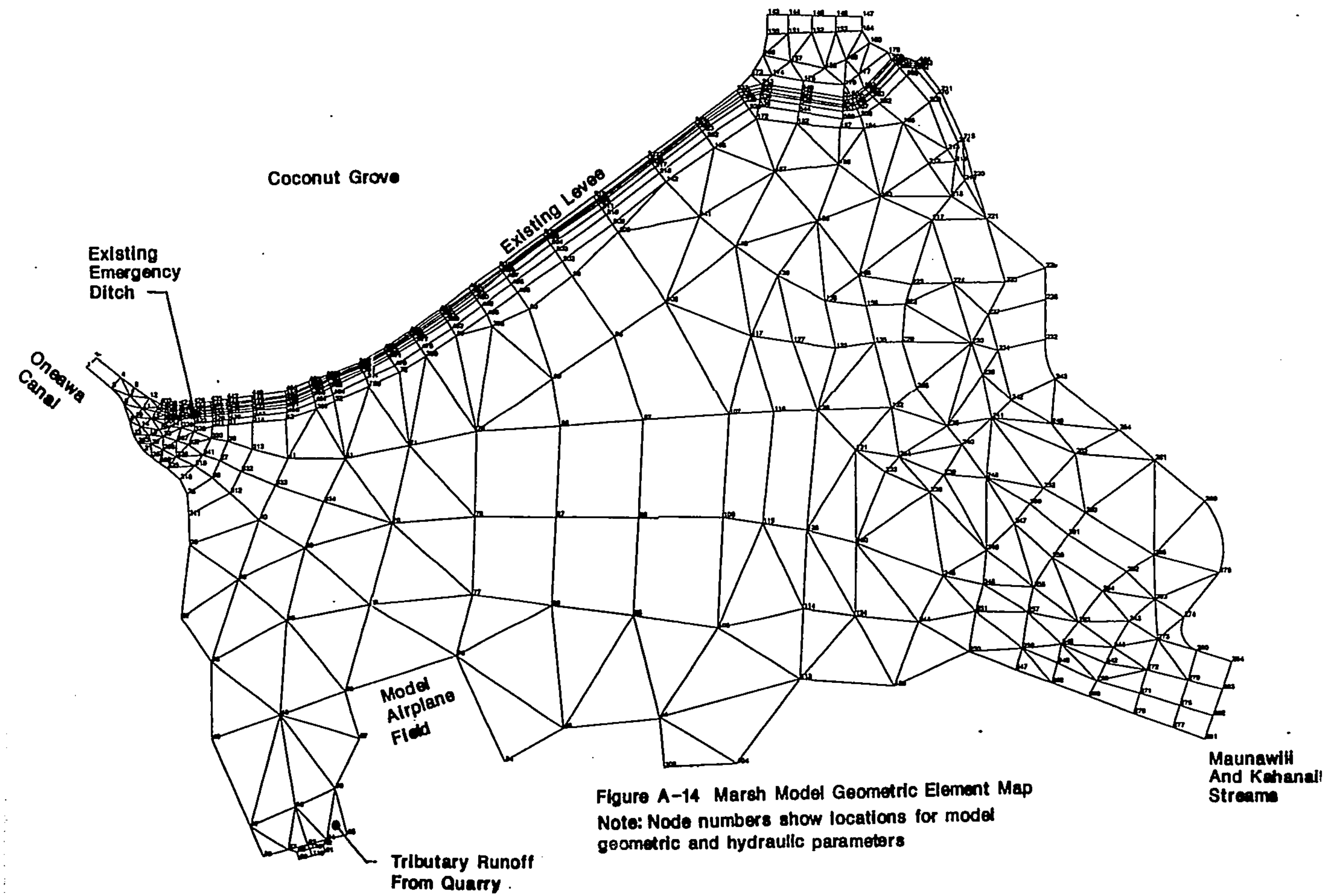


Figure A-14 Marsh Model Geometric Element Map
Note: Node numbers show locations for model geometric and hydraulic parameters

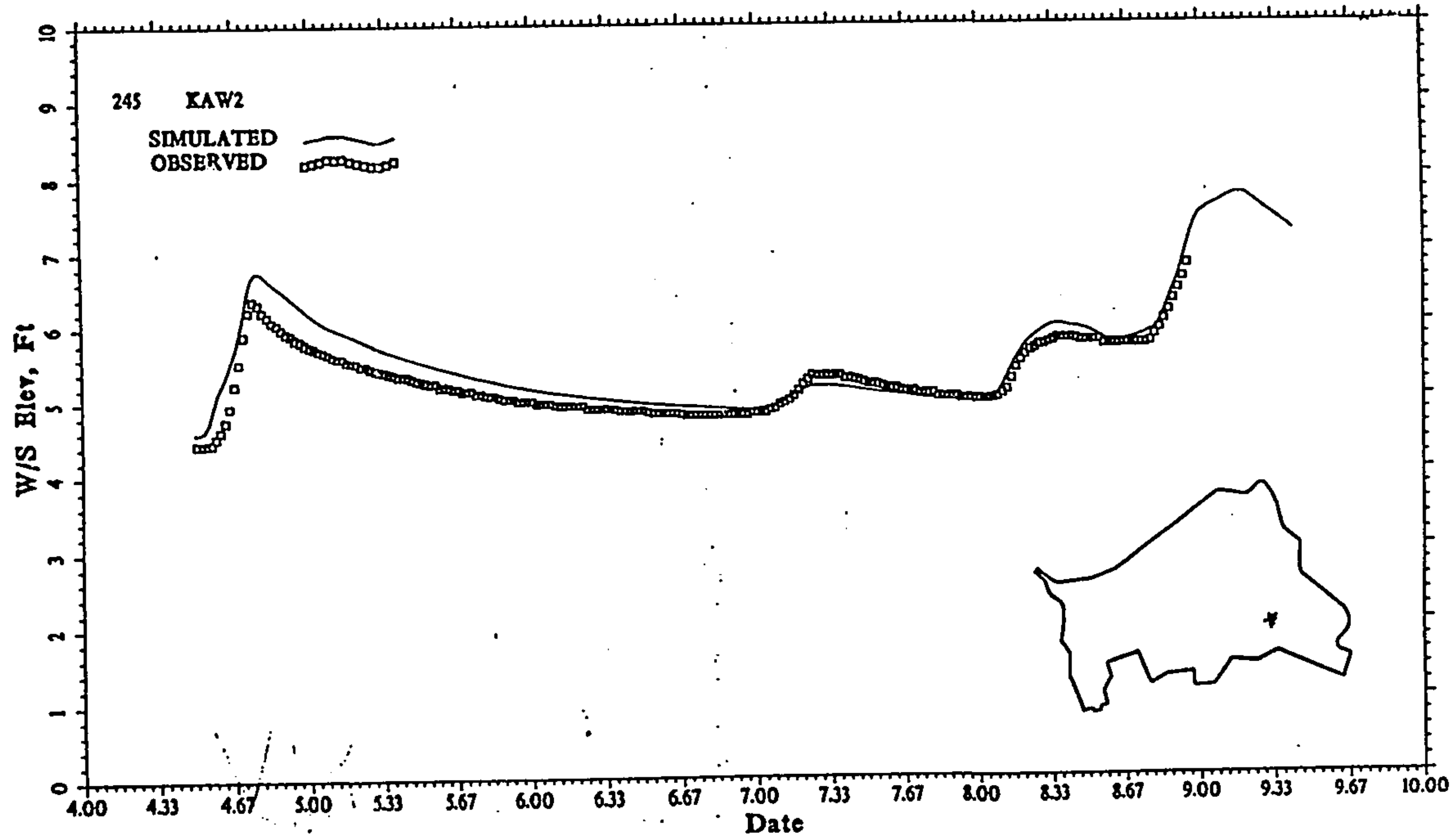


Figure A-15 Computed and Observed Water Surface Elevations at Gaging Station KAW2 During The April 4-9, 1989 Storm

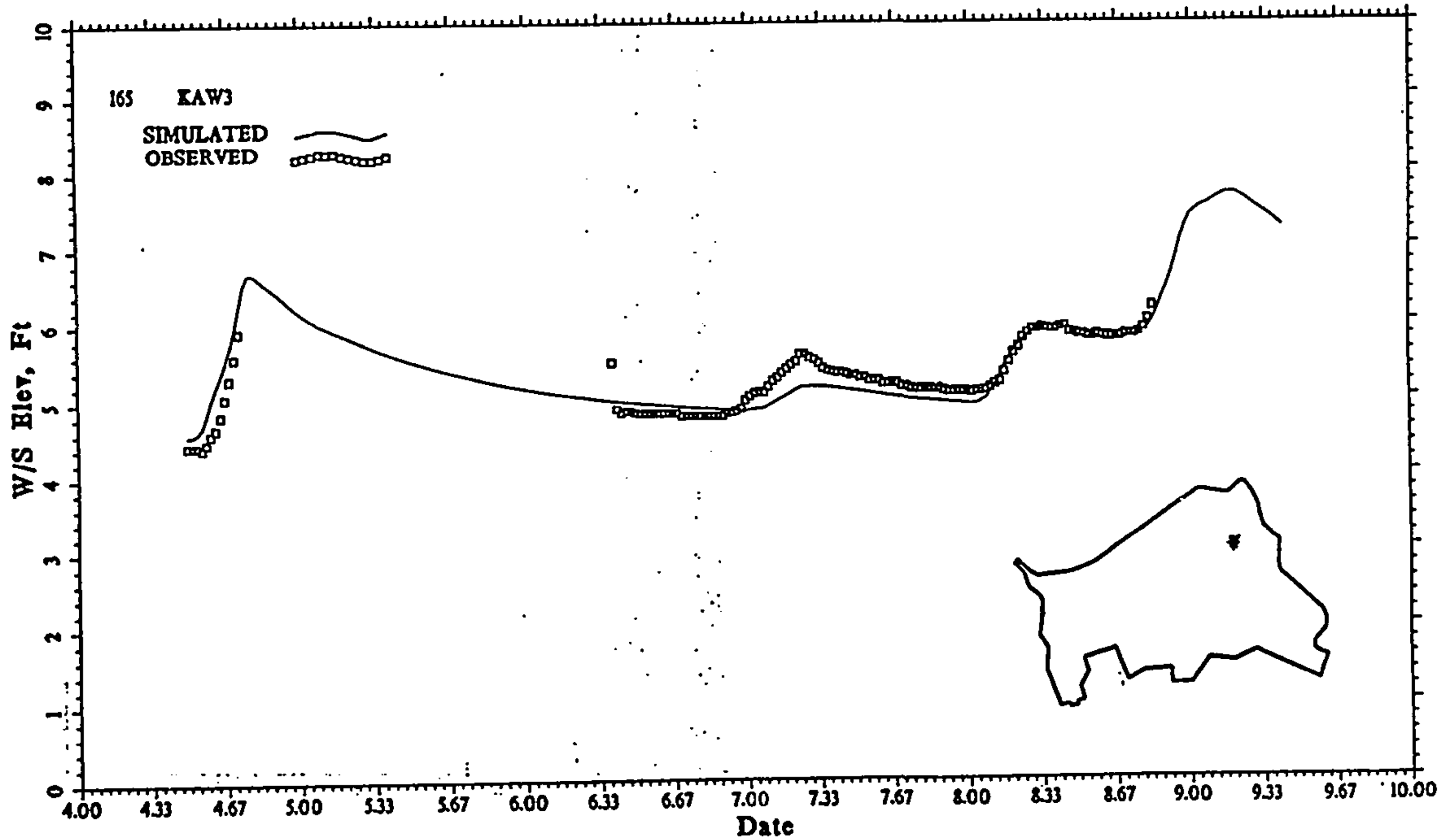


Figure A-16 Computed and Observed Water Surface Elevations at Gaging Station KAW3 During The April 4-9, 1989 Storm

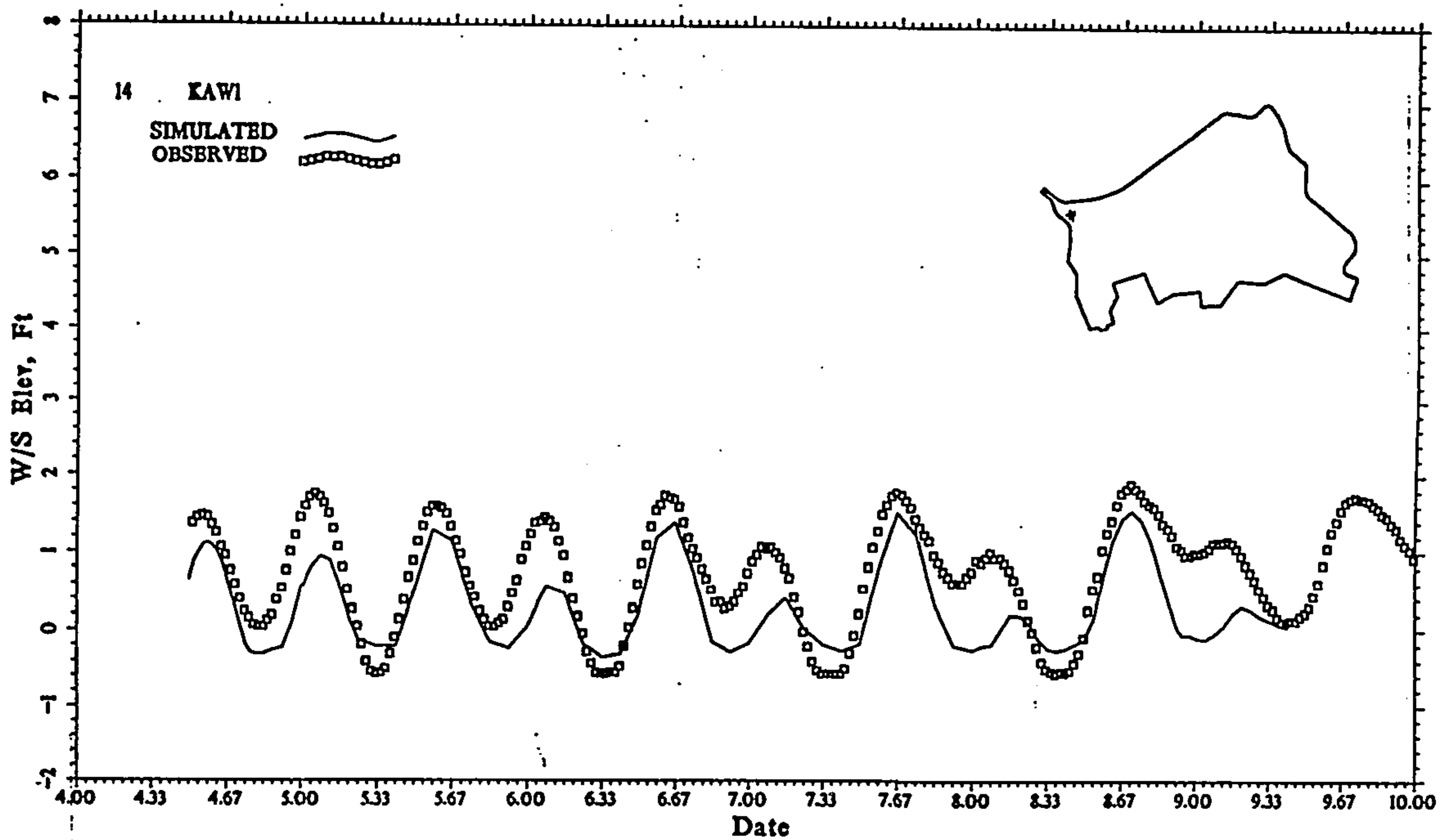


Figure A-17 Computed and Observed water Surface Elevation at Gaging Station KAW1 During The April 4-9, 1989 Storm

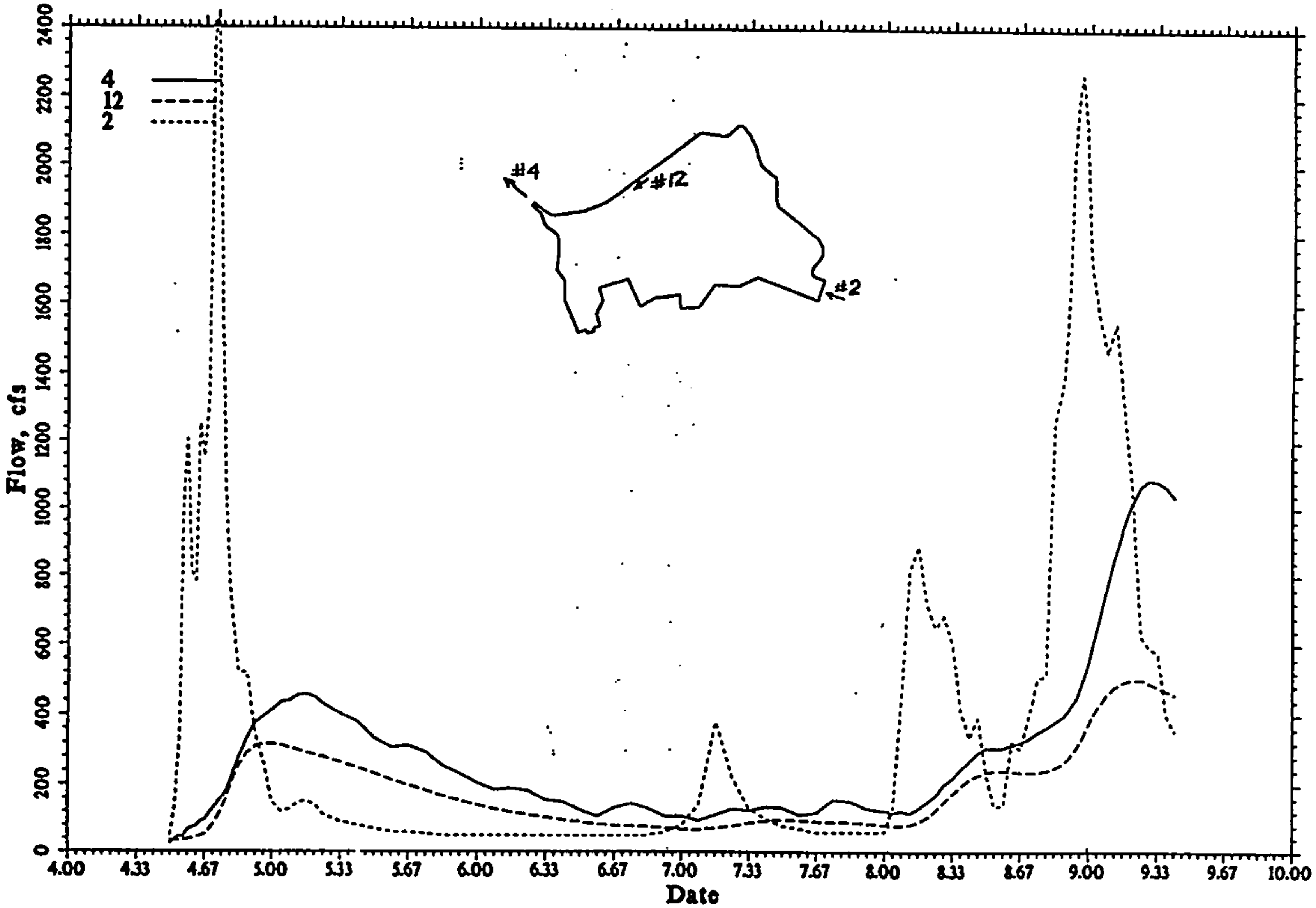


Figure A-18 Inflow, Outflow and Levee Channel Hydrograph During The April 4-9, 1989 Storm Event

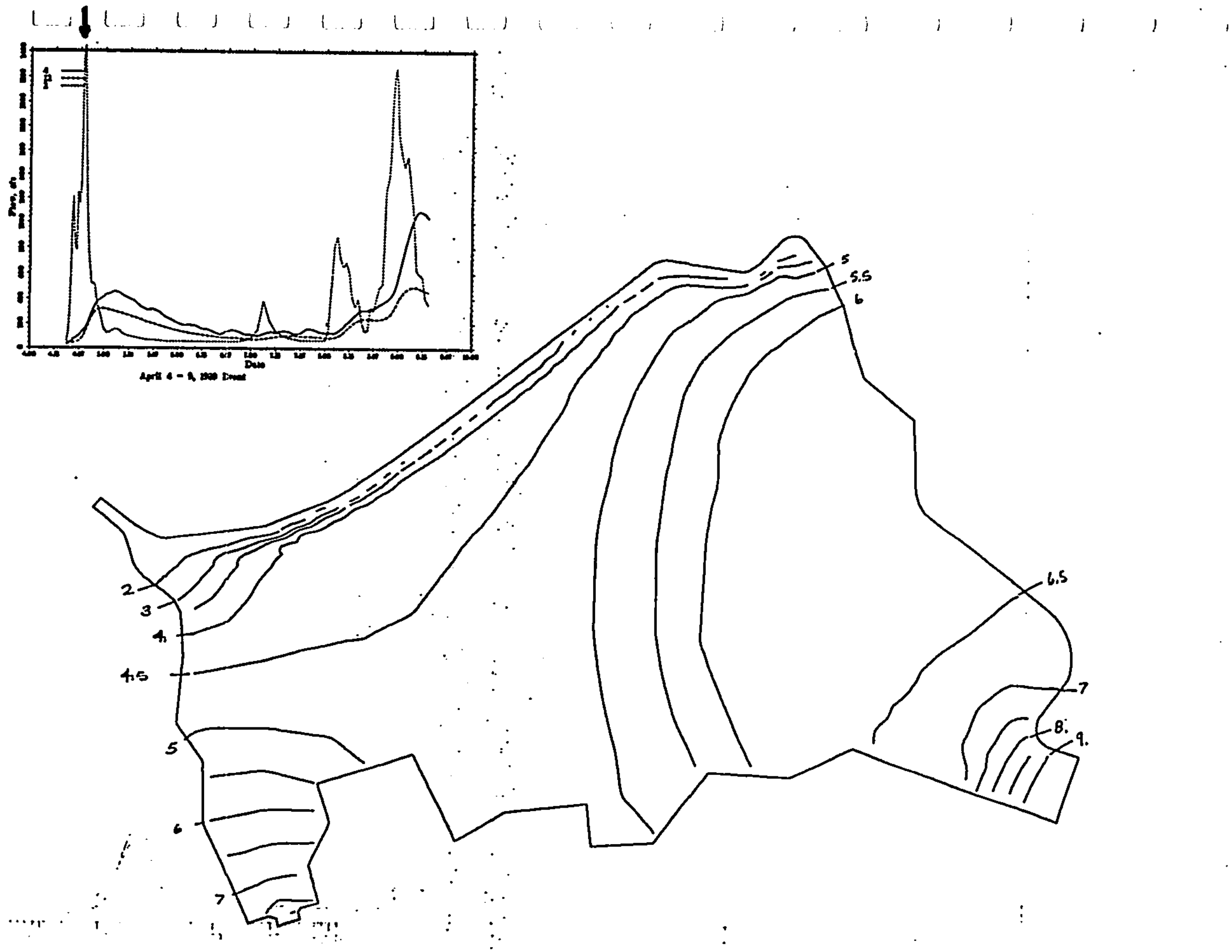


Figure A-19 **Contours of Computed Water Surface Elevations at the Time of the First Discharge Peak (5:30 PM, April 4)**

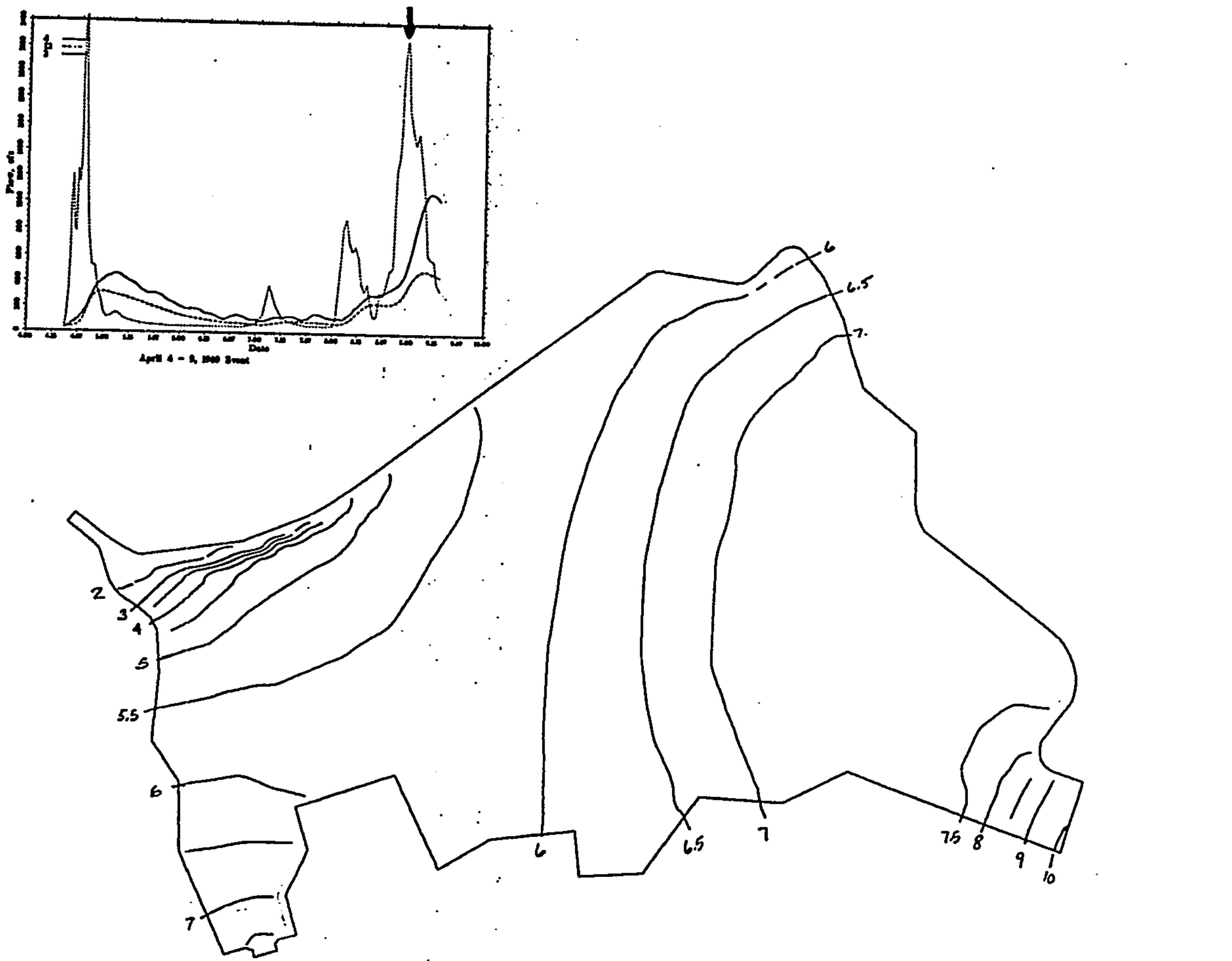


Figure A-20 Contours of Computed Water Surface Elevations at the Time of the Second Discharge Peak (11:00 PM, April 8)

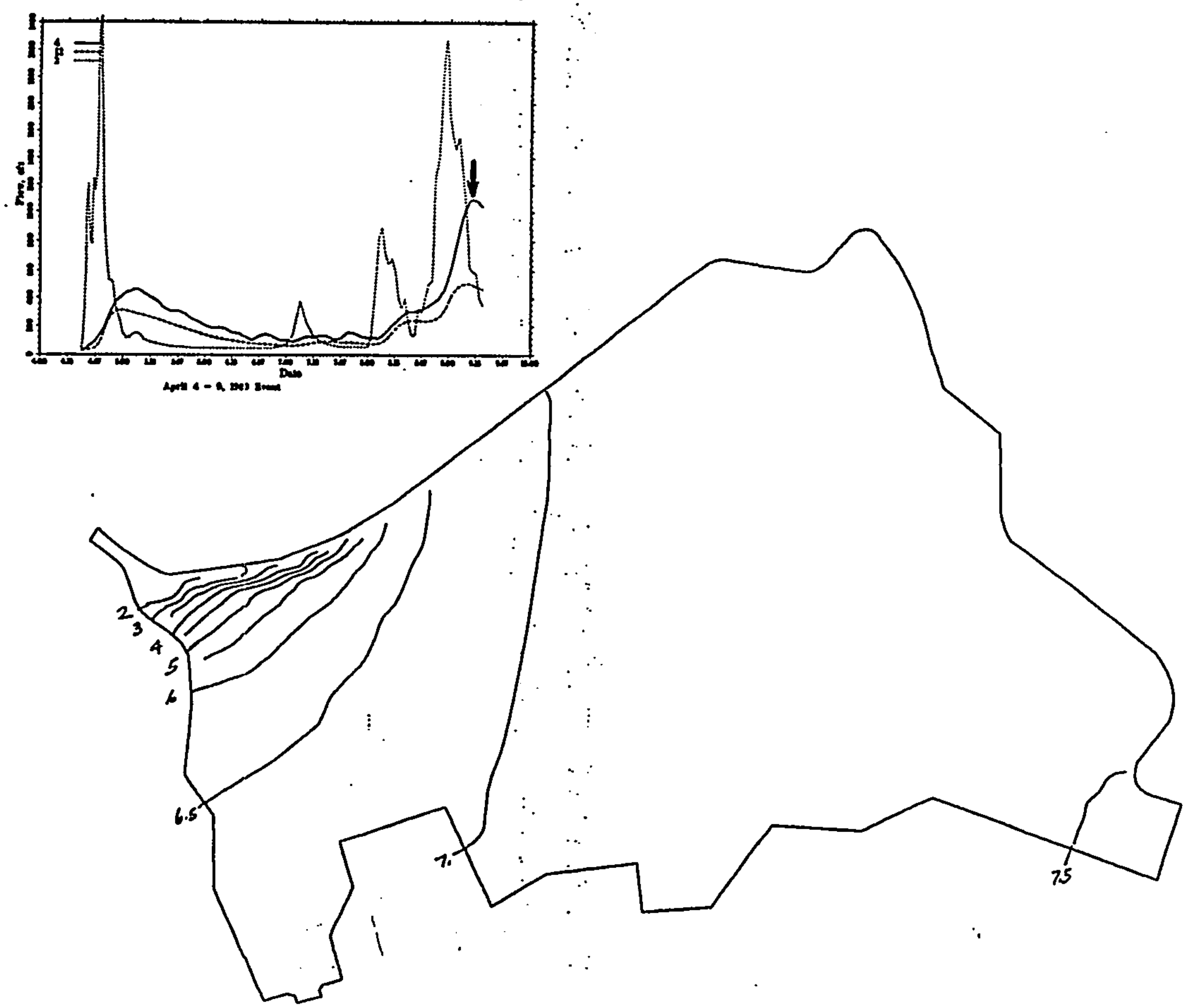


Figure A-21 Contours of Computed Water Surface Elevations at the Time of the Maximum Outflow (8:00 AM, April 9)

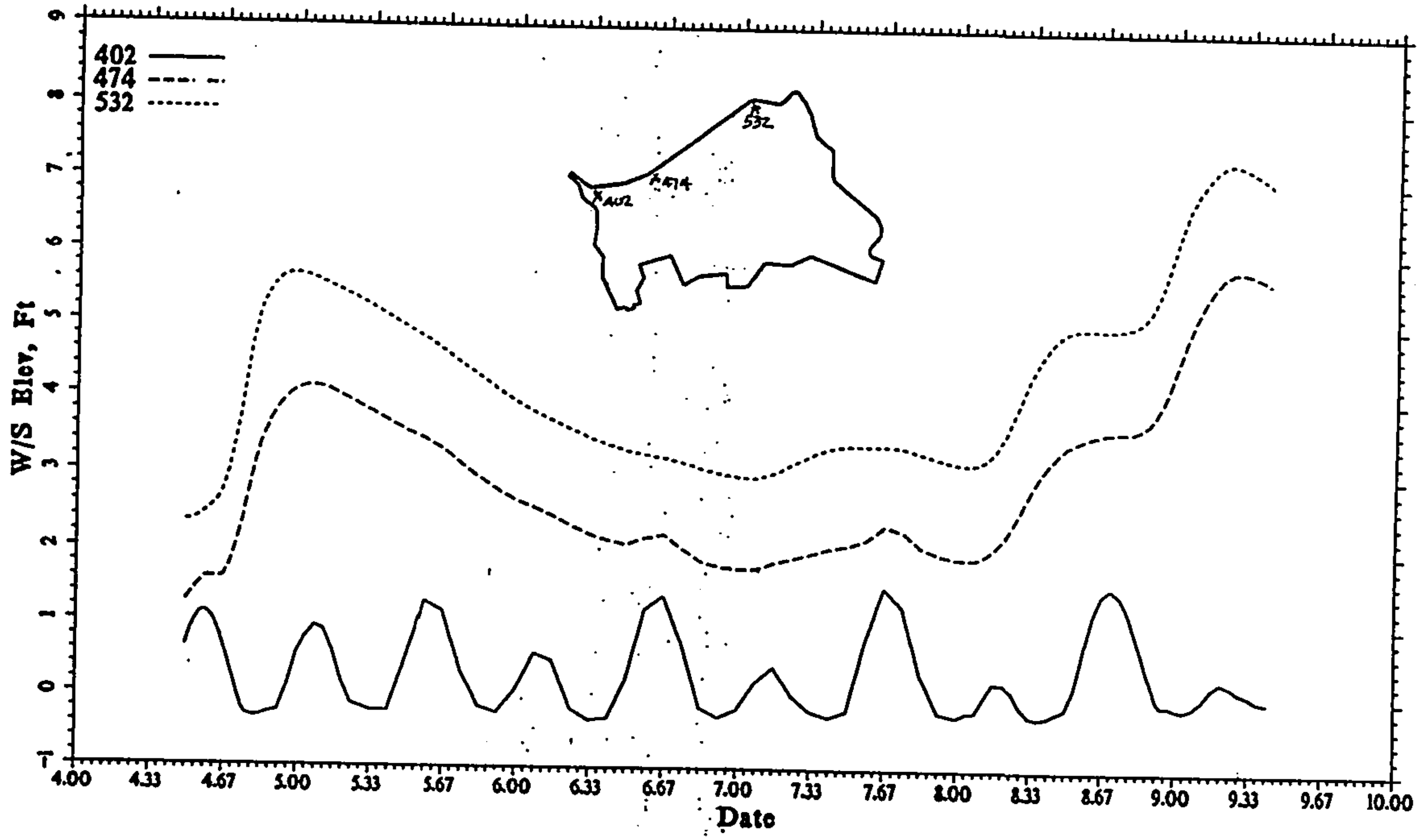


Figure A-22 Computed Water Surface Elevations at Three Locations Along the Levee Ditch During the April 4-9, 1989 Storm

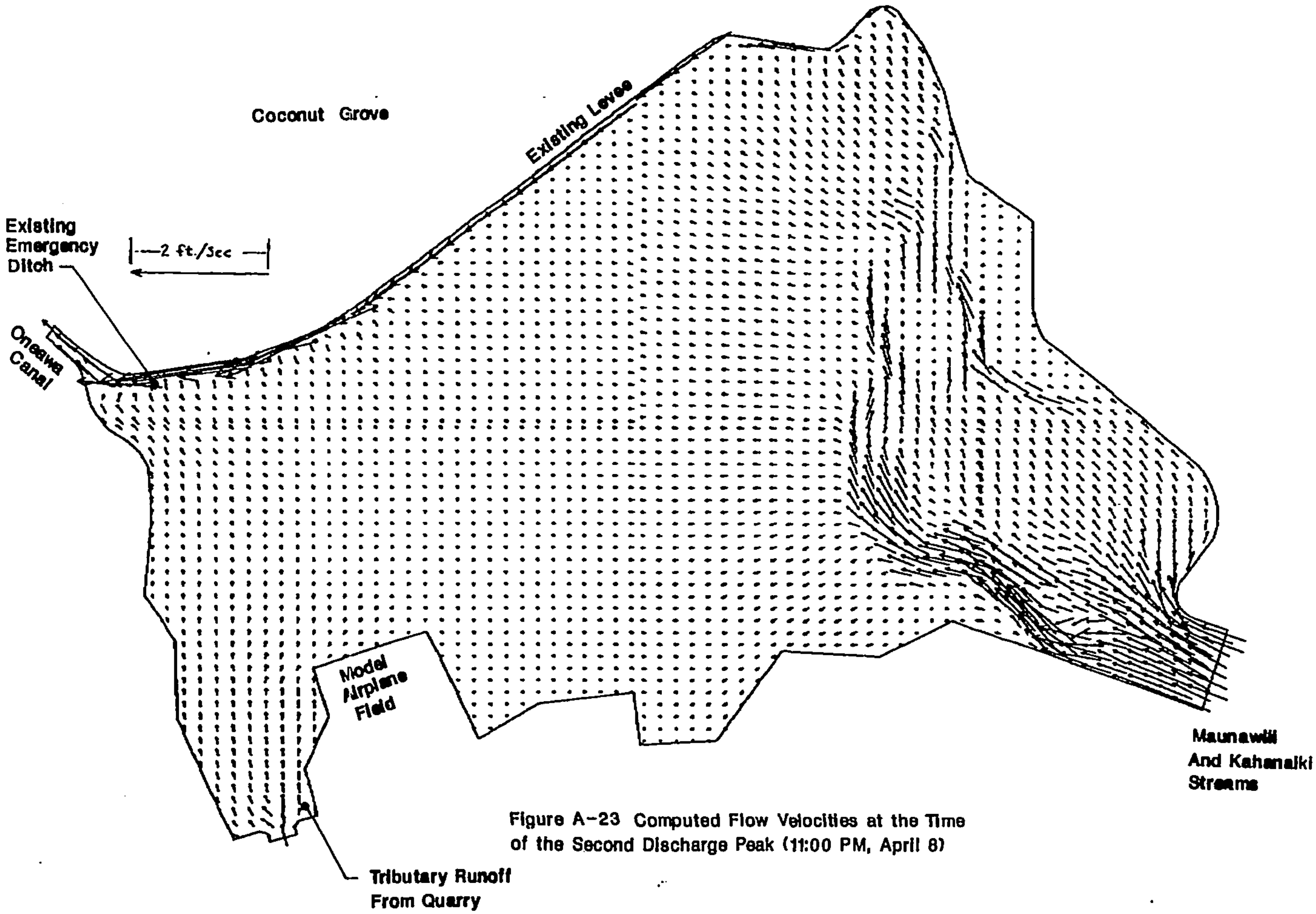
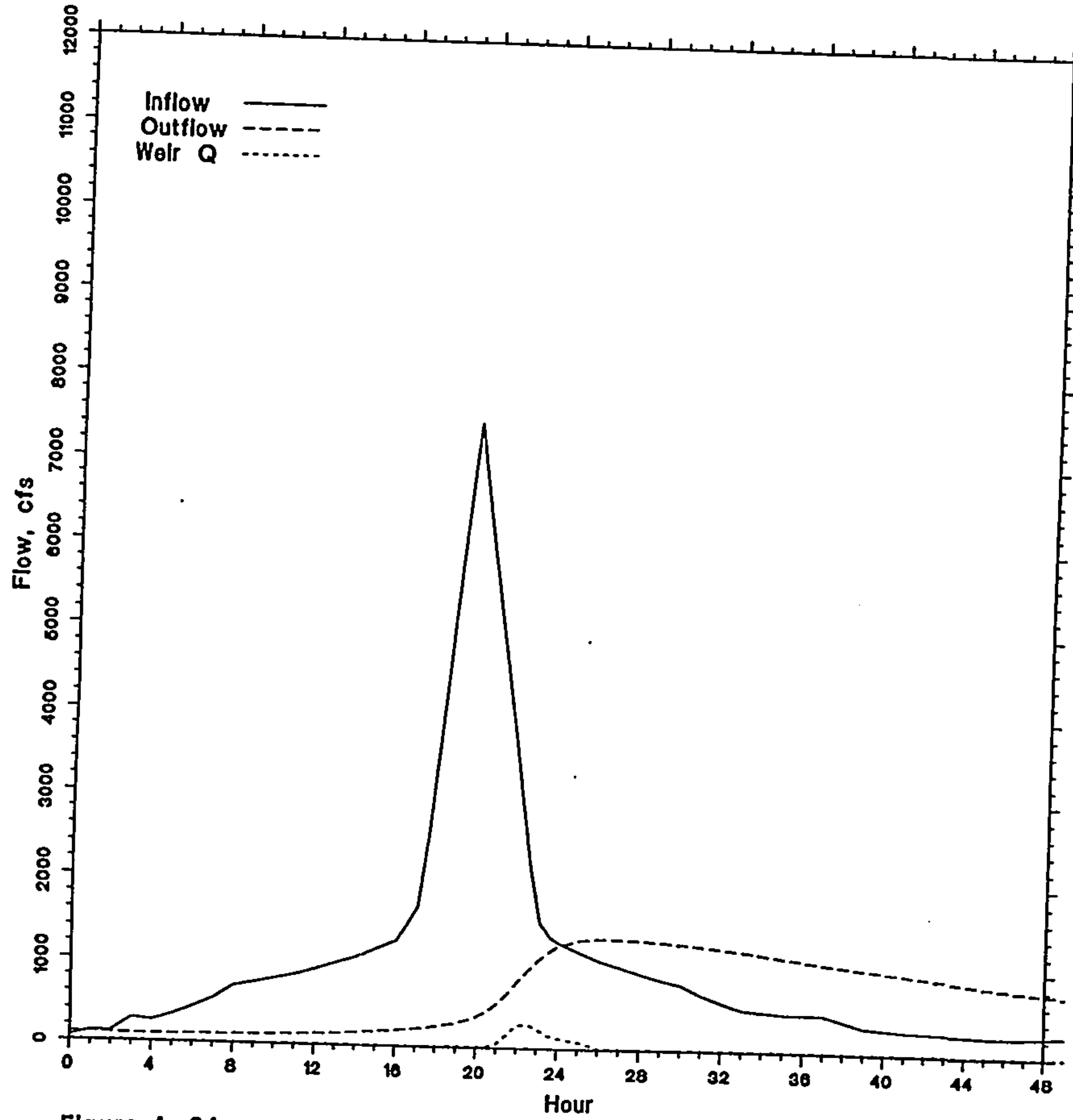


Figure A-23 Computed Flow Velocities at the Time of the Second Discharge Peak (11:00 PM, April 8)

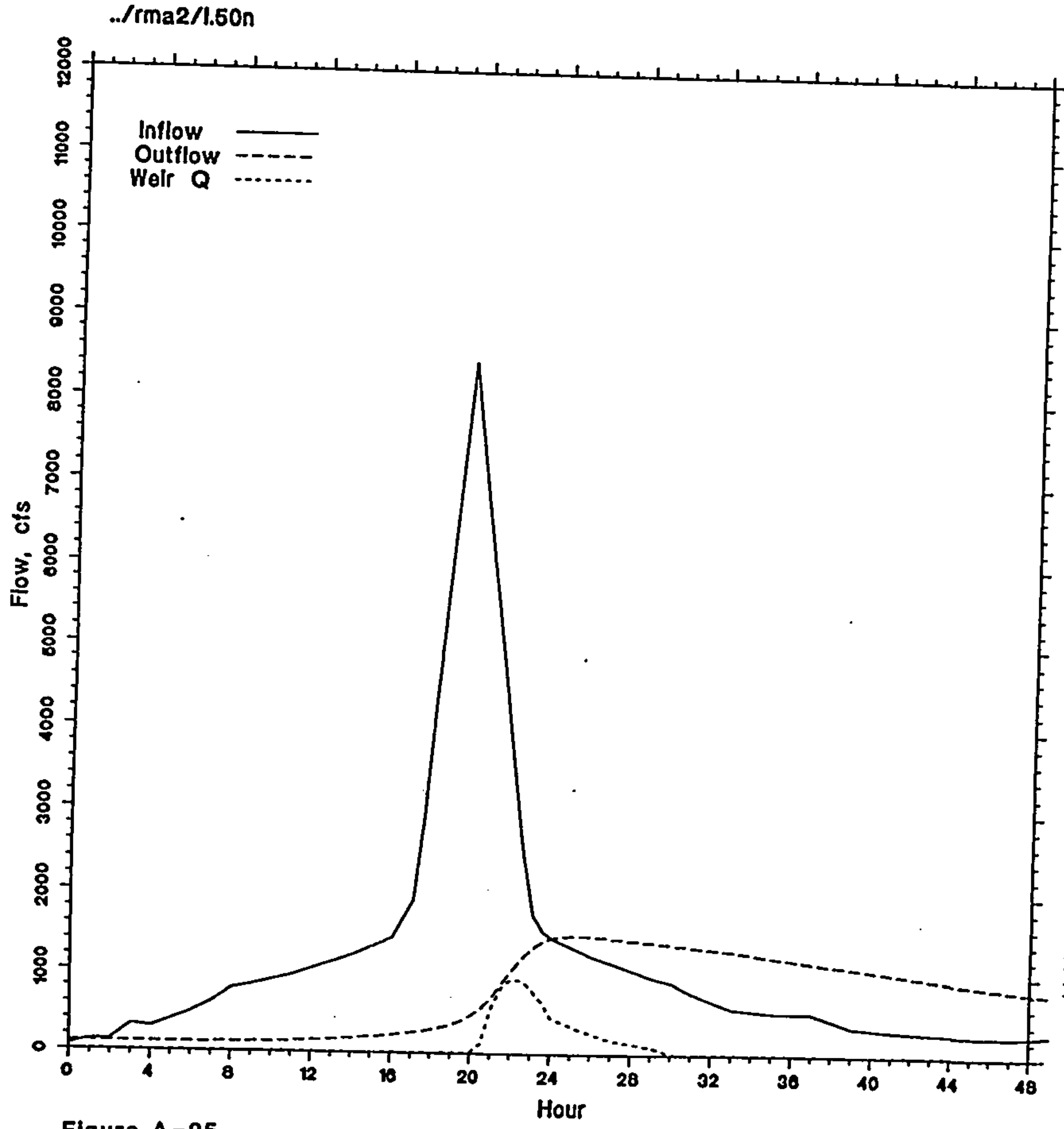
../rma2/l.25n



Time	Q in	Q out	Weir Q
18.0	3800.	247.	6.
18.5	5016.	267.	6.
19.0	6232.	292.	7.
19.5	7448.	327.	8.
20.0	6574.	374.	8.
20.5	5700.	442.	8.
21.0	4826.	537.	45.
21.5	3952.	658.	153.
22.0	3078.	797.	279.
22.5	2166.	939.	285.
23.0	1520.	1065.	228.
23.5	1338.	1164.	153.
24.0	1263.	1234.	122.
25.0	1163.	1302.	83.
26.0	1064.	1322.	6.
27.0	988.	1321.	5.
28.0	912.	1310.	6.
29.0	836.	1294.	5.
30.0	783.	1274.	5.
31.0	669.	1251.	5.
32.0	584.	1228.	5.
33.0	505.	1201.	5.

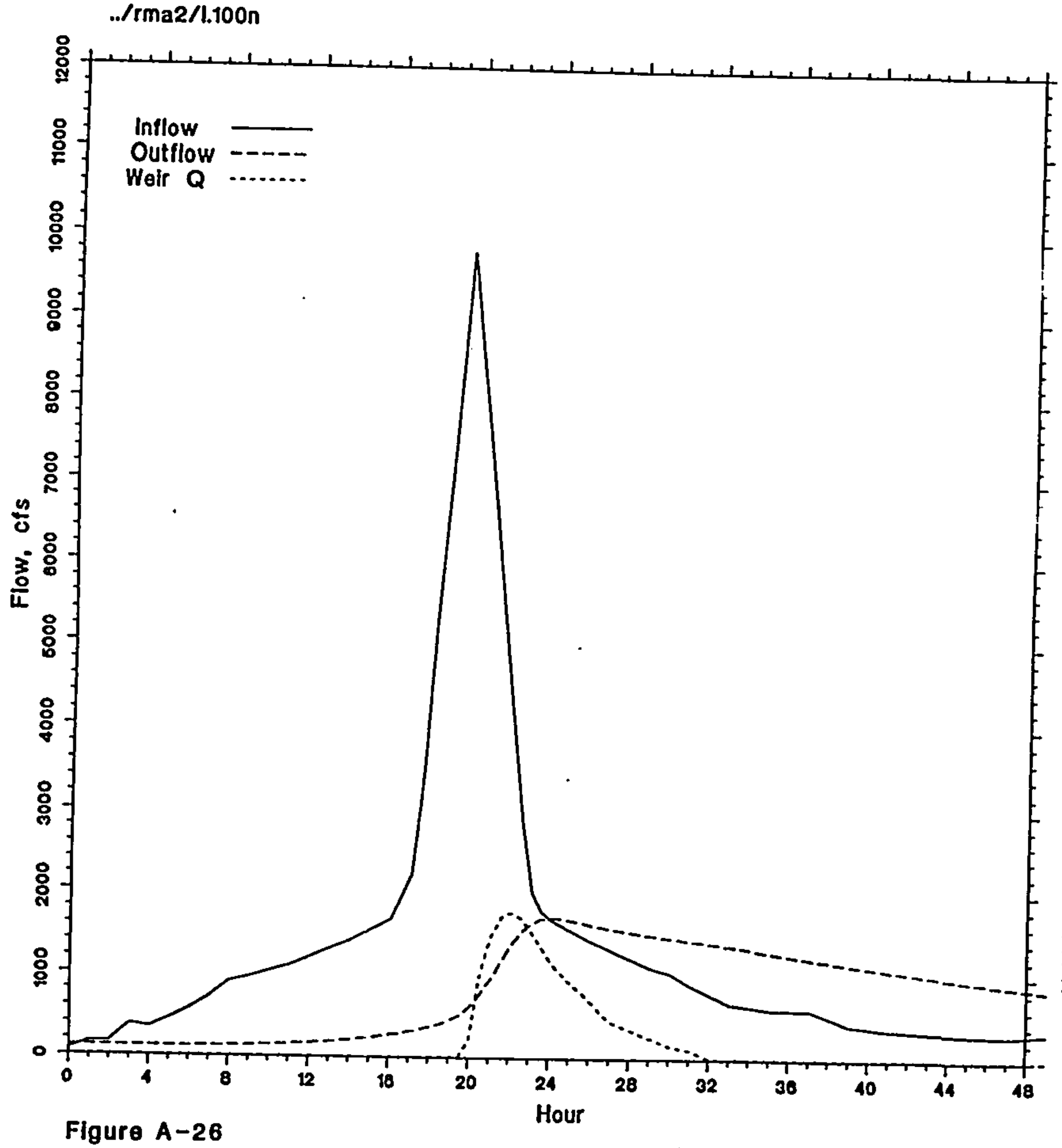
Figure A-24

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 25 Year Design Storm Without Levee or Marsh Modifications



Time	Q in	Q out	Weir Q
18.0	4300.	291.	6.
18.5	5676.	317.	7.
19.0	7052.	350.	7.
19.5	8428.	397.	8.
20.0	7439.	462.	8.
20.5	6450.	557.	114.
21.0	5461.	686.	564.
21.5	4472.	846.	808.
22.0	3483.	1017.	915.
22.5	2451.	1177.	897.
23.0	1720.	1305.	787.
23.5	1514.	1391.	644.
24.0	1429.	1442.	442.
25.0	1316.	1470.	340.
26.0	1205.	1461.	256.
27.0	1118.	1439.	169.
28.0	1032.	1414.	131.
29.0	946.	1389.	92.
30.0	886.	1363.	5.
31.0	757.	1337.	5.
32.0	661.	1312.	5.
33.0	571.	1283.	5.

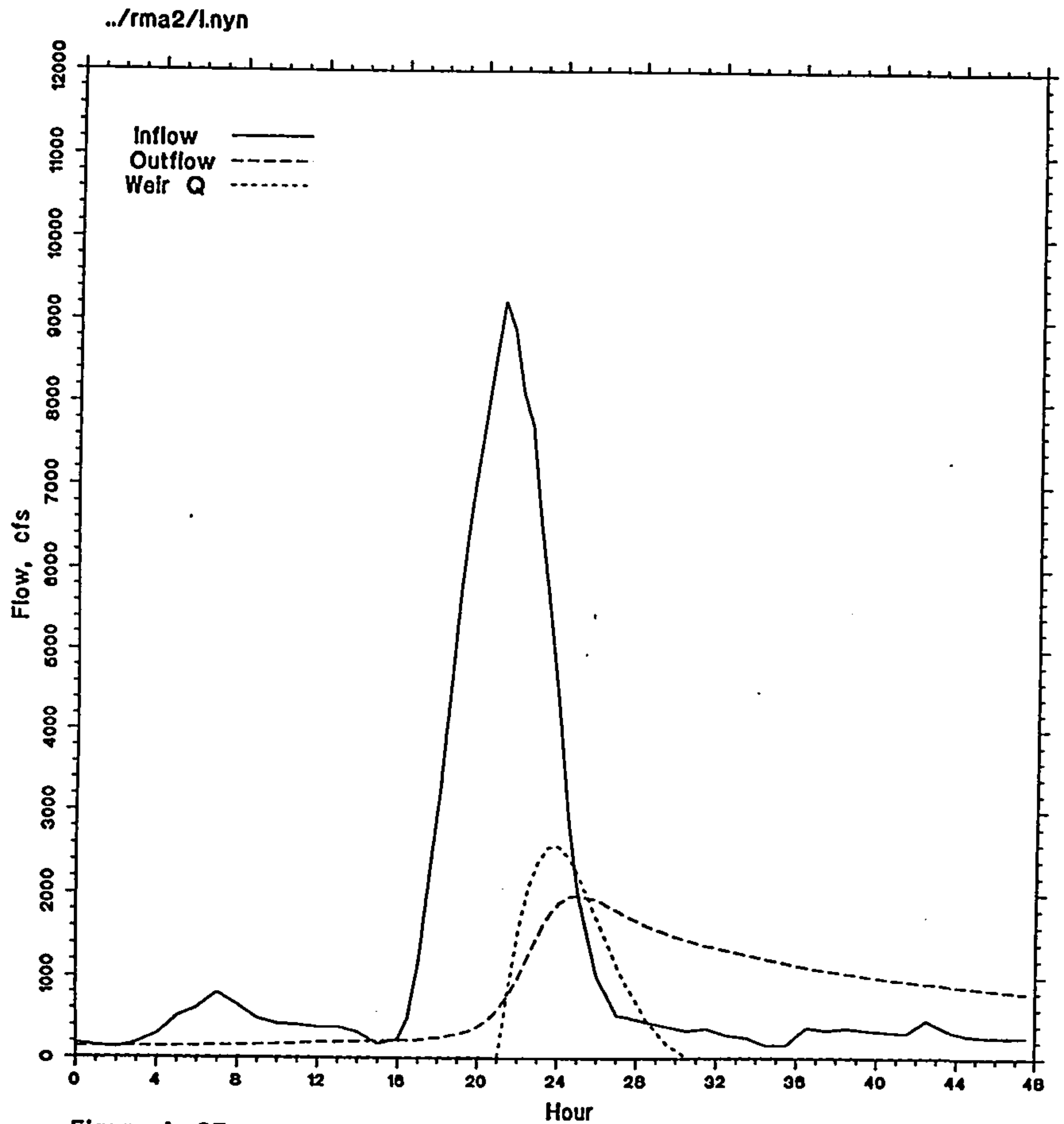
Figure A-25
Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 50 Year Design Storm Without Levee or Marsh Modifications



Time	Q in	Q out	Weir Q
18.0	5000.	361.	6.
18.5	6600.	397.	7.
19.0	8200.	444.	8.
19.5	9800.	512.	8.
20.0	8650.	609.	199.
20.5	7500.	749.	1020.
21.0	6350.	932.	1453.
21.5	5200.	1140.	1688.
22.0	4050.	1340.	1742.
22.5	2850.	1505.	1676.
23.0	2000.	1616.	1517.
23.5	1760.	1673.	1328.
24.0	1661.	1690.	1160.
25.0	1530.	1658.	899.
26.0	1401.	1605.	692.
27.0	1300.	1555.	443.
28.0	1200.	1513.	347.
29.0	1100.	1477.	254.
30.0	1030.	1443.	158.
31.0	880.	1410.	110.
32.0	768.	1382.	5.
33.0	664.	1350.	5.

Figure A-26

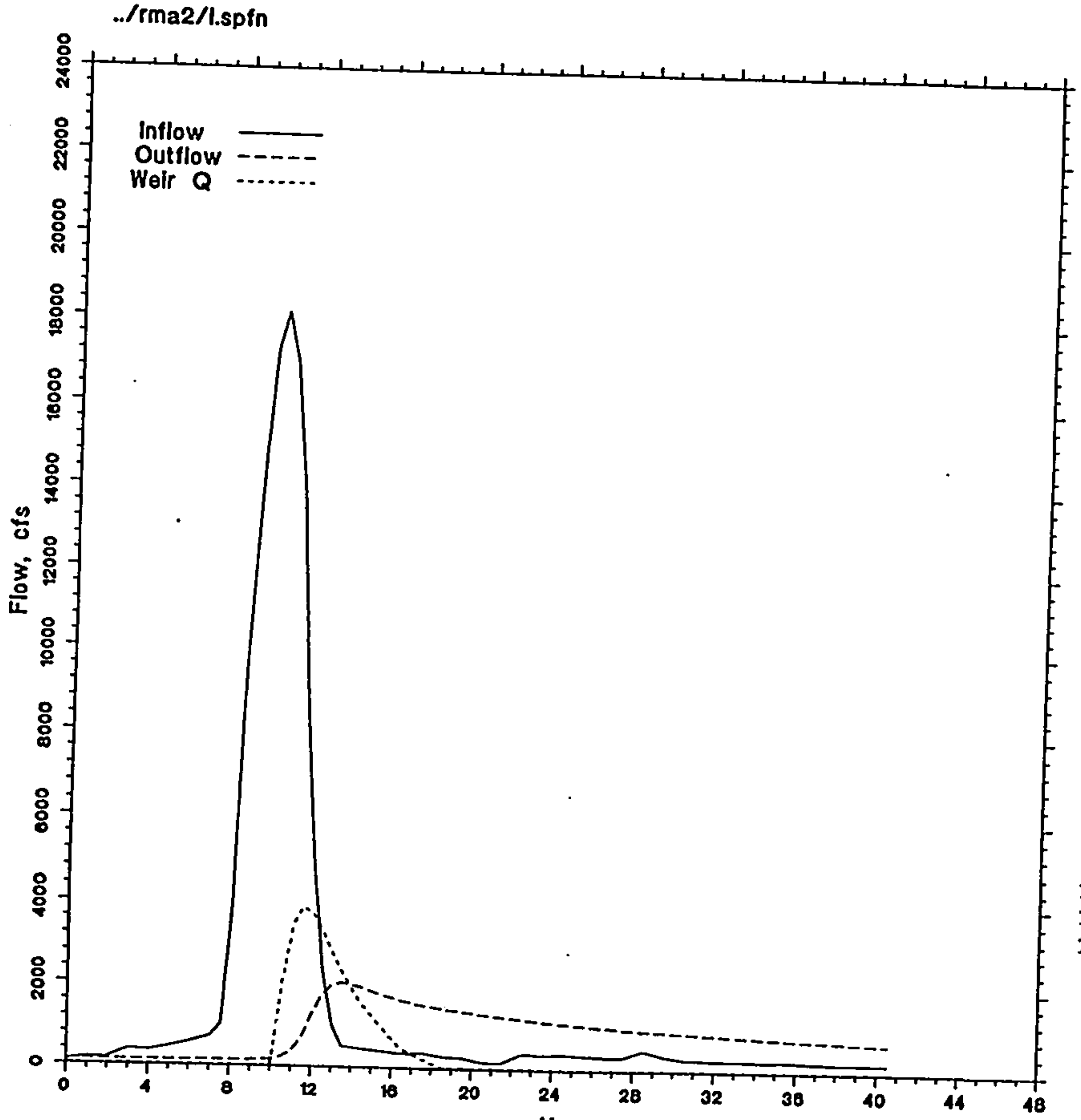
Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 100 Year Design Storm Without Levee or Marsh Modifications



Time	Q in	Q out	Weir Q
18.0	3163.	243.	6.
18.5	4440.	262.	6.
19.0	5733.	288.	7.
19.5	6735.	325.	7.
20.0	7534.	379.	8.
20.5	8408.	461.	9.
21.0	9219.	583.	9.
21.5	8865.	749.	816.
22.0	8093.	970.	1542.
22.5	7710.	1235.	2066.
23.0	6520.	1488.	2377.
23.5	5491.	1704.	2550.
24.0	4323.	1855.	2561.
24.5	2897.	1937.	2436.
25.0	1973.	1964.	2213.
26.0	986.	1904.	1663.
27.0	517.	1778.	1114.
27.5	501.	1712.	867.
28.5	440.	1599.	459.
29.5	385.	1506.	169.
30.5	330.	1430.	5.
31.5	360.	1365.	5.

Figure A-27

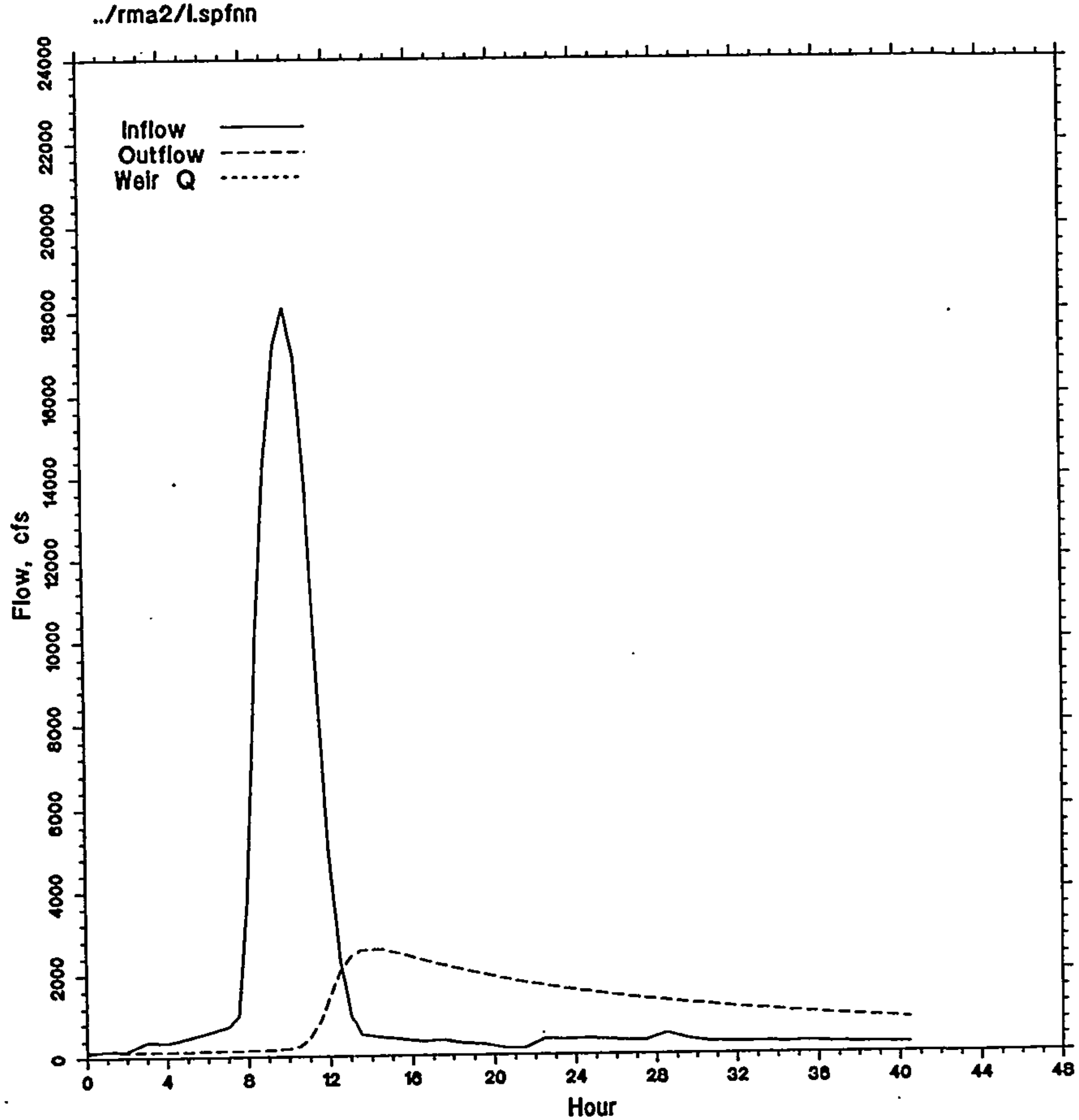
Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for the New years 1988 Storm Without Levee or Marsh Modifications



Time	Q in	Q out	Weir Q
7.5	1000.	124.	5.
8.0	3880.	127.	5.
8.5	10000.	129.	6.
9.0	14400.	133.	7.
9.5	17200.	138.	10.
10.0	18100.	154.	14.
10.5	16900.	205.	2005.
11.0	13800.	356.	3395.
11.5	8600.	709.	3845.
12.0	4900.	1270.	3698.
12.5	2300.	1756.	3259.
13.0	1000.	1982.	2736.
13.5	500.	2033.	2246.
14.5	440.	1924.	1493.
15.5	385.	1757.	944.
16.5	330.	1619.	424.
17.5	360.	1513.	204.
18.5	275.	1433.	5.
19.5	242.	1364.	4.
20.5	147.	1302.	5.
21.5	156.	1245.	5.
22.5	370.	1195.	5.

Figure A-28

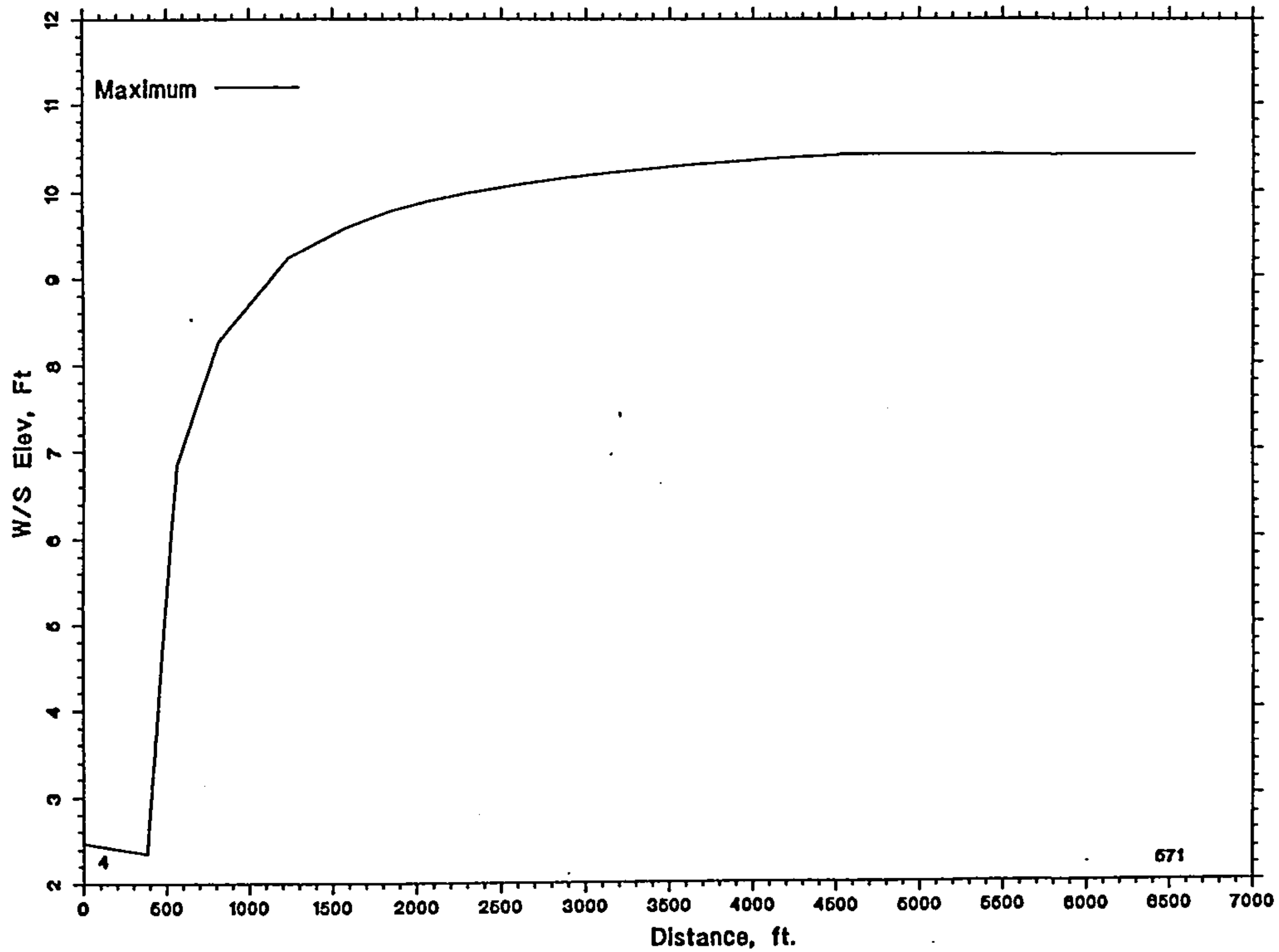
Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for the Corp's Standard Project Storm Without Levee or Marsh Modifications



Time	Q in	Q out
7.5	1000.	141.
8.0	3880.	144.
8.5	10000.	147.
9.0	14400.	151.
9.5	17200.	158.
10.0	18100.	178.
10.5	16900.	240.
11.0	13800.	417.
11.5	8600.	832.
12.0	4900.	1489.
12.5	2300.	2081.
13.0	1000.	2420.
13.5	500.	2576.
14.5	440.	2588.
15.5	385.	2465.
16.5	330.	2328.
17.5	360.	2198.
18.5	275.	2079.
19.5	242.	1967.
20.5	147.	1860.
21.5	156.	1760.
22.5	371.	1672.
23.5	337.	1595.
24.5	365.	1523.
25.5	336.	1454.
26.5	317.	1392.
27.5	306.	1334.
28.5	465.	1284.
29.5	340.	1239.
30.5	275.	1194.
31.5	260.	1150.
32.5	248.	1107.
33.5	257.	1066.
34.5	237.	1026.
35.5	260.	990.
36.5	229.	955.
37.5	223.	923.
38.5	218.	892.

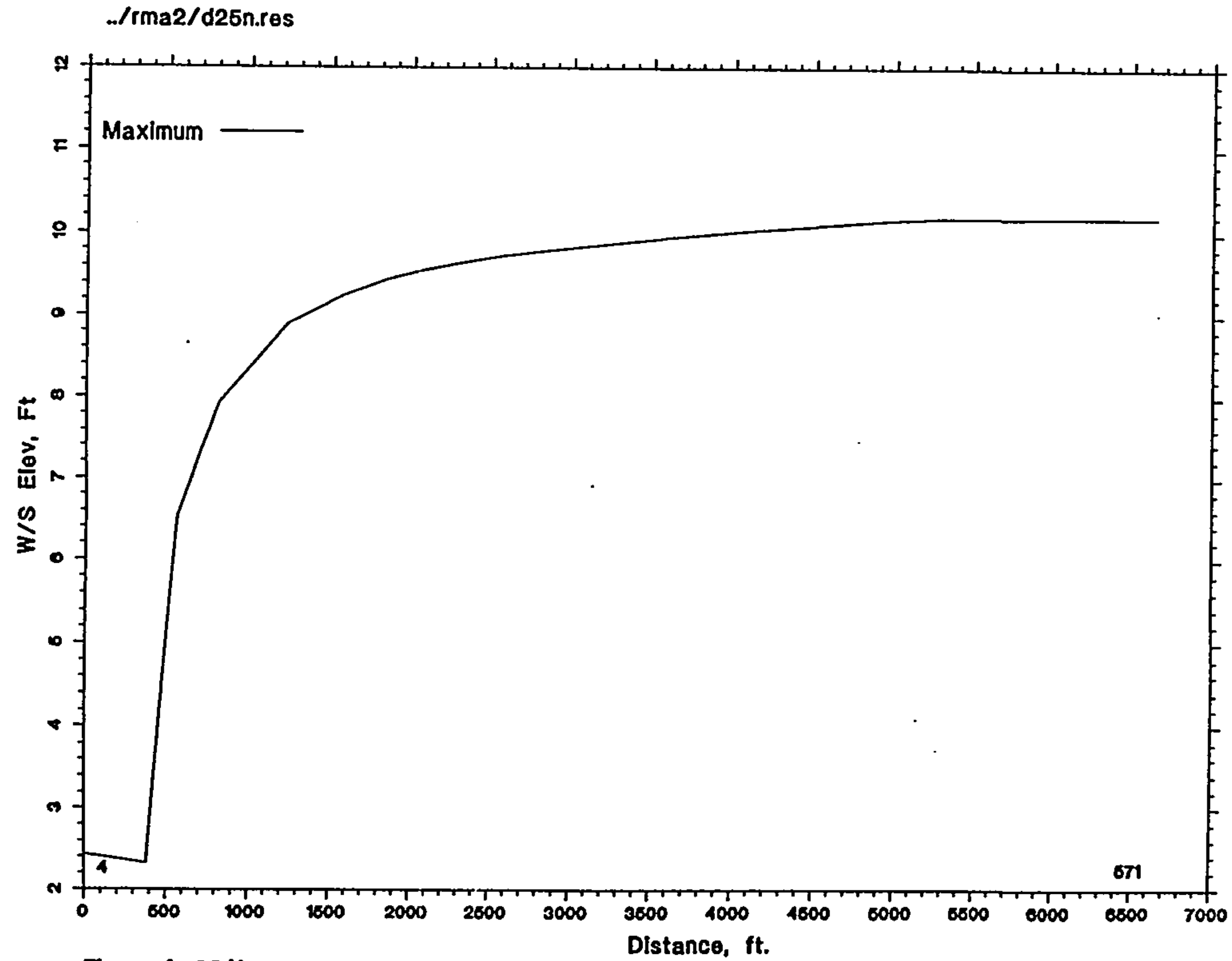
Figure A-29 Corp's Standard Project, No Levee Modifications or Overtopping

../rma2/d50n.res



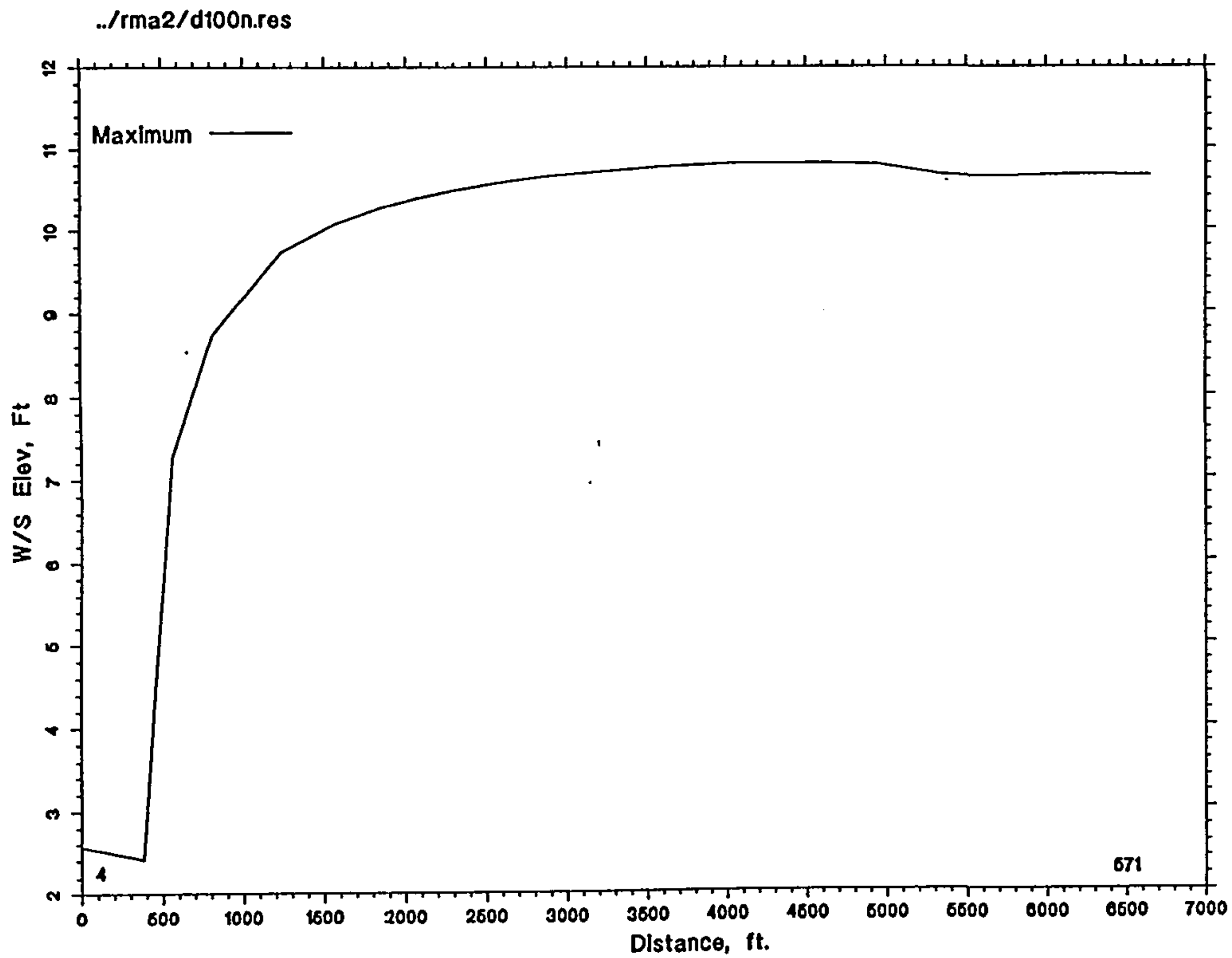
Node	Length	H max
4	0.	2.47
413	380.	2.34
426	560.	6.83
440	812.	8.26
454	1236.	9.24
467	1576.	9.58
391	1842.	9.77
473	2058.	9.89
479	2292.	9.98
486	2568.	10.07
492	2848.	10.14
499	3128.	10.20
506	3544.	10.29
513	4008.	10.35
519	4508.	10.40
525	4948.	10.42
531	5334.	10.41
541	5504.	10.41
547	5814.	10.41
559	6224.	10.42
571	6644.	10.42

Figure A-30
Profile of Maximum Water Surface Elevation Along the Levee for a 50 Year Design Storm Without Levee or Marsh Modifications



Node	Length	H max
4	0.	2.42
413	380.	2.31
426	560.	6.52
440	812.	7.92
454	1236.	8.89
467	1576.	9.23
391	1842.	9.43
473	2058.	9.54
479	2292.	9.63
486	2568.	9.71
492	2848.	9.78
499	3128.	9.84
506	3544.	9.93
513	4008.	10.01
519	4508.	10.08
525	4948.	10.15
531	5334.	10.18
541	5504.	10.19
547	5814.	10.19
559	6224.	10.19
571	6644.	10.19

Figure A-30/1
Profile of Maximum Water Surface Elevation Along the Levee for a 25 Year Design Storm Without Levee or Marsh Modifications

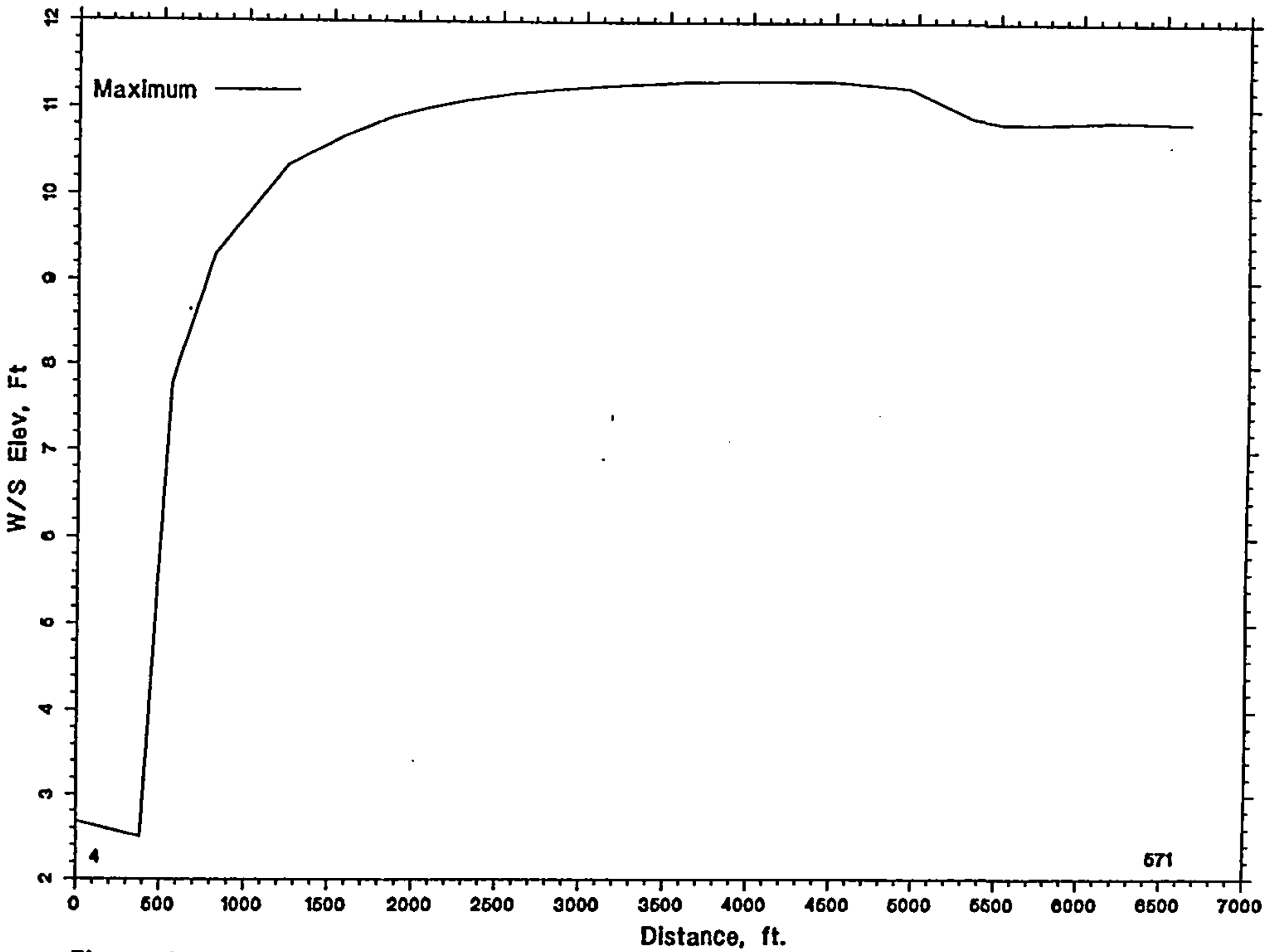


Node	Length	H max
4	0.	2.55
413	380.	2.40
426	560.	7.26
440	812.	8.73
454	1236.	9.73
467	1576.	10.08
391	1842.	10.28
473	2058.	10.39
479	2292.	10.47
486	2568.	10.56
492	2848.	10.63
499	3128.	10.68
506	3544.	10.75
513	4008.	10.79
519	4508.	10.81
525	4948.	10.79
531	5334.	10.66
541	5504.	10.64
547	5814.	10.64
559	6224.	10.65
571	6644.	10.64

Figure A-31

Profile of Maximum Water Surface Elevation Along the Levee for a 100 Year Design Storm Without Levee or Marsh Modifications

../rma2/nyn.res

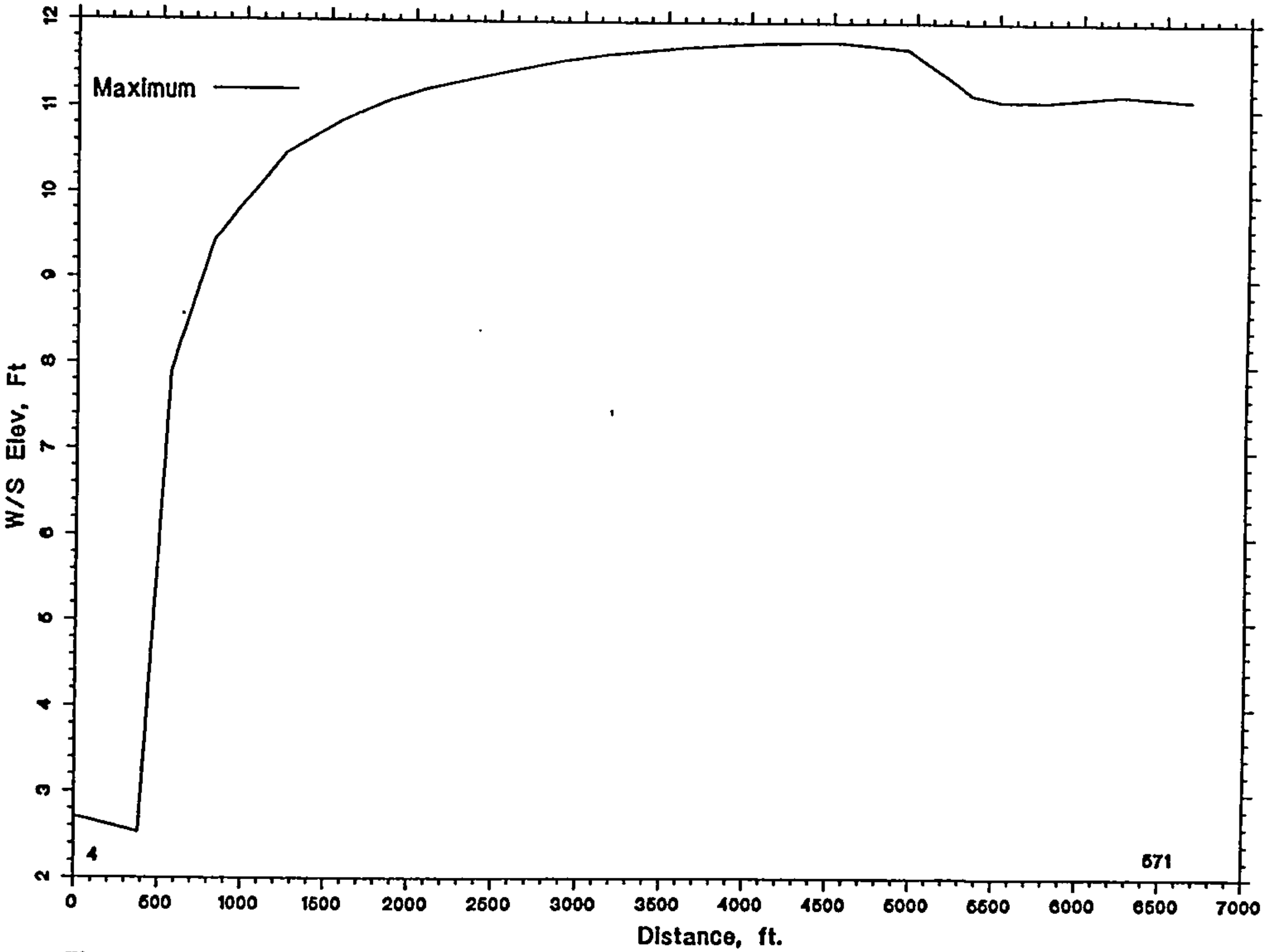


Node	Length	H max
4	0.	2.67
413	380.	2.50
426	560.	7.77
440	812.	9.30
454	1236.	10.32
467	1576.	10.67
391	1842.	10.87
473	2058.	10.99
479	2292.	11.08
486	2568.	11.16
492	2848.	11.22
499	3128.	11.26
506	3544.	11.30
513	4008.	11.32
519	4508.	11.31
525	4948.	11.23
531	5334.	10.89
541	5504.	10.83
547	5814.	10.83
559	6224.	10.86
571	6644.	10.83

Figure A-32

Profile of Maximum Water Surface Elevation Along the Levee for the New Years 1988 Storm Without Levee or Marsh Modifications

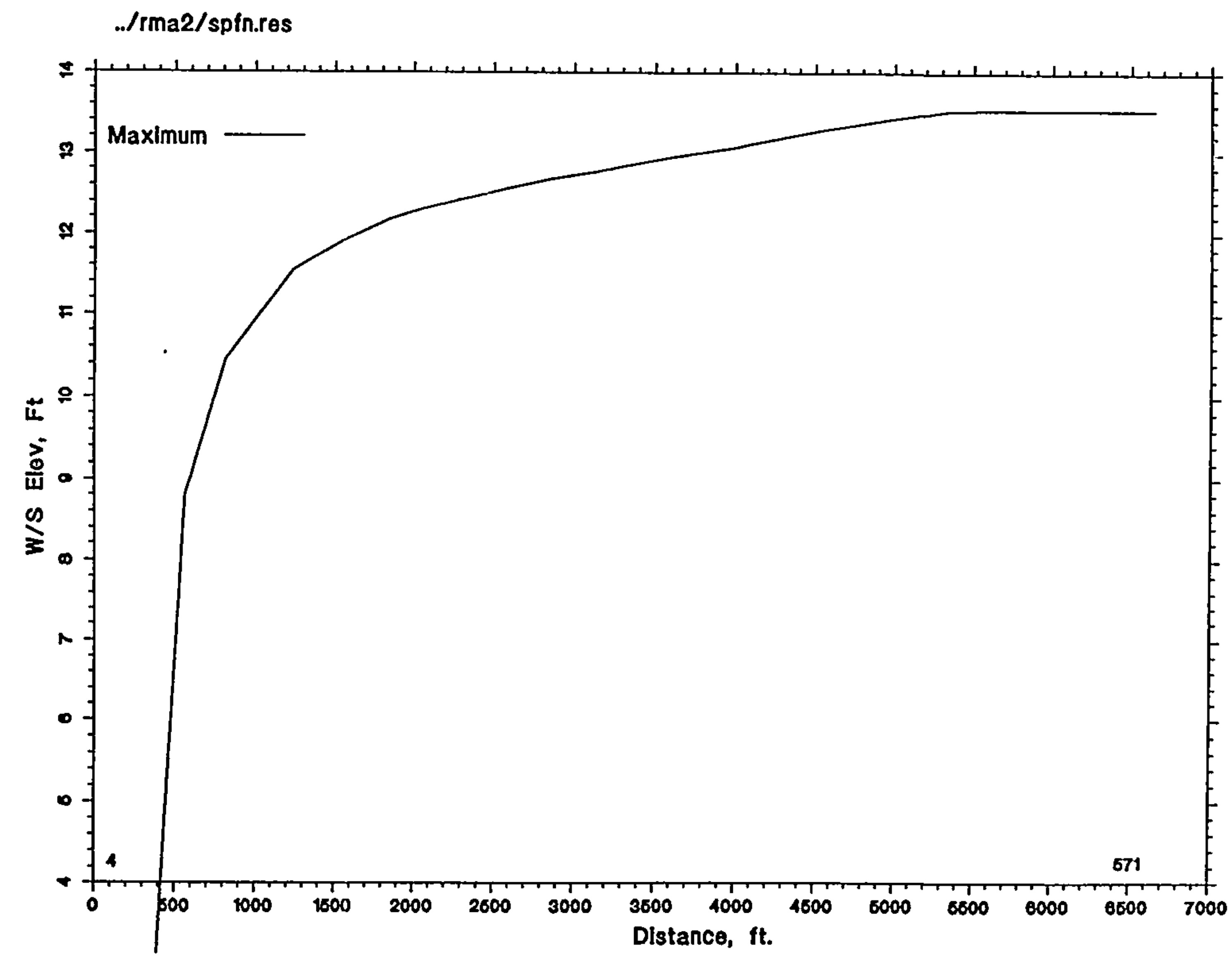
../rma2/spfn.res



Node	Length	H max
4	0.	2.70
413	380.	2.52
426	560.	7.88
440	812.	9.43
454	1236.	10.45
467	1576.	10.83
391	1842.	11.07
473	2058.	11.20
479	2292.	11.30
486	2568.	11.42
492	2848.	11.54
499	3128.	11.61
506	3544.	11.69
513	4008.	11.74
519	4508.	11.77
525	4948.	11.69
531	5334.	11.17
541	5504.	11.10
547	5814.	11.10
559	6224.	11.17
571	6644.	11.11

Figure A-33

Profile of Maximum Water Surface Elevation Along the Levee for the Corp's Standard Project Storm Without Levee or Marsh Modifications



Node	Length	H max
4	0.	2.98
413	380.	2.78
426	560.	8.78
440	812.	10.43
454	1236.	11.54
467	1576.	11.93
391	1842.	12.16
473	2058.	12.30
479	2292.	12.42
486	2568.	12.55
492	2848.	12.66
499	3128.	12.75
506	3544.	12.92
513	4008.	13.07
519	4508.	13.26
525	4948.	13.41
531	5334.	13.52
541	5504.	13.53
547	5814.	13.53
559	6224.	13.54
571	6644.	13.54

Figure A-34 Profile Along Levee, Corp's Standard Project Flood, 10' weir, No Veg. Removal

Kawainui Marsh Cross Sections
View Looking South

Figure A-35
Cross Section A

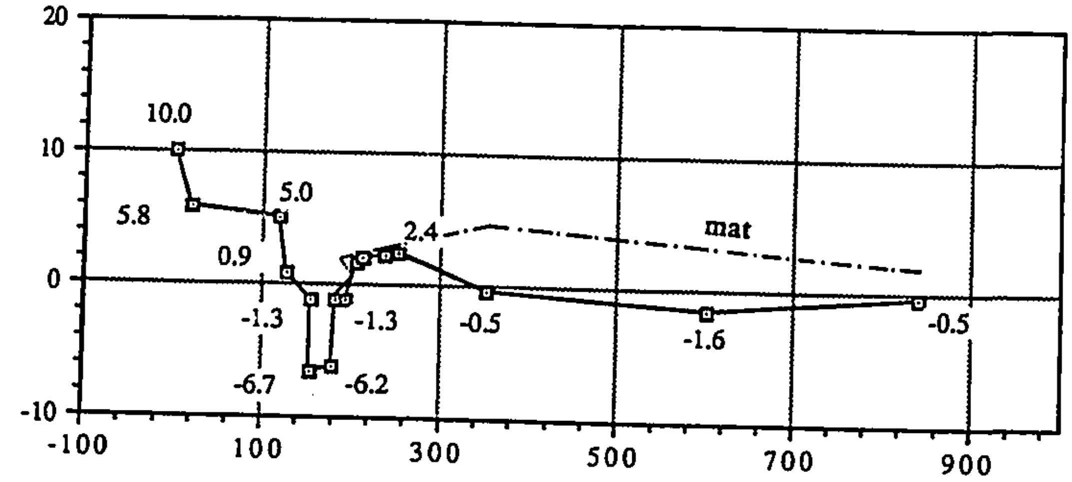


Figure A-36
Cross Section (Station 55+50)

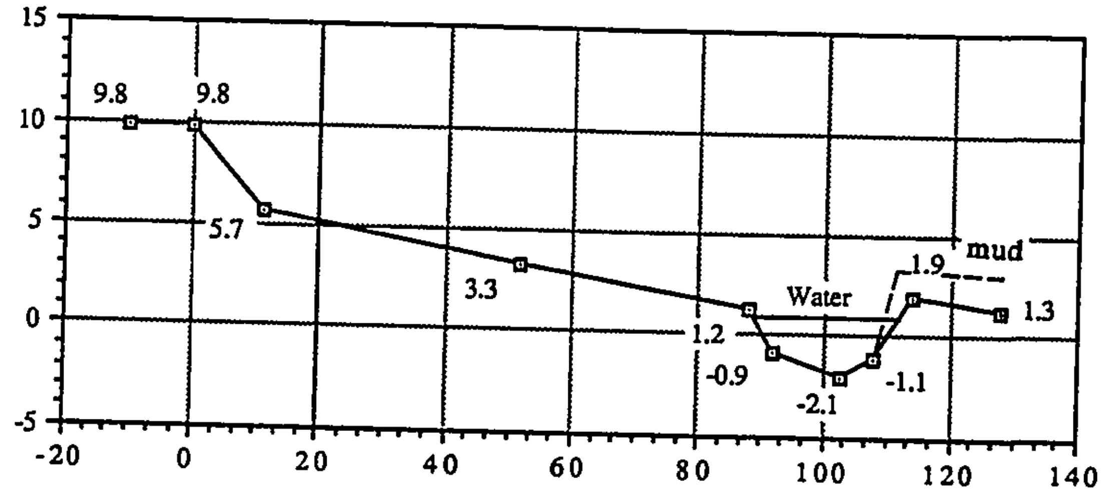
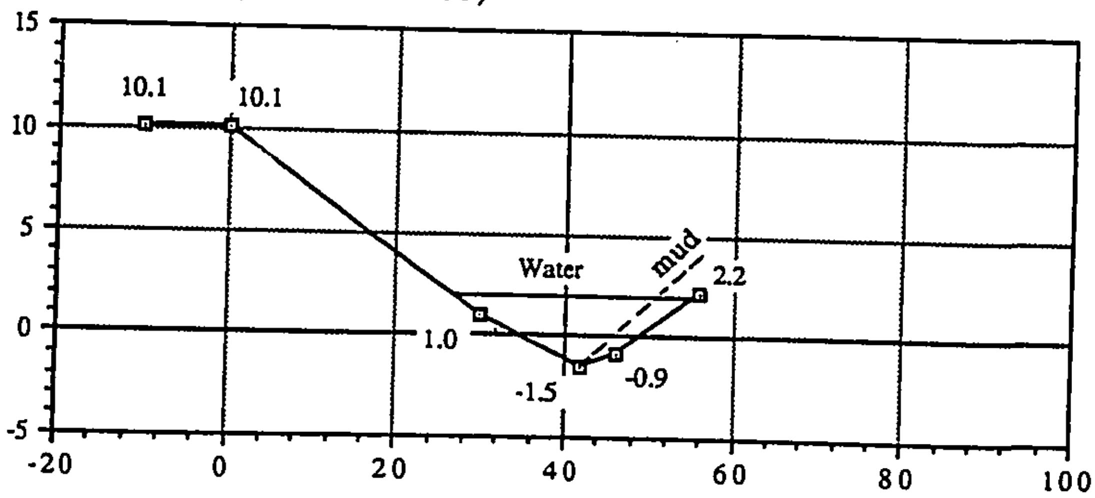


Figure A-37
Cross Section (Station 50+00)



Kawainui Marsh Cross Sections
View Looking South
Figure A-38
Cross Section (Station 45+00)

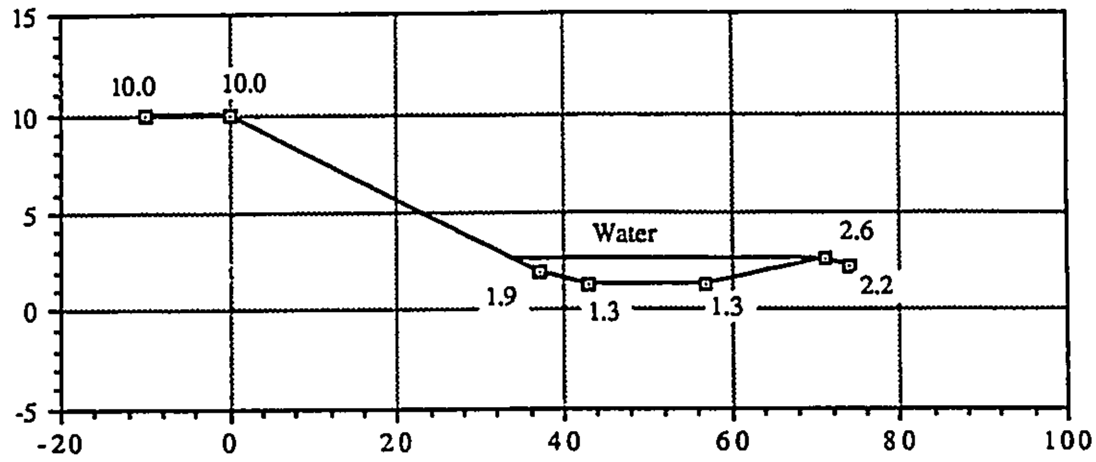


Figure A-39
Cross Section (Station 39+50)

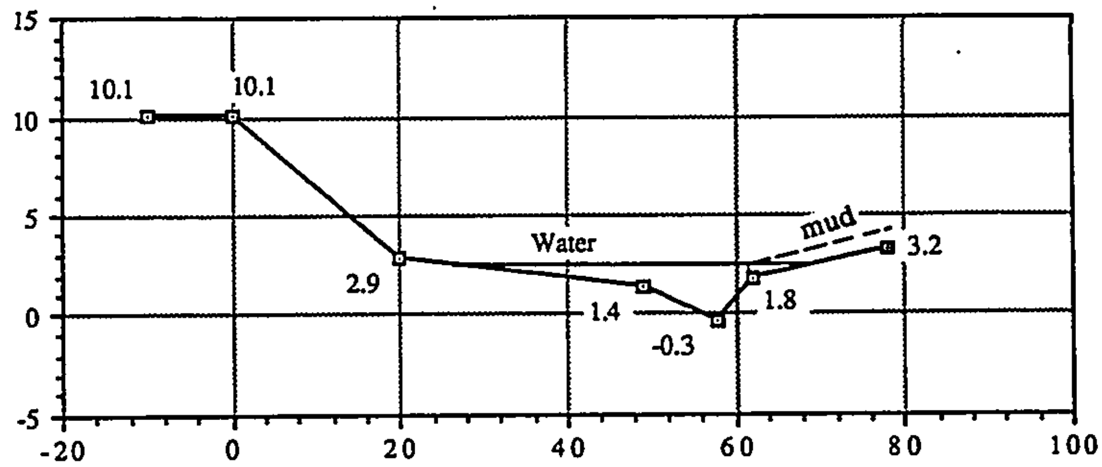
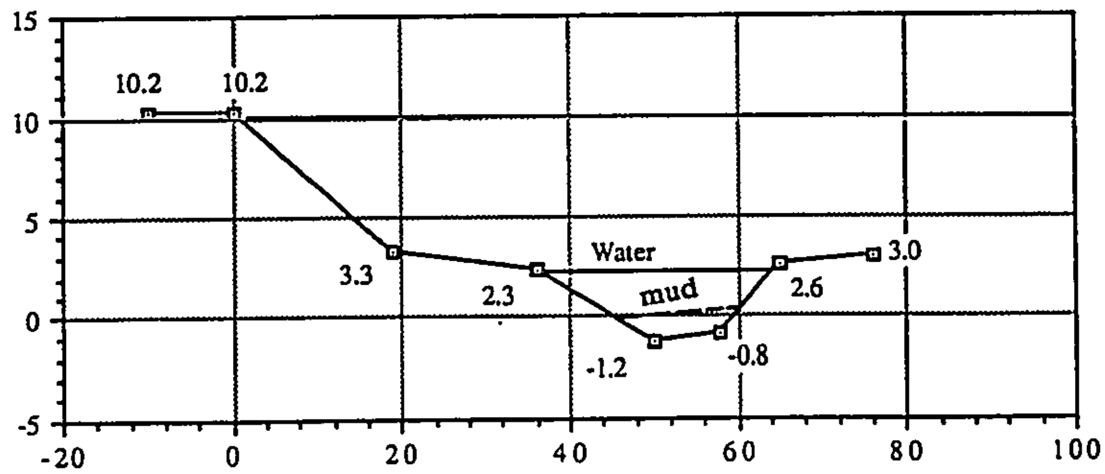


Figure A- 40
Cross Section (Station 34+50)



Kawainui Marsh Cross Sections
View Looking South

Figure A-41

Cross Section (Station 29+00)

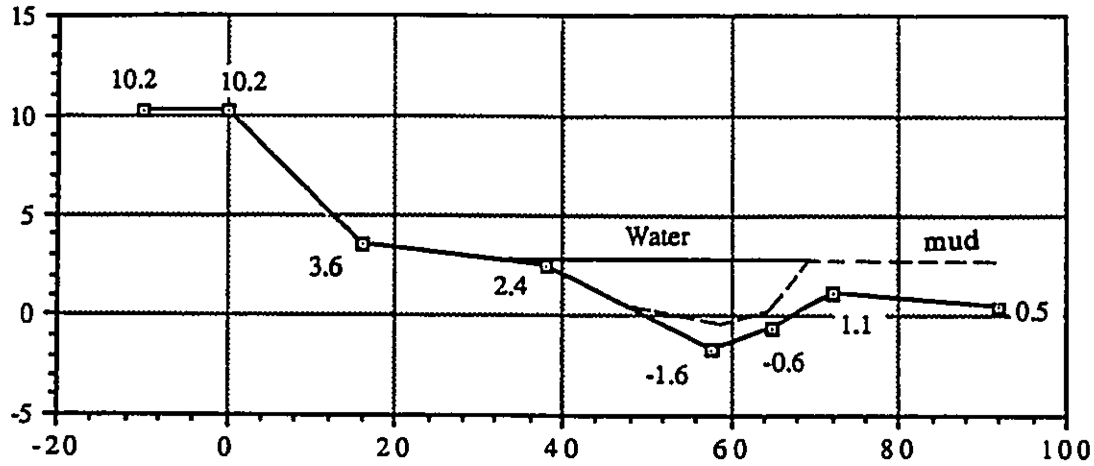


Figure A-42

Cross Section (Station 24+50)

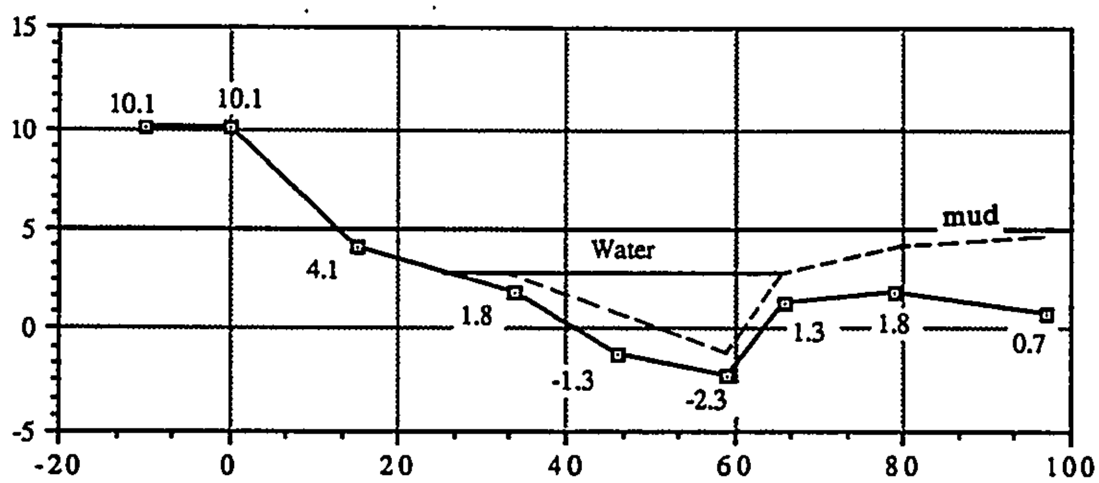
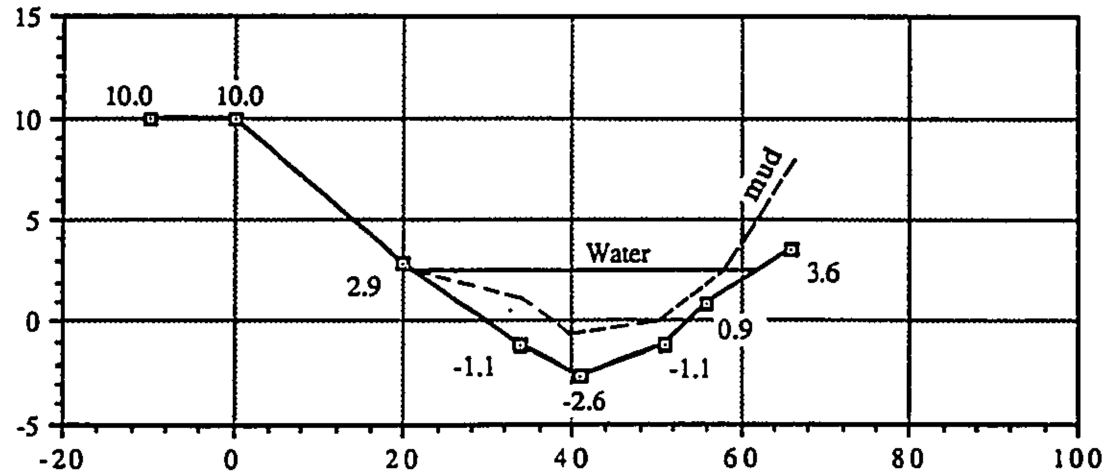


Figure A-43

Cross Section (Station 18+50)



Kawainui Marsh Cross Sections
View Looking South

Figure A-44
Cross Section (Station 13+00)

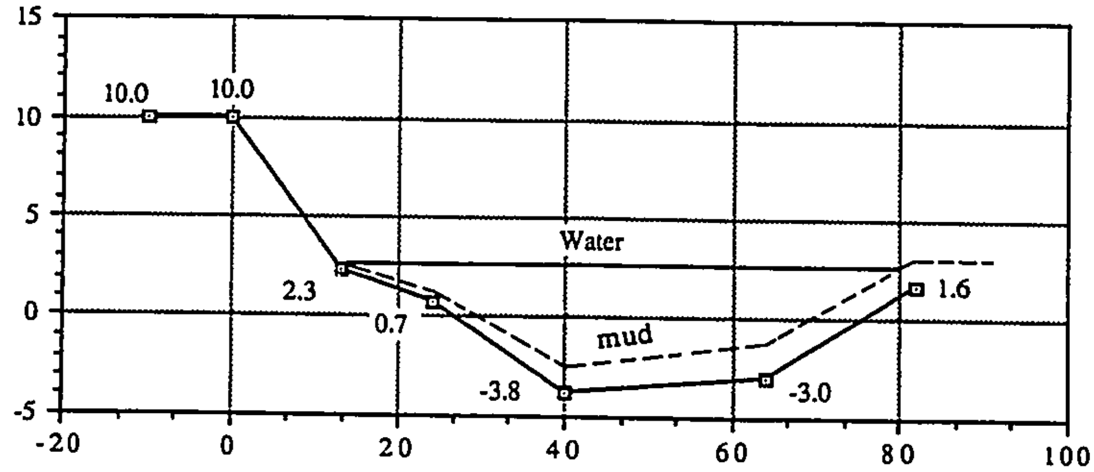


Figure A-45
Cross Section (Station 7+00)

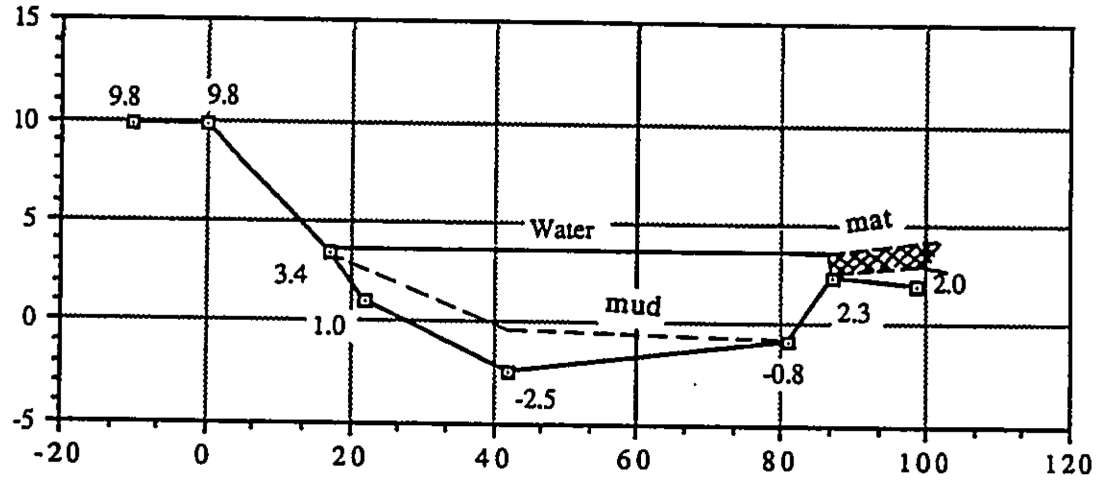
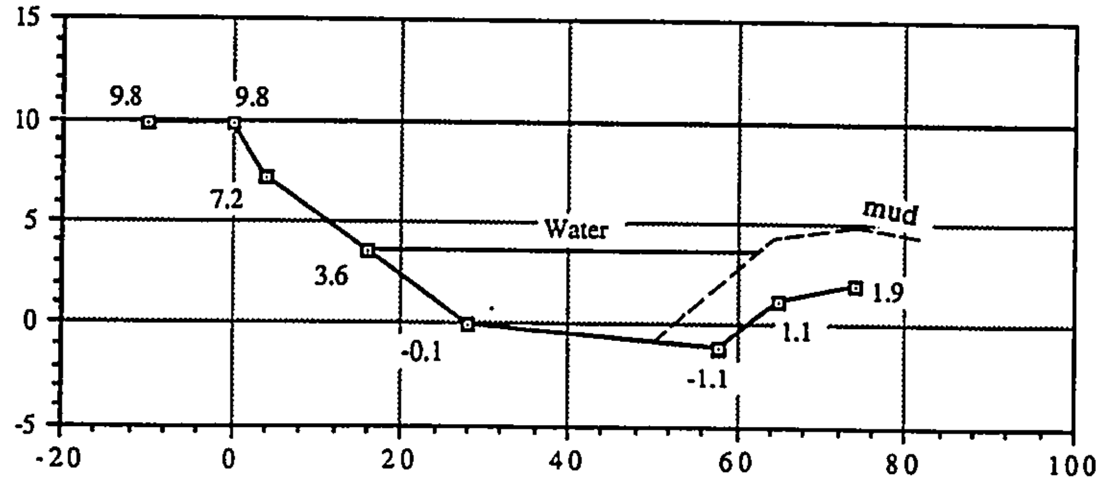


Figure A-46
Cross Section (Station 2+00)



Kaelepulu Stream Cross Sections
View Looking North

Figure A-47

Cross Section (Station 0+00)

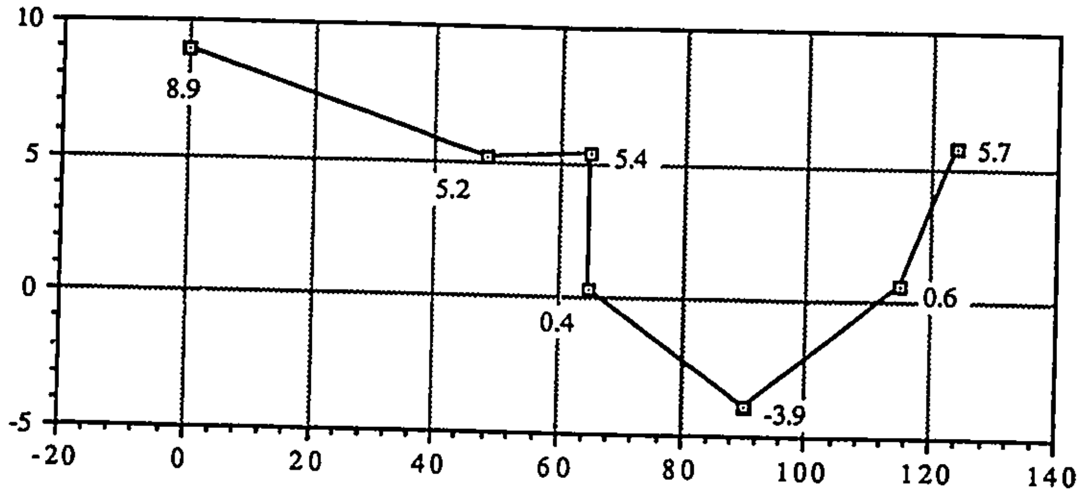


Figure A-48

Cross Section (Station 3+00)

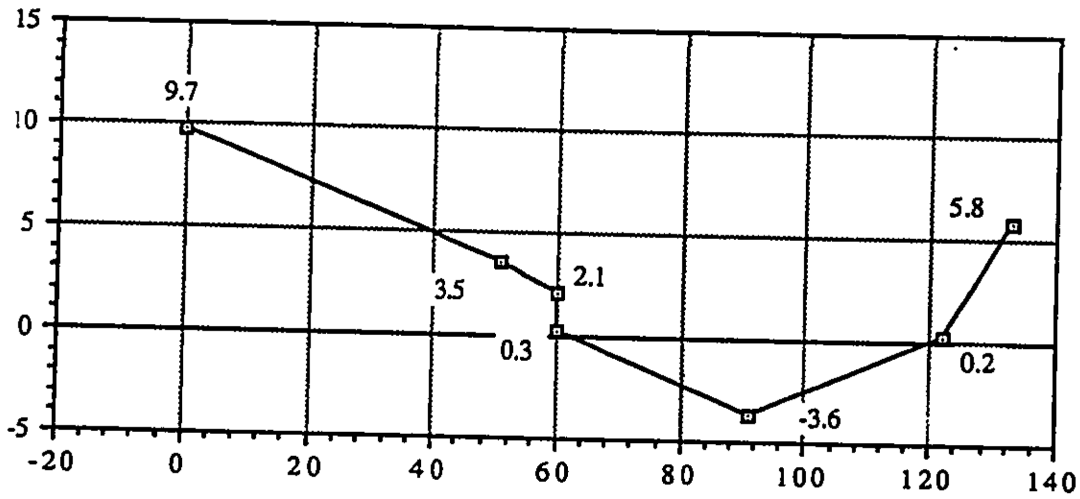
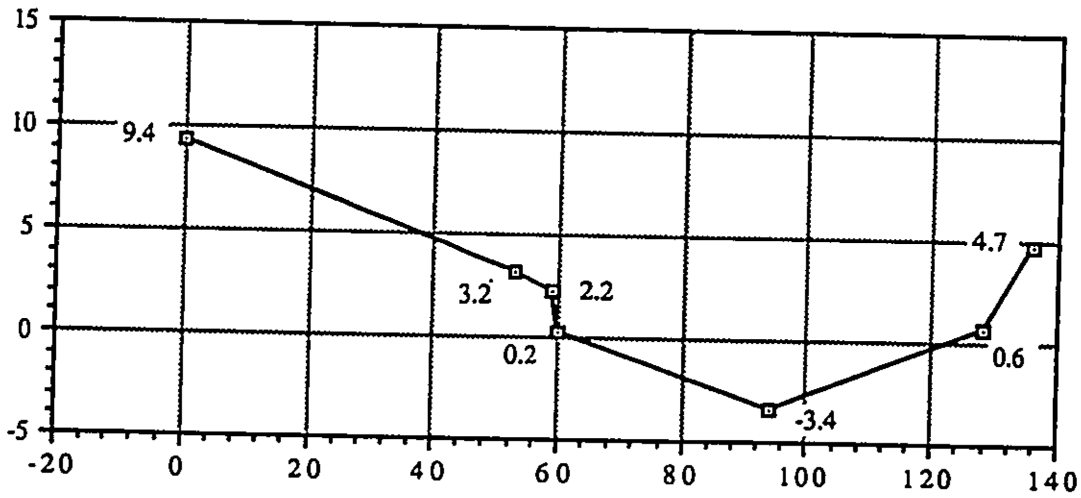


Figure A-49

Cross Section (Station 6+00)



Kaelepulu Stream Cross Sections
View Looking North
Figure A-50
Cross Section (Station 9+00)

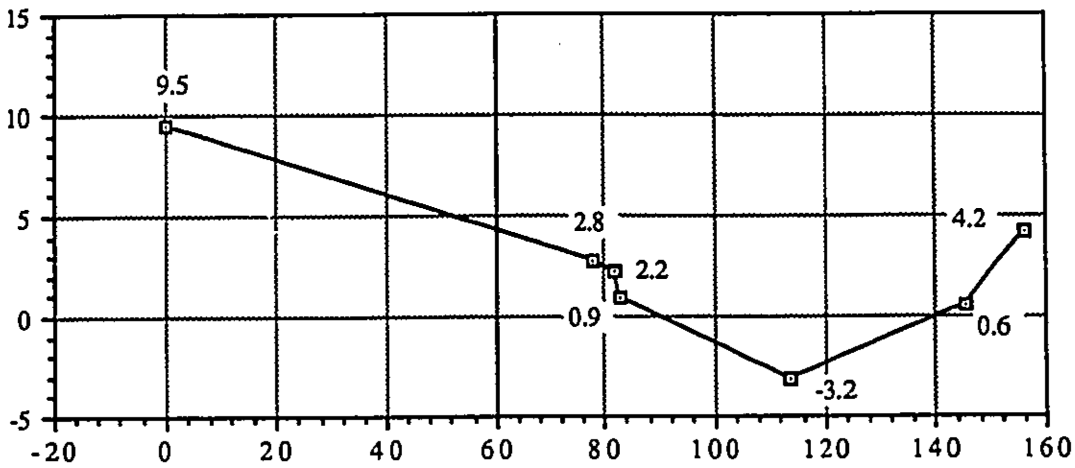


Figure A-51
Cross Section (Station 11+35)

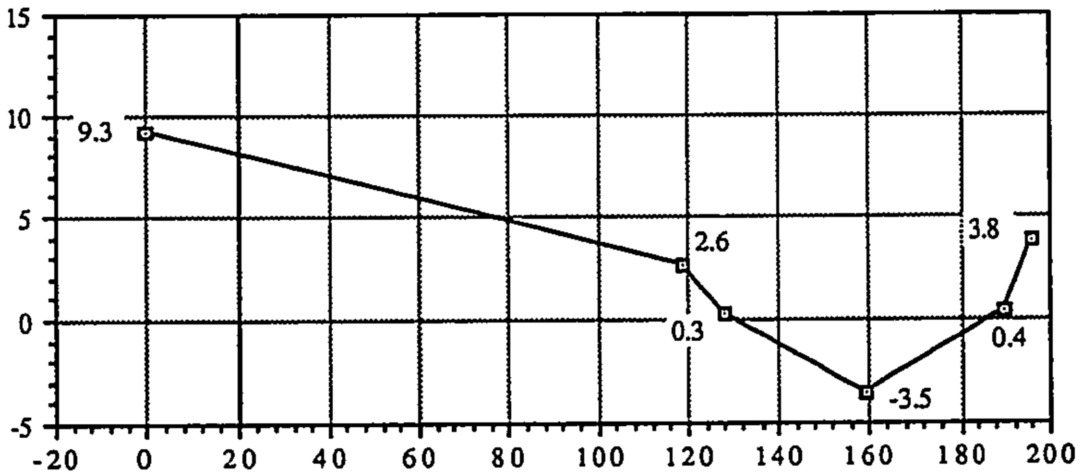
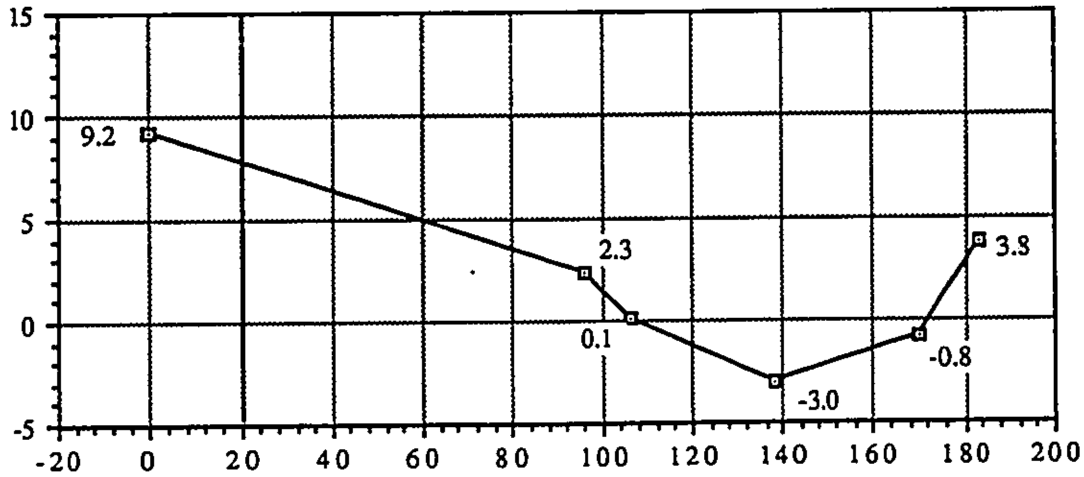


Figure A-52
Cross Section (Station 15+00)



Kaelepulu Stream Cross Sections
View Looking North
Figure A-53
Cross Section (Station 18+00)

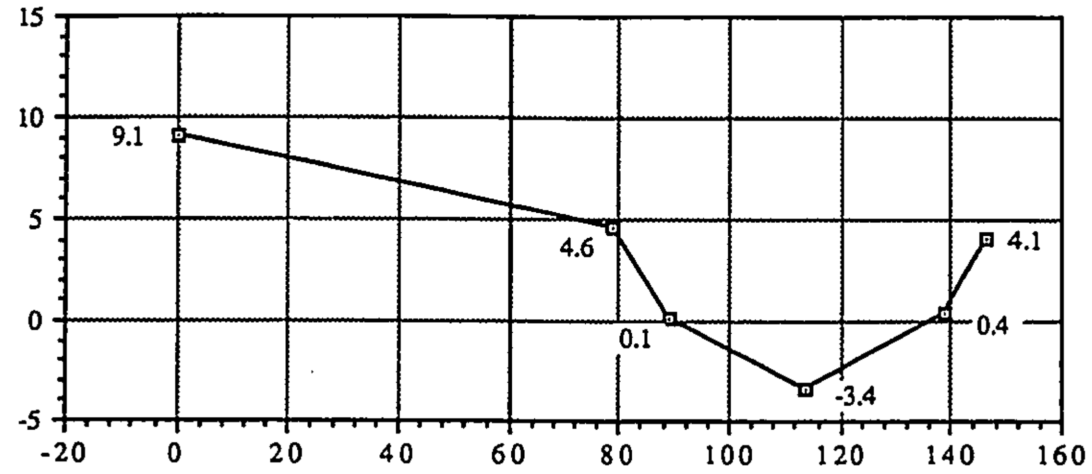


Figure A-54
Cross Section (Station 21+00)

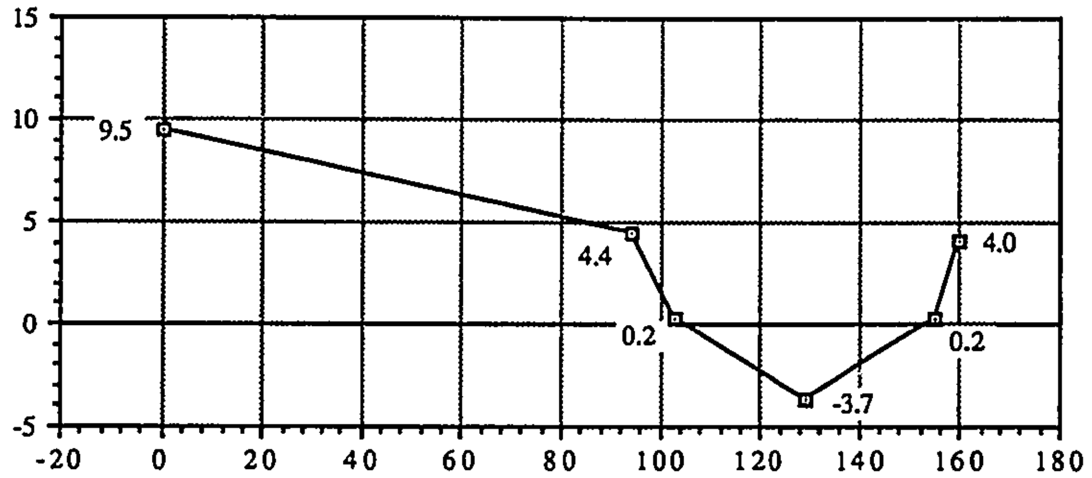
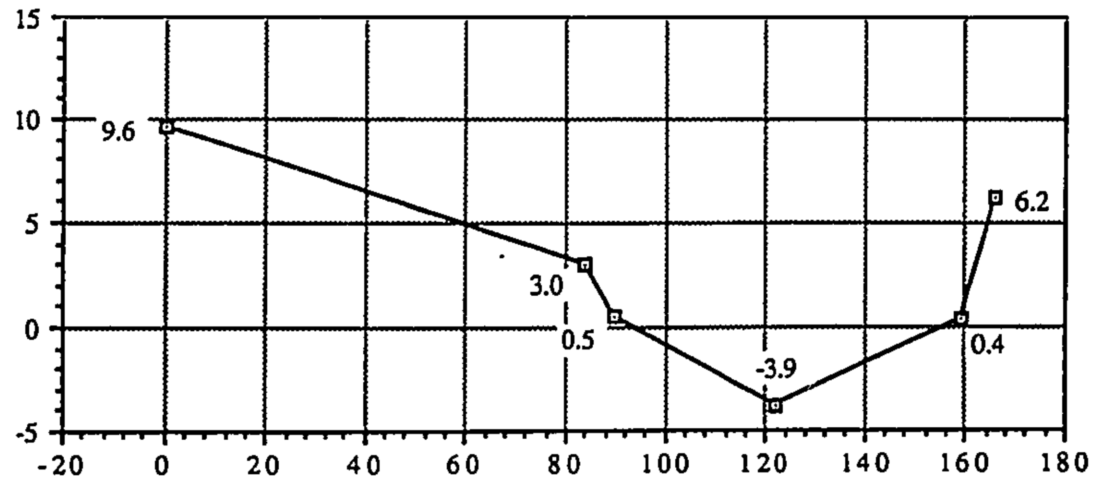


Figure A-55
Cross Section (Station 24+00)



Kaelepulu Stream Cross Sections
View Looking North
Figure A-56
Cross Section (Station 27+00)

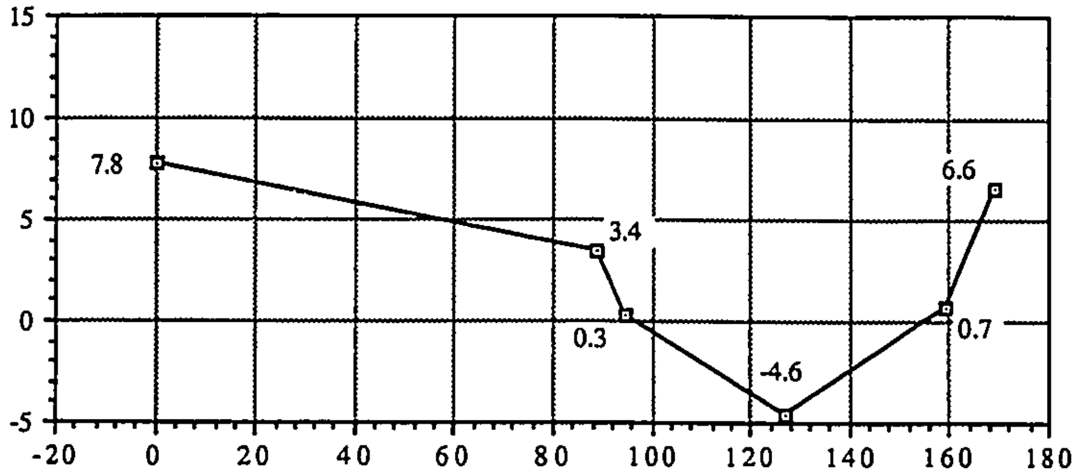


Figure A-57
Cross Section (Station 30+00)

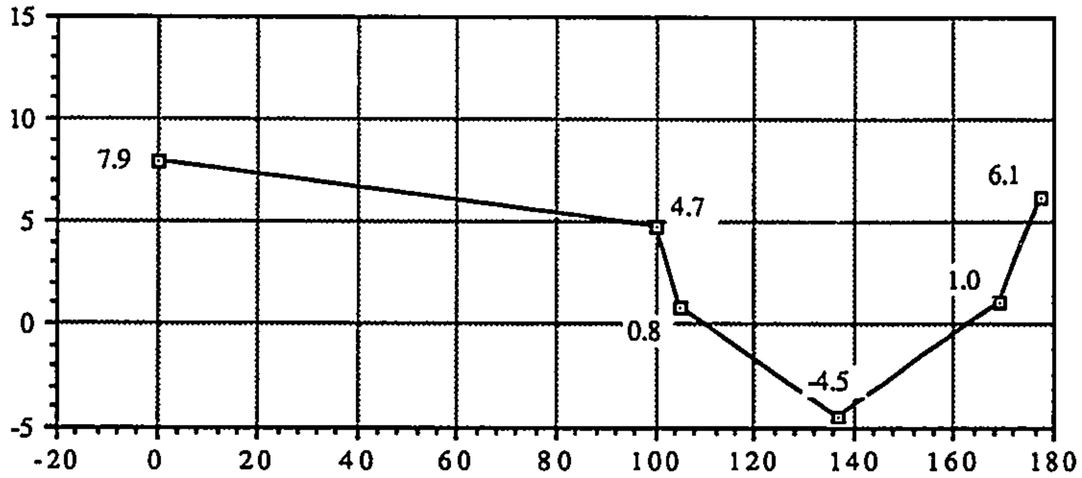
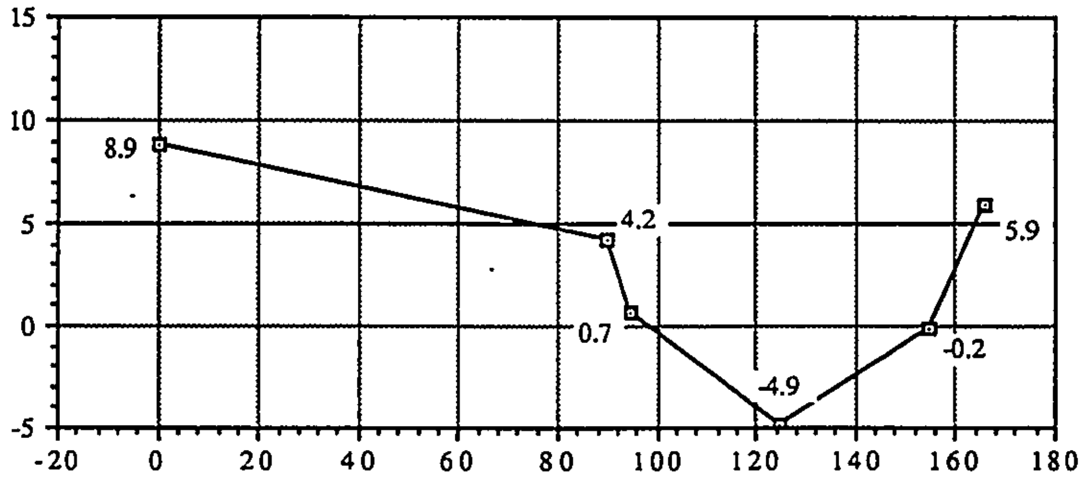


Figure A-58
Cross Section (Station 33+00)



Kaelepulu Stream Cross Sections
View Looking North
Figure A-59
Cross Section (Station 36+00)

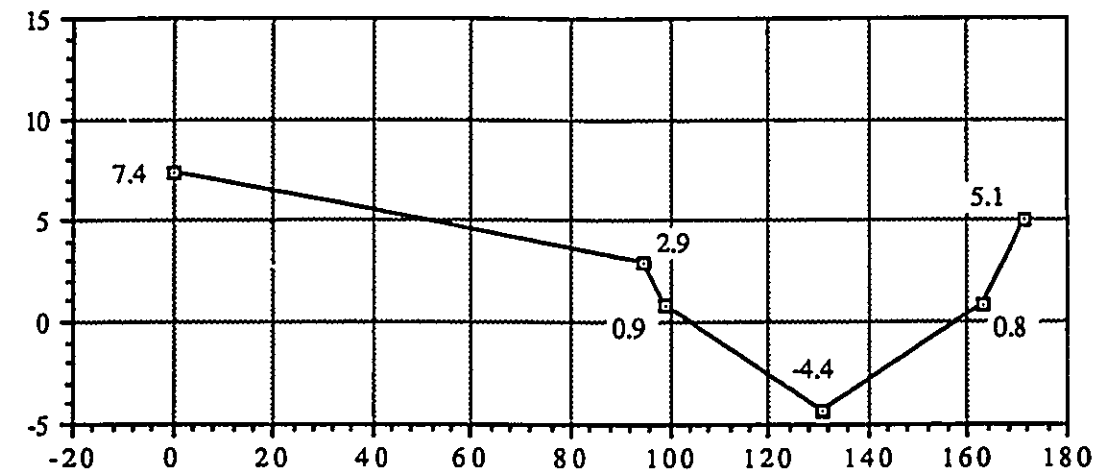


Figure A-60
Cross Section (Station 39+00)

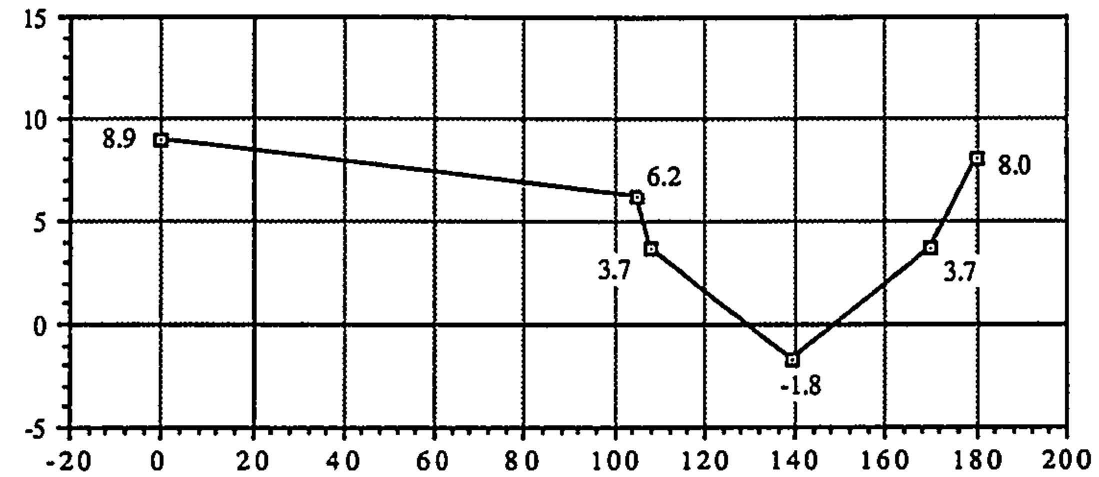
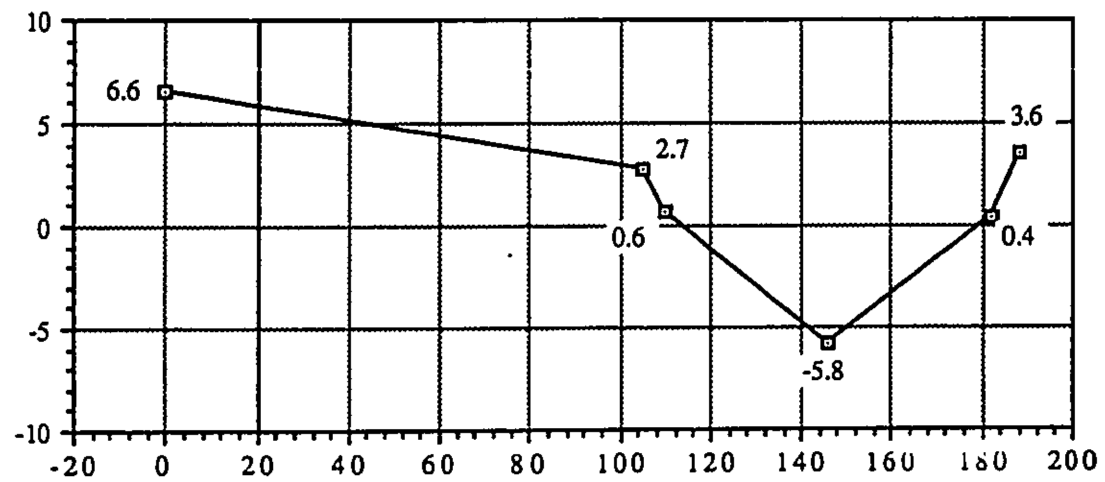


Figure A-61
Cross Section (Station 42+00)



Kaelepulu Stream Cross Sections
View Looking North
Figure A-62
Cross Section (Station 45+00)

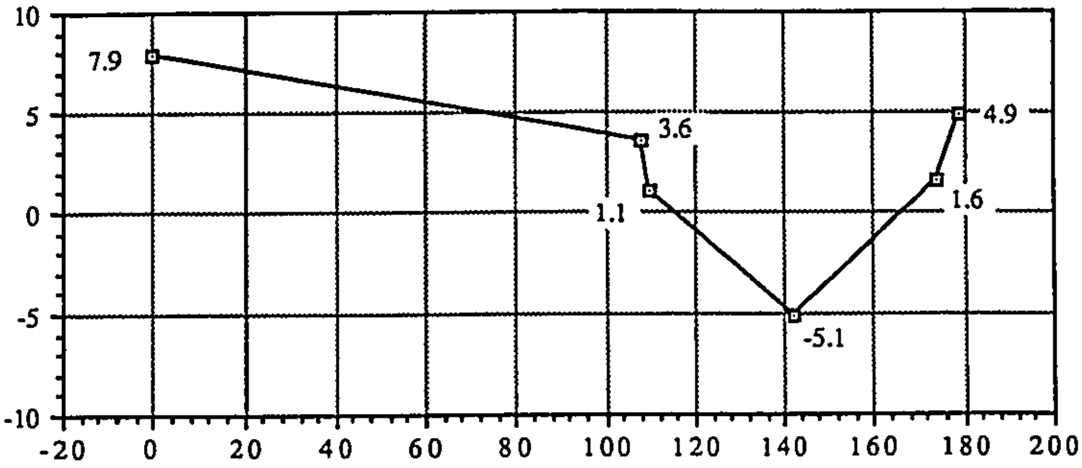


Figure A-63
Cross Section (Station 48+00)

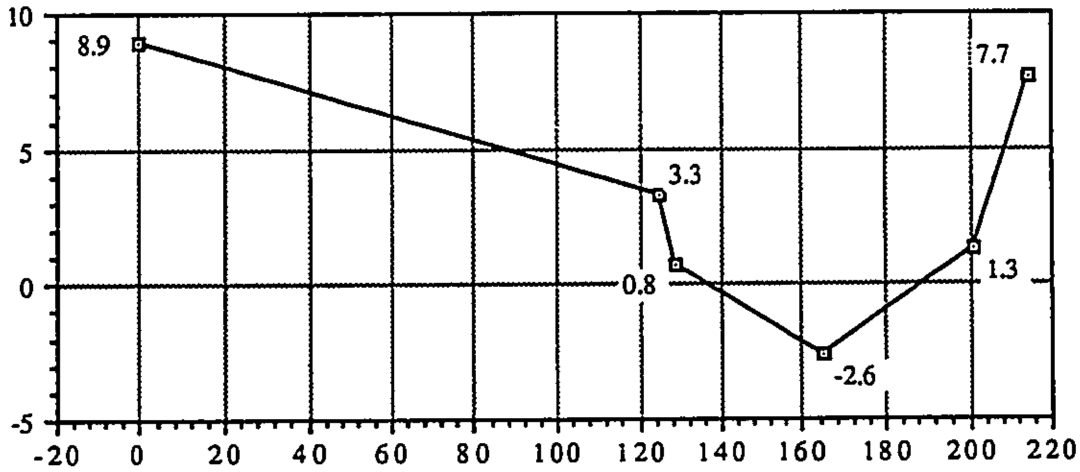
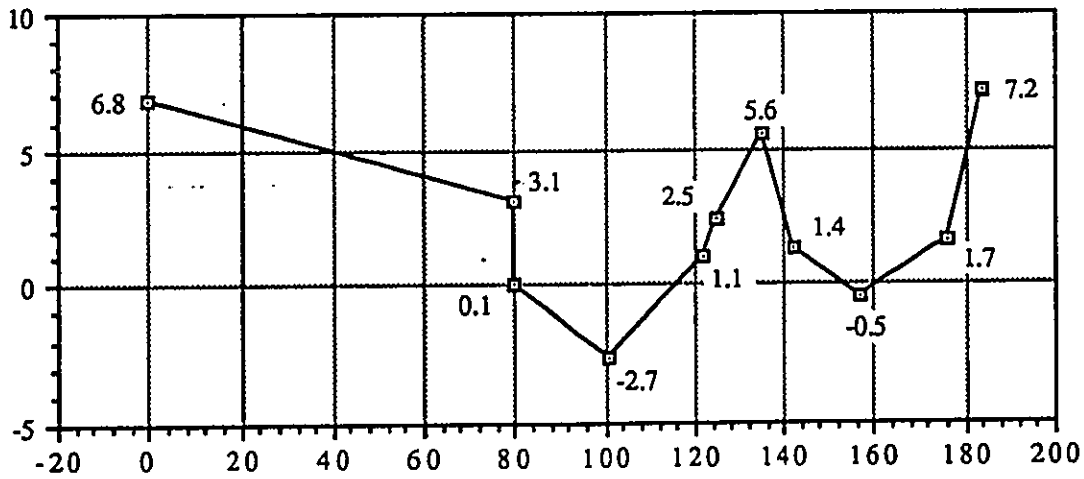
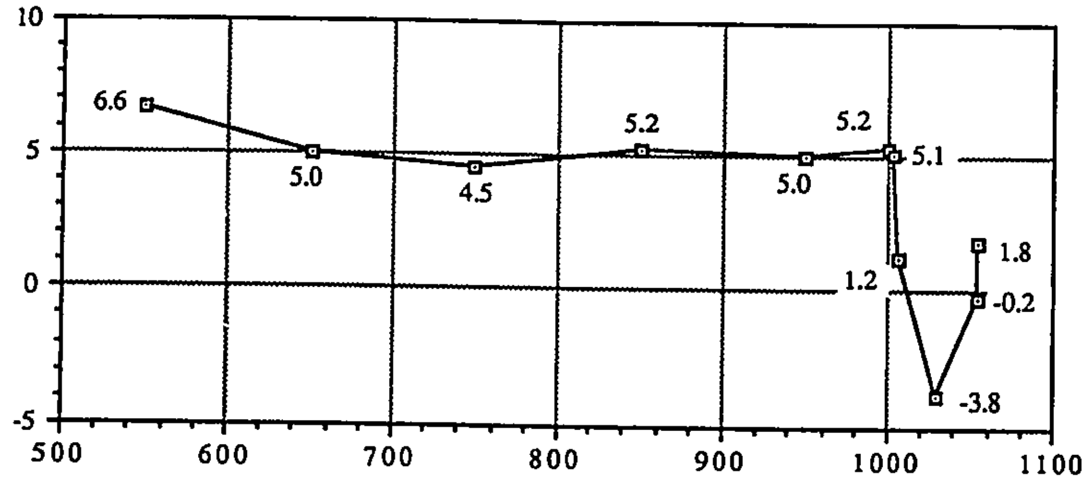
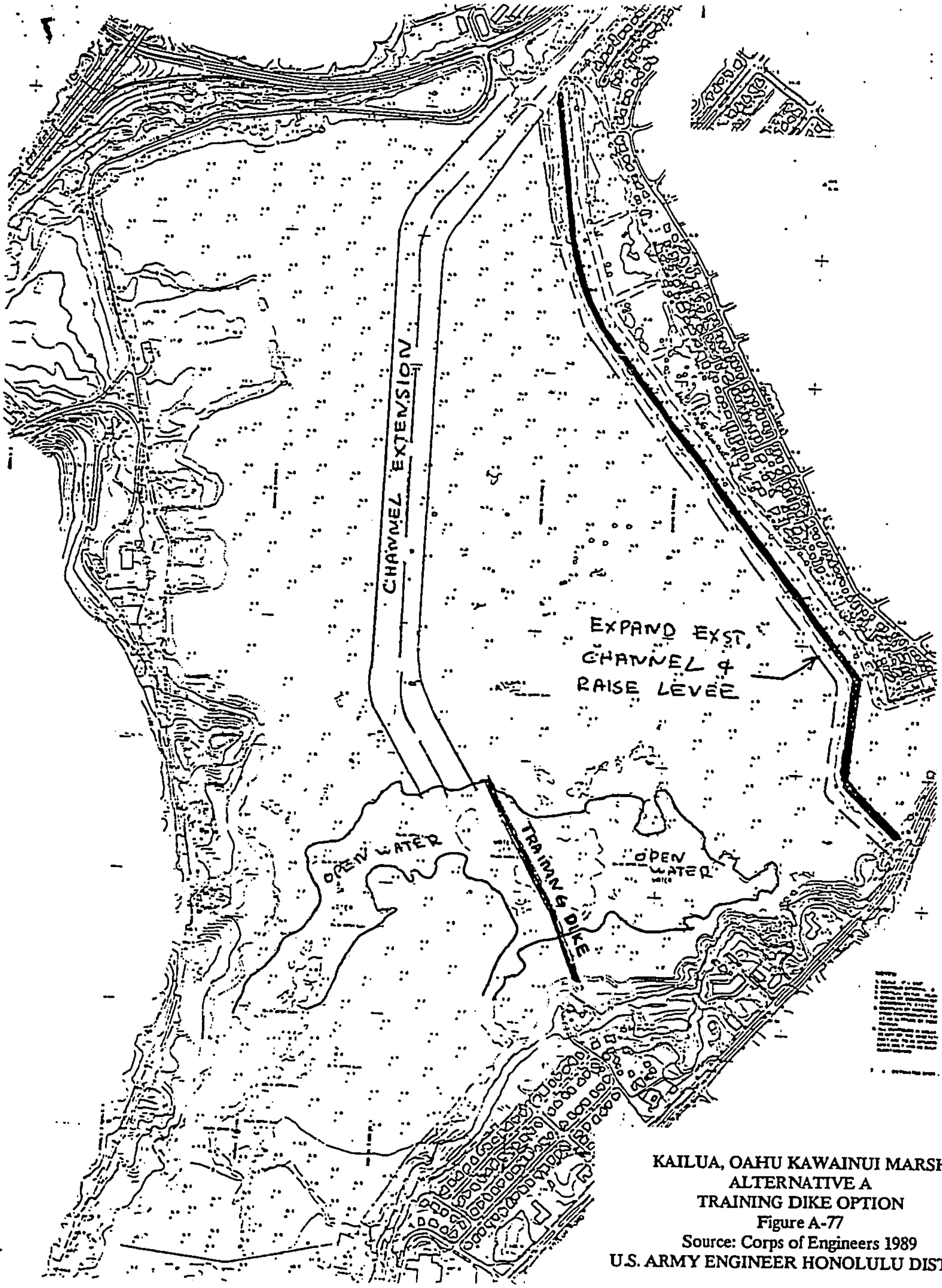


Figure A-64
Cross Section (Station 51+00)

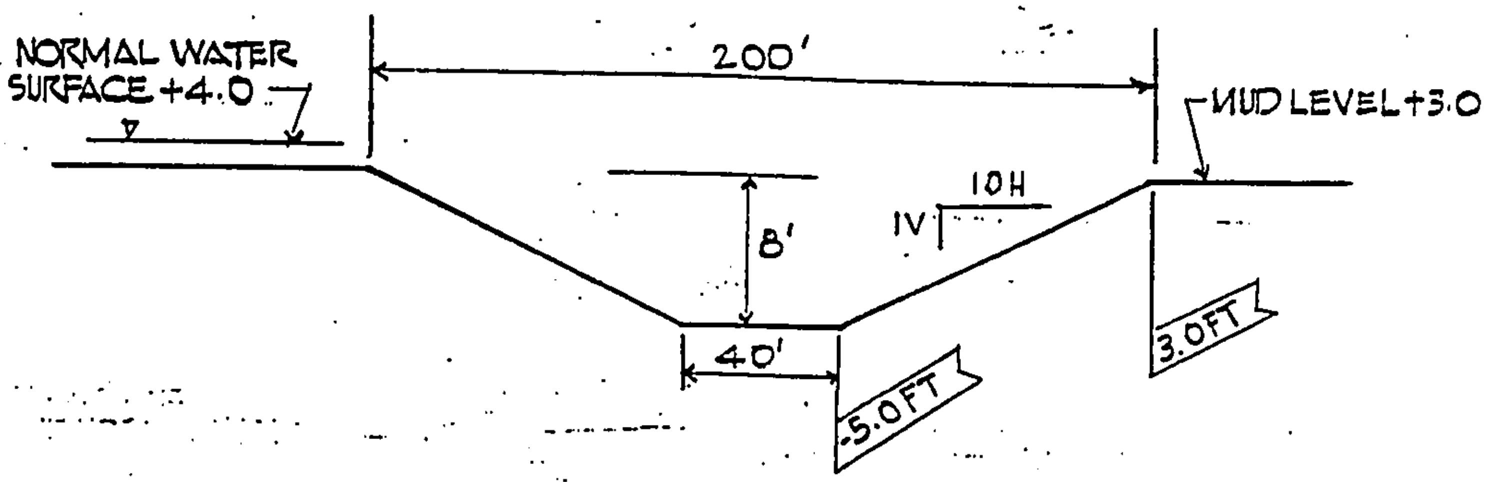


Kaelepulu Stream Cross Sections
View Looking North
Figure A-65
Cross Section (Station 54+21)





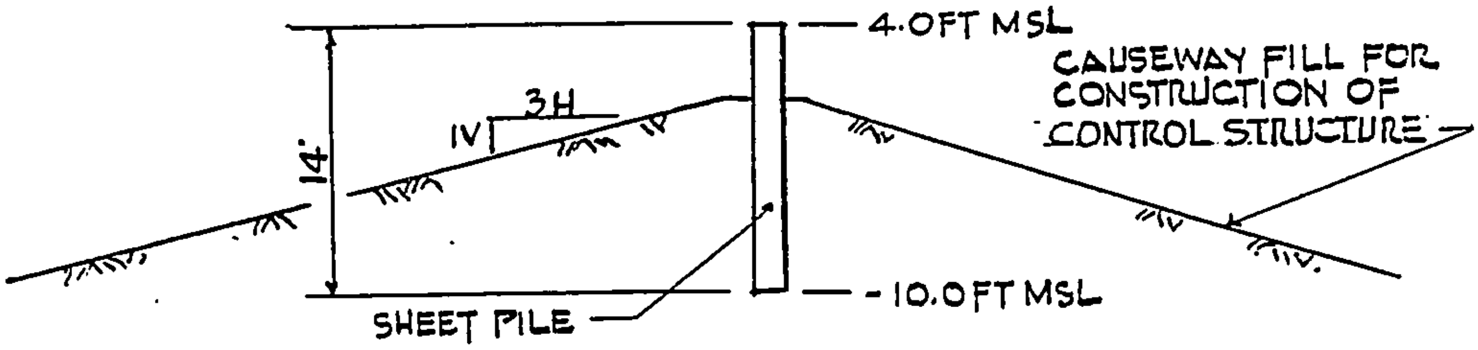
KAILUA, OAHU KAWAINUI MARSH
ALTERNATIVE A
TRAINING DIKE OPTION
Figure A-77
Source: Corps of Engineers 1989
U.S. ARMY ENGINEER HONOLULU DISTRIC



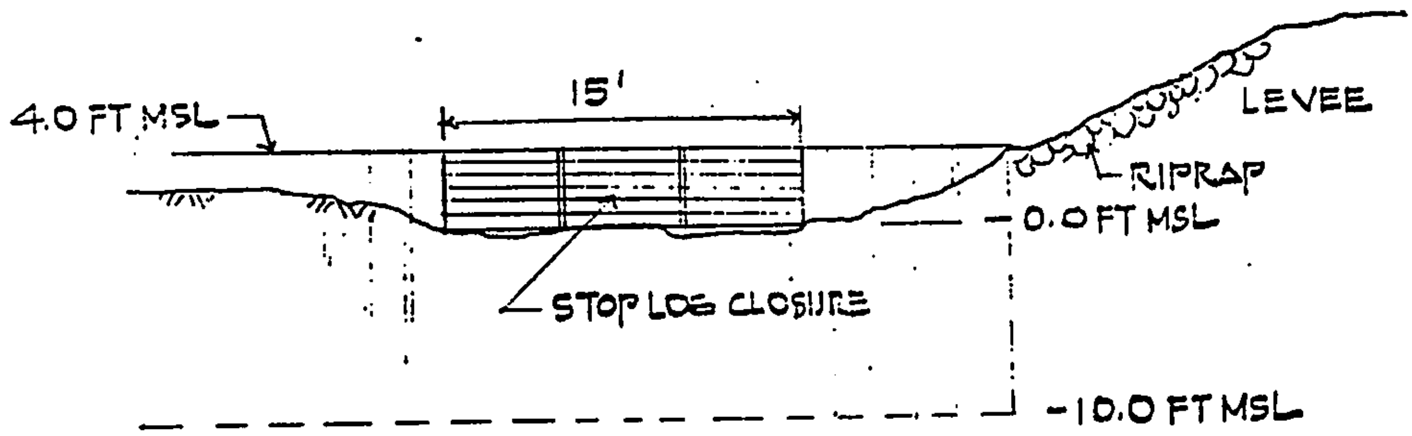
TYPICAL CHANNEL SECTION
ELEVATION VIEW

KAILUA, OAHU KAWAINUI MARSH
TYPICAL CHANNEL SECTION
Figure A-76
Source: Corps of Engineers
1988
U.S. ARMY ENGINEER HONOLULU DISTRICT

KAILUA, OAHU KAWAINUI MARSH
PROJECT LOCATION MAP
Figure A-74
Source: Corps of Engineers
1988
U.S. ARMY ENGINEER HONOLULU DISTRICT



CROSS SECTION - WATER CONTROL STRUCTURE
ELEVATION VIEW



CROSS SECTION - WATER CONTROL STRUCTURE
ELEVATION VIEW

KAILUA, OAHU KAWAINUI MARSH
WATER CONTROL STRUCTURE
Figure A-75
Source: Corps of Engineers
1988
U.S. ARMY ENGINEER HONOLULU DISTRICT

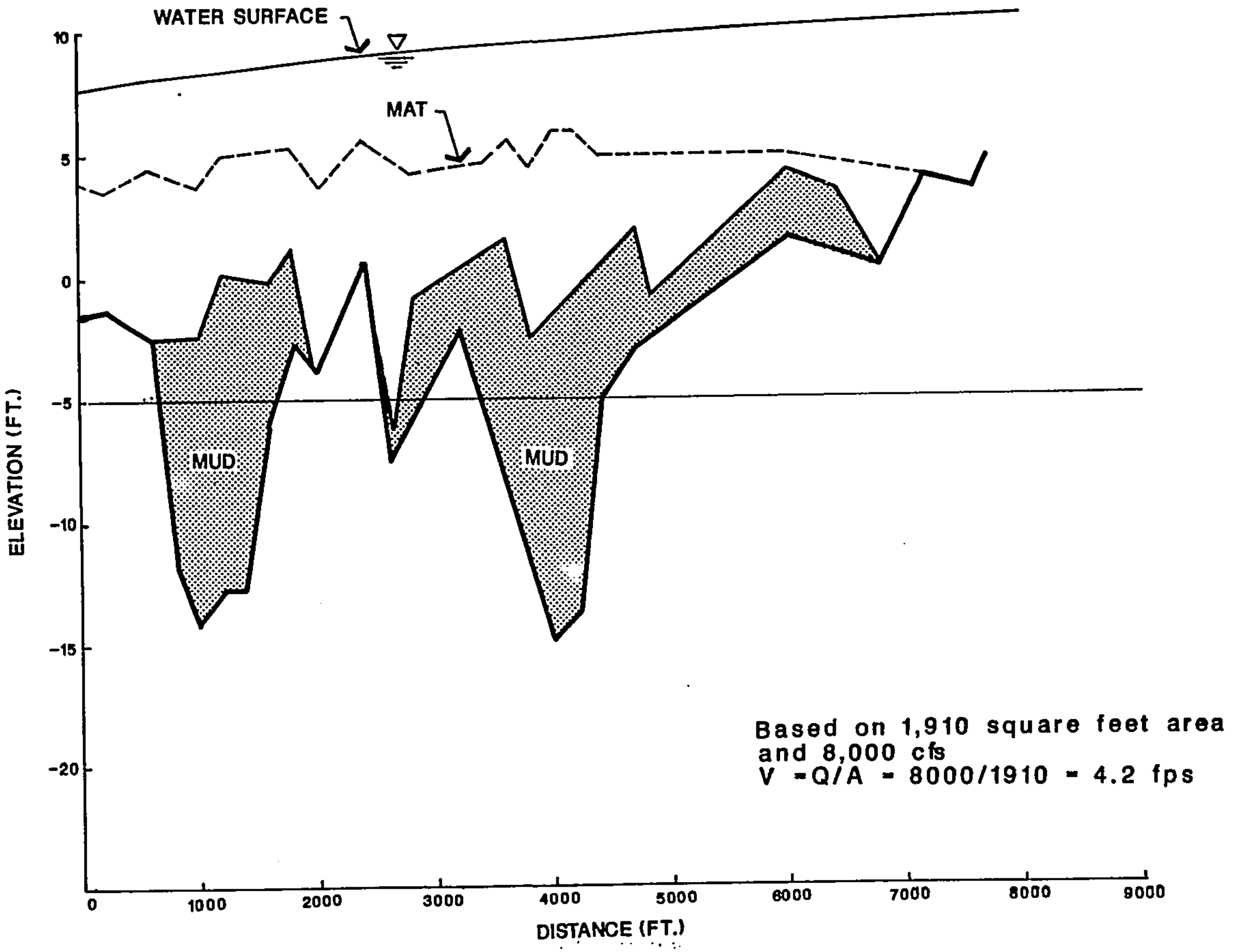


FIGURE A-73 CHANNELIZATION ALTERNATIVE PROFILE RESULTS

SCHEMATIC SKETCH AND RUN NUMBERS	UNIT DISCHARGE cfs/ft ($m^3/s/m$)	TIME (HRS) Δt	EROSION OF AVAILABLE VOLUME OF MATERIAL PERCENT	TOTAL VOLUME OF MODEL EROSION cu ft (m^3)
1	40 (3.7)	1	15.8	9.13 (0.26)
2	40 (3.7)	1	7.2	4.13 (0.12)
3	40 (3.7)	1	13.4	7.71 (0.22)
4	40 (3.7)	1	2.4	1.38 (0.04)
		5	4.6	2.67 (0.08)
5	40 (3.7)	1	11.7	4.11 (0.12)
6	40 (3.7)	1	3.8	1.58 (0.04)
		5	8.4	3.50 (0.10) ← Selected Design
7	40 (3.7)	1	9.1	3.82 (0.11)
		5	14.1	5.90 (0.17)
8	87 (8.1)	1	6.5	2.57 (0.07)
		5	6.5	2.57 (0.07)
9	87 (8.1)	1	12.7	5.31 (0.15)

Figure A-71 Model Results of Various Methods to Reduce Embankment Erosion
Prototype Scaling of Time
17 minutes = 1 hour
77 minutes = 5 hour
Prototype:
32 feet high sand embankment
4 feet depth of overtopping

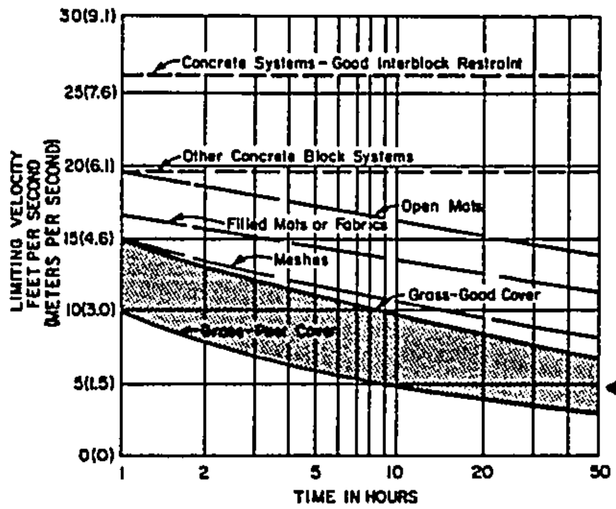
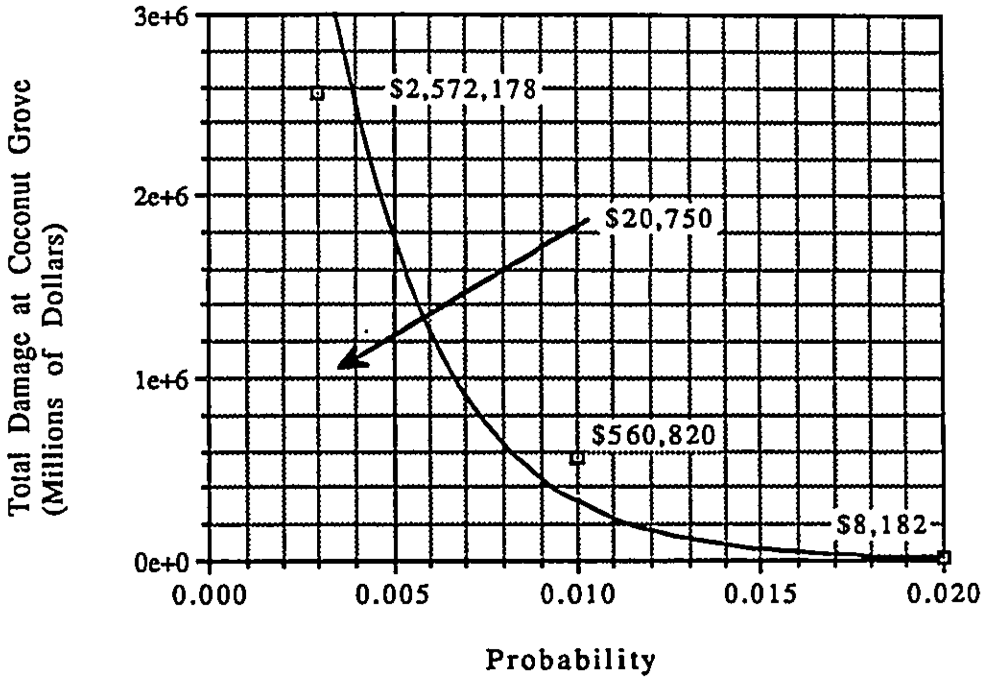


Figure A-72 Recommended Limiting Values for Erosion Resistance of Grass

Source: Powledge, George R., Ralston, David C., Miller Paul, Chen, Yung Hai, Clopper, Paul E., Temple, D.M. 1989. "Mechanics of Overflow Erosion on Embankments. I: Research Activities, II: Hydraulic and Design Considerations." Journal of Hydraulic Engineering, *ASCE.*

Figure A-69
Expected Value of Structural & Content Damage



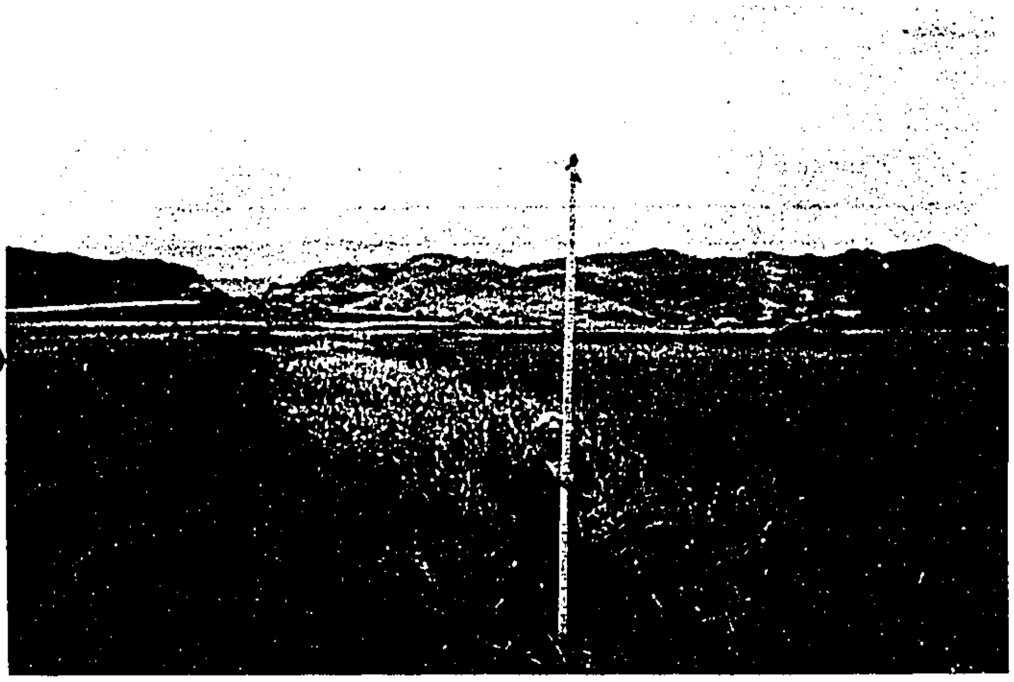


Figure A-70

Location of Edge of Proposed Emergency Overflow

Note: Height of Levee Relative to the Adjacent Wetland

Figure A-68

(Kaelepulu/Kailua Road to Kaelepulu End)

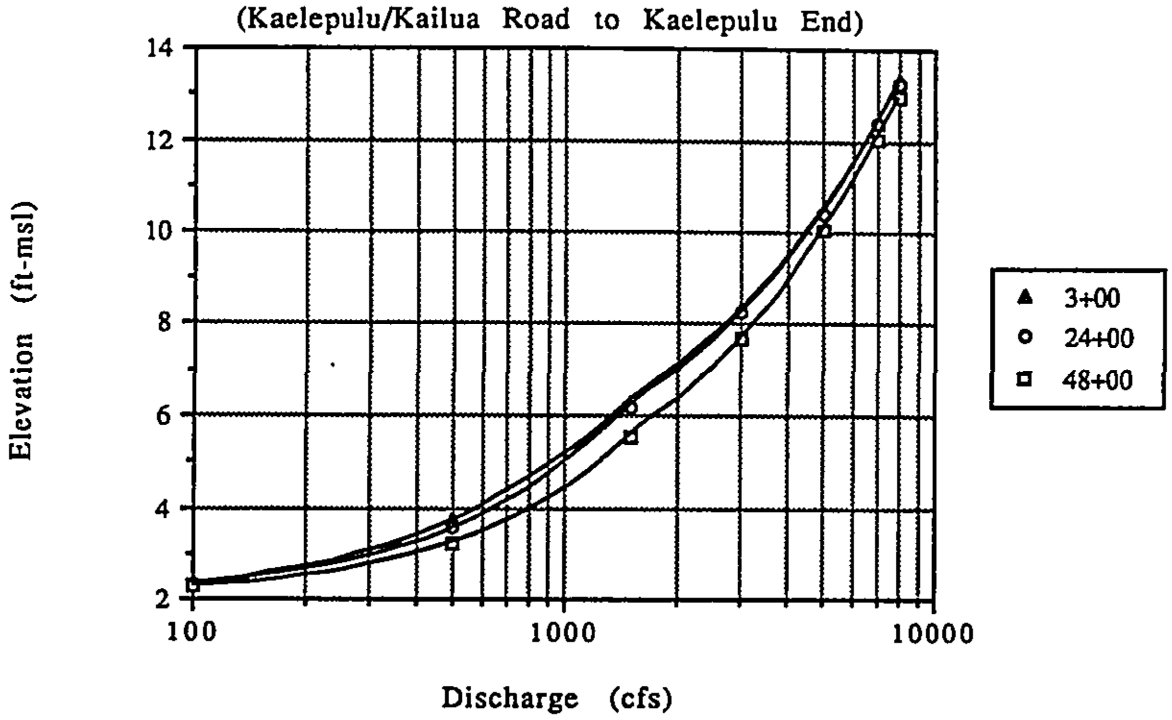
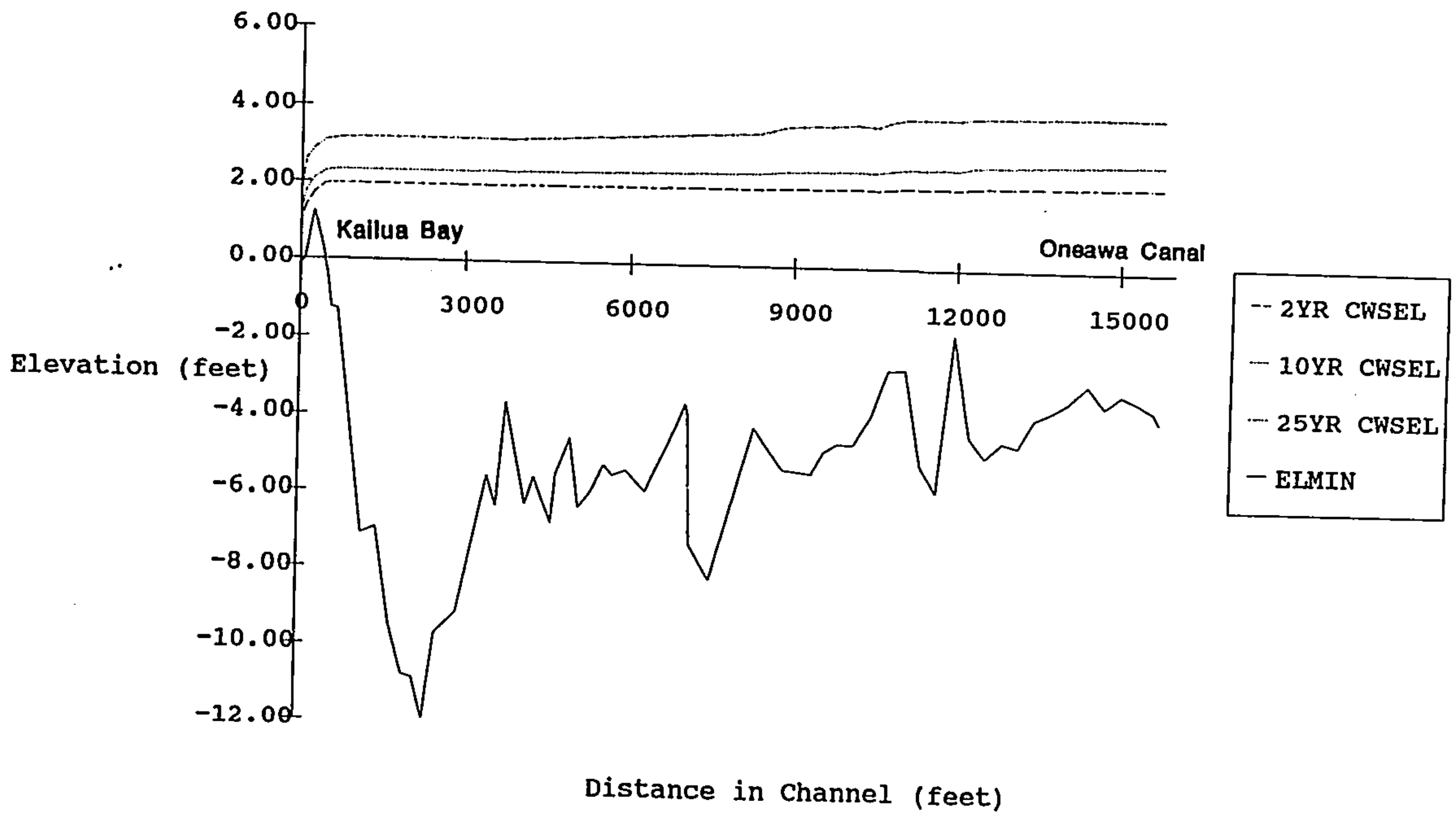
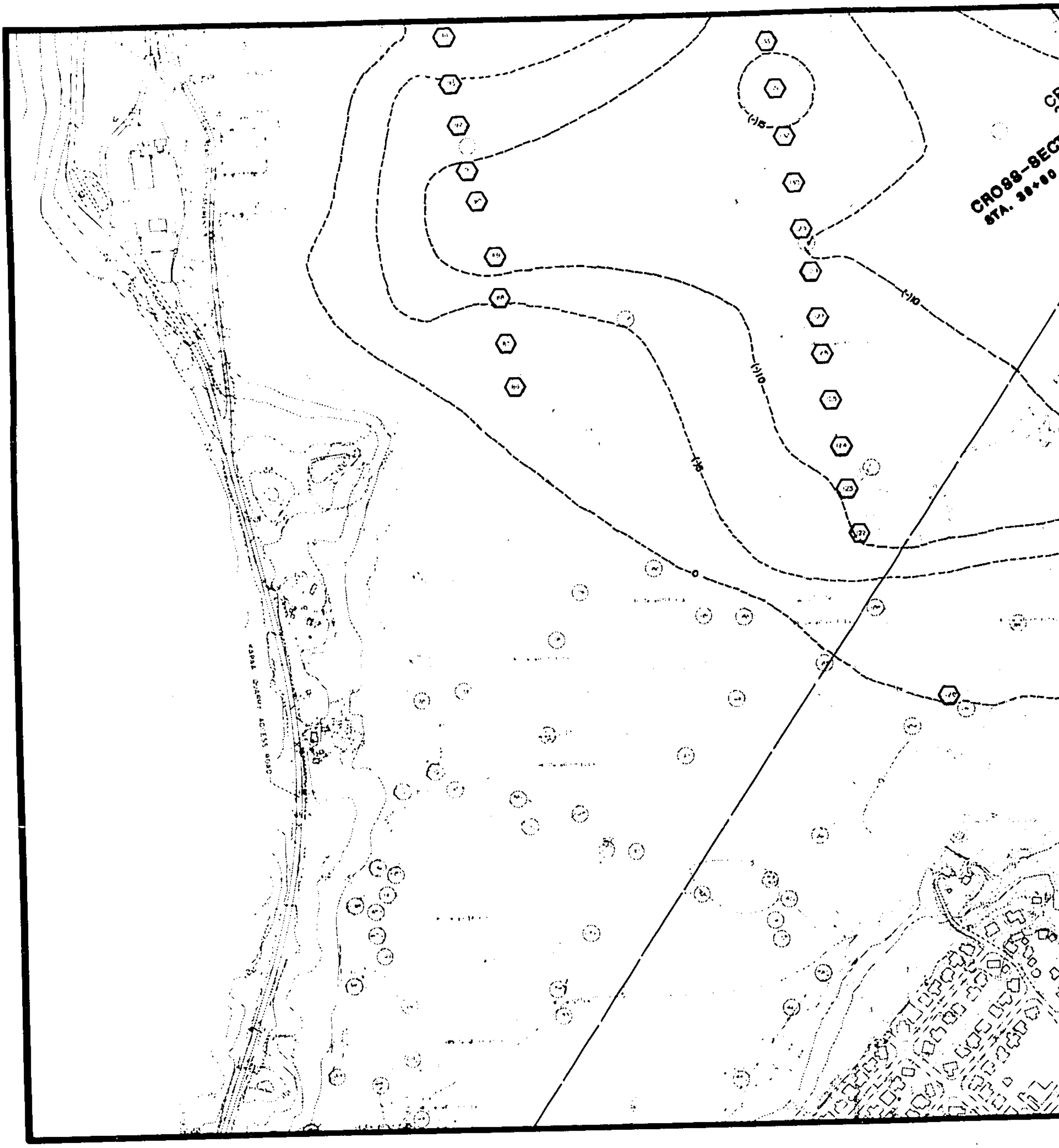
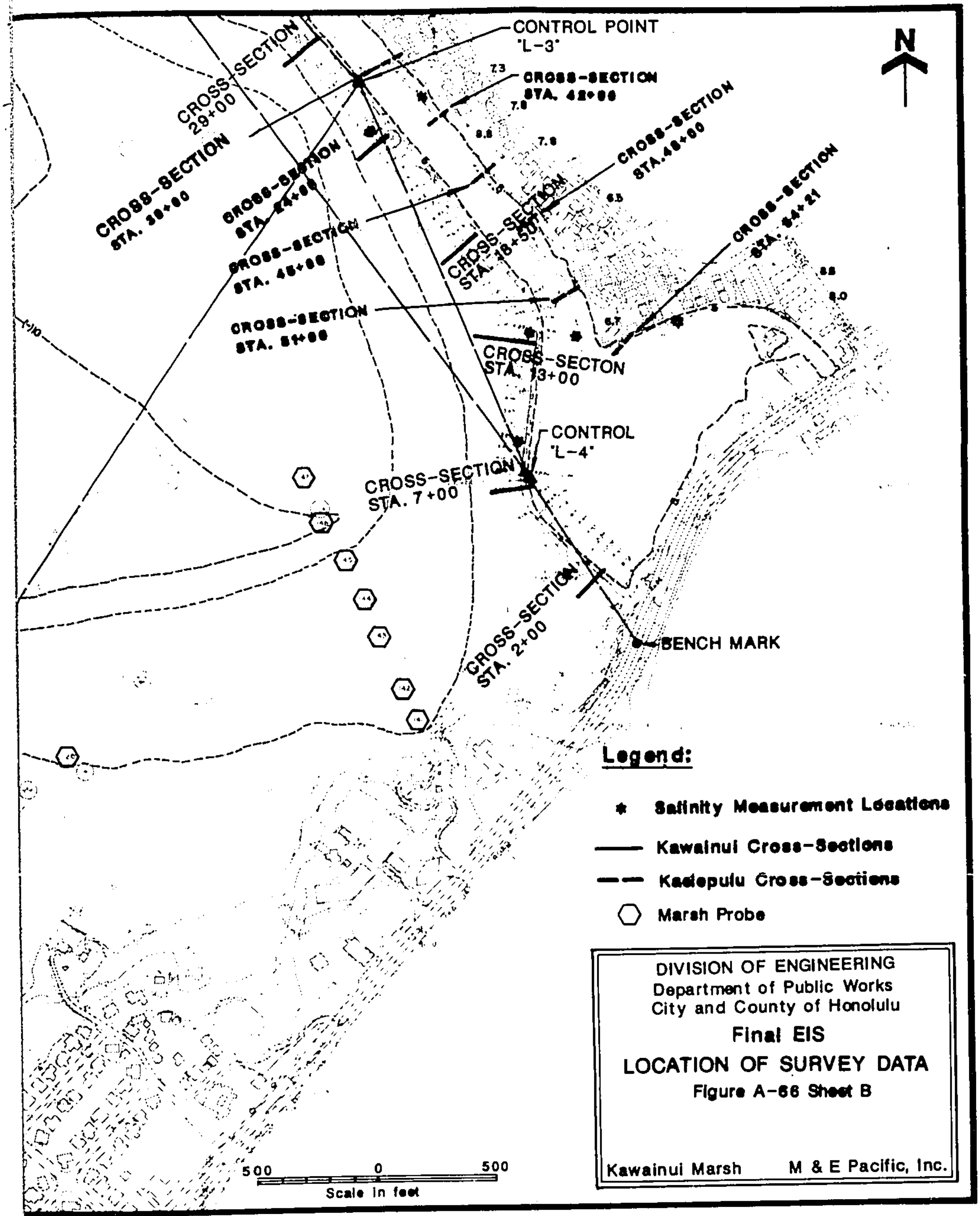


Figure A-67 Kaelepulu Stream

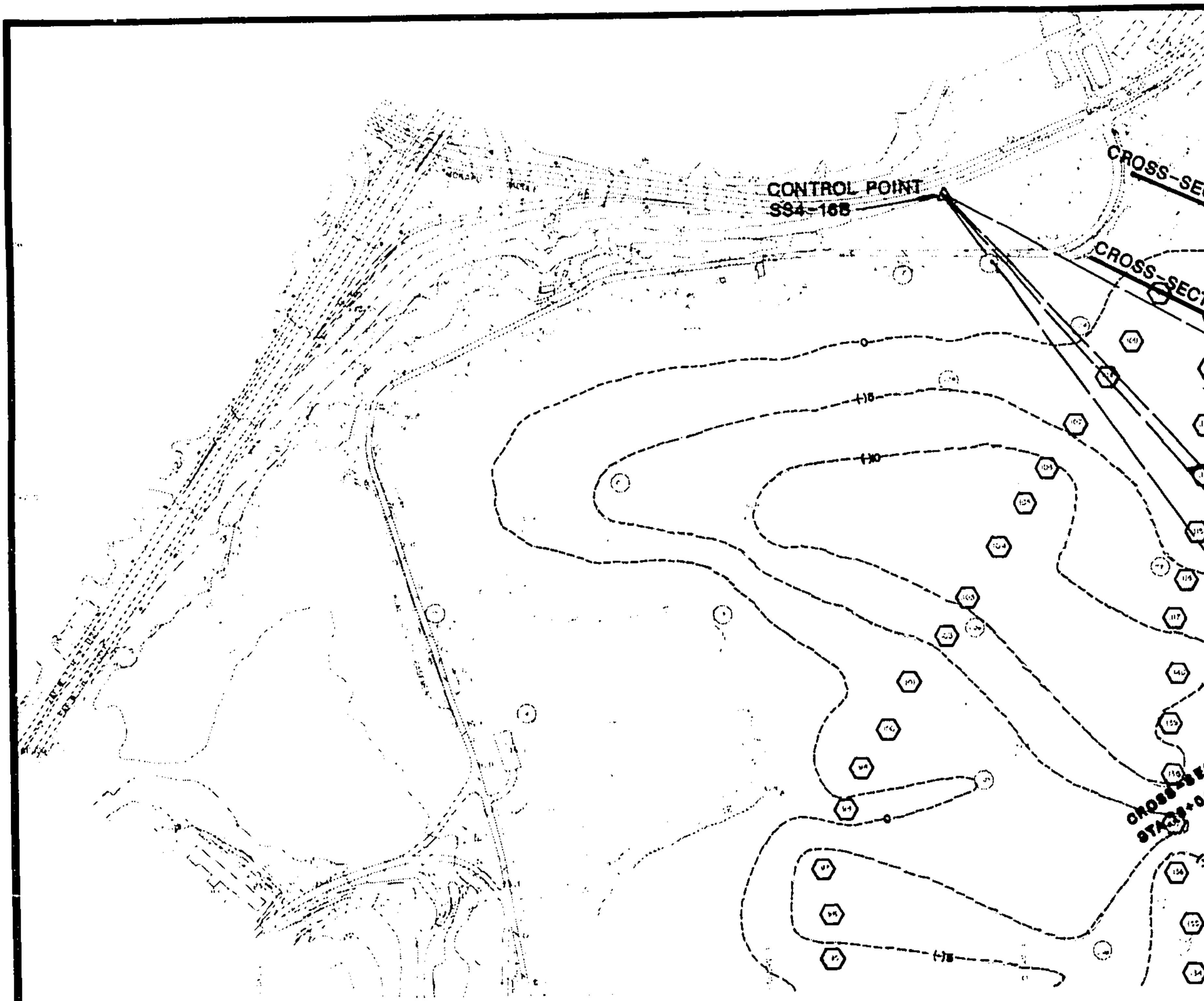




CROSS-SEC
STA. 39+00
(-)10
(-)15
(-)5
0



N
CONTROL POINT
"L-3"
CROSS-SECTION
29+00
CROSS-SECTION
STA. 42+00
CROSS-SECTION
STA. 28+00
CROSS-SECTION
STA. 24+00
CROSS-SECTION
STA. 48+00
CROSS-SECTION
STA. 45+00
CROSS-SECTION
STA. 18+50
CROSS-SECTION
STA. 54+21
CROSS-SECTION
STA. 51+00
CROSS-SECTON
STA. 13+00
CONTROL
"L-4"
CROSS-SECTION
STA. 7+00
CROSS-SECTION
STA. 2+00
BENCH MARK
Legend:
Salinity Measurement Locations
Kawainui Cross-Sections
Kaelepulu Cross-Sections
Marsh Probe
DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu
Final EIS
LOCATION OF SURVEY DATA
Figure A-66 Sheet B
Kawainui Marsh
M & E Pacific, Inc.
500 0 500
Scale in feet



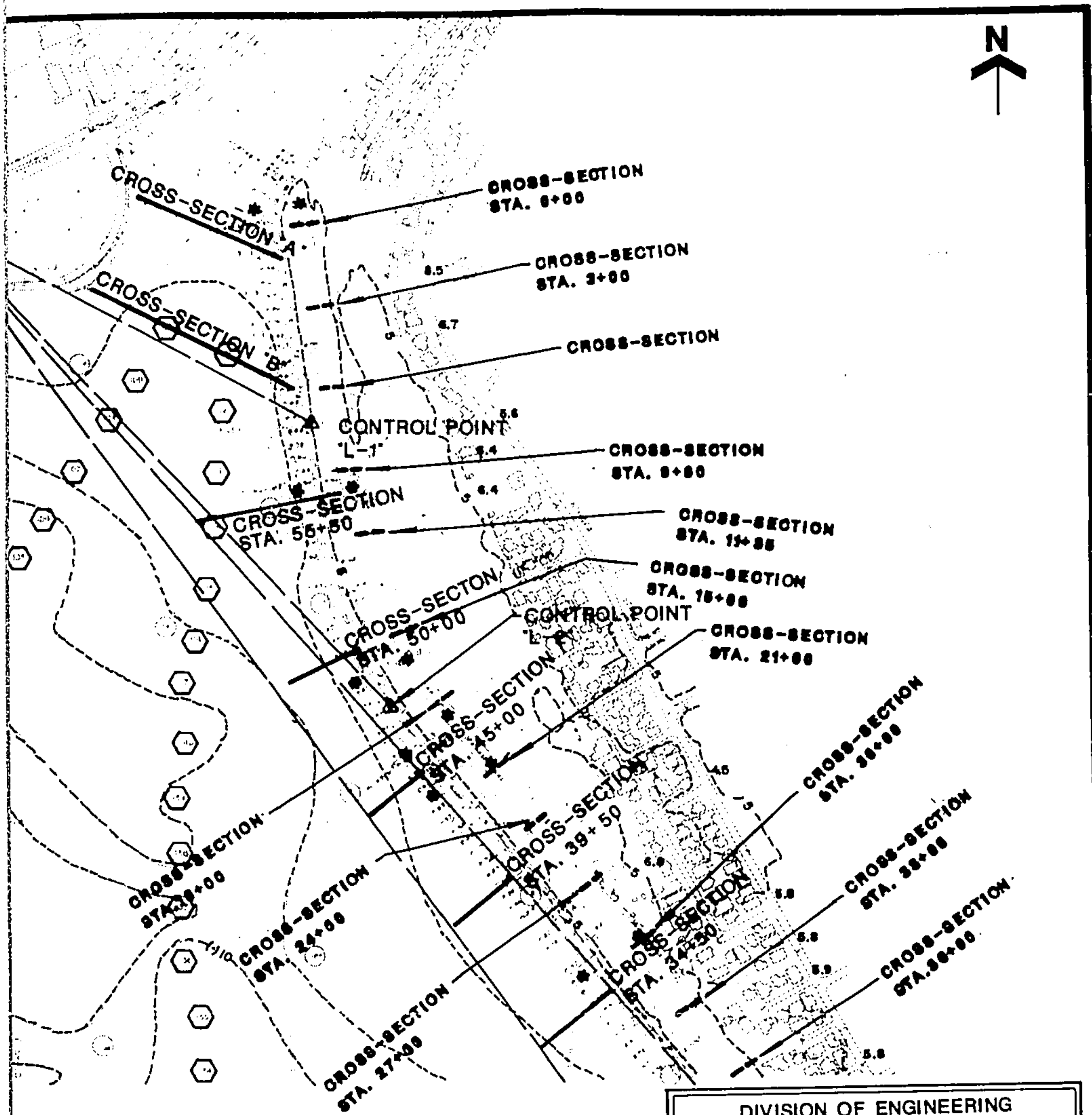
Legend:

* Salinity Measurement Lo

—— Kawainui Cross-Sectio

— — Kaelepulu Cross-Sectio

⬡ Marsh Probe



lity Measurement Locations

ainui Cross-Sections

epulu Cross-Sections

h Probe

500 0 500

Scale in feet

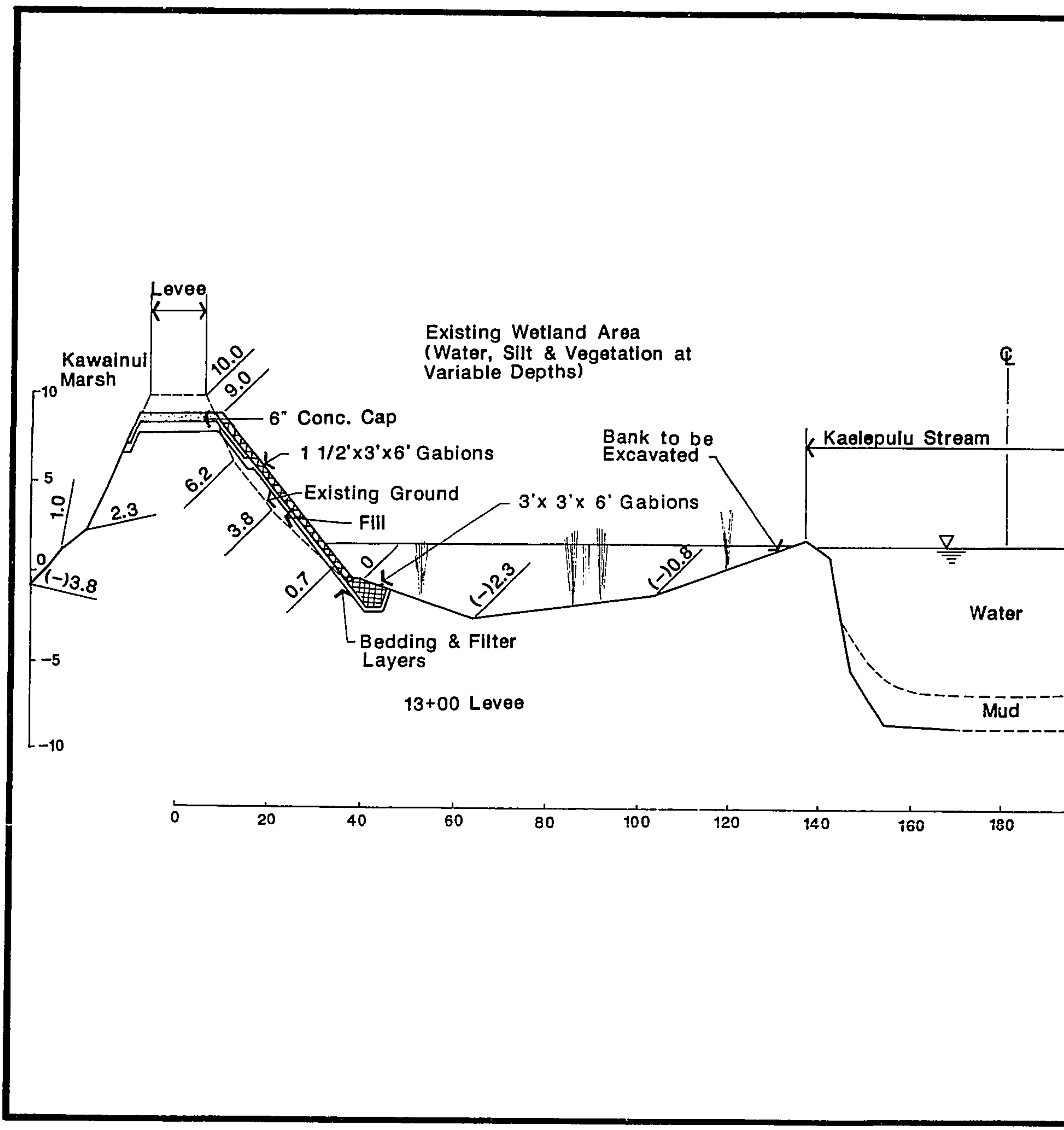
DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu

Final EIS

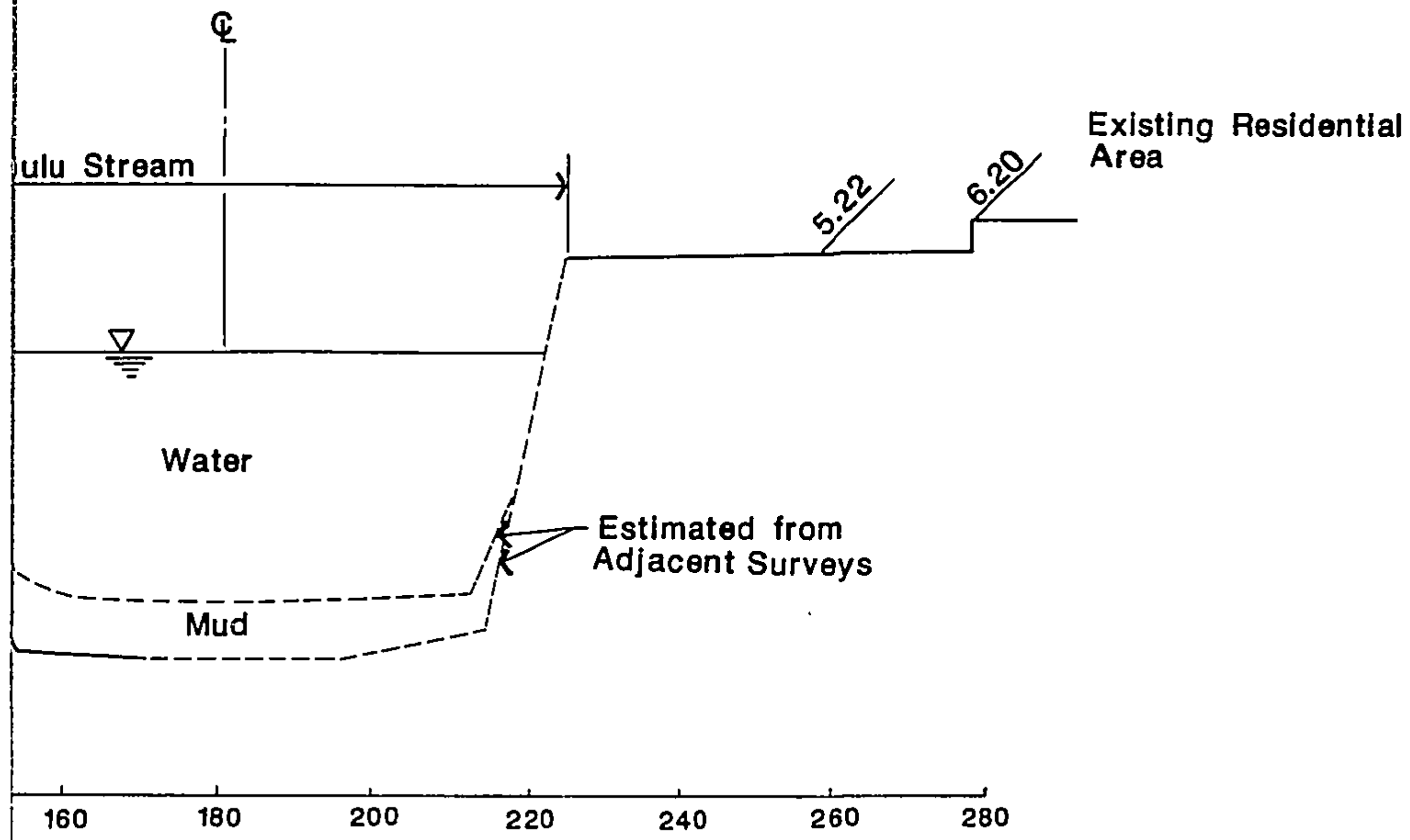
LOCATION OF SURVEY DATA

Figure A-66 Sheet A

Kawainui Marsh M & E Pacific, Inc.



Levee
Existing Wetland Area
(Water, Silt & Vegetation at
Variable Depths)
Kawainui
Marsh
10.0
9.0
6" Conc. Cap
1 1/2'x3'x6' Gabions
Bank to be
Excavated
Kaelepulu Stream
6.2
Existing Ground
3'x 3'x 6' Gabions
1.0
2.3
3.8
Fill
0
(−)3.8
0.7
(−)2.3
(−)0.8
Water
Bedding & Filter
Layers
13+00 Levee
Mud
10
5
0
-5
-10
0
20
40
60
80
100
120
140
160
180



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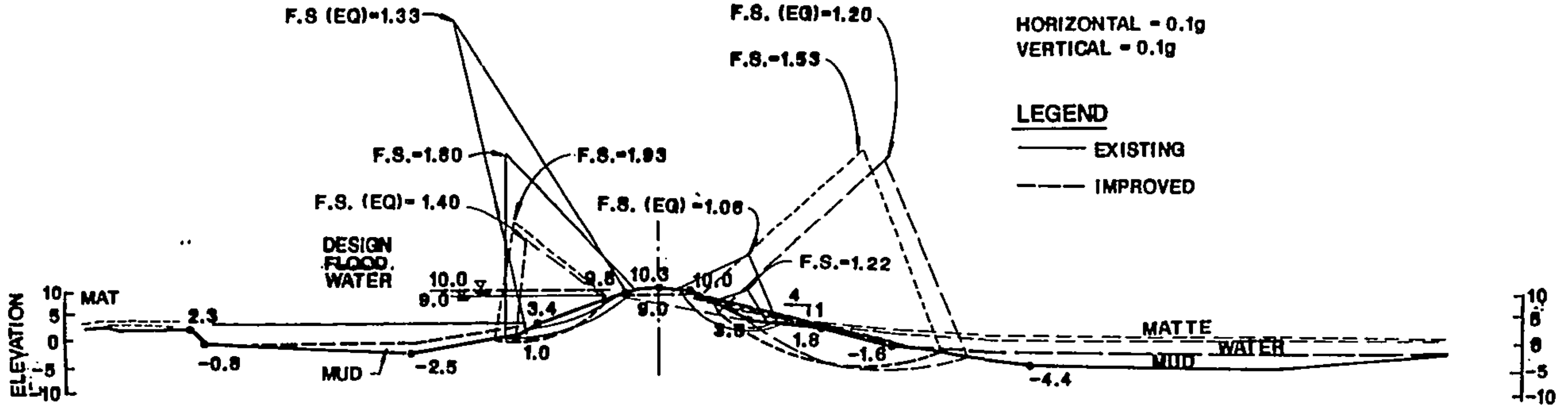
EMERGENCY OUTLET

Figure A-81

Kawainui Marsh M & E Pacific, Inc.



SOIL STRENGTH PARAMETERS

SOIL UNIT WEIGHT = 110 P.C.F.
COHESION = 0
INTERNAL FRICTION ANGLE = 36°

SEIMIC COEFFICIENT

HORIZONTAL = 0.1g
VERTICAL = 0.1g

LEGEND

——— EXISTING
– – – IMPROVED

LEVEE SECTION AT STATION 7+00
Not to Scale

DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu

Figure A-81/1

EMERGENCY OVERFLOW WEIR STABILITY ANALYSIS

Kawainui Marsh M & E Pacific, Inc.

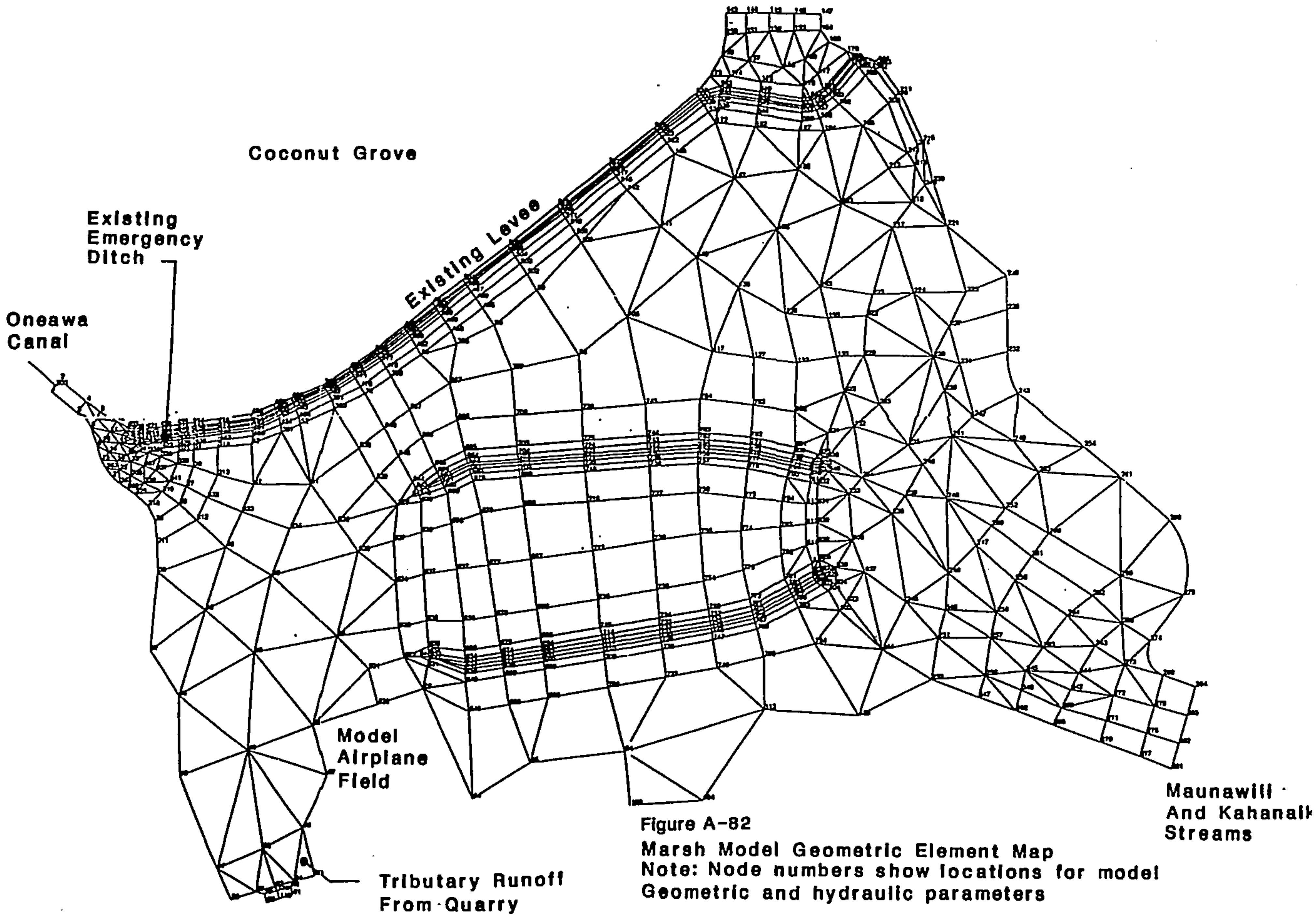


Figure A-82
Marsh Model Geometric Element Map
Note: Node numbers show locations for model Geometric and hydraulic parameters

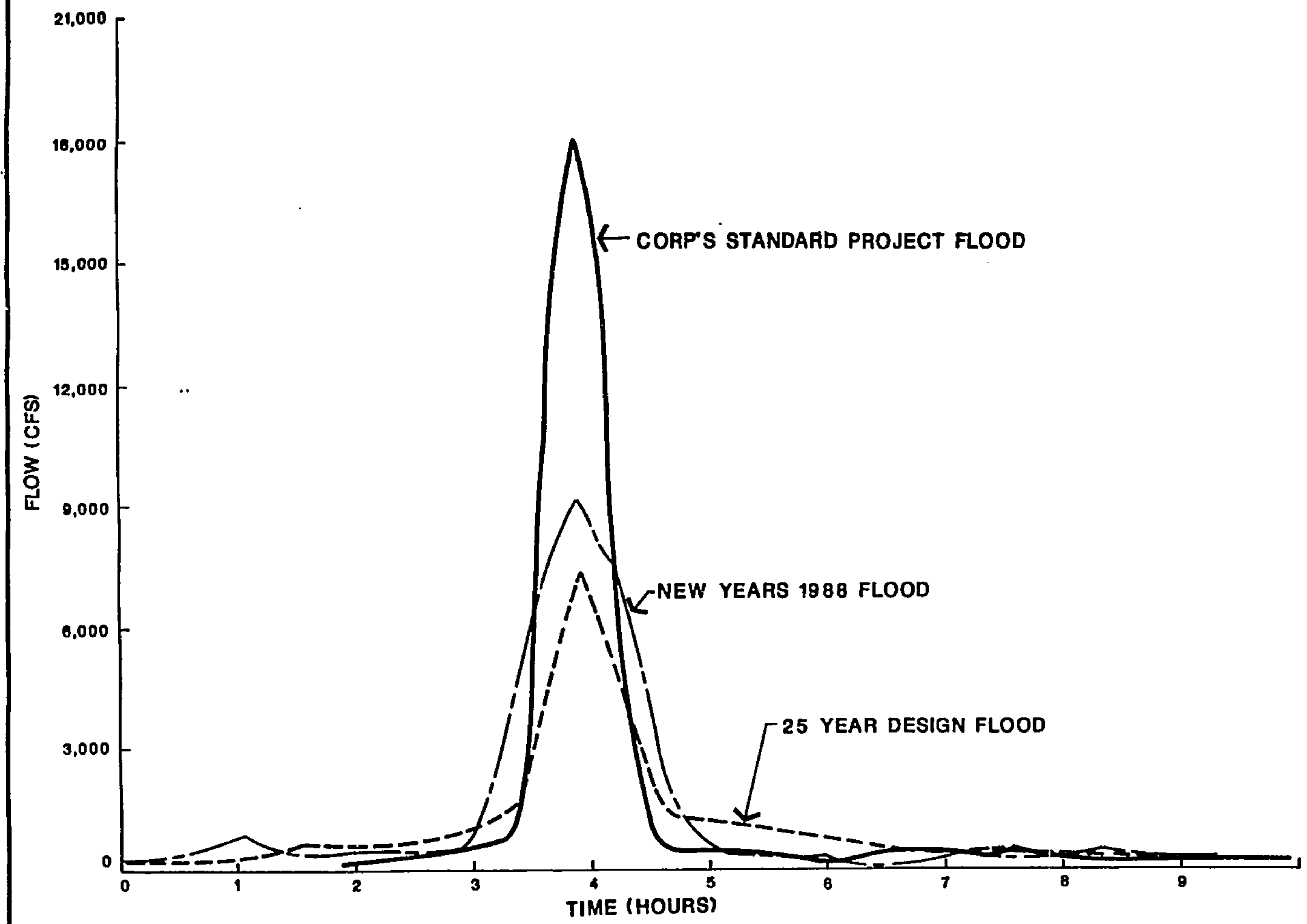
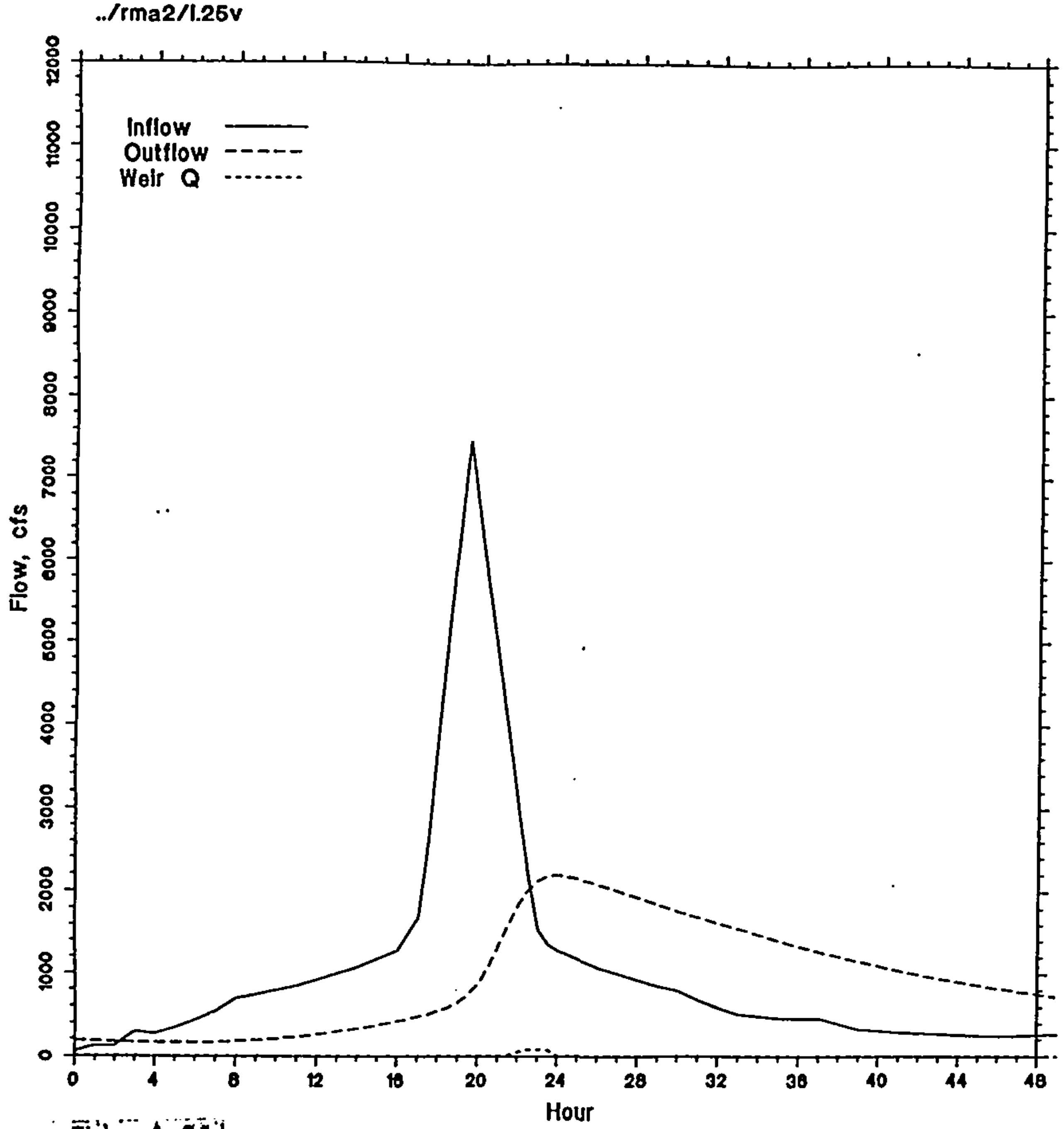


FIGURE A-83 KAWAINUI MARSH INFLOW

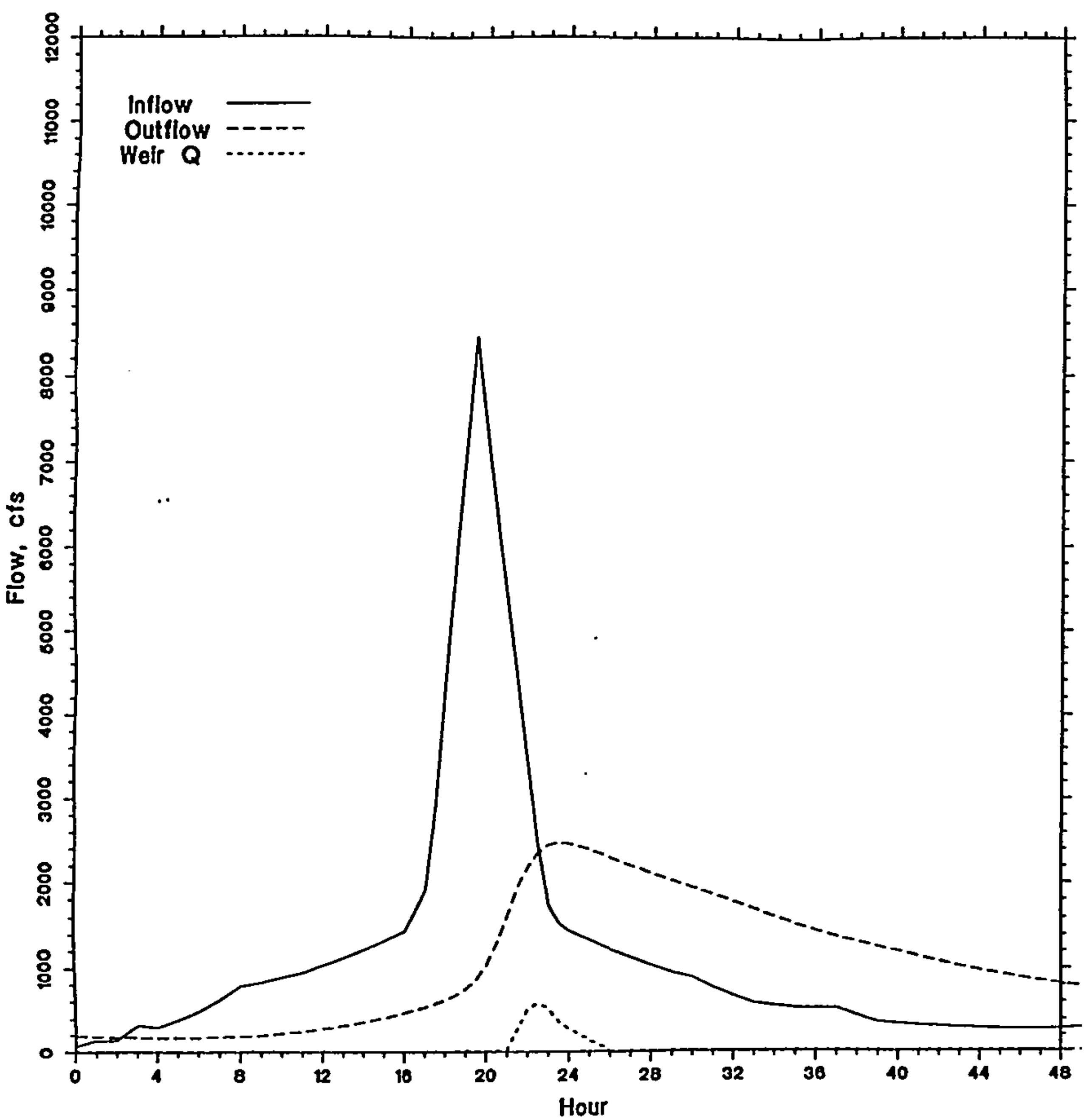


Time	Q in	Q out	Weir Q
18.0	3800.	535.	5.
18.5	5016.	577.	6.
19.0	6232.	634.	6.
19.5	7448.	720.	7.
20.0	6574.	853.	7.
20.5	5700.	1050.	8.
21.0	4826.	1307.	8.
21.5	3952.	1581.	7.
22.0	3078.	1820.	44.
22.5	2166.	1998.	74.
23.0	1520.	2110.	77.
23.5	1338.	2164.	68.
24.0	1261.	2176.	5.
25.0	1163.	2138.	5.
26.0	1065.	2072.	5.
27.0	988.	1995.	5.
28.0	912.	1917.	5.
29.0	836.	1838.	5.
30.0	783.	1759.	5.
31.0	669.	1682.	5.
32.0	584.	1612.	5.
33.0	505.	1539.	5.

Figure A-64.

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 25 Year Design Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

../rma2/l.50v

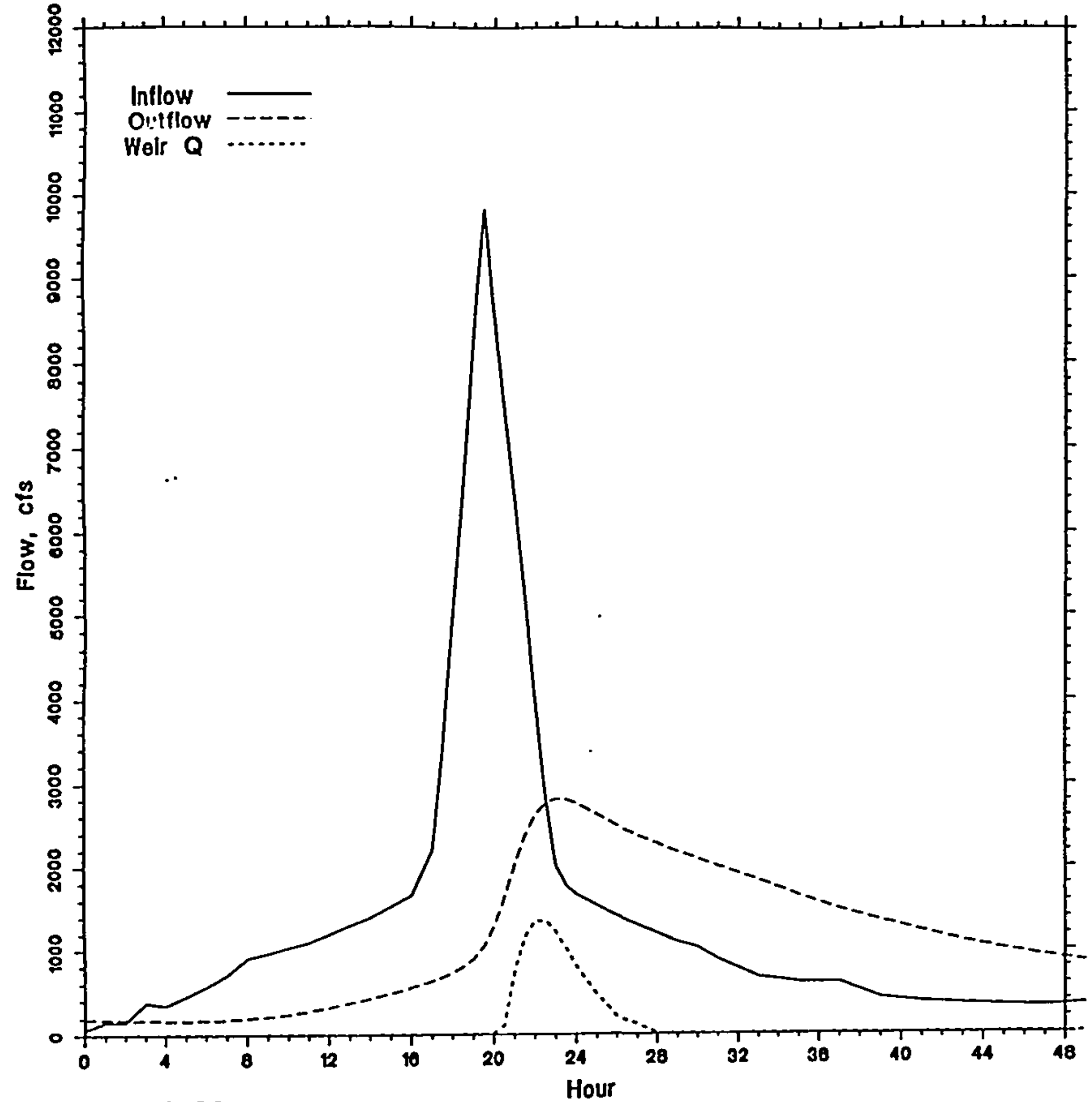


Time	Q in	Q out	Weir Q
18.0	4300.	610.	6.
18.5	5676.	661.	6.
19.0	7052.	733.	6.
19.5	8428.	845.	7.
20.0	7439.	1020.	8.
20.5	6450.	1277.	8.
21.0	5461.	1596.	8.
21.5	4472.	1914.	263.
22.0	3483.	2166.	509.
22.5	2451.	2336.	572.
23.0	1720.	2430.	516.
23.5	1514.	2462.	353.
24.0	1427.	2452.	269.
25.0	1316.	2378.	124.
26.0	1205.	2287.	5.
27.0	1118.	2197.	5.
28.0	1032.	2107.	5.
29.0	946.	2018.	5.
30.0	886.	1931.	5.
31.0	757.	1846.	5.
32.0	660.	1767.	5.
33.0	571.	1685.	5.

Figure A-85

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 50 Year Design Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

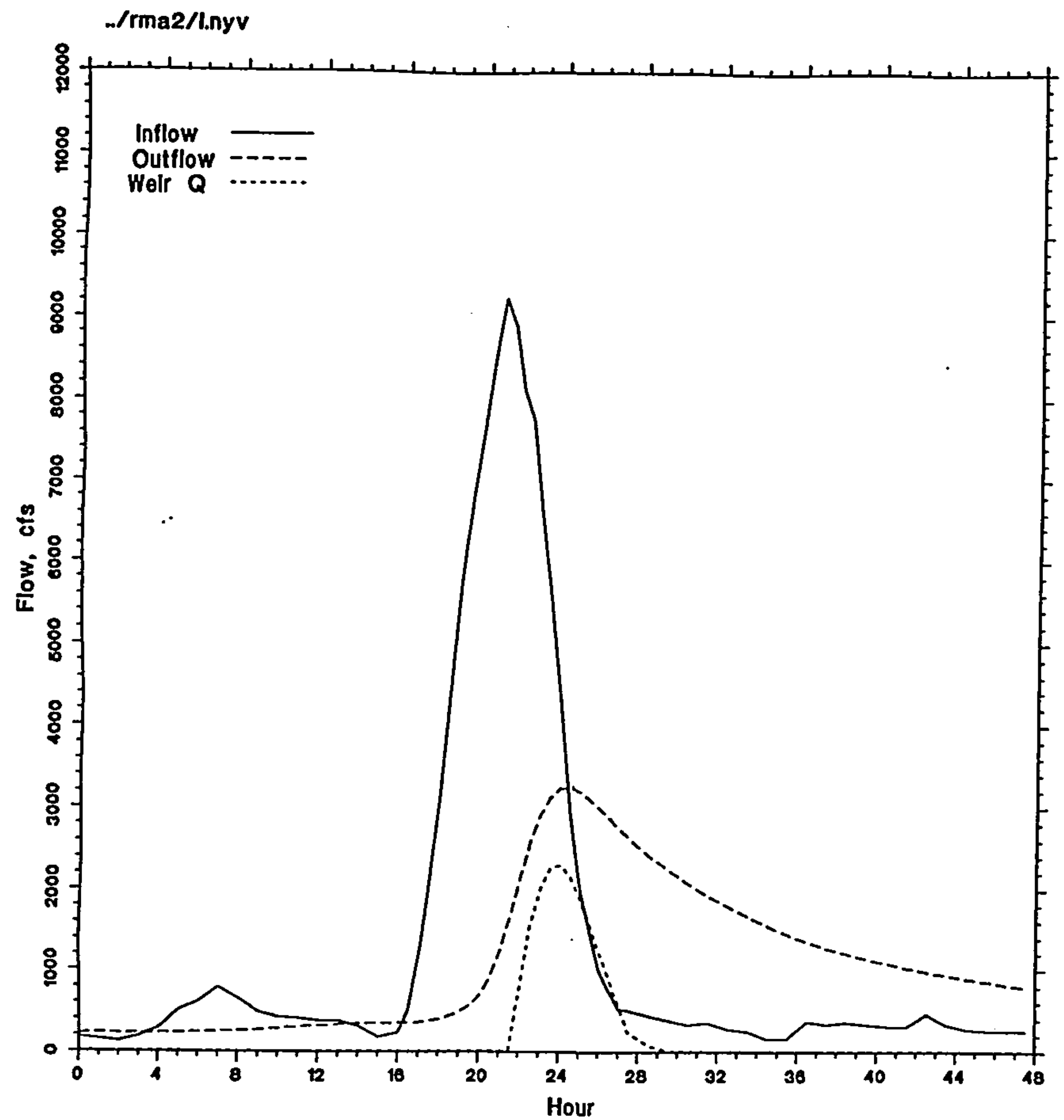
../rma2/l.100v



Time	Q in	Q out	Weir Q
15.0	1530.	481.	6.
16.0	1660.	550.	6.
17.0	2200.	626.	6.
17.5	3400.	670.	6.
18.0	5000.	721.	6.
18.5	6600.	787.	6.
19.0	8200.	885.	7.
19.5	9800.	1041.	8.
20.0	8650.	1287.	8.
20.5	7500.	1633.	102.
21.0	6350.	2022.	752.
21.5	5200.	2362.	1163.
22.0	4050.	2601.	1347.
22.5	2850.	2743.	1344.
23.0	2000.	2802.	1206.
23.5	1760.	2796.	998.
24.0	1660.	2748.	787.
25.0	1530.	2616.	451.
26.0	1401.	2487.	191.
27.0	1300.	2375.	109.
28.0	1200.	2274.	5.
29.0	1100.	2180.	5.

Figure A-86

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 100 Year Design Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

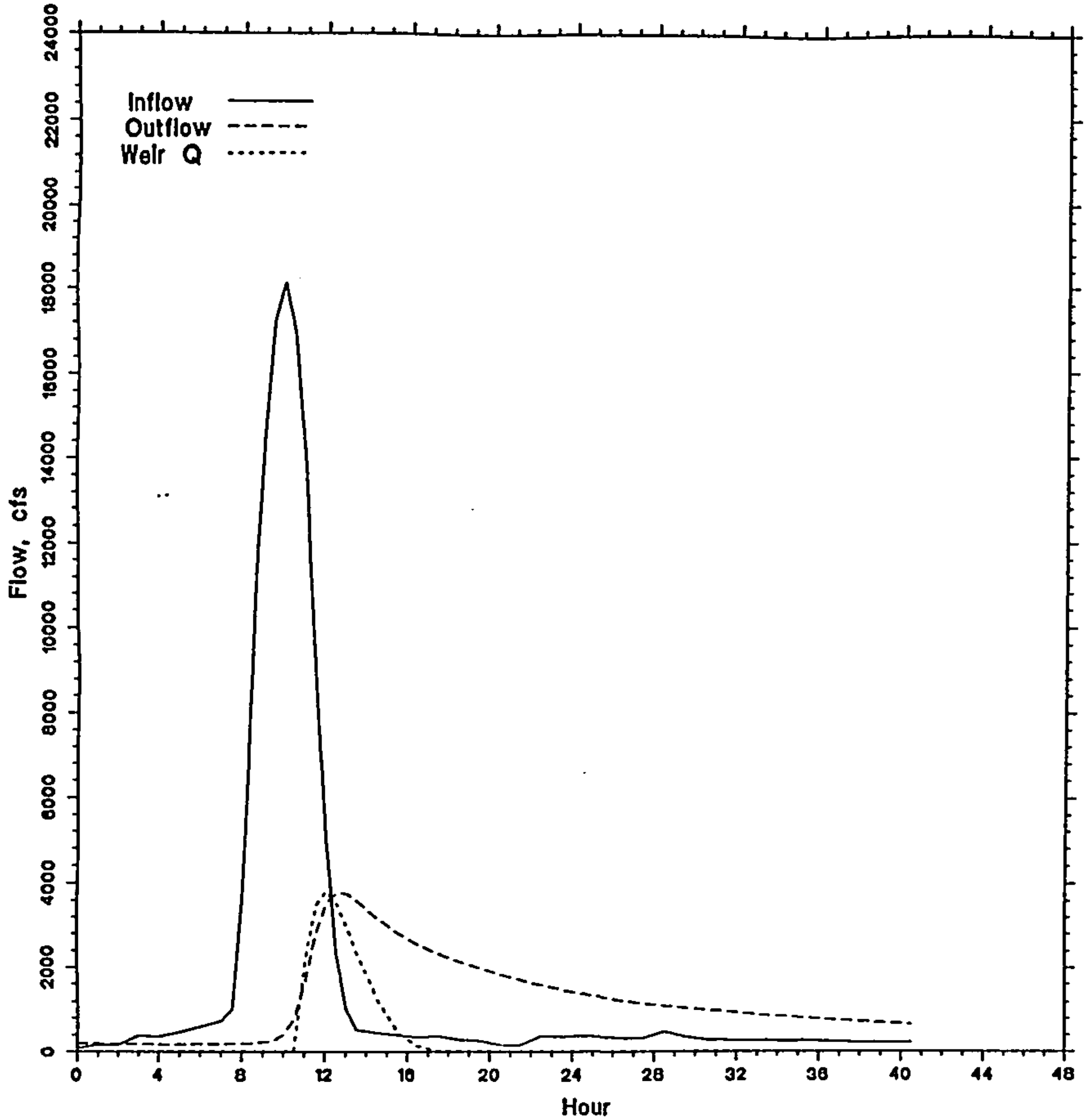


Time	Q in	Q out	Weir Q
18.0	3163.	396.	5.
18.5	4440.	428.	5.
19.0	5733.	475.	6.
19.5	6735.	547.	6.
20.0	7534.	665.	7.
20.5	8408.	872.	8.
21.0	9219.	1198.	9.
21.5	8865.	1629.	9.
22.0	8093.	2109.	723.
22.5	7710.	2555.	1517.
23.0	6520.	2881.	1984.
23.5	5491.	3101.	2241.
24.0	4323.	3213.	2280.
24.5	2897.	3231.	2140.
25.0	1973.	3183.	1876.
26.0	986.	2973.	1200.
27.0	517.	2722.	557.
27.5	500.	2606.	232.
28.5	440.	2400.	76.
29.5	385.	2220.	5.
30.5	330.	2057.	4.
31.5	360.	1908.	5.

Figure A

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for the New Years 1988 Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

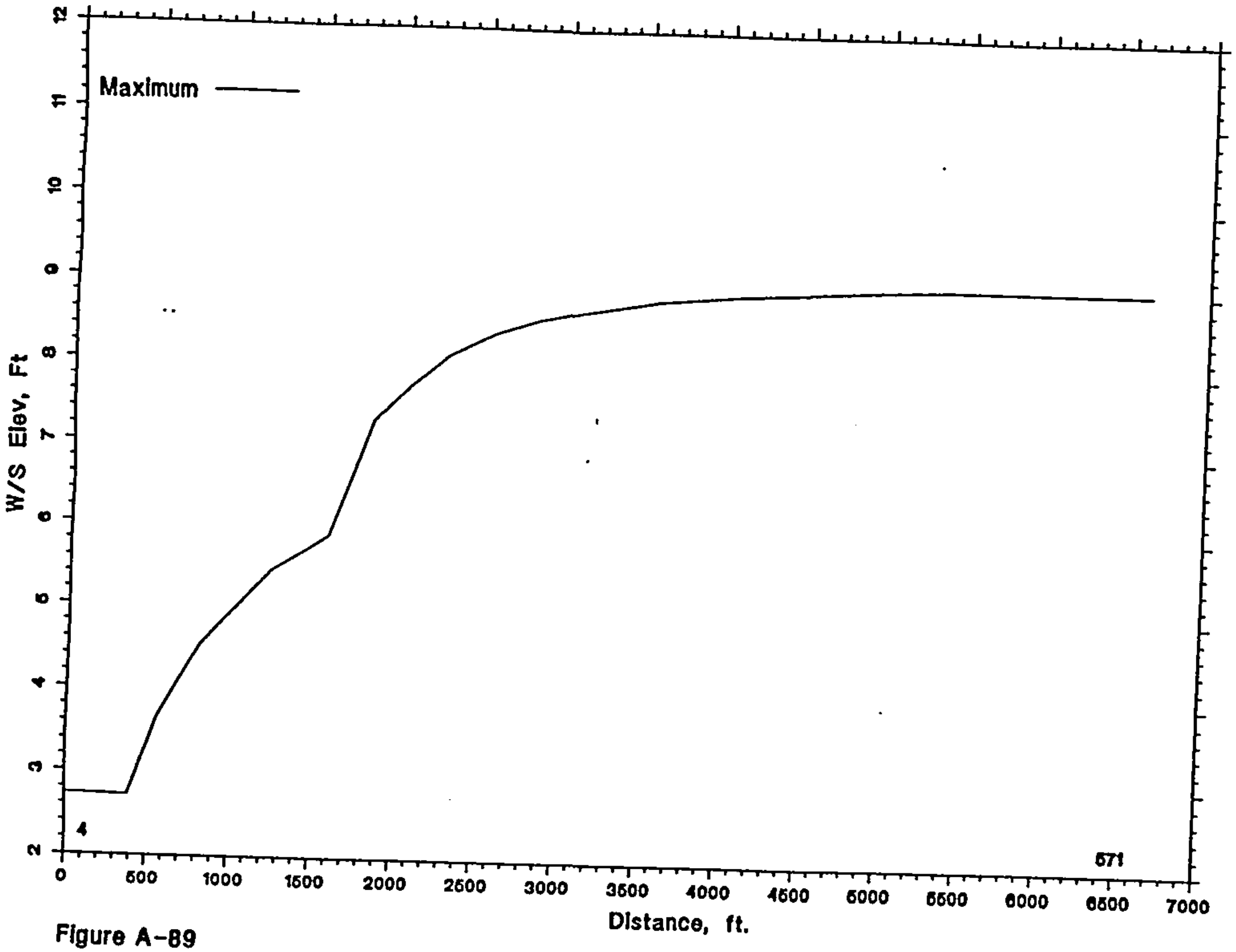
../rma2/l.spfv



Time	Q in	Q out	Weir Q
6.0	563.	174.	4.
7.0	706.	179.	4.
7.5	1000.	184.	4.
8.0	3880.	191.	4.
8.5	10000.	200.	4.
9.0	14400.	215.	5.
9.5	17200.	258.	7.
10.0	18100.	384.	11.
10.5	16900.	751.	14.
11.0	13800.	1612.	2118.
11.5	8600.	2748.	3457.
12.0	4900.	3502.	3791.
12.5	2300.	3762.	3469.
13.0	1000.	3723.	2910.
13.5	500.	3543.	2282.
14.5	440.	3121.	1241.
15.5	385.	2771.	445.
16.5	330.	2503.	127.
17.5	360.	2283.	4.
18.5	275.	2104.	5.
19.5	242.	1942.	5.
20.5	147.	1794.	5.

Figure A-88
Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for the Corp's Standard Project Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

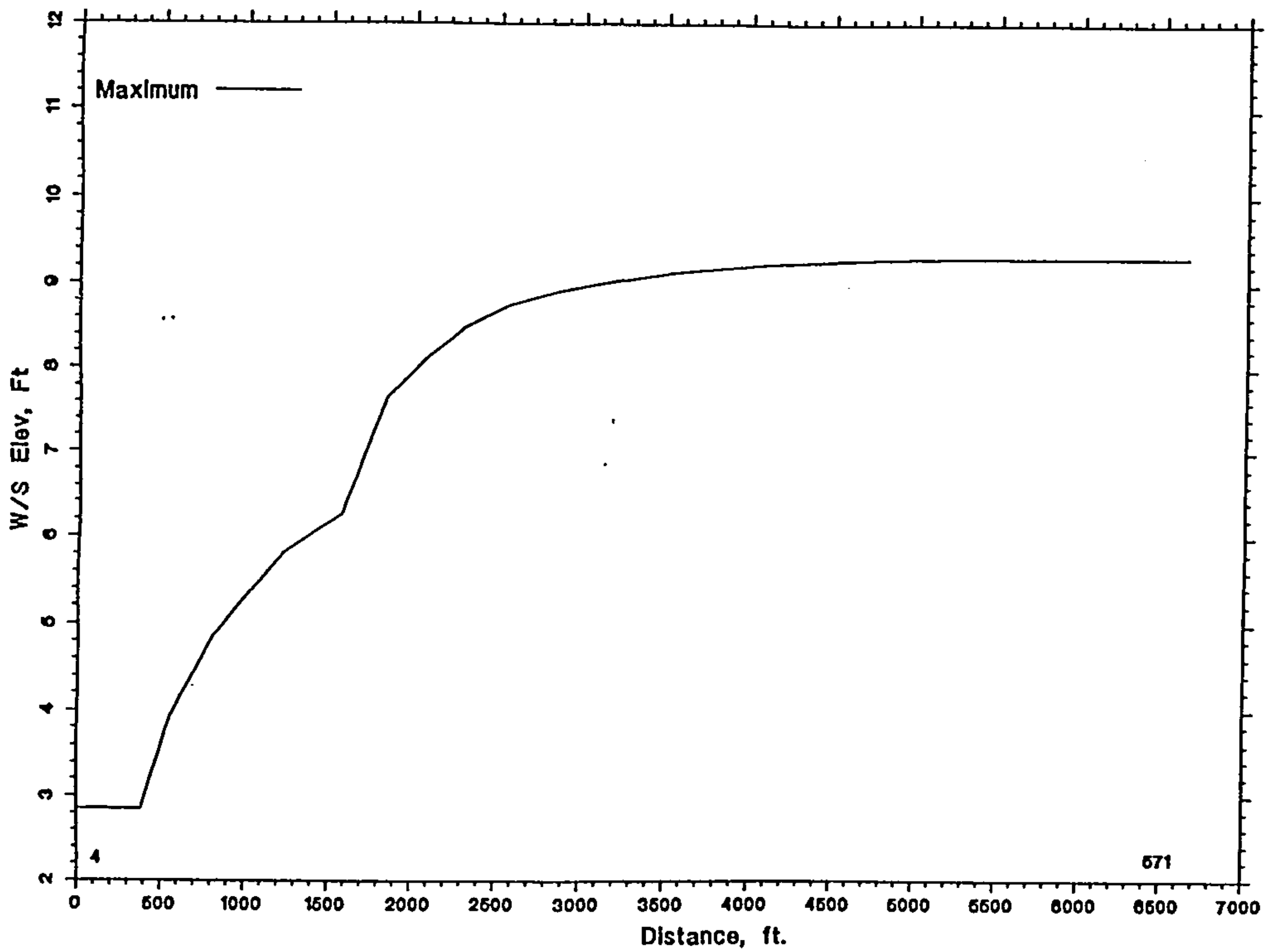
../rma2/d25v.res



Node	Length	H max
4	0.	2.72
413	380.	2.70
426	560.	3.66
440	812.	4.52
454	1236.	5.44
467	1576.	5.86
391	1842.	7.28
473	2058.	7.70
479	2292.	8.09
486	2568.	8.36
492	2848.	8.53
499	3128.	8.65
506	3544.	8.79
513	4008.	8.87
519	4508.	8.93
525	4948.	8.98
531	5334.	9.01
541	5504.	9.02
547	5814.	9.02
559	6224.	9.02
571	6644.	9.02

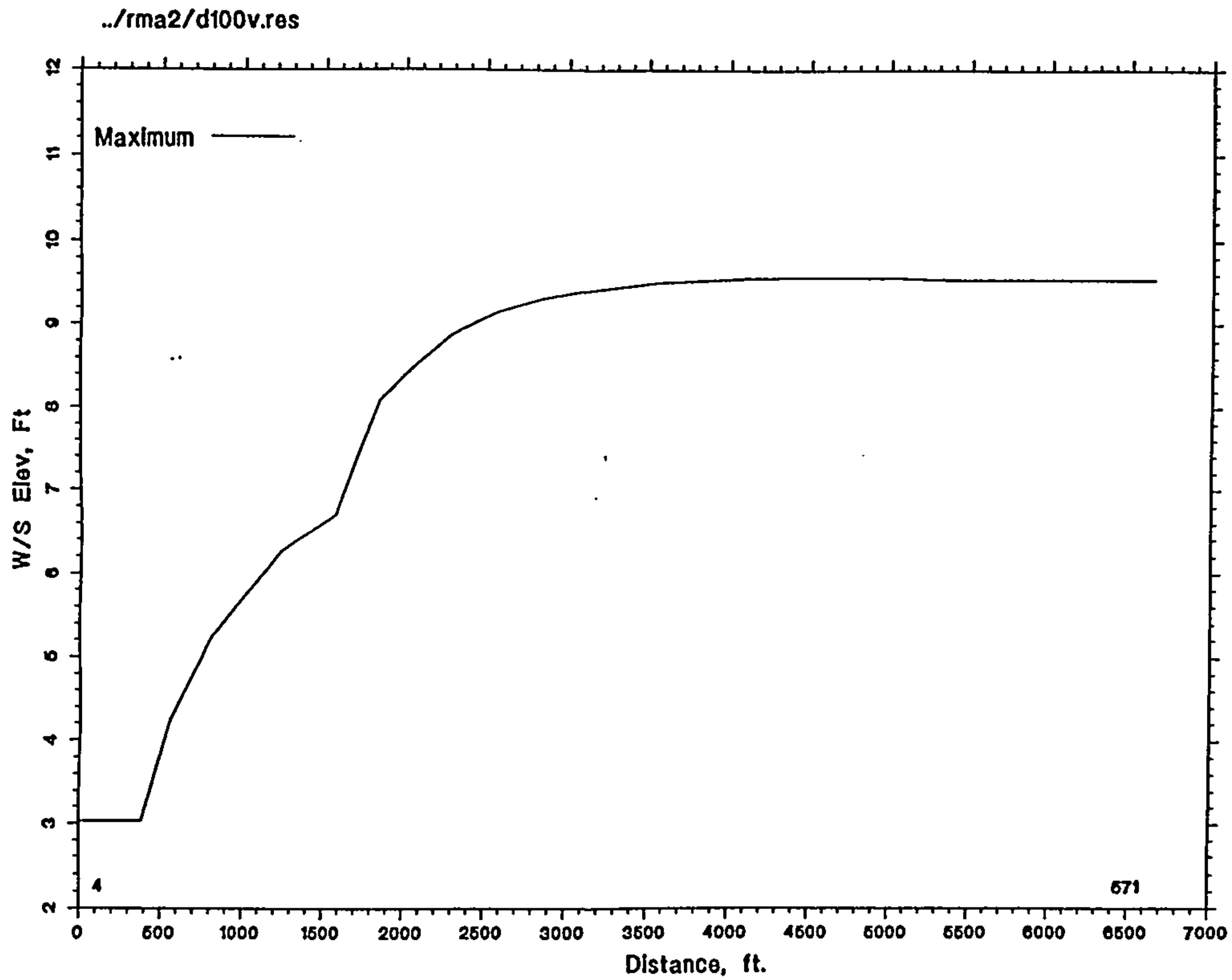
Figure A-89
Profile of Maximum Water Surface Elevation Along the Levee for a 25 Year Design Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

../rma2/d50v.res



Node	Length	H max
4	0.	2.85
413	380.	2.84
426	560.	3.93
440	812.	4.85
454	1236.	5.81
467	1576.	6.25
391	1842.	7.65
473	2058.	8.00
479	2292.	8.47
486	2568.	8.73
492	2848.	8.90
499	3128.	9.00
506	3544.	9.13
513	4008.	9.21
519	4508.	9.25
525	4948.	9.29
531	5334.	9.30
541	5504.	9.30
547	5814.	9.30
559	6224.	9.30
571	6644.	9.30

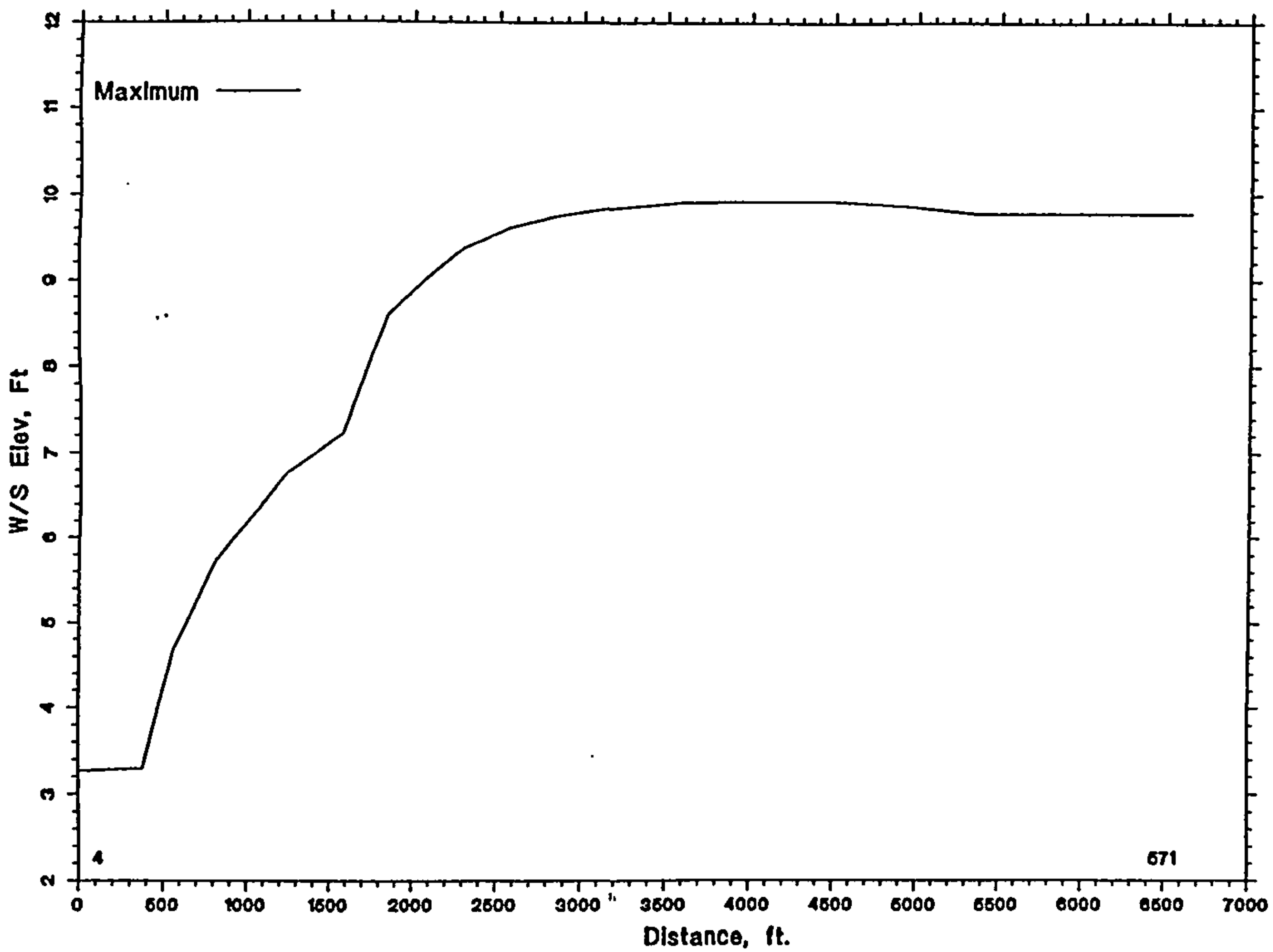
Figure A-90
Profile of Maximum Water Surface Elevation Along the Levee for a 50 Year Design Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal



Node	Length	H max
4	0.	3.02
413	380.	3.02
426	560.	4.25
440	812.	5.24
454	1236.	6.24
467	1576.	6.69
391	1842.	8.08
473	2058.	8.50
479	2292.	8.88
486	2568.	9.13
492	2848.	9.29
499	3128.	9.39
506	3544.	9.49
513	4008.	9.55
519	4508.	9.56
525	4948.	9.56
531	5334.	9.55
541	5504.	9.54
547	5814.	9.54
559	6224.	9.54
571	6644.	9.54

Figure A-91
Profile of Maximum Water Surface Elevation Along the Levee for a 100 Year Design Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

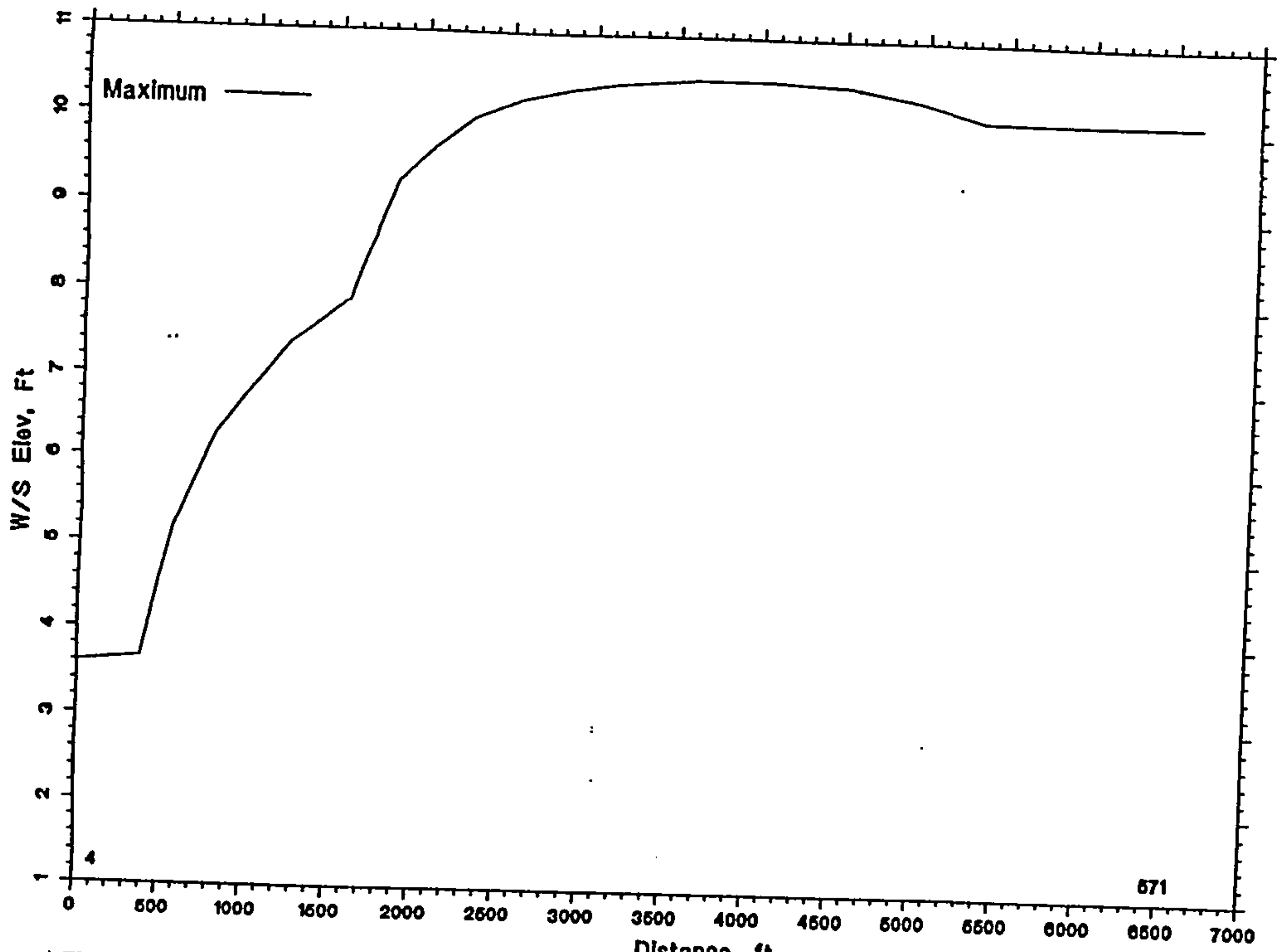
../rma2/nyv.res



Node	Length	H max
4	0.	3.26
413	380.	3.29
426	560.	4.66
440	812.	5.72
454	1236.	6.75
467	1576.	7.22
391	1842.	8.58
473	2058.	9.00
479	2292.	9.36
486	2568.	9.59
492	2848.	9.73
499	3128.	9.82
506	3544.	9.89
513	4008.	9.92
519	4508.	9.91
525	4948.	9.86
531	5334.	9.78
541	5504.	9.78
547	5814.	9.77
559	6224.	9.78
571	6644.	9.77

Figure 2
Profile of Maximum Water Surface Elevation Along the Levee for the New Years 1988 Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

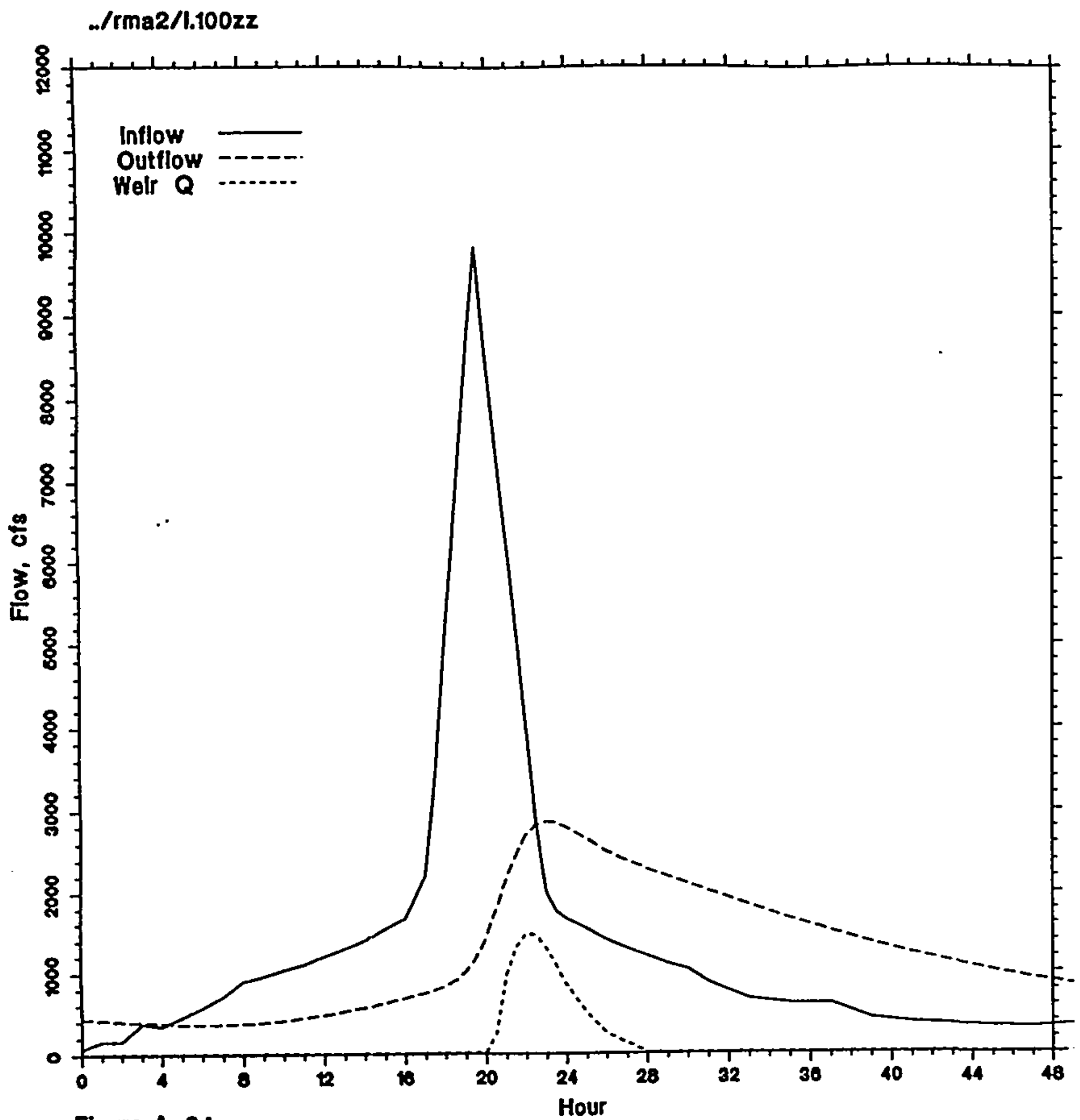
../rma2/spfv.res



node	Length	H max
4	0.	3.59
413	380.	3.65
426	560.	5.18
440	812.	6.30
454	1236.	7.40
467	1576.	7.89
391	1842.	9.25
473	2058.	9.65
479	2292.	10.00
486	2568.	10.22
492	2848.	10.33
499	3128.	10.41
506	3544.	10.48
513	4008.	10.49
519	4508.	10.45
525	4948.	10.30
531	5334.	10.09
541	5504.	10.10
547	5814.	10.10
559	6224.	10.10
571	6644.	10.10

Figure A-93

Profile of Maximum Water Surface Elevation Along the Levee for the Corp's Standard Project Storm, 9' Levee Weir Elevation and Partial Marsh Vegetation Removal

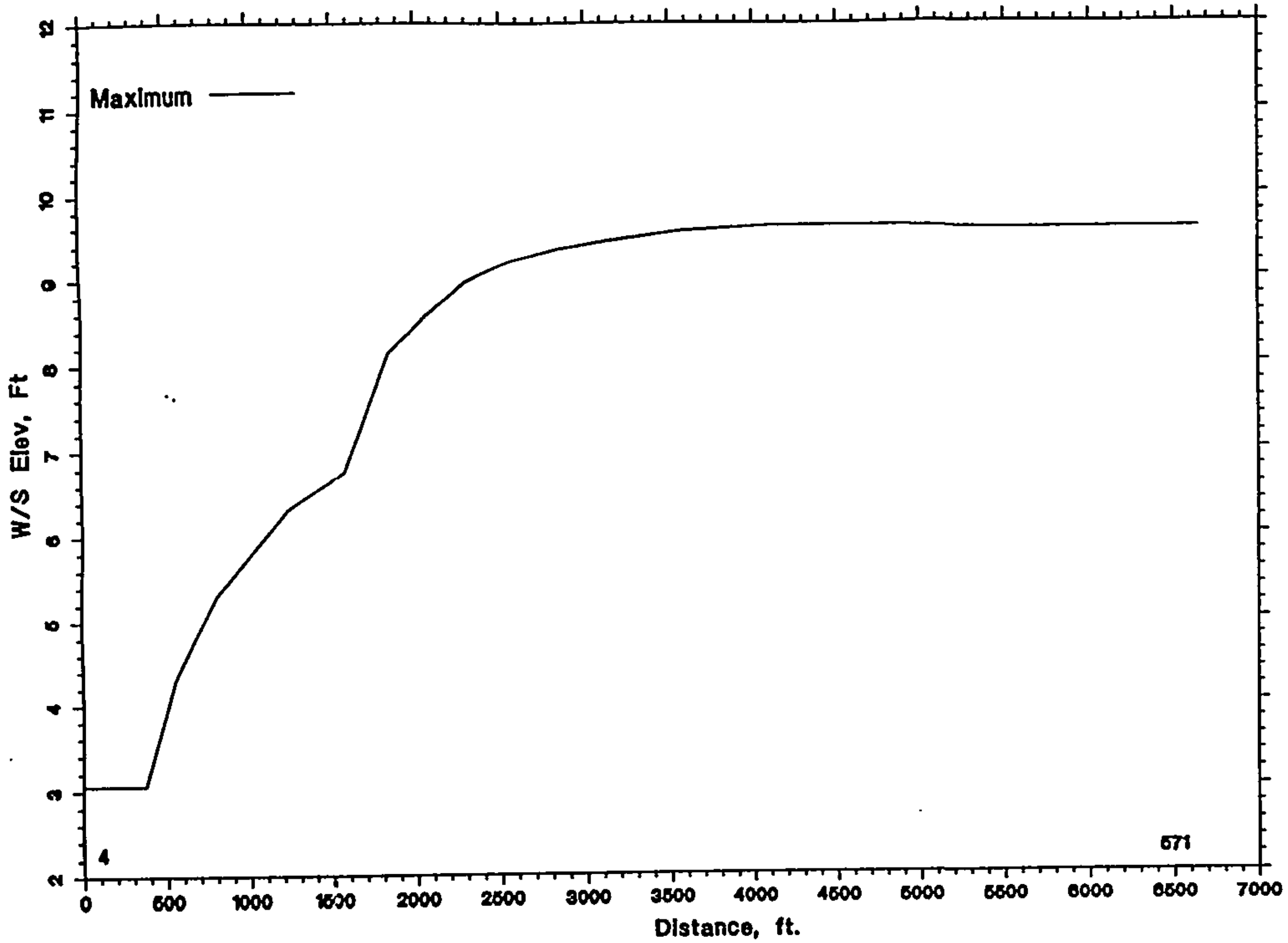


Time	Q in	Q out	Weir Q
15.0	1530.	617.	6.
16.0	1660.	676.	6.
17.0	2200.	744.	6.
17.5	3400.	785.	6.
18.0	5000.	835.	6.
18.5	6600.	902.	6.
19.0	8200.	1005.	7.
19.5	9800.	1171.	8.
20.0	8650.	1427.	8.
20.5	7500.	1775.	250.
21.0	6350.	2152.	956.
21.5	5200.	2469.	1315.
22.0	4050.	2687.	1475.
22.5	2850.	2813.	1448.
23.0	2000.	2858.	1293.
23.5	1760.	2841.	1070.
24.0	1660.	2785.	847.
25.0	1530.	2641.	491.
26.0	1401.	2505.	240.
27.0	1300.	2387.	115.
28.0	1200.	2283.	5.
29.0	1100.	2188.	5.

Figure A-94

Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 100 Year Design Storm with 9' Levee Weir Elevation, Partial Marsh Vegetation Removal and a Beginning Water Surface Elevation of 6.2 Feet

../rma2/d100zz.res

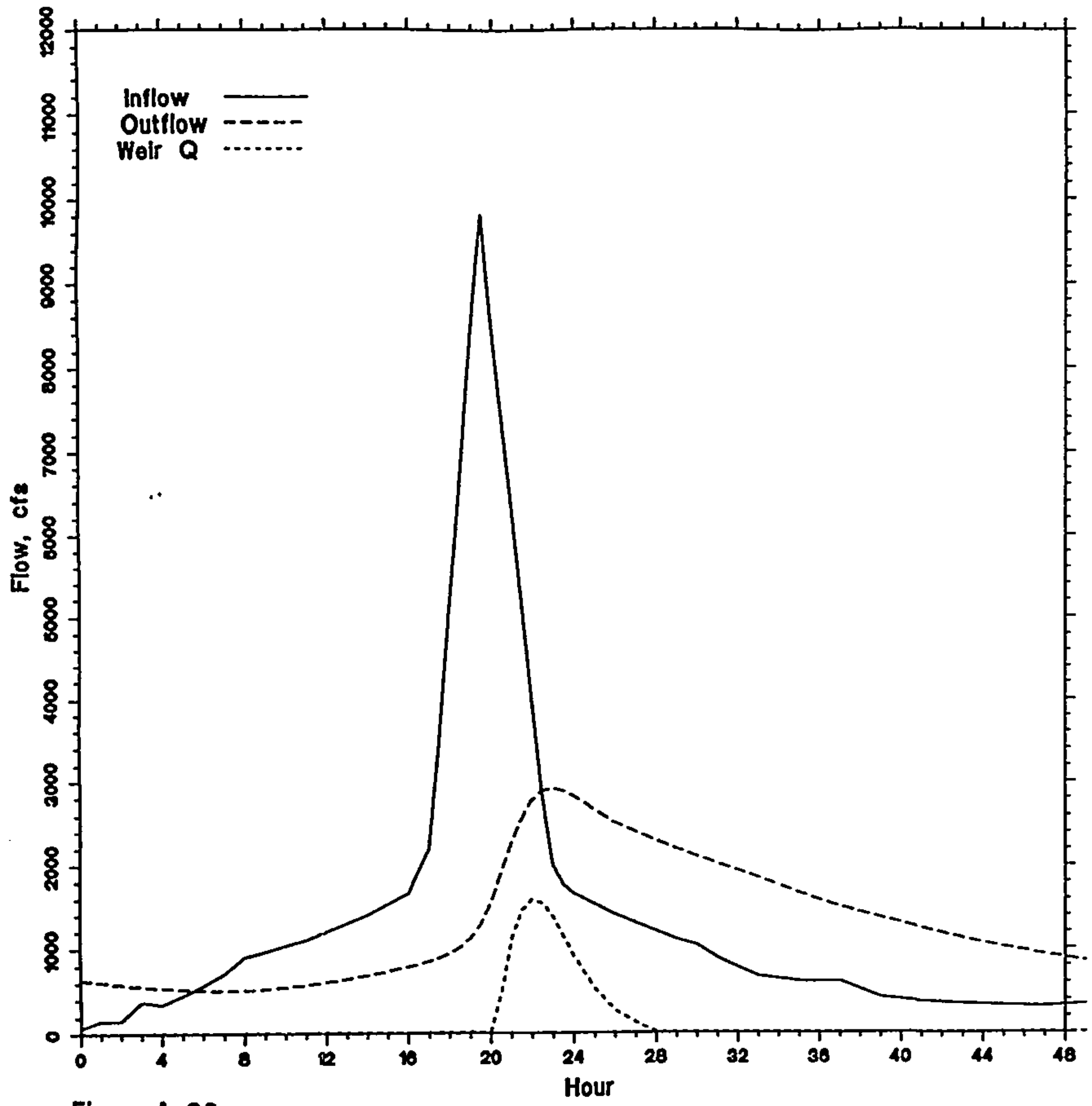


Node	Length	H max
4	0.	3.05
413	380.	3.06
426	560.	4.31
440	812.	5.30
454	1236.	6.31
467	1576.	6.76
391	1842.	8.14
473	2058.	8.56
479	2292.	8.94
486	2568.	9.19
492	2848.	9.34
499	3128.	9.44
506	3544.	9.54
513	4008.	9.59
519	4508.	9.60
525	4948.	9.60
531	5334.	9.58
541	5504.	9.58
547	5814.	9.58
559	6224.	9.58
571	6644.	9.58

Figure A-95

Profile of Maximum Water Surface Elevation Along the Levee for a 100 Year Design Storm with 9' Levee Weir Elevation, Partial Marsh Vegetation Removal and a Beginning Water Surface Elevation of 6.2 Feet

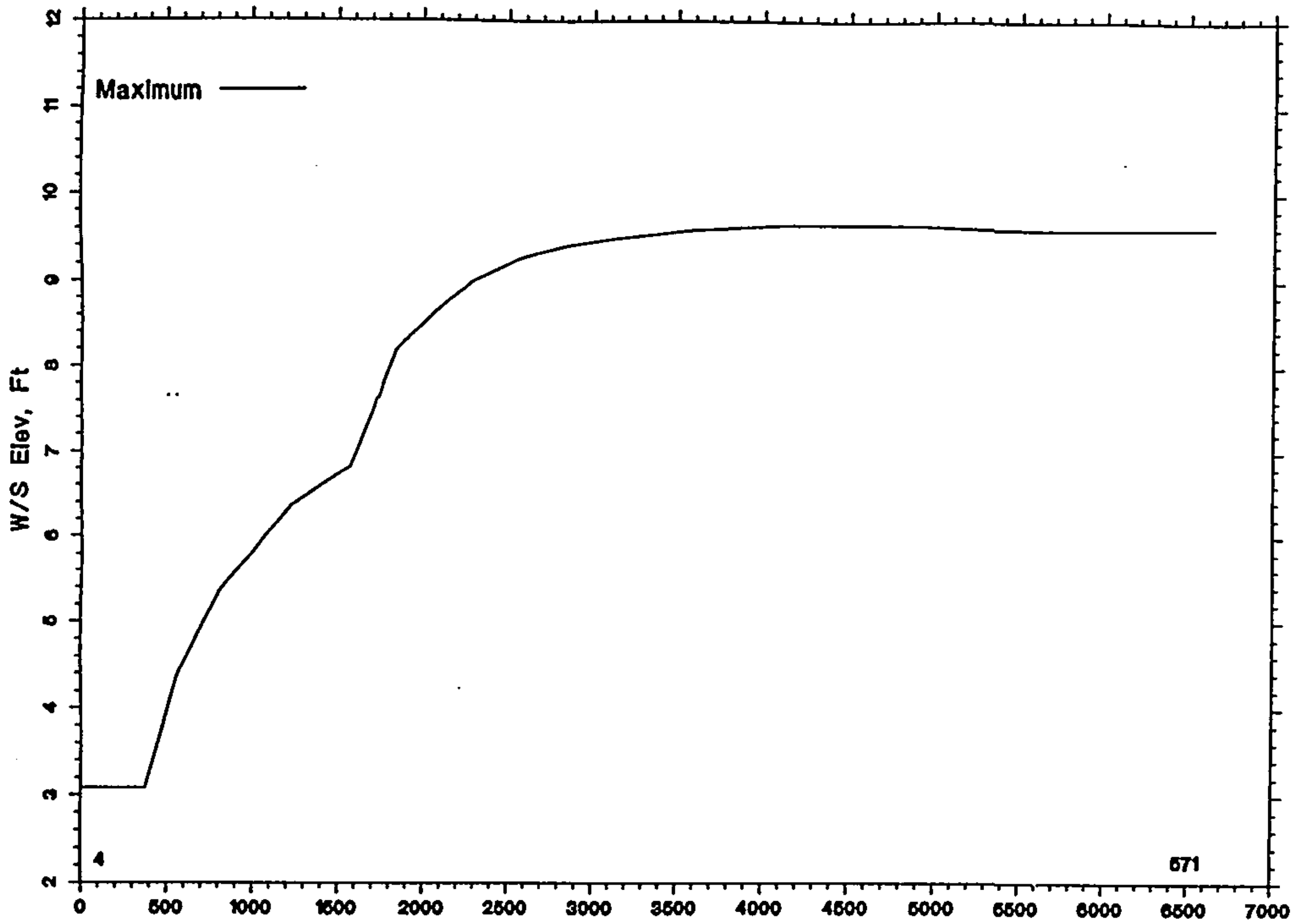
../rma2/l.100z



Time	Q in	Q out	Weir Q
15.0	1530.	729.	6.
16.0	1660.	782.	6.
17.0	2200.	845.	6.
17.5	3400.	885.	6.
18.0	5000.	934.	6.
18.5	6600.	1003.	6.
19.0	8200.	1112.	7.
19.5	9800.	1286.	8.
20.0	8650.	1551.	8.
20.5	7500.	1899.	463.
21.0	6350.	2262.	1112.
21.5	5200.	2560.	1449.
22.0	4050.	2760.	1582.
22.5	2850.	2872.	1537.
23.0	2000.	2906.	1367.
23.5	1760.	2879.	1132.
24.0	1660.	2816.	898.
25.0	1530.	2663.	525.
26.0	1401.	2520.	256.
27.0	1300.	2399.	123.
28.0	1200.	2293.	5.
29.0	1100.	2197.	5.

Figure A-96
Total Marsh Inflow, Outflow to the Oneawa Canal and Levee Overflow Rate for a 100 Year Design Storm with 9' Levee Weir Elevation, Partial Marsh Vegetation Removal and a Beginning Water Surface Elevation of 7.2 Feet

../rma2/d100z.res



Node	Length	H max
4	0.	3.08
413	380.	3.09
426	560.	4.35
440	812.	5.36
454	1236.	6.36
467	1576.	6.81
391	1842.	8.19
473	2058.	8.62
479	2292.	8.99
486	2568.	9.24
492	2848.	9.39
499	3128.	9.49
506	3544.	9.58
513	4008.	9.63
519	4508.	9.64
525	4948.	9.64
531	5334.	9.61
541	5504.	9.60
547	5814.	9.60
559	6224.	9.61
571	6644.	9.61

Figure A-97--

Profile of Maximum Water Surface Elevation Along the Levee for a 100 Year Design Storm with 9' Levee Weir Elevation, Partial Marsh Vegetation Removal and a Beginning Water Surface Elevation of 7.2 Feet

FIGURE A-98
COMPUTER SIMULATION RESULTS WITH PROPOSED PLAN

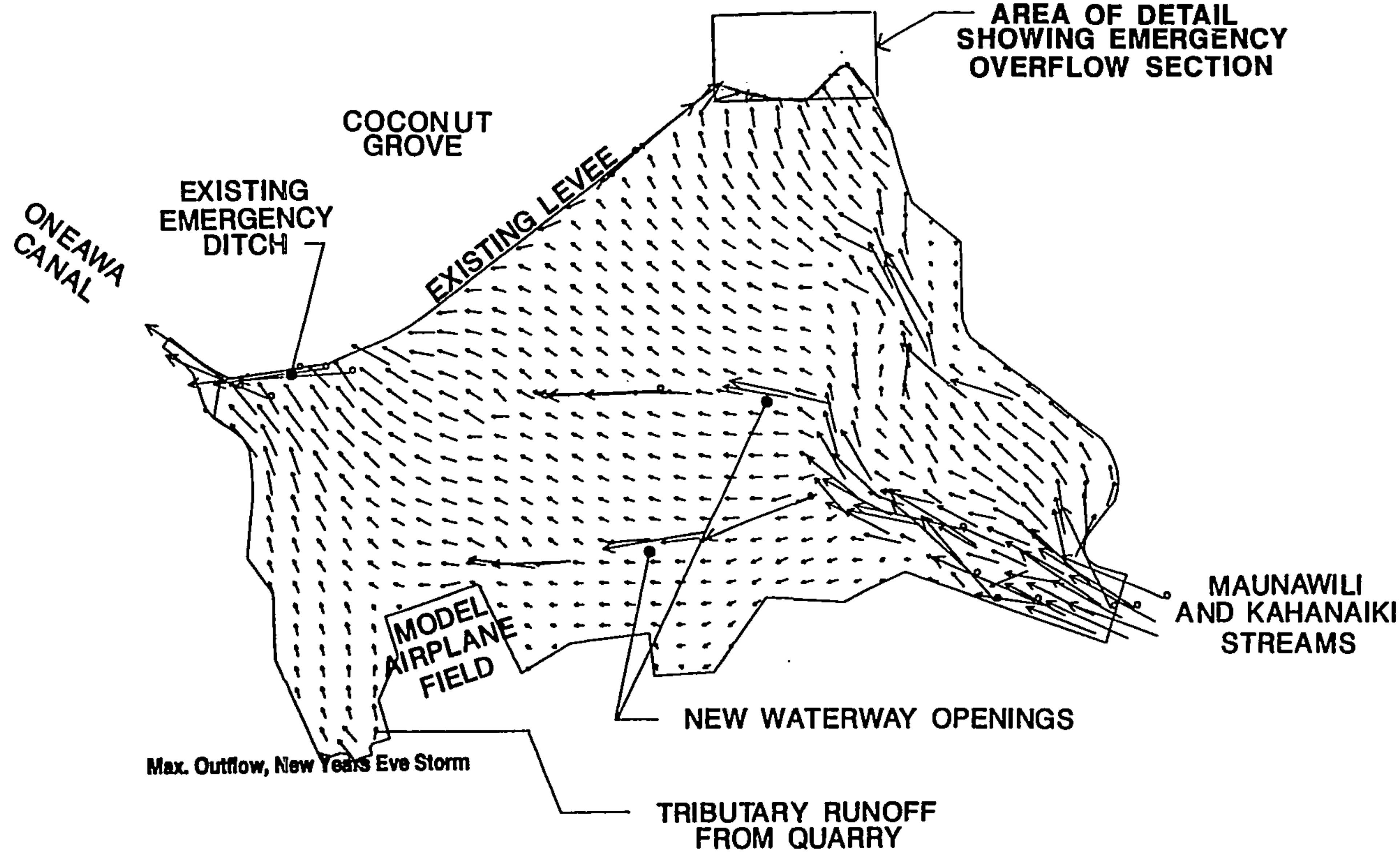
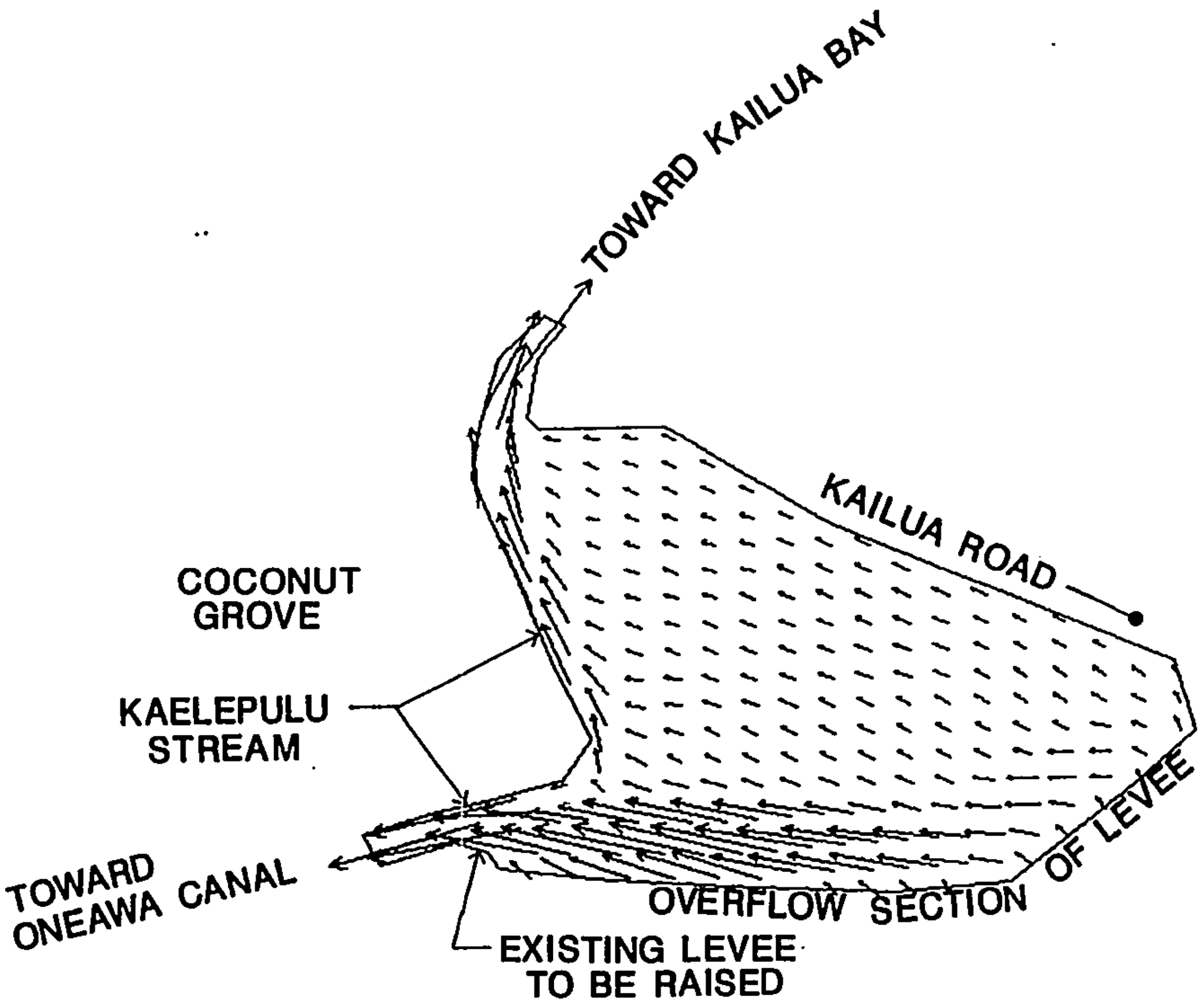
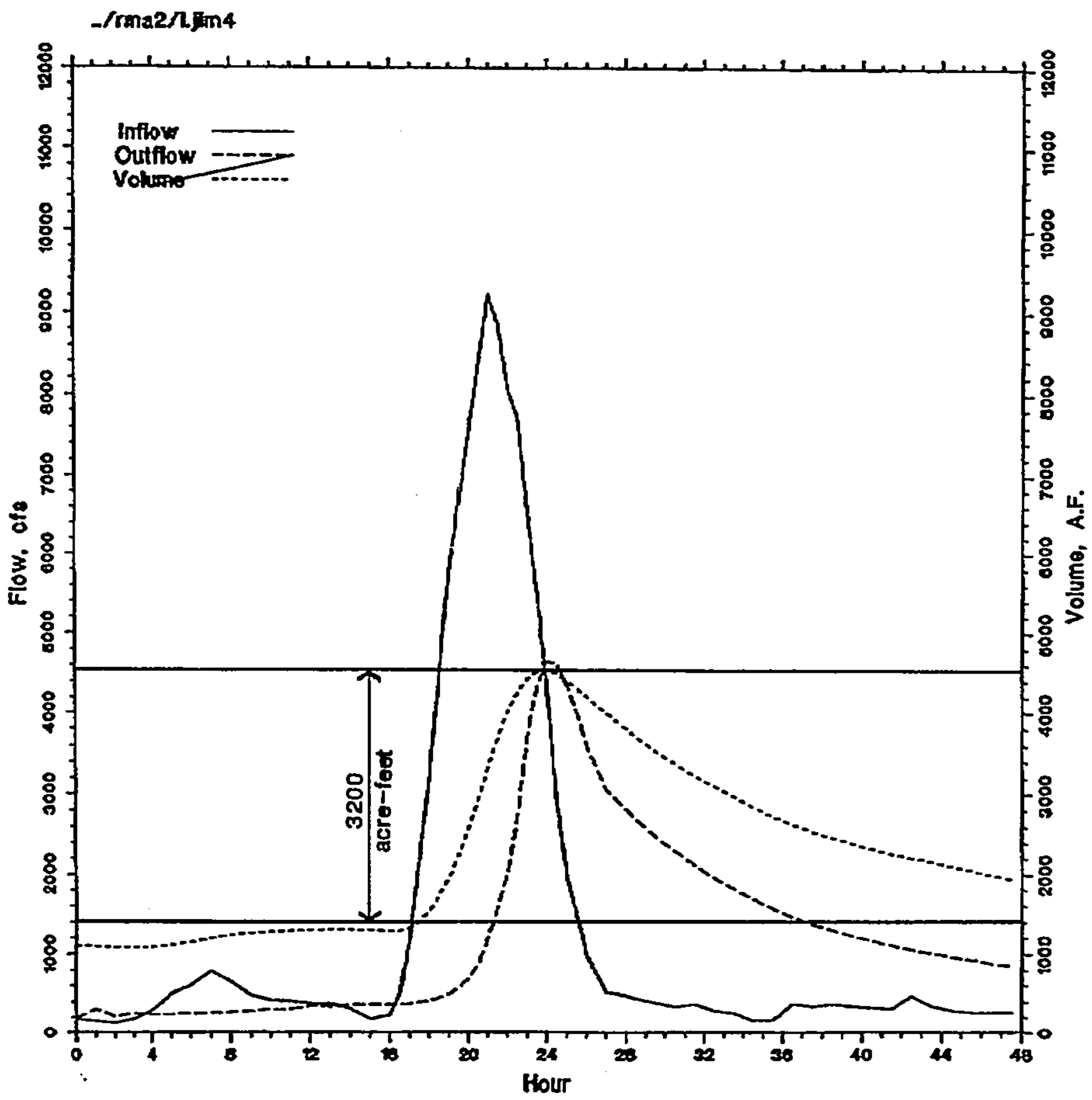


FIGURE A-99

DETAIL OF EMERGENCY OVERFLOW AREA





Time	Q in	Q out	Volume*
16.5	498.	358.	1297.
17.0	1191.	365.	1330.
17.5	2221.	383.	1413.
18.0	3163.	403.	1541.
18.5	4440.	434.	1728.
19.0	5733.	482.	1973.
19.5	6735.	549.	2265.
20.0	7534.	653.	2591.
20.5	8408.	820.	2953.
21.0	9219.	1071.	3343.
21.5	8865.	1398.	3710.
22.0	8093.	1810.	4027.
22.5	7710.	2788.	4291.
23.0	6520.	3725.	4462.
23.5	5491.	4347.	4554.
24.0	4323.	4655.	4573. ← Peak Storage
24.5	2897.	4649.	4523.
25.0	1973.	4412.	4433.
26.0	986.	3644.	4221.
27.0	517.	3046.	4010.
27.5	501.	2868.	3907.
28.5	440.	2650.	3734.
29.5	386.	2448.	3559.
30.5	330.	2261.	3406.
31.5	361.	2089.	3253.
32.5	275.	1937.	3128.
33.5	243.	1798.	2995.
34.5	149.	1669.	2871.
35.5	155.	1552.	2755.
36.5	370.	1451.	2659.
37.5	335.	1365.	2576.
38.5	365.	1288.	2497.
39.5	336.	1217.	2424.
40.5	316.	1153.	2354.
41.5	305.	1094.	2285.
42.5	465.	1044.	2236.
43.5	340.	1001.	2187.
44.5	275.	960.	2132.
45.5	259.	920.	2077.
46.5	248.	881.	2024.
47.5	257.	844.	1972.

* Rainfall not included in volume

Figure A-113 Total Inflow, Total Outflow and Storage Volume With a 10' Levee During the New Years Storm With Interior Channels

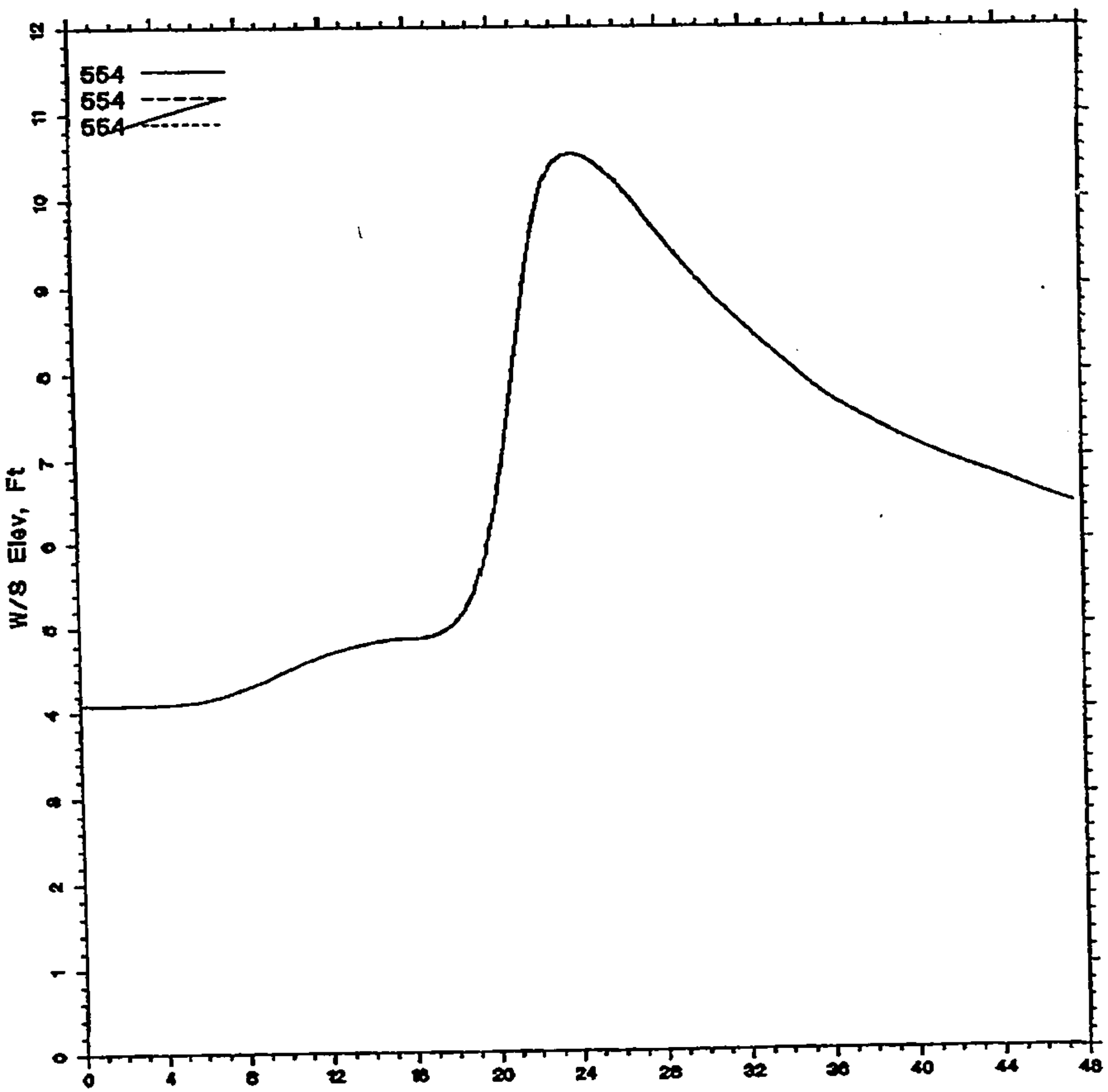


Figure A-112 Water Surface Elevation at Levee Station 7+00
During the New Years Storm With Interior Channels

Time	Stage
16.5	4.86
17.0	4.87
17.5	4.92
18.0	5.00
18.5	5.15
19.0	5.40
19.5	5.79
20.0	6.38
20.5	7.16
21.0	8.06
21.5	8.94
22.0	9.68
22.5	10.19
23.0	10.40
23.5	10.49
24.0	10.52← Peak Stage = 10.52 ft. msl
24.5	10.49
25.0	10.41
26.0	10.20
27.0	9.90
27.5	9.74
28.5	9.43
29.5	9.15
30.5	8.89
31.5	8.64
32.5	8.42
33.5	8.20
34.5	7.99
35.5	7.79
36.5	7.62
37.5	7.48
38.5	7.35
39.5	7.22
40.5	7.11
41.5	6.99
42.5	6.89
43.5	6.81
44.5	6.72
45.5	6.62
46.5	6.52
47.5	6.43

Note: Levee Elevations = 10 ft.

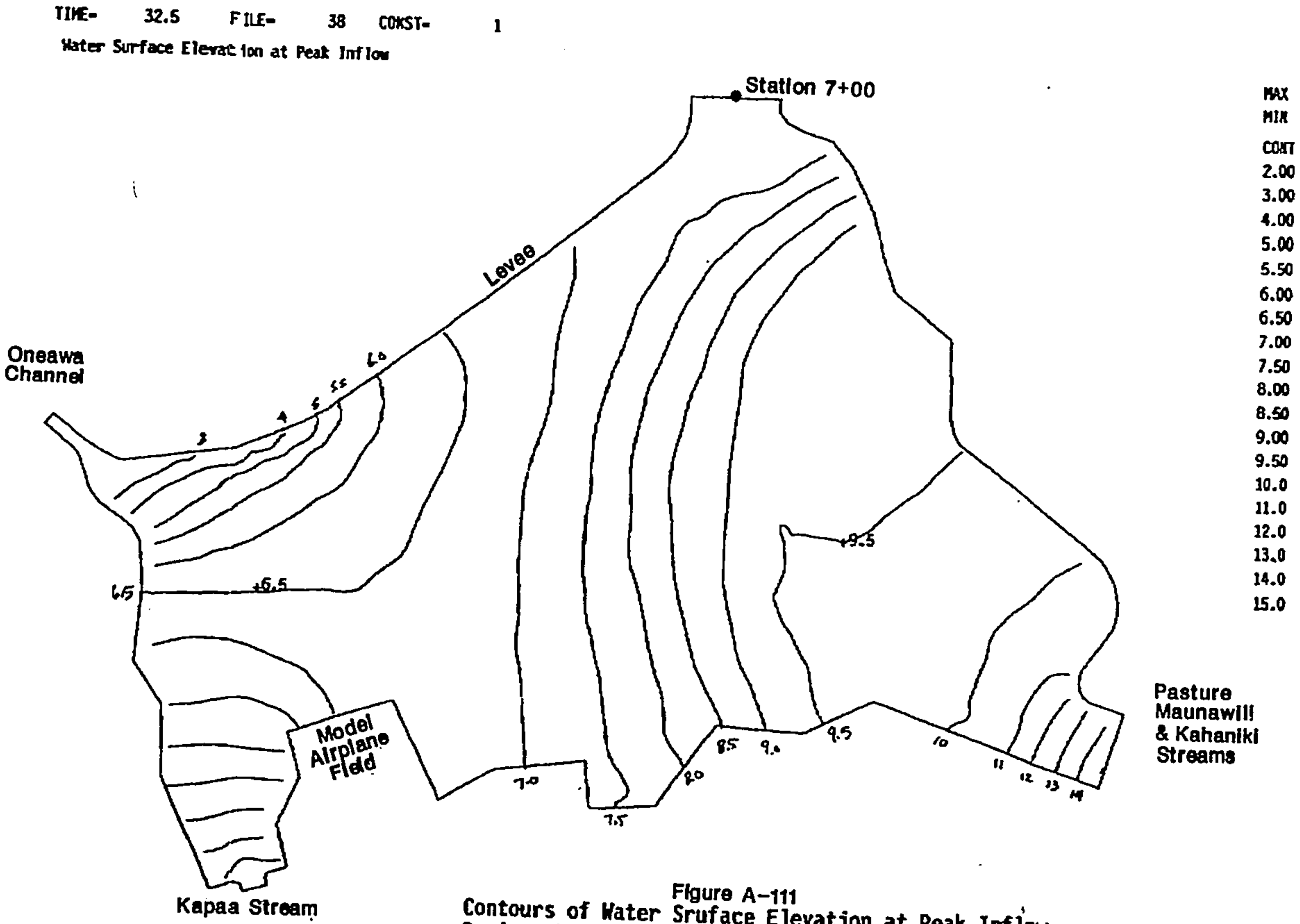
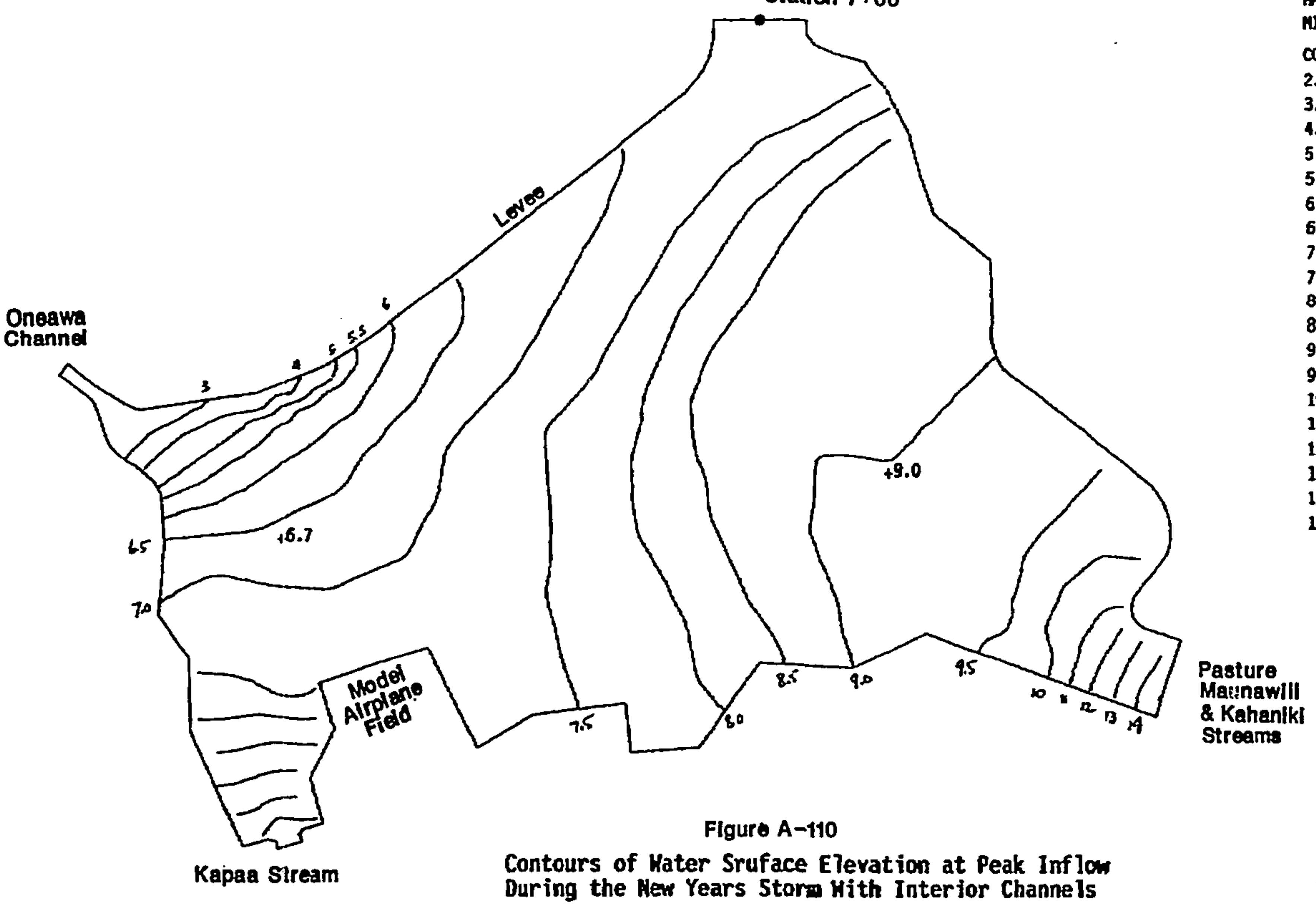


Figure A-111
Contours of Water Sruface Elevation at Peak Inflow
During the New Years Storm Without Interior Channels

TIME= 32.5 FILE= 38 CONST= 1

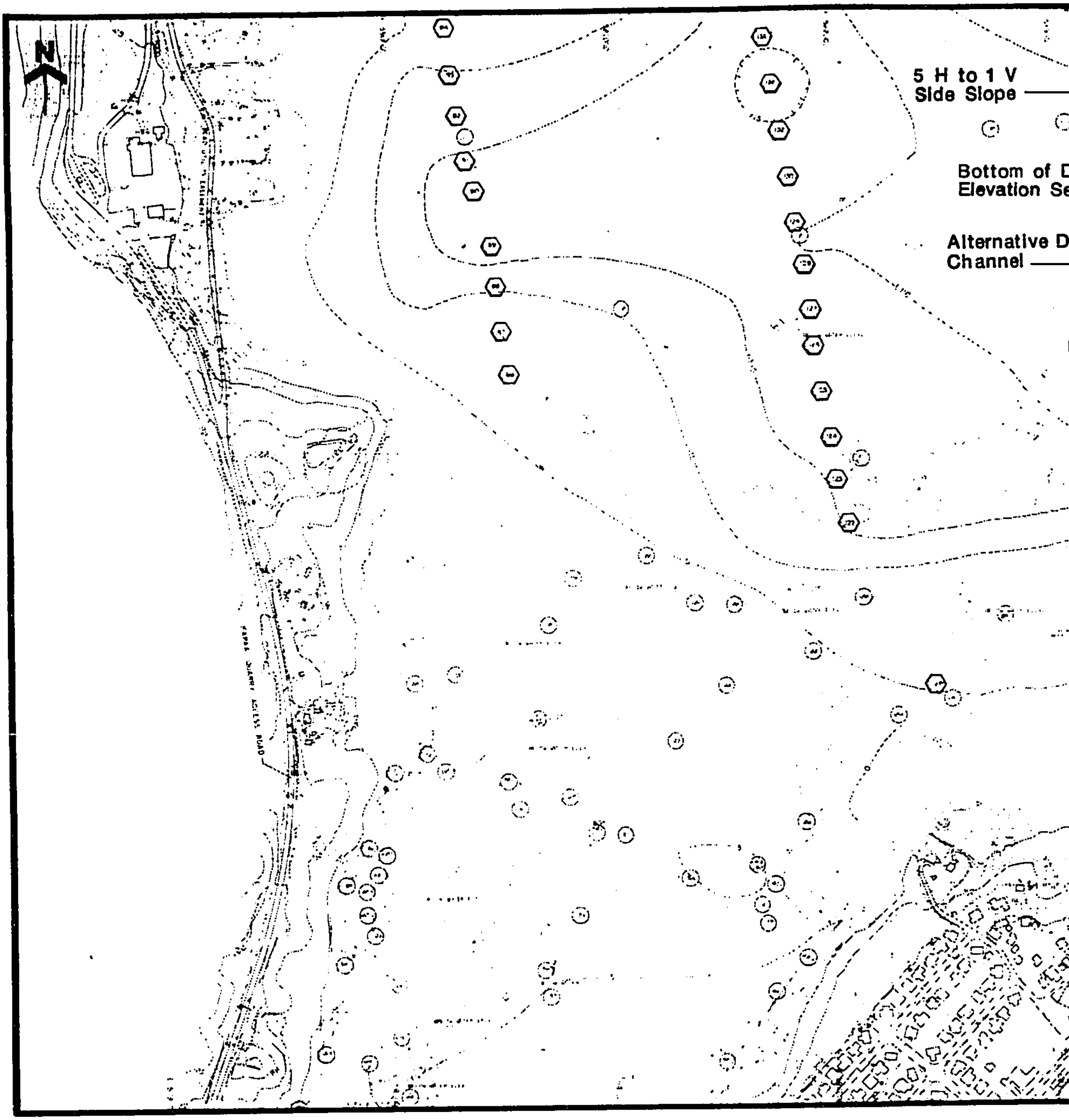
Water Surface Elevation at Peak Inflow

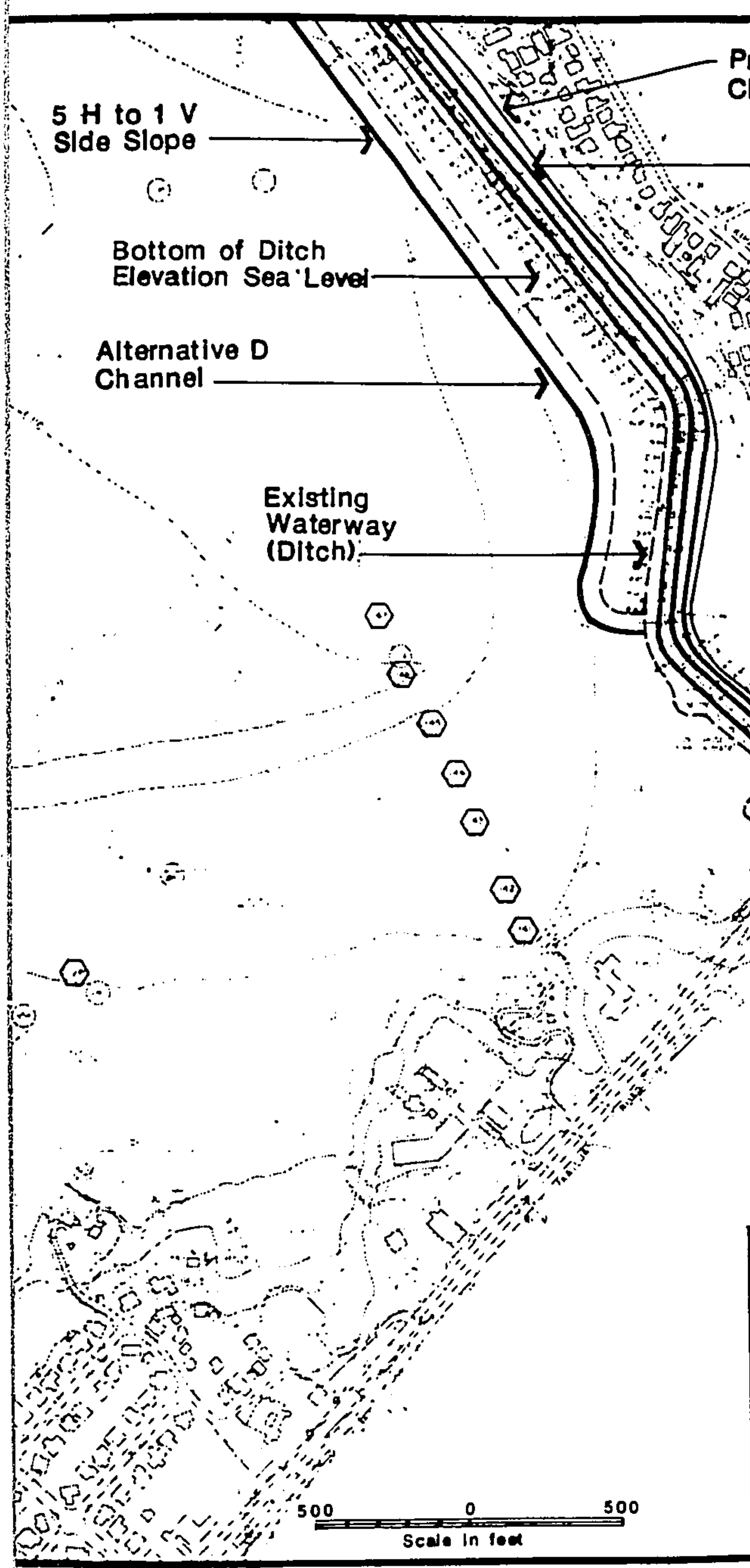


MAX
MIN
CONT
2.00
3.00
4.00
5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00
9.50
10.0
11.0
12.0
13.0
14.0
15.0

Figure A-110

Contours of Water Sruface Elevation at Peak Inflow During the New Years Storm With Interior Channels


N
5 H to 1 V
Side Slope
Bottom of D
Elevation Se
Alternative D
Channel



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ALTERNATIVE D CHANNELIZATION LEVEE RAISE
Figure A-109 Sheet B
Kawainui Marsh M & E Pacific, Inc.

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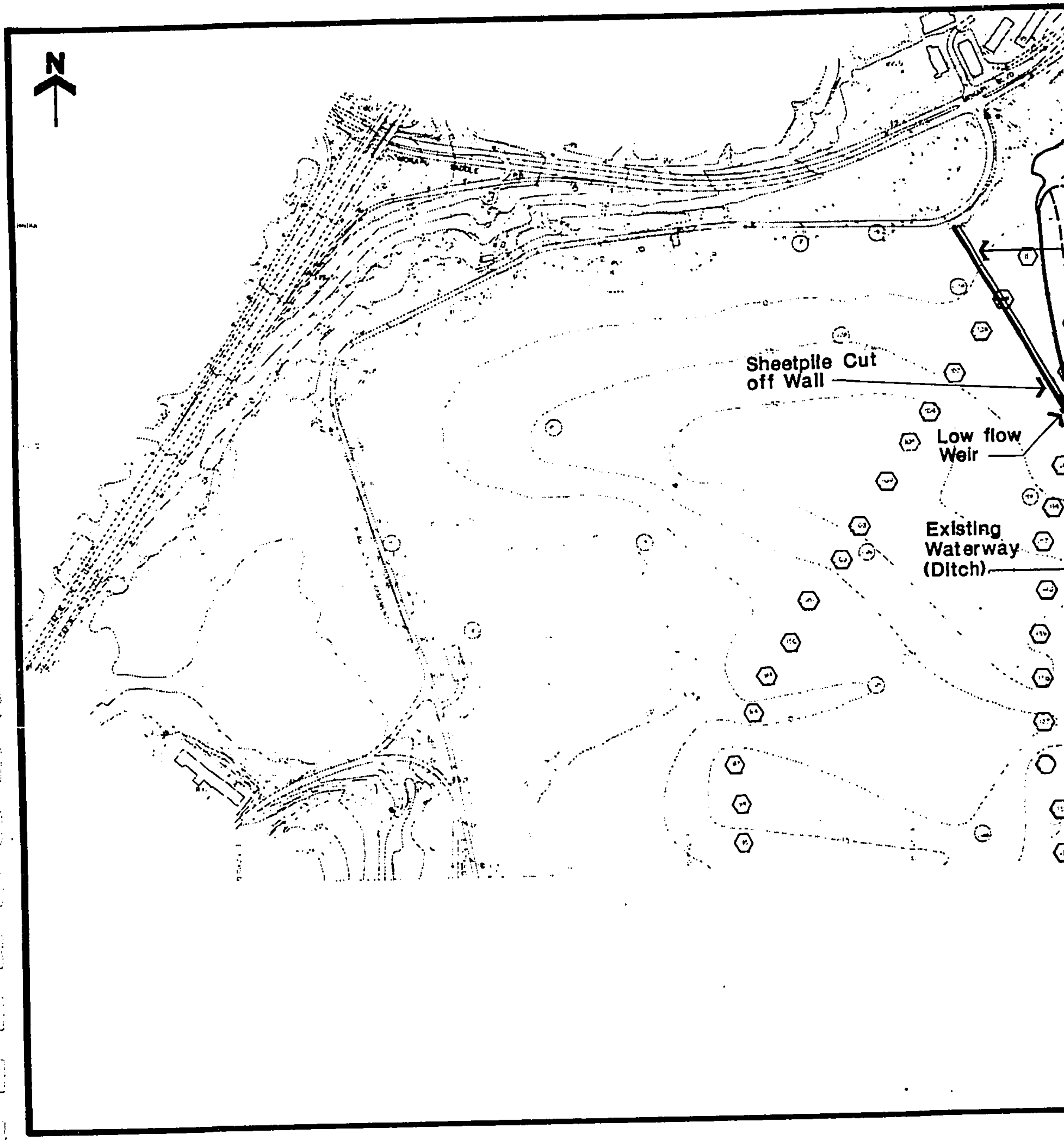
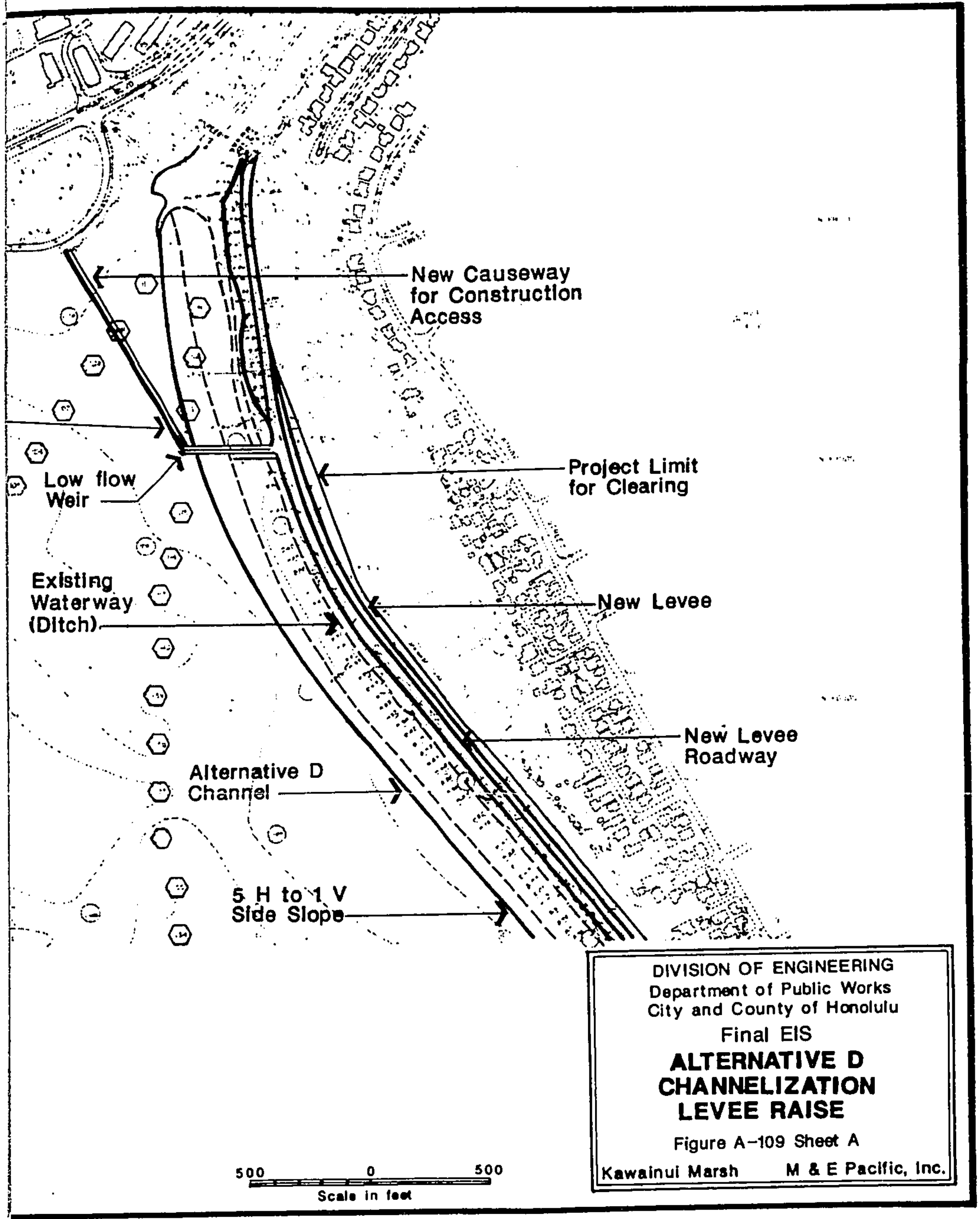


DOCUMENT CAPTURED AS RECEIVED



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ALTERNATIVE D CHANNELIZATION LEVEE RAISE
Figure A-109 Sheet A
Kawainui Marsh M & E Pacific, Inc.

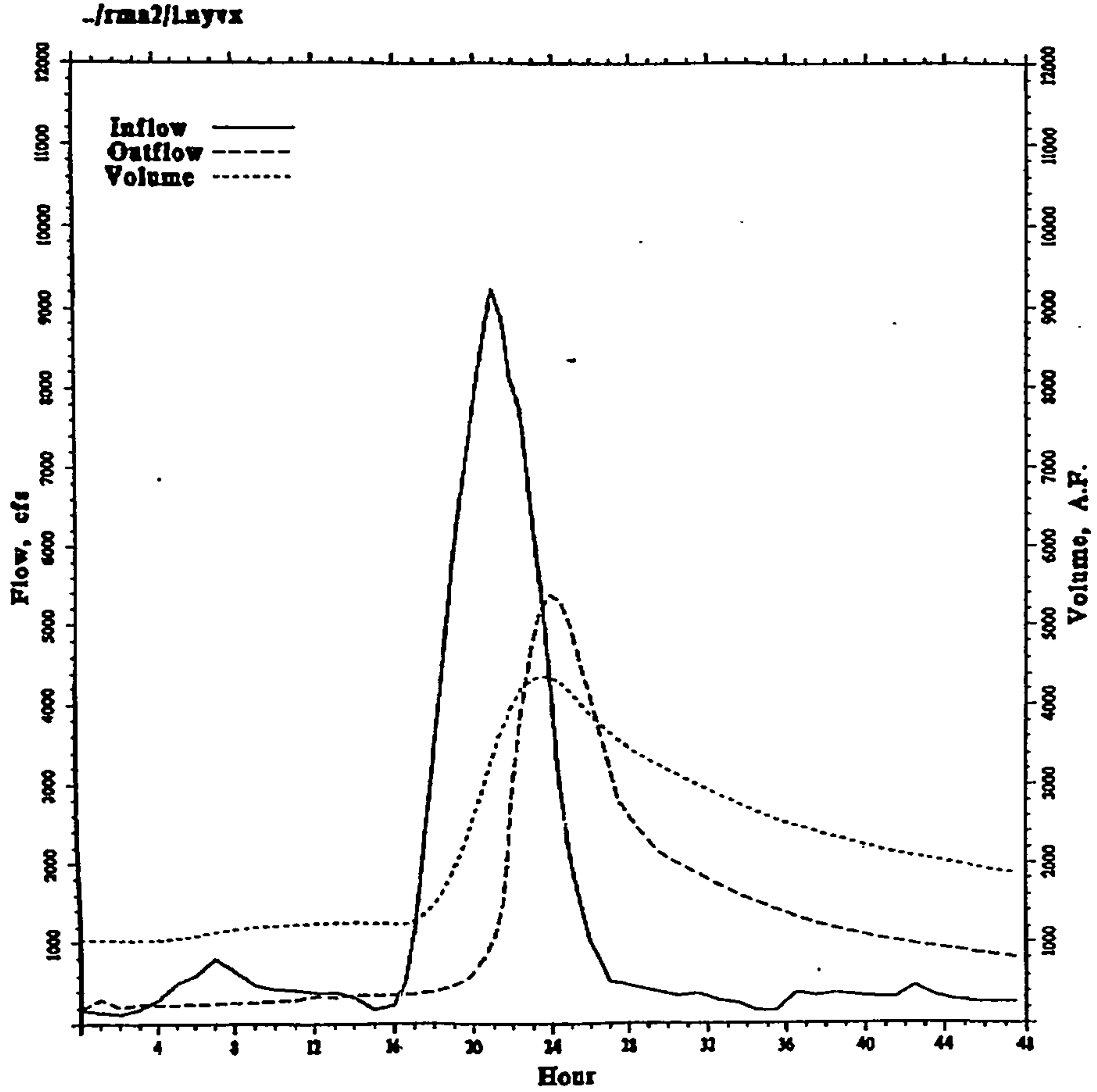


Figure A-107/1 New Years Storm, No Vegetation Removal

Time	Q in	Q out	Volum
17.5	2221.	376.	134
18.0	3163.	396.	147
18.5	4440.	427.	166
19.0	5733.	472.	190
19.5	6735.	534.	220
20.0	7534.	629.	252
20.5	8408.	783.	289
21.0	9219.	1018.	328
21.5	8665.	1479.	364
22.0	8093.	2811.	393
22.5	7710.	3856.	415
23.0	6520.	4644.	429
23.5	5491.	5151.	434
24.0	4323.	5356.	433
24.5	2897.	5281.	426
25.0	1973.	5005.	414
26.0	986.	4163.	388
27.0	517.	3282.	364
27.5	500.	2780.	355
28.5	440.	2418.	338
29.5	385.	2137.	324
30.5	330.	1983.	310
31.5	360.	1842.	298
32.5	275.	1717.	286
33.5	242.	1603.	275
34.5	147.	1496.	264
35.5	155.	1398.	253
36.5	370.	1312.	245
37.5	335.	1239.	238
38.5	365.	1174.	231
39.5	336.	1114.	224
40.5	316.	1059.	218
41.5	307.	1008.	212
42.5	465.	965.	208
43.5	340.	928.	203
44.5	275.	893.	199
45.5	259.	858.	194
46.5	248.	824.	189
47.5	257.	792.	184

* Rain not included in volume

Figure A-108.
Water Surface Profile
Alternative D2

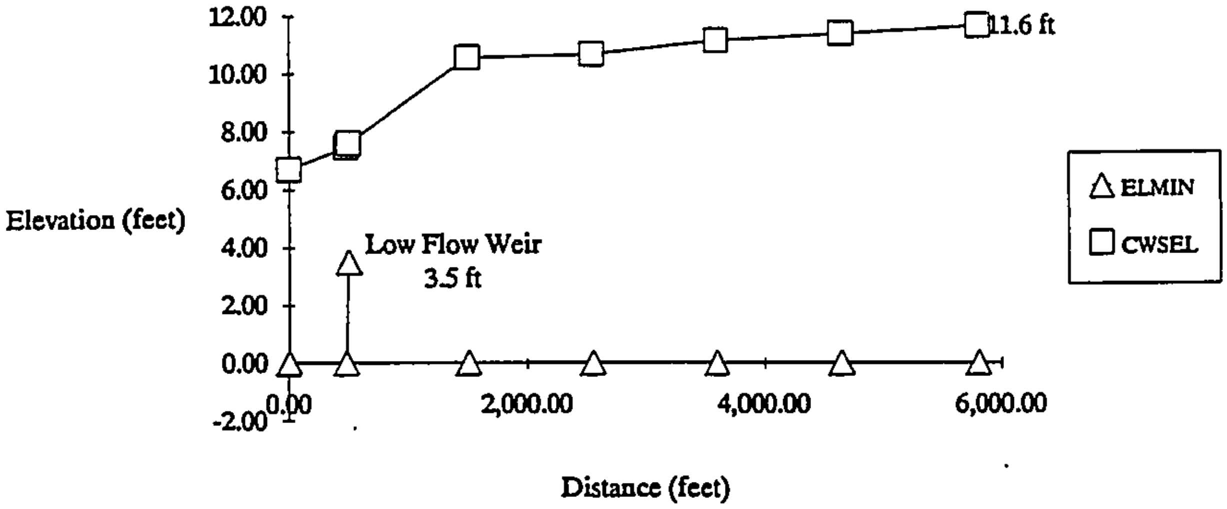
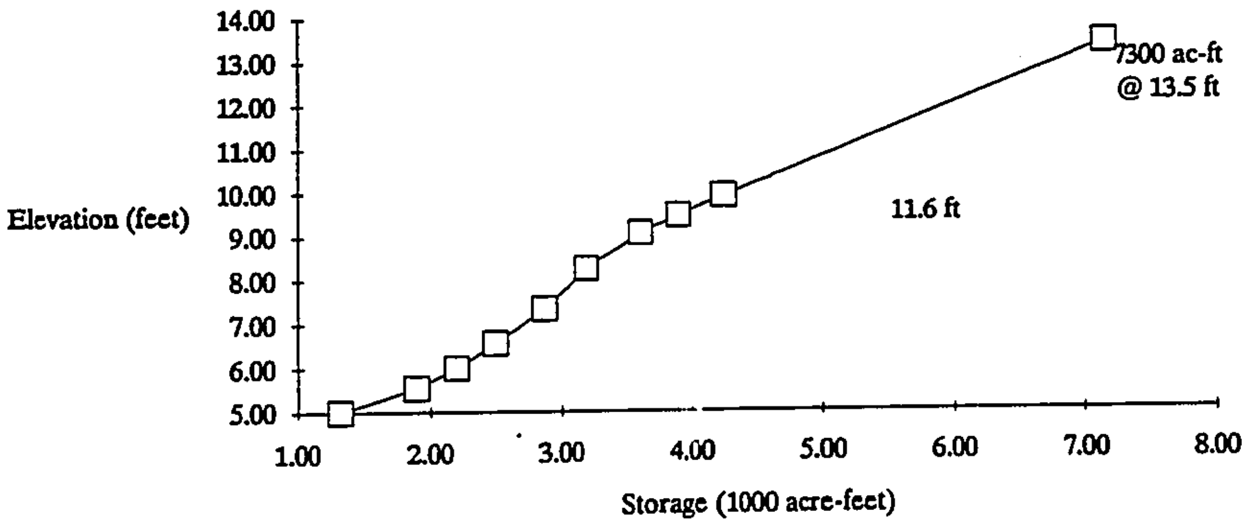
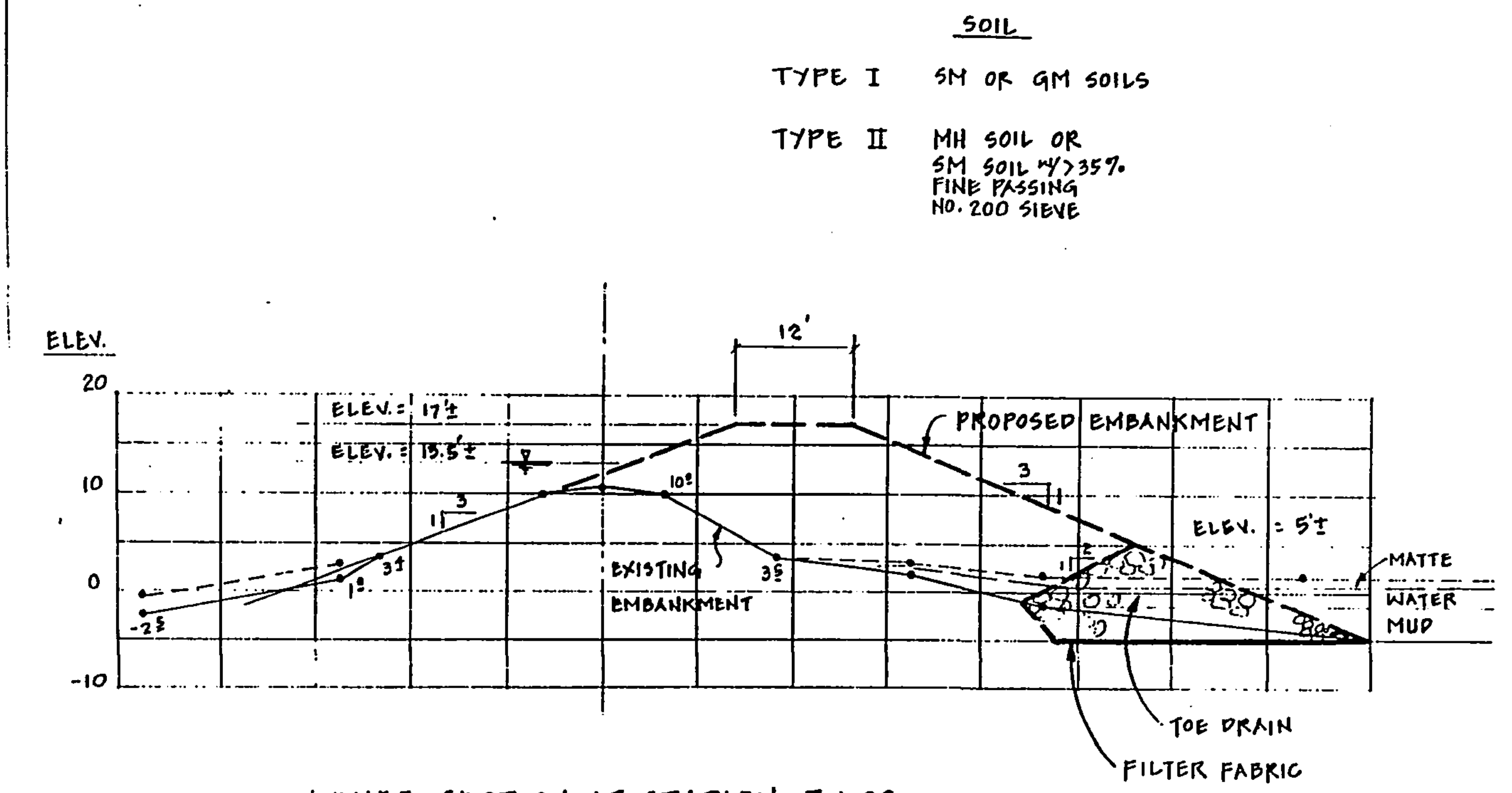


Figure A-108/1
Storage in Marsh at Indicated Elevation
At Levee Station 7+00





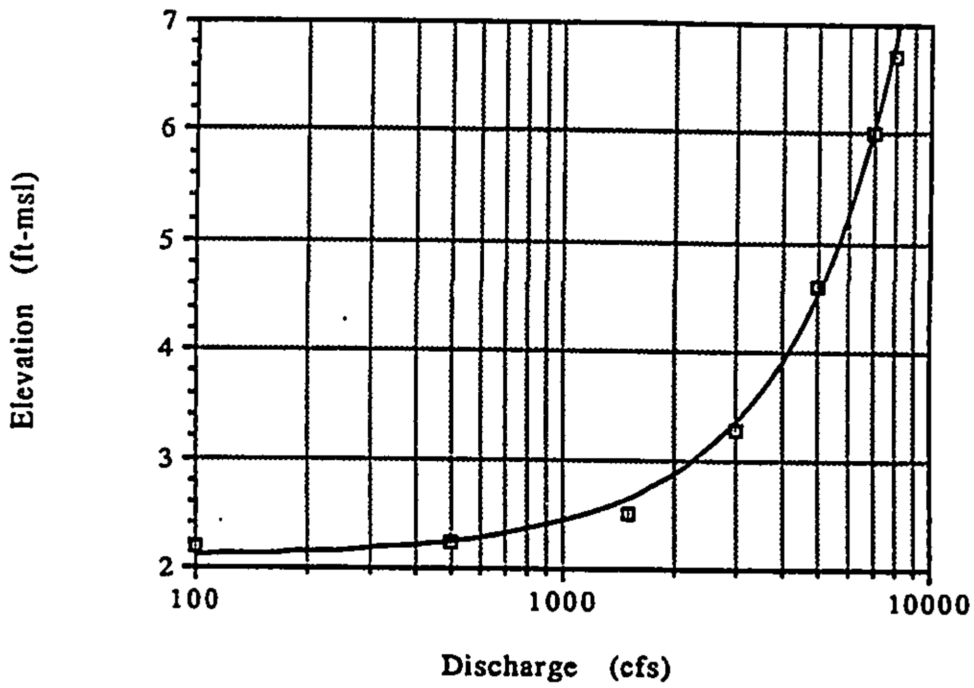
LEVEE SECTION AT STATION 7+00

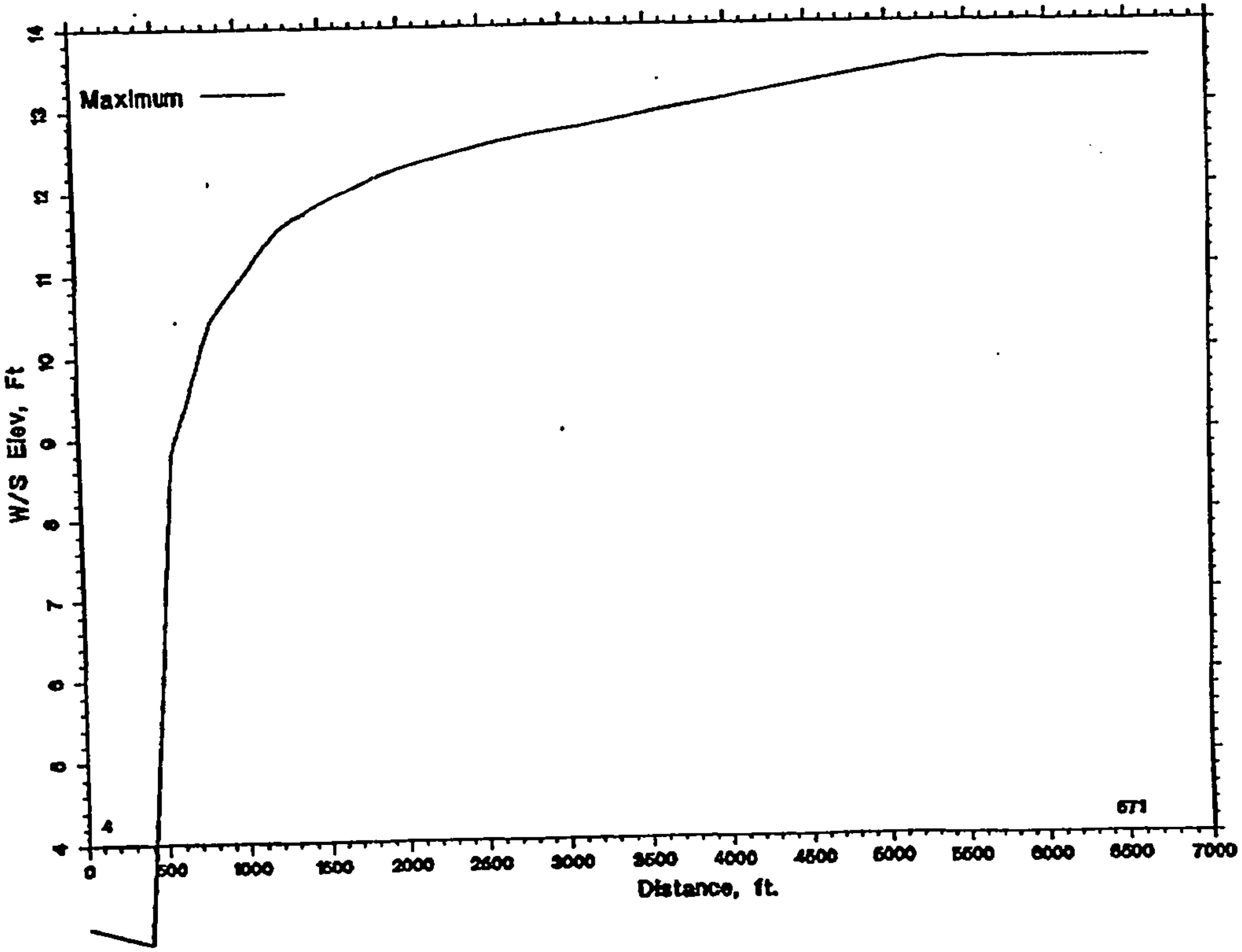
SCALE : 1" = 15'

FIGURE A-106 TYPICAL SECTION @ STA. 7+00
KAWAINUI MARSH LEVEE IMPROVEMENT
KAILUA, OAHU, HAWAII

HAWAII GEOTECHNICAL GROUP, INC. dba
WALTER LUM ASSOCIATES, INC.
SOILS & FOUNDATION ENGINEERS

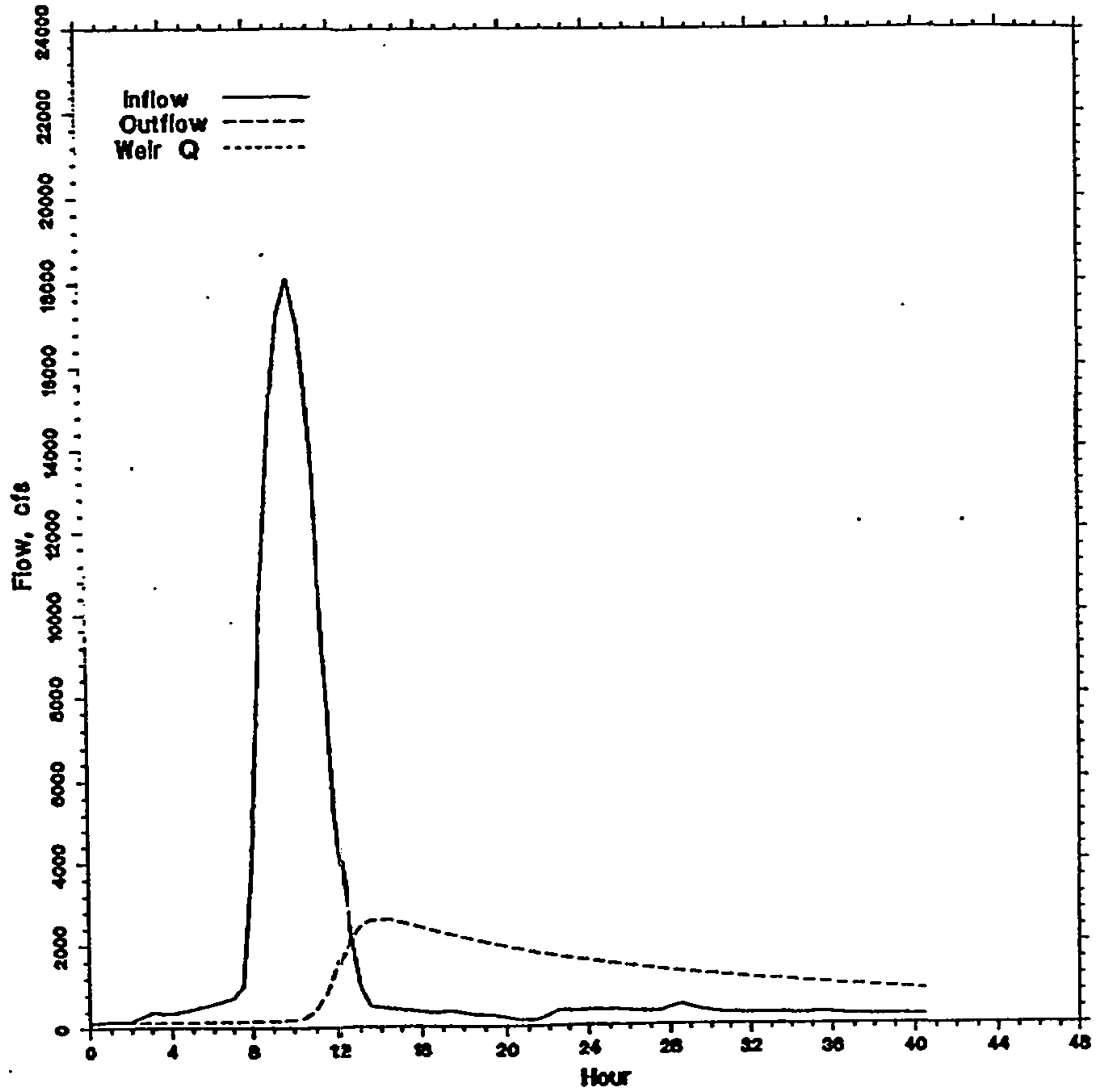
Figure A-107
Oneawa Canal Rating Curve
Station 93+00





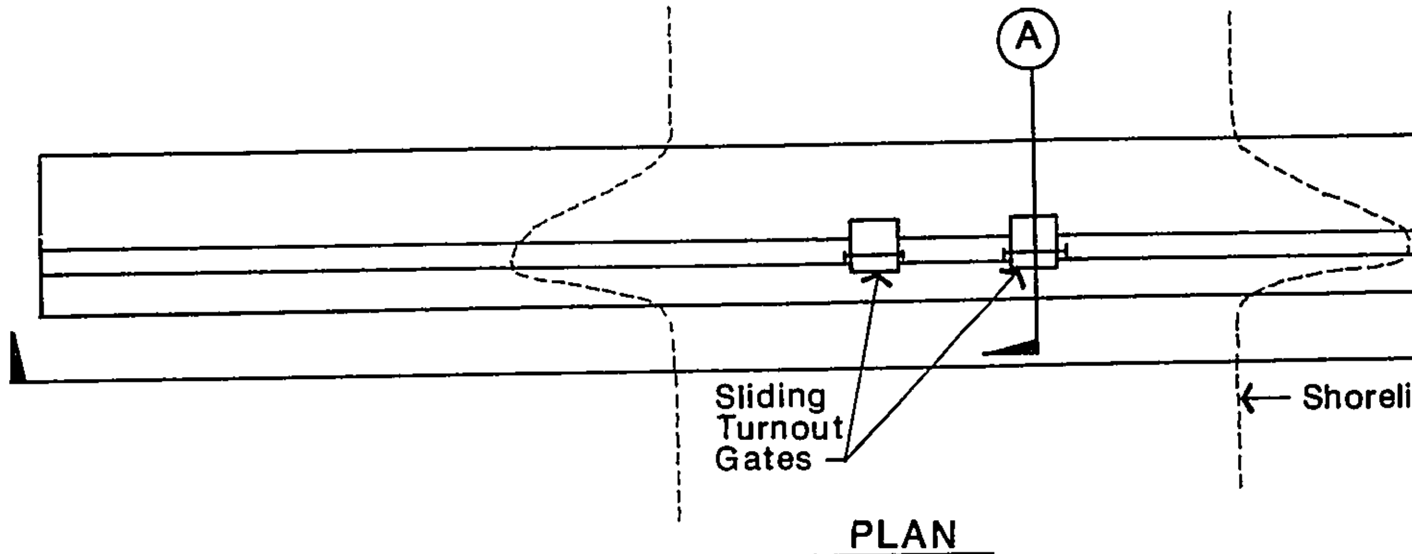
Node	Length	H max
4	0.	2.98
413	380.	2.78
426	560.	6.78
440	812.	10.43
454	1236.	11.54
467	1576.	11.93
391	1842.	12.16
473	2058.	12.30
479	2292.	12.42
486	2568.	12.55
492	2848.	12.66
499	3128.	12.75
506	3544.	12.92
513	4008.	13.07
519	4508.	13.26
525	4948.	13.41
531	5334.	13.52
541	5504.	13.53
547	5814.	13.53
559	6224.	13.54
571	6644.	13.54

Figure A-105 Profile Along Levee, Corp's Standard Project Flood, 10' weir, No Vegetation Removal

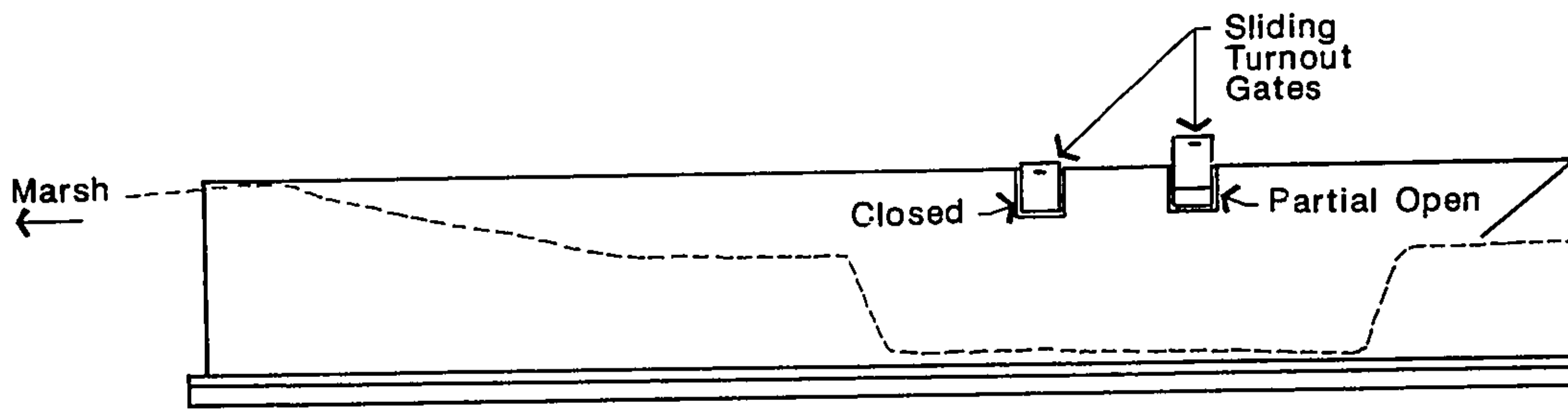


Time	Q in	Q out
7.5	1000.	141.
8.0	3880.	144.
8.5	10000.	147.
9.0	14400.	151.
9.5	17200.	158.
10.0	18100.	178.
10.5	16900.	240.
11.0	13800.	417.
11.5	8600.	832.
12.0	4900.	1489.
12.5	2300.	2081.
13.0	1000.	2420.
13.5	500.	2576.
14.5	440.	2588.
15.5	385.	2465.
16.5	330.	2328.
17.5	360.	2198.
18.5	275.	2079.
19.5	242.	1967.
20.5	147.	1860.
21.5	156.	1760.
22.5	371.	1672.
23.5	337.	1595.
24.5	365.	1523.
25.5	336.	1454.
26.5	317.	1392.
27.5	306.	1334.
28.5	465.	1284.
29.5	340.	1239.
30.5	275.	1194.
31.5	260.	1150.
32.5	248.	1107.
33.5	257.	1066.
34.5	237.	1026.
35.5	260.	990.
36.5	229.	955.
37.5	223.	923.
38.5	218.	892.

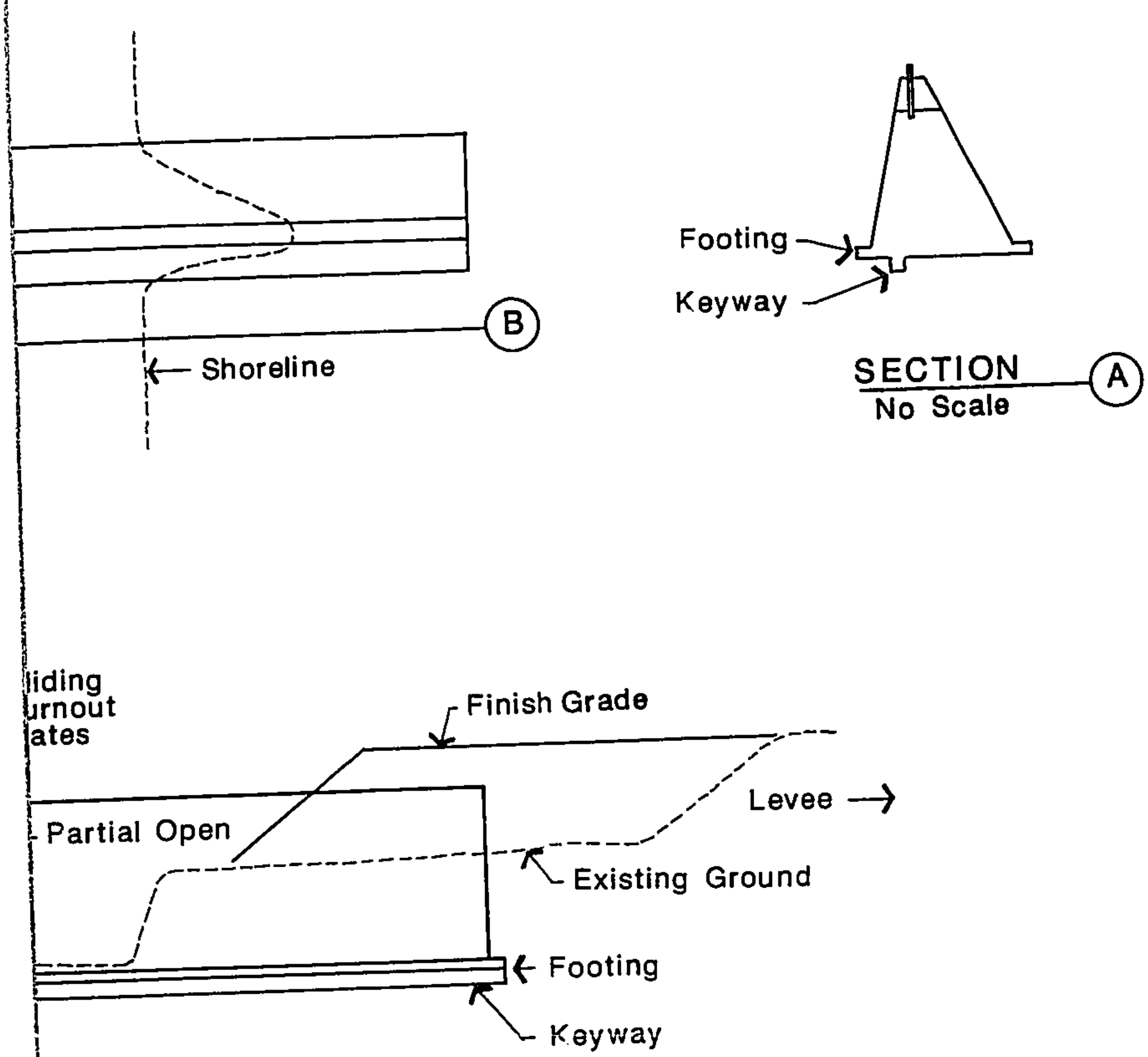
Figure A-104 Corp's Standard Project. No Levee Modification or Overtopping



PLAN
No Scale



ELEVATION (B)
No Scale



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KAWAINUI DITCH WEIR

Figure A-103

Kawainui Marsh M & E Pacific, Inc.

Figure A-102/1
Kaelepulu Stream Elevations
(Left Bank is Kawainui Marsh Side)

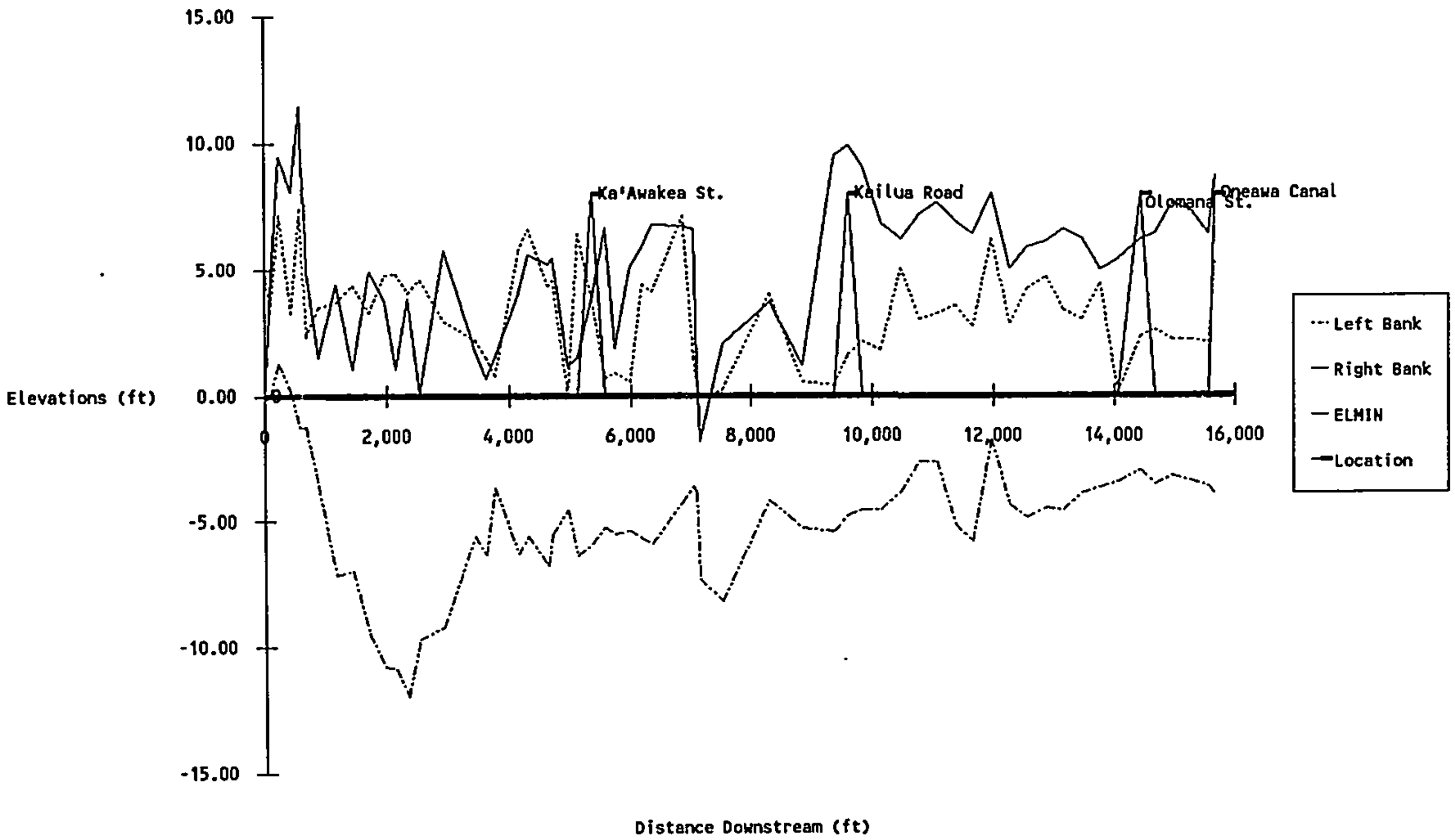
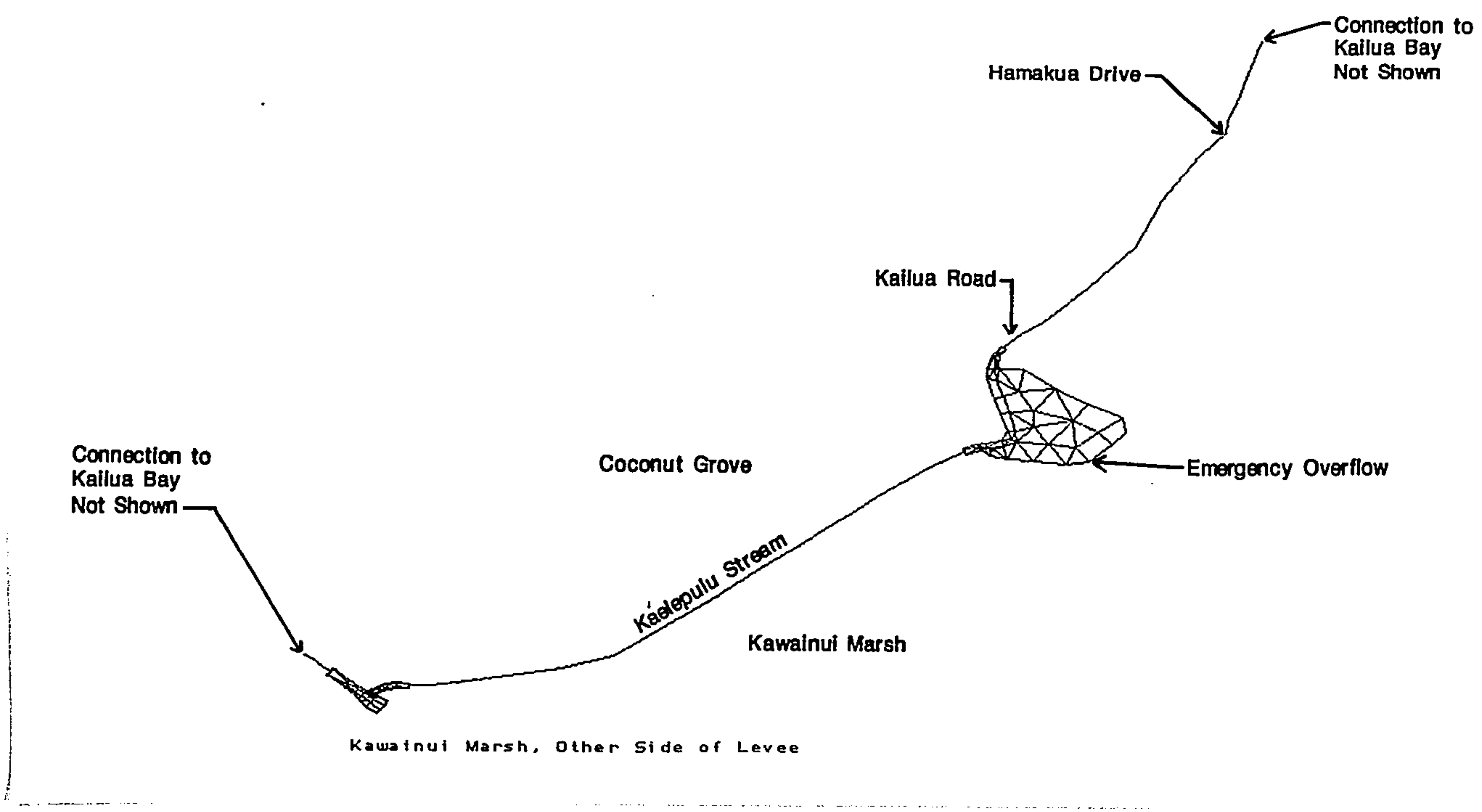
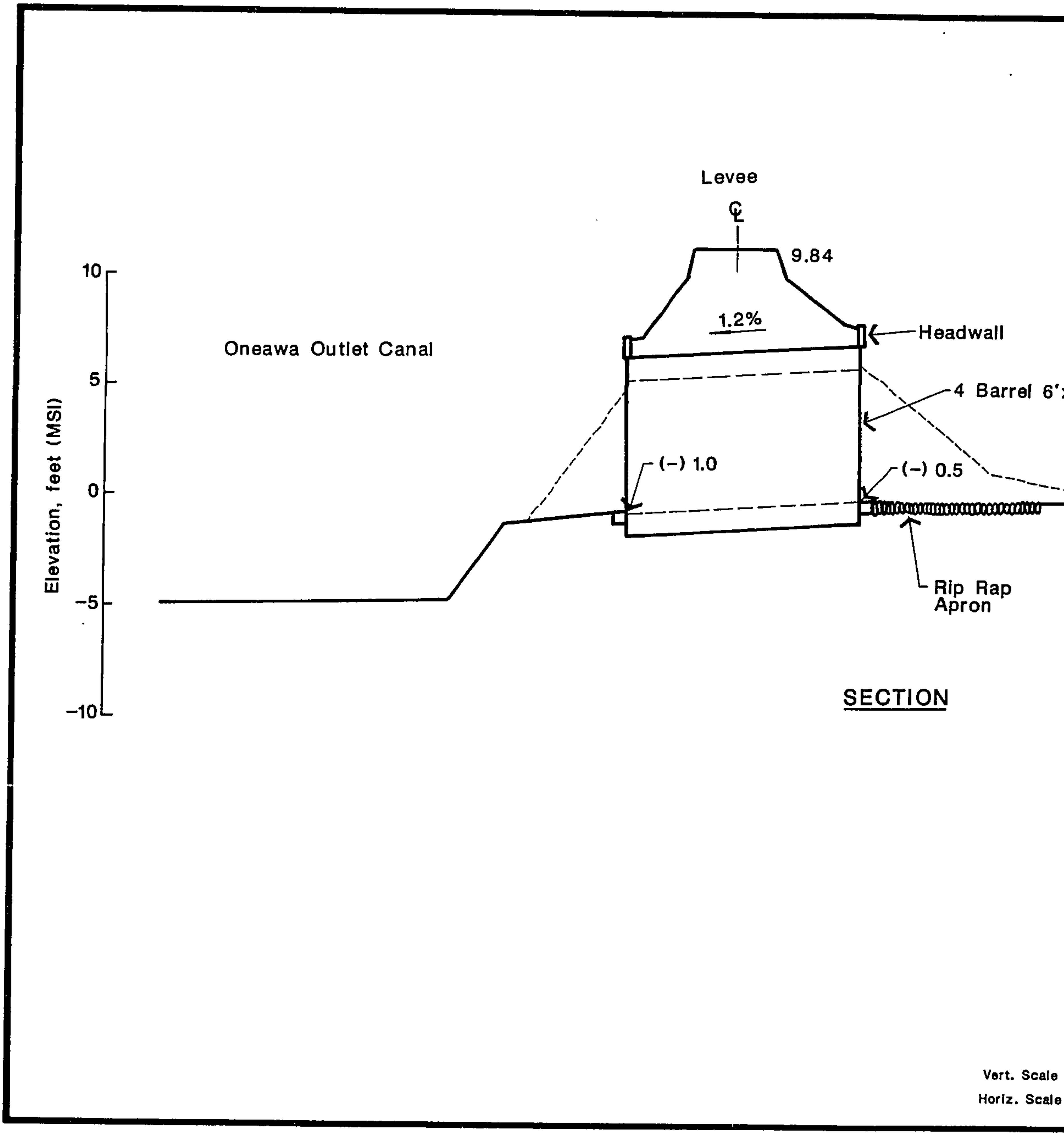
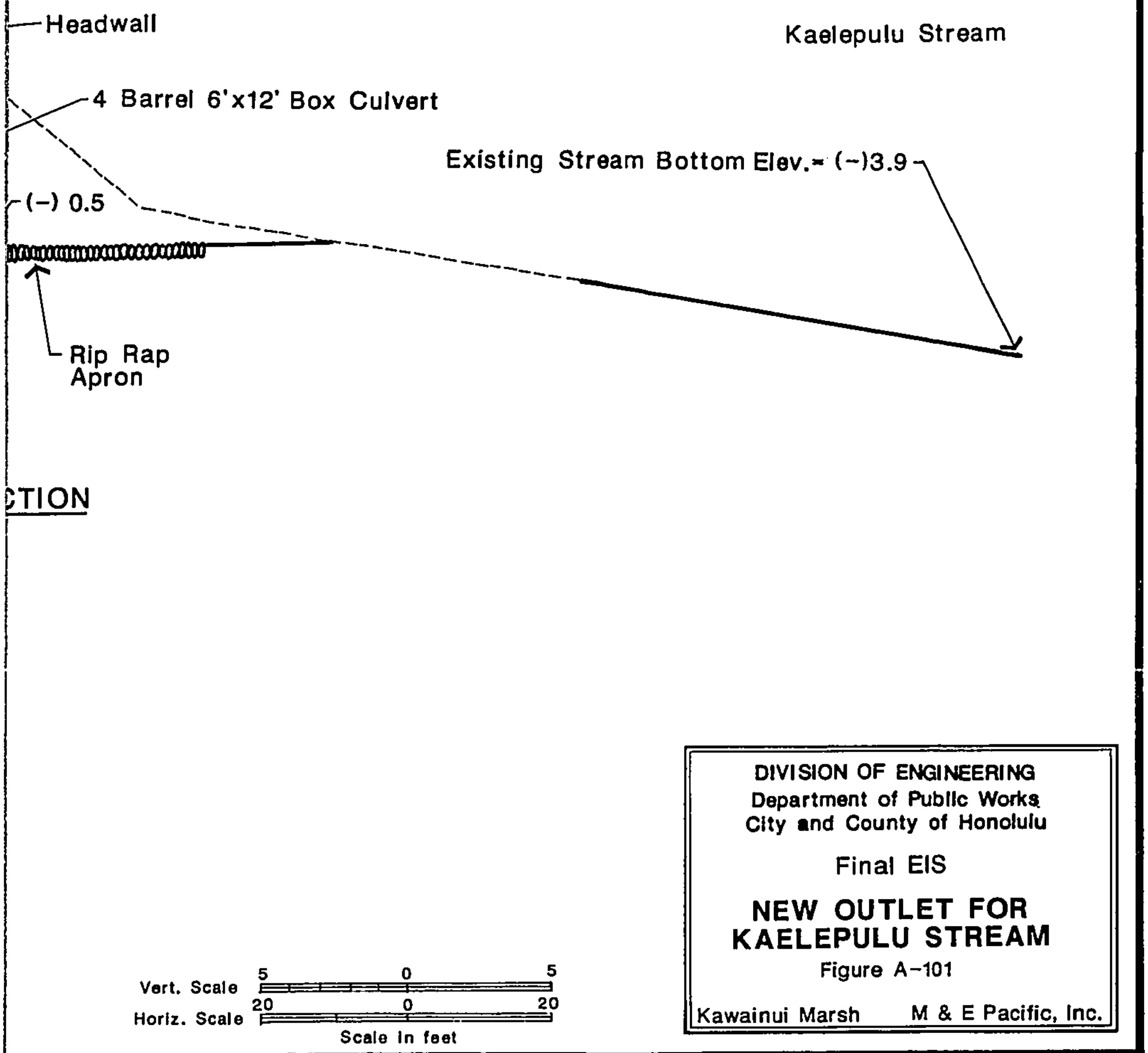


Figure A-102 Kaelepulu Stream Finite Element Model Geometric Grid





Levee
℄
9.84
1.2%
Headwall
Oneawa Outlet Canal
4 Barrel 6'
(–) 1.0
(–) 0.5
Rip Rap Apron
Elevation, feet (MSl)
10
5
0
-5
-10
SECTION
Vert. Scale
Horiz. Scale



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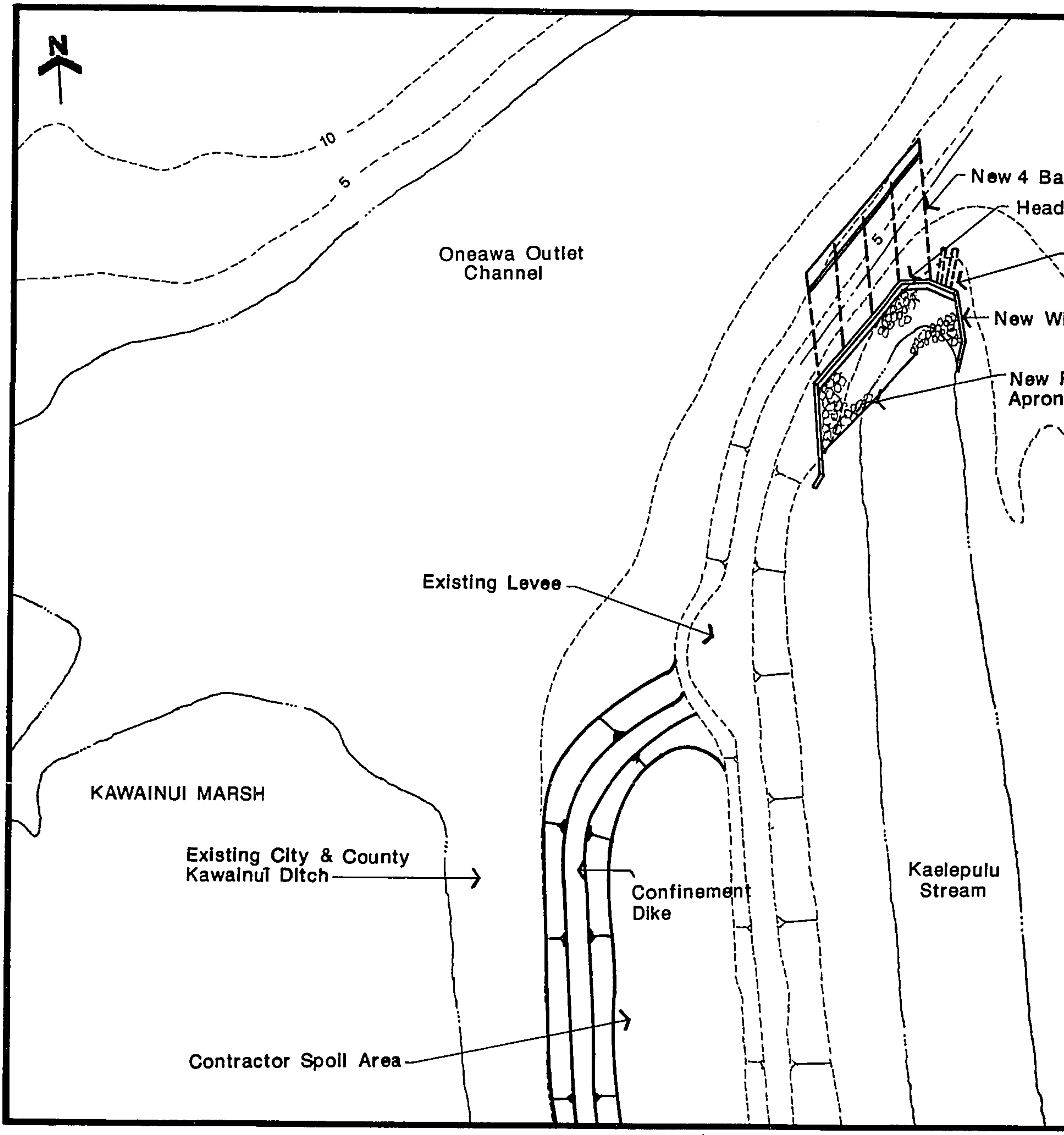
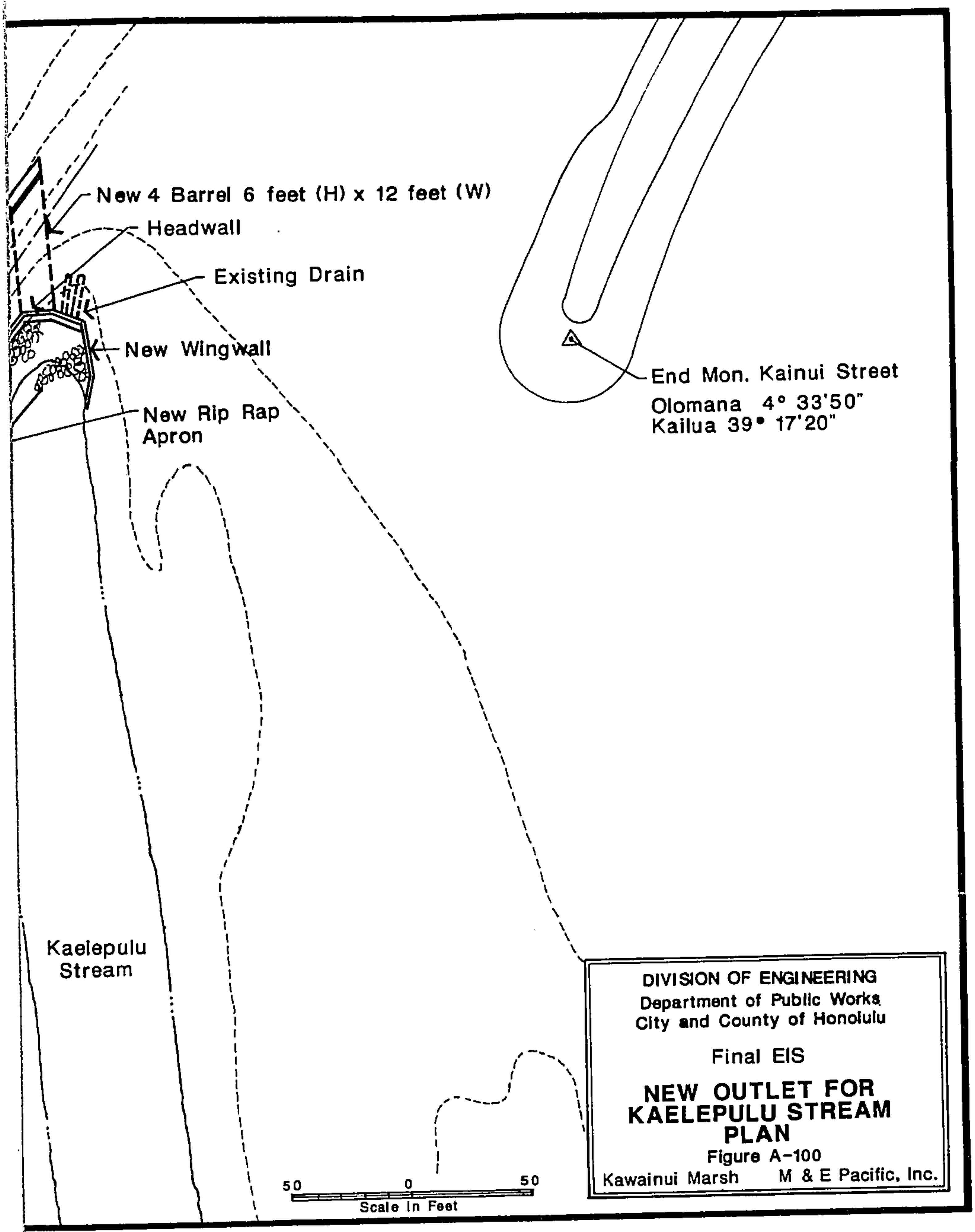
NEW OUTLET FOR KAELEPULU STREAM

Figure A-101

Kawainui Marsh M & E Pacific, Inc.


N
10
5
Oneawa Outlet
Channel
New 4 Ba
Head
New Wi
New F
Apron
Existing Levee
KAWAINUI MARSH
Existing City & County
Kawainui Ditch
Confinement
Dike
Kaelepulu
Stream
Contractor Spoil Area



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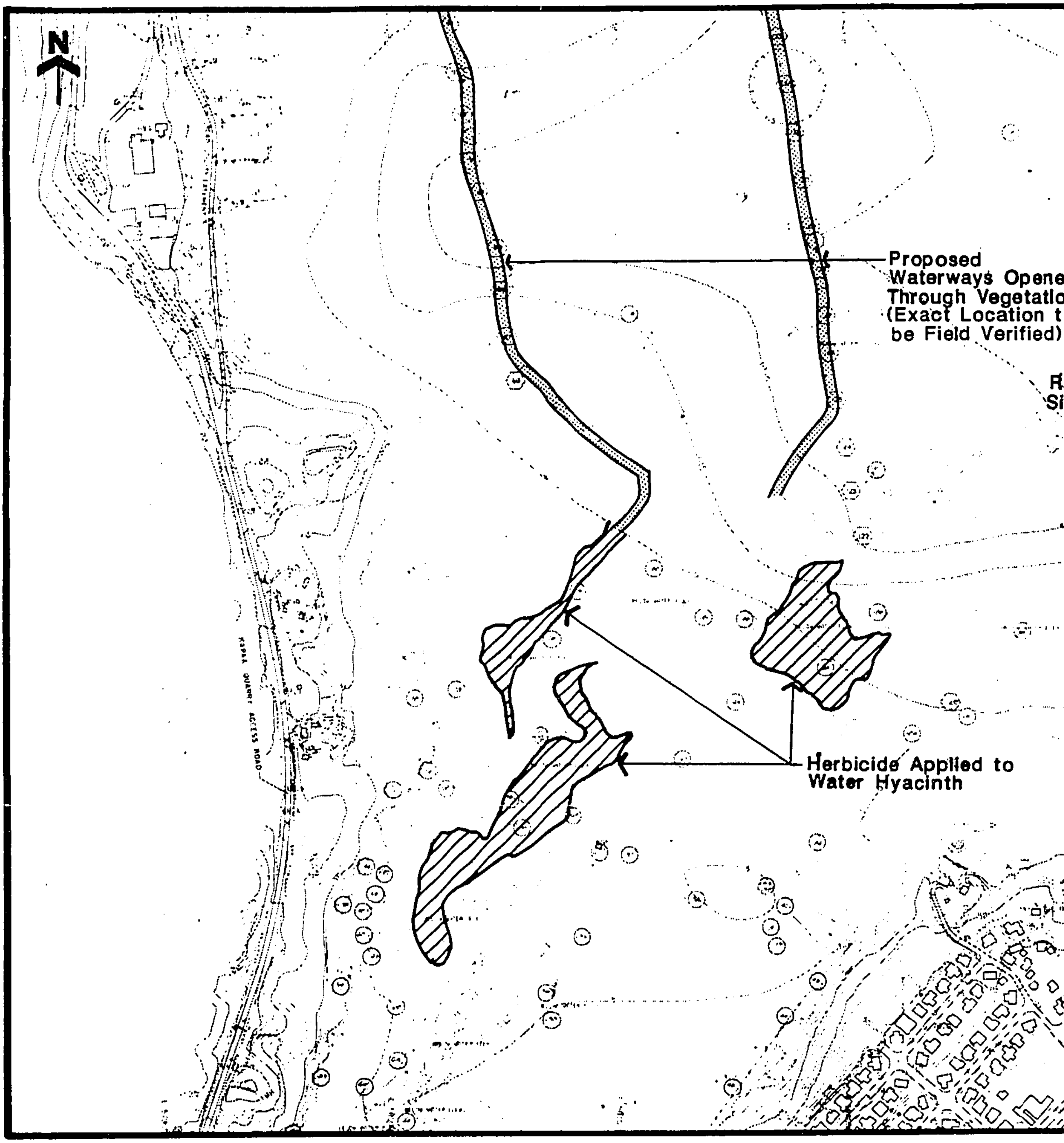
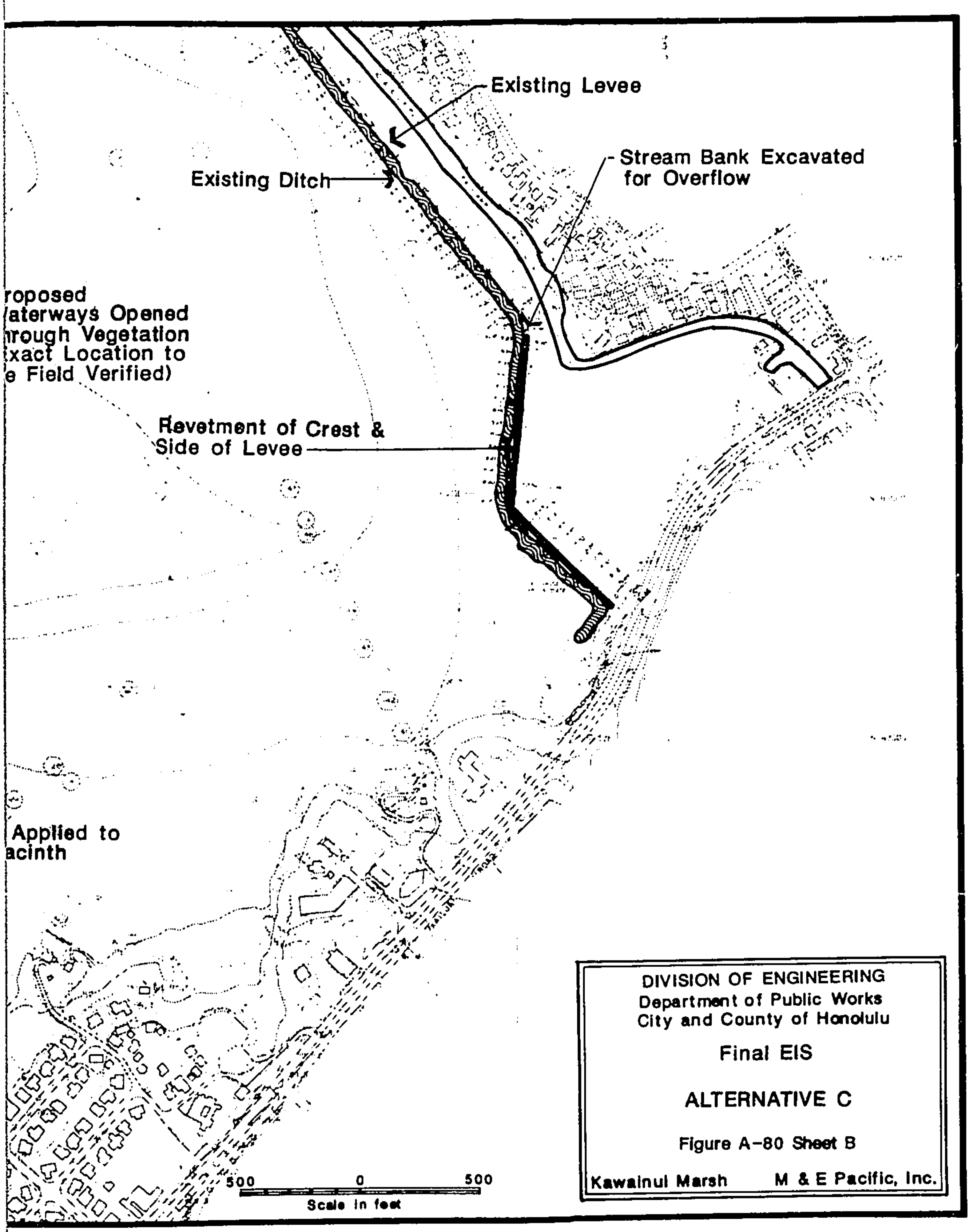
NEW OUTLET FOR KAELEPULU STREAM PLAN

Figure A-100

Kawainui Marsh M & E Pacific, Inc.


N
Proposed
Waterways Opene
Through Vegetatio
(Exact Location t
be Field Verified)
Herbicide Applied to
Water Hyacinth
KAPAA QUARRY ACCESS ROAD



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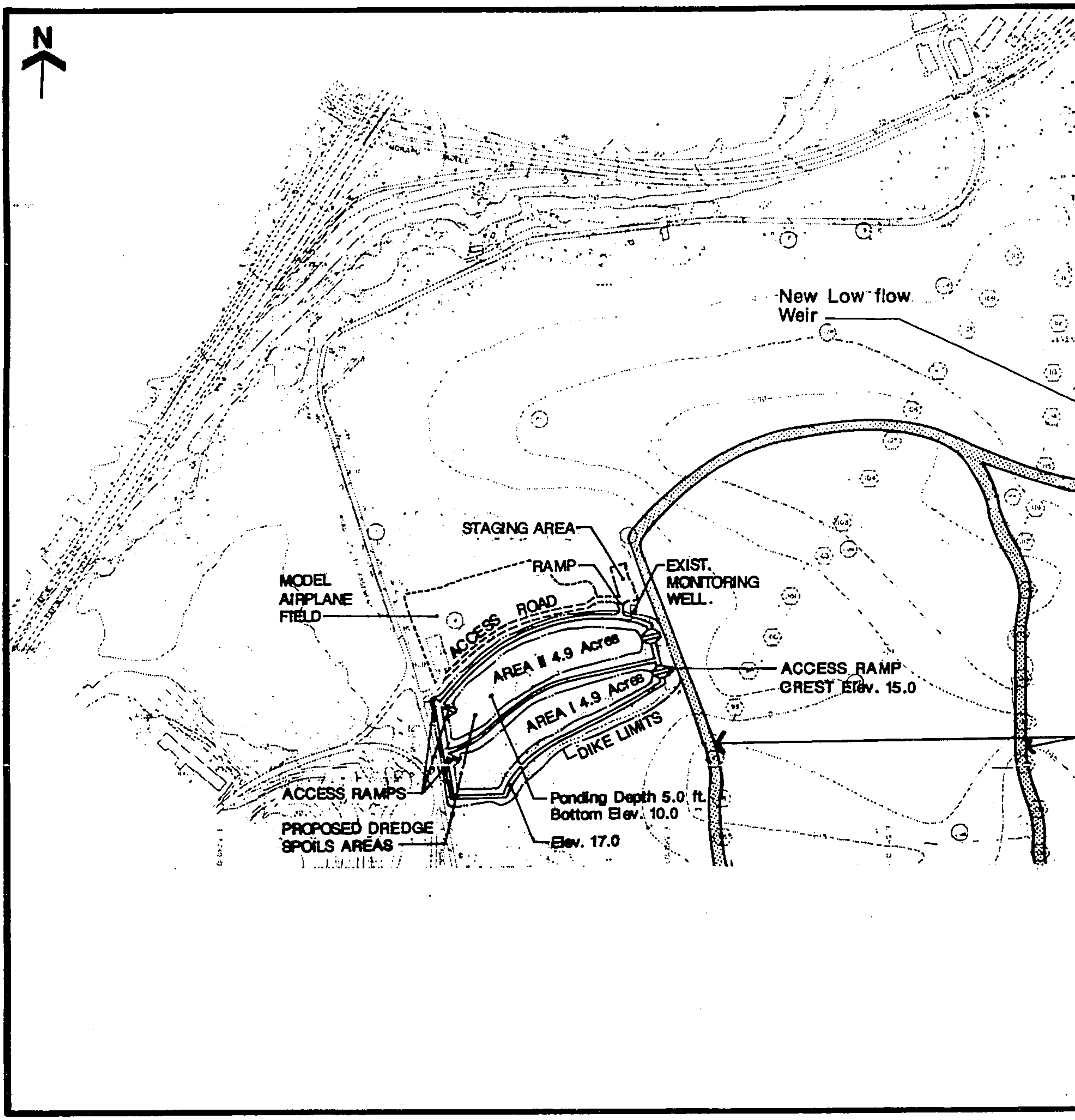
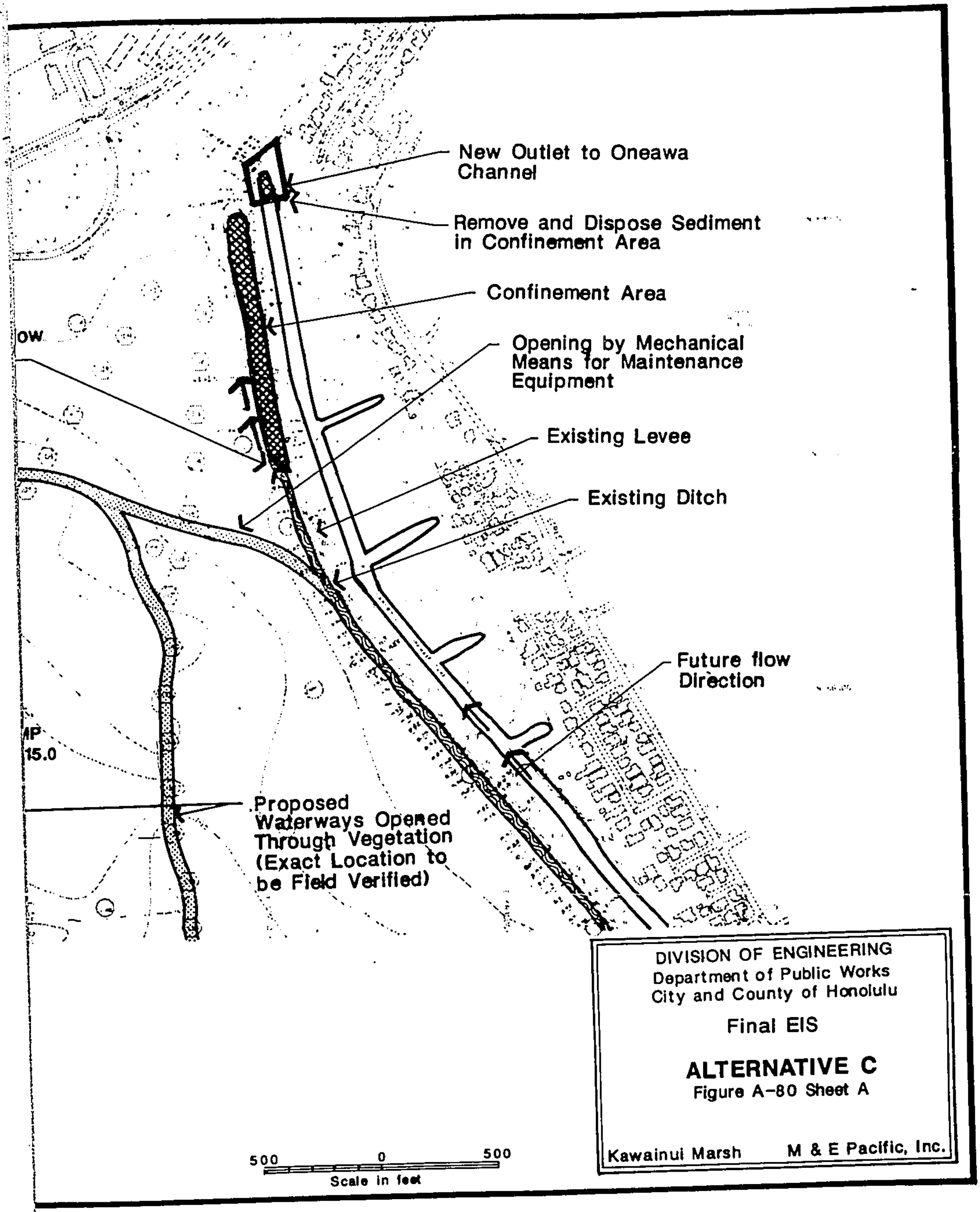
ALTERNATIVE C

Figure A-80 Sheet B

Kawainui Marsh M & E Pacific, Inc.


N
New Low flow
Weir
STAGING AREA
RAMP
EXIST.
MONITORING
WELL.
MODEL
AIRPLANE
FIELD
ACCESS ROAD
AREA II 4.9 Acres
AREA I 4.9 Acres
ACCESS RAMP
CREST Elev. 15.0
DIKE LIMITS
ACCESS RAMPS
Ponding Depth 5.0 ft.
Bottom Elev. 10.0
PROPOSED DREDGE
SPOILS AREAS
Elev. 17.0



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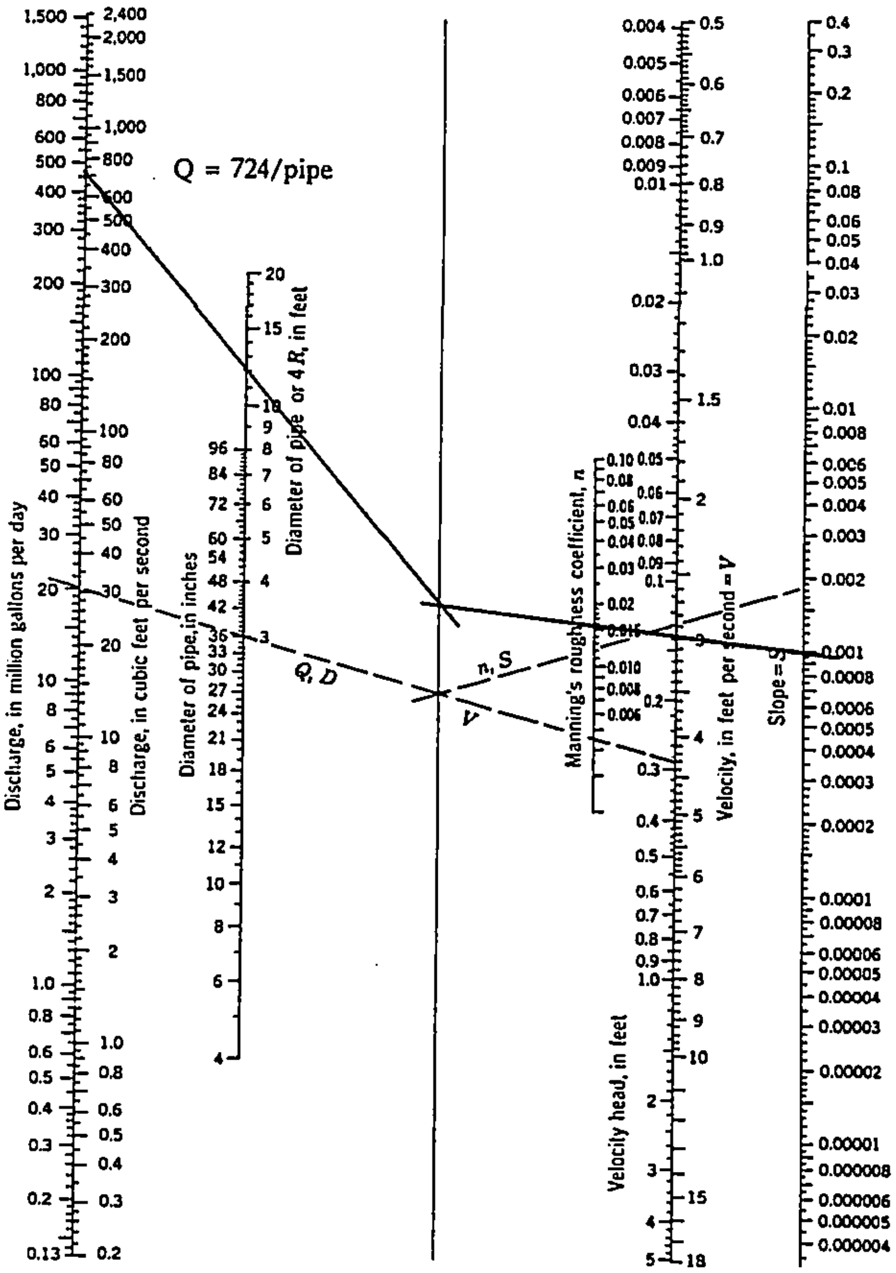
ALTERNATIVE C
Figure A-80 Sheet A

Kawainui Marsh — M & E Pacific, Inc.

Figure A-79

HYDRAULICS OF SEWERS



Alignment chart for Manning formula for pipe flow.

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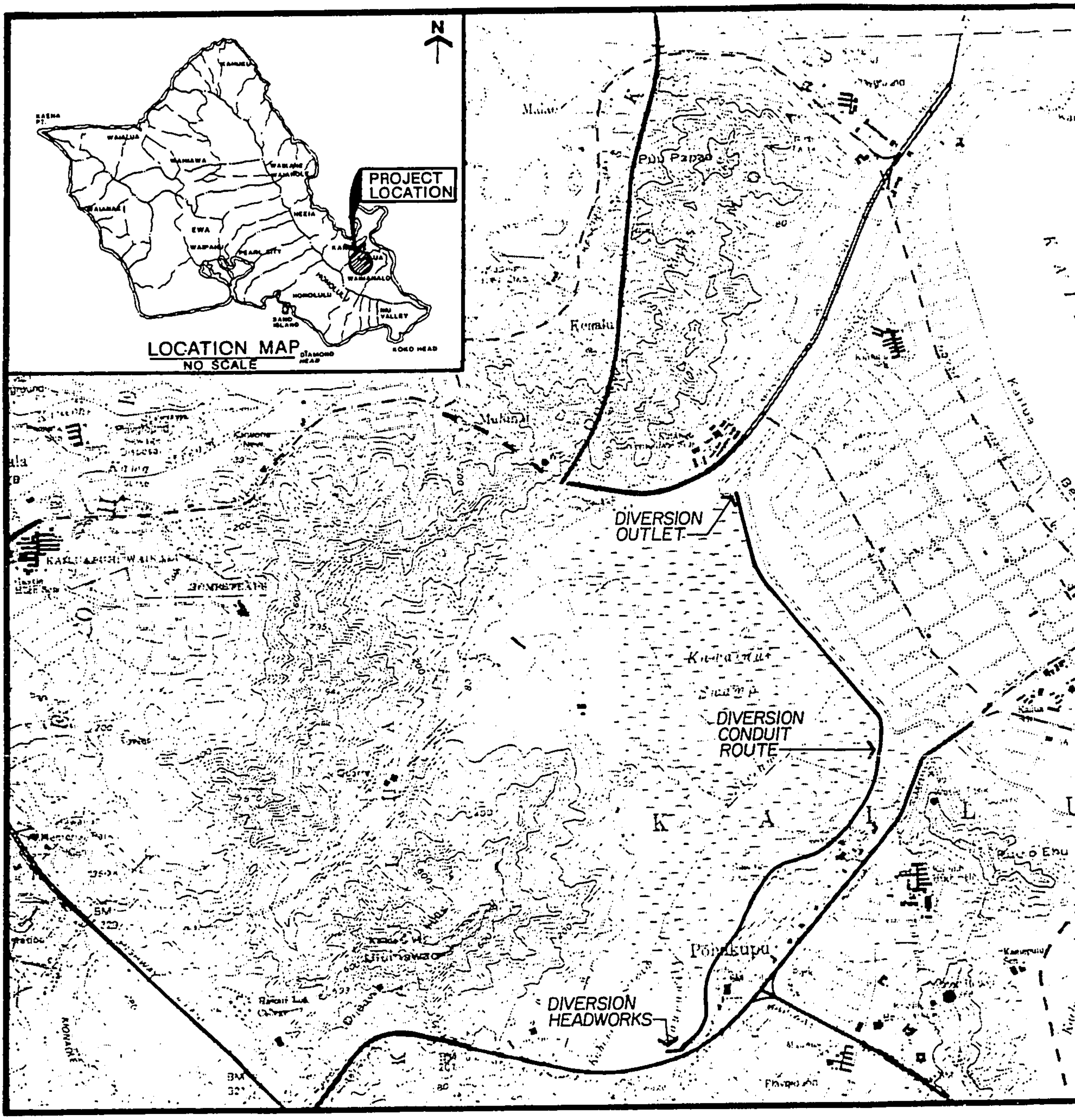
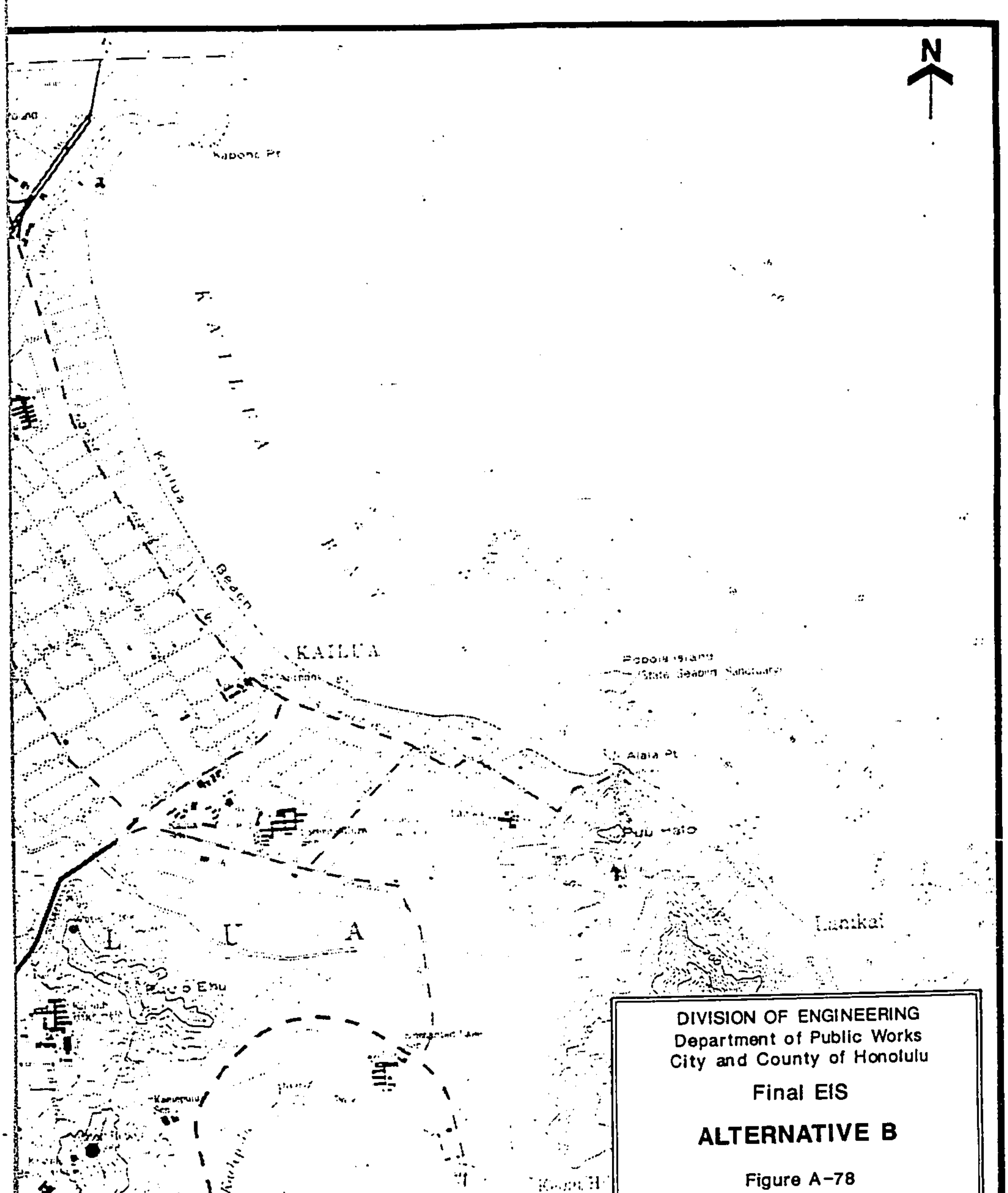


DOCUMENT CAPTURED AS RECEIVED



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ALTERNATIVE B

Figure A-78

Kawainui Marsh M & E Pacific, Inc.

Appendix B

Environmental Studies

APPENDIX B

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List of Figures
(End of Appendix B)

List of Tables

APPENDIX B

ENVIRONMENTAL STUDIES

SECTION 1. Marsh Wetland Environment

Development

Kawainui Marsh serves at least three ecological functions. The first is that of modifying the hydrology of the Maunawili watershed from the marsh to the ocean through the retention of flood water, evapotrans-piration and, to a lesser degree, by groundwater recharge. The second function has been that of a final treatment facility for sewage effluents, sediment, and urban storm water runoff. Both abiotic and biotic removal occur as water leaves the marsh. In its third role, the marsh is a prime example of a tropical freshwater wetland habitat for a variety of plants and animals, including nesting ground for native birds of which at least four are endangered waterbirds. The first role was discussed in Appendix A; the latter roles are discussed in this appendix.

Wetlands are lands where the water surface is near the ground surface long enough each year to maintain saturated soil conditions. Swamps are wetlands within which the dominant species are woody plants such as mangroves, for example. Marshes are wetlands within which the predominant species are soft fibrous plants. Kawainui Marsh is typically characterized by emergent aquatic vegetation such as plants of the genus *Typha* (cattails) and genus *Scirpus* (bulrush).

The high productivity of the marsh plants is caused by retention of nutrients in the substrata and rapid recycling of nutrients by the benthos. The amount of grazing by insects and animals is believed to be relatively small, compared to the loss of nutrients through entombment in the peat and underlying sediments. There is, therefore, a natural tendency towards eutrophication because the wetland acts as a nutrient trap.

Marshes are valuable natural systems due to their importance in food production, fish and wildlife habitat, nutrient cycling, erosion control, floodwater retention, groundwater recharge, and aesthetics. In order to mitigate wetland losses and to improve existing relatively unproductive wetlands, new marsh development on fast land is being undertaken on the mainland.

Marsh development typically goes through a process of terrestrialization of lakes into bogs and ultimately marsh meadows and forests. This may occur through either the accumulation of mineral soils approaching the water surface, or the establishment of mats of vegetation creating a substratum for colonization by other plants while providing a matrix which traps water-borne sediments. These floating mats of emergent vegetation become clogged with debris, and through decomposition deposit an organic ooze on the bottom (Smith, 1978). This is believed to be the main sedimentation force in marsh development, with the fine resultant peats having a high mineral content.

Succession is accomplished by the soil level approaching that of the water level (i.e. from the bottom upwards) (Smith, 1978). As sediments are deposited to the point where the peat bog is no longer influenced by surface waters, the frequency of flooding decreases. The succession to a wooded bog is enhanced at this stage. The climax stage of Kawainui Marsh succession is believed (Smith, 1977) to be a wooded bog dominated by trees and sawgrass.

In an early photo of the area (1926), the marsh appears much as it does today with only 7 ha (17 acres) of open water (in 1978, there were 5 ha [12 acres]). In 1890, 26 ha (64 acres) of open water existed; thus, in less than 36 years, emergent aquatics have almost completely covered the open water. A similar closure of open water is described by Elliott and Hall (1977) in Kaau Crater, Oahu. The vegetation there consists of cattails (*Scirpus validus*), sawgrass (*Cladium leptostachyum*), and honohono grass (*Commelina diffusa*), all aquatics that are similar to those in the bulrush community of Kawainui Marsh.

Water hyacinth exists on the surface and edges of the open water areas covering approximately 11 hectares (27-acre) area. This plant is rapidly encroaching on open water ponds and therefore poses the most serious threat to the waterbird habitat. Until 1978, this plant was located merely on the periphery of the main pond and not considered to be a pest plant. Since then, mats have been spreading out onto the main pond from the periphery. Water hyacinth does provide a food source for some waterbirds. The Hawaiian coot may feed on leaves and flowers occasionally. The extensive coverage of the open water areas by water hyacinth reduces the availability of preferred foods of the endangered waterbirds and migratory waterfowl. The vegetation cover reduces light penetration, inhibiting underwater plant growth. Plant decomposition decreases the oxygen available to aquatic life, gradually decreasing the pond depth through accumulation of organic matter on the bottom.

The construction of the levee and Oneawa outlet channel caused changes to the hydrology. Prior to construction, the marsh looked much as it did in the 1945 photo shown in Figure B-1. Figure B-2 shows the marsh in 1986. The most significant changes were in peak water lev s within the marsh due to blockage of the natural outlet and salinity stress to aquatic plants n the head of the Oneawa outlet channel. Data contained in Appendix A shows the average pe..k water level at crest gage 2648 was approximately 1.5 feet higher after the levee was constructed than before. Other data support this conclusion. The borings taken by Dames & Moore (1961) show the water level at that time (April-May 1961) at approximately sea level. The significance of this water level change is that higher water levels within the marsh will improve the circulation of nutrients improving the conditions for sustained growth. However, at the Oneawa outlet channel, the intrusion of salt water has successfully prevented the growth of aquatic plants very far into the excavated channel because of the salt stress which most emergent plants cannot tolerate. At the cellular level of the plant structure damage is caused by high osmotic imbalances in salt concentration.

After a fire in 1975, 60 paperbark (*Melaleuca leucadendra*) seedlings were found at the foot of two paperbark trees in the bulrush community. The presence of the paperbark in itself may suggest a tendency for the development of a woody community if further burning were allowed. Paperbark exhibits a positive germination response to fire, yet it is a slow process; in June 1976 no seedl gs were found. Sawgrass also shows a positive growth response to fire (Smith, 1978).

The District Fire Log Report, August 6-7, 1975, notes that the fire in Kawainui Marsh started on the quarry side (northwest) where the dominant vegetation was California grass (*Brachiaria mutica*)and bulrushes. Two types of burn were noted; an area where burn was incomp with scorching of the bulrushes, and an area of complete burn with little vegetation left at the root system. The area of complete burn was probably an area of drier conditions with predominant vegetation being California grass. The incomplete burn area was probal moister, with the vegetation mat covering bodies of water.

A survey was conducted to assess the effects of fire on the vegetation. The area from the eastern corner of the marsh extending to the large body of open water was completely burned, with the grasses and bulrushes burned close to the ground, leaving a charred, black surface. This area was approximately one-third of the total area burned. The remainder of the burned area was brown in color where the bulrush had been killed or scorched, and knocked down by the wind. In this area the burn was not complete, leaving behind a mass of dead material on the mat surface with an estimated height of thirty-six inches. In the affected area, the fire consumed most of the top growth but did not affect to a great degree the root systems of the California grass and bulrushes, leaving the roots intact. Apparently, fire does not consume the vegetation mat. Approximately 69 percent of the entire wetland burned, of which 24 percent was a complete and clear burn with no vegetation left standing.

After four weeks the area was surveyed again. In the completely burned area, the bulrush plants were approximately twice the height of the bulrush plants in the incomplete burn area. The California grass also exhibited rapid growth in the completely burned area resulting in almost complete coverage of the burned area. There was no crossover of any of the major plant species from one area to another. The new growth came from the existing root structures that had remained intact and viable after the fire.

A nutrient analysis was conducted finding that both nitrogen and phosphorus concentrations were higher than those of the incomplete and unburned area. It appears that burning may stimulate primary production through the release of nutrients into the water column. If burning is to be used as a management technique, the vegetation mat should first be burned, followed by herbicide application to ensure that the root systems are also killed, thereby discouraging prolific regrowth.

Past water impoundments and drawdowns have substantially altered the relative size of the two general vegetation communities. Without any active management, the bulrush community tends to occupy 160 ha (395 acres). With impoundment, the community increases to 220 ha (543 acres); with drawdown, it decreases to 100 ha (247 acres). Water level manipulations have altered the relative areas of the two plant communities, but not their species composition. More complete information on the effects of perturbations are described by Smith (1978).

The present stage of marsh development is simplified in Figure 3-7 (main text) which shows major vegetation and water bird communities. The factors which limit the abundance and distribution of species in the habitat include: bathymetry, tidal circulation, growths of emergent vegetation, and freshwater discharge rates from the marsh into the canal. The emergent vegetation or floating vegetation mats serve as a barrier not only to aquatic species migration but also to increased mixing of marine waters from the marsh due to the density of the sediments that accumulate near the exit of the marsh.

Vegetation in Kawainui Marsh is not managed except for grazing along selected upper edges of the marsh. California grass interspersed with honohono, water hyacinth, arrowhead (*Sagittaria sagittaefolia*), scattered stands of cattail (*Typha angustata*), and a bulrush community consisting primarily of bulrush, sawgrass and taro patch fern (*Cyclosorus interruptus*) are the dominant forms of vegetation. The grass grows on fine alluvial clays which are constantly damp, and form thick, dense floating mats that can support the weight of a man and animals while covering small ponds. The character of the vegetation in Kawainui Marsh has been influenced by changes in nutrient levels, water levels and the introduction of exotic plants. A list of vegetation identified by Smith (1978) is contained at the end of Appendix B.

Avifauna

Kawainui Marsh provides a variety of habitat values for several important waterfowl characterized in Table B-1. All four endangered Hawaiian waterbird species nest and breed in Kawainui Marsh: Hawaiian Coot; (*Fulica americana alai*), Hawaiian Gallinule (*Gallinula chloropus sandvicensis*), Hawaiian Duck (*Anas wyvilliana*), and Hawaiian Stilt (*Himantopu mexicanus knudsenii*). The Hawaiian Coot builds nests in the vegetated areas of wetlands or its edges, above water levels, yet is an excellent diver and obtains much of its food from below the water surface. The Hawaiian Gallinule also nests in vegetated areas of wetlands or on the edge of the wetlands. Feeding however on aquatic insects, molluscs, aquatic plants and algae, the bird is dependent on the presence of open water for adequate feeding habitat. The Hawaiian Duck is a ground nester and therefore dependent on relatively dry areas for successful reproduction. This omnivore is more reliant on moist areas for food production, yet feeds in shallow open waters as well. The Hawaiian Stilt is a common inhabitant of the shallow water shorelines of Kawainui. Feeding on aquatic insects and crustaceans, this species nests close to the water.

In addition, the Black-crowned Night Heron (*Nycticorax nycticorax)*, the Great Frigatebird and a variety of seasonally migratory waterfowl are prevalent in the marsh. The heron is also frequently seen along the shorelines of Kawainui Marsh. Preferred feeding habitat includes areas supporting aquatic insects and fish as well as small amphibians and small mammals; consequently, the Black-crowned Night Heron needs aquatic as well as upland habitat, although nests are located generally close to the water. A variety of other birds (egrets, ducks, doves, sparrows and finches) also make occasional use of the wetland/upland boundary habitat surrounding Kawainui Marsh.

A portion of the marsh has been declared a major and essential habitat for the endangered species by the Hawaii Waterbird Recovery Team. However, its importance is based primarily on the potential for substantial habitat improvement and not on its recent condition. Vegetation growth and sedimentation have reduced valuable open waterbird habitat and degraded the marsh.

The marsh is considered a primary nesting habitat for four species of Hawaii's endangered waterbirds. Although no wetland habitat has yet been designated as critical habitat for endangered species, a waterbird recovery team report designated the marsh as essential habitat to the recovery efforts of these waterbirds. Although habitat in the marsh was steadily degraded during the past two decades due to the infilling and choking off of open water habitat as a result of sediment and sewage discharges, the marsh can be restored to important functions for endangered waterbirds. Historical use and past distribution of waterfowl has been described and documented by Shallenberger (1977) and Conant (1981). The 1988 status of waterbird use in the marsh is summarized by an unpublished report from the Division of Forestry and Wildlife, DLNR (Engilis, 1988) noting the New Year's Eve 1988 flood had:

> " . . . profound positive effect on the native waterbirds. . . [the] small resident population of all four species of Hawaiian waterbirds . . .responded favorably to conditions created by the New Year's Day flood.
>
> The flood effectively cleared and moved floating vegetation creating 75 acres of open water. . .and edge habitat. The flood also scoured the delta region of the Maunawili and Kahanaiki Streams creating flooded fields, meandering channels, and open mudflats. The water level in the marsh was estimated at +4.5 feet (above mean sea level). By late March, water levels began to recede and edge vegetation, including

TABLE B-1

Characteristics of Waterbirds in Kawainui Marsh

BREED	HABITAT/NESTING	FEEDING	PREDATORS
HAWAIIAN STILT *Himantopus mexicanus knudseni*	Nest in or close to fresh or brackish water ponds, mud-flats, marshlands Nest constructed in scrape in the ground, but maybe made of debris/vegetation lined with pebbles, twigs, and debris Clutch - 4 eggs 24-26 days incubation Nest: March-July Breed: Feb-Aug	Seek food in low-lands habitats, mudflats, settling basins, marshes, reservoirs, etc. Eat: polychaete worms, crabs, aquatic insects, small fishes	Eggs & young, by mongoose, dogs, cats, rats and cattle egrets
HAWAIIAN COOT *Fulica americana alai*	Prefer open water, fresh, brackish or, rarely, saline: need deeper water because builds nest on large floating aquatic vegetation anchored to emer-gent vegetation Clutch - 4-10 eggs, avg. 5-6, 22 days incubation Peak Nest: Apr-June	Feed close to nesting sites Eat: seeds and green parts of aquatic plants, invertebrates, tadpoles, and small fish	Mongoose, cats, dogs, possibly rats, largemouth bass and herons, man
HAWAIIAN GALLINULE (moorhen) *Gallinula chloropus sandvicensis*	Freshwater ponds, marshes, streams ditches Nests are incon-spicuous in emergent vegetation on folded reeds Clutch - 6-9, avg. 5-6, 22 days incubation Peak Nest: Apr-June	Algae, seeds, grasses, aquatic insects, variety of mollusks	Mongoose, cats, dogs, possibly bass and heron, man

BREED	HABITAT/NESTING	FEEDING	PREDATORS
HAWAIIAN DUCK *Anas wyvilliana*	Taro patches, reservoirs, drainage ditches, flooded fields Clutch: 8 eggs 28 days incubation Nest: Dec-May Nests on the ground near water	Eat: Snails, earthworms, dragon flies, algae, leaf parts and seeds seeds of a variety of wetland plants, mollusks, etc.; opportunistic feeders	Mongoose, dogs, pigs, cats, rats Young eaten by bullfrogs and bass, Mynas and owls Poaching for sport or food by man
BLACK-CROWNED NIGHT HERONS *Nycticorax* *Nycticorax hoactli*	Ponds, marshes, lagoons, tide pools Bulky nests of twigs and sticks in trees Clutch: 2-4 eggs Breed: May-June	Eat: Crustaceans, fish, frogs, mice, insects, and chicks of other birds	Mongoose, dog, cats, bats

California grass and water hyacinth, began to grow. A warm May, June and July enhanced this growth and large tracts of open water became overgrown. By August, the receding waters, to approximately +3.0 feet, exposed large mudflats bisecting the main pond. Also, at this time, the delta region had dried except for the stream channels.

All of the waterbirds seemed to prefer a shallow water/mud and vegetation interface. In February-March this interface was located in the delta region and nearly all of the waterbirds were concentrated in this area. However, by late May to July this interface increased in the center of the main pond. The majority of resident birds responded by shifting their activities to this section.

However, some individuals of stilt and gallinule remained in the delta. Stilts and Koloa were documented on several occasions feeding in the city and county emergency channel. Coots were also documented in Hamakua and Oneawa canals. Nesting was documented for all four species of endangered waterbirds. Migratory birds (waterfowl and shorebirds) also utilized the open water and mudflats created after the flood."

Engilis describes the 1988 status of the birds by species as follows:

"Hawaiian Duck (Koloa). Permanent resident in small numbers: restricted to open waterways, ponds and channels. Most activity was in the delta and main pond areas. One adult with three young were seen in the main pond in late June. In March, four pairs were observed in courtship flight in the delta. Very few Koloa are recorded annually along the windward coast of Oahu. For this reason, the 10-12 birds that can be regularly seen in Kawainui represent the largest known concentration on windward O'ahu.

Hawaiian Gallinule. Permanent resident in good numbers in open waterways, channels, and dense marsh vegetation. The actual number of resident gallinule in Kawainui Marsh may never be known due to their secretive behavior. Documented as many as 35 birds, in late June, around the main pond's emergent vegetation. One adult with two young were seen in late July). The significant number of gallinules in Kawainui makes it a primary colonizing source for this species on the windward coast.

Hawaiian Coot. Permanent resident as long as open water is present. Can occur in large numbers (20) if optimal flooded conditions exist. In Kawainui, prefers the open water of the main pond and delta, but can also be seen in Hamakua Canal and upper Oneawa canal. One adult with one young was seen in late June. Hawaiian Coot is local on O'ahu and the population at Kawainui is important as a colonizing source for the windward portion of the island.

Hawaiian Stilt. Permanent resident in small numbers as long as shallow open water with mudflats exist. The stilt responded well to the flood. The usual 3-4 birds that occur in the delta were soon joined by other stilt (presumably from nearby Nuupia Ponds). Three nests were documented this season. The pair successfully reared one young: nesting began in March. Two other pairs were incubating eggs on the large exposed mudflat in the center of the main pond in late July. The high waters resulting from tropical storm Gilma inundated these nests in August. Stilts were frequently documented feeding along the city and county channel. The approximately 12 stilts residing at Kawainui represent a small percentage occurring along the windward coast. The 130+ nesting at nearby Nuupia Ponds is one of the largest concentrations in the state."

Any project being planned for the marsh must consider the impact upon these endangered species as the waterbirds fall under the jurisdiction of U.S. Fish and Wildlife Service (USFWS) management regulations.

Problems which limit existing and potential waterbird use include: vegetation/ aquatic weed encroachment into valuable open water areas, human disturbance, predation, fluctuating water levels, limited access to food, public attitudes, and sedimentation.

The fast land areas of the marsh especially near the confluence of the Maunawili and Kahanaiki Streams provide pasture for cattle. These cattle are also known to graze into the marshy areas where Koloa frequent. This intrusion has the potential for trampling active nests.

At least four other mammalian predators have access to the marsh with potentially serious consequence to the endangered waterbirds and their nests. These include the mongoose, rats, cats and dogs.

The primary recommendations for improving the habitat of the marsh for endangered and other waterbirds focus on increasing the amount of open water available and the control of vegetation which competes for this water space. The Kawainui Resource Management Plan recommends increasing the open water areas, in stages, up to 150 acres, at the same time controlling the water hyacinth, water lilies, cattails and California grass. Recent survey activities appear to reenforce the management plan recommendations.

The proposed action changes the water levels within Kawainui Marsh by reducing the magnitude of excursions of water level changes, but not eliminating the fluctuating water level so necessary to sustain this vital ecosystem. The proposed changes will also reduce the seasonal extreme water level fluctuations caused by the impoundment conditions surrounding the marsh. By providing a more seasonally stable, yet moderately fluctuating, water level, the proposed management approach will provide more protected vegetated wetland habitat for nesting as well as feeding. In addition, the vegetation control proposed will result in more permanent areas of open water where open water feeding activities can occur. With improved seasonally stable nesting habitat and additional, continually available open water feeding areas, these waterfowl should experience a significant improvement as a result of implementation of the proposed actions. Continuation of small excursions in water level will afford suitable feeding habitat for many shorebirds and herons as well.

Other Fauna

The open waterways are nearly always eutrophic and are dominated by exotic warm water species such as tilapia and mosquitofish. Freshwater turtles occur in the Hamakua Drive canal; however, their existence in Kawainui Marsh has not been well documented.

The lower Maunawili and Kahanaiki Streams are dominated by exotic species: Chinese catfish, Cuban limia, swordtails, smallmouth bass and koi. Louisiana crayfish, as well as frogs, toads, and snails are also found. Cuban limia, reticulated guppy, mosquitofish, and tilapia may be periodically reintroduced to Kawainui Marsh by the State Department of Health Vector Control Branch as required for mosquito control after flooding.

The most abundant invertebrate species in the central marsh is Physa, existing above and below the water surface. These snails are apparently a secondary host for a bird parasite (schistosome) which infests the marsh. Mongoose are thought to be the primary predators of the avian life in the marsh. Feral dogs and cats are also found, as well as rats and mice. Cattle and horses graze in the upper parts of the marsh.

The Oneawa Channel and the immediate upstream portion of the marsh adjacent to the channel is presently an estuarine habitat with potential value for recreational fishing (aholehole, mullet, barracuda, o'opu, lizard fish).

The head of the canal is the most productive aquatic habitat with respect to fishery resources. Itinerant marine and estuarine species frequent the canal including o'opu, o'ophu-hue, awa, lizardfish, papio, oio, kaku, iao, uouoa, 'amaama, aaolehole, upapalu, aaole crab, hapa crab, Samoan crab, opae'oeha'a, opae lolo, and Tahitian prawn. The removal of rooted vegetation will substantially increase the availability of the marsh as a habitat for native stream species.

Mosquitos

Hawaii has four harmful and two beneficial species of mosquitos. Three of the species carry a variety of disease ranging from viral encephalitis to yellow fever. Although the *Aedes veans nocturnus* is not known to carry any disease it is known for its vicious biting habits. The two beneficial species *Toxorhynchites* (cannibal mosquito) are known to feed on the larva of the other harmful species. The harmful species are listed according to their color, biting pattern, type, location (islands), disease carried, breeding environment, and flight distance . The most common and abundant species of the greatest concern is *Culex quinquefasciatus*.

Description of Mosquito Species

	Culex quinquefasciatus	*Aedes aegypti*	*Aedes albopictus*	*Aedes vexans nocturnus*
color	brown	black/dark grey	black/dark grey	
biting pattern	night	day	day	night
type	common		forest	flood water
flight distance	1-3 miles	100-150 yards		20 miles
breeding water	polluted	relatively clean	relatively clean	
(a) islands found on	8	5,6	8	1,4,5,7
(b) diseases carried	1,2,3	4,5,6	5	
(c) breeding sites	1	2	2,3,4	

Source: Vector Control Branch Bulletin, Department of Health, No. 3.

Notes:

(a) Islands
1. Oahu
2. Maui
3. Lanai
4. Kauai
5. Molokai
6. Hawaii

(b) diseases
1. viral encephalitis
2. human filariasis
3. dog heartworm
4. yellow fever
5. dengue fever
6. hemorrhagic fever

(c) breeds in:
1. water rich in organic materials
   a. swamp lands
   b. sewage ponds
   c. plantation
   d. ponded agriculture waste water
2. artificial containers
   a. tin cans
   b. tires
   c. bottles
3. trees
4. rock holes

APPENDIX B, SECTION 1

There are two effective ways of controlling the mosquito population: (1) larvivorous fishes and (2) larviciding. The common fish are listed below:

List of Common Mosquito Predatory Fishes in Hawaii (5)

Species	Source	Common Name	Date of Introduction
Gambusia affinis	(Baird & Girard)	Mosquito fish	1905
Lebistes reticulatus	(Peters)	Guppy	1922
Limia vittata	(Guichenot)	Top minnow	not available
Mollienesia latipinna	Le Sueur	Sailfin molly	1905
Mollienesia sphenops	(Cuvier & Valenciennus)	Liberty molly	not available
Xiphophorus maculatus	Gunther	Moon fish	1922
Xiphophorus helleri	Heckel	Swordtail	1922/1940
Chchlasoma meeki (a)	(Brind)	Firemouth	1940
Astronotus ocellatus (a)	(Agassiz)	Oscar	1958
Cichla ocellaris (a)		Tucnare	not available
Tilapia mossambica (a,b)	(Peters)	Tilapia	1951
Tilapia machochei (a,b)	(Boulenger)	Tilapia	1957
Tilapia zillii (a,b)	Gervas	Tilapia	1955
Tilapia melanopleura (a,b)	Dumeril	Tilapia	1956
Lepomis macrochirus (a)	Rafinesque	Bluegill	1946
Cyprinius carpio	(Linnaeus)	Carp	before 1900
Carassius autatus	(Linnaeus)	Goldfish	before 1900

Source: *Nakagawa,Patrick Y., and Ikeda, James*
Biological Control of Mosquitos with Larvivorous Fishes in Hawaii
Mosquito Control Branch, Hawaii State Department of Health
Honolulu, Hawaii

Notes: (a) sports fishing
(b) algae and weed feeders
(5) adapted from Brock (1960) and Kanayama (1967)

It was determined (Nakagawa and Ikeda, 1969) that the most successful rate of seeding was 1000-2000 fish per acre, which took approximately 6-8 weeks for the colony to multiply. It was found that by introducing multiple mosquito fish species the combination exploited the full potential of the control by eliminating the possibility of one or several of the species not being able to coexist within the environment. For example the innovative combination of mosquito fishes and *Tilapia mossambica* proved capable of providing total control of mosquito breeding in a 35- to 40-acre rain-created basin in the floor of Diamond Head Crater (Nakagawa and Hirst, 1959). The effective control of Kawainui Marsh represents the attainment of the lowest practical level of control possible from a realistic cost-benefit standpoint. This represents a residual breeding which averages 1.25 females per night during three-fourths of the year, which is for all practical purpose infinitesimal compared to the full mosquito breeding potential of this marsh (Nakagawa and Ikeda, 1969).

Of the 17 species listed above, the four principal species that contribute effectively as biological control agents are: (1) *Gambusia affinis* (mosquito fish), (2) *Lebistes reticulatus* (guppies), (3) *Limia vittata* (top minnow), and (4) *Tilapia mossambica* (tilapia). Sources of mosquito fish are available from fresh-water streams, fresh-water reservoirs, and fish farms. By combining the different varieties and origins of the fish, the entire spectrum of mosquito breeding environments can be covered. For example, the mosquito fish stocked in fresh-water streams exist in water temperatures ranging from 63.5 to 74.0°F with pH values of 7.0-7.9, and water hardness varying from 5-53 ppm calcium carbonate. They can combat the day mosquitos (*Aedes aegypti*, and *Aedes albopictus*) which breed in relatively clean water. Whereas the fish found in fish farms of more polluted conditions (pH of 5.7-6.4, and temperatures of 70-76°F) raise the more hardy guppies that can combat the more common species *Culex quinquefasciatus*. This is of great importance when considering the diverse conditions that presently exist in Kawainui Marsh. Kawainui Marsh is one particular area in which several species of fish have survived and jointly contributed their share to the total biological control effort. The explanation to the multi-species survival is the existence of varying ecological niches within this vast area. The marsh has diverse habitats ranging from a fresh-water stream situation at its entrance to an estuarine situation at its outlet, with waters of varying degrees of pollution occurring in between these two extremes (Nakagawa and Ikeda).

Following heavy rains, potentially new mosquito breeding sites are seeded with a combination of larvivorous fish. Although it takes 6-8 weeks for the colony to multiply to handle the population increase this control is supplemented with spraying of larvicide. The most effective chemical used to date is the GB 1111, GB1356, and diesel oil combination. On January 12, 1988 a helicopter was used to treat mosquito breeding sites in the marsh using 1 percent Dursban granules at a rate of #25 lbs. per acre for covering a total of 30 acres in Kawainui Marsh (Ronald Arakawa, April 17, 1989). Presently the most cost effective mixtures for mosquito larviciding are as follows: (a) 2:1 mixture (2 parts diesel oil: 1 part GB 1356, or GB 1111) @ 4 gallons/acre by hand pump; and (b) 95:5 mixture (95 parts diesel oil; 5 parts GB 1356, or GB 1111) @ 10 gallons/acre by helicopter (Toyama, January 23, 1989). The larvicide of choice would have to be selective and nontoxic to the various species of mosquito fishes. The combination of larvicide and larvivorous fish is term "integrated control."

SECTION 2. Sedimentation

Sources of sediment input into the marsh include terrigenous material principally from the three tributary streams, decay of organic material into silt, and discharges in the past from the four wastewater treatment plants.

At one time, four wastewater treatment plants discharged effluents directly into Kawainui Marsh or into Maunawili Stream above the marsh. The combined flow of these plants was 0.73 mgd in the early 1980s (AECOS, 1981). The effluents from three of these facilities have since been diverted: Pohakupu WWTP in June 1987, Maunawili Park WWTP in May 1988, and Kukanono WWTP in June 1988. Maunawili Estates WWTP is scheduled for diversion in February 1990, but presently continues to discharge approximately 0.10 mgd of treated effluent into Maunawili Stream.

The production and decomposition of organic material is discussed in a later section of this appendix. The potential sources, amounts, and effects of the terrigenous material are discussed in this section. The analyses herein rely upon extrapolation from studies for similar watersheds on the windward side of Oahu because there are no continuous sediment sampling stations on streams flowing into the marsh.

Sources of sediment include stream bank erosion, agricultural activities, construction scars, and dirt and debris from urban runoff sources (e.g. yards and streets). Major contributors 50 to 100 years ago were pineapple, sugarcane, and grazing operations.

A study of Kaneohe Bay made by Sunn, Low, Tom, and Hara, Inc., in 1976 includes a table (Table B-2) that shows that approximately two-thirds of the accumulated long-term sediment load is contributed by flood events with a relative frequency of ten years or less. This study noted that a single event on Kamooalii Stream resulted in 9,096 tons of suspended sediment, thus demonstrating that sediment discharge can vary considerably between events. Average annual flow estimates are more reliable for Maunawili Basin than are estimates of extreme floods, and therefore more useful for predicting annual sediment yield. Thus while individual floods can have dramatic sediment loads they are not necessarily useful for predicting the long term annual sediment yield.

Sediment transport estimates from the headwaters to the marsh were based upon a generalized sediment rating curve adopted for effect assessment in the absence of a long-term site specific (Maunawili Basin) data collection program. The curve selected for this study is shown in Figure B-3. Sediment transport for Maunawili and Kahanaiki Streams was based on this relationship. The results of the study by Engineering Science, et al, 1972 showed the dependence of sediment loads on average storm runoff regardless of apparent differences in land use and other factors bearing upon sediment yield. Storm runoff seemed to be the critical factor for the watersheds under the conditions at the time of the study.

Average annual stream flow has not been estimated previously for the Kapaa sub-basin. In order to estimate the sediment yield of this portion of the Kawainui Marsh tributary area, a correlation was made between annual sediment yield and drainage area based upon three watersheds for which sediment discharge data were available. This correlation is shown in Figure B-5.

Table B-2 Relative Sediment Contributions of Flood Events
Kamooalii Stream, Gauging Station #2739

Frequency of Event (in years)	Representative Frequency (In years)	Number of Events in 100 years	Stream Discharge 1/ (q)	Dimensionless Ratio $\frac{q}{q_2}$	Relative Sediment Contribution per Event $q_s = \left(\frac{q}{q_2}\right)^{1.5}$	Relative Sediment Contributions in 100 Years	% of Long-Term Sediment Load	Accumulated % of Long-Term Sediment Load
.25 - 1.50	.90	350	660	.287	.154	53.80	24.0	24.0
1.50 - 3.50	2.00	30	2,300	1.000	1.000	30.00	13.4	37.4
3.50 - 7.50	5.00	10	5,500	2.391	3.698	36.98	16.5	53.9
7.50 - 15.00	10.00	5	8,000	3.478	6.487	32.43	14.5	68.4
15.00 - 35.00	20.00	3	11,000	4.783	10.459	31.38	14.0	82.4
35.00 - 75.00	50.00	1	15,000	6.522	16.655	16.66	7.4	89.8
75.00 -100.00	100.00	1	18,500	8.043	22.812	22.81	10.2	100.0
						224.06		

1/ Based on a frequency curve drawn for events recorded at Kamooalii Stream, gaging station #2739, 1958-1973.

Notation: q = peak stream discharge per event, in cubic feet per second
q_2 = peak stream discharge for a flood with a probability of being equaled or exceeded about once in two years.
q_s = relative sediment discharge per event

Table B-3 shows estimates of the potential storm generated sediment transport into the basin. Based upon an average detention time of 0.08 years (6000 acre-feet / 78,913 acre-feet/year), an average trap efficiency of 85 percent (U.S. Corps of Engineers, 1977) is indicated as shown in Figure B-4. Figure B-4 shows this trap efficiency can vary 75 to 91 percent.

Figure B-6 shows the storage capacity assumed in the design memorandum (U.S. Corps of Engineers, 1957) for the Federal flood control project. In addition, the storage capacity that would exist if there were no sediments or vegetation in the marsh is also shown based upon the hard bottom indicated by probe survey data. Note on Figure B-6 the capacity at -2.5 feet, msl, is estimated at 1560 acre-feet. In Appendix B, Section 5, the sediment accumulation from tributary streams is estimated at 380 acre-feet during a 22-year period (1966-1988). The maximum theoretical capacity based on the 1988-1989 surveys is greater than the estimated sediment inflow since the completion of the federal flood control project and yet the surveys along the probe alignments indicate that the sediments in the marsh have in many places exceeded elevation of -2.5 feet, msl. Another explanation for the deposits is the decomposition of organic growth.

Sediment data collected from four sites in the marsh are shown in Figure B-7. It indicates that the composition of the sediments change in the upstream direction. As one proceeds in the upstream direction note that the percentage of course grained material is higher, the total organic carbon decreases and the carbonate percentage decreases. "Coarse grained material" is defined as particles retained on a No. 200 sieve. Table B-4 shows this as fine sand or larger particles. The carbonate fraction is greater near the levee because a portion of the materials in the City and County emergency ditch originated from the construction of the levee and subsequent vegetation removal activities.

The amount of scour of the existing sediments that is anticipated under existing conditions and with the alternatives for flood damage reduction is difficult to predict due to the cohesive nature of some of the sediments. The analysis of sediment grain size indicates that the majority of the material is clay and silt size particles. At present, there is no universally accepted sediment transport theory for cohesive materials. Bedload transport functions in use have been developed for non-cohesive materials. However, it is instructive for relative comparisons of the alternatives to apply the concept of unit tractive force.

Table B-5 indicates the relative erodibility of each alternative channel. On the basis of the calculated tractive forces, the amount of material will be least for Alternative C, and greatest for Alternative A, with Alternative D falling in between close to the former.

The amount of nonfilterable residue (suspended sediment) that is permissible under the State Department of Health Chapter 54 Water Quality Standards is shown in Table B-6. The discharges from dredge disposal areas into inland waters that have been identified as unique or critical habitat for threatened and endangered species must meet these criteria. Similarly, the discharge through the outlet of the marsh to Oneawa canal is into a brackish water estuary and thus would fall into the category of an inland water. Because the discharge from sediment disposal areas would be required to comply with the criteria for total nonfilterable residue shown in Table B-6, the preliminary design of sediment disposal basins for Alternative E was based on not exceeding 10 mg/l of suspended material in the discharge stream. However, for practical purposes, the benefit of this standard is questionable because, as the next section discusses, natural inflows to the marsh exceed this regularly. Total compliance may be difficult without establishing a zone of mixing at the discharge point for return waters. Permission for zones of mixing will be included in the Section 401 Water Quality Certification permit application to DOH.

Table B-3
Estimated Sediment Transport from Average Runoff

Stream	Average Annual (1) Storm Flow (mgd)	Average Annual Sediment Discharge (Tons/year)
Maunawili	18.0	37,600[2]
Kahanaiki	***	2,200[3]
Kapaa Quarry	***	1,400[3]
Total	***	41,200

Notes:
(1) Based on U.S. Geological Survey Records at Station 2605 for 1967-1971

(2) Based on Qs = 452 Qave^^1.53
From Water Quality Program for Oahu with Special Emphasis on Waste Disposal Engineering Science, Sunn, Low, Tom and Hara Dillingham Environmental Company, 1972.

(3) Based on Figure B-5

Table B-4 Sediment Classification

Sediment Grade Scale

Size				Approximate Sieve Mesh Openings per Inch		
Millimeters		Microns	Inches	Tyler	U.S. Standard	Class
4000–2000			160–80			Very large boulders
2000–1000			80–40			Large boulders
1000–500			40–20			Medium boulders
500–250			20–10			Small boulders
250–130			10–5			Large cobbles
130–64			5–2.5			Small cobbles
64–32			2.5–1.3			Very coarse gravel
32–16			1.3–0.6			Coarse gravel
16–8			0.6–0.3	$2\frac{1}{2}$		Medium gravel
8–4			0.3–0.16	5	5	Fine gravel
4–2			0.16–0.08	9	10	Very fine gravel
2–1	2.00–1.00	2000–1000		16	18	Very coarse sand
$1–\frac{1}{2}$	1.00–0.50	1000–500		32	35	Coarse sand
$\frac{1}{2}–\frac{1}{4}$	0.50–0.25	500–250		60	60	Medium sand
$\frac{1}{4}–\frac{1}{8}$	0.25–0.125	250–125		115	120	Fine sand
$\frac{1}{8}–\frac{1}{16}$	0.125–0.062	125–62		250	230	Very fine sand
$\frac{1}{16}–\frac{1}{32}$	0.062–0.031	62–31				Coarse silt
$\frac{1}{32}–\frac{1}{64}$	0.031–0.016	31–16				Medium silt
$\frac{1}{64}–\frac{1}{128}$	0.016–0.008	16–8				Fine silt
$\frac{1}{128}–\frac{1}{256}$	0.008–0.004	8–4				Very fine silt
$\frac{1}{256}–\frac{1}{512}$	0.004–0.0020	4–2				Coarse clay
$\frac{1}{512}–\frac{1}{1024}$	0.0020–0.0010	2–1				Medium clay
$\frac{1}{1024}–\frac{1}{2048}$	0.0010–0.0005	1–0.5				Fine clay
$\frac{1}{2048}–\frac{1}{4096}$	0.0005–0.00024	0.5–0.24				Very fine clay

Table B-5
Estimate of Relative Erodibility

Assumptions:
- Permissible tractive force is the maximum unit tractive force that will not cause serious erosion and can be used (critical value in lab experiments) to compare against computed values as basis for relative erosion potential.

Basis of Evaluation:
- Unit tractive force = τ = WRS

where: τ [=] lb/ft^2
W = unit weight of water [=] 62.4 lb/ft^2
R = hydraulic radius (depth for wide shallow channel)
S = energy slope

- Permissible tractive forces are shown in Figure B-9 for cohesive and noncohesive materials.
- Unit tractive force is distributed as shown in accompanying Figure B-10.
- Comparison of computed velocities versus permissible velocities in Figure B-9 serves as a check on this evaluation.
- Energy slope = 0.0006
- Depths based on difference between design water surface and invert of channel.

Typical Values for Erodibility (lb/sf)

Alternative	D-value	Erodibility
A	15 = 10.0 ft ws - (-5.0)	0.62 = 62.4 x 15.0 x 0.00066
C	8.1 = 10.1 ft ws - 2.0	0.33 = 62.4 x 8.1 x 0.00066
D	11.6 = 11.6 ft ws - 0.0	0.48 = 62.4 x 11.6 x 0.00066

Effect of Shape (side slope and b/D)

Alternative	On Side	On Bottom	Z	b/D
A	1.4*	1.4*	10	2.67 = 40/15 (trapezoidal)
C	1.0	1.8	5	0 = 0/8.1 (triangular)
D	1.0*	2.0*	10	12.1 = 140/11.6 (trapezoidal)

* approximate values

Adjustment of Unit Tractive Force for Shape

Average Side & Bottom Factor	Alternative	τ (lb/sf)
1.40	A	0.87 = 1.40 x 0.62
1.25	C	0.41 = 1.25 x 0.33
1.50	D	0.62 = 1.50 x 0.48

Table B-6 Hawaii State Water Quality Standards for Inland Waters

Parameter	Geometric mean not to exceed the given value	Not to Exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (ug N/L)	250.0* 180.0**	520.0* 380.0**	800.0* 600.0**
Nitrate + Nitrite Nitrogen (ug [NO_3+NO_2] -N/L)	70.0* 30.0**	180.0* 90.0**	300.0* 170.0**
Total Phosphorus (ug P/L)	50.0* 30.0**	100.0* 60.0**	150.0* 80.0**
Total Nonfilterable Residue (mg/L)	20.0* 10.0**	50.0* 30.0**	80.0* 55.0**
Turbidity (N.T.U.)	5.0* 2.0**	15.0* 5.5**	25.0* 10.0**

*Wet season - November 1 through April 30.
**Dry season - May 1 through October 31.

L = liter

N.T.U. = Nephelometric Turbidity Units. A comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the intensity of scattered light, the higher the turbidity.

SECTION 3. Water and Sediment Quality

Water quality measurements were made at eight locations spread over the wetland and in the two major streams entering the marsh. Owing to logistic problems, the stations were not visited all at one time, but sampled on two occasions: March 11, 1989 and April 15, 1989. Sampling locations are shown in Figure B-8.

Nutrients

Measurement of nutrients (organic and inorganic compounds containing nitrogen and phosphorus which promote vegetation growth) were made at all eight stations. Measured were concentrations of nitrate plus nitrite (essentially nitrate in oxygenated waters), ammonia, and orthophosphate which constitute the dissolved inorganics; and both total nitrogen and total phosphorus. The latter two measurements lump together the organic and inorganic fractions, as well as the suspended and dissolved fractions. A good approximation of organic nitrogen can be calculated by subtracting the nitrate + nitrite and ammonia values from the total nitrogen value. Organic phosphorus is estimated by subtracting orthophosphate from total phosphorus.

The nutrient measurements (Table B-7) made in Maunawili and Kahanaiki Streams on April 15 show similar concentrations of nitrogen and phosphorus compounds. Although orthophosphate appears slightly elevated in Maunawili Stream as compared with Kahanaiki, both values are easily within the range of natural variation for unpolluted streams.

Stations 3A and 3B represent two channels located below the confluence of Maunawili and Kahanaiki Streams. The two locations are connected by a lateral channel and therefore represent essentially the same body of water. These samples thus provide some overlap between the two sampling dates: 3B was sampled on March 11 and 3A was sampled on April 15. A comparison of the nutrient results shows that the concentrations of nitrogen compounds were slightly greater during the April sampling as compared with the March sampling; in April, water flow was greater. Orthophosphate and total phosphorus were, however, slightly less in April than in March. Comparison with the samples collected further upstream (Stations 1 and 2) shows that there is little alteration in nutrients occurring as these stream waters combine and flow through the wet pasture land at the upper end of Kawainui Marsh.

The input from Maunawili and Kahanaiki Streams flows partly into an open body of water represented by the Station 4 sample and partly across pasture and marsh lands surrounding this pond. The nutrient content of the water at Station 4 in March 1989 was little changed from that entering the system (as measured at Stations 1, 2, and 3).

Table B-7. Results of 1989 nutrient measurements in Kawainui Marsh and tributary streams (in mg/L as N or P).

STATION		NO2+NO3	NH4	Total N	PO4	Total P
WQ 1	Maunawili Str. [1]	0.179	0.022	0.395	0.012	0.034
WQ 2	Kahanaiki Str. [1]	0.199	0.015	0.327	0.005	0.040
WQ 3	southwest (A) [1]	0.181	0.026	0.376	0.013	0.043
WQ 3	southwest (B) [2]	0.089	0.018	0.242	0.019	0.054
WQ 4	middle pond [2]	0.054	0.020	0.314	0.014	0.051
WQ 5	southeast [2]	0.003	0.275	0.626	0.247	0.339
WQ 6	east [2]	0.003	0.007	0.388	0.110	0.166
WQ 7	northeast [2]	0.001	0.014	0.378	0.070	0.123
WQ 8	northwest [1]	<0.003	0.217	1.400	0.209	0.363

1 sampled 4/15/89
2 sampled 3/11/89

Stations 5, 6, and 7 represent water flowing out of the densely vegetated parts of the marsh, collected just before entering Oneawa canal (Stations 6 and 7) and at the upper end of the city emergency ditch (Station 5). Samples from stations 6 and 7 are very similar, characterized by low dissolved nitrates and ammonia, elevated organic nitrogen, and elevated dissolved orthophosphates as compared with the input (stream) concentrations. Total nitrogen values appear unchanged or are perhaps slightly elevated, but the organic fraction accounts for a much greater proportion (over 90%).

By contrast, at Station 5, ammonia and orthophosphate are clearly elevated by an order of magnitude, and higher levels of organic forms of nitrogen and phosphorus are indicated. The character of this water would appear to be the result of biochemical activities occurring in the ditch itself rather than in the marsh prior to entering the ditch.

Station 8 represents water from beneath the vegetation mat in the northwest corner of the marsh. This water derives from a different drainage area than Maunawili Stream. The character of this water with respect to nutrient content is similar to that found at Station 5: ammonia, organic nitrogen, and orthophosphate are all elevated relative to the other samples collected.

Suspended Solids and Turbidity

Suspended solids (now termed non-filterable residue or NFR) were measured in each of the nine samples. The turbidity of these samples was also recorded. These data are presented in Table B-8. In general, the variation from place to place is not great and the only apparent pattern is related to sampling dates: the NFR of samples collected on April 15 tend to be higher generally than the NFR of samples collected on March 11. The correlation between turbidity and NFR is certainly poor, although turbidities recorded on April 15 are again higher than those recorded on March 11. The fact that mostly different kinds of water areas were sampled on the two occasions precludes any meaningful comparisons between the March and April data sets. The NFR measurements at Station 3 sampled both in March and in April differ in a direction opposite to the overall trend (whereas the trend is supported by the turbidity measurements).

Measurements of pH were made on the March 11 samples (Table B-8). Subsequently, a special "tour" of the marsh was undertaken on May 25, 1989 for the purpose of collecting pH, temperature, and dissolved oxygen data from many different places in the marsh and inflowing streams in a short span of time. These measurements were made at the stations using field probes and the results appear in Table B-9. The initial pH measurements as shown in Table B–8 indicate an increase in hydrogen ion concentration (decrease in pH units) as water passes through the marsh. The May 25 pH measurements further confirm this change. The lowering of the pH of the stream water as it flows through the marsh follows from the addition of organic acids leached from the decomposing vegetation. Water draining from the marsh is yellow-brown in color, an indication of dissolved organics leaching from the peaty material. Such material is typically acidic. The pH of the marsh water is "restored" upon contact with brackish water and limestone substrata in the drainage channel and Oneawa canal. The pH of brackish water is ordinarily close to 7.0 (neutral), whereas seawater is typically slightly alkaline at a pH of around 8.2.

Table B-8. Results of 1989 water quality measurements other than nutrients from Kawainui Marsh and tributary streams.

STATION		NFR	Turb. mg/L	pH ntu	Cl mg/L	Cond. µmhos/cm
1	Maunawili Str.	15.7	4.6	---	21.6	186
2	Kahanaiki Str. [1]	6.9	4.6	---	26.0	226
3	southwest (A) [1]	9.2	5.4	---	21.9	189
3	southwest (B) [2]	6.5	9.6	7.00	21.4	221
4	middle pond [2]	5.5	8.6	7.01	21.6	207
5	southeast [2]	5.5	18.0	6.71	24.7	252
6	east [2]	7.0	16.6	6.52	24.8	215
7	northeast [2]	7.5	9.3	6.92	30.0	259
8	northwest [1]	10.6	3.3	---	85.5	613

[1] sampled 4/15/89
[2] sampled 3/11/89

Temperature and Dissolved Oxygen

Measurements of temperature and dissolved oxygen were made in the field on May 25, 1989 and are reported here in Table B-9. Both the pH meter and the oxygen meter provided temperature readings. The temperature value given in Table B-7 is the average of these two readings differing by no more than 0.5°C.

Chlorides and Conductivity

Measurement of chlorides and conductivity relate, in this instance, to what can be termed brackishness of the water. That is, both measurements provide a conservative measure of mixing of fresh water from streams and sea water (or brackish ground water) in which the chloride content (>18,000 mg/L in seawater) and conductivity would both be high.

The samples shown in Table B-8 all show low chlorides content (<30 mg/L) and low conductivity (<260 µmhos/cm at 25°C) indicative of fresh water. The results are consistent from place to place, with the exception of the sample from Station 8 where both chloride and conductivity are slightly elevated. The increase is not great (chloride content remains less than 0.4% that of sea water), but appears real. The next highest chloride (and conductivity) was recorded at Station 7, ostensibly downstream from Station 8, although the sample was collected one month earlier.

Table B-9. Results of May 25, 1989 field measurements for temperature, pH, and dissolved oxygen at selected locations in Kawainui Marsh and tributary streams.

STATION		Time	pH	Temp. °C	DO mg/L
1	Maunawili Str.	1141	7.93	23.2	7.5
2	Kahanaiki Str.	1154	7.71	24.0	7.9
3	southwest (A)	1125	7.60	25.0	6.6
5	flow off marsh	0945	6.69	24.2	3.6
-	head end of drainage channel	0927	6.83	24.2	2.2
-	drainage channel above 1st riffle zone	1015	6.89	26.1	3.6
-	drainage channel 20 m below start of riffles	1020	6.90	25.5	3.1
7	upper end Oneawa canal at mouth of drainage channel	1035	7.05	25.8	3.2
8	northwest (2 ft below WL)	1212	7.28	24.9	1.2

Sediment Metals

Sediment samples (Table B-10) were collected at Stations 3, 5, and 8 on April 15, 1989. All samples were vertical cores of the upper sediment layer to a depth not exceeding 30 cm. A duplicate sample was taken at Station 3. The Station 8 sample was actually collected within a few meters of the old landfill (whereas the water quality station was some 30 meters away from the landfill). The Station 5 sample represents the silty mud at the bottom of the city emergency ditch.

The results of total metals analysis for selected heavy metals are given in Table B-10. In addition to analysis of a duplicate sample, an aliquot of the Station 3 sample was spiked with a known amount of each of the metals analyzed. Spikes were generally at the same order of magnitude concentrations as the initial results. Recoveries varied between 118.5% (Zn) and 87.8% (Cu) and averaged 97.4%.

Table B-10. Sediment heavy metals in Kawainui Marsh (mg/kg dry wt.)

STATION	As	Cd	Cu	Cr	Hg	Ni	Pb	Ag	Zn
SQ									
3	1.44	0.34	35.9	56.7	0.08	53.0	12.4	0.28	35.2
3	1.42	0.35	34.8	53.3	0.06	48.0	12.0	0.34	30.8
2	0.50	0.35	9.2	9.8	0.03	17.0	6.0	0.36	6.8
8	0.40	0.38	41.4	48.5	0.03	86.6	6.8	0.45	33.2

With the exception of cadmium, and perhaps mercury, both of which occur much the same concentration in all three areas sampled, the heavy metal burden of the upper marsh (Station 3) sediment is seen to be substantially greater than that of the lower marsh sediments. However, nickel in particular, was found in greatest concentration at Station 8.

The sediment samples were also analyzed for a variety of other chemical properties shown on Table B-11, for pesticides and PCBs by Gas Chromatography, and for polynuclear aromatic hydrocarbons (PAH) and phenols by EPA Method 8270 (GC/MS scan for semi-volatile organics). All of latter results are included at the end of Appendix B. However, for reporting purposes, the results of the pesticides and PCB analyses on three samples plus one duplicate, as well as the results of the GC/MS scan on three sediment samples, were all less than reporting limits. That is, none of these potentially hazardous organic compound was detected in the sediment samples.

Table B-11. Miscellaneous analyses of sediments from Kawainui Marsh (mg/kg dry wt.)

STATION	TOC	Total CN^-	Total S^-	Oil & Grease	Pet.HydroC
SQ					
3	86,000	< 1	33	<100	<100
3	38,000	< 1	32	180	<100
2	96,000	< 1	17	<100	<100
8	11,000	1.4	81	320	<100

Vegetation Mat Samples

Three samples of the vegetation mat, consisting of stems, leaves, and roots of marsh vegetation and a mixture of living plant tissue and debris in various stages of decomposition, were analyzed. These results are presented in Tables B-12 through B-16. The samples were subjected to an EPTox extraction and the extract analyzed for heavy metals. The extraction procedure provides an indication of the concentration of heavy metals that are mobilized at pH 4. That is, unlike the metals concentrations given in Table B-14 which are the total concentration of each heavy metal element in each sample, the EP Toxicity metals are concentrations that might be found in moderately acidic water percolating through the dried sample. These concentrations are given in Table B-15.

Table B-12. Some properties of vegetation mat samples from three areas in Kawainui Marsh.

Sample BQ	Total solids % wet wt	TOC mg/Kg	Ash % dry wt	Alkalinity mg/L $CaCO_3$	Density wet kg/m^3	Density dry kg/m^3
1	8.82	16,069	10.66	1110	1076	90
2	11.31	217,730	13.47	3000	900	121
3	8.95	306,000	25.69	1900	894	230

Table B-13. Chemical properties of vegetation mat samples from Kawainui Marsh (mg/kg[1]).

Sample BQ	TKN	Si[2]	P	K	Na	SO_4[3]	SO_4[4]	SO_4[5]
1	5250	2.76	612	938	718	141	1600	1598
2	4250	4.55	1184	4936	1533	575	5100	5083
3	14000	20.17	618	637	1002	107	1200	1195

1 As the element on a dry weight basis unless otherwise indicated.
2 Insoluble silica.
3 Sulfate concentration in fresh sample (wet wt basis).
4 Sulfate concentration after drying sample (dry wt basis).
5 Sulfate in fresh sample corrected to dry weight basis.

Table B-14. Heavy metals in vegetation mat samples from Kawainui Marsh (mg/kg dry wt.)

Sample BQ	As	Ba	Cd	Cr	Fe	Pb	Hg	Se	Ag
1	0.13	8.0	0.20	10.2	13720	13.9	0.032	0.046	0.20
2	0.016	19.9	[illegible].20	14.9	20390	7.5	0.016	0.058	0.49
3	0.063	5.05	.30	34.4	12450	8.0	0.024	0.023	0.23

Table B-15. EP Toxicity metals in vegetation mat samples from Kawainui Marsh (mg/L).

Sample SQ	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
1	<0.01	0.5	<0.01	<0.1	<0.1	<0.0001	<0.002	<0.01
2	<0.01	0.7	<0.01	0.4	0.1	0.003	<0.002	<0.01
3	<0.01	0.6	<0.01	<0.1	<0.1	0.0006	<0.002	<0.01

Table B-16. Additional elements measured in the EP Toxicity extracts of vegetation mat samples from Kawainui Marsh (mg/kg dry wt.)

Sample BQ	P	K	Na	Fe
1	1.1	19.9	38.4	18.0
2	6.1	29.5	40.2	102.5
3	<0.1	0.6	35.0	<0.5

Discussion

It is instructive first to compare the 1989 nutrient values with a series of dry and wet weather measurements made in 1981 and summarized here (Tables B-17 and B-18) from AECOS (1982). These values are based on averages of hourly measurements taken over three 24-hour periods between August and early October (dry period) and three 24-hour periods between late October and December (wet period). Thus, they are more representative of the waters sampled than our single measurement at each station. The significance of any differences between 1981 and 1989 must, therefore, be regarded as speculative.

Table B-17. Mean nutrient and suspended solid (NFR) concentration for major inputs to and discharges from Kawainui Marsh under dry weather conditions (mg/L) (AECOS, 1982).

Nutrient	Kahanaiki Stream	Maunawili Stream	WWTP	Kawainui Canal
Nitrate	0.027	0.700	15.9	0.0
Ammonium	0.002	0.022	---	0.006
Organic Nitrogen	0.032	0.062	11.7	0.504
Total Nitrogen	0.061	0.784	27.6	0.510
Percent Organic	52	8	42	99
Phosphate	0.005	0.215	41.8	0.013
Organic Phosphorus	0.051	0.114	17.2	0.072
Total Phosphorus	0.056	0.329	59.0	0.085
Percent Organic	91	35	30	85
Inorganic SS	1.52	3.90	---	6.9
Organic SS	0.70	1.70	---	5.2
Total SS	2.22	5.60	27.4	12.1
Percent Organic	32	0	---	43

Table B-18. Mean nutrient and suspended solid (NFR) concentration for major inputs to and discharges from Kawainui Marsh under wet weather conditions (mg/L) (AECOS, 1982).

Nutrient	Kahanaiki Stream	Maunawili Stream	WWTP	Kawainui Canal
Nitrate	0.314	0.206	15.9	0.0
Ammonium	0.001	0.003	---	0.023
Organic Nitrogen	0.287	0.804	11.7	0.628
Total Nitrogen	0.602	1.049	27.6	0.651
Percent Organic	48	80	42	96
Phosphate	0.005	0.059	41.8	0.013
Organic Phosphorus	0.090	0.283	17.2	0.159
Total Phosphorus	0.095	0.342	59.0	0.172
Percent Organic	95	82	30	92
Inorganic SS	24.0	74.7	---	10.1
Organic SS	7.3	21.8	---	10.4
Total SS	31.3	96.5	27.4	20.5
Percent Organic	23	22	---	50

Important differences appear with respect to stream inputs. In 1981, Maunawili Stream was receiving a greater volume of WWTP effluents, and differed appreciably from Kahanaiki Stream with respect to all measured forms of nutrient loadings. Our recent survey found little difference in the water quality of these two streams, and values which are generally close to the 1981 wet weather conditions in Kahanaiki Stream. One exception is ammonia, which is presently found at levels in both streams comparable to 1981 dry weather conditions in Maunawili Stream. The percent organic nitrogen for Maunawili Stream in 1989 was 48%; for Kahanaiki the value is 34%. The situation with respect to forms of phosphorus is the same; the 1989 values being roughly equivalent to 1981 Kahanaiki Stream wet weather values.

Additional nutrient data are available for Maunawili Stream, collected from just upstream of Station 1 and analyzed by AECOS, Inc. in 1988 (Table B-19). The nitrite plus nitrate and total N values fit very well with the 1989 Station 1 measurements. Total P values are slightly higher. However, AECOS (1981) found that total P increased in Kahanaiki Stream from the dry period to the wet period, with the wet period mean being 0.095 mg P/L. Also, the 1988 samples precede the diversion of Maunawili Park WWTP by two months. The data in Table B-19 help to confirm that the differences seen in Maunawili Stream in 1989 as compared with 1981 are in fact real and are likely a result of the diversion of Maunawili Park WWTP effluent (around 0.10 mgd) from the stream.

Table B-19. Miscellaneous nutrient measurements from lower Maunawili Stream (mg/L as N or P).

Sample Date	$NO_2 + NO_3$	TN	TP
02/08/88	0.182	0.381	0.056
02/10/88	0.168	0.315	0.050
02/12/88	0.198	0.314	0.056

The AECOS, 1981 study made no measurements within the marsh, but included a series of measurements taken at the head of Oneawa canal, in a location which corresponds closely with Station 7. Comparing 1989 Station 7 results with the 1981 Oneawa canal "marsh station" shows many basic similarities. Nitrate is very low, ammonia is elevated, and organic nitrogen accounts for most of the nitrogen in the water flowing out of the marsh (96% in the 1981 wet season and in 1989). Total phosphorus values are very similar, although a higher orthophosphate value in 1989 produces a much lower calculated proportion of organic phosphorus (43%) as compared with 1981.

The two "unique" samples in the data set are from Stations 5 and 8. Although these two samples are from different areas, one from the City and County emergency ditch, the other from the interior of the marsh, they have in common one important characteristic. Both areas are typified by (relatively) deep, still water.

Measurements of stream suspended solids (NFR) in 1989 gave values comparable to dry weather conditions in Maunawili Stream in 1981. Considering that the NFR will vary tremendously during flood conditions, the differences between Maunawili and Kahanaiki Streams in 1989 and between these streams comparing 1981 to 1989, are not significant. NFRs measured at our Station 7 (and Station 6) and at the 1981 marsh station were also not greatly different.

A number of metals, while considered priority pollutants, do occur naturally in the environment at relatively high concentrations. Usually, these metals are complexed in insoluble forms and are therefore not very mobile (that is, do not move readily into solution in the aquatic environment). The toxicity of these precipitated or adsorbed forms is not very great under circumstances normally encountered in aquatic environments because they remain bound to the sediment so long as the pH is neutral or slightly basic, becoming soluble only if the pH shifts to acidic. Comparison of metals concentrations using the total recoverable method (Table B–14) and the RCRA EP Tox extraction method (Table B-15) provides an indication of the mobility of metals in Kawainui vegetation material. The EP Tox extraction procedure at pH 5 tends to release more metal into solution than will occur in the pH range of 6 to 8 which is typical of waters in the marsh.

A number of heavy metals are present naturally in weathered basalts (Nakamura and Sherman, 1958) and therefore would be expected in sediments derived from erosion of terrigenous material, as is shown in Table B-20. For example, chromium appears to be naturally concentrated in weathered basalts, becoming less concentrated as the soil is eroded and carried as bedload in a stream and then added to coastal deposits. Lead, although leached out of the parent material, is complexed in the fine deposits of stream and particularly estuarine sediments, where its concentration rises.

Table B-20. Heavy Metals Concentrations (ppm*) in Basalts, Soils, and Stream Bed and Coastal Sediments in Hawaii.

METAL	KOLOA BASALTS[1]	KOLOA SAPROLITE[1]	KU TREE SEDIMENTS[2]	KAHANA SEDIMENTS[3]	COASTAL SEDIMENTS[4]
As			2-17	3-12	ND-29
Cd			ND-2	ND-2	ND-10
Cr	400	560-860	209-403	47-147	1-122
Cu	290	33-80	47-160	ND-160	
Hg			0.3-0.5	ND-0.2	ND-2
Ni	840	250-580	108-350	ND-350	
Pb	12	0.5-3	21-34	5-34	5-58
Zn					ND-105

* Table values are mg/Kg (ppm) of dried material.
1 Patterson, 1971; basalt and weathered basalt.
2 AECOS, 1984; Ku Tree Reservoir.
3 Lau, et al., 1973; Kahana Stream sediments.
4 Lau, et al., 1973; Kahana Bay sediments.

In a study (Table B-21) of heavy metals in estuarine sediments in Hawaii (DOH, 1978), the State Dept. of Health found a relative abundance of nickel, zinc, chromium, lead, and copper and concluded that "... [estuarine sediment] metal concentrations in general appear to be influenced by soil mineral composition and weathering of Hawaiian basalts ..." This source would be what Jonasson and Timperley (1975) term the "catchment regime."

With regard to the results presented in Table B-21, it is to be noted that Kahana Bay, on Oahu's windward coast, is a relatively pristine area with an undeveloped watershed. Ku Tree Reservoir represents an equally pristine watershed in the Koolau Range east of Wahiawa on Oahu. However, activities (military training or dam construction) around the reservoir may have influenced sediment metals values at this location. Nonetheless, the values in Table B-21 are intended to be representative of the catchment and estuarine regimes in the absence of anthropogenic (pollution) influences. These values are in line with the natural contents of heavy metals in fine sediments from tropical rivers (Thailand and Java) reported in de Groot and Allersma (1975).

Although many of the heavy metals present in our local soils and sediments can be attributed to the geochemistry of the catchment regime (i.e., volcanic), Jonasson and Timperley, 1975 demonstrate that urban pollution is a significant contributor to some estuarine sediment concentrations. Locations which are clearly the more urban/industrial of those sampled in the DOH study are the Ala Wai Canal (Waikiki) and Kapalama Canal (Kalihi), and for most of the metals measured these two locations show the highest levels reported (exceptions being cadmium and arsenic).

Proposed state pollutant standards for freshwaters will establish the following "chronic" pollutant levels for heavy metals:

Arsenic - 0.19 mg/l
Cadmium - 0.003 mg/l
Chromium - 0.011 mg/l *
Copper - 0.006 mg/l
Lead - 0.029 mg/l *
Mercury - 0.00055 mg/l *
Nickel - 0.005 mg/l
Selenium - 0.005 mg/l
Silver - 0.001 mg/l
Zinc - 0.022 mg/l

The asterisk (*) indicates the elements that were extracted at levels that exceed the standard when the vegetation was tested using the EP Toxicity procedure.

The concern with heavy metals is that the runoff from vegetation and sediments taken from the marsh must not be allowed to acidify, which could mobilize the ions to the degree indicated in the above tests. Acid conditions could result when the sediments are exposed to the air and hydrogen sulfide is converted to hydrogen sulfate. Additional tests were made for the heavy metals mobility in sediments to predict the levels of pollution that might occur with alternatives (e.g. Alternative A) that involve large amounts of dredge material disposal and the runoff cannot be contained in the available disposal area.

Heavy metals are entombed in the sediments and concentrated through plant uptake into fibrous tissue in the biomass. Table B-10 through B-15 contain data from DEIS investigations of sediment and vegetation quality. Continuous monitoring of the sediment and vegetation removed from the marsh is not required by existing environmental rules and regulations. An inquiry was made with the Department of Health, Hazardous Waste Section concerning hazardous waste notification requirements. EPA notification reuirements would apply only if test results from representatie samples exceed requirements of 40 CFR 261.20-261.24. Periodic testing and laboratory analysis will be conducted as a requirement of the maintenance program. The research that was done on this topic to reach this assessment is presented subsequently below.

The potential issue of metal toxicity in the environment is discussed in terms of the two media - sediment that is desiccated in a drying bed and vegetation that is compacted and transported off site for disposal. Present plans are for disposal of the sediment into a landfill facility. Two methods of vegetation disposal have been identified: 1) landfill disposal and 2) anaerobic digestion. The second method reuses the biomass decomposition materials in the form of either animal feed supplements or soil amendments. In either case, the fate and potential for toxicity in the environment must be assessed.

Table B-10 presents the metal concentrations that were determined from sediment sampled from relatively shallow depths (using a sample tube five feet in length). Additional samples were analyzed that have been taken at depths up to fifteen feet below the top of the sediments along proposed alignments to waterways.

Based on the available data at this time, however, the maximum EP TOX concentrations obtained in marsh sediments and vegetation samples shown below do not warrant characterizing the sediments or vegetation as EP toxic wastes for landfill disposal purposes.

Comparisons of EP TOX Extraction Metal Concentrations
(mg/L) to EP Toxicity Criteria

	METAL			
	As	Ba	Cd	Cr
Kawainui Sediments [a]	<0.05	<1	<0.1	0.7
Kawainui Vegetation [b]	<0.01	0.7	<0.01	0.4
Maximum Concentration [c]	5.0	100.0	1.0	5.0
	Pb	**Hg**	**Se**	**Ag**
Kawainui Sediments	<0.5	<0.01	<0.05	<0.1
Kawainui Vegetation	0.01	0.003	<0.002	<0.01
Maximum Concentration	5.0	0.2	1.0	5.0

Notes:

a) Maximum concentration measured from sediments SM-6, SM-7, SM-8 sampled March 1990

b) Maximum concentration measured from vegetation BQ-1, BQ-2, BQ-3 sampled 1989 and reported in Table B-15, DEIS

c) Table I-Maximum Concentration of Contaminants for Characteristic of EP Toxicity; CFR 40-261 Protection of Environment, July 1, 1985.

In addition to metals analyses, analyses of the sediments for pesticides and PCB's did not indicate the presence of these types of compounds at concentrations above the reporting limits.

The test data above indicate that provided the acidity does increase above the levels simulated by the EP TOX analysis, namely, pH of 5, the toxicity of the metals in solution will remain below acceptable criteria for landfill disposal.

Relative to proposed state pollutant standards for heavy metals, chromium, lead and mercury concentrations may exceed proposed standards for chronic unless surface runoff from sediment and vegetation handling and disposal areas remains neutral or only slightly acid. To control the runoff quality, the construction specifications will require testing the pH of return water that has drained after harvesting and dredging and to require the application of lime is the pH falls below 6.0. This will provide return water of comparable acidity to that drawn from the marsh. A polishing pond will be included in the design to provide additional suspended solids removal and pH control. A zone of mixing will be established immediately below the discharge point of the return flow from sediments for dilution of concentrations exceeding 10 mg/L suspended solids. This zone will be within the waterway limit and periodically dredged of excess accumulation.

Application of the vegetation as a soil amendment to lawns and other non-agricultural land would also be permitted under the proposed rules for the use and disposal of sewage sludge. Note this does not infer that the material extracted from the marsh should be technically classified as sewage sludge. It is meant to infer that if these standards were applied, because they are deemed technically conservative relative to health and safety of the environment, then the fate of the metals in the environment should pose no serious health risks. For example, the proposed national pollutant limits for metals (Federal/Vol. 54, No. 23/February 6, 1989 are as follows (for metals):

Comparison of Vegetation Metals to Maximum Sewage Sludge Concentration for Non-Agricultural Land (mg/kg)

	As	Cd	Cr	Cu
Kawainui Vegetation	0.063	0.30	34.4	--
Maximum Concentration	36	380	3100	3300

	Pb	Hg	Ni	Se	Zn
Kawainui Vegetation	13.9	0.032	--	0.058	--
Maximum Concentration	1600	30	990	64	8600

Table B-21
Distribution of Heavy Metals in Hawaiian Estuarine Sediments (after DOH, 1978)

Location	Metal (Mean - ppm Dry Weight)							
	Copper	Zinc	Lead	Cadmium	Chromium	Nickel	Mercury	Arsenic
Kaneohe Bay	72.7	120.9	80.0	2.5	184.2	161.1	0.3	19.8
Pearl Harbor, West Loch		231.6	96.3	<10	198.3	108.5	0.6	4.5
Ala Wai Canal		385.9	534.6	3.5	230.5	197.3	1.4	13.6
Kapalama Canal	272.9	523.4	391.9	6.5	126.3	100.1	1.1	16.7
Kaiaka Bay	103.1	132.4	32.9	<10	200.3	248.9	0.4	12.3
Kahana Bay	21.6	43.8	95.6	11.1	19.9	81.1	<.25	18.5
Nawiliwili Bay	77.5	83.0	56.3	21.6	346.8	249.2	<.25	13.5
Hanapepe Bay	8	116.1	35.3	3.5	211.8	400.0	<.25	19.3
Manele/Hulopoe	[illegible]	71.4	<100	<10	117.8	427.0	<.25	<4
Hilo Bay	98.2	197.8	114.7	5.0	207.1	125.8	0.8	675.4

SECTION 4. Ocean and Estuarine Conditions

Kaelepulu Stream Estuary

Kaelepulu Stream terminates at Kailua Beach Park towards the southern end of Kailua bay and originates on the Coconut Grove side of the levee in the north-eastern corner of Kawainui Marsh. Presently, four canals discharge into Kaelepulu Stream from the Coconut Grove area. In all there are thirteen major and minor storm water discharge points between the head of the stream and Kailua Road. This portion of the stream is a man-made canal, however the portion to the south appears to have been formed naturally. The Kawainui Marsh Management plan contains a figure which shows this outlet to Kailua Bay could have existed approximately 200 years ago. Another figure (Smith, 1978) shows the stream as the only outlet from the marsh in 1851.

The estuarine conditions in the stream are a function of the tides and the condition of the outlet. When the outlet is blocked by the sand bar that periodically forms at the mouth of the stream at Kailua Bay, the water quality in the stream resembles that of a inland stream rather than an estuary. However, when the outlet is open to the influence of the tides, the water within the stream becomes markedly brackish resembling an estuary. For example, Smith (1978) reports one water sample made in the stream that measured 18 parts per thousand (18,000 ppm) salinity. This is the same order of magnitude for the salinity measured several feet below the surface in Oneawa Canal. The Kaelepulu Stream bottom is below sea level (Figure A-67) which is why the salt water will intrude over a large length of the stream when the outlet is open to Kailua Bay.

Selected water quality measurements were made in Kaelepulu Stream within the reach adjoining Coconut Grove in July 1989. Measurements of salinity, temperature, and dissolved oxygen for Kaelepulu Stream were determined by taking readings on two separate days at various locations. Testing sites were chosen corresponding to survey cross-section locations. The stations and cross-sections are shown in Figure B-11; test results are shown in Figure B–12.

The surface salinity ranged from 2.4 to 3.3 parts per thousand (ppt) for measurements taken at depths of 0.7 and 1.2 feet below the water surface respectively, with an average value of 2.84 ppt taken from 9 measurement stations along Kaelepulu Stream. The same maximum and minimum salinity values occurred at the same station for both the eight and two tenths of the stream depth. The lowest salinity values occurred at station 55+50 at both the 0.7 and 2.9 feet below the water surface, and the highest value of 3.5 ppt occurred at station 54+21 at 3.0 feet below the water surface. This constant salinity at variable depths, and variable salinity at station locations indicates little or no salinity stratification corresponding to stream depth, but a gradual salinity gradient along Kaelepulu Stream's length, with the exception of the upstream end. Figure B-12 shows a slight increase in salinity at the head (Oneawa canal) end.

Morning temperature readings were approximately 3.4 degrees lower than the average afternoon temperature readings. The average "afternoon" temperature (30°C) readings were higher than the "noon" temperature readings (29°C). Temperature readings seemed to be more stable at test stations 18+00 to 9+00 located near the canal outlets discharging into Kaelepulu Stream. The lowest temperature reading of all three temperature sets were found to be at station 0+00, which coincides with the lowest flow rate, and slightly higher salinity, at that point.

The dissolved oxygen results yielded average readings of 3.2 and 6.9 ppm for the morning and afternoon tests respectively. The difference (3.7 ppm) in the morning and afternoon dissolved oxygen readings were more than double the average morning reading of 3.2 ppm. This is attributed to photosynthetic oxygen production by algae within the water column.

The portion of the stream in the immediate project area is bordered by Coconut Grove along its eastern bank, and the Federal levee of Kawainui Marsh on the western edge. The bank adjacent to Kawainui Marsh of Kaelepulu Stream is predominantly the facultative wetland species California grass on alluvial soil. The facultative species prefer wetland habitats, where the amount of soil water during all or part of the year is greater than optimal for the average plant. Because of the stream proximity adjacent to the levee, and the effects of it's construction, certain stretches of the stream bank appear extremely dry, whereas other areas at greater distance from the levee are dispersed with great bulrush (*Scirpus lacustris*) which is more adapted for growth only in water or in soils containing excessive amounts of water. Obligate species often display morphological or structural specializations, such as sponginess of tissue, or special aerating mechanisms, which allow them to cope with their unusual oxygen deficient environment. The bank adjacent to Coconut Grove experiences patches of Indian pluchea (*Pluchea indica*) frequently found on margins of Hawaiian wet lands, particularly salt marshes and brackish areas, where it often forms dense thickets. The roots are sometimes used as a medicine, while the leaves may be used to color or flavor food. The majority of the Coconut Grove bank is predominantly domestic vegetation, planted by residents of the area.

All four endangered Hawaiian waterbirds have been observed in Kaelepulu Stream, although the existing waterbird population consists mainly of the Hawaiian Duck (Koloa), which are presently interbreeding with feral mallards. Some of the more common Hawaiian birds have also been seen within the stream area, like the Majido sparrow, and the Mynabird.

Like other corresponding fauna found in Kawainui Marsh, Kaelepulu Stream provides habitat for mongoose, dogs, feral cats, and rats.

Cross sections taken of Oneawa canal near the exit of Kawainui Marsh show the canal is relatively deeper than either Kaelepulu Stream to the south across the levee or the emergency ditch that extends to the south along the levee and within the marsh.

Table B-22 provides some salinity measurements taken at the outlet of the marsh at the USGS staff gage (2648A); approximately Station 93+00 (Oneawa Canal Stationing).

The presence of a zone of dense, saline water is indicated by a marked stratification in salinity. Fresh water flows in the upper few feet of the canal and brackish water exists at greater depths.

Identification of Potential Impacts to Kaelepulu

Table B-23 compares Oneawa canal and Kaelepulu Stream in terms of abiotic and biotic parameters. In terms of surface salinity, the two channels are comparable, but the fresh water invertebrates and fish indicate a more fresh water environment in the upper end of Kaelepulu Stream.

A major effect of the outlet between Kaelepulu Stream and Oneawa canal is lowering the water level in the former. The amount of change is dependent upon tides, precipitation, and ground water levels. Thus the effect must be stated in terms of a range of values. Elevation differences between water surfaces in the two water bodies at close proximity were surveyed as part of this environmental assessment and on one occasion found only 0.4 to 0.5 feet difference between Oneawa and Kaelepulu Stream (the latter being higher). The U. S.

Table B-22
Salinity Measurements in Oneawa Canal, 26 March 1989

Low Tide			High Tide		
Elevation (msl)	Depth (BWS)	Salinity (ppt)	Elevation (msl)	Depth (BWS)	Salinity (ppt)
-2.3	1.5	2.1	-0.6	1.5	4.6
-3.8	3.0	18.6	-2.1	3.0	20.8
-5.3	4.5	19.5	-3.6	4.5	21.0
-6.8	6.0	20.0	-5.1	6.0	21.6

Note: Salinity measured 4.6 ppt at -0.6 ft, msl

Table B-23 Biological Comparison of Kaelepulu Stream and Oneawa Canal
Source: Student Papers, Kailua High School, Biology Class for Mr. Todd Hendricks

Name / Date / Time / Tide	17-Mar-82 8:30 0.4	B. Riss 8-Mar-83 12:30 0.4		Hendricks 16-Apr-85	J. Weller 22-Apr-86 8:30	A. Shinn 28-Apr-87 8:30 0	T. Nakamura 3-May-88	S. Mas-Morel 2-May-89 8:30 -0.3
Abiotic								
Wind Direction	variable	NE	E/NE	E	NE	NE	SE/variable	NE/variable
Wind Speed	0-5	0 - 5	5 - 10		10 - 20	10 - 15	0 - 3	5 - 10
Weather Condition	cloudy	p.cloudy	cloudy,rain		p.cloudy	m.cloudy	cloudy	m.sunny
Water Temperature (C)	22.0	26.0	26.0	25.0	28.0	20.0	26.0	25.5
Water Temperature (F)	70.0	77.0		78.0	82.4	68.0		
Paper-pH	7.5, 6.5	6.0	7.2	7.4	7.2	6.0	7.1	7.0
Hach cube set-pH		7.0	8.5			7.8	8.0, 6.5	8.1, 7.8
Liquid Test-pH			[illegible]		7.7	6.8	7.5	8.5
Hydrometer	0.009	1.004, 9.0	1.006, 11.0	1.000	1.000, 6.0	1.000, 3.0	1.000, 4.0	1.005
Salinity Titration Kit (ppt)	2.0, 2.0	7.0	.0, 10.0, 9.0	1.8, 1.0	4.0, 2.5, 3.0	1.0, 2.0	9.0, 8.4, 8.5	7.5, 8.5
Turbidity-Secchi (m)	0.152					0.925		
Dissolved Oxygen								
O2-Hach Kits		9.0	10.0, 12.0					
O2-Titration (ppm)	3.2	4.0	6.0	5.0, 3.0	2.2, 2.4	6.6, 6.4	3.5, 2.2	3.2, 3.5
Biotic								
plankton								
invertebrates	S-1,O-9,					P-10,F-12		F-U
fish	T-7,O-2,A-1					G-U		M-U,T-U
Oneawa Cannal								
Abiotic								
Wind Direction	variable	NE	E/NE	E	NE	NE	SE/variable	NE/variable
Wind Speed (mph)	0-5	0 - 5	0 - 5		10 - 20	10 - 15	0 - 3	5 - 10
Weather Condition	cloudy	p.cloudy	cloudy,rain		p.cloudy	m.cloudy	cloudy	m.sunny
Water Temperature (C)		27.0	27.0		25.0	20.0	26.0	23.0
Water Temperature (F)		80.0		69.0	77.0	68.0		
Paper-pH	8.0, 7.5, 8.0	7.0	7.5	7.1	6.8, 6.8	7.0	7.0	6.3
Hach cube set-pH		7.5	9.0			7.0	7.2, 6.0	7.8, 8.5
Liquid Test-pH			8.0		6.5	7.7	7.6	6.7
Hydrometer	0.009	1.001, 6.0	0.008, 4.5	1.001	1.000, 4.0	1.000, 3.0	1.001, 6.0	1.000
Salinity Titration Kit (ppt)	0	6.0	3.0, 3.0	4.0, 3.0	2.0, 2.0	2.0, 2.0	4.0, 5.0, 8.0	2.5
Turbidity-Secchi (ppm)					1.2			
Dissoved Oxygen								
O2-Hach Kits		5.0	9.0, 9.0					
O2-Titration (ppm)	1.7, 1.8	2.6	4.0	5.0, 6.0	2.0, 1.8	5.9, 5.8	3.6, 4.0	2.8, 3.9
Biotic								
plankton	P-U						P-U	
invertebrates						S-1,H-4,B-1	F,O,B,T-U	O-U,F-U
fish						G-U	G,T-U	G-U,T-U

Note: That the salinity measurements were taken at the surface of the water.
The data does not take into account the salinity water wedge effect.

Biotic Key:
Invertebrates:
A-Tahitian Prawn
B-Blue Pincher Crab
D-Dragon Fly Larve
F-Fresh Water Snails
H-Hawaiian Crab

O-Opai
P-Tadpoles
R-Crabs
S-Samoan Crab

Fish:
A-Aholehole
G-Guppies
I-Fish
M-Mosquito Fish
O-Oopu
[illegible]

Notes:
E-Easterly
NE-North Easterly
P-Plankton
S-Southerly
SE-South Easterly
[illegible]

Geological Survey shows water surface elevations in Kaelepulu varying between 1.5 to 3.7 feet, generally about 2.5 feet. Oneawa canal, which is tidal, exhibits elevations slightly higher than tide elevations at the coast. Assuming mean lower low water is approximately -0.6 feet, msl, in Oneawa canal, a typical upper range for the decrease in Kaelepulu water level is estimated by subtracting - 0.6 from 2.5 yielding 3.1 feet. Thus a range of approximately 0.6 to 3.1 feet is given here as the expected decrease in the water level in Kaelepulu Stream. This will impact the banks creating drier conditions and altering the environment for the wetland plant species. It is likely these species will be replaced along the stream banks by plants more adapted to drier conditions.

The tentative design of the Kaelepulu outlet was based on the higher invert (upstream side) of the Alternative C box culvert at elevation -0.5 feet, msl. At this setting, water salinity in Kaelepulu Stream is expected to be more saline compared with existing conditions more often. At times, there will be little difference, however. For example, measurements at elevation -0.6 feet in Oneawa canal indicate the concentration (4.6 ppt on Table B-22) will be comparable to conditions shown on Figure B-12.

With construction of an outlet in the northern end of Kaelepulu Stream, water circulation from Oneawa into Kaelepulu, will introduce most of the aquatic fauna found in Oneawa like the aholehole, mullet, barracuda, o'opu, and lizard fish. This increase in aquatic residence along with the decrease in water level would lead to increased competition for habitat. Since Oneawa canal experiences salinity gradients ranging from 2-20 ppt between low and high tides (at various depths), the opening of Kaelepulu to Oneawa canal will lead to salinity increases corresponding with the salinity gradient in the surface level of Oneawa canal. The effect on vegetation along Kaelepulu is a gradual replacement with salt tolerant species similar to vegetation along the upper stretches of Oneawa canal. Invertebrate populations will be adversely effected in Kaelepulu Stream.

An outlet at the northern end of Kaelepulu Stream may cause a decrease in stream water elevation, resulting in lower soil water saturation levels along the ITT parcel edge bordering Kaelepulu Stream. Flood overtopping of the levee with Alternative C would occur with the same relative frequency as under existing conditions and thus not offset this effect. Maintaining minimum water levels in the marsh with the low flow weir will retain a hydraulic gradient between the marsh and stream. Because most of this wetland area (ITT) is at or below 3.0 feet, msl, ground water movement between the marsh to the stream will maintain saturated conditions in this area.

Kailua Bay

Circulation studies (Bathen, 1972) using surface drift cards indicate ". . . that a rather consistent surface onshore drift can be found in the Bay during the seasons when tradewinds predominate. This onshore drift is estimated to range between 10 to 25 cm sec-1 in strength. As is indicated in the vertical current profile data this surface wind influenced layer extends from the surface to approximately the 5m depth. Tradewinds blowing onshore from the northeast quadrant generally predominate in this area from April through November and a surface onshore drift would be expected during these months. During December to March the prevailing wind directions can be variable, coming from all other quadrants in addition to tradewinds from the northeast. January is the month of most significant deviation from the predominate tradewind pattern, and it statistically represents the month of potentially strongest and most frequent Kona, or southerly, winds blowing offshore. During these months the surface drift may be onshore, alongshore or offshore, but it is anticipated the surface wind drift would be weak."

Figure B-13 shows the direction of this surface drift for one period, February 1972. In this case, storm runoff exiting Oneawa canal would be transported onshore and alongshore towards Kailua Beach Park to the south. Turbid storm runoff also enters the southern part of Kailua Bay from Kaelepulu Stream.

SECTION 5. Vegetation - Primary Productivity and Management

Introduction

One of the most important natural resource values of Kawainui Marsh, is its primary productivity. The many wetlands habitat values and functions, such as feeding, resting, and nesting areas for wildlife, are all functionally derived from the primary productivity of the wetland area. These areas are large food factories that incorporate nutrients, sunlight energy, and through photosynthesis, produce large quantities of living plant tissue. The objective of this section is to summarize the technical basis for this statement, and to evaluate alternative means to manage the resultant primary productivity.

Studies of agricultural productivity and wetlands primary productivity indicate that wetlands are among the most productive systems on the face of the earth. Early successional stages (such as mono-specific stands of grasses) are more productive that later ecological stages (shrubs, pole stage trees, and swamps). Consequently, many strategies for wetlands vegetation management favor keeping the wetlands in their early ecological successional stages to enhance primary productivity.

The ecological importance of primary productivity and concurrent detritus production in wetland ecosystems has been well documented in the literature (Odum, 1961, Odum and de la Cruz 1963, Gosselink, et al. 1974). Reimold, et al. 1980). A majority of studies of coastal wetlands ecosystem energetics have been primarily based on studies of *Spartina alterniflora* (Johnson, 1970, Kirby, 1976, and Kirby and Gosselink, 1976).

In addition to measurement of primary productivity and detritus production, contemporary studies have also focused on mathematical models of *Spartina* wetlands productivity. The models incorporate algal activity, nutrient cycling, aerial harvest data, and below-ground biomass production, and are utilized to project the impacts of various perturbations (Pomeroy et al., 1972, Day et al., 1973, Reimold, 1974; and Wiegert et al., 1975). Other than species of the genus *Spartina*, few coastal wetlands plants have been subjected to such detailed studies relative to marsh perturbation to and management decisions. These other species have generally been considered less important or "minor species," mainly because of their lesser areal extent when contrasted with the expanse and volumes of scientific literature related to *Spartina alterniflora*. More recent studies have focused on the productivity of many of these minor plant species (Linthurst and Reimold 1978a, Gallagher et al., 1980, Good et al., 1982), and contemporary means for making accurate productivity measurements of these species (Linthurst and Reimold, 1978b, and Singh et al., 1975).

Vegetation - Primary Productivity

Vegetation in Kawainui Marsh can generally be divided into two major communities (Smith, 1978). In the area toward the north, there is a bulrush marsh (*Scirpus* spp.), with floating mats of live vegetation and peat deposits. In the more dry part toward the south and west, there is a bog meadow of California grass occupying mineral soils (rather than peat). Both communities are supplied with water by several streams (as described in Appendix A, Section 1).

The bulrush community consists mainly of the California bulrush. Within this community, including some 18 different plant species (Smith, 1978), thick mats of roots and living plant materials are formed, due to incomplete decay of the detritus (dead vegetation). These detritus mats provide a pseudo-terrestrial environment supporting other members of the vegetative community including paperbark trees, wild sugarcane (*Saccharum spontaneum*), and sawgrass, and *Cladium jamaicense*). In some areas, *Cladium* and *Scirpus* form thin mats which float on a slurry of organic muds. In other locations, pure stands of sawgrass form transition areas between the bulrush and other grass communities.

A second vegetative community in Kawainui Marsh is dominated by California grass. This community, located in the more south and west portion of the marsh, grows on alluvial soils. This area has a lower plant species diversity (only 6 species) than the bulrush community, and is an important grassland lowland pasture (Smith, 1978).

The Hawaiians used Kawainui Marsh as an active freshwater fishpond of 180 hectares (445 acres). Smith (1978) believes this size to be validated by the extent of peat deposits sampled and reported by Dames and Moore (1961). The time at which anthropogenic activities by the Hawaiians ceased has not been established (personal communication, Joyce Bath), but it is possible that the growth of wetland vegetation may have begun in portions of the marsh prior to the cessation of their activities. Smith (1978) shows a composite map depicting the area of water and rice and dry land farming around the borders of the marsh approximately 1884-1890. Large portions of the interior were apparently not used for agriculture. The marsh is shown to be over 3 kilometers wide on this map, and presumably some of the interior contained wetland vegetation such as sedges as Smith concludes "... bulrush was present in the marsh, as a native plant, from pre-Polynesian times." During the late 1800s rice became an important use of lands within and along the borders of the marsh. Later weirs were constructed over the years to prevent seawater from intruding into the marsh because the marsh water was diverted for agricultural purposes. Over time, water levels began to decrease, rice cultivation was introduced and, as early as the 1890s, cattle grazing began to dominate the upland area. Introduced plant species include cattail, water hyacinth, and California grass. Siltation, effluent discharge, and flood control measures have effected the nutrient circulation in the basin, but the predominant plant species have been established for at least 100 years and perhaps several centuries.

Wetland vegetation is believed to have been dominant in the marsh since the early 1900s. It certainly existed before the construction of the Federal levee in 1966. Figure B-1 shows a January 1945 aerial photo of the marsh on which the sawgrass and bulrush community is clearly distinguishable from the California grass that was introduced (at an earlier period) for cattle grazing. Also readily noticeable are the canal alignments that cross the interior of the marsh diverting water to the pumping station near Kailua Road in the southeast corner of the marsh. The original drainage to Kaelepulu Stream to the south is also distinguishable. These canal building activities and maintenance were obviously done at a time when marsh levels were much lower than at present. A weir was constructed at Kailua Road to prevent salt water intrusion.

The cessation of irrigation withdrawals in 1965 along with the construction of the levee in 1966 resulted in a significant increase in average water levels (Appendix A, Section 4). The levee construction blocked the natural drainage to the south and the cessation of irrigation withdrawals occurred at approximately the same period; the relative impact of each action on higher water levels is unknown. It is instructive to note, however, that the Dames and Moore (1961) borings show the water level at sea level in the interior of the marsh. Higher water levels will increase the distribution of water within the marsh for the entire spectrum of inflows. There is no comparative productivity data before the levee construction, however, to determine how much the increased levels could have stimulated productivity resulting in additional material for the peat mat and provided additional sediment products derived from the decomposition process.

Figure B-2 shows the marsh as it appeared in January 1986. Note that the bulrush and sawgrass community has moved farther to the southeast and the open water ponds in the southwest that were previously surrounded by pasture are enlarged. The vestiges of the earlier irrigation canal is still discernible near the present model airplane field. Interestingly, the California grass community is still predominant in the southeast and has not been dominated by bulrush. However, the lighter shaded areas near the outlet to Oneawa canal to the northeast are indicative of vegetation which favors drier (and higher elevations) that existed in 1945 (see Figure B-1). Figure B-2 shows this area in greater detail.

The significance of the above information is that consideration must be given with each alternative to the long term effects that manipulation of water levels have on the hydrologic patterns within the marsh. It is evident from this photographic comparison that changes in vegetation occurred with previous water level changes. Mechanical harvesters can remove vegetation at selected alignments but do not address the entire marsh. Long-term flood damage mitigation measures need a built in factor for this succession and accompanying elevation changes.

Smith (1978) has prepared a description of all the emergent macrophytes in Kawainui Marsh, and made preliminary measurements of standing crop biomass of several plant genera in the wetlands. While there is a paucity of site specific data on the primary productivity and detritus production of specific individual species of the indigenous flora of Kawainui Marsh (Corn, 1989), comparisons of limited data developed by Smith (1978) with data developed in other geographic locations are instructive in establishing the estimated order of magnitude of productivity (Table B-24). Note that Smith's (1978) estimate of peak standing crop productivity for Kawainui marsh species ranks among the highest of those reported.

Estimates of net productivity provide some insight as to the rate of sedimentation from organic sources, and thus help identify the magnitude of the feedback from the marsh environment upon the hydrology and management of flood losses. The approach used herein is based upon a simplified categorization of the vegetation into the above noted bulrush association and grass association.

Net productivity following Smith's report (1978) is defined as

$$P = \frac{\text{Sum Change Total Standing Crop}}{\text{Number of Days}} + \text{Decay Constant} \times \text{Standing Litter}$$

Productivity and decomposition rates below the surface have received little attention in studies of the marsh. For the estimate herein, it was assumed that submerged production of the grass community equalled above ground productivity which was measured by Smith (1978). The submerged productivity for the bulrush association was assumed to be 40 percent of the standing crop productivity based on data reported in Mitsch and Gosselink (1986). The Smith report (1978) notes that the grass association root system readily decomposes but that portions of the bulrush association remain as peat for an extended period of time. Using the decay constant value in Smith's report (1978) shown in Table B-25, the half-life of litter material was estimated as 0.9 year. The decay rate for the peat mat was assumed 50 percent of the rate for the standing crop. Rounding these values to the nearest year, the accumulation of organic matter over an ten year cycle was estimated as shown in Table B-25. In other words, the amount of vegetation in the marsh was assumed to be the summation of that years' standing and submerged production plus the amount that remains from previous years production. The variation between grazed and ungrazed grass was noted and taken into account. Based on Table B-25, an estimate of the total amount of biomass in the marsh is 34,986 metric tons.

Table B-24. COMPARISON OF WETLANDS PRODUCTIVITY DATA

genus	density culms/m2	live standing crop g/m2	dead g/m2	peak standing crop g/m2	total standing crop g/m2	Source
Cladium	23.6	1130	1152			Seward & Orne (1975)
Scirpus						
americanus(min)	257	69			72	Biroux & Bedard, (1988a)
americanous (max)	623	2853			1446	Biroux & Bedard, (188b)
torreyi	40	8				Giroux & Bedard (1988b)
validus	7	3			86	
mixed species				3111		Smith (1978)
fluviatilis					943	Van der Valk Davis (1978)
Spartina cynosuroides				2311		Odum et al. (1984)
Typha						
latifolia					1370	Good et al., (1982)
mixed species				1214		Odum et al. (1984)
Juncus gerardii						
Maine	0-8680	644	1050			Linthurst & Reimold, (1978a)
Delaware	0-560	1491	566			Linthurst & Reimold, (1978a)
Juncus roemerianus						
Georgia				2200		Gallagher, et al., (1980)
Spartina alterniflora						
Georgia	1804	431	641			Linthurst & Reimold, (1978a)
				3700		Gallagher, et al (1980)
Spartina patens						
Maine	12880	912	2124			Linthurst & Reimold, (1978a)
Delaware	5900	962	962			Linthurst & Reimold, (1978a)
Georgia	2900	980	1324			Linthurst & Reimold, (1978a)

Table B-25
Estimated Vegetation Biomass

	Bullrush Association		Grass Grazed		Grass Ungrazed		
	Submerged (mt)	Standing Crop (mt)	Submerged (mt)	Standing Crop (mt)	Submerged (mt)	Standing Crop (mt)	Total (mt)
Initial	2,861	7,152	939	939	2,712	2,712	17,315
year 1	1,915	3,204	421	421	1,215	1,215	8,391
year 2	1,282	1,435	188	188	544	544	4,181
year 3	858	702	92	92	266	266	2,276
year 4	574	358	47	47	136	136	1,298
year 5	384	129	17	17	49	49	645
year 6	257	58	8	8	22	22	375
year 7	172	26	3	3	10	10	224
year 8	115	12	2	2	4	4	139
year 9	77	5	1	1	2	2	88
year 10	52	2					54
Total	8,547	13,083	1,718	1,718	4,960	4,960	34,986

Notes: (1) Submerged bullrush association production at a rate 40% of standing crop (Mitsch & Gosselink; 1986)
Submerged grass production assumed to equal standing crop

(2) Grass vegetation will decay to original live weight over a 8 yr period
Bulrush vegetation will decay to 2% of original live weight over 10 yr period

(3) Yearly reduction in mass based upon following formula;
Wt=Woe^-kt Where: Wt= Weight at time (mt)
Wo= Initial Weight (mt)
t= time (days)
k= Decay Rate=0.0022 g/m^2/day (Smith, 1978) for grass/standing bulrush
0.0011 g/m^2/day for submerged bulrush
From this equation: W50= 315 days=0.9 year (for grass community)
W99.98= 2920 days=8 year
W50= 620 days=1.7 years for submerged bulrush
W98= 3650 days=10 years

(4) Based on following areas measured from 1988 aerial photo of marsh:
Bulrush/sawgrass- 149 hectares (368 acres)
California grass ungrazed- 104 hectares (257 acres)
grazed- 45 hectares (111 acres)

(5) Standing Crop Production (Smith, 1978)
Bulrush/Sawgrass Community- 48 mt/ha/yr
Grazed Grass Community- 21 mt/ha/yr
Ungrazed Grass Community- 26 mt/ha/yr

(A metric ton is 2,205 pounds.) Given the level of precision of the data base, rounding to 35,000 metric tons is warranted. The means for harvesting this amount of organic material are dubious.

The total annual accumulation of vegetation is not entirely entombed in the marsh. Some of this material is flushed from the system, particularly during wet weather flows. Subtracting the estimated inorganic and organic suspended sediments (AECOS, 1982), the net accumulation of organics is 44,731 tons per year, rounding to 45,000 tons per year. Assuming the dry unit weights as shown in Table B-26, based on pounds per cubic foot (Dames and Moore, 1961), the estimated dry volume of organic accumulation is 453 acre-feet between 1966 to 1988. In comparison, the estimated accumulation of terrigenous sediment over 22 years was estimated to be 380 acre-feet. Table B-26 also shows a calculation of the amount that will accumulate over 200 years assuming these average values applied to the entire period. As a check on the order of magnitude of this value, Figure B-6 was used to estimate the average elevation of the top of the mat assuming 5900 acre-feet of filling. Figure B-6 shows that at approximately 5.5 feet elevation, msl assuming uniformly distributed sediments, a volume of approximately 5900 acre-feet is stored. Using 1981 aerial surveys of the marsh, a typical value for the mat elevation is between 3.5 to 4.0 feet. The volume at 4.0 feet from Figure B-6 is 5200 acre-feet, indicating the fill volume is overstated by at least 12 percent (1.0 - 5200/5900 x 100%). Factors which make precise estimates impossible are the limited accuracy of the bottom surveys, the variable rates of sediment accumulated and compaction, and changes in loss rates (outflow to the bay). More relevant is the estimated 22-year accumulation rate of approximately 800 acre-feet. This equates to an average elevation change of +2 feet on Figure B-6.

Over the last two hundred years since the marsh has filled and drained through Kaelepulu Stream to the ocean, the amount of open water has fluctuated, the nutrient loading has changed, and different types of vegetation have been introduced. The fill estimate (5900 acre-feet) estimate does not include these dynamic conditions. The estimate is instructive because it provides a rudimentary check on the order of magnitude of sedimentation processes (from both terrigenous and organic sources). The previous flood control design report (U.S. Army Corps of Engineers, 1957) does not discuss this factor. The conclusion of this estimate is that the accumulation of organic sediments had the potential to have as great an effect upon sedimentation of upland sources over 200 years.

Another implication of this estimate is that managing future productivity has to be included in the overall flood damage management plan. The natural processes of growth, decomposition, and sedimentation will continue slow but sustained changes in the marsh levels. The above accumulation estimates indicate that productivity is significant in the short term, e.g. 800 acre-feet accumulation would roughly equate to the loss of channel or levee design freeboard (Appendix A, Section 6). Productivity rates need to be verified by additional studies, but it appears that changes measured in a few decades of time can effect the basis of flood control designs. Over the long term, i.e. measured in scores of years, as sedimentation continues, the accumulation means structural measures have less effectiveness against major floods. Structural flood control measures such as raising the levee or channel improvements need to consider this impact in terms of the long-term reductions in storage which will necessitate continuing modifications to the levee height or channel dimensions to preserve equivalent levels of flood protection. A strategy that manages to control long-term productivity still needs additional study, testing and public discussion.

There are possible means for long-term management in order to effectively evaluate long-term alternatives to managing the primary productivity resulting from these two vegetative

Table B-26. Estimated Sediment Accumulation (ac - ft)

Material	Initial Weight	Final Weight 22-yr	Final Weight 200-yr	Accumulated Volume 22-yr	Accumulated Volume 200-yr
		(lb/cu ft)		(ac - ft)	
Clay (Terrigenous)	70	91	107	380	2922
Silt (Organic)	30	38	44	116	908
Peat (Organic)	7	22	32	337	2104
Total				833	5934

Notes:

(1) Consolidated weight based on following formula:
$W_t = W_o + (k)\log10(T-1)$ (Corps of Engineers, 1977)
where k = consolidation constant for material type:
clay = 16
silt = 6
peat = 11

Initial weight based on Dames & Moore (1961)

(2) Accumulated volume = $\frac{\text{rate of annual accumulation}}{W_t}$ X
(2000 lb/ton) (1 ac-ft/43560 cu ft) (T years)

(3) Assumed annual accumulation rates:

clay - 41,200 tons/yr
silt - 7,302 mt/yr - 8,032 tons/yr (grass production)
peat - 10,013 mt/yr - 11,014 tons/yr (bulrush production)

(4) Assumed inorganic and organic outflow (AECOS, 1981):
inorganic - 6,499 mt/yr = 7,149 tons/yr (22% outflow; 78% removal)
organic - 6,696 mt/yr = 7,366 tons/yr (77% outflow; 23% removal)

(5) Estimated net accumulation rates:
clay - 34,051 tons/yr (41,260 - 7,149)
silt - 4,349 tons/yr (8,032 - (50% x 7,366)
peat - 7,331 tons/yr (11,014 - (50% x 7,366)

communities. It is instructive to examine site specific species life history and productivity data for the predominant flora of Kawainui Marsh.

There are several species of the genus *Cladium* inhabiting Kawainui Marsh (Smith, 1978). All species of the genus are reasonably early colonizers of a marsh, and form a floating mat. Steward and Ornes, (1975) characterized typical stands of sawgrass, *Cladium jamaicense Crantz*, in the Florida Everglades. Sawgrass has extremely low nutrient requirements, and is not grazed except to a very minor extent by microorganisms and some insects. The plant forms dense stands which retards the growth of other plant species except those which are extremely shade-tolerant. Although sawgrass exhibits sexual reproduction with seasonal flowering and subsequent seed production, this in an insignificant mode of propagation when compared with the asexual rhizome production. Consequently, even after intense fires, the plant regenerates rapidly due to the extensive rhizome production. (Forthman, 1973). More recent studies of mineral nutrition (Steward and Ornes, 1983) document that high levels of phosphorus (25ppm in the soils) have a significant inhibitory effect on the growth and primary production both rhizomes and aerial portions of this species.

Heiser (1979) discusses the ethnobotanical uses of sawgrass and its historic culture. Sawgrass has also been considered for its potential in the manufacture of paper.

These could have a management implications for long-term resource management. For the short-term management scenario related to flood control, selection of harvesting equipment for this vegetation needs consideration of the removal of the rhizomes as well as of the standing crop.

California grass, *Brachiaria mutica* [Forsk.] Stapf., was introduced to Hawaii from its native Africa around the turn of the century (Funk, 1986). There is a paucity of data on productivity of *Brachiaria*, as well as management of the genus (Stur and Humphreys, 1987). Following burning, tiller (sprout from the base of the plant or axis of its lower leaves) production was inversely related to maximum surface temperatures and duration of the fire. Low fire temperatures promoted tiller production, while high fire temperatures fueled by thicker mats of vegetation, burned deeper into the crown of the plant and damaged potential tiller buds more severely. The potential implication for management is that the use of fire as a control requires intense heat; dense mats are more conducive to lower productivity results.

Significantly more data are available related to productivity of the water hyacinth *Eichornia crassipes* (Mart.) Solms. Through vegetative propagation a single plant can provide over 65,000 plants in one year (Hari, 1968), and a growing season from March to November, water hyacinths provide a floating platform type habitat for a number of aquatic, wetland and terrestrial species of plants and animals. Due to its low specific gravity (0.136), the wet weight of an 8 year old mat varied from 320 tons (wet weight) in the winter, to over 500 tons per hectare in the summer. Mat size varied depending on wind and water circulation patters.

The water hyacinth is probably one of the world's most studied plants with respect to production and nutrient uptake. A perennial, widely distributed throughout the tropics and subtropics (Penfound and Earle, 1948; Das, 1968), this plant grows rapidly forming mats over the water surface. Nutrient uptake is influenced by nutrient concentrations in the water, temperature and plant density as well as nutrient uptake and nutrient concentration within the plants (Reedy and Sutton, 1984; Imaoka and Teranishi, 1988).

In addition to productivity, some wetland plants are highly efficient to dewatering wetland areas through the process of evapotranspiration. The rates of evapotranspiration have been documented for a number of plants (Brenzy et al, 1973). Rates of evapotranspiration of water hyacinth are approximately 1.75 times the rate of open-water evaporation, while maximum rates of up to 2.52 have been measured (Snyder and Boyd, 1987). The rate of evapotranspiration is related to meteorological conditions (solar radiation and heat inputs) as well as plant canopy characteristics and nutrient availability.

Snyder and Boyd determined equations for estimating evapotranspiration for both water hyacinth, as well as cattail, *Typha latifolia*. Monthly water losses (mm/month) for *Eichornia*, E_{EC}; and for *Typha*, E_{TY}, are represented by the equations:

$$E_{EC} = (4.19 + (7.32 \times 10^{-6})S^2 + (0.00035 \times 10^{-3})H^2D$$

and

$$E_{TY} = (1.43 + (2.79 \times 10^{-15})S^4 + 1.44L)D$$

Where, S is the average daily solar radiations in W m^{-2}, integrated over 24 hours for the month; H is the plant height in meters; L is the leaf area index (dimensionless) which for *E. crassipes* has a daily value of 0.31 and a monthly value of 0.72; and D is the number of days in the month.

For *Typha latifolia*, growth and water loss were greatest during early summer, and standing drop did not increase after mid summer, while evapotranspiration declined steadily with senescence of the plants. On the other hand, water hyacinth growth steadily increased until late August/early September, and water loss did not vary with season. While water hyacinths have high evapotranspiration rates throughout the year, evapotranspiration is somewhat reduced in winter months.

In humid tropical areas, Rao (1988) determined that even during dry periods (November to May) water hyacinths enhanced water loss by 32 to 51 percent. In other studies, Bernatowicz et al (1976) found evapotranspiration rates of *Typha latifolia* in open ponds to be between 1.05 and 2.5.

The implication for management is that water hyacinth removal from selective area prior to the start of the growing season has greatest potential for reducing water loss through evapotranspiration and thus help to maintain minimum water levels.

The paperbark tree, *Melaleuca leicademdra*, is one of a number of tree species introduced to the island. A number of species of *Melaleuca* have been the subject of studies related to the biochemical changes in plants under water and salinity stress ever since the discovery of proline accumulation in wilted plant tissue (Kemble and McPherson, 1954). Neidu et al. (1987) evaluated a number of *Melaleuca* species relative to the proline analogues. The presence of these compounds provides protection of the plans to desiccation and is involved in maintaining osmotic balance during periods of increased salinity or drought. This is though to be the mechanism that enables paperbark to invade an area following a fire, and replace pine and cypress. Current research is underway in Florida (Hofstetter, 1989) regarding the displacement of native brackish and freshwater plants by this genus, as well as estimates of density, biomass and reproductive capacity. In addition, Hall (1989) is determining impacts of anoles, ants, beetles and spiders inhabiting *Melaleuca*, as well as soil salinity and water relationships related to invasion. Hoffstetter (1989) is also about to publish data on the comparison of the transpiration rates of *Melaleuca* and sawgrass as measured in the Florida Everglades. Using increased salinity and fire would not be considered effective control measures for this plant in order to halt its colonization.

The plants of the genus *Scirpus* are also inhabitants of Kawainui Marsh. Koyama and Stone (1960) have described the species as well as selected aspects of their life histories. *Scirpus californicus* is though to be a species introduced from either North or South America, where is indigenous. Seeds from this plant serve as food for migratory waterfowl.

Near the fringes of portions of Kawainui Marsh, there are pure stands of the taro patch fern. The occurrence of the species is usually concurrent with moving water. Means of propagation is by extension of the underground root/rhizome system (Loveless, 1959).

Mechanical Means/Options for Management

A number of mechanical, chemical and biological control agents have been investigated over the past several decades with respect to managing the growth of the above described aquatic plants. Harvesting techniques include managed animal populations was well as mechanical means (National Academy of Sciences, 1976).

A number of mechanical harvesters have been engineered to mechanically cut and remove the portion of the wetlands vegetation that exists either above the water surface, or above the wetland substrata (Livermore, et al. 1975). In addition to disposal problems associated with disposition of the plant material once harvested, the mechanical harvesting of many wetland plants actually exacerbates their growth. Just as mowing a lawn enhances the production of the grass and results in a thicker stand of grass, so too the mechanical harvesting of the aerial portions of the wetland plants enhances the production of the underground stems, and stimulates asexual reproduction of the plants resulting in increased density and productivity. If one of the goals of vegetation control is to diminish the density and productivity of the species, then careful consideration must be given to employment of any mechanical harvest method before implementation. Disposal of the vegetation through dewatering and use a soil amendment (Bingh, 1968), supplemental animal feed (Taylor, 1968), use as a source of pulp paper of fiber (Morton, 1975), or as a supplemental energy source (Singh, 1972), are also options to be evaluated. Rudescu (1976) reports on modifications of harvesters used normally on the reed Phragmites, for harvest of sawgrass in the delta region of the Danube in Romania. Thus harvesting provides one option for control.

Other forms of mechanical harvesting remove the entire root/rhizome complex as well as the aerial portion of the plant. This usually is done through dredging to remove the entire plant (Livermore and Wunderlich, 1969). In Kawainui Marsh, root and rhizome structures extend approximately three feet downward into the sediments. Dredging would be required to a depth equal to or greater than that reached by over 90 percent of the wetland plant root/rhizome systems if effective control is to result.

Another form of more limited dredging involves the use of explosives. DuPont (1977) describes blasting means to excavate ditches. Lipetzky, 1989) described blasting techniques Ducks Unlimited, Inc. has used in wetlands for the creation of potholes for waterfowl habitat improvements. U.S. Fish and Wildlife Service (USFWS) (Reinecke, 1989) have also utilized this technique for wetlands enhancement. This means could be utilized in Kawainui Marsh to make open water channels with minimal disruption to aquatic life, and at minimal costs.

A literature review of a number of articles written by state conservation departments, USFWS, and investigators in scientific periodicals such as the *Journal of Wildlife Management* did not identify any long-term effects on waterfowl from the use of blasting. Most recommended it consideration with other alternatives, for example water level manipulation, as an appropriate means for creating habitat. One such publication is Technical Report EL-89-14 Artificial

Potholes-Blasting Techniques, prepared by Chester O. martin and Larry E. Marcy, Environmental Laboratory, Department of the Army, Waterways Experiment Station (September 1989) in November 1989, after the DEIS had been prepared. This report summarizes objectives, uses and limitations, methods, maintenance, personnel and costs for pothole blasting. It recommends this technique should be compared to other wetland management means, particularly where heavy construction equipment access is limited. These other means for providing shallow open water include raising the water level with low elevation dams or mechanical removal. However, raising the water level, particularly during the rainy season is counterproductive to flood control efforts. Sufficient depths of open water can be created with vegetation management which can be accomplished with mechanical means and blasting is one of those means.

Coordination of the use of explosives with fish and wildlife agencies will be included as a requirement in the construction contract to provide oversight on operations in order to minimize negative impacts.

Test blasts were made along the proposed waterway alignments at a small scale to clarify the potential magnitude of negative impacts of blasting as well as obtain technical details on the effectiveness of the procedure. The test blasting was conducted in February 1990. Specifically, the test objectives were to:

1. verify assumptions relative to the size of the openings created and the location of the material ejected from the excavation;

2. study the pattern, charge weight and depth of placement on the amount of excavation and the resultant seismic and sonic impacts;

3. observe what potential adverse effects may occur to either aquatic or avifauna in the marsh during full scale operation from noise, air blast overpressure, and the escape of gases upon detonation.

Explosives were detonated at two sites shown on Figure B-8, Sheet A within the marsh on February 5, after obtaining a temporary variance from the State Land Use Commission for testing within the conservation district boundary. Seismographs were installed at three locations (see Figure B-8, Sheet A) around the marsh to monitor both seismic (ground) motion and sonic (air blast) effects. At both test sites, precautions were taken not to endanger any water birds. A warning shot was initiated prior to the main detonation. No water fowl or fish were observed in the area either prior to or after the blast. The explosives were carried into the marsh. Approximately 150 pounds were used at each site.

The first site was approximately 2400 feet from the levee adjoining Coconut Grove. Vegetation was ejected over a maximum distance of approximately 150 feet from the site. The vegetation mat disintegrated into small pieces generally less than six inches maximum dimension with the largest piece having a maximum dimension of six feet in size. A shallow excavation between 5 and 10 feet, averaging 7.5 feet approximately, was created. The surface dimensions were approximately 47 feet by 33 feet.

The second site was approximately 3400 feet from the levee. Similar effects were obtained at this site in terms of vegetation mat disintegration. A shallow excavation between 2.5 to 7 feet, averaging approximately 5 feet in depth, was created. The surface dimensions were approximately 42 feet by 33 feet.

The early findings of the test were as follows:

1. Explosives will create waterways of the shape and dimensions envisioned during the planning of flood control improvements in the DEIS.

2. Large spoil mounds are not created; the mat is disintegrated over a restricted area surrounding the site in the downwind (generally mauka) direction. Ejecta of silt and organic matter covered the downwind areas for approximately 150 to 230 feet depending upon the site.

3. Shallow excavations can be created that do not disturb deep-seated sediments, e.g. at 15 to 20 feet depths; the disturbed zone can be limited to the shallow, more recent organic deposits.

4. The shape of the excavation may be conducive to water bird habitat creation; e.g. the edge areas of parts of excavations are shallow 2.5 feet, and mud flats are created due to the irregular nature of the excavation.

5. Seismic and sonic impacts are within acceptable levels relative to structures; no visible disturbance of avifauna occurred due to the fact that neither solitary nor flocks of birds took flight; however, as this was a small scale test, the length of the blast was relatively short.

Results of the seismograph recordings are shown in the Miscellaneous Data (Section 7). The three seismograph stations were 2400,2950, and 2750 feet, respectively, from test site #1; they were 3400,4650 and 1450 feet from test site #2, respectively. Seismograph station #1 results were invalidated due to interference from UHF radio frequency transmissions in the area. The results at the other two sites indicated that there were no measured seismic motions from test #1. Test #2 registered a peak longitudinal particle velocity of 0.00010 inches per second at a blast frequency of 85.5 hertz. In comparison to the U.S. Bureau of Mines standard (Section 7), these ground motions were within acceptable limits. In terms of sonic blast, the maximum overpressure of 135 decibels was measured from test #2 at seismograph station #3 (adjacent to Kapaa Landfill). A community noise permit is required for construction activity in residential/preservation areas for noise levels exceeding 95 decibels between 9:00 AM to 5:30 PM. The noise level experienced at the landfill monitoring site is permitted in several states, but represents an upper limit that will be controlled by the contract specifications.

Two months after the test blasts, in April 199(the sites were checked to identify effects. The following observations were made:

1. At test site #1, water birds were flushed from the site upon the approach of humans indicating that some use is being made of these sites;

2. The ejecta from the excavation could not be distinguished from the surrounding vegetation growth;

3. At test site #2, the peat material that was buried below the level of the explosives placement surfaced. The depth of the peat deposit at this site was estimated (by probing with a survey rod) to be approximately 16 feet thick. The explanation offered at this time is that the hydrostatic buoyancy of the peat positioned the material at its new hydrostatic equilibrium; in other words, the material, relieved of four feet of overburden pressure (estimated to weigh approximately 900 pounds per square foot) rebounded to the surface.

4. At test site #1, there was some rebound noticed, but not to the same degree, presumably because the depth of peat was less at this location and more of it was removed during the test blast.

Prior to blasting, the waterway alignments to be blasted will be walked to flush any waterbirds from loafing or nesting sites. A warning blast will be initiated a few minutes before the actual main detonation to frighten birds from the area. By watching the direction of these flights, it can be determined when birds are safely away from the area in order to detonate the main blast. The alignments will be created in segments to reduce the amount of the air blast. The total time to complete the alignments is estimated to be less than one month. The work will be scheduled during the period between October to February when it will be the least disruptive to breeding and nesting. Blasting will be conducted on days when atmospheric conditions favor the dissipation of both noise and gases away from the community and existing nesting areas.

The obvious short-term impacts of blasting are the noise, which will frighten the birds, the release of poisonous gases immediately at the site of the blast which are quickly dissipated, and the air blast which could be dangerous for any birds flying over the site at the time. With proper precautions, these impacts can be mitigated.

Biological Means/Options For Management

Ecologically, one of the oldest means for managing vegetation is the use of fire (Odum, 1983). A naturally occurring event, fire can be used to attain early stages i the succession of a wetland. In wetlands where there are not naturally occurring major hydrological events (such as flushing associated with equinox tides, or major floods), fire (from natural causes - lightning) is one way of consuming the large accumulations of organic matter and converting it to inorganic forms. Provided such forms are reasonably quickly flushed from the system before new vegetative growth is stimulated, (i.e. if burning were conducted at the end of the dry season, just before the beginning of the annual wet season) this could be an effective means for managing productivity in the wetland. In addition, fire reduces the elevation of the wetlands surface due to combustion of the organic vegetative mat. In wetlands where a flow results in the natural accumulation of thick vegetative mats (e.g. mature stands of *Brachiaria*), fire will significantly negatively impact the flora unless, as mentioned earlier, the combustion temperature is very high. Because the roots and rhizomes of the plants are in water or wet mud, they would be less subject to combustion. Following a fire, seeds of some species will sprout. These ecological consequences of fire have been well documented in the Florida Everglades (Egler, 1952). Thus, fire has the possibility of introduction new plant species in the new open spaces, and keeping the marsh in an early successional stage. From an economic standpoint, fire is a cost effective means of vegetative management provided controlled burning based on U.S. Forest Services practices, is utilized. However, concern over public safety and health make this option one requiring considerable additional research, documentation of expected effects, planning in terms of fire breaks and contingency efforts, and public education. It is not recommended at this time.

Another ecological management strategy is based on the physiology of the wetlands plants. While water hyacinths can tolerate full strength sea water for several days, most freshwater plants including those found in Kawainui Marsh, are susceptible to increasing salinity. Sculthorpe (1967) has summarized that most of these plants can not reasonably tolerate over 5 parts per thousand salinity, for extended periods of time. Very few plants are habitual colonists of brackish water. Most either exist in fresh water, or full strength sea water. In the review of the ecology of plants tolerant of salts (Reimold and Queen, 1972), none of the plants indigenous to Kawainui Marsh are included as those being able to tolerate extended periods of time in salinities exceeding 4 to 5 parts per thousand. Consequently, the management of salinity through introduction of high salinity ocean water for extended periods of time, could afford a somewhat natural means of vegetation control (Waisel, 1972).

Another harvest management option is afforded through grazing. Throughout many wetlands of the world (Chapman, 1960), grazing by cattle, horses, pigs and sheep results in vegetative control in wetlands. Due to the high protein content of most wetlands plants (Ranwell, 1967), the plants serve as an excellent food for livestock production. Reimold, et al, (1975) documented a 62 percent reduction in primary productivity associated with grazing. In addition to domestic livestock a number of other animals have also been considered with respect to marsh vegetation control. Grazing cattle have, however, been observed in nesting areas for endangered birds. Thus increased grazing pressure should be considered for long-term management plans when more detailed plans for wild fowl habitat management have been developed for the marsh.

Several other herbivorous animals have been evaluated for aquatic vegetation control. Water buffalo, *Bubalis bubalis*, have been used for the control of water hyacinths (Cockrill, 1974). The nutria, *Mycocaster coypus*, feed on aquatic vegetation, and have been shown to eat water hyacinth leaves and roots (Warkentin, 1968). Based however on problems associated with their introduction into Europe and North America, caution should be used in considering this species. Before decisions are made regarding their introduction, other habitat requirements for these species need to be fully evaluated. Some of these species may be useful to maintain open water areas once they are created by other means.

Trichechus sp., cow or manatee, is an euryhaline mammal which has been considered for control of aquatic vegetation (Allsopp, 1960). Energy efficient adults of the genus consume approximately 20kg of wet vegetation daily, but require water depths of 2 to 3 meters.

Waterfowl have traditionally been considered for wetlands vegetation management due to their natural preference for the plant species that are indigenous to wetlands. Ross (1971) has evaluated the efficacy of White Chinese Geese for control of aquatic vegetation. Research suggest that dietary supplements may be needed if these are to become managed forms of vegetation removal. There may be an important role for waterfowl, especially gees, in maintaining open water areas, once they are initially created by other means.

Fish, including *Ctenonpharyngodon idella Va.*, known as white amur, or Chinese grass carp, are among the fast feeding herbivores that have been used for control of small floating plants, such as duckweed, or small stemmed and small leaved submerged aquatic vegetation (Baily, 1972). Fish of the genus *Tilapia* live under a wide variety of conditions, and also are candidates for vegetation control. Also, the herbivorous *Mylossoma argenteum* consume the base of the stems of aquatic plants.

Biological control of floating plants has also been achieved with several different species of insects. Deloach and Cordo (1981) have evaluated two weevils, *Meochetina bruchi*, and *Acigona infusella*, as biological control agents for floating aquatic plants. In addition, the pyralid, *Sameodes albiguttales* (Warren), has been distributed at the first larval stage to control water hyacinths (Center and Durden, 1981). The use of such organisms could facilitate the maintenance of additional open water.

Chemical Control

While herbicides are reasonably available and provide rapid visible results in terms of apparent reduction in vegetation, they require repeated application to achieve results, are reasonably costly, and have impacts expressed in biomagnification and tropic magnification. In addition, the toxicity of herbicide residuals and their metabolites is not well documented. In recent years the most common form of water hyacinth control in Hawaii has been with the herbicide, Rodeo, manufactured by Monsanto Company (Funk, 1986). Dalapon and other glyphosphate chemical have been used also. Corn (1989) indicated the most common herbicide in use currently is Roundup, but no specific work has been done in Hawaii with respect to wetlands vegetation control.

With a reputation of being one of the world's potentially most destructive ruderal plants, water hyacinth control has been the focus of many studies over the past several decades. Specific chemicals that can be used to control water hyacinths include Dalapon, Rodeo, 2, 4-D, Diquat, Aminotriazole T, and Fenotrop. While early control mechanisms employed the ethyl ether of the herbicide, 2,4-D, at a rate of 4.5 kg active ingredient per hectare (Hari, 1968), more recent control has been achieved using 2.5 to 5.0 kg active ingredient per hectare using aminotriazole. Growth control efficacy was enhanced by application during the height of the growing season.

One control option specifically recommended for sawgrass, is the use of Dalapon and diesel oil at a rate of 10-20 pounds in 200 gallons of water and 1 gallon of oil in 100 gallons of water. With the Dalapon and oil mixed before spraying on the foliage during the active growth season. Joshi and Paharia (1969) conclude that significant control can be achieved.

For *Scirpus* sp., control, 2.4-D at the rate of 2 pounds in 500 gallons of water combined with 1 gallon diesel oil per 100 gallons of water, is recommended to be applied just when flower heads emerge. (Joshi and Paharia, 1969). They also recommend aminotriazole or aminotriazole T (1 pound per 500 gallons water with 6 oz of a wetting agent per 100 gallons) for management of *Typha* sp.

Rodeo is recommended for initial application to water hyacinths as part of the proposed action. This recommendation considered its previous review and approval by governmental agencies. Monsanto's studies show it is practically non-toxic to fish and did not cause cancer when tested with rats. It adheres to soil particles and breaks down rapidly in the environment into carbon-dioxide, water, nitrogen, and phosphate.

Since Rodeo application is being recommended as part of the proposed action, its character is discussed further. Glyphosate (N-phosphonomethyl glycine) is commonly marketed as Roundup or Rodeo (Nelson, 1989). It is a highly effective chemical for control of numerous annual, biennial and perennial broad leaf weeds and grasses, and operates by interrupting the biosynthesis of phenylalanine through repression of chorismatic acid. Based on aerial application when the plants are actively growing, at application rates from 5.3 to 8.8 lb/ha (4.5 to 6.5 pt/acre) (0.75 to 1.5% solution), glyphosate persists for short periods in both soils and water.

Glyphosate (U.S. EPA, 1984) is registered and approved for use at all aquatic sites with no restriction on use to control nuisance vegetation in waters used for irrigation, recreation or domestic purposes. It is not to be applied within 0.5 miles upstream of potable water intakes. Treatment frequency should not exceed one treatment per 24 hour period and application rates should not exceed 8.8 lb/ha (7.5 pt/acre). The visible effects on most annual plants occur within 2-4 days while perennial plants may not show effects for over one week. Toxicity of glyphosate increases with increasing water temperature and alkalinity. Bioassays indicate low toxicity to fish and aquatic life. The 96 hours static acute toxicity, LC_{50}, for Rainbow trout was 7.0 to 11.0 mg/l (of 41% liquid Roundup), and 5.3 mg/l for the Cladoceran shrimp, *Daphnia*. Due to the relatively low inherent toxicity of glyphosate, studies have documented that it will not adversely affect humans, wildlife, or the environment when applied as discussed earlier. Glyphosate has an extremely low vapor pressure and does not volatilize, thus eliminating possibilities for human and or animal exposure due to vaporization and movement to nontarget areas following application. U.S. EPA (1984) established the human acceptable daily intake (ADI) value for glyphosate at 0.10 mg/kg body weight per day. This ADI translates to a maximum permissible intake (MPI) of 6mg glyphosate per day for the entire human life span. Based on application instructions, it would be impossible for any human to consume an amount of glyphosate necessary to cause adverse effects due to drinking water or eating food obtained from areas treated.

In soils, glyphosate is relatively immobile primarily because of its adsorption to and inclusion in expanding lattice clays, common to wetland areas. The chemical actions of glyphosate become inactivated upon sorption. Also, degradation in soil by microbes occurs fairly rapidly (1-2 months) under both aerobic and anaerobic conditions. Studies have documented that soil microorganisms exposed to up to 25ppm of glyphosate showed no measurable adverse effect in terms of nitrogen fixation, nitrification or degradation of protein, starch or plant litter. The principal soil metabolite of glyphosate is aminomethylphosphonic acid which is also highly biodegradable. In water, glyphosate biodegrades in 7-10 weeks. It is well-documented that glyphosates do not bioaccumulate in aquatic organisms. Results of environmental fate studies document that no glyphosate was leached from soil that was eluted with water continuously for 45 days.

Recent attempts to control water hyacinth have been based on a better understanding of the growth cycles of this plant (Luu and Getsinger, 1990). This approach is analogous to integrated pest management. These studies have been aimed at documenting the physiologically weak points in metabolic cycles of the plant which would facilitate the more effective control of this vegetation. The weak periods of the water hyacinth growth cycle occur in the period shortly before autumn scenesce begins when the plants are actively translocating carbohydrates to stem-bases, and in early spring when new growth results in young ramet (a plant that is an independent member of a clone), emergence and carbohydrates in the stem-bases are low.

Since glyphosate degrades quickly in both soil and water through microbial metabolism, and is relatively immobile, there are minimal risks for potential injury to nontarget plant species and minimal risks for potential ground water contamination from migration. There is also minimal risk to animal species since it has low animal toxicity and does not bioccumulate. Applied at the most sensitive stages in the life cycle of water hyacinth, defined earlier, glyphosate is an appropriate approach for successful control at Kawainui Marsh, affording the least potential for short-term and long-term impacts of herbicides evaluated. Applications at these times will not occur during seed production. Therefore, no potential problems for avian ingestion of seeds that may have been sprayed will occur. Applications at these times will also afford the most cost-effective and ecologically sound chemical control method.

This method of water hyacinth control (using glyphosate) has been widely used by the U.S. Army Corps of Engineers in maintaining open waterways in all areas of the United States and its territories where water hyacinths grow. The same approach has been used in the Nile River valley, the Sudan, India, etc. Glyphosate is a commonly used, EPA-approved herbicide specifically used to control floating nuisance weeds (EPA 1988). Shireman et al. (1982) pointed out that it is one of the most commonly used methods of chemical control. Consequently it is clear that it is an applicable mechanisms for vegetation control at Kawainui Marsh.

The experience obtained from a previous herbicide application is partially indicative of the impact of chemical control measures expected from the proposed action. A single aerial application of Rodeo was made in November 1988. The objective of the application was to control vegetation. The single application of the herbicide demonstrated the effectiveness of this method for controlling new growth, but it had little or no effect in terms of altering the structural characteristics of the peat formations above and below the water surface in the marsh. Documentary evidence of this fact was collected in the form of photographs taken during excursions through the marsh and videotapes made from a helicopter overflight. Furthermore, the rapid regrowth shows the chances for control are slight from single applications. Grossbard and Atkinson (1985) suggested it is almost impossible in practice to obtain 100% control of water hyacinth with a single application of herbicide when growing in dense infestations because of the screening effect of one plant by another. They note the plant could double the number of floating leaves every 7-10 days under good conditions.

Approximately 7.0 kg/ha active ingredient were applied to nearly 90 acres. Approximately six pints of chemical were mixed with 20 gallons of water. Surfactant and drift control additives were mixed with the chemical just before application. The helicopter used a 40-foot boom to spray the mix from approximately 10 feet above the target area. Maximum wind speed was estimated to be six miles per hour at the time. The pilot estimated the drift from the target area to be 12 to 15 feet. The entire application required approximately 3 hours.

By autumn of 1989, the brownish swaths which had been created by the herbicide application were evidencing revegetation. Common species observed colonizing these areas were taro vine (*Epipremnum pinnatum*) and honohono (*Commelina diffusa*). Water level measurements commenced in March 1989 and therefore actual data to show the improvement of water circulation through the marsh as a result of this treatment is nonexistent. In order to make valid comparisons of the effect of the treatment for flood control, water level measurements at various locations during storm runoff periods would be needed both prior to the treatment and after the treatment with herbicide. Furthermore, the biomass remaining after the treatment did not immediately decompose and added another layer of material which creates resistance to horizontal water movement. Species such as sawgrass (*Cladium majaicense*) and bullrush (*Scirpus* spp), which have long leaves and stems, were bent over but still able to reduce flow velocity due to their physical obstruction of possible flow paths.

The effectiveness of repeated applications of the herbicide in terms of preventing any regrowth was not assessed. It appears, based on the single application, that some type of plant succession will persist. The research reviewed did not indicate concern relative to toxicity if applied at recommended rates or biological accumulation in the food chair, however, the number of long-term studies obtained is limited. There is some evidence that it will accumulate at extreme dosage levels, but not bioaccumulate at rates comparable to other chemicals. The bioaccumulation factor for glyphosate was reported to be 0.03 for rainbow trout to 0.18 for channel catfish following fourteen days exposure at 10 milligrams per liter concentration. In comparison DDT has a concentration factor of about 22,500.

The action being recommended proposes two applications of Rodeo. These applications are timed to reduce the dosage levels and coverage in order to reduce the magnitude of adverse effects on water quality. The first application will be made immediately after the completion of the first waterway. The portion of the marsh to be treated includes the waterway and the portions of the adjoining pond containing water hyacinth (*Eichornia crassipes*). The portions of the pond invested by water hyacinth. It will be part of the construction contract to maintain the open water in this first pond. The second application will be made at the height of the growing season and will cover the same area as the first application and, in addition, will include the open water to the south of the waterways abutting the pasture. Cattle will be moved to a pasturage away from the area for a minimum of two weeks during this period. Short-term effects of this type of application are believed to be benign. The chemical decomposes into carbon dioxide, nitrogen, water, and phosphate by microorganisms present in the soil and water column. Under laboratory conditions, it is reported to be broken down in four weeks. Water samples in Oneawa canal taken on November 9, 1988, the day of the aerial application and at four-day intervals thereafter (for twenty days) were analyzed for glyphosate and its metabolite aminomethylphosphonic acid. No level of glyphosate was found greater than the laboratory detection limit of 0.01 ppm. Its short persistence in the environment is demonstrated by the relatively rapid revegetation that occurred in the marsh in 1989.

SECTION 6. Archaeological Investigations

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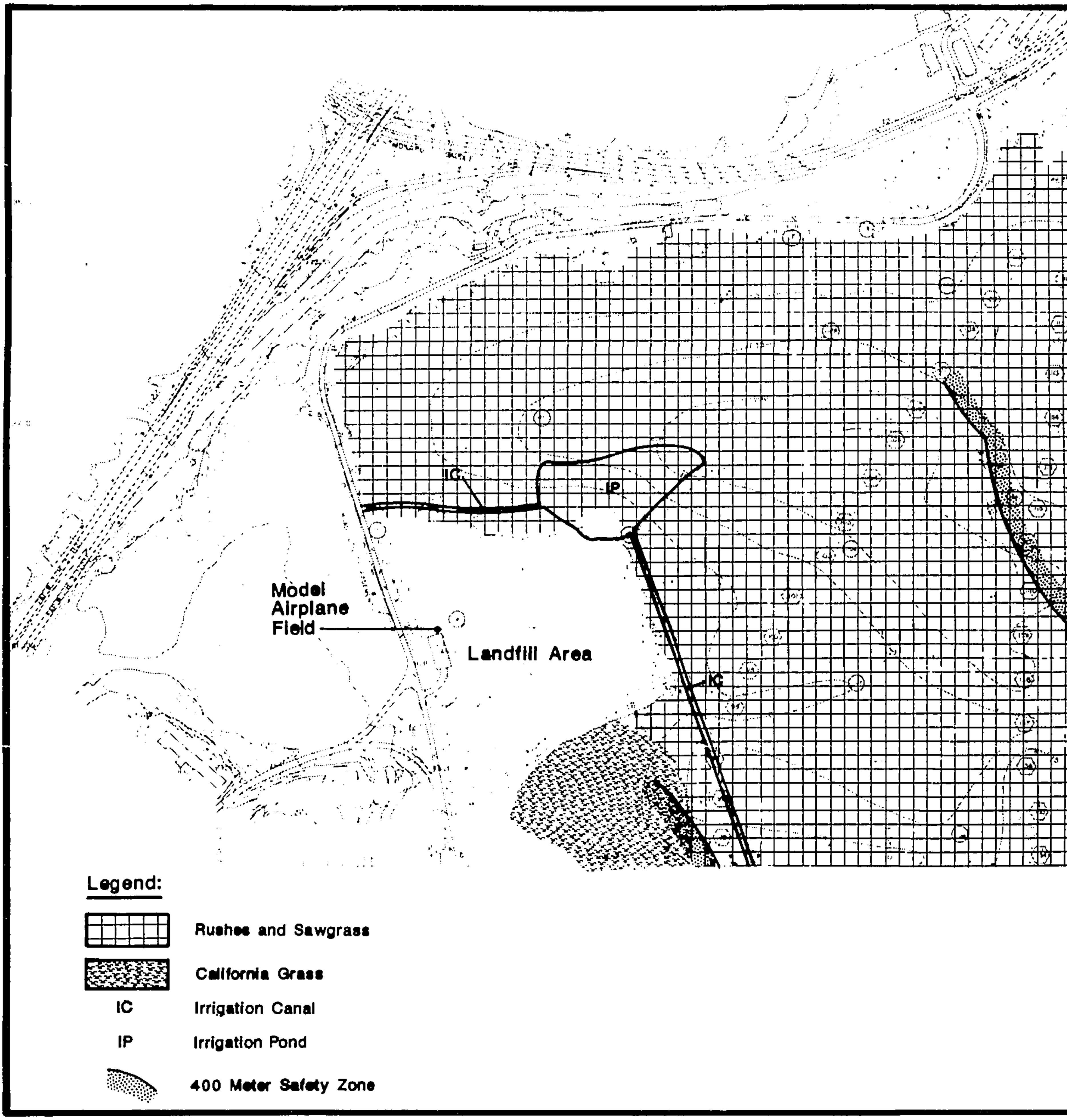

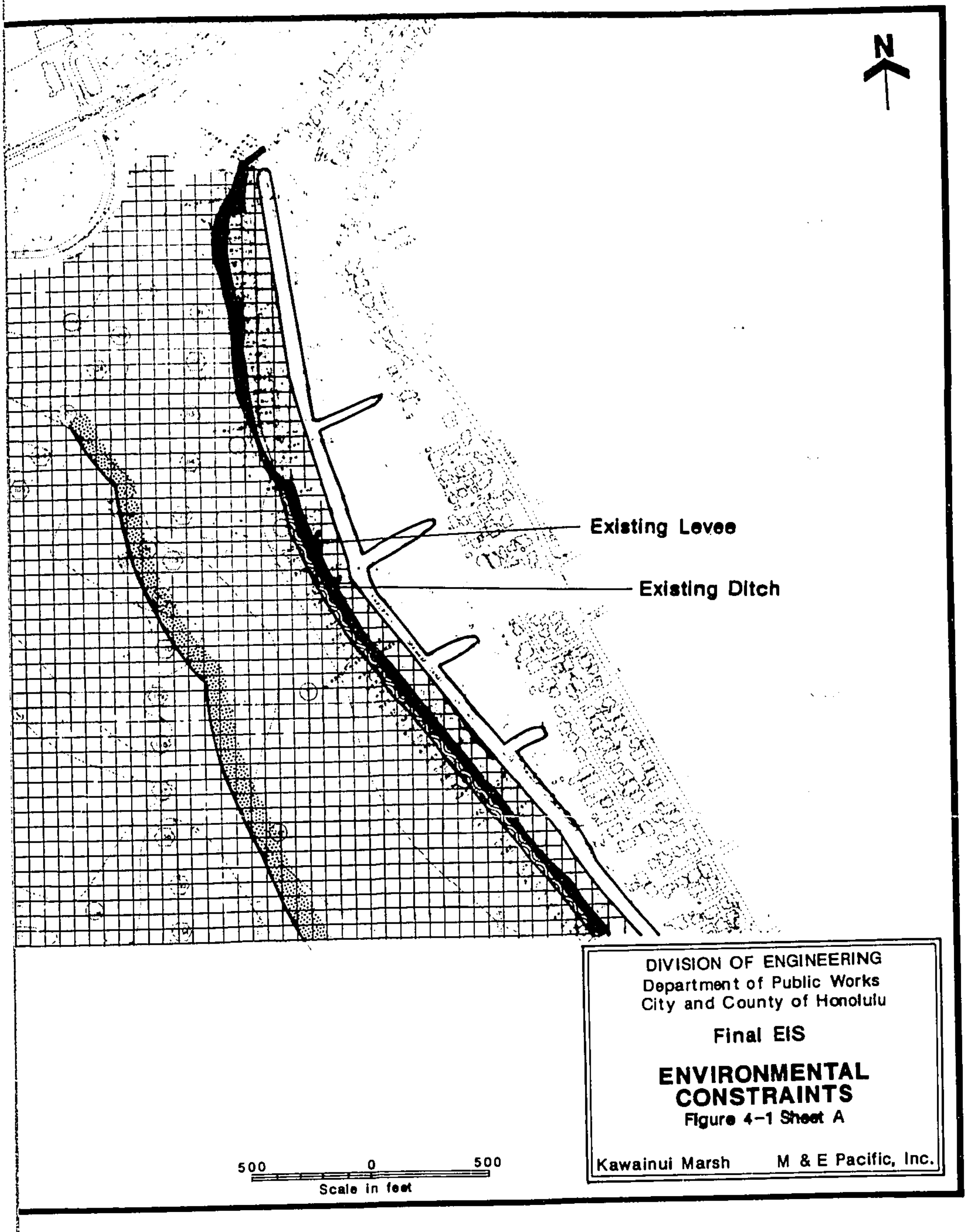

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Final EIS

ENVIRONMENTAL CONSTRAINTS
Figure 4-1 Sheet A

Kawainui Marsh M & E Pacific, Inc.

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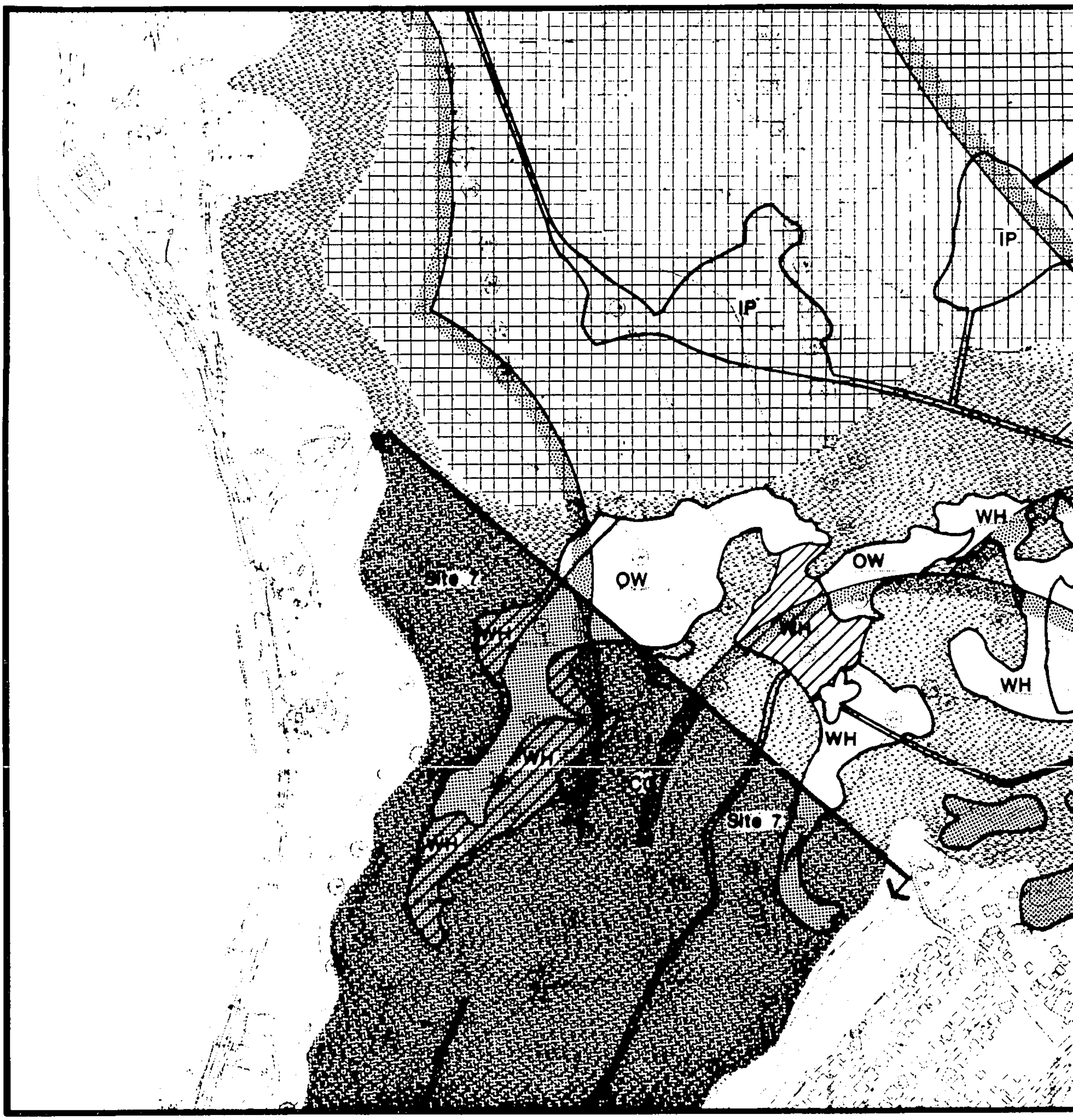

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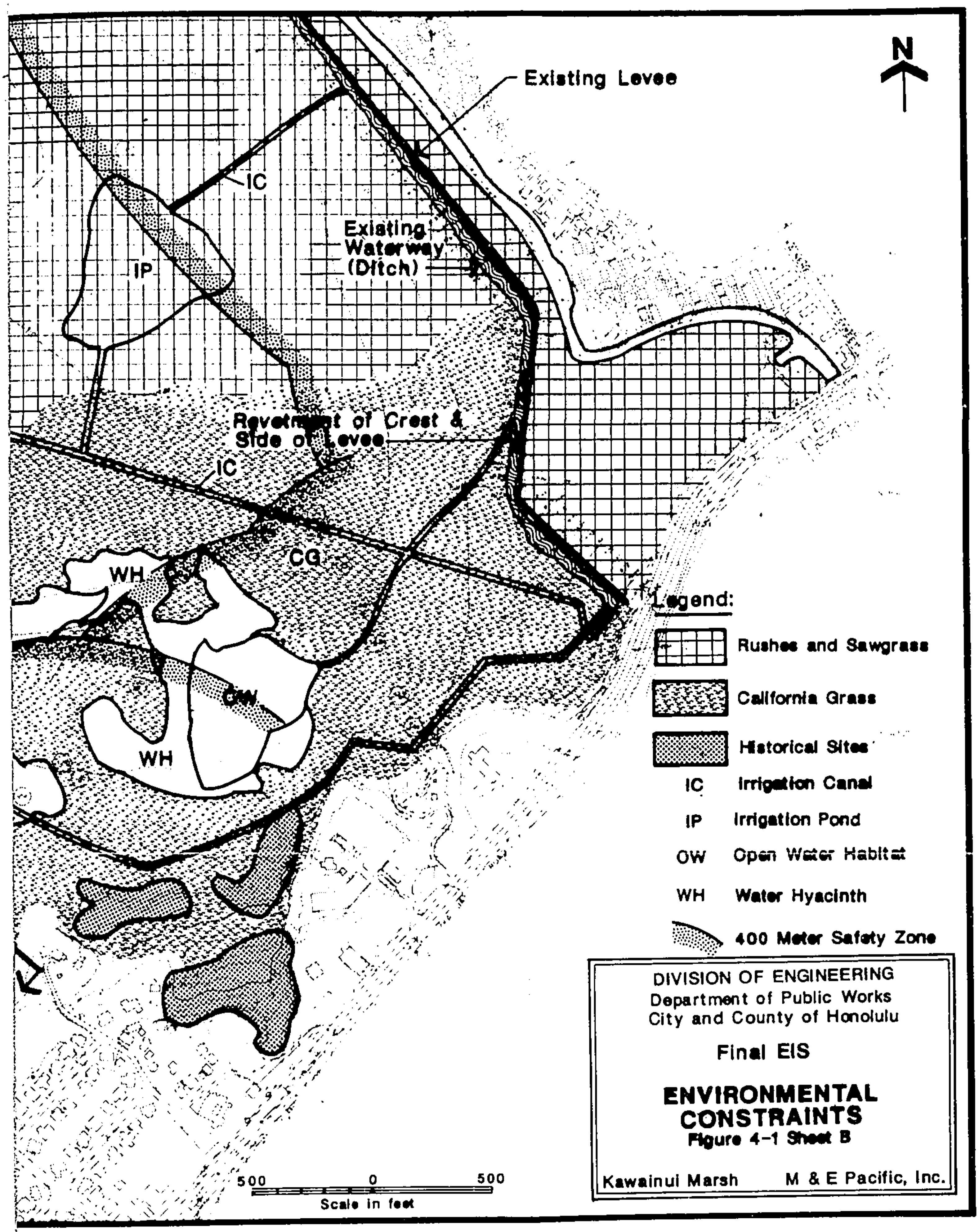


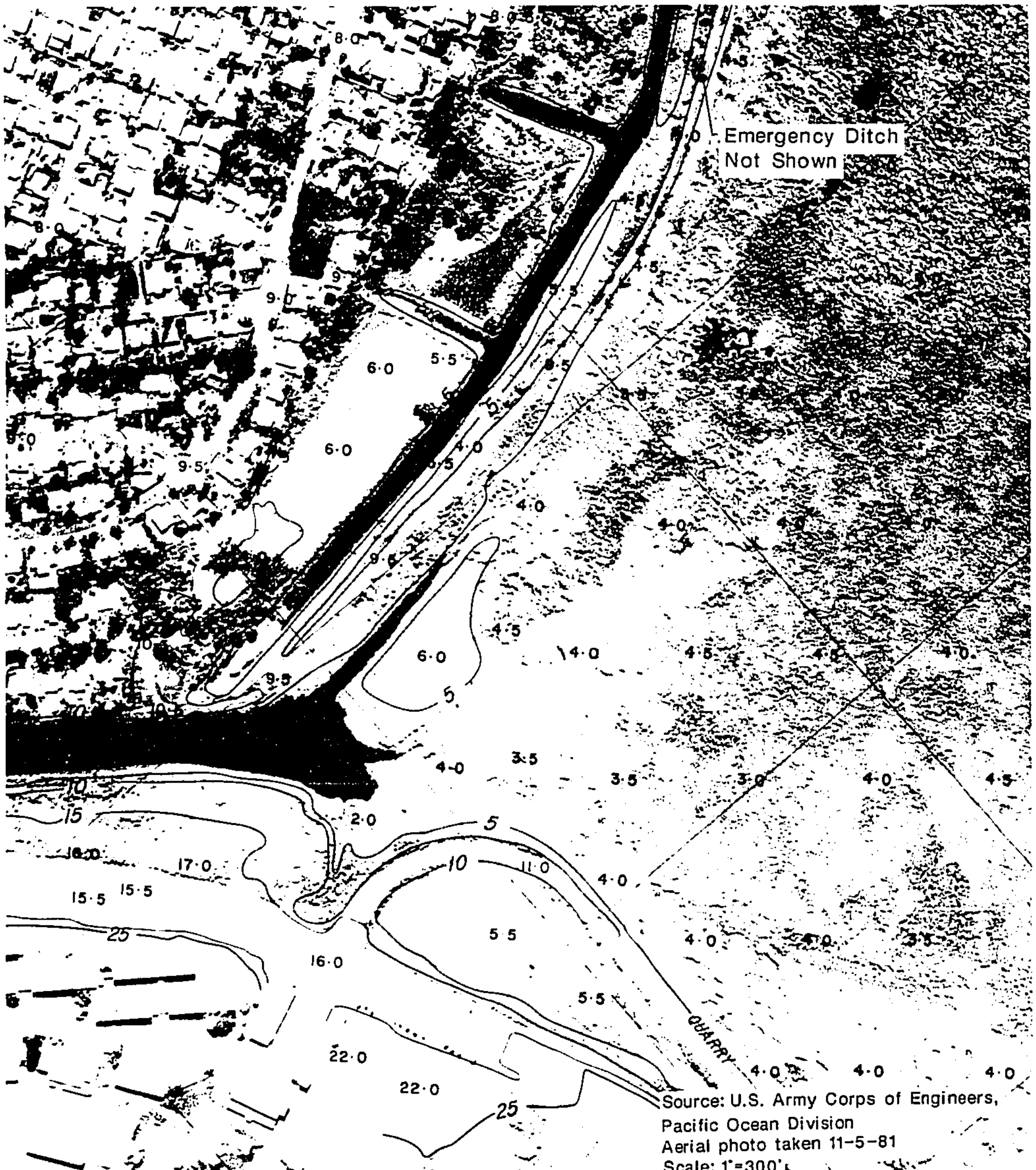


Figure 4-2

ONEAWA CANAL
KAWAINUI MARSH OUTLET

SECTION FIVE

ALTERNATIVES TO THE PROPOSED ACTION

Six basic alternatives were considered: no action, constructing a channel through the marsh, diverting flood water above the marsh, increasing the ability of the marsh to distribute and store flood water with an emergency outlet, raising the levee, and improving storage ability only.. The impacts of these alternatives are compared in Table 5-1. The major impacts are discussed in the following subsections.

I No Action Alternative

Under the no action alternative, no management or construction options would be implemented by public agencies to reduce the risk of flooding to the residential and business areas of Coconut Grove. Environmental changes will continue to occur within the marsh. The primary productivity of the marsh will continue to create the wooded bog which is believed to be the climax stage of natural succession. The availability of nutrients, even with the diversion of upstream sewage treatment effluents, is still significant. The sediments contain past accumulations of these nutrients which will provide part of the requirements for photosynthesis, the primary force controlling productivity. Ecological succession will continue to occur.

It is likely that individual household efforts to reduce the exposure to the risk of damage due to flooding will continue. Some efforts to flood-proof individual residences will be made and flood insurance will be purchased to reduce the financial impact of losses.

The major impacts of this alternative are the continued large scale negative economic and psychological effects of continued flooding in the residential and business areas of Coconut Grove. Without measures to reduce the severity and frequency of these flooding impacts, the private and public costs associated with these effects will continue for the foreseeable future. Private losses, measured in terms of the expected average annual damage are estimated (Appendix A, Section 5) in the tens of thousands of dollars.

II Channelizing Flow Through the Marsh Alternative - Alternative A

This alternative involves vegetation removal of floating peat and dredging the substrate to obtain the desired waterway capacity to convey the design flood flow. The recommended excavation of a channel (see Figure 5-1) measuring 200 feet wide at the top and 8,000 feet long to a depth of -5.0 feet (msl) (U.S. Army Corps of Engineers, 1988) forms the basis of this alternative. The estimated 250,000 cubic yards of material to be removed was planned to be disposed adjacent to the

TABLE 5-1
Significant Effect Evaluation Matrix
for Alternatives

CATEGORY OF EFFECT PRIMARY EFFECT	Unit	N No action	A Channelization	B Diversion	C Storage Emergency Outlet	D1/D2 Levee Raise/ w/ Channel	E Storage
Environmental							
1. Physical Substrate Excavated	acre-feet	•	212	620	5	9/44	Similar to Alt. C
2. Flood Water Circulation	hour	>48	<1	see note	<48	no change/<1	<48
3. Erosive Force Channel	lb/sq ft	•	0.87	see note	0.41	no change/0.72	0.41
4. Contaminants from Construction	yes/no	no	yes (note)	yes (note)	yes (note)	ye/yes (note)	Same as Alt. C
5. Habitat Alteration	ac	23 (note)	27	60	10/14 (note)	9/38	10/20 (note)
6. Noise (construction)	yes	yes	yes	yes	yes	yes/yes	yes
Technical							
7. Constructability	crew size	•	37	22	39	10/15	Similar to Alt. C
8. Design Criteria	flood magnitude	25-yr	<100-yr	100-yr	100-yr	SPF/SPF	<100-yr
9. Maintainability	crew size	4	12	10	8	6/8	Similar to Alt. C
10. Alteration of Coconut Grove Existing Drainage	yes/no	no	no	no	yes	no/no	no
11. Construction Schedule	mo	•	15	60-72	12	14/15	24
12. Cost of Construction	$1,000	•	28,786	220,794	3,573	7,251/9,848	See Table 5-2
SECONDARY EFFECT	Unit	N No action	A Channelization	B Diversion	C Storage Emergency Outlet	D1/D2 Levee Raise/ w/ Channel	E Storage
Downstream/Adjoining Marsh							
13. Achievement of Water Quality Standards (Oneawa)	yes/no						
a. Dry Season	yes/no	yes (note)	no (note)	yes (note)	yes (note)	yes/no (note)	yes (note)
b. Wet Season	yes/no	No (note)	no (note)	no (note)	no (note)	yes/no (note)	no (note)
14. Impact to Landfill During Construction	mt	•	391,902	336,204	841	4,781/51,787	Similar to Alt. C
15. Traffic/Transportation							
Quarry Road	yes/no	yes	no	no	yes	yes/no	yes
Kailua Road		no	yes	yes	no	yes/yes	no
16. Aesthetics Downstream		yes	yes	yes	yes	yes/yes	yes
17. Avoidance of Known Historical/Site Cultural Impacts	yes/no sites	•	no	no	yes	yes/yes	yes
18. Noise Impacts (maintenance)		yes	yes	yes	yes	yes	yes
19. Annual Economic Impacts	yes/no	yes	yes	yes	yes	yes	yes

Notes: Keyed to alternative and row number

A.4 Turbidity, oils, and grease, increased biochemical oxygen demand, potential effect of heavy metals from dredge spoil unknown
A.13 Dry and wet weather flows will exceed standards
B.2 No circulation of approximately 80% of wet weather stream inflow to marsh
B.3 Suspended solids would not be eroded from marsh, but transport from Maunawili Stream through diversion will occur
B.4 Turbidity, oils, and crease
B.13 Dry weather flows "treated" oy marsh, wet weather diversions exceed standards
C.4 Turbidity, oils, and grease
C.5 10 acres of new waterway constructed, 14 acres of existing water hyacinth treated with herbicide
C.13 Dry weather flows treated by marsh, wet weather flows exceed standards
D.13 Dry weather flows treated by marsh, wet weather flows exceed standards
D1.4 Turbidity, oils, and grease
D2.4 Turbidity, oils, and grease, potential effect of heavy metals from dredge spoil unknown
N.5 Estimated size of existing open water
N. 13 Dry weather suspended solids, nitrate + nitrite, and phosphorus meet standards; wet weather flows exceed standards
E.6 Waterway chanels/pond areas to be cleared of vegetation
E.13 Dry weather flows treated by marsh, wet weather flows exceed standards

model airplane field or in dredged material disposal piles along the channel alignment.

A water level control structure was also proposed as part of this alternative to prevent draining the marsh and the intrusion of salt water. The crest (top) elevation of this structure was planned to be built at 4.0 feet (msl) to retain water in the marsh. A low-flow gate was also proposed to permit the manipulation of the water levels for waterbird habitat purposes.

The length of the proposed channel has been the subject of some revisions and, due to concerns over archaeological impacts, a shorter version of 6,000 feet has recently been suggested. It has also been suggested to improve flow into the shorter channel to build a "training dike" type structure presumably from earth and stone to divert peak flow into the inlet to this shorter channel. The proposed alignment of this dike will impact archaeological site 3961 (Figure 3-3). The effectiveness of a training structure is debatable as noted in Appendix A, Section 4.

The major negative environmental impacts of this alternative include turbidity accompanying modification of the existing physical substrate along the alignment of the proposed channel; diversion of inflowing water through the marsh with accompanying changes to detention time and water circulation in peripheral areas and increases in suspended particles (major impacts both in terms of the quantity and duration of the time that water quality standards will be exceeded); destruction of a significant portion of the existing wetlands ecosystem along the alignments; and potential impacts to archaeological sites near the training dike construction. There is also the potential that effluent discharges from the sediment disposal areas will exceed recommended heavy metals limits if the runoff from these areas becomes strongly acidic.

A potential effect on productivity rates is possible from the water control structure which has been proposed to manipulate water levels. The water level will rise due to this structure which has a planned crest elevation of 4.0 feet, msl. There are compensating factors that make it difficult to predict the long-term effect without additional productivity measurements. For example, a rise in water level in the short term will flood the drier portions of the marsh with water carrying dissolved organic nutrients. However, the long-term effect may be reversed because the proposed channelization will dramatically alter currents, velocities, circulation patterns, and periodicity and duration of long-term inundation. In the short-term, productivity may be increased until vegetation builds up the level of the mat to where flood water infrequently will reach the fringe areas of the marsh. In these areas, different species supported in drier conditions may become dominate (this supposition is based solely upon the literature on hydrological cycles in wetlands [Mitsch and Gosselink, 1986]).

The positive impact of this plan would be the creation of open water area some of which is suitable for waterbird habitat. Deeper portions of the channel would not be as preferred as the shallow edge areas by dabbling ducks that forage for bottom foods. This plan, as for the other alternatives, will re-direct the flow of flood water, but the upstream nutrient inputs effecting the primary productivity of the marsh will not likely be decreased by this alternative. Therefore, to maintain the waterway, a regular maintenance program of applying herbicide or mechanically harvesting the new vegetation growth would be essential to maintaining its effectiveness.

The major negative technical impacts include the constructability, construction schedule and cost. The difficulty in mobilizing equipment along the central alignment, removal of the vegetation from the alignment, disposal of both vegetation and dredged material, and insuring the bottom material does not slough back into the excavation after the completion of work are some of the constructability concerns. Heavy equipment would need to work from a stable platform, such as a fill causeway or floating barge to remove the vegetation and excavate the channel. A floating platform was assumed for the cost estimates; the most logical access point would be from the western edge of the marsh, which would necessitate creating additional open waterways (in addition to the main channel) to float the equipment into a position to excavate the main channel. In addition to negative environmental impacts, the sediment and vegetation disposal problems would mean that this alternative would have a major impact on landfills on Oahu. The cost for this alternative is shown in Table 5-2. This estimate does not include substantial annual maintenance cost or mitigation costs.

The major positive impact of the channel is that from a hydraulic standpoint, once constructed and maintained as designed, it would lower flood stages at the upstream end of the marsh.

III Diversion of Flow Around Marsh Alternative - Alternative B

Another alternative (Figure 5-2) similar to channelizing flow through the marsh is to divert flow from the upstream end of the marsh around the edge of the marsh to either the Oneawa outlet canal or another outlet such as Kaelepulu Stream which presently flows to the southeast into Kailua Bay. One method of conveying the peak flow would be to construct a set of large storm sewers. To convey the design peak discharge (8000 cfs) at the entrance of the marsh, a bank of nine 12-feet diameter pipes would be required.

To insure that some water was still returned to the marsh, a water level control structure would be needed to bypass low flows and intercept only the peak inflow during floods.

TABLE 5-2

Construction Cost Comparison Summary

ITEM DESCRIPTION	ALT "A"	ALT "B"	ALT "C" CONC WEIR	ALT "C" EARTH WEIR	ALT "D" OPTION D1	ALT "D" OPTION D2	ALT "E"
MOBILIZATION	524,880	1,337,040	28,080	28,080	66,960	644,760	53,000
CLEAR & GRUB		393,120	77,760	77,760			
DISPOSAL AREA	1,626,480		1,626,480	1,626,480		1,626,480	3,701,000
LEVEE MODIFICATION			891,000	891,000	7,422,840	3,838,320	
CHANNELIZATION	28,529,280		410,400	410,400		3,468,960	348,000
CULVERT		233,398,800					
OUTLET STRUCTURE			698,760	698,760			
CONCRETE WEIR	408,240		85,320	0			
EARTH WEIR				95,040			
CONCRETE WORK		2,409,480				612,360	
EROSION CONTROL		919,080					
KAELEPULU WORK			30,240	30,240			
TRAFFIC CONTROL					341,280	444,960	
TOTAL	31,088,880	238,457,520	3,848,040	3,857,760	7,831,080	10,635,840	4,102,000

Note: Cost estimates found in Appendix A, Section 12 (based upon July 1990 mid-contract date) are adjusted herein by 8.00% to a July 1991 mid-contract date. Costs for the alternatives do not include mitigation costs.

The principal technical concern with this alternative is the cost shown in Table 5-2. The principal environmental impacts would be the excavation through archaeological sites, the noise and sedimentation effects associated with the construction, and similar downstream water quality degradation and aesthetic/recreational impacts during the bypassing of large flood flows.

IV **Storage and Emergency Outlet - Alternative C**

This alternative consists of several actions to increase the capability of Kawainui Marsh to distribute and store stormwater runoff and convey emergency overflow away from Coconut Grove. There are three elements to the plan for flood damage mitigation (see Figure 5-3). These elements are: 1) open new waterways, 2) protect the levee from overflows, and 3) provide for the rapid evacuation of overflow water from Kaelepulu Stream into Oneawa outlet canal in the event of overflow.

The elements are as follows:

Open new waterways. The purpose of creating the new waterways is to meet or exceed the design objective of providing 3,000 acre-feet of flood storage capacity between the marsh and the top of the levee, the basis for the design of the Oneawa canal/levee size established for the original U.S. Army Corps of Engineers' project (U.S. Army Corps of Engineers, 1957). The present circulation of flood water within the marsh is restricted due to the flow resistance caused by the vegetation.

The top width of these waterways will be approximately 40 feet wide, though the edges will be irregular. Assuming the minimum marsh level is 3.5 feet, msl, the depth of the waterways after construction will be a minimum of three and one-half feet. The maximum will depend upon the existing bottom which can be greater than five feet in depth once the floating mat is removed.

Opening waterways into the interior will decrease the time for internal distribution of flood water and will reduce storage at the upper end of the marsh. This will result in lower flood levels at the upstream end next to the levee.

Three means are proposed to open waterways: 1) mechanical removal; 2) explosives to blow apart the vegetation mat, and 3) herbicides.

The initial method of vegetative removal will be to place explosives in holes set below the top of the mat.

The charges are required to be set sufficiently below this level to allow for some loose sediments to slough into the bottom of the excavation without filling the excavation above 2.0 feet, msl after the initial displacement of vegetation and soil by the blast. Sufficient clearance must be provided to allow for operation of the maintenance equipment barges which will have a draft of approximately 18 inches.

Mechanical means would be used to remove vegetation in close to the levee, because of the proximity of the residential area to the outlet of the marsh, and some portions of the waterway in the northwest corner near the model airplane field where the mat is not as dense by mechanical means. The exact type of machinery will depend upon the type of bids received and their evaluation by the City and County of Honolulu for the construction and maintenance contract. In general it is recommended that the machinery be equipped with attachments that can pull up the roots of plants rather than merely cut and spray the vegetation. This is to reduce the propagation potential of the cuttings and also to reduce the accumulation of sediments.

Water hyacinth at the waterway inlets pose a threat because the plants can be dislodged by floods, as was witnessed during the flood in 1988, and can close the inlets. Another concern is that propagules will overgrow the water surface before maintenance equipment can be mobilized. Two doses of herbicide are proposed. Three brand names are identified in Appendix B, Section 5 that are considered safe for application. One includes the herbicide Rodeo which has been approved once before (aerial application in 1988) for use in the marsh. The first proposed application will be with Rodeo. It will be broadcast by helicopter over the proposed waterway alignment including the open water ponds to the south of the inlets prior to the initiation of blasting. The second application will be made from a boat after the waterways are opened. Another benefit of the herbicide will be improved access for people walking along the alignments during the blasting.

Protect the levee from overflows. Increasing the distribution of flood water within the marsh will not by itself prevent floods greater than an estimated 50-year flood from overtopping the levee. The historical and current evidence collected concerning the circulation of water in the marsh indicates the "drain" is at the upstream end of the levee, namely the southeastern corner of the marsh adjoining Kailua Road. This area has been the outlet for the marsh during historic and recent times when the marsh was manipulated for agricultural purposes. The likelihood that another flood could overtop the levee in this area is increased by the character of the marsh vegetation.

An essential element of the plan is to prepare for an event, the probability of which is estimated equal to or exceeding 4 percent each year, that this overflow will occur in the southeastern corner (Figure 5-3) and design features that can safely accept the flood water and redirect it away from the community. To protect the levee, a combination of concrete cap and stone revetment is recommended for approximately 1400 feet of the existing levee where the flow will concentrate. In order to ensure that the overflow occurs where the least negative impact and greatest amount of protection can be provided, the levee should be maintained 0.5 feet below the original as-built grade (9.5 feet, msl) for this 1400 foot distance, and an additional 2.5 feet of height added to approximately 3000 feet of the levee to the north of the overflow.

The existing wetland on the Coconut Grove side of the levee is primarily bulrush (*Scirpus californicus*) with some California grass (*Brachiaria mutica*) near the edge of the levee. It is proposed to remove a 25-foot wide strip of vegetation on the Coconut Grove side of the levee to facilitate construction of the overflow weir. In addition, flow alongside the levee will be permitted through an excavation in the west bank of Kaelepulu Stream. This excavation will be to the level of the existing stream channel invert (bottom) at levee station 14+50 to allow water overflowing the levee to enter the stream and flow north to Oneawa canal. This will reduce the risk that water in the wetland (east side of levee) will overtop the bank on the residential side of the stream.

Provide for the rapid evacuation of overflow water from Kaelepulu Stream into Oneawa outlet canal. In order to evacuate flood water rapidly from Kaelepulu Stream before it rises to stages that will inundate residences and businesses, a new outlet structure to Oneawa canal at the northern end of Kaelepulu Stream is recommended. The plan is to construct a reinforced concrete box outlet with a clear width of 48 feet to convey water into Oneawa canal without constricting the flow. The outlet invert will be set at -0.5 feet and the water salinity in the stream will become more brackish than at present. Normal water levels will decrease in Kaelepulu Stream which will fluctuate with the tidal range observed at the head of Oneawa canal. These lower levels will improve local storm drainage conditions particularly during storms less than ten-year return period.

The combination of marsh storage and outflow through this outlet will meet the City and County of Honolulu Storm Drainage Standard of conveying a 100-year flood with a 2-foot freeboard. It will also pass a flood the magnitude of the New Year's Eve, 1988 flood without damaging structures and contents in the nearby community.

The outflow from Kawainui Marsh was considered in the design of this outlet and it is shown in Appendix A, Section 4 and 5, that there will be no adverse effect on flooding within Coconut Grove. If this opening had existed at the time of the New Year's Eve 1988 flood, the water levels which exceeded 9.5 feet behind the levee in Coconut Grove would have been lower. In the simulated design flood condition, from water level measurements taken since the New Year's Eve storm, and water level conditions during the New Year's Eve storm it is demonstrated (Appendix A, Section 4 and Section 5) that the outflow from the marsh has only minor impact upon the stage in the head of Oneawa canal, and not sufficient to induce flooding within the area protected by the Federal levee.

Maintenance facility. The maintenance of waterways is an important portion of the proposed action. New growth of vegetation will be harvested by mechanical means and barged to a handling/storage area. The vegetation will be transferred from the vegetation barge to the vegetation compactor by either a crane or conveyor depending upon the contractor's equipment. The sediment disposal area, adjacent to the model airplane field, is to be regraded, lined with an impermeable landfill cap, and diked to contain runoff. Sediment from barges will be pumped into this sediment basin for drying. Fresh vegetation that is barged to the site will be transferred to the handling area, compacted, and baled, to reduce the weight (water content).

V Levee Raise/Channelization - Alternatives D1 and D2

Another alternative is to raise the levee, or raise the levee in combination with some enlargement of the City and County emergency ditch. The height required at the upstream end of the existing levee to prevent a flood equal to the original U.S. Army Corps of Engineers' design flood, provide the Corps' design requirement for a minimum three-foot freeboard between the design water level and the top of the flood control embankment, and provide a six-inch gravel base course roadway for maintenance vehicles requires a new levee elevation of 17.0 feet, msl, at the upstream (Kailua Road) end of the levee. This height diminishes in the downstream direction a few tenths of a foot for the next 4000 feet. The reason that this height is so much greater than the original design height (9.5 feet, msl) is that this analysis includes the effect of friction due to hydraulic resistance of the marsh. The numerical model of the marsh developed for the DEIS was used to estimate the peak water level that would occur if overtopping were prevented.

An alternative that is based solely upon raising the levee (Alternative D1) has significant impacts and high costs. The site plan assumed herein is for a levee that would prevent levee overtopping by the design flood used in the original levee project design. Because of poor foundation conditions in the marsh the levee is assumed to be extended toward Coconut Grove. (The exact alignment would depend upon additional subsurface investigations.) The base width of this new levee is approximately 122 feet. The extension of a levee of this width would reach the limit of construction shown on Figure 5-4. The base of the new levee will encroach upon Kaelepulu Stream necessitating either realignment of some channel sections and bank reshaping, or retaining structures for the channel bank. The wetland area on the Coconut Grove side of the existing levee will have to be converted to an embankment area supporting the new levee. This will require some type of mitigation measures to be identified by USFWS. The amount of mitigation will depend upon their evaluation of the habitat value. There would also be significant changes in the views of the marsh and surrounding terrain from the residences near Kaelepulu Stream because the height of this levee will be nearly twice the height of the original levee.

The major technical impacts of this alternative are the cost, the vegetation disposal impacts, and Kaelepulu Stream alteration. The major environmental impacts are the loss of nine acres of wetland, the impact upon views and the construction traffic.

This alternative has less maintenance requirements than the proposed plan both in terms of manpower and equipment commitments. However, as noted in Appendix B, Section 5, the basis for the long-term design of this alternative with respect to sedimentation, biomass production, and deposition in the marsh is uncertain. The requirement for additional levee raises in the future should be anticipated, even with attempts to manage productivity because terrigenous sedimentation is part of the natural environment and will continue to reduce the level of protection that will be provided by the initial 17.0 foot levee height.

An option studied to this alternative is to enlarge the existing emergency ditch to increase its flood conveyance which would reduce the storage of floodwater and permit designing a lower levee. However, creating a channel large enough to convey the peak discharge of the design flood (18,100 cfs) is not recommended because this will exceed the design capacity for Oneawa canal (7350 cfs per Table 2-1). Assuming the emergency ditch can be enlarged to carry a peak discharge of 8000 cfs without endangering properties bordering Oneawa Canal, the amount that storage in the marsh can be reduced at the time of the peak discharge is estimated to be 1850 acre-feet as shown in Appendix A, Section 10. The reduction in this amount of storage was the basis for sizing an intermediate levee height that requires an elevation of 15.1 feet, msl when all the other factors (freeboard, roadway, etc.) were included. This levee and resulting channel size (140 foot bottom width) are shown on Figure 5-4. The cost for this option is, however, more expensive than for raising the levee primarily due to sediment/vegetation removal and disposal costs (see Table 5-2).

This option (D-2) is less difficult to construct than Alternative A, channelization in the marsh interior, and requires less dredge disposal and vegetation removal. However, it has similar major impacts on landfills due to disposal and has major traffic impacts. It also has the same maintenance concerns as Alternative A, though to a lesser degree, because the channel is smaller and located in an area where the sediments are less prone to sloughing as evidenced by the relatively steep banks shown in the cross sections of the existing emergency ditch (Appendix A, Section 5).

VI Proposed Project - Alternative E

Alternative E is a modification of the proposal (Alternative C) in the Draft Environmental Impact Statement. The basic elements of the revised plan are:

a) Opening approximately 10,000 linear feet of waterway which will create approximately 10 acres of open water to distribute flood water more efficiently within the interior of the marsh;

b) Clearing vegetation and sediment from existing ponds to provide approximately 20 acres of open water to enhance flow into the waterways and reduce the presence of floating material which could block flow and impede flood water distribution;

c) Construction of a processing and handling area for the materials planned for removal in order to maintain the elements completed in a) and b) above in a functioning condition.

There are several differences in the revised plan. The waterway alignments have been changed to follow as much as possible the abandoned agricultural canals within the marsh and their size has been increased (but no change in proposed depth) to improve flood water distribution. The waterways have been shortened; they extend only to the central areas of the marsh and not to Oneawa canal. The low flow weir within the marsh on the emergency ditch, the levee modifications and overflow system as well as changes to the Kaelepulu drainage system have been deleted. Corps of Engineers studies will address proposed changes to the levee and outlet. City and County of Honolulu proposals to clean Kaelepulu Stream will be addressed by separate study.

VII Basis of Cost Comparison

The construction cost estimates prepared for each alternative in Table 5-2 include a contingency and are priced in July 1990 dollars. Costs include contractor's overhead and profit.

Alternative A is based on the use of floating conventional excavating equipment to remove the vegetation and transport it to the disposal/handling area. It is assumed a suction dredge will be brought from the mainland to remove sediments. The dredge can only advance the excavation as fast as the vegetative mat can be removed to prevent clogging the pump. It is estimated that the vegetation removal barge is limited to a removal rate of approximately 100 cubic yards per hour.

Because of the quantity of material involved, the Kapaa Landfill would not be the most likely site for disposal because of its limited capacity and the Refuse Division limitation of 75 cubic yards of sludge per day. The disposal area has approximately 9.8 usable acres for sediment dewatering and consolidation and is unable to contain the entire volume of material removed. It will require approximately 23,000 truckloads to remove the sediment and 18,000 truckloads for the vegetation. It is assumed the material will be disposed in commercial landfills on the leeward side of Oahu.

Construction time is estimated at 15 months including mobilization. Actual construction time assuming an industry standard double shift, six days per week activity, is 11 months assuming no delays or equipment problems. Total first cost of construction is estimated at approximately $31,089,000 (see Table 5-2). Details of the estimate are shown in Appendix A, Section 12.

Alternative B requires the installation of 40,000 pound pieces of 12-foot diameter pipe. Due to the weight, a special frame would have to be fabricated. Laying of pipe would proceed from the marsh toward fast land. The pipe would be laid underwater using the frame to steady the pipe and complete jointing work.

Two shifts of 20 people would be required. Two 150-ton cranes are required, one on shore to off-load pre-cast sections and one on the material barge to lay the pipe and bedding material. The estimated construction time is 5 to 6 years.

Total first cost of construction is $238,458,000 as shown in Table 5-2. Details of the estimate are shown in Appendix A, Section 12.

Alternative C was the proposed action in the DEIS. Its first cost of construction is $3,848,000. This includes the construction of disposal area/siltation basins which are needed for maintenance of the waterways. The cost for two basins is approximately $1,626,000. Herbicide treatment is estimated to cost an additional $10,000. The details of the cost estimate are contained in Appendix A, Section 12. The time for construction is 12 months including mobilization.

Alternative D has been evaluated two different ways. One option is to raise the levee as the only measure to reduce flood damages. The second option is to raise the levee (to a lower elevation than the first option, above) and excavate a ditch next to the toe of the existing levee; actually this amounts to an enlargement of the existing emergency ditch.

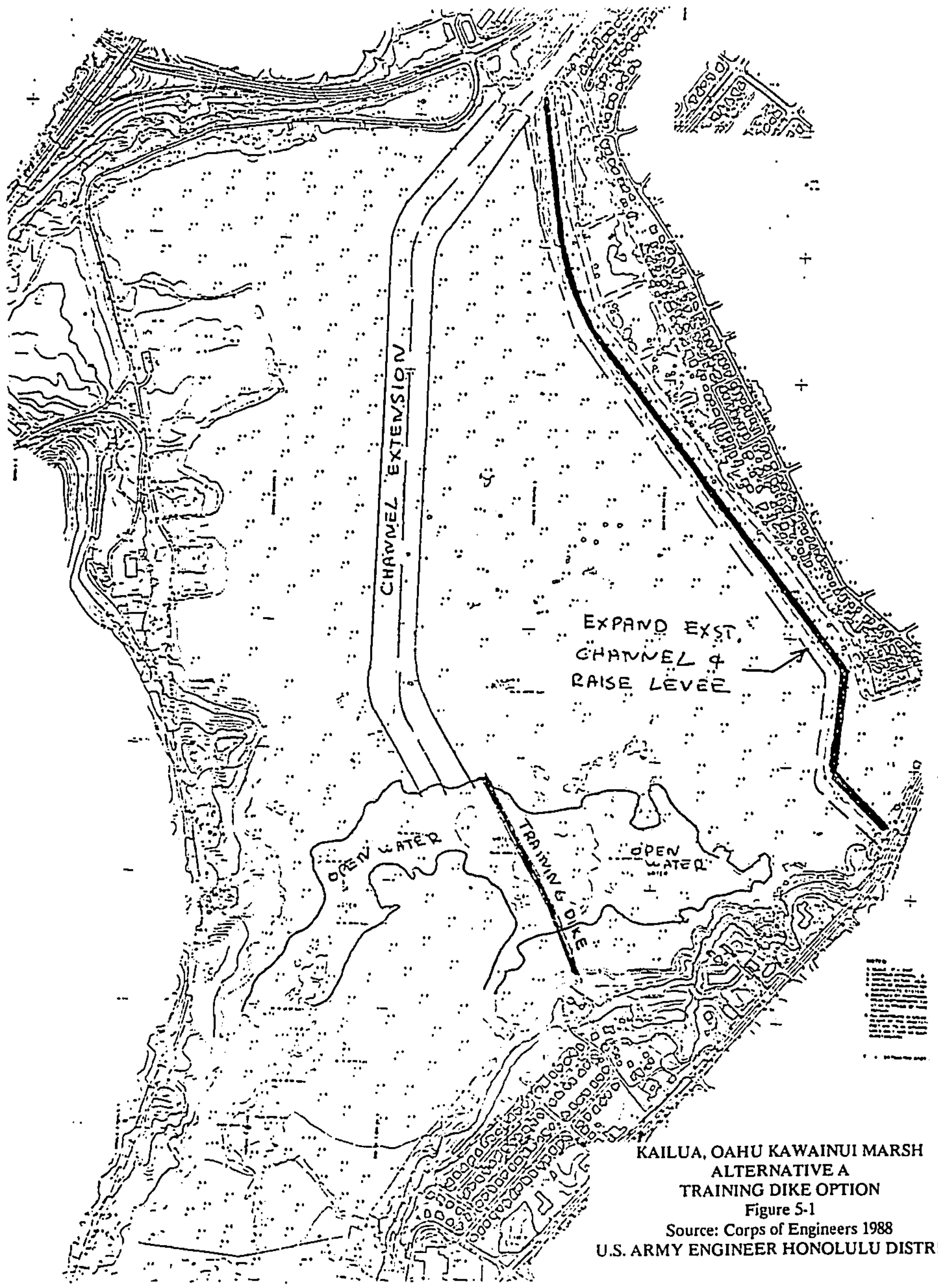
Construction costs for the levee assumes all access of construction equipment from Kailua Road. This assumption is based on the fact that the City and County of Honolulu receives complaints when its maintenance equipment use the entrance near Oneawa canal and have stopped using this access point. After removing and stockpiling the existing gravel surface, the back side would be scarified and the wetland toward the existing streambank cleared and prepared for the new embankment. Approximately 21,240 truckloads of material would be imported for the embankment and toe drain. It was assumed that suitable embankment material will be located within a 25 mile round trip of this site. Assuming double shifts, six day a week operation, construction would take fourteen months.

The total first cost of construction is estimated at $7,831,000. The details of this cost estimate are contained in Appendix A, Section 12.

For the second option of Alternative D, i.e. levee raise with a dredged channel, material would be removed adjacent to the existing ditch using a barge-mounted dragline. Vegetation and sediment would be trucked to commercial disposal areas on leeward Oahu. Approximately 5580 truckloads would be required to remove vegetation and sediment and 7920 truckloads required to import embankment construction materials. Assuming a double shift, six day a week operation, the construction period would last 15 months. Total first cost of construction is $10,636,000. Details are provided in Appendix A, Section 12.

Alternative E is the proposed action. The estimated first cost of construction is $4,102,000. This assumes the material removed from the marsh must be disposed at a landfill. Efforts are ongoing to identify alternative means to recycle this material, but additional time is required to complete all the necessary technical analyses and administrative review.

The waterways will be constructed by a combination of mechanical equipment removal, blasting, and application of chemicals to control new vegetation growth. The unused portion *(adjacent to the model airplane field)* will be converted into a processing area for green vegetation, peat and sediment. The drying beds will be sealed to reduce potential for leachate through the old landfill material. The materials will be processed and treated to control odors and acidity, and dried to meet federal and state regulations for landfill disposal.



KAILUA, OAHU KAWAINUI MARSH
ALTERNATIVE A
TRAINING DIKE OPTION
Figure 5-1
Source: Corps of Engineers 1988
U.S. ARMY ENGINEER HONOLULU DISTRICT

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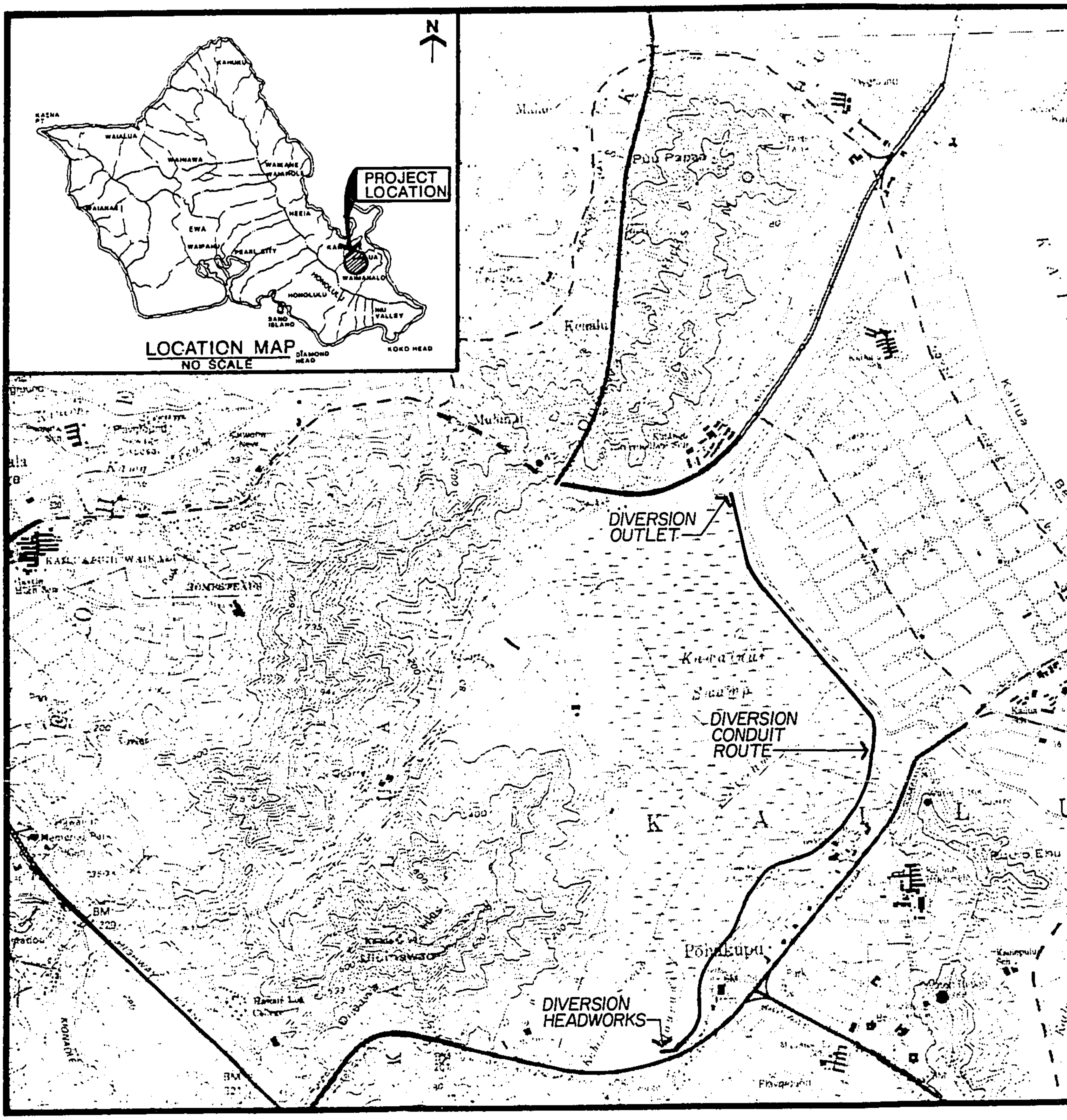

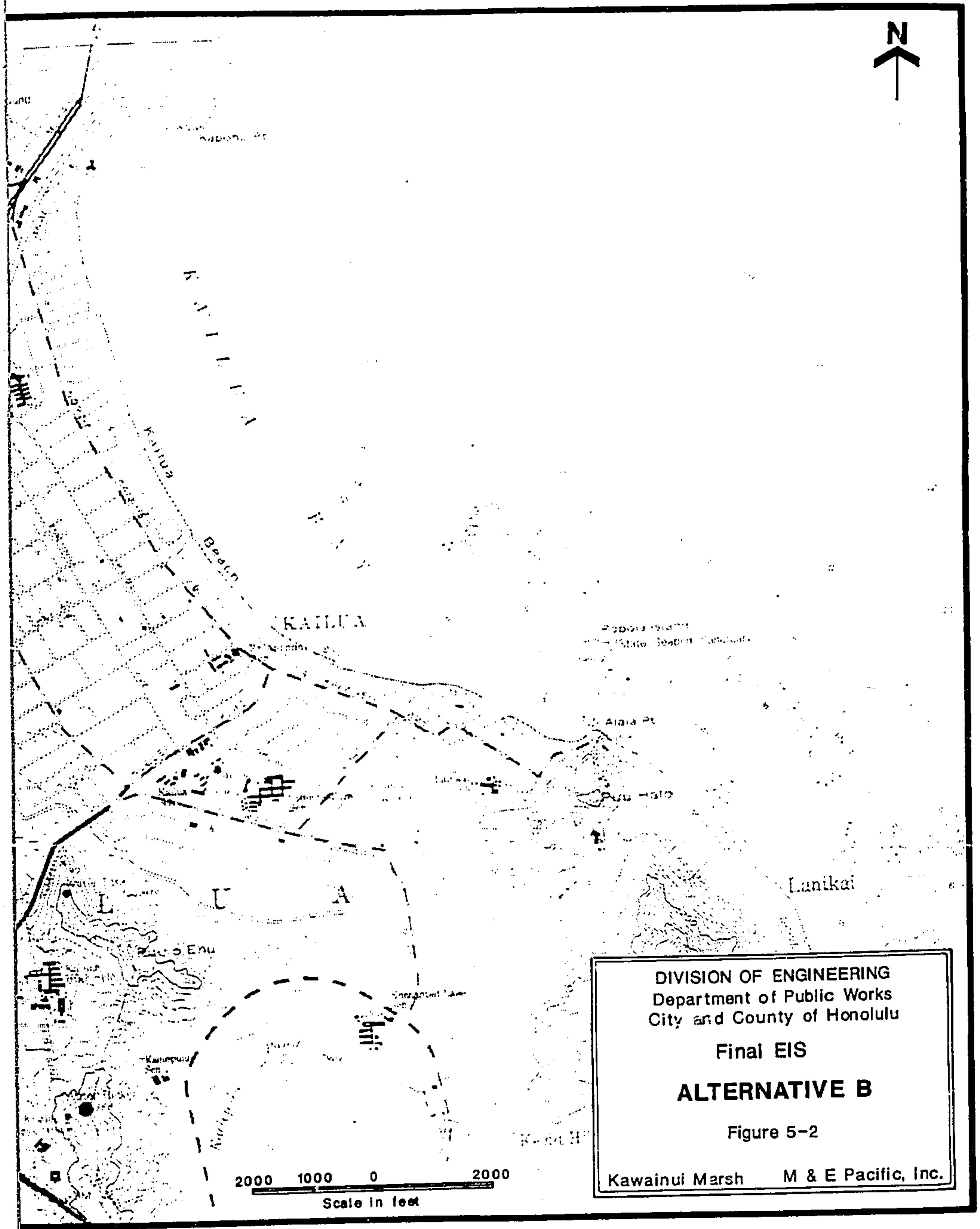

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ALTERNATIVE B

Figure 5-2

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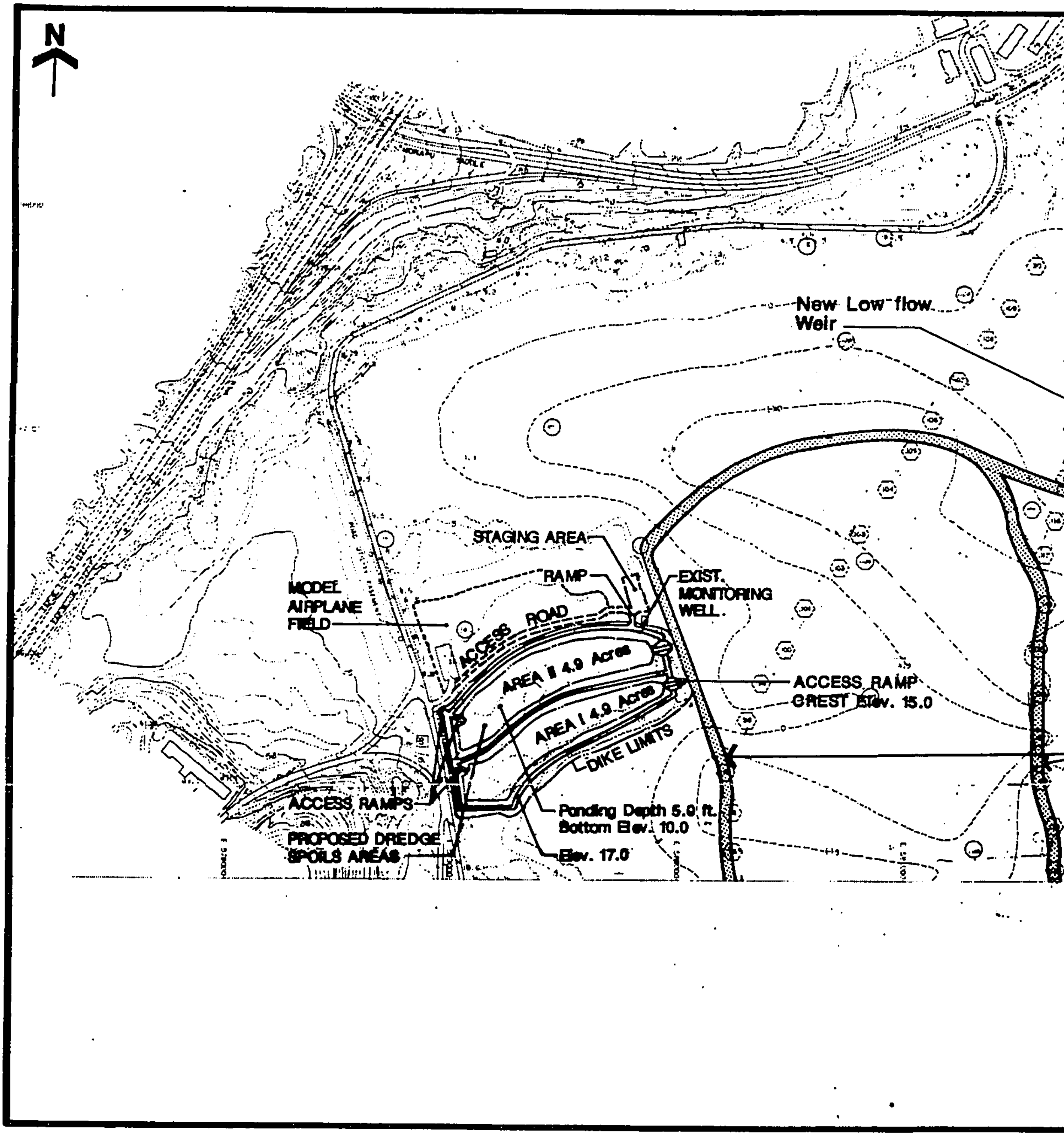

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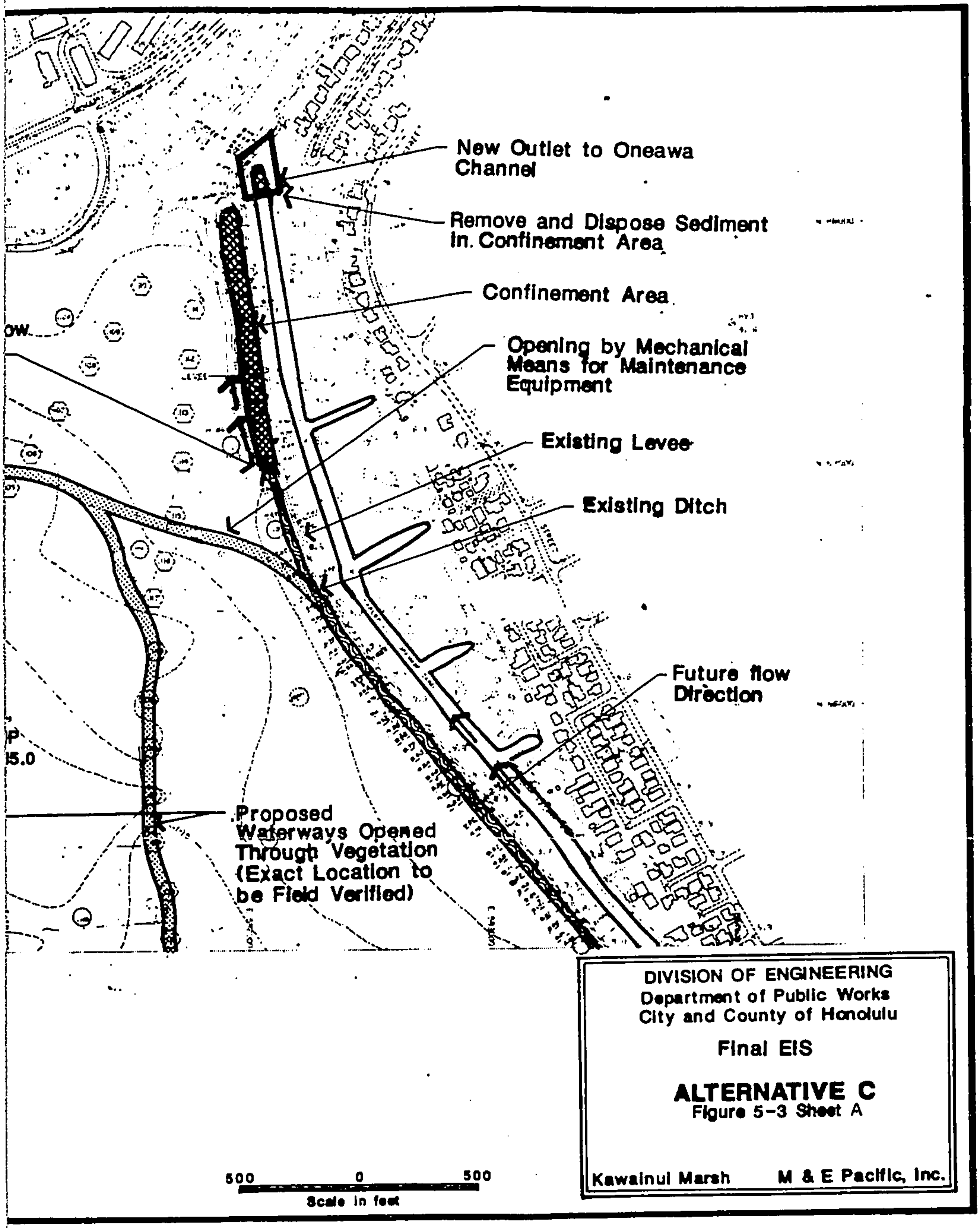

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ALTERNATIVE C
Figure 5-3 Sheet A

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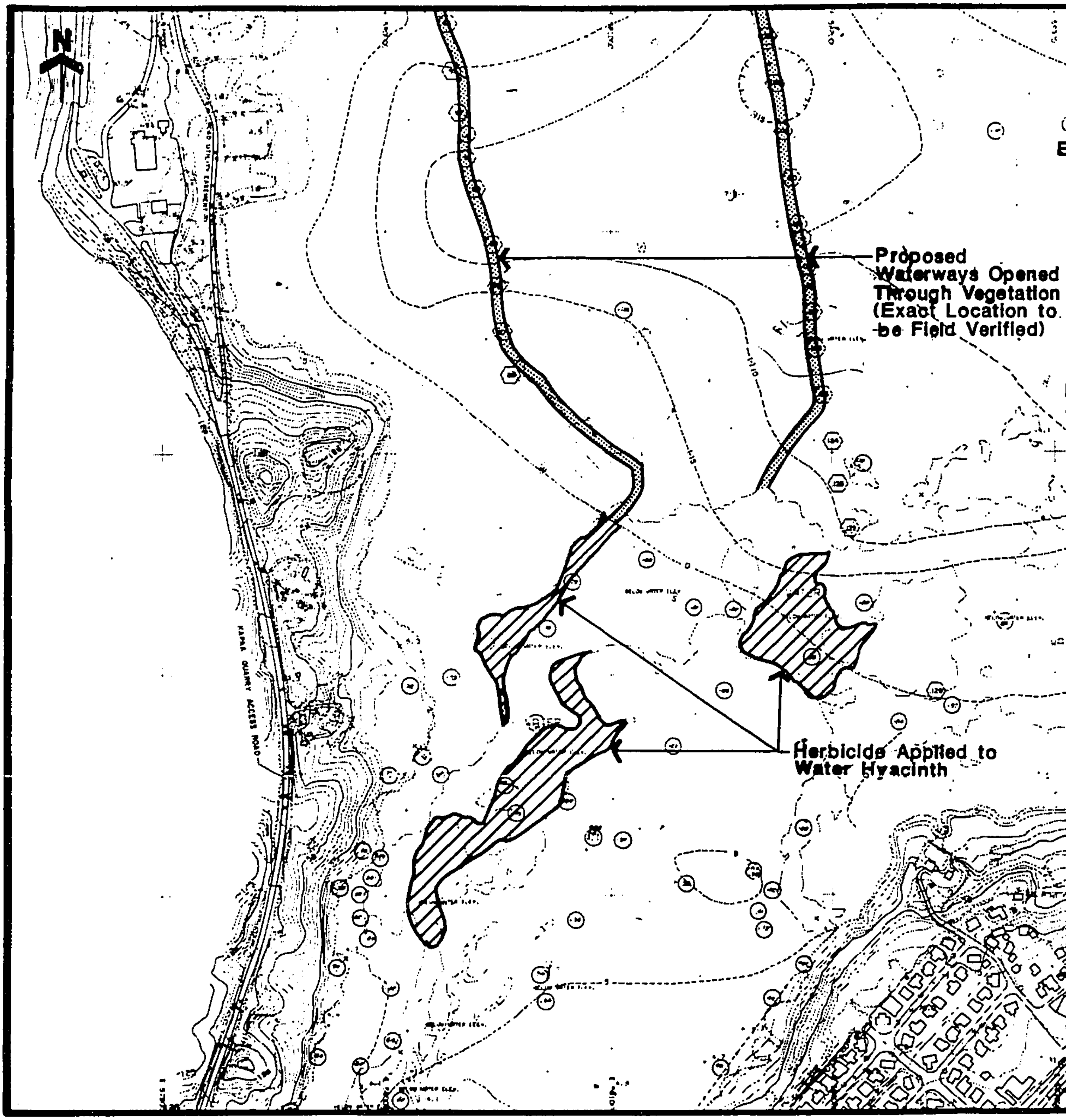
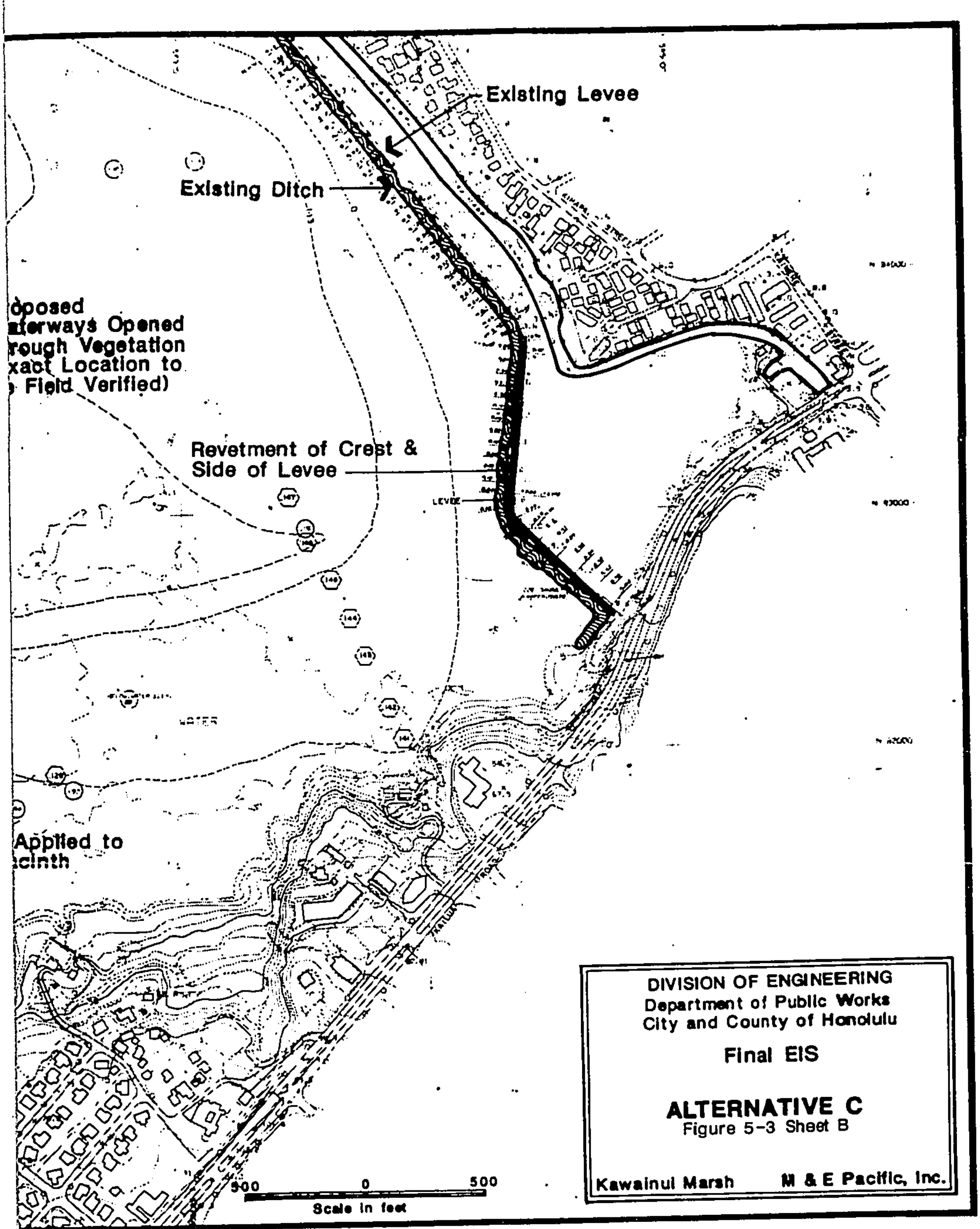

N
Proposed Waterways Opened Through Vegetation (Exact Location to be Field Verified)
Herbicide Applied to Water Hyacinth



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ALTERNATIVE C
Figure 5-3 Sheet B

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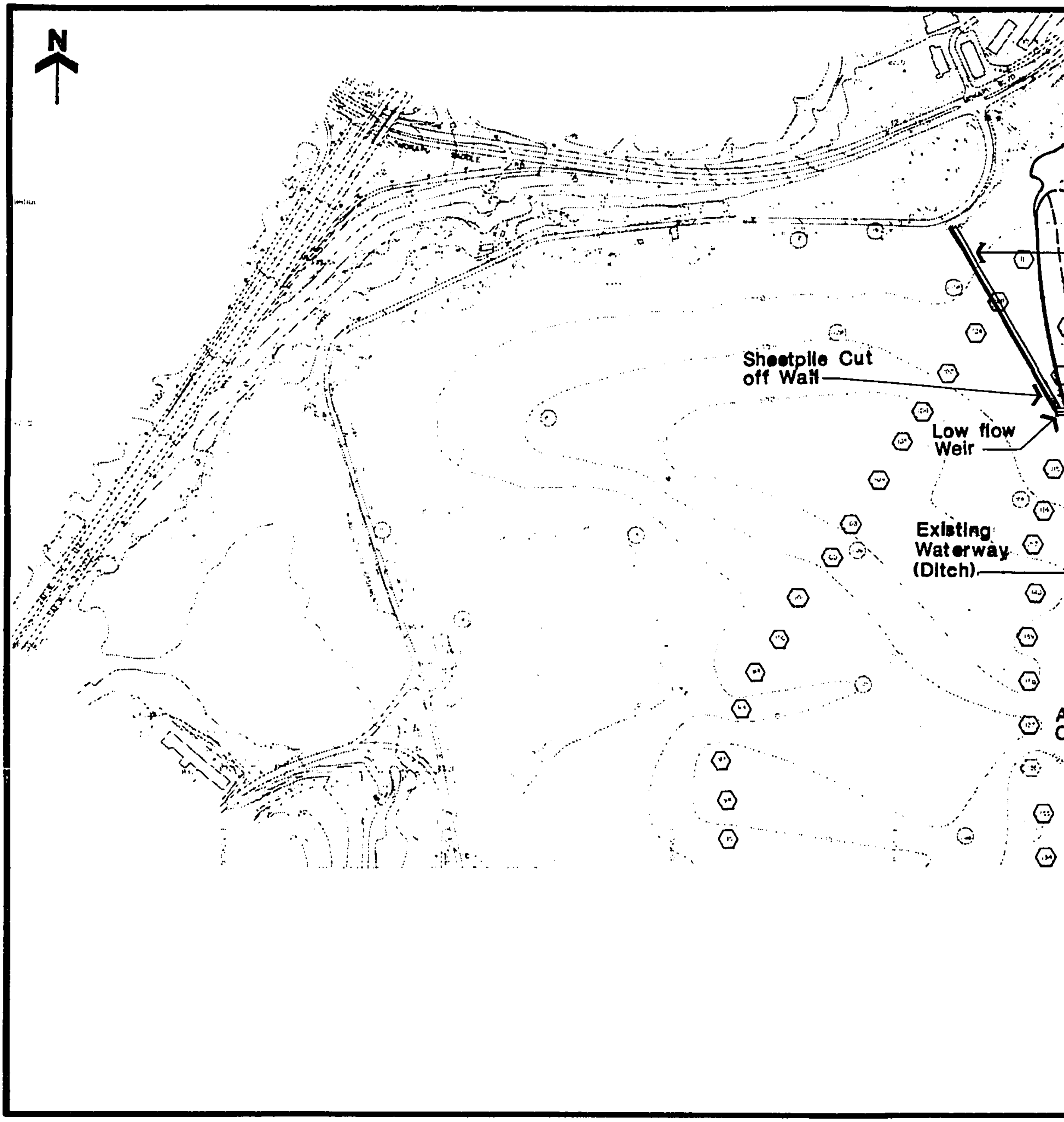

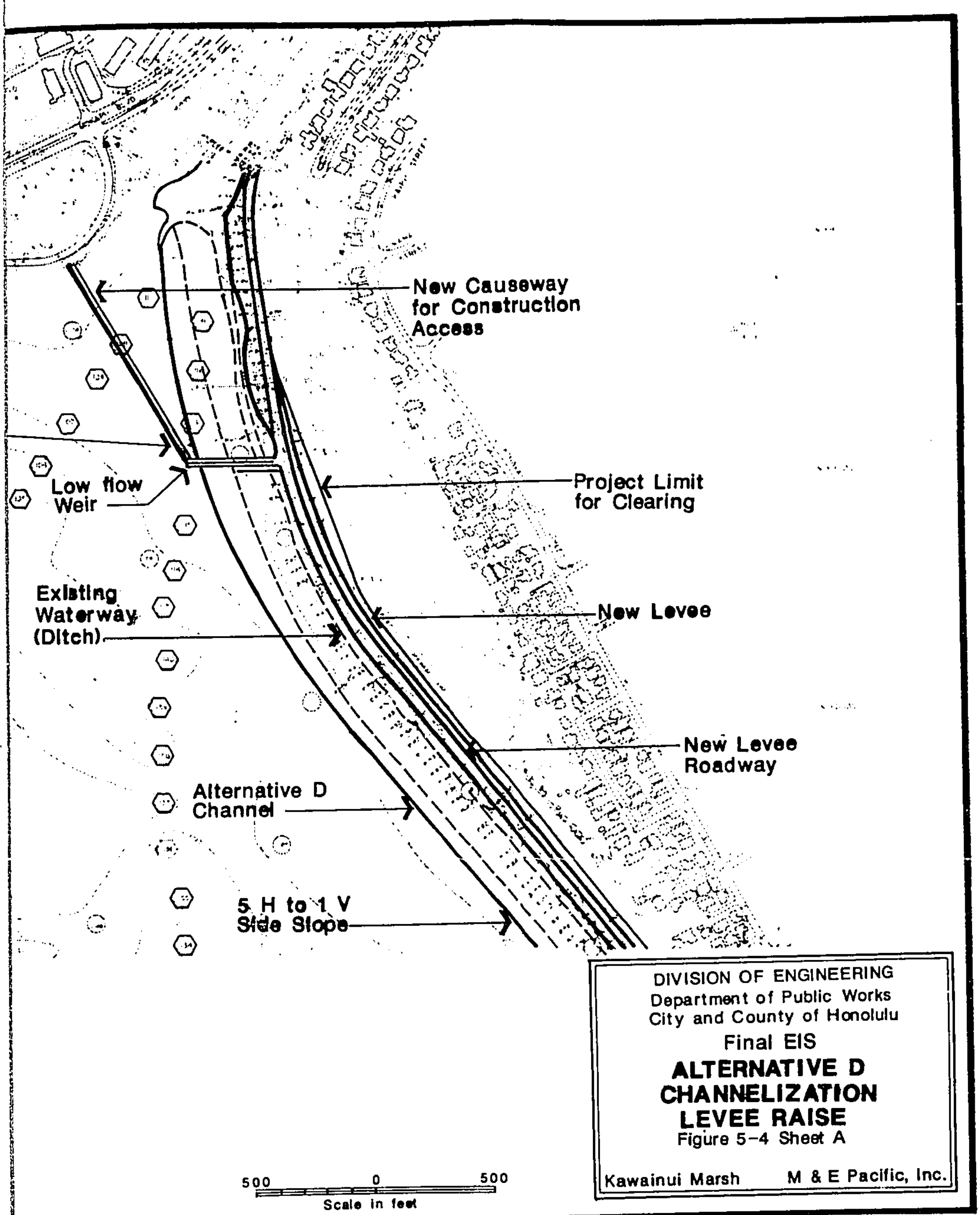

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Final EIS

ALTERNATIVE D CHANNELIZATION LEVEE RAISE

Figure 5-4 Sheet A

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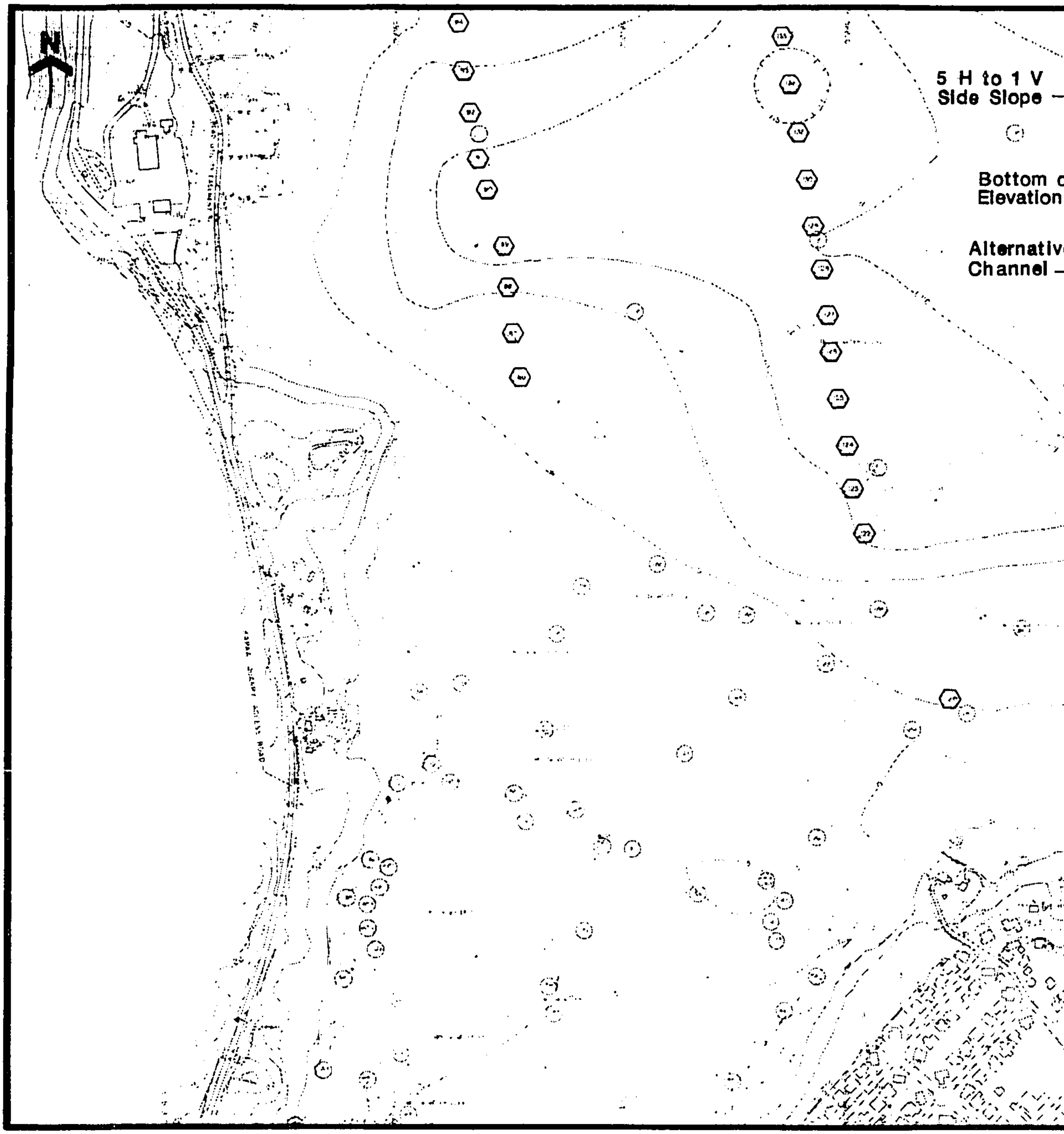

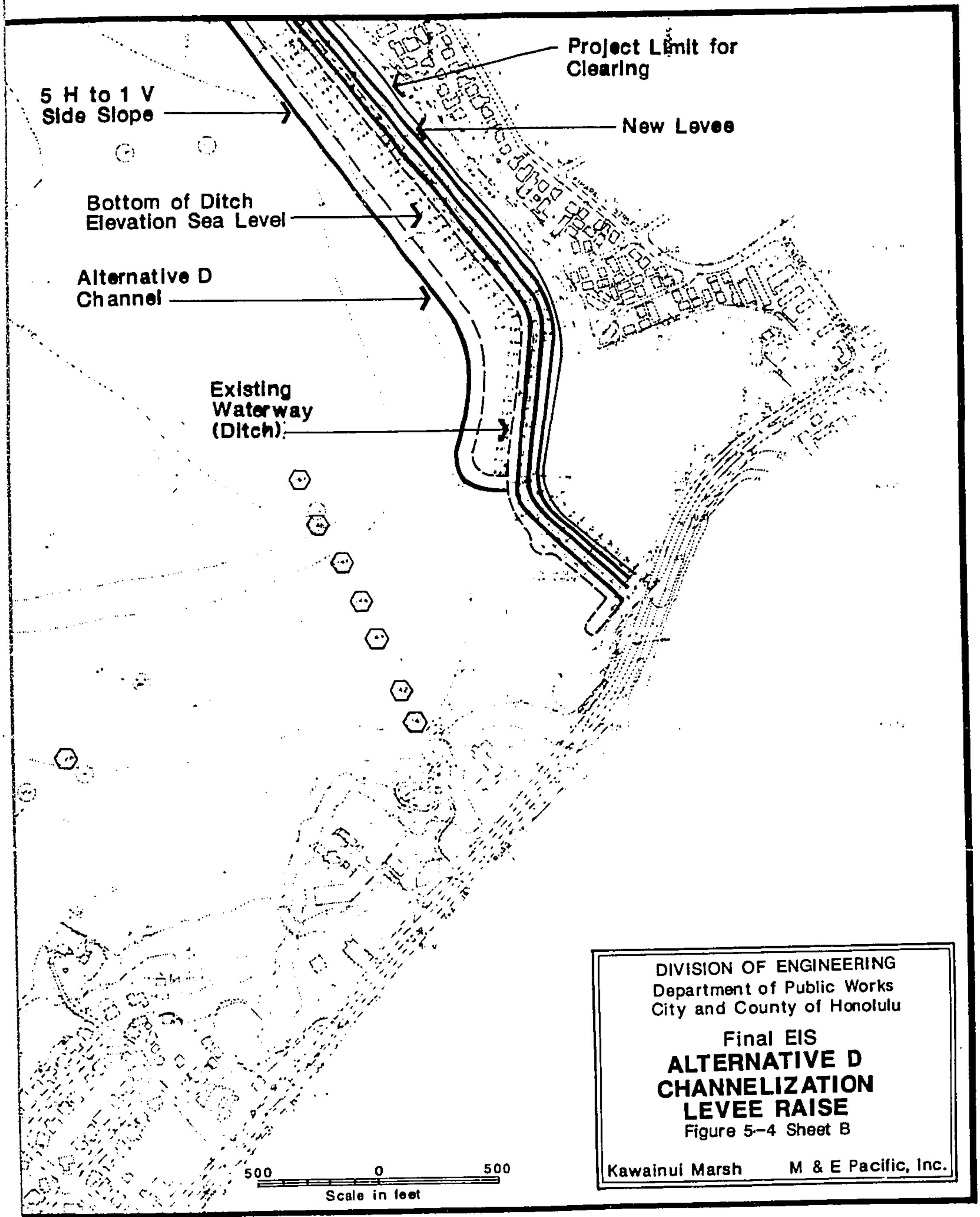

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ALTERNATIVE D CHANNELIZATION LEVEE RAISE
Figure 5-4 Sheet B

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SECTION SIX

RELATIONSHIP TO PLANS, POLICIES, AND CONTROLS

I Plans and Policies

In Hawaii, land use planning and control functions are shared between state agencies and the four counties. There are no separate municipalities. The island of O'ahu is governed by a combined entity, the City and County of Honolulu. The State Land Use Commission is responsible for basic land use designations or districts including the conservation designation for the marsh and the urban designation for the residential and commercial lands to the east and south. The State Department of Land and Natural Resources (DLNR) administers controls on all land in conservation districts and is the issuing authority for permits for the use or modification of conservation land and alteration of stream courses. The Governor's Office of State Planning houses the State Coastal Zone Management (CZM) office which is responsible for managing the state-level CZM program. The CZM office sponsored development of the Resource Management Plan for Kawainui Marsh described below.

Land designated as urban is the responsibility of the City and County of Honolulu. Administration is divided between two departments. General planning and the implementation and modification of development plans are under jurisdiction of the Department of General Planning. Zoning of urban lands and administration of other county land use controls including the issuance of Special Management Area (SMA) permits for land uses within designated areas of the coastal zone are handled by the Department of Land Utilization. Kawainui Marsh falls within the SMA boundaries and is zoned for preservation use by the city. Under the General Plan, the marsh interior is designated for preservation, while the peripheral areas are designated for agricultural, highway, industrial, and residential uses. The City and County has zoned the peripheral area for R-6 residential areas with a minimum of 5,000 sq. ft. and R-4 areas with a minimum of 7,500 sq. ft.

In 1979, the Outdoor Circle submitted a proposal for funding to the Hawaii Coastal Zone Management Program to develop a resource management plan for the marsh. This was the beginning of a three year process which included creating a multi-disciplinary advisory body representing a broad spectrum of special interests. This body consisted of representatives from the three levels of government, community organizations, land owners and principal industrial interests in the marsh area. The goal of this committee process was to:

Develop and obtain approval for an effective and implementable resource management plan that reconciles existing conflicts and resolves principal resource management issues that have been identified in past discussions and current resource studies of the marsh.

A list of studies was developed and funded contributing to the existing reports and technical studies on the various resources of the marsh.

The result of this effort was the creation of a joint-effort comprehensive Resource Management Plan in 1983 establishing objectives in the three general areas of scientific/environmental, cultural, and economic/planning. The State Department of Land and Natural Resources (DLNR) was designated the lead agency responsible for the implementation of the Plan. DLNR has established an intra-departmental Kawainui Project Committee and has requested Capital Improvement Project funding for the development of a master plan for the Kawainui Marsh management area, as well as for plan, design and construction funds for fencing, boardwalks, trails, moats, viewing sites, signs and specialized equipment. The preliminary list of members/organizations to make up the Citizen Advisory Committee for implementation of the management plan has been prepared and invitations to become a participant have been sent.

II Applicable Permits and Approvals

Existing uses of the marsh and surrounding urban environment are consistent with all county and state land use control policies and plans. Flood control has been an authorized and dedicated land use function of the Kawainui Marsh ecosystem since the county agreed to manage and maintain the federally built project in 1966. Modifications to the existing project, however, will be subject to certain land use and regulatory approvals. These are described below and summarized in Table 6-1.

Conservation District Use Application (CDUA). Because the marsh is classified as Conservation under the state land use district system, any new activity requires permission from the Department of Land and Natural Resources. The method of issuing a permit depends on the proposed use and the subzone category. Permit applications for activities that are listed as "permitted uses" for each subzone in the administrative rules are processed by DLNR staff and acted upon by the Chairman of the Board of Land and Natural Resources. Uses not listed require a conditional use permit which must be acted upon by the full board. As part of the CDUA process, the State Office of Historic Preservation, Division of Water and Land, Aquatic Resources, and Forestry and Wildlife are consulted.

TABLE 6-1

APPLICABLE REVIEWS, PERMITS, AND/OR APPROVALS

AGENCY AND PERMIT	LEGISLATION OR REGULATION	CONCERN
<u>STATE</u>		
<u>Board of Land & Natural Resources</u>		
Conservation District Use Permit	Chapter 183, HRS DLNR Adminstrative Rules, Title 13, Chapter 2	Protection of natural resources; required for any use* within a Conservation District
State Historic Preservation Officer Approval	Chapter 6E, HRS	Protection of historic sites

*including "maintenance and protection of desired vegetation, including removal of dead, deteriorated and noxious plants" (§13-2-11 Protective (P) subzone) and "flood, erosion, or siltation control projects" (§13-2-12 Limited (L) subzone).

AGENCY AND PERMIT	LEGISLATION OR REGULATION	CONCERN
<u>Commission on Water Resources Management</u>		
Stream Channel Alteration Permit	Chapter 174C, HRS DLNR Administrative Rules, Title 13, Subtitle 7, Chapter 13-169	Protect instream uses
<u>Office of Environmental Quality Control</u>		
Environmental Impact Statement	Chapter 343, HRS DOH Adminstrative Rules, Title 11, Chapter 200	Environmental protection

TABLE 6-1 (Continued)

AGENCY AND PERMIT	LEGISLATION OR REGULATION	CONCERN
STATE (cont'd)		
Department of Health		
401 Water Quality Certification	DOH Administrative Rules Title 11, Chapter 54	Inland water quality protection
CITY & COUNTY OF HONOLULU		
Special Management Area Permit	Chapter 205A, HRS	Protection of coastal areas
Grading, Grubbing, and Stockpiling Permit	City & County of Honolulu Ordinance No. 3968	Environmental impacts of vegetation and/or earth moving and storage activities
Amendment to Development Plan Public Facilities Map	Title V, Chapter 4, Section 5-409, Revised Chapter of the City and County of Honolulu 1973 (1983 Edition)	Coordination of land use planning and construction of public facilities

Special Management Area (SMA). The purpose of SMA permits is to place special management controls on development to avoid permanent losses of valuable resources and foreclosure of management options. The permits are administered by the Department of Land Utilization and issued or denied by the City Council. Applicants for Conservation District Use permits must secure clearance from the City on whether or not a SMA permit is required before the DLNR will act on the CDUA. An SMA permit is required for this project and an application must be filed. Processing of the two permits may take place concurrently; however, the SMA must be approved prior to CDUA approval.

Environmental Assessment and Environmental Impact Statements. Pursuant to Chapter 343, Hawaii Revised Statutes, a state or county action that may have a significant effect on the environment, as defined by Title 11-200-9, Department of Health, requires the preparation and filing of an environmental impact statement (EIS). Minor or purely administrative actions are exempt from the EIS process. These exemptions are compiled, publicized and approved by the Environmental Council in accordance with provisions established by Title 11-200-8. Agencies must assess proposed actions "at the earliest practicable time" in order to determine the significance of the impacts. For actions that are not exempt, the proposing and/or approving agency prepares an environmental assessment that examines the potential impacts of the proposed action. If the actions are deemed significant, a determination is made that a full EIS is required.

A Federal EIS, pursuant to the National Environmental Policy Act (NEPA) will not be needed for the proposed project. The project, as modified, will not required federal action or funding. According to a letter from the Department of the Army, a permit will not be required for the proposed project. The need for a federally issued permit would have constituted a "Major Federal Action," as defined by 40 CFR (Combined Federal Register) Part 1508.18, and this, in turn, would have triggered NEPA.

Other approvals. It will be necessary to request a Stream Channel Alteration permit from the State Commission on Water Resource Management.

A 401 Water Quality certification permit must be obtained from the State Department of Health. An application to establish a zone of mixing will be made at the same time as the application for 401 certification. The zone of mixing will be required for treated return flow from sediment drying beds.

SECTION SEVEN

AGENCIES, ORGANIZATIONS AND INDIVIDUALS CONSULTED

I Plan Development Process

The proposed actions to improve flood control measures within Kawainui Marsh were developed through a process that included several activities. These were:

(a) informal meetings and telephone conversations were held with individuals, groups, and Federal, State and City agencies to obtain pertinent data and literature previously prepared on Kawainui Marsh. The list of contacts is shown in Section II. A body of literature exceeding sixty reports and papers were identified and obtained which were reviewed for significant material effecting the plan formulation and effect assessment process.

(b) a series of technical workshops were held with specialists in the fields of engineering and environmental sciences to review alternatives, make preliminary effect assessments, and identify monitoring and mitigation measures.

(c) agencies responsible for the review of permits to which the proposed actions are subject were briefed on June 14, 1989 of the nature of these actions and why they were selected among the other possible alternatives described in this environmental impact statement.

(d) modifications to the plan proposed in the DEIS were made after receipt of reviewer's comments.

II Agencies, Organizations, and Individuals Consulted

Public information meetings were held with both the Kailua Neighborhood Board and the Citizens Advisory Ad-hoc Committee on Kawainui Marsh. A public information meeting for the general public was held in Kailua on July 13, 1989.

Letters were mailed to the respondents to the Corps of Engineers original environmental assessment (EA) and notice to prepare an environmental impact statement (NOP) informing them of the change in the proposed action and the preparation status of the EIS. The parties who indicated a desire to be consulted on the proposed action were included in the mailing list for the new EA and

NOP. Respondents with substantial comments are identified by an asterisk (*) and their comments are reproduced along with the responses in Appendix C.

A copy of the DEIS was mailed to parties indicating a desire to review it as well as to parties on OEQC's distribution list. Respondents with substantial comments are identified by an asterisk (*) and their comments are reproduced along with the responses in Appendix C.

The following agencies were included in the mailing list.

FEDERAL

Department of the Army
  Army Corps of Engineers

Department of Agriculture
  Soil and Conservation Service

Department of the Interior
  Fish and Wildlife Service
  Geological Survey

U.S. Environmental Protection Agency

STATE

Department of Agriculture

Department of Business and Economic Development

Department of Defense

Department of Education

Department of Health

Department of Land and Natural Resources
  State Historic Preservation Office, DLNR
  Commission on Water Resource Management

*Office of Environmental Quality Control

*Office of Hawaiian Affairs

Office of State Planning
  Coastal Zone Management Program

Office of Hawaiian Affairs

University of Hawaii
  *Environmental Center
  Water Resources Research Center

State Legislature
  Senator Mary George
  Senator Stanley T. Koki
  Representative Reb Bellinger
  Representative Ed Bybee
  Representative Cam Cavasso
  Representative John Medeiros
  Richard M. Matsuura, Chair, Senate Committee on Energy and Natural Resources
  Mark J. Andrews, Chair, House Committee on Planning, Energy and Environmental Protection
  David Hagino, Chair, House Committee on Water and Land Use

CITY AND COUNTY OF HONOLULU

Office of the Mayor

City Council
  City Council Kawainui Task Force

Department of General Planning

Department of Land Utilization

Department of Parks and Recreation

Department of Transportation Services

ORGANIZATIONS

American Lung Association of Hawaii
Conservation Council of Hawaii
*Hawaii Audubon Society
Hawaii's Thousand Friends
Hui Malama 'Aina o Maunawili
Kailua Community Association
*Kailua Neighborhood Board No. 31
Kainui Flood Victims Association
Kawai Nui Heritage Foundation
Lani-Kailua Outdoor Circle
Life of the Land
Maunawili Community Association
The Nature Conservancy
Pohakupu Community Association
Sierra Club, Hawaii Chapter
Sierra Club Legal Defense Fund

The following individuals were consulted in the preparation of the environmental impact statement.

FEDERAL AGENCIES

U..S. Army Corps of Engineers
Bill Lennon
Clarence Lee
Mike Lee
James Maragos
John Pelowski
James Pennaz

U.S. Fish and Wildlife Service
John Ford
Tom Harvey

Andrew Yuen
Paul Chang

U.S. Geological Survey
Iwao Matsuoka
Richard Nakahara

STATE AGENCIES

Department of Health
Environmental Protection & Health Services Division
Bruce Anderson, Deputy Director for Health
Paul Aki
Ron Arakawa
Steven Chang
Denis Lau
Department of Land and Natural Resources
State Historic Sites Office
Joyce Bath
Ross Cordy
Division of Forestry and Wildlife
Ronald Walker
Andrew Engilis, Jr.
David Smith
Thomas Kaiakapu
Roy Saito
Office of Conservation and Environmental Affairs
Roger Evans
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Commission on Water Resource Management
Sherrie Samuels

Office of State Planning
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University of Hawaii
Edmond Cheng

CITY AND COUNTY OF HONOLULU

Department of Public Works
  Engineering Division
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    Richard Suzuki
    Laverne Higa
    Faith Kunimoto
  Refuse Division
    John Lee

Department of General Planning
  Donald Clegg

Department of Land Utilization
  Robin Foster
  Bennett Mark

Department of Parks and Recreation
  Steve Salas

INDIVIDUALS

Francis Adler
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Dorothy Rose Babineau
Sylvia Baldwin
Sheila Conant
Kathlen B. Cooper
Bryce Decker
*Diane C. Drigot
Todd Hendrick
Robert Herlinger
Marion Kelly
Dana Kokubun
Doug Meller
Susan E. Miller
Robert Merriam
Kenneth Miyashiro

Earl E. Neller
Muriel B. Seto
George Staples
Chad Taniguchi
James L. Watson
Phil Whitesell

III Preparers of FEIS

A list of the persons involved in the preparation of the final environmental impact statement, the firms with which they are associated, and their areas of expertise and qualifications is presented in Table 7-1.

Table 7-1

LIST OF EIS PRINCIPAL PREPARERS

Name	Firm	Title	Expertise on this EIS
James Dexter, PE PhD Engineering	M&E Pacific	Project Manager	water resources, civil engineering
Robert Reimold PhD Biology	M&E Pacific	Principal Biologist	wetland ecology, environmental impact analysis
Jacqueline A. Parnell, AICP MCP	KRP Information Services	Environmental Planner	technical writing
William H. Dendle, III MURP, MPH	KRP Information Services	Environmental Planner	research and analysis
Eric B. Guinther B.S. Biology	AECOS, Inc.	President	environmental and laboratory services
Eugene P. Dashiell	Eugene P. Dashiell Planning Services	Principal	public information
Edmond Cheng, Ph.D. Engineering	Consultant	Professor of Civil Engineering, U.H., Manoa	flood hydrology
Hallett Hammatt, Ph.D.	Cultural Surveys Hawaii	Principal	archaeology

Ian King, Ph.D Engineering	Resource Management Associates	Principal	numerical hydraulic modeling
Donald Smith, P.E.	"	President	"
Robert MacArthur, P.E., Ph.D. Engineering	"	Principal	"
Sung Ho Lai, P.E., Ph.D. Engineering	Hawaii Geotechnical Group	Soils Engineer	geotechnical engineering
Mark Cramer, B.S., M.S. Civil Engineering	M & E Pacific	Project Engineer	civil engineering cost engineering
Frank Scheffner, P.E.	FPS Engineering Associates	Principal	cost engineering
Lyle Oda, B.S. Chemical Engineering	M & E Pacific	Engineer	water chemistry environmental engineering
Patrick Cummins, R.L.S.	Cummins & Cummins Land Surveying	President	surveying and mapping
C. Anna Ulaszewski, B.S. MURP	M & E Pacific	Environmental Planner	permitting and planning

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Appendix A

Engineering Studies

APPENDIX A

Engineering Studies

Table of Contents

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List of Figures
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List of Tables (cont'd)

List of Tables (cont'd)

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SUMMARY OF SCOPE

Two open waterways are proposed to connect low-laying areas of the marsh to the existing ponds. These two parallel waterways will traverse the marsh from south to north and will aid in drainage of flood water discharged from Maunawili Valley at the south and southwest portion of the marsh.

To address possible archaeological impacts of blasting and removal of vegetation, 10 sediment cores were extracted along 500-1000 foot intervals of the waterways. Cores 7, 1, 3, 4 and 10 (south to north) were taken along the proposed alignment of the east waterway. Cores 5, 6, 2, 9 and 8 (south to north) were taken along the west alignment. Core piping (2 inch P.V.C. is in five foot sections) penetrated as much as 40 feet below the top vegetation layer of the marsh. Depth of sediment recovered within the core reached a maximum of 15 feet. The core locations are shown on Figure 3-3 in the main text.

All cores were opened; the strata identified and the sediments were described. One core which represented the most well preserved and representative sample of the stratigraphic history of holocene marsh sediments was sampled for various analyses. Core 6 at the south end of the west waterway was chosen. Other cores were sampled for supplemental and corroborative analyses. Analysis includes C14 dating, pollen analysis, clay mineralogy percent organic matter and lead isotope dating. In addition, 6 cores were sampled (top and bottom) for heavy metal analysis. Stratigraphic interpretation, chronology, sedimentary history and vegetation reconstruction based on the results of these analyses will be presented in a final archaeological report. The stratigraphy is shown on Figure B-14.

PRELIMINARY RESULTS AND ANTICIPATED IMPACTS

During the course of the coring field work, approximately 8,000 feet of the 10,000 foot proposed waterway was inspected on foot. No archaeological remains were observed. In general, this portion of the marsh consists of a thick vegetation mat of diverse plant communities floating on water which reaches depths of 10-12 feet. Waterlogged muds, peats and clays representing terrestrial, and marine environment resulting from slow, still water deposition extend to 40 feet or more in the western and southern portions of the transects. To the northeast approaching Oneawa Canal, medium to fine coral sand and cemented coral deposits are found in places within a few feet of the surface. Because of the soft nature of the sediments, archaeological materials or features dropped in the marsh would sink quickly and deeply. As far as the age of the sediments themselves, only the top meter of compacted sediment in the cores is contemporaneous with the presently established age of Hawaiian occupation (post dating 500 AD). The C14 dates shown below indicate that Kawainui Marsh was well established as a terrestrial wetland as early as 400 B.C. The Hawaiians utilized and modified the marsh fringes for toro loi. However, it seems unlikely that the deeper waterlogged portions were suitable for any use other than gathering and aquaculture. The open water portions of the marsh were probably used as natural fishponds with little or no human modifications.

C14 DATES

NO.	Core	Stratum	Depth In CM	Adjusted Age	Range
1	6	I	0-25	340±70BP	1420 - 1650AD
2	6	II	25-35	320±80BP	1410 - 1800 AD
3	6	III	65-85	1,640±70BP	230 - 570 AD
4	6	III	165-185	2,020±70BP	405BC - 45 BC
5	6	IV	260-280	2,260±60BP	420BC - 170 BC
6	6	V	340-360	5,370±90	4425BC - 3890 BC
7	5A(Top)	III	72- 85	830±60	1055AD - 1270 AD
8	5A(Base)	III	355-350	2,075±80	390BC - 200 AD
9	7(Top)	III	44-55	650±80	1230AD - 1415 AD
10	7(Top)	III	400-410	2,430±70	780BC - 400 AD

It is believed that the coring program, given the limits of present technology, is the only practical method available for addressing potential archaeological impact of proposed construction. In such an environment, conventional survey and testing methods are not feasible. As a further measure to address the possibility of uncovering buried cultural materials, the following monitoring measures will be required in the contract specifications:

1) Recommendation to the contractor to make geophysical soundings of the subsurface along the proposed alignments for the purpose of locating buried items (such as pipelines) which pose a threat to the safe operation of the clearing and dredging equipment and to provide such information to the Engineer's archaeological representative for further interpretation of potential archaeological impacts.

2) Requirement for an archaeologist to be on-site during blasting operations to conduct a field reconnaissance for any remains. Access to the excavations will be provided by the Contractor.

3) In the event that remains are identified, the work shall be halted until State Historic Preservation Officer has been notified and is able to assess the potential impacts of the project and make further recommendations for mitigative action if deemed necessary.

4) During the course of mechanical dredging and vegetation harvesting, all work shall be halted upon the excavation of material of suspected human origin, and notification made as in paragraph 3), above.

SECTION 7. Miscellaneous Data

Sediment Sample Analytical Report

Fauna and Flora Lists

Seismograph Monitoring Results

Burmah
Burmah Technical Services, Inc.
Analytical Laboratories Division
15199 Community Road
P.O. Drawer 2609
Gulfport, MS 39505
601-863-3036

ANALYTICAL REPORT

AECOS
970 N. Kalaheo, Suite A300
Kailua, Hawaii 96734

ATTENTION: Ms. Kay Town

DATE SAMPLE RECEIVED: 4/19/89
MONTH COVERED: April, 1989
CLIENT NUMBER: AEC200
SAMPLED BY: Client
FREQUENCY: As Requested
DATE: April 26, 1989

IDENTIFICATION: Sediment Samples

SAMPLE NUMBER:	CLIENT I.D.	TOC	UNITS
14655	3520 Sta 3	86,185	mg/kg
14656	3520 Sta 3 Dup.	38,000	mg/kg
14657	3520 Sta 5	96,050	mg/kg
14658	3520 Sta 8	11,300	mg/kg
	*3520 Spike	N/A	mg/kg

*Note: Spiking procedure calls for sample spike prior to prep. Prep procedure calls for multiple rinses with dilute acid and D.I. water. The prep procedure would rinse off spike.

2000 Standard - 1998
Date Analyzed - 4/24/89
Analyst - DD

RECEIVED MAY 0 1 1989

APPROVED BY:

RONALD MCAFEE
LABORATORY MANAGER

CHEMWEST ANALYTICAL LABORATORIES
SEMIVOLATILE ORGANICS

Client I.D.: Sta.3
Date Extracted : 04/24/89
Date(s) Analyzed: 05/03/89

CHEMWEST I.D.: 3683-1
Matrix : Soil

Compound	Amount Detected (ug/Kg)	RL (ug/Kg)
Phenol	BRL	200
2-Chlorophenol	BRL	200
bis(2-Chloroethyl) ether	BRL	200
1,3-Dichlorobenzene	BRL	200
1,4-Dichlorobenzene	BRL	200
1,2-Dichlorobenzene	BRL	200
Benzyl alcohol	BRL	200
2-Methylphenol	BRL	200
bis(2-Chloroisopropyl) ether	BRL	200
Hexachloroethane	BRL	200
N-Nitroso-di-n-propylamine	BRL	200
4-Methylphenol	BRL	200
Nitrobenzene	BRL	200
Isophorone	BRL	200
2-Nitrophenol	BRL	200
2,4-Dimethylphenol	BRL	200
bis(2-Chloroethoxy) methane	BRL	200
2,4-Dichlorophenol	BRL	200
1,2,4-Trichlorobenzene	BRL	200
Benzoic acid	BRL	400
Naphthalene	BRL	200
4-Chloroaniline	BRL	200
Hexachlorobutadiene	BRL	200
4-Chloro-3-methylphenol	BRL	200
2-Methylnaphthalene	BRL	200
Hexachlorocyclopentadiene	BRL	200
2,4,6-Trichlorophenol	BRL	200
2,4,5-Trichlorophenol	BRL	400
2-Chloronaphthalene	BRL	200
2-Nitroaniline	BRL	400
Acenaphthylene	BRL	200
Dimethylphthalate	BRL	200
2,6-Dinitrotoluene	BRL	200
3-Nitroaniline	BRL	400
Acenaphthene	BRL	200
2,4-Dinitrophenol	BRL	400
Dibenzofuran	BRL	200
4-Nitrophenol	BRL	400
2,4-Dinitrotoluene	BRL	200
Fluorene	BRL	200
4-Chlorophenyl-phenylether	BRL	200
Diethylphthalate	BRL	200
4-Nitroaniline	BRL	400
4,6-Dinitro-2-methylphenol	BRL	400

CHEMWEST ANALYTICAL LABORATORIES
SEMIVOLATILE ORGANICS

Client I.D.: Sta.3

CHEMWEST I.D.: 3683-1
Matrix : Soil

Compound	Amount Detected (ug/Kg)	RL (ug/Kg)
N-Nitrosodiphenylamine	BRL	200
4-Bromophenyl-phenylether	BRL	200
Hexachlorobenzene	BRL	200
Pentachlorophenol	BRL	400
Phenanthrene	BRL	200
Anthracene	BRL	200
Di-n-butylphthalate	BRL	200
Fluoranthene	BRL	200
Pyrene	BRL	200
Butylbenzylphthalate	BRL	200
Benzo(a)anthracene	BRL	200
3,3'-Dichlorobenzidine	BRL	400
Chrysene	BRL	200
bis(2-Ethylhexyl)phthalate	BRL	200
Di-n-octylphthalate	BRL	200
Benzo(b)fluoranthene	BRL	200
Benzo(k)fluoranthene	BRL	200
Benzo(a)pyrene	BRL	200
Indeno(1,2,3-cd)pyrene	BRL	200
Dibenz(a,h)anthracene	BRL	200
Benzo(g,h,i)perylene	BRL	200

Surrogates	% Recovery	Acceptance Window
2-Fluorophenol	71%	25-121%
Phenol-d5	85%	24-113%
Nitrobenzene-d5	76%	23-120%
2-Fluorobiphenyl	98%	30-115%
2,4,6-Tribromophenol	76%	19-122%
Terphenyl-d14	81%	18-137%

BRL: Below Reporting Limit.
RL: Reporting Limit.

Approved by: ___

REV4:1.89

CHEMWEST ANALYTICAL LABORATORIES
SEMIVOLATILE ORGANICS

Client I.D.: Sta.5
Date Extracted : 04/24/89
Date(s) Analyzed: 05/03/89

CHEMWEST I.D.: 3683-2
Matrix : Soil

Compound	Amount Detected (ug/Kg)	RL (ug/Kg)
Phenol	BRL	200
2-Chlorophenol	BRL	200
bis(2-Chloroethyl) ether	BRL	200
1,3-Dichlorobenzene	BRL	200
1,4-Dichlorobenzene	BRL	200
1,2-Dichlorobenzene	BRL	200
Benzyl alcohol	BRL	200
2-Methylphenol	BRL	200
bis(2-Chloroisopropyl) ether	BRL	200
Hexachloroethane	BRL	200
N-Nitroso-di-n-propylamine	BRL	200
4-Methylphenol	BRL	200
Nitrobenzene	BRL	200
Isophorone	BRL	200
2-Nitrophenol	BRL	200
2,4-Dimethylphenol	BRL	200
bis(2-Chloroethoxy) methane	BRL	200
2,4-Dichlorophenol	BRL	200
1,2,4-Trichlorobenzene	BRL	200
Benzoic acid	BRL	400
Naphthalene	BRL	200
4-Chloroaniline	BRL	200
Hexachlorobutadiene	BRL	200
4-Chloro-3-methylphenol	BRL	200
2-Methylnaphthalene	BRL	200
Hexachlorocyclopentadiene	BRL	200
2,4,6-Trichlorophenol	BRL	200
2,4,5-Trichlorophenol	BRL	400
2-Chloronaphthalene	BRL	200
2-Nitroaniline	BRL	400
Acenaphthylene	BRL	200
Dimethylphthalate	BRL	200
2,6-Dinitrotoluene	BRL	200
3-Nitroaniline	BRL	400
Acenaphthene	BRL	200
2,4-Dinitrophenol	BRL	400
Dibenzofuran	BRL	200
4-Nitrophenol	BRL	400
2,4-Dinitrotoluene	BRL	200
Fluorene	BRL	200
4-Chlorophenyl-phenylether	BRL	200
Diethylphthalate	BRL	200
4-Nitroaniline	BRL	400
4,6-Dinitro-2-methylphenol	BRL	400

CHEMWEST ANALYTICAL LABORATORIES
SEMIVOLATILE ORGANICS

Client I.D.: Sta.5

CHEMWEST I.D.: 3683-2
Matrix : Soil

Compound	Amount Detected (ug/Kg)	RL (ug/Kg)
N-Nitrosodiphenylamine	BRL	200
4-Bromophenyl-phenylether	BRL	200
Hexachlorobenzene	BRL	200
Pentachlorophenol	BRL	400
Phenanthrene	BRL	200
Anthracene	BRL	200
Di-n-butylphthalate	BRL	200
Fluoranthene	BRL	200
Pyrene	BRL	200
Butylbenzylphthalate	BRL	200
Benzo(a)anthracene	BRL	200
3,3'-Dichlorobenzidine	BRL	400
Chrysene	BRL	200
bis(2-Ethylhexyl)phthalate	BRL	200
Di-n-octylphthalate	BRL	200
Benzo(b)fluoranthene	BRL	200
Benzo(k)fluoranthene	BRL	200
Benzo(a)pyrene	BRL	200
Indeno(1,2,3-cd)pyrene	BRL	200
Dibenz(a,h)anthracene	BRL	200
Benzo(g,h,i)perylene	BRL	200

Surrogates	% Recovery	Acceptance Window
2-Fluorophenol	77%	25-121%
Phenol-d5	90%	24-113%
Nitrobenzene-d5	79%	23-120%
2-Fluorobiphenyl	93%	30-115%
2,4,6-Tribromophenol	72%	19-122%
Terphenyl-d14	76%	18-137%

BRL: Below Reporting Limit.
RL: Reporting Limit.

Approved by: [illegible]

REV4:1.89

CHEMWEST ANALYTICAL LABORATORIES
SEMIVOLATILE ORGANICS

Client I.D.: Sta.8
Date Extracted : Ø4/24/89
Date(s) Analyzed: Ø5/Ø3/89

CHEMWEST I.D.: 3683-3
Matrix : Soil

Compound	Amount Detected (ug/Kg)	RL (ug/Kg)
Phenol	BRL	2ØØ
2-Chlorophenol	BRL	2ØØ
bis(2-Chloroethyl) ether	BRL	2ØØ
1,3-Dichlorobenzene	BRL	2ØØ
1,4-Dichlorobenzene	BRL	2ØØ
1,2-Dichlorobenzene	BRL	2ØØ
Benzyl alcohol	BRL	2ØØ
2-Methylphenol	BRL	2ØØ
bis(2-Chloroisopropyl) ether	BRL	2ØØ
Hexachloroethane	BRL	2ØØ
N-Nitroso-di-n-propylamine	BRL	2ØØ
4-Methylphenol	BRL	2ØØ
Nitrobenzene	BRL	2ØØ
Isophorone	BRL	2ØØ
2-Nitrophenol	BRL	2ØØ
2,4-Dimethylphenol	BRL	2ØØ
bis(2-Chloroethoxy) methane	BRL	2ØØ
2,4-Dichlorophenol	BRL	2ØØ
1,2,4-Trichlorobenzene	BRL	2ØØ
Benzoic acid	BRL	4ØØ
Naphthalene	BRL	2ØØ
4-Chloroaniline	BRL	2ØØ
Hexachlorobutadiene	BRL	2ØØ
4-Chloro-3-methylphenol	BRL	2ØØ
2-Methylnaphthalene	BRL	2ØØ
Hexachlorocyclopentadiene	BRL	2ØØ
2,4,6-Trichlorophenol	BRL	2ØØ
2,4,5-Trichlorophenol	BRL	4ØØ
2-Chloronaphthalene	BRL	2ØØ
2-Nitroaniline	BRL	4ØØ
Acenaphthylene	BRL	2ØØ
Dimethylphthalate	BRL	2ØØ
2,6-Dinitrotoluene	BRL	2ØØ
3-Nitroaniline	BRL	4ØØ
Acenaphthene	BRL	2ØØ
2,4-Dinitrophenol	BRL	4ØØ
Dibenzofuran	BRL	2ØØ
4-Nitrophenol	BRL	4ØØ
2,4-Dinitrotoluene	BRL	2ØØ
Fluorene	BRL	2ØØ
4-Chlorophenyl-phenylether	BRL	2ØØ
Diethylphthalate	BRL	2ØØ
4-Nitroaniline	BRL	4ØØ
4,6-Dinitro-2-methylphenol	BRL	4ØØ

CHEMWEST ANALYTICAL LABORATORIES
SEMIVOLATILE ORGANICS

Client I.D.: Sta.8

CHEMWEST I.D.: 3683-3
Matrix : Soil

Compound	Amount Detected (ug/Kg)	RL (ug/Kg)
N-Nitrosodiphenylamine	BRL	200
4-Bromophenyl-phenylether	BRL	200
Hexachlorobenzene	BRL	200
Pentachlorophenol	BRL	400
Phenanthrene	BRL	200
Anthracene	BRL	200
Di-n-butylphthalate	BRL	200
Fluoranthene	BRL	200
Pyrene	BRL	200
Butylbenzylphthalate	BRL	200
Benzo(a)anthracene	BRL	200
3,3'-Dichlorobenzidine	BRL	400
Chrysene	BRL	200
bis(2-Ethylhexyl)phthalate	BRL	200
Di-n-octylphthalate	BRL	200
Benzo(b)fluoranthene	BRL	200
Benzo(k)fluoranthene	BRL	200
Benzo(a)pyrene	BRL	200
Indeno(1,2,3-cd)pyrene	BRL	200
Dibenz(a,h)anthracene	BRL	200
Benzo(g,h,i)perylene	BRL	200

Surrogates	% Recovery	Acceptance Window
2-Fluorophenol	71%	25-121%
Phenol-d5	73%	24-113%
Nitrobenzene-d5	72%	23-120%
2-Fluorobiphenyl	86%	30-115%
2,4,6-Tribromophenol	65%	19-122%
Terphenyl-d14	72%	18-137%

BRL: Below Reporting Limit.
RL: Reporting Limit.

Approved by: ___

REV4:1.89

Source: Smith, Linda Lea. Development of Emergent Vegetation in a Tropical Marsh. Master of Science Thesis, 1978.

Endemic Species

Common Name	Scientific Name
1. Koloa or Hawaiian Duck	*Anas wyvilliana*
2. Hawaiian Gallinule	*Gallinula chloropus sandvicensis*
3. Hawaiian coot	*Fulica americana alai*
4. Hawaiian black-necked stilt	*Himantopus h. knudseni*

Other Indigenous Birds

1. Black-crowned night heron	*Nycticorax h. hoactli*
2. Pacific golden plover	*Pluvialis dominica fulva*
3. Wandering tattler	*Heteroscelus incanus*
4. Pintail	*Anas acuta*
5. Shoveler	*Anas clypeata*

Introduced Birds

1. Cattle egret	*Bulbulcus ibis*
2. Feral pigeon or rock dove	*Columba livia*
3. Spotted or Chinese dove	*Steptopelia chinensis*
4. Barred dove	*Geopelia striata*
5. Melodious laughing-thrush	*Garrulax striata*
6. Red-vented bulbul	*Pycnonotus cafer*
7. Shama thrush	*Copsychus malbaricus*
8. Japanese bush warbler	*Cettia diphone cantans*
9. Japanese white-eye	*Zosterops j. japonica*
10. Common Indian mynah	*Acridotheres t. tristis*

11. House finch — Carpodacus mexicanus frontalis

12. Ricebird or spotted munia — Lonchura punctulata

13. House sparrow — Passer domesticus

14. Cardinal — Cardinalis cardinalis

15. Red-crested cardinal — Paroaria coronata

Berger cautioned that his study was conducted in the summer only and that other species of birds are likely to be present in other seasons of the year.

Ford (1975) prepared a report, unpublished, on a preliminary survey of the marsh. In the waters of the central and upper marsh he found fish of the family Poecilidae (top-water minnows, Tilapia mossambica, one carp (Cyprinus carpio), and a rice eel (Monopterus sp.). Apparently Tilapia were purposely introduced as a mosquito control measure (B. Sugarmann, personal communication).

Along the middle and lower course of Maunawili and Kahanaiki Streams Ford found the gastropod Melania sp., caddisfly larvae (Cheumatopsyche analis), two species of of chiromid larvae, some small leeches, a crayfish (Procumbus clarkii), amphipods, isopods, a polychaete (Namalycastis sp.), toad and frog tadpoles, poecilid fish, Chinese catfish (Calrias fuscus), a smallmouth bass, and Tilapia mossambica.

Source: Smith, Linda Lea. Development of Emergent Vegetation in a Tropical Marsh. Master of Science Thesis, 1978.

Table 3. Plant species list. Plants of Kawainui Marsh and peripheral areas bounded by Kailua and Quarry Roads. Common names are given if known. An asterisk denotes that the plant was found within the study area of the marsh, below the 3-m topographic contour. Voucher specimens are in the herbarium of the Department of Botany, University of Hawaii. Nomenclature is after St. John (1973) except where alternate names have been supplied by Dr. F. Raymond Fosberg, Senior Botanist, National Museum of Natural History, Smithsonian Institution, Washington, D.C. Some plants listed here do not appear in St. John. For these names other sources were consulted (e.g., Neal 1965, Degener and Degener 1957).

FRF indicates a specimen collected by Dr. Fosberg. The collection number is his. E&H indicates a plant reported by Elliot and Hall (1977). They gave no collection numbers. Under "status" I indicates an introduced plant, N a native one.

FLOWERING PLANTS

Family / Scientific Name	Status	Common Name	Collection Number
Acanthaceae			
<u>Asystasia gangetica</u> (L.) T. Anders	I	asystasia	49
Alismataceae			
*<u>Sagittaria sagittaefolia</u> L.	I	arrowhead	150a
Amaranthaceae			
*<u>Amaranthus spinosus</u> L.	I	spiney amaranth	13
*<u>Alternanthera sessilis</u> (L.) R. Br.	I	none	57428FRF

Table 3 (continued)

Family Scientific Name	Status	Common Name	Collection Number
Caricaceae			
Carica papaya L.	I	paypaya	86
Chenopodiaceae			
Chenopodium murale L.	I	goosefoot	145
Commelinaceae			
*Commelina diffusa Burm. f.	I	day flower	7
Zebrina pendula	I	wandering Jew	15
Compositae			
Ageratum conyzoides L.	I	ageratum	82
*Bidens pilosa L.	I	Spanish needle	76
Bidens pilosa var. minor (Bl.) Sherf.	I	none	none
*Conyza bonariensis (L.) Cronq.	I	hairy horseweed	131
*Eclipta alba (L.) Hassk	I	false daisy	57429FRF
Elephantopus mollis HBK	I	elephant's foot	E&H
*Emilia fosbergii Nicolson (E. javanica sensu St. John)	I	flora's paintbrush	none
*Emila sonchifolia (L.) DC	I	flora's paintbrush	8
*Pluchea x fosbergii Coop. & Gal.	I	pluchea	73
*Pluchea indica (L.) Less.	I	Indian pluchea	none
*Pluchea symphytifolia (Mill.) Gillis (P. odorata sensu St. John)	I	shrubby fleabane	none
Siegesbeckia orientalis L.	I	siegesbeckia	88
*Sonchus oleraceus L.	I	sow thistle	75
Synedrella nodiflora (L.) Gaertn.	I	nodeweed	6
*Verbesina encelioides (Cav.) Benth.	I	golden crownbeard	77
Vernonia cinearea (L.) Less.	I	ironweed	81
Wedelia trilobata L.	I	wedelia	16

CORRECTION

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

Table 3 (continued)

Family / Scientific Name	Status	Common Name	Collection Number
Caricaceae			
Carica papaya L.	I	paypaya	86
Chenopodiaceae			
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Vernonia cinearea (L.) Less.	I	ironweed	81
Wedelia trilobata L.	I	wedelia	16

Table 3 (continued)

Family Scientific Name	Status	Common Name	Collection Number
Anacardiaceae			
*Schinus terebinthifolius Raddi	I	Christmasberry	38
Apocynaceae			
Allamanda hendersonii Bull.	I	cup-of-gold	132
Araceae			
Epipremnum pinnatum (L.) Engler	I	taro vine	123
Philodendron lacerum (Jacq.) Schott	I	none	118
Philodendron scandens Koch & Sello	I	none	150
Pistia stratiotes L.	I	water lettuce	none
Syngonium podophyllus Schott	I	syngonium	114
*Xanthosoma sagittifolium (L.) Schott	I	taro	110
Araliaceae			
Brassaia actinophylla Endl.	I	octopus tree	129
Balsaminaceae			
Impatiens sultanii Hook	I	impatiens	122
Bignoniaceae			
Spathodea campanulata Beauv.	I	African tulip	138
Casuarinaceae			
Casuarina equisetifolia L.	I	ironwood	137

Table 3 (continued)

Family Scientific Name	Status	Common Name	Collection Number
Chloris inflata Link	I	swollen finger grass	55
Cynodon dactylon (L.) Pers.	I	Bermuda grass	none
Eleusine indica (L.) Gaertn.	I	wire grass	56
Panicum maximum Jacq.	I	Guinea grass	60
Paspalum conjugatum Berg.	I	Hilo grass	E&H
Paspalum dilatatum Poir.	I	dallis grass	40
*Paspalum distichum L.	I	knott grass	149
*Pennisetum purpureum Schumach.	I	napier grass	143
Pennisetum clandestinum Hochst.	I	kikuyu grass	E&H
Saccharum officinarum L.	I	sugarcane	41
Saccharum sponteneum L.	I	wild sugarcane	34
Setaria palmaefolia (Koen.) Stapf	I	palm grass	113
Sorghum halepense (L.) Pers.	I	johnson grass	43
Sporobolus virginicus (L.) Kunth	N	beach dropseed	none
Trichachne insularis (L.) Nees	I	sour grass	9
Leguminosae			
Canavalia cathartica Thouars	N	mauna loa	21
Cassia bicapsularis L.	I	none	57421FRF
*Cassia surattensis Burm. f.	I	kolomona	48a
*Crotalaria incana L.	I	fuzzy rattlepod	146
*Crotalaria pallida Wit. (C. mucronata sensu St. John)	I	rattlebox	147
*Desmanthus virgatus (L.) Willd.	I	virgate mimosa	35
*Desmodium canum (Gmel.)Schinz & Tellung	I	Spanish clover	48
*Indigofera suffruticosa Mill.	I	indigo	3
*Leucaena leucocephala (Lam.) de Wit.	I	haole koa	39
*Mimosa pudica L.	I	sleeping grass	17
Mucuna gigantea (Willd.) DC	N	sea bean	103
*Phaseolus lathyroides L.	I	wild bean	168

Table 3 (continued)

Family Scientific Name	Status	Common Name	Collection Number
Convolvulaceae			
Ipomoea alba L.	I	moon flower	57423FRF
*Ipomoea indica (Burm.) Merr. (I. congesta sensu St. John)	I	morning glory	68
*Ipomoea aquatica Forsk.	I	swamp cabbage	57432FRF
*Ipomoea obscura (L.) Ker-Gawler	I	none	89
Merremia tuberosa (L.) Rendle	I	wood rose	133
Cucurbitaceae			
Momordica charantia L.	I	bitter melon	80
Cyperaceae			
*Cladium leptostachyum Nees & Meyen	N	sawgrass	98
*Cyperus alternifolius L.	I	umbrella plant	97
Cyperus brevifolius (Rottb.) Hassk.	I	kyllingia	E&H
Cyperus diformis L.	I	none	E&H
*Cyperus kyllingia	I	kyllingia	116
Eleocharis acicularis (L.) R.&S.	I	pipi wai	E&H
Eleocharis obtusa (Willd.) Schult.	N	none	E&H
Scirpus californicus (C.A. Mey.) Stendel	N	bulrush	11
Euphorbiaceae			
Euphorbia cyathophora Murr. (E. glomerifera sensu St. John)	I	none	42
Euphorbia hirta L.	I	garden spurge	32
Ricinis communis L.	I	castor	20
Gramineae			
*Brachiaria mutica (Forsk.) Stapf	I	California grass	12
*Cenchrus echinatus L.	I	sand bur	69

Table 3 (continued)

Family / Scientific Name	Status	Common Name	Collection Number
Samanea saman (Jacq.) Merr.	I	monkeypod	136
Lemnaceae			
*Lemna minor L.	I	duckweed	57433FRF
Spirodela polyrrhiza (L.) Schleid	I	greater duckweed	E&H
*Spirodela punctata (G.F.W. Meyer) Thompson	?	duckweed	150
*Wolffia columbiana Karst.	?	water meal	29719FRF
Liliaceae			
Cordyline fruticosa (L.) Chev. (C. terminalis sensu St. John)	I	ti	27
Loganiaceae			
Buddleja asiatica Lour.	I	dogtail	148
Malvaceae			
*Abutilon grandifolium (Willd.) Sweet	I	hair abutilon	130
*Hibiscus tiliaceus L.	N	hau	45
*Hibiscus youngianus Gaud.	N	native pink hibiscus	154
*Sida acuta var. carpinifolia Burm. f.	I	ilima	1
Sida rhombifolia L.	I	Cuba jute	46
Sida spinosa L.	I	prickly sida	62
Moraceae			
Ficus elastica Roxb. ex Hornum	I	rubber plant	62
*Ficus microcarpa L.	I	Chinese banyan	151
Myrtaceae			
[illegible] cumini (L.) Druce	I	Java plum	54

Table 3 (continued)

Family Scientific Name	Status	Common Name	Collection Number
*Melaleuca leucadendra (Stickm.) L.	I	paperbark	99
Psidium guajava L.	I	guava	47
Musaceae			
Heliconia caribaea Lam.	I	heliconia	126
Musa paradisiaca L.	I	banana	none
Strelitzia sp.	I	bird-of-paradise	145
Nyctaginaceae			
Mirabilis jalapa L.	I	four o'clock	90
Nymphaceae			
*Nymphaea lotus L.	I	Egyptian lotus	57427FRF
Onagraceae			
*Ludwigia octovalvis (Jacq.) Raven	I	primrose willow	2
Ludwigia palustris (L.) Ell.	I	water purslane	E&H
Orchidaceae			
*Spathoglottis plicata Bl.	I	Maylayan ground orchid	147
Oxalidaceae			
Oxalis corniculata L.	I	yellow wood sorrel	14
Oxalis corymbosa DC (O. martiana sensu St. John)	I	pink wood sorrel	85
Passifloraceae			
Passiflora edulis Sims	I	lilikoi	167
*Passiflora foetida L.	I	scarlet-fruited passion flower	140

Table 3 (continued)

Family Scientific Name	Status	Common Name	Collection Number
Passiflora subpeltata Ortega	I	white passion flower	19
Plantaginaceae			
**Plantago major* L.	I	common plantain	36
Plumbaginaceae			
**Anagalis arvensis* L.	I	scarlet pimpernel	16
Pontederiaceae			
**Eichhornia crassipes* (Mart.) Solms.	I	water hyacinth	none
Monochoria vaginalis (Burm.f.) Kunth	I	cordate monochoria	E&H
Portulacaceae			
**Portulaca oleracea* L.	I	stink vine	none
Scrophulariaceae			
Bacopa monnieri (L.) Wettst.	N	water hyssop	E&H
Solanaceae			
Capsicum frutescens L.	I	red pepper	84
Lycopersicon esculentum Mil.	I	tomato	74
Solanum nigrum L.	?	black nightshade	83
Solanum seaforthianum Andr.	I	none	none
**Solanum sodomeum* L.	I	apple of sodum	147
Tiliaceae			
Triumfetta rhomboidea Jacq.	I	Sacramento bur	5

Table 3 (continued)

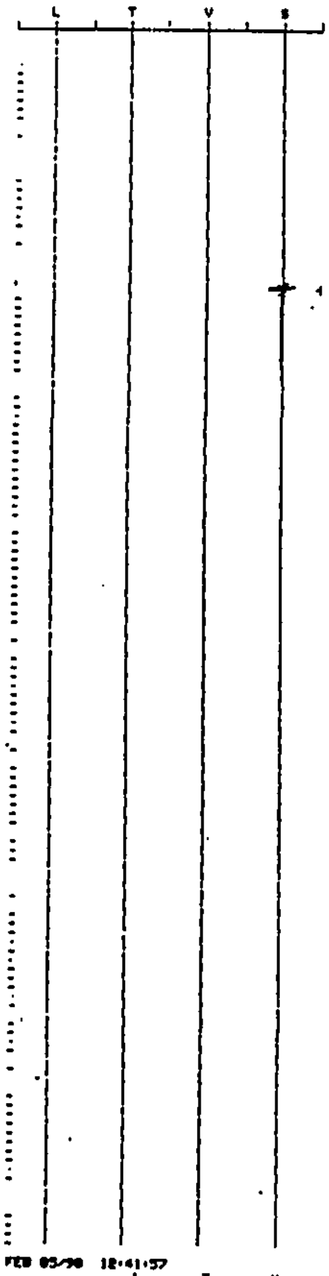
Family Scientific Name	Status	Common Name	Collection Number
Typhaceae			
Typha latifolia L.	I	cattail	23
(T. angustata sensu St. John)			
Verbenaceae			
Clerodendrum philippinum Schau.	I	fragrant clerodendrum	67
*Stachytarpheta urticaefolia (Salisb.) Sims	I	false vervain	18
Zingerberaceae			
Alpinia speciosa (Wendl.) K. Schum.	I	shell ginger	117
FERNS			
Parkeriaceae			
Ceratopteris siliquosa (L.) Copel	?	swamp fern	E&H
Polypodiaceae			
Pityogramma calomelanos (L.) Link	I	gold fern	72
Microsorium scolpendra Burm. f.	I	none	152
Nephrolepis hirsutula (Forst.) Presl.	?	sword fern	71
Thelypteridaceae			
*Cyclosorus interruptus (Willd.) H. Ito	I	taro patch fern	146

SEISMOGRAPH MONITORING RESULTS

BLAST #1 SITE #2

** SAFEGUARD SEISMIC UNIT 1000-D **
FEB 05/90 12:41:57
INSTRUMENT # SSU 1033
EVENT # 007
CLIENT:CCH
OPERATION:FUNCTION TEST
SSU LOCATION:SITE 2
DISTANCE TO BLAST (Ft): 2950
OPERATOR:U09
SEIS TRIG LVL (IPS): 0.05
SOUND TRIG LEVEL (dB): 120
RECORD TIME (Sec): 15

GRAPHICAL RECORD
****
TIME = 1.00 SEC/IN
SOUND= .01 PSI/DIV
L.T.V= .25 IPS/DIV



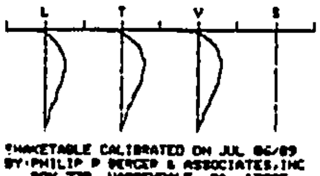
FEB 05/90 12:41:57

	L	T	V
PPV(in/s)	0.00	0.00	0.00
PPD (in)	0.00000	0.00000	0.00000
PPA (G)	0.00	0.00	0.00
F(Vel) Hz			

PPPV (in/s): 0.00
PEAK SOUND: 121 DB. .00336 PSI
** A/D CALIBRATED OK **

CALIBRATION GRAPH

TIME = .167 SEC/IN
L.T.V= 1 IPS/DIV

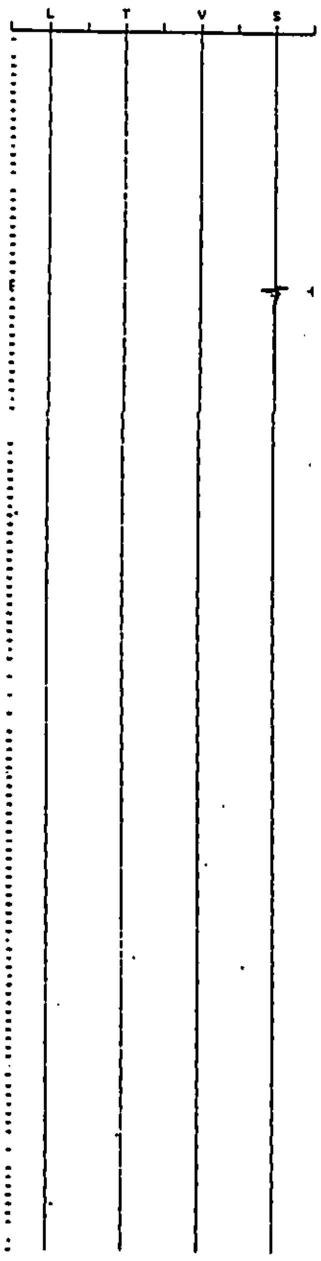


SHAKETABLE CALIBRATED ON JUL 06/89
BY:PHILIP R BERGER & ASSOCIATES,INC
BOX 779, WARRENDALE, PA. 15095
TEL:412-776-3600

BLAST #2 SITE #2

** SAFEGUARD SEISMIC UNIT 1000-D **
FEB 05/90 16:12:12
INSTRUMENT # SSU 1033
EVENT # 004
CLIENT:CCH
OPERATION:FUNCTION TEST
SSU LOCATION:SITE 2
DISTANCE TO BLAST (Ft): ~~2950~~ 4650
OPERATOR:U09
SEIS TRIG LVL (IPS): 0.05
SOUND TRIG LEVEL (dB): 120
RECORD TIME (Sec): 15

GRAPHICAL RECORD
****
TIME = 1.00 SEC/IN
SOUND= .01 PSI/DIV
L.T.V= .25 IPS/DIV



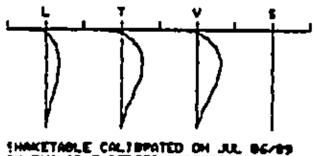
FEB 05/90 16:12:12

	L	T	V
PPV(in/s)	0.00	0.00	0.00
PPD (in)	0.00000	0.00000	0.00000
PPA (G)	0.00	0.00	0.00
F(Vel) Hz			

PPPV (in/s): 0.00
PEAK SOUND: 121 DB. .00336 PSI
** A/D CALIBRATED OK **

CALIBRATION GRAPH

TIME = .167 SEC/IN
L.T.V= 1 IPS/DIV

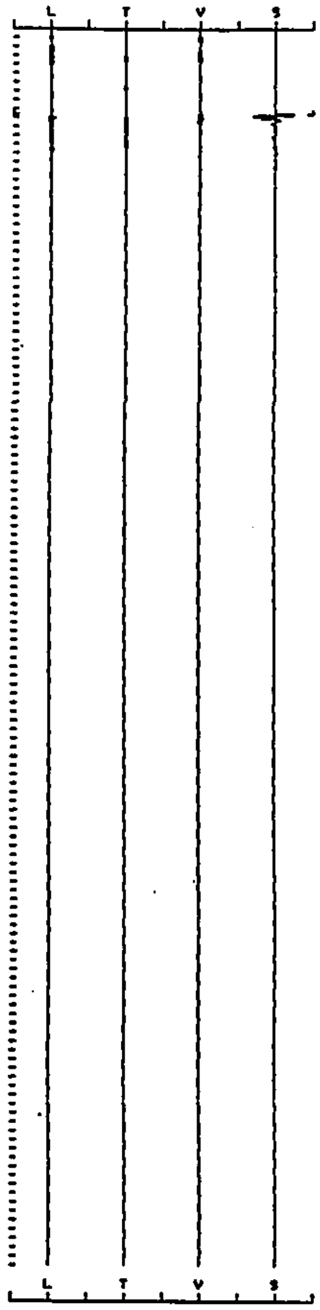


SHAKETABLE CALIBRATED ON JUL 06/89
BY:PHILIP R BERGER & ASSOCIATES,INC
BOX 779, WARRENDALE, PA. 15095
TEL:412-776-3600

BLAST #2 SITE #3

** SAFEGUARD SEISMIC UNIT 1000D **
FEB 05/90 16:12:05
INSTRUMENT # SSU 1330
EVENT # 011
COPY # 1
CLIENT:CCH
OPERATION:TEST #2
SSU LOCATION:LANDFILL
DISTANCE TO BLAST (ft): 1450
OPERATOR:LHO
SEIS TRIG LVL (IPs): 0.05
SOUND TRIG LEVEL (dB): 120
RECORD TIME (sec): 15

GRAPHICAL RECORD
****
TIME = 1.00 sec/in
SOUND= 0.028 Psi/div
L.T.V= .25 IPs/div



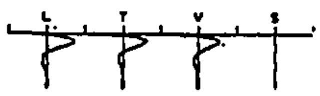
FEB 05/90 16:12:05

	L	T	V
PPV(in/s)	0.02	0.01	0.02
PD(in)	0.00018	0.00005	0.00007
PPA(G)	0.028	0.014	0.014
Fr(Hz)	05.3	42.6	34.2

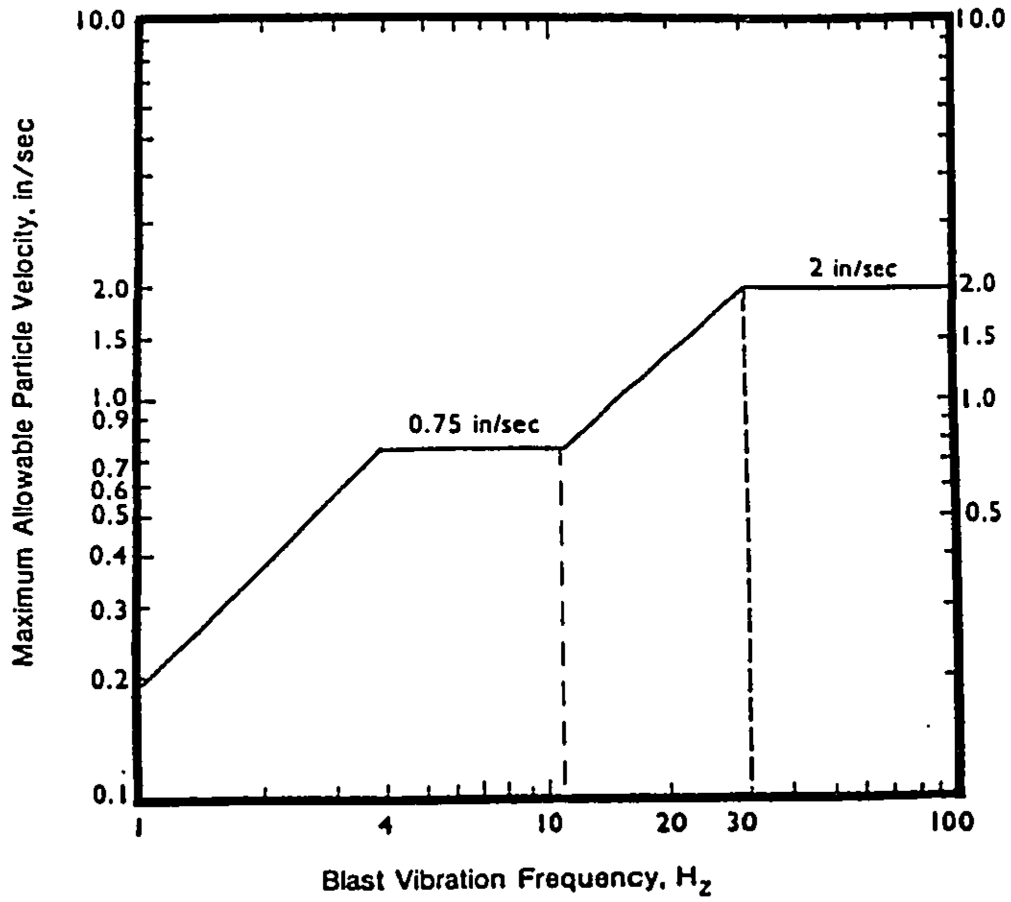
RPPV(in/s) 0.02
PEAK SOUND 135 dB 0.01645 Psi
** A/D CALIBRATED OK **

CALIBRATION GRAPH

TIME = .384 sec/in
SOUND= 0.028 Psi/div
L.T.V= 1 IPs/div



SHAKETABLE CALIBRATED ON JUN 06/89
BY:PHILIP R BERGER & ASSOCIATES,INC.
BOX 779, WARRENDALE, PA. 15095
TEL:412-776-3600



(Source: Modified from figure B-1, Bureau of Mines RI8507)

Figure B-1

KAWAINUI MARSH 1945

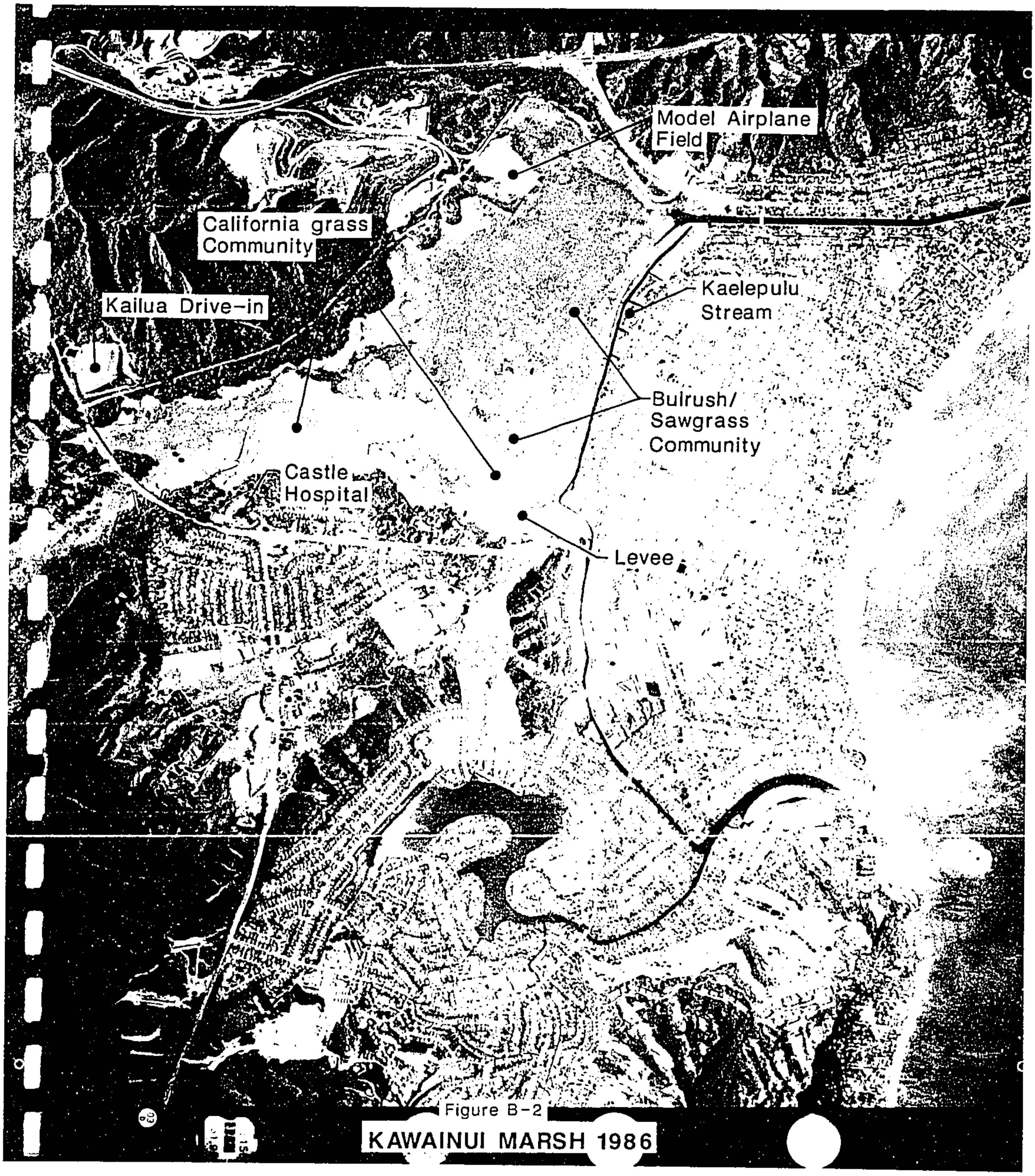
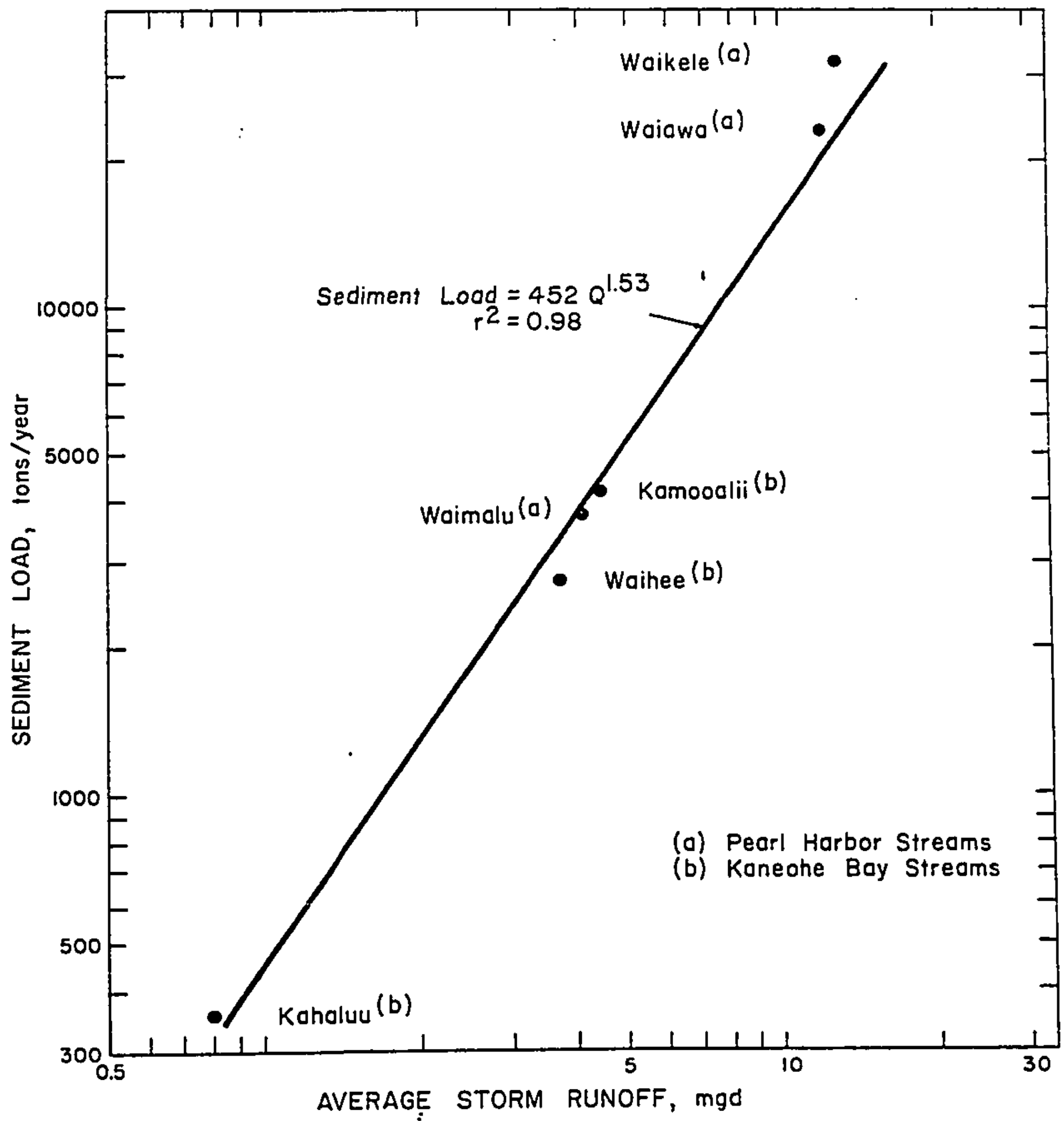


Figure B-2
KAWAINUI MARSH 1986

Figure B-3

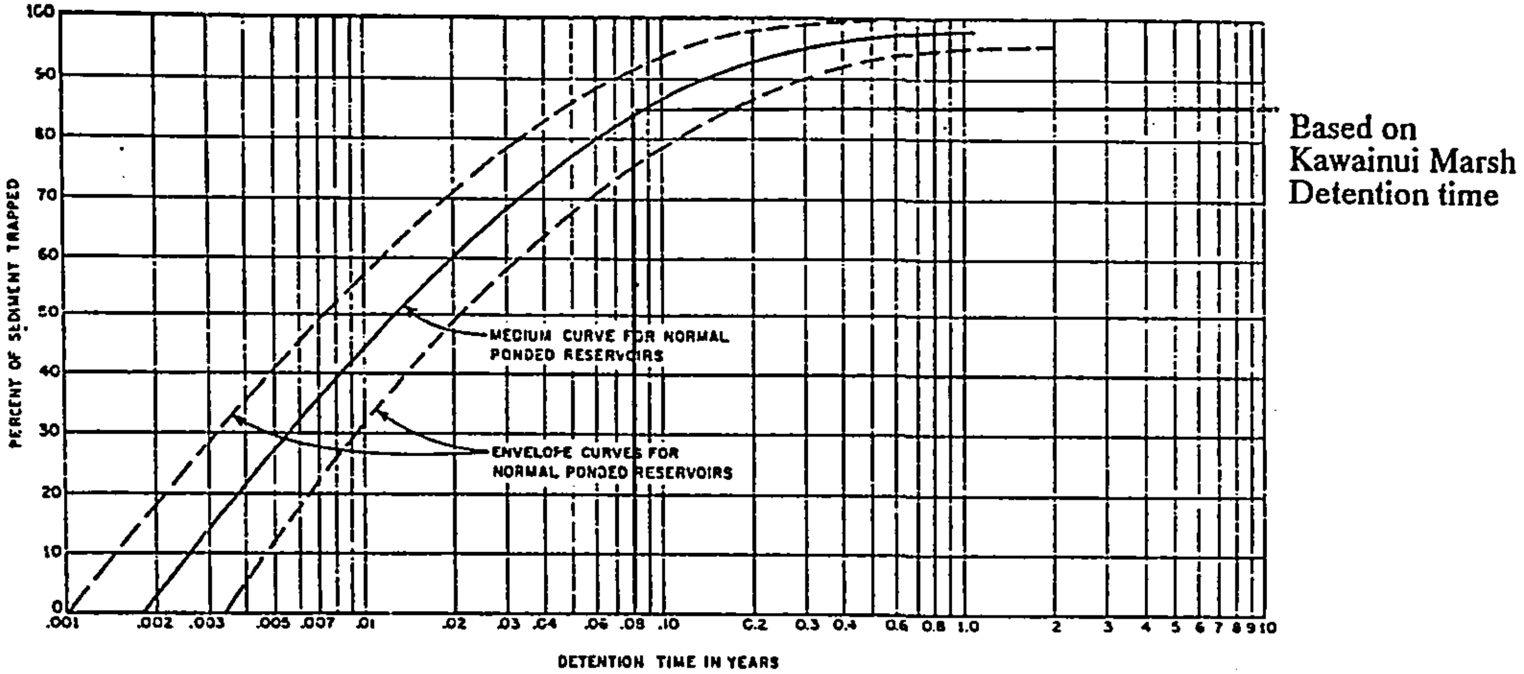
RELATIONSHIP BETWEEN
STORM RUNOFF AND SEDIMENT LOAD



NOTE: Pearl Harbor and Kaneohe Bay Streams Based on USGS Unpublished Data

From Water Quality Program for Oahu with Special Emphasis on Waste Disposal Engineering Science, Sunn, Low, Tom and Hara Dillingham Environmental Company, 1972.

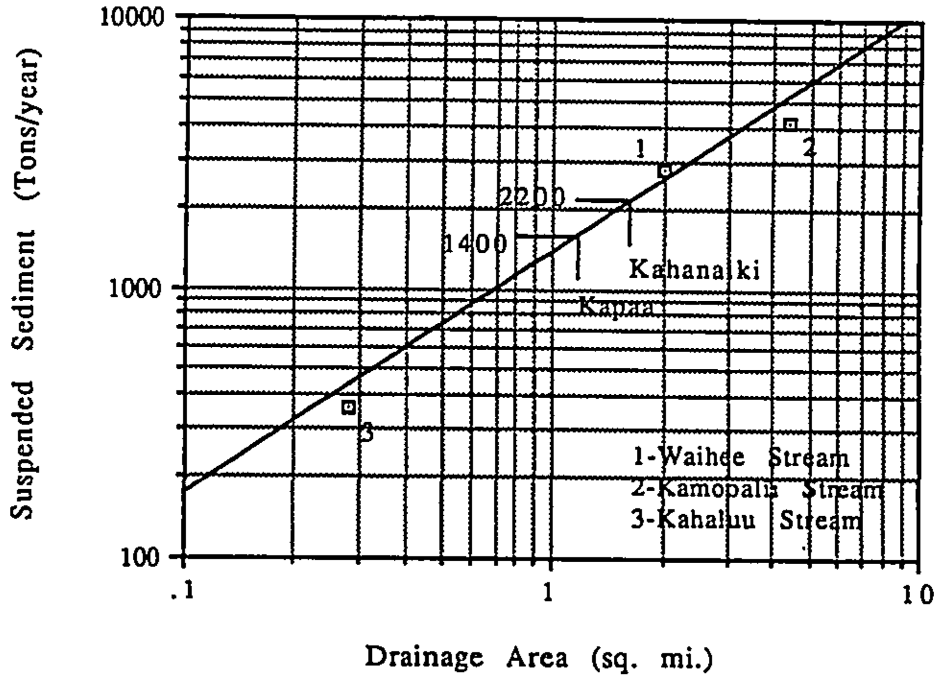
Figure B-4 Estimated Sediment Trap Efficiency



NOTE: Reproduced from Gunner Brune's Article, "Trap Efficiency of Reservoirs" Published in Trans. A.G.U., June 1953.

Figure B-5

Suspended Sediment Estimate for Kapaa Tributary



From Water Quality Program for Oahu with Special Emphasis on Waste Disposal Engineering Science, Sunn, Low, Tom and Hara Dillingham Environmental Company, 1972.

Figure B-6
Storage-Elevation Curve
Kawainui Marsh

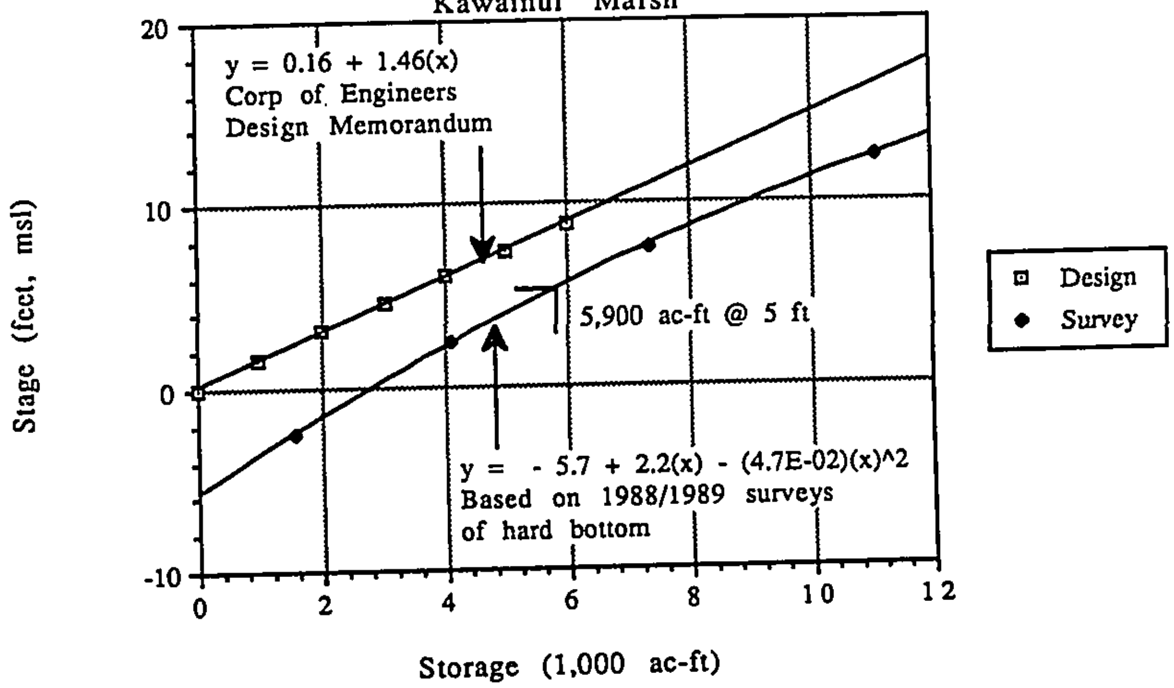
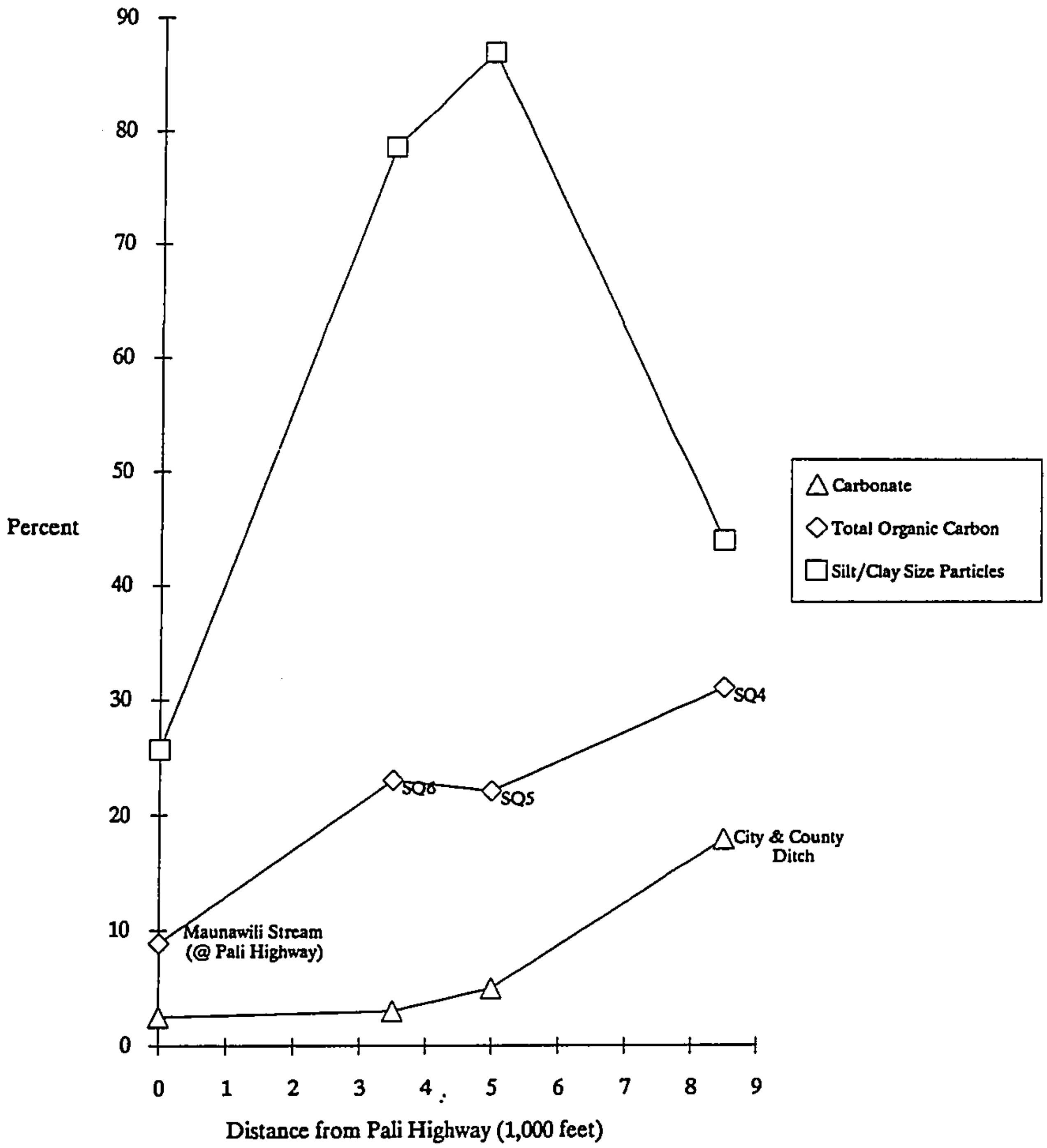
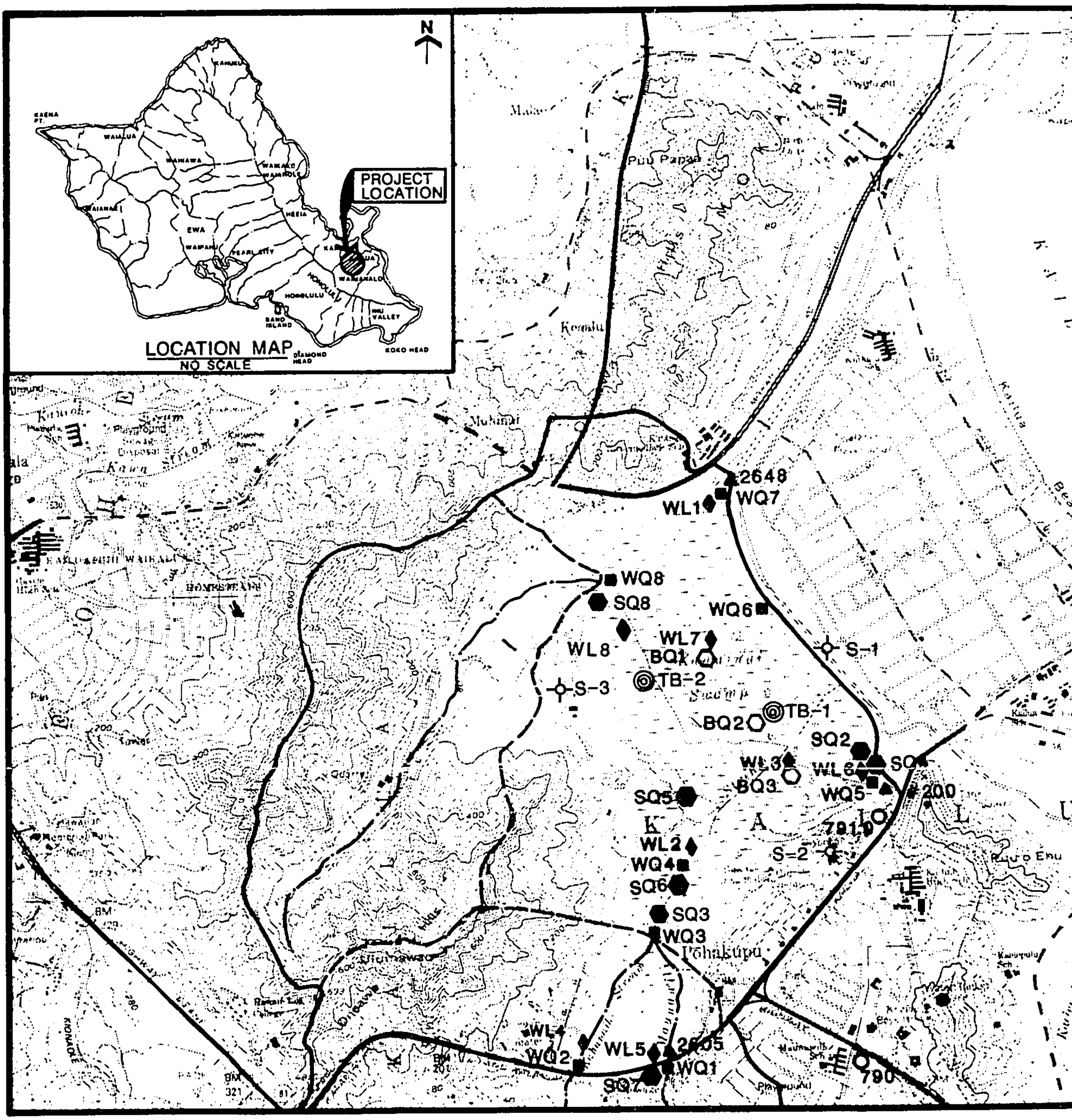
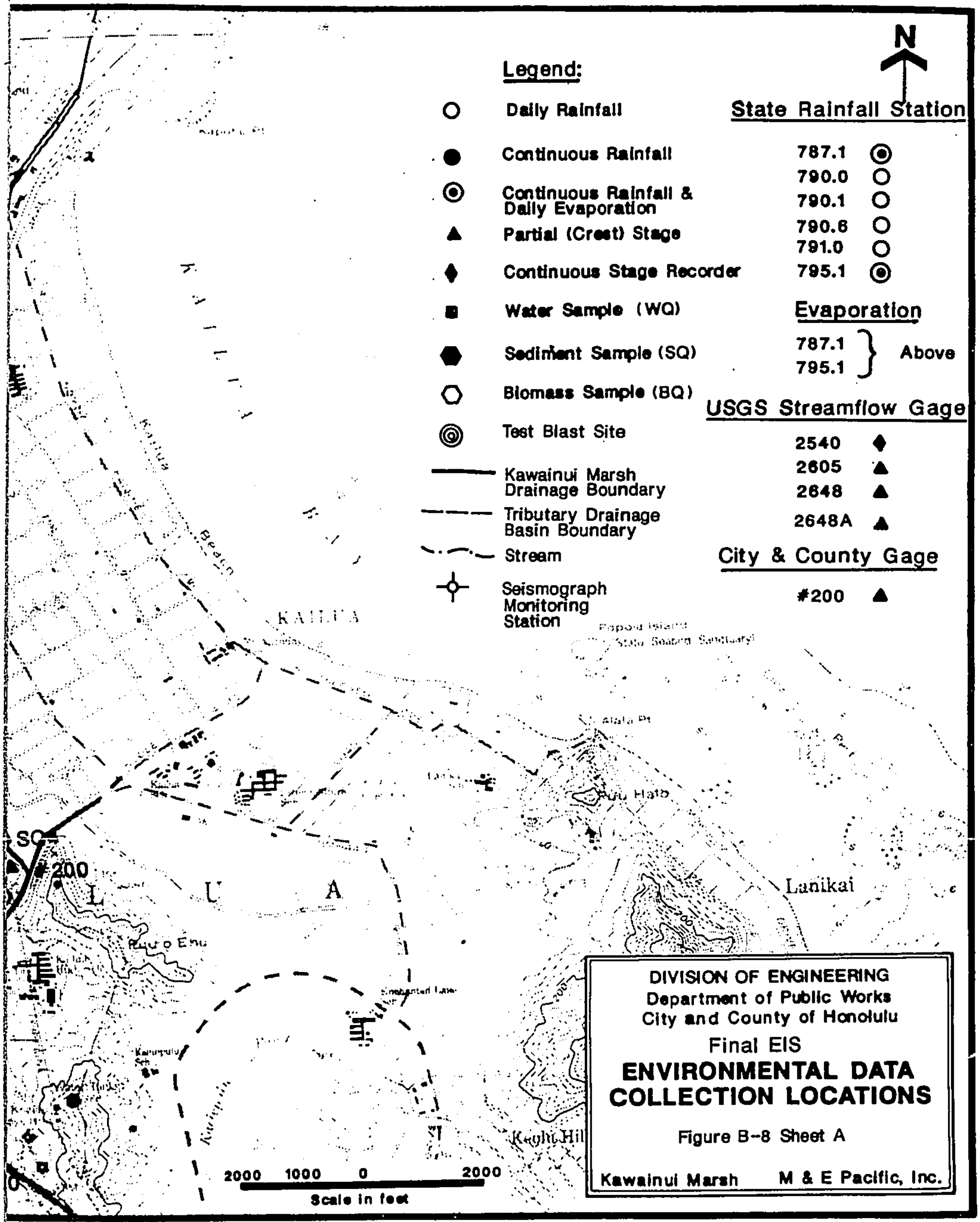


Figure B-7
Comparison of Sediment Sample Characteristics

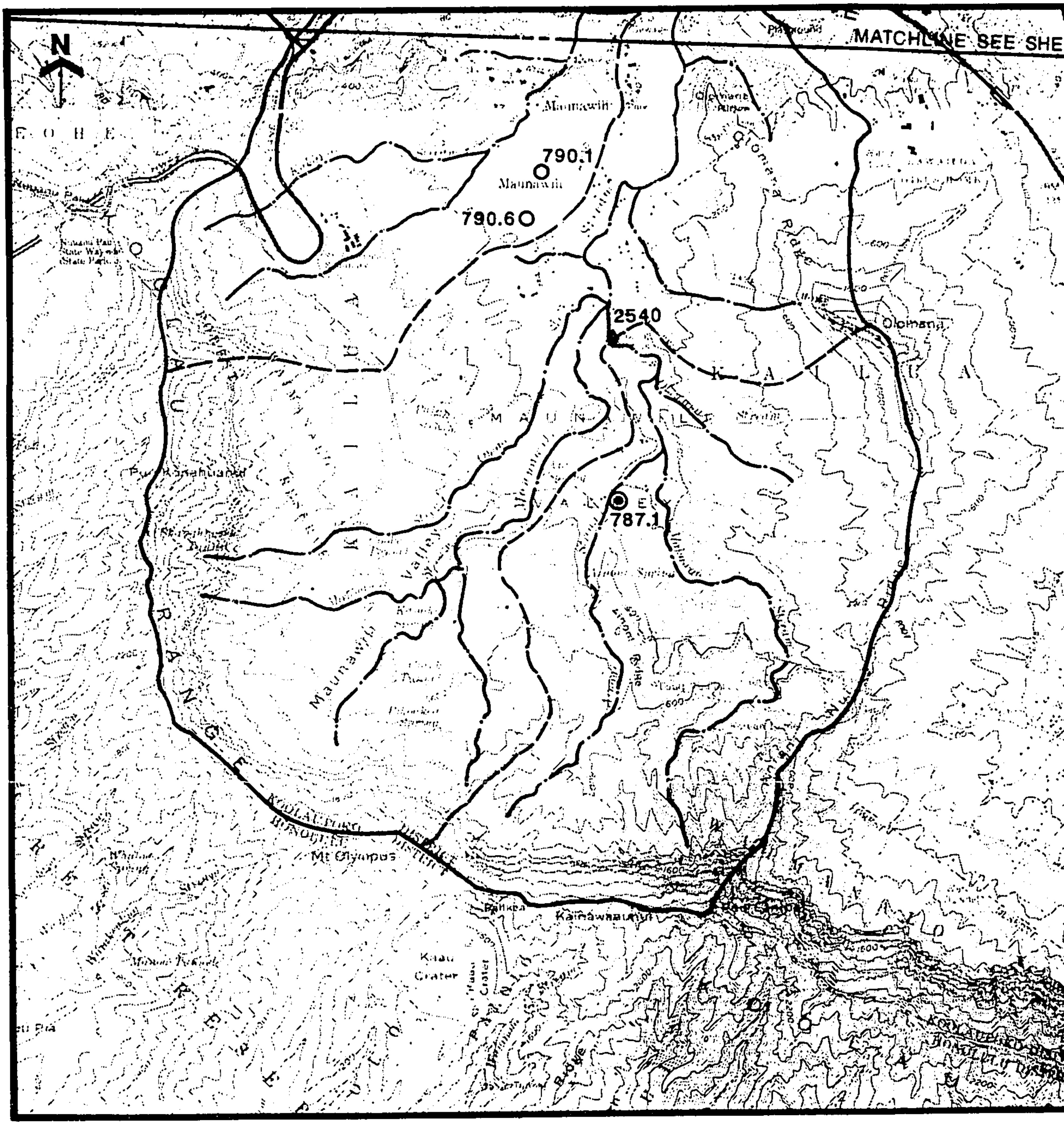



N
PROJECT LOCATION
LOCATION MAP
NO SCALE
KAHUKU
KAENA PT.
WAIALUA
WAHIAWA
WAIKANE
WAIANAE
EWA
WAIPAHU
PEARL CITY
HEEIA
HONOLULU
WAIMANALO
SAND ISLAND
NIU VALLEY
DIAMOND HEAD
KOKO HEAD
2648
WQ7
WL1
WQ8
SQ8
WQ6
WL7
WL8
BQ1
S-1
S-3
TB-2
TB-1
BQ2
SQ2
WL3
WL6
BQ3
WQ5
SQ5
200
791.9
WL2
S-2
WQ4
SQ6
SQ3
WQ3
Pohakupu
WL4
WL5
2605
WQ2
WQ1
SQ7
790
Puu Papaa
Kawainui Swamp



DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu
Final EIS
ENVIRONMENTAL DATA COLLECTION LOCATIONS
Figure B-8 Sheet A
Kawainui Marsh M & E Pacific, Inc.

DOCUMENT CAPTURED AS RECEIVED



DOCUMENT CAPTURED AS RECEIVED

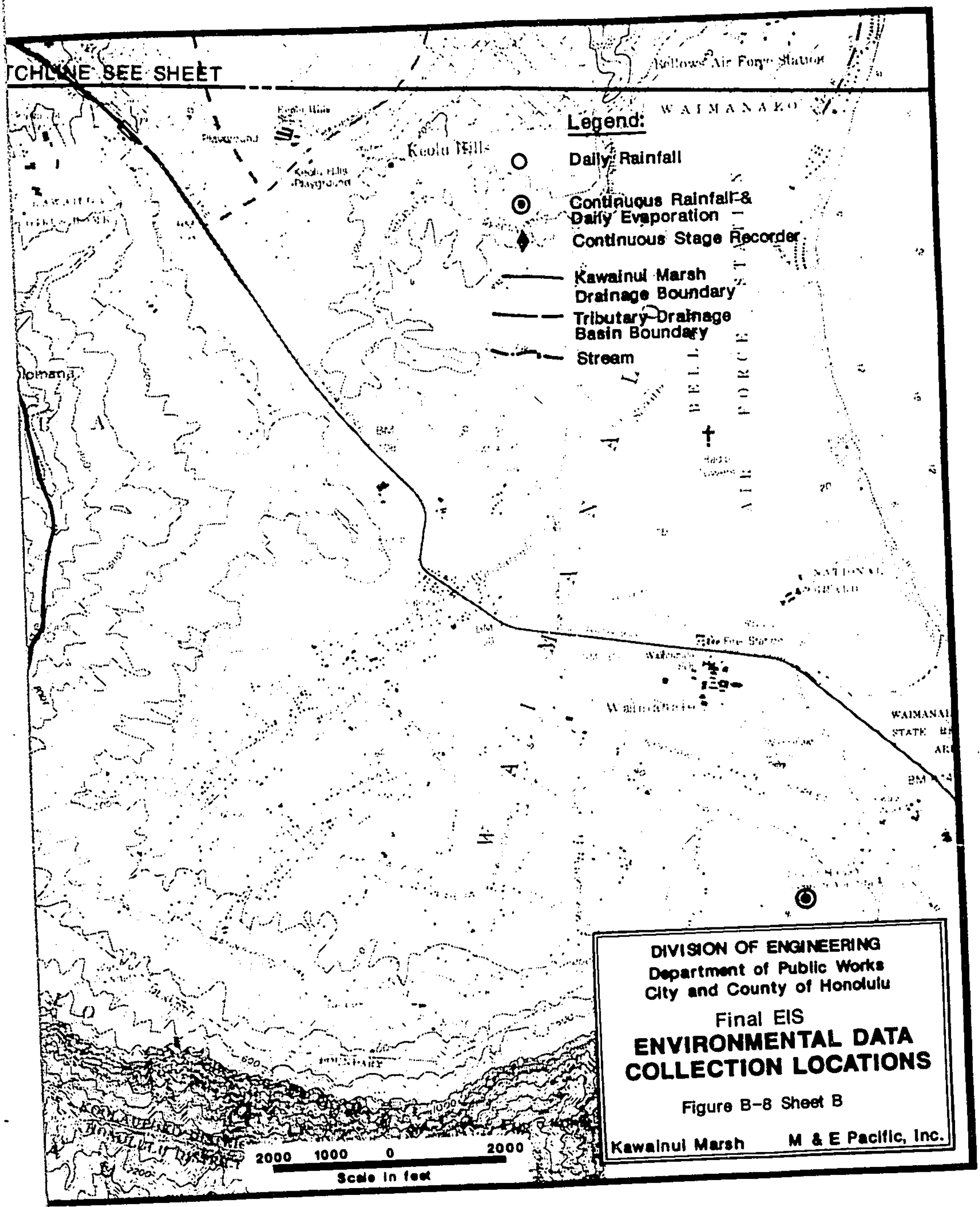
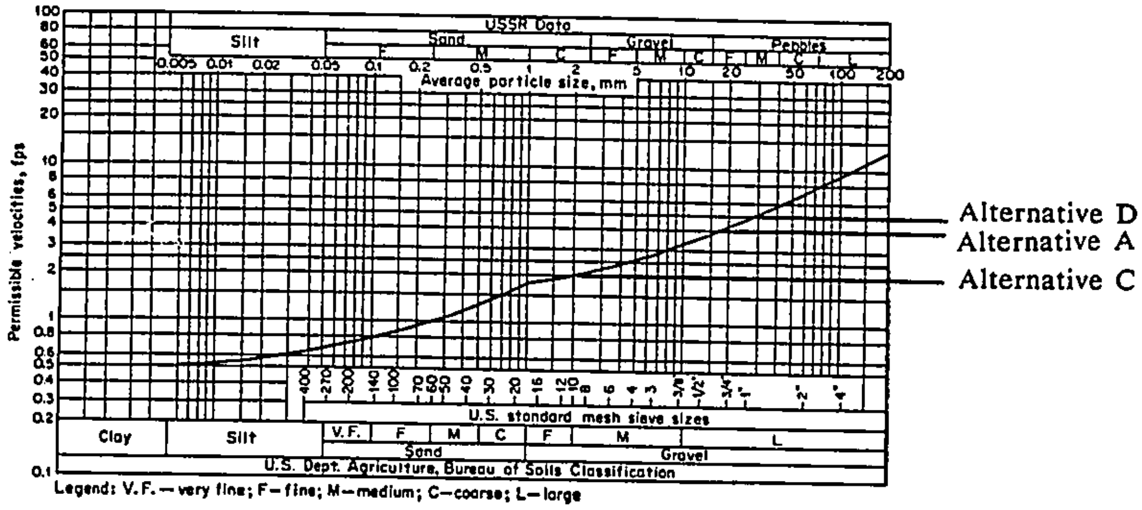
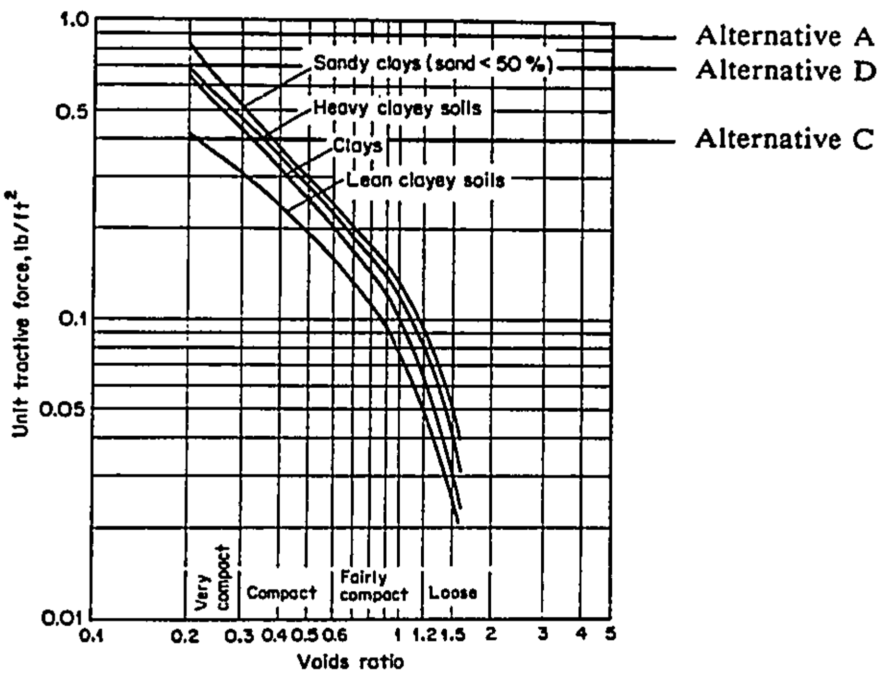


Figure B-9



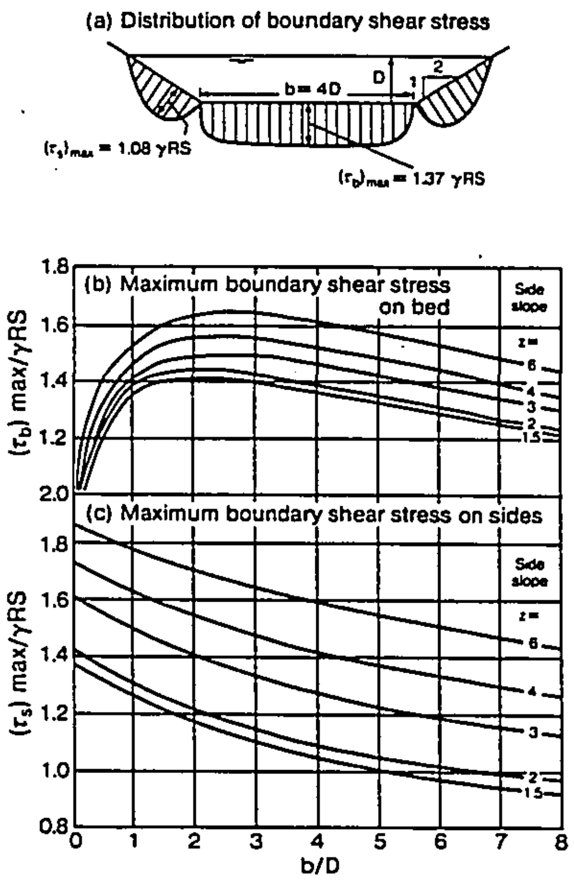
U.S. and U.S.S.R. data on permissible velocities for noncohesive soils.



Permissible unit tractive forces for canals in cohesive material as converted form the U.S.S.R. data on permissible velocities.

Source: Chow, Ven Te. Open-Channel Hydraulics. New York: McGraw-Hill Book Company; 1959. p 166, 174.

Figure B-10



Distributions of boundary shear stress in trapezoidal channels.

Source: Chang, Howard H. Fluvial Processes in River Engineering. New York: John Wiley & Sons, 1988.

Figure B-11
Kaelepulu Data
(July 29, 1989)

Channel Station	Distance * from Kailua Rd.	Dissolved Oxygen (ppm)		Salinity (ppt)		Temperature (C)		
		Morning	Noon	0.2 Depth	0.8 Depth	Morning	Noon	Afternoon
54+21	800	4.32	7.20	3.3	3.5	27.0	31.0	30.0
51+00	1300	3.10	7.10	3.3	3.3	27.3	30.0	31.0
30+00	3450	2.85	7.00	2.8	2.8	26.9	29.0	31.0
18+00	4400	2.28	7.00	2.8	2.6	27.2	30.0	30.0
18+00	4500	3.30	6.90	2.7	2.6	27.0	29.0	30.0
15+00	5000	2.80	6.90	2.4	2.4	27.0	29.0	30.0
9+00	5550	3.58	6.90	2.4	2.4	26.9	29.0	30.0
0+00	6650	3.38	6.20	2.8	2.5	24.2	25.0	29.0
	Maximum	4.32	7.20	3.30	3.50	27.30	31.00	31.00
	Minimum	2.28	6.20	2.40	2.40	24.20	25.00	29.00
	Average	3.20	6.90	2.81	2.76	26.69	29.00	30.13
	Std. Dev.	0.61	0.30	0.34	0.42	1.01	1.77	0.64

* Distance Corresponding to Kawainui Cross Sections

Kaelepulu Stream Cross Sections
View Looking North
Figure A-47
Cross Section (Station 0+00)

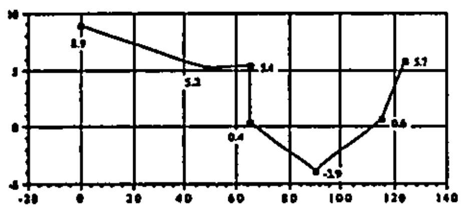


Figure A-53
Cross Section (Station 18+00)

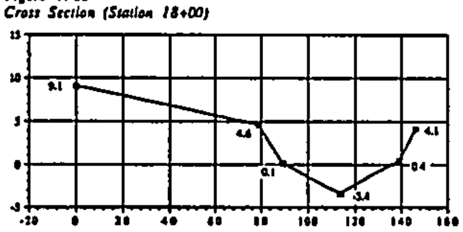


Figure A-50
Cross Section (Station 9+00)

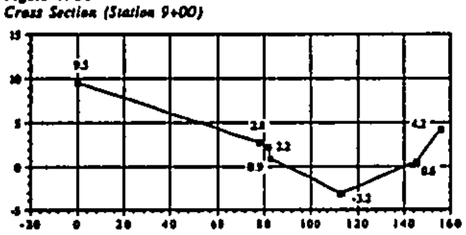


Figure A-57
Cross Section (Station 30+00)

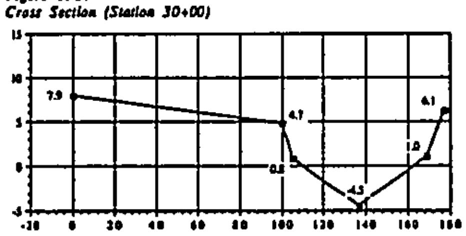


Figure A-52
Cross Section (Station 15+00)

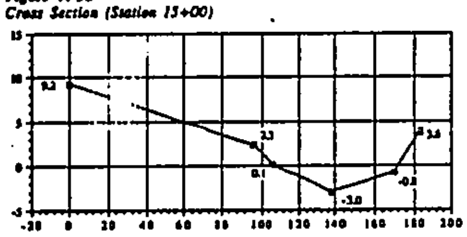


Figure A-64
Cross Section (Station 51+00)

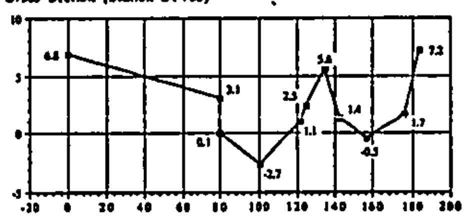


Figure A-65
Cross Section (Station 54+21)

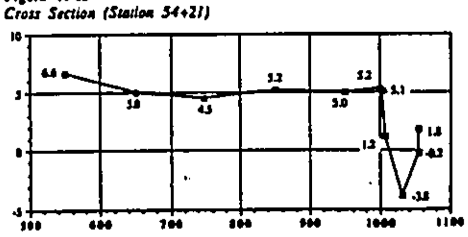
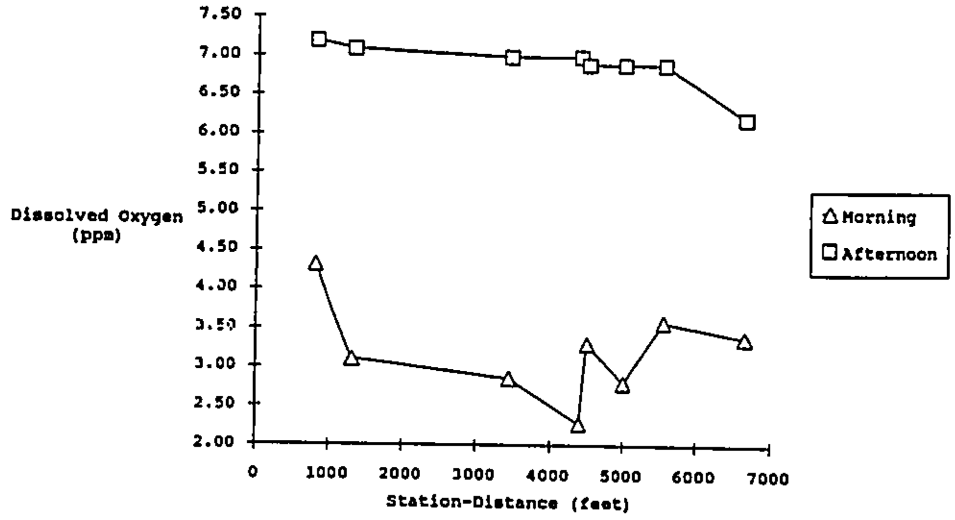
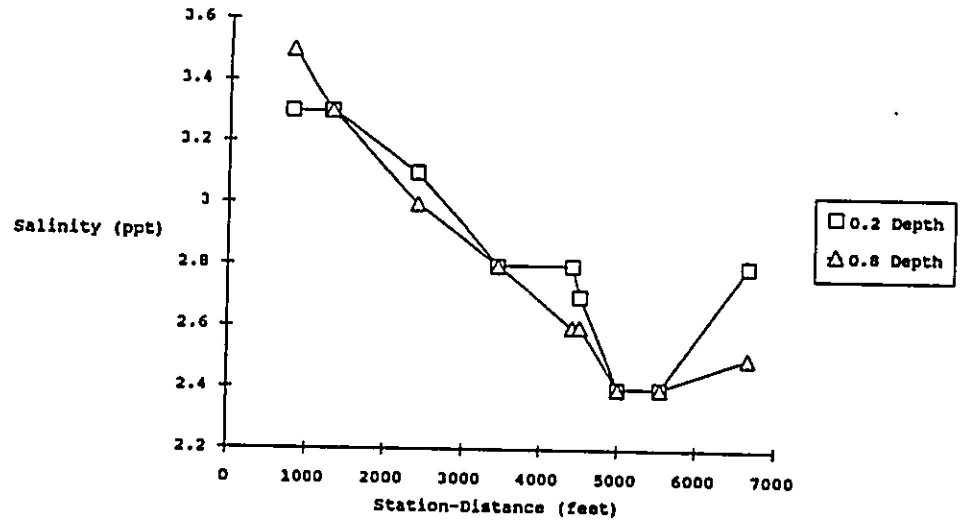
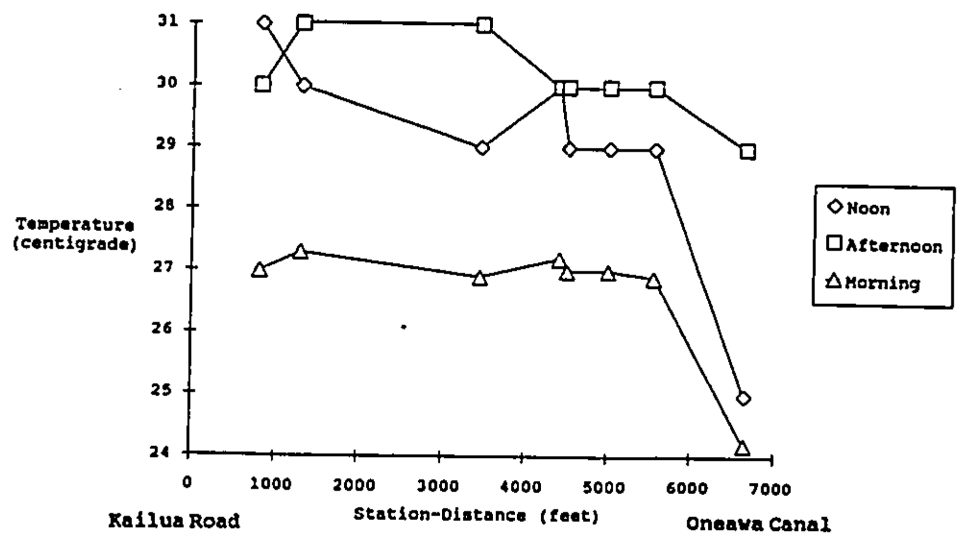


Figure B-12
Kaelepulu Stream Testing Results
(July 29, 1989)







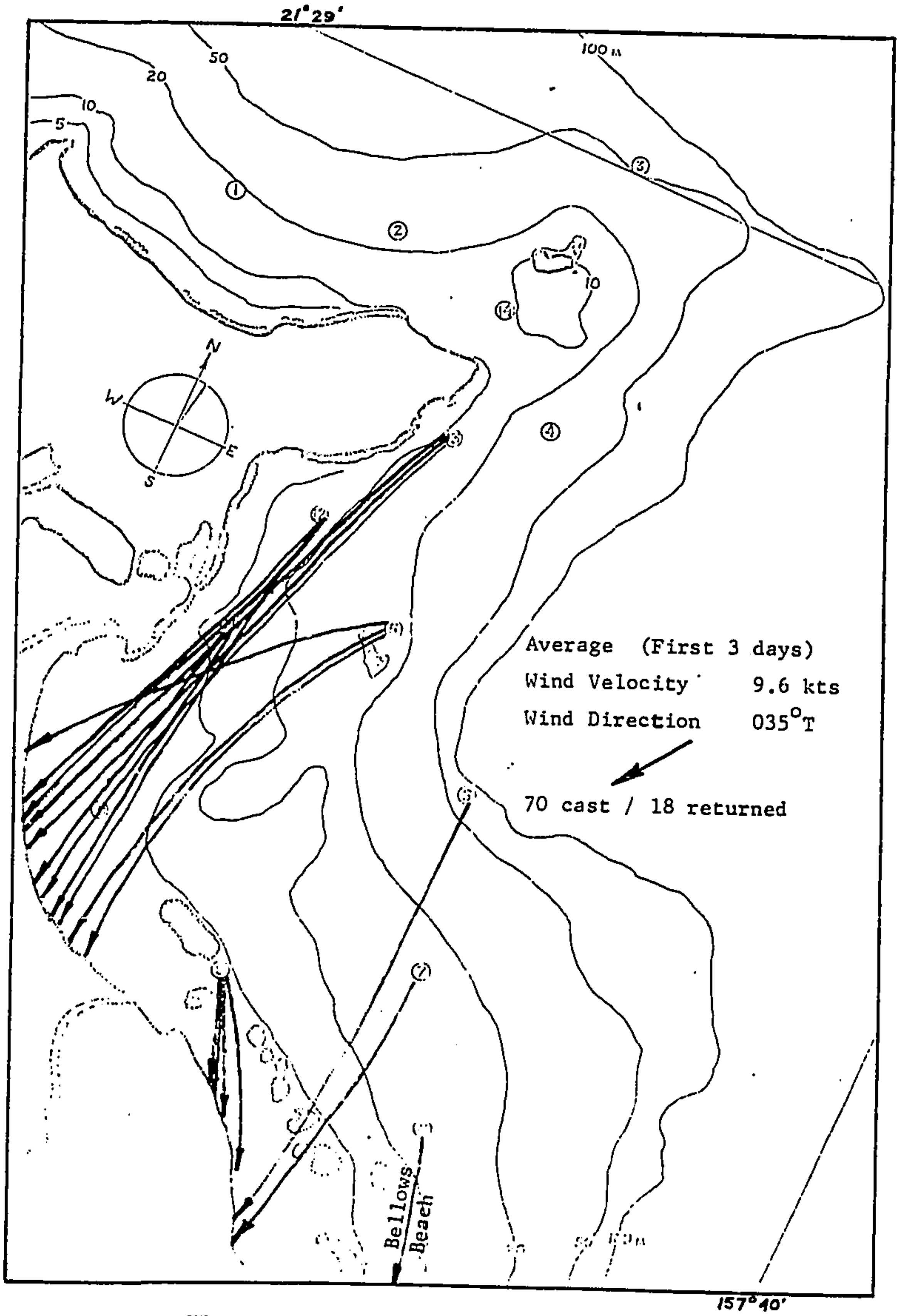


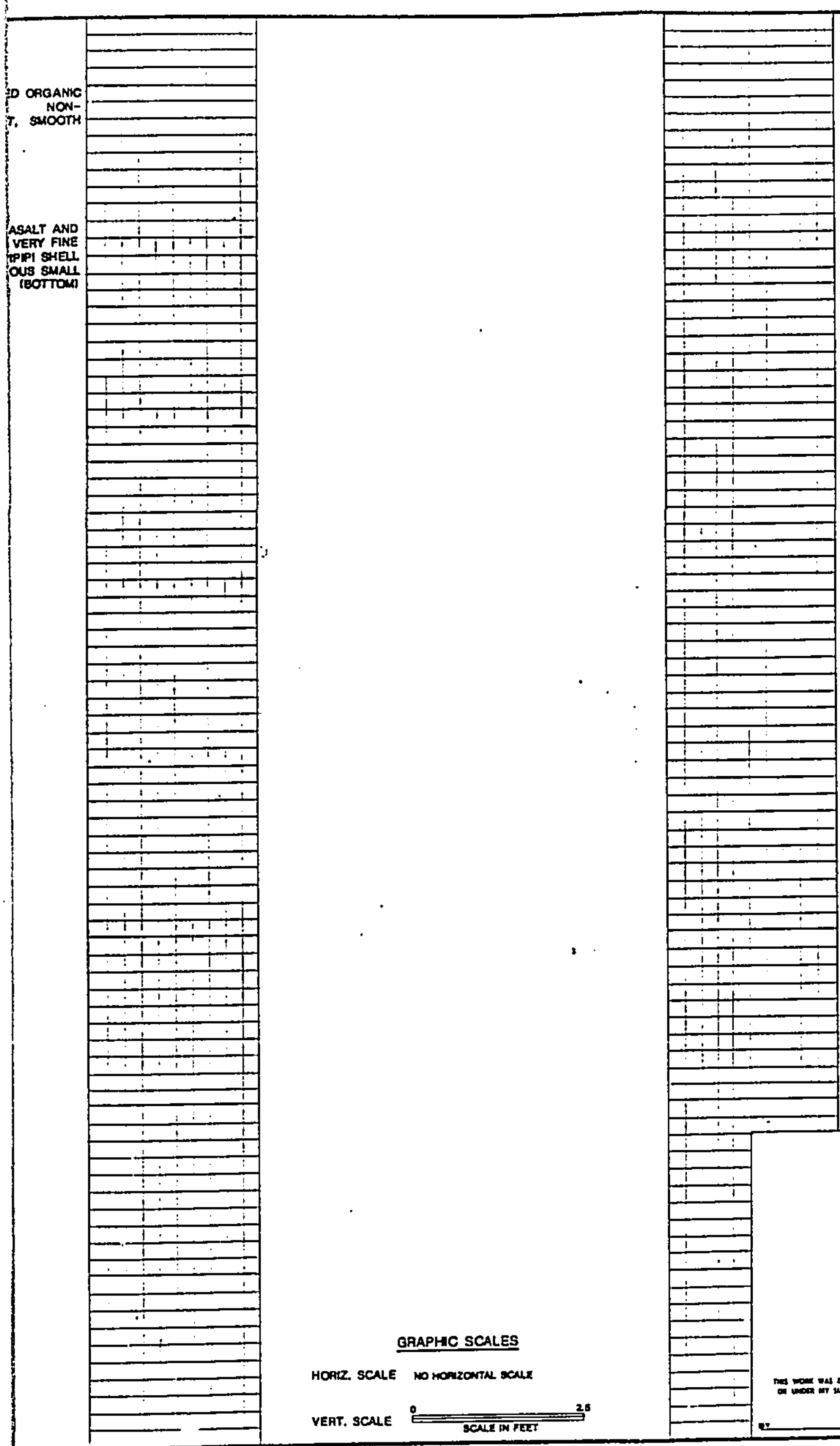
Figure B-13 Drift Card Results for February 1972
Source Bathen, 1972

CORE 8

STRATUM 1	0 - 0.33 ft	GREYISH BROWN ORGANIC MATTER WITH PARTLY DECOMPOSED ROOTS & STEMS. BEACH SAND STUCK ALONG WALLS OF CORE, ASSUMED TO BE 0 - 0.33 ft
STRATUM 2	0.33 - 2.46 ft	DARK GREY CLAY LOAM TO CLAY, STICKY, PLASTIC. NO APPARENT SHELL, CLEAR BOUNDARY.
STRATUM 3	2.46 - 7.41 ft	GREENISH GREY CLAY LOAM TO CLAY, STICKY PLASTIC. CONTAINS ABUNDANT MARINE SHELL (SOME WHOLE) C. BRACHIDONTIS AND TELLINA, ABRUPT BOUNDARY.
STRATUM 4	7.41 - 7.55 ft	DARK GREENISH GREY SILTY CLAY LOAM TO CLAY LOAM, SLIGHTLY STICKY, SLIGHTLY PLASTIC. NO APPARENT MARINE SHELL. ABRUPT BOUNDARY.
STRATUM 5	7.55 - 12.96 ft	GREENISH GREY GRADES DOWNWARDS TO GREENISH GREY. SILTY CLAY LOAM TO CLAY LOAM, STICKY, PLASTIC. CONTAINS SMALL PIECES MARINE SHELLS. NO LARGE SHELLS VISIBLE. CLEAR BOUNDARY.
STRATUM 6	12.83 - 12.96 ft	DARK BLUISH GREY (WET), CLAY LOAM, SLIGHTLY STICKY, SLIGHTLY PLASTIC. LIGHTER COLORED MOTTLING (PROBABLY FROM CORE). NO MARINE SHELL VISIBLE.

CORE 10

STRATUM 1	0 - 0.68 ft	(WET) BLACK, PARTIALLY DECOMPOSED ORGANIC MATTER, ROOTS AND TWIGS. SMALL OR NON-EXISTENT MINERAL COMPONENT. ABRUPT, SMOOTH BOUNDARY.
STRATUM 2	0.68 - 11.15 ft	(WET) GREY, MEDIUM TO COARSE BASALT AND CORRALINE BEACH SAND WITH A VERY FINE COMPONENT OF SAND. WHOLE PIPIPI SHELL (INTERIDAL) AT 5.25 ft DEPTH NUMEROUS SMALL SHELL INCLUSIONS 0.68 TO 10.30 ft (BOTTOM) WITH NO CHARGE IN CHARACTER.



REVISION	DATE	BRIEF	BY	APPR'D

M & E PACIFIC, INC.
ENGINEERS & ARCHITECTS
HONOLULU, HAWAII

KAWAINUI MARSH FINAL EIS
KAILUA, OAHU, HAWAII

FIGURE B-14

SEDIMENT CORE DESCRIPTIONS

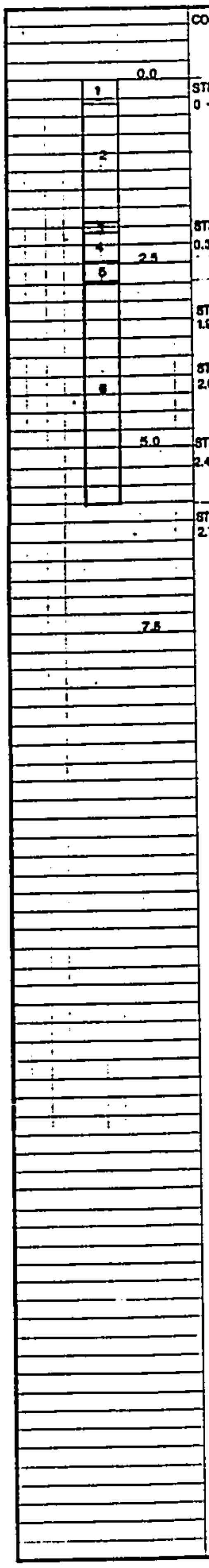
DRAWN BY H.L. ENGINEER J.D.

APPROVED BY:

THIS WORK WAS DONE BY ME OR UNDER MY SUPERVISION

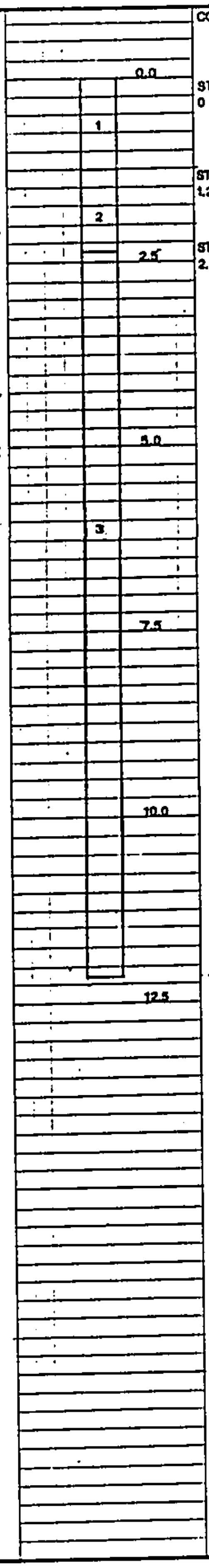
BY

SHEET 2 OF 2 SHEETS



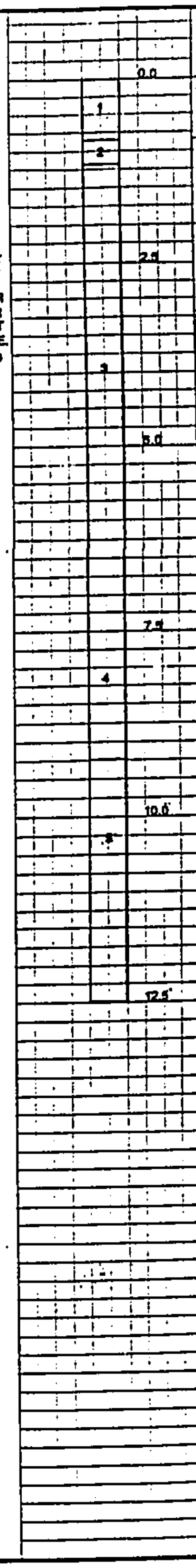
CORE 3

STRATUM 1 0 - 0.33 ft	DARK OLIVE GREY (WET). HIGHLY ORGANIC, SILTY CLAY LOAM. NONSTICKY, SLIGHTLY PLASTIC. GEL LIKE. CLEAR BOUNDARY.
STRATUM 2 0.33 - 1.94 ft	VERY DARK GREY (WET). SILTY CLAY LOAM. STICKY, PLASTIC. HIGHLY ORGANIC BUT DECREASING DOWNWARDS. CONTAINS LAND SNAILS. ABRUPT BOUNDARY.
STRATUM 3 1.94 - 2.07 ft	BLACK SILTY CLAY LOAM. HIGHLY ORGANIC. CONTAINS LAND SNAILS. ABRUPT BOUNDARY.
STRATUM 4 2.07 - 2.46 ft	DARK OLIVE GREY, SILTY CLAY LOAM. SLIGHTLY STICKLY, SLIGHTLY PLASTIC, GEL LIKE, HIGH ORGANIC CONTENT.
STRATUM 5 2.46 - 2.72 ft	(WET) DARK GREY, SILTY CLAY LOAM. HIGHLY ORGANIC. GEL LIKE. ABRUPT BOUNDARY. CONTAINS LAND SNAILS.
STRATUM 6 2.72 - 5.74 ft	(WET) VERY DARK DREY, SILTY CLAY LOAM. SLIGHTLY *STICKY, SLIGHTLY PLASTIC.* HAS VEINS OF VERY FINE SAND (WHITE). ALSO OCCURRING AS SPECKS THROUGHOUT LAYER.



CORE 5A

STRATUM 1 0 - 1.25 ft	VERY DARK GREYISH BROWN, SILTY CLAY LOAM. SLIGHTLY STICKY, SLIGHTLY PLASTIC. 5 - 10% FINE ROOTS AND STEMS NOT DECOMPOSED 0 TO 1.25 ft
STRATUM 2 1.25 - 2.36 ft	(WET) BLACK, HIGHLY ORGANIC LOAM. ORGANIC CONTENT ESTIMATED WELLOVER 50%. PEAT LIKE.
STRATUM 3 2.36 - 12.14 ft	VERY DARK GREY SILTY CLAY LOAM. ESTIMATED 20 - 30% ORGANIC CONTENT SOME UNDECOMPOSED ORGANIC MATTER. AT 2.46 ft UNIDENTIFIED - GOURD LIKE VEGETABLE MATTER AND 5.25 ft , WOOD LIKE (FIBERIOUS) MATTER (EXTRACT VEG. MATTER FOR I.D.). ABUNDANT MARINE SHELL AT 10.66 ft, TO BOTTOM OF CORE. ABOVE 10.66 ft ONLY MOTTLES VERY FINE SAND



AY LOAM.
5 - 10%
D 0

IC LOAM.
VER 50%.

AY LOAM.
NT SOME
2.46 ft
E MATTER
MATTER
BUNDANT
OF CORE.
NE SAND

CORE 6

0.0 / 2.5 / 5.0 / 7.5 / 10.0 / 12.5

STRATUM 1
0 - 0.82 ft
(WET) VERY DARK GREY. 5 - 10% UNDECOMPOSED OGANIC MATTER. SLIGHTLY STICKY, SLIGHTLY PLASTIC, SILTY CLAY LOAM.

STRATUM 2
0.82 - 1.15 ft
(WET) BLACK. 30 - 40% UNDECOMPOSED OGANIC MATTER. PEAT LIKE. SLIGHTLY STICKY, SLIGHTLY PLASTIC, SILTY CLAY LOAM.

STRATUM 3
1.15 - 7.22 ft
(WET) VERY DARK GREY, SILTY CLAY LOAM, SLIGHTLY STICKY, SLIGHTLY PLASTIC.

STRATUM 4
7.22 - 9.19 ft
(WET) VERY DARK GREY, SILTY CLAY LOAM, SLIGHTLY STICKY, SLIGHTLY PLASTIC. SOME FINE, FAINT SAND MOTTLES.

STRATUM 5
9.19 - 12.47 ft
(WET) GREENISH GREY SILTY CLAY LOAM, SLIGHTLY STICKY, SLIGHTLY PLASTIC. MARINE SHELL (TELLINA SP.) COMPONENT.

CORE 7

0.0 / 2.5 / 5.0 / 7.5 / 10.0 / 12.5 / 15.0

STRATUM 1
0 - 0.33 ft
VERY DARK GREYISH BROWN, SILTY CLAY LOAM, 20 - 40% UNDECOMPOSED ORGANIC MATTERS (ROOTS AND STEMS). SLIGHTLY STICKY, SLIGHTLY PLASTIC.

STRATUM 2
0.33 - 1.44 ft
BLACK (WET) SILTY CLAY LOAM, 20 - 40% PARTLY DECOMPOSED ROOTS & STEMS. SOME GREY SILTY CLAY LOAM MOTTLING, SLIGHTLY STICKY, SLIGHTLY PLASTIC.

STRATUM 3
1.44 - 14.60 ft
VERY DARK GREY (WET) AT 1.64 ft. GRADES DOWNWARDS TO 5Y 4/1 (WET), DARK GREY AT 13.12 ft. ORGANIC MOTTLING AT 12.07 TO 12.14 ft. ORGANIC MATTER DECOMPOSED DOWNWARDS IN GENFRAL. SILTY CLAY LOAM. SLIGHTLY STICKY, SLIGHTLY PLASTIC. MARINE SHELL STARTS AT 11.48 ft TO BOTTOM.

STRATUM 4
10.99 - 11.32 ft
GREENISH GREY (WET) SILTY CLAY LOAM. SLIGHTLY STICKY, SLIGHTLY PLASTIC. MARK. SHELL COMPONENT.

GRAPHIC SCALES

HORIZ. SCALE NO HORIZONTAL SCALE

VERT. SCALE 0 — 2.5 SCALE IN FEET

THIS WORK WAS DONE BY ME OR UNDER MY SUPERVISION

BY

REVISION	DATE	BRIEF	BY	APPR'D

M & E PACIFIC, INC.
ENGINEERS & ARCHITECTS
HONOLULU, HAWAII

KAWAINUI MARSH FINAL EIS
KAILUA, OAHU, HAWAII

FIGURE B-14

SEDIMENT CORE DESCRIPTIONS

DRAWN BY H.L. ENGINEER J.D.

APPROVED BY:

SHEET 1 OF 2 SHEETS

Appendix C

Public Information Documentation

Status of Consultation/Comments

NOP/EA Comments/Responses	Letter Dated	Date Answered
FEDERAL		
U.S. Fish and Wildlife Service	26-Sep-89	**
U.S. Army Corps of Engineers	26-Oct-89	*
STATE		
Environmental Center UH	4-Oct-89	30-Oct-89
Office of Hawaiian Affairs	5-Oct-89	30-Oct-89
Office of Environmental Quality Control	6-Oct-89	
CITY AND COUNTY OF HONOLULU		
Department of Parks and Recreation	10-Oct-89	*
ORGANIZATIONS AND INDIVIDUALS		
Sierra Club Legal Defense Fund	23-Aug-89	30-Oct-89
Kawai Nui Heritage Foundation	3-Sep-89	3-Nov-89
Kailua Neighborhood Board #31	8-Sep-89	30-Oct-89
Lani-Kailua Outdoor Circle	20-Sep-89	31-Oct-89
Diane Drigot	23-Sep-89	1-Nov-89
National Audubon Society	6-Oct-89	20-Oct-89
Hawaii's Thousand Friends		16-Oct-89

The following letters were received on a preliminary (June 1989) edition of the draft environmental impact statement. The comments were considered in this edition.

FEDERAL
U.S. Corps of Engineers
U.S. Fish and Wildlife Service
STATE
Department of Health
Department of Land and Natural Resources
CITY AND COUNTY OF HONOLULU
Department of Parks and Recreation
Department of General Planning
Department of Public Works
Division of Road Maintenance
Division of Wastewater Management

** Received after October 7, 1989 closing date. Responses annotated to comments.*

*** Requested Constulted Party. No comments at this time/Request noted /DEIS will be provided.*

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF:

October 26, 1989

Planning Branch

RECEIVED
Oct 26 1 55 PM '89

Mr. Sam Callejo
Director and Chief Engineer
City and County of Honolulu
650 South King Street
Honolulu, HI 96813

Dear Mr. Callejo:

We have reviewed the July 17, 1989 Environmental Assessment (EA) and Notice of Preparation of Environmental Impact Statement (NOI) prepared by M&E Pacific for the Kawainui Marsh Flood Damage Mitigation project. As requested in your transmittal letter of October 5, our comments are enclosed.

We have no objections to the concept of creation of channels in the marsh which are part of the proposed action; however, a Department of the Army permit may be required. We cannot support the proposed plan of modifying the federal flood control levee for reasons provided previously and included in the enclosed comments. As you know, any action proposing modifications to this levee requires approval of the Assistant Secretary of the Army for Civil Works.

We concur with the consultant's conclusion that modification to the existing flood control project is needed, in addition to any marsh management measures, to reestablish adequate and long-term flood protection for Coconut Grove. This conclusion, reached in August, 1989 has led us to initiate a Reconnaissance Report under Section 205 of the Flood Control Act of 1948, as amended, to identify an implementable flood control plan. This report will be completed soon and will recommend a joint Corps-City and County feasibility analysis and design leading to Federal and City and County construction of an acceptable solution.

I understand your position and intent to release the Draft Environmental Impact Statement (DEIS) for public review in early November. I also appreciate the opportunity for Corps input at this time to the EA and NOI. However, in view of the enclosed comments and per the telephone discussion on October 23rd between you and John Pelowski of my staff, I request they be made part of the DEIS for public review.

Sincerely,

Donald T. Wynn
Lieutenant Colonel, U.S. Army
District Engineer

Enclosure

U.S. Army Engineer District, Honolulu October 25, 1989

Review of Environmental Assessment and Notice of Preparation of Environmental Impact Statement Titled Kawainui Marsh Flood Damage Mitigation Project Prepared by M&E Pacific Dated July 17, 1989

These comments are provided by the Honolulu Engineer District in response to a letter dated October 5, 1989 from the City and County of Honolulu, Department of Public Works (DPW). These comments are essentially no different than those we stated on July 6 and at subsequent meetings with the consultant and DPW staff and which were summarized in letters dated August 4 and 16, and again stated at our August 21 meeting at the DPW.

These comments were received after the Oct 7, 1989 closing date. However, due to their importance, preliminary responses annotated below:

Response

Please refer to the attached comments received on July 11, 1989 and the responses given on July 12, 1989, and the present status.

1. We favor the portions of the proposed plan which recommend the creation of open water habitat. We are in support of marsh management action. However, we cannot support the analysis and conclusions reached with respect to the proposed modifications to the federal flood control levee. It has been difficult to adequately assess and comment on the proposed action at this time as supporting data have not been available for review in a timely manner. The data are expected to be presented in greater detail in the DEIS.

Please refer to Appendix A and B.

2. The EA discusses four elements associated with a single alternative but omits detailed evaluation of other potentially feasible alternatives, such as a channel through the marsh and a levee raise. The document states that the proposed action is "an alternative to construction of a channel through the Marsh". In reality, this proposal also recommends marsh channels identified as "opening new waterways" and "excavating fine sediments". A basic misunderstanding of the role of a cleared channel through the marsh appears evident in the document with respect to water quality. Even at peak flood conditions, water moving through a cleared channel would not exceed about 2 feet per second. No evidence is presented to support the statement that there will be "major impacts both in terms of quantity and duration of the time that water quality standards will be exceeded" with such an alternative.

Please refer to Appendix A which provides detailed evaluations of all alternatives.

3. A levee raise alternative is also dismissed in the EA as "self-defeating and too costly" despite proposing selective

Encl.

TO: M & E PACIFIC
C/O MR. JAMES DEXTER

11 JULY 1989

Please provide us with information on the Kawainui Marsh project as outlined below:

HYDRAULIC DESIGN

a. Backwater computations used to develop Oneawa Canal rating curve for Kaelepulu Stream outlet.

b. Hydraulic computations of the Kaelepulu outlet structure at Oneawa Canal.

c. All hydraulic computations on the City and County emergency ditch including the design of the proposed rock weir.

d. Hydraulic design of levee overflow section including marsh water surface elevations used for various frequency events.

e. Users manual for finite element model.

f. Finite element model-input parameters for storm of 9 April 1989, New Years Eve storm, and Standard Project Flood for
(1) existing conditions,
(2) high levee (no overtopping),
(3) and proposed design.

FOUNDATION DESIGN

a. Flow velocities upstream and downstream of the 4 barrel, 8x12 box culverts. Riprap design calculations and details of riprap apron including thickness, stone sizes, bedding layer, filter fabric, etc.

b. Backup data on slope stability analysis including
(1) sketch of levee cross section investigated,
(2) phreatic surface assumed,
(3) soil parameters assumed,
(4) sketch of various failure surfaces investigated including critical failure surface, and respective factors of safety,
(5) tabular summary of all conditions investigated with corresponding minimum factor of safety.

c. For overflow section provide velocity of water running down landward slope, details of concrete and gabion linings including thickness, cutoff wall details, bedding layer/filter fabric details, and details for protection of gabion wire baskets against corrosion.

d. Typical section of proposed levee section raised to el 12.4 ft msl.

Response on July 12

Status of Data Requested

a) b) The RMA-2 model results covers both of these topics & will be provided 7/17
• provided 7/24 •

c) Gradually varied flow profile to be provided 7/17• provided 7/24 •

d) The design of the weir will be forwarded along with other design calcs within 30 days

e) To be provided 7/17 • provided 7/24 •

f) To be provided 7/17 • provided 7/24 •

a) The design of the outlet and scour protection will be forwared along with foundation analysis in 30-60 days

b) Preliminary soils report to be furnished 7/17 • provided 7/24 •

c) d) Design calculations for overflow and raised levee sections to be forwarded in 30-60 days • provided 7/24 •

• Notes date provided •

Present Status as of Oct. 24, 1989

a) b) Covered Appendix A, Section 4 (And previously provided to COE)

c) Covered Appendix A, Section 9 (And previously provided to COE)

d) Design of emergency overflow deferred pending COE Washington review. Preliminary basis in Appendix a, Section 9

e) Covered in Appendix A

f) Covered in Appendix A

a) This part of the detailed design deferred until subsequent studies. Preliminary basis of design in Appendix A, Sec. 9

b) Soils analysis contained in Appendix A, Section 9; (And previously furnished to COE)

c) This part of the design can be completed during subsequent studies. Preliminary basis of design in Appendix A, Sec. 9

d) Provided in soils analysis previously furnished in Appendix A, Section 9

TO: M & E PACIFIC
C/O MR. JAMES DEXTER

11 JULY 1989

Please provide us with information on the Kawainui Marsh project as outlined below:

HYDRAULIC DESIGN

a. Backwater computations used to develop Oneawa Canal rating curve for Kaelepulu Stream outlet.

b. Hydraulic computations of the Kaelepulu outlet structure at Oneawa Canal.

c. All hydraulic computations on the City and County emergency ditch including the design of the proposed rock weir.

d. Hydraulic design of levee overflow section including marsh water surface elevations used for various frequency events.

e. Users manual for finite element model.

f. Finite element model input parameters for storm of 9 April 1989, New Years Eve storm, and Standard Project Flood for
(1) existing conditions,
(2) high levee (no overtopping),
(3) and proposed design.

FOUNDATION DESIGN

a. Flow velocities upstream and downstream of the 4 barrel, 6x12 box culverts. Riprap design calculations and details of riprap apron including thickness, stone sizes, bedding layer, filter fabric, etc.

b. Backup data on slope stability analysis including
(1) sketch of levee cross section investigated,
(2) phreatic surface assumed,
(3) soil parameters assumed,
(4) sketch of various failure surfaces investigated including critical failure surface, and respective factors of safety,
(5) tabular summary of all conditions investigated with corresponding minimum factor of safety.

c. For overflow section provide velocity of water running down landward slope, details of concrete and gabion linings including thickness, cutoff wall details, bedding layer/filter fabric details, and details for protection of gabion wire baskets against corrosion.

d. Typical section of proposed levee section raised to el 12.4 ft msl.

Response on July 12 Status of Data Requested	Present Status as of Oct. 24, 1989
a) b) The RMA-2 model results covers both of these topics & will be provided 7/17 • provided 7/24 •	a) b) Covered Appendix A, Section 4 (And previously provided to COE)
c) Gradually varied flow profile to be provided 7/17• provided 7/24 •	c) Covered Appendix A, Section 9 (And previously provided to COE)
d) The design of the weir will be forwared along with other design calcs within 30 days	d) Design of emergency overflow deferred pending COE Washington review. Preliminary basis in Appendix a, Section 9
e) To be provided 7/17 • provided 7/24 •	e) Covered in Appendix A
f) To be provided 7/17 • provided 7/24 •	f) Covered in Appendix A
a) The design of the outlet and scour protection will be forwared along with foundation analysis in 30-60 days	a) This part of the detailed design deferred until subsequent studies. Preliminary basis of design in Appendix A, Sec. 9
b) Preliminary soils report to be furnished 7/17 • provided 7/24 •	b) Soils analysis contained in Appendix A, Section 9; (And previously furnished to COE)
c) d) Design calculations for overflow and raised levee sections to be forwarded in 30-60 days • provided 7/24 •	c) This part of the design can be completed during subsequent studies. Preliminary basis of design in Appendix A, Sec. 9
	d) Provided in soils analysis previously furnished in Appendix A, Section 9

• Notes date provided •

11-6

raising of the levee as part of the recommended plan. The recommended plan, as well as other alternative plans will be subject to the same sediment inflow and products of decomposition of the biomass in the marsh. In terms of costs, we believe that a levee raise is comparable to other flood mitigation measures being seriously considered.

Refer to Append.A Both the recommended plan and alternativ need to consider long term sedimentation in the design. Please refer to Appendix B, Section 5.
Refer to cost estimates in Appendix A, Section 11, and Table 5-2.

4. The proposed 1,400 foot long levee overflow would allow uncontrolled release of floodwaters into Coconut Grove. If flood water flowing over the levee would exceed the proposed design level by inches, potentially catastrophic flooding could occur. Uncontrolled release of floodwaters as proposed would subject the residential community to extremely high risks. A "concrete cap and stone revetment" to protect the proposed levee overflow section is not acceptable for structural integrity requirements and public safety. The overflow structure must be designed as a spillway.

The preliminary basis of design is based on the overflow structure acting as a spillway, as recommended; sensitivit to various water levels were considered. Please refer to sensitivity studies in Appendix A, Section 9 in particular Figures A-94 through A-97 and Figure A-72.

5. If high flood stages occur at the north end of the marsh, the proposed outlet culvert leading into the Oneawa Channel could allow floodwaters to back up into the Kaelepulu Stream and endanger the residential community. An uncontrolled opening through the levee would be unacceptable.

Please review the data provided in Appendix A, Section 9 in particular Table A-35, results for Node "12". This study has not identified any data or contemporary analysis that supports this assumption.

6. The document fails to indicate what level of flood protection is to be provided by the proposed actions.

Please refer to Appendix A, Section 6, and Table 5.1.

7. The EA does not address the impact of the proposed action to archaeological sites identified near the south end of the existing levee by Corps archaeologists in February, 1988. These sites would appear to be impacted by the proposed plan. Further, no evidence is presented to support the belief that confining flood flows above the inlet area towards the western side of the marsh would be technically difficult to accomplish and would cause significant impacts to archaeological resources. Archaeology will be a concern regardless of what action is taken and appropriate monitoring under an agreement with the Council on Historic Preservation must be a component of any alternative proposed.

Please forward studies of the archaeological sites mentioned. Coordination with the State Historic Preservation Office to date has not identified any of these sites and will want to have an impact assessment made by our archaeologist in consultation with State Historic Sites.

8. The EA states that the historical and current evidence indicates that the "drain" is at the upstream end (namely SE corner) of the Marsh. John Kraft's map printed in the State Resource Management Plan shows a large drain at the Oneawa channel existing circa 1800. It is doubtful, and probably insignificant, if either outlet can be identified as historically the "drain". Since 1966, the only "drain" has been the Oneawa Channel.

This is correct. The referenced figure also shows the Kaelepulu outlet. Figure 1 in Smith (1978) shows only the Kaelepulu outlet in 1851. Please refer to the discussion in Appendix B, Section 1.

In 1988, after the New Year's Eve flooding of Coconut Grove, the water receded through the Kaelepulu Stream channel.

Encl.

9. The EA identifies several Corps individuals (Bill Lennan, Clarence Lee, Mike Lee, James Maragos, and John Pelowski) in the list of individuals consulted, infering participation in the development of the proposed action. This is not the case for the proposed levee modification and attendant features.

10. We continue to seek a solution to the flood problem for residents of Coconut Grove, being fully aware of their need for protection as soon as possible. We urge you to reject the proposed plan to modify the levee in the manner identified in the EA. We will continue working with the City and County of Honolulu to provide acceptable flood protection to the residents of Coconut Grove.

The term "consulted party" derives from DOH, Title 11, Chapter 200, para. 11-200-15 which states "In preparation of an EIS, proposing agencies and applicants shall insure that all appropriate agencies noted in Section 11-200-10 (10) and other citizens groups and concerned individuals...are consulted." Please do not confuse thi term with "concurring" party. It in no way infers agreement or endorsement.

This study identifies several alternatives for flood damage reduction and their impacts. The proposed action was recommended because of reasons given in Section 2. The Assistant Secretary of the Army's review may identif overriding legal and policy concerns that are not identi fied in this study that may eliminate parts of the plan. While awaiting the decision of the Assistant Secretary of the Army, construction of an outlet between Kaelepulu Stream and Oneawa Canal, which has been requested by the residents, will lower the risk of damages.

Encl.

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

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ENG

ES
Room 6307

SEP 26 1989

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Re: Environmental Assessment and Notice of Preparation of Environmental Impact Statement, Kawainui Marsh Flood Damage Mitigation Project, Oahu

Dear Mr. Callejo:

The U.S. Fish and Wildlife Service has reviewed the referenced June 17, 1989 Environmental Assessment. Please refer to our July 31, 1989 letter on the preliminary draft Environmental Impact Statement for a discussion of our concerns and recommendations on the proposed flood control project.

We appreciate the opportunity to comment.

Sincerely,

Ernest Kosaka
Field Office Supervisor
Pacific Islands Office

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

In reply refer to:
[illegible]-12-0762

October 30, 1989

Ms. Jacquelin Miller, Associate Director
Environmental Center
University of Hawaii at Manoa
317 Crawford Hall
2550 Campus Road
Honolulu, Hawaii 96822

Dear Ms. Miller:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project, Kailua, Oahu

Thank you for your letter of October 4, 1989. We will be filing a draft environmental impact statement (DEIS) for publication on November 8, 1989 which will address your concerns. Brief responses to your specific comments are as follows:

1. Precision

   The DEIS discusses the biology of the Marsh in substantially greater detail than the Environmental Assessment and addresses the areas of your concern.

2. Documentation

   Efforts have been made to improve the citations and clarity references to specific items and where they can be found.

3. Other Concerns

   Herbicides are planned for use only in the initial states of vegetation removal. Maintenance of the open waterways will be by mechanical means.

Clearing and maintaining the open water areas is addressed in detail in Appendix B of the DEIS. A list of preparers and their qualifications is included in Section Seven of the DEIS.

We appreciate your constructive comments and hope that we have been able to address of your concerns in a satisfactory manner.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

October 4, 1989
RE:0538

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Callejo:

Environmental Assessment and Notice of Preparation
of Environmental Impact Statement
Kawainui Marsh Flood Damage Mitigation Project
Kawainui Marsh, Kailua, Oahu

The above referenced project proposes implementation of a plan to increase the ability of Kawainui Marsh to distribute and store stormwater runoff in order to reduce the danger of downstream flooding. The plan consists of four elements: 1) to use a) explosives or b) a "conventional crane" or "floating equipment manufactured on the mainland" to remove the vegetation mat in order to open up approximately ten acres of new waterways, 2) to protect approximately 1400 feet of the levee at the point of most concentrated flow with a concrete cap and stone revetment and by excavating the west bank of Kaelepulu Stream, 3) to construct a new "outlet structure" to allow escape of overflow from Kaelepulu Stream into Oneawa Canal, and 4) to construct a replacement weir and gate structure at the intersection of Kailua Road and Kaelepulu Stream to control flooding in the southern Kaelepulu Stream area. This review was prepared with the assistance of Sheila Conant, General Science, and Harriett Kessinger-Lee of the Environmental Center.

In our review of the above referenced document we noted some general as well as some specific areas of concern.

Precision

Specificity and accuracy are absolutely necessary for an effective review of proposed actions based on scientific data. Our reviewers encountered numerous instances of a somewhat loose or uninformed interpretation of scientific information in the above referenced document. For example, on page 3-18 in paragraphs three and seven the

author refers to "(18 species)" and "(6 species)" respectively. It is unclear what the author is referring to - species of what? Also on page 3-18, paragraph four, C. jamaicense would not be a "subspecies" of Cladium leptostachyum; it would be another species altogether. If it were a subspecies it would be C. leptostachyum jamaicense. On page 3-19, paragraph six the Great Frigatebird is not "prevalent", but present, in the marsh.

Documentation

Proper documentation and clear citation of sources are also essential in order to provide proper means for effective review. Our reviewers found very few instances of citation of sources for the vast amount of factual information casually provided in the above referenced document. Often it is necessary to have knowledge of the source of the information in order to put it into context or make sense of it. For example, on page 3-19 in paragraph three, "the extensive coverage of the open water areas by water hyacinth reduces the availability of preferred foods of the endangered waterbirds and migratory waterfowl." Also on page 3-19, paragraph four, "the water hyacinth causes greater rates of water loss through evapotranspiration at a rate of 2 to 6 times faster than water in the pond. The combination of increased water loss with the accumulation of organic material on the bottom result in the acceleration of the succession process, with the resultant permanent loss of open water habitat." These two quotations state very definite scientific "facts" but are not documented or even qualified. On page 3-19, paragraph six, reference is made to Figure 3-5 to indicate the area declared essential habitat for endangered species by the Hawaii Waterbird Recovery Team but the Waterbird Recovery Plan is not cited on the map. On page 3-20, paragraph six contains reference to three sources; in paragraph seven the author refers to "the report cited above" and does not clarify to which source this "intent" refers. On page 3-22, paragraph six, what is meant by "high","medium" and "low sensitivity areas", and who is the authority consulted? On page 3-23 in paragraph 3, whose "primary recommendations for improving the habitat of the marsh for endangered and other waterbirds" are being cited?

Quotations should be indicated by the use of quotation marks rather than indentations alone which do not clearly indicate direct quotations.

Other Concerns

Another concern noted by our reviewers pertains to the maintenance plan for the open waterways. Have studies been done to illustrate the efficacy of proposed herbicide control programs and their long-term, short-term and cumulative impacts on the ecosystem and waterfowl? What alternate means of maintenance of the newly-opened waterways were considered? What types of herbicide were considered, and what are their prescribed application schedules? Is there an actual maintenance plan, and does it include disposal of the dying plant matter?

We suggest that the peak nesting periods (as referenced on page 3-21, paragraph four) of each of the four endangered waterbird species be addressed individually in the DEIS.

Finally, the DEIS should specify which information presented in the document was derived through field and/or literature surveys, and it should also note the qualifications of the preparers.

Thank you for the opportunity to comment on this document. We look forward to reviewing the forthcoming DEIS.

Yours truly,

Jacquelin Miller
Associate Environmental Coordinator

cc: OEQC
James Dexter ✓
L. Stephen Lau
Sheila Conant
Harriett Kessinger-Lee

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

In reply refer to:
89-12-0-67

October 30, 1989

Mr. Richard K. Paglinawan, Administrator
Office of Hawaiian Affairs
1600 Kapiolani Boulevard, Suite 1500
Honolulu, Hawaii 96814

Dear Mr. Paglinawan:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project, Kailua, Oahu

Thank you for your letter of October 5, 1989. We will be filing a draft environmental impact statement (DEIS) for publication on November 8, 1989 which will address your concerns. Brief responses to your specific comments are as follows:

The State Office of Historic Preservation has been consulted during the preparation of the DEIS. Additional subsurface investigations of the Marsh are proposed to be undertaken in connection with the project, in further consultation with the Office of Historic Preservation, to ensure the proper placement of explosive charges to avoid any potential damage to archaeological features. We will be happy to provide you with a copy of the findings from these underwater probes.

We agree with your comments on the need for planning for the interpretive and educational uses of the Marsh and the importance of the items that you identify. We will be addressing all of those that relate to the mitigation project. The others will be more appropriately addressed in the Kawainui Marsh Master Plan to be developed by the State Department of Land and Natural Resources.

We appreciate your constructive comments and hope that we have been able to address your concerns in a satisfactory manner.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

STATE OF HAWAII
OFFICE OF HAWAIIAN AFFAIRS

October 5, 1989

Mr. James Dexter
M & E Pacific, Inc.
Pauahi Tower, Suite 500
1001 Bishop Street
Honolulu, Hawai'i 96813

Dear Mr. Dexter:

RE: EISPN: KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT, KAILUA, O'AHU

Thank you for your letter of September 14, 1989, and for the opportunity to comment. We encourage the Department of Public Works to proceed with their plans to improve the flood control capabilities of the Marsh.

Our concerns are related to the impact the proposed undertaking will have on the extensive archaeological and cultural resources in the area. These resources include the buried agricultural fields that contain a stratigraphic record of human land use in the mauka portions of Kailua. They include the Marsh's potential for containing well preserved organic remains such as temple images and kapa beaters. They include the Marsh's potential for interpretation of the prehistoric Hawaiian landscape. They include the four endangered species of water birds that are known to inhabit the Marsh. In addition to being an integral part of the natural environment, these birds have a cultural significance to Hawaiians that also mandates the consideration of preservation measures during the planning process. The goddess Hina learned the art of firemaking from a gallinule or mudhen, and the bird-goddess is known as Ka'alaenui-a-Hina (Hina-the-big-gallinule).

For the most part, archaeological survey work in the Marsh has been limited to surface survey. Important research and planning questions, such as defining the boundaries of Kawainui Pond, mapping the prehistoric irrigation system, or sampling the subsurface remains in the Kapaa area have not been investigated. Without this basic inventory data, planning for historic preservation and making the proper review recommendations become difficult.

Kawainui Marsh was determined eligible for the National Register because of its heritage value as a site important in Hawaiian history. The Marsh was once a very large inland fishpond that belonged to the ali'i (chiefs). Hauwahine was the mo'o (goddess) of the pond, and there are old Hawaiians in Kailua who insist that she has never left Kawainui. When the plants in the Marsh take on a yellowish hue, it is a sure sign that the mo'o is present. Hauwahine was a beneficent goddess who brought an abundance of fish, punished the pond owners if the oppressed the poor, and warded off sickness. Kawainui was also known as a dwelling place of Haumea, the earth-mother, who married Wakea and later Haloa. She was the mother of Pele. Kawainui was the site of the Makalei Tree, a famous tree which had the power of attracting fish. The importance of Kawainui and Kailua to Hawaiians is indicated by the numerous temple sites in the area: Pahukini Heiau, Holomakani Heiau, Ulu Po Heiau, Kukuiopilau Heiau, Halaualolo Heiau, and Kukapuki Heiau.

The proposed mitigation project needs to consider the interpretive and educational uses of the Marsh. A plan is needed that 1) removes noxious vegetation from the Marsh; 2) restores appropriate vegetation such as makaloa, taro, 'awa, wauke and niu; 3) restores Kawainui Pond and an auwai system providing water to numerous pondfields; 4) provides for public access to the area; 5) provides for continued maintenance of water flow through the Marsh; and 6) provides for comprehensive archaeological investigations during all phases of the project.

Please send our office copies of all archaeological reports related to this project, including preliminary reports, draft reports, reconnaissance reports, excavation reports, and monitoring reports.

Sincerely yours,

Richard K. Paglinawan
Administrator

RKP/EN:mka

cc: Earl Neller

RECEIVED OCT 25 1989 GB- JD

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

In reply refer to:
89-12-0737

October 20, 1989

Dr. Marvin T. Miura, Director
Office of Environmental Quality Control
State of Hawaii
465 South King Street, Room 115
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Your Letter of October 6, 1989, Regarding Environmental Assessment and Notice of Preparation of Environmental Impact Statement of the Kawainui Marsh Flood Damage Mitigation Project

Thank you for transmitting your comments regarding the above subject to our consultant, M & E Pacific, Inc.

The City's plan to implement the blasting to open waterways will be done in 2 stages. First, a test blasting is recommended by our consultant to verify that the effects of this method will have no significant impact on the environment in and surrounding the marsh and to provide data for the basis of design of the waterways. Second, the final blasting of the marsh will be determined by the test blasting to open waterways.

The test blasting is necessary so that we can properly address the comments that we have received regarding the details of the waterways in the final EIS.

The City plans to test blast in November 1989, if we receive the required approvals from the State Board of Land and Natural Resources and the City Department of Land Utilization.

The City will not proceed with the final blasting until the final EIS is accepted and the Conservation District Use Application and Shoulin Management Permit are approved. The earliest final blasting date would be in October 1990.

The U.S. Army Corps of Engineers will be a consulted party to draft EIS.

Very truly yours,

Sam Callejo

SAM CALLEJO
Director and Chief Engineer

cc: M & E Pacific, Inc.
(Attn: Dr. James Dexter)

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL

October 6, 1989

James Dexter
M&E Pacific, Inc.
1001 Bishop Street, Suite 500
Honolulu, HI 96813

Dear Mr. Dexter:

RE: ENVIRONMENTAL ASSESSMENT OF THE KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT

CONFORMANCE WITH THE EIS LAW
In reviewing this assessment, we considered the information presented in "City Planning to Blast Its Way through Marsh," an article that appeared in the September 3, 1989 issue of the Sunday Star-Bulletin & Advertiser. With regard to the project schedule, the article states as follows:

> If the proposed plan encounters no significant opposition, the blasting could start in late November or early December, even if the annual rain season sets in before then, Callejo said Wednesday. . . .
> "I hate to guess on how soon we can start on this because of the permitting process, but I would like to see us begin within 60 days after the draft statement is released."
> That would push the start of construction into December.

Such a schedule is in direct contradiction of section 5 of the EIS law (chapter 343 of the Hawaii Revised Statutes), which states, "Acceptance of a required final statement shall be a condition precedent to implementation of the proposed action." If the Department of Public Works begins blasting before the final EIS has been accepted, it will be in violation of the law.

MITIGATION MEASURES
If the schedule presented in the newspaper article is followed, it would nullify one of the mitigation measures presented in section 3 of the assessment. Page 3-23

describes the mitigation measure for the project's effects on endangered native Hawaiian waterbirds:

> The peak nesting seasons must be left undisturbed and any work done in the marsh should avoid this time. Although the breeding/nesting season occurs year round, March through September is the period of peak nesting. It would therefore be advisable to keep work limited to the months of October and November, and possibly December.

Commencement of construction work in December would probably mean ongoing work during the peak nesting period.

WITHDRAWAL OF U.S. ARMY CORPS OF ENGINEERS FROM THE PROJECT
If it has not done so already, the Army Corps of Engineers should formally withdraw from the project in a letter to the Department of Public Works.

Thank you for the opportunity to comment on this assessment.

Sincerely,

Marvin T. Miura/oan

Marvin T. Miura, Ph.D.
Director

cc: Sam Callejo

DEPARTMENT OF PARKS AND RECREATION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

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October 10, 1989

TO: SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER
DEPARTMENT OF PUBLIC WORKS

FROM: WALTER M. OZAWA, DIRECTOR

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE FOR KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT

These comments were received after the Oct. 7, 1989 closing date. However, due to their importance, preliminary responses are annotated below.

We have the following comments and questions on the proposed project.

1. Improvements Mauka of the Levee

A. Opening 10 acres of shallow new waterways in the Marsh will be beneficial to both waterbirds and to flood control. Would it be possible to extend some of these waterways to a publicly accessible area, such as the model airplane field? This would allow possible boating and canoeing access for educational use.

The waterways have been extended. Please refer to Figure 2-3.

B. We are unclear as to the rationale and benefits of the proposed "low-flow weir with side gates" at the Oneawa Canal end of the Marsh. To improve waterbird habitat and recreational boating, a horizontal weir across the entire neck of the Canal may be preferable. Such a longer weir would allow water to be impounded and water levels to be manipulated within the Marsh. From the standpoint of flood control, if a horizontal weir were extended across the entire neck of the Canal, what is the highest elevation that the top of the weir could be without significantly aggravating risk of flood waters overtopping the levee?

The weir is intended to maintain minimum water levels during dry weather; the slide gates are intended to allow wildlife agencies to lower water levels at certain times for habitat management. The weir is also a long-term mitigation measure (Section 4, Subsection III). The selection of the height is discussed in Appendix A, Section 9.

2. Improvements Makai of the Levee

A. Reference is made on page 2-8 of the EIS Preparation Notice to excavation between "the west bank of Kaelepulu Stream to the level of the existing stream channel ... bottom . . at levee station 14+50 ...." It would be helpful if the EIS indicated where this excavation would take place, the existing topography and the proposed topography.

This is shown on Figure 2-3.

B. Connection of Kaelepulu Stream to the Oneawa Canal may allow salt water from the Canal to move into waterbird habitat in the Stream. If this is so, would it be feasible to redesign the proposed Kaelepulu Stream outlet or install a weir in the Stream to prevent tidal ocean water intrusion?

Please refer to Appendix A, Section 9 for details of the outlet design. The invert of this outlet was raised one foot from the original concept presented in July 1989 public meeting because of this concern. However, data collected since then indicate the stream is already brackish, particularly when the outlet is opened at Kailua Bay. The design changes minimize the salinity impact, but do not elimate them entirely.

WALTER M. OZAWA, Director

WMO:js

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

October 30, 1989

Mr. Arnold K. Lum
Sierra Club Legal Defense Fund
212 Merchant Street, #202
Honolulu, Hawaii 96813

Dear Mr. Lum:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project, Kailua, Oahu

Thank you for your letter of August 23, 1989. We will be filing a draft environmental impact statement (DEIS) for publication on November 8, 1989 which will address your concerns. The DEIS includes a thorough discussion on the interrelationships of the vegetation in the marsh, flood control options, and waterbird habitat. Planning for the project has involved staff of both the U.S. Fish and Wildlife Services and the State Department of Land and Natural Resources to ensure that planned flood control mitigation measures will be consistent with resource management objectives and, in fact, enhance habitat values.

We appreciate your constructive comments and hope that we have been able to address your concerns in a satisfactory manner.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

81X3327

SIERRA CLUB
LEGAL DEFENSE FUND, INC.

212 Merchant Street, Suite 202 Honolulu, Hawaii 96813

August 23, 1989

James Dexter
M & E Pacific, Inc.
Suite 500
1001 Bishop Street
Honolulu, Hawaii 96813

Re: Revised EIS Preparation Notice, Kawainui Marsh Flood Control Mitigation Project

Dear Mr. Dexter:

The Sierra Club Legal Defense Fund, Inc. would like to request a copy of the draft EIS for the above-referenced project, and would also like to request that we be made a consulted party pursuant to Haw. Admin. Rule §11-200-15(b).

We would also like to note that we have briefly scanned the EISPN, and hope that the DEIS will include a thorough discussion and quantitative estimate of the amount of open water and shallow water/mud and vegetated interface which will be gained or lost, especially within the native Hawaiian waterbird essential habitat area, as a result of the flood control mitigation project. In this regard, the DEIS should discuss those aspects of the project which will be consistent or inconsistent with the DLNR's Kawainui Master Plan.

We look forward to reviewing the DEIS.

Very truly yours,

Arnold L. Lum

ALL:smg
cc: Steve Holmes

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

In reply refer to:
89-12-0775

November 3, 1989

Mr. Robert Merriam, President
Kawai Nui Heritage Foundation
P.O. Box 1101
Kailua, Hawaii 96734

Dear Mr. Merriam:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project, Kailua, Oahu

Thank you for your letter of September 3, 1989. We will be filing a draft environmental impact statement (DEIS) for publication on November 8, 1989 which we believe will address your concerns. The DEIS contains extensive information developed from field studies that were in process during the time the environmental assessment was available for review and the preparation notice was soliciting public input. Because the field studies were not complete, the data were not available for inclusion in the EA. It seemed prudent to proceed with the EA/NOP process while the studies were being undertaken rather than wait until all information was available to start the process. This information is in Appendix B of the DEIS.

The DEIS also contains detailed engineering studies, presented in Appendix A, which address your concerns about the levee and Kaelepulu Stream. Descriptions of the history of the Marsh have been rewritten to correct errors in the document.

We appreciate your constructive comments and trust that the draft EIS will address your concerns in a satisfactory manner.

Very truly yours,

f- SAM CALLEJO
Director and Chief Engineer

KAWAI NUI HERITAGE FOUNDATION
P.O. Box 1101
Kailua, HI 96734

September 3, 1989

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu

Dear Mr. Callejo,

Thank you for sending us a copy of the Kawainui Marsh Flood Damage Mitigation Project EIS Preparation Notice. The Kawai Nui Heritage Foundation wishes to be a consulted party on this project. We present the following questions/comments for your consideration at this time.

1. The first complete sentence on p. 2-7 indicates some confusion as to how the open-waterway project will work.

2. The plan to protect the levee from "inevitable overflow" by creating a protected spillway seems incredible in view of the lack of hydrologic and environmental studies supporting the document.

3. If 2.5 feet of height is to be added to the levee except for the spillway area it seems there would need to be 5400 feet rather than the 3000 feet mentioned. This will require widening the base, which will mean filling the wetland. (The impacts are discussed on p.4-2). Also the fine sediment to be dredged from Kaelepulu Stream near its Oneawa outlet is to be placed in the Marsh, albeit on fast land. How is 'fast' land described in a situation such as the flood control basin of KawaiNui Marsh? Where will the excavated material from the west bank of Kaelepulu Stream be placed?

4. What will be the effect on storm drains from Coconut Grove if Kaelepulu Stream is to carry significant flow? Why is the outlet designed for existing conditions? (See 1. above) Aren't improvements to be made?

5. What do you mean that steel gates will divert water to the south on Kaelepulu Stream? Elsewhere you state that the natural grade at 14+50 will be the divide.

6. The discussion of Maintenance Considerations (P.2-9) focuses only on Kaelepulu Canal. We agree that Kaelepulu Canal needs maintenance, and has needed it desparately for some time, from its outlet at Enchanted Lake to the ocean as well as the reach of Kaelepulu Stream from Coconut Grove. However, you indicate that an automatic gate will control flow during flood and that Kawainui will not contribute to flood discharge through Kaelepulu Canal. We have heard quite enough about what 'should' be done. Lets have some commitment that it 'will' be done. Then address the maintenance of Kawainui!

7. The discussion of Ecological Considerations also needs commitment, not 'shoulds'.

8. You recognize the State's interest in the 'ITT parcel'. However your levee spillway scheme would flood that property first.

9. The Historical Perspective section mentions that the walls of the fishpond have not been found. Later you refer to dikes under Kaelepulu Stream. Is there any possibility that they are one and the same?

10. I do not understand the comment (p3-5) that Kawainui was "not designated a fishpond as of yet" in [illegible] Marion Kelly refers to its use as a fishpond at the time of Kamehameha I.

11. You report (p.3-14) that terrigenous sediment is estimated to be 117 acre-feet. That is only about 0.1 inch per year. If that is the case isn't the restoration of the basin to its flood holding capacity in 1966, along with the planned but not completed weir, a realistic alternative to consider?

12. The first paragraph under Vegetation [illegible] should more correctly state that lack of maintenance of the flood control project created the bog.

13. I am interested in the source of your statement (p 3-10) that water hyacinth causes evapotranspiration loss [illegible] to 6 times that of open water.

14. The last paragraph on page 4-1 refers to the effects of opening the north end of Kaelepulu Stream to the Oneawa Canal. Then it says "To mitigate this effect, a new low flow weir will be constructed at the outlet of the City and County emergency ditch..." It is my understanding that the C/C ditch is on the marsh side of the levee. Also I find no other mention of such a weir.

15. Reference is made on p.4-4 to a "gate-opening schedule". Earlier it was said to be automatic.

Thank you for your attention. I am sure there will be additional comments when the full range of hydrologic and environmental studies necessary for an adequate EIS are presented in the complete draft.

Sincerely yours,

Robert A. Merriam
President

cc: Annetta Kinnicutt
James Dooley

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

In reply refer to:
89-12-0764

October 30, 1989

Ms. Bonnie L. Heim, Chair
Kailua Neighborhood Board No. 31
c/o Kailua Satellite City Hall
629-A Kailua Road
Kailua, Hawaii 96734

Dear Ms. Heim:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project, Kailua, Oahu

Thank you for your letter of September 8, 1989. We will be filing a draft environmental impact statement (DEIS) for publication on November 8, 1989 which will address your concerns. Brief responses to your specific comments are as follows:

1. Effect of future land development mauka of Marsh; and

2. Potential pollution from landfills and quarry.

   The effects of future development in the hills and adjacent areas in increasing runoff and water distribution in the Marsh will be minor in comparison to the total quantities of water involved in a 100-year flood scenario. Because the principal contributor to flooding in the marsh is organic matter and not silt, which is trapped in the upper marsh area, any increase in flooding due to siltation caused by future mauka development will also be minor.

3. Protection for Maunawili Stream

   Maintenance of flows of Maunawili Stream upgradient of the Marsh is not part of the flood mitigation project. It is also the subject of litigation.

4. Protection for archaeological or historic sites

   The State Office of Historic Preservation has been consulted during the preparation of the DEIS. Additional subsurface investigations of the Marsh are proposed to be undertaken in connection with the project, in further consultation with the Office of Historic Preservation, to ensure the proper placement of explosive charges to avoid any potential damage to the archaeological features. Any useful findings from these underwater probes will be made available for use by OHA and other interested parties.

5. Responsibility for maintenance

   We agree that responsibility for the maintenance is a critical factor in implementing the project and have addressed the subject in greater depth in the DEIS.

We appreciate your constructive comments and hope that we have been able to address your concerns in a satisfactory manner.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

KAILUA NEIGHBORHOOD BOARD NO. 31
c/o KAILUA SATELLITE CITY HALL • 439-A KAILUA ROAD • KAILUA, HAWAII 96734

September 8, 1989

89-4729 Div
9/11 cc: Eng

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City & County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

RECEIVED
SEP 12 8 26 AM '89

Subject: Kawai Nui Marsh Flood Damage Mitigation Project.

Dear Mr. Callejo:

Thank you for sending us the Kawai Nui Marsh Flood Damage Mitigation Project EIS Preparation Notice. The Kailua Neighborhood Board wishes to be a consulted party on this project. We present the following questions and comments for your consideration at this time and hope that these concerns will be addressed in the final EIS.

Because the area of the Marsh does not exist as a separate entity and is part of a much greater whole, that of the ahupua'a of Kailua, we are concerned not only with the Marsh itself, but the surrounding area as well. With this in mind ...

1. What effect will future or present land movement and development on hills mauka of Quarry Road and in Maunawili Valley have on further siltation and water distribution in the Marsh?

2. What specific measures need to be undertaken now to prevent further pollution of Marsh waters from Kaleheo Landfill, Kapaa Landfill and future landfills, as well as the planned Waste Transfer Station and Quarry operations? It appears that all of these help to undermine the efforts being made to control further siltation and water flow in the Marsh.

3. What measures need to be undertaken to insure adequate protection for Maunawili Stream and its waters to be sure the amount of water going into the Marsh is adequate and flowing at a natural velocity?

4. What provisions will be made for possible intrusion into archeological or historical sites as yet unknown in the Marsh and surrounding fast land?

5. We feel maintenance responsibility needs to be clearly assigned with time tables and taskings specified more exactly. It seems only loosely alluded to in the present format.

In conclusion, we were especially impressed with the ideas presented as being designed "with Nature instead of trying to overcome it." Everything sounds well thought out with most of our environmental concerns have been taken into consideration. Thank you for this opportunity to comment. Our Board stands ready to offer all assistance in protecting our community against flood, while working to restore and preserve Kawai Nui Marsh as a wetland treasure for future generations.

Sincerely,

Bonnie L. Helm

BONNIE L. HELM, Chairman
Kailua Neighborhood Board

cc: Councilman David Kahanu
Councilman John Henry Felix

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

In reply refer to: 89-12-0765

October 31, 1989

Ms. Doris N. Barck, President
Lani-Kailua Outdoor Circle
P.O. Box 261
Kailua, Hawaii 96734

Dear Ms. Barck:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui <u>Marsh Flood Mitigation Project, Kailua, Oahu</u>

Thank you for your letter of September 20, 1989. We will be filing a draft environmental impact statement for publication on November 8, 1989.

We appreciate your comments and support. Unfortunately, your suggestion to grass over the top of the enlarged levee cannot be implemented because of the need to use the levee to support heavy maintenance equipment. A grass surface is too unstable and slippery for safe operations. However, we will investigate providing a paved path for joggers and bicyclists.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

THE LANI-KAILUA OUTDOOR CIRCLE
P. O. BOX 261
KAILUA, HAWAII 96734

September 20, 1989

Mr. James Dexter
M&E Pacific Inc.,
Pauahi Tower, Suite 500
1001 Bishop Street
Honolulu, Hi 96813

Dear Mr. Dexter:

Thank you for sending Lani-Kailua Outdoor Circle a copy of M&E's Environmental Assessment and Notice of Preparation of Environmental Impact Statement for a Kawai Nui Marsh Flood Damage Mitigation Project.

The way you propose to open up drainage in the marsh for controlling flood damage appears to be far more in keeping with our traditional dreams for Kawai Nui as a beautiful intact resource for education, preservation and recreation.

We do request that the top of the enlarged levee be grassed over for aesthetics and pleasant walking. A paved path for joggers and bicyclers may also be necessary. If these concerns are met during construction they will save the City's money and our time in the long run and be much appreciated by residents and visitors.

Sincerely,

Doris N. Barck, President

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

In reply refer to:
89-12-0766

November 1, 1989

Ms. Diane C. Drigot
101 Ohana Street
Kailua, Hawaii 96734

Dear Ms. Drigot:

Subject: Environmental Assessment and Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Mitigation Project, Kailua, Oahu

Thank you for your letter of September 23, 1989. We will be filing a draft environmental impact statement (DEIS) for publication on November 8, 1989 which will address your concerns. Brief responses to your specific comments are as follows:

1. Channel alternative

   The discussion in the alternatives has been expanded along with the detailed cost estimates. See Appendix A of the DEIS.

2. Definition of the problem/proposed action; and

3. Description of the proposed project

   The proposed project is designed for a 100-year storm with two feet of freeboard. The project design is described in the DEIS. Supporting detailed data are contained in Appendix A.

4. Methods of vegetation removal

   Herbicides, explosives, and mechanical methods are all being considered for vegetation removal, separately and in combination. However, herbicides are planned for use only in the initial states of vegetation removal, not for maintenance. The U.S. Fish and Wildlife Service has been consulted throughout the development of the proposed project.

5. Level of levee

   The remaining portions of the levee will stay at their present level. The role of the Department of the Army in the approval process is unclear at this time. The Corps has stated that a 404 permit is <u>not</u> required. However, because the levee is part of a Corps project, the Department of the Army must approve the proposed action. Since the Department has stated that it prefers the channel alternative to increasing the storage capacity of the Marsh, it is unclear at this time how this issue will be resolved.

6. Historic preservation concerns

   The State Office of Historic Preservation has been consulted during the preparation of the DEIS. Additional subsurface investigations of the Marsh are proposed to be undertaken in connection with the project, in further consultation with the Office of Historic Preservation, to ensure the proper placement of explosive charges to avoid any potential damage to archaeological features. Any useful findings from the underwater probes will be made available for use by OHA and other interested parties.

   Description of the history of the Marsh have been rewritten to correct errors in the document.

7. Vegetation removal impact; and

8. Maintenance considerations

   Vegetation removal and maintenance of open waterways are the heart of the proposed project. The subject is discussed in the DEIS and in Appendix B.

9. Endangered species

   Staff of both the U.S. Fish and Wildlife Service and the Department of Land and Natural Resources have been involved in field investigations and planning of the proposed project to ensure that the proposed flood control measures will result in optimizing habitat for the waterbirds in the Marsh.

10. Existing uses around marsh

    This section has been updated.

We appreciate your constructive comments and believe that the draft EIS will address your concerns in a satisfactory manner. The DEIS contains extensive information developed from field studies that were in process during the time the environmental assessment was available for review and the preparation notice was soliciting public input. Because the field studies were not complete, the data were not available for inclusion in the EA. It seemed prudent to proceed with the EA/NOP process while the studies were being undertaken rather than wait until all information was available to start the process.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

Dr. Diane C. Drigot
101 Ohana Street
Kailua, Hawaii 96734

September 23, 1989

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Callejo:

Thank you for your letter of August 16 providing me an opportunity to comment on the Environmental Assessment/ Notice of Preparation of Environmental Impact Statement for the Kawainui Marsh Flood Damage Mitigation Project of July 17, 1989. I would like to continue to be a consulted party in this project formulation process and look forward to commenting onthe draft EIS when it becomes available for public review. I expect to continue to receive notices of any public hearings, scoping meetings, etc. related to that process.

In the meantime, I offer the following comments for consideration in preparation of that draft EIS:

1. Thank you for responding to many of the concerns I raised in my earlier review comments of August 10, August 19, and October 7, 1988, as reflected in your re-definition of the project design to emphasize vegetation removal and raising the height of the levee vice continuing with the drainage channel as the preferred alternative. Many of the concerns raised by myself and other concerned citizens during the earlier project review are summarized on pp. 5-2 and 5-3 of this new Draft EA, under Section 5, Alternatives to the Proposed Action. I am concerned, however, about your summary of the "major positive impact" of the channel alternative, on top of p. 5-3, where you state "from a hydraulic standpoint, once constructed and maintained as designed, it would lower flood stages at the upstream end of the marsh." Recommend you revise that sentence to say IF constructed and maintained as designed--since your preceding paragraph acknowledges that the very "constructability" of the channel is challengable and indicates that no maintenance costs (essential to the project's success) are "available."

2. Definition of the Problem/Proposed Action--On p. 1-1, your stated objective of the proposed action is to "reduce the potential for downstream flooding." On p. 2-4, you state the purpose of these actions is to "meet or exceed the original design objective of 3,000 acre-feet of flood storage capacity." What is the maximum level of flooding which can be accomodated by this project and by what frequency of occurence is this level of flooding expected to occur? I.E. will the project, as currently defined, have a maximum capacity to accomodate the 25-year storm, the 50-year storm, the 100-year storm, or what? Surely your hydrologists have calculated this in the basis of design. Otherwise, how will they be able to explain to the flood victims and other concerned citizens of Kailua that this project is going to make a significant difference in their exposure to flooding risks? I am especially interested in knowing how this project will be able to achieve the 3,000 acre-feet of flood storage capacity which was calculated prior to the current situation where several feet of sediment have been allowed to accumulate on the marsh floor since this original flood storage capacity was calculated.

3. Description of the Proposed Project--This section (pp. 2-4 to 2-9) makes many statements about how water is expected to behave in the marsh during current and predicted flood conditions or during construction of the proposed project without referencing the basis/source of these assertions. For example, on top of p. 2-7, what level of vegetation removal is considered "sufficient" to improve flood storage capability; and how was it determined? If vegetation is subjected to "mechanical removal," where in the marsh would water depths become "excessive" for use of a conventional crane. If explosives were used, what is considered a "sufficient depth" to place these explosives such as to attain the desired objective "to cast the material from the proposed waterway." What is "enough length of waterway" to insure the water would be distributed throughout the marsh in sufficient time(?) to reduce water levels near the levee. On p. 2-8, what is meant by saying "flow patterns during low inflow periods are influenced by previous irrigation practices." How do you know that "an essential element of the plan is to anticipate the inevitable overflow in the southeast corner of the marsh.?" The way this is written presumes that the reader is willing to passively accept undefended judgements about the hydrology of the marsh. Please provide more specifically referenced source data to defend your assertions in the Draft EIS. What scientific data support your statements and predictions made here and how were they gathered? If you performed hydrological studies, why can't you say anything more specific about the number of acres of vegetation removal required or the precise length of waterway predicted as necessary or the exact depth of explosives to be placed in order to accomplish flood relief objectives? Give the knowledgeble, concerned citizenry some basis of evaluating that you know what you are doing, before significant levels of taxpayers dollars are spent on this project.

4. Vegetation Removal vis Mechanical/or Means Explosives(p. 2-7)--This action is discussed in such a manner as to present them as "either/or" alternatives. Why not consider the alternative of one-time explosives followed by repeated, phased removal of vegetation over multiple-year time frame, employing mechanical devices? Why limit the discussion to use of "conventional cranes."? There are specialized mechanical means to maintain open water in wetlands employed in other locations around the world. The U.S. Fish and Wildlife Service and citizen groups, such as the Kawai Nui Heritage Foundation, have already done the research and provided you with examples of these alternatives. Why have they been excluded from discussion here? If you wish to avoid challenges of inadequacy in addressing this alternative in the full project EIS, you will expand this alternative in a more creative way. Please also expand on the discussion of herbicide application on p. 2-7.Herbicides were deployed in the marsh last year and in previous years with limited noticeable effects. In my review comments of October 7, 1988 I asked but never received an opportunity to review the environmental documentation that should have been developed prior to the execution of this vegetation removal project. What has the city learned about herbicide application effectiveness from these earlier actions? How can this experience help in the proposed project design

5. p. 2-8--You assert in the top paragraph of this page that the levee should be maintai at the original as-built grade for a 1400-foot distance and an additional 2.5 foot height added to approximately 3,000 feet of the levee north of the overflow. This acco for a total of 4,400 feet of levee. If the levee is still 6,850 feet long (p. 2-1), then what happens to the structure of the levee over the remaining 1,940 feet unaccount- for? On p. 4-2, you state that the method of creating additional levee height is to be "widening of the base of the levee and placing additional material along the side slopes." These actions constitute dredging and filling of a federally-protected wetland requiring application for a 404 permit from the U.S. Army Corps of Engineers and a 401 permit from the State Dept. of Health, among other things.

These permit requirements are not discussed anywhere in the draft EA. This major dredging and fi l action should also trigger the requirement of federal EIS procedures and public review/scoping to be followed in the planning stages of this project.

6. Historic Preservation Concerns--Another form of federal oversight required in this project is mandated by Section 106 of the National Historic Preservation Act and 36 CFR Part 800. You allude to the requirements of this process in the bottom paragraph of p. 3-7. However, you give no evidence that the process has been initiated in the Draft EA document. Historic preservation consultation is supposed to take place (per the regs.) early in the planning process and be integrated with the EIS prep. process. The project proponent must decide whether the proposed action has a "no affect", "affect" , "adVerse affect" or "no adverse affect" on cultural resources and propose ways to mitigate any unavoidable adverse affects. The record of decision must be defended with data (usually gathered by a qualified archaeologist) and presented for required review and consent to the State Historic Preservation Officer and (if non-currence occurs at the state level); with the President's Advisory Council on Historic Preservation, as well. In addition, review comment must be sought from native Hawaiian individuals and/or groups who may claim vested intetests in the project or its impacts. Groups such as (but not exclusively) the Office of Hawaiian Affairs must be involved as consulted parties. Your draft EIS must show evidence that you have initiated this required consultation process, if you wish to avoid legal challenges and project delays at a later date. A completed EIS, in order to be considered adequate in this area, should contain, in the Appendix, a copy of the consultation correspondence between the City and the StateHistoric Preservation Officer, the OHA, and others indicated above. It should also contain a copy of a Data Recovery Plan if monitoring of the project actions is determined to be advisable.

Other historic preservation improvements recommended are as follows:

p. 1-1, 2nd para. Saying that Kawai Nui Marsh "contains important archaeological artifacts" misses the central point made on the bottom para. of p. 3-7. That the marsh as a whole has been declared eligible for listing in (not on) the National Reigster of Historic Places as a Cultural/Historic District. The emphasis in the District designation is that the cumulative significanceof the individual sites or artifacts within the district boundaries exceeds the sum of the individual parts. I.e. the historic significance of Kawai Nui does not reside in the notion that it is a mere receptacle of "important archaeological artifacts" just waiting to be collected. In preparation of the required assessment of effects on the historic significance of this Cultural District, the City officials must refer to the qualities listed in the eligibility nomination form as the basis of determining ... effects. Recommend reword of this sentence on p. 1-1 to say Kawai Nui Marsh is an "essential habitat for four endangered Hawaiian waterbird species and a historic property deemed eligible for listing as a Cultural District in the National Register of Historic Places.

p. 3-5 Please state the source of your highly questionable statement that Kawai Nui was not yet a "designated fishpond" in 1851. Also, please clarify your statement that active management of the marsh waters began with the marsh's use as a source for irrigation water (implied here as beginning with rice farming in the 1800s). The pre-historic manipulations of the watershed by the Hawaiians in the area to form sophisticated system of taro lo'i and fishpond(s) through a complex water delivery system of canals or 'auwai--what is this if it is not active management of the waters? In fact, the area that was once fishpond is now a marsh, in part, because this active management of the waters ceased when the fishpond was abandoned!

p. 3-5--Please do not refer to the mo'o, as a mere guardian spirit of the fishpond wh. took the shape of a lizard. The mo'o of Kawai Nui often took the female form of a goodess, Hauwahine. She and a companion mo'o reside at Kawai Nui. They are able to change their body forms, but are not often seen. They appear sometimes as women and other times as long, black-colored dragon-like forms, much bigger than a lizard. For a review of these and other important legendary attributes associated with Kawai Nui and its eligibility to the National Register of Historic Places, consult Chapter 2 of my book, Ho'ona'auao No Kawai Nui and the Legendary History section of Kawainui Marsh: Historical and Archaeological Studies, by Marion Kelly and Jeffrey Clark, September 1980, Bishop Museum Report 80-3.

p. 4-2--Top paragraph. You list different types of monitoring to take place during the construction phase of this project. However, you make no reference to the possibility of archaeological monitoring. What is the basis of your excluding this possibility without having completed the Section 106 Historic Preservation consultati. process mandated by federal law?

Figure 3-2 Archaeological Resources--Please clarify the source of your "Archaeological District Boundary" listed in the Legend and on the map. Is this boundary contiguous with that drawn when the marsh was designated eligible to be listed in the National Register of Historic Places?If not, it should be.

p. 2-6--Correct the name "Kridler's Rock" in your"Existing Profile through Kawainui Marsh" on the Plan of Improvements for Flood Damage Reduction. Please be consistent with the name of this rock cited on p. 19 of the official State Resource Management Plan for Kawainui Marsh as "Na Pohaku O Hauwahine (Kridler's Rock)." Hauwahine has been resident in the marsh and will continue to be resident in the marsh longer than Mr. Kridler and many local residents (Hawaiian and non-Hawaiian) are more familiar with the Hawaiian designation of this rock.

p. 7 Vegetation Removal Impact--On pp. 4-1, and 4-2, you indicate that a negative environmental impact on the marsh vegetation will occur, but are quick to point out that "this is not a significant long term impact, given the expanse of the remainder of the marsh which will not be disturbed." If a significant reduction of plant life does not occur, then there will be no effective flood control or bird habitat enhancement. Why is this project to be undertaken if the impact on vegetation (many of them alien, undesirable species) is not significantly adverse? If the vegetation is not adversely impacted in a permanent way through a continuing vegetation removal plan initiated by this project, then the project fails to achieve its objective of flood relief. Also, you state on p. 4-2 that the goal of designing with nature includ. the objective of creating flood storage capability which will allow the "natural succession" of the wetland to proceed. The succession of this wetland from a fishpond to a marsh and beyond to fast land has been progressing at unnaturally accelerated rates due to human influences (sedimentation, sewage effluent input, etc., deliberate fill, etc.). Our objective is to reverse this trend and through active management retain the marsh at the marsh stage of succession in order to fulfill resource management objectives of flood control and endangered waterbird habitat enhancement. Please modify this discussion accordingly. Regardless of what action or inaction is taken, the succession process on-going in the marsh is far from proceeding at "natural " rates(presuming natural means in the absence of human influences, which began hundreds of years ago).

Maintenance Considerations (p. 2-9) Although this section mentions the need for routi. vegetation clearing in Kaelepulu Canal, the need for periodic dredging of the emergency waterway on the marsh side of the levee is ignored. This must be a part of the maintenance plan since, as pointed out on p. 2-4(top), between 2 and 3 feet of mud has already been deposited within this waterway since the New Year's Eve flood in January 1988.

Endangered Species Consultations--Another form of federal oversight required in the planning stages of this project is mandated by Section 7 of the Endangered Species Act. Although the Draft EA acknowledges some waterbird impacts in various sections, no evidence that required consultations with the U.S.Fish and Wildlife Service is available in the text of the Draft EA. The consultation process must begin in these planning stages. Also, the documentation that the consultation took place must be incorporated into the Appendix of the EIS. For example, p.4-1, bottom, it is insufficient to say that the weir elevation will be determined during design phase after consultation with both the State Department of Land and Natural Resources and the U.S. Fish and Wildlife Service. Rather, some estimate of impact (positive or adverse) must be made vis-a-vis waterbirds of the proposed weir design and then seek comment from the U.S. Fish and Wildlife Service. By saying you are deferring the decision on weir elevation to the design stage, after the completion of public review of the EIS, you are tacitly admitting that you have done insufficient studies to know what specific elevations the weir should be at to avoid adverse impact on the endangered species. The U.S. Fish and Wildlife Service cannot be expected to come up with the answers for you. If you anticipate an adverse impact, you must finance your own biological assessment and present the results to U.S. Fish and Wildlife Service for review. An EIS is not adequate without a complete description of the action (if weir elevation is not given, then the action description is incomplete) Furthermore, an EIS is not complete without a complete up-front description of anticipated impacts--not deferring them to the design stage. Modify this section to state why the weir is necessary, and what scientific data you have to back up a proposed elevation height of the weir. If your proposed weir elevation is a guess, based on no scientific data, just educated hunches, then so state. But you cannot defer this discussion to the design stage, when it is out of the public purview.

Other comments regarding endangered species:

p. 4-3--In this section on long-term impacts you indicate that plant species will shift in the northern end of Kaelepulu Stream to composition favoring those species more salt-tolerant. But this section is silent on the long-term impacts of waterbird use of that area. Please modify to address this point.

Figure 3-5--Vegetation and Water Bird Habitat--This map does not indicate that All Waterbirds (cross-hatching) utilize that portion of Kaelepulu Stream along Hamakua Canal. Numerous formal and informal bird surveys have documented use by all four endangered Waterbirds along Hamakua Canal--please modify accordingly.

Diversion Structures associated with this project--On p. 2-9, you state that the new weir and gate structure to divert flood water in Kaelepulu Stream to the south will close automatically when threatening water levels occur; but on p. 4-4, you refer to the need for coordination of the detailed plan for operating this structure to be developed during the design stage--please clarify this apparent inconsistency. In addition, how will the new low-flow weir mentioned on p. 4-1 for the northern end of Kaelepulu Stream be operated--will it require active manipulation during storm conditions or work automatically. In both structures, if automatic, how often will the automation be checked to make sure the devices are functioning as they should?

<u>Depiction of Existing Uses in and Around Kawai Nui Marsh</u>--On p. 3-3, please modify the third para. from top of page to indicate that a golf course is being constructed (not planned for construction) in Maunawili above the marsh.
At the bottom of page 3-3 and the top of page 3-4 you do acknowledge use of the marsh for educational purposes and the existence of educationalmaterials which have been widely distributed throughout the public schools and, by private purchase, throughout the community. However, as I have indicated in earlier review comments, why do you keep calling it "potential" educational public use when it is actually being used. The potential for more use is not being realized until the State's Marsh Management Plan is implemented fully, but the use itself is happening--it is not a mere "potential." Also, please correct the sentence at the top of page 3-4 where it says a "comprehensive educational source book,slide show, and video have been developed. The slide show is a <u>slide/sound</u> production and companion to the comprehensive educational book I developed. . Thank you for adding it to your list of references in the EA. Several video productions are also available and have been shown on public educational T.V.. Primary among them is Linda Lembeck's production for children of elementary school age entitled "Hauwahine's Dreamstory" which also has a companion book to go along with it. I suggest you add this educational sourcebook/video production to your list of references in the EA as well.

Thank you again for this opportunity to comment. I look forward to receiving some indication that these extensive review comments have been seriously considered in the udpate of the EIS being developed for this project. I also look forward to receiving notice of the public release of this EIS for further review.

Sincerely,
Diane C. Drigot
Diane C. Drigot, Ph.D.

CC: National Wildlife Federation
Conservation Council for Hawaii
President's Council on EnvironmentalQuality
Natural Resources Defense Council
Sierra Club Legal Defense Fund
Society for Hawaiian Archaeology
Hawaii Audubon Society/National Audubon Society
U.S. Fish and W... Service
Kawai Nui Heritage ...
✓Office of Hawaiian Affairs
James Dexter, M&E Pacific, Inc.
Hawaii's Thousand Friends
University of Hawaii Environmental Center
Others

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

In reply refer to:
89-12-9738

October 20, 1989

Ms. Dana Kokubun, Director
National Audubon Society
Hawaii State Office
212 Merchant Street, #320
Honolulu, Hawaii 96813

Dear Ms. Kokubun:

Subject: Your Letter of October 6, 1989, Regarding Environmental Assessment and Notice of Preparation of Environmental Impact Statement <u>Kawainui Marsh Flood Damage Mitigation Project</u>

Thank you for transmitting your comments regarding the transfer of Kawainui Marsh from the City to the State to our consultant M & E Pacific, Inc. Attached is a letter that was sent to Governor Waihee which should provide you with the information on the transfer.

Flood control management will be discussed in the draft Environmental Impact Statement.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

Attach.

cc: M & E Pacific, Inc.
(Attn: Dr. James Dexter) w/attach.

RECEIVED

SEP 29 1 12 PM '89

LA 89-7113

September 26, 1989

The Honorable John Waihee
Governor
State of Hawaii
State Capitol
Honolulu, Hawaii 96813

Dear Governor Waihee:

This is a follow-up of earlier correspondence on the transfer of Kawainui Marsh to the State. These letters are attached for your reference. As you know, the Governor's Task Force on State-County Relations had made recommendations on the transfer of City/State parks which were not adopted by the 1989 Legislature.

As we had previously noted, the transfer of this particular park can be processed expeditiously with minimal impact on staff and funding. Accordingly, we wish to complete this transaction as quickly as possible. The transfer (except for the community park area and the model airplane field) will be in fee simple which will enable the State Department of Land and Natural Resources (DLNR) to have sole jurisdiction over the management of wildlife, cultural and recreational resources as well as the maintenance and operations of flood control improvements. As stipulated by the DLNR staff, we will agree to complete construction of flood control improvements to State and U.S. Corps of Engineers requirements.

With your concurrence, we will proceed to obtain the necessary approvals.

Warm personal regards.

Sincerely,

FRANK F. FASI

FFF:jn (Fred Chan - DPW/Land)
Attachments

bcc: Office of the Mayor
Managing Director's Office
Department of Parks and Recreation
Department of Land Survey and Acquisition
DPW - Division of Land Survey and Acquisition
DPW - Division of Engineering
DPW - Division of Road Maintenance

DOCUMENT CAPTURED AS RECEIVED

National Audubon Society

HAWAII STATE OFFICE, 212 MERCHANT STREET #320 HONOLULU, HI 96813 (808) 522-5566

October 6, 1989

M&E Pacific, Inc.
Attention: James Dexter
1001 Bishop Street, Suite 500
Honolulu, HI 96813

RE: Comments on Environmental Assessment for Kawai Nui Marsh Flood Damage Mitigation Project

Dear Mr. Dexter:

The National Audubon Society appreciates the opportunity to comment on the flood control measures developed and analyzed by M&E Pacific for the City & County of Honolulu.

The National Audubon Society has determined that the restoration of the natural wetland qualities of Kawai Nui Marsh, the largest remaining freshwater marsh in the state of Hawaii, is of the highest priority among our specific objectives to conserve and restore wetlands throughout the state. Accordingly, the National Audubon Society would like to be a consulted party in the preparation of the EIS for the Kawai Nui Marsh Flood Damage Mitigation Project.

We have no specific comments on the technical aspects of the project at this time, as we prefer to await the more detailed information forthcoming in the DEIS. However, we request that you incorporate information on the question of transfer of land title and management responsibilities, including flood control and natural resources management.

The city/state task force on intergovernmental affairs, chaired by Ed Hirata of the State Department of Transportation has recommended that the city transfer ownership of Kawai Nui Marsh to the state; however, at least one key state Department (DLNR) has publicly stated it prefers that flood control responsibility remain with the city & county. Further, we understand that it may not be legally possible to separate the city from its flood control responsibilities.

At the same time, we understand some support transfer of ownership (including flood control reponsibility) to the state. It appears that transfer of title and whether flood control responsiblity is or is not included is a key question. Without a thorough understanding of the legal options available to both the city and the state, it will be impossible to settle this matter, and flood control maintenance and natural resource management will face an uncertain future.

Beyond the question of legal ability, there is the matter of the actual capabilities of whomever is assigned reponsibility for flood control and for Kawai Nui marsh's natural resources. We suggest that the DEIS examine flood control management from the standpoint of the city's current ability to carry it out. Similarly, the state's current ability to manage flood control improvement should be examined. Financial resources as well as staff expertise should be considered in this evaluation.

In summary, the National Audubon Society believes the question of which level of government will manage the flood control improvements to Kawai Nui marsh, and which will manage the natural resources is key to future flood control success.

Thank you again for the opportunity to comment.

Sincerely,

Dana Kokubun

Dana Kokubun, Director

For the Protection of Hawaii's Native Wildlife

HAWAII AUDUBON SOCIETY 212 Merchant St., 320
Honolulu, HI 96813

September 25, 1989

James Dexter
M & E Pacific
1001 Bishop St., Suite 500
Honolulu, HI 96813

Re: Environmental impact statement preparation notice for Kawainui Marsh flood damage mitigation project.

Dear Mr. Dexter:

The Hawai'i Audubon Society hereby requests to be a consulted party for the above-referenced project and requests that a copy of the draft EIS be sent to the Society at the following address:

212 Merchant St., Room 320
Honolulu, HI 96813

Mahalo nui loa.

Sincerely,

Marjorie F.Y. Ziegler
Conservation Committee
Hawai'i Audubon Society

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

89-12-0721

October 16, 1989

Ms. Muriel B. Seto
Executive Director
Hawaii's Thousand Friends
305 Hahani Street, Suite 282
Kailua, Hawaii 96734

Dear Ms. Seto:

Subject: Revised Environmental Impact Statement Preparation Notice Kawainui Marsh Flood Control Mitigation Project

Comments received from the public and our own reformulation of alternatives have led to a change in the recommended action for the reduction of potential flood damage for Kawainui Marsh. This action is described in the EIS Preparation Notice which was published in the September 8, 1989 OEQC Bulletin.

A copy of the EIS Preparation Notice was sent to your previous address at 941 River Street. No forwarding address was left, therefore the Notice was returned to us on October 13, 1989.

Because of your previously indicated interest in this project, we had requested your comments on the EIS Preparation Notice, for which the deadline for comments was October 7, 1989.

However, you will have an opportunity to review and comment on the Draft EIS, the notice for which should be published in the November 8, 1989 OEQC Bulletin.

Very truly yours,

Sam Callejo

SAM CALLEJO
Director and Chief Engineer

cc: M & E Pacific, Inc.
(Attn: Dr. James Dexter)

DOCUMENT CAPTURED AS RECEIVED

DEPARTMENT OF PARKS AND RECREATION

CITY AND COUNTY OF HONOLULU

ENV ENG

June 30, 1989

TO: SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER
DEPARTMENT OF PUBLIC WORKS

FROM: WALTER OZAWA, DIRECTOR

SUBJECT: PRELIMINARY DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
FOR KAWAINUI MARSH FLOOD CONTROL IMPROVEMENTS
(DPW FILE 89-12-0142)

As requested, my staff has provided an expedited review of the subject preliminary draft environmental impact statement (DEIS). Our major questions and concerns are set forth in this memorandum. To meet your deadlines, I am returning the copy of the preliminary DEIS you provided with minor comments and suggestions directly attached to applicable pages. If you or your consultants have any questions, please contact Doug Meller of our Advance Planning Branch at extension 4246.

ORGANIZATION

The preliminary DEIS does not comply with the format and content requirements of Chapter 200 of Title 11, State Environmental Impact Statement Rules. It needs to be reorganized so that the project description chapter follows the summary. There should be separate chapters for analysis of reasonable alternatives and analysis of environmental impacts. Comments on the EIS Preparation Notice and responses need to be attached.

In the interest of time, it probably is prudent to prepare a DEIS which also meets NEPA requirements. Rather than waiting for the Corps of Engineers to require an NEPA EIS, we recommend that you publish a Notice of Intent in the Federal Register and schedule the required "scoping meeting" as quickly as possible.

GRAPHICS

Several of the figures in the preliminary DEIS were unintelligible. Simplification of base maps to exclude unnecessary information might help. Use of two-color printing might help. Overlay figures are needed so that the

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DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

DIVISION OF ROAD MAINTENANCE

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June 29, 1989

MEMORANDUM

TO: MR. MARVIN T. FUKAGAWA, CHIEF
DIVISION OF ENGINEERING

FROM: YUKIO UYEHARA, CHIEF

SUBJECT: KAWAINUI MARSH - PRELIMINARY DRAFT EIS

The Maintenance Considerations Section on pages 7-10 should be modified. We see no relationship between Kaelepulu Stream and the maintenance of the Marsh under normal conditions. It should also be noted that we routinely open the stream mouth at least eight times annually. The stream mouth naturally closes within two weeks after each opening.

Couple of minor errors are noted:

Page 3-3, 4th paragraph, last line - "windward" instead of "leeward"

Page 4-3, 3rd paragraph, 8th line - "September" instead of "November"

We are still leery of the recommendations to allow overflow from the Marsh over the Dike Road into Kawainui Stream. We have grave reservations whether the Coconut Grove residents will agree to this measure unless a 100% guarantee that no flooding will occur can be given.

We are puzzled by one aspect of this report. We understood early on that interim and final flood control measures would be recommended. It appears they have evolved into one and the same recommendation.

Should you have any questions, please call Albert Miyashiro, at 4472.

Yukio Uyehara

YUKIO UYEHARA, Chief

project description is superimposed on other relevant figures, such as archaeological resources, land use controls, land ownership, vegetation, and waterbird habitat.

It would be less confusing if the DEIS text and figures used consistent names for various structures and geographic features. For example, the preliminary DEIS alternatively refers to the man-made drainage ditch makai of the levee as Kaelepulu Stream, Kaelepulu Canal, and Kawainui Stream. The Oneawa Channel is also referred to as Kawainui Canal and Oneawa Canal.

HYDROLOGY

We suggest that the DEIS discuss the long-term implications of the proposal to connect the drainage canal makai of the levee to the Kawainui Canal. Will it foreclose the option of removing vegetation from Kawainui Marsh to improve waterbird habitat? Growth of vegetation in the Marsh has reduced flood water levels in the Kawainui Canal to less than 2.7 feet since 1980. But as recently as 1968, flood water levels in Kawainui Canal exceeded 7 feet. If the drainage canal makai of the levee had been connected to the Kawainui Canal in 1968, flood water would have flowed out of the Kawainui Canal and into Coconut Grove. Hence, the DEIS needs to address the potential cumulative effects of the proposed project and proposed waterbird habitat improvement on peak flood water levels in the Kawainui Canal.

On page 7-3, the preliminary DEIS indicates that extending the drainage canal makai of the levee to the Kawainui Canal will lower water levels and increase salinity in the drainage canal. We suggest that the DEIS discuss the feasibility of installing a weir to prevent salt water intrusion and lower water levels in parts of the drainage canal which provide waterbird habitat. Figure 5-1 of the preliminary DEIS describes parts of the subject drainage canal and abutting lands as being the habitat of endangered waterbirds which do not tolerate very brackish conditions. Although not mentioned in the preliminary DEIS, the same is true for parts of the canal and Kawainui Stream south of Kailua Road.

We suggest that the DEIS address the impacts of the emergency Kawainui Marsh drainage ditch on dry-weather water retention and waterbird habitat within the Marsh. The preliminary DEIS Figures 7-1 and 7-6 propose a new "low flow weir with side gates" across this emergency drainage ditch. [However, no explanation is provided in the preliminary DEIS as to the environmental benefits that will result.]

We suggest that the DEIS address the feasibility and implications of constructing a weir across the entire mauka end of the Kawainui Canal. This was proposed (but not built) when the Kawainui Canal was widened in 1965-6. Page 6-1 of the preliminary DEIS describes an updated version of this weir as a mitigation measure to an unimplemented 1988 proposal that a channel be excavated across the Marsh.

On page 7-3, the preliminary DEIS proposes a new weir to regulate the southern flow of water in the drainage canal makai of the levee. Although the statement is made that this will prevent flooding south of Kailua Road, Figure 4-2 does not indicate any risk of flooding south of Kailua Road. The DEIS needs to provide better justification for the proposed weir and analysis of the risks that the weir poses to flooding of Coconut Grove.

VEGETATION CONTROL IN KAWAINUI MARSH

It would be beneficial to consult with Sheila Conant and Evangeline Funk on proposed strategies of vegetation control. The proposed long-term measures in the preliminary DEIS are likely to be controversial and warrant expert review before the DEIS is made public.

IMPACTS ON WATERBIRD HABITAT

Proposed dredging of a new channel makai of the levee will directly impact waterbird habitat. Unless a weir is installed to prevent salt water intrusion, connection of the drainage canal makai of the levee to the Kawainui Canal will adversely affect waterbird habitat both north and south of Kailua Road. The preliminary DEIS neither mentions these impacts nor includes relevant information to evaluate their significance. The DEIS needs to better address the issue.

WALTER M. OZAWA, Director

WMO:js

Attach.

cc: Department of Land Utilization

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

DIVISION OF WASTEWATER MANAGEMENT

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

JUL 11 9 45 AM '89

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

GEORGE M. UYEMA
CHIEF

WPP 89-273

July 6, 1989

MEMORANDUM

TO: MR. MARVIN T. FUKAGAWA, CHIEF
DIVISION OF ENGINEERING

FROM: GEORGE M. UYEMA, CHIEF
DIVISION OF WASTEWATER MANAGEMENT

SUBJECT: KAWAINUI MARSH PRELIMINARY DRAFT
ENVIRONMENTAL IMPACT STATEMENT
DATED JUNE 19, 1989

The following comments are provided on the subject draft EIS:

1. Page 3-9, fourth paragraph:

Recommend that the entire section on Olomana-Maunawili sewer collector project write-up be deleted because it identifies an option that was considered but not implemented for that sewer project. For correct information on the sewer system on the Olomana-Maunawili area, see Department of Public Works, City and County of Honolulu's Negative Declaration for the proposed Kailua Road Interceptor Sewer, Maunawili Wastewater Pump Station and Force Main, and Kukanono Wastewater Pump Station and Force Main dated July 1984.

2. Page 5-1, first paragraph:

"Kawainui Marsh serves at least three functions. The first is that of flood control. The second function has been that of a final treatment facility for sewage effluent,...The first two roles are discussed in other sections..."

Recommend the deletion of the underscored portion which reflects obsolete sewage disposal methods for the area. Three of the four wastewater

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89-[illegible] ENV [illegible]

DEPARTMENT OF GENERAL PLANNING

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

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TO ______

FRANK F. FASI
MAYOR

DONALD A. CLEGG
CHIEF PLANNING OFFICER

GENE CONNELL
DEPUTY CHIEF PLANNING OFFICER

MH/DGP 6/89-2383

July 3, 1989

MEMORANDUM

TO: SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER
DEPARTMENT OF PUBLIC WORKS

FROM: DONALD A. CLEGG, CHIEF PLANNING OFFICER
DEPARTMENT OF GENERAL PLANNING

SUBJECT: KAWAINUI MARSH PRELIMINARY DRAFT
ENVIRONMENTAL IMPACT STATEMENT (DEIS)

This is in response to your request for a quick review and comments on the Kawainui Marsh Preliminary Draft Environmental Impact Statement.

In our view, the Draft EIS is generally adequate.

However, the EIS should indicate that an amendment to Development Plan Public Facilities Map may be necessary to establish drainage improvements for Kawainui. The need for an amendment would depend upon the total cost of the improvements and whether the improvements are considered major or minor.

The alternatives section should be expanded or reorganized to provide a clearer discussion as to the effectiveness of each alternative in meeting the perceived problem; i.e., the need for drainage improvements in Kawainui Marsh to effectively distribute and store storm water runoff in order to reduce the potential for downstream flooding.

DONALD A. CLEGG
Chief Planning Officer

DAC:gy

89-3578 GIDir/Engr

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF:

July 11, 1989

Planning Branch

Mr. Sam Callejo
Director of Public Works
City and County of Honolulu
Honolulu, Hawaii 96728

Dear Mr. Callejo:

We appreciate the briefing on Kawainui Marsh provided by your staff and M&E Pacific, Inc. on July 11, 1989. As the additional information we requested at the briefing is being transmitted today for our review, we are unable at this time to state a Corps of Engineer's position on the proposed action.

Modifications of a Federally constructed flood control project require review by our Washington Headquarters and approval by the Assistant Secretary of the Army for Civil Works. We will work closely with your staff to expedite this review process.

Sincerely,

for [signature]

F. W. Wanner
Colonel, U.S. Army
District Engineer

Mr. Marvin T. Fukagawa - 2 - July 6, 1989

treatment facilities have been closed and their flows are currently pumped to the Kailua Sewage Treatment Plant for treatment and disposal. Upon completion of the Maunawili Estates Pump Station and Force Main in March 1990, the Maunawili Sewage Treatment Plant will be closed and its flow will be pumped to the Kailua Sewage Treatment Plant. Until then, the effluent, which receives secondary treatment and meets EPA discharge standards, is discharged into Maunawili Stream.

Page 5-1, first paragraph, last sentence: sentence indicates that sewage effluent is discussed in other sections. No discussion is found in other sections of the DEIS.

3. Page 6-3, second paragraph:

Change "sewer" to read "drain" for clarity.

4. Ref.: Meeting of June 14, 1989 at Liquor Commission Conference Room with consultants, M&E Pacific:

The existing grade along the driveway at Kailua Road Wastewater Pump Station is around 6.5-7.0 feet. Will this project affect the pump station?

If there are any questions, please call Richard Leong at extension 5863.

[signature]
GEORGE M. UYEMA
Chief

89-4004
DIR
ENV
cc: EIS/PRO
8/2 K.C.

AUG 2 10 45 '89

JOHN WAIHEE
GOVERNOR OF HAWAII

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

IN REPLY, PLEASE REFER TO:
EPHSO

July 24, 1989

Memorandum

To: Mr. Sam Callejo, Director and Chief Engineer
Department of Public Works
City and County of Honolulu

From: Deputy Director for Environmental Health

Subject: Draft Environmental Impact Statement (DEIS) for Kawainui Marsh, Koolaupoko, Oahu

Vector Control

The Kawainui Marsh is a major mosquito breeding source, especially after heavy flooding. The resulting adult mosquitoes affect the entire Kailua town and outlying areas.

The Vector Control Branch is hampered in its effort to control the mosquitoes for various reasons including: heavy floods, difficulty in accessing area for treatment, and difficulty in contending with uncontrolled vegetation. During certain emergencies, we must rely on aerial control, but results are less than satisfactory because the chemical cannot penetrate the dense vegetative cover under which the actual breeding occurs. Additionally, chemical control will be more difficult because of the concern regarding endangered species and EPA pesticide restrictions.

Accordingly, all of the proposed changes such as diversion of water flow, increasing the water storage capacity, maintenance strategies for vegetation control, etc. should be addressed in manners that are consistent with our pest management practices. Considerations must be made for the use of mosquito fishes for biological control, accessibility to all breeding site for inspections and control, contiguous ponds, and routine weed control.

Noise

The following potential noise impact must be addressed when proposing the EIS for the subject project;

1. Construction and excavation activities must comply with the provisions of Title 11, Administrative Rules Chapter 43, Community Noise Control for Oahu.

a. The contractor must obtain a noise permit if the noise levels from the construction and excavation activities are expected to exceed the allowable levels of the regulation.

b. Construction equipment and on-site vehicles requiring an exhaust of gas or air must be equipped with mufflers.

c. The contractor must comply with the requirements specified in the regulations and conditions issued with the permit.

2. Traffic noise from heavy vehicles travelling to and from the construction site must be minimized near existing residential areas and must comply with the provisions of Title 11, Administrative Rules Chapter 42, Vehicular Noise Control for Oahu.

BRUCE S. ANDERSON, Ph.D.

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

89-4110
ENV
EIS

REF: OCEA-sor

AUG 7 1989

FILE: 89-772
DOC.: 6224E

The Honorable Sam Callejo, Director
Department of Public Works
City and County of Honolulu
650 So. King Street
Honolulu, Hawaii 96813

Dear Mr. Callejo:

SUBJECT: Kawainui Marsh Preliminary Draft Environmental Impact Statement (DEIS)

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.

We found very few major problems with the proposed actions and their effects on native endangered wildlife known to occur in the marsh. We are in support of the utilization and modification of existing flood control systems, as it would have little impact on wildlife, if mitigated as suggested in the draft EIS.

The proposed action has four primary elements. The first, opening new waterways, will have a positive impact on the waterbirds as it will create additional habitat. We support and recommend the removal, not control, of all water hyacinth in the existing water areas. The EIS has used both removal and control listed in the same paragraph (pages 1-3 and 7-4). The second element, protecting the levee from overflows by rebuilding it in key areas, will have little if any impact on native birds. The third element, providing for rapid evacuation of water (by utilizing a spillway and weirs) will have little affect on native birds. In fact, the weirs might prove useful in manipulating water levels for habitat management. The fourth element, diverting water flow in the Kaelepulu Stream, may affect habitat use in the main pond area but is not perceived as a major problem as this would be more than likely a necessity only during extreme flood events.

The preferred alternative seems to both cost effective and efficient, since it was derived from intensive hydrologic studies and modeling. The proposal would also fit in with the State's future management plans for the marsh.

We have found several small problems in the EIS and these are addressed point by point below:

1. Page 3-4 was not readable due to an error in photocopying.

2. One incorrect statement that needs to be corrected is on page 7-12, section VI: "The State Department of Land and Natural Resources is responsible (emphasis added) for the management for ecological and cultural functions of the marsh."

   The Department of Land and Natural Resources is "responsible" for regulatory management of the Conservation District, which includes the Marsh. The document might more accurately add "and the City and County of Honolulu handles all functions and responsibilities of ownership of the Marsh." "Land Ownership," (3-13 section V paragraph three) explains the situation more accurately.

3. Two actions that took place in 1988 were overlooked by the EIS. One was the City and County spraying of vegetation with "Rodeo" in November 1988; and second was the outbreak of avian botulism in Oneawa Canal near the outlet of the marsh, the latter the result of eutrophic and anaerobic conditions that currently exist in the marsh/canal interface. Discussions of both actions should be added to the EIS.

4. A table indicating the wildlife species that utilize the marsh should be assembled and presented as an appendix.

5. Section 1-2, paragraph 1, should state that a CDUA emergency authorization also was needed.

6. Another unresolved issue in 1-4 is the pesticide and herbicide runoff that might be generated from the Maunawili Golf Course.

7. Section 3-15, third line: after, "but does not want to be the lead agency for flood control," add "at this time." Also, Conservation District boundaries should be shown on a map.

8. Section 3-16, paragraph 4: Our Department's Division of Forestry and Wildlife (DOFAW) has sent preliminary invitations to organizations and interested citizens for participation on the Kawainui Marsh Citizen Advisory Committee. The committee has not as yet been finalized.

9. Section 5-6, last paragraph: Hyacinth is encroaching on open water, not other plants. Figure 7-1 depicts spraying of water hyacinth in open water areas. The objective is to spray the hyacinth where it occurs (see map labelled (Figure 6-2..."). We strongly urge these areas be treated to eradicate the hyacinth.

10. Section 5-8, first paragraph: The removal of invading upland plant species like Paperback Eucalyptus and other trees is essential in order to prevent further invasion and subsequent loss of wetland in the marsh.

11. Section 5-11, "(Engilis, 1976)" should read (Engilis, 1988) and "The intent of the report cited above" omits that there are three reports cited "above"; the EIS should specify which one.

12. Table 5-3 has many inaccuracies and errors. We recommend that the predators column be changed to Threats and that the EIS consultant discuss this table with our Division of Forestry and Wildlife.

13. Section 7-5, first paragraph: The EIS states that grazing may be detrimental to nesting species (5-13), but (on Page 7-3) increased grazing is recommended as a primary choice for controlling grass. We recommend maintaining grazing but think more study is needed to understand the impacts of increased grazing pressure.

    We also disagree with the alternative of fire as a management solution, except as a last resort or for very specific and tightly controlled situations. This alternative has been discussed in previous meetings and rejected due to the conditions created by fire in the marsh and air quality regulations. Also the EIS has discussed the problems with spreading eucalyptus and saw grass after fires.

14. Section 7-8, paragraph 3: We question the use of explosives so close to the houses of Coconut Grove. This issue has not been adequately discussed in the EIS.

15. Section 7-9, paragraph 4: We strongly urge that the State and the City and County work closely with the Maunawili Golf Course owners to insure that the pesticides and herbicides chosen would not impact downstream flora and fauna, particularly endangered waterbirds in Kawainui Marsh.

From an aquatic resources standpoint, we have no overriding objection to the proposal to increase the ability of the Marsh to distribute and store flood waters. The document acknowledges that the operation of water control weirs and associated water levels had been identified as an unresolved issue during the Draft EIS process. We were concerned that the water control structure at Oneawa Canal could affect the upstream and downstream migration of the native diadromous stream fauna.

Although past surveys of the Marsh and the Maunawili Watershed streams have indicated the predominance of exotic species, it is noted that the opae kalaole (*Atya bisculata*) occurs in the Watershed, and other native stream fauna including the o'opu nakea (*Awaous stamineus*) have been recorded in the vicinity of Oneawa Canal. Recent developments such as eliminating discharge of sewage effluent and the proposed flood control improvements in the Marsh could enhance establishment of o'opu in the Marsh and Watershed.

Both water retention and native stream fauna concerns can be accommodated. The water control structure should be constructed to allow continuous water flow and a suitable downstream face to allow passage of native stream fauna.

Thank you again for your cooperation in this matter. Please feel free to call me or Jay Lembeck of my staff, at 548-7837, if you have any questions.

Very truly yours,

WILLIAM W. PATY

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

89-4029 ENV
ES ENG
Room 6307

JUL 3 1 1989

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Re: Preliminary Draft Environmental Impact Statement for the Kawainui Marsh Flood Control Project, Oahu

Dear Mr. Callejo:

The U.S. Fish and Wildlife Service (Service) has reviewed the referenced Preliminary Draft Environmental Impact Statement (EIS) and offers the following comments for your consideration.

General Comments

The Preliminary Draft EIS recognizes the importance of the wetland habitats in Kawainui Marsh for endangered Hawaiian waterbirds and migratory waterfowl. The preferred [illegible] alternative uses the marsh to store flood waters, and [illegible] design features recommended by the Service and Hawaii Department of Land and Natural Resources to protect the wetland values of Kawainui Marsh.

Preferred Alternative

The goal of the preferred flood control alternative is to improve the ability of Kawainui Marsh to distribute and store flood waters. The higher ground elevations at the northern end of the marsh and the composition and density of wetland vegetation influences the transport and storage of flood waters in Kawainui Marsh. The topography and vegetation apparently causes flood waters to flow towards the southeastern end of the marsh and levee. Interior channels would be constructed through the dense emergent vegetation to distribute flood waters to the northern and western sectors of the marsh.

The preferred alternative is also designed to accommodate the overtopping of the levee in the southeastern corner of Kawainui Marsh. The crest and backslope of the levee would be reinforced to prevent erosion during overflow conditions. Floodwaters overflowing the levee would be conveyed to Oneawa Canal through a new culvert between Kaelepulu Canal and Oneawa Canal. A weir would be constructed adjacent to the Kailua Road bridge to force water to flow northward towards Oneawa Canal.

Another weir would be constructed near the head of the Oneawa Canal to control the drainage of Kawainui Marsh by the emergency ditch constructed by the City and County of Honolulu.

Specific Comments

a. The construction of the interior waterways and the eradication of water hyacinths in the existing ponds would improve the value of Kawainui Marsh for endangered Hawaiian waterbirds and migratory waterfowl. We recommend that the Draft EIS identify and describe the preferred method(s) for removing and controlling emergent vegetation in the proposed interior waterways and open water ponds. Additional information on the depth, width, and length of the interior waterways, and methods for disposing of the emergent vegetation from the interior waterways should be discussed in the Draft EIS. It would be useful to know water surface elevations and velocities in the interior channels under normal and flood conditions in order to evaluate potential impacts to waterbird habitats. This information should also be included in the Draft EIS.

b. The emergency ditch constructed along the levee is accelerating the draining of waters from Kawainui Marsh. Construction of a low flow weir at the outlet of the emergency ditch may reduce the ability of the emergency ditch to drain the marsh, particularly during low streamflow periods. The proposed low flow weir would span the emergency ditch, and extend a short distance into the marsh. We recommend that the low flow weir extend from the levee to Quarry Road near the inlet to Oneawa Canal. The low flow weir should use stop logs instead of a sliding turnout gate to allow the manual manipulation of water levels in the marsh.

Determining the crest elevation of the low flow weir should be based on an analysis of water levels in the marsh. The data collected from the stage recorders in the marsh, and the corresponding rainfall and stream discharge values would be valuable in identifying a target water surface elevation. This information should also be included in the Draft EIS.

We also recommend that the irrigation canals which extend from the interior of the marsh to the emergency ditch be plugged. Sealing these irrigation canals would reduce the potential for excessive drainage of the marsh. These irrigation canals are depicted on Figure 6-2 Sheet A in the Preliminary Draft EIS.

c. The invert for the culvert connecting Kaelepulu Canal to Oneawa Canal would be set below sea level. To prevent flood waters from flowing south, a weir would be constructed across Kaelepulu Canal south of the Kailua Road bridge. Opening Kaelepulu Canal to Oneawa Canal is expected to lower existing water surface elevations and increase the salinity in Kaelepulu Canal.

The ITT wetland and the Hamakua Drive wetland are flooded by the Kaelepulu Canal. Reducing water surface elevations in Kaelepulu Canal may cause these marshes to drain and may reduce the length of time that they are saturated with standing water. Such changes would hasten the conversion of the wetlands to fastlands, thereby reducing their value for endangered waterbirds. Increasing the salinity may alter the composition of the emergent vegetation in the wetlands and may also make them less suitable for endangered waterbirds.

Information on existing water levels in Kaelepulu Canal and Oneawa Canal; ground elevations at both the ITT wetland and Hamakua Drive wetland; frequency and duration of time that these wetlands are saturated with water; and, the role of flood waters in maintaining these wetlands should be collected to evaluate potential impacts to these wetlands from the proposed opening of Kaelepulu Canal to Oneawa Canal.

The weir south of the Kailua Road bridge should be designed to prevent the drainage of the Hamakua Drive wetland and the maintenance of existing water levels in the Hamakua Drive Canal. Mitigation measures to maintain the integrity of the ITT wetland still need to be identified.

d. We suggest that the Draft EIS include a water budget for Kawainui Marsh. The water budget would be valuable in estimating water losses from the marsh from evaporation and transpiration from the opening of the interior waterways and the eradication of water hyacinths. This information would also be useful in predicting changes to water levels in the marsh during low streamflow conditions during the summer.

e. We recommend that sediment retention basins be constructed within the pasture lands at the southern end of Kawainui Marsh. The basins could be designed to capture and retain silt and other debris carried by Maunawili and Kohanaiki Streams during flood events. Construction of sediment basins may also increase the flood storage capacity of Kawainui Marsh.

f. The statement on page 5-13, paragraph #2, "The importance of these waterbirds also has impact on any project being planned for the marsh as the waterbirds fall under the jurisdiction of USFWS management regulations.", should be changed. We suggest that the sentence read as follows: "The four species of endangered Hawaiian waterbirds are protected under the Endangered Species Act. Any federal action that may affect these endangered species would have to comply with Section 7 of the Endangered Species Act."

Summary Comments

We have no major objections to the proposed flood control alternative provided that the necessary studies and mitigation measures to protect wetland habitat values are included in the project design. We look forward to further coordination on this project.

We appreciate the opportunity to comment.

Sincerely,

William R. Kramer

for Ernest Kosaka
Field Supervisor
Pacific Islands Office

cc: U.S. Army Corps of Engineers
MCB Pacific, Inc.
DLNR
CZU
RH

DEIS COMMENTS/RESPONSES

Agency/organization individual	Letter Dated	Date Answered
FEDERAL		
Department of Agriculture	18-Dec-89	7-Jun-90
U. S. Navy	13-Nov-89	7-Jun-90
U. S. Corps of Engineers	18-Dec-89	6-Jun-90
U. S. Fish & Wildlife	18-Dec-89	13-Jun-90
STATE		
Department of Health	8-Jan-90	7-Jun-90
Department of Defense	6-Dec-89	7-Jun-90
Department of Business & Economic Development	16-Nov-89	7-Jun-90
Department of Accounting & General Services	16-Nov-89	7-Jun-90
Department of Agriculture	22-Dec-89	5-Jun-90
Department of Land & Natural Resources	3-Jan-90	7-Jun-90
State Historic Preservation Office	14-Dec-89	7-Jun-90
Environmental Center UH	21-Dec-89	13-Jun-90
CITY & COUNTY		
Department of Public Works		
Wastewater Management	6-Dec-89	7-Jun-90
Refuse Division	15-Dec-89	7-Jun-90
Department of Parks & Recreation	21-Nov-89	7-Jun-90
Department of Land Utilization	13-Dec-89	5-Jun-90
Department of General Planning	11-Dec-89	5-Jun-90
ORGANIZATIONS/INDIVIDUALS		
Hawaiian Electric Co.	27-Dec-89	6-Jun-90
Maunawili Community Assoc.	18-Dec-89	5-Jun-90
Kawai Nui Heritage Foundation	20-Dec-89	8-Jun-90
Kailua Neighborhood Board	21-Dec-89	13-Jun-90
Lani-Kailua Outdoor Circle	20-Dec-89	13-Jun-90
Diane Drigot	21-Dec-89	7-Jun-90
Life of the Land	21-Dec-89	13-Jun-90
National Audubon Society	20-Dec-89	13-Jun-90

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

January 8, 1990

In reply, please refer to:
EPHSD

MEMORANDUM

To: Marvin T. Miura, Director
Office of Environmental Quality Control

From: Director of Health

Subject: Kawanui Marsh Flood Damage Mitigation Project, Draft Environmental Impact Statement (DEIS)
Kailua, Oahu

Thank you for allowing us to review and comment on the DEIS. We do not have any additional comments at this time.

JOHN C. LEWIN, M.D.

cc: Sam Callejo, City & County of Honolulu
James Dexter, M & E Pacific, Inc.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO:
90-12-0255

June 7, 1990

Dr. John C. Lewin
Director of Health
Department of Health
State of Hawaii
P. O. Box 3378
Honolulu, Hawaii 96801

Dear Dr. Lewin:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Letter dated January 8, 1990 (EPHSD)

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Very truly yours,

for SAM CALLEJO
Director and Chief Engineer

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

DIVISION OF WASTEWATER MANAGEMENT

650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

GEORGE M. UYEMA
CHIEF

WPP 89-509

December 6, 1989

Mr. James Dexter
M & E Pacific, Inc.
Pauahi Tower, Suite 500
1001 Bishop Street
Honolulu, Hawaii 96813

Dear Mr. Dexter:

Subject: Draft Environmental Impact Statement
Kawainui Marsh Flood Damage Mitigation Project

We have reviewed the Draft EIS and have no objections to the proposed plan.

If there are any questions, please call the Planning Section at 523-4653.

Very truly yours,

GEORGE M. UYEMA
Chief

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO

90-12-0260

June 7, 1990

MEMORANDUM

TO: MR. GEORGE M. UYEMA, CHIEF
DIVISION OF WASTEWATER MANAGEMENT

FROM: MARVIN T. FUKAGAWA, CHIEF
DIVISION OF ENGINEERING

SUBJECT: KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
RESPONSE TO YOUR LETTER DATED DECEMBER 6, 1989

Thank you for your interest in this project. Your review of the DEIS is appreciated.

DEPARTMENT OF PARKS AND RECREATION

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

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FRANK F. FASI
MAYOR

WALTER M. OZAWA
DIRECTOR

HIROSHI MORITA
DEPUTY DIRECTOR

Engr 89-6178

November 21, 1989

Marvin T. Miura, Ph.D., Director
Office of Environmental Quality Control
State of Hawaii
Kekuanaoa Building, Room 104
465 South King Street
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Draft EIS for Kawainui Flood Damage Mitigation Project

The subject Draft EIS adequately addresses our previous questions.

Sincerely,

WALTER M. OZAWA, Director

WMO:js

cc: Department of Public Works

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DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0261

June 7, 1990

MEMORANDUM

TO: MR. WALTER M. OZAWA, DIRECTOR
DEPARTMENT OF PARKS AND RECREATION

FROM: SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER
DEPARTMENT OF PUBLIC WORKS

SUBJECT: KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
RESPONSE TO YOUR LETTER DATED NOVEMBER 21, 1989

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Marvin T. Fukagawa
for SAM CALLEJO
Director and Chief Engineer

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STATE OF HAWAII
DEPARTMENT OF DEFENSE
OFFICE OF THE ADJUTANT GENERAL
3949 DIAMOND HEAD ROAD, HONOLULU, HAWAII 96816-4495

November 20, 1989

Eng. 89-6140

Engineering Office

Dr. Marvin T. Miura, Director
Officer of Environmental Quality Control
465 South King Street, #104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Kawainui Marsh Flood Damage Mitigation Project
Environmental Impact Statement
Kailua, Oahu

Thank you for providing us the opportunity to review the above subject project.

We have no comments to offer at this time regarding this project.

Sincerely,

Jerry M. Matsuda
Lieutenant Colonel
Hawaii Air National Guard
Contracting & Engineering Officer

cc: Mr. Sam Callejo
Director & Chief Engineer
C&C of Honolulu

Mr. James Dexter
M & E Pacific, Inc.

NATIONAL GUARD
Americans At Their Best.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0254

June 7, 1990

Lieutenant Colonel Jerry M. Matsuda
Office of the Adjutant General
Department of Defense
State of Hawaii
3949 Diamond Head Road
Honolulu, Hawaii 96816-4495

Dear Colonel Matsuda:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Letter dated November 20, 1989

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Very truly yours,

Marvin T. Fukagawa
for SAM CALLEJO
Director and Chief Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

P. O. BOX 50004
HONOLULU, HAWAII
96850

DEC 27 7 35 AM '89

December 18, 1989

89-C764 ENV

Dr. Marvin T. Miura, Director
Office of Environmental Quality Control
465 S. King Street, #104
Honolulu, HI 96813

Dear Dr. Miura:

Subject: Draft Environmental Impact Statement (DEIS) - Kawainui Marsh Flood Damage Mitigation Project, Kailua, Oahu

We have no comments to offer at this time; however, we would appreciate the opportunity to review the final EIS.

Sincerely,

WARREN M. LEE
State Conservationist

cc:
Mr. Sam Callejo, Director and Chief Engineer, C&C of Honolulu, 650 S. King Street, Honolulu, HI 96813
Mr. James Dexter, M & E Pacific, Inc., Pauahi Tower #500, 1000 Bishop St., Honolulu, HI 96813

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DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0256

June 7, 1990

Mr. Warren M. Lee
State Conservationist
United States Department
of Agriculture
Soil Conservation Service
P. O. Box 50004
Honolulu, Hawaii 96850

Dear Mr. Lee:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Letter dated December 18, 1989

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

DEPARTMENT OF BUSINESS AND ECONOMIC DEVELOPMENT

JOHN WAIHEE, GOVERNOR
ROGER A. ULVELING, DIRECTOR
BARBARA KIM STANTON, DEPUTY DIRECTOR
LESLIE S. MATSUBARA, DEPUTY DIRECTOR

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November 16, 1989 89-6112 ENV'L Engr.

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Dr. Marvin T. Miura, Director
Office of Environmental Quality Control
465 S. King St., #104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement, Kailua, Oahu

In response to your request for comments regarding the subject Environmental Impact Statement, please be advised that we have none to offer.

Also, as requested, we are returning the EIS to you as we have no further use for it.

Thank you for the opportunity to review the document.

Sincerely,

Maurice H. Kaya
Energy Program Administrator

MHK:lf

cc: ✓Mr. Sam Callejo
Mr. James Dexter

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI, MAYOR

SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO: 90-12-0257

June 7, 1990

Mr. Maurice H. Kaya
Energy Program Administrator
Department of Business and
Economic Development
State of Hawaii
P. O. Box 2359
Honolulu, Hawaii 96804

Dear Mr. Kaya:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Letter dated November 16, 1989

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Very truly yours,

for SAM CALLEJO
Director and Chief Engineer

Nov 17 3 09 PM '89

(P)2145.9

NOV 16 1989

Dr. Marvin T. Miura
Director
Office of Environmental
Quality Control
465 South King Street, Rm. 104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Kawainui Marsh Flood Damage Mitigation Project Draft EIS

Thank you for the opportunity to review the subject document. We have no comments to offer.

Should there be any questions, please contact Mr. Cedric Takamoto of the Planning Branch at 548-7192.

Very truly yours,

TEUANE TOMINAGA
State Public Works Engineer

CT:em
cc: ✓City and County, Department of Public Works
Mr. James Dexter

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0258

June 6, 1990

Mr. Teuane Tominaga
State Public Works Engineer
Public Works Division, Room 426
Department of Accounting &
General Services
State of Hawaii
1151 Punchbowl Street
Honolulu, Hawaii 96813

Dear Mr. Tominaga:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Letter dated November 16, 1989

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Very truly yours,

for SAM CALLEJO
Director and Chief Engineer

DEPARTMENT OF THE NAVY
COMMANDER
NAVAL BASE PEARL HARBOR
BOX 110
PEARL HARBOR, HAWAII 96860-5020

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IN REPLY REFER TO
5090 (181B)
Ser 032/2925
13 Nov 1989

89-6027
ENGR

Dr. Marvin T. Miura
Director
465 S. King St., #104
Honolulu, HI 96813

Dear Dr. Miura:

KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT

The Draft Environmental Impact Statement (DEIS) for Kawainui Marsh Flood Damage Mitigation Project has been reviewed, and we have no comments to offer. Since we have no further use for the DEIS, it is being returned.

Thank you for the opportunity to review the draft.

Sincerely,

W. K. Liu

W. K. LIU
Assistant Base Civil Engineer
By direction of
the Commander

Encl
(1) DEIS Kawainui Marsh

Copy to:
M&E Pacific, Inc.
Chief Engineer, C&C of Honolulu,
Dept of Public Works

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0259

June 7, 1990

Mr. W. K. Liu
Assistant Base Civil Engineer
Naval Base Pearl Harbor
Department of the Navy
Box 110
Pearl Harbor, Hawaii 96860-5020

Dear Mr. Liu:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Letter dated 1989, 5090 (181B) Ser 032/2925

Thank you for your interest in this project. Your review of the DEIS is appreciated.

Very truly yours,

Marvin T. Fukagawa

SAM CALLEJO
Director and Chief Engineer

Hawaiian Electric Company, Inc.

William A. Bonnet
Manager
Environmental Department

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December 27, 1989

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89-6820
ENG

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Marvin T. Miura, Ph.D, Director
465 S. King Street, #104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Draft Environmental Impact Statement for Kawainui Marsh Flood Damage Mitigation Project

We have reviewed the above subject document and have the following comments:

1. There are no existing HECO facilities within the proposed project site.

2. As shown marked in "red" on the attached xerox print of the project site, HECO has existing overhead lines along roadways surrounding the project area; however, the effect of the project on these facilities should be minimal.

Sincerely,

William Bonnett

Attachment

cc: Mr. Sam Callejo
Director & Chief Engineer
C&C of Honolulu

Mr. James Dexter
M & E Pacific, Inc.

An HEI Company

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0226

June 6, 1990

Mr. William Bonnett, Manager
Environmental Department
Hawaiian Electric Company, Inc.
P.O. Box 2750
Honolulu, Hawaii 96840-0001

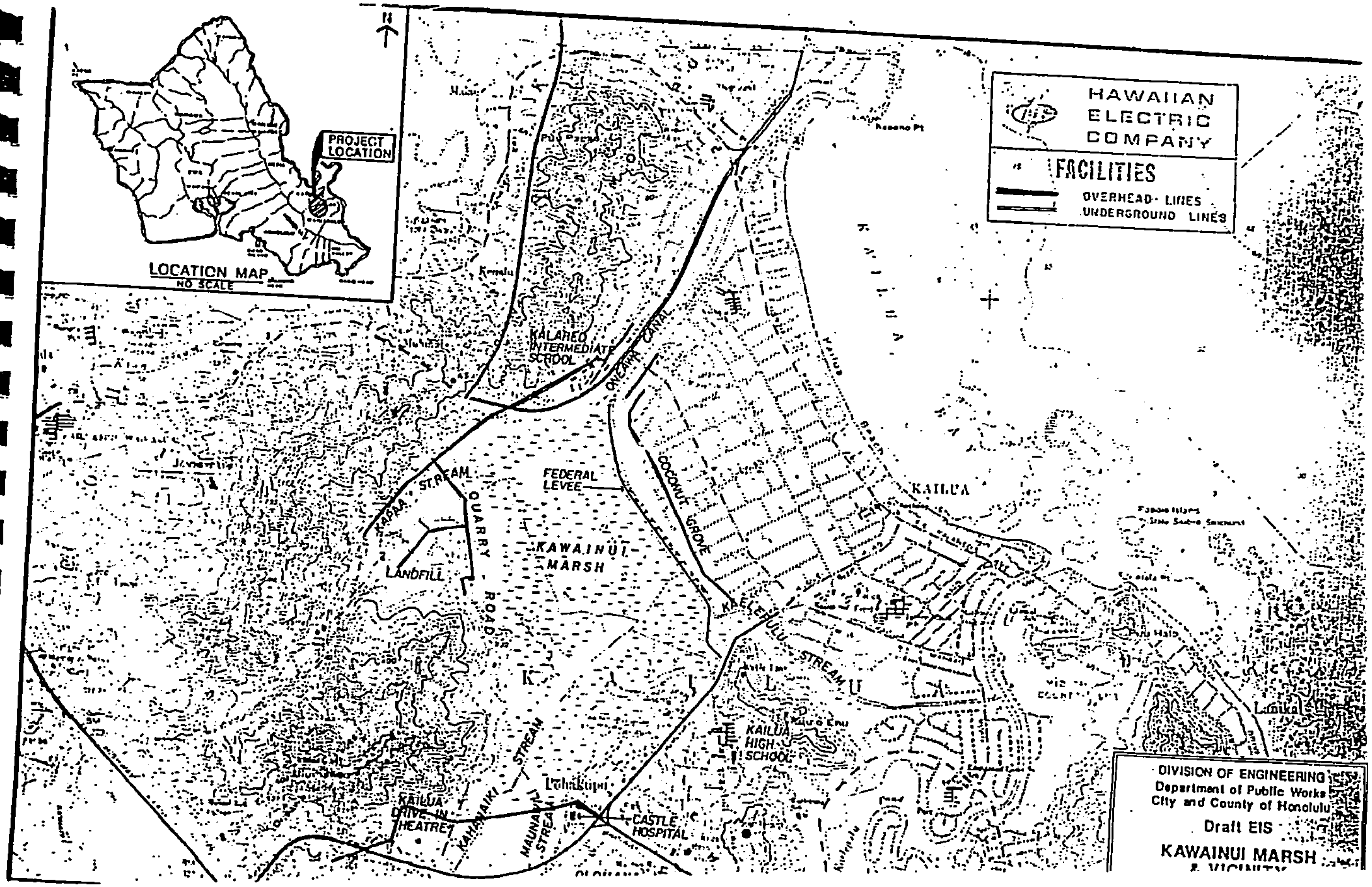
Dear Mr. Bonnett:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
<u>Response to Your Comments Dated December 27, 1989</u>

Thank you for reviewing the DEIS and providing us with the information regarding the overhead lines.

Very truly yours

for SAM CALLEJO
Director and Chief Engineer


HAWAIIAN ELECTRIC COMPANY
FACILITIES
OVERHEAD LINES
UNDERGROUND LINES
PROJECT LOCATION
LOCATION MAP
NO SCALE
KAILUA
KALAHEO INTERMEDIATE SCHOOL
OANEAWA CANAL
COCONUT GROVE
FEDERAL LEVEE
KAWAINUI MARSH
KAPAA STREAM
QUARRY ROAD
LANDFILL
KAELEPULU STREAM
KAILUA HIGH SCHOOL
CASTLE HOSPITAL
KAILUA DRIVE-IN THEATRE
KAHANAIKI STREAM
MAUNAWILI STREAM
DIVISION OF ENGINEERING
Department of Public Works
City and County of Honolulu
Draft EIS
KAWAINUI MARSH

Eng. 89-6791

COPY

December 22, 1989

MEMORANDUM

To: Marvin T. Miura, Ph.D
Director
Office of Environmental Quality Control

Subject: Draft Environmental Impact Statement (DEIS) for Kawainui Marsh Flood Control Damage Mitigation Project
Department of Public Works
City and County of Honolulu
THK: 4-2-16

DEC 29 10 45 AM '89

The Department of Agriculture has reviewed the subject document and offers the following comments.

According to the document, a recommended herbicide is Rodeo (page 2-7 and Appendix B, Section 5, page B-46). This herbicide is registered for use on aquatic sites. Considerable care should be taken to limit the area treated at one time to minimize the effects of biochemical oxygen demand from decaying vegetation.

As for the application of the herbicide, we suggest that techniques which minimize drift be utilized first before considering aerial application. Such a technique includes wiping applications from airboats.

If the herbicide Dalapon is selected, the labeling should be reviewed to determine if the site is listed on the labeling. The toxicity of this compound should also be more fully discussed. Dalapon is being withdrawn from the market by Dow Chemical because of oncogenicity concerns.

In all cases, the use of herbicides and pesticides must be in accordance with instructions found on the labels.

Thank you for the opportunity to comment.

YUKIO KITAGAWA
Chairperson, Board of Agriculture

cc: City and County Department of Public Works ✓
M & E Pacific, Inc.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0227

June 5, 1990

Mr. Yukio Kitagawa, Chairperson
State of Hawaii
Department of Agriculture
1428 South King Street
Honolulu, Hawaii 96814

Dear Mr. Kitagawa:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Comments Dated December 22, 1989

Thank you for reviewing the DEIS and providing us with the information in regard to herbicides.

We will use herbicides in accordance with the instruction labels.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

Maunawili

COMMUNITY ASSOCIATION

P.O. Box 943, Kailua, Hawaii 96734 • 262-7439

December 18, 1989

Attn: Mr. James Dexter

The Maunawili Community Association's concerns on the Kawai Nui Flood Damage Mitigation Project report put out by M L& E Pacific, Inc. are limited to two areas.

The first area of comment has to do with the marsh area not included in the report. On the Maunawili Valley side of the Kalanianaole Highway are two areas declared wetlands by the Army Corps of Engineers which are really part of the Kawai Nui Marsh, but which have been detached from the rest of the marsh for various reasons. This detachment, however, makes an open invitation to dump dirt (as did the C&C with the Corp's permission during last year's stream repairs); to develop (several schools have inquired about acquiring the land along the Kahanaiki Stream on the Maunawili side of the Highway for grade through high school); the Golf Courses Developer in Maunawili has tried to offer the community land in the middle of the wetlands for a much desired Art Museum, and it has been rumored that other land next to the park will be offered for a parking lot for the park; and an Honorary Animal Group (Moose, Elks, ?) and acquired the land and plans to build a temple right alongside Maunawili Stream (where so much dirt has been dumped in recent years that that area no longer retains identifiable characteristics of wetlands). These two "declared" wetland areas impact the marsh and discussion about them should be included in the report. Even if the State and the Corps should write them off, a serious mistake in our judgement, these decisions should be part of this report which aims to deal with the marsh as a total project.

Our other area of concern has to do with the watershed, which is briefly mentioned in this report. We are concerned that increased demands for water, in particular the increased withdrawal from any of the elements of that watershed, including the tunnels, the Springs, the Maunawili Ditch System, and the Maunawili-Kahanaiki Stream systems. Changes in any or possible several element(s) can affect the Kawai Nui Marsh water levels. I understand the State Tropical Ag system in Waimanalo is soon going to need more water in Waimanalo from the Maunawili Ditch system (if it hasn't yet registered this need); I also heard that the Golf Course Developer has considered requesting water from the Ditch system to use for his golf course(s); the Developer has received permission from the Water Commission Dec. 14, to use pumps to get out groundwater from the wells which have not yet produced the necessary water for the golf courses. Conditions for this permit include monitoring of Maunawili Stream which, due to the Ditch system withdrawal of source waters since the mid to late 1900s, are only a half of the stream's historical capacity. Whoever controls the Marsh management must take an active role in decisions made to all these elements of the watershed feeding the marsh, and criteria need to be established as to what constitutes temporary and permanent threats from the watershed to the marsh system, so it is on the books, part of the record, and not something to be given away for the asking, for one well, for one withdraw, for one whatever as time goes by and people are feeling friendly, but the welfare of the marsh is jeopardized.

The EPA, we hear, has come out with more specifics about chemicals used in herbicides, pesticides and fertilizers for golf courses, and banana growing and these studies need to be tracked very carefully with regard to the water quality in the marsh. And more to the point, at a recent open meeting with the Corrections Department and the area community associations, a Towill engineer stated that the water coming from the Maunawili wells to the Olomana project site under discussion was contaminated so as to be totally unusable and the water lines have been permanently shut off due to this contamination. Is it not possible that such well water is indicative of contamination of ground water in Maunawili and would this not also naturally affect the downflow area of the marsh? Such information should also be part of the Marsh mitigation plans.

The Kapaa lands are also part of the watershed for the marsh, and this report should commented upon water quality and quantity affected by this watershed. There are chemical seeping into the water from the dump and methane is produced from the deterioration of wastes. How has this affected and how will it continue to affect the marsh? The report also should include, in our opinion, possible impacts effected by the proposed golf course development still being planned for the Drive-In area and above.

It has been a pleasure, for the most part, to read this report. We feel that all those who have participated have added immensely to the literature of environmental impact mitigation assessments and this is one of the better reports of this kind produced in recent years. Mr. Ron Walker's contributions are evident and welcomed. There has been much thought and good planning in this report. Thank you for allowing us input in such an important undertaking.

Victoria S. Creed, President

cc: Mr.Callejo,DPW, HECA, OCA, PCA, Kawai Nui Heritage Fnd., KNB, WNB, Sen. Koki, Rep. Anderson, Councilman Felix

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0228

June 5, 1990

Ms. Victoria S. Creed, President
Maunawili Community Association
P.O. Box 943
Kailua, Hawaii 96734

Dear Ms. Creed:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 18, 1989

Thank you for transmitting your comments regarding the DEIS.

The City has always believed that the Kawainui Marsh flood damage mitigation project issues were complex and controversial. There are many viewpoints to consider: technical, economical, historical, environmental, fish and wildlife, recreational and more. There is no course of action which would be totally agreeable to everyone.

The City feels that it has done its best to satisfy the needs and concerns of private and government agencies.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

DIVISION OF ENGINEERING
650 SOUTH KING STREET • HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

MARVIN T. FUKAGAWA
CHIEF

90-12-0240

June 7, 1990

MEMORANDUM

TO: MR. FRANK J. DOYLE, CHIEF
DIVISION OF REFUSE COLLECTION AND DISPOSAL

FROM: MARVIN T. FUKAGAWA, CHIEF
DIVISION OF ENGINEERING

SUBJECT: KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
RESPONSE TO YOUR COMMENTS DATED DECEMBER 15, 1989

Thank you for transmitting your comments regarding the DEIS.

We offer the following response to your comments:

1. The term commercial landfills implies private landfills i.e., privately operated sites which do not have stipulations on the quantity of sludge that can be delivered per day.

2. The word leeward was mistakenly used instead of windward in the referenced paragraph. It will be corrected in the Final Environmental Impact Statement (FEIS).

3. Figure 3-4 will be corrected to show the City and County ownership of the parcels upon which the proposed action is to be implemented. Private land ownership mauka of the Kapaa quarry access road will also be included when the map is corrected in the FEIS.

4. Heavy metals are entombed in the sediments and concentrated through plant uptake into fibrous tissue in the biomass. Table B-10 through B-15 contain data from DEIS investigations of sediment and vegetation quality. Continuous monitoring of the sediment and vegetation removed from the marsh is not required by

existing environmental rules and regulations to determine if the material is acceptable for landfill disposal. An inquiry was made with the Department of Health, Hazardous Waste Section concerning hazardous waste notification requirements. EPA notification requirements would apply only if test results from representative samples exceed requirements of 40 CFR 261.20-261.24. Periodic testing and laboratory analysis will be conducted as a requirement of the maintenance program. The research that was done on this topic to reach this assessment is presented subsequently below.

The potential issue of metal toxicity in the environment is discussed in terms of two media - sediment that remains after the supernatant is decanted in a drying bed and vegetation that is dried and transported off site for disposal. Present plans are for disposal of the sediment into a landfill facility, although options for disposal at private facilities where recycling of the vegetation may have economic worth is still being reviewed. Two methods of vegetation disposal have been identified: 1) landfill disposal and 2) anaerobic digestion. The second method reuses the biomass decomposition materials in the form of either animal feed supplements or soil amendments. In either case, the fate and potential for toxicity in the environment must be assessed.

Table B-10 (DEIS) presents the total metal concentrations that were determined from sediment sampled from relatively shallow depths (using a sample tube five feet in length). EP TOX analyses were not conducted on those samples. Additional samples more representative of the material along the waterway alignments were analyzed that have been taken at depths up to fifteen feet below the top of the sediments.

Based on the available data at this time, however, the maximum EP TOX concentrations obtained in marsh sediments and vegetation samples shown below do not warrant characterizing the sediments or vegetation as EP toxic wastes for landfill disposal purposes.

<u>Comparisons of EP TOX Extraction Metal Concentrations (mg/L) To Toxicity Classification Criteria</u>

	METAL			
	As	Ba	Cd	Cr
Kawainui Sediments a)	<0.05	<1	<0.1	0.7
Kawainui Vegetation b)	<0.01	0.7	<0.01	0.4
Maximum Concentration c)	5.0	100.0	1.0	5.0
	Continued			
	Pb	Hg	Se	Ag
Kawainui Sediments	<0.5	<0.01	<0.05	<0.01
Kawainui Vegetation	0/01	0.003	<0.002	<0.01
Maximum Concentration	5.0	0.2	1.0	5.0

Notes:

a) Maximum concentration measured from sediments SM-6, SM-7, SM-8 sampled March 1990

b) Maximum concentration measured from vegetation BQ-1, BQ-2, BQ-3 sampled 1989 and reported in Table B-15, DEIS

c) Table I-Maximum Concentration of Contaminants For Characteristic of EP Toxicity; CFR 40-261 Protection of Environment, June 1, 1985.

In addition to metals analyses, analyses of the sediments for pesticides and PCB's did not indicate the presence of these types of compounds at concentrations above the reporting limits.

The test data above indicates that provided the acidity does increase above the levels simulated by the EP TOX analysis, namely, pH of 5, the toxicity of the metals in solution will remain below acceptable criteria for landfill disposal.

Relative to proposed State pollutant standards for heavy metals, chromium, lead and mercury concentrations may exceed proposed standards for chronic toxicity unless surface runoff from sediment and vegetation handling and disposal areas remain neutral or only slightly acid. To control the runoff quality, the construction specifications will require testing the pH of return water that has drained after harvesting and dredging and to require the application of lime if the pH falls below 6.0. This will provide return water of comparable acidity to that drawn from the marsh. A polishing pond will be included in the design to provide additional suspended solids removal and pH control.

Application of the vegetation as a soil amendment to lawns and other non-agricultural land would also be permitted under the proposed rules for the use and disposal of sewage sludge. Note this does not infer that the material extracted from the marsh should be technically classified as sewage sludge. It is meant to infer that if those standards were applied, because they are deemed technically conservative relative to health and safety of the environment, then the fate of the metals in the environment should pose no serious health risks. For example, the proposed national pollutant limits for metals (Federal Register / Vol. 54, No. 23 / February 6, 1989), are as follows for metals:

<u>Comparison of Vegetation Metals to Maximum Sewage Sludge Concentration For Non-Agricultural Land (mg/kg)</u>

	As	Cd	Cr	Cu
Kawainui Vegetation	0.063	0.30	34.4	-
Maximum Concentration	36	380	3100	3300

Continued

	Pb	Hg	Ni	Se	Zn
Kawainui Vegetation	13.9	0.032	-	0.058	-
Maximum Concentration	1600	30	990	64	8600

CORRECTION

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

existing environmental rules and regulations to determine if the material is acceptable for landfill disposal. An inquiry was made with the Department of Health, Hazardous Waste Section concerning hazardous waste notification requirements. EPA notification requirements would apply only if test results from representative samples exceed requirements of 40 CFR 261.20-261.24. Periodic testing and laboratory analysis will be conducted as a requirement of the maintenance program. The research that was done on this topic to reach this assessment is presented subsequently below.

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	As	Cd	Cr	Cu
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Maximum Concentration	36	380	3100	3300

Continued

	Pb	Hg	Ni	Se	Zn
Kawainui Vegetation	13.9	0.032	-	0.058	-
Maximum Concentration	1600	30	990	64	8600

RECEIVED DEC 21 1989

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

DIVISION OF REFUSE COLLECTION AND DISPOSAL
650 SOUTH KING STREET, 14TH FLOOR
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

FRANK J. DOYLE
CHIEF

IN REPLY REFER TO
R 89-1537

December 15, 1989

M & E Pacific, Inc.
1001 Bishop Street
Honolulu, Hawaii 96813

Gentlemen:

Subject: DEIS Kawainui Marsh Flood Damage Mitigation Project

We have reviewed the subject document and have the following comments.

1. Page 2-10, 2nd paragraph, What are commercial landfills?

2. Page 3-2, 4th paragraph, What is the basis for the last sentence that the windward landfill was used mostly to accommodate the population growth on leeward Oahu. Since the early 1960's most of the City collected leeward refuse has been disposed of at the Waipahu landfill, through incinerators, or the private landfill at Palailai.

3. Page 3-6, 2nd paragraph, ownership of private landowner has to be verified.

4. Page 3-11, 5th paragraph, states presence of heavy metals in sediment. Will sediment be tested before transporting to landfill?

5. Figure 3-4, Why is City land ownership mauka of quarry road shown and no other ownership shown?

6. Older references refer to Kawainui Marsh as Kawainui Swamp. Explanation should be given in text that they are the same.

Sincerely,

FRANK J. DOYLE

Attach.

DEPARTMENT OF LAND UTILIZATION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

REC'D
DEPT OF PUBLIC WORKS
DEC 14 8 08 AM '89

FRANK F. FASI
MAYOR

JOHN P. WHALEN
DIRECTOR

BENJAMIN B. LEE
DEPUTY DIRECTOR

Engr. 89-6599

LU11/89-7325(BWM)

December 13, 1989

Marvin T. Miura, Ph.D, Director
Office of Environmental Quality Control
State of Hawaii
465 South King Street, #104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Comments on Draft EIS for the
Kawainui Marsh Flood Damage
Mitigation Project (November 1989)
Kailua, Koolaupoko, Oahu, Hawaii
Tax Map Key: 4-2-16: 01

We have reviewed the Draft EIS for the Kawainui Marsh Flood Damage Mitigation Project (November 1989). Our comments and questions are as follows:

1. Section 4, Part III "Long Term Impacts".

In the discussion on p.4-4, reference is made to the "potential for passive recreational access to the marsh for ecological education purposes." Does the project itself create any of these opportunities? Are there any plans by the State Parks Department or the City Parks Department to develop such passive recreational areas? If so, how do these proposals relate to the flood damage mitigation project? Where would the passive recreation areas and the access to these passive recreation areas be located?

2. Special Management Area (SMA)

The section on the SMA on p. 6-5 should note: (1) that the SMA permit is the first among all land use permits, and (2) that SMA approval must be obtained prior to CDUA approval.

Thank you for the opportunity to comment. If you have any questions regarding the content of this letter, or on the processing of the SMA Permit for this project, please call Bennett Mark of our staff at 527-5038.

Very truly yours,

JOHN P. WHALEN
Director of Land Utilization

JPW:sl
0299N/6-7

cc: DPW, Sam Callejo
M&E Pacific Inc., James Dexter

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0230

June 5, 1990

MEMORANDUM

TO: MR. DONALD A. CLEGG, DIRECTOR
DEPARTMENT OF LAND UTILIZATION

FROM: SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER
DEPARTMENT OF PUBLIC WORKS

SUBJECT: KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
RESPONSE TO YOUR COMMENTS DATED DECEMBER 13, 1989

Thank you for transmitting your comments regarding the DEIS.

We offer the following response to your comments:

1. Section 4, Part III "Long Term Impacts"

   No, however, the potential for access is created because the waterways can provide access routes (by small boats).

2. Special Management Area (SMA)

   The DEIS will be revised.

SAM CALLEJO
Director and Chief Engineer

RECEIVED
DEPT OF PUBLIC WORKS
DEC 26 4 26 PM '89
TO ________

Dr. Diane Drigot
101 Ohana Street
Kailua, Hawaii 96734

December 21, 1989

ENV. 89-6765

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

Dear Mr. Callejo:

RE : REVIEW COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT(DEIS) FOR KAWAINUI MITIGATION FLOOD DAMAGE MITIGATION PROJECT OF NOVEMBER 1989

Thank you for acknowledging my written comments submitted on September 23, 1989 on the preceding Environmental Assessment/Notice of Preparation of EIS documents. Your M&E Pacific consultants addressed most of my stated concerns. By Enclosure (1) to this letter, I am resubmitting for further addressal some remaining concerns and additional comments which were not addressed since my September 23 input. In the remainder of this cover letter, however, I would like to focus my attention on the apparent pattern of repeated abortions of the public participation process in the various proposed actions related to the subject Project.

I would like to continue to be a consulted party to this project, at all stages of its development. However, I am concerned that the public is only now being informed of Army Corps of Engineers' objections to your proposed levee alterations raised by them as early as July 1989 and, in part, reprinted in AppendixC of the subject DEIS, for the first time, for public review. Why has the city spent untold amounts of dollars to proceed with the subject project involving major levee alterations with apparent fore-knowledge that the definition of the proposed action was likely to change significantly, due to the Army Corps of Engineers' concerns and their regulatory authority over any modifications to the levee structure?

I have just learned of your recent negotiations with the Army Corps of Engineers to initiate a revised project scope-to redesign the levee--which will prolong the planning process by two additional years! (Personal communication w/D. Kokubun, Hawai'i Office, National Audubon Society & R. Merriam, President of Kawai Nui Heritage Foundation--who themselves only recently learned of these negotations only after repeated diligent attempts to receive clarification directly from these public officials).

These negotiations are taking place before the public review period for this "old" project scope is completed. These circumstances look like an apparent attempt to mislead the public by asking them to review one project and then turning around and starting another! The taxpaying citizens, the concerned groups, and the flood victims of Coconut Grove deserve better treatment than that. Your M&E Pacific consultatns were proceeding in an apparent sincere attempt to involve the public in this DEIS preparation. Now, with the apparent revised scope in the works, much of their efforts will have to be double-stroked and duplicated.

During the July "public meeting" you held on this project, I personally voiced and wrote down concerns that the Federal regulations be followed in thepreparation of this EIS, not just the state regulations. The Federal regulations involve the public early in the scoping process and require public hearings (not just public meetings). (Refer to 40 Code of Federal Regulations Part 1500 for details) Instead, you are proceeding to revise the scope of a project involving re-entry of a federal agency as a major partner, without advance public notice, toward the objective of a major alteration of the levee. This federal agency--the Army Corps of Engineers --had developed an earlier Environmental Assessment on an earlier version of this project(July 1988) which was also aborted due to overwhelming concerns about their apparent attempts to bypass full public review by doing an EA when clearly an EIS was required. Public outcry at the time is a matter of public record. Nevertheless, I find it especially interesting and apparentlyinconsistent for that agency to have, in that earlier EA, summarily dismissed the levee alteration option because "a massive amount of material" would be required which "may also cause potentially hazardous conditions" and could result in a "catastrophic event if the levee failed during a major flood." Now, they are planning with you toward building such a levee. Clearly, it is a matter of their own records thatthis revised scope will be a major federal action with significant potential for adverse effects on the total human environment. That fact, along with the sporadic record of public input to-date on the various versions of this project, are clear bases for demanding that a full federal EIS process be initiated for this project without further delay!

I am urging this be done inseparate correspondence to the President's Council on Environmental Quality(the entity created by the National Environmental Policy Act to oversee federal agency compliance with the same), the Hawaii congressional delegation, the City Council , the Governor, the Army Corps of Engineers and others at both the national and local levels who are vitally concerned about the proper management of our precious few remaining wetlands, endangered species, national historic heritage, and flood control resources for our taxpaying citizens.

In closing, I repeat my request to continue to be a consulted party for all aspects of this subject project.

Sincerely,

Diane C. Drigot

Diane C.Drigot, Ph.D.

Enclosure (1): Specific Comments on the DEIS

Enclosure (1) to
Dr. D. Drigot's
review comments
on DRAFT EIS for
KAWAINUI FLOOD PROJECT
OF NOV 89

A. Methods of Vegetation Removal

1. You have not yet answered my question raised in my Sep 23 input on what has the city learned about previous applications of herbicide in the marsh/its effectiveness? How has this experience helped the proposed project design now?. Why are these experiences not included as an element in the discussion?

2. Explosives--Your DEIS cites only several references on use of blasting as a wildlife management technique. I have just acquired a new publication produced by the Army Corps of Engineers (cover page attached) that critically evaluates the pros and cons of this technique and includes an extensive bibliography. I urge you to secure a copy from the Army Corps to assist you in planning this aspect of the project.

B. Level of Levee/EIS Requirement

1. You never fully answered my query (par. 5 of Letter of Sep 23) regarding alterations of the levee requiring permits, and federal EIS procedures be followed.

C. Historic Preservation Concerns

1. You attempted to address my concerns about compliance with Section 106 of the National Historic Preservation Act and 36 CFR part 800 regulations about consultation process on this project. Yet your response is still not adequate:

a. You state on p. 2-7 of the DEIS that soil analyses will be taken and consultations will occur with the State Historic Preservation Office; but you say nothing about whether you have determined the project will have "no effect," "no adverse effect" , "adverse effect" or what. and you make no mention of a Data Recovery Plan in progress for monitoring during construction.

b. On p. 3-3 of the DEIS you state that "walls of the fishpond" have not been located which needs clarification. All Hawaiian fishponds did not have walls. Furthermore, an archaeological monitoring report produced by Army archaeologists during emergency clearing of the ditch behind the levee after the New Year's Eve flood documents that archaeological features (possibly fishpond walls) were present in the area. (See Memo for the Record, Army Corps of Engineers CEPOD-ED-PV) of 3 Feb 88.)

c. I am shocked to see a major recent archaeological report omitted from your literature review. Secure a copy of this report and consider its findings in your project assessment of effects. See Allen-Wheeler, Jane. Archaeological Excavations in KawaiNui Marsh, island of O'ahu, (Honolulu: Department of Anthropology, Bishop Museum), prepared for the State Department of Planning and Economic Development, November 1981.

d. You have still not addressed my comment in page 4 of my Sep23 letter regarding why you make no reference to archeological monitoring requirements during construction.

Enclosure (1) to Dr. D. Drigot's
review comments on DRAFT EIS for
KAWAINUI FLOOD PROJECT OF NOV 89

D. Endangered Species Concerns

1. P. 3-19 of the DEIS states that all waterbirds seem to prefer a shallow water/mud and vegetation interface—so use of explosives will have to be shaped toward that end.

2. On p. 3-21 of the DEIS, a list of four means of mitigating potential adverse impacts on endangered species are listed. You need to assure these conditions are built into the specifications for the project. Mitigation measures promised in EIS documents are worthless and canot be complied with if the construction contractor is not aware of them; the contractor's compliance document is the project specifications, so the mitigation measures must be internalized in that document. Assure this is done in the design stage. (Ditto for archaeological monitoring and other measures to mitigate adverse effects on historic/cultural resources that may be agreed to before this project is constructed.)

3. Figure 3-7 of the DEIS has not been revised to reflect accuracy concerns I raised on p. 5 of my September 23 review comments. This figure does not include reference to the presence of endangered waterbird habitat along Hamakua Canal where Kaelepulu stream drains toward Enhanted Lake. Revise to show that endangered waterbirds do reside in that area. This can be verified by examining official bird count records maintained by both the Federal U.S. Fish and Wildlife Service and the State Dept. of Land and Natural Resources Forestry and Wildlife Division. In personal communication with Mr. R. Walker of the DLNR, I asked why this figure did not showthe fact that endangered waterbirds reside along that canal. He said it was because Mr. Engilis's scope of work did not include bird studies along the canal. Yet, your map on figure 3-7 outlines vegetation types along that canal (thus implying that this area was covered in the scope of work). It appears that a false impression is being created here__ (on the map at least) that there are no waterbirds present here.

E. Vegetation Characteristics in Marsh

I am also concerned that this Figure 3-7 shows a vegetation map derived from a 1978 study done my a University of Hawaii student, Linda Lea Smith. Why do you reference a twelve-year old study, after you assured us in the public meeting of July 1989 that you had brought in from Boston a top-notch wetlands ecologist to join your team and make a fresh assessment of the vegetation situation in the marsh? At time of this writing, I am not able to verify with University of Hawaii (offices closed during holiday), but I have it on reliable authority that the Smith Master's Thesis referenced was not accepted as adequate for the thesis defense. If this is indeed true, you are not basing your information on current conditions in the marsh regarding vegetation on the most up-to-date reliable sources. EIS's are supposed to be based on the latest, most accurate scientific information available, from reliable sources. Please verify the currency, reliability, and validity of this resource document.

Enclosure (1) to Dr. D. Drigot's
review comments on the DEIS for
KAWAINUI FLOOD PROJECT ··· ··V 89
Page Three

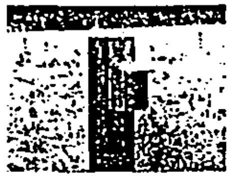
F. Diversion Structure, South End of Kaelepulu Stream

1. Why has this structure been deleted from the DEIS? See my comments on earlier draft EA (p. 5, bottom of my Sep 23 Letter).

G. Conditions under which a Federal EIS would be required

1. The discussion on pp. 6-5 and 6-6 of the DEIS is oversimplified in citing conditions under which a federal EIS review process is triggered for a major action of this nature. I refer you to federal regulations at 40 CFR Part 1508.27, where "Significantly" is further defined. Factors such as degree to which the proposed action affects public health and safety; unique characteristics of the geographic area; the degree the effects on the quality of human environment are deemed to be controversial; the degree to which possible effects are highly uncertain or involve unique or unknown risks; the degree to which the action may establish a precedent for future actions with significant effects; whether the action is related to other actions with cumulatively significant impacts on the total human environment; the degree to which the action adversely affects sites eligible for listing in the National Regiser of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources; the degree to which the action may adversely effect endangered species or habitat; whetherthe action threatens a violation of federal state, or local law or requirements--all these factors affect the determination of whether to perform an EA or EIS on a project.

US Army Corps of Engineers



DEPARTMENT OF DEFENSE
NATURAL RESOURCES PROGRAM

TECHNICAL REPORT EL-89-14

ARTIFICIAL POTHOLES--BLASTING TECHNIQUES

Section 5.5.4, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

by

Chester O. Martin, Larry E. Marcy

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

September 1989
Final Report

Approved For Public Release; Distribution Unlimited

Prepared for DEPARTMENT OF DEFENSE
Fish and Wildlife Committee
Defense Natural Resources Council

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0222

June 7, 1990

Dr. Diane Drigot, Ph.D.
101 Ohana Street
Kailua, Hawaii 96734

Dear Dr. Drigot:

Subject: Kawainui Marsh Flood Damage Mitigation Project - Draft Environmental Impact Statement (DEIS) Response to Your Comments Dated December 21, 1989

Thank you for transmitting your comments regarding the DEIS.

The City has always believed that the Kawainui Marsh flood damage mitigation project issues were complex and controversial. There are many viewpoints to consider: technical, economical, historical, environmental, fish and wildlife, recreational and more. There is no course of action which would be totally agreeable to everyone.

Therefore, the City felt that the appropriate course of action was to publicly present its proposed alternatives and have the public, including the U.S. Army Corps of Engineers (COE) submit comments. It turned out that the COE did have an honest difference of opinion with the City and its consultant, but the City felt that this was positive since concerns were made in the open.

On the other hand, one can imagine the potential public uproar had the City and COE resolved all their differences behind closed doors, especially to the extent that all matters were resolved without public review and input?

The City would like to offer these comments:

1. At no time did the City intentionally mislead the public nor delay the project.

2. If people do not agree with the above, then it's their privilege to believe otherwise. People are entitled to their opinions.

3. The COE held public workshops on February 27, 1990 and April 19, 1990 to discuss alternative solutions.

4. People, however, should refrain from making false remarks or misleading statements. In spite of emotions, only facts and evidence are worthy of serious consideration.

5. Again, since the Kawainui Marsh issues are complex and controversial, the City does not anticipate that a quick and singular alternative can be implemented. Rather, the City would not be surprised to see the implementation of several alternatives over the course of time. These alternatives probably will have varying degrees of success as well as shortcomings.

Attached are our responses to your specific comments.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

Attach.

Response to Your Specific Comments:

A. Methods of Vegetation Removal

1. A single aerial application of Rodeo was made in November 1988. The herbicide Rodeo is a trademark name for a product containing the chemical glyphosate. The objective of the application was to control vegetation. Approximately 7.0 kg/hectare active ingredient was applied to nearly 90 acres. Approximately six pints of chemical were mixed with twenty gallons of water. Surfactant and drift control additives were mixed with the chemical just before application. The helicopter used a 40-ft boom to spray the mix from approximately 10 feet above the target area. Maximum wind speed was estimated to be six miles per hour at the time. The pilot estimated the drift from the target to be 12 to 15 feet. The entire application required approximately 3 hours.

   The single application of the herbicide demonstrated the effectiveness of this method for controlling new growth, but it had little or no effect in terms of altering the structural characteristics of the peat formations above and below the water surface in the marsh. Documentary evidence of this fact was collected in the form of photographs taken during excursions through the marsh and videotapes made from a helicopter overflight.

   By autumn of 1989, the brownish swaths which had been created by the herbicide application were evidencing revegetation. Common species observed colonizing these areas were taro vine (*Epipremnum pinnatum*) and honohono (*Commelina diffusa*). Water level measurements commenced in March 1989 and therefore actual data to show the improvement of water circulation through the marsh as a result of this treatment is nonexistent. In order to make valid comparisons of the effect of the treatment for flood control, water level measurements at various locations during storm runoff periods would be needed both prior to the treatment and after the treatment with herbicide. Furthermore, the biomass remaining after the treatment did not immediately decompose and added another layer of material which creates resistance to horizontal water movement. Species such as sawgrass (*Cladium jamaicense*) and bulrush (*Scirpus spp*), which have long leaves and stems, were bent over but

still able to reduce flow velocity due to their physical obstruction of possible flow paths. The effectiveness of repeated applications of the herbicide in terms of preventing any regrowth were not assessed. It appears, based on the single application, that some type of plant succession will persist. The research we have reviewed did not indicate concern relative to toxicity if applied at recommended rates or biological accumulation in the foodchain (see references accompanying this letter); however, the number of long-term studies we obtained was limited. There is some evidence that it will accumulate at extreme dosage levels but not bioaccumulate at rates comparable to other chemicals. The bioaccumulation factor for glyphosate was reported to range from 0.03 for rainbow trout to 0.18 for channel catfish following fourteen days exposure at 10 milligrams per liter concentration. In comparison DDT has a concentration factor of about 22,500.

The action being recommended proposes two applications of Rodeo. These applications are timed to reduce the dosage levels and coverage in order to reduce the magnitude of adverse effects on water quality. The first application will be made immediately after the completion of the first waterway. The portion of the marsh to be treated includes the waterway and the adjoining pond containing water hyacinth (*Eichornia crassipes*). It will be part of the construction contract to maintain the open water in this first pond. The second application will be made at the height of the growing season and will cover the same area as the first application and, in addition, will include the open water to the south of the waterways abutting the pasture. Cattle will be moved to the pasturage away from the area for a minimum of two weeks during this period. Short-term effects of this type of application are believed to be benign. The chemical decomposes into carbon dioxide, nitrogen, water and phosphate by microorganisms present in the soil and water column. Under laboratory conditions it is reported to be broken down in four weeks. Water samples in Oneawa Canal taken on November 9, 1988, the day of the aerial application, and at four day intervals thereafter (for twenty days) were analyzed for glyphosate and its metabolite. No level of glyphosate was found greater than the laboratory detection limit of 0.01 pp. Its short persistence in the environment is demonstrated by the relatively rapid revegetation that occurred in the marsh in 1989.

A combination of biological, chemical and mechanical control is preferred for long-term maintenance. Total eradication of water hyacinth is not being planned because of its contribution to water quality improvement to waters debouching from the marsh into the emergency ditch and thence to Oneawa Canal. Management of vegetation growth must accompany initial construction; however, long-term maintenance will ultimately depend upon plans not yet formulated with respect to other resource management objectives such as habitat improvement.

2. H&E Pacific received a copy of Technical Report EL-89-14 Artificial Pothole-Blasting Techniques, prepared by Chester O. Martin and Larry E. Marcy, Environmental Laboratory, Department of the Army, Waterways Experiment Station (September 1989) in November 1989, after the DEIS had been prepared. This report summarizes objectives, uses and limitations, methods, maintenance, personnel and costs of pothole blasting. It recommends this technique should be compared to other wetland management means for providing shallow open water such as raising the water level with low head dams or mechanical removal, particularly where heavy construction equipment access is limited.

Raising the water level, particularly during the rainy season is counterproductive to flood control efforts. Sufficient depths of open water can be created with vegetation management; this can be accomplished with mechanical means and blasting, and both are recommended for use in Kawainui Marsh. In the long-term it is essential to learn how to manage the vegetation better because the enormous biological productive capacity has the potential to outstrip efforts to continually raise water levels. In other words, some type of vegetation management must be sought and it would logically have to be done even if a damming structure is built at the downstream end of the marsh.

The report noted above, however, does not address in sufficient technical detail the manner by which explosives could be used to create waterways in a specific setting such as Kawainui marsh. Therefore test blasting was conducted in February 1990. The test objectives were to:

1. Verify assumptions concerning the effectiveness of the explosives in excavating the vegetation;

2. Study pattern, charge weight and depth of placement of the charge on the amount of excavation and the resultant seismic and sonic impacts;

3. Observe what potential adverse effects may occur to either aquatic or avifauna in the marsh during full scale operation.

Explosives were detonated to two sites within the marsh on February 5. Seismographs were installed at three locations around the marsh to monitor both seismic (ground) motion and sonic (air blast) effects. At both test sites, precautions were taken not to endanger any water birds. A warning shot was initiated prior to the main detonation. No water fowl or fish were observed in the area either prior to or after the blast. The explosives were carried into the marsh by personnel contracted by the City to conduct the tests. Approximately 150 pounds were used at each site.

The first site was approximately 2,400 feet from the levee adjoining Coconut Grove. Vegetation was ejected over a maximum distance of approximately 150 feet from the site. The vegetation mat disintegrated into small pieces generally less than six inches maximum dimension with the largest having a maximum dimension of six feet in size. A shallow excavation between 5 to 10 feet, averaging approximately 7.5 feet, was created. The surface dimensions were approximately 47 feet by 33 feet.

The second site was approximately 3,400 feet from the levee. Similar effects were obtained at this site in terms of vegetation may disintegration. A shallow excavation between 2.5 to 7 feet, averaging approximately 5 feet in depth was created. The surface dimensions were approximately 42 feet by 33 feet.

The early findings of the test are as follows:

1. Explosives will create waterways of the shape and dimensions envisioned during the planning of flood control improvements in the DEIS.

2. Large spoil mounds are not created; the mat is disintegrated over a restricted area surrounding the site in the downwind (generally mauka) direction. Ejecta of silt and organic matter covered the downwind areas for approximately 150 to 230 feet depending upon the site.

3. Shallow excavations can be created that do not disturb deep seated sediments, e.g. at 15 to 20 feet depths; the disturbed zone can be limited to the shallower, more recent organic deposits.

4. The shape of the excavation may be conducive to waterbird habitat creation; e.g. the edge areas of parts of excavations are shallow 2.5 feet, and mud flats are created due to the irregular nature of the excavation.

Two months after the test blasts, in April 1990, the sites were checked to identify effects. The following observations were made:

1. At test site 1, waterbirds were flushed from the site upon the approach of humans indicating that some use is being made of these sites;

2. The ejecta from the excavation could not be distinguished from the surrounding vegetation growth;

3. At test site 2, the peat material that was buried below the level of the explosives placement resurfaced. The depth of the peat deposit at this site was estimated (by probing with a survey rod) to be approximately 16 feet thick. The explanation offered at this time is that the hydrostatic buoyancy of the peat repositioned the

material at its new hydrostatic equilibrium; in other words, the material, relieved of four feet of overburden pressure (estimated to weight approximately 900 pounds per square foot) rebounded to the surface.

4. At test site 1, there was some rebound noticed, but not to the same degree, presumably because the depth of peat was less at this location.

B. Level of Levee/EIS Requirement:

1. The City will implement flood control improvements within the marsh. The U.S. Army Corps of Engineers (COE) will concentrate on structural modification to the levee (if any) and related structures. The COE will conform to the NEPA regulation regarding their EIS.

C. Historic Preservation Concerns:

a. An intensive sediment coring study has been undertaken in an attempt to determine what effected the proposed project will have on archaeological resources. This study, which has been coordinated with and reviewed by Dr. Joyce Bath of the State Historic Preservation Office, included the extraction of 10 sediment cores from the proposed channel alignment. The analysis of samples from these cores will provide chronological, paleo vegetation and sedimentary information on the subsurface environment to be impacted by blasting. Until sedimentation rates and chronology of the deposits to be impacted are known, the affect on archaeological resources will remain conjecture. At this point all field work is completed, all 10 cores have been collected and the most representative have been sampled, characterized, and submitted for analysis. The analysis will include C14-dating, lead isotope dating, clay mineralogy organic matter percent and pollen analysis. In addition marine shells have been collected for identification and heavy metal analysis will be conducted. The work should allow for a comprehensive interpretation of the paleoenvironment of the marsh through, its primary purpose is to assess archaeological of the marsh through, its primary purpose is to assess archaeological impact of the proposed channel construction. Contract specifications have been prepared in draft form that addresses data recovery during construction.

b. Archaeologists have covered the area on foot during the coring field work. The environment varies from open water to heavily vegetated marsh, with a vegetation mat floating on 10-15 feet of water. No archaeological features were observed.

c. The report on the coring results to be submitted at the completion of the analysis will include discussion of all relevant previous research, including the work by Allen Wheeler in 1981.

d. As part of the mitigation plan, Dr. Hallett Hammatt was contracted to conduct a subsurface archaeological survey. Joyce Bath, of the State Office of Historic Preservation (SOHP) was consulted in regards to the survey. As a result of this scoping session with SOHP, it was decided that ten core samples would be taken at 1,000 foot intervals along the proposed waterway alignments and the results of the analysis of these cores would be included in the FEIS.

We are anticipating that after analysis of the cores and further consultation with SOHP, it has been determined that no archaeological or historic resources will be affected by the proposed project. SOHP will continue to be consulted as work progresses. In the event that any unanticipated sites or remains are discovered, work will be stopped until SOPH has been notified and is able to assess the potential impacts of the project and make further recommendations for mitigative action if deemed necessary.

D. Endangered Species Concerns:

Kawainui Marsh provides a variety of habitat values for several important waterfowl. The Hawaiian Coot, *Fulica americana alai*, build nests in the vegetated areas of wetlands or its edges, above water levels, yet is an excellent diver and obtains much of its food from below the water surface. The Hawaiian Gallilnule, *Gallinula chloropus sandvicensis*, also nests in vegetated areas of wetlands or its edges, on the edge of the wetlands. Feeding, however, on aquatic insects, mollusks aquatic plants and algae, the bird is dependent on the presence of open water for adequate feeding habitat. The Hawaiian Duck, *Anas wyvilliana*, is a ground nester and

therefore dependent on relatively dry areas for successful reproduction. This omnivore is more reliant on moist areas for food production, yet feeds in shallow open waters as well. The Hawaiian Stilt, *Himantopus mexicanus kundseni*, is a common inhabitant of the shallow water shorelines of Kawainui. Feeding on aquatic insects and crustaceans, this species nests close to the water. The black-crowned night heron, *Nycticorax nycticorax hoactli*, is also frequently seen along the shorelines of Kawainui Marsh. Preferred feeding habitat includes areas supporting aquatic insects, fish, as well as small amphibians and small mammals; consequently the black-crowned night heron needs aquatic as well as upland habitat, although nests are located generally close to the water. A variety of other birds (egrets, ducks, doves, sparrows and finches) also make occasional use of the wetland/upland boundary habitat surrounding Kawainui Marsh.

Proposed changes in the water levels within Kawainui Marsh will reduce the magnitude of excursions of water level changes, but not eliminate the fluctuating water level so necessary to sustain this vital ecosystem. The proposed changes will also reduce the seasonal extreme water level fluctuations caused by the impoundment conditions surrounding the marsh. By providing a more seasonally stable, yet moderately fluctuating, water level, the proposed management approach will provide more protected vegetated wetland habitat for nesting as well as feeding. In addition, the vegetation control proposed will result in more permanent areas of open water where open water feeding activities can occur. With improved seasonally stable nesting habitat and additional, continually available open water feeding areas, these waterfowl should experience a significant improvement as a result of implementation of the proposed actions. Continuation of small excursions in water level will afford suitable feeding habitat for many shorebirds and herons as well..

E. Vegetation Characteristics in Marsh:

While office studies relied on the identification of Kawainui Marsh vegetation based on published and unpublished studies (including the work of Linda Lea Smith), identification of the major plant species was confirmed by M&E's Wetlands Science Technology Leader. With over 26 years experience in wetlands ecology, Dr. Robert J. Reimold has published widely on wetlands from numerous locations around the world. Based on postdoctoral studies with Professor Eugene P. Odum, Dr. Reimold also spent one year working with Professor V. J. Chapman (Aukland University) author of numerous books and technical articles regarding wetlands of the world. During his site visit to Kawainui in May 1989, Dr. Reimold confirmed the identification of plant species and also conferred with University of Hawaii staff and others on Ms. Smith's committee regarding the validity of Ms. Smith's thesis, and the veracity of the data in the document. There are no reasons to determine that there are any deficiencies in the identification of wetlands plants in Kawainui.

F. Division Structure, South end of Kaelepulu Stream, see B.

The impacts of this structure would be minimal, therefore deleted from the DEIS. However, the proposed action doesn't include work outside the marsh.

G. The proposed action will not be financed by Federal Funds, nor will a Federal permit be required. Compliance with Section 106 of the National Historic Preservation Act and a formal Memorandum of Agreement (MOA) is not required for the proposed project since Federal action is not involved.

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JOHN WAIHEE
GOVERNOR OF HAWAII

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JAN 3 1990

REF:OCEA-VIN

90-0019

File No.: 90-276
Doc. No.: 7099E

Marvin T. Miura, Ph.D., Director
Office of Environmental Quality Control
465 South King Street
Honolulu, Hawaii 96813

Dear Dr. Miura,

Subject: Draft EIS for the Kawainui Marsh Flood Damage Mitigation Project

We have reviewed the subject document and offer the following Divisional comments for consideration.

Historic Preservation Program:

In section 3, Description of the Affected Environment, cultural/archaeological resources are addressed. However, the DEIS states only that consultation culminating in an Memorandum of Agreement should be sought. The final must state that such consultation shall be sought, and a Memorandum of Agreement concluded. Our office supplied M&E with a table identifying the archaeological sites shown on Figure 3-3, and this table should be included in the final EIS.

The probable impacts of the proposed action on archaeological sites are not addressed in Section 4. In this section, the EIS should state that the known archaeological sites will be avoided, and thus "no adverse effect" to known sites is anticipated.

It should also state that an archaeologist has been contracted to work with M&E engineers in analyzing soil samples from the areas of the marsh which will be impacted, to retrieve data which will help identify ancient Hawaiian uses of the marsh. These samples will be taken by coring, with the initial purpose of charting the bottom profile of the marsh. In effect, analysis of these cores will also constitute a subsurface archaeological survey. The survey results will constitute a base for determining further appropriate mitigation, and developing the MOA.

Division of Aquatic Resources:

Although a temporary upset to the biota dependent upon the marsh will occur, the clearance of channels with resultant increased water flows should, over the long term, substantially improve associated environmental conditions, including utilization of the marsh as a nursery area by marine/estuarine species. In addition, passage through the Marsh by native stream species, specifically a goby (Awaous stamineus) and a shrimp (Atyoida bilsulcata) and perhaps other species, will be encouraged. (The draft EIS, in an error of ommission, does not recognize the presence of these highly significant species.) Removal of rooted grass in particular will substantially increase the availability of habitat for larger aquatic organisms in the Marsh.

Control of water hyacinth may prove to be more intractable than is envisioned in the draft. Consideration may have to be given to periodic herbicide applications. With judicious use, the risk to aquatic organisms would be small.

If at all possible, the use of explosives should be restricted to the summer and early fall, when the native stream species are less likely to be migrating through the swamp. These species tend to move enmasse over short periods. Badly timed blasting could significantly deplete the local populations.

It is unclear whether movement between the Marsh and the Oneawa Canal will be possible for fishes during low flow periods or whether that passage will be blocked by weirs. Provisions should be made to ensure such movements can occur with minimal interference.

Division of Forestry and Wildlife:

1. Page 2-1: II Emergency Improvements, line 4. An emergency authorization for temporary exemption from the CDUA process was also granted by the Department of Land and Natural Resources.

2. Pages 2-4 through 2-12: Section 2, Description of the Proposed Action. A discussion of the effects of the improvements on water levels within the Marsh as related to current open water habitat for endangered waterbirds and migratory waterfowl should be included.

3. Pages 2-8 & 4-2: "Provide for rapid evacuation of overflow water from Kaelepulu Stream into Oneawa outlet canal."

We would be opposed to reducing the present water level of Kaelepulu Stream and the anticipated increase in salinity as Kaelepulu Stream feeds other wetland areas along the stream. This action would require a discussion on the environmental effects or impact on the biota of Kaelepulu Stream and adjacent wetland areas. It is also not clear if there will be any effect on the marsh when fresh waters drawn from the marsh is used to influence the water level in Kaelepulu during dry spells when run-off from Coconut Grove does not occur.

However, if it is necessary to open a drainage for Kaelepulu into Oneawa Canal, [illegible] recommend the construction of a water level control str[illegible] this drainage to maintain a constant water level in Kaelepulu at a level that would not cause an increase in salinity and drainage or drying of adjacent wetlands.

4. Page 3-10: It should be noted that the State Department of Land and Natural Resources also has regulatory responsibilities of wildlife and activities related to land use within the Conservation zoned lands.

5. Page 3-18: Native fresh water fauna in Oneawa Canal, Kaelepulu Stream or Kawainui Marsh is not listed.

   1st paragraph. The entire wetland of Kawainui Marsh is considered essential habitat for endangered waterbirds by the Recovery Team, not "a portion."

   Fauna. The previous paragraph (Birds) includes "fauna" (animals) as well. Suggest this be labelled "Other Fauna."

   Endangered Species. Englis was reporting on current significant use of the marsh by waterbirds, not designating essential habitat. The Waterbird Recovery Plan previously cited did that (see previous comment above).

6. Page 3-22: Table 3-2. Hawaiian Stilt: The heron should also be listed as a predator of stilt chicks. The nesting period could extend into August.

   Hawaiian Coot: The Hawaiian Coot is not known to prefer brackish water over fresh water. They will utilize fresh, brackish, and salt water.

   Hawaiian Duck: The Koloa will also feed on crustaceans and small fish.

7. Figure 3-7: It should be noted that the Hawaiian Gallinule will utilize the "Rushes and Sawgrass" area.

8. Page 4-2: The test and use of explosives should be coordinated with U.S. Fish and Wildlife Service and State Department of Land and Natural Resources.

9. Page 4-7: It should be noted that the State Department of Land and Natural Resources regulates land use activities in Conservation Zoned lands through a permit system and does not have ecological and cultural management responsibilities of the Marsh at this time. This was also pointed out in our comments on August 7, 1989 to the Draft EIS for Kawainui Marsh.

10. As the proposed action will create open water that would be an attraction to certain segments of the public, wouldn't fencing the Marsh be a part of this project as liability could be a big problem.

11. We would be opposed to alternatives I - "No Action"; III - "Diverson of Flow Around the Marsh"; and IV - "Levee Raise/Channelization."

Division of Water and Land Development

We continue to support the utiliztion and modification of the existing flood control systems within the Kawainui Marsh. The draft EIS adequately describes the various flood control alternatives. However, we suggest that the Final EIS disclose the fact that the Corps of Engineers has expressed a desire to implement its own design for levee improvements, as noted in the City and County of Honolulu Department of Public Works memorandum of October 20, 1989.

INSTREAM USE PROTECTION. The draft EIS adequately describes the aquatic fauna and avifauna present in the marsh. However, attention is focused on impact to and management of waterbird habitat. Potential impact to native diadromous stream species should be given more attention; in particular, the effect of water control structures on stream fauna migration and changes in salinity within Oneawa Canal, Kaelepulu Stream, and the marsh.

We also note that the statement under the heading "Other Approvals", on page 6-6 inidicates that action by the Commission on Water Resource Management depends on whether the proposed action falls under the Commission's definition of stream maintenance.

It should be noted that under the State Water Code only routine streambed and drainageway maintenance acitivities and the maintenance of existing facilities are exempt from obtaining a stream channel alteration permit as required under Chapter 13-169-50, Department of Land and Natural Resources Administrative Rules. Routing maintenance generally means the periodic removal of vegetation and debris from the channel. Channel dredging, large scale vegetation removal, and similar maintenance work are not exempt activities. Furthermore, the construction of water control structures, levees, and new channels, as well as changing the direction of streamflow within an existing channel, are activities that are considered to be stream channel alterations. As such, under the State Water Code, a stream channel alteration permit will be required for the marsh work being proposed.

Thank you for the opportunity to review and comment on this draft EIS.

Very truly yours,

William W. Paty

cc: Sam Callejo, Director and Chief Engineer, DPW
James Dexter, M&E Pacific, Inc.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0233

June 7, 1990

Mr. William W. Paty, Chair
State of Hawaii
Department of Land and Natural Resources
P.O Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated January 3, 1990

Thank you for transmitting your comments regarding the DEIS.

Our response to your comments are as follows:

Historic Preservation Program Concerns:

A Memorandum of Agreement (MOA) is usually done when Federal action is required for a project. The MOA outlines what additional testing and monitoring are to be done and signifies a commitment to historic preservation. We believe that a commitment has been made to preserving the archaeological integrity of the site of the proposed project.

Dr. Hallett Hammat was contracted to conduct a subsurface archaeological survey. Ten core samples were taken at 1,000-foot intervals along the proposed waterway alignments and the results of the analysis of these cores will be included in the Final Environmental Impact Statement (FEIS). Joyce Bath, of the State Office of Historic Preservation has been consulted in regards to the coring and core analysis. The State Office of Historic Preservation will continue to be consulted as work progresses. The table which identifies the archaeological sites will be included in the FEIS.

Division of Aquatic Resources:

Concern over potential long-term effects of indiscriminate herbicide spraying is the reason why more applications of chemicals is not presently being recommended. However, as the comment notes, removal of vegetation is challenging. At least, two applications are planned at this time during the initial construction of the waterways. The amount of open water that is to be created and maintained is being carefully considered in relationship to the necessary equipment and handling facilities that must be constructed to manage vegetation growth along the waterways.

A contingency plan may be warranted as this comment suggests. In response to this concern, a stipulation has been added to the proposed action to indicate that further chemical applications may be necessary at yet undetermined intervals and locations. However, to limit indiscriminate application, the initial Conservation District Use Application (CDUA) will seek permission to make repeated applications at the same recommended dosage to problematic areas along the waterways each year up to a period not to exceed two years after the initial applications. During this time, more complete documentation of the possible effects can be determined. Applications that may be required after that period can be scrutinized during permit renewal based on the experience accumulated during the ensuing period.

The recommendation has been made that the use of explosives should be limited to summer and early fall in order to minimize impact on migratory fish. Unfortunately, the peak nesting time of the four species of endangered waterbirds living in the marsh occurs between March and September. In order to avoid affecting these birds, blasting must take place between October and February.

However, the use of explosives during the construction of the waterways can be accomplished with minimum impact to aquatic animals. The alignments for the waterways have been reconnoitered to verify that the existing subsurface is not suitable habitat for the species identified as being of concern. (The FEIS will contain additional information regarding marine/estuarine species). The factors that preclude habitat viability at this time include:

1. Presence of saturated peat deposits along major portions of the waterway which eliminates the possibility of movement of fish;

2. The anaerobic condition of the subsurface environment, as indicated by the low dissolved oxygen measurement (see Table B-9, DEIS).

Other factors that will provide necessary environmental quality oversight include:

1. Stipulations developed in the contract specifications to prohibit the use of explosives in areas adjoining the existing open water ponds;

2. Requirements in the contract specifications that require the construction contractor to submit a blast design, conduct a test of the design prior to full scale implementation, and submit plans that provide the sequence of construction activities desirable to minimize exposure of fish population.

The low flow weir contained in the proposed action shown in the DEIS would have restricted upstream migration of fish during low flow period. However, at present, when the outflow through the emergency ditch is very limited, migratory movements are restricted due to the shallow depths of flow over rock outcrops that form riffles in the ditch. With the previously proposed weir, this restriction would have been more difficult for species to traverse, but not impossible.

However, due to comments received from the COE regarding the previously proposed plan, all elements of that plan associated with or impacting the levee have been abandoned in favor of the COE's engineering studies now underway. Thus, there are no weirs being recommended, nor are there any changes to the existing outlet of the marsh as part of this action by the City, therefore, no impact relative to movement between Oneawa Canal and the marsh.

Division of Forestry and Wildlife:

The FEIS will be amended to state that an emergency authorization for temporary exemption from the CDUA process was also granted by the State Department of Land and Natural Resources (DLNR).

Table 6, which summarizes the applicable reviews, permits, and/or approval required for the proposed action will be amended in the FEIS to reflect the Division of Forestry and Wildlife's responsibilities in regard to wildlife and activities related to land use within the Conservation District. Also, the FEIS will be amended as recommended in regards to fauna and endangered avifauna.

Both the U.S. Fish and Wildlife Service and the Division of Forestry and Wildlife have been consulted in regards to the use of explosives in the marsh. Both agencies will be consulted as work progresses.

No fencing will be included in this project.

Proposed changes in the water levels within Kawainui Marsh will reduce the magnitude of excursions of water level changes but not eliminate the fluctuating water level so necessary to sustain this vital ecosystem. The proposed changes will also reduce the seasonal extreme water level fluctuations caused by the impoundment conditions surrounding the marsh. By providing a more seasonally stable, yet moderately fluctuating, water level, the proposed management approach will provide more protected vegetated wetland habitat for nesting as well as feeding. In addition, the vegetation control proposed will result in more permanent areas of open water where open water feeding activities can occur. With improved seasonally stable nesting habitat and additional, continually available open water feeding areas, these water fowl should experience a significant improvement as a result of implementation of the proposed actions. Continuation of small excursions of water level will afford suitable feeding habitat for many shorebirds and herons as well.

Division of Water and Land Development:

The FEIS will contain information regarding the present status of the agreement between the City and the COE.

A determination will be required to resolve whether the proposed action falls under the Commission's definition of stream maintenance. Preliminary inquiry indicates that the proposed action is beyond the scope of routine maintenance as defined by the Commission; if this is the case, a stream channel alteration permit will be sought.

In regards to potential impact to native diaromous stream species, as previously mentioned, there are no weirs being recommended, nor are there any changes to the existing outlet of the marsh as part of this action by the City and therefore, no impact relative to movement between Oneawa Canal and the marsh.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

JOHN WAIHEE
GOVERNOR OF HAWAII

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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
LIBERT K. LANDGRAF
MANABU TAGOMORI
RUSSELL N. FUKUMOTO

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE HISTORIC PRESERVATION
STATE PARKS
WATER AND LAND DEVELOPMENT

December 14, 1989

MEMORANDUM

TO: Marvin T. Miura, OEQC

FROM: Don Hibbard, Director, Historic Preservation Program

SUBJECT: Review of DEIS - Kawainui Marsh Flood Damage Mitigation Project File No.: 90-276

HISTORIC PRESERVATION PROGRAM CONCERNS:

In section 3, Description of the Affected Environment, cultural/archaeological resources are addressed. However, the DEIS states only that consultation culminating in an Memorandum of Agreement should be sought. The final must state that such consultation shall be sought, and a Memorandum of Agreement concluded. Our office supplied M & E with a table identifying the archaeological sites shown on Figure 3-3, and this table should be included in the final EIS.

The probable impacts of the proposed action on archaeological sites are not addressed in Section 4. In this section, the EIS should state that the known archaeological sites will be avoided, and thus "no adverse effect" to known sites is anticipated.

It should also state that an archaeologist has been contracted to work with M & E engineers in analyzing soil samples from the areas of the marsh which will be impacted, to retrieve data which will help identify ancient Hawaiian uses of the marsh. These samples will be taken by coring, with the initial purpose of charting the bottom profile of the marsh. In effect, analysis of these cores will also constitute a subsurface archaeological survey. The survey results will constitute a base for determining further appropriate mitigation, and developing the MOA.

DON HIBBARD

cc: James Dexter, M & E Pacific
Sam Callejo, Director & Chief Engineer, DPW

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0234

June 7, 1990

Mr. Don Hibbard, Director
Historic Preservation Program
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Hibbard:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 14, 1989

Thank you for transmitting your comments regarding the DEIS.

Our response to your comments are as follows:

Historic Preservation Program

A Memorandum of Agreement (MOA) is usually done when Federal action is required for a project. The MOA outlines what additional testing and monitoring are to be done and signifies a commitment to historic preservation. We believe that a commitment has been made to preserving the archaeological integrity of the site of the proposed project.

Dr. Hallett Hammatt was contracted to conduct a subsurface archaeological survey. Ten core samples were taken at 1,000 foot intervals along the proposed waterway alignments and the results of the analysis of these cores will be included in the FEIS. Joyce Bath of the State Office of Historic Preservation has been consulted in regards to the coring and core analysis. The State Office of Historic Preservation will continue to be consulted as work progresses. The table which identifies the archaeological sites will be included in the FEIS.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET

FRANK F. FASI
MAYOR

DONALD A. CLEGG
CHIEF PLANNING OFFICER

MM/DGP 11/89-4152

December 11, 1989

Honorable Marvin T. Miura, Director
Office of Environmental Quality Control
State of Hawaii
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)

This is in res... to your request for comments on the Kawainui Marsh Dr... Environmental Impact Statement.

The EIS should indicate that an amendment to the Development Plan Public Facilities Map is necessary to establish drainage improvements for Kawainui.

The Alternatives section should be revised to provide a clearer discussion as to the effectiveness of each alternative in meeting the perceived problem; i.e., the need for drainage improvements in Kawainui Marsh to effectively distribute and store storm water runoff in order to reduce the potential for downstream flooding.

The Final EIS should also incorporate the findings of the Corps of Engineers' recently initiated Reconnaissance Report and elaborate on funding i.e. City, Federal, State, of the proposed improvements.

Thank you for the opportunity to comment on this matter.

Sincerely,

DONALD A. CLEGG
Chief Planning Officer

DAC:js

cc: Department of Public Works
✓H & E Pacific, Inc.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0239

June 5, 1990

MEMORANDUM

TO: MR. BENJAMIN LEE, CHIEF PLANNING OFFICER
DEPARTMENT OF GENERAL PLANNING

FROM: SAM CALLEJO, DIRECTOR AND CHIEF ENGINEER
DEPARTMENT OF PUBLIC WORKS

SUBJECT: KAWAINUI MARSH FLOOD DAMAGE MITIGATION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
RESPONSE TO YOUR COMMENTS DATED DECEMBER 11, 1989

Thank you for transmitting your comments regarding the DEIS.

We offer the following response to your comments:

1. The DEIS will indicate that an amendment is required. This will be shown on Table 6-1. My staff will submit the necessary documents to have the map amended.

2. See Section Two for discussion.

3. See Section One for discussion.

You review of the DEIS is appreciated.

SAM CALLEJO
Director and Chief Engineer

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0232

June 13, 1990

Ms. Doris N. Barck, President
The Lani-Kailua Outdoor Circle
P.O. Box 261
Kailua, Hawaii 96734

Dear Ms. Barck:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 20, 1989

Thank you for transmitting your comments regarding the DEIS.

The City has always believed that the Kawainui Marsh flood damage mitigation project issues were complex and controversial. There are many viewpoints to consider: technical, economical, historical, environmental, fish and wildlife, recreational and more. There is no course of action which would be totally agreeable to everyone.

Therefore, the City felt that the appropriate course of action was to publicly present its proposed alternatives and have the public, including the U.S. Army Corps of Engineers (COE) submit comments. It turned out that the COE did have an honest difference of opinion with the City and its consultant, but the City felt that this was positive since concerns were made in the open.

On the other hand, one can imagine the potential public uproar had the City and COE resolved all their differences behind closed doors, especially to the extent that all matters were resolved without public review and input?

In closing, the City would like to offer these comments:

1. At no time did the City intentionally mislead the public nor delay the project.

THE LANI-KAILUA OUTDOOR CIRCLE
P. O. BOX 261
KAILUA, HAWAII 96734
December 20, 1989

RECEIVED
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Mr. Sam Callejo, Director
Department of Public Works
650 South King Street 11th Floor
Honolulu, HI 96813

Dear Mr. Callejo:

Following is our response to a new Draft Environmental Impact Statement for Flood Control in Kawai Nui Marsh. We were completely taken by surprise by it as we were assuming that the M&E proposal was still in process. Our representative participated in Councilman Felix's Public Works Committee Task Force in September and October without discussion of any current objections by the COE or rationale for possible change in the works. Some element of inappropriate parallel discussion and decision-making by COE and DPW seems to have been in process at that time. It was obviously withheld from the collective interest and expertise comprising the Felix Task Force.

We understand and agree that flood control is the primary issue, but we are unqualified to argue levee vs. flood gates vs. alternate drainage patterns, etc. We were pleased with the esthetics of the M&E alternative and were reassured by the idea of a new overflow flood drainage scheme. However, this new prospect of adding 6 ft. to the height and the width of the existing levee and paving it over got our attention. It is hard to envision this wall as anything but an unacceptable insult to the esthetics and all other intangible values of Kawai Nui Marsh, the green heart of Kailua and a world class resource for education and preservation.

We hope that more constructive interagency discussion and cooperation will elicit a better solution to the problem of flood control for Kawai Nui.

Sincerely yours,

Doris N. Barck
Doris N. Barck, President
Lani-Kailua Outdoor Circle

cc: Corps of Engineers
Councilman Felix

2. If people do not agree with the above, then it's their privilege to believe otherwise. People are entitled to their opinions.

3. The COE held public workshops on February 27, 1990 and April 19, 1990 to discuss alternative solutions.

4. People, however, should refrain from making false remarks or misleading statements. In spite of emotions, only facts and evidence are worthy of serious consideration.

5. Again, since the Kawainui Marsh issues are complex and controversial, the City does not anticipate that a quick and singular alternative can be implemented. Rather, the City would not be surprised to see the implementation of several alternatives over the course of time. These alternatives probably will have varying degrees of success as well as shortcomings.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

KAILUA NEIGHBORHOOD BOARD NO. 31
c/o KAILUA SATELLITE CITY HALL • 639-A KAILUA ROAD • KAILUA, HAWAII 96734
Please Note New Address: P.O. BOX 487, Kailua HI 96734

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TO ________

December 21, 1989

Eng. 89-6800

DEC 28 4 23 PM '89

Director and Chief Engineer Sam Callejo
Department of Public Works
City and County of Honolulu
650 So. King Street
Honolulu, HI 96813

SUBJ: Kawai Nui Marsh Flood Damage Mitigation Project EIS.

Dear Mr. Callejo:

We were intending to comment extensively on the Kawai Nui Marsh Flood Damage Mitigation Project Environmental Impact Statement. However, it has come to our attention that the Corps of Engineers and the City have been having meetings discussing alternative solutions without notifying the public. This appears to be a subversion of the public review process. Therefore, we would assume this EIS to be invalid at this time.

We have heard that the City has known since July 1989 that the Corps would reject the design modifications proposed in this plan. Why has the City pursued this course of action knowing the Corps would never issue the necessary permits? If the idea of overtopping the dike at Kaelepulu is unacceptable to the Corps because of present dike construction, then why was it proposed in the first place? We understand the alternative plan is to build a 17 foot high concrete flood wall along the length of the dike. We question the prudence or desirability of such an undertaking. And, we doubt the people of Kailua will find this plan acceptable, given the potential for sudden failure and inundation such a barrier might pose.

We are in favor of the proposed clearing of waterways randomly throughout the marsh to create more open water and more water edges for the birds that frequent the area. We are concerned that if a flood gate of some sort is not installed at the Oneawa end there might be a problem with maintaining an adequate water level in the marsh to sustain wildlife opimally in times of drought or low water flow.

Another concern we have is the increased time another feasibility study and implementation will take. It looks like another two years before anything will be accomplished. We doubt that the people of Coconut Grove are willing to jeopardize their lives and property while the City and the Corps continue with this seemingly endless procrastination. An *"Unresolved Issue"* is cited as:"*. . .the vast array of government responsibilities in resource management have not been coordinated nor enforced systematically . . .*" We suggest that it is time that SOMEONE took overall responsibility for this situation. All along we have had the City and State bickering, and now we have the Federal government in on the fray! And the people of Coconut Grove continue to be vulnerable to flood.

A second *"Unresolved Issue"* is the problem of controlling the input of nutrients and sediment into the marsh. No proposals have been identified to address this ongoing concern. We cannot help but feel that increased development upslope or around the perimeter of the marsh or along it's feeder streams will continue to exacerbate this problem. Yet, nothing is being done to prevent increased earth movement and development around the marsh. There are no controls which limit the fertilizers being used near streams that flow into the marsh and ultimately contribute to increased vegetative productivity therein. We think this should be taken into consideration, especially in the Maunawili Valley area.

In addition to a new feasibility study, we would like to see a full environmental review be done in accordance with the National Environmental Protection Act. And we would like a precise definition and description of the project that we are asked to review.

Finally, since significant changes appear to have been incorporated into the overall project, we feel the people of Kailua should be fully informed as to the new proposals which are under consideration. We would be happy to offer our Neighborhood Board resources to facilitate such a presentation. We are confident that your agency shares our community's concern for proper marsh management and effective flood control and we stand ready to offer any assistance possible to accomplish timely achievement of that goal.

Sincerely,

Bonnie L. Heim

BONNIE L. HEIM, Chair
Kailua Neighborhood Board

cc: Hawaii's Congressional Delegation
Kailua's State Legislators
Kailua's City Councilmen
Sun Press

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO:

90-12-0222

June 13, 1990

Ms. Bonnie L. Heim, Chair
Kailua Neighborhood Board No. 31
c/o Kailua Satellite City Hall
629-A Kailua Road
Kailua, Hawaii 96734

Dear Ms. Heim:

Subject: Kawainui Marsh Flood Damage Mitigation Project - Draft Environmental Impact Statement (DEIS) Response to Your Comments Dated December 21, 1989

Thank you for transmitting your comments regarding the DEIS.

The City has always believed that the Kawainui Marsh flood damage mitigation project issues were complex and controversial. There are many viewpoints to consider: technical, economical, historical, environmental, fish and wildlife, recreational and more. There is no course of action which would be totally agreeable to everyone.

Therefore, the City felt that the appropriate course of action was to publicly present its proposed alternatives and have the public, including the U.S. Army Corps of Engineers (COE) submit comments. It turned out that the COE did have an honest difference of opinion with the City and its consultant, but the City felt that this was positive since concerns were made in the open.

On the other hand, one can imagine the potential public uproar had the City and COE resolved all their differences behind closed doors, especially to the extent that all matters were resolved without public review and input?

The City would like to offer these comments:

1. At no time did the City intentionally mislead the public nor delay the project.

2. If people do not agree with the above, then it's their privilege to believe otherwise. People are entitled to their opinions.
3. The COE held public workshops on February 27, 1990 and April 19, 1990 to discuss alternative solutions. The COE will conform to NEPA regulations regarding their EIS.
4. People, however, should refrain from making false remarks or misleading statements. In spite of emotions, only facts and evidence are worthy of serious consideration.
5. Again, since the Kawainui Marsh issues are complex and controversial, the City does not anticipate that a quick and singular alternative can be implemented. Rather, the City would not be surprised to see the implementation of several alternatives over the course of time. These alternatives probably will have varying degrees of success as well as shortcomings.

Your review of the DEIS is appreciated.

Very truly yours,

Sam Callejo

SAM CALLEJO
Director and Chief Engineer

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

89-6684 ENV ENGR.

REPLY TO ATTENTION OF:

December 18, 1989

Planning Branch

RECEIVED DEPT. OF PUBLIC WORKS
DEC 20 4 47 PM '89
TO

Honorable Frank F. Fasi
Mayor of the City & County of Honolulu
c/o Department of General Planning
650 South King St., 8th Floor
Honolulu, Hawaii 96813

Dear Mayor Fasi:

We have reviewed the November 1989 DEIS for the Kawainui Marsh Flood Damage Mitigation Project prepared by M&E Pacific for the City and County of Honolulu. Attached are our comments which have been forwarded to the parties indicated in the November 23, 1989 OEQC Bulletin. Thank you for the opportunity to comment.

Sincerely,

for K... LRC DOE
Donald T. Wynn
Lieutenant Colonel, U.S. Army
District Engineer

Attachment

Copy Furnished:

✓Mr. Sam Callejo
Director and Chief Engineer
City and County of Honolulu
Department of Public Works
650 South King Street
Honolulu, Hawaii 96813

Mr. James Dexter
M&E Pacific
1000 Bishop St., Suite 500
Honolulu, Hawaii 96813

RECEIVED
DEC 26 AM '89

U.S. Army Engineer District, Honolulu — 15 December, 1989

Review of Draft Environmental Impact Statement

Titled

Kawainui Marsh

Flood Damage Mitigation Project Prepared by M&E Pacific

Dated November, 1989

These comments are provided by the Honolulu Engineer District in response to a letter dated November 14, 1989 from the City and County of Honolulu, Department of Public Works (DPW). We wish to set the record straight regarding the timeliness of our comments on the EA and EIS Preparation Notice. The Corps did not receive a copy of these in August of 1989 when many others apparently did. In fact, the Corps did not receive its copy until after it was mailed with a letter of transmittal dated October 5, 1989 from the City and County of Honolulu Department of Public Works (DPW). Since the stated deadline for comments on the EA and EIS Preparation Notice was October 7, 1989 the Corps obviously did not have sufficient time to meet the deadline. Although our comments dated October 26,1989 are included in the DEIS, the Corps received unjustified criticism in the DEIS and from other reviewers for not responding in a timely manner.

SUMMARY OF MAJOR CONCERNS

1. As we stated in our prior written comments of October 26, we support the portions of the preferred plan which recommend the concept of creating open water habitat. We are in support of marsh management action which enhances the marsh from fish and wildlife, educational, and cultural resource perspectives.

2. However, we remain unable to support the analysis and conclusions reached with respect to the proposed modifications to the federal flood control levee. The additional data provided in the DEIS confirm our earlier concerns as stated in our August 4, 1989 letter to the Department of Public Works regarding assumptions made, conclusions reached, and the overall safety of the proposed action.

3. The DEIS contains a wealth of information, is well written, but somewhat disorganized since important information on the proposed action and alternatives is scattered in several portions of the document and appendices. Most importantly, the DEIS is deficient in information pertinent to allow comparisons among

Encl

alternatives. Options within the alternatives should be evaluated (e.g. vegetation clearing only, combination of clearing vegetation and along existing ditch). The DEIS needs to clearly, comprehensively, and rigorously present these analyses. Comparisons should also involve feasible integrated combinations of two or more generic alternatives. Not adequately addressed in the DEIS are combined plans of 1) opening up waterways in the marsh, 2) raising the levee, and 3) widening the existing C&C ditch. There exists criticism in the DEIS for the feasible alternative of a levee raise, yet a levee raise is considered in the proposed plan.

4. The DEIS recommends concurrent review of the proposed action by our Corps of Engineers headquarters to expedite construction of the proposed action. In fact, the proposed action for modification of the levee cannot be recommended to Corps headquarters for their review for the many reasons stated below.

WATERWAYS

5. Although we support the creation of open water which the DEIS recommends, we question the manner in which the discussion explains its contribution to flood control. On pages 2-5 and A-55 the DEIS states that the purpose of creating the new waterways is to "meet or exceed the design objective of providing 3,000 acre-feet of flood storage capacity between the marsh and the top of the levee". The DEIS further states that this is the central principle for the preferred alternative and why it is designated improvement of storage. It would seem that the DEIS should indicate clearly what contribution the creation of waterways has to flood control as well as to waterbird habitat and aesthetic value. Perhaps it should be more clearly stated that vegetation removal to provide open waterways would help in transporting floodwaters to portions of the marsh not otherwise utilized for flood storage during a flood event.

6. The creation of the waterways or channels is proposed first using explosives and then followed by mechanical means. No analysis is presented to support the selection of two waterways versus one larger open waterway regarding initial construction cost or followup maintenance. The equipment identified for mechanical removal of vegetation (e.g. Aquamog, Cookie Cutter) should not require blowing apart the vegetation to facilitate removal and may not warrant the additional cost and risk associated with blasting in areas that will utilize the aquamog anyway. Other areas, in which heavy equipment cannot be deployed, may benefit from the blasting technique. Burning of dried, stockpiled vegetation in situ should also be evaluated as a disposal alternative.

LEVEE DESIGN CHANGES

7. The table shown on page A-59 purports to show that no matter what the beginning elevation of stored water in the marsh is at before the occurrence of a flood event, the maximum water level reached from the 100-year design event will be virtually unchanged. This illogical conclusion may have been reached through errors in properly calibrating the finite-element-model used to design the proposed project. The basic model calibration was from high flows in April 1989 which represented about a 10-year frequency occurrence. The April 1989 event should not be totally relied upon to predict 100-year marsh levels when even slight errors in peak marsh levels along the levee overflow section will result in catastrophic conditions within Coconut Grove. As water levels change in the marsh, the relative roughness between nodes may also change. The model as used in this design may not predict the effects of natural channels which form through the marsh during major flood events. Additionally, the proposed plan assumes marsh hydraulic conditions will remain static and predictable. The New Year's 88 flood clearly demonstrated the results of continuous marsh change. Since the levee overflow section is very long (1400 feet) and is uncontrolled, small changes in peak water levels will result in large changes in total flows passing over the levee overflow section. There is no margin for error in the proposed design as the Corps previously informed M&E Pacific in July, 1989.

8. Although the velocity and depth of water overtopping the levee and flowing down the Coconut Grove side is not provided, the gabion revetment proposed is unacceptable because Corps criteria do not allow gabions to be used for spillways.

9. The DEIS states that the historical and current evidence indicates that the "drain" is at the upstream end (namely SE corner) of the marsh. The DEIS further states that "the greater hydraulic gradient is toward the southeastern levee flank". If flood water tends to flow in that direction, it is more likely a result of the choking vegetation than any historical tendency. Since 1966, the only outlet has been the Oneawa Channel. Post flood improvements by the City and County to facilitate flow along the levee to Oneawa Channel prevented an estimated $2,500,000 in flood damages during the April 1989 storm and demonstrated that floodwaters drain through Oneawa Channel. If "historical tendency" is the argument supporting overflow of the levee, it should be better justified, especially in light of the proposed vegetation removal. The DEIS should discuss what effects the new waterways will have on flood stages at the head of Oneawa Channel based on additional flow of water toward the NE.

10. Water quality concerns expressed in the DEIS for other alternatives (flood flows into Oneawa) should be addressed equally for the preferred alternative. The document should address the amount of suspended sediment anticipated within Kaelepulu Stream and out into Kailua Beach Park compared with sediment carried by flood waters out through Oneawa Channel into north Kailua Bay.

11. The Corps has a number of other concerns regarding the directing of Kawainui Marsh flood flows into Kaelepulu Stream and out into Kailua Beach Park at one end and to Oneawa Channel at the other end. Impacts to Kaelepulu Stream have not been adequately addressed for this alternative. It would appear that both increased and decreased water levels in Kaelepulu Stream would occur at various times resulting from the proposed alternative with a new outlet for marsh flows to both Oneawa Channel and to Kailua Beach Park. The potential for flooding and erosion would increase due to the limited capacity of Kaelepulu Stream.

12. Heavy rains and surface water runoff in Kaelepulu Stream have eroded portions of the area under lease to the Mid-Pacific Country Club. The impacts of increased flows in aggravating streambank erosion should be addressed.

13. Water can back up into Kaelepulu Stream as much as two to three feet above mean sea level if the conditions at Kailua Bay (sand buildup) prevent rapid escape of stream flows. The hydraulic evaluation in Appendix A, Section 5 evaluates water surface elevations based on two sea levels (1.2 feet msl and 2.2 feet msl). The higher 2.2 feet msl is not a conservative assumption based upon historic sand buildup at the mouth of Kaelepulu Stream and possible blockage of flows which could result in higher stream water levels. Furthermore, the additional flows along Kaelepulu Stream from the marsh via the proposed levee overflow, would also elevate water levels. Thus, the hydraulic evaluation needs to address possible erosive effects and overbank flooding that might occur to the residents along Kaelepulu attributed to the higher water levels and flows.

14. If high flood stages were to occur at the north end of the marsh, as the result of opening waterways and increasing flood storage, the proposed outlet culvert leading into the Oneawa Channel could allow floodwaters to back up into the Kaelepulu Stream and flood the residential community. As stated in our 26 October comments, an ungated opening through the levee would be unacceptable for the safety of residents of Coconut Grove.

15. The information we have repeatedly requested since July, 1989 on hydrology and hydraulics continues to be

inadequate in the DEIS and appendices for a thorough evaluation by Corps personnel.

ARCHAEOLOGY

16. The DEIS does not address the impact of the proposed action to archaeological features identified near the south end of the existing levee by Corps archaeologists in February, 1988. A copy of the report which describes these features is on file in the Historic Sites Section, Department of Land and Natural Resources. It appears that these features may be adversely affected by the proposed construction and therefore appropriate avoidance or mitigative measures should be taken. Notation of the location of these features should be added to Figure 3-3 and they should be addressed in Section 3.

17. In the Historical Perspective section the DEIS states, "the portion of the marsh now covered by *Brachiaria* (California grass) was in taro cultivation" (DEIS 3-3). Suggest that this be reworded to "portions of the marsh formerly utilized for taro cultivation are now covered by *Brachiaria* (California grass)". Former taro cultivation has not been verified historically or archaeologically to have been present in some areas now covered by California grass in Figure 3-7.

18. Kawainui Marsh has been determined eligible for inclusion in the National Register of Historic Places. Compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, is an appropriate means to insure review of design and study options to protect this significant cultural resource. Section 106 procedures, however, only apply if federal permits or funds are involved with the proposed project.

COSTS

19. The scope of City and County responsibility for maintenance of the flood control project would be greatly expanded beyond their present maintenance agenda to include the following additions: 1) marsh vegetation control; 2) maintenance of the paved 1400 foot levee overflow section; 3) new outlet into Oneawa Channel,; 4) maintenance of the unlined Kaelepulu Stream from the ocean at Kailua Beach Park to the Oneawa Channel (approximately 3 miles, as depicted by Figure A-102/1); and 5) maintenance of the vegetation growth in such a manner that there is no long term change in the marsh flood attenuation characteristics. Thus it appears that the preferred alternative would have the highest maintenance costs associated with it.

20. Information contained in the DEIS and appendices is insufficient to evaluate and compare the cost of various

feasible alternatives. Since cost would be a major consideration in selecting an alternative, additional details and clearer presentation of cost figures would assist the Corps in evaluating the various options. The cost of mitigation associated with each alternative should be included and itemized.

21. The total first cost for at least some of the alternatives appears to omit equipment costs. For example, equipment costs for mechanical removal of vegetation required for the initial project appears either not to be itemized or included as a cost. Although the appendix includes equipment quotations from commercial suppliers ("Cookie Cutter", "Aquamog") it is not clear how, if, or which set of figures were used in the project cost estimates. If the estimates for mechanical equipment are based upon use of the Aquamog proposal in the appendix, then the costs appear excessive. Although the supplier recommended two sets of three Aquamog vehicles, totalling two cutters and four transporters, it would seem that one set of vehicles (one cutter and one or two transporters) would be sufficient. A cost estimate based upon two vehicles rather than six vehicles would render mechanical removal more economically feasible. Thus, the Corps suggests that all first costs and all projected maintenance costs of the several technically feasible alternatives be carefully reviewed and presented in a manner to allow clear comparisons in the DEIS.

CORPS REGULATORY REQUIREMENTS

22. The DEIS states (page 2-9) that "Because the proposed actions identified may affect the existing federal project, a permit request will be filed with the U.S. Army Corps of Engineers". A Department of the Army permit may be required, as clarified below.

23. A Department of the Army (DA) permit is not required for the removal of vegetation by mechanical means, blasting or herbicides, provided that these methods can be employed without temporary causeways or roadway fills in wetlands for equipment access.

24. Permits are required under Section 10 of the Rivers and Harbors Act of 1899 or Section 404 of the Clean Water Act, for the actions described below. The construction of the sediment disposal and handling areas shown on Figure 2-3, Sheet A appears to extend into the marsh proper, involving the placement of fill for dikes and subsequently, sediment deposition in wetlands; therefore, a DA permit is required for this portion of the project. Other portions of the proposal which require a DA permit include construction of a new outlet structure to Oneawa Canal, removal of sediments

in the tidal reaches of Kaelepulu Canal, and construction of low flow weirs and a revetment for the levee. Additional approvals are required by the Assistant Secretary of the Army (Civil Works) for modification to a Federal Project per Section 14 of the Rivers and Harbors Act of 1899. Reference to Section 14 should be added to Table 6-1.

25. The wording in the discussion of the Corps permit on page 6-2 of the DEIS should be revised from "Dredge and Fill Permit" to "Department of the Army permit." DA permits are issued under several authorities, not just Section 404 of the Clean Water Act. Information is available from our office which describes the applicable Corps permit authorities. In light of the above comments, the discussion of EA and EIS requirements on pages 6-5 and 6-6 of the DEIS should be rewritten to reflect these permit requirements.

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0237

June 6, 1990

Lieutenant Colonel Donald T. Wynn
Department of the Army
U.S. Army Engineer District
Building 230
Ft. Shafter, Hawaii 96858-5440

Dear Colonel Wynn:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 18, 1989

Thank you for transmitting your comments for the DEIS.

Our response to your comments are as follows:

Summary of Major Concerns:

Since the signing of the intergovernmental agreement for a Feasibility Study between the U.S. Army Corps of Engineers (COE) and the City and County of Honolulu (City), both government agencies will be working together and towards a common goal of flood protection for Coconut Grove.

The City's role will be to implement flood control improvements in the marsh and the COE will proceed to develop alternatives for flood control improvements to the levee and related structural improvements.

As stated in your comments, the "DEIS contains a wealth of information..." which the COE will be able to use in formulating flood control alternatives. The City urges you to make full use of the information provided in the DEIS.

Waterways:

5. The reviewer of the DEIS "question[s] the manner in which the discussion explains its [waterways] contribution to flood control". The DEIS provides in-depth explanations of the contribution both in

general terms for the non-technical reader as well as robust detail for those interested in understanding the basic physics. Examples of non-technical explanations are located on pages 2-5: "Opening waterways into the interior will decrease the time for internal distribution of flood water and reduce storage at the upper end of the marsh. This will result in lower flood levels at the upstream end next to the levee...." and page 4-3: "The objective is to create storage during floods within the interface between the bottom zone of the existing peat mat and the top of the levee without raising the long-term levels of the marsh". Table A-29 provides the governing equations used in the model and pages A-56 through A-59 (and accompanying figures) provide detailed results. In addition, the Corps staff was provided with detailed technical presentations on the results in July and September, 1989.

6. The reviewer questions the means of excavation of the waterways using explosives, because they are an "additional cost and risk ... in areas that will utilize the Aquamog anyway". Utilizing the cost section of the Appendix comparison of blasting to conventional equipment removal of vegetation was made. Blasting costs $5.00 per cubic yard, and mechanical removal costs $50.00 per cubic yard. In addition, experience in arranging for a demonstration of the Aquamog machine indicates the cost disadvantage of machinery; for example, the lease rental rate is approximately $526.50 per cubic yard of material removed on a short term basis.

The reviewer comments on the "risk" involved with blasting in a nonspecific context which makes a direct response difficult. Evaluation of specific risks were made during test blasts in February 1990. In the specific context of seismic and sonic impacts to structures adjoining the marsh, the risks are deemed acceptable in terms of Federal Standards promulgated by the U.S. Bureau of Mines. The details of this evaluation are explained below:
Explosives were detonated at two sites within the marsh on February 5, 1990. Seismographs were installed at three locations around the marsh to monitor both seismic (ground) motion and sonic (air blast) effects. At both test sites, precautions were taken not to endanger any waterbirds. A warning shot was initiated prior to the main detonation. No water fowl or fish were observed in the area, either prior to or after the blast. In fact, it was documented during

both main blasts that no avifauna were flushed from nesting areas anywhere in the marsh.

The explosives were carried into the marsh by personnel contracted by the City to conduct the tests. Approximately 150 pounds were used at each site. The first site was approximately 2400 feet from the levee adjoining Coconut Grove. Vegetation was ejected over a maximum distance of approximately 150 feet from the site. The vegetation mat disintegrated into small pieces generally less than six inches maximum dimension, with the largest having a maximum dimension of six feet. A shallow excavation between 5 to 10 feet, averaging approximately 7.5 feet, was created. The surface dimensions were approximately 47 feet by 33 feet.

The second site was approximately 3400 feet from the levee. Similar effects were obtained at this site in terms of vegetation mat disintegration. A shallow excavation between 2.5 to 7 feet, averaging approximately 5 feet in depth was created. The surface dimensions were approximately 42 feet by 33 feet.

The early findings of the test are as follows:

a. Explosives will create waterways of the shape and dimensions envisioned during the planning of flood control improvements in the DEIS.

b. Large spoil mounds are not created; the mat is disintegrated over a restricted area surrounding the site in the downwind (generally mauka) direction. Ejecta of silt and organic matter covered the downwind areas for approximately 150 to 230 feet depending upon the site.

c. Shallow excavations can be created while not disturbing deep seated sediments, e.g. at 15 to 20 feet depths; the disturbed zone can be limited to the shallower, more recent organic deposits.

d. The shape of the excavation may be conducive to water bird habitat creation; e.g. the edge areas of parts of excavations are shallow 2.5 feet, and mud flats are created due to the irregular nature of the excavation.

e. Seismograph responses are shown in the Final Environmental Impact Statement (FEIS).

Two months after the test blasts, in April 1990, the sites were checked to evaluate the effects. The following observations were made:

a. At test site 1, waterbirds were flushed from the site upon the approach of humans indicating that the birds are using these sites;

b. The ejecta from the excavation could not be distinguished from the surrounding vegetation growth;

Regarding the reviewer's proposal to evaluate "burning of dried, stockpiled vegetation in situ, the City and County of Honolulu investigated this option in December, 1988. In a letter dated January 12, 1989, the State Department of Health advised the City and County that: "The Kawainui Marsh is not an agricultural operation, therefore, does not qualify for an agricultural burning permit. As previously recommended, we advise that you use mechanical means to remove the vegetation."

Levee Design Changes:

7. The reviewer questions the results of the hydraulic model presented in the first paragraph, page A-59, and further states that "slight errors in peak marsh levels along the levee overflow section will result in catastrophic conditions within Coconut Grove". The results of the model can be better understood by recalling that the flow over the levee is limited to the amount of water which can be conveyed through the marsh to the levee. The water surface elevation along the levee is a function of the volume of water reaching the levee, the conveyance capacity of the city ditch and the hydraulics of flow over the levee. Even a breach of the levee would not greatly increase flows since the marsh would still limit the flow to the levee. The marsh is not like a reservoir with a spillway where there is an essentially unlimited volume of water upstream.

Concerning the comment that the "model may not predict the effects of natural channels which form through the marsh during flood events", it is impossible to say that this, or any deterministically derived model, would be applicable to all flow conditions. The sensitivity of the model to antecedent conditions has no bearing on the quality of calibration as implied by the reviewer's comments. Channels may be forced into the marsh, but the experience of the New Year's Flood, as evident from photographs, indicates this has been restricted to the upstream end. During the New Year's Eve Storm, the marsh grasses were compressed to further impede the flow through the marsh, which is consistent with the model assumption that the resistance to flow will not diminish with higher stages within the marsh. The calibration was valid for the only available, and relatively large event, but further evaluation of the predictive capability of the model will be made as the proposed waterways are opened.

8. The reviewer states that gabion revetments such as intended for the levee overflow are not acceptable. Since no specific reference to an engineering regulation or technical manual was provided nor was any technical analysis presented, we can only infer this is a matter of opinion. We defer to the Corps to provide an official interpretation of pertinent criteria and thus no response is provided to this comment.

9. The reviewer comments that "the DEIS should discuss what effects the new waterways will have on flood stages at the head of Oneawa Canal based on additional flow of water toward the NE." Please refer to pages A-60 to A-66 for data on the computed water surface elevations in Kaelepulu Canal, the head of Oneawa Canal with the proposed waterways. Note that these computations are based upon the assumption that overflow over the levee and an outlet to Oneawa Canal is constructed. The DEIS notes, page A-61, "the peak elevations for the SPF simulation in Oneawa Canal (including the flood outflow from Kawainui Marsh) is estimated to be 4.4 feet, MSL". Table A-35 shows both flow and stage hydrographs, in particular, at node 12 which is approximately Oneawa Canal station 93+00 adjacent to the previously proposed outlet beneath the levee. In comparison, the values computed for peak stage for the New Year's Eve Flood and the estimated 100-year flood were 3.89 feet and 3.34 feet respectively. These values were computed assuming construction of the proposed waterways into the interior of the marsh.

10. Water quality in terms of sedimentation is addressed in Section 2, Appendix B. Comparisons are made of relative erodibility of alternatives in Table B-5. In terms of nutrient loadings, page B-16 to B-17, and B-22 to B-24 present and discuss available data on existing conditions. Quantitative comparisons of alternatives would be highly speculative in view of the limited data. Deductive reasoning can be applied to make limited qualitative assessments of the relative impacts of various alternatives on nutrient uptake and

recycling. For example, removal of nitrogen and phosphorous have been modeled as exponential functions of time and other parameters; thus intuitively, alternatives which short-circuit the contact time between biological uptake in the marsh increase nutrient discharge to the ocean via Oneawa Canal. However, there is too little data available to make numerical comparisons and expect field verification. These types of verification require long-term data collection and additional analysis not envisioned for this EIS.

11., 12., 13., 14., and 15. The reviewer requests an evaluation of the erosive effects and overbank flooding that might occur to residents along Kaelepulu Stream. The stream will not be affected by the revised proposal since the City will only implement improvements in the marsh. However, the City will be conducting a hydraulic study for Kawainui Stream independent of any flood control improvements outside the marsh. This information will be made available for your use.

Archaeology:

16. & 18. The action, as proposed by the FEIS will not affect the area near the south end of the levee. At present, only part of Kawainui Marsh has been determined eligible for inclusion in the National Register of Historic Places. The area identified as Site 7, is located near Kailua Road and is outside of the project area. The State Office of Historic Preservation has been consulted in regards to subsurface archaeological investigation and will continue to be consulted as work progresses.

17. The FEIS will be amended to reflect the uncertainties regarding taro cultivation in the marsh.

Costs:

19. & 20. As stated in our response to your major concerns, the City will implement improvements in the marsh and at present, the City's proposed maintenance agenda will only cover keeping the waterways open and any present maintenance work on the levee and emergency ditch will be continued. Until the COE selects its preferred alternative, the overall

maintenance costs are unknown. However, the City and the COE will be working together in developing a maintenance plan for the alternatives.

21. Because of the uncertainties of the marsh terrain, to determine an accurate cost is difficult. See Pages 2-11; ranges listed here are based on the equipment manufacturers costs in Appendix A, Section 11.

Corps Regulatory Requirements:

22. & 23. Since the City will implement improvements in the marsh, the federal project will not affected. However, the City will obtain all necessary Corps permits for the opening of waterways.

24. & 25. A clarification is needed in regards to the construction of the sediment disposal and handling areas. Attached is a letter to the Operations Branch and their response to the matter.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

Attach.

LIFE OF THE LAND

RECEIVED
DEPT OF PUBLIC WORKS
DEC 27 7 35 AM '89

89-6759 Engr

December 21, 1989

Subject: Draft EIS for Kawainui Marsh Flood Damage Mitigation Project

DEC 27 2 41 PM '89

Marvin T. Miura, Ph.D
Director
State of Hawaii
Office of Environmental Quality Control
465 South King Street Room 104
Honolulu, Hawaii 96813

Sam Callejo
Director and Chief Engineer
City and County of Honolulu
Department of Public Works
650 South King Street
Honolulu, Hawaii 96813

Gentlemen:

The actions proposed in the subject Draft EIS are a bandaid where major surgery is needed. According to Appendix B Section 5 of the Draft EIS, almost 38 acre-feet of sediment and decomposed plants are deposited within Kawainui Marsh every year. Of this, the Draft EIS estimates that over 20 acre-feet/year is due to decomposition of plants growing in the Marsh. If we are to preserve waterbird habitat and flood control capacity in Kawainui Marsh, then we cannot indefinitely continue to allow the Marsh to fill in.

Although the Draft EIS does not come right out and say it, Appendix B Section 5 strongly suggests that it would be desirable public policy to:

1. establish a long-term dredging program to stabilize the flood retention capabilities and waterbird habitat in Kawainui Marsh;

2. dredge a grid of small canals across the lower parts of Kawainui Marsh and a few times per year allow salt water from the Oneawa Channel to flow into these canals and kill vegetation which cannot tolerate brackish or saline conditions; and

3. judiciously use napalm to kill vegetation in the Marsh.

19 Niolopa Place, Honolulu, Hawaii 96817. Tel. 595-3903

We request that the Final EIS discuss the feasibility, potential benefits, and potential costs of these three options. If such measures can permanently achieve the same benefits as the one-shot temporary measures proposed in the Draft EIS, then the public and decision-makers need to be informed.

Sincerely,

D.T. for

Corinne Ching
President

cc: James Dexter

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO:

90-12-0245

June 13, 1990

Ms. Corinne Ching, President
Life of the Land
19 Niolopa Pl.
Honolulu, Hawaii 96817

Dear Ms. Ching:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 21, 1989

Thank you for transmitting your comments regarding the DEIS.

Our response to your comments are as follows:

1. The City has a strong commitment to provide a maintenance program to keep the waterways open. The type of maintenance will be determined after the waterways are constructed.

2. Regarding the option of using salt water intrusion as a biological control mechanism for vegetation growth, this concept would require additional biological research and engineering to learn if it is indeed a viable concept in this setting. For instance, changes in salinity would probably affect the invertebrate population that is one of the food sources for waterfowl. Overall changes in the food web could occur which might be undesirable unless other management measures were taken. This was identified as a possible long-term option in the DEIS, but for the short-term purposes of the proposed action, it is not recommended because mechanical removal measures appear to have less negative impact.

Regarding the reviewer's proposal to use napalm to burn vegetation insitu, the City and County of Honolulu investigated open burning in December, 1988, and were advised by letter January 12, 1989 from the State Department of Health that "The Kawainui Marsh is not an agricultural operation, therefore, does not qualify for an agricultural burning permit. As previously recommended, we advise that you use mechanical means to remove the vegetation."

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

89-6796 Env'l Engr

December 21, 1989
RE:0544

Dr. Marvin T. Miura, Director
office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Draft Environmental Impact Statement
Kawainui Marsh Flood Damage Mitigation Project
Kailua, oahu

The Kawainui Marsh Flood Damage Mitigation Project proposes to implement a plan to increase the ability of Kawainui Marsh to both distribute and store storm water runoff thereby reducing the flood potential to the Coconut Grove housing area. We have been assisted in this review by Don Drake, Botany; Michael Graves, Anthropology; Sheila Conant, General Science; Charles Lamoureux, Arts and Sciences, Botany; Ed Murabayashi, Water Resources Research Center; James Parrish, Hawaii Cooperative Fisheries Reearch Unit; Hans-Jurgen Krock, ocean Engineering; and Harriett Kessinger-Lee, Environmental Center.

General Comments

The Draft EIS appropriately recognizes the ecological importance of Kawainui Marsh, its significance as the largest wetland in the state, as providing habitat for several endangered species, and for serving as a sediment trap thus reducing sediment impacts to the coastal ecosystems. More recently, the importance of the marsh for flood control has been in the forefront following the devasting New Years flood of 1988. Hence, it is the need for the marsh to serve two, potentially conflicting uses, that has lead to the presently proposed flood management plan and Draft EIS. The Draft EIS seems quite comprehensive in that it does acknowledge the potentially conflicting uses of the marsh and attempts to address those needs. There are, however, several key issues that have been brought to our attention that should be addressed further in the Final EIS.

Hydrology of Kaelepulu Stream

As indicated in the Draft EIS, the construction of the outlet to Oneawa canal will lower water levels in Kaelepulu Stream and to mitigate the adverse effect a new, low-flow weir will be constructed in the existing City and County ditch. This weir will serve to maintain water levels in the ditch sufficient to accommodate the waterbirds. our reviewers have expressed concern that both the feasibility of reversing the flow in Kaelepulu Stream as well as the impacts associated with that reversal, ie. changes in salinity leading to changes in the stream ecology, should be more fully addressed in the Final EIS. If, for example, the waterbirds are dependent on the existing plant species for their nesting or feeding requirements, then a modification of the stream to euryhaline conditions may eliminate the use of the stream by some species. Furthermore, since water level in the marsh is of critical importance to the waterbirds, ie. to assure sufficient water for maintaining plants for food and nesting but not enough to flood nest sites, and since that water level will be controlled by management of the weir, the weir takes on an inordinate importance to the project. Procedures to assure adequate maintenance and management of the weir should be set forth in the Final EIS. We note that the slope of the Oneawa canal and Kaelepulu stream is very slight. Is there likely to be a sand/silt-sediment build up in the Oneawa canal?. The hydraulics of the stream-channel combination are not entirely clear.

Impacts and Mitigation options

The Draft EIS states that "Because the overall impact will be beneficial, there is no requirement forseen at this time for mitigation of the effects of actions to open waterways" (p. 4-1). We take exception to this statement which implies that the "end justifies the means". Mitigation measures will surely be needed to minimize silt transport to downstream locations, to reduce impacts to endangered species, and to protect existing drainage channels from clogging by floating vegetation so as to minimize flood risks during construction.

Blasting

We question the effectiveness of the plan to use explosives to "blow apart the vegetation mat" (p. 2-5). We suspect that in fact, blasting will create thousands of small pieces of vegetation that will serve as propagules and generate even more plants and the need for additional maintenance actions. Furthermore blasting will, at the least, disturb the endangered waterbirds. The use of the various dredging devices shown in the appendices, such as the "cookie cutter" or the "Aquamog" would appear to be a better approach. This would permit use of the dredged material for use as animal feeds or fuel for HPOWER, etc. Particularly since the vegetation must ultimately be removed if the flood flows are to be accommodated. Appendix B, Section 5 states that blasting will be scheduled when it will be least disruptive to breeding and nesting. However, the endangered gallinules breed all year long. In addition, the area along Hamakua Drive is a particularly sensitive habitat as it is a major breeding area for gallinules, and coots. Blasting in this area or the use of chemicals should be avoided.

Chemical Controls

We note that Appendix B, Section 5 discusses some of the chemical options being considered. However, with the exception of "Rodeo", there is no indication of the toxicity of the various chemicals to aquatic biota. Furthermore, potential impacts to birds of the ingestion of seeds or grasses that have been sprayed are not discussed. Both the short and long term impacts of the use of chemicals to control vegetation should be addressed in the Final EIS.

Weir Maintenance

Our reviewers have expressed considerable concern as to the long term maintenance of the system and thus the efficacy of the whole project. Flood control as s the ecological viability of the marsh are both dependent on the operation of the weir structure. Should it fail, flood waters will be delivered to the lower elevations at an even more rapid rate than present, "opening waterways into the interior will decrease the time for internal distribution of flood water and will reduce storage at the uppper end of the marsh" (p. 2-5). If the weir is too low, it will drain the marsh. We suggest that the requirements and costs of maintaining the weir structure and its operation be fully disclosed in the Final EIS.

Impacts to Kaelepulu Stream and Kailua Bay

The proposed connection between Oneawa canal and Kaelepulu stream will modify the salinity of Kaelepulu stream. Given the destructive effects of the intrusion of salt water on the existing fresh water stream ecology, additional information on the flora and fauna of the stream seems necessary. What is the potential for reverse flow and resultant flooding from Oneawa canal into the Kaelepulu stream? At the present time, Kaelepulu stream and Oneawa canal both serve as outlets to Kailua Bay. What effects will the proposed changes in the hydrology of the marsh and the connection of Kaelepulu stream and Oneawa canal have on Kailua Bay? What provisions are being made to reduce sediment or vegetation (from blasting) inputs to the bay?

Archaeological and Historical Resources

There are a number of problems with the treatment of archaeological and historical resources within the project area. First, there is no indication of how the sites shown on the map were identified, although it appears that the sites may have been selected from records at the Historic Sites office at the Department of Land and Natural Resources. There is no documentation

provided on any of the sites listed and the referenced "accompanying table" is not in our copy of the Draft EIS. Thus, it is not possible to evaluate the significance of the sites which exist at Kawainui Marsh, nor can we determine if it is likely that all sites have been located within the project area. Furthermore, the City and County indicate on page 3-5 that the marsh is eligible for inclusion on the National Register of Historic Places and thus they must comply with Section 106 of the National Historic Preservation Act (NHPA). Yet, there is no indication in the DEIS that they have begun to comply with NHPA. The Final EIS must document possible impacts on the historical and prehistorical sites and certainly must address what mitigation measures will be taken to minimize or avoid impacts to those sites if the Final document is to be an acceptable EIS.

We appreciate the opportunity to provide comments on this document and hope you will find them helpful in the preparation of the Final EIS.

Yours truly,

Jacquelin N. Miller

Jacquelin N. Miller
Associate Environmental Coordinator

cc: Sam Callejo, C&C of Honolulu
James Dexter, M&E Pacific, Inc.
L. Stephen Lau
James Parrish
Ed Murabayabashi
Don Drake
Michael Graves
Sheila Conant
Charles Lamoureux
Hans-Jurgen Krock
Harriett Kessinger-Lee

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO
90-12-0236

June 13, 1990

Ms. Jacquelin N. Miller
Associate Environmental Coordinator
University of Hawaii at Manoa
Environmental Center Crawford 317
2550 Campus Road
Honolulu, Hawaii 96822

Dear Ms. Miller:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 21, 1989

Thank you for transmitting your comments regarding the DEIS.

Our response to your comments are as follows:

Hydrology Of Kaelepulu Stream:

Because of comments received from the U.S. Army Corps of Engineers concerning previous proposals to modify the levee, all actions that are associated with or impact the levee have been eliminated from the proposed action in the Final Environmental Impact Statement (FEIS). Therefore, the revised action will not impact the hydrology of Kaelepulu Stream.

Impacts and Mitigation Options:

The reviewers "take exception" to the statement on p. 4-1 in the DEIS because they feel it "implies that the 'end justifies the means'". The full context of the statement better describes the intention of the preparers of the DEIS and in no way was meant to draw the conclusion the reviewers interpreted from it. The DEIS states (p. 4-1, third paragraph) "Because the overall impact will be beneficial, there is no requirement foreseen at this time for mitigation of the effects of actions to open waterways. All of the proposed actions will be subject to the soil erosion and sedimentation ordinance, and the construction plans will

address these concerns." The construction plans for the waterways include provisions for eliminating sediment discharge during construction downstream, minimizing impacts to endangered species and vegetation removal. These are not considered special mitigation measures but appropriate design. "Mitigation measures", in the context of the statement by the preparers, means alternative actions to offset the negative impacts of the proposed action. For example, one possible mitigative measure identified for the levee raise alternative is to create additional wetland or restore an existing one to improve its habitat quality in order to mitigate the loss of wetland due to levee construction.

Blasting:

The reviewers "question the effectiveness of the plan to use explosives to 'blow apart the vegetation mat'". The explanations given for this concern by the reviewers relate to distribution of material ensuing maintenance problems and disturbance of endangered waterbirds. Based on the results of the test blasts conducted in February 1990, these are conjectures that are not supported by the recorded observation during the tests. The objectives of these tests were:

1. Verify assumptions concerning the effectiveness of the explosives in excavating the vegetation;

2. Study pattern, charge weight and depth of placement of the charge on the amount of excavation and the resultant seismic and sonic impacts;

3. Observe what potential adverse effects may occur to either aquatic or avifauna and vegetation in the marsh during full scale operation.

Explosives were detonated at two sites within the marsh on February 5, 1990. Seismographs were installed at three locations around the marsh to monitor both seismic (ground) motion and sonic (air blast) effects. At both test sites, precautions were taken not to endanger any waterbirds. A warning shot was initiated prior to the main detonation. No water fowl or fish were observed in the area either prior to or after the blast. In fact, it was documented during both main blasts that no avifauna were flushed from nesting areas anywhere in the marsh.

The explosives were carried into the marsh by personnel contracted by the City to conduct the tests. Approximately 150 pounds were used at each site. The first site was approximately 2400 feet from the levee adjoining Coconut Grove. Vegetation was ejected over a maximum distance of approximately 150 feet from the site. The vegetation mat disintegrated into small pieces generally less than six inches maximum dimension with the largest having a maximum dimension of six feet in size. A shallow excavation between 5 to 10 feet, averaging approximately 7.5 feet, was created. The surface dimensions were approximately 47 feet by 33 feet.

The second site was approximately 3400 feet from the levee. Similar effects were obtained at this site in terms of vegetation mat disintegration. A shallow excavation between 2.5 to 7 feet, averaging approximately 5 feet in depth was created. The surface dimensions were approximately 42 feet by 33 feet.

The early findings of the test were as follows:

1. Explosives will create waterways of the shape and dimensions envisioned during the planning of flood control improvements in the DEIS.

2. Large spoil mounds are not created; the mat is disintegrated over a restricted area surrounding the site in the downwind (generally mauka) direction. Ejecta of silt and organic matter covered the downwind areas for approximately 150 to 230 feet depending upon the site.

3. Shallow excavations can be created that do not disturb deep seated sediments, e.g. at 15 to 20 feet depths; the disturbed zone can be limited to the shallower, more recent organic deposits.

4. The shape of the excavation may be conducive to waterbird habitat creation; e.g. the edge areas of parts of excavations are shallow 2.5 feet, and mud flats are created due to the irregular nature of the excavation.

Two months after the test blasts, in April 1990, the sites were checked to identify effects. The following observations were made:

1. At test site 1, waterbirds were flushed from the site upon the approach of humans indicating that some use is being made of these sites;

2. The ejecta from the excavation could not be distinguished from the surrounding vegetation growth;

The proposed action includes the use of mechanical equipment but recognizes the physical limitations of the machinery to remove the required quantities of vegetation from the waterways and, furthermore, the space limitations adjacent to the marsh to handle the material. For example, the material can not be used without drying to at least 40 percent solids (by weight) to reduce the moisture content required for landfill disposal. There is not enough available fast land to handle all of the vegetation and sediment material (drying and compacting for transport) that must be removed to create the waterways unless the construction of the waterways can be staggered over several years.

The preparers of the DEIS envisioned a multiple methods approach that calls for mechanical, chemical and biological means of vegetation management as having less risk that any one element not completely capable of satisfying the objective of restoring storage capability. The initial phase of construction may (or may not) include the use of explosives; however, it is recommended for the initial phase only and not on a permanent maintenance basis. The time of the year that the blasting may be used is being determined by the United States Fish and Wildlife Service, and the contract specification will require the contractor to adhere to those provisions. Blasting was never proposed for the Hamakua Drive area.

Chemical Controls:

1. Several commentors raised questions regarding the efficacy, proper application period and potential impacts of chemical control of water hyacinths, (*Eichhotina crassipes* (Mart.) Solms). Several chemical control options were discussed in the EIS. The following information supplements that already provided:

One of the chemical control methods considered is glyphosate (N-phosphonomethyl glycine). This is commonly marketed as Roundup or Rodeo (Nelson, 1989). It is a highly effective chemical for control of numerous annual, biennial and perennial broad leaf weeds and grasses, and operates by interrupting the biosynthesis of phenylnlanine through repression of chorismatic acid. Based on aerial application when the plants are actively growing, at application rates from 5.3 to 8.8 lb/ha (4.5 to 6.5 pt/acre) (0.75 to 1.4% solution), glyphosate persists for short periods in both soils and water.

Glyphosate (US EPA, 1984) is registered and approved for use at all aquatic sites with no restriction on use to control nuisance vegetation in waters used for irrigation, recreation or domestic purposes. It is not to be applied within 0.5 miles upstream of potable water intakes. Treatment frequency should not exceed one treatment per 24 hour period and application rates should not exceed 8.8 lb/ha (7.5 pt/acre). The visible effects on most annual plants occur within 2-4 days while perennial plants may not show effects for over one week. Toxicity of glyphosate increases with increasing water temperature and alkalinity. Bioassays indicate low toxicity to fish and aquatic life. The 96 hours static acute toxicity, LC_{50}, for Rainbow trout was 7.0 to 11.0 mg/l (of 41% liquid ROUNDUP), and 5.3mg/l for the Cladoceran shrimp, *Daphnia*. Due to the relatively low inherent toxicity of glyphosate, studies have documented that it will not adversely effect humans, wildlife or the environment when applied as discussed earlier. Glyphosate has an extremely low vapor pressure and does not volatilize, thus eliminating possibilities for human or animal exposure due to vaporization and movement to nontarget areas following application. US EPA (1984) established the human acceptable daily intake (ADI) value for glyphosate at 0.10 mg/kg body weight per day. This ADI translates to a maximum permissible intake (MPI) of 6mg glyphosate per day for the entire human life span. Based on application instructions, it would be impossible for any human to consume an amount of glyphosate necessary to cause adverse effects due to drinking water or eating food obtained from areas treated.

In soils, glyphosate is relatively immobile primarily because of its adsorption to and inclusion in expanding lattice clays, common to wetlands areas. The chemical actions of glyphosate become inactivated upon sorption. Also, degradation in soil by microbes occurs fairly rapidly (1-2 months) under both aerobic and anaerobic conditions. Studies have documented that soil microorganisms exposed to up to 25ppm of glyphosate showed no measurable adverse effect in terms of nitrogen fixation, nitrification or degradation of protein, starch or plant litter. The principal soil metabolite of glyphosate is aminomethylphosphonic acid which is also highly biodegradable. In water, glyphosate biodegrades in 7-10 weeks. It is well documented that glyphosates do not bioaccumulate in aquatic organisms. Results of environmental fate studies document that no glyphosate was leached from soil that was eluted with water continuously for 45 days.

Another chemical control method considered is herbicide, 2,4,D (2,4-dichlorophenoxyacetic acid) is commonly sold as Weedone LV-6, Esteron 99 Concentrate, Weedar 64, and Formula 40. It is a selective annual and perennial broad leaf weed control chemical. Plants readily absorb, translocate and metabolize 2,4-D. However, phytotoxic levels of residue do not persist in dead vegetation. The main pathway of environmental degradation is through microbial metabolism in warm most soils. Absent these favorable conditions, 2,4-D may persist for many months. The breakdown products of 2,4-D, are also reasonably stable especially in cool, nutrient-poor waters. 2,4-D is toxic to many nontarget plants and has a highly variable toxicity to fish, although it does not reportedly bioaccumulate in fish nor mammals.

Similar detailed information is available for other control chemicals considered, including Dalapon, Diquat, Aminotriazole T and Fentrop. Since the EIS recommended chemical control of water hyacinth using Rodeo, additional discussion is provided regarding means to maximize the efficiency of Rodeo (glyphosate) in controlling water hyacinth.

Recent attempts to control Water hyacinth have been based on a better understanding of the growth cycles of this plant (Luu and Getsinger, 1990). This approach is analogous to Integrated Pest Management. These studies have been aimed at documenting the physiologically weak points in metabolic cycles of the plant which would facilitate the more effective control of this vegetation. The weak periods of the water hyacinth growth cycle occur in the period shortly before autumn scenesce begins when the plants are actively translocating carbohydrates to stem-bases, and in early spring when new growth results in young ramet (a plant that is an independent member of a clone), emergence and carbohydrates in the stem-bases are low.

Since glyphosate degrades quickly in both soil and water through microbial metabolism, and is relatively immobile, there are minimal risks for potential injury to nontarget plant species and minimal risks for potential ground water contamination from migration. There is also minimal risk to animal species since it has low animal toxicity and does not bioaccumulate. Applied at the most sensitive states in the life cycle of water hyacinth, (defined earlier), glyphosate is an appropriate approach for successful control at Kawainui Marsh, affording the least potential for short-term and long-term impacts of herbicides evaluated. Applications at these times will not occur during seed production. Therefore, no potential problems for avian ingestion of seeds that may have been sprayed will occur. Applications at these times will also afford the most cost effective and ecologically sound chemical control method.

This method of water hyacinth control (using glyphosate) has been widely used by the U.S. Army Corps of Engineers in maintaining open waterways in all areas of the United States and its territories where water hyacinths grow. The same approach has been used in the Nile River valley, the Sudan, India, etc. Glyphosate is a commonly used, EPA approved herbicide specifically used to control floating nuisance weeds (EPA 1988). Shireman et al. (1982) pointed out that it is one of the most commonly used methods of chemical control. Consequently it is clear that it is an applicable mechanism for vegetation control at Kawainui Marsh.

Weir Maintenance:

The proposed project as presented in the DEIS has been modified and the FEIS only addresses the waterway clearing aspect of the original project.

Impacts to Kaelepulu Stream and Kailua Bay:

As noted in the reply to the comment on the hydrology of Kaelepulu Stream, the revised action will not impact the hydrology of Kaelepulu Stream.

Provisions will be made to the construction contract to minimize inputs of sediment and vegetation into Oneawa Canal during the completion of new waterways. No work is intended to be done under the construction contract along the existing emergency ditch; however, City crews, periodically will continue to maintain this outlet.

The blasting will be limited to a period from October through February which coincides with the rainy season in Hawaii. There will be naturally occurring increases in suspended sediment concentrations during this period. The project actions should be carried out in a manner that will not increase the suspended solids discharge, but it would be impossible to prevent any increase in discharge in suspended material because the magnitude of suspended solids may exceed the limits of the State Water Quality Standards For Inland Waters (see Tables B-6, B-17, and B-18, DEIS) from other flow paths through the marsh.

Several procedures will be detailed in the construction plans and specifications to mitigate the impact of construction relative to suspended solids. Construction will be halted at periods when water sampling at the outlet of the marsh at Oneawa Canal indicates that continued construction will be in violation of State Water Quality Standards For Inland Waters. Vegetation material that is dislodged during storm runoff and floats to the outlet will be collected by a silt screen located across Oneawa Canal at the outlet of the marsh. During runoff events, the sediment discharge into the marsh will increase and the suspended solids concentration at Oneawa Canal will also increase. The alignment of the waterways will be designed to provide a minimum of 1000 feet buffer between the outlet and the closest point of waterway construction; a minimum of 600 feet will be provided between the new waterways and the existing City and County emergency ditch. These buffer strips will inhibit the movement of ejecta and retard the movement of water toward the outlet which will allow resedimentation of silt and clay particles suspended during blasting.

Archaeological and Historical Resources:

The table referred to by Figure 3-3 was inadvertently omitted from the DEIS and will be included in the FEIS. At present, only part of Kawainui Marsh has been determined eligible for inclusion in the National Register of Historic Places. The area identified as Site 7, is located near Kailua Road and is outside of the project area. A subsurface survey of the project area was undertaken; ten core samples were taken at 1,000 foot intervals along the proposed waterway alignments. The purpose of the subsurface survey was to determine the presence of historical and/or prehistorical sites. The results of the analysis of these cores will be included in the FEIS. The State Office of Historic Preservation has been consulted in regards to the subsurface archaeological investigation and will continue to be consulted as work progresses.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

National Audubon Society

HAWAI'I STATE OFFICE, 212 MERCHANT STREET #320 HONOLULU, HI 96813 (808) 522-5566

89-6765 DIR ENV EVC

RECEIVED DEPT. OF PUBLIC WORKS DEC 21 4 36 PM '89

RECEIVED DEC 29 8 55 AM '89

December 20, 1989

Mr. Sam Callejo
Director & Chief Engineer
Department of Public Works
City & County of Honolulu
650 South King Street
Honolulu, Hawai'i 96813

RE: Draft Environmental Impact Statement, Kawai Nui Marsh Flood Damage Mitigation Project.

Dear Mr. Callejo:

The Hawai'i State Office of the National Audubon Society has reviewed the Draft Environmental Impact Statement dated November 1989 for the above-referenced project and would like to make the following comments:

1. <u>The National Audubon Society has primarily considered the wildlife impacts of the project in its review.</u>

We have reviewed the flood damage mitigation project from the standpoint of its impacts on wildlife and their habitats, particularly the four endangered waterbird species – the Hawaiian Stilt, Duck, Gallinule and Coot – known to live and breed in Kawai Nui Marsh. We are concerned that any measures undertaken by the City do not negatively impact these species or jeopardize any future actions to restore the wetland. At the same time, we are keenly aware of the need of Kailua residents in the vicinity of the marsh to obtain assurances that the damage they sustained in the New Year's 1988 flood will not be repeated.

2. <u>The preferred alternative is essentially sound from the perspective of flood damage mitigation and wildlife impacts.</u>

After carefully considering the elements of the preferred alternative (Alternative C), it is our opinion that the preferred alternative

will succeed in mitigating damage from future floods and enhance the wildlife habitat in Kawai Nui marsh with some modifications listed below. We commend the city for its sensitivity to the environmental concerns expressed by the community during the public information hearings for this project. We are particularly pleased with the philosophy expressed in the design and selection of the preferred alternative: "with Nature instead of trying to overcome it."

3. The following modifications should be made to the preferred alternative.

a. Our principal concern is for maintaining water levels in Kaelepulu Stream and preventing intrusion of salt water through the new outlet structure between Kaelepulu Stream and Oneawa Canal. As noted in the DEIS, increasing salinity and lowered water levels will have a negative effect on waterbirds using this area. Could a low level weir be installed to help maintain water levels in Kaelepulu Stream?

b. The low flow weir at the Kailua Road end of Kaelepulu Stream should be constructed in such a way that the wetlands along Hamakua Drive receive adequate water to support waterbirds that frequent the area.

c. The emergency ditch constructed by the city shortly after the January 1988 flood has accelerated the evacuation of water from the marsh proper. The flow should be regulated to maintain water levels in the marsh through the construction of a low level weir on the emergency ditch at its northern end near the inlet to Oneawa Canal.

d. The timing of blasting waterways through the marsh should not occur during the breeding cycle of waterbirds, as noted in the DEIS.

4. <u>The city's preferred alternative will be changed considerably by the U. S. Army Corps of Engineers after the conclusion of this environmental review.</u>

We are aware that, since at least July 2, 1989, well before the DEIS was released, the U.S. Army Corps of Engineers raised grave concerns with certain design recommendations of the preferred alternative and expressed those concerns to the city. The Corps claims regulatory authority over any modifications to the levee, and has expressed its intent to reject the city's preferred alternative. The Corps recently initiated a redesign of the levee with the concurrence and financial participation of the city. It is our understanding that after receiving final approval from the Assistant Secretary of the Army (Civil Works), the Corps will embark upon a two-year planning process, culminating in a different federal project.

At this time, few details of the Corps' design are available. A reconnaissance report transmitted by memorandum to the Commander of the Pacific Ocean Division of the Corps of Engineers, describes the Corps' preference for raising the existing levee by filling or by sheet pile wall by an additional 5.5 feet and widening the existing emergency ditch on the mauka side of the levee.

The reconnaissance report states that: "(r)aising the levee would provide a positive means of restoring flood control and can be formulated to be as independent as required so as not to be affected by the vagaries of future marsh conditions." However, in the draft environmental assessment for their proposed Kawainui marsh flood control mitigation project dated July 25, 1989 the Corps states, "Other alternatives considered included raising of the levee and widening the Oneawa Canal. The levee alternative is rejected because of the massive amount of material required to raise the levee to a sufficient elevation to preclude future flooding. This large raised levee may also cause potentially hazardous conditions unless the levee incorporates a design similar to a dam." Furthermore, in rejecting a combination levee raise and channel through the marsh the EA concludes, "(T)he levee cannot be raised enough to act as an effective flood control measure unless it is reconstructed." The EA also states that "(r)aising the existing levee to a sufficient height (possibly an additional 6 or more feet) could result in a <u>catastrophic</u> event if the levee failed during a major flood. A levee break could inundate most of the Kailua area." (emphasis added)

The option of widening of the emergency ditch was also considered in the July 1988 EA. At that time, the Corps dismissed this alternative as

well: "This previously initiated emergency action may protect the nearby residential areas from any major rainstorms occurring in the near future, but is considered inadequate to protect the community from a major flood event."

5. <u>The state environmental review process has been subverted by the lack of interagency coordination between the city and the Corps.</u>

We wish to raise our strongest objections to the subversion of the state environmental review process for this project. The city has known since July 1989 that the preferred alternative was unacceptable to the Corps and that the Corps would not issue a permit for part of the project design. The possibility of Corps rejection of the city's design recommendations for the levee is noted in the DEIS. Yet the city has chosen to continue with the environmental review process, releasing for public comment a project description and analysis that was, in part, already impossible to implement.

The net result is that the public is led to believe that the City will be taking an environmentally sensitive approach to flood control when it is actively cooperating with the Corps to design a project with possibly severe and unacceptable environmental impacts. It is unconscionable to subject the public to this kind of environmental charade.

Further, public funds for the preparation of the DEIS (approximately $395,000 pursuant to telephone conversation with James Dexter, M&E Pacific, Inc., December 15, 1989) have been partially wasted, and valuable planning time has been lost. The Corps plans to spend at least $400,000 in planning and design of its new project, and the city recently committed $250,000 to assist the Corps in completing the feasibility study.

The DEIS prepared by M&E Pacific was started on March 1st, 1989 and released in November 1989. The Corps may begin their planning process in January 1990, IF approval from the Assistant Secretary of the Army is received. The "definite project report" will not be completed until January underway and it is determined more accurately that the proposed handling facility can process the annual productivity.

The axes on Figure B-6 are correct as shown.

Your review of the DEIS is appreciated

Very truly yours,

C. Michael Stuart

for SAM CALLEJO
Director and Chief Engineer

KAWAI NUI HERITAGE FOUNDATION
P.O. Box 1101
Kailua, HI 96734

December 20, 1989

Mr. Sam Callejo
Director and Chief Engineer
Department of Public Works
City and County of Honolulu

Dear Mr. Callejo,

Thank you for sending us a copy of the Draft Environmental Impact Statement for the Kawainui Marsh Flood Damage Mitigation Project. The Kawai Nui Heritage Foundation wishes to continue to be a consulted party on this project. We do have several comments for your consideration at this time.

These comments are strongly influenced by the fact that the U.S. Army Corps of Engineers has informed you that two major components of the plan are unacceptable, namely (1) Protecting the levee from overflows and (2) Provide for the rapid evacuation of overflow water from Kaelepulu Stream into Oneawa outlet canal.

Because of that fact, most of the time spent reviewing this document, and its predecessor, the Preparation Notice, has been wasted. We resent that. We will not waste your time with our comments on the null parts of the plan.

We agree that opening new waterways within the marsh is an absolute necessity. The flood waters within the marsh must be distributed much more evenly than presently permitted by the vegetation. However, any plan which proposes to redistribute water within the marsh with less than 1.5 percent of the area in open water will certainly be questioned. A system of interconnected ponds and waterways should be investigated. Any further discussion about appropriate amount and arrangement of openings, given that the balance of the project is unknown, appears pointless at this time.

As an organization, we do not object in principle to any of the three means proposed to open the waterways. Each may have its place and be appropriate. We will defer to others with more expertise on that matter, at least for now.

We applaud the following statement. "The maintenance of waterways is an important portion of the proposed action." The neglect of vegetation management within the marsh got us to where we are today.

The axes are mislabelled on Figure B-6.

Extensive review of many features of this DEIS by members of our organization will be sent to you separately (and very likely) as a part of another organization's or individual's comments.

As an organization vitally concerned about the entire ahupua'a of Kailua, and especially the management of Kawai Nui Marsh, the Foundation regrets that the provision of adequate flood protection for Kailua is to be further delayed.

Sincerely,

Robert A. Merriam
President

cc: James Dexter, M&E Pacific
National Audubon Society
Kailua Neighborhood Board
Maunawili Community Association
Dr. Diane Drigot

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO

90-12-0222A

June 8, 1990

Mr. Robert A. Merriam, President
Kawai Nui Heritage Foundation
P.O. Box 1101
Kailua, Hawaii 96734

Dear Mr. Merriam:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 20, 1989

Thank you for transmitting your comments regarding the DEIS.

The City has always believed that the Kawainui Marsh flood damage mitigation project issues were complex and controversial. There are many viewpoints to consider: technical, economical, historical, environmental, fish and wildlife, recreational and more. There is no course of action which would be totally agreeable to everyone.

Therefore, the City felt that the appropriate course of action was to publicly present its proposed alternatives and have the public, including the U.S. Army Corps of Engineers (COE) submit comments. It turned out that the COE did have an honest difference of opinion with the City and its consultant, but the City felt that this was positive since concerns were made in the open.

On the other hand, one can imagine the potential public uproar had the City and COE resolved all their differences behind closed doors, especially to the extent that all matters were resolved without public review and input?

The City would like to offer these comments:

1. At no time did the City intentionally mislead the public nor delay the project.

2. If people do not agree with the above, then it's their privilege to believe otherwise. People are entitled to their opinions.

3. The COE held public workshops on February 27, 1990 and April 19, 1990 to discuss alternative solutions.

4. People, however, should refrain from making false remarks or misleading statements. In spite of emotions, only facts and evidence are worthy of serious consideration.

5. Again, since the Kawainui Marsh issues are complex and controversial, the City does not anticipate that a quick and singular alternative can be implemented. Rather, the City would not be surprised to see the implementation of several alternatives over the course of time. These alternatives probably will have varying degrees of success as well as shortcomings.

Also, the City would like to respond to your comment regarding the effectiveness of the proposed waterways.

The waterways do not need to be large to have an effect upon the conveyance of water throughout the marsh. For example, compare Figure A-30/a and A-89. These figures show the computed water surface elevations using the RMA hydraulic model of the marsh for 25-year floods. The former figure, assuming there is no vegetation removal, shows the 25-year flood elevation adjacent to the levee computed to be approximately 10.2 feet, MSL. In comparison, Figure A-89, assuming vegetation removal along the proposed waterways, shows the same flood will have a computed peak stage of 9.2 feet, MSL, i.e. one foot lower due to the effect of the waterways.

The amount of open water that can be created is directly proportional to the available area adjacent to, but outside the wetland area for handling the material that is removed from the marsh. This material must be prepared for transport and disposal. The maximum amount of space that is presently available for this purpose is to be developed into a handling area as part of the proposed project. Because of the amount of material that will need to be initially removed and thereafter continuously removed (due to new growth) on a regular basis cannot be accurately predicted at this time; a proposal to develop large amount of open waterways is premature, not knowing whether the proposed handling facility area can process the biomass. Additional waterways may be developed once the maintenance program gets of 1991 and will then undergo review by the Washington office of the Corps, which is expected to conclude in April of 1991. This schedule, taken from the reconnaissance report cited earlier, does not appear to take into account the requirements of the National Environmental Policy Act for review; it is a timetable of internal deadlines.

The impacts of the design objections of the Corps was completely avoidable and temporally and financially costly. We strongly urge the City and the Corps to work cooperatively to expedite the planning and execution of the final design for the flood damage mitigation project. We also ask that the requirements of the National Environmental Policy Act, the Endangered Species Act and the Fish & Wildlife Coordination Act (particularly Section 7) be fully satisfied during the review of the new project.

Thank you for the opportunity to comment.

Sincerely,

Dana Kokubun

Dana Kokubun, Director
Hawai'i State Office
National Audubon Society

cc: James Dexter, M&E Pacific
Robert Merriam, Kawai Nui Heritage Foundation
Bruce Ellerts, Hawai'i Audubon Society
Representative Ed Bybee
Councilmember John Henry Felix
Ronald Walker, Department of Land & Natural Resources
U.S. Representative Patricia Saiki

DEPARTMENT OF PUBLIC WORKS

CITY AND COUNTY OF HONOLULU

650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO

90-12-0245

June 13, 1990

Ms. Dana Kokubun, Director
National Audubon Society
Hawai'i State Office
212 Merchant Street #320
Honolulu, Hawaii 96813

Dear Ms. Kokubun:

Subject: Kawainui Marsh Flood Damage Mitigation Project
Draft Environmental Impact Statement (DEIS)
Response to Your Comments Dated December 20, 1989

Thank you for transmitting your comments regarding the DEIS.

The City has always believed that the Kawainui Marsh flood damage mitigation project issues were complex and controversial. There are many viewpoints to consider: technical, economical, historical, environmental, fish and wildlife, recreational and more. There is no course of action which would be totally agreeable to everyone.

Therefore, the City felt that the appropriate course of action was to publicly present its proposed alternatives and have the public, including the U.S. Army Corps of Engineers (COE) submit comments. It turned out that the COE did have an honest difference of opinion with the City and its consultant, but the City felt that this was positive since concerns were made in the open.

On the other hand, one can imagine the potential public uproar had the City and COE resolved all their differences behind closed doors, especially to the extent that all matters were resolved without public review and input?

In closing, the City would like to offer these comments:

1. At no time did the City intentionally mislead the public nor delay the project.

2. If people do not agree with the above, then it's their privilege to believe otherwise. People are entitled to their opinions.

3. The COE held public workshops on February 27, 1990 and April 19, 1990 to discuss alternative solutions. The COE will conform to National Environmental Policy Act regulations when preparing their EIS.

4. People, however, should refrain from making false remarks or misleading statements. In spite of emotions, only facts and evidence are worthy of serious consideration.

5. Again, since the Kawainui Marsh issues are complex and controversial, the City does not anticipate that a quick and singular alternative can be implemented. Rather, the City would not be surprised to see the implementation of several alternatives over the course of time. These alternatives probably will have varying degrees of success as well as shortcomings.

Your review of the DEIS is appreciated.

Very truly yours,

SAM CALLEJO
Director and Chief Engineer

DRAFT & FINAL ENVIRONMENTAL ASSESSMENT CHECKLIST

Title: Kawai Nui Marsh Management Plan

DRAFT ENVIRONMENTAL ASSESSMENT

Document Received: 9-11-98 DEA placed in nearest public library? ____

Was the "OEQC Publication Form" completed? ____

Is EA a complete and separate document? ____

Conditions which triggered the EIS Law. Check all that apply:

- ___ Use of State or County Land or Funds
- ___ Amendment to a County General Plan
- ___ Use of Conservation District Lands
- ___ Reclassification of Conservation Lands
- ___ Use of Shoreline Setback Area
- ___ Construction or Modif. of Helicopter Facilities
- ___ Use of Historic Site or District
- ___ City & County of Honolulu SMA
- ___ Use of lands in the Waikiki Special District
- ___ Other

Comments/Recommendation/Justification:

____

____

APPROVED FOR PUBLICATION: (sign) ____________________

DATE OF PUBLICATION: ____________

DRAFT EA COMMENT DEADLINE: ____________

FINAL ENVIRONMENTAL ASSESSMENT (FONSI)

Document Received: ____________

Was the "OEQC Publication Form" completed? ______

Comments/Recommendation/Justification:

____

____

APPROVED FOR PUBLICATION: (sign) ____________________

DATE OF PUBLICATION: ____________

DRAFT ENVIRONMENTAL ASSESSMENT

_____ (1) Agency submittal letter and anticipated determination;

_____ (2) Identification of applicant or proposing agency;

_____ (3) Identification of approving agency, if applicable;

_____ (4) Identification of agencies, citizen groups, and individuals consulted in making the assessment;

_____ (5) General description of the action's technical, economic, social, and environmental characteristics; time frame; funding/source

_____ (6) Summary description of the affected environment, including suitable and adequate regional, location and site maps such as Flood Insurance Rate Maps, Floodway Boundary Maps, or United States Geological Survey topographic maps;

_____ (7) Identification and summary of impacts and

_____ (8) Proposed mitigation measures;

_____ (9) Alternatives considered;

_____ (10) Discussion of findings and reasons supporting the agency anticipated determination;

_____ (11) List of all permits and approvals (State, federal, county) required; and

_____ (12) Written comments and responses to the comments under the early consultation provisions of sections 11-200-9(a)(1), 11-200-9(b)(1), or 11-200-15.

FINAL ENVIRONMENTAL ASSESSMENT

_____ **(13) Agency submittal letter;**

_____ **(14) Agency determination;**

_____ **(15) Discussion of findings and reasons supporting the agency determination;**

_____ **(16) Written comments and responses to the comments under the statutorily prescribed public review periods.**

Kauai Nui Education Center
Initial Stage (9/08/98)

ENVIRONMENTAL ASSESSMENT CHECKLIST

In a summary section include the following:

✓ 1. Identify the applicant or proposing agency. p. iii, Hawaii Audubon Society
✓ 2. Identify the approving agency, if applicable. p. iii, DLNR
✓ 3. Describe the anticipated determination (is a FONSI anticipated?) p. iii
✓ 4. List individuals, community groups and agencies consulted. Copies of any correspondence should be appended to the draft EA. p. iii

Other helpful information which should be listed in the summary section includes:

✓ 5. Tax map key numbers of affected properties. TMK 4-2-13: par. 5, p. iii
✓ 6. Names of property owners and lessees. State of Hawaii, p. iii
✓ 7. Land use classifications: state designations; and county designations including general, community/development plans and zoning. U, P-2, (Conserv.-wetlands) p. IV
✓ 8. Special designations: special management area (SMA), shoreline setback, historic site or facility listed on the state or federal register. SMA, p. iv

In the body of the text include the following:

____ 9. Describe the action's technical, economic, social and environmental characteristics; time-frame, funding and source.
- ____ a. If a facility is planned, provide floor plans and a photo or drawing of its final appearance.
- ____ b. Indicate anticipated start and end dates of the project.
- ____ c. Disclose the amount of any state or county funds involved, including federal or other funds administered by state or county agencies.

____ 10. Describe the affected environment and include appropriate maps. If the project is located in or near a sensitive environment discuss the impacts of the project on the area as well as mitigation measures planned to prevent, lessen or counteract these impacts. Sensitive areas include flood plains, tsunami zones, beaches, streams, rivers, ocean, estuaries, anchialine ponds, fresh or coastal waters, erosion-prone areas and geologically hazardous land.
- ____ a. Descriptions of flora, fauna, significant habitats, historical archaeological and cultural sites. Impacts to sensitive habitats (such as a refuge) and their mitigation measures need to be discussed.
- ____ b. Maps and graphics will help the reader visualize your project. Location and site maps are required that show the island, the area of the project and the immediate neighborhood, each with the project site indicated. Maps should always include a title, a north arrow and a scale.

____ 11. Identify and summarize positive as well as negative major impacts. The impacts of concern are of the proposed action on the surrounding environment and community, not the impact of the environment on the action. If certain types of impacts are not applicable, explain why rather than glossing over them. For example, discuss why certain impacts (such as those to threatened or endangered species or construction impacts on a nearby stream) are not present rather than not mentioning them at all.

____ 12. Describe proposed mitigation measures, if any. It is not sufficient to state that appropriate mitigation measures will be instituted whenever necessary. The potential problems must be identified and appropriate mitigation described. If a mitigation measure is identified, the corresponding impact should also be described. Best management practices should be described and employed whenever possible.
- ____ a. For mitigation at Historic Sites, the environmental assessment must include: 1) copies of the mitigation and/or preservation plans prepared for the Department of Land and Natural Resources' State Historic Preservation Program; and 2) a copy of the approval letter for the plans from the State Historic Preservation Program.

____ 13. Consider alternative methods and modes of your project, and discuss them in the draft EA. Select the one with the least detrimental effect to the environment. Alternatives to consider include:
- ____ a. Different sites: is one site less likely to infringe on an environment that needs protection, such as a wetlands or an historic district?
- ____ b. Different facility configurations: is one configuration less likely to intrude on scenic viewplanes?
- ____ c. Different implementation methods: can a rocky area be cleared by backhoe removal rather than blasting?

Alternative analysis should include input from the community. Community members may be aware of concerns and impacts that make a particular alternative more or less desirable.

____ 14. List the expected determination, either a Finding of No Significant Impact (FONSI) or the requirement to prepare an EIS. In anticipating a determination, the agency shall consider every phase of a proposed action, the expected primary and secondary consequences, and the cumulative as well as the short and long-term effects of the action. Include the findings and reasons supporting the determination.