DRAFT

PAAUAU STREAM

FLOOD CONTROL STUDY

Pahala, Island of Hawaii, Hawaii

US Army Corps
of Engineers
Honolulu District

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DRAFT DETAILED PROJECT REPORT AND ENVIRONMENTAL ASSESSMENT
FOR FLOOD CONTROL
PAAUAU STREAM
PAHALA, ISLAND OF HAWAII, HAWAII

U.S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FORT SHAFTER, HAWAII 96858
JANUARY 1982

SUMMARY

The purpose of this document is to describe the feasibility and impacts of proposed flood-damage reduction improvements for the Paauau Stream at Pahala, Hawaii. The potential improvements are designed to alleviate flood conditions and thereby reduce flood damages due to the overbank flows through the residential areas.

The draft Detailed Project Report, accompanied by the draft Environmental Assessment, is submitted for public review and comment. The scope of the report includes identification of the flood problem, examination of alternative plans, and evaluation of plans in terms of technical, economic, environmental and social acceptability. The evaluation and tentative plan selection process is guided by the dual national objectives of national economic development and environmental quality.

The flood problem at Paauau Stream is due to urban encroachment and the overbanking of the stream. Also, the steep grades of the area produce high velocity flows through Koali Street and the adjacent properties. The prevention of overbanking at the upper portion of the subdivision would provide the necessary flood protection.

Based on the evaluation of alternative plans, the tentatively selected plan consists of a 410-foot-long reinforced concrete lining and a 660-foot-long reinforced concrete wall along the right bank (looking downstream), and removal of a rock constriction at the left bank of the stream.

The reinforced concrete lining and wall would be located adjacent to six developed lots at the upper portion of the subdivision. The stream widening would relieve a constriction near the lower end of the proposed concrete wall. The overbanking at the lower portion of the subdivision causes minor damage, and therefore, it is not feasible to provide flood improvements in this lower area.

The estimated first cost of the tentatively selected plan is $382,000 of which $60,000 is the non-Federal share. The average annual benefits are $90,000 with average annual charges of $58,000, the benefit-to-cost ratio is 2.8. This finding is tentative and subject to resolution of all significant issues relative to this report.

The public is invited to submit comments on this document by 31 March 1982. Following the review and coordination period, the District Engineer will recommend the final selected plan and the extent of Federal participation for flood damage reduction improvements. This report will serve as the authorizing document for construction.

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INTRODUCTION

This report describes the feasibility and impacts of potential flood-damage reduction improvements for Paauau Stream drainage basin, island of Hawaii, Hawaii.

STUDY AUTHORITY

This draft Detailed Project Report and Environmental Assessment was prepared under the authority of Section 205 of the 1948 Flood Control Act, as amended (33 USC 701s), in response to a request from the Mayor of the County of Hawaii. The legislation authorizes the Chief of Engineers to perform investigation and construction of small local flood control works subject to statutory Federal monetary limits and agreement by Federal and local authorities.

SCOPE OF THE STUDY

The study provides an analysis of the flood problems at the Paauau Stream drainage basin and describes the formulation, assessment and evaluation of detailed plans for alleviating the flood problems. The investigation includes identification of the problems, descriptions of possible solutions, their assessment and evaluation with respect to engineering, economic, environmental and social/cultural criteria, and financial impacts on implementing institutions.

STUDY COORDINATION

The US Army Corps of Engineers is responsible for conducting and coordinating the study and for preparing this report. Community groups, private organizations, County of Hawaii, and State and Federal agencies have been consulted and their comments considered throughout the planning and design process.

An informational public workshop was conducted on 16 July 1981 at Pahala. The session generated public interest in the study and aided planners in identifying the flood problems. The people present were supportive of the concept and the need for flood protection. They also asked that the planning study, and the preparation of plans and specifications be completed in the shortest time possible.

PRIOR STUDIES AND REPORTS

Several reports have been published on the February 1979 and the March 1980 storms. The "Flood of February 20, 1979 in Hilo, Kau, and Puna Districts, Island of Hawaii" was prepared by the U.S. Geological Survey, and the "Storms of March 16-19 and 23-24, 1980, Islands of Oahu and Hawaii" was prepared by Pacific Weather, Inc., for the Department of Land and Natural Resources, State of Hawaii.

In response to the June 1980 request from the Mayor of the County of Hawaii, the Corps of Engineers completed a Reconnaissance Report (October 1980) under the authority of Section 205 of the 1948 Flood Control Act, as amended. The report concluded that additional Federal flood control studies were warranted.

PROBLEM IDENTIFICATION

The purpose of problem identification is to develop planning objectives which will guide the formulation of alternative plans. Public concerns which relate to water and related land resources problems are identified, and then refined based on national and local policies. To verify these resource problems, the base condition of the study area is identified. Then, future conditions are projected and analyzed to determine the "most probable future" which would prevail without any changes to existing plans ("without" condition). The planning objectives are based on the problems and needs of the study area as related to the "without" condition, and national and local policies.

NATIONAL OBJECTIVES

Federally-assisted water and related land resources planning must be directed to achieve two co-equal national objectives. These objectives are protection and enhancement of national economic development (NED), and protection and enhancement of environmental quality (EQ). Contributions to national economic development are increases in the values of the national output of goods and services. Contributions to environmental quality are favorable changes in the ecological, cultural and aesthetic attributes of natural and cultural resources, and ecological systems that sustain and enrich human life.

EXISTING CONDITION

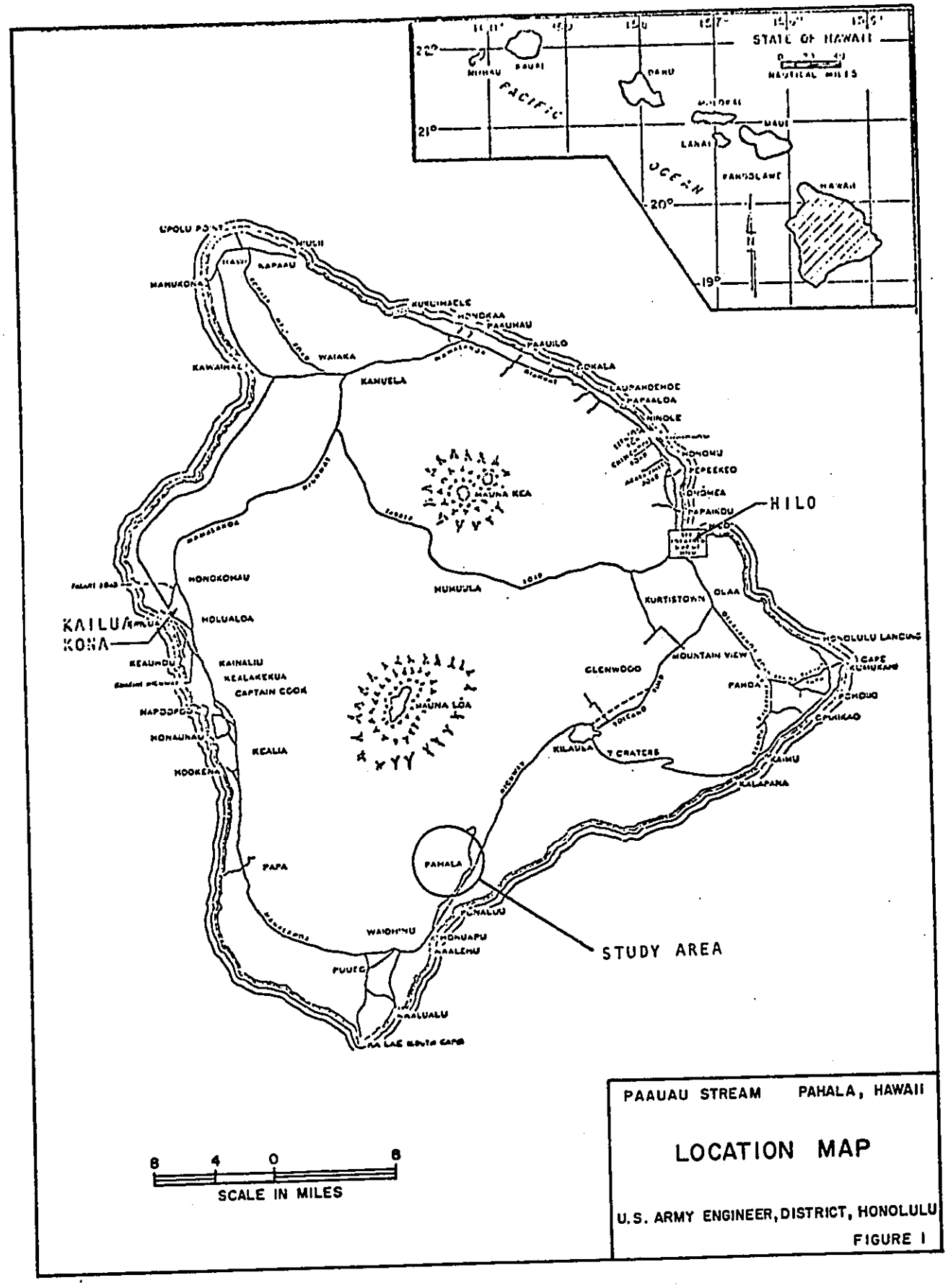
Study Area. The island of Hawaii is the largest of the Hawaiian Islands, encompassing 4,038 square miles of land area (see Figure 1). The island has two main population centers, Kailua-Kona on the west coast and Hilo on the east coast. The town of Hilo is the economic and political center of the island.

Hawaii has a subtropical climate with relatively uniform day lengths and mild temperatures. The mean temperature at Hilo is 73.4°F. Northeasterly trade winds are prevalent throughout the year.

Mean annual rainfall in the Paauau Stream area ranges from 125 inches at the headwaters to about 48 inches at Pahala. There are approximately six precipitation gages within the study area. The gage nearest the project area, Pahala 21, has about 89 years of record.

Paauau Stream is in the Kau District of the County of Hawaii, approximately 45 miles southwest of Hilo. The study area is located adjacent the town of Pahala, a community in the Kau District (see Figure 2). The drainage area is approximately 6.5 square miles. Kauhuhuula Gulch and an unnamed gulch are tributaries to Paauau Stream. Paauau Stream is ephemeral with the runoff percolating through lava covered lands then probably flowing to the ocean through lava tubes and cracks. Accordingly, the drainage area may not accurately represent the contributing area. The watershed is characterized by barren lava-covered areas, macadamia nut orchards and sugarcane fields.

Paauau Stream is located on the northeast end of Pahala with developed lots along approximately 2600 feet of the right bank (looking downstream). The left bank consists of unimproved residential land (used as pasture land) and agriculture land. The Paauau Stream is located on private property. At certain places the riverbed extends 60± feet into developed properties along the right bank.



PAAUAU STREAM PAHALA, HAWAII

LOCATION MAP

U.S. ARMY ENGINEER, DISTRICT, HONOLULU

FIGURE 1

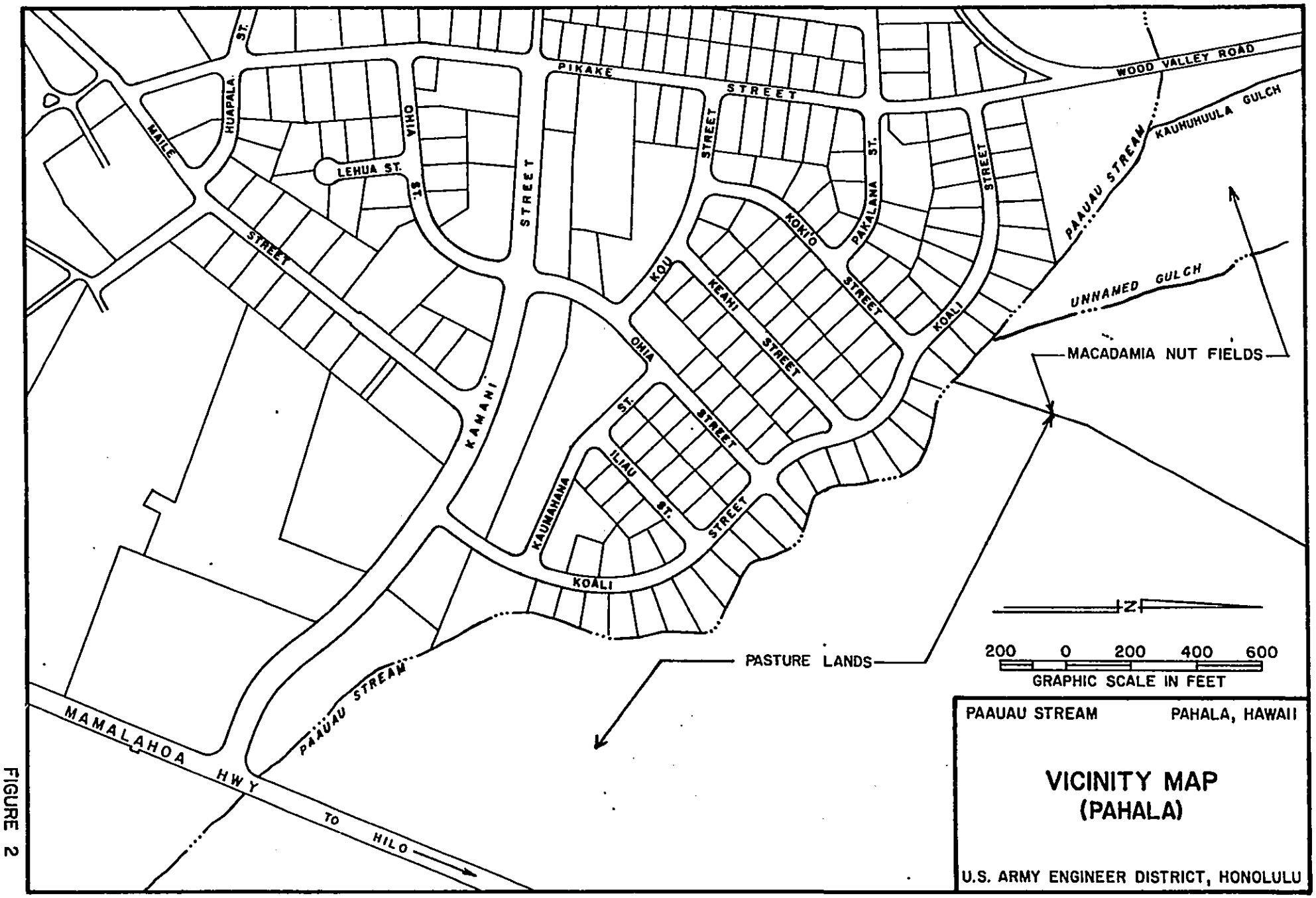


FIGURE 2

FIGURE 2

Geology. The island of Hawaii is the youngest of the Hawaiian island archipelago and is the result of the coalescence of the lava flows of five volcanoes. The volcanoes Mauna Loa and Kilauea are still very active. Pahala is in an area designated "E" (zone of greatest hazard) hazard zone or an area subject to being covered by lava should an eruption of these volcanoes occur.

The base rock in the area is crystalline lava basalt and is very permeable. This is overlain by soil consisting of volcanic ash (clay) and weathered base rock approximately 4 feet thick. The stream channel has eroded through the soil to base rock with loose rocks of the same material lying on the surface. Very permeable basalt downstream from the project area permits stream flow to percolate into the subsurface material.

Socio-Economic Characteristics. Pahala is a plantation town of over 1,600 people (1980 population of 1,631), and is dependent on the sugar and macadamia nut industries. The 1970 population was approximately 39 percent Filipino and 30 percent Japanese, compared to a countywide figure of about 16 and 38 percent, respectively. The study area includes a subdivision south of Paauau Stream and two large parcels north of Paauau Stream. The stream flows through the subdivision lots and the two parcels north of the stream. The subdivision was developed in 1972-1973, and homes have been constructed on most of the lots. Undeveloped lots include a lot adjacent to Wood Valley Road and six lots near Mamalahoa Highway--all zoned for single-family residences.

The two parcels north of Paauau Stream are owned by Seamountain-Hawaii Ranch Company and Brewer Orchids, Inc. The Seamountain-Hawaii parcel (87 acres) is zoned residential and is presently used as pasture land. This parcel's south boundary adjoins the Paauau Stream from Mamalahoa Highway to about 1,900 feet northwest of Mamalahoa Highway.

The Brewer Orchids' parcel (624 acres) is zoned agriculture and is planted with macadamia nut trees. The south boundary adjoins the Paauau Stream from the Seamountain-Hawaii parcel to about 500 feet northwest.

The drainage basin above Pahala is zoned agriculture and conservation with the agricultural lands planted with sugarcane and macadamia nuts.

Biological Resources. There is little vegetation within the streambed since it consists of *in situ* basalt and the streambanks have been severely eroded by past floodwaters. Vegetation along the stream channel consists of grass and a few trees. Macadamia nut orchards are upstream, above Pikake Road. Vegetation within the residential area consists of exotic cultivated species. The urban area is probably inhabited by introduced birds, and feral dogs and cats. The outlying areas are probably inhabited by mongoose. No threatened or endangered species are known to use the project area as a habitat.

Water Quality. The intermittent waters of Paauau Stream are designated class 2 by the State of Hawaii (Chapter 37-A, Water Quality Standards, rev. 1979). Class 2 waters are to be protected for recreational purposes, the propagation of fish and other aquatic life, and agricultural and industrial water supply. During storm conditions, the stream waters are turbid and contain suspended sediments. The stream is not used for potable public water supply.

Cultural Resources. A check of the Federal Registers of 1978-1980 revealed no sites in the study area listed on or eligible for the National Register of Historic Places. Historic sites are unlikely to be found in areas disturbed by residential development, sugarcane fields and macadamia nut orchards. A Corps-sponsored archaeological reconnaissance of the study area by Science Management, Inc. in September 1981 revealed no archaeological deposits or other items of cultural, historical or archaeological interest.

FUTURE CONDITION WITHOUT FEDERAL ACTION

If no Federal action is taken to provide flood control improvements for Paauau Stream, flooding in the area near the stream will continue. Of more serious consequence, a catastrophic event may result from the high-velocity flows generated by the steep profile of the area. There are no plans at the present time by local, State or Federal agencies for flood control improvements at Paauau Stream. There are no development plans for the land north of the Paauau Stream.

PROBLEMS AND NEEDS

Flooding at Pahala is primarily a result of overbanking of the Paauau Stream coupled with the development of the residential subdivision adjacent to the right streambank. The overbanking at the right bank at the upper portion of the subdivision (from the confluence of the Paauau Stream and the Kauhuhuula Stream to about 800 feet downstream) results in high-velocity flows through Koali Street and the adjacent lots, where major damages have occurred (see Plates 1 and 2). Although there is overbanking at the lower portion of the subdivision, damages are considered minor. The left bank also overtops but no significant damage results due to this overtopping.

The 20 February 1979 storm produced about 17 inches of rainfall over a 24-hour period. The floodwaters washed out portions of the Mamalahoa Highway and inundated certain locations so that the Kau District was cutoff from the rest of the island during the height of the flood. Twenty-five families were evacuated from their homes at Pahala during the storm. Estimated damages were $750,000 to sugar and $100,000 to diversified agriculture. On 24 February 1979, Governor George Ariyoshi declared the Hilo, Kau and Puna Districts major disaster districts on the island of Hawaii. Then on 7 March 1979, President Carter declared the island of Hawaii a major disaster area.

During the March 1980 storm, approximately 18 inches of rainfall was recorded over a 2-day period. Floodwater depths of 2 to 3 feet occurred along Koali Street, homes and properties were flooded, and the flow velocity along Koali Street was high enough to prevent residents from crossing the street to safety. Agriculture damages amounted to about $900,000 at the Kau District with $750,000 to the Kau Sugar Company. A couple was killed along the Mamalahoa Highway within the Kau District (not within the study area) when their vehicle got caught in the floodwaters crossing the highway.

There are no major flood control improvements at Pahala. The Paauau Stream is unimproved. General improvements consist of a bridge at Mamalahoa Highway built by the State Department of Transportation, two culverts along Wood Valley Road, the embankment located west of the Wood Valley Road culvert (Paauau Stream) and south of Paauau Stream, and a few privately built walls along the right bank.

The U.S. Soil Conservation Service (SCS) and the County of Hawaii implemented temporary emergency measures after the February 1979 and March 1980 storms. The stream was widened and the embankments were improved after each storm. Using emergency funds, the U.S. Soil Conservation Service in cooperation with the County, widened the streambed and constructed four (total length 440± linear feet) reinforced concrete retaining walls along the right bank at areas that were severely eroded. The improvements are emergency-type measures and were not designed to provide permanent, long-term protection from severe storm conditions.

PHOTOGRAPH NO. 1

Turbulent Stream near Sta 32+00
(March 1980)

PHOTOGRAPH NO. 2

Sediment and debris after flood
(February 1979)

PHOTOGRAPH NO. 3

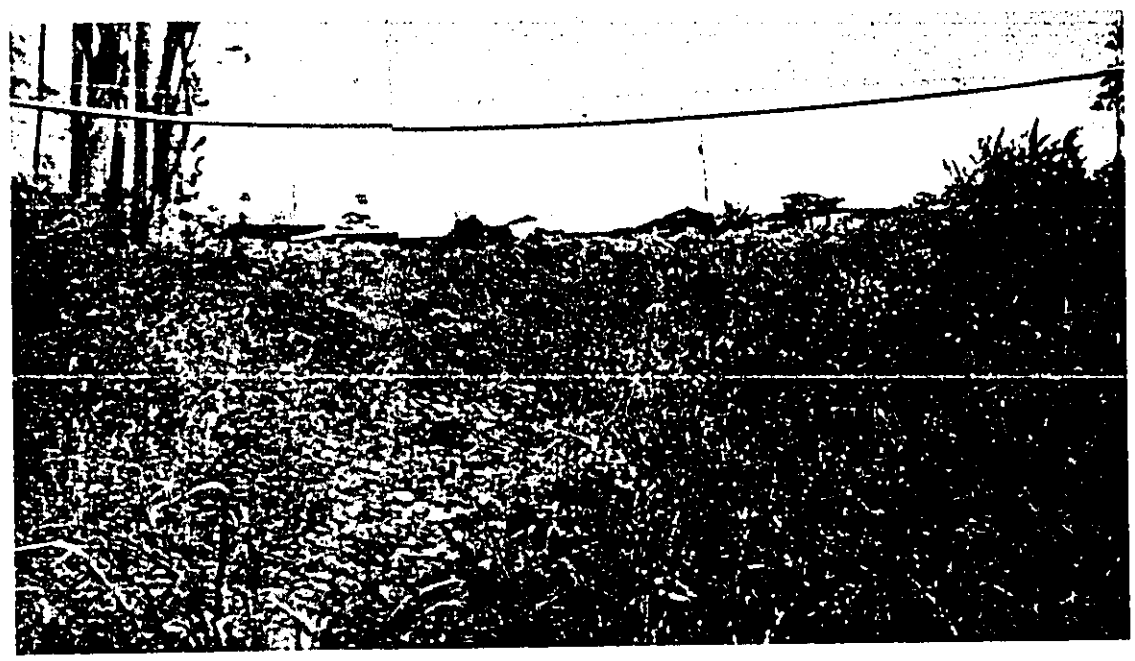
Mamalahoa Bridge, looking downstrea,
(June 1981)

PHOTOGRAPH NO. 4

Homes along lower Koali Street
Concrete wall along streambank at center
(June 1981)

PHOTOGRAPH NO. 5

Right bank near Sta 33+00
(February 1981)



Looking downstream from Sta 39+00±
(June 1981)

PHOTOGRAPH NO. 6

During past storms, the flood water overbanked the Mamalahoa Highway at the Paauau Stream Bridge and undermined the highway. The bridge has remained intact but the damages to the highway have caused inconveniences to the residents of the area. No property damage was caused by this overbanking. This problem is a recurring one at the numerous stream crossings along Mamalahoa Highway and has been brought to the attention of the responsible local agency.

The Paauau Stream does not serve as a source of drinking water. The stream also has limited value as a recreation area. Consequently water supply development and enhancement of recreation values were not pursued in conjunction with flood protection.

PLANNING CONSTRAINTS

Various planning constraints were considered throughout the planning effort. Planning constraints generally specify limitations that are used to guide plan formulation and restrict adverse impacts. As limitations, they affect a broad range of concerns, including legal, social, economic and environmental factors, and are discussed below.

a. The Corps may participate in the construction of flood-control measures, when in the opinion of the Chief of Engineers such work is advisable. Any project recommended must be justified under established Federal planning criteria, must be complete in itself, and must not obligate the Federal government to future work. Local interests must agree to assume responsibility for designated items of local cooperation and for all project costs in excess of the specified Corps cost limitation. The Corps will participate up to a limit of $2.0 million, subject to project authorization by the Chief of Engineers. However, a limit of $3.0 million shall be allotted for a project if the project protects an area which has been declared to be a major disaster area in the five-year period immediately preceding the date the Chief of Engineers authorizes the work. The President declared the subject area a disaster area in 1979.

b. Consistent with the Hawaii County floodplain and tsunami ordinance, the 100-year level of protection was considered the minimum design protection level.

c. The Paauau Stream is within private property. The County of Hawaii will be required to provide all lands, easements and rights-of-way necessary for the construction and maintenance of the proposed flood control works.

d. Federal statutory and regulatory requirements guided the analysis of environmental resources and impacts. The required coordination was primarily related to evaluation and assessment of potential project implementation effects.

PLANNING OBJECTIVES

The planning objectives are based on the problems and needs of Pahala as related to the "without" condition, and national and local objectives and policies. The planning objectives are:

a. Contribute to the safety and well-being of the Pahala community in areas subject to flooding for the period 1984 to 2034.

b. Contribute to the protection of property potentially damageable by floodwaters, and to promote the efficient use of lands within the study area.

FORMULATION OF PRELIMINARY PLANS

An alternative plan is a system of structural and/or nonstructural measures, strategies or programs formulated to relieve specific problems or to take advantage of specific opportunities associated with water and related land resources in a study area.

MANAGEMENT MEASURES

Management measures for flood relief at Paauau Stream area can be broadly categorized as either structural or nonstructural plans. A "No Action" measure would result in continued flood damages. A "No Action" measure is not responsive to the planning objectives established for this study and is therefore eliminated from further consideration.

Structural Measures. These are physical measures which act directly on riverine or tidal waters to change their direction, area of inundation, volume, stage or timing to reduce flood damages or to enhance the economic value of the floodplain. Included in this category are such traditional flood damage prevention works as channels and reservoirs.

Nonstructural Measures. These are measures to relieve flood damages and minimize loss of life without significant alteration of the existing elements. This category includes floodplain use regulations, floodproofing, bridge modification, relocation and other actions which tend to minimize flood damages rather than control, store or reduce floodwaters.

PLAN FORMULATION RATIONALE

Formulation of alternative plans responsive to the planning objectives of the study was guided by eight criteria of acceptability discussed below.

Engineering Adequacy. Plans should eliminate or reduce the Paauau Stream flood problem, consistent with design and safety requirements.

Economic Feasibility. Quantifiable benefits should be greater than project economic costs, with project scope and scale formulated so that each alternative plan maximizes its net benefits.

Environmental Sensitivity. Plan impacts should be limited to short-term, nonsignificant, minimal or mitigable impacts on environmental resources of the Paauau Stream area.

Social/Institutional Compatibility. Plans should be accepted and supported by Pahala residents, the sponsoring local agency, other relevant government agencies, and interested individuals and organizations.

Federal/Other Agency Implementation. Plans are not to be limited to the implementation responsibility of the Federal planning agency, but should consider plans of other agencies.

Regulatory or Administrative Impact. Plans may consider changes in statutes and laws or be in compliance with existing statutes and laws.

Water Conservation. Plans should consider effects of reduced water demand or conservation.

Scheduling. Various implementation schedules are to be considered which would result in the most favorable mix of effects on the NED and EQ objectives.

PRELIMINARY SCREENING

Nonstructural Measures. Flood prediction, warnings, preparation of temporary flood protection measures and temporary evacuation would help to decrease both the loss of human lives and damages. However, due to the uncertainty of predicting variables over a relatively small drainage basin and the flashy nature of streamflows typical of the Kau area, these methods of damage reduction are not considered reliable or effective.

The concept of evacuation and relocation has been considered on the basis of moving all the homes in the floodplain to another site in the Kau area. Based on the investment committed to the existing homes and the sentimental values involved, evacuation would have tremendous adverse effects from both the economic and social viewpoints. Relocation would also involve development of a new site for the relocated community or locating suitable homes for the displaced families.

Floodplain regulation would control future development, especially on the left bank. However, this approach will not alleviate the existing flood problems in the developed areas.

Floodproofing presents many disadvantages. This nonstructural measure entails raising the floors of structures posted on footings and providing floodwalls for existing slab-on-grade buildings. The temporary relocation during construction would present economic and social problems, and inconveniences. Floodproofing also imposes adverse visual impacts on the aesthetic-architectural characteristics of the affected homes. In addition, floodproofing will not alleviate the damages from erosion and damages to structures, equipment and materials outside of the flood-proofed structures. Finally, the danger to human life and the anxiety due to the high-velocity flows along Koali Street and around the homes will not be diminished.

Structural Measures. Various structural methods for alleviating the flood threat and preventing flood damages were considered. These included detention of the floodwaters in reservoirs; increasing channel capacity by deepening and widening, and by construction of levees and floodwalls; and combinations of the above. Preliminary assessments indicated that reservoirs could not provide the protection as economically as could be provided by channel or levee improvements. The topography of the land and the foundation conditions does not lend itself to construction of reservoirs. Therefore, the construction cost of reservoirs would be very high. Consequently, alternative flood-protection plans consisting of increasing channel capacities by channel deepening and widening, and construction of channel lining and floodwall were developed for further investigation.

Applicable Nonstructural and Structural Combinations. Various combinations of channel deepening and widening, and construction of channel lining and floodwall with nonstructural measures were also investigated. A combination of structural measures with floodplain regulation is applicable, and further investigations are warranted. Based on potentially adverse social impacts,

and disruption of community cohesion, other structural and nonstructural combinations were viewed as less favorable than either structural or nonstructural alternatives.

TABLE 1. SCREENING OF POSSIBLE MEASURES

Measures	Preliminary Findings
Flood Warning/Temporary Evacuation	Warning time short and unreliable for small, flashy basins.
Floodproofing	Has merit in combination with other measures, should consider further.
Permanent Evacuation and Relocation	High cost and significant adverse social impact.
Floodplain Regulation	Applicable for the undeveloped areas; does not alleviate the existing flood problems in developed area.
Reservoirs	Not feasible economically relative to other structural measures.
Floodwall/Levees	Has merit, should consider further.
Channel Widening/Deepening	Has merit, should consider further.
Combination Nonstructural and Structural	Except for floodplain regulation and the floodproofing, other nonstructural measures combined with structural measures are less desirable than either all nonstructural or all structural measures.

ASSESSMENT AND EVALUATION OF DETAILED PLANS

To provide a basis for selecting the alternative plan that best met this study's planning objectives, the beneficial and adverse contributions of the alternative plans carried into detailed analysis were identified, measured and compared.

STRUCTURAL PLANS

Level of Protection. The Standard Project Flood (SPF) level of protection was selected, where the SPF is the hypothetical flood that would occur assuming a severe combination of hydrometerological conditions, excluding extremely rare combinations. The SPF level of protection was selected on the basis of benefits with SPF benefits about double the one percent flood benefits while the construction costs for the SPF and the one percent flood were comparable.

Alternative 1 Description. Alternative 1 consists of reinforced concrete lining of the right bank, a reinforced concrete wall on the right bank above the concrete lining, rock excavation along the left bank and a flowage easement (see Plate 3).

The lining of the right bank would be 10 to 12 feet in height and about 410 feet in length. The side slope of the lining will be 1.5H (horizontal) to 1.0V (vertical). The concrete wall will be about 660 feet long, 4 to 7 feet high and will be located on top of the right bank. The concrete lining is required to stabilize the erodible right bank, and the concrete wall provides the required height for overbanking protection and freeboard.

The rock excavation along the left bank will be 390 feet long by 10 to 60 feet wide and up to 15 feet in height involving 670 cubic yards of materials. The excavation would straighten the channel and eliminate the constriction in the channel.

Lands, easements, and rights-of-way would be required for both structural alternative plans for project construction, maintenance, and further encroachment on the floodway. The project land requirements as shown on Plates 3 and 4 are based on the Alternative 1 improvements, as well as the one percent flood limit (in conjunction with the National Flood Insurance Program which the County of Hawaii will adopt in the new future).

Interior drainage structures at the Alternative 1 improvements would not be required because the slope of the terrain falls away from the stream.

Alternative 2 Description. Alternative 2 is similar to Alternative 1 with the addition of stream widening along the left bank (see Plate 5). The reinforced concrete lining and wall are similar to Alternative 1 in section, but longer in length by 455 feet and 310 feet, respectively. The reinforced concrete wall will be 2 to 5 feet in height. Alternative 2 will require approximately 10,000 cubic yards of additional fill at Sta. 27+00 to 30+50, and the stream widening (60-foot channel) will require 19,000 cubic yards of additional excavation.

Impact Assessment of Alternatives 1 and 2. Within the proposed construction limits, the stream will be widened, vegetation will be removed from the stream course, the channel will be lined along the right bank and a concrete wall erected 2 to 7 feet above the existing ground. The vegetation in the streambed will grow back after the construction period. The right bank will be replaced by a reinforced concrete lining and wall which will present a visual impact. The visual impact of the lining and wall will be more severe for Alternative 1 due to its 4- to 7-foot-high wall versus the 2- to 5-foot-high wall for Alternative 2.

The excavation to widen and straighten the stream will also present a visual impact. The impact of Alternative 2 will be more severe due to the 19,400 cubic yards of excavation versus the 670 cubic yards of excavation for Alternative 1.

A temporary increase in sediment discharge due to construction is expected. However, this effect would be restricted to the construction period and no long-term sedimentation problems are anticipated. Rather, an overall decrease in sediment problems should result with the reduction in bank erosion. Real estate requirement for the concrete lining and wall would be primarily stream bank lands.

Evaluation of Alternatives 1 and 2. Each alternative's contributions to the study's planning objectives, response to the plan formulation criteria and contribution to the National Economic Development (NED), Environmental Quality (EQ), and Other Social Effects (OSE) accounts are displayed in Tables 3 and 4.

NED benefits represent reduction in damages to structures and their contents, reduction of damages to roads and utilities, and reduction in emergency relief costs. The benefits are the estimated difference between conditions with and without a proposed plan of protection. The benefit-to-cost ratios (BCR) for protection against the SPF levels of protection are 2.8 and 1.6 for Alternatives 1 and 2, respectively. There is no significant net EQ enhancement for the two alternatives. Therefore, Alternative 1 is justified on the basis of economic, but not on environmental benefits (net beneficial effects rule).

Implementation Responsibilities for Alternatives 1 and 2. Discussion of project costs and apportionment can be found in Appendix D, Economic Evaluation. The relevant figures for SPF protection (50-year, 7-5/8%) are summarized in Table 2.

TABLE 2. ALTERNATIVES 1 AND 2 PROJECT COST AND APPORTIONMENT

Alternative 1		
Project First Cost		
Federal	$322,000	
Non-Federal	60,000	
TOTAL PROJECT FIRST COST		$382,000
Average Annual Cost		
Interest & Amortization	$ 29,900	
Operation & Maintenance	1,700	
TOTAL ANNUAL COST		$ 31,600
Alternative 2		
Project First Cost		
Federal	$638,800	
Non-Federal	60,000	
TOTAL PROJECT FIRST COST		$698,800
Average Annual Cost		
Interest & Amortization	$ 54,700	
Operation & Maintenance	3,300	
TOTAL ANNUAL COST		$ 58,000

NONSTRUCTURAL PLAN

Level of Protection. To meet planning requirements for the development of a nonstructural plan, a combination relocation, floodproofing and temporary evacuation concept plan was carried into detailed analysis. The SPF level of protection was selected.

Alternative 3 Description. Alternative 3 provides for relocation of 13 lots (see Plates 6 & 7), floodproofing 8 structures and temporary evacuation during severe storms. The relocation and floodproofing would produce flood damage reduction benefits for 21 developed lots.

The temporary evacuation would be necessary for the residents along Koali Street due to the danger of the high velocity flows along Koali Street after the Paauau Stream overbanks at the upper portion of the subdivision. The evacuation would be signalled by a warning system activated by a stream gage.

TABLE 3 SUMMARY COMPARISON OF FINAL ALTERNATIVE PLANS

Plan Description	Without Condition	Alternative 1	Alternative 2	Alternative 3
1. Type of improvement.	No action.	Stream lining, wall and removal of constriction.	Stream lining, wall and widening.	Floodproofing, relocation, evacuation.
2. Distinguishing feature.	NA	Concrete lining and wall along portion of right bank; removal of constriction to straighten channel; SPF design flood.	Same as Alternative 1; also widening to 60 feet along portion of stream.	Raising 8 existing structures, relocation of 13 lots, temporary evacuation through warning system.
PLAN EVALUATION AND IMPACT ASSESSMENT				
Contribution to Planning Objectives				
1. Safety and well-being of residents.	No protection beyond 2% flood	Provides SPF protection.	Same as Alternative 1.	Provides SPF protection. Koali Street may be inaccessible during floods.
2. Protection of property.	Potential for damage remains.	Reduction in potential damage.	Same as Alternative 1.	Same as Alternative 1 except for more erosion due to flows along Koali Street.
3. Protection of environmental and social resources.	Existing environmental resources, anxiety and danger to life will remain.	Temporary destruction of existing vegetation at location of proposed improvements.	Same as Alternative 1.	Existing environmental resources will remain. Possible enhancement through park development.
Responses to Plan Formulation Tests				
1. Completeness.	NA	Complete.	Complete.	Complete.
2. Effectiveness.	Ineffective.	Effective.	Effective.	Partially.
3. Efficiency.	Inefficient.	Efficient.	Efficient.	Inefficient.
4. Acceptability.	Unacceptable.	Acceptable.	Acceptable.	Unacceptable.

TABLE 3. SUMMARY COMPARISON OF FINAL ALTERNATIVE PLANS (Cont)

Plan Description	Without Condition	Alternative 1	Alternative 2	Alternative 3
Contribution to National Economic Development (NED) Account (Avg Annual)				
1. Beneficial.	$ (-) 120,000	$ 90,000	$ 95,000	$ 10,000
2. Adverse (Cost of Construction and Maintenance).	0	$ 32,000	$ 58,000	$ 99,000
3. Net.	$ (-) 120,000	$ 58,000	$ 37,000	$(-) 89,000
4. Benefit-Cost Ratio (BCR).	NA	2.8	1.6	0.10
Contribution to Environmental Quality (EQ) Account				
1. Significant beneficial impacts.	Will maintain existing vegetation.	Less streambank erosion and associated turbidity.	Same as Alternative 1.	Same as Without Condition; vacated lots could be open park.
2. Significant adverse impacts.	Continued streambank erosion.	Loss of existing natural streambank; 4'-7' wall at streambank.	Loss of existing natural stream; 2'-5' wall at streambank.	Same as Without Condition.
Contribution to Other Social Effects (OSE) Account				
1. Significant beneficial impacts.	Aesthetic, social significance of natural stream maintained.	Enhanced quality of life resulting from reduced flood hazards.	Same as Alternative 1.	Same as Without Condition; anxiety and danger to life reduced.
2. Significant adverse impacts.	Anxiety and danger to life will remain.	Natural stream altered at project area.	Same as Alternative 1.	13 residents displaced

TABLE 3. SUMMARY COMPARISON OF FINAL ALTERNATIVE PLANS (Cont)

Plan Description	Without Condition	Alternative 1	Alternative 2	Alternative 3
RANKING OF PLAN CONTRIBUTIONS				
NED Account	NA	1 (NED Plan).	2	3
EQ Account	NA	2	3	1 (LED PLAN).
OSE Account	NA	1	2	3
RED Account	NA	NA	NA	NA
IMPLEMENTATION RESPONSIBILITIES				
1. Federal (Corps of Engineers)	Flood hazard information.	Provide design and construction. First cost (PW) = $322,000.	Same as Alternative 1. First cost (PW) = $638,000.	Same as Alternative 1. First cost (PW) = $960,000.
2. Non-Federal (County of Hawaii).	Emergency evacuation.	Provide lands, easements, rights-of-ways, and bridge improvements. First cost (PW) = $60,000.	Same as Alternative 1. First cost (PW) = $60,000.	Provide 20% of costs. First cost (PW) = $240,000.

TABLE 4. SYSTEMS OF ACCOUNTS

Plan Description	Without Condition	Alternative 1	Alternative 2	Alternative 3
Type of Improvement.	No action	Stream lining, wall and removal of constriction.	Stream lining, wall and widening.	Floodproofing, relocation, evacuation.
Distinguishing Features.	NA	Concrete lining and wall along portion of right bank; removal of constriction to straighten channel; SPF design flood.	Same as Alternative 1; also widening to 60 feet along portion of stream.	Raising 8 existing structures, relocation of 13 lots, temporary evacuation through warning system.
ACCOUNT				
NATIONAL ECONOMIC DEVELOPMENT (NED)				
Average Annual Benefits	$(-) 120,000	$90,000	$95,000	$10,000
Average Annual Costs (Construction & Maintenance)	0	$32,000	$58,000	$ 99,000
Net Annual Benefits	$(-) 120,000	$58,000	$37,000	$(-) 89,000
Benefit-to-Cost Ratio	NA	2.8	1.6	0.10

TABLE 4. SYSTEM OF ACCOUNTS (Cont)

Plan Description	Without Condition	Alternative 1	Alternative 2	Alternative 3
ENVIRONMENTAL QUALITY (EQ)				
1. Land and natural resources.	No change.	Land erosion reduced; loss of existing natural streambank due to construction of concrete lining & wall (2,6,7,9).	Same as Alternative 1.	Potential enhancement through open park development.
2. Water quality.	No change.	Less turbidity during flood flows (2, 6, 7, 9). Increased turbidity during construction (1, 6, 7, 9).	Same as Alternative 1.	No change.
3. Stream habitat and organisms.	No change.	Insignificant change.	Same as Alternative 1.	No change.
4. Terrestrial vegetation.	No change.	Riparian vegetation at impacted areas will be destroyed; vegetation will regrow except for concrete lined bank (1, 6, 7, 9).	Same as Alternative 1.	No change; possible enhancement through open park development.
5. Archaeological and historic sites.	No change.	No impact; absent from project area.	Same as Alternative 1.	No change.
OTHER SOCIAL EFFECTS (OSE)				
1. Aesthetic values.	No change.	Natural stream aesthetics destroyed at location of concrete lining and wall (2, 6, 7, 9).	Same as Alternative 1.	Potential enhancement through open park development.
2. Leisure opportunities.	No change.	Stream inaccessible at location of concrete lining and wall (2, 5, 8, 9).	Same as Alternative 1.	Potential enhancement through open park development.
3. Health, safety, well-being.	No change.	Protection of life and property from flood waters (2, 6, 7, 9).	Same as Alternative 1.	Anxiety and danger to life reduced.

TABLE 4. SYSTEM OF ACCOUNTS (Cont)

Plan Description	Without Condition	Alternative 1	Alternative 2	Alternative 3
OTHER SOCIAL EFFECTS (OSE) (Cont)				
4. Community cohesion.	No change.	Flood evacuation conditions eliminated (2, 6, 8, 9).	Same as Alternative 1.	13 residents displaced.
REGIONAL ECONOMIC DEVELOPMENT (RED)	No change.	NA	NA	NA

INDEX OF FOOTNOTES:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

Uncertainty

4. The uncertainty associated with the impact is 50% or greater.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because additional actions are lacking.

Impact Assessment of Alternative 3. The nonstructural alternative would have the least impact on the existing stream environment. The physical habitat of the stream would not be disturbed. However, the relocation of 13 residents and the raising of 8 structures would have an adverse effect on the community cohesion and the well-being of the community. A potential beneficial effect would be that the vacated lots could be acquired and used as an open park.

Evaluation of Alternative 3. Alternative 3 does not satisfy this study's planning objectives of contributing to the efficient use of lands and the elimination of the danger of high velocity flows along Koali Street. Also it would probably not be an acceptable solution to the residents along Koali Street. With a BCR of 0.10, minimal EQ beneficial effects and minimal OSE beneficial effects, this plan is inefficient and probably unacceptable to the residents affected.

Implementation Responsibilities for Alternative 3. Project cost and apportionment are summarized below.

Alternative 3 Cost Apportionment

Project First Cost		
Federal	$960,000	
Non-Federal	240,000	
TOTAL PROJECT FIRST COST		$1,200,000
Average Annual Cost		
Interest & Amortization	$ 93,900	
Operation & Maintenance	4,800	
TOTAL ANNUAL COST		$ 98,700

COMPARISON OF DETAILED PLANS

This study's planning objectives were based on the identified problems and needs of the study area as related to the "without" condition, and national and local policies. The planning objectives in turn, guided the formulation of alternatives plans. These alternatives have now been evaluated with respect to their contributions to the planning objectives, response to the plan formulation tests, and contribution to the NED and EQ accounts. Comparing each alternative's positive and negative impacts with those of the other alternatives will assist in the designation of the NED plan and the EQ plan.

Only the structural alternatives substantially meet all three of the study's planning objectives. The nonstructural alternative's EQ account is superior to the structural alternative's EQ account. The nonstructural alternative's EQ account has minimal adverse effects and some enhancement.

RATIONALE FOR DESIGNATION OF NED PLAN

The National Economic Development (NED) Plan addresses the planning objectives in a way which maximizes net economic benefits. Alternative 1 (reinforced concrete lining and wall, and removal of stream constriction) has the lowest construction cost and the highest benefits. Alternative 1 is therefore designated the NED plan.

RATIONALE FOR DESIGNATION OF EQ PLAN

None of the alternatives resulted in a significant positive environmental contribution. Therefore, no alternative is designated the EQ plan. However, the nonstructural alternative, Alternative 3, results in the least damage to the natural environment and is therefore designated the Least Environmentally Damaging (LED) plan.

TENTATIVE SELECTION

The objective at this stage of the study is to formulate and analyze a variety of plans to determine potential feasibility, to analyze impacts and to present for public review a document on the analysis to date. A tentative selection is provided to inform the public of the direction and scope of any proposed action. The final plan selection will follow the review of this draft report and environmental assessment. Following a formal public meeting and a comment period, public input will be documented and considered in the final report.

Following the selection of a plan, a letter of intent assuring local cooperation for the selected plan must be provided by the County of Hawaii. The County of Hawaii must also execute a formal local cooperation agreement prior to construction of any improvements. All necessary federal and local certifications for consistency and conformance to environmental (water quality, discharges, etc.) and land-use regulations must be completed prior to any construction. The preparation of plans and specifications, and the initiation of construction must be approved and authorized by the Chief of Engineers.

The final report will include the letter of intent, if applicable, and the necessary federal and local certifications. The selected plan will also be covered in a "conclusion" section and a recommendation statement will be made by the District Engineer.

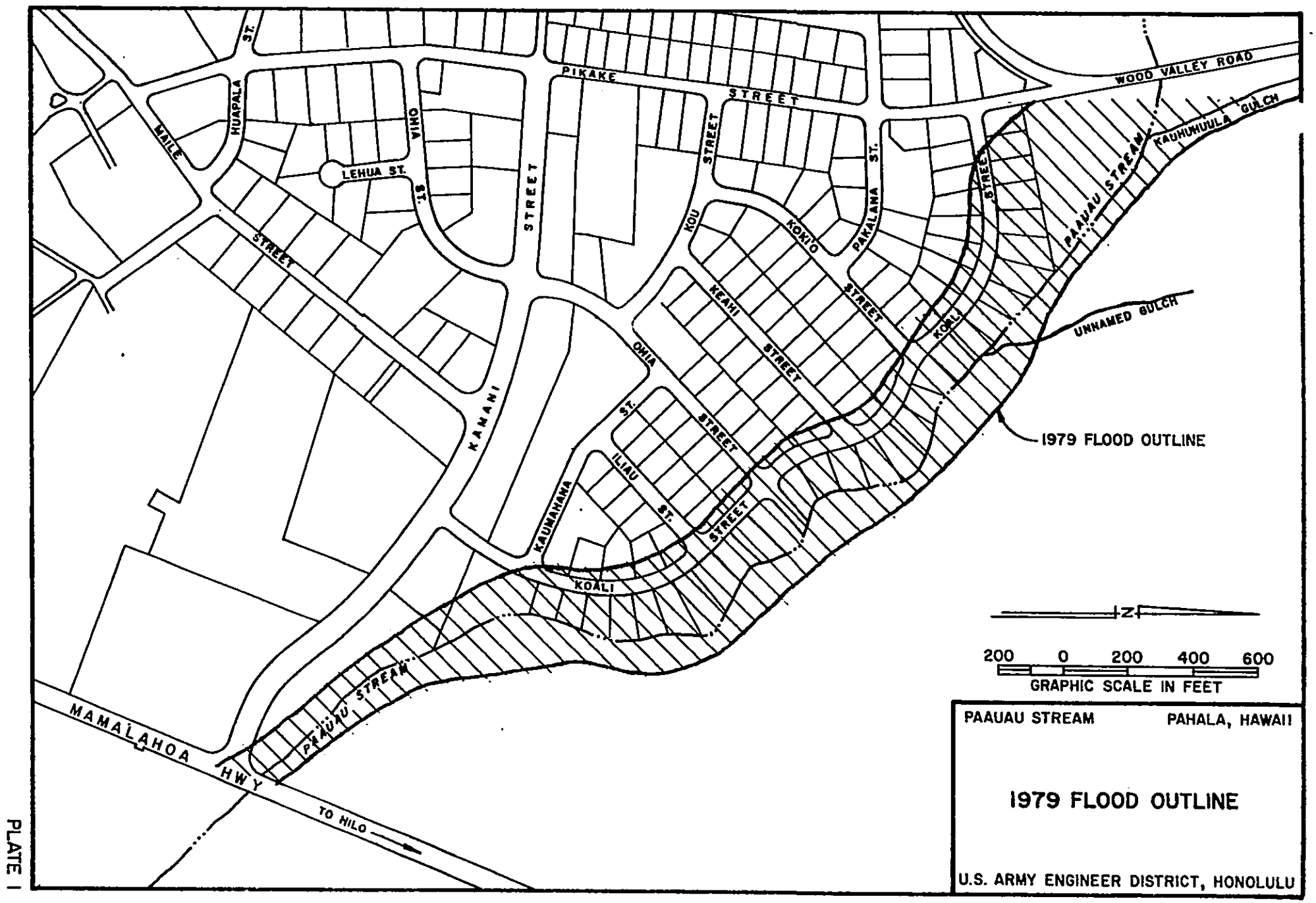
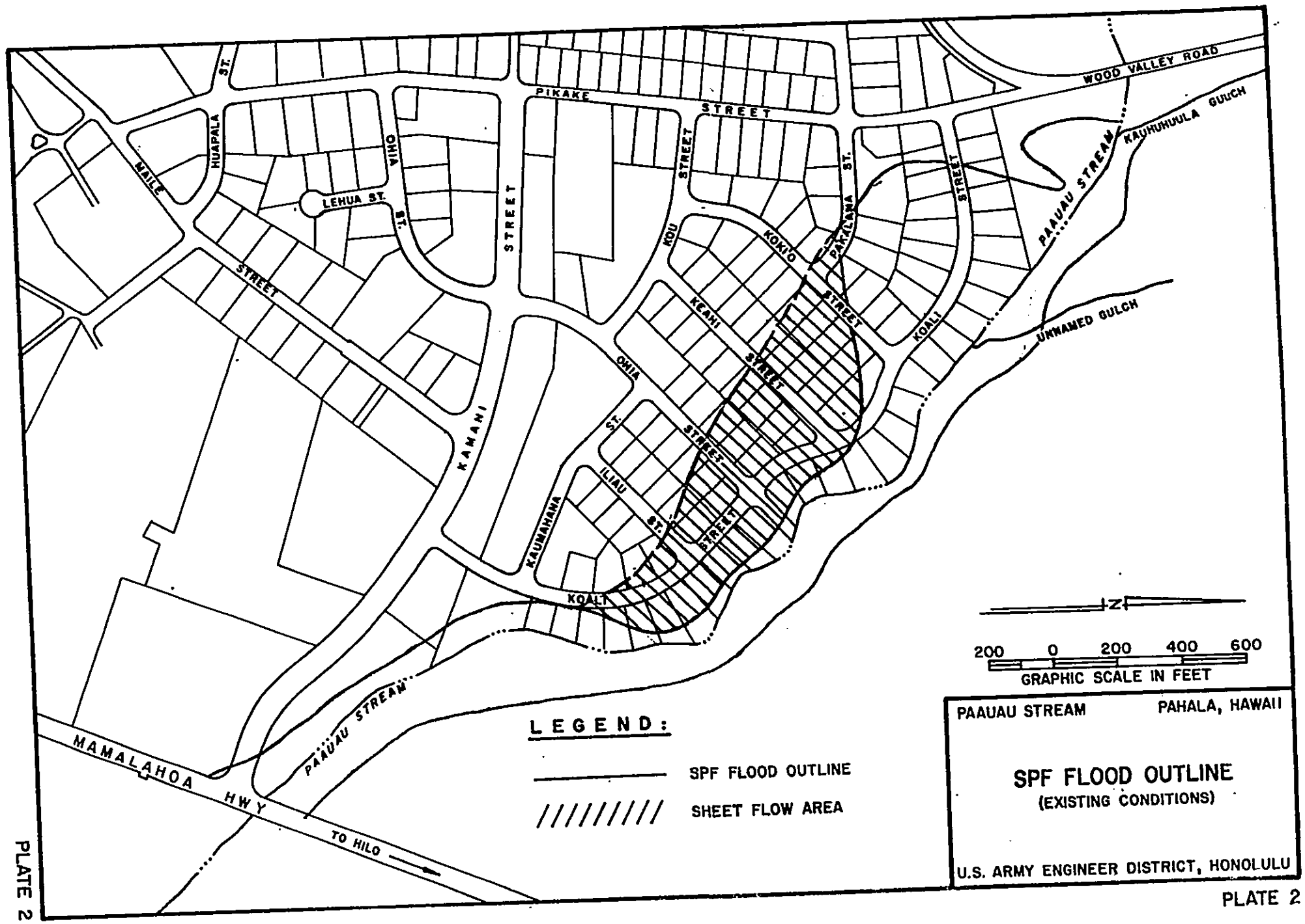
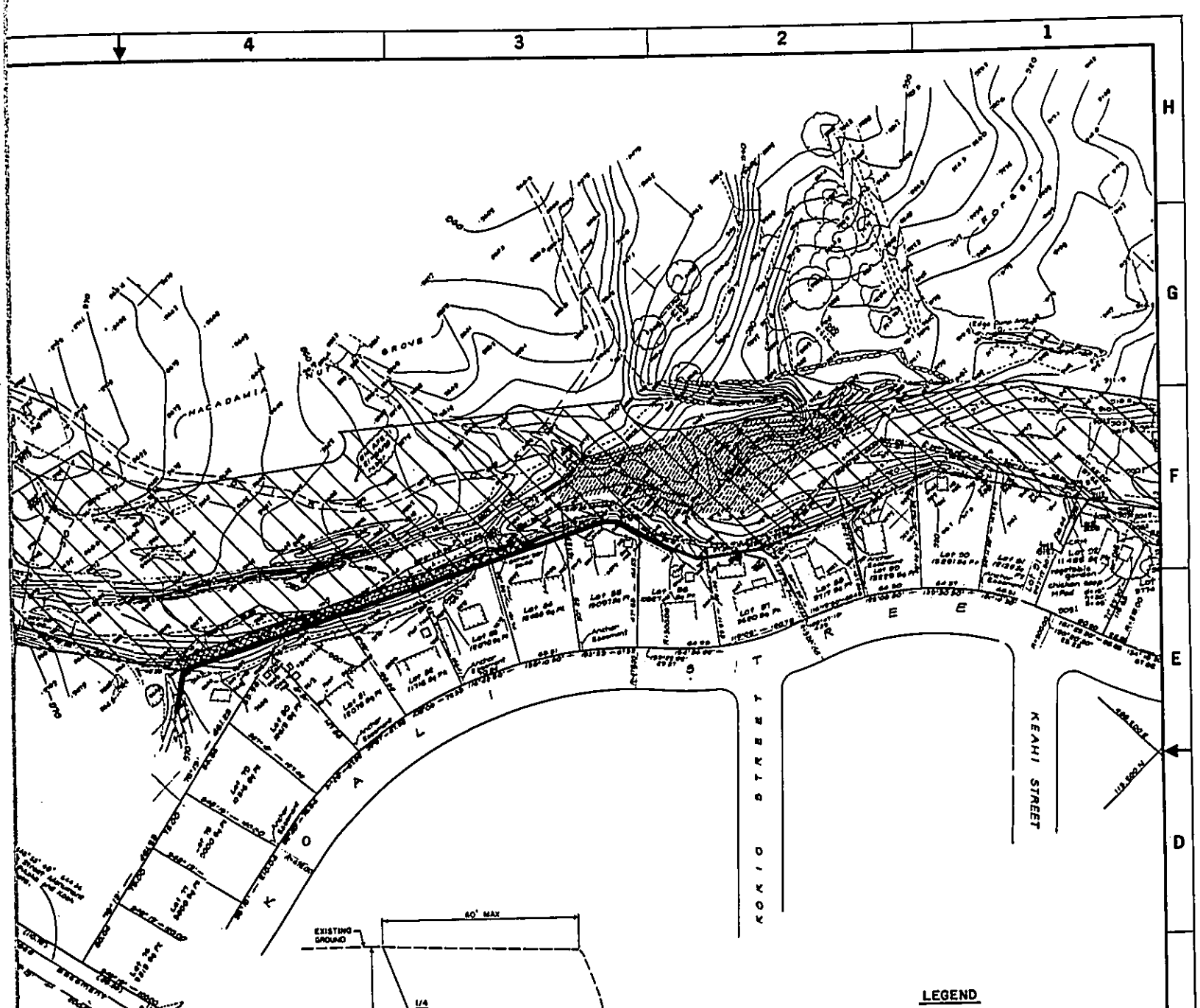


PLATE I

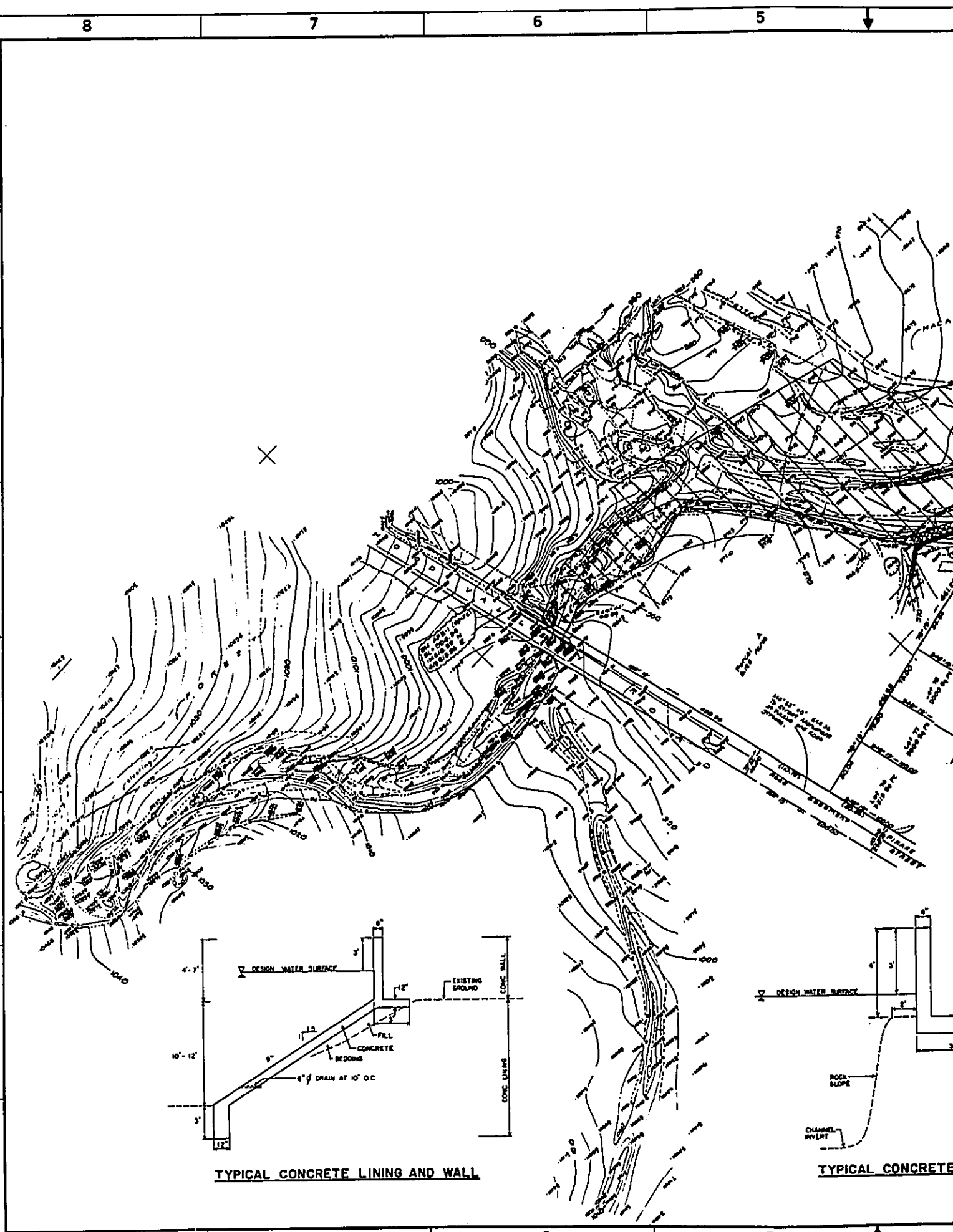
PLATE I


WOOD VALLEY ROAD
PIKAKE STREET
KAUHUHUULA GULCH
PAAUAU STREAM
UNNAMED GULCH
MAILE ST.
HUAPALA ST.
LEHUA ST.
VIHO ST.
KAMANI STREET
KOU STREET
KOKIO ST.
KEAHI STREET
KOALI STREET
OMIA ST.
ILIAU ST.
KAUMAHANA ST.
KOALI
MAMALAHOA HWY
TO HILO
PAAUAU STREAM
LEGEND:
SPF FLOOD OUTLINE
SHEET FLOW AREA
N
200 0 200 400 600
GRAPHIC SCALE IN FEET
PAAUAU STREAM PAHALA, HAWAII
SPF FLOOD OUTLINE
(EXISTING CONDITIONS)
U.S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE 2
PLATE 2


4
3
2
1
H
G
F
E
D
C
B
A
KOKIO STREET
KEAHI STREET
MACADAMIA
GROVE
PIIKAA STREET
EXISTING GROUND
60' MAX
1/4
1
8'-15'
ROCK
CHANNEL INVERT
TYPICAL CUT AT EXCAVATION AREA
LEGEND
CONCRETE WALL
CONCRETE LINING
EXCAVATION FOR STREAM WIDENING
REQUIRED LANDS, EASEMENTS, & RIGHTS - OF - WAY
DESIGN WATER SURFACE
EXISTING GROUND
ROCK SLOPE
CHANNEL INVERT
TYPICAL CONCRETE WALL
GRAPHIC SCALE
60 0 60 120 180
SCALE : 1" = 60'
PAAUAU STREAM
PAHALA, HAWAII
ALTERNATIVE I
AND
REQUIRED LANDS, EASEMENTS
AND RIGHTS - OF - WAY
US ARMY ENGINEER DISTRICT, HONOLULU
PLATE 3

8 7 6 5

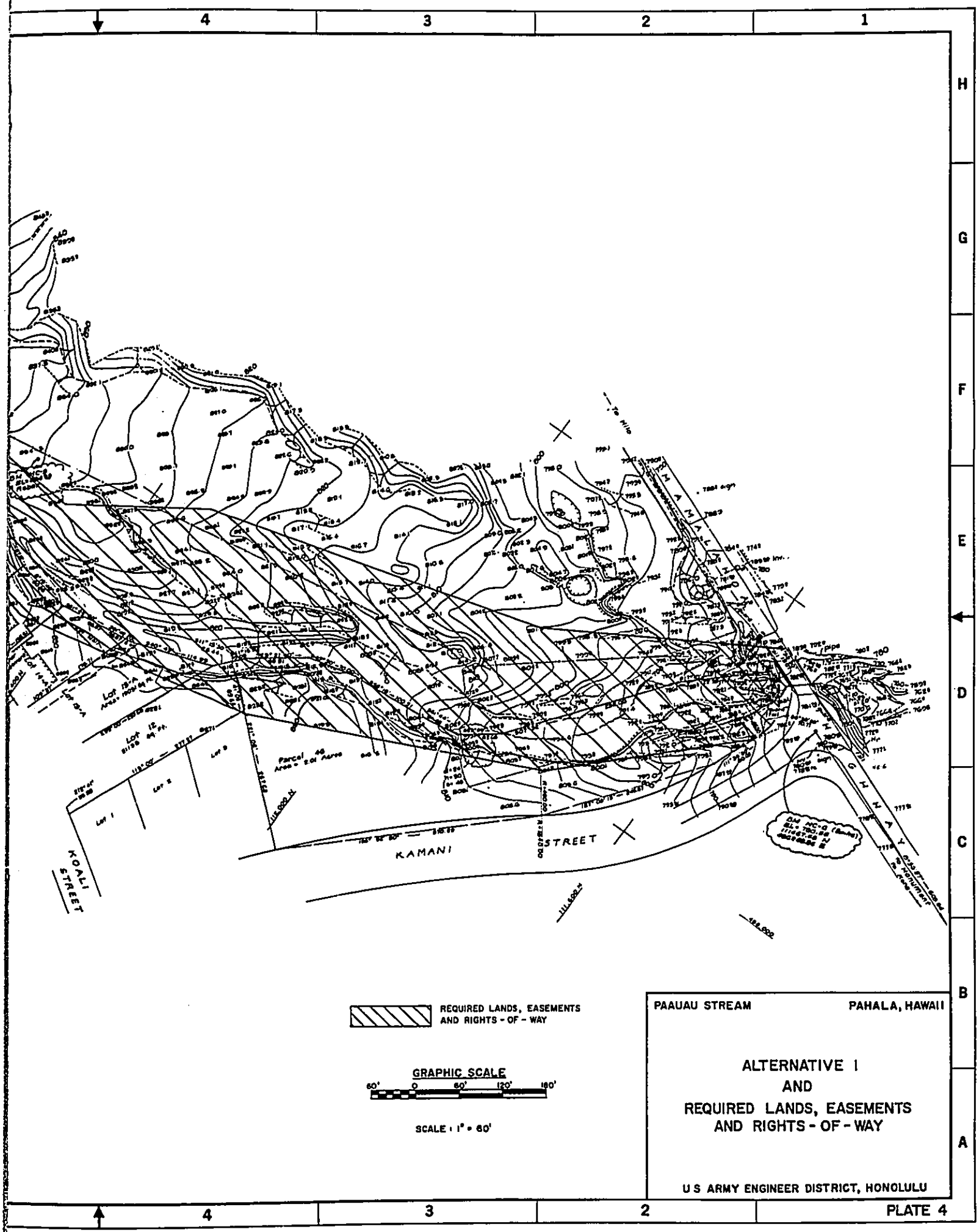
H G F E D C B A



TYPICAL CONCRETE LINING AND WALL

TYPICAL CONCRETE

8 7 6 5


KAMANI STREET
KOALI STREET
Lot 15-A
Lot 12
Parcel 46
Area = 8.61 Acres
REQUIRED LANDS, EASEMENTS AND RIGHTS - OF - WAY
GRAPHIC SCALE
60' 0 60' 120' 180'
SCALE : 1" = 60'
PAAUAU STREAM
PAHALA, HAWAII
ALTERNATIVE I
AND
REQUIRED LANDS, EASEMENTS AND RIGHTS - OF - WAY
U S ARMY ENGINEER DISTRICT, HONOLULU
PLATE 4


KOALI STREET
STREET
'LIAU STREET
KOALI
OHIA STREET
5
6
7
8
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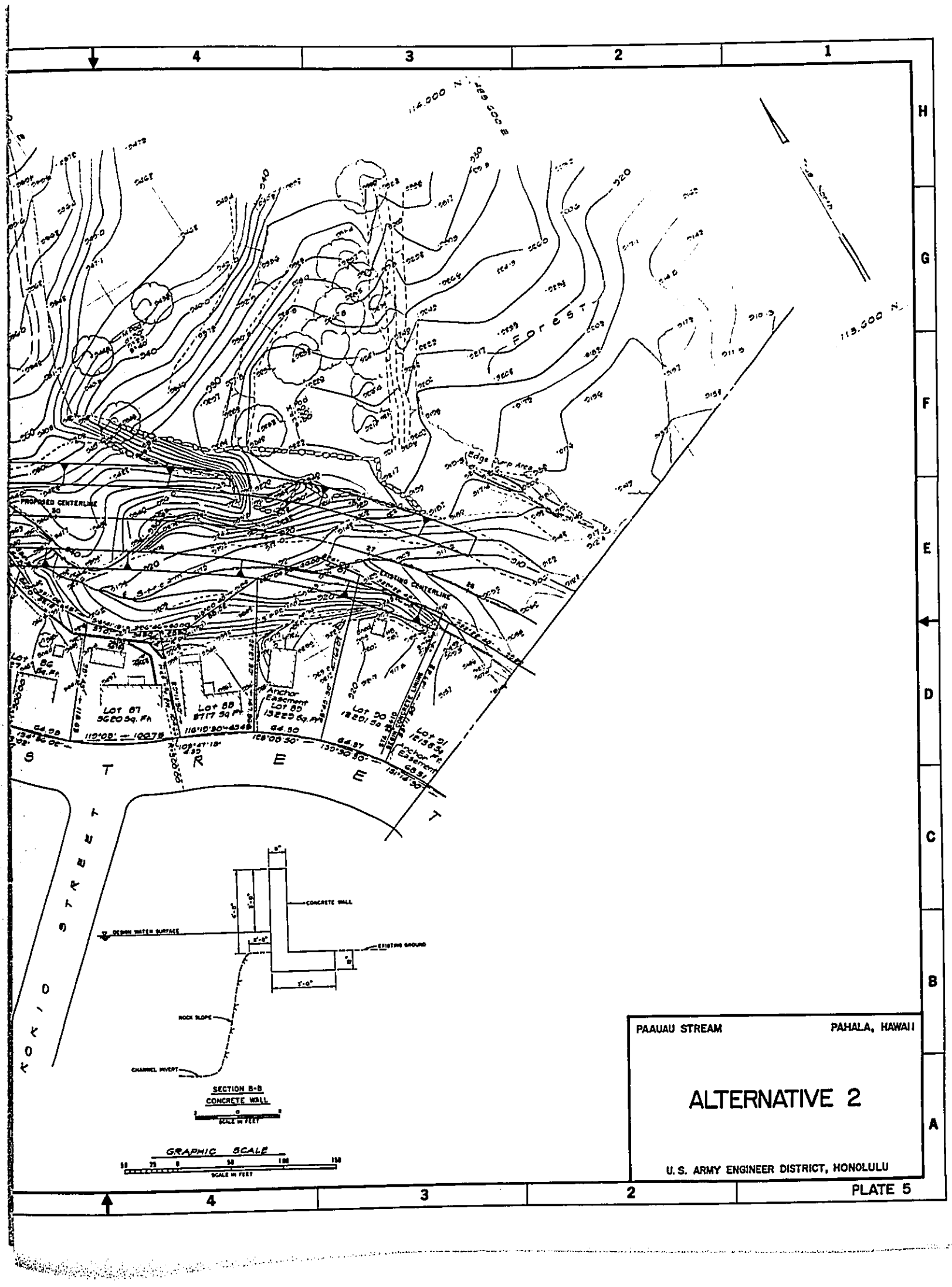
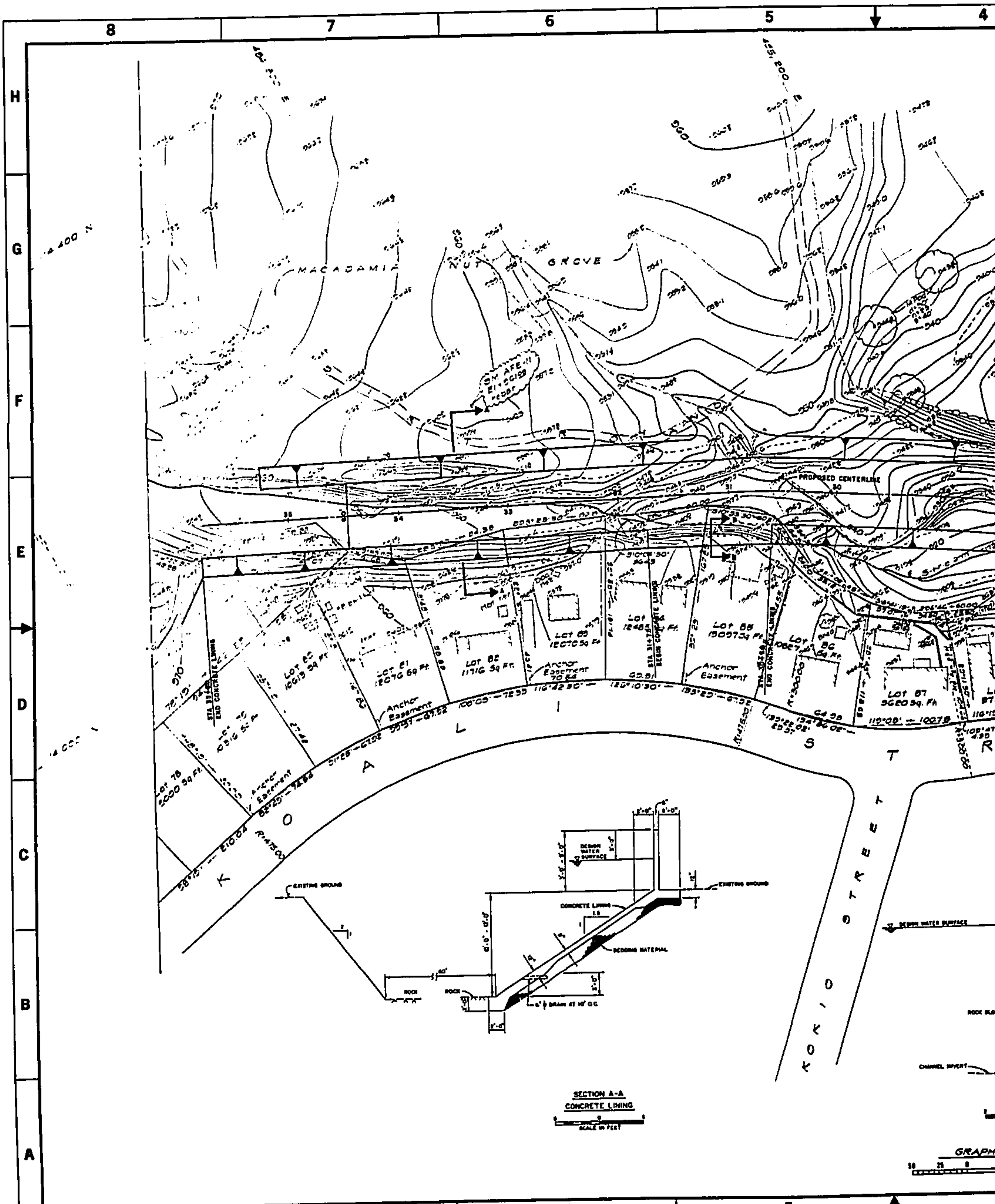
G
F
E
D
C
B
A


4
3
2
1
H
G
F
E
D
C
B
A
114,000 N.
113,000 N.
F o r e s t
PROPOSED CENTERLINE
EXISTING CENTERLINE
Anchor Easement
Lot 87
9660 Sq. Ft.
Lot 88
8717 Sq Ft
Lot 89
13225 Sq. Ft.
Lot 90
12201 Sq.
Lot 91
12134
S T R E E T
K O K I O S T R E E T
CONCRETE WALL
EXISTING GROUND
ROCK SLOPE
CHANNEL INVERT
SECTION B-B
CONCRETE WALL
SCALE IN FEET
GRAPHIC SCALE
SCALE IN FEET
PAAUAU STREAM
PAHALA, HAWAII
ALTERNATIVE 2
U. S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE 5



MACADAMIA NUT GROVE
PROPOSED CENTERLINE
Anchor Easement
KOALI STREET
KOKIO STREET
EXISTING GROUND
DESIGN WATER SURFACE
CONCRETE LINING
BEDDING MATERIAL
ROCK
SECTION A-A
CONCRETE LINING
SCALE IN FEET

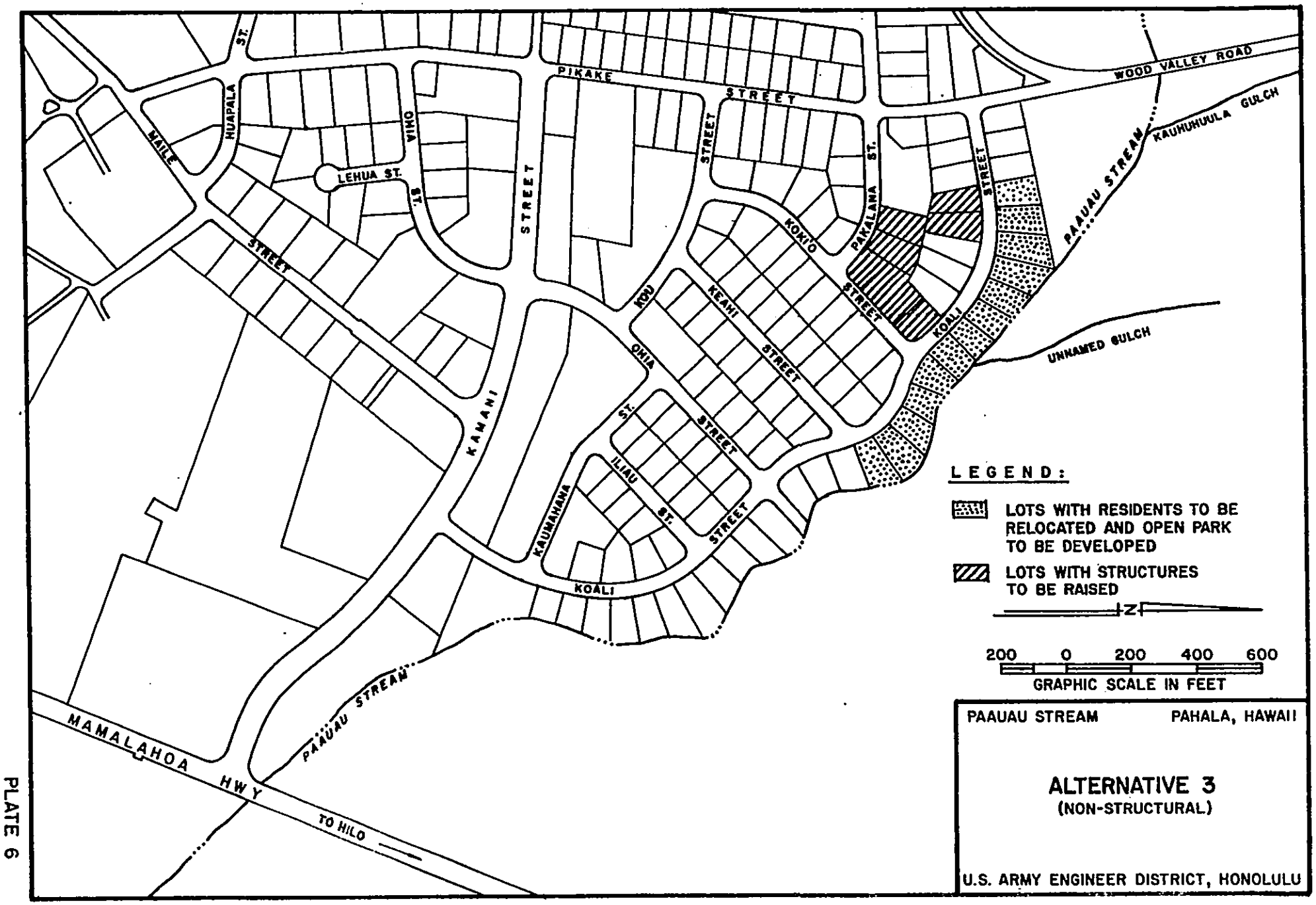
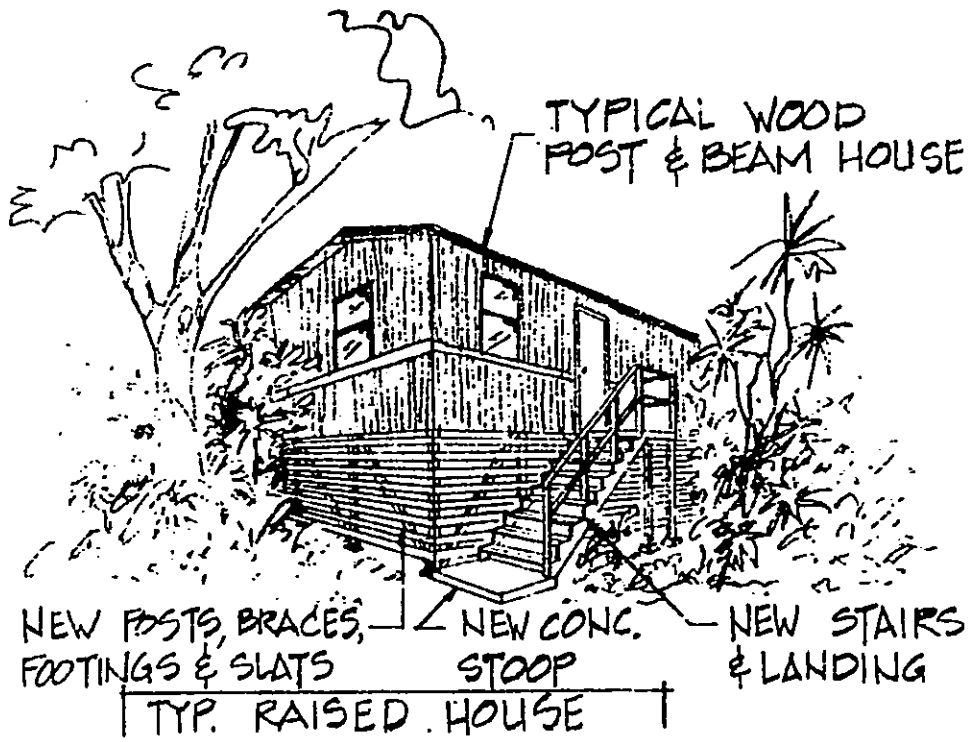
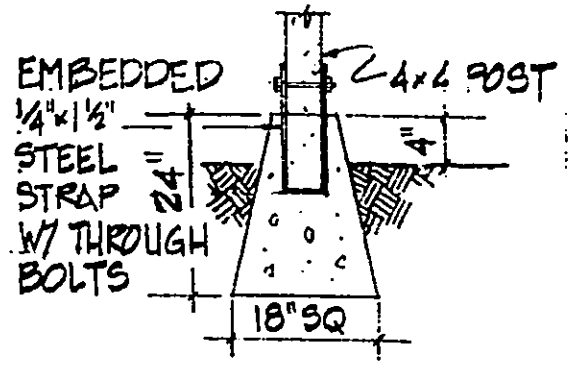


PLATE 6

PLATE 6



TYP. RAISED HOUSE



TYPICAL NEW FOOTING

PLATE 7

PAAUAU STREAM PAHALA, HAWAII

RAISED HOUSE DETAILS
(ALTERNATIVE 3)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE 7

DRAFT ENVIRONMENTAL ASSESSMENT

PAAUAU STREAM FLOOD CONTROL PROJECT, PAHALA, HAWAII

January 1982

The responsible Federal lead agency is the U.S. Army Engineer District, Honolulu, Hawaii. The responsible Federal cooperating agency is the U.S. Fish and Wildlife Service.

Abstract: The project site is the Paauau Stream at Pahala, island of Hawaii. The proposed project will reduce flood damage and erosion of residential property along the right bank of the Paauau Stream. The project is authorized by Section 205 of the Flood Control Act of 1948, as amended (PL 94-241). The tentatively selected plan (Alternative 1) consists of reinforced concrete lining of the right bank of the stream for 410 feet. The lining would have a sideslope of 1.5H to 1.0V and a vertical height of 10 to 12 feet. A reinforced concrete wall 660 feet in length with a height of 4 to 7 feet will be placed on the concrete lining and along the existing right bank. A rock outcrop on the left bank will be removed to straighten the channel. The rock excavation would be approximately 390 feet long, 10 to 60 feet wide, and up to 15 feet in height.

Four alternative plans, including a no-action alternative and a non-structural alternative, were evaluated. The nonstructural alternative consists of relocation, floodproofing by raising residences, and temporary evacuation of residents during periods of potential flooding. The two structural alternatives considered consist of a concrete lining and wall along the right bank and channel widening at selected places. Implementation of Alternative 1 would not affect any historic properties, refuges, sanctuaries, critical habitats, endangered/threatened or endangered species, prime agricultural lands, or special aquatic sites.

DRAFT ENVIRONMENTAL ASSESSMENT
PAAUAU STREAM FLOOD CONTROL PROJECT
PAHALA, HAWAII

TABLE OF CONTENTS

LIST OF TABLE

1. SUMMARY

1.1 Major Conclusions and Findings - The environmental impacts associated with this proposed project are not anticipated to be significant. Adverse effects of the project would be temporary and consist predominantly of construction-generated noise, hydrocarbon emissions and dust. The US Fish and Wildlife Service believes that the tentatively selected plan will have no adverse or beneficial impacts on fish and wildlife resources in the project area, and therefore, makes no recommendations. Within the project area there are no listed, proposed, or candidate endangered or threatened species. No historic properties were reported within the project area. On the basis of these findings, the nature and scope of the recommended work, the lack of significant environmental impacts and the mitigation of temporary adverse effects, it has been determined that an environmental impact statement is not required.

1.2 Areas of Controversy - None.

1.3 Unresolved Issues - None.

1.4 Relationship to Environmental Requirements - These relationships are shown on Table E-1.

1.5 Land Use Plans - In full compliance. Stream is dedicated to flood control.

2. PURPOSE AND NEED FOR THE PROPOSED ACTION

2.1 Study Authority - The proposed action is authorized by Section 205 of the Flood Control Act of 1948, as amended (PL94-241).

2.2 Public Concerns - During large rainstorms, residential properties have been flooded and river banks eroded. The residents of Pahala are concerned that preventative measures should be taken to prevent erosion and property damage during storms. This concern and favorable responses to proposed flood control measures were expressed during a workshop conducted by the Corps of Engineers on 16 July 1981. A major concern of the residents was the danger and the resulting fear and anxiety caused by the high periodic flows in Paauau Stream. Councilman James Dahlberg and other residents asked POD to expedite the study and to implement protective measures as soon as possible.

2.3 Purpose of the Action - The purpose of the action is to provide flood protection to the residents of Pahala, to reduce property damage and erosion, and contribute to the safety and well-being of the residents.

3. ALTERNATIVE PLANS CONSIDERED

3.1 No-Action Alternative Plan - This alternative would provide no flood protection to the residents and their properties. The stream bank and the affected properties would continue to erode during storms, and property damage, anxiety and safety would continue to be problems.

TABLE E-1

CERTIFICATION OF COMPLIANCE WITH ENVIRONMENTAL PROTECTION STATUTES

Project Title: Paauau Stream Flood Control Project
Date: January 1982
Prepared by: Arthur G. Cropper

FEDERAL ENVIRONMENTAL LAWS	STATUS	COMMENTS
1. Preservation of Historic & Archaeological Data Act	Full Compliance	Reconnaissance final report received.
2. Clean Air Act	Full Compliance	Suitable provisions in Plans & Specifications.
3. Clean Water Act	Full Compliance	Section 404(b)(1) Evaluation completed.
4. Coastal Zone Management Act	Full Compliance	Consistancy Determination completed.
5. Endangered Species Act	Full Compliance	FWS 2(b) Report states endangered species not present in project area.
6. Estuary Protection Act	Not Applicable	Not an estuary
7. Federal Water Project Recreation Act	Full Compliance	Stream area not appropriate for recreation activities, i.e., in a floodplain.
8. Fish & Wildlife Coordination Act	Full Compliance	FWS 2(b) Report received 8 June 1981, no impacts.
9. Land & Water Conservation Fund Act	Full Compliance	
10. Marine Protection, Research, & Sanctuaries Fund Act	Not Applicable	Located in a non-marine area.
11. National Environmental Policy Act	Full Compliance	
12. National Historic Preservation Act	Full Compliance	
13. Rivers & Harbors Act of 1899	In Compliance	Not applicable to Corps projects affirmatively authorized by Congress.
14. Watershed Protection & Flood Prevention Act	In Compliance	Not applicable to Corps projects.
15. Wild & Scenic Rivers Act	In Compliance	Not applicable; no wild & scenic river in POD area.
STATE & LOCAL ENVIRONMENTAL LAWS/REGULATIONS	**STATUS**	**COMMENTS**
1. Applicable County of Hawaii Laws and/or Regulations	Pending	To be complied with by State & County agencies.
2. Draft 343, HRS, State EIS Law	Partial	
3. State Water Quality Certification	In Compliance	Water Quality Certification received.

3.2 Structural Alternative Plans - Two structural alternatives were evaluated. Alternative 1 (reinforced concrete lining and wall, and excavation) and Alternative 2 (reinforced concrete lining and wall, and stream widening) were considered to be the reasonable alternatives based on cost and impacts to the environment. Descriptions of the two structural alternatives are provided below. Alternative 1 is the tentative selected plan.

3.2.1 Alternative 1 - This alternative consists of a 410-foot concrete-lined right bank with a sideslope of 1.5H to 1.0V and a vertical height of 10 to 12 feet. A concrete wall 660 feet in length with a height of 4 to 7 feet will be placed on the lining and along the existing right bank. A rock outcrop on the left bank will be removed to straighten the channel. The rock excavation would be approximately 390 feet long, 10 to 60 feet wide and up to 15 feet in height.

3.2.2 Alternative 2 - The existing channel would be enlarged to a 60-foot wide trapezoidal channel for about 1,220 feet. The right bank would be concrete lined for approximately 855 feet with sideslopes of 1.5H to 1.0V. A reinforced concrete wall 2 to 5 feet high and 970 feet long would be constructed on top of the right bank. Sideslopes of the trapezoidal channel on the left bank would be 2H to 1V.

3.3 Non-Structural Alternative - Under this plan, 13 residents would be permanently relocated, 8 structures would be raised and temporary evacuation of residents along Koali Street would be instituted during severe storms. The evacuation would be necessary due to the danger of the high velocity flows along Koali Street after the Paauau Stream overbanks at the upper portion of the subdivision.

4. AFFECTED ENVIRONMENT

4.1 General - Information presented in this assessment concentrates on a description of the areas and resources to be affected by the proposed action and summarizes detailed information presented elsewhere.

4.2 Setting - Paauau Stream is in the Kau District of the County of Hawaii, approximately 45 miles southwest of Hilo. The community of Pahala is the major community in the drainage basin. Paauau Stream borders Pahala on its north side, and is intermittent. The drainage basin is characterized by barren lava, and macadamia and sugarcane fields. Paauau Stream is characterized by a streambed composed of basaltic bedrock and thin sediment deposits distributed randomly along the stream course.

4.3 Water Quality - The intermittent waters of Paauau Stream are designated class 2 by the State of Hawaii (Chapter 37-A, Water Quality Standards, rev. 1979). Class 2 waters are for recreational purposes, the propagation of fish and other aquatic life, and agricultural and industrial water supply. During storms the stream waters are turbid and contain suspended sediments. The stream is not used for public water supply.

4.4 Biological Resources - The Fish and Wildlife Service in their 2(b) Report state that:

Within the project area there are no listed, proposed or candidate endangered or threatened species pursuant to the Endangered Species Act of 1973. In fact, there are no significant wildlife resources in the project area.

The plant community is highly disturbed since the general area of the project has been in agriculture for a long time. It is composed of various ornamentals associated with the residences: introduced trees, shrubs, grasses, weeds and common native plants.

Domestic dogs and mongooses have been observed in the area. It is probable that domestic and feral cats, rats and mice also inhabit the area. The only birds observed were introduced species.

There are no aquatic animals (except insects) living in Paauau Stream. The stream is ephemeral, having water only during heavy rains. As a result of field reconnaissance surveys by the Corps of Engineers, the Corps concurs with the U.S. Fish and Wildlife Service observations.

4.5 Recreational Resources - The proposed project site is not a dedicated recreational area. The dry streambed has limited value to hikers as a pathway. Erosion caused by flooding has damaged the backyards of residences along the waterway and decreased the value and use of residential backyards for recreational purposes.

4.6 Cultural Resources - Applicable Federal laws (Reservoir Salvage Act of 1960, as amended, and National Historic Preservation Act of 1966 and regulations 36 CFR 305 and 36 CFR 800) have been reviewed. There are no historic sites or cultural resources at the project site that are listed on the Hawaii or National Register of Historic Places. The entire study area was inspected on foot by a professional archaeologist on August 20, 1981. Both banks of the stream as well as the streambed itself were examined. A report prepared by the archaeologist (Science Management Inc., September 1981) noted that no archaeological deposits or other items of cultural, historical or archaeological interest were observed. Given the extensive disturbance along both banks of the stream, it is very unlikely that any such features that may once have been present remain intact. Inspection of the stream banks in areas where alluvial deposits were present also revealed no signs of any archaeological deposits.

4.7 Land Use. The study area includes a subdivision south of Paauau Stream and two large parcels north of Paauau Stream. The stream is within the subdivision lots and the two parcels north of the stream. The subdivision was constructed in 1972-1973, and homes have been constructed on most of the lots. Undeveloped lots include a lot adjacent to the Wood Valley Road and six lots near Mamalahoa Highway--all zoned for single-family residents.

The two parcels north of Paauau Stream are owned by Seamountain-Hawaii Ranch Company and the Brewer Orchids, Inc. The Seamountain-Hawaii parcel (87 acres) is zoned residential and is presently used as pastureland. This parcel's south boundary adjoins the Paauau Stream from Mamalahoa Highway to about 1,900 feet northwest of Mamalahoa Highway.

The Brewer Orchids' parcel (624 acres) is zoned agriculture and is planted with macadamia nut trees. The south boundary adjoins the Paauau Stream from the Seamountain-Hawaii parcel, to about 500 feet northwest.

The drainage basin above Pahala is zoned agriculture and conservation with the agricultural lands planted with sugarcane and macadamia nut.

4.8 Socio-Economic Characteristics - The community of Pahala, population 1,631 (1980), accounts for roughly 1.8% of the population of the island of Hawaii. Since 1960, Pahala has increased in population 8.2% each decade. In 1970 the population of Pahala was almost 39 percent Filipino and 30 percent Japanese compared to countywide figures of about 16.5 and 37.5 percent, respectively. The Paauau Stream in the project area is bordered on one side by the community of Pahala and on the other side by open space. The town of Pahala is a major community in the drainage basin and in the district of Kau, and is located approximately 45 miles from Hilo, the economic center of the island. Pahala is a plantation town housing predominantly agricultural workers employed by the sugar and macadamia nut plantations. The district's only hospital is located about 500 feet south of Paauau Stream adjacent to Mamalahoa Highway.

5. ENVIRONMENTAL CONSEQUENCES

5.1 General - Lining of the right streambank with a reinforced concrete lining will provide partial channelization of Paauau Stream to minimize flood damage to properties and to enhance the safety and well-being of the residents of Pahala. The project will not significantly alter the flushing characteristics of the watershed. The floodwall will impose a new visual element in the stream area where none previously existed.

5.2 Water Quality - Construction is anticipated to occur during periods when the streambed is dry. During the first storm runoff after completion of the project, increased but temporary turbidity is expected due to the flushing of loose soil, rocks and debris. No ocean dumping is required for the project, therefore implementation of Sections 102 and 103 of the Marine Protection, Research and Sanctuaries Act of 1972 is not required. The suitability of the discharge site for the Paauau Stream Flood Control Project has been determined through the application of the Section 404(b)(1) Guidelines.

Pursuant to the Safe Drinking Water Act of 1974, the project will not affect drinking water in any manner since the Paauau Stream is not used as a potable water source.

5.3 Biological Resources - The Corps and the US Fish and Wildlife Service have determined that there are no significant fishery resources, no fish spawning or nursery areas, no commercial harvestable shellfish beds in or adjacent to the project area. No marine sanctuaries or national wildlife refuges, special aquatic sites, or wetlands will be affected by the project. The project will have no significant adverse effects upon biological resources.

5.4 Cultural Resources - The proposed flood control project will have no effect on any cultural resources eligible for inclusion on or presently included on the National or Hawaii Register of Historic Places. Though extremely improbable, it is possible that subsurface cultural deposits may be revealed during excavation. In this event, it is recommended that work be halted and a qualified archaeologist be consulted as to the appropriate course of action. The Corps has determined that the project would not adversely affect any known cultural sites and has coordinated this project with the State Historic Preservation Officer. No further archaeological work in the study area is warranted at this time.

5.5 Socio-Economic Impacts - Social effects will include temporary inconvenience, and a temporary increase in noise, dust and hydrocarbon emission levels. The completed flood control project would enhance the safety and sense of well-being of the residents within the floodplain of the Pahala community, and reduce property damage and loss due to periodic flooding. No residences, businesses or farms will be relocated or displaced. The project will not provide for amenities that would change the social structure or cohesion of the community.

6. PUBLIC INVOLVEMENT

6.1 Public Involvement Program - A Public Workshop was held by the Corps on 16 July 1981 at the Pahala Senior Citizens' Center, Pahala, Hawaii. Total attendance was approximately 60 persons. In attendance were mostly residents of Pahala and Hawaii County officials. The overall reaction to the study was favorable with no unresolved issues. The major concern of the residents was the danger and anxiety caused by the high flood flows, and potential damage from these flows. The general feeling was that the study and protective measures should be implemented as soon as possible.

Other informal meetings with local officials by the Corps have not elicited negative comments or any controversial issues regarding the proposed project.

6.2 Required Coordination (also see Table E-1)

a. State Historic Preservation Officer - The project was determined by the Corps not to have an effect on properties listed on or eligible for inclusion to the National Register of Historic Places. The project has been coordinated with the State Historic Preservation Officer.

b. Endangered Species - The Fish and Wildlife Service has determined in its 2(b) Report of 8 June 1981 that pursuant to the Endangered Species Act of 1973 there are no listed, proposed or candidate endangered or threatened species within the project area.

c. Fish and Wildlife Coordination - A FWS 2(b) Report, dated 8 June 1981, has been received, which states that there are no significant wildlife resources in the project area.

d. The suitability of the discharge site for the project has been determined through the application of the Section 404(b)(1) Guidelines.

e. The State Department of Health has provided a Water Quality Certification for this project.

7. LIST OF PREPARERS

The following people were primarily responsible for preparing this Environmental Assessment:

Name	Experience	Expertise	Professional Discipline
Mr. Arthur G. Cropper (EA Preparer)	Geology	BA, MS, Geology; 3 years research in marine geology 6 years consultant; 4 years EIS studies, US Army Corps of Engineers, Honolulu District	Physical Environmental Specialist
Dr. James E. Maragos (EA Coordinator)	Marine Ecology	BS, Zoology; PhD Oceanography; 2 years post-doctoral research; 10 years environmental consultant; 6 years EIS studies, US Army Corps of Engineers, Honolulu District	Supervisory Environmental Biologist
Mr. David G. Sox	Historical & Cultural Geography	BA, MA Geography; 6 years research; 6 years EIS studies, US Army Corps of Engineers, Honolulu District	Social-Environmental Specialist
Mr. George Takamiya	Civil Engineering	BA, Civil Engineer; MS, Sanitary Engineer; 5 years design; 3 years construction and 1 year water resources planning, US Army Corps of Engineers, Honolulu District	

PUBLIC VIEWS AND RESPONSES
APPENDIX A

APPENDIX A

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PUBLIC INVOLVEMENT PROCESS

OBJECTIVES

The public, as broadly interpreted by the US Army Corps of Engineers, is any affected or interested non-Corps of Engineers entity; other Federal and State Government entities and officials; public and private organizations, and individuals. The objectives of the public participation program are:

a. To inform citizens of the current Corps of Engineers planning process and direction.

b. To surface key planning issues and concerns so that they are given full consideration.

c. To help formulate and review potential plans of improvement.

d. To offer technical, historical and localized information pertinent to the study.

e. To provide a communicative forum between the Corps, local agencies, advocacy groups and interested citizens on the subject plan and problems.

TECHNIQUES

The types of public participation forums in this study are small meetings, workshops and formal meetings:

a. Informal Meetings. These meetings are of less than 10 persons with specific invited agency personnel, group representatives or citizens. These meetings will be undertaken at various intervals throughout the study to help the planners obtain information and address certain issues.

b. Workshops. These meetings are informal exchange sessions numbering approximately 10 to 50 persons. The purpose is to promote the full airing of various views in recognition of current Corps' planning efforts.

c. Public Meeting. A public meeting will be held at key points in the study effort. The purpose will be to notify all interested parties of the planning effort to date and to obtain views of the various items on the agenda. The meeting, presided by the District Engineer, will include a summary of findings to date, an informal question and answer period, a presentation of formal statements of others and tentative conclusions. Public notice of the meeting will be issued to the media and the general public will be invited.

ACTIVITIES CONDUCTED

WORKSHOP

The initial effort in direct public participation was performed during the period 16-17 July 1981 for the purpose of conducting interagency coordination, site inspection and a public workshop. The workshop was held on 16 July 1981 at the Paauau Senior Citizen Center. Information from participants of the workshop indicated the community was very much in favor of flood control improvements.

INFORMAL MEETINGS

Informal meetings were held with the local sponsoring agency and the Hawaii County Economic Opportunity Council in May 1981 and July 1981. The purpose of these meetings was to clarify plan formulation efforts and potential alternative plans.

FUTURE ACTIVITIES

A public meeting is scheduled for February 1982. The purpose of the meeting will be to receive community response on the tentative plan of improvement as documented in the draft Detailed Project Report and draft Environmental Assessment. The report will be made available to the public prior to the meeting. Provided there are no major unresolved issues, this meeting will be the final formal meeting.

The public shall be given an opportunity to comment on the proposed action in the draft Detailed Project Report (DPR) and the draft Environmental Assessment. Significant environmental concerns or issues surfaced during the draft circulation period shall be addressed in the final document. The final document shall be expanded, modified or clarified, and responses to all correspondence appropriately referenced or displayed. No administrative action shall be taken sooner than 90 days after the draft Environmental Assessment has been filed with the Environmental Protection Agency (EPA) as noticed in the Federal Register.

FINAL REPORTS

Subsequent to completion of the final DPR and Environmental Assessment, the Office of the Chief of Engineers will file the reports with the EPA. No administrative action shall be taken sooner than a minimum of 30 days after the final documents have been filed with the EPA as noticed in the Federal Register. All agencies, groups and individuals shall be given opportunity to respond. A Record of Decision shall not be signed until the remaining substantive issues are resolved. Subsequently, the Division Engineer shall release a public notice informing the public of the proposed action.

DRAFT REPORT AND ENVIRONMENTAL ASSESSMENT REVIEW

The draft document was sent to the following agencies and organizations for review:

Members of Congress

Honorable Spark M. Matsunaga
United States Senator

Honorable Daniel K. Inouye
United States Senator

Honorable Cecil Heftel
House of Representatives

Honorable Daniel K. Akaka
House of Representatives

State Senators and Representatives

Honorable John T. Ushijima
Hawaii Senate

Honorable Dante K. Carpenter
Hawaii Senate

Honorable Richard Henderson
Hawaii Senate

Honorable Herbert A. Segawa
Hawaii House of Representatives

Honorable Virginia Isbell
Hawaii House of Representatives

Honorable Andy Levin
Hawaii House of Representatives

Honorable Yoshito Takamine
Hawaii House of Representatives

Honorable Richard Matsuura
Hawaii House of Representatives

County of Hawaii

Honorable Herbert T. Matayoshi
Mayor

Director
Department of Planning

Director
Department of Civil Defense

Director
Department of Parks and Recreation

Chairman
Planning Commission

Chairman, Big Island Resource
Conservation and Development Council

Mr. Edward Harada, Chief Engineer
Department of Public Works

Mr. William Sewaki, Managing Engineer
Department of Water Supply

Director
Department of Research and Development

Mr. Spencer Kalani Schulte, Vice Chairman
Hawaii County Council

County of Hawaii (Cont'd)

Mr. Stephen K. Yamashiro, Chairman
Hawaii County Council

Councilman James Dahlberg
Hawaii County Council

Federal Agencies

State Conservationist
Soil Conservation Service
US Department of Agriculture

District Conservationist
Soil Conservation Service
US Department of Agriculture

Director, Pacific Region
National Weather Service, NOAA
US Department of Commerce

Hawaii Administrator
Fish and Wildlife Service
US Department of the Interior

Director
US Department of Energy

Manager, Pacific Islands Office
US Environmental Protection Agency

Administrator, Hawaii Division
Federal Highway Administration
US Department of Transportation

Commander-in-Chief
Pacific Air Forces

Commander
14th Coast Guard District

Endangered Species Coordinator
Division of the Endangered Species
Fish and Wildlife Service
US Department of the Interior

District Chief
Geological Survey
US Department of the Interior

Commander
US Naval Base
Pearl Harbor

Federal Agencies (Cont'd)

Administrator
SW Region, Western Pacific Program Office
National Marine Fisheries Service
US Department of Commerce

Director
Institute of Pacific Islands Forestry
Forest Service
US Department of Agriculture

Advisory Council on Historic Preservation

US Department of Commerce

Office of Coastal Zone Management

US Department of Interior
Washington, DC

US Department of the Interior
San Francisco, CA

US Environmental Protection Agency
Washington, DC

US Environmental Protection Agency
San Francisco, CA

US National Park Service

Advisory Council
Colorado

National Park Service
Interagency Archaeological Service

US Fish and Wildlife Service
Regional - Portland, OR

US Department of Housing and Urban Development

National Park Service
San Francisco, CA

State Agencies

Office of Environmental Quality Control

Department of Defense

Department of Transportation

Department of Health

State Agencies (Cont'd)

Department of Land and Natural Resources

Department of Education

Department of Planning and Economic Development

Department of Agriculture

Environmental Center, University of Hawaii

Water Resources Research Center, University of Hawaii

Department of Social Services & Housing

State Historic Preservation Officer

Department of Accounting and General Services

Special Interest Groups

Chairwoman
RC&D, Recreation and Historic Sites Commission

Manager
Kau Sugar Company

President
Kau Kamaaina Fishing Association

Seamountain-Hawaii
Hawaii Ranch Company, Inc.

Hawaiiana Investment Company, Inc.

Brewer Support Housing, Inc.

Mauna Loa Nut Corporation

Soil and Water Conservation District

Director
Hawaii County Economic Opportunity Council

PERTINENT DOCUMENTS

TABLE OF CONTENTS

DATE	SUBJECT	INITIATING AGENCY
9 June 1980	Request for Assistance	Mayor of County of Hawaii
10 March 1981	Public Notice	Corps of Engineers
6 April 1981	Historical, Cultural, Architectural and/or Archaeological Resources	State Department of Land and Natural Resources
July 1981	Public Workshop Notice	Corps of Engineers
23 Nov 1981	Archaeological Review	Department of Land and Natural Resources
5 Jan 1982	Water Quality Review	Department of Health

HERBERT T. MATAYOSHI
MAYOR

Office of the Mayor

June 9, 1980

Mr. Clarence Fujii
Planning Branch
Corps of Engineers
Pacific Ocean Division
Building 230
Ft. Shafter, HI 96858

SUBJECT: Paauau Stream

Recent rains in the Ka'u area caused considerable damage to public as well as public property by the overflow of flood waters from the Paauau Stream.

Congressman Daniel Akaka in his recent visit to the site called attention to the need for review of the problem. Accordingly, this is to request the Corps to study the flood problem at Paauau Stream under appropriate authority.

Your assistance in this most critical problem will be sincerely appreciated.

HERBERT T. MATAYOSHI
Mayor

cc: Mr. George Yokoyama
Chief Engineer

COUNTY OF HAWAII • HILO, HAWAII 96720

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858

PODED-PJ

10 March 1981

PUBLIC NOTICE

NOTICE OF STUDY INITIATION
ON FLOOD CONTROL FOR
PAAUAU STREAM, PAHALA, ISLAND OF HAWAII

1. The US Army Engineer District, Honolulu, has initiated a detailed project investigation on flood control for the Paauau Stream, Pahala, Island of Hawaii (Figure 1). Initiated at the request of the County of Hawaii, the study is being conducted under Section 205 of the Flood Control Act of 1948, as amended. This notice is issued to inform all interested parties of the study and request any information pertinent to the study.

2. The study, to be conducted through Fiscal Year 1982, will determine the feasibility of flood mitigation measures and the extent to which the Federal Government should participate in implementation. Detailed technical, economic, environmental, and social studies will be conducted in conformance with essential elements of the US Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources." The end product of the study will be a detailed report including an environmental statement, addressing the feasibility and impacts of any proposed solution.

3. For assessment of the problems and needs, information will be needed on past floods, flood damages, existing conditions, and future plans for the study area. Please advise the Corps, at the address above, of the availability of any information of this nature. Recipients of this notice are requested to bring this information to the attention of any interested individuals or organizations.

ALFRED J. THIELE
Colonel, Corps of Engineers
District Engineer

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES
EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
CONSERVATION AND ENFORCEMENT
CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

APP - 5 1981

Alfred J. Thiede
Colonel, Corps of Engineers
U.S. Army Engineer District, Honolulu
Ft. Shafter, Hawaii 96858

Dear Colonel Thiede:

SUBJECT: Notice of Study Initiation of Flood Control for Paauau Stream, Pahala, Hawaii.
TMK: 9-6-02: 9-6-07:
9-6-05: 9-6-18:
9-6-06: 9-6-22:

A review of our records indicates that this project does not occur on historic properties that are listed on the Hawaii Register and/or the National Register of Historic Places, or that have been determined eligible for inclusion on the National Register of Historic Places. However, this does not confirm the absence of historical, cultural, architectural and/or archaeological resources on the property.

In the event that any unanticipated sites or remains such as artifacts, shell, bone or charcoal deposits; human burials; rock or coral alignments, pavings, or walls are encountered, please inform the applicant to stop work and contact this office (548-7460) immediately.

Sincerely yours,

Susumu Ono
Chairman of the Board and
State Historic Preservation
Officer

PAAUAU STREAM
FLOOD CONTROL STUDY

U.S. ARMY ENGINEER DISTRICT, HONOLULU BUILDING 230 FORT SHAFTER, HAWAII 96858

At the request of the Mayor, County of Hawaii, the US Army Corps of Engineers is conducting a study of possible flood control improvements for Paauau Stream at Pahala, Hawaii (see map on reverse side) under authority of Section 205 of the Flood Control Act of 1948, as amended (PL 94-241).

A public workshop is being held to generate public awareness for the study and to share information and comments on the problems and potential solutions. The meeting will be held on:

Thursday, 16 July 1981 at 7:30 pm
Senior Citizen Center
Pahala, Hawaii

Your attendance and participation will provide valuable input to the study. For further information or comments, please contact:

Mr. George Takamiya
US Army Engineer District, Honolulu
ATTN: PODED-PJ
Building 230
Fort Shafter, HI 96858

Telephone: 438-9526

Public Workshop

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

NOV 23 1981

Mr. Kisuk Cheung, Chief
Engineering Division
U. S. Army Engineer District,
Honolulu
Ft. Shafter, Hawaii 96858

Dear Mr. Cheung:

SUBJECT: Review of Archaeological Reconnaissance
Pa'au'au Stream Flood Control Study Area
Pahala, Ka'u, Hawaii, TMK 9-6-17: var.,
9-6-18: var., and 9-6-22: var.

Thank you for the opportunity to review the subject document.

The document, entitled, "An Archaeological Reconnaissance of the Pa'au'au Stream Flood Control Study Area, Pahala, Ka'u, Hawaii" by Hamilton H. Ahlo, Jr., concludes that the area is void of any surface archaeological or historical features and the proposed flood control project should have no effect on any cultural resources eligible for inclusion on or included on the National (or State) Register of Historic Places (1981:2).

We concur with Mr. Ahlo's conclusions and further recommend that in the event of any previously unidentified sites or remains such as artifacts, shell, bone, or charcoal deposits; human burials; rock or coral alignments, pavings, or walls are encountered, please stop work and contact our office at 548-6108 immediately.

Sincerely yours,

Susumu Ono
Chairman and
State Historic Preservation
Officer

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. BOX 3378
HONOLULU, HAWAII 96801

January 5, 1982

GEORGE A. L. YUEN
DIRECTOR OF HEALTH

JOHN P. CHALMERS, M.D.
DEPUTY DIRECTOR OF HEALTH

HENRY N. THOMPSON, M.A.
DEPUTY DIRECTOR OF HEALTH

MELVIN K. KOIZUMI
DEPUTY DIRECTOR OF HEALTH

ABELINA MADRID SHAW, M.A., J.D.
DEPUTY DIRECTOR OF HEALTH

In reply, please refer to
File: EPHS-SS

Major Edmund A. Thal
Corps of Engineers
Deputy District Engineer, Honolulu
Department of the Army
Ft. Shafter, Hawaii 96858

Dear Major Thal:

Subject: Paauau Stream Flood Control Project, Island of Hawaii

We concur that the discharge impacts on water quality are acceptable and have been mitigated to the extent practicable and that the discharge will conform to State water quality standards.

Sincerely,

SHINJI SONEDA
Chief, Environmental
Protection & Health
Services Division

APPENDIX B

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LIST OF TABLES

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LIST OF PLATES

INTRODUCTION

1. Scope. This appendix contains descriptions of studies made to determine the runoff process for various selected concentration points within the Paauau watershed which has a total drainage area of about 6.5 square miles (Plate B-1). The four objectives of this appendix are: (a) to present the basic meteorologic and hydrologic characteristics of the study area; (b) to outline the methods and techniques used to determine the runoff process; (c) to present discharge frequency values for the present and future (project and no-project) conditions; and (d) to provide standard project flood, 100-year, and 50-year design discharges for the alternative flood control plans.

2. Alternative Flood Control Plans. Three alternative plans were investigated, two plans are structural alternatives and the other a nonstructural alternative. All structural alternatives consist of various channel improvements above Mamalahoa Highway. While all the schemes were hydrologically analyzed, only the results from Alternative 1 are discussed and displayed graphically. The design concepts for all alternatives are stated in the main report.

GENERAL DESCRIPTION

3. Location and Basin Description. The island of Hawaii is the largest of the Hawaiian Islands, encompassing 4,038 square miles of land area. The island has two main population centers, Kailua-Kona on the west coast and Hilo on the east coast. The town of Hilo is the economic and political center of the island. Paauau Stream is in the Kau District of the County of Hawaii, approximately 45 miles southwest of Hilo. The drainage area is approximately 6.5 square miles. Kauhuhuula Gulch and an unnamed gulch are tributaries to Paauau Stream. Paauau Stream does not directly drain into the ocean but dissipates through lava covered lands probably making its way to the ocean through lava tubes and cracks. The watershed is characterized by barren lava covered areas and macadamia and sugarcane fields. The town of Pahala is the major community in the basin. Paauau Stream runs along Koali Street in Pahala and is ephemeral.

4. Streamflow Data. Paauau Stream is an ephemeral stream. The gradient of the stream varies from 250 feet per mile at the lower reaches to 750 feet per mile at the upper reaches (Plate B-2). Its runoff patterns are similar to those for other streams with comparable drainage areas. Floods occur within a few hours after a heavy rainstorm as indicated by the almost vertical rise on the hydrograph. The recession is also steep and the stream returns to near normal conditions in a few hours. The USGS has operated a recording gage on Paauau Stream since 1963. The maximum known discharge during the period of record is 3,600 cfs which occurred twice, on 5 January 1969 and 8 January 1975. This gage was destroyed by the flood of 20 February 1979. The annual maximum flows are shown in Table B-1.

TABLE B-1. Annual Peak Discharges for Paauau Gulch At Pahala, Hawaii (USGS GAGE 7705), Drainage Area = 1.74 square miles

WATER YEAR	DATE	DISCHARGE (cfs)
1963	18 October 1962	1,260
1964	22 March 1964	108
1965	14 November 1964	260
1966	14 November 1965	464
1967	5 November 1966	1,520
1968	27 January 1968	2,360
1969	5 January 1969	3,600
1970	26 August 1970	131
1971	27 January 1971	250
1972	25 November 1971	2,060
1973	15 October 1972	619
1974	1 December 1973	1,030
1975	8 January 1975	3,600
1976	5 January 1976	3,150
1977	12 August 1977	990
1978	29 May 1978	95
1979	20 February 1979	2,800

5. Precipitation Data. Records of 10 or more years are available for 21 precipitation stations in and near the drainage area. The National Weather Service operates two recording precipitation gages, and Kau Sugar Company operates the remaining 19 precipitation stations. The longest record in the study area is for the Pahala gage (No. 21) which has 84 years of record, from 1894 to 1978. Pertinent data on the Pahala gage is given in Table B-2.

TABLE B-2. Summary of Precipitation Data at Pahala (USWB No. 21), Hawaii

	PRECIPITATION (inches)		
Month	Mean Monthly	Maximum Monthly	Minimum Monthly
January	8.03	30.16	.12
February	6.59	23.13	.02
March	5.58	20.53	.64
April	3.16	18.71	.19
May	2.32	6.27	.20
June	1.33	3.51	.00
July	1.52	6.89	.03
August	3.06	12.74	.03
September	2.53	11.97	.24
October	4.01	18.84	.17
November	5.44	22.43	.34
December	4.43	40.52	.03
Period of Record	48.00 (Total)	40.52 (max)	.00 (min)

6. Flood History. The storms of 20 February 1979 and 17 March 1980 caused serious flood problems in the subdivision area. The 1979 storm had a recorded flow of 2,800 cfs (Plate B-3). The 1979 storm was island-wide, but the Kau District had the greatest flooding. Because of extensive road overflow much of the Kau District was cut off from the rest of the island during the height of the flood. Twenty-five (25) families were evacuated from their homes in Pahala when floodwaters overbanked the stream. A stream gaging station on Paauau (16-7705) was destroyed. On 7 March 1979, President Carter declared the island a disaster area.

During the March 1980 storm, floodwater depths of 2 to 3 feet occurred along Koali Street and flooded homes along the stream. The velocity of the water down Koali Street prevented residents from crossing the street to safety. During storm runoff, the stream is not of sufficient cross-sectional area to adequately channel the flow. Water flow is characterized by high velocity flows which contribute to the streambank erosion problems. Considerable erosion has occurred and the right streambank is 20 to 50 feet into some of the developed lots.

7. Existing Flood Control Improvements. The US Soil Conservation Service (SCS) and the County of Hawaii implemented temporary emergency measures after the February 1979 and March 1980 storms. The stream was widened and the embankments were improved after each storm. Using emergency funds, the US Soil Conservation Service, in cooperation with the County, widened the streambed and constructed four short reinforced concrete retaining walls along the right bank in areas of critical erosion. The improvements are emergency type measures and were not designed to provide protection under severe storm conditions.

SPF FLOOD HYDROGRAPH DERIVATION

8. Unit Hydrographs. A unit hydrograph is a flood resulting from 1 inch of effective rainfall occurring uniformly over a watershed in a specified time duration. The unit hydrograph concept is a useful tool in that it provides a linear description of runoff from a watershed and facilitates the generation of synthetic flood hydrographs for basins which are ungaged. The procedure used by the Pacific Ocean Division for determination of synthetic unit hydrographs was derived from Snyder's unit hydrograph relations outlined in EM 1110-2-1405.

Snyder's unit hydrograph parameters, used for the Paauau watershed analysis, were obtained from the Kohakohau Stream gage. The Kohakohau gage was one of five stream gages formerly used in the research project, "Hydrologic Relations in Hawaii," conducted by the Honolulu Engineer District. The Kohakohau unit hydrograph was developed from the 16 January 1963 flood (Plate B-4). The 1963 storm data were also analyzed by the HEC-1, a flood hydrograph computer program developed by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers. The following Snyder's unitgraph parameters were computed: Cp = 0.65 and C_t = 0.18. Regional curves defining the unit hydrograph widths, W_{75} and W_{50}, were developed by drawing lines parallel to the standard unit hydrograph (Peak = 1,860 cfs; D.A. = 1.74 sq mi; peak discharge per square mile = 1,070 cfs per sq mi; W_{75} = 0.32 hours; and W_{50} = 0.50 hours). By applying the Kohakohau base unitgraph data to the physical dimensions of the

Paauau drainage areas, 10-minute unit hydrographs for Paauau were developed. A 10-minute time interval was chosen since it provided adequate description of the unit hydrographs. In accordance with EM 1110-2-1405, the peaks of the unit hydrographs were increased to account for differences noted in past analyses of minor and major floods. A 50 percent increase was selected for the mountain areas, and 25 percent increase for the valley areas. Plates B-5 and B-6 show the unitgraphs used to develop the SPF for the Paauau watershed. Plate B-7 depicts the regional W_{75} and W_{50} curves used to shape the unit hydrographs. Table B-3 summarizes the unit hydrograph calculations. The applicability of the derived unit hydrographs to model the Paauau watershed is discussed in Paragraph 19; "Verification of Hydrologic Investigation."

TABLE B-3. UNIT HYDROGRAPH PARAMETERS

	WATERSHED CHARACTERISTICS				
SUBAREA	DA (SQ MI)	L (MILE)	L_{ca} (MILE)	C_t —	$640C_p$ —
A	3.88	9.90	5.50	0.18	416
B	1.74	5.07	2.13	0.18	416
C	0.51	1.70	0.95	0.18	416
D	0.32	0.52	0.43	0.18	416

	10-MINUTE UNIT HYDROGRAPH (EXISTING CONDITIONS)			
SUBAREA	Q_{pr} (cfs)	t_{pr} (Minutes)	W_{75} (Minutes)	W_{50} (Minutes)
A	2,630	37	31	48
B	1,860	24	19	30
C	890	15	12	18
D	835	10	8	12

	10-MINUTE UNIT HYDROGRAPH PEAK INCREASED BY 50 & 25 PERCENT (EXISTING CONDITIONS)			
SUBAREA	Q_{pr} (cfs)	t_{pr} (Minutes)	W_{75} (Minutes)	W_{50} (Minutes)
A	3,950	25	19	31
B	2,790	16	14	21
C	1,110	12	10	14
D	1,040	9	6	10

TABLE B-3. UNIT HYDROGRAPH PARAMETERS (Cont)

SUBAREA	10-MINUTE UNIT HYDROGRAPH PEAK INCREASED FOR FUTURE CONDITIONS			
	Q_{pr} (cfs)	t_{pr} (Minutes)	W_{75} (Minutes)	W_{50} (Minutes)
A	3,950	25	19	31
B	2,790	16	14	21
C	1,520	9	7	11
D	1,330	6	5	8

TERMINOLOGY

DA: Drainage area of the watershed

L: Length of the longest watercourse from the outflow point to the upstream, watershed boundary.

L_{ca}: Length along the longest watercourse from the outflow point to the point nearest the centroid of the watershed.

C_t and C_p: Regional coefficients which represent the basin slopes, stream patterns, basin shape, and other properties.

Q_{pr}: Peak discharge of the unit hydrograph.

t_{pr}: Time between the mid-point of 1 inch rainfall excess and the peak discharge of the unit hydrograph.

W_{75}: Width of the unit hydrograph at the ordinate that equals 75% of the peak discharge.

W_{50}: Width of the unit hydrograph at the ordinate that equals 50% of the peak discharge.

9. Unit Hydrographs for Future Conditions. To determine the effects of urbanization on peak discharges, unit hydrographs and rainfall runoff hyetographs were first developed for the existing condition and then modified to reflect the future condition. The unit hydrographs for the existing condition are identical to the non-increased unit hydrograph developed for the SPF and are shown on Plates B-5 and B-6. The non-increased unit hydrographs were used for all flood frequencies to provide a uniform basis of comparison. Since the drainage areas are small, the unit hydrographs for the minor and major floods are not expected to vary considerably. The increased peak for the SPF unit hydrograph was a conservative estimate. For the future condition, the lag times of the unit hydrographs were recomputed and determined by the relationship, Lag = 0.6 x Time of Concentration, where the Time of Concentration represents the time of travel of rainfall from the most distant part of the watershed to the outflow point. The Time of Concentration was determined from the Soil Conservation Service publication entitled "Urban Hydrology for Small Watersheds," January 1975. The unit hydrographs for the future condition were constructed based on the changes made to the lag time and are shown on Plate B-8.

10. Standard Project Storm. The standard project floods computed for Paauau Stream at selected concentration points were derived from Memo for Record ENGCW-EY, dated 19 September 1962. The index rainfall for the Paauau basin is 23.5 inches in 24 hours. Depth-duration values were computed by applying percentages extracted from the above memorandum, based on drainage area and time interval to the rainfall index. A unit-time interval of 10-minutes was considered the most practical for storm computations to adequately define the computed hydrograph. Ten-minute intensity patterns were arranged in a sequence favorable to the production of critical runoff. Depth-duration relationships for the subareas are given in Table B-4. The precipitation-intensity pattern is shown on Plate B-9.

TABLE B-4. STANDARD PROJECT STORM DEPTH-DURATION RELATIONSHIP, PAAUAU STREAM, PAHALA, HAWAII

Subarea* Designation	Drainage Area (Sq mi)	AVERAGE DEPTH OF PRECIPITATION OVER THE VARIOUS SUBAREAS FOR INDICATED DURATION			
		Maximum 1/2 Hour (inches)	Maximum 1 Hour (inches)	Maximum 3 Hours (inches)	Maximum 6 Hours (inches)
A	3.88	4.00	6.00	9.97	13.45
B	1.74	4.05	6.03	10.00	13.50
A&B	5.62	3.95	5.95	9.90	13.40
A,B,&C	6.13	3.92	5.92	9.85	13.35
A,B,C,&D	6.45	3.90	5.90	9.82	13.32

*For location, see Plate B-1.

11. Precipitation - Loss Rates and Base Flow. Because of the wide variation in rainfall and the absence of recording rain gages in the basin, rainfall corresponding to studies in connection with Civil Works Project ES-182, Hydrologic Relations in Hawaii, shows a variation in hourly loss rate ranging from 0.2 to 1.2 inches per hour. The Hydrologic Engineering Center was asked to perform a reconstitution of 43 flood hydrographs that were collected under Civil Works Project ES-182. The Kohakohau flood of 16 January 1963 was among the 43 floods analyzed. For regional analysis of the loss function (HEC Special Project Memo 338 and 344), HEC recommended the following constraints: (1) An exponent (ERAIN) of 0.5 for the loss rate function, and (2) a constrained ratio of 2.5 DLTKR/STRKR. For the standard project flood determination, the following values were chosen:

STRKR = 0.40 DLTKR = 1.0 RTIOL = 3.0 ERAIN = 0.50

A graphical representation of this loss rate function is shown on Plate B-10. The HEC loss rate function accounts for the effects of urbanization by reducing the effective loss rate in direct proportion to the percent impervious cover. The RTIMP value for the HEC-1 program (Ratio of basin that is Impervious) was assigned a value of 0.20. Several flood hydrographs were calculated using the HEC loss rate function. However, these flood hydrographs did not produce high peak flows. Therefore, a constant loss rate of 0.6 inch per hour was assumed to occur during the standard project storm. Base flow was considered negligible for the Paauau area as runoff occurs only as direct response to high intensity rainfall.

12. Flood Routing. Flood hydrographs were routed by the Modified Puls Method using HEC-1. The outflow-discharge relationship was derived using the HEC-2 computer program. Flood wave travel time in a reach was determined from the HEC-2 computer printout (Time). This value is the cumulative travel time in hours between the first cross section and the current cross section based on the weighted average velocity in the cross sections. The value (VOL) is the cumulative volume of water in channel and overbanks upstream of the current cross section. Table B-5 presents flood routing coefficients from the confluence of Paauau Stream and Kauhuhuula Gulch to Mamalahoa Highway.

TABLE B-5. FLOOD ROUTING COEFFICIENTS FROM HEC-2 SUMMARY PRINTOUT

REACH STATION	Q (cfs)	CWSEL (ft)	TIME (hr)	VOL (ac ft)	DEPTH ft	TOPWID ft	VCH fps
38+50	14,000	970.36	0.00	0.00	12.36	104.18	17.92
	20,000	972.39	0.00	0.00	14.39	158.56	19.99
	25,000	973.56	0.00	0.00	15.56	226.98	21.63
00+01	14,00	773.20	0.06	72.82	11.20	206.36	21.58
	20,000	774.59	0.05	97.20	12.59	263.20	23.13
	25,000	775.47	0.05	116.82	13.47	299.32	24.29

Flood routing studies indicate an insignificant attenuation in peak flows due to channel topograph and limited overbank storage.

13. Standard Project Flood (SPF). The SPF was developed in accordance with directions and criteria contained in EM 1110-2-1411. Derivation of the SPF was made by applying the unit hydrographs to the rainfall excesses of the Standard Project Storm (SPS). The rainfall intensity patterns were structured to produce the maximum runoff for the SPF. The SPF hydrograph for the Paauau Stream at the confluence are shown on Plate B-9. The standard project flood at various concentration points was determined by routing the flood hydrograph of the stream areas (subareas A&B) and combining the routed flood hydrographs with the downstream areas (subareas C & D). Plates B-11 and B-12 show the combined hydrograph at Mamalahoa Highway. Flow diagrams for the standard project flood, with and without project improvements, are shown on Plates B-13 and B-14.

DISCHARGE - FREQUENCY

14. General. Frequency studies for Paauau Stream were conducted using the criteria described in "Statistical Methods," by Leo R. Beard, U.S. Army Engineer District, Sacramento, dated 1962, and in Water Resources Council Bulletin No. 17A, "Guidelines for Determining Flood Flow Frequencies," dated March 1976. The derived frequency curve was then adjusted for expected probability as required in Civil Works Engineer Letter 63-5, dated 6 May 1963.

15. Flood Frequency of Annual Peak Flows. The USGS recording gage No. 16-7705, "Paauau Gulch at Pahala," with 17 years of record (Table B-1) was not used as the basis for peak discharge-frequency analysis. Considerable amount of surface runoff during minor floods is diverted by Kau Sugar Company for irrigation and storage. Flood frequencies were determined by regression analysis, and the Paauau gage data was included in this analysis.

TABLE B-6. LISTING OF FLOOD MAGNITUDES FROM FREQUENCY CURVES AND BASIN CHARACTERISTICS

Station	Q2	Q10	Q50	Q100	Q500	DA	CSLOPE	CLENGTH	PA	FC	ELEV	P24-2
7000	212	522	886	1,070	1,540	17.40	3.55	17.90	1.25	0.93	4.96	7.80
7012	627	1,260	1,910	2,210	2,950	33.60	3.10	25.80	1.22	0.85	3.78	8.50
7014	466	726	944	1,040	1,250	5.08	2.91	8.06	1.85	0.60	1.24	10.20
7017.5	899	4,030	9,850	13,480	25,920	34.80	6.68	14.80	1.04	0.35	7.60	8.50
7040	17,130	32,660	48,310	55,490	73,500	125.00	4.38	26.10	1.05	0.79	5.50	7.50
7174	101	183	260	295	380	0.24	3.17	1.60	1.60	0.01	0.53	10.00
7176	348	533	685	748	890	0.58	3.44	3.77	1.75	0.14	1.10	10.40
7176.5	701	942	1,120	1,190	1,350	1.09	4.17	4.38	1.80	0.07	0.74	9.60
7178	2,500	4,760	6,980	7,980	10,450	2.76	5.00	8.98	1.98	0.78	2.50	9.50
7176.5	121	285	473	565	810	0.62	6.55	3.46	1.24	0.39	1.91	8.30
7179.2	71	389	1,060	1,500	3,030	2.27	3.53	7.03	0.67	0.35	2.40	7.00
7200	1,110	2,170	3,220	3,700	4,890	1.58	1.71	2.50	1.70	1.00	4.54	6.60
7250	316	868	1,580	1,950	2,970	0.87	4.22	2.40	1.56	1.00	4.38	8.50
7370	411	689	936	1,040	1,290	0.40	6.00	3.20	2.00	1.00	3.76	8.00
7390	353	1,000	1,850	2,300	3,540	1.40	6.61	3.35	2.00	1.00	2.99	8.00
7400	41	87	136	159	217	0.20	9.00	0.80	2.00	1.00	2.32	8.00
7410	299	565	823	939	1,230	0.60	7.66	1.88	2.00	1.00	2.84	8.00
7420	116	205	288	324	410	0.21	7.79	1.50	2.00	1.00	2.46	8.00
7526	45	268	773	1,120	2,360	1.52	4.70	3.49	0.72	0.20	1.02	5.50
7558	98	211	333	390	540	0.32	9.02	2.30	0.67	0.02	4.13	4.40
7560	912	3,180	6,660	8,620	14,500	2.51	4.10	3.90	1.27	1.00	4.56	6.20
7565	1,050	2,560	4,300	5,160	7,440	4.30	4.85	6.25	0.56	0.71	3.95	6.00
7570	507	1,350	2,400	2,940	4,420	0.78	5.70	1.88	1.23	1.00	3.88	6.40
7580	543	1,570	2,960	3,690	5,760	1.18	2.91	2.55	1.14	1.00	3.77	6.20
7590	215	496	616	970	1,380	0.47	3.64	1.32	0.90	1.00	3.48	5.00
7590.4	140	349	598	722	1,060	0.27	15.60	1.46	0.75	0.89	3.42	4.90
7590.6	15	685	6,700	14,890	74,020	50.60	6.80	18.20	0.23	0.30	5.66	3.30
7590.8	399	2,213	6,100	8,710	17,800	33.10	39.30	14.40	0.18	0.30	4.79	3.30
7591.8	407	693	951	1,060	1,330	2.61	8.69	4.42	0.75	0.82	2.98	4.90
7593	616	1,780	3,350	4,170	6,490	8.74	7.32	7.32	0.60	0.50	5.33	5.60
7595	1,000	3,480	7,286	9,430	11,850	9.80	7.15	9.83	0.55	0.53	4.57	3.40
7598	35	69	103	118	156	0.67	2.48	3.42	0.75	1.00	4.06	3.10
7620	650	1,450	2,320	2,740	3,820	2.87	4.73	5.41	0.75	0.35	2.20	7.00
7700	2,730	7,220	12,830	15,690	23,520	9.41	6.57	14.20	0.60	0.46	5.23	8.30
7705	777	3,590	8,900	12,220	23,130	1.42	6.86	5.19	0.90	0.54	2.39	6.30

16. Flood Freqency Regression Analysis. In 1976, POD conducted a regional frequency analysis for the Island of Hawaii Flood Insurance Study. The objective of this analysis was to provide a regional flood-frequency analysis for all streamflow data on the island of Hawaii, and to prepare discharge criteria for determining the 10-, 50-, 100- and 500-year floods at ungaged locations.

a. Method of Analysis.

The multiple regression technique was used to develop the relationship between pertinent characteristics of the station flood-frequency curves and basin, and climatological characteristics. The station flood-frequency curves were determined following the procedures outlined in the Water Resources Council Bulletin No. 17, "Guidelines for Determining Flood Flow Frequency," March 1976. As suggested in the guidelines, a generalized skew coefficient of -0.05 was used for all station frequency curves.

From the station flood-frequency curves, discharges at selected recurrence intervals of 2, 5, 10, 25, 50, 100 and 500 years were determined. Each set of discharges was then correlated to various basin and climatological characteristics using a regression equation of the following form:

$$Q_T = aX_1^{b1}X_2^{b2}\ldots X_n^{bn}$$

where

Q_T is the discharge corresponding to recurrence intervals of T years (T = 2, 5, 10, ... 500).

$a, b_1, b_2, \ldots b_n$ are constants.

$X_1, X_2, \ldots X_n$ are basin and climatological characteristics.

Seven basin and climatological characteristics were considered in the analysis and are as follows:

(1) Drainage Area (DA) - in square miles as determined from standard U.S. Geological Survey topographic quadrangles.

(2) Main Channel Slope (CS) - in 100 feet per mile, determined by computing the average slope of the main channel between points 10 and 85 percent of the distance upstream from the point of interest to the basin divide.

(3) Main Channel Length (CL) - in miles, determined as the length of the main channel between the point of interest and the basin divide, as shown on standard U.S. Geological Survey quadrangle maps.

(4) Mean Annual Precipitation (PA) - in hundreds of inches, determined by placing a grid over an isohyetal map and locating 20-25 random points within the basin boundary and computing the arithmetic average of these points. This value is then divided by 100 for inclusion as an independent variable.

(5) Forested Area (FC) - This index is the portion of the total basin area shown as forest on standard U.S. Geological Survey topographic maps expressed as a decimal.

(6) Mean Basin Elevation (ELEV) - in thousands of feet, determined by placing a grid over the outline of the drainage basin on a standard U.S Geological Survey topographic map and determining the mean elevation of the sum of at least 25 grid intersections within the basin boundaries. This mean divided by 1,000 is the elevation index.

(7) 2-year 24-hour Precipitation (P_{24-2}) - inches, determined by placing a grid over a 2-year 24-hour isohyetal map and calculating the average intensity within the basin boundaries.

The regression constants were computed by the method of least squares and statistical tests were made to eliminate those basin and climatological characteristics that had little or no significance. From the final equations for discharges corresponding to selected recurrence intervals, a flood-frequency curve can be constructed for any site once the values of the significant characteristics are determined.

b. Analysis for the Island of Hawaii.

A thorough examination of all gaging-station records for the island of Hawaii was made to determine which records were suitable for inclusion in a regional flood-frequency analysis. The examination yielded 35 stations with adequate records for this flood-frequency analysis. These stations are located on Figure B-1. The records ranged in length from 10 to 47 years, with only three stations having records of 25 years or longer.

The station flood-frequency curves were computed and discharges at selected recurrence intervals were picked off for the 35 stations as listed in Table B-6. The seven basin and climatological characteristics computed for the gaging stations are also listed in Table B-6.

The multiple regression analysis was made using the records for the entire island of Hawaii and separating the records into the windward and leeward stations. The best relationships in terms of standard error and multiple correlation was found using the windward and leeward split.

The most significant basin and climatological characteristics for the windward area of Hawaii were found to be drainage area (DA) and the mean annual precipitation (PA), and those for the leeward area were drainage area (DA) and the 2-year 24-hour precipitation (P_{24-2}). The regression equations, standard error, and correlation coefficients, which were computed for the discharges at selected recurrence intervals, are listed in Tables B-7 and B-8. For comparison the regionalized frequency curve for Paauau Stream is shown on Plate B-15, along with the high peak flows from the Paauau gage data. Discharge frequency values for the present condition without project are shown on Plate B-16, and the discharge frequency values for the authorized plan are shown on Plate B-17.

TABLE B-7. Regression Equations, Standard Errors, and Multiple Correlation Coefficients for Leeward Hawaii Grouping

Regression equation	Standard error (percent)	Multiple correlation coefficient
$Q_2 = 1.6\ DA^{0.27} P_{24-2}^{3.07}$	130	0.68
$Q_{10} = 8.7\ DA^{0.55}\ P_{24-2}^{2.62}$	75.9	0.84
$Q_{50} = 24.1\ DA^{0.72}\ P_{24-2}^{2.35}$	71.8	0.88
$Q_{100} = 34.3\ DA^{0.77}\ P_{24-2}^{2.26}$	76.4	0.88
$Q_{500} = 62.1\ DA^{0.88}\ P_{24-2}^{2.14}$	90.8	0.87

TABLE B-8. Regression Equations, Standard Errors, and Multiple Correlation Coefficients for Windward Hawaii Grouping

Regression equation	Standard error (percent)	Multiple correlation coefficient
$Q_2 = 93\ DA^{0.71}\ PA^{2.24}$	105	0.79
$Q_{10} = 313\ DA^{0.67}\ PA^{1.27}$	102	0.80
$Q_{50} = 641\ DA^{0.64}\ PA^{0.70}$	102	0.80
$Q_{100} = 822\ DA^{0.64}\ PA^{0.50}$	105	0.80
$Q_{500} = 1361\ DA^{0.62}\ PA^{0.10}$	106	0.80

FLOODPLAIN ANALYSIS

17. General. The probable overflow area is defined as that area most susceptible to overflow based on the areas inundated by historical flood events and existing conditions. Probable overflow limits for the 100-year and standard project flood, and the limits of possible overflow were prepared for use in the economic determination of flood damages caused by each return period flood. These limits are delineated for purposes of evaluating potential flood damages for benefit analysis and constitute no assurance that shifting debris would not cause overflow to move to other locations within the gross area subject to inundation.

18. Flood Limits. Flood elevations associated with the peak discharges were determined by the HEC-2 computer program. Manning's Roughness Coefficient, n, of 0.035 to 0.06 was used for overland flow. Paauau is subject to flood flows in the super-critical flow regime. Velocities are high ranging from 18 to 31 feet per second for the 100-year flood. The standard project flood outline under existing conditions is shown on Plate B-18.

VERIFICATION OF HYDROLOGIC INVESTIGATION

19. A study to substantiate the computed results of the hydrologic investigation with observed data is impossible due to the absence of rainfall data for the Paauau watersheds. The only reliable known flood data for the area are the 20 February 1979 storm high water marks surveyed by the USGS. Compared against flood elevations computed by the HEC-2 computer program using peak discharges derived in the hydrologic investigation, the 1979 flood was estimated to range between a 10-year and a 20-year flood. The range of flood frequencies is not very significant since the flood elevations of the 10-year and 30-year floods vary by an average of only 0.25 to 0.30 foot. Perhaps the primary reason that the 1979 flood cannot be exactly matched with a flood frequency is the inability of the HEC-2 computer program to accurately model the subtleties of overland flow where local obstructions, dividing flows, intermixing flows, actual flood hydrograph, and splash waves add to its complexity. The surveyed high water marks attest to the irregular nature of overland flow in the Paauau area. In one instance, a difference of 0.4 feet between high water mark elevations was measured in a residential lot. In another, the upstream high water mark elevation was slightly lower than a downstream mark. Surveying errors are very possible and would further distort comparisons between actual and computed flood surface elevations. The 1979 flood was remembered as the most severe flood encountered in the Paauau area by many long-time residents, an account which favors a 30-year flood classification for the 1979 flood. Other flood data such as rainfall intensities, flood stages and peak discharges for the Paauau watershed are not known to exist. Thus, the results of this investigation are without verification due to the absence of data.

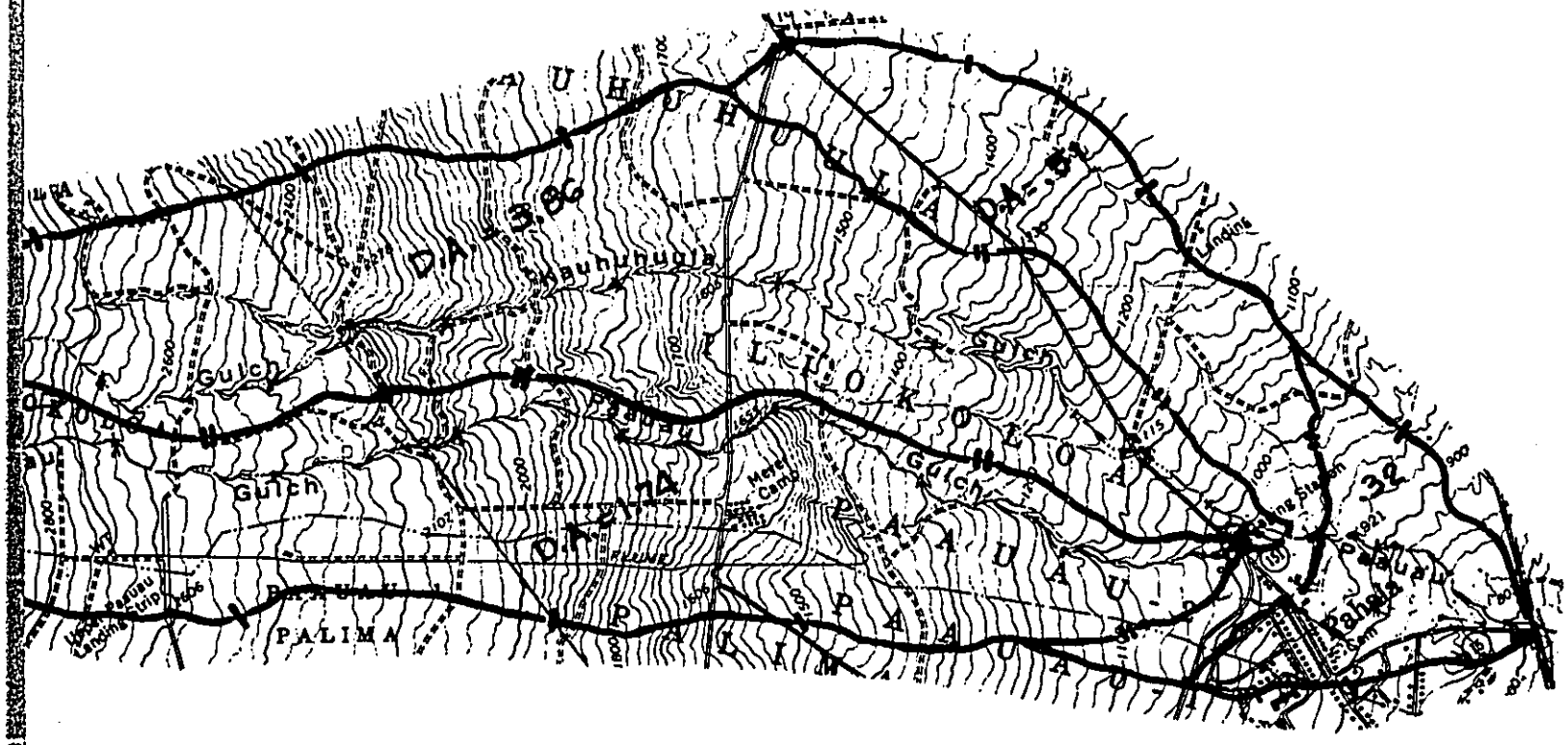
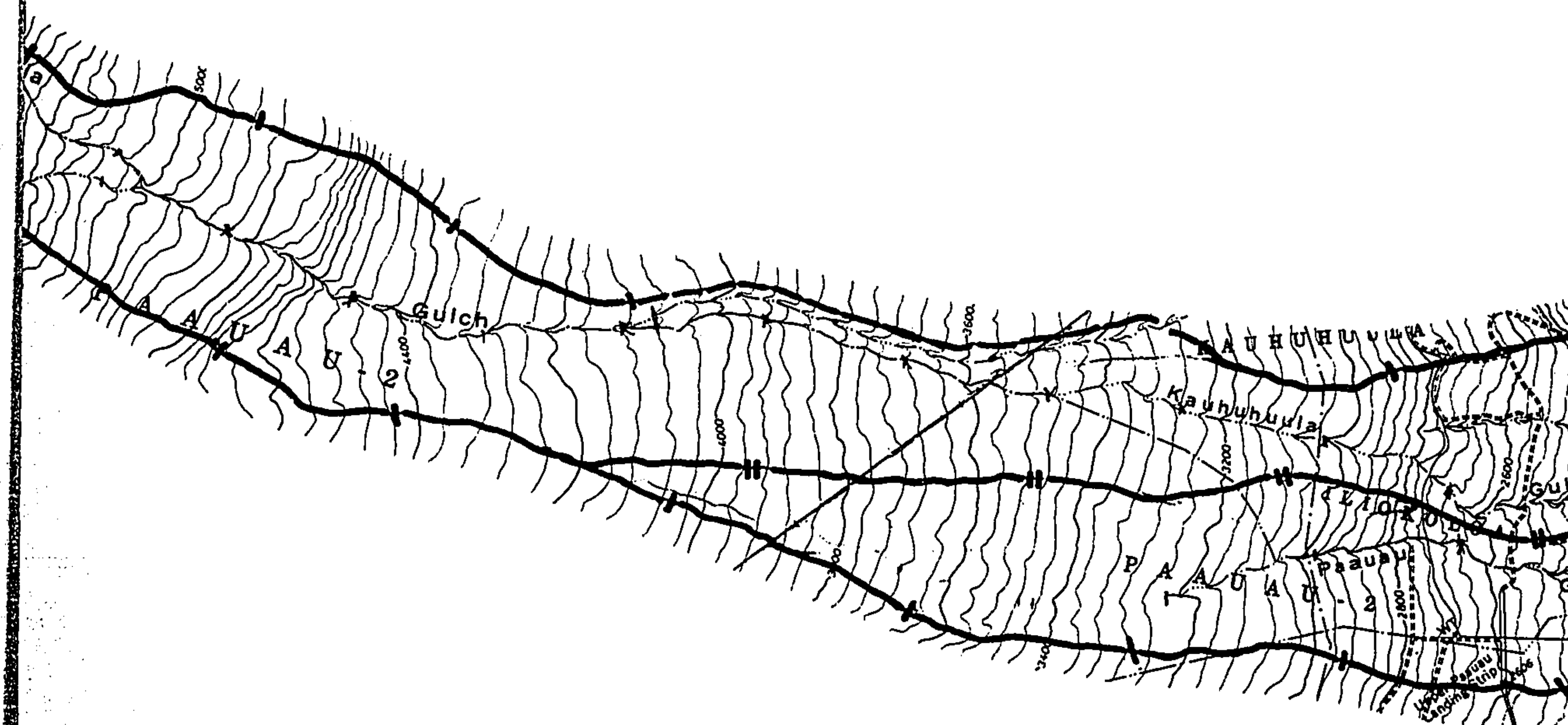
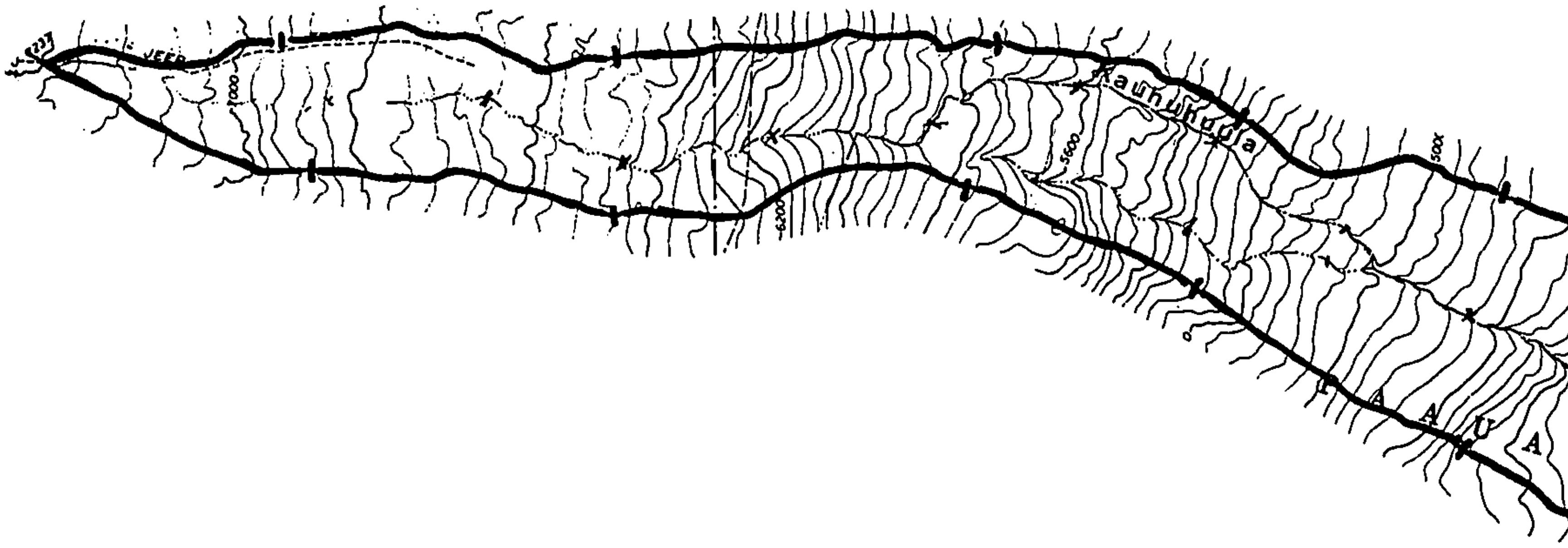
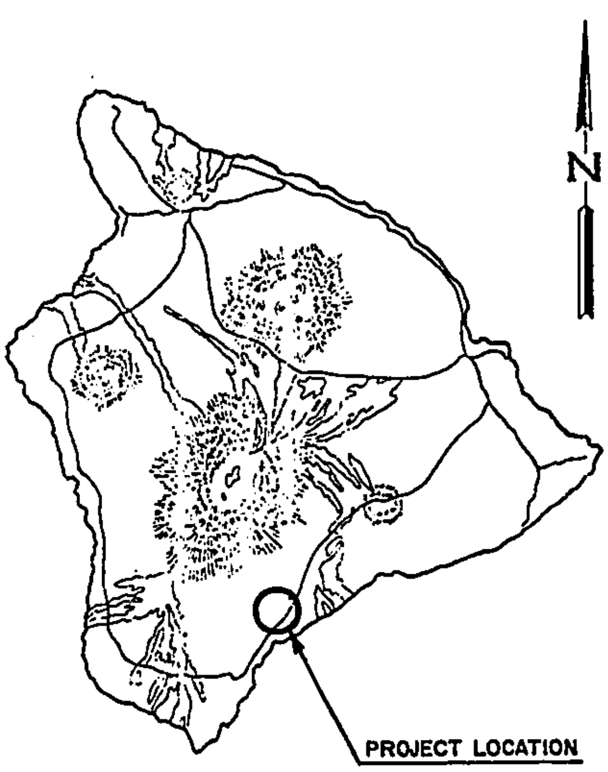

PAAUAU STREAM
PAHALA, HAWAII
DRAINAGE AREA MAP
PAAUAU WATERSHED
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-1


Gulch
P A A U A U - 2
Kauhuhuula
P A A U A U - 2
Paauau
5000
4000
3600
3200
2600



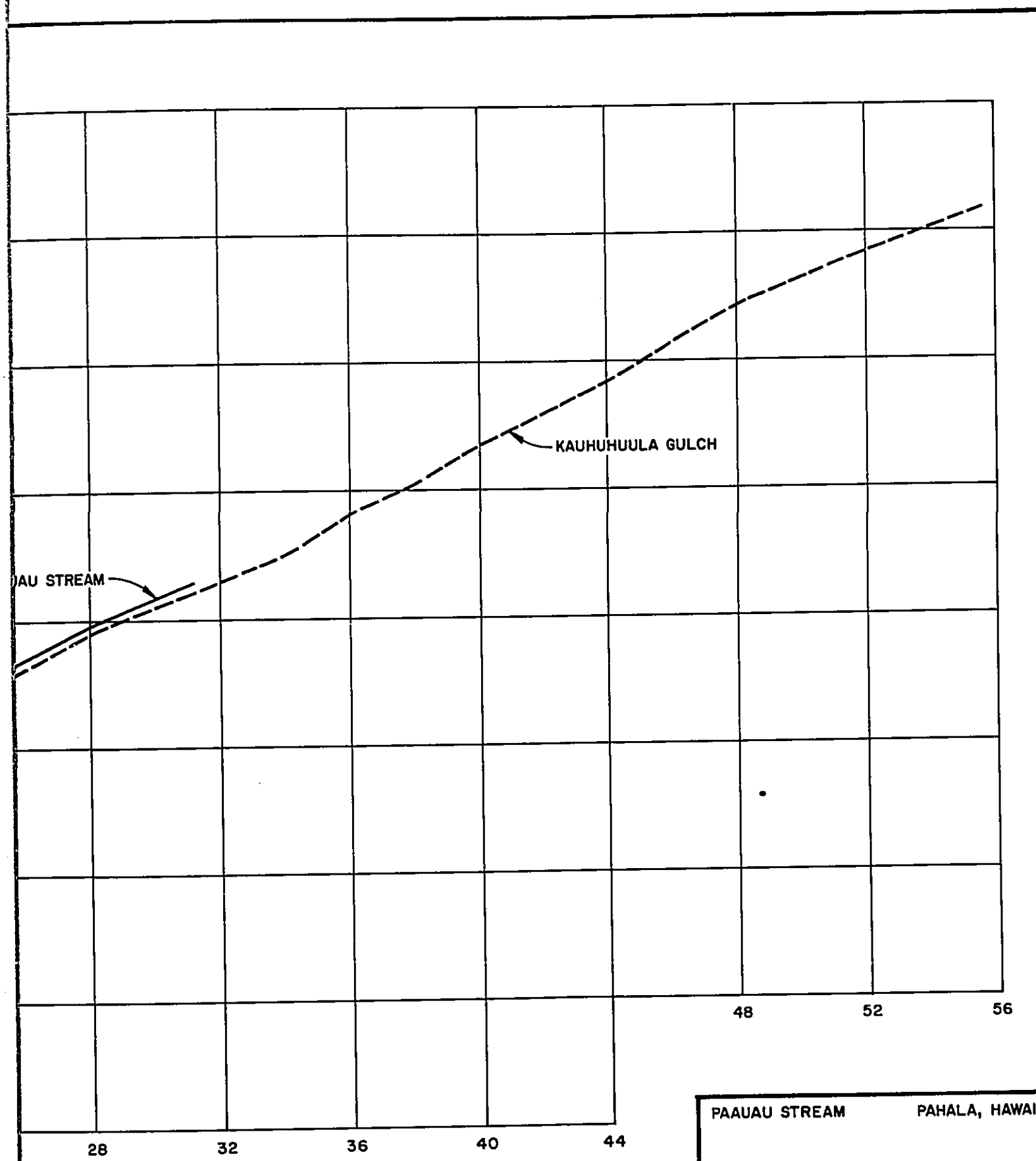


LOCATION MAP

NOT TO SCALE

0 5 10 15

SCALE IN MILES

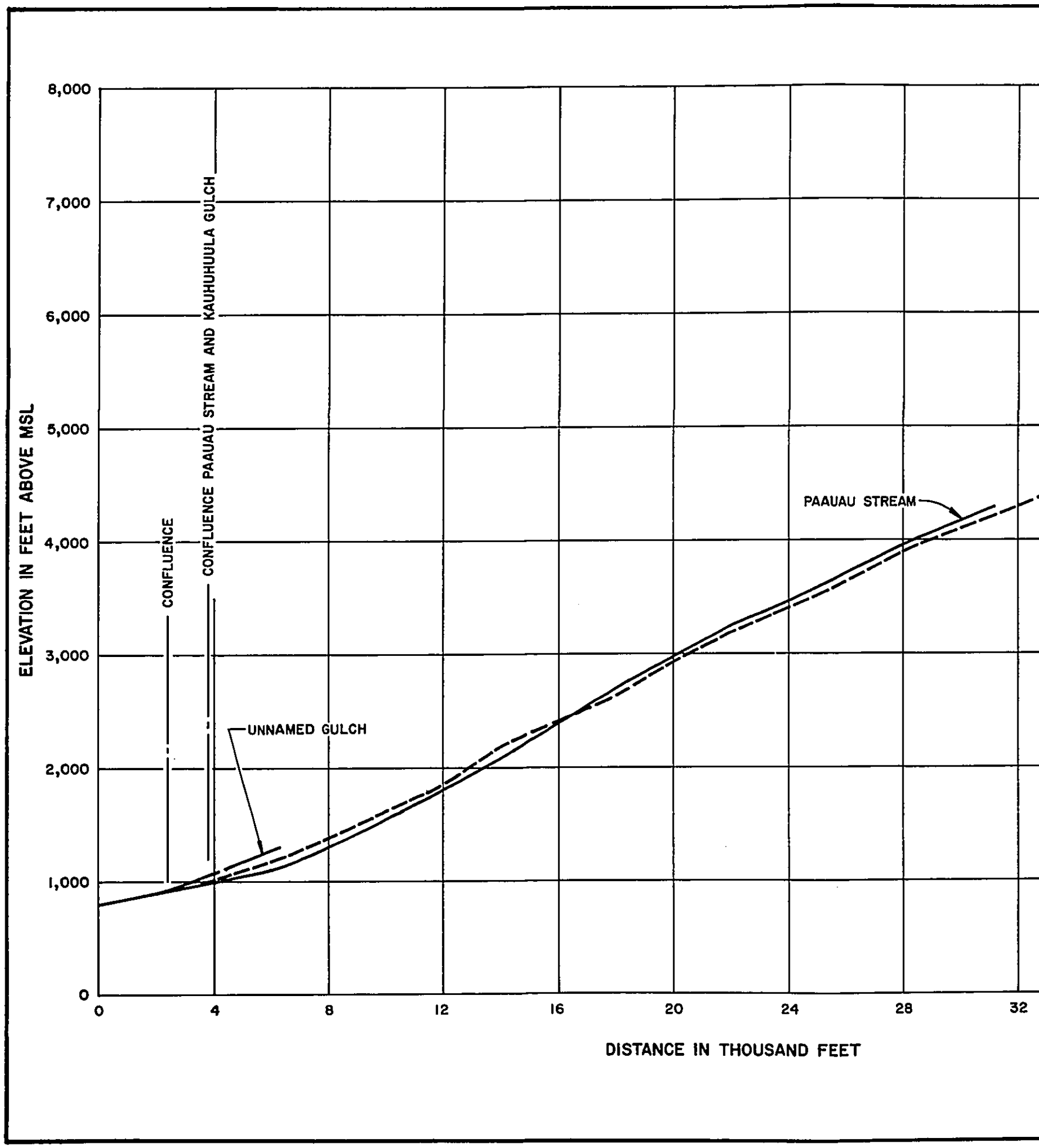


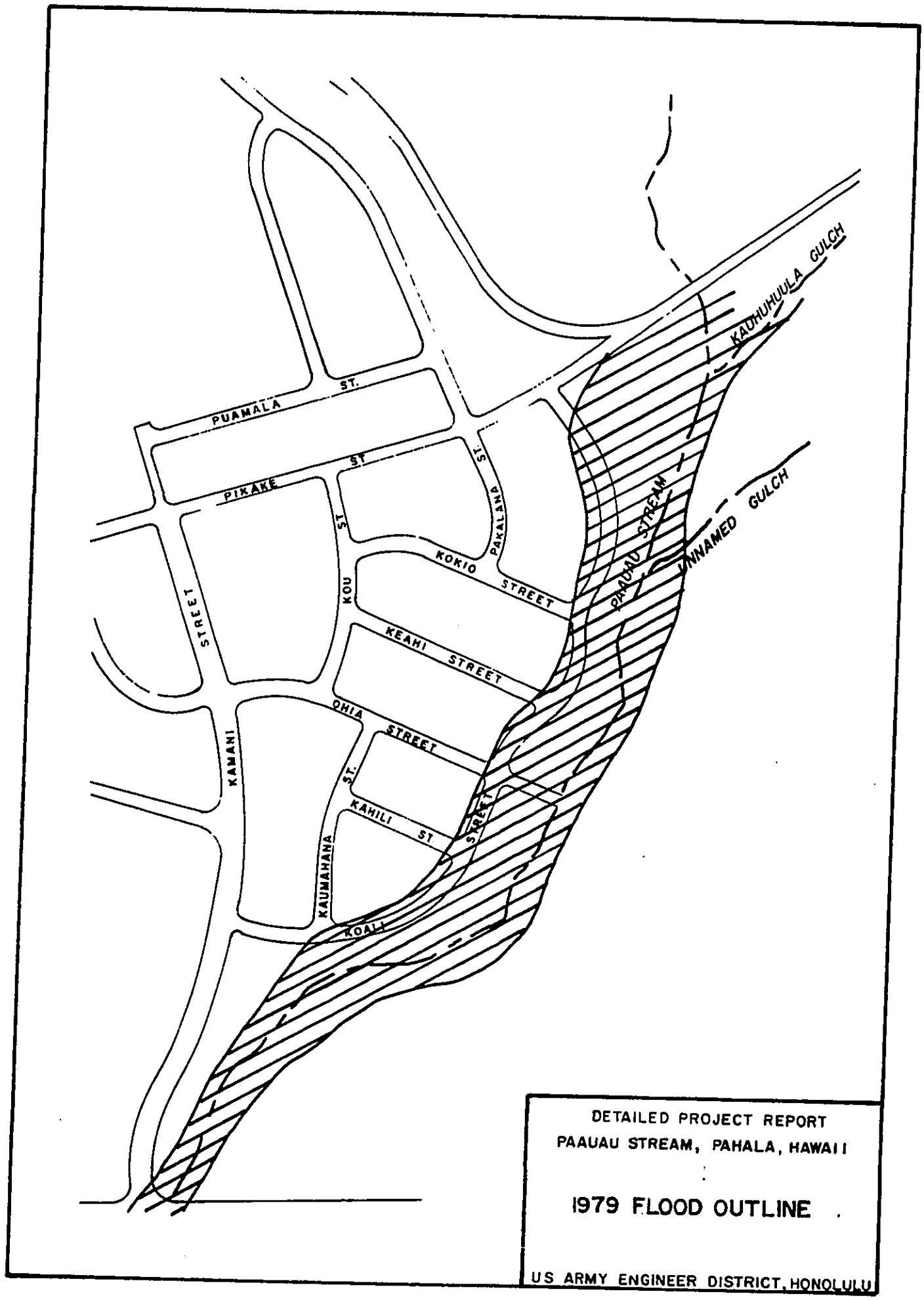
PAAUAU STREAM PAHALA, HAWAII

STREAM PROFILES

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 2


ELEVATION IN FEET ABOVE MSL
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0
4
8
12
16
20
24
28
32
DISTANCE IN THOUSAND FEET
CONFLUENCE
CONFLUENCE PAAUAU STREAM AND KAUHUHUULA GULCH
PAAUAU STREAM
UNNAMED GULCH



DETAILED PROJECT REPORT
PAAUAU STREAM, PAHALA, HAWAII

1979 FLOOD OUTLINE

US ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-3

TOTAL DRAINAGE AREA _____ 2.51 SQUARE MILES
AVERAGE PRECIPITATION DEPTH OVER AREA:
TOTAL STORM (6-HOURS) _____ 2.18 INCHES
EFFECTIVE RAIN _____ 0.48 INCHES

"HEC-1" VALUES

LAG = 0.57 HOURS
Cp = 0.65
Ct = 0.18
STRKR = 0.53
DLTKR = 1.02
RTIOL = 2.59
ERAIN = 0.62

OOD HYDROGRAPH
FS

COMPUTED FLOOD HYDROGRAPH

8 9 10 11 12 13

IOURS
5, 1963

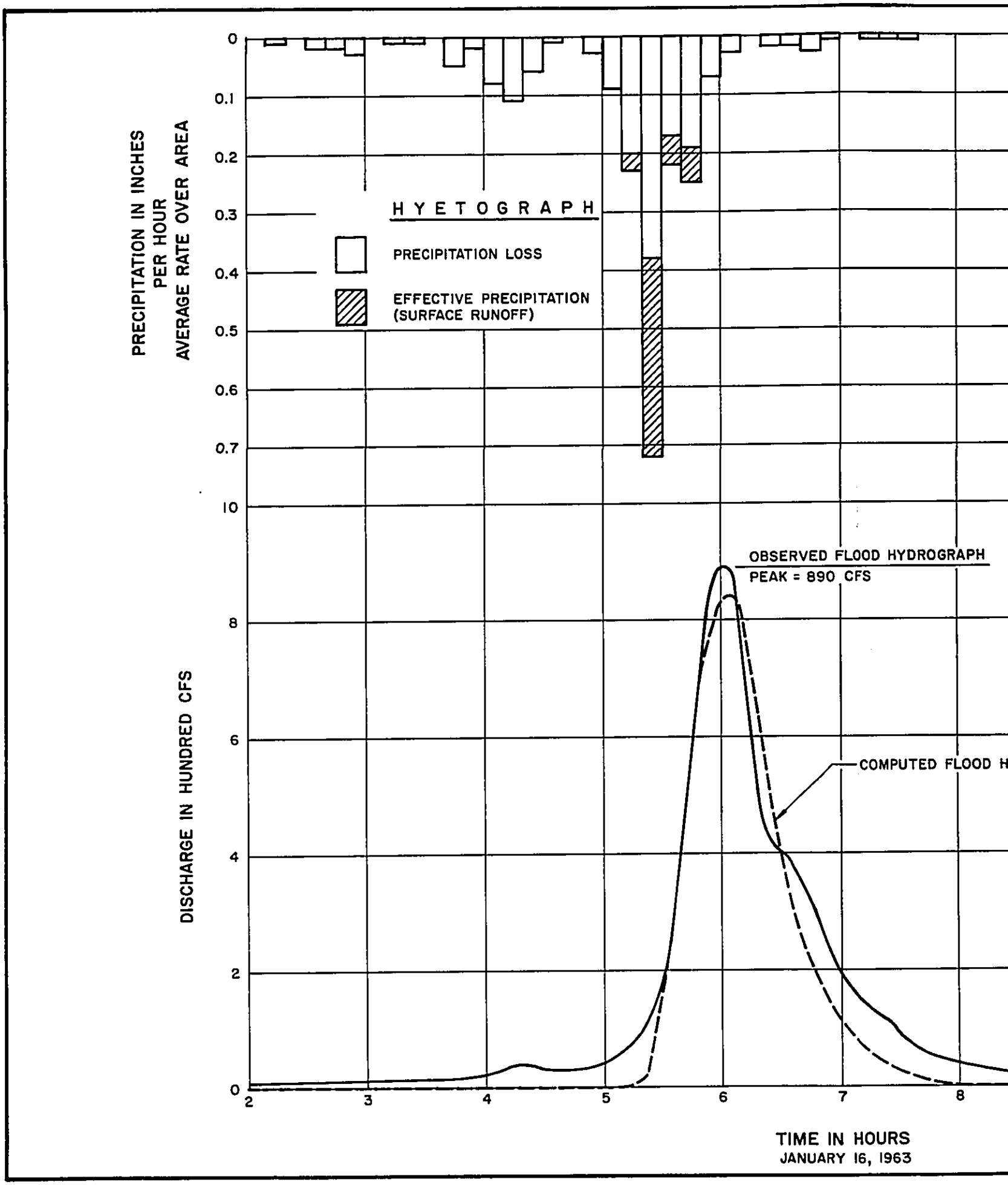
PAAUAU STREAM PAHALA, HAWAII

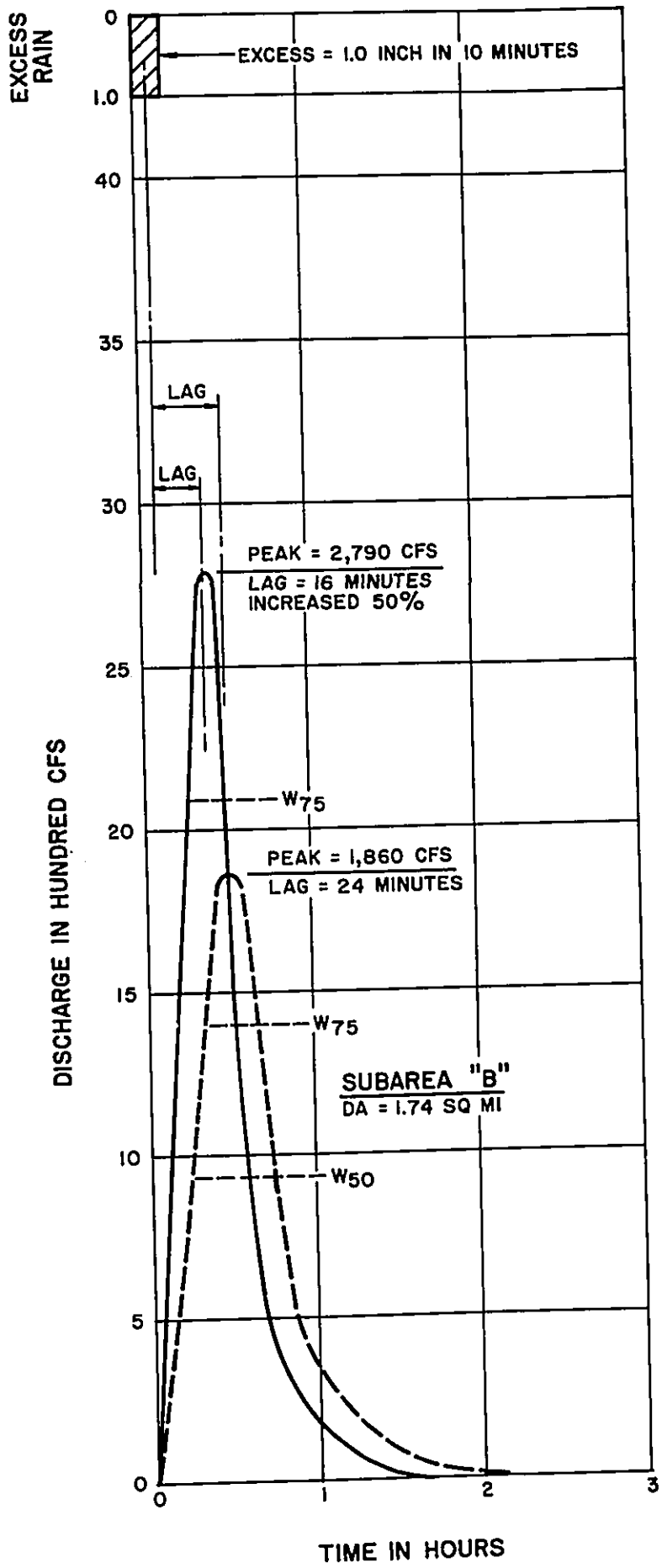
FLOOD RECONSTITUTION

KOHAKOHAU STREAM NEAR KAMUELA
(FLOOD OF JANUARY 16, 1963)
DA = 8.51 SQ MI

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 4


PRECIPITATION IN INCHES
PER HOUR
AVERAGE RATE OVER AREA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
10
HYETOGRAPH
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
(SURFACE RUNOFF)
OBSERVED FLOOD HYDROGRAPH
PEAK = 890 CFS
COMPUTED FLOOD H
DISCHARGE IN HUNDRED CFS
8
6
4
2
0
2
3
4
5
6
7
8
TIME IN HOURS
JANUARY 16, 1963



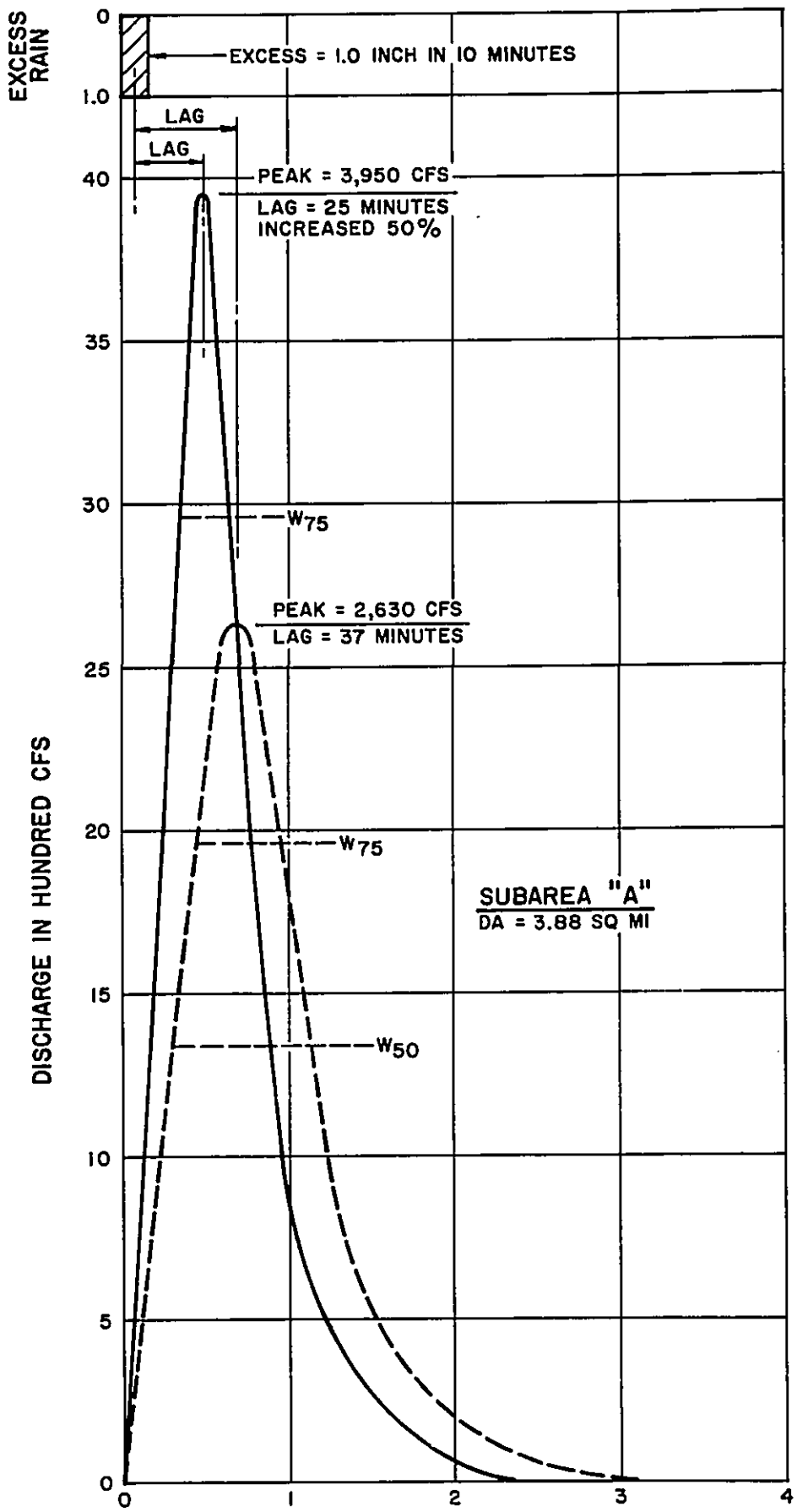
PAAUAU STREAM PAHALA, HAWAII

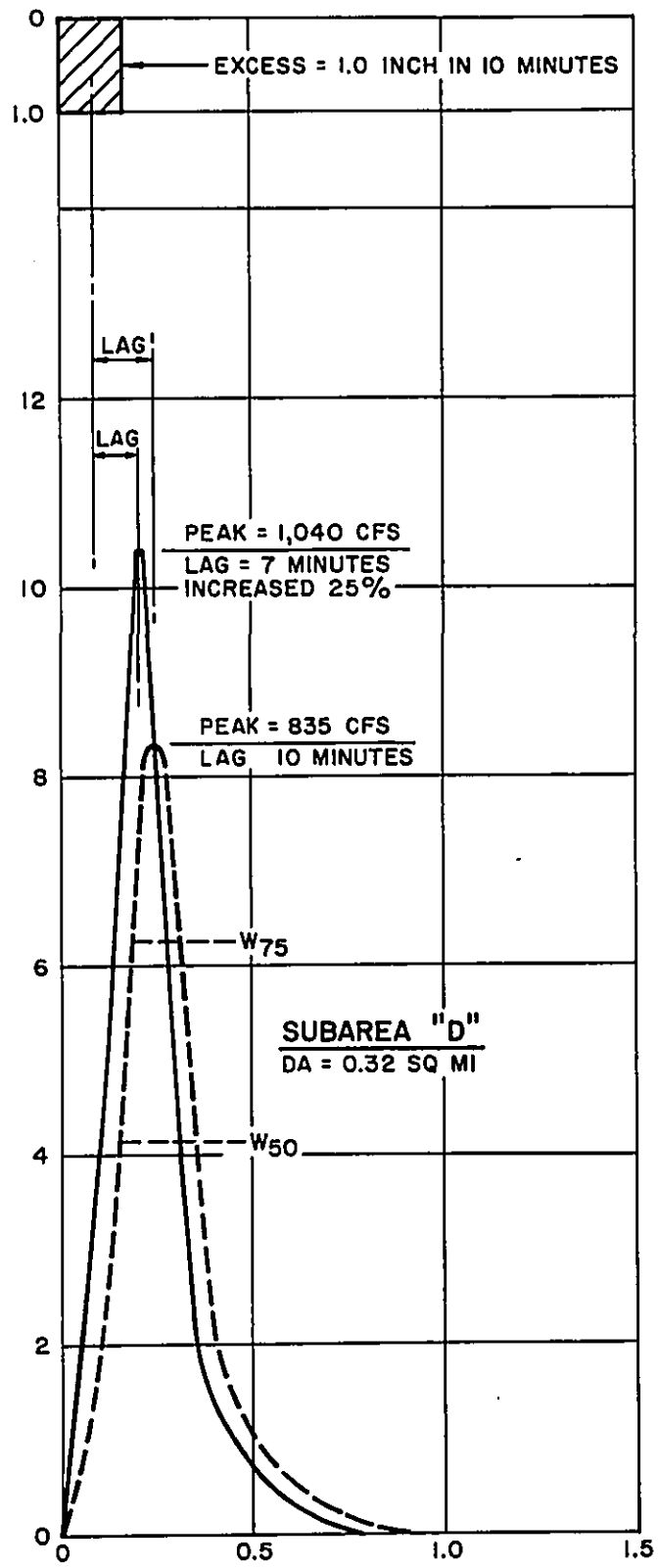
UNIT HYDROGRAPHS

SUBAREAS A & B
NON-INCREASED AND INCREASED
10-MINUTE UNIT HYDROGRAPHS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 5


EXCESS RAIN
0
1.0
40
35
30
25
20
15
10
5
0
EXCESS = 1.0 INCH IN 10 MINUTES
LAG
LAG
PEAK = 3,950 CFS
LAG = 25 MINUTES
INCREASED 50%
W75
PEAK = 2,630 CFS
LAG = 37 MINUTES
W75
W50
SUBAREA "A"
DA = 3.88 SQ MI
DISCHARGE IN HUNDRED CFS
0
1
2
3
4
TIME IN HOURS



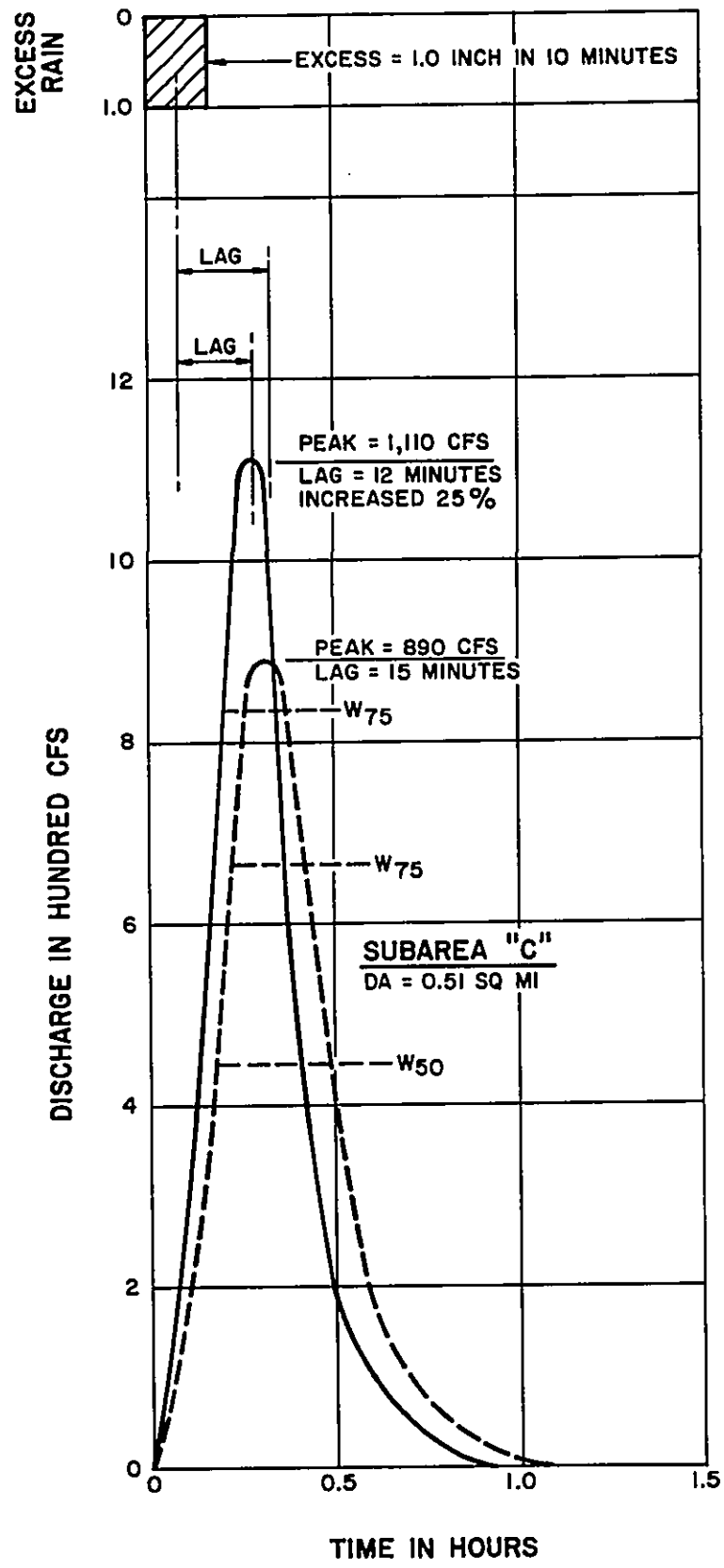
PAAUAU STREAM PAHALA, HAWAII

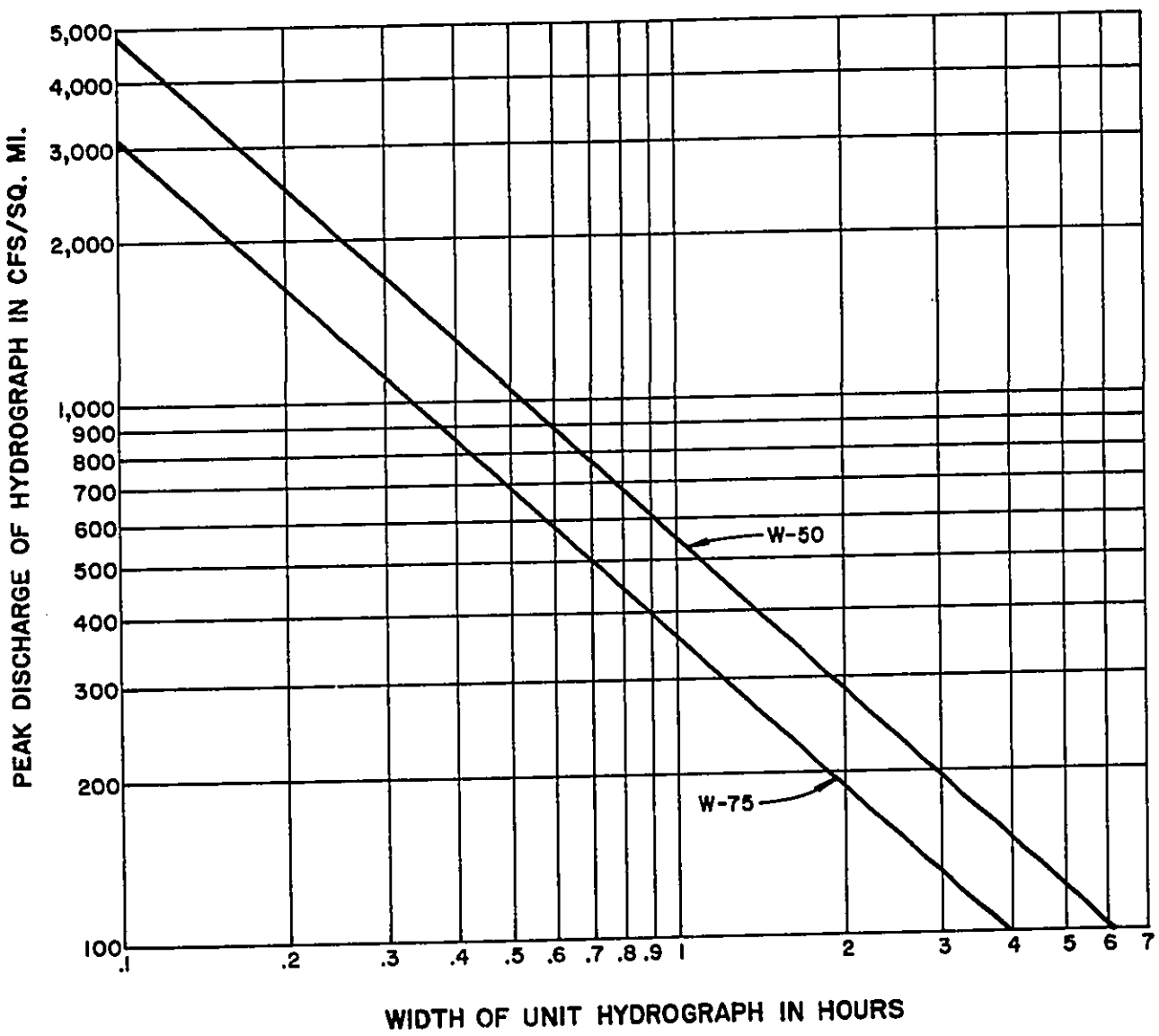
UNIT HYDROGRAPHS

SUBAREAS C & D
NON-INCREASED AND INCREASED
10 MINUTE UNIT HYDROGRAPHS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 6


EXCESS RAIN
0
1.0
EXCESS = 1.0 INCH IN 10 MINUTES
LAG
LAG
12
PEAK = 1,110 CFS
LAG = 12 MINUTES
INCREASED 25%
10
PEAK = 890 CFS
LAG = 15 MINUTES
W75
8
W75
6
SUBAREA "C"
DA = 0.51 SQ MI
W50
4
2
0
0
0.5
1.0
1.5
DISCHARGE IN HUNDRED CFS
TIME IN HOURS

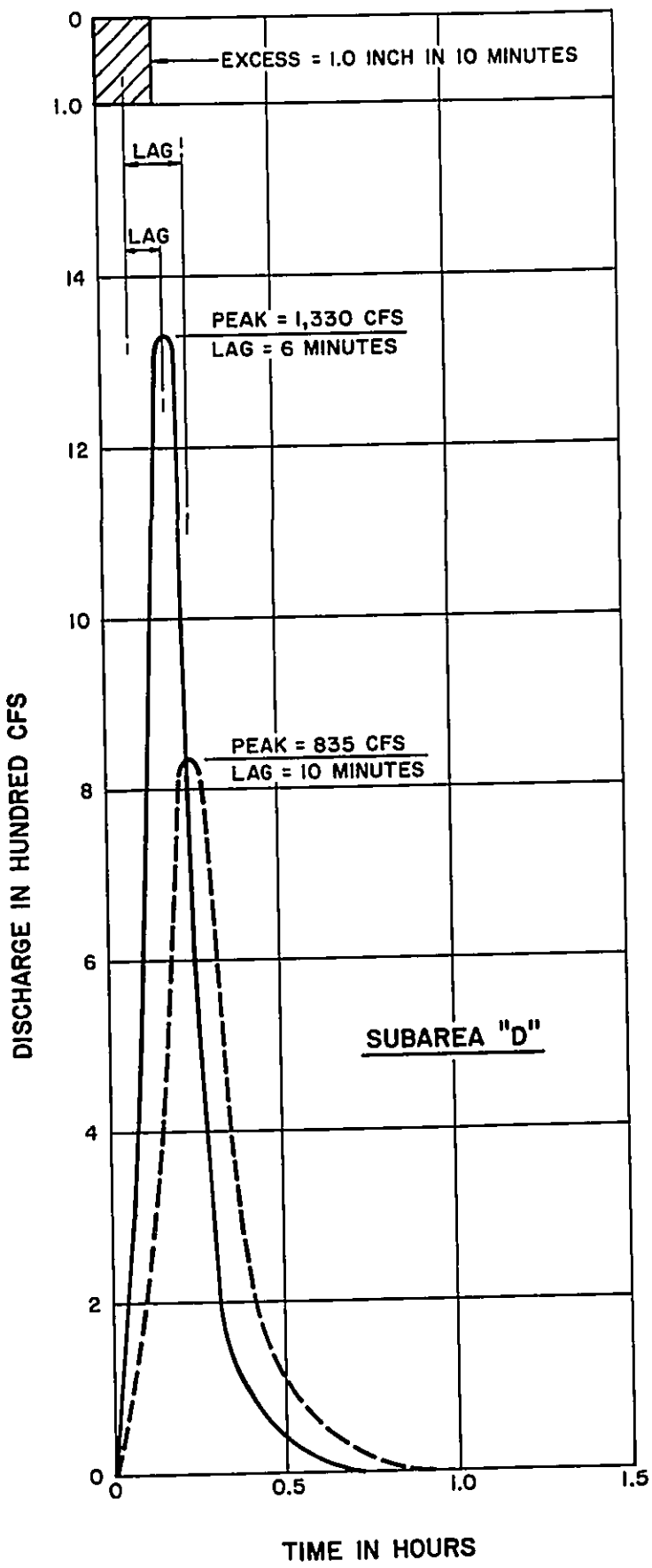


PAAUAU STREAM PAHALA, HAWAII

UNIT HYDROGRAPH
PEAKS VERSUS WIDTHS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 7

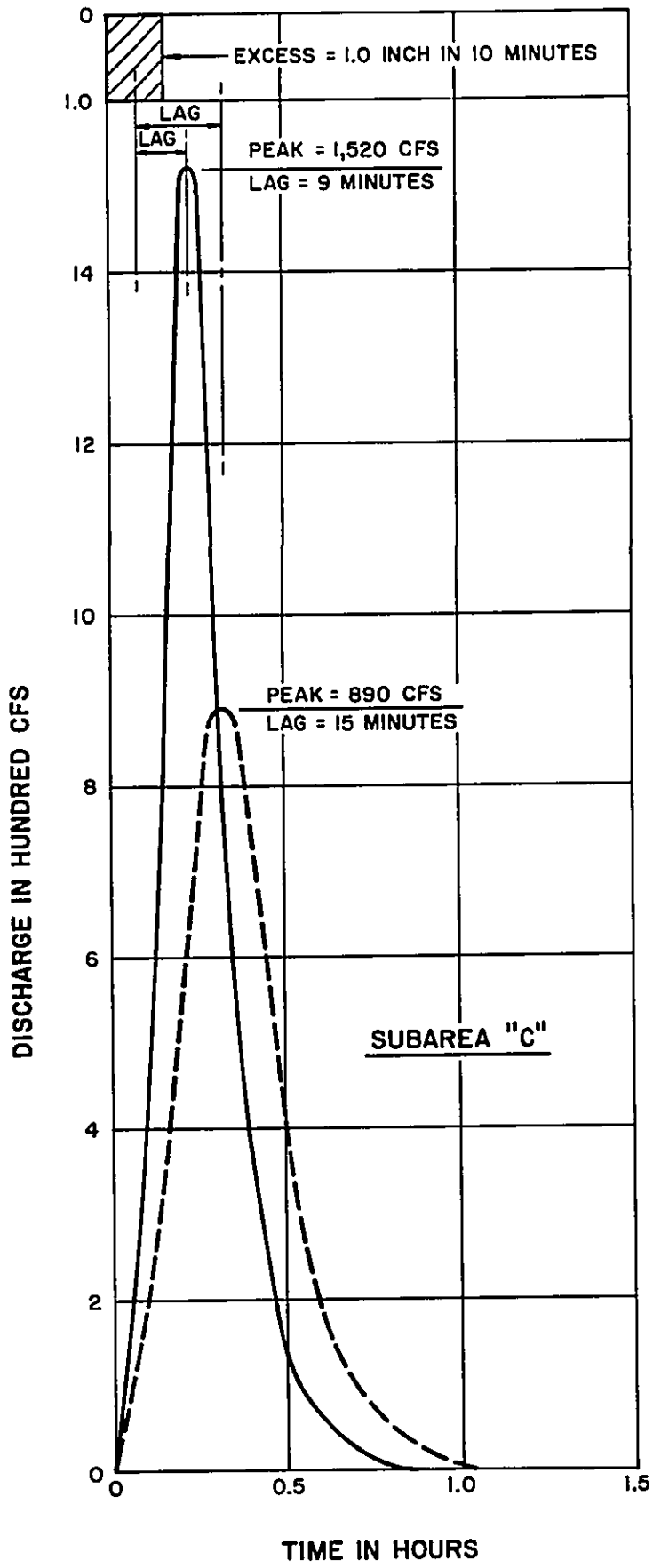


PAAUAU STREAM PAHALA, HAWAII

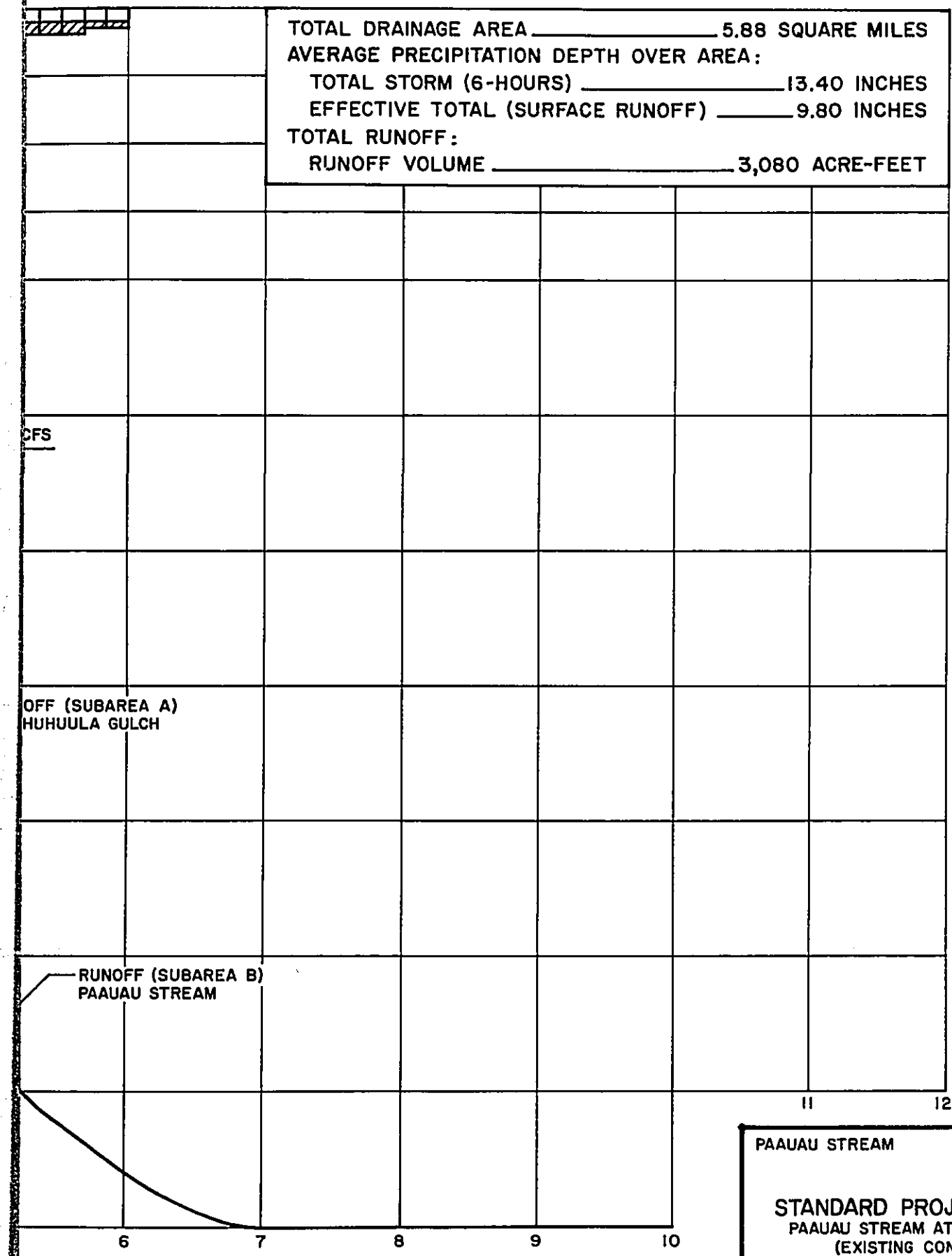
UNIT HYDROGRAPHS
(FUTURE CONDITIONS)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 8


EXCESS = 1.0 INCH IN 10 MINUTES
LAG
LAG
PEAK = 1,520 CFS
LAG = 9 MINUTES
PEAK = 890 CFS
LAG = 15 MINUTES
SUBAREA "C"
DISCHARGE IN HUNDRED CFS
TIME IN HOURS
0
1.0
14
12
10
8
6
4
2
0
0.5
1.0
1.5

TOTAL DRAINAGE AREA ____ 5.88 SQUARE MILES
AVERAGE PRECIPITATION DEPTH OVER AREA:
TOTAL STORM (6-HOURS) ____ 13.40 INCHES
EFFECTIVE TOTAL (SURFACE RUNOFF) ____ 9.80 INCHES
TOTAL RUNOFF:
RUNOFF VOLUME ____ 3,080 ACRE-FEET

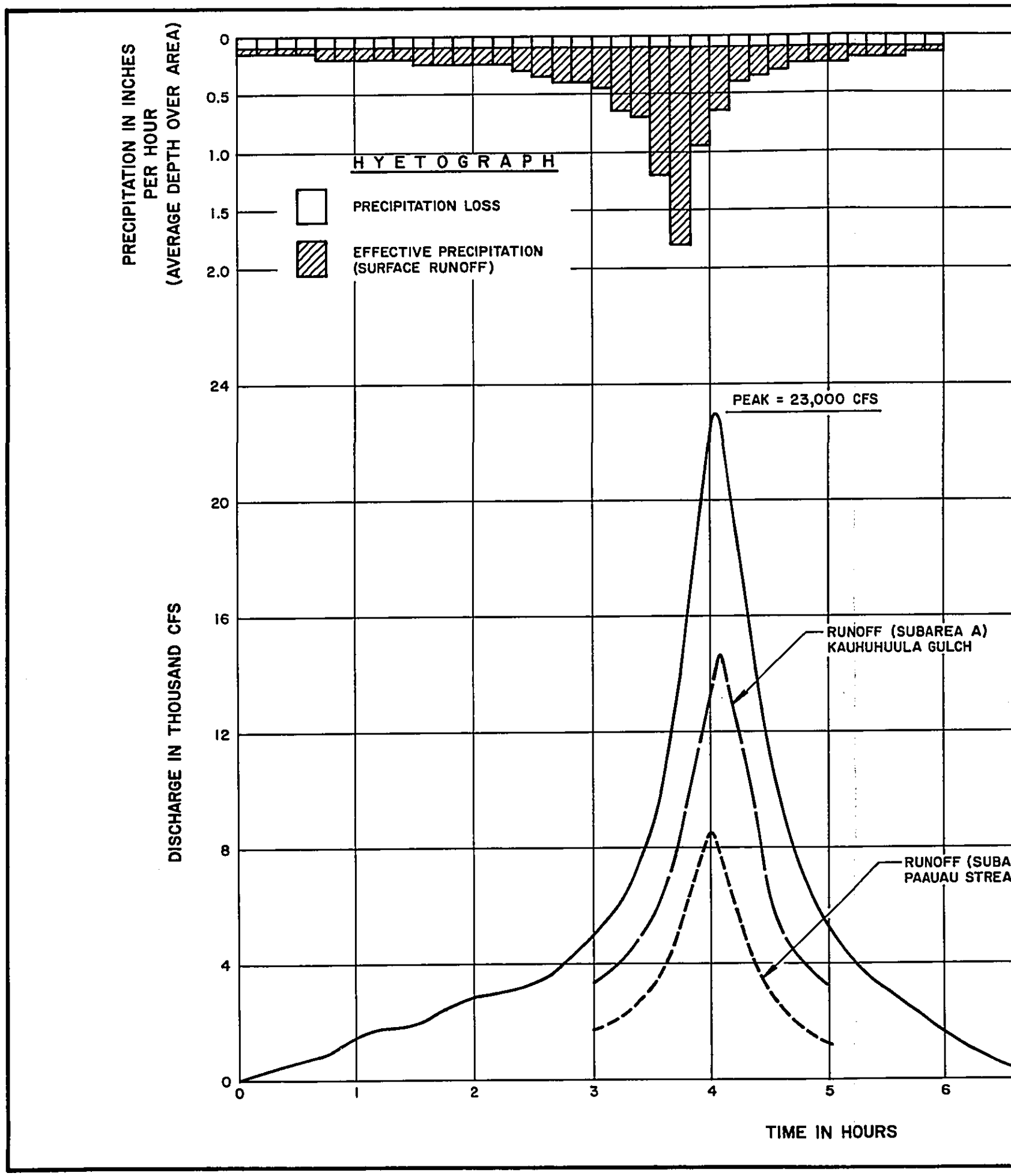


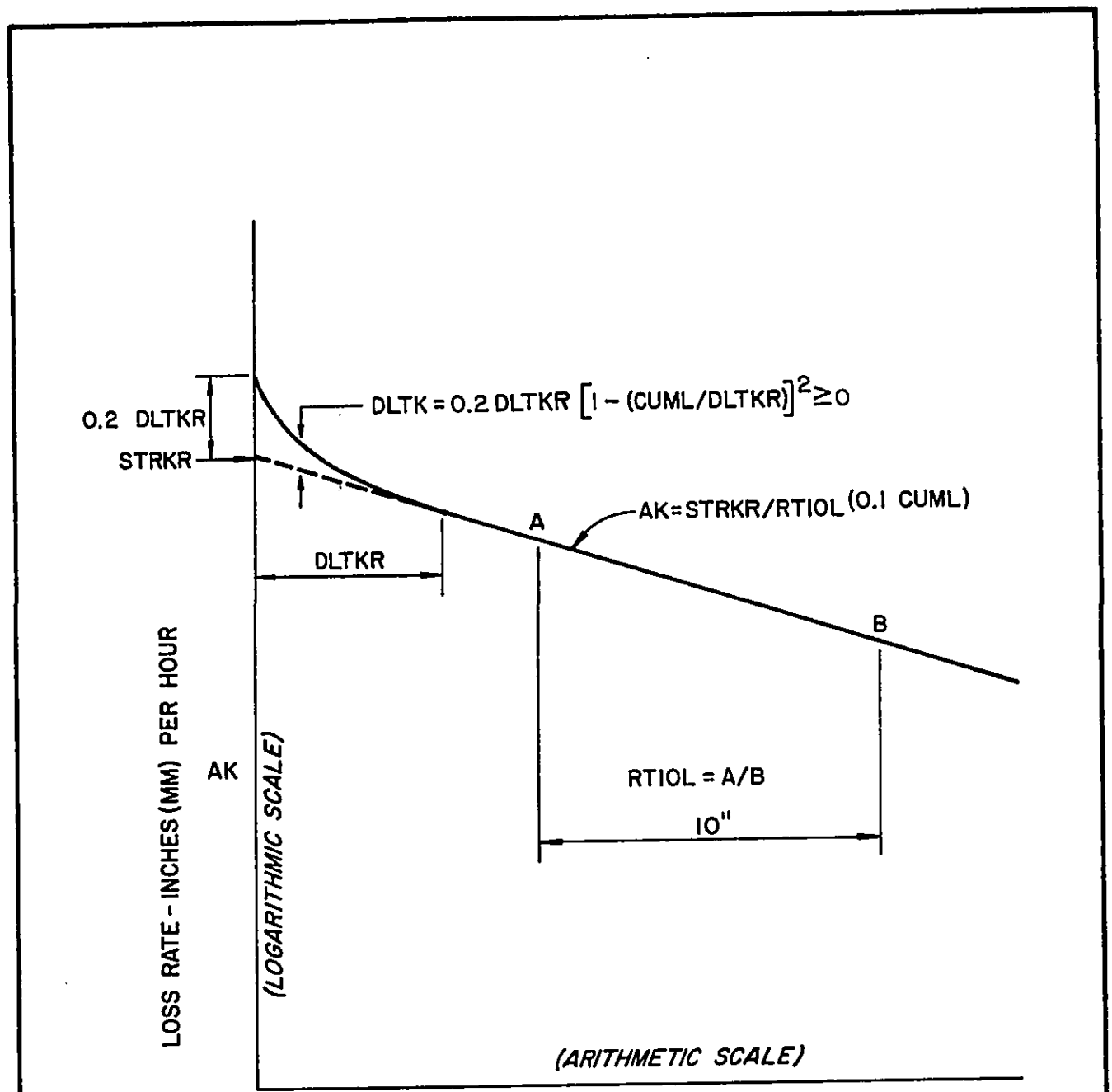
PAAUAU STREAM PAHALA, HAWAII

STANDARD PROJECT FLOOD
PAAUAU STREAM AT CONFLUENCE
(EXISTING CONDITIONS)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 9


PRECIPITATION IN INCHES
PER HOUR
(AVERAGE DEPTH OVER AREA)
0
0.5
1.0
1.5
2.0
HYETOGRAPH
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
(SURFACE RUNOFF)
DISCHARGE IN THOUSAND CFS
24
20
16
12
8
4
0
PEAK = 23,000 CFS
RUNOFF (SUBAREA A)
KAUHUHUULA GULCH
RUNOFF (SUBA
PAAUAU STREA
0
1
2
3
4
5
6
TIME IN HOURS

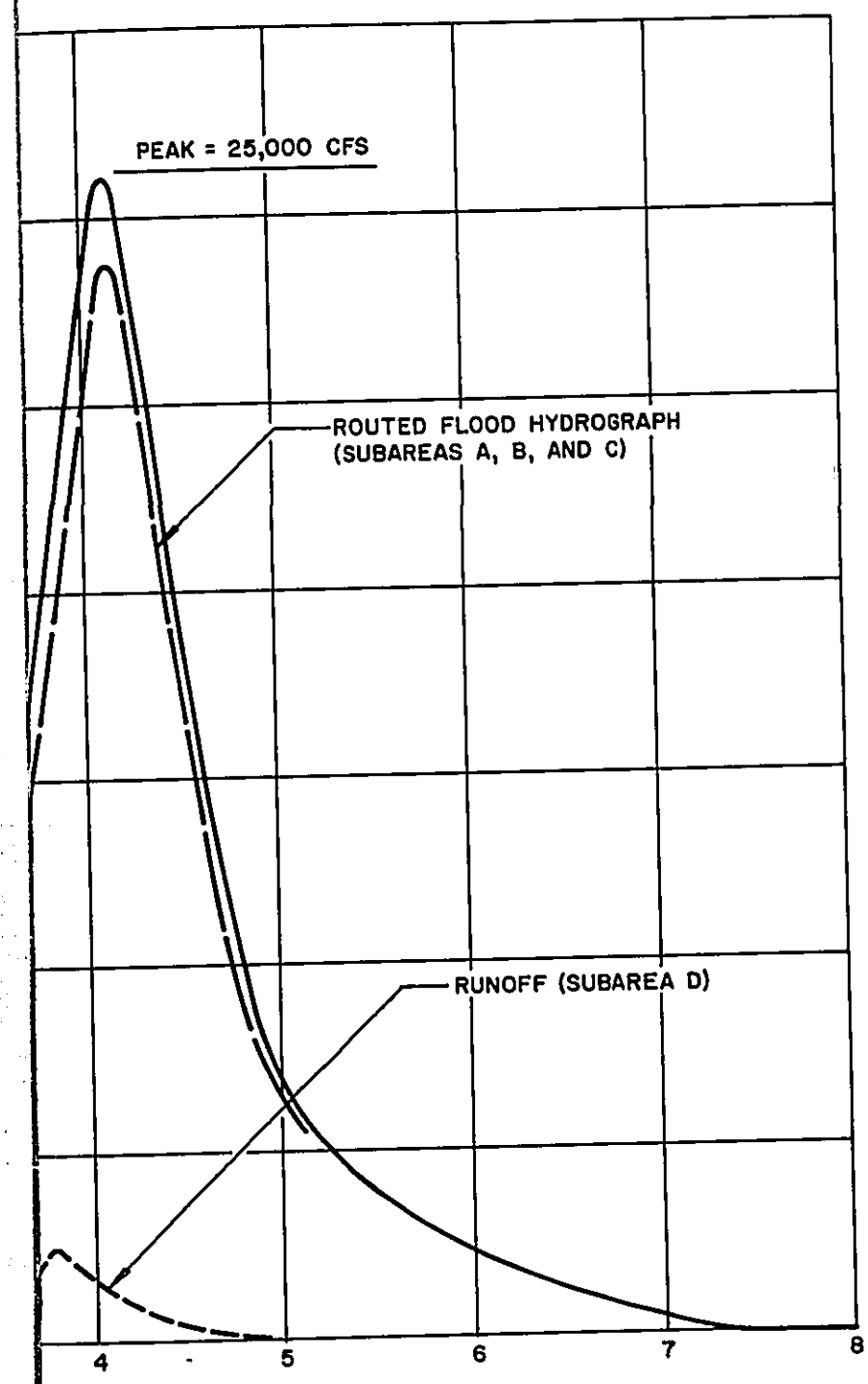


PAAUAU STREAM PAHALA, HAWAII

H.E.C. LOSS RATE FUNCTION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 10



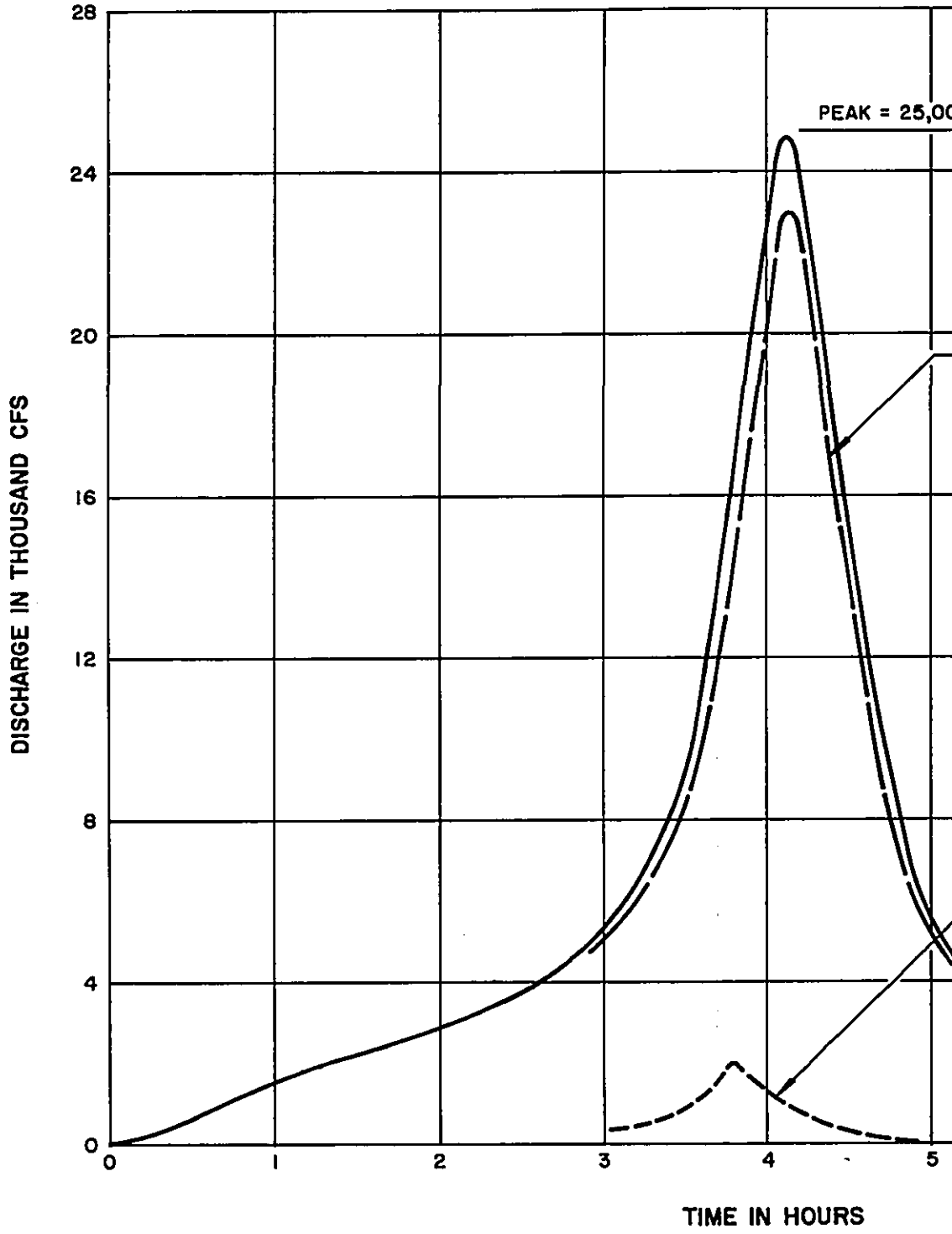
E IN HOURS

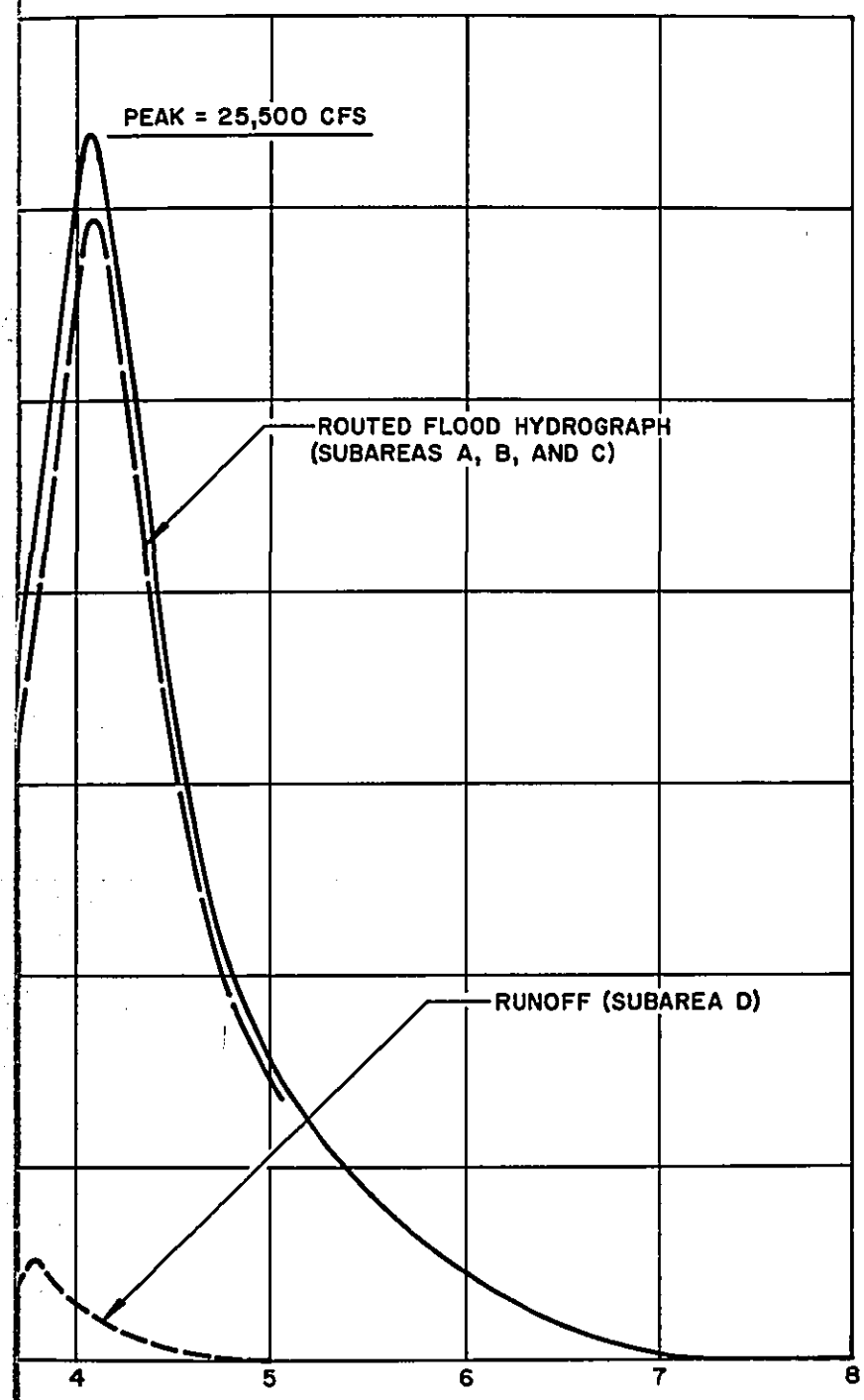
PAAUAU STREAM PAHALA, HAWAII

STANDARD PROJECT FLOOD

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - II


28
24
20
16
12
8
4
0
0
1
2
3
4
5
PEAK = 25,00
DISCHARGE IN THOUSAND CFS
TIME IN HOURS



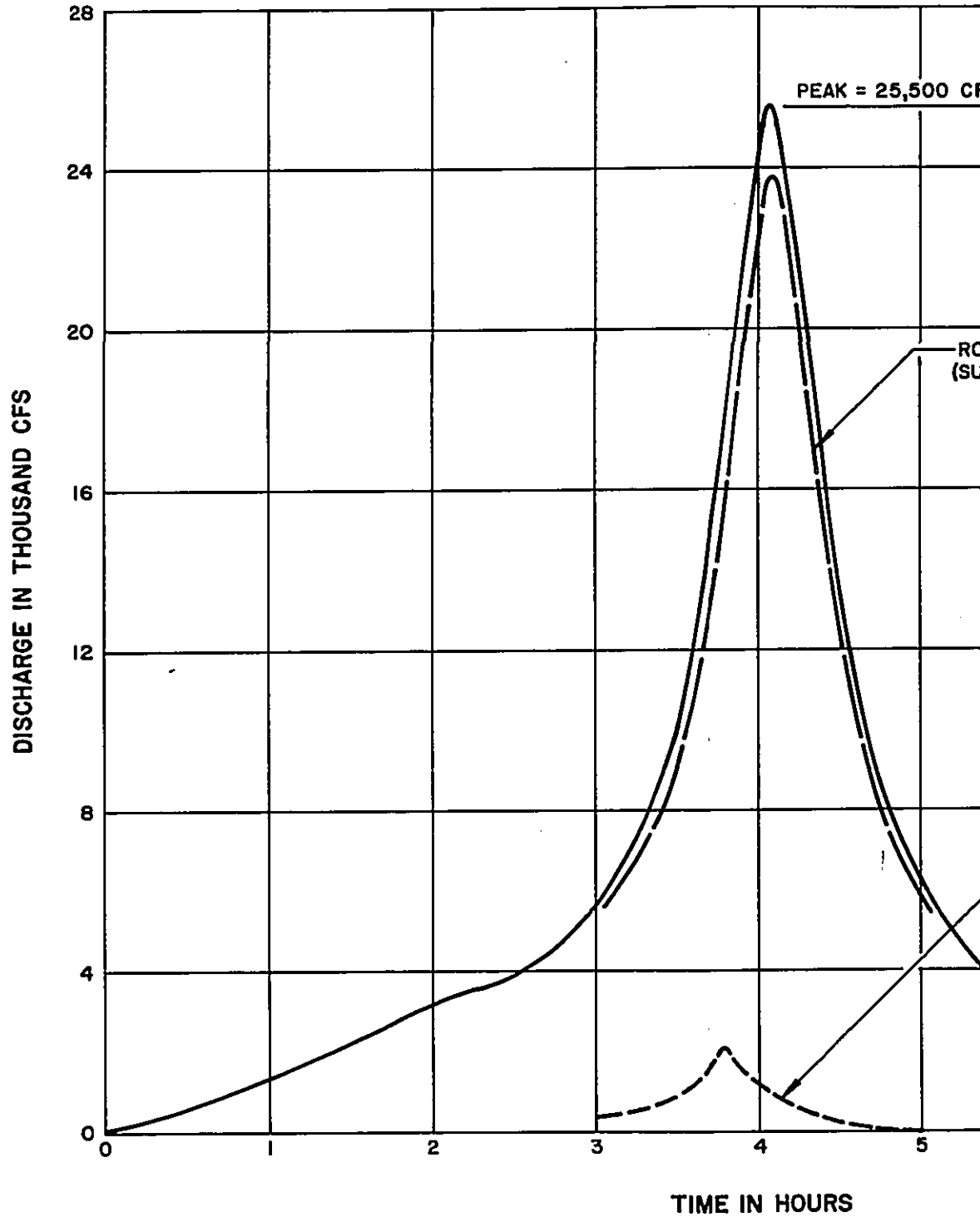
E IN HOURS

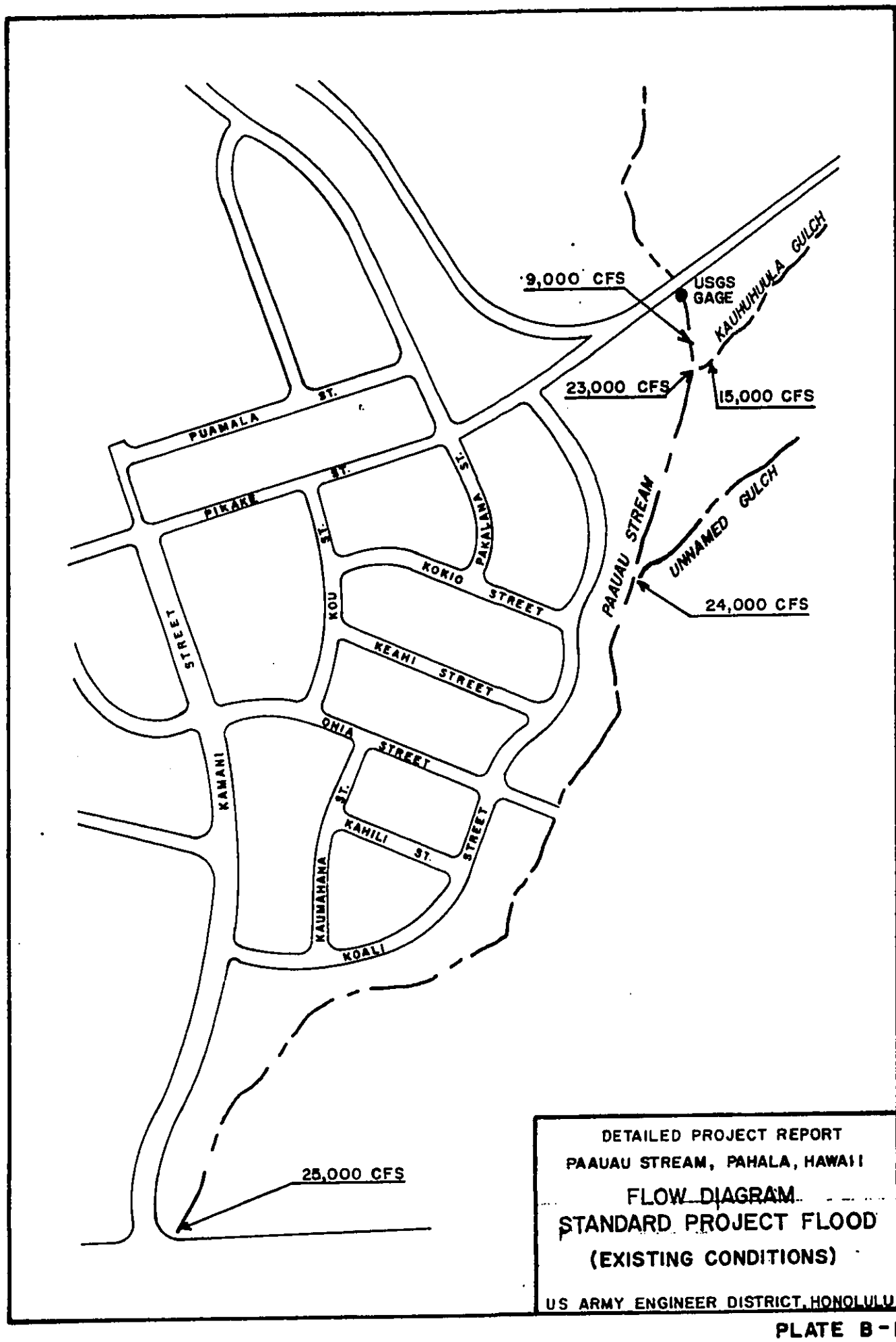
PAAUAU STREAM PAHALA, HAWAII

HYDROGRAPH
STANDARD PROJECT FLOOD
AT MAMALAHOA HIGHWAY
(PROJECT CONDITIONS)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

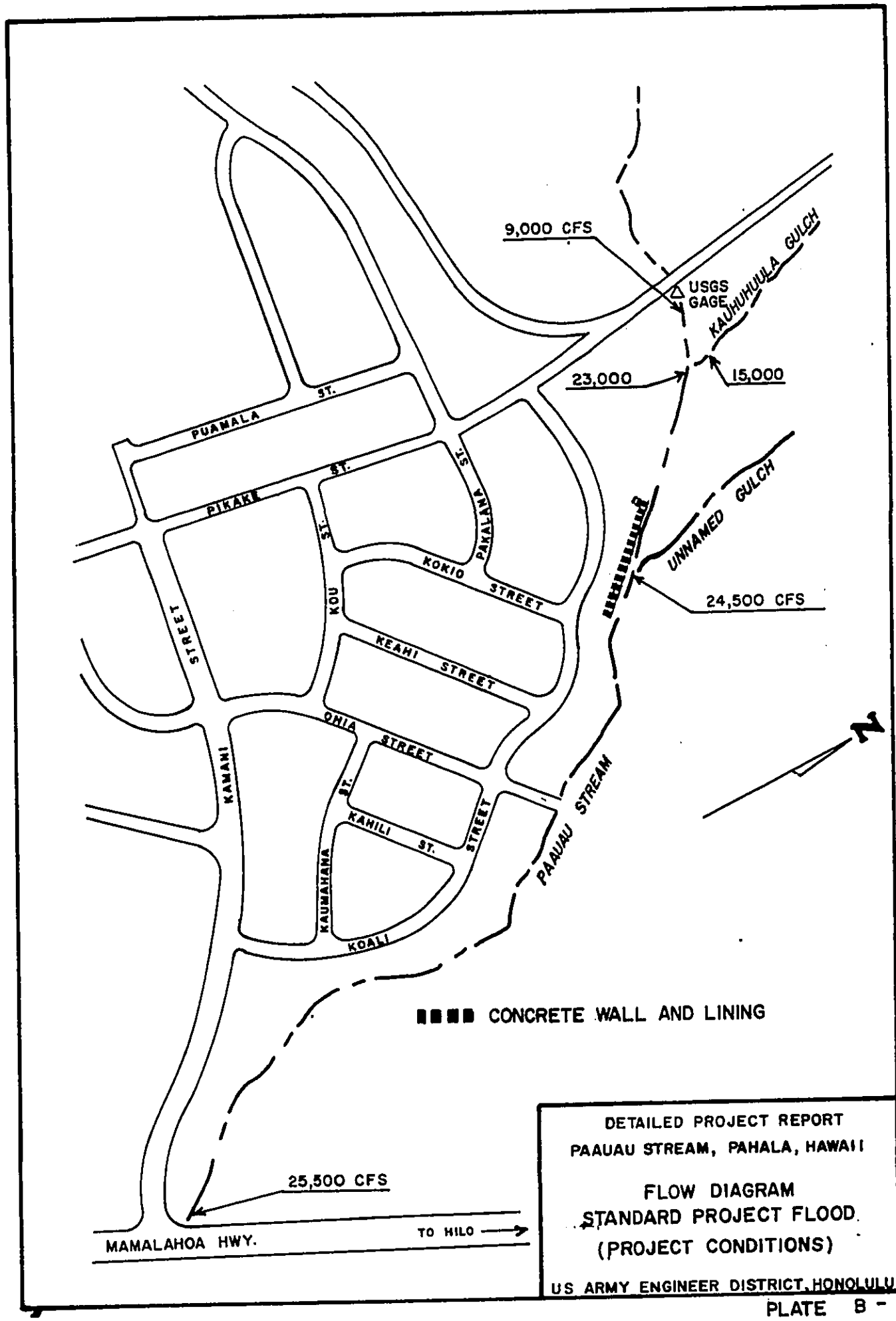
PLATE B - 12


28
24
20
16
12
8
4
0
0
1
2
3
4
5
PEAK = 25,500 CF
RC
(SU
DISCHARGE IN THOUSAND CFS
TIME IN HOURS



DETAILED PROJECT REPORT
PAAUAU STREAM, PAHALA, HAWAII
FLOW DIAGRAM
STANDARD PROJECT FLOOD
(EXISTING CONDITIONS)
US ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-13

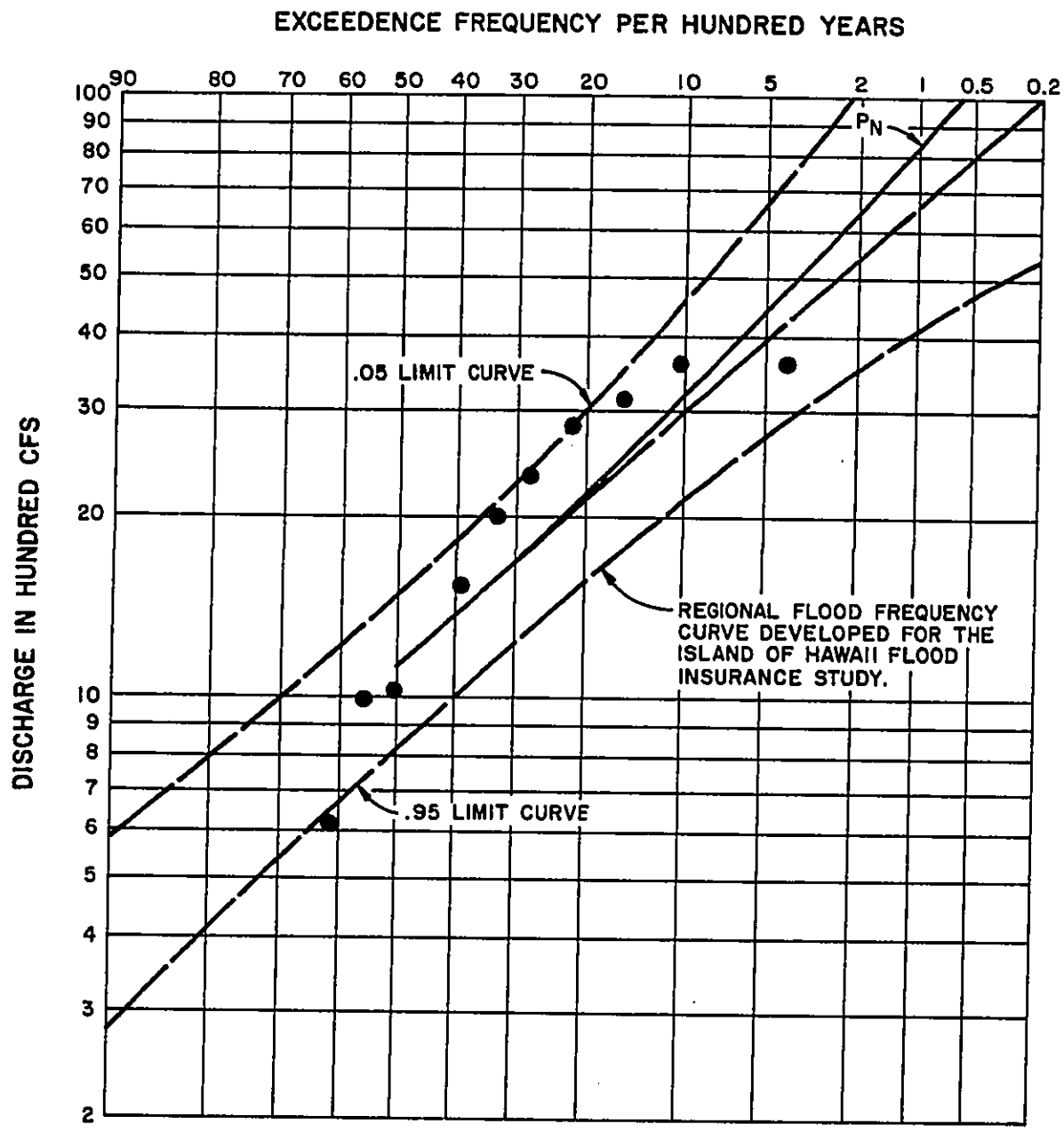


DETAILED PROJECT REPORT
PAAUAU STREAM, PAHALA, HAWAII

FLOW DIAGRAM
STANDARD PROJECT FLOOD
(PROJECT CONDITIONS)

US ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 14



NOTES:

- ● PLOTTING POSITIONS OF ACTUAL FLOW DATA FOR PAAUAU STREAM (N = 17 YEARS)

  EXPECTED PROBABILITY AND CONFIDENCE LIMITS BASED ON 17 YEARS OF RECORD

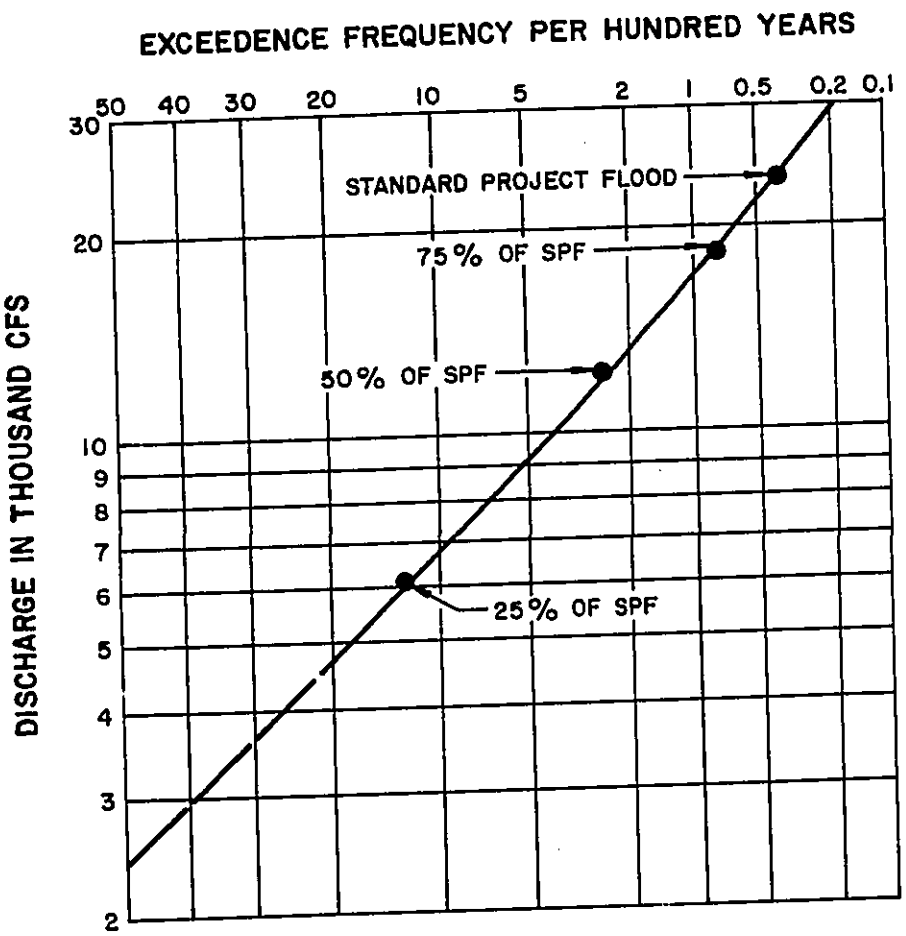
  SPF PEAK DISCHARGE = 9,000 CFS

PAAUAU STREAM PAHALA, HAWAII

DISCHARGE-FREQUENCY CURVES
PAAUAU STREAM AT PAHALA
USGS GAGE NO. 7705
(DA = 1.74 SQ MI)

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-15



NOTE:

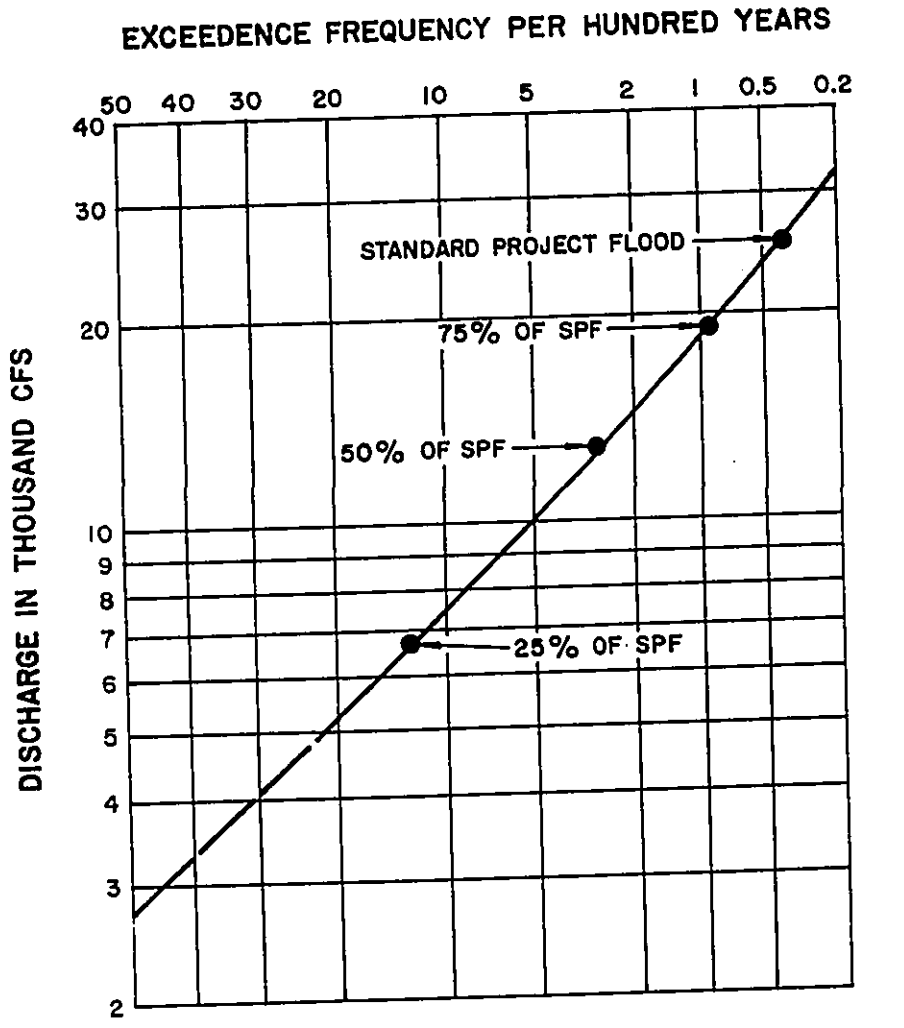
FREQUENCY CURVE WAS DETERMINED BY COMPUTING THE STANDARD PROJECT FLOOD FOR EACH CONCENTRATION POINT; 75, 50, AND 25 PERCENT OF THE SPF WERE TAKEN AND THESE PERCENT HYDROGRAPHS WERE ROUTED AND COMBINED FOR UNGAGED LOCATIONS ON PAAUAU STREAM.

PAAUAU STREAM PAHALA, HAWAII

DISCHARGE-FREQUENCY CURVE
PAAUAU STREAM AT CONFLUENCE
(EXISTING CONDITION)
DA = 5.62 SQ. MI.

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 16



NOTE:

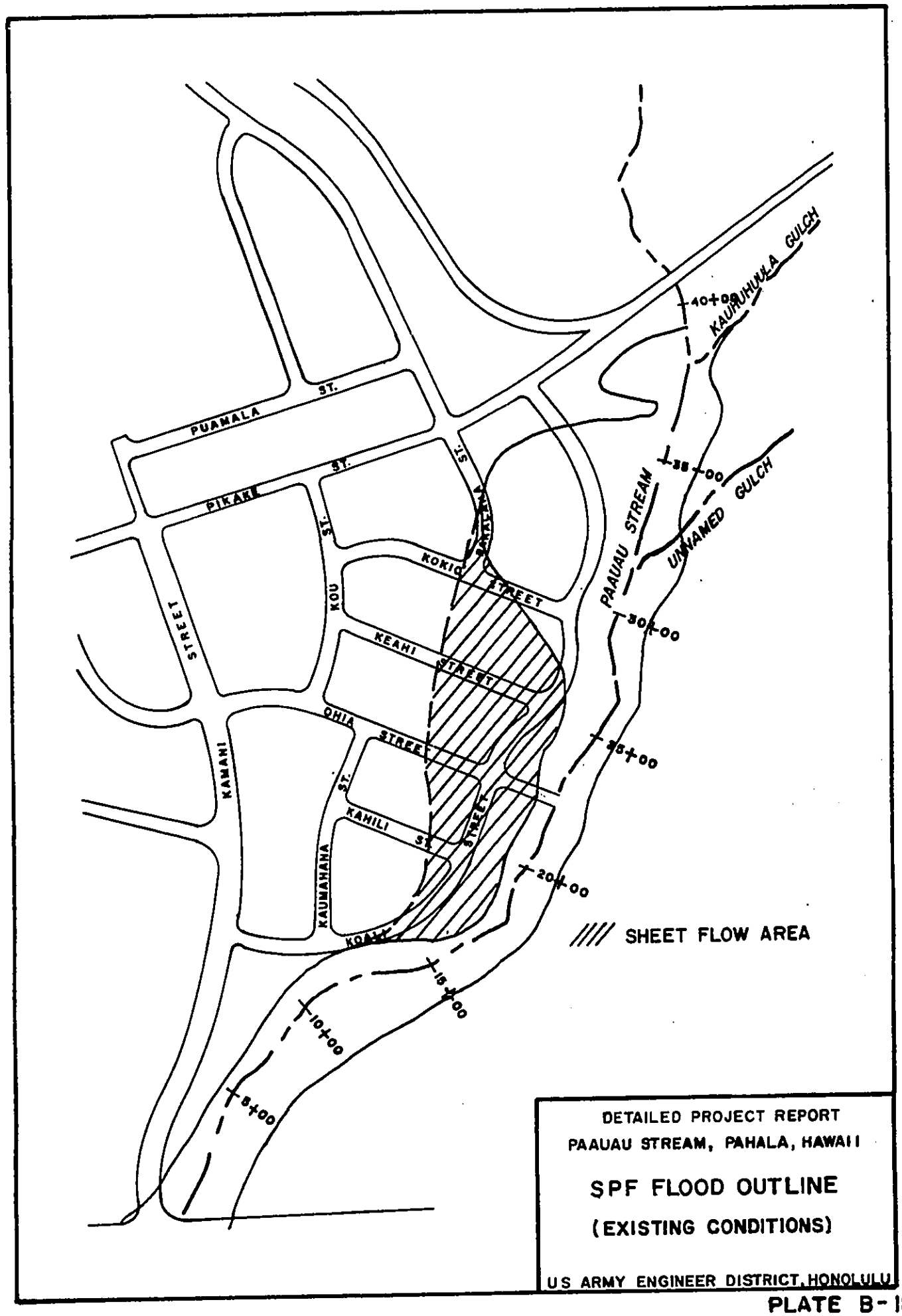
FREQUENCY CURVE WAS DETERMINED BY COMPUTING THE STANDARD PROJECT FLOOD FOR EACH CONCENTRATION POINT; 75, 50, AND 25 PERCENT OF THE SPF WERE TAKEN AND THESE PERCENT HYDROGRAPHS WERE ROUTED AND COMBINED FOR UNGAGED LOCATIONS ON PAAUAU STREAM.

PAAUAU STREAM PAHALA, HAWAII

DISCHARGE-FREQUENCY CURVE
PAAUAU STREAM AT
MAMALAHOA HIGHWAY
(PROJECT CONDITION)
DA = 6.45 SQ. MI.

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE B - 17



DETAILED PROJECT REPORT
PAAUAU STREAM, PAHALA, HAWAII

SPF FLOOD OUTLINE
(EXISTING CONDITIONS)

US ARMY ENGINEER DISTRICT, HONOLULU

PLATE B-18

APPENDIX C

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

PROJECT DESIGN

The study limits include the area which extends from the Paauau Stream culvert at Wood Valley Road to the Mamalahoa Highway Bridge. This study is concerned with the containment of floodwaters at the right bank at the upper portion of the subdivision (from the confluence of the Paauau Stream and the Kauhuhuula Gulch downstream about 800 feet). Containment at the upper portion of the subdivision will alleviate the high-velocity flows through Koali Street and the adjacent lots, and the major damages associated with the high-velocity flows. Although there is overbanking at the lower portion of the subdivision, damages are minor.

The left bank also overtops but to a limited extent and no significant damage results due to this overbanking. The left bank is zoned agriculture from Wood Valley Road approximately 1,200 feet downstream and residential downstream to the Mamalahoa Highway Bridge. The residentially zoned parcel, owned by Seamountain-Hawaii Ranch Co., is undeveloped and is presently used as pasture land.

HYDRAULIC DESIGN

Two alternative structural plans were developed from an analysis of appropriate flood-control measures. Both alternatives were formulated to provide for SPF protection. The scope of the engineering investigations resulted in design data of sufficient detail for the purposes of cost estimating and evaluation of effects of the alternative plans on the environment.

Evaluation of the design level of protection was limited to the SPF level of protection due to the higher benefits for the SPF flood over the one percent flood. The construction cost for the SPF and the one percent level were comparable due to about a 1-foot difference in elevation of the reinforced concrete wall.

Alternative 1 includes a reinforced concrete lining and wall at the right bank and removal of a constriction at the left bank. Alternative 2 includes the same features as Alternative 1 plus channel widening to reduce the height of the concrete wall.

DESIGN GUIDES

The hydraulic design followed the US Army Corps of Engineers' Engineering Manual, EM 1110-2-1601, "Hydraulic Design of Flood Control Channels," dated 1 July 1970. This discussion, in general, follows the information specified in ETL 1110-2-230, "Hydrologic and Hydraulic Engineering for Survey Investigations," dated 15 May 1978.

FREEBOARD

Freeboard is the computed, vertical distance between the design water surface and the top of channel wall or embankment. The freeboard computed for the flood control alternatives was 3.0 feet which will protect the project area from overtopping of the concrete wall.

WATER SURFACE PROFILE

Water surface profiles for the 100-year, 500-year and SPF were computed for each alternative (Plates C-3 and C-4). Bernoulli's energy theory and Manning's equation were applied in the analysis. The computational procedure generally followed Method 1, Engineering Manual, EM 1110-2-1409, "Backwater Curves in River Channels," dated 7 December 1959. The actual computations were performed utilizing the computer program "HEC-2, Water Surface Profiles," dated November 1976 (updated April 1980), developed by the Corps' Hydrologic Engineering Center. The following parameters were selected:

a. Manning's roughness coefficient

Concrete	.015
Rock	.035
Overbank	.050

b. Contraction coefficient .1

c. Expansion coefficient .3

DEBRIS BASIN

A debris basin is generally recommended at the upstream end of a flood-control channel when the drainage basin above the flood-control channel has a severe problem with erosion of large rocks and large debris. Paauau Stream is mainly located in an area of highly permeable lava flows with a thin covering of soil. The upper portion of the drainage basin is an agricultural area planted with sugarcane and macadamia nut trees and erosion is not a serious problem. Consequently, a debris basin was not considered essential and was not included in the design of the proposed alternatives.

BASELINE CONDITIONS

Elevations were based upon mean sea level (MSL) datum . The physical baseline conditions were determined from the following topographic surveys:

a. Topographic Survey for the Paauau Stream Flood Control Project by Austin, Tsutsumi, and Associates for US Army Corps of Engineers, Pacific Ocean Division, 4 sheets, July 1981.

b. Roadways and Water System in Pahala Village, Ninth Series, by Murray, Smith and Associates, July 1970.

FLOOD CONTROL ALTERNATIVES

ALTERNATIVE 1

Alternative 1 (Plate C-1) would consist of concrete lining the right bank, a concrete wall on the right bank adjacent to and joining the concrete lining, rock excavation along the left bank, and a flowage easement. The SPF design discharge is 25,000 cfs with velocities varying from 20 to 25 cfs. The flood depth would range between 13 and 16 feet.

The lining of the right bank would be 10 to 12 feet in height and would be about 410 feet in length. The sideslope would be 1.5H to 1.0V. The concrete wall would be 4 to 7 feet in height and would be about 660 feet in length. The concrete wall would extend 200 feet downstream and 50 feet upstream of the concrete lining. The wall would tie into a ridge line at the upstream end to direct the flow away from the homes and would tie into an existing concrete wall at the downstream end. The concrete lining is required to stabilize portions of the erodible right bank.

The rock excavation along the left bank would be 390 feet long and 10 to 60 feet wide. The depth of excavation would vary between 8 and 15 feet and would tie into the existing streambed. The rock excavation would straighten the channel by removing a large constriction which presently directs the water towards the right bank.

A flowage easement would be required for the water course based on the one percent flood. The easement would minimize damages by providing a defined area for the water course and by controlling development within the easement. The one percent flood was selected over the SPF for the easement outline to be consistent with the Federal Emergency Management Agency (FEMA) flood insurance guidelines. One of FEMA's guidelines is to minimize future flood damages through the use of floodplain management within the 100-year floodplain.

ALTERNATIVE 2

Alternative 2 (Plate C-2) is similar to Alternative 1 with the addition of stream widening along the left bank. The SPF design discharge is 25,000 cfs with velocities between 20 and 25 fps. The flood depth would range from 11 to 14 feet.

The lining of the right bank would be 10 to 12 feet in height and would be about 855 feet in length. The sideslope would be 1.5H to 1.0V. The concrete wall would be 2 to 5 feet in height and would be about 970 feet in length. The concrete lining is required to stabilize portions of the erodible right bank.

Excavation would be performed on the left bank to enlarge the channel bottom width to 60 feet. The length of the channel excavation would be 970 feet in length. The sideslope would be 2H to 1V. The left bank would be grass lined to provide minimal bank protection.

COST ESTIMATES

BASIS OF COST ESTIMATES

Quantity computations for fill and excavation of the riverbed were made by the average end area method. Existing ground lines were determined from maps prepared from field surveys completed in 1981. An island of Hawaii contractor is assumed to perform the work.

UNIT COSTS

Unit and lump-sum prices, based on January 1982 price levels in Hawaii, were derived on the assumption that construction can be accomplished with standard equipment. Wage rates were based on the contractor working 5-day, 8-hour shifts per week.

PROJECT COST

The estimated total project cost of Alternative 1 is $382,000, including a 20 percent contingency. Table C-1 shows the detailed project cost breakdown.

All costs are Federal costs except for the flowage easement. The non-Federal cost is $60,000.

TABLE C-1. ALTERNATIVE 1 DETAILED PROJECT COST ESTIMATE

Item	Quantity	Unit Cost	Total Cost
A. FEDERAL FIRST COST			
Mobilization & Demobilization	Job		$25,000
Clear and Grub	1.5 Acres	$1,620	2,400
Excavation			
Rock	730 CY	39	28,500
Loose	990 CY	6	5,900
Concrete			
Lining	280 CY	273	76,400
Wall	80 CY	782	62,600
Bedding	160 CY	46	7,400
Subdrain	395 LF	12	4,700
Fill	170 CY	5	900
Contingency 20%			42,800
SUBTOTAL DIRECT COST			$256,600
Engineering and Design			40,000
Supervision and Administration			25,400
TOTAL FEDERAL FIRST COST			322,000
B. NON-FEDERAL FIRST COST			
Flowage Easement and Indirect Costs			50,000
Contingency 20%			10,000
TOTAL NON-FEDERAL FIRST COST			60,000
TOTAL PROJECT FIRST COST			$382,000

ANNUAL COSTS

Alternative I estimates of annual costs summarized below are based on a 50-year period of analysis . Interest and amortization charges are based on an interest rate of 7-5/8 percent. The estimated cost for operation and maintenance, a local responsibility, is also included.

Interest & Amortization ($382,000 x 0.07823)	$29,900
Operation & Maintenance	1,700
TOTAL PROJECT ANNUAL COST	$31,600

GEOLOGY AND GEOTECHNICAL CONSIDERATIONS

REGIONAL GEOLOGY

The Hawaiian Islands are a chain of broad, shield basalt domes built on a 1600 mile long fissure in the ocean floor. The Island of Hawaii is the largest, youngest and southermost of the chain. It is the result of many thousands of thin lava flows from rift zones (zones of fractures) from five volcanoes.

Mauna Loa is the volcano reponsible for the greater bulk of the island's southern half. Erupting as late as 1975, it is one of two active volcanoes in this area. The slopes of Mauna Loa are covered with finger-shaped recent flows of lava-basalts, tuffs and ash deposits of the Kau Volcanic Series. Small but frequent "Kipukas" (Hawaiian word referring to an areas of older land surface surrounded by the lava of new flow) expose the Kahuku Volcanic Series. The Kahuku Volcanic Series consist of thin lava-basalt flows intercalated with ash and capped with yellow pyroclastic ash (Pahala Ash).

The Kahuku and Kau Volcanic Series occurred during the Middle Pleistocene (50,000 ± years) and Late Pleistocene to Recent Epochs of geologic time, respectively. The young age of the Island of Hawaii is characterized by rough, irregular coast lines with cliffs, frequently exposed lava-basalt flows, steep offshore margins and lack of extensive coral reefs.

SITE GEOLOGY

Paauau Stream is located south of Mauna Loa's summit. The limits of the project area are shown on Figure C-1. The stream borders the north edge of the community of Pahala.

Ash and basalt outcrops of the Kahuku Volcanic Series alternate along the length of the streambed. Ash is seldom exposed, but is typically gullied and covered with 6-inches of basalt cobbles, gravels, sand and clinker material. Vegetation grows freely in this material. Basalt outcrops on the streambed are smooth-surfaced and creviced. The stream is dry and dusty most of the year and flows only during heavy storms. A small (7x5 feet) lava tube opening was observed in the channel approximately 200 feet east of the Wood Valley Road which suggests that flooding along this stream may result from underground mechanisms as well as surface runoff.

The side slopes of the stream (banks) alternate between rock and a rubble/ash mixture. Where the stream velocity is high (curves), the slope of the ash is vertical. Otherwise, the slope is 3H to 1V, with heavy brush vegetation covering it. Dense basalt outcrops are typically vertical and occasionally undermined by the stream where clinker zones are exposed. The dense basalt layer appears no more than 4 feet thick at any location.

The abundance of cobbles in the streambed indicates that the clinker zone may be continuous along the stream. Depth of the natural stream channel is 5 to 15 feet. After storms in 1979 and 1980, loose material was bulldozed from the channel by the Soil Conservation Service (SCS). It was then pushed against and over about 1000 feet of the southern slope. This widened the channel and increased the height of the southern slope to approximately 25 feet. The slope of the material is 2H to 1V.

The SCS also constructed four small concrete walls on the south side of the stream where erosion had been causing excessive loss of material.

INVESTIGATIONS

Reconnaissance of the site was made on 23 February to observe and photograph surface conditions. No subsurface investigation has been made of the project to date. It is recommended that subsurface investigations be made during the design stage.

SEISMICITY

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

The strongest earthquakes in historic time in the islands occurred on April 2, 1868 and was centered along the south coast of the island of Hawaii. The earthquake had a Richter magnitude of about 7.5 and caused serious damage across the entire island, even stopping clocks as far away as Honolulu. Practically all earthquakes on the island of Hawaii and Maui are associated with intermittent volcanic activity. However, potential earthquakes in the islands can also be caused by deep seated tectonic forces and not from the indirect action of volcanic activity. A Richter magnitude 7 earthquake on January 23, 1938 had an epicenter 25 miles north of Pauwela Point on the north shore of Haleakala, Maui. Recent explorations by geophysical methods show that faults and rift zones cut through the major islands and that these faults are branches of a gigantic fracture system known as the Molokai Fracture Zone.

The only major earthquake felt on Oahu since 1938 occurred in April 26, 1973. The tremor registered 6.2 on the Richter scale and was centered offshore about twelve miles northeast of Hilo, Hawaii and about 35 miles deep.

The Uniform Building Code and the Army Technical Manual 5-809-10 assign a zone three (3) seismic risk rating to the island of Hawaii for design considerations. Draft Army Technical Manual 5-809-10 (April 1981), scheduled for publication in the near future, increases the seismic risk rating from Zone 3 to Zone 4.

The magnitude of Hawaiian earthquakes was not routinely determined locally until 1958. Prior to that, magnitudes of large earthquakes were measured by seismograph stations on continental United States, usually by those at the California Institute of Technology, University of California at Berkeley and at Columbia University.

ENGINEERING CONSIDERATIONS

Both pahoehoe and aa flows are common on the slopes of Mauna Loa with aa usually found at lower elevations. The terms pahoehoe and aa are Hawaiian words and are used to classify surface appearances and structure of lava flows. At Pahala, lava basalt rocks are variable and unpredictable in physical and chemical properties. The loose scoriaceous surface layer (clinker) of aa is open, porous and very easy to excavate. Dense, hard basalt underlies the clinker layer and generally requires ripping to excavate. Excavation of some of the harder layers will require drilling and blasting or comparable effort. Rough, irregular cutslopes are anticipated in all excavations regardless of excavation methods because of varying rock properties. The designed excavation slope of 1.5 horizontal to 1.0 vertical is the flattest slope anticipated for these materials.

The lava-basalt flows provide an adequate foundation for the structures designed. Removal of basalt cobbles and loose clinker material in the foundation will be required. Ash deposits are moisture sensitive and may provide poor foundation characteristics.

STRUCTURAL DESIGN

CONCRETE LINING AND WALL

The structural design of the reinforced concrete lining and wall will be based on EM 1110-2-2501, "Flood Wall Design," January 1948, and EM 1110-2-2502, "Retaining Walls," 29 May 1961. The design loadings are as follows:

a. Loading No. 1.

(1) Channel empty.

(2) Two feet surcharge load on backfill.

(3) Backfill saturated to midway between drain elevation and design stage.

b. Loading No. 2.

(1) Channel empty.

(2) Backfill saturated to drain level.

(3) Wind load on projected stem.

c. Loading No. 3.

(1) Channel empty.

(2) Backfill saturated to drain level.

(3) Seismic loads.

SOIL PARAMETERS

a. Concrete Lining (Assume cohesionless backfill):

(1) Moist unit weight of soil: γ_m = 120 PCF

(2) Angle of internal friction: ϕ = 30°

(3) Cohesion: C = 0

(4) Allowable soil bearing capacity (With bedding layer thicknesses recommended in paragraph: Design Considerations) q = 1,000 PSF

OTHER DESIGN FACTORS

Design Stresses. The structural design will be in accordance with EM 1110-1-2101, "Working Stresses for Structural Design," 1 November 1963.

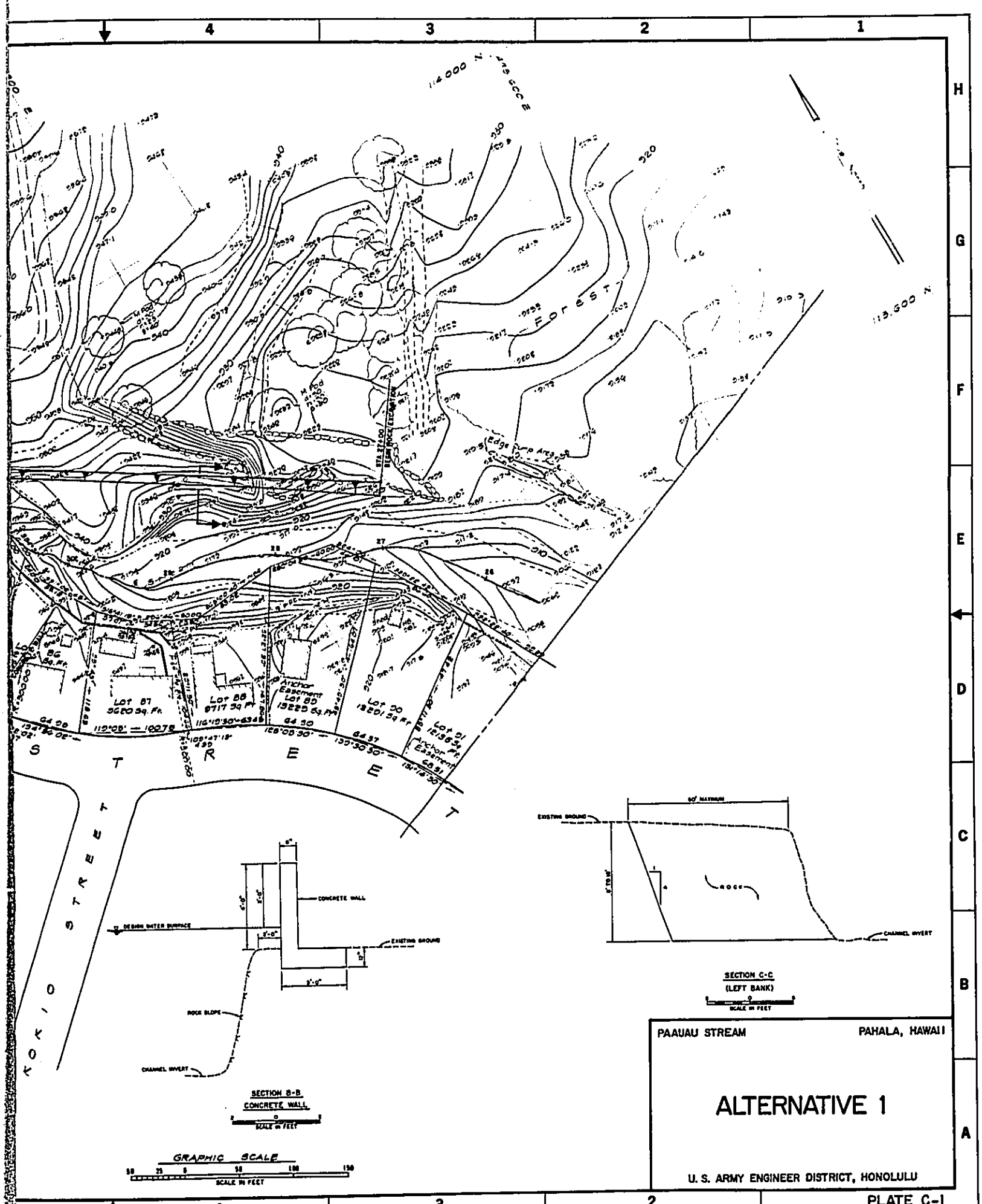
a. Concrete (28-day compressive strength) f_c = 4,000 PSI

b. Reinforcing steel: f_y = 40,000 PSI

Concrete Cover over Reinforcing Steel. The concrete cover for hydraulic structures will be in accordance with EM 1110-2-2103, "Details of Reinforcement - Hydraulic Structures," 21 May 1971.

Wind. The peak gust velocity is 80 miles per hour.

Seismic Zone. The seismic zone is Zone IV.


4
3
2
1
H
G
F
E
D
C
B
A
114,000 N.
113,500 N.
FOREST
S T R E E T
KOKIO STREET
Lot 87
9620 Sq. Ft.
Lot 88
9717 Sq. Ft.
Lot 89
19220 Sq. Ft.
Lot 90
19201 Sq. Ft.
Lot 91
12136 Sq. Ft.
Anchor Easement
Edge Pump Area
Concrete Wall
Rock Excavation
Existing Ground
Design Water Surface
Rock Slope
Channel Invert
Rock
SECTION B-B
CONCRETE WALL
SECTION C-C
(LEFT BANK)
GRAPHIC SCALE
SCALE IN FEET
PAAUAU STREAM
PAHALA, HAWAII
ALTERNATIVE 1
U. S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE C-1

8 7 6 5 4

H G F E D C B A

MACADAMIA NUT GROVE

KOKIO STREET

Lot 78 5000 Sq. Ft.

Lot 80 10513 Sq. Ft.

Lot 81 12070 Sq. Ft.

Lot 82 11716 Sq. Ft.

Lot 85 12670 Sq. Ft.

Lot 86 12485 Sq. Ft.

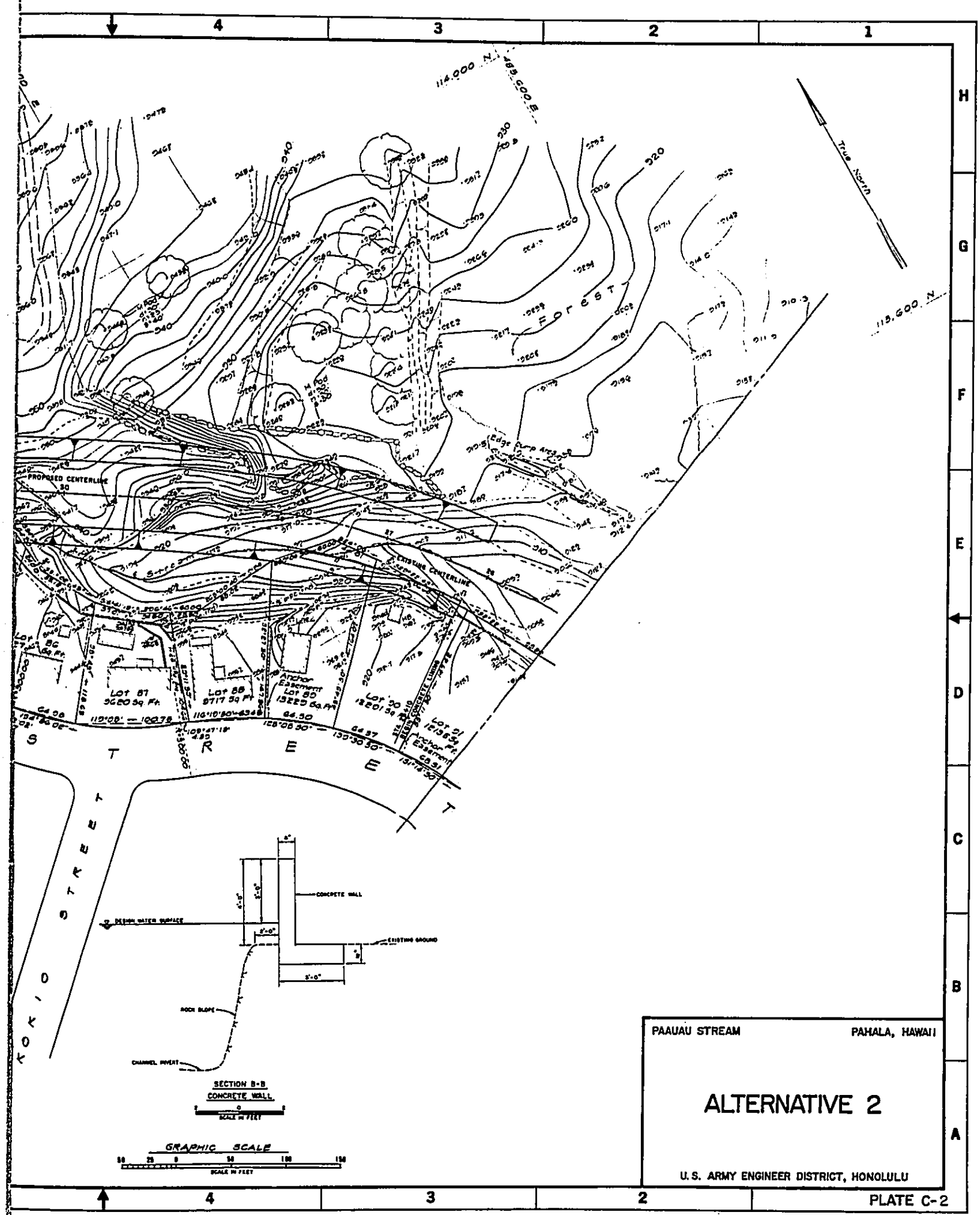
Lot 88 13007 Sq. Ft.

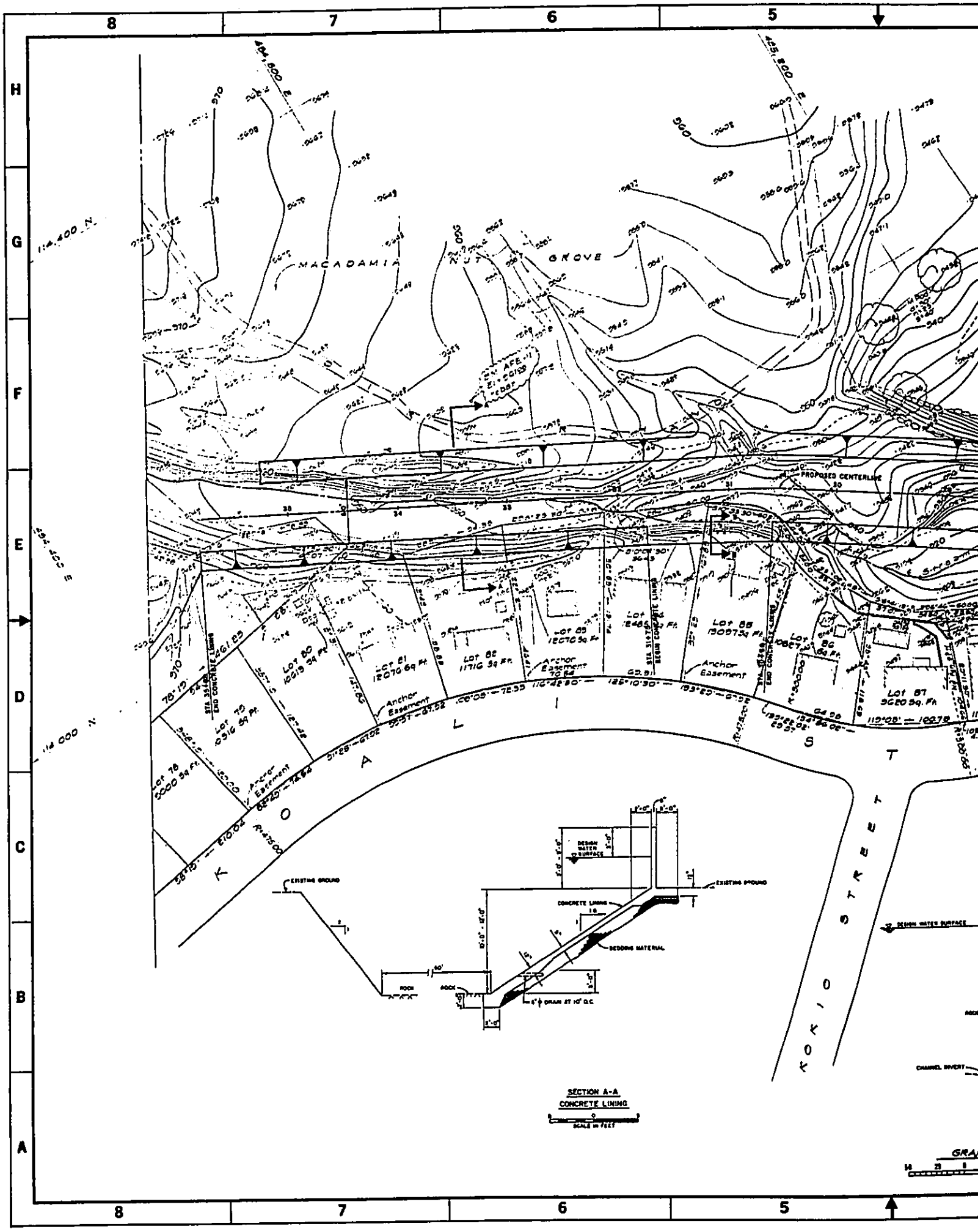
Lot 87 9620 Sq. Ft.

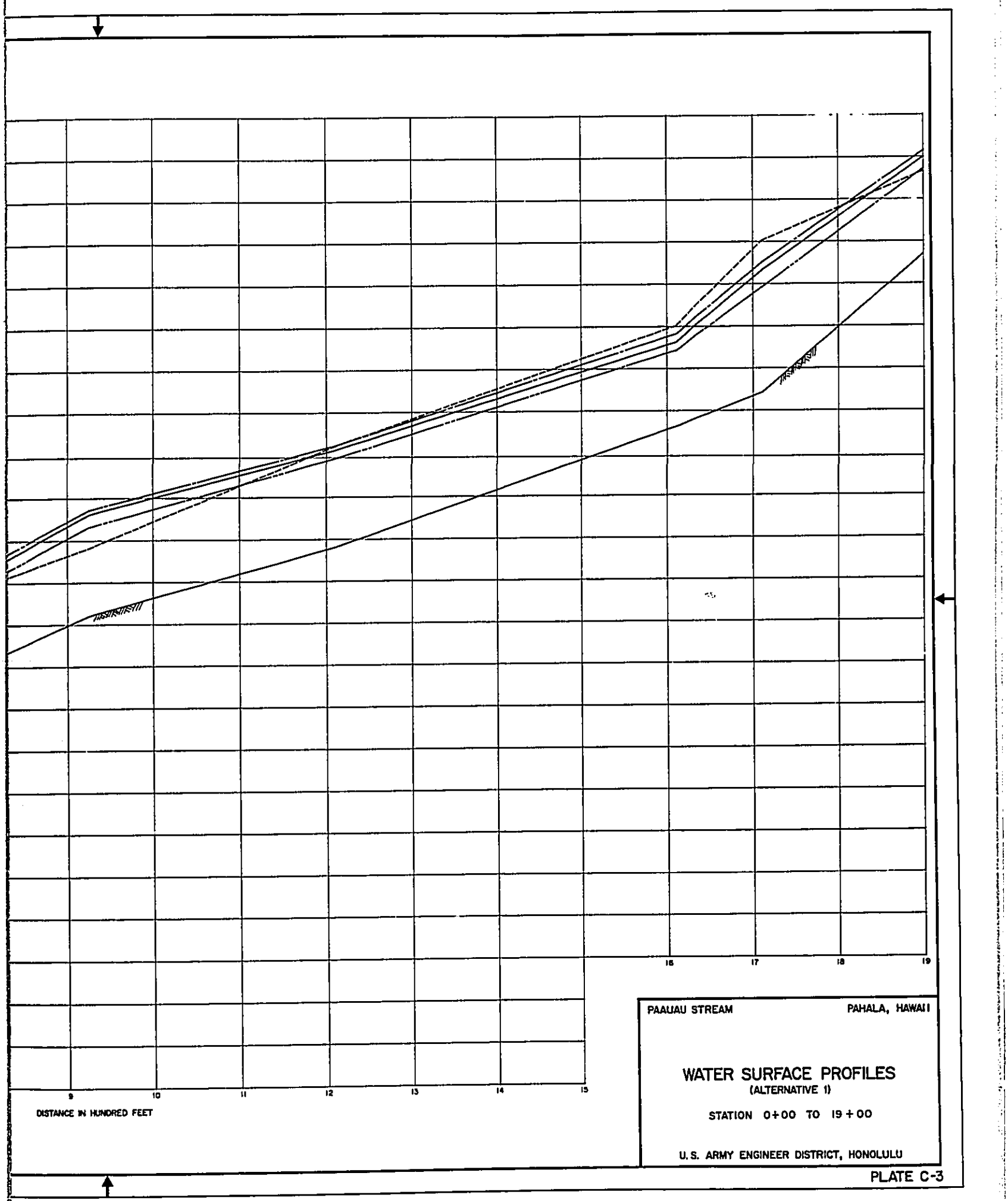
Anchor Easement

SECTION A-A
CONCRETE LINING

8 7 6 5 4


4
3
2
1
H
G
F
E
D
C
B
A
114,000 N.
489,600 E.
115,600 N.
True North
F O R E S T
S T R E E T
K O K I O
PROPOSED CENTERLINE
EXISTING CENTERLINE
Anchor Easement
Lot 87
9620 Sq Ft
Lot 88
9717 Sq Ft
Lot 89
13229 Sq Ft
Lot 90
12201 Sq Ft
Lot 91
12136 Sq Ft
Anchor Pt. Easement
Edge Pump Area
CONCRETE WALL
DESIGN WATER SURFACE
EXISTING GROUND
ROCK SLOPE
CHANNEL INVERT
SECTION B-B
CONCRETE WALL
GRAPHIC SCALE
SCALE IN FEET
PAAUAU STREAM
PAHALA, HAWAII
ALTERNATIVE 2
U. S. ARMY ENGINEER DISTRICT, HONOLULU
PLATE C-2


8
7
6
5
H
G
F
E
D
C
B
A
MACADAMIA NUT GROVE
PROPOSED CENTERLINE
Lot 87
9620 Sq. Ft.
Anchor Easement
KOKIO STREET
DESIGN WATER SURFACE
EXISTING GROUND
CONCRETE LINING
BEDDING MATERIAL
ROCK
SECTION A-A
CONCRETE LINING
SCALE IN FEET



PAAUAU STREAM PAHALA, HAWAII

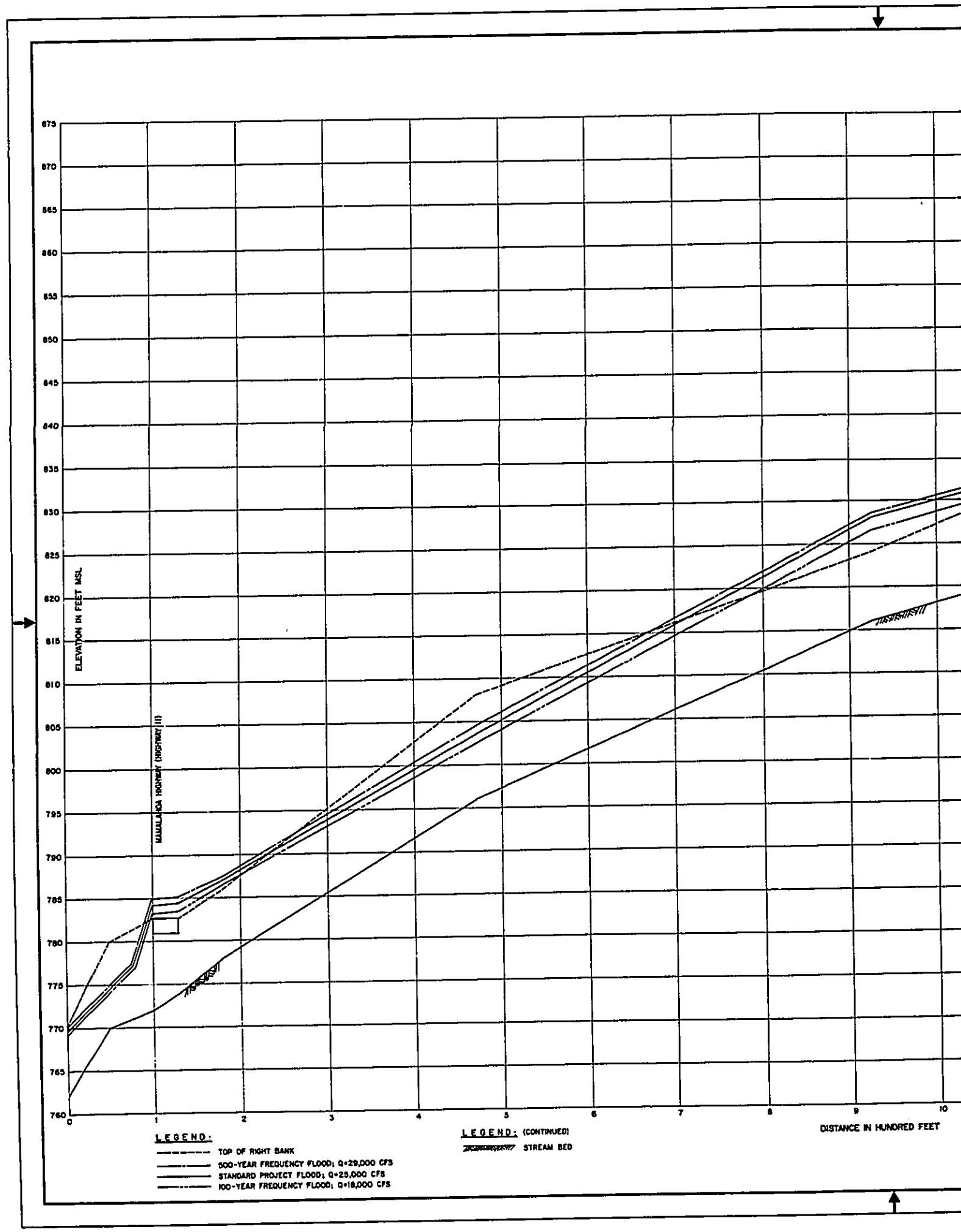
WATER SURFACE PROFILES

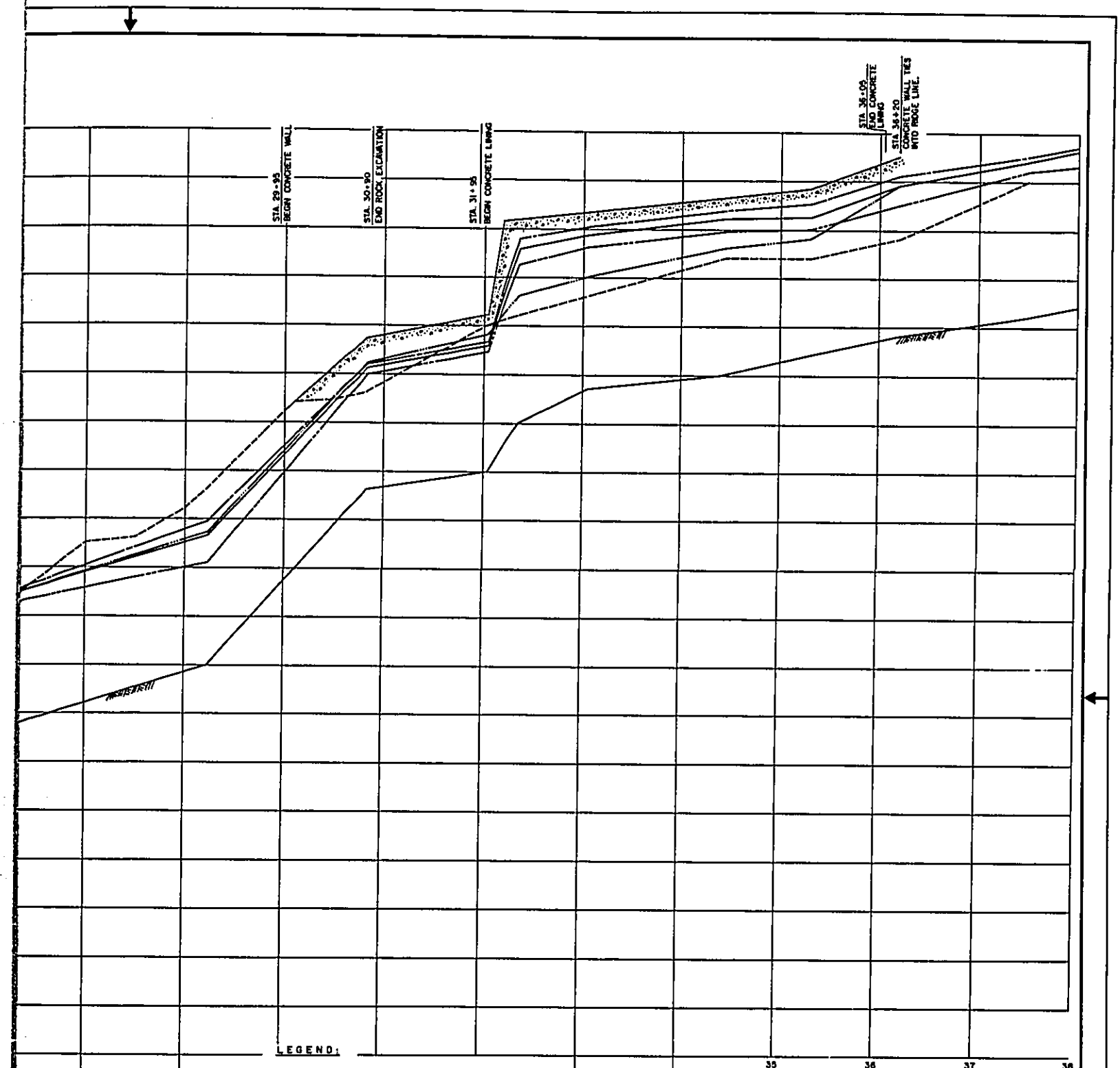
(ALTERNATIVE 1)

STATION 0+00 TO 19+00

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-3


ELEVATION IN FEET MSL
875
870
865
860
855
850
845
840
835
830
825
820
815
810
805
800
795
790
785
780
775
770
765
760
0
1
2
3
4
5
6
7
8
9
10
DISTANCE IN HUNDRED FEET
MAMALAHOA HIGHWAY (HIGHWAY 11)
LEGEND:
TOP OF RIGHT BANK
500-YEAR FREQUENCY FLOOD; Q=29,000 CFS
STANDARD PROJECT FLOOD; Q=25,000 CFS
100-YEAR FREQUENCY FLOOD; Q=18,000 CFS
LEGEND: (CONTINUED)
STREAM BED



NOTE:

PROJECT CONDITION PROFILES AND EXISTING CONDITION PROFILES ARE CONGRUENT DOWNSTREAM OF STATION 27+50.

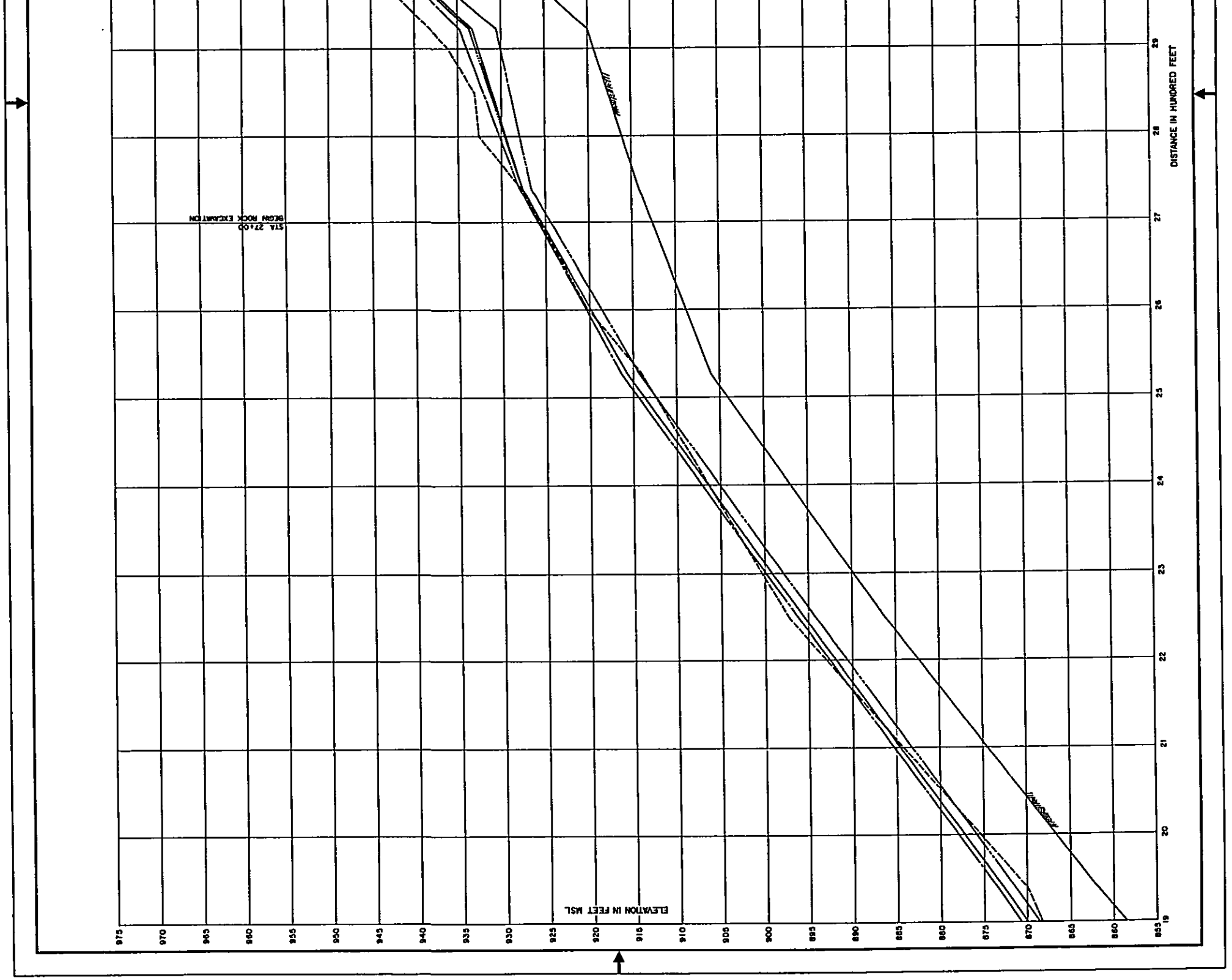
PAAUAU STREAM — PAHALA, HAWAII

WATER SURFACE PROFILES
(ALTERNATIVE 1)

STATION 19+00 TO 38+00

U. S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE C-4


STA 27+00
BEGIN ROCK EXCAVATION
MASSARTH
MASSARTH
DISTANCE IN HUNDRED FEET
ELEVATION IN FEET MSL
975
970
965
960
955
950
945
940
935
930
925
920
915
910
905
900
895
890
885
880
875
870
865
860
855
29
28
27
26
25
24
23
22
21
20
19

APPENDIX D

TABLE OF CONTENTS

LIST OF TABLES

GENERAL

Floodplain management, including flood control and prevention, can contribute to the National Economic Development (NED) objective by improving the net productivity of flood-prone land resources. This occurs by an increase in output of goods and services and/or by reducing the cost of using the land resources (improvement in economic efficiency). The benefit standard is the willingness of users (benefiting activities) to pay for each increment of output from a plan.

In the case of Paauau Stream at Pahala, Hawaii, the three flood control alternatives under consideration are aimed at improving net NED efficiency by reducing the cost of using land resources. Floodplain land use on the right bank is residential and the major effect of flood prevention is to reduce the costs of flood damages to the community. The left bank of the floodplain will continue to be subject to flooding with or without a plan of protection. Damages to left bank property are negligible. This area consists of lands in agricultural use.

The two economic principles governing the selection of an alternative are economic justification and optimality. Project economic benefits must exceed project costs, and there should be no other alternative with greater net benefits (benefits less costs).

Estimated project benefits result from a reduction in damages to structures and their contents, elimination of emergency relief costs, reduction in damages to roads and utilities, and protection against further losses of land along the stream. Estimated project costs are discussed in Appendix C, and are the costs of all goods and services used in project construction, operation and maintenance. Both costs and benefits are expressed in terms of estimated January 1982 price levels. Costs and benefits occurring at different points in time are converted to an average annual equivalent basis over the 50-year period of analysis for comparison using the federal discount rate prescribed for water resource projects. This rate is currently set at 7-5/8%.

BENEFITS

INTRODUCTION

Benefits are the measured difference between conditions with and without a flood prevention plan. Damages to structures and contents are the primary source of major flood-associated costs which can be assigned dollar values in evaluating floodplain management plans. Benefits resulting from the three alternatives include reduction of damages to structures and their contents, elimination of emergency relief costs, reduction in damages to public roads and utilities, reduced erosion, increased market value of property (relocation plan), and eliminating the threat to human safety.

Some land adjacent to the stream along the right bank was lost to erosion in a recent flood with a relatively low estimated return period (about 2 years). Total land lost was about 20 feet along about 4,000 feet of the stream, for a total loss of approximately 1.8 acres. In the absence of

protection, it is possible that some additional erosion may occur during future floods. Due to the high uncertainty surrounding estimates of the actual extent of additional erosion, an economic measure of this effect has not been included in this study.

The right bank development is basically entirely residential, and fully developed with the exception of one or two lots. No significant future change in the nature of floodplain development is likely during the 50-year period of analysis. Similarly, except for contents of residential structures, no significant increases in the real value of the stock of damageable assets are likely to occur in the foreseeable future.

Damage-frequency data for structures and contents located in the study area were developed using a computer program developed at Pacific Ocean Division (POD), Corps of Engineers. The program computes estimated damage for each structure for floods of varying magnitude. Damages are assumed to be a function of flood levels relative to first floor elevations, and are estimated in terms of percent of total market value of structures and contents. Flood levels are based on water surface profile data developed through hydrologic and hydraulic analysis.

The steep slopes in the Paauau Stream floodplain make potential floodwater destruction significantly more devastating near the streambanks. Recognizing this factor, the properties in the floodplain were divided into "high-velocity" and "low-velocity" zones, for which different standardized stage-damage curves were used to compute estimated probable damage resulting from different flood magnitudes. For purposes of this analysis, the high velocity zone includes the structures immediately adjacent to the streambanks, or about one-third of the properties within the floodplain. The standardized stage-damage curves used are based on previous studies, experience in POD and type of construction, as well as engineering judgment. Based on field checks within the study area, calculations in the damage analysis assume average first floor elevations of 3 to 4 feet above ground level. All of the structures are wood frame on post and beam construction.

Structure market values are based on data from the State of Hawaii Department of Taxation. Values of residential structure contents were estimated based on studies recently conducted on the Island of Hawaii by POD relating the market value of contents to the market value of the structure.

INUNDATION DAMAGE REDUCTION

After damages for each flood are estimated, the data for all of the structures are summed to arrive at an array of estimated damage-probability data. Integration of this data results in estimated average annual flood damage for the without-project condition, and for each of the three alternatives under consideration.

Damage-probability data for structures and contents in the Paauau Stream floodplain are displayed in Tables D-1 through D-4 for conditions without protection, and for Alternatives 1, 2 and 3, respectively.

TABLE D-1. ESTIMATED DAMAGE-PROBABILITY
DATA WITHOUT PROJECT ($1,000) 1/

	Exceedence Probability	Structure Damage	Content Damage	Total Damage
	.5000	30	1	32
	.3333	103	9	112
	.1000	245	36	282
	.0333	463	79	542
	.0200	517	106	623
	.0100	653	144	798
	.0074	687	166	854
(SPF)	.0033	768	200	968
	.0020	837	221	1058

1/ Totals may not add due to rounding.

TABLE D-2. ESTIMATED DAMAGE-PROBABILITY
DATA WITH ALTERNATIVE 1 ($1,000) 1/

	Exceedence Probability	Structure Damage	Content Damage	Total Damage
	.5000	19	0	20
	.3333	41	5	46
	.1000	47	13	60
	.0333	84	16	100
	.0200	93	17	111
	.0100	118	24	142
	.0074	133	31	164
(SPF)	.0033	173	40	214
	.0020	223	44	267

1/ SPF protection from Station No. 27+00 upstream. Conditions downstream are the same as without the project. Totals may not add due to rounding.

TABLE D-3. ESTIMATED DAMAGE-PROBABILITY DATA WITH ALTERNATIVE 2 ($1,000) 1/

	Exceedence Probability	Structure Damage	Content Damage	Total Damage
	.5000	18	0	19
	.3333	35	5	40
	.1000	40	12	52
	.0333	51	15	66
	.0200	55	16	72
	.0100	76	20	96
	.0074	83	22	105
(SPF)	.0033	118	26	145
	.0020	156	29	185

1/ SPF protection from Station No. 26+00 upstream. Conditions downstream are the same as without the project. Totals may not add due to rounding.

TABLE D-4. ESTIMATED DAMAGE-PROBABILITY DATA WITH ALTERNATIVE 3 1/

Exceedance Probability	WITHOUT FLOODPROOFING Structure Damage	Content Damage	Total Damage	WITH FLOODPROOFING Structure Damage	Content Damage	Total Damage
.5000	24	0	25	24	0	25
.3333	55	6	61	55	6	61
.1000	98	20	119	98	20	118
.0333	208	39	248	198	35	234
.0200	239	55	294	224	50	275
.0100	331	79	410	293	64	358
.0074	354	91	446	310	74	385
.0033	422	115	538	353	88	442
.0020	486	128	615	416	99	515

1/ Alternative 3 is the primarily non-structural plan, and consists of a relocation component and a floodproofing component. The data in this table excludes the 13 structures involved in the relocation component. The floodproofing component consists of raising 8 structures, located in the major flood hazard zone, to above the SPF level. The rest of the structures in the floodplain remain subject to flooding, largely sheet flow flooding. Totals may not add due to rounding.

Integration of the data in Tables D-1 through D-4 results in average annual inundation damages for each of the three conditions and average annual inundation damage-reduction benefits for the three alternatives. This information is tabulated in Table D-5. Included in Table D-5 is the effect of the increasing real value of contents throughout the period of analysis. Growth in the real value of contents and in the average annual damages to contents is assumed to parallel growth in real per capita income expected to occur in the future. The OBERS 1980 BEA Regional Projections (U.S. Department of Commerce, Bureau of Economic Analysis, 1981) for per capita income in the NON-SMSA (outside of Honolulu) portion of Hawaii are equivalent to about 2.0% per year from 1980-2030. Water resource planning regulatory guidelines allow for the effect of increasing real value of contents to be incorporated into damage calculation analysis subject to the constraint that projected real value of contents does not exceed 75% of the real value of the structure. Presently, the estimated average market value of contents is about 30% of the average market value of the structure. At an average annual growth of 2.0% per year, the average real value of contents will be 75% of the real value of the structure in about 46 years from now, or about 2028 (i.e., $1.02^{46} \times .30 = .75$).

Since the estimated first year of project life is 1985, the estimated real value of contents and contents damages in 1985 will be 6% higher than at present (three years of growth at 2.0% per year = $(1.02)^3 = 1.061$). Growth from 1985 to 2028 at 2.0% per year, with no further growth through 2035, the end of the period of analysis, results in an average annual equivalent factor of 1.32, as shown in the following calculation:

Average annual equivalent factor = (A/P, 7-5/8%, 50)
$\times \left(\left(\sum_{n=1}^{43} (1.02/1.07625)^n\right) + (1.02)^{43} \times (P/A, 7\text{-}5/8\%, 7)\right.$
$\times \left.(P/F, 7\text{-}5/8\%, 43)\right) = (.07823)(16.33 + .52) = 1.32,$

Where the notation (A/P, i, n) signifies the factor for the annual equivalent of periodic amounts at interest rate i per period and for n periods, P/A = the present worth of an annual amount, and P/F = the present worth of a future amount.

Multiplying estimated average annual contents inundation damages in 1985 by this factor of 1.32 results in estimated average annual equivalent contents inundation damages for the 50-year period of analysis.

TABLE D-5. AVERAGE ANNUAL INUNDATION DAMAGES AND INUNDATION DAMAGE REDUCTION BENEFITS 1/

Condition	Average Annual Damages ($1,000)					
		Contents			Total Structures and Contents 5/	Average Annual Damages Inundation Reduction Benefits 6/
	Structures 2/	1982 2/	1985 3/	1985-2035 4/		
Structural Plans:						
Without Project	95	14	14.8	20	115	0
Alternative 1	24	4	4.2	6	30	85
Alternative 2	19	4	4.2	6	25	90
Primarily Non-Structural Plan:						
Without Floodproofing	45	8	8.5	11	56	0
With Floodproofing	43	7	7.4	10	53	3

1/ Jan 1982 prices, 7-5/8% interest rate, and 50 year period of analysis, 1985-2035.
2/ From integration of damage-probability data in Tables D-1 through D-4.
3/ From multiplying 1982 figure by 1.06 to account for 3 years of real growth at 2.0% per year.
4/ From multiplying 1985 figure by 1.32 to account for effect of increasing real value of contents during period of analysis.
5/ Structures figure plus contents figure for 1985-2035.
6/ Benefit equals damage without alternative less damage with alternative.

RELOCATION BENEFITS

Alternative 3, the primarily non-structural plan, consists of a floodproofing component, and a relocation-evacuation and warning system component. The relocation plan for SPF protection under Alternative 3 includes the relocation of 13 structures in the "high-velocity" flood-hazard zone. These structures are located on lots immediately adjacent to Paauau Stream along Koali Street at the upstream portion of the stream in Pahala. Physical relocation of existing floodplain development to floodsafe locations results in a benefit equal to the market value of the relocation sites with the relocated structures, less the market value of the sites with improvements prior to relocations, and adjusted to reflect net changes in the market value of the vacated floodplain sites. No specific sites have been determined as yet for this relocation plan, and benefits are based on assumptions regarding relevant factors for analysis. Table D-6 shows the calculation of relocation benefits for Alternative 3.

OTHER BENEFITS

During the brief history of record there have been emergency relief efforts during flood conditions throughout the Hilo coast area, and specifically in the Paauau Stream floodplain. Available data on emergency relief costs specific to the Paauau Stream floodplain are sketchy at best and such costs generally tend to be relatively insignificant in terms of overall flood damages. Estimates from the Civil Defense, the Police, and the County Department of Public Works are usually overall totals including many items and many areas. Since there are such costs, however, an estimate has been included as outlined in Table D-7.

TABLE D-6. RELOCATION BENEFITS, ALTERNATIVE 3

Market Values After Relocations		
New Structures[1/]	$481,000	
New Sites[2/]	100,000	
Evacuated Floodplain Land[3/]	0	
Structural Improvements for Recreation on Evacuated Floodplain Land[3/]	NA	
Total Market Value After Relocation		$581,000
Market Values Before Relocations		
New Sites[4/]	$1,750	
Improvements Already on New Sites[4/]	0	
Floodplain Sites[5/]	71,000	
Existing Structures[5/]	433,000	
Total Market Value Before Relocation		$505,750
Net Increase in Market Values		$75,250
Annual Equivalent (50 years, 7-5/8%)		$6,000

1/ Assumes that comparable structures will be used, and that market value of existing structures have experienced about 10% depreciation. Most of the houses have been constructed in the past 10 years.
2/ Assumed to be equivalent to land within Pahala, not in immediate flooding danger, about $.66/SF, and 151,000 SF required, roughly the same area occupied by the existing 13 lots.
3/ No significant use assumed. Ample vacant land for recreation and other open-space uses exists in the Pahala area. No recreation development on evacuated floodplain land (could be developed into open park).
4/ Assumed to be vacant agricultural land, available for about $500 per acre.
5/ From Hawaii Department of Taxation data.

TABLE D-7. ESTIMATED EMERGENCY RELIEF COSTS

Flood Exceedance Probability	Estimated Number of Houses Affected	Cost[1/]
(SPF) .0033	87	$8,700
.0100	80	8,000
.1000	35	3,500

1/ Based on an estimated $100 per house affected.

With Alternatives 1 and 2, SPF protection is provided. Although some emergency relief costs could conceivably be incurred with the occurance of

rare flood events exceeding SPF protection, the equivalent annual effect is negligible. Benefits for reducing emergency relief costs for Alternatives 1 and 2, therefore, amount to about $2,000, from integrating the damage-probability data in Table D-7. With Alternative 3, estimated benefits assume a reduction in emergency relief costs of at least 50%, on the basis of warning system availability. Also, since 13 houses will have been removed, total emergency relief effort will be reduced further. Table D-8 shows estimated emergency relief cost data for Alternative 3. The cost estimate in Table D-8 translates into an average annual amount of about $1,000. Emergency relief cost reduction benefits for Alternative 3, then, are about $1,000 annually. This is the difference between the without condition and Alternative 3.

TABLE D-8. ESTIMATED EMERGENCY RELIEF COSTS, ALTERNATIVE 3 1/

Flood Exceedance Probability	Estimated Number of Houses Affected	Cost 1/
(SPF) .0033	74	$3,700
.0100	67	3,400
.1000	22	1,100

1/ Based on an estimated $50 per house affected. Number of houses affected is 13 less than in Table D-7, due to relocation.

Although no floods of major magnitude have occurred during the brief history of development in Pahala, large floods would most likely result in damage to public facilities. The major damage anticipated is undermining of Koali Street which runs parallel to Paauau Stream for about 4000 feet within the floodplain. Even with relatively minor floods, floodwaters have moved rapidly down Koali Street. No significant damage to Koali Street and associated utilities is expected to occur with floods less than the 2% frequency event (50-year flood). Assuming an estimated 1000 feet of repair required with the 2% event and 4000 feet with the SPF and larger floods, and a repair cost of $50/foot, the average annual equivalent of such damage is an estimated $3,000. Alternatives 1 and 2 would eliminate virtually all of this effect so that these two alternatives have benefits in this category of about $3,000. With Alternative 3, all of this will likely still occur so that there would be no such benefits for the primarily non-structural plan.

In addition to loss of land, emergency relief costs and damage to public property, flooding along Paauau Stream poses a significant threat to human safety. While difficult to measure in quantifiable economic terms, this threat is nevertheless very real and a matter of major concern to those living in the area. Water at fairly high velocities flooding some of the streets in the community have left families stranded in their homes during flood conditions in the past. High velocity flows carrying debris could cause serious injury to residents, in addition to devastating destruction to property along the stream. Such conditions have not yet occurred, but preventing their likelihood is a major consideration in proposing a flood control alternative.

BENEFIT-COST SUMMARY

A summary of average annual benefits, costs and two measures of feasibility, the B/C ratio and net benefits, are tabulated below in Table D-9.

TABLE D-9(713.533-1). 1/ SUMMARY OF ANNUALIZED NED BENEFITS AND COSTS FOR ALTERNATIVES 1, 2 and 3 ($1,000)

Applicable Discount Rate: 7-5/8%

	Alternative		
	1	2	3
Flood Hazard Reduction Benefits			
Inundation			
Structures	71	76	2
Contents	14	14	1
Emergency	2	2	1
Public Property	3	3	0
Relocation	0	0	6
Erosion	- 2/	- 2/	0
Human Safety	- 2/	- 2/	- 2/
Total Benefits (B)	90	95	10
Project Costs (C)	32	58	99
B/C Ratio	2.8	1.6	.10
Net Benefits	58	37	-89

1/ Table 713.533-1 is required by Federal Regulations to be displayed. See Federal Register, Vol. 44, No. 242, Rules and Regulations, 14 Dec 79 (Water Resources Council Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning).

2/ While these effects will most likely occur, no credit is included due to measurement problems.

It should be recognized that an analysis of this nature is subject to limitations due to data availability, a relatively short history of flooding experience, and the fact that this is a relatively small floodplain. However, the application of the flood reduction model utilizes a set of assumptions which are internally consistent throughout the computations, so that arbitrary calculations are absent from the assessment of flood damages and flood damage reduction benefits.

REQUIRED TABLES

U.S. Water Resources Council procedures require the display of four specific information tables in flood control study reports conducted by federal agencies. One of these displays is in Table D-9. Tables D-10 through D-12 below are the other three, and contain information on residual damages

(damages with a project in place), damages without a project, and number of structures in the floodplain without a project and each of the three alternatives.

TABLE D-10 (713.533.2)[1/] AVERAGE ANNUAL RESIDUAL FLOOD DAMAGES BY DECADE ($1,000)

Applicable Discount Rate: 7-5/8%

	Time Periods [2/]						
Project	P0	P10	P20	P30	P40	P50	AAE[3/]
1	28	29	30	32	33	34	30
2	23	24	25	27	28	29	25
3	54	56	58	60	63	64	57

1/ Water Resources Council (WRC) procedures required table designation.
2/ P10, P20, etc., denote the 10th and 20th years of project life, respectively.
3/ Growth is due to growth in contents damages through P43. AAE = average annual equivalent.

TABLE D-11 (713.533-3). [1/] AVERAGE ANNUAL FLOOD DAMAGES BY DECADE WITHOUT PROJECT ($1,000)

Applicable Discount Rate: 7-5/8%

		Time Period [2/]						
Property Type	Existing	P0	P10	P20	P30	P40	P50	AAE[3/]
Residential								
Structures	95	95	95	95	95	95	95	95
Contents	14	15	18	22	27	33	35	20
Emergency	2	2	2	2	2	2	2	2
Public								
Roads and Utilities[3/]	3	3	3	3	3	3	3	3
Total	114	115	118	122	127	133	135	120

1/ WRC procedures required table designation.
2/ P10, P20 denote the 10th and 20th years of project life, respectively.
3/ AAE = average annual equivalent.

TABLE D-12(713.533-4). 1/ NUMBER OF STRUCTURES IN FLOODPLAIN

Condition	Structures 2/ Time Period 3/ Existing	P0	P10	P20	P30	P40	P50
Without Project	90	90	90	90	90	90	90
Alternative 1	90	90	90	90	90	90	90
Alternative 2	90	90	90	90	90	90	90
Alternative 3	90	77	77	77	77	77	77

1/ WRC procedures required table designation
2/ All residential. Floodplain fully developed, and reduced number for Alternative 3 reflects relocation of 13 structures.
3/ P10, P20 denote 10th, 20th years, respectively.

APPENDIX E

TABLE OF CONTENTS

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

PAAUAU STREAM FLOOD CONTROL PROJECT, PAHALA, HAWAII

January 1982

1. DESCRIPTION OF THE PROPOSED ACTION. The project site is the Paauau Stream at Pahala, island of Hawaii. The proposed plan of improvement consists of the construction of 410 feet of reinforced concrete lining, 660 feet of concrete wall and excavation of 670 cubic yards of basaltic material to remove a constriction in the stream. The reinforced concrete wall will be about 8-inches thick and 4 to 7 feet in height. Foundation for the concrete lining would be excavated in the dry streambed of Paauau Stream. The project would reduce erosion and damage to properties located near the stream and would contribute to the safety and well-being of community residents.

2. BASIS FOR FINDING.

a. The Paauau Stream Flood Control project site is not a wetland, a special aquatic site, municipal water supply area, harvestable shellfish area, fishery, fish spawning or nursery area, a wildlife habitat, a formal recreational area, a special aquatic site, nor a habitat for threatened or endangered species. Paauau Stream is an intermittent stream with runoff occurring only during large storms.

b. Applicable Federal laws (Reservoir Salvage Act of 1960, as amended, and National Historic Preservation Act of 1966 and regulations 36 CFR 305 and 36 CFR 800) have been applied. There are no historic sites or cultural resources at the project site that are listed on the Hawaii or National Register of Historic Places. The Corps has determined that the project would not adversely affect any cultural sites and has coordinated this determination with the State Historic Preservation Officer.

c. There are no species in the project area that are listed as endangered or threatened pursuant to the Endangered Species Act of 1973.

d. The Corps and the US Fish and Wildlife Service have determined that there are no significant fishery resources, no fish spawning or nursery areas, and no commercial harvestable shellfish beds in or adjacent to the project area. No marine sanctuary, national wildlife refuge or wetland will be affected by the project.

e. No ocean dumping is required for the project, therefore implementation of Sections 102 and 103 of the Marine Protection, Research and Sanctuaries Act of 1972 is not required. No discharge of dredged or fill material under Section 404 of the Clean Water Act is anticipated.

f. Pursuant to the Clean Air Act Amendments of 1977, the project will not result in a new, long-term air pollution source.

g. Pursuant to the Safe Drinking Water Act of 1974, the project will not affect drinking water in any manner since potable water sources are not withdrawn from the stream.

h. Pursuant to the Noise Control Act of 1972, construction-generated noise in the project area will be minor and temporary, and may be mitigated by the use of mufflers on motorized construction equipment. The project will not result in a new, long-term noise pollution source.

i. No human residences or residents will be relocated or displaced. The project will restore property safety and will not provide for any amenities that would change the social structure, cohesion or social well-being of the community.

j. Informal meetings with local officials by the Corps have not elicited negative comments or any controversial issues regarding the proposed project.

Based upon the above factors, the US Army Corps of Engineers finds that the Paauau Stream Flood Control Project does not constitute a major Federal action significantly affecting the quality of the environment. An EIS will not be prepared for this project.

Date: _____

KENNETH E. SPRAGUE
LTC, Corps of Engineers
District Engineer

January 1982

PAAUAU STREAM FLOOD CONTROL
PAHALA, ISLAND OF HAWAII, HAWAII

EVALUATION OF THE EFFECTS OF THE
DISCHARGE OF DREDGED OR FILL MATERIAL
INTO WATERS OF THE UNITED STATES
USING THE SECTION 404(b)(1) GUIDELINES

I. PROJECT DESCRIPTION

a. Location. The proposed project site is the Paauau Stream at Pahala, island of Hawaii, Hawaii. Pahala is located approximately 45 miles south of Hilo.

b. General Description. The tentatively selected plan (Alternative 1) consists of lining the right bank of the stream with reinforced concrete for 410 feet. The lining would have a sideslope of 1.5H to 1.0V and a vertical height of about 12 feet. A concrete wall 660 feet in length with a height of 4 to 7 feet will be placed on the concrete lining and on the existing right bank. A rock outcrop on the left bank will be removed to straighten the channel. The rock excavation would be 390 feet long, 10 to 60 feet wide, and up to 15 feet in height.

c. Authority and Purpose. The study is authorized under Section 205 of the 1948 Flood Control Act, as amended (33 USC 701s), in response to a request from the Mayor of the County of Hawaii. The purpose of the proposed project is to reduce property damage and erosion, and to contribute to the safety and well-being of community residents.

d. General Description of Dredged or Fill Material.

(1) General Characteristics of Material. The lining and wall material is concrete. The backfill will consist of volcanically derived soil and rocks from the streambed excavation.

(2) Quantity of Material.

Approximately 280 cubic yards of concrete for lining
Approximately 80 cubic yards of concrete for wall
Approximately 170 cubic yards of backfill soil

e. Description of the Proposed Discharge Site.

(1) Location. See Figure 1.

(2) Size. 2+ acres.

(3) Type of Site. Confined within intermittent streambed.

(4) Type of Habitat. The intermittent streambed is not a habitat for aquatic or terrestrial biota.

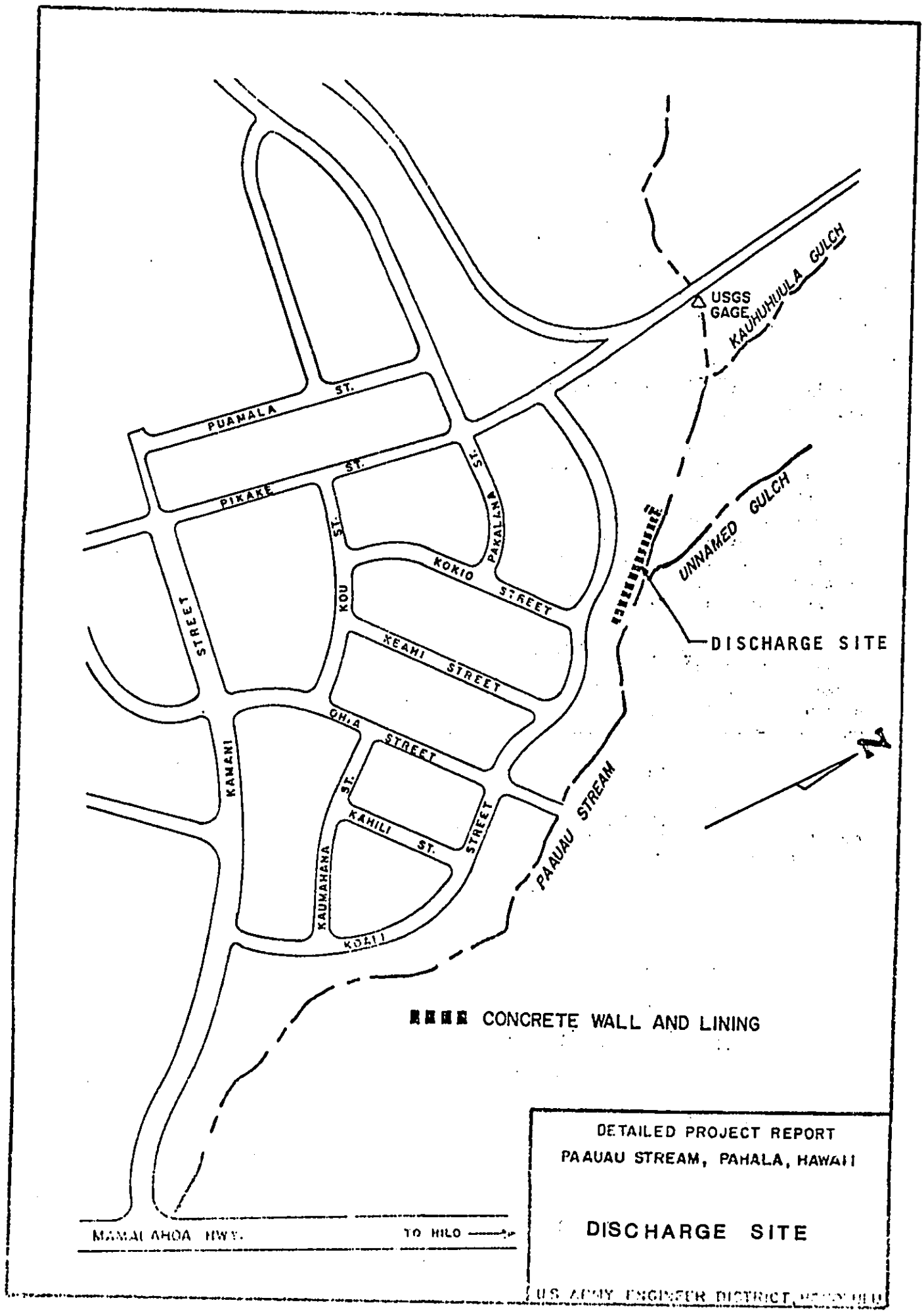

USGS GAGE
KAUHUHULA GULCH
UNNAMED GULCH
DISCHARGE SITE
PUAHALA ST.
PIKAKE ST.
KOU ST.
PAKALANA ST.
KOKIO STREET
KEAHI STREET
OHIA STREET
KAHILI ST.
KAUMAHANA ST.
KAMANI STREET
KOAII STREET
PAAUAU STREAM
CONCRETE WALL AND LINING
MAMALAHOA HWY.
TO HILO
DETAILED PROJECT REPORT
PAAUAU STREAM, PAHALA, HAWAII
DISCHARGE SITE
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1

(5) Timing and Duration of Discharge. The project will be implemented within 4 years. The construction period will be approximately 6 months. Work within the streambed to be completed within 4 months.

f. Description of Disposal Method. Materials for the project will be placed by dump truck, crane and concrete mixer trucks.

II. FACTUAL DETERMINATIONS.

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope. The concrete lining will cover a portion of the existing streambed along the right bank of the stream. The lining will change the elevation and character along the right bank. However, the change to the character of the basaltic rock streambed will not be substantial.

(2) Sediment Type. The intermittent streambed consists essentially of basaltic baserock overlain by random areas of volcanic sediments and loose basaltic rocks.

(3) Dredged/Fill Material Movement. None. All fill material will be design attached to the baserock and concreted in place.

(4) Physical Effects on Benthos. None. No benthos present.

(5) Other Effects. None.

(6) Actions Taken to Minimize Impacts. Construction in streambed to be completed within 4 months. Contractor will remove equipment, materials and other obstructions from streambed during storm conditions.

b. Water Circulation, Fluctuation and Salinity Determinations.

(1) Water. Not applicable. Streamflows present only during storms.

(2) Current Patterns and Circulation.

(a) Current Patterns and Flow. The completed concrete lining will have minimal effects on the current patterns and flow characteristics.

(b) Velocity. 20-25 fps (under design flood conditions).

(c) Stratification. None. Turbulent flow during storm runoff.

(d) Hydrologic Regime. Intermittent stream.

(3) Normal Water Level Fluctuations. From dry bed to about 15 feet flood height (at area of proposed floodwall) during SPF (standard project flood).

(4) Salinity Gradients. Not applicable. Freshwater intermittent stream.

(5) Actions that Will be Taken to Minimize Impacts. Not applicable.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of the Disposal Site. None.

(2) Effects on Chemical and Physical Properties of the Water Column. None.

(3) Effects on Biota. None.

(4) Actions Taken to Minimize Impacts. Construction in streambed to be completed within 4 months. Contractor will remove all equipment, materials and other obstructions from streambed during storm conditions.

d. Contaminant Determinations. No contaminants are suspected to be contained in the fill materials. Therefore, it is anticipated that discharge of the fill materials will not introduce or increase contaminants within the project area.

e. Aquatic Ecosystem and Organism Determinations. No aquatic ecosystem or special aquatic sites are present in the project area.

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination. Not applicable.

(2) Determination of Compliance with Applicable Water Quality Standards. Turbid storm runoff not applicable to water quality standards.

(3) Potential Effects on Human Use Characteristic.

(a) Paauau Stream not used as a potable public water supply.

(b) Recreational and Commercial Fisheries. Not applicable.

(c) Water Related Recreation. Not applicable.

(d) Aesthetics. Possible increased turbidity during heavy storms. Increased turbidity applicable only during construction and just after construction period.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves. None.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. None.

h. Determination of Secondary Effects on the Aquatic Ecosystem. None.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH RESTRICTIONS ON DISCHARGE.

a. Adaptation of the Section 404(b)(1) Guidelines to this Evaluation. The discharge site for the construction of the Paauau Stream Flood Control project is allowable and complies with the Section 404(b)(1) Guidelines promulgated by the Environmental Protection Agency.

b. Evaluation of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem. Not applicable.

c. Compliance with Applicable Water Quality Standards. In compliance.

d. Compliance with Applicable Toxic Effluent Standards or Prohibition Under Section 307 of the Clean Water Act. In compliance.

e. Compliance with Endangered Species Act of 1973. In compliance.

f. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972. Not applicable.

g. Evaluation of Extent of Degradation of the Waters of the United States.

(1) Significant Adverse Effects on Human Health and Welfare. (a) through (g). Not applicable.

(2) Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems. None.

(3) Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity, and Stability. None.

(4) Significant Adverse Effects on Recreational, Aesthetic, and Economic Values. None.

h. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem. Construction within streambed to be completed within 4 months.

i. On the basis of this evaluation, the Proposed Disposal Site for the Discharge of Fill Material is specified as complying with the requirements of the Section 404(b)(1) guidelines.

EXECUTIVE ORDER 11988 EVALUATION REPORT

PURPOSE

This evaluation report documents pertinent data required under the President's Executive Order 11988 on Floodplain Management, 24 May 1977, and in accordance with U.S. Army Corps of Engineers' regulations. The information provided is self-contained. Expanded and detailed information is provided in the main report, in the appendices of the report and in the Environmental Assessment.

DESCRIPTION OF FACTORS FOR THE TENTATIVELY SELECTED PLAN

1. Proposed Action Location. The proposed action is located within the base flood limits. The base flood is defined as the SPF (Standard Project Flood) frequency flood.

2. Designation of Practicable Alternatives for Action Outside the Floodplain. The action is defined as any Federal activity including acquiring, managing and disposing of Federal lands and facilities; providing Federally-undertaken, financed or assisted construction and improvements; and constructing Federal activities and programs affecting land uses, including but not limited to water and related land resources planning, regulating and licensing activities. A possible alternative is a broad-based floodplain management plan. In this plan, the building, zoning and other regulatory controls would be implemented in conjunction with certain other building modifications and relocations. Existing Federal programs offering alternatives to the proposed action are as follows:

a. Floodplain Management Services program are provided by the U.S. Army Corps of Engineers under authority of Section 206 of the 1960 Flood Control Act. The services include providing flood hazard data, technical assistance and planning guidance.

b. Flood insurance program is provided by the Federal Emergency Management Agency, Federal Administration, under the authority of the National Flood Insurance Act of 1968, as amended.

c. Minimum building standard requirements are specified for Federally-subsidized housing projects and are administered by the U.S. Department of Housing and Urban Development (HUD). The County of Hawaii building standards are administered by the Public Works Department.

d. Emergency operations, when in effect, are administered by the Federal Emergency Management Agency (FEMA). The disaster recovery operation includes protection of life and property, damage surveys, restoration of public services and providing technical services.

e. Relocation assistance for persons displaced as a result of Federal and Federally-assisted programs are authorized by the Uniform Relocations Assistance and Real Property Acquisition Act of 1970 (Public Law 91-646). This statute provides moving and related expenses to insure fair and equitable treatment of displaced persons.

3. Potential Floodplain Development with the Project. The existing bridge, culverts and walls built by government and private interests provide partial protection for the Pahala residents. Significant changes in land zoning are not anticipated with or without the project. Based on the development trend at Pahala, the project is not expected to induce accelerated or greater development.

4. Identification of Adverse Impacts of Action. The adverse impacts are as follows:

a. Loss of aesthetic appeal of natural stream due to reinforced concrete lining and wall.

b. Access to streambed difficult at proposed improvement.

c. 4- to 7-foot wall at rear of 8 lots restricts view across stream.

5. Identification of Other Methods and Alternatives which would Minimize Induced Development and Preserve Natural Floodplain Values. The sole practicable alternative was described in item (2) above. Methods within the proposed action to preserve natural streamlife values include the following:

a. Minimal utilization of reinforced concrete works. Lining limited to only 410-foot length and only at right bank.

b. Utilization of 1.5H to 1.0V slope at bank lining.

c. Excavation in streambed limited to removal of a constriction. Invert elevation of streambed is not changed.

6. Adverse Impacts on the Floodplain Due to the Proposed Action.

a. No adverse hydraulic impacts on the floodplain are expected.

b. No long-term environmental adverse impacts are expected. The construction of the proposed structure and stream widening is not expected to cause a significant reduction of plants in the area.

c. The proposed action will have a visual impact on the community. However, it is anticipated that the action will not be an eyesore.

7. Loss of Natural and Beneficial Values of the Floodplain. No permanent loss of the natural and beneficial values of the floodplain are expected.

8. Viable Methods to Minimize the Adverse Impacts of the Proposed Action.

a. The only probable long-term adverse impact of the proposed action is the visual impact. To minimize its impact, the concrete lining is sloped to 1.5 horizontal to 1 vertical and the proposed action is limited to a 410-foot reinforced concrete lining and a 660-foot reinforced concrete wall along the right bank.

b. The short-term impacts due to construction activity will be minimized by proper scheduling and control. These items will be specified in the contract documents and will be enforced by proper inspection.

9. Methods to Restore and Preserve the Natural and Beneficial Values of the Floodplain. The beneficial values of the floodplain will not be affected by the proposed action.

10. Recommendation of the Tentatively Selected Plan. The proposed action is the most desired plan. It satisfies the needs and desires of the local community and the County of Hawaii. It also satisfies the goals of EO 11988. The proposed project should be constructed in the floodplain and is the only practicable alternative. It will reduce the hazard and risk of flood loss, and will minimize the impact of floods on human safety, health and welfare.

The project meets the objectives and policies of the CZM program as follows:

SECTION 205A-2(b)(1). Recreational Resources.

OBJECTIVE: "Provide coastal recreational opportunities accessible to the public."

The proposed project will not add recreational areas nor will it adversely impact existing recreational areas.

SECTION 205A-2(b)(2). Historic Resources.

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

Construction of the project features is not expected to impact on historic sites or cultural resources. A reconnaissance survey was conducted by a qualified archaeologist and concluded that no historical or culturally significant resources would likely be disturbed. Also due to the extensive previous disturbances by flood flows, it is unlikely that historical or cultural artifacts would be present at the banks of the stream.

SECTION 205A-2(b)(3). Scenic and Open Space Requirements.

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

The project features will have no significant effects on scenic and open space resources. The visual impact of the concrete lining will be minimized by sloping the lining to 1.5 horizontal to 1.0 vertical. The surrounding vegetation will eventually grow along the concrete features of the project.

SECTION 205A(b)(4). Coastal Ecosystems.

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

Some of the plants covering the streambed and right bank would be destroyed or damaged by construction activities. However, the plants are expected to grow back after completion of the project.

SECTION 205A-2(b)(5). Economic Uses.

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

The project would protect life and property, and enhance the well-being of residents living within the floodplain. A floodplain management policy will be implemented which will reduce future damages.

SECTION 205A(b)(6). Coastal Hazards.

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

While the project would reduce safety and health hazards due to stream flooding, future development controls are primarily the responsibility of the local government. Since the County of Hawaii will be a participant in the National Flood Insurance Program, any proposed development in flood-prone areas must conform with requirements under the program to minimize or eliminate the risk of flood damage.

As a project requirement, a flowage easement in the area would be designated. This easement would have a restrictive effect upon future development within this area since no fill or structures would be allowed there.

SECTION 205A-2(b)(7). Managing Development.

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

The project planning is being conducted in accordance with existing regulations associated with present and future coastal zone management policies. An Environmental Assessment has been prepared and all potential short- and long-term impacts of alternative actions are being identified, evaluated and brought to the attention of the affected public through meetings and review of study documents.

United States Department of the Interior

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

IN REPLY REFER TO:
ES
Room 6307

JAN 25 1982

LTC Kenneth E. Sprague
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Re: Supplemental 2(b) Report for Paauau Stream Flood Control Project, Pahala, Hawaii County, Hawaii

Dear Colonel Sprague:

This is a supplemental report of the U.S. Fish and Wildlife Service on the U.S. Army, Corps of Engineers flood control project for Paauau Stream, Pahala, Hawaii County, Hawaii (Fig. 1). It has been prepared in accordance with the provisions of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. *661 et seq.*) and other authorities mandating Department of Interior concern for environmental values. It is consistent with the intent of the National Environmental Policy Act.

This report supplements our 2(b) report on the project dated June 8, 1981. It contains a description of the final plan developed by the Corps of Engineers and provided to the Service on January 19, 1981. It supercedes the "Description of the Plan" and associated figures in our previous report.

DESCRIPTION OF THE PLAN

The plan for flood control will provide a 660-foot-long concrete wall along the west bank of Paauau Stream, 410 feet of reinforced concrete lining, and excavation of 670 cubic yards of basaltic material to remove a constriction in the stream (Fig. 2). The concrete wall will be approximately 8 inches thick and 4 to 7 feet in height (Fig. 3). The concrete lining will be 10 to 12 feet in height and the walls will have a slope of 1.5 horizontal to 1.0 vertical (Fig. 3).

DISCUSSION/RECOMMENDATIONS

The Service believes that the proposed plan will have no adverse or beneficial impacts on fish and wildlife resources in the project area; therefore, we have no recommendations to offer. This is the same conclusion as stated in our 2(b) report dated June 8, 1981.

We appreciate this opportunity to comment.

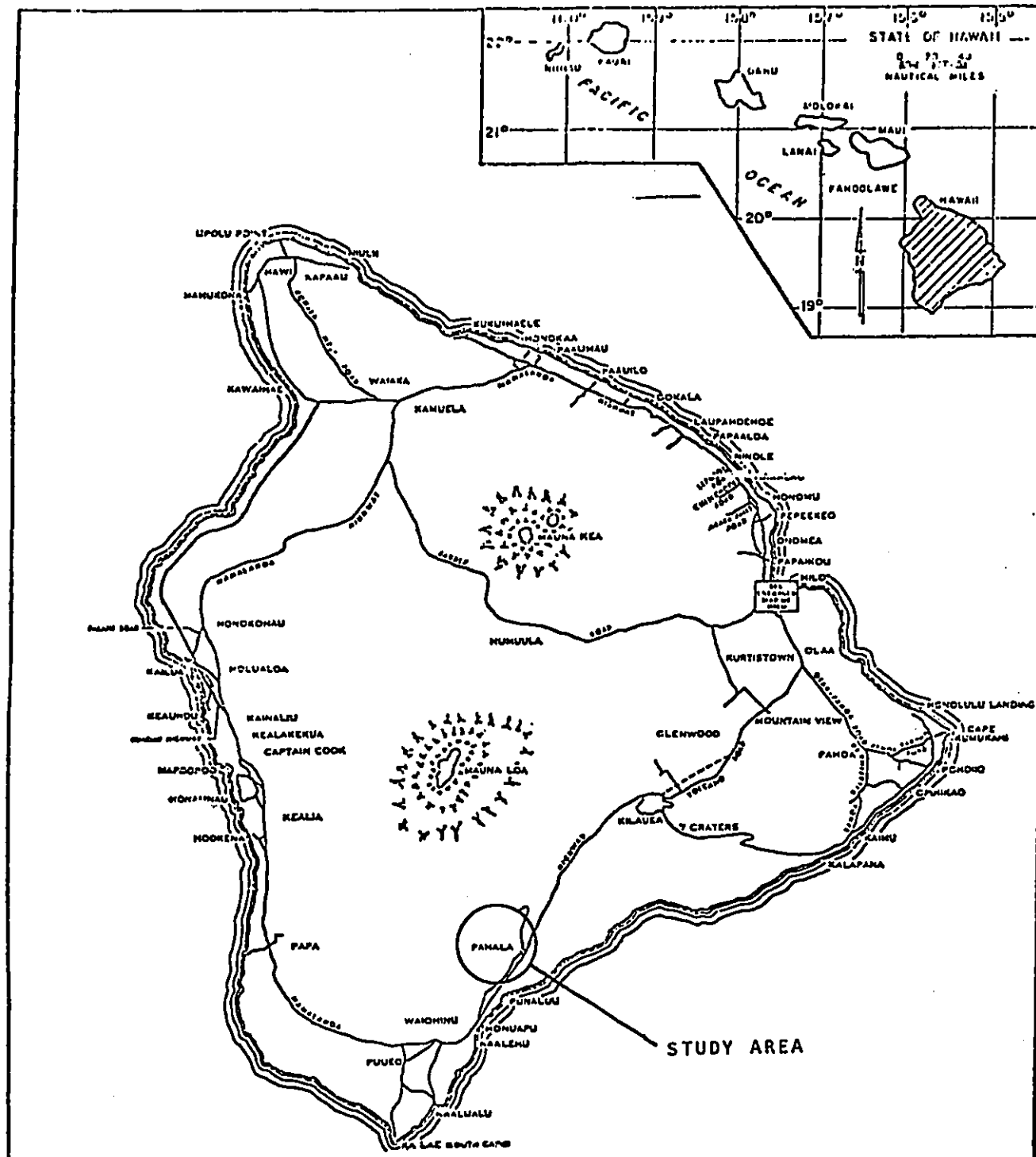
Sincerely yours,

Robert Shallenberger

ACTING Pacific Islands Administrator

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!



SCALE: 1" = 8 Miles

LOCATION MAP
PAAUAU STREAM, PAHALA
HAWAII

FIGURE 1

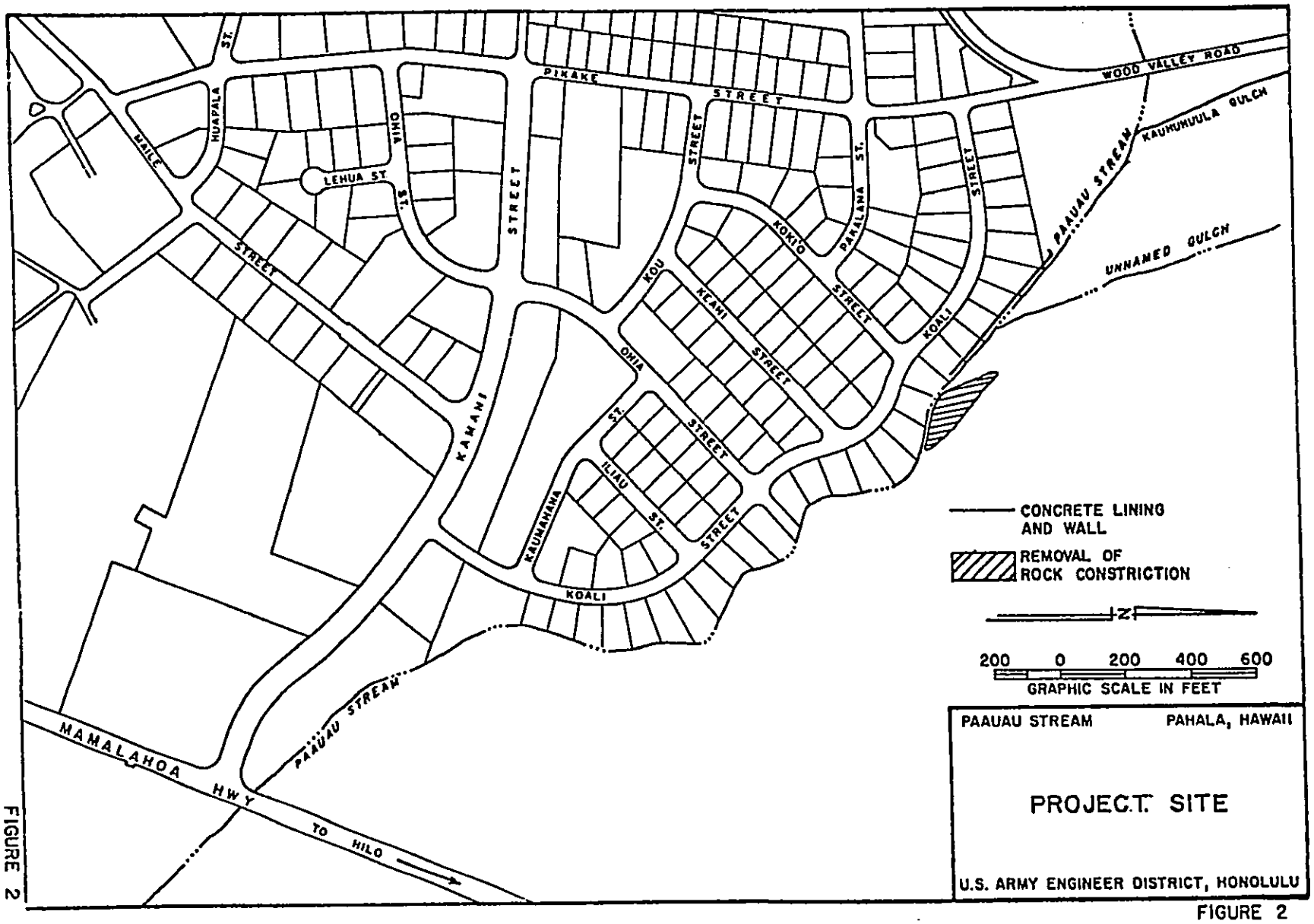
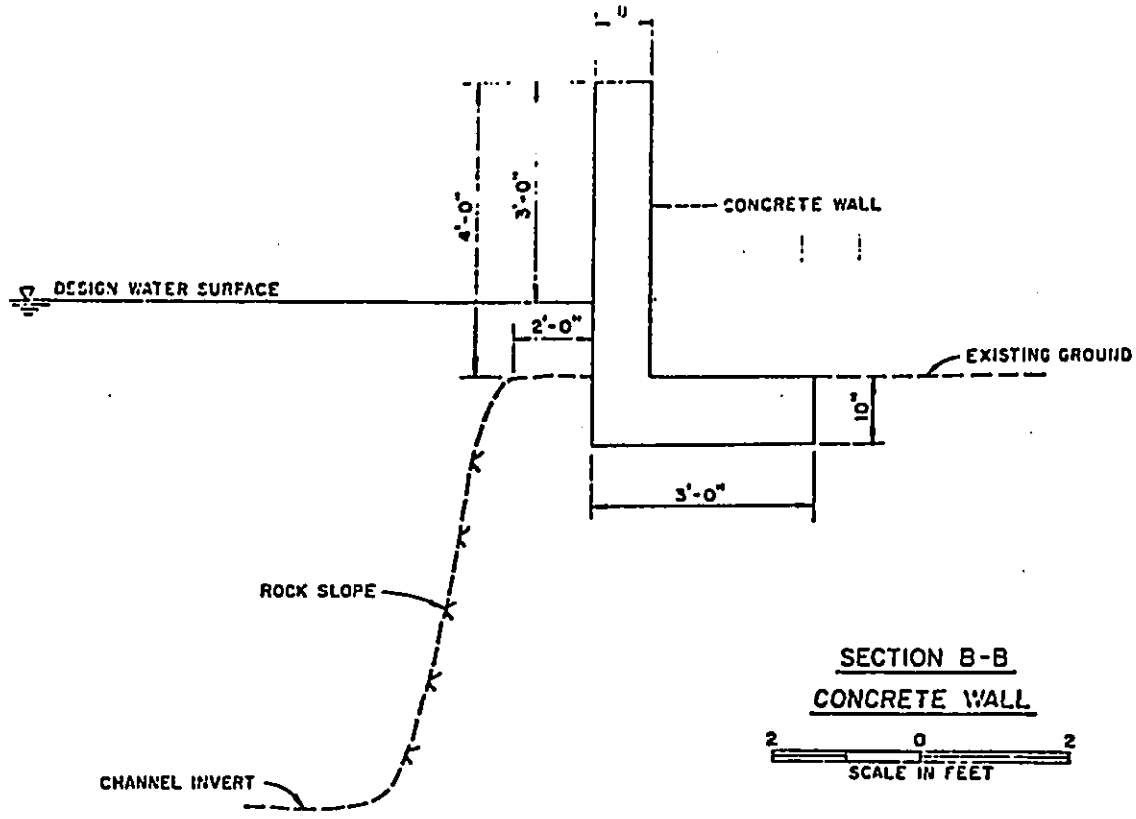


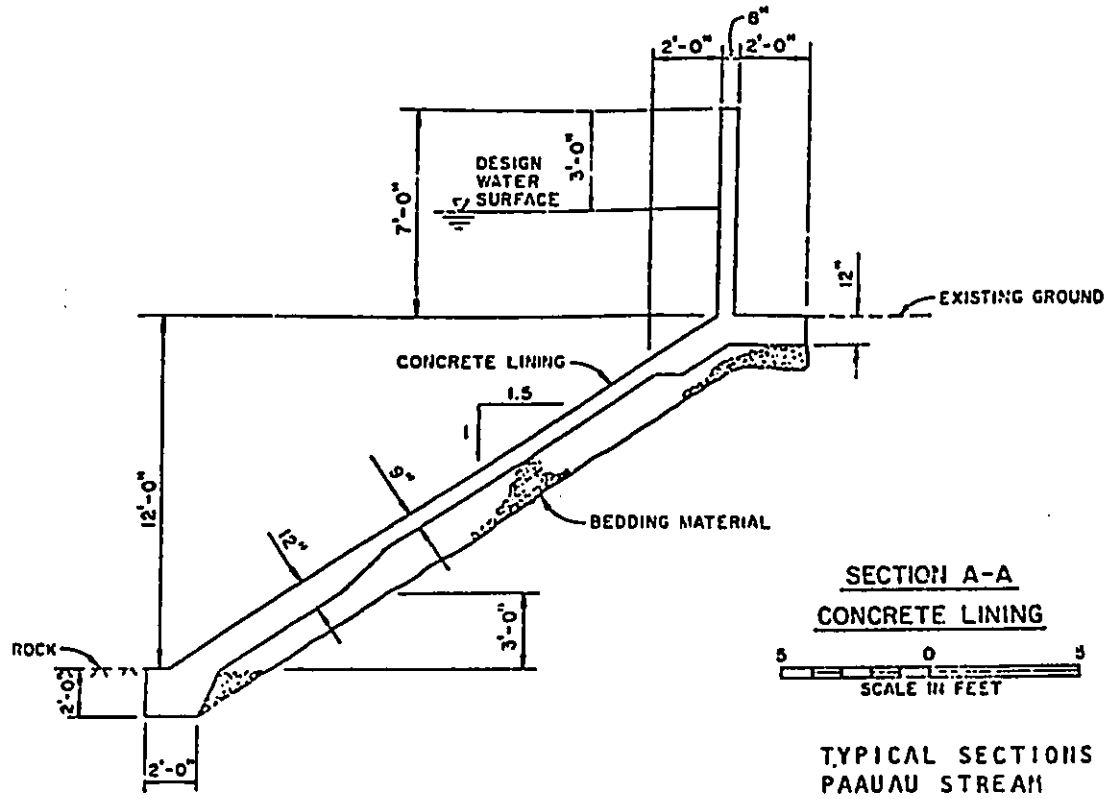
FIGURE 2

FIGURE 2



SECTION B-B
CONCRETE WALL

2 0 2
SCALE IN FEET



SECTION A-A
CONCRETE LINING

5 0 5
SCALE IN FEET

TYPICAL SECTIONS
PAAUAU STREAM
PAHALA, HAWAII

FIGURE 3

AN ARCHAEOLOGICAL RECONNAISSANCE OF THE PA'AU'AU STREAM FLOOD CONTROL STUDY AREA, PAHALA, KA'U, HAWAII

BY

HAMILTON M. AHLO, JR.

PREPARED UNDER PURCHASE ORDER NO. DACW84-81-M-0486

SEPTEMBER 1, 1981

SCIENCE MANAGEMENT INC.

INTRODUCTION

At the request of the Pacific Ocean Division, U.S. Army Corps of Engineers, the author undertook an on the ground archaeological reconnaissance of Pa'au'au Stream Flood Control Study Area, Pahala, Ka'u, Hawaii. The work was performed under Purchase Order No. DACW84-81-M-0486.

The study area is composed of an area approximately 25 feet (ca. 7.6m) on either side of Pa'au'au Stream between H-11 (Mamalahoa Hwy. or Volcano Road) and Wood Valley Road approximately 4000 feet (1.2 km.) upstream from the highway. The western bank of the stream has been extensively modified by residential construction. The eastern bank of the stream has also been modified by bulldozing, pasture use and orchards. Vegetation in the area consists of various grass species, eucalyptus species, koa haole (Leucaena glauca) and kukui (Aleurites moluccana). The study area receives approximately 50" of rain a year, primarily during the winter months.

The stream bed is predominantly bedrock though some alluvial deposits are present in the lower portion of the project area. The stream gradient is relatively gentle: the total elevation differential within the study area is only 400 feet (122m). The banks of the stream range from vertical basalt escarpments 20 feet (6.1m) high in the upper portion of the study area to gradually sloping alluvium in the lower portion of the study area. The stream was not flowing at the time of the survey though it appears to be an intermittent stream with periods of high energy, short duration discharge.

The study area lies within two land units (cf. U.S.G.S. Pahala 15' Quadrangle): Pa'au'au 2nd and Iliokoloa. It is unclear whether these represent ili or ahupua'a though it is probable that they are both ili that share a common boundary (Pa'au'au Stream).

LITERATURE SEARCH

A brief literature search of readily available material at the State Historic Preservation Office, the University of Hawaii Hawaiian Pacific Collection and the B.P. Bishop Museum Library was conducted to determine if any previous archaeological work had been conducted in the area and to identify any known archaeological or historic properties in the area. In addition, Ms. Virginia Goldstein of Hawaii County Planning Department and Mrs. Violet Hansen, a know-

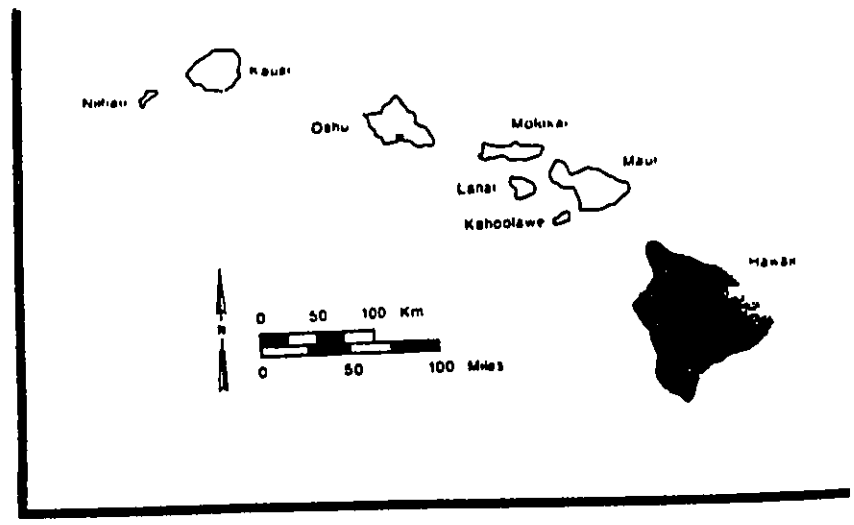
ledgeable resident of the Volcano area were consulted to see if they were aware of any previous work or of any sites in the area. No references to previous work near the Stream or of any sites near the Stream were found.

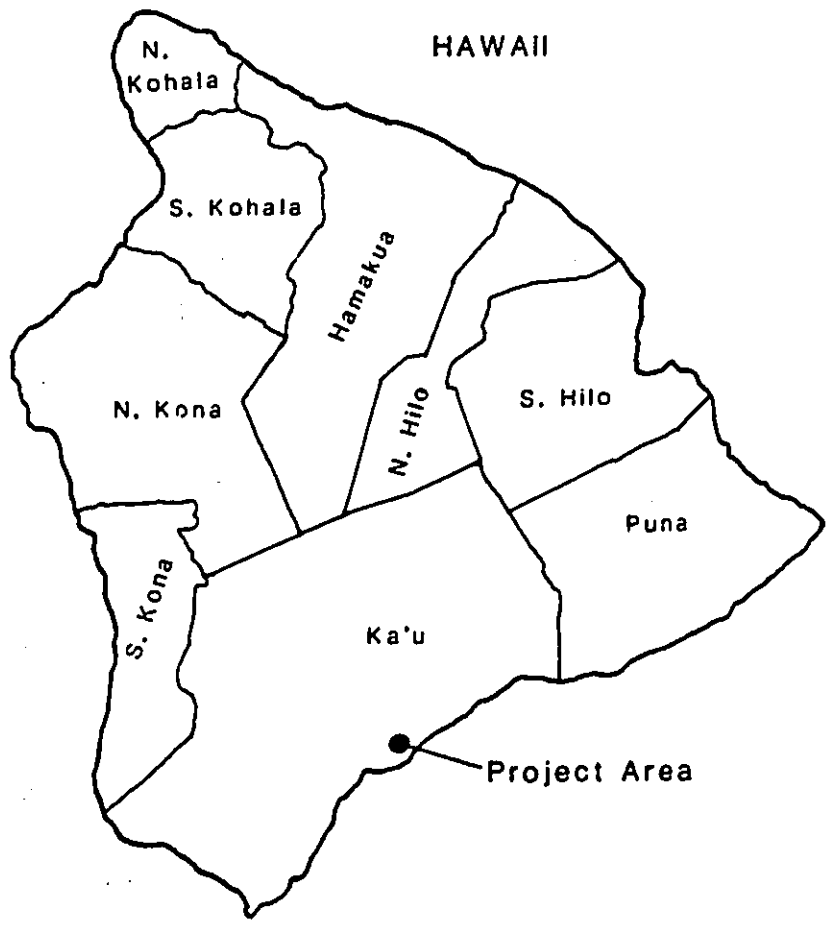
SURVEY RESULTS

The entire study area was inspected on foot on August 20, 1981. Both banks of the stream as well as the stream bed itself were examined. No arcaheological deposits or other items of cultural historical or archaeological interest were noted. Given the extensive disturbance along both banks of the stream, it is very unlikely that any such features that may once have been present remain intact. Inspection of the stream banks in areas where alluvial deposits were present revealed no signs of any archaeological deposits.

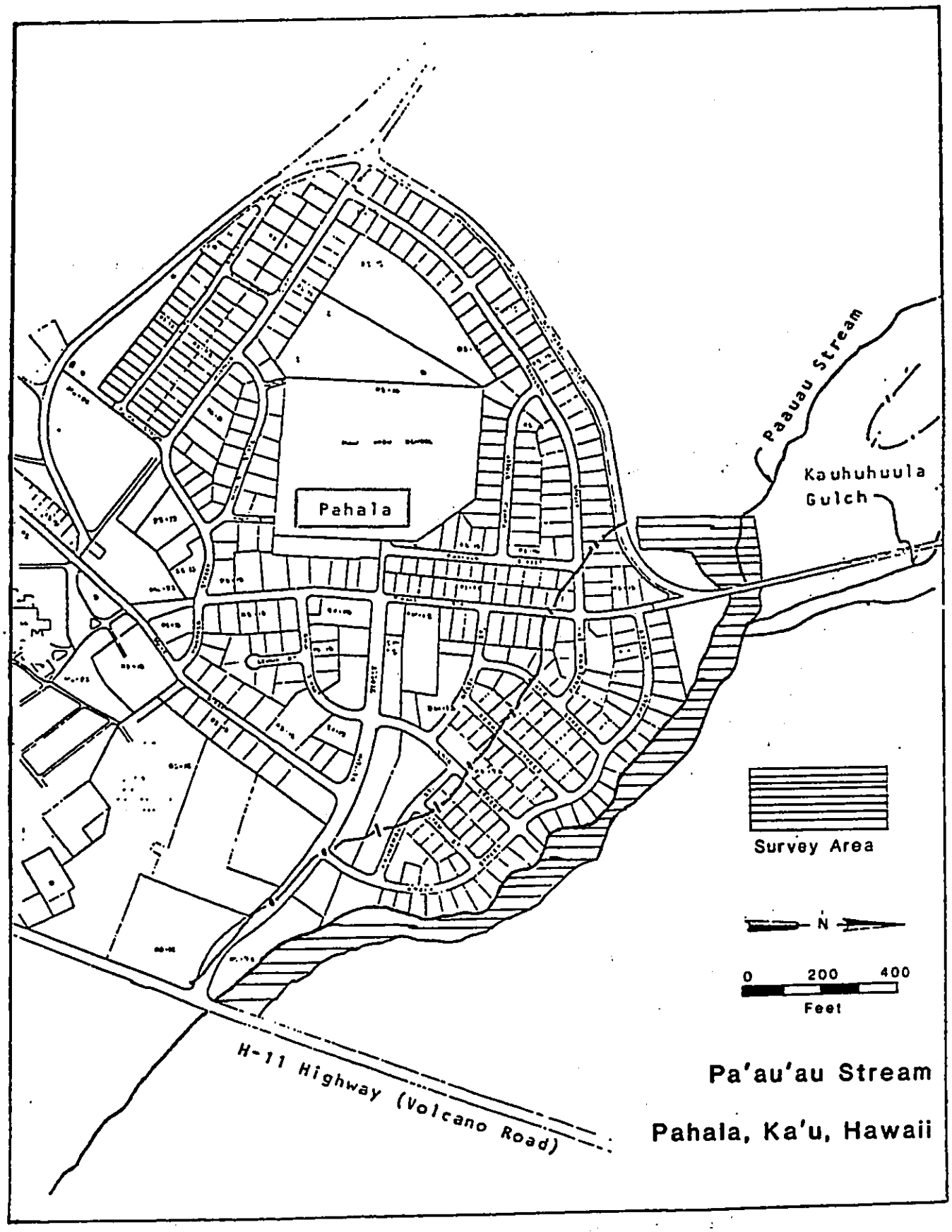
RECOMMENDATIONS

The proposed flood control project should have no effect on any cultural resources eligible for inclusion on or included on the National Register of Historic Places. Though extremely improbable, it is possible that subsurface cultural deposits may be revealed if the flood control project is implemented. In this event, I recommend that work be halted and a qualified archaeologist be consulted as to the appropriate course of action. No further archaeological work in the study area is warranted.





General Study Area
Pahala, Ka'u, Hawaii


Pahala
Paauau Stream
Kauhuhuula
Gulch
Survey Area
N
0
200
400
Feet
H-11 Highway (Volcano Road)
Pa'au'au Stream
Pahala, Ka'u, Hawaii