

United States  
Department of  
Agriculture

Soil  
Conservation  
Service

Honolulu,  
Hawaii

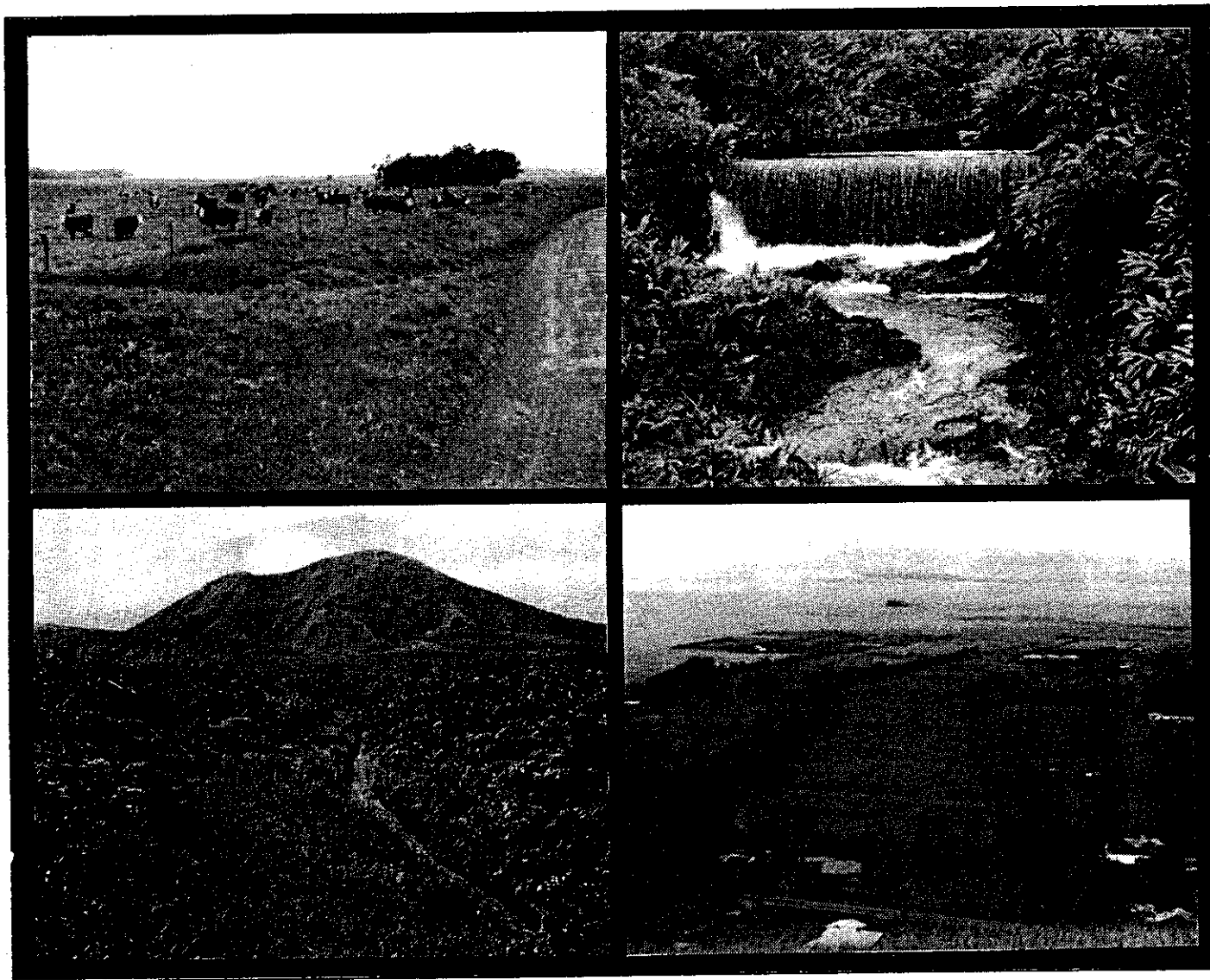


# Watershed Plan and Environmental Assessment

## **WAIMEA-PAAUILO WATERSHED**

### Hawaii County, Hawaii

September 1989





WAIMEA-PAAUILO WATERSHED  
HAWAII COUNTY, HAWAII

WATERSHED PLAN AND ENVIRONMENTAL ASSESSMENT  
AUGUST 1989

This document describes a plan for agricultural water management. Alternatives considered during planning include Future Without Project, National Economic Development (NED) plan, and Agricultural Water Management Plan. Project costs are \$9,648,700. Total annualized project benefits are \$1,277,700. Project measures include water conveyance, reservoir storage, and irrigation and livestock water distribution systems to complement the ongoing land treatment program of the Soil and Water Conservation District. This document fulfills requirements of the National Environmental Policy Act, the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, and the Soil Conservation Service's National Watershed manual. It also serves as a basis for authorization of Public Law 83-566 funding.

Prepared under the authority of the Watershed Protection and Flood Prevention Act, Public Law 83-566, as amended (16 U.S.C. 1001-1008) and in accordance with National Environmental Policy Act of 1969, Public Law 91-190, as amended (42 U.S.C. 4321 et seq.).

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WATERSHED AGREEMENT  
between the

MAUNA KEA SOIL AND WATER CONSERVATION DISTRICT

STATE OF HAWAII, DEPARTMENT OF HAWAIIAN HOME LANDS

STATE OF HAWAII, DEPARTMENT OF AGRICULTURE

(Referred to herein as the Sponsors)

STATE OF HAWAII

and the

SOIL CONSERVATION SERVICE  
UNITED STATES DEPARTMENT OF AGRICULTURE  
(Referred to herein as SCS)

Whereas, application has heretofore been made to the Secretary of Agriculture by Sponsors for assistance in preparing a plan for works of improvement for the Waimea-Paauilo Watershed, State of Hawaii, under the authority of the Watershed Protection and Flood Prevention Act (16 U.S.C. 1001-1008); and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to SCS; and

Whereas, there has been developed through the cooperative efforts of the Sponsors and SCS a plan for works of improvement for the Waimea-Paauilo Watershed, State of Hawaii, hereinafter referred to as the Watershed Plan-Environmental Assessment, which plan is annexed to and made a part of this agreement;

Now, therefore in view of the foregoing considerations, the Secretary of Agriculture, through SCS, and the Sponsors hereby agree on this plan and that the works of improvement for this project will be installed, operated, and maintained in accordance with the terms, conditions, and stipulations provided for in this watershed plan and including the following:

1. The Sponsors will acquire, with other than Public Law 566 funds, such landrights as will be needed in connection with the works of improvement. (Estimated cost \$201,900)
2. The Sponsors hereby agree that they will comply with all of the policies and procedures of the Uniform Relocation Assistance and Real Property Acquisition Policies Act (42 U.S.C. 4601 et seq. as implemented by 7 CFR Part 21) when acquiring real property interests for this federally assisted project. If the Sponsors are legally unable to comply with the real property acquisition requirements of the Act, it agrees that, before any federal financial assistance is furnished, it will provide a statement to that effect, supported by an opinion of the chief legal officer of the state containing a full discussion of the facts and law involved. This statement may be accepted as constituting compliance. In any event, the Sponsors agree that they will reimburse owners for necessary expenses as specified in 7 CFR 21.1006 (c) and 21.1007.

The cost of relocation payments in connection with the displacements under the Uniform Act will be shared by the Sponsors and SCS as follows:

	<u>Sponsors</u> (Percent)	<u>SCS</u> (Percent)	<u>Estimated Relocation Payment Costs</u> (dollars)
Relocation Payments	49.2	50.8	0 <u>1/</u>

3. The Sponsors will acquire, or provide assurance that landowners or water users have acquired, such water rights pursuant to state law as may be needed in the installation and operation of the works of improvement.
4. The Sponsors will obtain all necessary federal, state, and local permits required by law, ordinance, or regulation for installation of the works of improvement.
5. The percentages of construction costs to be paid by the Sponsors and by SCS are as follows:

1/ Investigation of the watershed project area indicates that no displacements will be involved under present conditions. However, in the event that displacement becomes necessary at a later date, the cost of relocation assistance and payments will be cost-shared in accordance with the percentages shown.

<u>Works of Improvement</u>	<u>Sponsors</u> (percent)	<u>SCS</u> (percent)	<u>Estimated Construction Costs</u> (dollars)
Upper Hamakua Ditch Improvement			
UHD By-pass Pipelines	50	50	416,000
UHD to Waimea II Reservoir Supply Pipeline	50	50	600,000
Waimea II Reservoir			
Irrigation Water	50	50	4,609,300
Livestock Water	100	0	217,200
Total - Reservoir			4,826,500
Distribution			
Irrigation			
Waimea II to Exist.			
Mainline	50	50	128,300
Lalamilo - Phase I	50	50	198,800
Hawaiian Home Lands - Phase I and II	50	50	497,200
Livestock Water			
Main, Group 2, E, E-1	100	0	398,000
Group 1	100	0	23,500
Group 3	100	0	228,700
Group 5	100	0	210,700
Group 7	100	0	23,100
Group 9	100	0	67,500
Total - Construction			7,618,300

6. The percentages of the engineering services to be borne by the Sponsors and SCS are as follows:

Works of Improvement	Sponsors (percent)	SCS (percent)	Estimated Engineering Costs (dollars)
Upper Hamakua Ditch Improvement			
UHD By-pass Pipelines	0	100	66,600
UHD to Waimea II Reservoir Supply Pipeline	0	100	96,000
Waimea II Reservoir			
Irrigation Water	0	100	737,500
Livestock Water	0	100	34,800
Total - Reservoir			772,300
Distribution			
Irrigation			
Waimea II to Exist.			
Mainline	0	100	20,500
Lalamilo - Phase I	0	100	31,800
Hawaiian Home Lands - Phase I and II	0	100	79,600
Livestock Water			
Main, Group 2, E, E-1	0	100	63,700
Group 1	0	100	3,800
Group 3	0	100	36,600
Group 5	0	100	33,700
Group 7	0	100	3,700
Group 9	0	100	10,800
Total - Engineering			1,219,100

7. The Sponsors and SCS will each bear the costs of project administration that each incurs, estimated to be \$152,300 and \$457,100 respectively.

8. The Sponsors will be responsible for the operation, maintenance, and replacement of the works of improvement by actually performing the work or arranging for such work, in accordance with agreements to be entered into before issuing invitations to bid for construction work.

9. The costs shown in this plan are preliminary estimates. Final costs to be borne by the parties hereto, will be the actual costs incurred in the installation of works of improvement.

10. This agreement is not a fund-obligating document. Financial and other assistance to be furnished by SCS, and funds, land and water rights, and other commitments to be provided by the sponsors, in carrying out the plan are contingent upon the fulfillment of applicable laws and regulations and the availability of appropriations for this purpose.







Addendum No. 1 to Watershed Agreement

For Waimea-Paauilo Watershed, Hawaii

By

Exchange of Correspondence

The parties to the above-referenced Watershed Agreement signed September 20, 1989, and the State of Hawaii, Department of Land and Natural Resources (DLNR) agree that, although the DLNR is not a Sponsor under the Agreement in light of the statutory transfer of the management and operation of the Waimea Irrigation System from DLNR to the State of Hawaii, Department of Agriculture (DOA) effective July 1, 1989, the DLNR will continue to provide technical assistance to the DOA and support this project as outlined in the Watershed Plan-Environmental Assessment.

All other terms, conditions and stipulations of the Watershed Agreement not modified herein remain the same and are agreed to:

Signed: <u><i>James I. Pabro</i></u>	<u>Mauna-Kea SWCD</u>	<u>10/2/89</u>
(Title) <u>Chairman</u>	(Sponsor)	(Date)
<u><i>Zukeo Hetea</i></u>	<u>Department of Agriculture (DOA)</u>	<u>10/6/89</u>
(Title) <u>Chairperson</u> <u>Board of Agriculture</u>	(Sponsor)	(Date)
<u><i>Ilima A. Piianaia</i></u>	<u>Department of Hawaiian Home Lands</u>	<u>OCT 12 1989</u>
(Title) <u>Chairman</u>	(Sponsor)	(Date)
<u><i>William W. Patu</i></u>	<u>Department of Land and Natural Resources (DLNR)</u>	<u>OCT 11 1989</u>
(Title) <u>WILLIAM W. PATU, Chairperson</u> <u>Board of Land and Natural Resources</u>	(DLNR)	(Date)
<u><i>Warren M. Lee</i></u>	<u>Soil Conservation Service</u>	<u>10/12/89</u>
(Title) <u>WARREN M. LEE</u> <u>State Conservationist</u>	<u>USDA</u>	(Date)

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WAIMEA-PAAUILO WATERSHED  
GLOSSARY OF ABBREVIATIONS

ACP	Agricultural Conservation Program
DHHL	Department of Hawaiian Home Lands
DLNR	Department of Land and Natural Resources
DOA	Department of Agriculture
DOWALD	Division of Water and Land Development, DLNR
DWS	Department of Water Supply, County of Hawaii
FWO	Future Without Project
HAAWS	Hamakua Area Agricultural Water Study
MG	Million Gallons
MGD	Million Gallons per Day
NED	National Economic Development
NEPA	National Environmental Policy Act
O&M	Operation and Maintenance
OM&R	Operation, Maintenance and Replacement
P&G	Principles and Guidelines
Plan-EA	Plan and Environmental Assessment
RCCP	Reinforced Concrete Cylinder Pipe
SCS	Soil Conservation Service, USDA
SHPO	State Historic Preservation Officer
SWCD	Soil and Water Conservation District
UHD	Upper Hamakua Ditch
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WIS	Waimea Irrigation System
WRC	Water Resource Council



# SUMMARY

PROJECT NAME: WAIMEA-PAAUILO WATERSHED  
Hawaii County, Hawaii

SPONSORS: Mauna Kea Soil and Water Conservation District (SWCD)  
State of Hawaii, Department of Land and Natural  
Resources (DLNR)  
State of Hawaii, Department of Hawaiian Home Lands  
(DHHL)  
State of Hawaii, Department of Agriculture (DOA)

DESCRIPTION OF RECOMMENDED PLAN:

The purpose of this watershed project is agricultural water management (irrigation and livestock water). The project will include the installation of collection system by-pass pipelines, a reservoir supply pipeline, a storage reservoir, an irrigation pipeline, and livestock water pipelines.

This plan was formulated considering the criteria of the National Economic Development Plan (NED) and has been accepted by the local Sponsors for implementation. The project improves agricultural water management through more efficient irrigation and livestock water distribution systems, protects the soil resource base by facilitating better pasture management and improves the production of crops that are in deficit supply within the state of Hawaii.

RESOURCE INFORMATION:

SIZE OF WATERSHED: 143,900 acres

LAND USE:	Irrigated cropland	802 acres
	Pastureland	118,622 acres
	Urban and builtup	3,142 acres
	Forest Reserve & Watershed	7,584 acres
	Cropland (sugar cane)	12,200 acres
	Other	1,550 acres

LAND OWNERSHIP:	Private - 88,629 acres	62 percent
	State - 55,246 acres	38 percent
	Municipal - 25 acres	< 1 percent

NUMBER OF: Farmlots - 65; cropland averages 12 acres.  
Ranches and Ranchlots - 127; average size is approximately 934 acres.

PRIME, UNIQUE, AND LANDS OF STATEWIDE IMPORTANCE: 56,650 acres.

ENDANGERED SPECIES: Hawaiian Duck

CULTURAL RESOURCES: Significant historic structures include the Parker homestead on Mana Road, the Spencer House, Imiola Church, and the Hind House. The Waimea Agricultural System, an important early agricultural, residential, and livestock-oriented historic district, is adjacent to the proposed Lalamilo Agricultural Addition.

The Waimea Agricultural System, a subsystem of the Kohala Agricultural System, is typical of the types of archeological sites encountered in the study area. These consist primarily of stone alignments, walls, habitation sites and platforms, irrigation canals, field remnants, and various mounds. No effects to cultural resources are anticipated.

PROBLEM IDENTIFICATION: The major problem of the watershed is an inadequate water supply due to insufficient agricultural water storage reservoirs and a water collection system with high seepage losses. The distribution systems are inadequate for the agricultural enterprises in the watershed area.

CANDIDATE PLANS CONSIDERED:

1. Future without project action.
2. National Economic Development (NED).
3. Agricultural Water Management Plan.

PROJECT PURPOSE: The major project purpose is agricultural water management (irrigation and livestock).

PRINCIPAL PROJECT MEASURES OF RECOMMENDED PLAN:

The project will install:

- |   |             |
|---|-------------|
| 1. UHD by-pass pipelines:                           | 8,000 ft.   |
| 2. UHD To Waimea II Reservoir supply pipeline:      | 3,100 ft.   |
| 3. Waimea II reservoir (one):                       | 133 MG      |
| 4. Irrigation pipeline with pumping station:        | 21,800 ft.  |
| 5. Livestock water pipelines with pumping stations: | 184,400 ft. |

PROJECT COSTS:

Items	PL-566 Funds		Other Than PL-566 Funds		Total
	(dollars)	(percent)	(dollars)	(percent)	
Construction					
Irrigation	\$3,224,700	50	\$3,224,900	50	\$6,449,600
Livestock water	0	0	1,168,700	100	1,168,700
Land Rights	0	0	201,900	100	201,900
Technical Assistance	1,219,100	100	0	0	1,219,100
Project Administration	457,100	75	152,300	25	609,400
TOTAL	\$4,900,900		\$4,747,800		\$9,648,700

PROJECT BENEFITS:

AGRICULTURAL ANNUALIZED BENEFITS:

Irrigation - Cropland damage reduction	\$ 764,600
Cropland Intensification	448,500
Livestock damage reduction	17,300
Livestock intensification	47,300
	<u>\$1,277,700</u>

ACRES BENEFITTED: Irrigated cropland benefitted 1,240 ac  
 Pastureland benefitted 22,800 ac

OPERATING UNITS BENEFITTED: Farmlots (No.): Puukapu 21  
 Lalamilo 36  
 DHHL 87  
Total 144

Ranchlots (No.): Private 26  
 DHHL 82  
Total 108

IMPACTS:

LAND USE CHANGES: There will be 363 acres of pastureland converted to irrigated cropland with the additional water provided by this project. There will be 22 acres of pastureland converted to permanent reservoir use.

NATURAL RESOURCES CHANGED:

1. Prime Farmland: 312 acres (increase)
2. Wildlife Habitat: 2.5 acres (temporarily affected)

OTHER IMPACTS:

MAJOR CONCLUSIONS: The additional storage and increased collection efficiency will conserve, for beneficial use, 440 MG/yr. This will help increase and stabilize the agricultural economy of the Waimea area by:

1. Reducing effects of droughts which reduce yields and increase costs.
2. Providing for increased production of vegetables and beef which are both in deficit supply in Hawaii.
3. Improving the county's domestic water supply by reducing the amount of domestic water utilized for agricultural purposes.
4. Providing a reliable livestock water supply and distribution system which will allow application of better grazing management practices to protect the resource base.

AREAS OF CONTROVERSY: None.

ISSUES TO BE RESOLVED: None.

# INTRODUCTION

## GENERAL

The watershed plan and environmental assessment (plan-EA) for this project have been combined into a single document. The document describes plan formulation, discloses the expected environmental, social, and economic impacts, and provides the basis for authorizing federal assistance for implementation.

The plan was prepared under the authority of the Watershed Protection and Flood Prevention Act, Public Law 83-566 as amended (16 U.S.C. 1001-1008). The Plan-EA is in accordance with the National Environmental Policy Act of 1969, Public Law 91-190, as amended (42 U.S.C. 4321 et seq.). Responsibility for compliance with the National Environmental Policy Act rests with the U.S. Department of Agriculture, Soil Conservation Service (SCS).

The sponsoring local organizations (Sponsors) which requested planning assistance are the Mauna Kea Soil and Water Conservation District (SWCD), State of Hawaii, Department of Land and Natural Resources (DLNR), and the State of Hawaii, Department of Hawaiian Home Lands (DHHL). The Sponsors participated in developing this plan with technical assistance from the SCS. Other federal, state, and local agencies, groups, and individuals participated and provided input in the planning process.

## READER'S GUIDE

The format of the plan-EA is directed by the SCS National Watershed Manual and other regulations and guidelines. This reader's guide describes the planning process and helps the reader find items of particular interest.

Planning begins with the Sponsors' request for assistance in solving water and related land resource problems. Interagency and interdisciplinary planners and the Sponsors, with public participation, then follow a process that involves nine basic steps--identify watershed problems and opportunities; inventory resources and forecast future conditions; formulate alternative plans; evaluate effects of the alternatives; compare the alternatives; select a recommended plan; complete Plan-EA; review, approve and authorize; and install the project.

The planning process including the environmental evaluation continues through the publication of the Draft to the Final Plan-EA, cycling back through the nine steps and adding refinements in each cycle. This document summarizes the process and presents the results. The recommended plan is the result.

The Watershed Agreement, although included in the front of the document, is the culmination of the planning effort and serves as the formal agreement (not the fund-obligating document) between the Sponsors and the SCS.

The Summary describes the plan in brief. Other sections should be consulted if specific details of the project are required.

The Project Setting actually begins the presentation by describing the area and its resources in general terms. Problem and Opportunity Identification covers the reasons for initiating the plan and examines problems and opportunities uncovered during the planning process. Table A, Problems and Opportunities provides a summary tabulation.

Inventory and Forecasting evaluates specific resources in depth and estimates the effect of various project actions on those resources. Table B, Evaluation of Identified Concerns, presents this information. The future conditions of those resources are forecast to provide the future without the project conditions.

Formulation of Alternatives is the heart of the planning process. Alternative plans are formulated to solve the identified problems. They are compared with each other and to future conditions without PL-566 project action.

The next two sections, Recommended Plan and Effects of the Recommended Plan, describe in detail the plan proposed for implementation and its effects on the economy and the environment. The numbered tables (blue pages for ready reference) present Estimated Installation Costs (1), Estimated Cost Distribution (2), Structural Data - Waimea II Dam and Reservoir (3), Structural Data - Upper Hamakua Ditch By-pass Pipelines (3A), Structural Data - Reservoir Supply Pipeline (3B), Structural Data - Irrigation Distribution System (3C), Structural Data - Livestock Water Distribution System Pipelines (3D), Annualized Adverse National Economic Development Effects (4), and Comparison of NED Benefits and Costs (6). These two sections explain in detail the project proposal and the effects of project installation upon the economy and the environment.

Appendices further illustrate or detail project conditions. Appendix A contains letters and comments on the Draft Plan-EA. Appendix B contains excerpts from selected drought reports. Appendix C provides detailed descriptions of the forest plant communities found along the Upper Hamakua Ditch. Appendix D contains Waimea II dam and reservoir details with breach inundation map. Appendix E provides the irrigation distribution system and proposed mainline extension map. Appendix F contains the livestock water distribution system. Appendix G provides the project map.

Questions regarding plan content or interpretation may be referred to Warren M. Lee, State Conservationist, U.S. Department of Agriculture, Soil Conservation Service, P.O. Box 50005, Honolulu, Hawaii 96850. The telephone number is (808) 541-2601 or FTS 551-2601.

# PROJECT SETTING

## LOCATION AND SIZE

The project area encompasses about 143,900 acres, and is located in the northeast part of the Island of Hawaii (see project map, Appendix G). The area is bounded by Highway 19 to the north and the town of Paauilo to the east. The project extends to the 8,000-foot level of Mauna Kea in the south, and to the Waikoloa Stream drainage in the west.

The two communities, Waimea (Kamuela) and Honokaa, lie within the project. They are 58 miles and 43 miles, respectively, from Hilo, the county seat and economic center of the Big Island. Waimea is a rural farming and ranching community. Honokaa is predominantly a sugar plantation community.

## CLIMATE

The climate of the project area is characterized by moderate variations in annual temperature, and significant variations in average annual rainfall. The average annual temperature varies from 75°F at the coastline to 40°F on the upper slopes of Mauna Kea. The average annual rainfall varies from over 175 inches in the Kohala Mountains to 20 inches south of Waimea. This variation occurs in a distance of about 4 miles. Rainfall is not uniform throughout the year. There are dry periods that last from 30 to 90 days or more.

## WATER RESOURCES

Most surface water in the project area originates on the higher slopes of the Kohala Mountain. Streams are perennial at their headwaters. Most of the flow in these streams is either diverted into lined ditches, tunnels, pipelines, and reservoirs or disappears into faults or lava tubes before reaching the coast.

The Upper Hamakua Ditch collects the water from several Kohala Mountain streams which begin in the wet, scrub-forested watershed north of Waimea. The major streams, Kawainui, Kawaiki, and Alakahi, contribute most of the flow, with Waima and Koiawe streams providing lesser amounts. The Upper Hamakua Ditch supplies the Waimea and Puu Pulehu reservoirs operated by the Department of Land and Natural Resources (to be transferred to the State Department of Agriculture on July 1, 1989). This water is the primary supply for the Waimea Irrigation System (WIS).

Waikoloa and Kohakohau streams provide water to the domestic water reservoirs operated by the County of Hawaii, Department of Water Supply (DWS).

The Parker Ranch water system diverts surface water from the upper reaches of several Kohala mountain streams and supplies water through pipelines to storage tanks and reservoirs for their livestock operations located south and southeast of Waimea. Other livestock operations rely principally on DWS water or on private catchment facilities located on the northern slope of

Mauna Kea. During water-short periods these livestock operations are the first to be placed on restriction from the DWS system.

Ground water as a potential source of water supply has been explored. In 1964, the State Department of Land and Natural Resources conducted drilling on the Kohala Mountains slope. The test hole, at the 3,600-foot elevation, revealed that there was no perched or dike-confined water at a depth of 930 feet. However, presence of dike-confined or perched water on the northern slopes of Kohala Mountain is evidenced by discharges from the canyon walls of Waipio Valley.

### GEOLOGY AND SOILS

The island of Hawaii, the largest in the Hawaiian group, was built by five major volcanoes. Kohala Mountain, a long-extinct shield volcano, forms the north end of the island and the upper watershed.

The Waimea Plain area of the watershed was also influenced by eruptions and associated deposits from Mauna Kea immediately southeast of the project. While Mauna Kea has not been active within historical times, it has constructed a large part of the island. The lava flows, ashfalls and cinder deposits originating from this volcano are the parent materials for many of the soils in the watershed. Volcanism continues to occur on the island of Hawaii, most notably at Mauna Loa and Kilauea Volcanoes to the south of the watershed area.

Ground water conditions within the watershed are extremely variable because of the nature of the volcanic bedrock. Lava flows in the upper watershed (Kohala Mountain area) frequently contain highly fractured zones or lava tubes. These conditions provide extremely high permeabilities, often reaching the point where entire stream flows discharge into the ground water system. Other sections of the watershed underlain by ash deposits are very slowly permeable.

The seismic environment of the watershed is characterized by frequent earthquakes. Over 400 events exceeding magnitude 4.0 have been recorded within a 300-mile radius. These events are believed to be related to the volcanic activity of the island and surrounding area.

The Amalu and Kahua soils of the uplands are strongly acidic, highly permeable, and poorly drained. They consist predominantly of mucky silt loam underlain by clay loam. In parts of the watershed, the soil and subsoil lie over a thin, discontinuous sheet of ironstone. The ashy gray Amalu soil is formed in place from deposits of the Hawi volcanic series. The Kahua soils near the head of Waima canyon are similar to the Amalu soils, but are dark brown instead of ashy gray.

The major agricultural soils in the Waimea area are Kikoni silt loam, very fine sandy loam, and Waimea very fine sandy loam. These are deep, well drained soils on nearly level uplands. They are formed in volcanic ash. The water erosion hazard is none to slight while the wind erosion hazard is moderate. A primary difference between these two soils is the effective rooting depth which is 40 to 60 inches for Waimea and 60 inches or more for Kikoni.



## VEGETATION AND WILDLIFE (2)

### Open Plains - Pastureland

This area includes the broad sweep of country between the Kohala Mountains and Mauna Kea and is by far the largest segment of the watershed. Original forest and shrub grassland has been converted, by 150 or more years of grazing and pasture management, to primarily kikuyu grass pastures. Vestiges of forest types remain, especially along the lower fringes of the Hamakua forests. Wildlife values are moderate, largely because of the adaptation of exotic (introduced) species to the grass and shrub lands. Introduced game birds include quail, pheasants, doves, and francolins. Several native shrubs such as the aalii, akia and prickly poppy remain because they are generally unpalatable by cattle. Grassland is especially suited to nesting and foraging by the pueo.

### Forested Area (2)

The forested area of the project generally reflects surviving elements of pristine vegetation. Those lands presently under state jurisdiction and zoned conservation in the Kohala Forest Reserve consisting of 34,800 acres, contain the only intact forest ecosystems. The project watershed contains 7,584 acres of the Kohala Forest Reserve.

A high rainfall regime, upland location, and boggy conditions in the flatlands combine to form a prime water source in the Kohala Mountain watershed. The lower segment of this forest has been disturbed by pipelines, dams, and a ditch system for water collection. Plantings of eucalyptus, sugi pine, hoop pine, and alder are mainly along the fringes of this forest. Vegetation along the Upper Hamakua Ditch is primarily exotic (introduced). Various grasses, herbs, ferns, sedges, rushes and ginger dominate. Ginger is common in places on the Upper Hamakua Ditch trail.

Feral pigs are the only large mammal present. They disturb the forest floor by rooting and consuming plants. The presence of the elepaio, apapane, amakihi, and widely distributed native forest birds, indicates basic needs are met in this specialized ecosystem where ohia, olapa, and sphagnum predominate. Many of these forest plants occur only in Hawaii, thus making this area very sensitive ecologically.

Hawaiian hoary bat, Hawaiian hawk, and Hawaiian duck are the only endangered species known in the project area. Endangered birds and the Hawaiian bat could range throughout the UHD project area but primarily in the intact native forest communities. Bats range widely while feeding on insects, as does the Hawaiian hawk during feeding activities; thus, they are not restricted to the forested portion of the project area. In recent years, the Hawaiian duck has been reintroduced to the Kohala Mountains because there is suitable forested wetland habitat in the forest preserve. Members of this species might use the slower sections of the UHD for loafing or the natural stream section in segment 4 (Griffin 1983).

An area to the north and west of the Upper Hamakua Ditch is in the process of being designated as the Pu'u o 'Umi Natural Area Reserve by the State of Hawaii, Department of Land and Natural Resources (DLNR). The Upper Hamakua Ditch, however, was never considered for inclusion in the Natural Area Reserve.

#### CULTURAL RESOURCES

The project area is rich in cultural and historic resources. The early land use pattern in the Waimea area was subsistence farming. Changes in this pattern started in the latter half of the 16th century and culminated with a type of "subsistence-support" farming. Eventually this changed again in the early historic period to a "subsistence-trade" form. Changes in economic pursuits led to changes in land use as the 19th century progressed. New economic activities, such as the cutting of sandalwood, were significant in the overall effect on cultural and ecological change and land use.

Cattle raising in the Waimea area brought major changes in land use. Once established, and aided by an initial ten-year ban on the hunting or taking of cattle, the feral cattle multiplied rapidly. For some two to three decades after the lifting of the protective ban, paniolos were employed to hunt down the wild cattle and take them to market. Merchants at Kawaihae added cattle to other products being exported in the early part of the last century. Cattle raising followed the period of hunting and, by the middle of the 1800's, the Waimea region gained its preeminent position as the center of the industry.

Many overall changes were sustained during this period of human interaction with the environment, especially during the last 200 years. Native vegetation was severely and negatively affected through the wholesale cutting of sandalwood and the collecting of pulu. More widespread damage to the native flora was caused by the introduction of exotic animals that quickly multiplied, spread, and became feral. Development of the cattle industry encompassing large portions of the land area added to these ecological-cultural changes.

A cultural resources literature search and a survey of potential project impact areas was obtained from a consultant by contract. Two potential reservoir locations (approximately 15 acres) and a 56% sampling inventory of the proposed agricultural expansion areas were given on-ground investigation (see fig. 2, Spencer, 1989). One historic district, the Waimea Agricultural System, was identified adjacent to the proposed Lalamilo Addition (see fig. 3, Spencer, 1989). The Waimea Agricultural System, a subdistrict of the Kohala Agricultural System, consists of a complex of prehistoric agricultural and residential districts. Cattle control features are a part of the latter 1800's alterations to the district.

A proposed pipeline corridor for the livestock water distribution system was investigated in-house by Alan C. Spencer, Cultural Resources Specialist. The investigation consisted of an on-ground inspection of proposed lines and an analysis of aerial photographs of areas that might be affected by livestock management programs. Most of the proposed corridors will be placed along existing roads. No cultural resources were identified. Based on conversations with the State Historic Preservation Officer's staff, the aerial

photography analysis, and the on-ground reconnaissance, more intensive investigations were not warranted.

The Upper Hamakua Ditch was constructed in the early 1900's by the Hawaiian Irrigation Company to tap the Kohala Mountain water supplies for fluming cane to the Hamakua District. Improvements to the system were carried out from 1915 to 1922. During the latter period, the ditch system was extended to the Puu Pulehu Reservoir. On August 1, 1948, the Hawaiian Irrigation Company surrendered the license for the ditch system to the government. When Hawaii attained statehood, the responsibility for the Upper Hamakua Ditch and 4,547 acres of the Kohala Forest Reserve was absorbed by the DLNR. Originally, much of the ditch was lined with concrete rubble masonry and concrete plaster.

Archaeological sites known to exist in the project area consist primarily of stone alignments, walls, habitation sites and platforms, and various mounds. These sites are those which have been brought to the attention of cultural institutions and do not represent a complete inventory. Historical sites were the subject of a fairly intensive investigation during the early 1980's; however, only specific areas have been intensively surveyed for archaeological sites. (2)

#### ECONOMIC CONDITIONS

Agriculture is the major source of employment in this rural area. The primary enterprises in the watershed are irrigated truck crops, livestock production, and sugar cane. Self-sufficiency, to the extent practical, is the State Department of Agriculture's goal.

According to Statistics of Hawaiian Agriculture - 1986, the State of Hawaii produces approximately 36 percent of the fresh market vegetables consumed in the State. The remaining 64 percent is imported, primarily from California. The climate and fertile soils in the area make the area ideal for growing truck crops, when irrigated. About 800 acres in the Waimea (Kamuela) area are devoted to such crops as broccoli, cauliflower, chinese cabbage, head cabbage, celery, head lettuce, romaine lettuce, burdock and daikon. Truck crop operations are concentrated on farmplots in the Hawaiian Home Lands, Puukapu and Lalamilo Agricultural Park areas. Three to five crops are grown per year.

Also included in the watershed are approximately 12,200 acres of caneland. The caneland that is irrigated receives its irrigation water supply from sources other than Upper Hamakua Ditch.

Livestock production is another important agricultural operation in the watershed area. Approximately 119,000 acres are devoted to livestock production, primarily cattle. A large portion of the 225,000-acre Parker Ranch is located in the watershed. The 1986 market supply for Hawaiian-grown beef and veal is 31 percent. The remainder comes from the mainland U.S. (54 percent) and foreign sources (15 percent).

Waimea (Kamuela), a rural farming and ranching community, is the major population center in the watershed. The population is approximately 1,700, according to the State Department of Business and Economic Development and the Census Bureau. The town of Waimea (Kamuela) has developed around the intersection of the Mamalahoa Highway and the Waimea-Kawaihae Road. A fairly

large shopping and business center attests to urban growth. Other population centers are Honokaa and Paauilo. Their estimated populations are 2,000 and 780, respectively, according to the State Department of Business and Economic Development and the Census Bureau.

# PROBLEM AND OPPORTUNITY IDENTIFICATION

The major resource problem in the project area is insufficient agricultural water caused by inadequate collection, storage and distribution facilities. Because of this condition, the irrigation and livestock water needs of the area cannot be met and agricultural development of the watershed is limited.

Excessive seepage loss of agricultural water is occurring from the Upper Hamakua Ditch. This is the result of structural deterioration of ditch lining, tunnel and flume sections. The ditch was constructed in the early 1900's and improved in 1915-22. The ditch has more than outlived its expected life. Losses also occur in the natural stream channel section through discharge into the porous lava flows.

Existing storage capacity for agricultural water is insufficient to carry irrigation operations through the frequent dry periods. The Puu Pulehu reservoir cannot be utilized to full capacity due to seepage losses.

The existing agricultural water distribution system limits the effective use of available crop and pasture lands. The extent and capacity of the system does not provide the service required to effectively manage irrigated croplands and pasturelands. Irrigation of additional cropland is precluded due to the limits of the present system.

Under present conditions, livestock water is drawn from the domestic water system by many ranchers. This has a significant negative impact upon the domestic supply during drought periods. Under extreme conditions, the domestic system is overdrafted and water is then trucked in for livestock. Occasionally untreated water has been used for domestic purposes, posing a serious health hazard.

Opportunities exist for watershed problem resolution through improved agricultural water management. The efficiency of the Upper Hamakua Ditch can be improved through the construction of a by-pass pipeline around the unlined channel and the repair of deteriorated sections.

Field investigations confirmed the opportunity for additional reservoir sites to store more water diverted during periods of excess stream flow. In addition to the increased storage, gravity pressure delivery could be utilized to significantly reduce the amount of pumping required to provide water to cropland and pasture areas.

Delivery system additions could extend the agricultural water service to additional croplands and reduce the reliance on the domestic system for livestock water by 40 million gallons.

A tabulation of the problems, opportunities and effects is presented in Table A.

TABLE A - PROBLEMS AND OPPORTUNITIES  
 Waimea-Paauilo Watershed, Hawaii

PROBLEMS	CAUSES	EFFECTS
Frequent water-short periods for irrigated crops	A) Inadequate storage B) Inefficient collection system C) Less than optimum irrigation application efficiencies	A) Frequent loss of crop production B) Loss of income C) Unstable crop production adversely affects marketing patterns D) Creates instability in the labor market
Frequent water-short periods for livestock	A) Inadequate collection system B) Inadequate storage C) Inadequate distribution system	A) Forced reduction in herd size B) Increased water supply costs C) Loss of income D) Need for beef imports <u>1/</u>
Agricultural demand aggravates domestic water shortages	A) Inadequate storage B) Excessive demand on domestic system by agricultural uses C) Inadequate distribution system	A) Domestic use of nonpotable water in extreme situations
Shortage of irrigated cropland	A) Inadequate water supply	A) Loss of farm income B) Need for crop imports <u>1/</u> C) Suppresses economy

1/ State goal is to become agriculturally self-sufficient.

### FREQUENT WATER-SHORT PERIODS FOR IRRIGATED TRUCK CROPS

The important vegetable-producing area at Waimea has been plagued by droughts of varying intensity since the 1960's. All of this area is serviced by the Waimea Irrigation System, operated by the Division of Water and Land Development (DOWALD), a subdivision of DLNR. In April 1983, water supplies at Waimea reached record lows. As a result, farmers lost mature crops and reduced new plantings as water was rationed. Subsequent rains replenished reservoirs and only occasional, minor restrictions on irrigation occurred the rest of the year. In September 1984, water levels again became critically low. By November, some farmers were allotted only 1,000 gallons per day. Toward the end of November, heavy rains returned and water restrictions were lifted. For a listing of noteworthy droughts, see Appendix B.

These and similar water shortages cause yield and quality reductions in vegetable crops. Farm income is thereby reduced. This income reduction is estimated at \$1,073,600 annually. Marketing patterns are also adversely affected.

### FREQUENT WATER-SHORT PERIODS FOR LIVESTOCK

Livestock production is limited by the supply and distribution of stockwater in the watershed area. During droughts, cattle must be moved to other areas, limiting the efficient use of pastures. In extreme situations, water must be hauled in trucks to provide for livestock. In the severe drought of 1981, 40 head of cattle died. Without additional dependable water supply, ranchers cannot increase herd sizes or implement intensive grazing methods. This increases Hawaii's dependence on mainland and foreign beef imports.

### AGRICULTURAL DEMAND AGGRAVATES DOMESTIC WATER SHORTAGES

Water for livestock in the watershed area comes from three main sources: the county water system, the Parker Ranch system and private catchment-storage systems. Using the county water system for their supply is more expensive to the ranchers than using agricultural water. Ranchers must pay about \$1 per thousand gallons, as opposed to the current charge of about ten cents per thousand gallons for agricultural water. The increased water cost for area ranchers is estimated at \$36,000 annually. The demand for water for the recently-awarded DHHL home sites is increasing. In the severe drought of 1981, the supply of domestic water was so low that untreated agricultural water was distributed into homes. Water for drinking and cooking was supplied by truck. Demands for water for livestock aggravated an already serious situation.

### SHORTAGE OF IRRIGATED CROPLAND

As stated previously, self-sufficiency, to the extent practical, is the State Department of Agriculture's goal. Because of an inadequate water supply in the Waimea area, the Waimea Irrigation System (WIS) is limiting the number of hookups and hence the number of acres of cropland. The proposed Lalamilo Agricultural Park Addition is waiting for the extension of the delivery system.

Until recently, DHHL would not lease homestead lots that did not have basic services in place. Homestead lots include areas for homesites and irrigated cropland. From 1984-86, DHHL undertook a major initiative to accelerate the awarding of homestead leases to native Hawaiians. Most of the lots awarded did not have the basic infrastructure in place, such as roads, electricity and water. DHHL has recommitted itself to a major capital improvements project program to provide the necessary infrastructure improvements and to award additional homestead lots.



# INVENTORY AND FORECASTING

## SCOPING OF CONCERNS

A scoping process was used to identify the concerns that might affect the selection of alternatives or be affected by project actions. Concerns may be significant because of public interest, technical or scientific interest, and/or legal status. The public, agencies of government, and the scientific community were involved in meetings to carry out the scoping process. Table B displays the level of significance of identified concerns as developed by the scoping process.

Concerns that were scoped out as not significantly affecting or being affected by any type of project action included: erosion, flood hazard, surface water quality, ground water quality, visual effects, recreation, and irrigation efficiency.

A brief discussion of each of the more significant concerns identified in Table B and their likelihood of being significantly affected by the formulation of alternatives follows:

### Prime Farmland - Truck crops

Increased water supply could help reduce drought effects on existing cropland.

### Crop Production

Yields could be maintained and increased by providing adequate irrigation water for the existing truck crops. New irrigated land may increase agricultural production. The State of Hawaii's objective is self-sufficiency in agriculture to the extent possible. Quality of crops could also be improved.

### Economics

Positive economic effects can be expected from increased reliability of irrigation water supply for existing cropland, new irrigated cropland, and distribution of adequate livestock water.

### Wildlife Habitat

Planned activities in the wildlife habitat will employ techniques to minimize adverse effects.

**TABLE B - EVALUATION OF IDENTIFIED CONCERNS**  
**Waimea-Paauilo Watershed, Hawaii**

Economic, Social, Environmental and Cultural Concerns	Degree of Significance to Decision Making <sup>1/</sup>	Remarks
Prime Farmland - Truck crops	High	Retain - include new land
Crop Production	High	Increase
Economics	High	Cost to individuals, new farms units
Erosion	Low	
Flood Hazard	None	
Wildlife Habitat	Medium	Effects on native plants and animals
Threatened and Endangered Species	Medium	Include state candidate species of plants
Surface Water Quantity	High	Inadequate supply and storage
Surface Water Quality	Low	
Ground Water Quantity	High	Possible supply source
Ground Water Quality	Low	
Forest Resources	High	Effects on the Kohala Forest Reserve
Air Quality	None	
Visual Effects	Low	Little effect
Recreation	None	
Irrigation Efficiency	Low	
Livestock Water	High	Inadequate supply and distribution system
Cultural Resources	Medium	No effect
Social Effects (Native Hawaiian & Limited Resource Farmers & Ranchers)	Medium	Differential project effects on ethnic groups
Urbanization - Land use Changes	Medium	Loss of agricultural land

- <sup>1/</sup> High - Must be considered in the analysis of alternative solutions  
Medium - May be affected by some alternative solutions  
Low - Consider, but not too significant  
None - No significance to decision making, need not be considered in analysis

### Threatened and Endangered Species

Planning will consider and avoid adverse effects on threatened, endangered or candidate species.

### Surface Water Quantity

Improvements to the Upper Hamakua Ditch will improve the collection and delivery efficiency of existing surface water. Repairs to Puu Pulehu Reservoir will sustain overall system storage capacity to help offset droughts. Additional new storage could satisfy current shortages on existing cropland, new cropland, and livestock water requirements.

### Ground Water Quantity

Ground water investigations for this area are planned. If sufficient quantities are found, this new source of water may have a significant impact on development of the area, primarily for municipal and domestic water.

### Forest Resources

Any design, layout, and construction in the Forest Reserve will be done to minimize damage to the Forest Reserve.

### Livestock Water

Any collection, storage, and distribution system for livestock water may allow more water to become available for domestic purposes.

### Social Effects

Because of the DHHL land in the watershed, any project activity may impact native Hawaiian ranchers and farmers.

### Cultural Resources

Any design, layout, and construction will avoid identified cultural resources.

### Urbanization

Irrigated cropland lost to urbanization can be replaced by shifting the irrigation water to suitable, non-irrigated areas.

### EXISTING RESOURCES

The area adjacent to Waimea has the necessary resources to help solve the state's deficit production of vegetables and beef when adequate agricultural water is available.

Rainfall on Kohala Mountain provides enough runoff to supply the existing and projected agricultural water requirements if adequate collection, storage, and distribution improvements are installed.

The Upper Hamakua Ditch is the collection and transportation system for the existing irrigation system (Figure 1). The ditch was constructed of concrete rubble masonry and concrete plaster and has outlived its expected life. Presently, the collection and transportation efficiency ranges from 50 to 75 percent for most of the water year. However, during periods of low flow, efficiency drops to 35 percent or less.

There are two existing reservoirs in the irrigation system. The Waimea Reservoir is lined and has a capacity of 60 MG (51 MG usable). The first phase rehabilitation of the Puu Pulehu reservoir to store 40 MG is currently under construction. A 70 MG extension (110 MG total) is planned. These two reservoirs will then be able to provide 161 MG of water for agricultural uses.

Presently, there are 802 acres of cropland being irrigated in the Lalamilo, DHHL, and Puukapu farm lots and homestead units. The soils are primarily silt loam and very fine sandy loams in capability classes I through III. When irrigated, 86 percent of the cropland soils are classified as prime farmland. The irrigation distribution system for these acres is minimally adequate. The following table gives a listing of the various major crops grown in the Waimea area and their average yields per harvested acre.

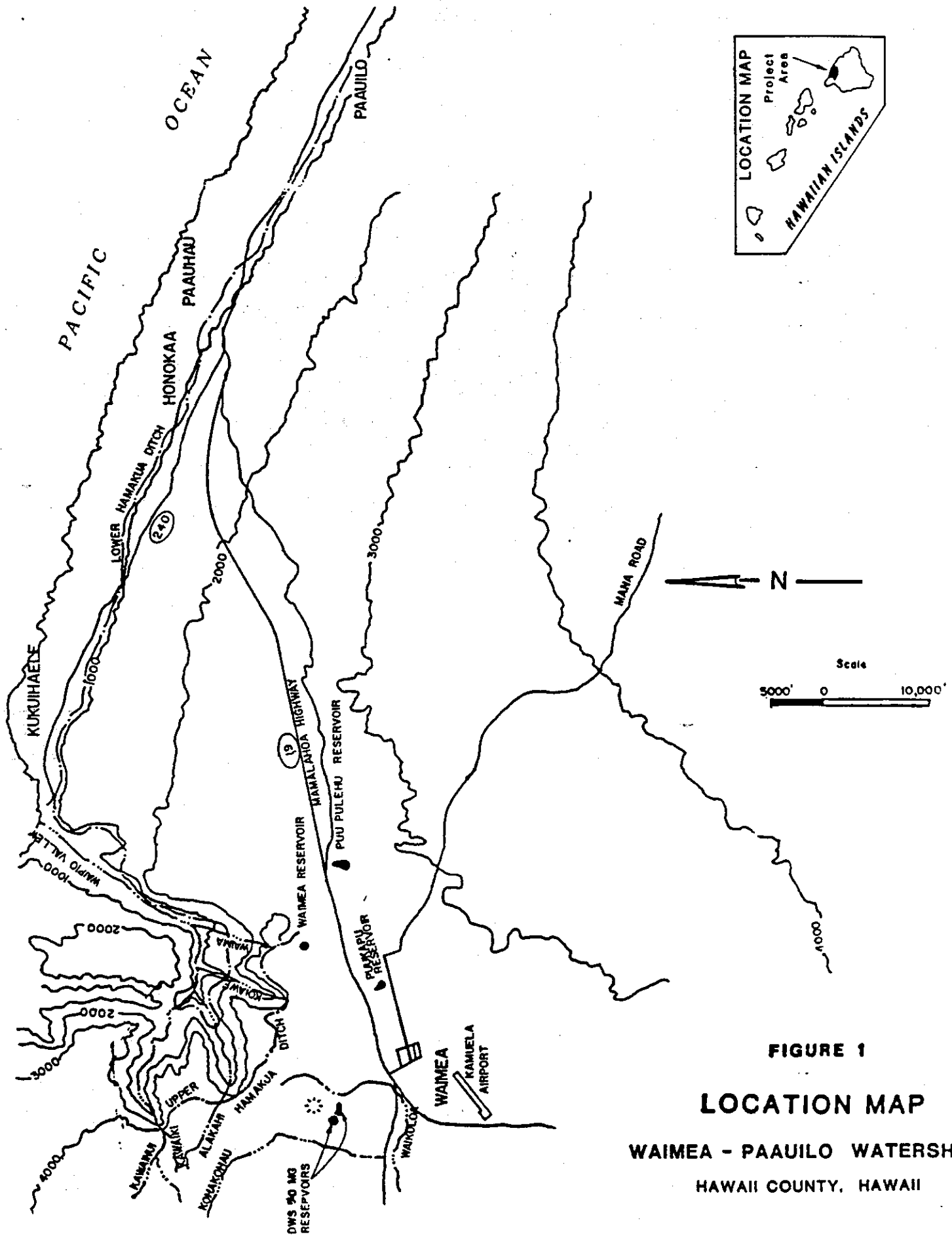
TABLE C - MAJOR CROPS AND YIELDS  
Waimea-Paauilo Watershed, Hawaii

Crop	1986 Yield (lbs./harvested acre)
Chinese Cabbage	20,600
Head Cabbage	20,100
Celery	25,400
Head Lettuce	8,900
Romaine	11,700
Burdock	17,000
Daikon	14,600

Source: Statistics of Hawaiian Agriculture - 1986

The Department of Water Supply (DWS), County of Hawaii, provides water to the private and DHHL ranch lots for household and livestock use. Delivery is limited by meter size and the users feel it is too expensive. During periods of drought, the livestock water is the first use to be curtailed. The domestic system is now serving 11,600 animal units on about 25,000 acres. This compares to the total of 43,800 animal units in the project area on 118,600 acres of pastureland.

The DHHL owns 21,700 acres in the project area. The inadequate nature of the present agricultural water supply and distribution system serving this area is a major factor to be considered in developing the land for agricultural uses. Although farm and pasture lots had been made available in the 1984-86 acceleration initiative, the land cannot be fully used for agriculture until water is available.



**FIGURE 1**  
**LOCATION MAP**  
**WAIMEA - PAAULO WATERSHE**  
**HAWAII COUNTY, HAWAII**

A botanical survey of forest resources identified nine plant communities in the forested area along the Upper Hamakua Ditch segments (Table D and Appendix C). Six of these communities are dominated by native species. Portions of four represent excellent examples of intact native communities, two of which are particularly unique. Intact, weed-free plant communities are rare in Hawaii. Detailed descriptions of the nine plant communities are presented in Appendix C(3).

#### FORECASTED CONDITIONS

Changes are expected to occur in the watershed without project implementation. A forecast of these changes is presented in this section.

The existing water collection and storage system will be repaired and maintained. The first phase of improvements to the Upper Hamakua Ditch and Puu Pulehu Reservoir is currently under construction by DLNR. Those improvements including the relining of the Alakahi (segments 2, 3, and 4) and Koiawe (undesignated) sections with fiber-reinforced cement-mortar and the rehabilitation of the Puu Pulehu reservoir to store 40 MG, are scheduled for completion in March, 1990. Planned future improvements include the repair of other sections of the UHD and 70 MG storage extension of Puu Pulehu Reservoir. No additional storage is planned and water shortages are expected to continue.

Irrigated cropland acreage is expected to expand by approximately 75 acres in the existing irrigated areas based on applications on file with Waimea Irrigation System. Most of this expansion will occur as inclusion parcels are brought into production in the Lalamilo, Puukapu, and DHHL areas. No further increase is projected due to constraints imposed by the collection and storage facilities. Crop losses during drought periods are expected to continue. Forecasted cropland area is displayed on table E.

TABLE D - FOREST PLANT COMMUNITIES IN UHD PROJECT AREA (3)  
 Waimea-Paauilo Watershed, Hawaii

COMMUNITY TYPE	SEGMENT					
	1	2	3	4	5	6
1. Open scrub vegetation comprised of mixed native species and much exposed <u>Sphagnum palustre</u> .		X				
2. Closed scrub vegetation comprised of mixed native species, or often dominated by <u>Metrosideros polymorpha</u> var. <u>glaberrima</u> and with emergent <u>Cheirodendron trigynum</u> .	X	X	X			
3. Closed forest dominated by <u>Metrosideros polymorpha</u> var. <u>glaberrima</u> , with native shrubs and ferns.	X		X	X		
4. Closed forest dominated by <u>Metrosideros polymorpha</u> var. <u>strigosa</u> with dense ground cover of <u>Sphagnum</u> .			X			
*5. Open canopy shrub community with mixed native species, ferns and matted ferns and with exotic understory.						X
*6. Open to closed canopy forest to 12 <sup>+</sup> m dominated by <u>Metrosideros polymorpha</u> var. <u>macrophylla</u> , and with an understory of exotic kahili ginger.						X
*7. Stream community.						X
*8. Forest to 15 <sup>+</sup> m of exotic trees with exotic species dominating the understory.	X			X	X	
*9. Exotic herbaceous and grass community found along roadsides, trails and in the pasture.	X	X	X	X	X	X

\* Community with exotic species as a major component.

TABLE E - FORECASTED CROPLAND  
Waimea-Paauilo Watershed, Hawaii

CONDITION AND LOCATION	NUMBER OF LOTS	TOTAL AREA (acres)	CROPLAND AREA 1/ (acres)	NET IRRIGATED AREA 2/ (acres)
<b>PRESENT</b>				
Puukapu Farmlots	21	370	230	161
Lalamilo Farmlots	28	670	443	310
DHHL Farmlots	16	273	129	90
<b>TOTAL</b>	<b>65</b>	<b>1,313</b>	<b>802</b>	<b>561</b>
<b>FUTURE WITHOUT PROJECT</b>				
Puukapu Farmlots	21	370	285	200
Lalamilo Farmlots	28	670	443	310
DHHL Farmlots	16	273	149	105
<b>TOTAL</b>	<b>65</b>	<b>1,313</b>	<b>877</b>	<b>615</b>

- 1/ Cropland area is about 57% to 77% of total area to allow for field roads, windbreaks, farmsteads, rock piles, etc.
- 2/ Net irrigated area is 70% of cropland. It is the area irrigated at any given time. It allows for the non-irrigated periods between crops and during harvest.

The average annual gross irrigation requirement for the future without project condition is 2.8 mgd. This is for an estimated area of 877 acres of irrigated cropland (615 ac. net). The peak daily gross irrigation requirement is 4.70 mgd.

Cattle ranching will continue to be the principal activity on pasture land. Stocking rates and range management will be constrained by the water supply system. Water rationing and emergency livestock water hauling will continue during drought conditions. Damage to the pasture resource base caused by over-grazing near water sources will continue to be a problem. Import levels of beef will remain at present levels or increase.

Applications by native Hawaiians for additional farm and pasture lots are expected to continue, but without water these units will not become fully utilized. Expansion of homestead programs will increase demands on the existing available water supply.

Residual forest trees, such as ohia, will continue to disappear in the face of little or no reproduction. Remaining shrub types will survive locally.

Plant community dynamics in forested areas are not sufficiently understood to make projections with absolute confidence as to actual disturbance effects. However, when native Hawaiian plant communities are directly impacted, the effect is irreparable. Any initial disturbance to areas presently dominated by native species provides habitat for the establishment of weedy species. Native species or communities in the areas to be impacted will consequently be replaced by a community dominated by exotic species.



Native communities did seem to recover to some extent following the initial ditch construction in the early part of this century as evidenced by the establishment of *Clermontia* spp. and *Lobelia hypoleuca* along the sides of the ditch. That recovery, however, occurred in the absence of many aggressive weedy species which now are present in the area.

Two sources of disturbance to the natural communities are present in this area which are beyond the effects of the proposed project. They are feral pigs and birds. Feral pigs cause continued ground disturbance which facilitates weed invasion, and further adversely affect the watershed by contributing to siltation. Bird-dispersed weedy species now present in the area, such as Kahili Ginger, will continue their invasion of relatively intact native vegetation.

If DOWALD used construction methods similar to past repair work, DOWALD modifications to segments 1, 2, and 3 of the ditch system will affect an estimated 4.3 acres of existing plant communities. In segment one, improvement activities will affect 3.2 acres of Community type 2 (Closed scrub vegetation comprised of mixed native species). In segment two, activities will affect less than one-tenth of an acre of Community type 1 (Open scrub vegetation comprised of native species and much exposed Sphagnum), and only one-half of an acre of Community type 2. In segment three, improvements will affect four-tenths of an acre of Community type 2, and one-tenth of an acre of Community type 3 (Closed forest dominated by Metrosideros polymorpha var. glaberrima with native shrubs and ferns).

Recent increases of sand grouse and black and gray francolins populations suggest these new resources will be permanent additions to game bird species.

# FORMULATION OF ALTERNATIVES

In the planning process, alternative plans were formulated to make a net contribution to national economic development (NED) with minimum effects to environmental quality. These alternative plans consisted of measures formulated to alleviate the specific watershed problems that were identified.

The scoping process described earlier was used in the conceptual phase of formulating alternatives to assure consideration of all measures, strategies and programs that might accomplish the Sponsors' objectives. These alternatives were not limited to those directly implementable under PL-566. Consideration was also given to the cooperative role of local, county, state, federal, and nongovernment interests in the implementation of alternatives. Alternative plans including the future without project plan (FWO) and the National Economic Development plan (NED) were developed and evaluated using this process.

As planning progressed the various plans were reevaluated and compared, and certain plans were identified as candidate plans. Candidate plans are those that could be selected by the Sponsors. The candidate plans were compared to the future without project, and the rationale was established for selecting the recommended plan.

## FORMULATION PROCESS

The major objective in formulating alternative plans is to solve identified water and land resource problems. To begin the formulation process, brainstorming and similar interdisciplinary problem-solving techniques were used to develop a list of TREATMENTS OR ACTIONS to solve the problems of water short periods and inadequate distribution systems for both crops and livestock. Development of the list involved the public, various local, county, state, and federal agencies, and special interest groups. These treatments or actions were evaluated for their effectiveness in water conservation and their environmental effects. The results are listed in Table F.

Next, combinations of treatments or actions were brought together incrementally to formulate alternative plans. PLANNING CONSIDERATIONS FOR ALTERNATIVES were used to guide the development of plans. Improving the efficiency of the Upper Hamakua Ditch was the first increment of all alternatives because it provided the maximum increase in water supply.

Detailed planning refined the magnitude of the problems and determined the incremental physical effect that various measures would be expected to have on the problems. The likely environmental effects of each measure were considered during the entire planning process. Areas where adverse effects might occur were noted and formulation for avoidance was begun.

**TABLE F - TREATMENTS OR ACTIONS AND EXPECTED RESULTS**  
**Waimea-Paaulo Watershed, Hawaii**

PROBLEMS and/or OPPORTUNITY	TREATMENTS/ACTIONS	RESULTS
Frequent water short periods for irrigated crops	A) Increase onfarm application efficiency B) Increase collection system efficiency C) Construct additional water storage facilities D) Improve distribution system	A) Increased efficiency of crop production B) Increase net farm and local income C) Stabilize production and marketing patterns
Frequent water short periods for livestock	A) Construct additional water storage facilities B) Improve distribution system C) Increase collection system efficiency	A) Increase cattle herd size B) Reduced water costs C) Increased net farm and local income D) Reduce income loss risk E) Reduce quantity of beef imported
Water short periods create domestic shortages	A) Construct additional water storage facilities B) Separate livestock water system will reduce demand on the domestic system C) Increase collection system efficiency	A) Reduced need to utilize untreated agricultural water for domestic purposes
Shortage of irrigated cropland	A) Increased water supply will make it possible to increase number of acres irrigated	A) Increase net farm and local income B) Increase employment C) Reduce quantity of agricultural commodities imported

## PLANNING CONSIDERATIONS FOR ALTERNATIVES

Following the identification of problems, the agricultural water supply system was evaluated. The USDA-SCS cooperative river basin study, Hamakua Area Agricultural Water Study (HAAWS) (March 1982), originally identified the planned agricultural water project. It provided useful information and guided conception of preliminary solutions. The evaluation considered primary components of the agricultural water supply system: collection, storage, and distribution. The South Kohala Water Supply Study (November 1984), a reconnaissance-level study prepared by the U.S. Army Corps of Engineers, investigated water supply problems and opportunities of the South Kohala and Hamakua districts. It identified the Upper Hamakua Ditch and its tributaries as a source of agricultural water. Report R-77, Investigation and Evaluation of the Upper Hamakua Ditch (June 1986), was provided by DLNR and future improvements were identified.

Reservoir storage requirements varied with the reliability of the water supply and DLNR plans for improving the Upper Hamakua Ditch. Engineering components were developed with varying levels of improvement to the Upper Hamakua Ditch. Improvements to the collection system increases the volume of water for storage and reduces the total storage volume required.

Investigations were made for potential reservoir locations near Puu Ohu, the three existing Waikoloa reservoirs (domestic) and the existing Waimea reservoir (agricultural). The Puu Ohu site was found to be impractical due to foundation condition and reservoir clearing requirement. The Waikoloa site was undesirable because of costly rock excavation. Modification of the existing Puukapu and Puu Pulehu reservoirs was evaluated. The potential storage increase was insufficient to meet project needs.

Additional sites were studied near Puu Io and Hauani Gulch. The most suitable reservoir site was located near the existing Waimea 60 MG reservoir

Livestock and irrigation water delivery systems were evaluated for various levels of participation. Irrigation and livestock water is supplied to the distribution system from the collection and reservoir storage systems. Distribution costs are dependent on the area to be served and location of storage reservoirs. Measures which would cause adverse impacts in the forest reserve were avoided to the extent possible.

## NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN FORMULATION

The Economic and Environmental Principles and Guidelines for Planning Water and Related Land Resources Implementation Studies (P&G) require the identification of a plan that reasonably maximizes national economic development. By definition, the NED alternative is the one plan that maximizes net benefits. For the purpose of the incremental analysis, four evaluation units were considered.

1. Existing irrigated truck crop areas
2. Lalamilo Agricultural Park expansion area
3. Hawaiian Home Lands expansion area
4. Livestock water distribution system areas

A single reservoir site was selected. The size of the proposed Waimea II Reservoir was then determined by finding the storage volume with the least cost per million gallons. The reservoir size was thus determined to be 133 MG.

Table G shows the incremental analysis. Average annual costs per acre for the Upper Hamakua Ditch and Waimea II Reservoir are apportioned over the total acres served. Otherwise, a true picture of the incremental costs for the irrigation distribution systems for the Lalamilo Agricultural Park Expansion and Hawaiian Home Lands Expansion and the livestock water distribution system would not be possible. Average annual cost includes the amortized cost of installation, using a 50-year project life and an interest rate of 8.625 percent, plus the average annual cost for operation, maintenance and replacement.

The NED alternative for the Waimea-Paauiilo Watershed Plan included the following features:

1. Improvement to the Upper Hamakua Ditch.
2. Reservoir storage for irrigation water.
3. Irrigation water distribution system.

Elements for providing livestock water were found to be not feasible.

TABLE G - INCREMENTAL ANALYSIS OF THE NED PLAN  
Waimea-Paauiilo Watershed, Hawaii

Description of Increment	No. of Acres	Average Annual (dollars)		
		Cost per acre	Benefits per acre	Net Benefits per acre
UHD Improvement and Waimea II Reservoir	877	756	1,224	468
Irrigation Water Distribution System - Lalamilo Ag. Park Addition	163	720	2,161	1,441
Irrigation Water Distribution System - DHHL Additions	200	943	1,617	674
Livestock Water Distribution System	22,800	7.00	5.25	-1.75

Price base: 1987

## EVALUATION OF ALTERNATIVE PLANS

As a result of the plan formulation process described above, alternatives, including the future without project (no project action alternative), were evaluated and developed to the extent necessary to determine costs, benefits, and effects on environmental resources. These tentative plans were discussed with the Sponsors and other agencies at workshops and public meetings. The advantages, disadvantages, risk and uncertainty of each plan were presented and considered.

The sponsors evaluated the viability of each alternative plan by applying the following four criteria:

- Completeness - The extent to which an alternative plan accounts for all investments and actions necessary to realize planned results.
- Effectiveness - The extent to which an alternative plan alleviates the problems and achieves the opportunities identified.
- Efficiency - The extent to which an alternative plan is most cost effective.
- Acceptability - The extent to which an alternative plan is accepted by the public and compatible with existing laws, regulations, and policies.

Three alternative plans were developed:

1. Future Without Project.
2. NED plan: Waimea II reservoir with by-pass conveyance improvement and with irrigation water delivery.
3. Agricultural Water Management Plan: Waimea Reservoir II with a by-pass conveyance improvement and with irrigation and livestock water delivery.

Features of the alternatives are described on the following pages.

### ALTERNATIVE 1 - FUTURE WITHOUT PROJECT

No Action Alternative: The conditions discussed in the section entitled Forecasted Conditions would apply if this alternative is selected. This alternative foregoes project implementation.

Components: The ongoing soil and water conservation program, which consists of technical assistance to cooperators under the Conservation Operations Program (PL-46) and cost sharing practices through the Agricultural Conservation Program (ACP), would continue. The projected conservation application in the watershed will include limited replacement of onfarm irrigation systems and onranch conventional grazing systems.

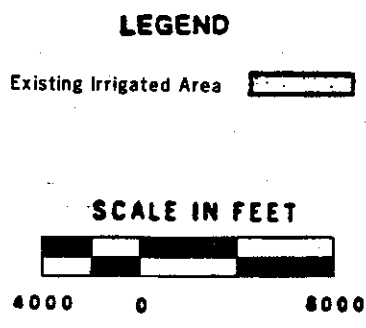
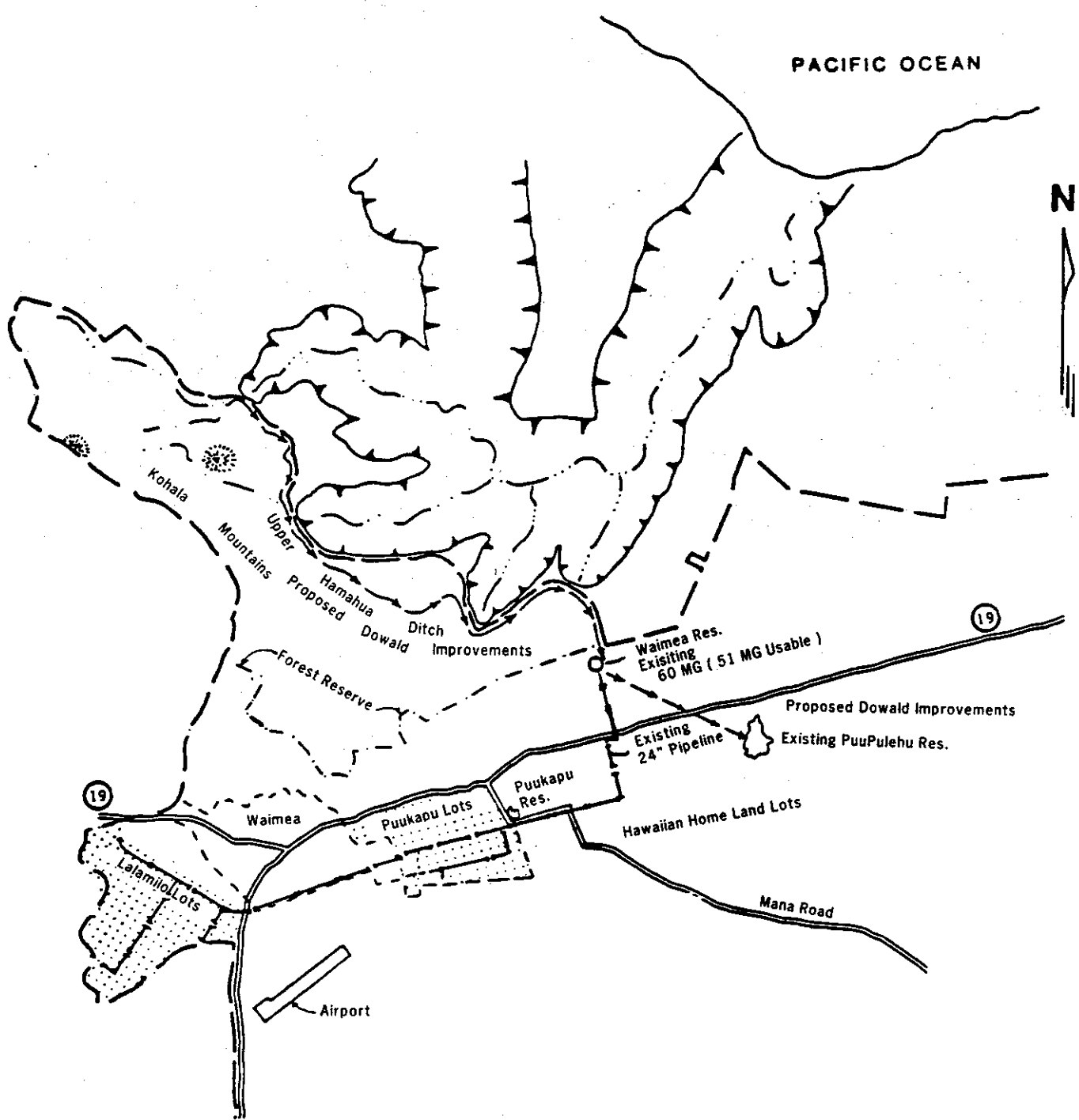
The agricultural water supply system collection ditch, tunnels and flumes will be maintained by the State of Hawaii. Improvements to Upper Hamakua Ditch collection system are under construction by DOWALD and will reduce current water losses. Also under construction by DOWALD is improvement of Puu Pulehu Reservoir to store 40 MG with a future extension of 70 MG (110 MG total). No

change would occur to expand the existing irrigation pipeline distribution system. A total of 877 acres of irrigated truck crops will be served. Livestock water would continue to be limited, and supplied from the domestic and private water systems. Pastureland will consist of 118,622 acres with 43,797 animal units.

Costs: Onfarm and onranch cost-share assistance is provided for selected conservation practices through the ACP. The maximum annual ACP contribution for cost-sharing per farm is \$3,500. Total 1987 ACP allocation was \$241,600 to 112 farmers and ranchers for Hawaii County, Hawaii.

Improvements to Upper Hamakua Ditch by DOWALD are estimated at \$4,000,000 through installation and during the 20-year project evaluation period. Puu Pulehu Reservoir improvements are estimated to cost \$6,500,000.

Effects: Proposed work on the Upper Hamakua Ditch will result in 220 million gallons of water saved annually. About 4.3 acres of native/exotic mix vegetation will be affected by DOWALD plans in segments 1-3 of the Upper Hamakua Ditch.



**FIGURE 2**

**ALTERNATIVE 1**  
**WAIMEA - PAAULO WATERSHED**  
**HAWAII COUNTY, HAWAII**



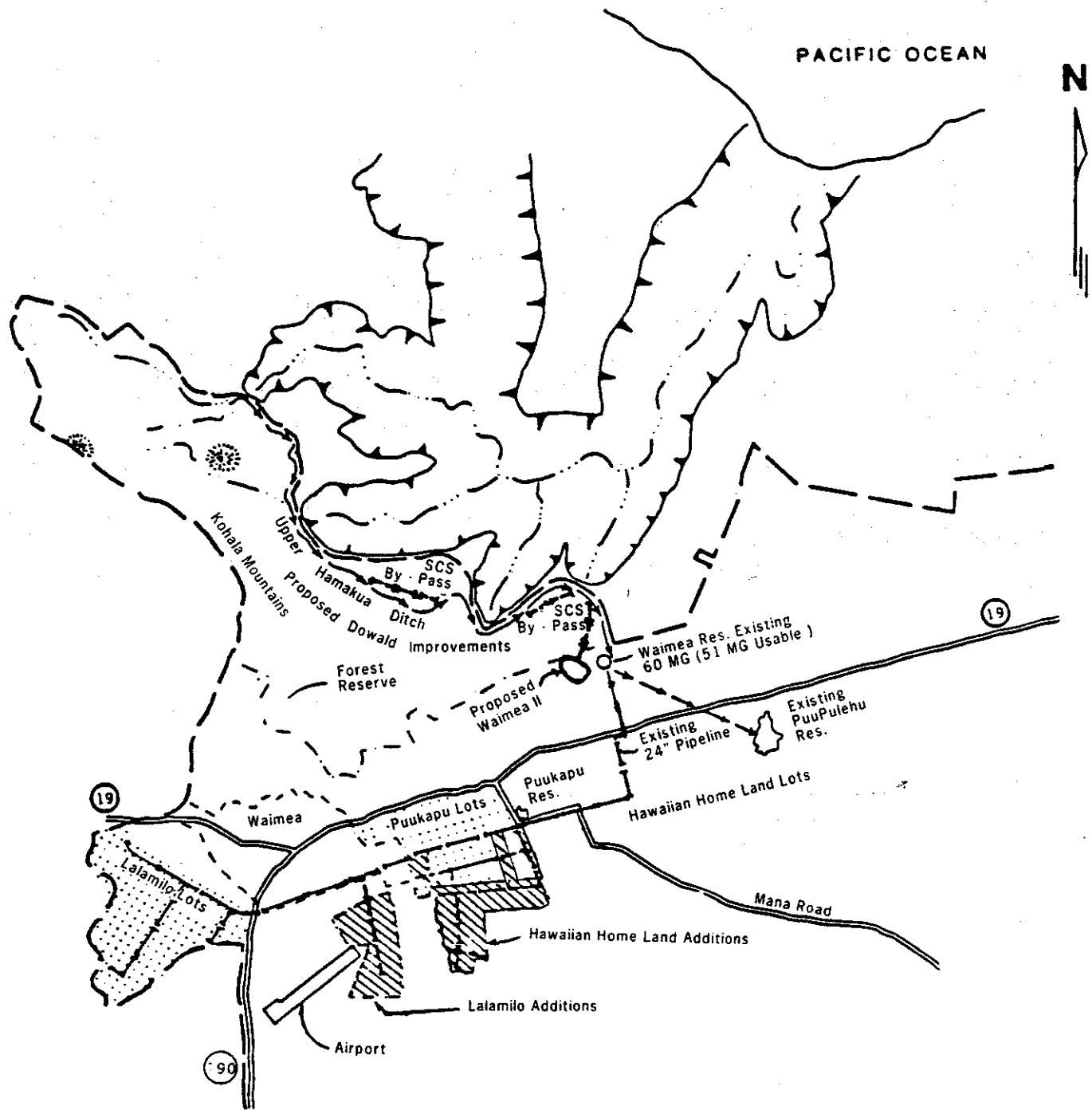
ALTERNATIVE 2 - NATIONAL ECONOMIC DEVELOPMENT PLAN

Components: This alternative consists of the same components as the Future Without project plus Waimea II reservoir, by-pass conveyance improvement, and irrigation water delivery system.



Cost: Total project cost would be \$8,042,200 consisting of \$4,643,700 of PL-566 funds and \$3,398,500 of other funds. The annualized amortized installation cost is \$510,800. Annualized operation, maintenance and replacement is \$38,000. Total annualized adverse NED effects are \$548,800.

Benefits: Installation of this alternative would accrue \$1,213,100 of average annual benefits through a reduction in damages due to water shortages and increased truck crop production.

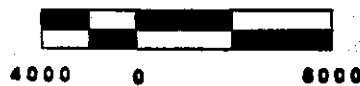
Other Effects: This alternative will include the effects of the Future Without project. In addition, it will save 220 million gallons annually for a total of 440 million gallons. Gravity pressure will be available from Waimea II reservoir. An estimated 2.5 acres of native vegetation will be affected by project activities in segments 4-6 of the Upper Hamakua Ditch. An additional 363 acres of irrigated truck crops will be supplied with water. A total of 1,240 acres of irrigated truck crops will be served.



**LEGEND**

- Existing Irrigated Area 
- Planned Irrigated Area 

**SCALE IN FEET**



**FIGURE 3**

**ALTERNATIVE 2  
WAIMEA - PAAULO WATERSHED  
HAWAII COUNTY, HAWAII**

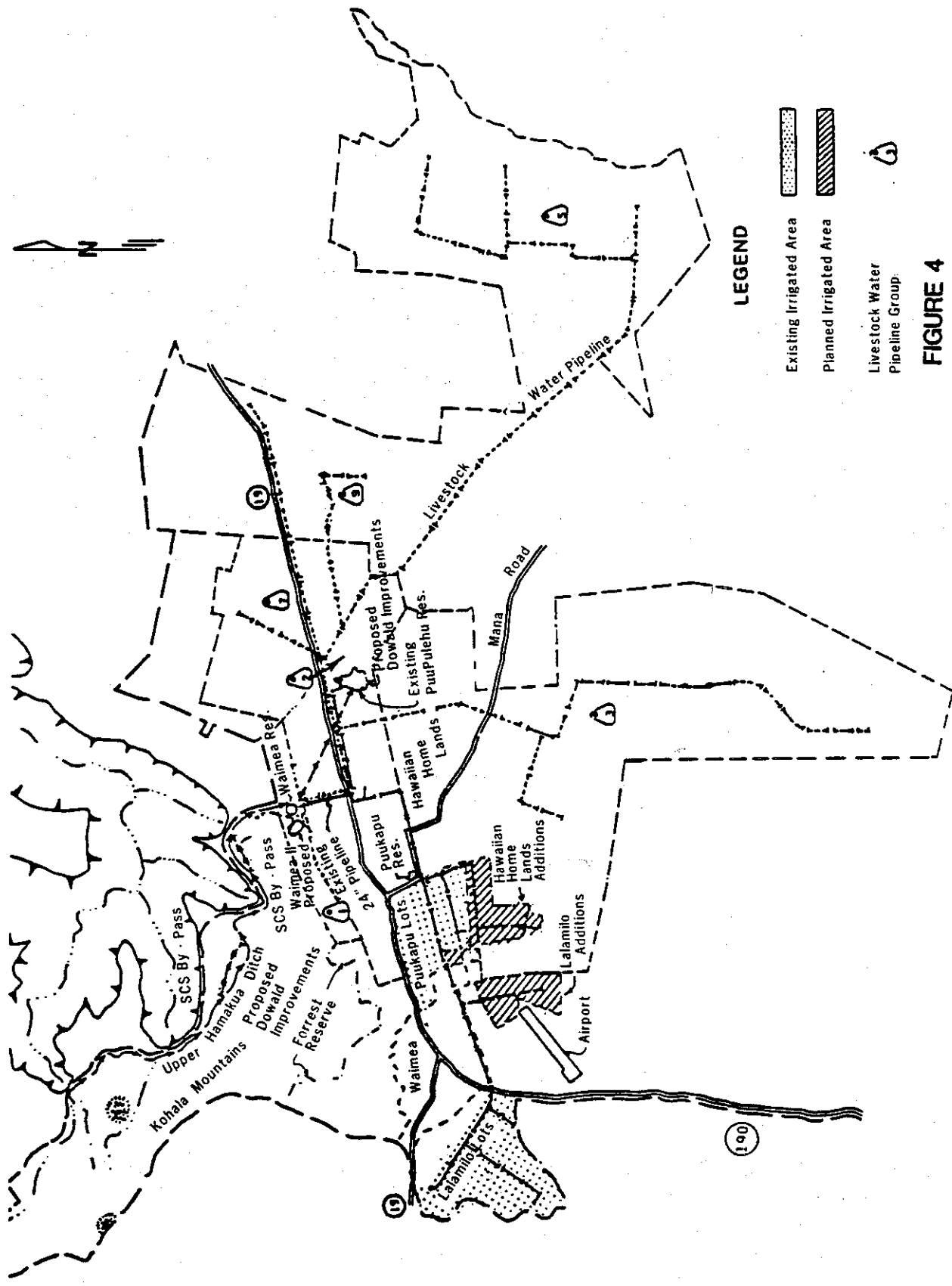
### ALTERNATIVE 3 - AGRICULTURAL WATER MANAGEMENT PLAN

Components: This alternative contains the same components as the Future Without project and the NED plan as well as the addition of measures to provide livestock water.




Cost: Total project cost would be \$9,648,700 consisting of \$4,900,900 of PL-566 funds and \$4,747,800 of other than PL-566 funds. The annualized installation cost is \$593,800. Annualized operation, maintenance and replacement is \$48,000. Total annualized adverse NED effects are \$641,800.

Benefits: Installation of this alternative would accrue \$1,277,700 of annualized NED benefits through increased truck crop production, reduced damages due to water shortages, and increased livestock production.

Other Effects: This alternative will include the effects of the Future Without project. In addition, it will save 220 million gallons annually for a total of 440 million gallons. Limited gravity pressure will be available from Waimea II reservoir. An estimated 2.5 acres of native vegetation will be affected by project activities in segments 4-6 of the Upper Hamakua Ditch. An additional 363 acres of irrigated truck crops will be supplied with water. A total of 1,240 acres of irrigated truck crops will be served. The project livestock water facilities will provide water to 19,100 animal units on 22,800 acres. Native Hawaiians on DHHL ranch lots are the main beneficiaries of livestock water.



**LEGEND**

-  Existing Irrigated Area
-  Planned Irrigated Area
-  Livestock Water Pipeline Group

**FIGURE 4**  
**ALTERNATIVE 3**  
**WAIMEA - PAAUILO WATERSHED**  
**HAWAII COUNTY, HAWAII**

## CANDIDATE PLANS

After the formulation of alternative plans, those alternatives that could most realistically be considered as candidate plans were identified. The no-project action or future without project (FWO); Alternative 2, the National Economic Development Plan (NED), and Alternative 3, Agricultural Water Management Plan, which is also the recommended plan, were identified as candidate plans and are displayed in Table H.

## PROJECT INTERACTION

DLNR has an ongoing maintenance program for Upper Hamakua Ditch, Waimea and Puu Pulehu Reservoirs, and the irrigation distribution system. Report R-77, A Report on the Investigation and Evaluation of Upper Hamakua Ditch (June 1986), assesses the Upper Hamakua Ditch condition, identifies problems, and proposes solutions. DLNR has initiated improvements to line the Puu Pulehu Reservoir to control its seepage problem and plans to repair the Alakahi (segments 2 and 3) and Koiawe (between Koiawe Intake and segment 5 sections of the Upper Hamakua Ditch. DLNR, as a Sponsor, has earmarked future funds for further improvements to the UHD and Puu Pulehu Reservoir. They are coordinating their activities with the other sponsors and participants. DLNR is also prepared to increase the irrigated cropland acreage within the project area and is in the process of a land exchange to accomplish this. This is in harmony with a statewide effort to preserve and develop suitable farmland. These plans are outlined in the Lalamilo Agricultural Park, Development Plan and Preliminary Engineering Report. DHHL has recently allocated additional farm lots and pasture lots and is planning for future leases. In order to realize the expected social benefits on these homestead lots, the development of a reliable agricultural water supply is necessary. Their plans are detailed in the Puukapu Development Plan. Project interaction is displayed in Table I.

## RISK AND UNCERTAINTY

The degree of risk and uncertainty involved in each alternative and in each project element was considered throughout the planning process. The project has a high likelihood of being installed.

The project water supply was evaluated using U.S. Geological Survey (USGS) data. A volume-duration-probability analysis was performed. The irrigation demand was evaluated using average consumptive use and 80 percent chance precipitation values. Livestock water demand was estimated to be 10 gallons per day per head, the average daily consumption by beef cattle.

The planned reservoir has been sized to ensure a full season water supply about 80 percent of the time, with the combined help of existing reservoirs and the improved Upper Hamakua Ditch. The remaining 20 percent of the time there will be some degree of shortage, mostly minor shortages.

TABLE H - SUMMARY AND COMPARISON OF CANDIDATE PLANS  
 Waimea-Paauilo Watershed, Hawaii

Effects	Alternative 1 - Future without Project	Alternative 2 - National Economic Development (NED) Plan	Alternative 3 - Agricultural Water Management Plan
Measures Included:	PuuPulehu Res. Improvement; UHD Improvement	PuuPulehu Res. Improvement; UHD Improvement; UHD By-pass Pipelines; Reservoir Supply Pipeline; Waimea II Reservoir; Irr. Water Dist. System	PuuPulehu Res. Improvement; UHD Improvement; UHD By-pass Pipelines; Reservoir Supply Pipeline; Waimea II Reservoir; Irr. Water Dist. System; Livestock Water Dist. Sys.
Total Project Cost	N/A	\$8,042,200	\$9,648,700
Annualized Adverse Costs	N/A	\$548,800	\$641,800
Benefits, Annualized	N/A	\$1,213,100	\$1,277,700
Net Beneficial	N/A	\$664,300	\$635,900
Acres Benefitted	877	1,240	1,240
Irrigated Cropland	0	0	22,800
Pastureland	877	1,240	24,040
Total			
Vegetation, including native vegetation	4.3 acres affected	6.8 acres affected	6.8 acres affected
Domestic Water	No effect	No effect	40 MG saved
Crop Production	Increase and maintain production on 877 ac. of irrigated truck crops	Increase and maintain production on 877 ac. of irrigated truck crops	Increase and maintain production on 877 ac. of irrigated truck crops
Prime Farmland	No effect	363 ac. increase in irrigated truck crops	363 ac. increase in irrigated truck crops
Threatened & Endangered Species	No effect	312 ac. increase	312 ac. increase
	No known effect	No known effect	No known effect

TABLE H - SUMMARY AND COMPARISON OF CANDIDATE PLANS (continued)  
 Waimea-Paauilo Watershed, Hawaii

Effects	Alternative 1 - Future without Project	Alternative 2 - National Economic Development (NED) Plan	Alternative 3 - Agricultural Water Management Plan
Surface Water Quantity	110 MG PuuPulehu Res. 220 MG saved due to work on the UHD.	110 MG PuuPulehu Res. 440 MG saved due to work on the UHD. 133 MG Waimea II Reservoir	110 MG PuuPulehu Res. 440 MG saved due to work on the UHD. 133 MG Waimea II Reservoir
Forest Resources	Slight adverse effect, due to work on the UHD.	Slight adverse effect, due to work on the UHD.	Slight adverse effect, due to work on the UHD.
Livestock Water	No effect	No effect	22,800 ac. of pasture benefitted 19,100 head of livestock provided water.
Cultural Resources	No known effect	No known effect	No known effect
Social Effects	877 ac. supplied with a more reliable source of water. Native Hawaiians and farmers in the Lalamilo Ag. Park and Puukapu areas benefit.	1,240 ac. supplied with a more reliable source of water. Native Hawaiians and farmers in the Lalamilo Ag. Park and Puukapu areas benefit.	1,240 ac. supplied with a more reliable source of water. Native Hawaiians and farmers in the Lalamilo Ag. Park and Puukapu areas benefit.
Urbanization	No effect	No effect	Provides livestock water for DHHL ranch lots leased to native Hawaiians. No effect

TABLE I - PROJECT INTERACTION WITH ONGOING OR PLANNED PROJECTS  
 Waimea-Paauilo Watershed, Hawaii

STATE DEPARTMENT OF LAND AND NATURAL RESOURCES 1/			
SOIL CONSERVATION SERVICE	NO ACTION	REPAIR UHD	REPAIR UHD AND PUU PELEHU RESERVOIR (110 MG)
No Action	877 acres of irrigated cropland with <40% reliability water supply.  43,800 head of livestock but no project water.  No native/exotic mix vegetation impacted.	877 acres of irrigated cropland with <45% reliability water supply.  43,800 head of livestock but no project water.  4.3 acres of native/exotic mix vegetation adversely impacted.	877 acres of irrigated cropland with 85% reliability water supply.  43,800 head of livestock with possibility of project water.  4.3 acres of native/exotic mix vegetation adversely impacted.
133 MG Waimea II Reservoir	1,240 acres of irrigated cropland with 20% reliability water supply.  51,900 head of livestock including 19,100 head with project water.  0.5 acres of native vegetation adversely impacted.	1,240 acres of irrigated cropland with 35% reliability water supply.  51,900 head of livestock including 19,100 head with water.  4.8 acres of native vegetation adversely impacted.	1,240 acres of irrigated cropland with 70%+ reliability water supply.  51,900 head of livestock including 19,100 with project water.  4.8 acres of native vegetation adversely impacted.
133 MG Waimea II Reservoir and Natural Channel By-pass	1,240 acres of irrigated cropland with 35% reliability water supply.  51,900 head of livestock including 19,100 head with project water.  2.5 acres of native vegetation adversely impacted.	1,240 acres of irrigated cropland with 45% reliability water supply.  51,900 head of livestock including 19,100 head with project water.  6.8 acres of native vegetation adversely impacted.	1,240 acres of irrigated cropland with 80% reliability water supply.  51,900 head of livestock including 19,100 head with project water.  6.8 acres of native vegetation adversely impacted.

1/ Effects of DLNR activities are estimated using current information from them. These effects will be addressed by a separate plan and environmental assessment prior to DLNR implementation or construction.



The efficiency of the Upper Hamakua Ditch between Kawainui stream and Alakahi stream has been measured at various flow rates. The efficiency ranges from 0-75 percent and is highly dependent on the level of discharge. The efficiency on the lower parts of the Upper Hamakua Ditch has not been measured. It is approximately the same as the upper sections. The Upper Hamakua Ditch flows for 8,300 feet in Koiawe stream. This stream is underlain by permeable lava flows and cinder deposits. The stream crosses several rift zones (faults). Numerous sink holes caused by collapsed lava tubes also exist along this section of the drainage. At one location all flow was observed to disappear into the ground. Further downstream flow was again observed. It is not known if this was the same flow or a "new" flow.

Koiawe stream has a drainage area of 0.7 sq. mi. to the point of diversion. It is ungauged and could be contributing significant flow to the Upper Hamakua Ditch. Determining its yield and conveyance efficiency would be desirable. This could be done with a stream gage at the Koiawe intake. This should be done before the by-pass pipeline is designed and constructed.

There are 363 acres of new irrigated cropland in the selected plan. This is based on the best information that could be obtained from DLNR and DHHL and is highly dependent on the rate at which the farms lots are developed. For the project, a conservative assumption was made that it will take 10 years to develop the Lalámilo Agricultural Park and 20 years to develop the DHHL land. There will be approximately 22,800 acres of pastureland supplied with water from a separate livestock water distribution system. Benefits will be provided for about 10,900 existing cattle which currently receive water from the domestic water system. The number of cattle is estimated to increase by 8,200 due to the project. This increase was conservatively assumed to take 20 years to develop.

Uncertainty centers around future changes that are difficult to predict and that could reduce project effectiveness. These changes could include a reduction in the number of acres to be irrigated and the number of livestock to be furnished project water. Uncertainty was minimized by conducting public and sponsor meetings where full disclosure of costs and effects was made. Care taken in the formulation of future with and without project conditions will minimize unexpected changes in land use or income projections.

#### RATIONALE FOR PLAN SELECTION

At a public meeting June 26, 1986, the local Sponsors and the general public selected Alternative 3, the Agricultural Water Management Plan, as the recommended plan. This alternative plan was selected because of its ability to satisfy most of the needs discussed in the PROBLEM AND OPPORTUNITY IDENTIFICATION section.

Alternative 2, the NED Plan, reasonably maximizes net economic benefits. It includes improvement of the Upper Hamakua Ditch, construction of the Waimea II Reservoir, and extension of the irrigation water distribution system. A total of 1,240 acres are benefitted. Total cost is \$8,042,200.

The recommended plan, Alternative 3, the Agricultural Water Management Plan, includes the same elements as the NED plan as well as the addition of a distribution system for livestock water. An additional 22,800 acres will be benefitted. The additional installation cost will be \$1,606,500. The annualized amortized installation cost of this increment is \$83,000; annualized OM&R is \$10,000. The total annualized adverse NED effect is \$93,000. Total annualized benefits are \$64,600. The benefit:cost ratio of the added increment is 0.7:1.0. Net economic benefits of \$28,400 will be sacrificed.

Hawaiian-grown beef accounts for approximately 31 percent of the beef consumed in Hawaii. The remaining 69 percent is obtained from the mainland (54 percent) and foreign (15 percent) sources. The added increment will reduce the demands for water on the domestic water system by 40 MG annually. The added increment will provide livestock water primarily to DHHL ranch lots. Benefits to ranchers due to a reduction in the price paid for water for their livestock (\$17,300) and an increase in the number of cattle raised (\$47,300) will accrue to primarily native Hawaiian ranchers.

# RECOMMENDED PLAN

## PURPOSE AND SUMMARY

This section of the Plan-EA contains a detailed description of the proposed structural measures to be installed, including financing, methods of installation, and operation and maintenance requirements.

The Agricultural Water Management Plan (Alternative 3) is the plan selected by the Sponsors. This plan includes all elements of the NED Plan as well as storage and distribution for livestock water and is the recommended plan. It will complement the ongoing land treatment program of the Conservation District. This plan provides improved water conveyance efficiency of the Upper Hamakua Ditch, reservoir storage for irrigation and livestock water, and irrigation and livestock water distribution systems.

This plan was developed to meet both the national objective of increasing the economic value of national output of goods and services and achieving the Sponsors' objective to improve agricultural water management. These measures will be installed under authority of PL-566 with their purpose being agricultural water management.

## PLAN ELEMENTS

### Land Treatment

No land treatment is required. Land above the reservoir is in the Forest Reserve and is adequately protected.

### Structural Measures

Structural agricultural water management measures will include a 133 MG storage reservoir located northwest of the existing Waimea 60 MG reservoir. A 30-inch diameter supply pipeline, 3,100 feet in length (segment 6), will convey water from the existing Upper Hamakua Ditch collection system to the proposed reservoir (see Table 3B and Appendix C-8). Improvement to the Upper Hamakua Ditch system is included. The collection system presently using sections of natural stream will be improved with 8,000 feet of by-pass pipeline segments 4 and 5 (see Appendix C-8 and Table 3A). Required right-of-way for the by-pass pipeline is 5.5 acres. The supply pipeline, most of which is located adjacent to an existing road, will require 1.8 acres in addition to use of this road (see Appendix D-1 and Table 3B).

The proposed Waimea II reservoir will be constructed on DHHL pastureland. A compacted earth-fill dam with maximum height of 65 feet and crest length of 1,450 feet will be constructed using fill material excavated from the reservoir and adjacent area. The reservoir will be lined with high density polyethylene. A geofabric and polyethylene drainage grid under the liner is proposed. The embankment will include a chimney drain and principal and emergency spillways. The reservoir will be filled by the supply pipeline from the Upper Hamakua Ditch (see Appendix D-1 and Table 3B).

Geotechnical investigation of the Waimea II dam site was made during planning to determine embankment and spillway foundation conditions and construction material type and volume. Backhoe excavation exposed the embankment foundation material which is composed of volcanic ash and debris flows, lavafloes, and alluvial gravels. The emergency spillway foundation consists of volcanic ash and debris flow material. Borrow material in excess of 300,000 cubic yards of silt (ML and MH) and gravel (GM) was identified.

The investigation also included an analysis of seismic records to determine embankment stability requirements. From this analysis, a magnitude 7.2 earthquake at a distance of 30 miles was used as the design event. The geotechnical investigation provided sufficient information to determine construction feasibility and safety of the planned structure.

The principal spillway inlet structure considered during planning is an SCS standard covered riser and the outlet structure is an impact basin (see References). A 30-inch diameter reinforced concrete cylinder pipe is considered to convey flows from inlet to outlet structure. Other structural options may be considered during detailed design.

The emergency spillway will be vegetated earth with a reinforced concrete crest control structure. Loose rock riprap obtained during reservoir excavation will be used to stabilize inflows from the emergency spillway to the gulch. The spillway entrance will be lined with the same high-density polyethylene material as the reservoir. The principal spillway will convey the 100-year, 10-day storm. Maximum reservoir storage during passage of this storm is 136.5 MG.

Minor clearing of brush and small trees will be required within the 34.7 acres of pastureland for which landrights will be required. A total of two acres clearing is estimated.

The embankment life of 100 years exceeds the project life assuming proper maintenance of spillway systems, reservoir lining and other principal features. Total sediment accumulation is approximately 1 acre-foot for the life of the project.

The existing Lalamilo irrigation delivery system will be expanded with 21,800 feet of pipeline. Pumps will be installed to supplement gravity pressure as needed during peak demand periods. Approximately 900 feet of 24-inch diameter ductile iron pipe (DIP) and 20,900 feet of polyvinyl chloride (PVC) pipe, 14-inch to 4-inch diameter, will be installed (see Appendix E and Table 3C). Required right-of-way is 4.8 acres.

The average annual gross irrigation requirement for the future with project condition is 4.0 MGD. This will serve an estimated area of 1,240 acres of irrigated cropland (870 acres net). The peak daily gross irrigation requirement is 6.7 MGD. The planned irrigation system assumes that irrigation is done for 12 hours each day, i.e. no irrigation at night. Therefore the irrigation system has been designed with a peak capacity of 13.4 MGD (20.7 cfs).

A separate livestock water distribution system will be constructed. Total length of the livestock water pipeline is 184,400 feet. Use of high-density polyethylene (PE) pipe ranging in diameter from 6-inch to 3/4-inch is proposed. Electric and diesel pumps will be required to provide water at higher elevations beyond the effective reach of gravity pressure. Storage tanks and ponds will satisfy demand fluctuation and will limit hours of pumping required. This will allow for periods of electrical failure, repairs and other shutdowns. A sequential control system will automate pump operation (see Appendix F and Table 3D). Total required right-of-way is 174.1 acres including temporary right-of-way of 84.5 acres.

### Safety

Potential for failure is minimized for Waimea II reservoir by design criteria which considered extreme precipitation events, earthquake loadings, and possible failure of reservoir lining or other materials used for construction. The planned dam has been classified as hazard class (c). This classification is given to dams located where failure may cause loss of life, serious damage to homes, industrial and commercial buildings, important public utilities, main highways and railroads. A breach inundation map has been prepared using criteria found in Technical Release No. 60, USDA, SCS (see Appendix D and References). The preliminary breach analysis has indicated that in the unlikely event of a sudden failure, the flood wave will be directed away from the residential areas and down Lalakea stream to Waipio Valley, approximately five miles away.

Two earthquakes with magnitudes of 6.5 and 6.9 have occurred near Kona, approximately 30 miles from the project reservoir site. Larger events (magnitude 7.0+) have occurred approximately 70 miles away on the south end of the island. Because of this seismic history, a design for earthquakes of magnitude 7.2, 30 miles away is considered appropriate for project planning. The embankment has been designed with a minimum of 1.1 factor of safety against failure when considering seismic forces.

Preliminary geologic and soils investigations indicate soils available in borrow areas can be effectively utilized to provide a stable structure on a stable foundation. The embankment chimney drain and telltale drain systems are proposed to minimize hazard from failure of the high-density polyethylene reservoir liner.

An emergency action plan will be developed for Waimea II dam and reservoir. If damage by flood, earthquake, or other events occurs to the structure, action may be carried out to provide for public safety and to minimize the threat of increased damage.

The shoreline of the reservoir will have safety features that provide individuals and animals a means of escape. The excavated sections were limited to 4:1 side slopes to facilitate construction and provide safety. Fencing will be provided around the reservoir, livestock storage ponds and pumping stations for public safety and facility security.

### MINIMIZING ADVERSE IMPACTS (3)

The most likely adverse condition resulting from project activity would be in the Forest Reserve. This will be the replacement of native vegetation components by exotic or foreign species, a consequence of disturbance to the native system and the transportation of weeds to the site. During construction, disturbance will be reduced by the use of lightweight equipment rather than heavyweight equipment wherever possible. Transportation of weeds to the site will be minimized by cleaning of construction equipment prior to being brought to the site.

Minimizing adverse impacts in segment 4 entails the avoidance of Clermontia plants as brush is cleared from the ditch, and the location of turnaround and equipment storage sites in the grass or ginger-dominated vegetation. In segment 5, minimizing adverse impacts will entail the avoidance of Cyanea, Touchardia, Lobelia, and Phyllostegia plants. In segment 6, construction will avoid the large ohia trees whenever possible (see Appendix C).

Minimizing adverse impacts for segments 4 and 5 will entail the services of a botanist for a day to familiarize the construction supervisor and workers as to the identity of these plants in the field (see Appendix C).

### PERMITS AND COMPLIANCE

Installation of the proposed measures will be performed in full compliance with all laws and policies of the federal, state, and local governments. In addition, compliance with the Water Resource Council's designated environmental statutes is shown in Table J. Local Sponsors are responsible for obtaining all required permits and approvals.

**TABLE J - COMPLIANCE OF THE RECOMMENDED PLAN WITH  
WRC - DESIGNATED ENVIRONMENTAL STATUTES  
Waimea-Paauilo Watershed, Hawaii**

FEDERAL POLICY	COMPLIANCE <u>1/</u>
1. Archeological and Historic Preservation Act, 16 U.S.C. 469, et seq.	Full Compliance
2. Clean Air Act, as amended, 42 U.S.C. 1857h-7, et seq.	Full Compliance
3. Clean Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full Compliance
4. Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not Applicable
5. Endangered Species Act, 16 U.S.C. 1531, et seq.	Full Compliance
6. Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
7. Federal Water Project Recreation Act, 16 U.S.C. 460-1(12), et seq.	Not Applicable
8. Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full Compliance
9. Land and Water Conservation Fund Act, 16 U.S.C. 4601 - 4601-11, et seq.	Not Applicable
10. Marine Protection, Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not Applicable
11. National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full Compliance
12. National Historic Preservation Act, 16 U.S.C. 470a, et seq.	Full Compliance
13. Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Not Applicable
14. Watershed Protection and Flood Prevention Act, 16, U.S.C. 1001, et seq.	Full Compliance
15. Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.	Not Applicable
16. Farmland Protection Policy Act, 7 U.S.C. 4201, et seq.	Full Compliance
<hr/>	
<u>1/</u>	<p>a. Full Compliance - Having met all requirements of the Statute for current stage of planning (either preauthorization or postauthorization.)</p> <p>b. Partial Compliance - Not having met some of the requirements that normally are met in the current stage of planning. Partial compliance entries should be explained in appropriate places in the report and referenced in the table.</p> <p>c. Non-Compliance - Violation of a requirement of the statute. Non-compliance entries should be explained in appropriate places in the report and referenced in the table.</p> <p>d. Not applicable - No requirements for the statute required compliance for the current stage of planning.</p>

## COSTS

Installation costs of the recommended plan are estimated to be \$9,648,700. The cost includes: \$7,618,300 cost of construction (base year 1987); \$1,219,100 engineering services for design and construction inspection; \$201,900 land rights cost; and \$609,400 project administration costs. The estimated installation costs are shown in tables 1 and 2.

Construction costs include the costs for structural measures to improve the collection system, to construct an additional storage reservoir, and to distribute the water for irrigation and livestock. Construction costs for the the collection system, reservoir storage for irrigation water, and the irrigation water distribution system will be cost shared 50 percent by Public Law 566 funds and 50 percent by other than Public Law 566 funds. Livestock water storage accounts for approximately 4.5 percent of the reservoir. Storage for livestock water and the livestock water distribution system will be cost shared 0 percent by Public Law 566 funds and 100 percent by other than Public Law 566 funds.

Construction costs associated with the collection system improvement total \$1,016,000. Costs include \$346,700 for the Upper Hamakua Ditch by-pass pipelines, \$500,000 for the supply pipeline from the Upper Hamakua Ditch to the proposed Waimea II Reservoir, and \$169,300 for contingencies for these items.

Total construction costs associated with increased water storage, Waimea II Dam and Reservoir, are \$4,826,500 and include \$355,000 for excavation, \$1,511,900 for earth fill, \$1,149,400 for reservoir lining, \$695,000 for the embankment drain, and \$629,600 for contingencies.

The construction costs for the irrigation distribution system total \$824,300. They include \$695,200 for pipelines, \$21,700 for a pump station, and \$107,400 for contingencies. Construction costs for the livestock water distribution system total \$951,500. Costs include \$696,200 for pipelines, \$131,200 for pumps and tanks, and \$124,100 for contingencies.

Engineering costs of \$1,219,100 include direct costs of engineers and others required for design-level investigations, inspections and engineering design, and preparation of specifications. These are cost shared up to 100 percent by Public Law 566.

Project administration costs include costs of preparing invitations to bid, administering contracts, inspection, and overhead costs of project installation, including legal opinions when needed. Project administration costs are estimated at \$457,100 Public Law 566 funds and \$152,300 other funds for a total of \$609,400. Each party will bear the costs that it incurs.



Land rights costs are paid for 100 percent by other than PL-566 funds. These costs include \$26,000 in legal fees and other local costs. Also included is \$175,900 as the value of permanent and temporary easements on about 216 acres.

#### INSTALLATION AND FINANCING

After authorization, the first year will be needed to acquire land rights and permits and begin design of structural measures. The planned sequence for installing this project is to begin with installation of the Upper Hamakua Ditch by-pass pipelines, reservoir supply pipeline and Waimea II Dam and Reservoir. The by-pass pipelines and supply pipeline are planned for installation in the first three years. The Waimea II Dam and Reservoir are planned for installation in the first four years. Installation of the irrigation distribution system is planned to start after construction of the Waimea II Dam and Reservoir is initiated. Installation of the livestock water distribution system is planned over a three-year period beginning the first year after the reservoir is constructed. The schedule of obligations is shown in Table K.

TABLE K - SCHEDULE OF OBLIGATIONS  
Waimea-Paauilo Watershed, Hawaii

(dollars) 1/

Year	Item	PL-566 Funds	Other than PL-566 Funds	Total
1	TECHNICAL ASSISTANCE			
	Engineering			
	UHD By-Pass Pipelines	40,000	0	40,000
	UHD-WaimeaII Res.Sup.PL	57,600	0	57,600
	Waimea II Reservoir	60,000	0	60,000
	Project Administration			
	UHD By-Pass Pipelines	2,500	800	3,300
	UHD-WaimeaII Res.Sup.PL	3,600	1,200	4,800
	Waimea II Reservoir	5,000	1,700	6,700
	Subtotal	168,700	3,700	172,400
2	TECHNICAL ASSISTANCE			
	Engineering			
	Waimea II Reservoir	60,000	0	60,000
	UHD By-Pass Pipelines	10,000	0	10,000
	UHD-WaimeaII Res.Sup.PL	10,000	0	10,000
	Project Administration			
	UHD By-Pass Pipelines	5,000	1,600	6,600
	UHD-WaimeaII Res.Sup.PL	7,200	2,400	9,600
	Waimea II Reservoir	57,900	19,300	77,200
	LAND RIGHTS			
	UHD By-Pass Pipelines	0	1,000	1,000
	UHD-WaimeaII Res.Sup.PL	0	2,700	2,700
	Waimea II Reservoir	0	33,600	33,600
	Subtotal	150,100	60,600	210,700
3	TECHNICAL ASSISTANCE			
	Engineering			
	UHD By-Pass Pipelines	16,600	0	16,600
	UHD-WaimeaII Res.Sup.PL	28,400	0	28,400
	Waimea II Reservoir	343,400	0	343,400
	Project Administration			
	UHD By-Pass Pipelines	15,000	5,100	20,100
	UHD-WaimeaII Res.Sup.PL	21,600	7,200	28,800
	Waimea II Reservoir	29,000	9,700	38,700
	Irrigation Dist. System	9,900	3,300	13,200
	FINANCIAL ASSISTANCE			
	UHD By-Pass Pipelines	208,000	208,000	416,000
	UHD-WaimeaII Res.Sup.PL	300,000	300,000	600,000
	LAND RIGHTS			
	Irrigation Dist. System	0	7,300	7,300
	Subtotal	971,900	540,600	1,512,500

TABLE K - SCHEDULE OF OBLIGATIONS (continued)  
 Waimea-Paauilo Watershed, Hawaii

(dollars) 1/

Year	Item	PL-566 Funds	Other than PL-566 Funds	Total
4	TECHNICAL ASSISTANCE			
	Engineering			
	Waimea II Reservoir	308,900	0	308,900
	Irrigation Dist. System	111,900	0	111,900
	Project Administration			
	UHD By-Pass Pipelines	2,500	800	3,300
	UHD-WaimeaII Res.Sup.PL	3,600	1,200	4,800
	Waimea II Reservoir	168,700	56,100	224,800
	Irrigation Dist. System	4,900	1,700	6,600
	FINANCIAL ASSISTANCE			
Waimea II Reservoir	2,304,600	2,521,900	4,826,500	
	Subtotal	2,905,100	2,581,700	5,486,800
5	TECHNICAL ASSISTANCE			
	Engineering			
	Irrigation Dist. System	20,000	0	20,000
	Livestock Wat.Dist.Sys.	5,000	0	5,000
	Project Administration			
	Waimea II Reservoir	29,000	9,700	38,700
	Irrigation Dist. System	29,700	9,800	39,500
	Livestock Wat.Dist.Sys.	11,400	3,800	15,200
	FINANCIAL ASSISTANCE			
	Irrigation Dist. System	412,100	412,200	824,300
LAND RIGHTS				
Livestock Wat.Dist.Sys.	0	157,300	157,300	
	Subtotal	507,200	592,800	1,100,000
6	TECHNICAL ASSISTANCE			
	Engineering			
	Livestock Wat.Dist.Sys.	132,300	0	132,300
	Project Administration			
	Irrigation Dist. System	4,900	1,700	6,600
Livestock Wat.Dist.Sys.	5,700	1,900	7,600	
	Subtotal	142,900	3,600	146,500

TABLE K - SCHEDULE OF OBLIGATIONS (continued)  
 Waimea-Paauilo Watershed, Hawaii

(dollars) 1/

Year	Item	PL-566 Funds	Other than PL-566 Funds	Total
7	TECHNICAL ASSISTANCE			
	Engineering			
	Livestock Wat.Dist.Sys.	10,000	0	10,000
	Project Administration			
	Livestock Wat.Dist.Sys.	23,400	7,800	31,200
	FINANCIAL ASSISTANCE			
	Livestock Wat.Dist.Sys.			
	Main,E,E-1,Groups 1,3	0	650,200	650,200
	Subtotal	33,400	658,000	691,400
8	TECHNICAL ASSISTANCE			
	Engineering			
	Livestock Wat.Dist.Sys.	5,000	0	5,000
	Project Administration			
	Livestock Wat.Dist.Sys.	14,800	4,900	19,700
	FINANCIAL ASSISTANCE			
	Livestock Wat.Dist.Sys.			
	Groups 5,7,9	0	301,300	301,300
	Subtotal	19,800	306,200	326,000
9	TECHNICAL ASSISTANCE			
	Project Administration			
	Livestock Wat.Dist.Sys.	1,800	600	2,400
	Subtotal	1,800	600	2,400
GRAND TOTAL		4,900,900	4,747,800	9,648,700

1/ Price base: 1988

## Responsibilities

Mauna Kea Soil and Water Conservation District, through their ongoing program, will encourage the installation and maintenance of land treatment measures. Final decisions on land treatment measures will rest with the landowners and/or operators.

The Department of Land and Natural Resources (DLNR) and the Department of Agriculture (DOA) will be responsible for the installation, operation, maintenance, and replacement of the Upper Hamakua Ditch by-pass pipelines, reservoir supply pipeline, reservoir, and irrigation distribution system.

The Department of Hawaiian Home Lands (DHHL) will be responsible for the installation, operation, maintenance, and replacement of the livestock water distribution system.

Agreements among individual sponsors will be entered into before the project agreements are signed. These agreements will define the appropriate management resources, timing, responsibilities and expected costs of installations, operation, maintenance, and replacements.

Soil Conservation Service (SCS) will provide engineering designs, contract preparation, and land rights maps for all structural measures. SCS will also provide relocation assistance under Uniform Relocation Act if necessary. The SCS will award and administer construction contracts, participate in operation and maintenance inspections and follow-up action, and perform annual status reviews. This assistance will be provided through the Small Watershed Program (PL-566).

SCS personnel will also provide technical assistance to project farmers and ranchers for installation of land treatment measures and irrigation water management assistance in conjunction with the Mauna Kea Soil and Water Conservation District. This assistance will be provided through the regular ongoing conservation program.

## Contracting

The Sponsors have requested SCS to carry out the contracting operations. SCS will prepare contract documents. Contracts for the construction of structural measures will be let by competitive bids. Contracts for works of improvement shall be mutually satisfactory and in accordance with requirements of the Sponsors and in agreement with SCS technical and administrative requirements.

## Land rights and Utilities

Sponsors are responsible for all needed land rights. Acquisition of all lands, easements, or rights-of-way shall be made in compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, and appropriate USDA and federal regulations. These

provide that in cases where land rights are not obtained by donation or land exchange, every reasonable effort will be made to acquire real property rights by negotiation. Prior to the initiation of negotiations, an appraisal of the fair market value of the real property interest will be made by a qualified land appraiser. No private landowner relocations are known to be required by this project.

Both buried and above-ground utility lines exist in the installation area. Most notable are the water, power, and telephone lines. Care must be taken during construction to prevent danger to workers and avoid excessive disruption of service. The Sponsors and installing contractor must obtain necessary cooperation and assistance from the appropriate utility companies.

### Cultural Resources

Any changes in design or location of project features will be coordinated with the State Historic Preservation Officer to maintain his concurrence. In the event that buried archeological and historical properties are discovered during the installation of measures, the SCS will follow the procedures in the SCS General Manual Title 420, Part 401 (October 1983) as amended.

### Financing

Federal assistance for installing the works of improvement as described in this plan will be provided under the authority of the Watershed Protection and Flood Prevention Act, PL-566, 83rd Congress, 68 Stat. 666, as amended. Under this authority, SCS will provide: (1) engineering services including preparation of plans and specifications, review of engineering plans prepared by others, construction surveys, and necessary inspection services during construction; (2) project administration including providing government representatives and carrying out contract administration; and (3) financial assistance to pay for structural works and cost sharing for relocation assistance.

DLNR and DHHL are legally constituted agencies of state government with funds appropriated by state government to finance their part of the project.

### Conditions for Providing Assistance

The following conditions shall be met before issuance of invitations to bid on any portion of construction:

1. The necessary land rights for each individual measure will be acquired before construction can proceed.
2. All necessary permits and cooperative agreements for each individual measure will be acquired before construction can proceed.

3. Sponsors will ensure full conformance with city and county, state, and federal laws and regulations. Reasonable evidence of such conformity shall be provided to the mutual satisfaction of all parties.

4. Funding and construction start authorization must be provided by the federal government prior to any SCS installation activities.

5. An Operation and Maintenance Agreement shall be agreed to in writing by each Sponsor and SCS prior to signing a land rights, relocation or project agreement.

6. An Emergency Action Plan shall be developed by the Sponsors and other local groups prior to initiating construction on the dam.

### OPERATION, MAINTENANCE, AND REPLACEMENT

#### General

DOA will be responsible for OM&R on Waimea II Dam and Reservoir, the Upper Hamakua Ditch by-pass pipelines and reservoir supply pipeline, and additions to the irrigation distribution pipeline.

The DHHL will be responsible for OM&R on the livestock water distribution system.

An operation and maintenance (O&M) agreement will be made prior to signing a project, land rights, or relocation agreement. The O&M agreement will include specific provisions for retention and disposal of property acquired or improved with Public Law 566 financial assistance. Operation and maintenance agreements will include specific Sponsor responsibilities and will be based on the SCS National Operation and Maintenance Manual. An operation and maintenance plan will be prepared for each structural measure. The emergency action plan developed for Waimea II Dam and Reservoir will be implemented if there is a threat of damage by flood, earthquake, or other events. Action will be carried out to provide for public safety and to minimize the potential for damages.

The estimated yearly OM&R costs for the various structural elements are shown in the table below. The values shown below are then annualized, amortized, and aggregated into the various evaluation units, the results of which are shown in Table 4 - Annualized Adverse NED Effects.

TABLE L - ESTIMATED YEARLY OM&R COST  
 Waimea-Paauiilo Watershed, Hawaii

Item	Operation, Maintenance, and Replacement Cost (Dollars)	
	1st Year	20th Year
Upper Hamakua Ditch Improvement UHD By-pass Pipelines UHD to Waimea II Reservoir Supply Pipeline Subtotal	4,200 6,000 10,200	4,200 6,000 10,200
Storage Waimea II Reservoir	24,100	24,100
Irrigation Water Distribution System Lalamilo Addition DHHL Additions Waimea II to Existing Mainline Subtotal	8,700 27,800 600 37,100	8,700 27,800 600 37,100
Livestock Water Distribution System Main, Group 2, E, E-1 Group 1 Group 3 Group 5 Group 7 Group 9 Subtotal	5,200 400 4,500 4,000 100 600 14,800	7,300 500 6,400 5,600 100 600 20,500
GRAND TOTAL	86,200	91,900

Price Base: 1987

Operation

Although the systems will operate pretty much unattended, there will be routine operational needs to manually operate the Upper Hamakua Ditch head gate, reservoir inlet and outlets, and pumps on the distribution systems in order to provide the required flows.



## Maintenance

All measures will be maintained in sound working condition. Items which will require attention prior to and during high flows are: the removal of debris from trash racks at inlets of the by-pass pipeline, reservoir supply pipeline, irrigation pipeline and livestock water pipeline. The pipelines will require occasional flushing to remove accumulated sediment. Occasional cleaning will be needed to remove sediment from traps located at points of surface runoff into Waimea II Reservoir.

Reservoir lining may require occasional patching or other repair prior to replacement during the project life. Periodic maintenance of access roads or trails to the by-pass pipeline, supply pipeline and Waimea II Dam and Reservoir will be needed to facilitate inspections and maintenance.

Irrigation and livestock water delivery systems will require regular servicing of pumping stations and control systems. Meters and valves will require frequent inspection and occasional repair. Security fences protecting pump stations will also require occasional repairs.

## Replacement

Replacement of worn or deteriorated items with a useful life shorter than the 50-year life of the project will be provided.

The Upper Hamakua Ditch by-pass pipelines have a useful life of 40 years, and polyvinyl chloride irrigation distribution pipelines have a useful life of 25 years. Culverts for access roads and trails have an estimated useful life of approximately 35 years.

High-density polyethylene reservoir and pond lining has a useful life of 20 years where exposed to frequent sunlight and 40 years where not exposed to frequent and intense sunlight.

For water delivery pumping plants, electric motors were assumed to have an estimated operating life of 50,000 hours. Livestock water delivery system diesel motor and pump units were estimated to have an operating life of seven years and electric motor and pump units were estimated to have an operating life of 12 to 16 years, depending on annual operating requirements.

## Inspection

An inspection to determine operation, maintenance, and replacement needs will be conducted annually and after major flood, seismic, or other unusual events. During the first three years after installation a qualified SCS employee will jointly assist in O&M inspections. Subsequent annual inspections will be made by the Sponsors.

Sponsors will maintain a record of all maintenance inspections, all maintenance required, the schedule for completion, and the actual cost. A copy will be submitted to SCS.

TABLES

The numbered tables (1 - 4, and 6) are presented on blue paper to facilitate their ready reference. They show the estimated costs of structural measures, their annualized values, the annualized benefits, and the benefit-to-cost comparison.

TABLE 1 - ESTIMATED INSTALLATION COST  
 Waimea-Paauilo Watershed, Hawaii

Installation Cost Item	Unit	Number		Estimated Cost (dollars) 1/		
		Nonfederal Land		PL-566 Funds	Other than PL-566 Funds	TOTAL
<b>STRUCTURAL MEASURES</b>						
Upper Hamakua Ditch Improvement	ft.	8,000		299,600	217,300	516,900
UHD By-Pass	ft.	3,100		432,000	314,700	746,700
UHD-Waimea II Res.Sup.Pipeline	each	1	3,366,500		2,652,000	6,018,500
Waimea II Reservoir	ft.	21,800		593,400	436,000	1,029,400
Distribution - Irrigation	ft.	184,400		209,400	1,127,800	1,337,200
Distribution - Livestock Water	ft.					
<b>SUBTOTAL - STRUCTURAL MEASURES</b>				<b>14,900,900</b>	<b>4,747,800</b>	<b>19,648,700</b>
<b>TOTAL PROJECT COSTS</b>				<b>14,900,900</b>	<b>4,747,800</b>	<b>19,648,700</b>

1/ Price base: 1988

January 1989

TABLE 2 - ESTIMATED COST DISTRIBUTION  
Maimea-Paauilo Watershed, Hawaii

(dollars) I/

Item	Installation Cost - PL-566 Funds			Installation Cost-Other than PL-566 Funds			GRAND TOTAL	
	Construction	Engineering	Project Admin.	Total	Construction	Land Rights		Project Admin.
Upper Hamakua Ditch Improvement	208,000	66,600	25,000	299,600	208,000	1,000	8,300	217,300
UHD By-Pass Pipelines	300,000	96,000	36,000	432,000	300,000	2,700	12,000	314,700
UHD-Waimea II Res.Sup.Pipeline	508,000	162,600	61,000	731,600	508,000	3,700	20,300	532,000
Subtotal								
Maimea II Reservoir	2,304,600	737,500	276,600	3,318,700	2,304,700	33,600	92,200	2,430,500
Irrigation	0	34,800	13,000	47,800	217,200	0	4,300	221,500
Livestock Water	2,304,600	772,300	289,600	3,366,500	2,521,900	33,600	96,500	2,652,000
Subtotal								
Distribution - Irrigation	64,100	20,500	7,700	92,300	64,200	0	2,600	66,800
Maimea II to Existing Mainline	99,400	31,800	11,900	143,100	99,400	2,000	4,000	105,400
Lalaimilo Ag. Park Expansion	248,600	79,600	29,800	358,000	248,600	5,300	9,900	263,800
Hawaiian Home Lands Expansion	412,100	131,900	49,400	593,400	412,200	7,300	16,500	436,000
Subtotal								
Distribution - Livestock Water	0	63,700	29,900	93,600	398,000	46,800	8,000	452,800
Main, E, E-1, Group 2	0	3,800	1,400	5,200	23,500	8,100	500	32,100
Group 1	0	36,600	13,700	50,300	228,700	34,300	4,600	267,600
Group 3	0	33,700	12,600	46,300	210,700	37,200	4,200	252,100
Group 5	0	3,700	1,400	5,100	23,100	7,600	500	31,200
Group 7	0	10,800	4,100	14,900	67,500	23,300	1,400	92,200
Group 9	0	152,300	57,100	209,400	951,500	157,300	19,000	1,127,800
Subtotal								
TOTAL - STRUCTURAL MEASURES	3,224,700	1,219,100	457,100	4,900,900	4,393,600	201,900	152,300	4,747,800

I/ Price base: 1988

**TABLE 3 - STRUCTURAL DATA**  
**WAIMEA II DAM AND RESERVOIR**  
 Waimea-Paauilo Watershed, Hawaii

Item	Unit	Quantity
Class of Structure		c
Seismic Zone		3.0
Uncontrolled Drainage Area	Sq. Mi.	0.13
Controlled Drainage Area	Sq. Mi.	0.0
Total Drainage Area	Sq. Mi.	0.13
Runoff Curve No. (1-day) (AMC II)		52
Time of Concentration ( $T_c$ )	Hrs.	0.44
Maximum Height of Dam	Ft.	65.0
Volume of Fill	Cu. Yd.	252,000
Elevation Top of Dam	Ft.	3,020.0
Elevation Crest Emergency Spillway	Ft.	3,016.5
Elevation Crest Principal Spillway	Ft.	3,015.7
Emergency Spillway Type		Vegetated
Emergency Spillway Bottom Width	Ft.	20
Emergency Spillway Exit Slope	%	5.0
Total Capacity <u>1/</u>	Ac. Ft.	418.9
Sediment Submerged	Ac. Ft.	1.04
Beneficial Use (irrigation & stockwater)	Ac. Ft.	408.2
Surface Area		
Sediment Pool	Acres	1.0
Beneficial Use Pool (irrigation/livestock)	Acres	14.0
Principal Spillway Design		
Rainfall Volume (1-day)	In.	12.0
Rainfall Volume (10-day)	In.	27.0
Runoff Volume (10-day)	In.	18.40
Capacity	cfs	35.0
Dimensions of Conduit (length/diameter)	Ft./In.	185/30
Type of Conduit		RCCP
Frequency Operation-Emergency Spillway	% chance	≤ 1.0
Emergency Spillway Hydrograph		
Rainfall Volume	In.	11.64
Runoff Volume	In.	5.04
Storm Duration	Hrs.	6.0
Velocity of Flow ( $V_e$ )	Ft./Sec.	2.7
Max. Reservoir Water Surface Elevation	Ft.	3,016.9
Freeboard Hydrograph		
Rainfall Volume	In.	22.0
Runoff Volume	In.	13.82
Storm Duration	Hrs.	6.0
Max. Reservoir Water Surface Elevation	Ft.	3,018.4
Discharge per Foot of Width ( $O_e/b$ )	Ac. Ft.	1.4
Bulk Length	Ft.	95.0

1/ Crest of Emergency Spillway.

TABLE 3A - STRUCTURAL DATA  
UPPER HAMAKUA DITCH BY-PASS PIPELINES  
 Waimea-Paauilo Watershed, Hawaii

Item	Unit	Quantity
<u>Segment No. 4</u>		
Diameter	In.	24
Length	Ft.	6,000
Design Capacity	cfs.	35
Design Head	psi.	72
<u>Segment No. 5</u>		
Diameter	In.	24
Length	Ft.	2,000
Design Capacity	cfs.	35
Design Head	psi.	20

TABLE 3B - STRUCTURAL DATA  
RESERVOIR SUPPLY PIPELINE  
 Waimea-Paauilo Watershed, Hawaii

Item	Unit	Quantity
<u>Segment No. 6</u>		
Diameter	In.	30
Length	Ft.	3,100
Design Capacity	cfs.	30
Design Head	psi.	19

TABLE 3C - STRUCTURAL DATA  
IRRIGATION DISTRIBUTION SYSTEM  
 Waimea-Paaulo Watershed, Hawaii

Item	Unit	Quantity
<u>Mainline from Waimea II Reservoir to existing Waimea Irrigation System</u>		
Pipe, ductile iron 24-inch diameter	Lin. Ft.	900
<u>Mainline for Lalamilo Addition</u>		
Pipe, Polyvinyl Chloride, Class 200		
12-inch diameter	Lin. Ft.	2,400
8-inch diameter	Lin. Ft.	2,100
6-inch diameter	Lin. Ft.	3,100
4-inch diameter	Lin. Ft.	<u>1,900</u>
Total		9,500
<u>Mainline for DHHL Additions</u>		
Pump, Booster, 25 HP	each	2
Pipe, Polyvinyl Chloride, Class 200		
14-inch diameter	Lin. Ft.	1,500
10-inch diameter	Lin. Ft.	5,900
8-inch diameter	Lin. Ft.	1,400
6-inch diameter	Lin. Ft.	1,700
4-inch diameter	Lin. Ft.	<u>4,800</u>
Total		15,300

**TABLE 3D - STRUCTURAL DATA**  
**LIVESTOCK WATER DISTRIBUTION SYSTEM PIPELINE**  
 Waimea-Paauilo Watershed, Hawaii

Item	Unit	Quantity
Area Served	Ac.	22,800
<b><u>MAINLINE (DHHL) FROM WAIMEA II RESERVOIR</u></b>		
Pipe, HDPE Pressure Rating 3408		
6-inch diameter	Lin. Ft.	7,800
5-inch diameter	Lin. Ft.	4,700
4-inch diameter	Lin. Ft.	6,000
<b><u>MAIN LATERALS (DHHL) FROM MAINLINE</u></b>		
<b><u>To Group 3</u></b>		
Pipe, HDPE Pressure rating 3408		
4-inch diameter	Lin. Ft.	3,200
<b><u>To Group 7 and 9</u></b>		
Pipe, HDPE Pressure Rating 3408		
3-inch diameter	Lin. Ft.	9,600
2-inch diameter	Lin. Ft.	6,300
TOTAL		<u>37,600</u>
<b><u>MAIN LATERALS (DHHL) FROM MAINLINE</u></b>		
<b><u>To Group 5 and 9</u></b>		
Pump (with Diesel Engine), 5 HP - minimum	each	3 <u>1/</u>
Pipe, HDPE Pressure Rating 3408		
4-inch diameter	Lin. Ft.	11,000
3-inch diameter	Lin. Ft.	4,100
TOTAL		<u>15,100</u>
<b><u>GROUP SYSTEMS FROM MAINLINE AND MAIN LATERALS</u></b>		
<b><u>Group No. 1 (DHHL)</u></b>		
Pump (with Electric Motor), 0.5 HP	each	1
Pipe, HDPE Pressure Rating 3408		
1-1/2-inch diameter	Lin. Ft.	6,700
1-1/4-inch diameter	Lin. Ft.	1,650

1/ Add stand-by parallel pumps (same size) as demand requires.



**TABLE 3D - STRUCTURAL DATA**  
**LIVESTOCK WATER DISTRIBUTION SYSTEM PIPELINE**  
 Waimea-Paauiilo Watershed, Hawaii  
 (cont'd)

Item	Unit	Quantity
<u>Group No. 2 (DHHL)</u>		
Served directly from Mainline	---	---
<u>Group No. 3 (DHHL)</u>		
Pump (with Electric Motor), 5 HP	each	1 $\frac{1}{2}$
Pump (with Diesel Engine), 5 HP	each	2 $\frac{1}{2}$
Pipe, HDPE Pressure Rating 3408		
4-inch diameter	Lin. Ft.	10,700
3-inch diameter	Lin. Ft.	13,800
2-inch diameter	Lin. Ft.	8,600
1-1/2 inch diameter	Lin. Ft.	<u>7,700</u>
TOTAL		40,800
<u>Group No. 5 (DHHL)</u>		
Pump (with Diesel Engine), 5 HP	each	3 $\frac{1}{2}$
Pipe, HDPE Pressure Rating 3408		
3-inch diameter	Lin. Ft.	17,400
2-inch diameter	Lin. Ft.	700
1-1/2-inch diameter	Lin. Ft.	4,600
1-1/4-inch diameter	Lin. Ft.	6,800
1-inch diameter	Lin. Ft.	<u>16,800</u>
TOTAL		46,300
<u>Group No. 7 (DHHL)</u>		
Pipe, HDPE Pressure Rating 3408		
2-inch diameter	Lin. Ft.	1,300
1-1/2-inch diameter	Lin. Ft.	5,400
3/4-inch diameter	Lin. Ft.	<u>2,500</u>
TOTAL		9,200
<u>Group No. 9 (DHHL)</u>		
Pump (with Electric Motor) 0.5 HP	each	1
Pipe, HDPE Pressure Rating 3408		
2-inch diameter	Lin. Ft.	1,200
1-1/2-inch diameter	Lin. Ft.	12,900
1-inch diameter	Lin. Ft.	9,400
3/4-inch diameter	Lin. Ft.	<u>3,500</u>
TOTAL		27,000

TABLE 4 - ANNUALIZED ADVERSE NED EFFECTS  
 Waimea-Paauilo Watershed, Hawaii

(dollars) 1/

Evaluation Unit	PROJECT OUTLAYS		Total
	Amortization of Installation Cost	Operation, Maintenance and Replacement Cost	
Irrigated Cropland	510,800	38,000	548,800
Livestock Water	83,000	10,000	93,000
GRAND TOTAL	593,800	48,000	641,800

1/ Price base: 1988, discounted and annualized at 8.625 percent interest for 50 years

January 1989

Note: Table 5, as described by SCS, National Watershed Manual, is not applicable to this report and is omitted.

TABLE 6 - COMPARISON OF NED BENEFITS AND COSTS  
 Waimea-Paauilo Watershed, Hawaii

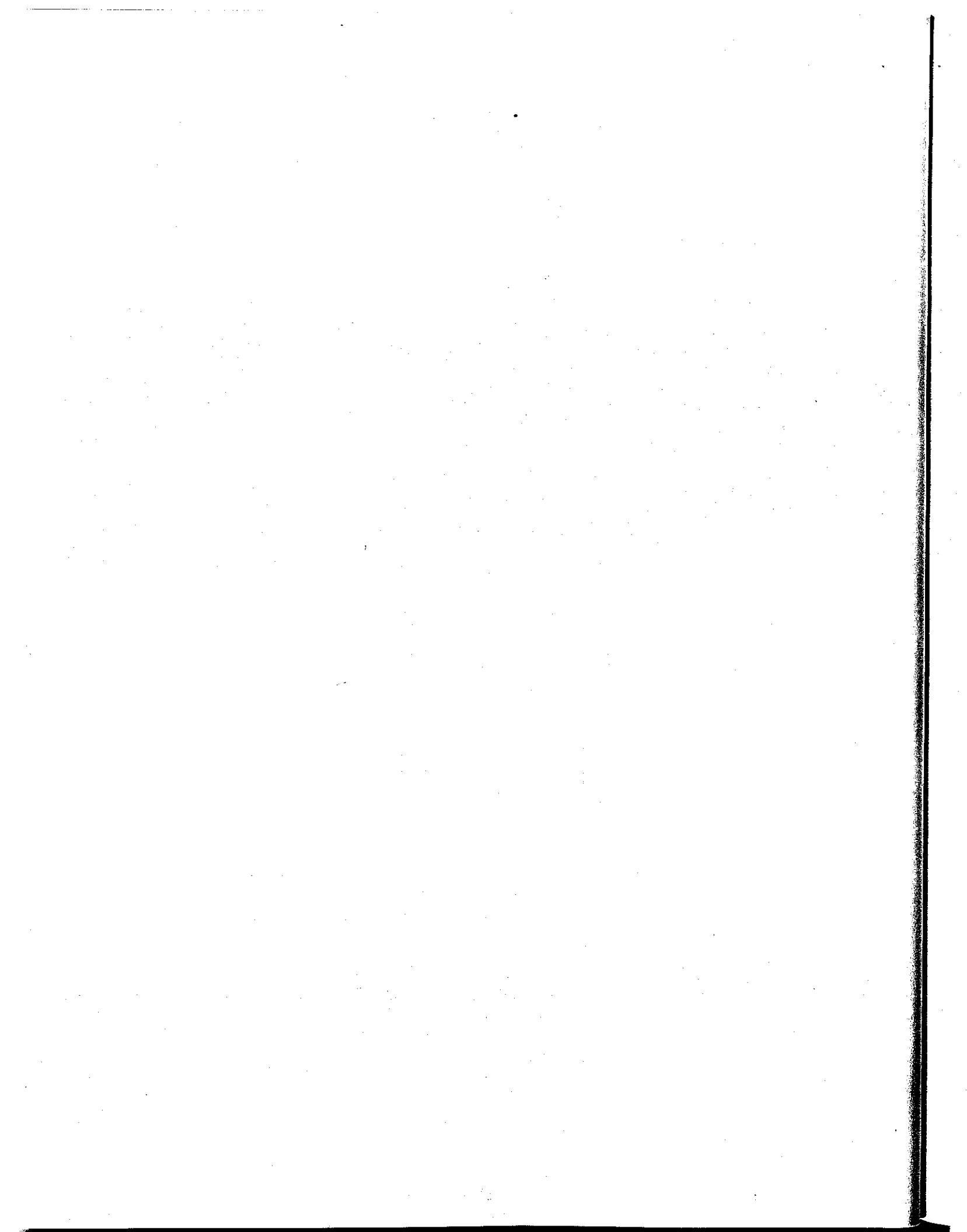
(dollars) <sup>1/</sup>

Evaluation Unit	AGRICULTURAL WATER MANAGEMENT			Total Annualized Benefits	Annualized Costs <sup>2/</sup>	Benefit: Cost Ratio
	Damage Reduction	Intensification				
Irrigated Cropland	764,600	448,500		1,213,100	548,800	2.2:1.0
Livestock Water	17,300	47,300		64,600	93,000	0.7:1.0
GRAND TOTAL	690,100	572,400		1,277,700	641,800	2.0:1.0

<sup>1/</sup> Price base: 1988

<sup>2/</sup> From Table 4

January 1989



# EFFECTS OF RECOMMENDED PLAN

## GENERAL

This section describes the economic, environmental, and social effects of the planned project and discusses five aspects of these effects. The FIRST ASPECT presents the Summary of the Effects. The SECOND ASPECT explains the degree or extent to which the recommended plan alleviates the problems and takes advantage of the opportunities listed in the Problem and Opportunity Identification section. The THIRD ASPECT covers features determined to have significant effects on concerns identified by the scoping process. The concerns are presented in Table B - Evaluation of Identified Concerns. The FOURTH ASPECT deals with specific resources that are recognized by federal policies. Table O - Effects of the Recommended Plan on Resources of Principal National Recognition lists the types of resources, the specific policy and the measurement of the effects. Relationship to Land and Water Plans, Policies and Controls is the FIFTH ASPECT.

## SUMMARY OF EFFECTS

Annualized benefits from reduced damages on irrigated truck crops due to droughts are estimated at \$764,600. The increase in irrigated truck crop acreage in the Lalamilo Agricultural Park and DHHL farm lots will account for \$448,500 in annualized benefits. Total annualized benefits for irrigated cropland are estimated at \$1,213,100.

For ranchers, annualized benefits are estimated at \$17,300 for reducing the cost of providing water for 10,900 cattle. The benefit for increasing the number of cattle produced in the watershed by 8,200 head is approximately \$47,300. Total annualized benefits for providing livestock water are estimated at \$64,600. These benefits will accrue to primarily native Hawaiian ranchers in the project area.

The total annualized benefits of this project are \$1,277,700.

The only adverse effect of the project on forest plant communities would be due to construction activities for the Upper Hamakua Ditch by-pass pipelines and the supply pipeline to Waimea Reservoir. The primary concern is the replacement of native vegetation by exotic vegetation. In segment 4 an estimated 0.5 acres of Community type 2, and 1.5 acres of Community type 3 would be affected. Improvements are not likely to adversely affect native vegetation in Segment 5. In segment 6, an estimated 0.5 acres of Community type 6 (closed canopy forest to 12 + m dominated by Metrosideros polymorpha var. macrophylla, and with Kahili ginger understory) would be removed. This project will affect an estimated total of 2.5 acres of communities dominated by native species in segments 4-6. There are 34,800 acres in the Kohala Forest Reserve.

The project will result in improvement in agricultural water management on 1,240 acres of cropland and improved water distribution on 22,800 acres of pastureland. The improvements will strengthen and expand the agricultural base and help retain important farmland in production.

Project installation will not result in adverse effects on minorities, handicapped, women, or the aged. The project will benefit native Hawaiian farmers and ranchers by providing water resources to their pasture and agricultural lots.

#### EFFECTS ON PROBLEMS AND OPPORTUNITIES

The Problem and Opportunity Identification section describes four major problems associated with the agricultural water supply in the watershed. The following discussion relates directly to these problems:

##### Water-Short Periods on Cropland

The planned project elements will make it possible to increase irrigated acreage from 877 to 1,240 acres - an increase of 363 acres. With this increased acreage the present system can only supply full season irrigation 45 out of every 100 years. The average annual shortage will be 27 days per year at 50 percent of normal daily delivery rate. The collection, storage and delivery system, when fully developed, will make it possible to supply adequate water for full season irrigation 80 out of every 100 years (see Figure 5). The other 20 years will have some degree of shortage. The average annual shortage will be 7 days per year at 50 percent of normal delivery rate. The increased acreage and improved reliability for full-season water will help to enhance and stabilize the area's agricultural income.

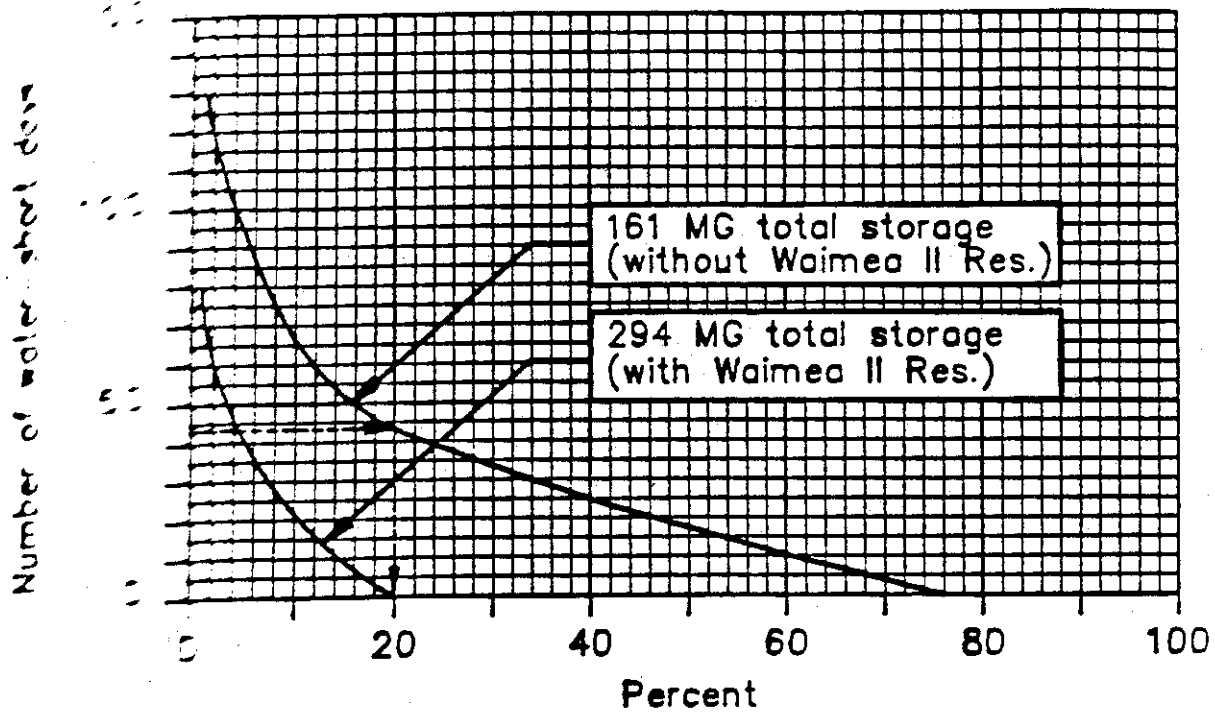


Figure 5. Probability of the number of water-short days being equaled or exceeded in any year.

Water Short Periods for Livestock

The proposed livestock water distribution system will replace the use of domestic water supply for 10,900 cattle currently dependent on DWS supplies. In addition, this system will support an opportunity to increase the carrying capacity in the same grazing area by 8,200 animal units through the application of intensive grazing management systems, notably by DHHL ranchers (see Table M). This proposed system will allow the ranchers to develop long-range plans for development and marketing. The increased number of animal units will stimulate the local agricultural economy. Although water short periods may occur occasionally, the intertie with the WIS supply system will adequately provide needed stockwater supplies.

**TABLE M - LIVESTOCK WATER DISTRIBUTION SYSTEM  
PASTURE ACREAGE AND ANIMAL UNITS  
Waimea-Paauilo Watershed, Hawaii**

Ownership	Pasture in Project Acres	Ranch Lots No.	Animal Units - No.	
			Without Project	With Project
DHHL	20,529	82	9,862	17,447
Private	2,274	26	988	1,593
<b>TOTAL</b>	<b>22,803</b>	<b>108</b>	<b>10,850</b>	<b>19,040</b>

Increased AU's with Project = 8,200 (rounded)

Domestic Water Shortage

Installation of a separate supply and distribution system for livestock water will reduce the demand on the domestic system by 40 MG. This water is now serving 10,900 head of livestock.

Shortage of Cropland

The recommended plan will make it possible to increase the irrigated cropland area from 877 acres to 1,240 acres, an increase of 363 acres. This increase will meet the area's short-term needs for irrigated cropland. The effect of the recommended plan on irrigated cropland area is illustrated in table N.

**TABLE N - EFFECT OF RECOMMENDED PLAN ON CROPLAND AREA  
Waimea-Paauilo Watershed, Hawaii**

LOCATION	NUMBER OF LOTS	TOTAL AREA (acres)	CROPLAND AREA 1/ (acres)	NET IRRIGATED AREA 2/ (acres)
Puukapu Farmlots	21	370	285	200
Lalamilo Farmlots	28	670	443	310
Lalamilo Addition	8	270	163	115
<b>SUB-TOTAL</b>	<b>36</b>	<b>940</b>	<b>606</b>	<b>425</b>
DHHL Farmlots	16	273	149	105
DHHL Add.-Phase I 3/	12	55	32	22
DHHL Add.-Phase II 3/	59	295	168	118
<b>SUB-TOTAL</b>	<b>87</b>	<b>623</b>	<b>349</b>	<b>245</b>
<b>TOTAL</b>	<b>144</b>	<b>1,933</b>	<b>1,240</b>	<b>870</b>



SUMMARY OF PLANNED ADDITIONS				
Lalamilo Addition	8	270	163	115
DHHL Add.-Phase I <sup>3/</sup>	12	55	32	22
DHHL Add.-Phase II <sup>3/</sup>	59	295	168	118
TOTAL	79	620	363	255

- 1/ Cropland area is about 57% to 77% of total area to allow for field roads, windbreaks, farmsteads, rock piles, etc.
- 2/ Net irrigated area is 70% of cropland. It is the area irrigated at any given time. It allows for the non-irrigated periods between crops and during harvest.
- 3/ DHHL Additions - Phase I and II - refers to DHHL development program.

#### SIGNIFICANT EFFECTS ON IDENTIFIED CONCERNS

This recommended plan addresses the 12 concerns listed in Table B that have high or medium significance to decisionmaking.

#### Prime Farmland

An additional 363 acres will be irrigated from the new system with a more dependable supply of water. Of this additional area, 312 acres will be classed as prime farmland.

#### Crop Production

Crop production will be improved on the existing 802 acres of irrigated cropland. Crop production also will be increased on the additional 75 acres which will come into production without the project. An additional 363 acres will be brought into production through project action. Improving the water supply will also stabilize crop production on all of the 1,240 acres.

#### Economics

Net farm income will be increased. The annualized benefits for farmers, due to reducing damages on irrigated truck crops because of droughts, are estimated at \$764,600. The increase in irrigated truck crop acreage in the Lalamilo Addition and DHHL Additions will account for \$448,500 in increased income for farmers in the Waimea area. Total annualized benefits for farmers with irrigated cropland are estimated at \$1,213,100.

For ranchers, annualized benefits are estimated at \$17,300 for reducing the cost of providing water for 10,900 cattle. The annualized benefit for increasing the number of cattle produced in the watershed area by 8,200 head is approximately \$47,300. Total annualized benefits for ranchers due to providing livestock water are estimated at \$64,600.

### Wildlife Habitat

No significant impact on wildlife or habitat is anticipated by the proposed project. Ditch and trail improvements pose no threat to native forest birds. Their primary habitat will not be affected.

### Threatened and Endangered Species (10)

Project activities will have no adverse effects on threatened and endangered species or their habitats. Although Hawaiian hoary bats and Hawaiian hawks are known to occur within the general project area, their range is relatively large, throughout variable habitats. These birds were not sighted during FWS bird surveys. There is little chance the project will adversely affect them.

Use of the UHD area by the Hawaiian duck Anas wyvilliana has been reported. It is probable that the slower sections of the ditch and the natural stream in segment 4 are utilized most. The bypass pipeline will eliminate ditch flows from the stream and it will revert to natural flow conditions. This action should have no effect on the use of the area by this species. New reservoir surface water may be beneficial.

### Surface Water Quantity

Irrigation and livestock water supplies will be increased by improving efficiency of the collection system and constructing another storage reservoir.

### Ground Water Quantity

Installation of project features will have no measurable effect on the quantity of ground water. Ground water has not been used as a source of water for this project.

### Forest Resources

This project will affect an estimated total of 2.5 acres of communities dominated by native species in segments 4-6 in the Upper Hamakua Ditch. Construction work in the Kohala Forest Reserve will have minimal adverse effects. The Kohala Forest Reserve consists of 34,800 acres.

### Livestock Water

Project features will ensure an increased supply of livestock water for those ranchers in the benefitted areas and a supply that is more dependable during drought periods.

### Cultural Resources

The Waimea Agricultural System, a subdistrict of the Kohala Agricultural System, borders the proposed project on the northern and western edges of the Lalamilo Addition (see fig. 3, Spencer, 1989). The Waimea Agricultural System consists of prehistoric agricultural, residential, and livestock-related site clusters. Although not nominated to the National Register of Historic Places,

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this historic district is eligible under several criteria. The irrigation pipeline corridors to the Lalamilo Addition have been designed to avoid this historic district by approximately 500 feet. Cropland expansion areas, when installed, will also be designed to avoid this historic district.

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Social Effects

The project will assist DHHL in providing water for farm and pasture lots to native Hawaiians.

Urbanization - Land Use Changes

No increased urbanization will result from this project.

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EFFECTS ON NATIONALLY RECOGNIZED RESOURCES

Certain federal policies and laws recognize specific types of resources. These policies and laws impose specific requirements for analysis of the effects of the recommended plan as shown in Table O.

RELATIONSHIP TO LAND AND WATER PLANS, POLICIES AND CONTROLS

Appropriate clearinghouse procedures have been followed by the Sponsors in processing the application for assistance under PL-566. The notification of application was issued April, 1983 by the state clearinghouse, Hawaii Department of Land and Natural Resources.

The selected plan is compatible with DHHL's Puu Kapu Development Plan and DLNR's long-range plan for the Lalamilo Agricultural Park.

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TABLE O - EFFECTS OF THE RECOMMENDED PLAN ON RESOURCES OF PRINCIPAL NATIONAL RECOGNITION  
 Waimea-Paauilo Watershed, Hawaii

Type of Resources	Principal Sources of National Recognition	Measurement of Effects
Air Quality	Clean Air Act, as amended (42 U.S.C. 1857h-7 et seq.)	No effect
Areas of particular concern within the coastal zone	Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1451 et seq.)	No effect
Threatened and endangered species critical habitat	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.)	No significant effect
Fish and wildlife habitat	Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.)	No significant effect
Floodplains	Executive Order 11988, Floodplain Management	Not applicable
Historic and Cultural Resources	National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.)	No effect
Prime and unique farmland	CEQ Memorandum of August 1, 1980; Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act Farmland Protection Policy Act of 1981	312 acres of prime farmland gained. Unique-Not applicable
Water Quality	Clean Water Act of 1977 (33 U.S.C. 1251 et seq.)	No significant effect
Wetlands	Executive Order 11990, Protection of Wetlands Clean Water Act of 1977 (33 U.S.C. 1251 et seq.)	No significant effect
Wild and scenic rivers	Wild and Scenic Rivers Act, as amended (16 U.S.C. 1271 et seq.)	Not present in planning area.

# CONSULTATION AND PUBLIC PARTICIPATION

Public participation and consultation with other agencies was an integral part in all phases of planning and environmental evaluation conducted by the Sponsors and SCS. All contacts were recorded and the results reported and evaluated in the documentation.

## AGENCY CONSULTATION

Formal agency consultation began with the notification by SCS, State of Hawaii (DLNR) and Mauna Kea Soil and Water Conservation District of the Application for Federal Assistance under PL-566 to area and state clearinghouses as part of the A-95 review process. All federal agencies with a possible interest in the project were also notified of the application for assistance. Informal coordination with the U.S. Fish and Wildlife Service and State of Hawaii was initiated early in 1983.

Based on the results of these meetings and preauthorization studies, SCS requested planning authorization from the Chief of SCS in Washington, D.C. This Authorization was granted, and agencies and the public were notified on July 5, 1983.

Intensive planning and environmental evaluation began in June, 1984 under the direction of the SCS. An interdisciplinary team was formed to identify resource problems and related environmental considerations in the watershed. The team was composed of federal, state, and local agency personnel, and private citizens representing local groups and organizations. Meetings held on December 7, 1984, resulted in the identification of concerns listed in Table B. Federal, state and county agencies participated in the "scoping process" described in the section, Inventory and Forecasting. The multidisciplinary planning staff and associated SCS specialists consulted with these agencies and group representatives on specific items as necessary, and periodically on an informational basis. Numerous meetings (formal and informal) were held with state, county, local agencies and groups and with federal agencies that were able to contribute data to the team and sponsors. The environmental evaluation required by the National Environmental Policy Act (NEPA) was conducted in conjunction with planning. Similar consultation continued throughout the environmental evaluation. Often one workshop, meeting, or contact served both planning and evaluation purposes.

The U.S. Fish and Wildlife Service (USFWS) was specifically consulted in accordance with Section 7 of the Endangered Species Act, as amended, concerning threatened and endangered species that may be present in Waimea-Paauilo Watershed. USFWS concurred in a no adverse impact assessment to listed or proposed species (10). USFWS also assisted, together with Hawaii Department of Forestry and Wildlife, in determining biological assessment needs and means to minimize adverse project effects.

The proposed project has been coordinated with the State Historic Preservation Officer and staff since 1985. Consultation and a concurrence of no effect was obtained February 15, 1989.

A Technical Review Plan-EA was distributed for an informal review to local agencies and to local offices of state and federal agencies and others who had participated. Discussions and informal comments on the technical review were incorporated into the Draft Plan-EA.

The notice of availability of the Draft Plan-EA for Waimea-Paauiilo Watershed will be published in the Federal Register and local newspapers. Notices will be mailed to residents and owners in the project area. The Plan-EA will be distributed for review and comment to individuals who had expressed interest in receiving a copy and to the agencies and groups shown on the following list:

U.S. Government

Department of Agriculture  
Office of Equal Opportunity  
Agricultural Stabilization and Conservation Service (State Office)  
Farmers Home Administration  
Forest Service (Pacific Southwest Regional Office)  
Department of Defense  
Corps of Engineers (Honolulu District Office)  
Department of Commerce  
Department of Housing and Urban Development  
Department of Health and Human Services  
Department of the Interior  
Advisory Council on Historic Preservation  
Fish and Wildlife Service (Regional Office)  
National Park Service  
Environmental Protection Agency (Regional Office)

State of Hawaii

Department of Business and Economic Development  
Department of Agriculture  
Department of Land and Natural Resources  
Division of State Parks, Outdoor Recreation  
and Historic Sites  
Division of Forestry and Wildlife  
Division of Water and Land Development  
Department of Hawaiian Home Lands  
Office of State Planning  
University of Hawaii - Manoa, Cooperative Extension Service

County of Hawaii

County Planning Commission  
County Department of Water Supply  
Mauna Kea Soil and Water Conservation District

Groups

Waimea Stockwater Committee

## PUBLIC PARTICIPATION

A major consideration in the development of the plan and environmental assessment was to provide interested and affected groups and individuals opportunity to participate. The Sponsors and SCS developed a public participation program to achieve a high level of participation. Many individual contacts were made with residents in the project area and other interested persons to gather data and, most importantly, to solicit participation in planning and environmental evaluation.

A mailing list was prepared and maintained to ensure timely notification of meetings and distribution of materials. A newsletter, Waimea-Paauiilo Watershed, was distributed to owners and residents in the project area at important points in the planning process. The newsletter was also used to advise local residents of meetings and the availability of information for their review.

Upcoming meetings and the availability of information were announced in newspaper notices and articles, media spots, posters, and at meetings of interested groups. Newspaper articles and media coverage also informed people of general progress during planning.

Public meetings were held beginning early in the preauthorization phase of planning with the public and interagency meetings held December 11 and 12, 1983. A public and interagency scoping meeting was held December 7, 1984. Participation was enthusiastic and opinions were expressed on various charts listing problems, opportunities and the alternative plans that were under consideration. NED and Without Project plans were included in the plan proposals. The ranchers' concern for livestock water was considered. The public scoping meeting to determine the concerns of the local people was held February 7, 1984. Public meetings on June 26, 1986 and February 12, 1987, reviewed and refined the various livestock water alternatives along with the irrigation element. A public meeting for discussion of the Technical Review Draft Plan was held September 20, 1988. Local ranchers were surveyed by a questionnaire in April 1987 to determine current status for livestock use and future projections on stocking rates and water needs. Meetings with the Sponsors were held during planning to modify project alternatives and obtain their participation on January 22, 1986, May 15, 1986, September 10, 1986, February 12, 1987, June 26, 1987, September 10, 1987, February 18, 1988, March 14 and 15, 1988, September 20, 1988 and July 26, 1989.

A Technical Review Copy of the plan-environmental assessment was given local distribution through public meeting notices. This preliminary version will be circulated within SCS for technical review and, at the same time, copies were made available for interested groups, individuals, and local agencies (including local offices of federal agencies) for an informal review.

After revision, the plan-environmental assessment was published as a Draft and officially distributed for formal, interagency review on May 1, 1989. The formal interagency review period concluded on June 27, 1989. Public participation in this review was encouraged.

SUMMARY OF COMMENTS AND RESPONSES

Comments from this review and editorial corrections were considered in preparing the Final Plan-EA. Comments received on the draft and the responses to those comments are included in Appendix A.



# LIST OF PREPARERS

LIST OF PREPARERS AND THEIR QUALIFICATIONS  
Waimea-Paauilo Watershed, Hawaii

Name	Present Title (Years in Job)	Education Degree(s) and Subject	Past Experience Titles and Years in Job	Other (License(s), Etc.)
------	---------------------------------	------------------------------------	--	-----------------------------

The draft plan and environmental assessment was reviewed and concurred on by State staff specialists having responsibility for engineering, soils, agronomy, range conservation, biology and geology. This review was followed by review of the document and supporting data by the West National Technical Center.

## SCS WNTC PLANNING STAFF

Thomas T. Fujii	Staff Leader 1989	BS - Agricultural Engineering BA - Business Administration	Field Office Engineer - 5 Area & Project Engineer - 6 River Basin Engineer - 3 Civil Engineer - 3 Head, EDS - 10 Irrigation Engineer - 2 Planning Engineer - 4	
Peter V. Patterson	Staff Leader - 2 (to 1988)	BS - Geology MS - Structural Geology	Sedimentation Geologist - 1 Nat'l. Engr. Geologist Regional Geologist - 2 Sedimentation Engineer - 3 Geotechnical Staff Ldr. - 2 Engineering Geologist - 3 Geologist - 9	Prof. Eng. Geologist - CA Prof. Eng. Geologist - OR Prof. Geol. Scntst. - AIPG
Earl B. Alderman	Engineering Technician - 4	Senior Standing - Civil Engineer (3 years college, civil engineer)	Engineer Technician - 15 Materials Testing - 8 Construction Inspector - 2	
Paul H. Cleary	Planning Engineer - 7	BS - General Engineering	Civil Engineer - 4 Hydraulic Engineer - 8 River Basin Staff Leader - 4	Prof. Eng. - WI

LIST OF PREPARERS AND THEIR QUALIFICATIONS (Continued - 2)  
 Waimea-Paauilo Watershed, Hawaii

Name	Present Title (Years in Job)	Education Degree(s) and Subject	Past Experience Titles and Years in Job	Other (License(s), Etc.)
<u>SCS WNTC PLANNING STAFF, cont'd</u>				
Benjamin E. Mouchett Jr.	Soil Conservationist - 6	BS - Mechanical Technology in Agriculture	District Conservationist - 16 Resource Conservationist/ IPA State SWCC - 4 RC&D Coordinator - 3	
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Eldena C. VanderZanden	Agricultural Economist - 5 (To 1989)	BA - Math & Economics	Agricultural Economist - 7 Regional Economist, C of E - 3	
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LIST OF PREPARERS AND THEIR QUALIFICATIONS (Continued - 3)  
 Waimea-Paauilo Watershed, Hawaii

Name	Present Title (Years in Job)	Education Degree(s) and Subject	Past Experience Titles and Years in Job	Other (License(s), Etc.)
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Larry J. Babich	State Conservation Engr. - 1	BS - Civil Engineering	Civil Engineer - 6 Planning Engineer - 9 Staff Leader - 1	PE - MT & AZ
George W. Love	Resource Conservationist - 8	BS - Animal Science MS - Range Science	Area Range Cons. - 5 Dist. Conservationist - 5 Resource Conservationist - 4	
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Gail H. Ichikawa	Economist - 8	BS - Agriculture	Student Trainee - 2	
Glenn G. Ahuna	Hydrologist - 10	BS - Civil Engineering		PE - HI & CA

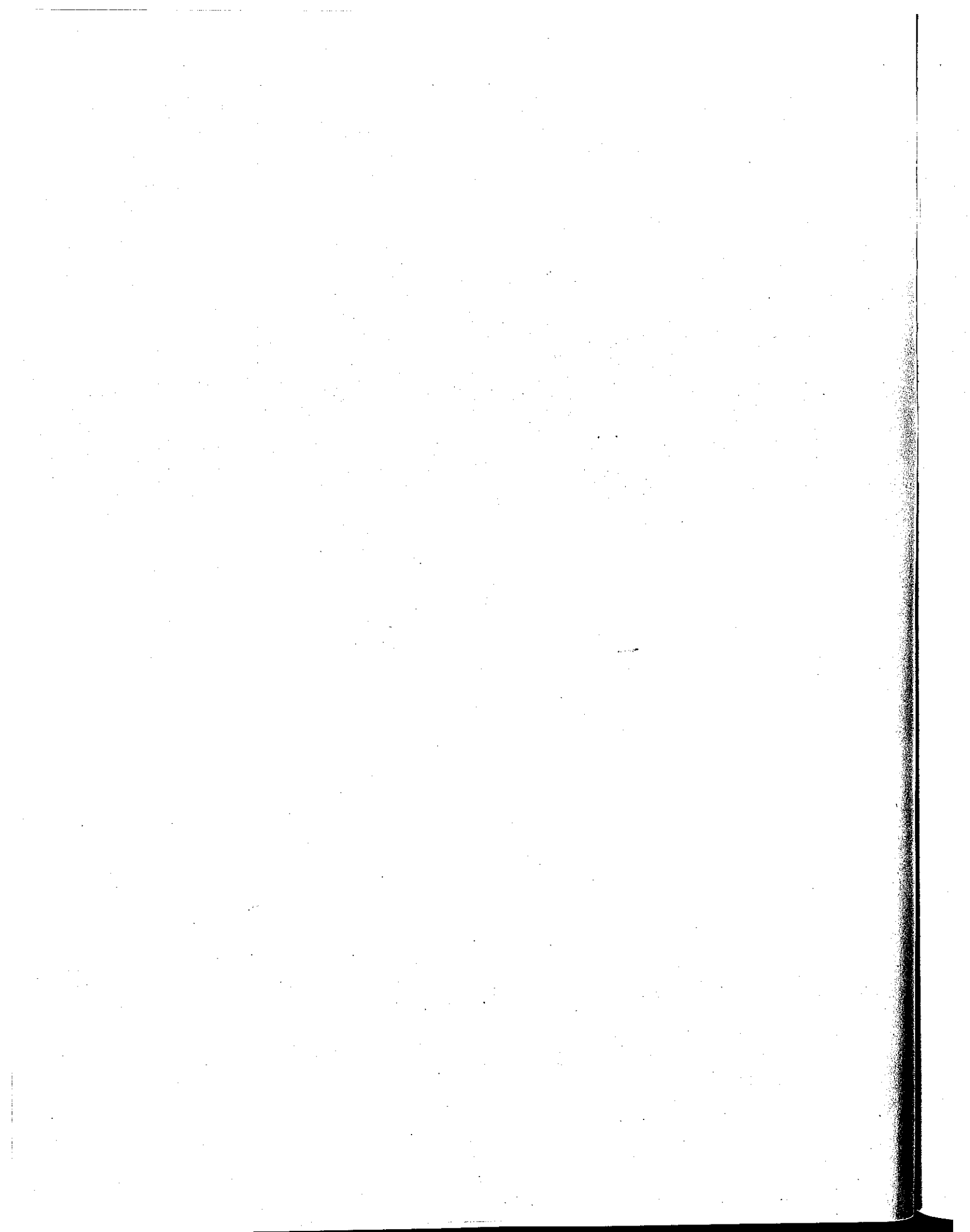
LIST OF PREPARERS AND THEIR QUALIFICATIONS (Continued - 4)  
 Waimea-Paauilo Watershed, Hawaii

Name	Present Title (Years in Job)	Education Degree(s) and Subject	Past Experience Titles and Years in Job	Other (License(s); Etc.)
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# APPENDICES

## APPENDIX LIST:

- APPENDIX A - Letters and Oral Comments on Draft Plan-EA
- APPENDIX B - Selected Drought Reports
- APPENDIX C - Upper Hamakua Ditch Forest Communities and Evaluation Units
- APPENDIX D - Waimea II Dam and Reservoir Details with Breach Inundation Map
- APPENDIX E - Irrigation Distribution System and Proposed Mainline Extension
- APPENDIX F - Livestock Water Distribution System
- APPENDIX G - Project Map



# APPENDIX C

## UPPER HAMAKUA DITCH FOREST COMMUNITIES AND EVALUATION UNITS

- C-1 Forest communities identified in the project area.
- C-5 Upper Hamakua Ditch Map





## APPENDIX C

### FOREST COMMUNITIES IDENTIFIED IN THE PROJECT AREA (3)

1. Open scrub vegetation comprised of mixed native species and much exposed *Sphagnum palustre*.--This scrub formation is typically less than 1 m in height. The common woody native shrub species which form 50 percent to 100 percent vegetation cover include a form of *Metrosideros polymorpha* var. *glaberrima*, *Vaccinium calycinum*, *Styphelia tameiameia*, *Myrsine sandwicensis*, *Broussaisia arguta*, *Ilex anomala* and *Labordia hedyosmifolia*. *Trematalobelia kohalaensis* is an occasional component of this vegetation and was seen blooming in October, 1986 with conspicuous numerous racemes of large whitish flowers. Two native grasses, *Isachne distichophylla* and *Deschampsia australis*, and the native sedge *Carex alligata*, are also occasional components of this vegetation. The indigenous peat moss, *Sphagnum palustre*, forms a dense, pale-green mat beneath and between the shrubs in this community, being particularly conspicuous where the shrub species do not form a closed canopy.

There is a very low occurrence of weedy, or alien species in this community, and as such, it is of high biological value. In the project area this community was located on level terrain west of the Upper Hamakua Ditch in segment 2 north of Tunnel No. 12, and between the ditch and the cliffs of Alakahi Valley south of Tunnel No. 12.

2. Closed scrub vegetation comprised of mixed native species, or often dominated by *Metrosideros polymorpha* var. *glaberrima* and with emergent *Cheirodendron trigynum*.--The woody components of this vegetation type are not different from those shrub species listed above. This is a higher statured community than the former, ranging from 1 to 5 m in height, with the woody species generally forming a closed canopy. Native ferns are common. *Sphagnum* is also present as a ground cover in much of this community. Several species of *Clermontia* occur in this community. These shrubs are particularly common overhanging Upper Hamakua Ditch in the northern end of segment 1, and throughout segment 2.

This is the predominant vegetation along segments 1 and 3 of the project, and in segment 2 except for where the low scrub community is present. It is within this vegetation unit that Corn and Davis (1983) located *Clermontia drepanomorpha* and *Diplazium molokaiense*, both candidate endangered species.

Much of this vegetation, as the former, is largely weed free. Sections of this vegetation, however, have been disturbed in the past, likely by feral pigs, and have a ground cover of exotic grasses.

3. Closed forest dominated by *Metrosideros polymorpha* var. *glaberrima*, with native shrubs and ferns--This forest differs from the former communities principally in its greater stature of 5-8 m tall. The shrub species of the previous communities also occur here. *Sphagnum*, however, is less frequent as

ground cover. Clermontia sp. also occur in this community particularly overhanging the ditch in the southern part of segment 4. A single loulu palm (Pritchardia sp.) also occurs in this vegetation in segment 4, but far enough from the ditch to avoid being impacted by the project.

This community occurs in segments 1, 3, and 4 of the Upper Hamakua Ditch project. While generally free of exotics, areas which have experienced past disturbance have an exotic grass understory.

4. Closed forest dominated by *Metrosideros polymorpha* var. *strigosa* with dense ground cover of *Sphagnum*.--This unique vegetation has a densely closed canopy at 4-6 m of the pubescent-leaved 'ohi'a, *M. p.* var. *strigosa*. These trees are festooned with thick mats of bryophytes (leafy liverworts and mosses). There are a few scattered native shrubs in this community including *Myrsine sandwicensis*, and *Labordia hedyosmifolia*, and the native sedge *Carex alligata*. *Sphagnum* is the conspicuous ground cover.

There are virtually no weeds in this community where the canopy remains intact. This vegetation type is present only at the periphery of the project area. Small sections of this forest occur southwest of the flume near the Kawainui intake and to the east of the flume. One notable patch of this forest occurs along the present access road south of the first Alakahi overlook. It represents a rare vegetation formation found nowhere else in the state, and is of limited extent even in the Kohala Mountains.

This, and the previous described vegetation types, are the primary types of vegetation found throughout the higher regions of the Kohala mountains. The dynamic relationships among them and the edaphic or ecological factors which influence the expression of these various communities are not known. The particular 'ohi'a which is dominant in this community is present as a low shrub in the area west of the flume in segment 3 and may one day mature to this unique closed forest.

5. Open canopy shrub community with mixed native species, ferns and matted ferns and with exotic understory.--*Metrosideros polymorpha* var. *glaberrima*, *Ilex anomala*, *Gouldia* sp., *Cheirodendron trigynum*, *Broussaisia arguta*, *Coprosma* sp., *Pipturus*, *Myrsine* sp., *Vaccinium calycinum*, and three species of tree ferns are the major components of this community which is found on the slopes above the waterfall at the upstream end of segment 5 and downstream on the slopes until the canopy is dominated by exotic trees. There appears to be more *Cheirodendron*, and less 'ohi'a on the steeper north-facing slope. Palm grass and white ginger, both exotics, are common in the understory along with uluhe, an indigenous matted fern.

6. Open to closed canopy forest to 12<sup>+</sup> m. dominated by *Metrosideros polymorpha* var. *macrophylla*, and with an understory of exotic kahili ginger.--'Ohi'a is the dominant canopy species in this community. It occurs along with a few scattered exotic trees (*Ficus*, *Alnus* and *Melaleuca*). Lower statured native trees are occasional in this community including *Coprosma*,

Cheirodendron trigynum, Gouldia terminalis, Myrsine lessertiana, Pelea clusiaefolia, and Ilex anomala along with three species of tree fern and the exotic strawberry guava (Psidium cattleianum). Kahili ginger (Hedychium gardnerianum) forms virtually a solid understory in this forest.

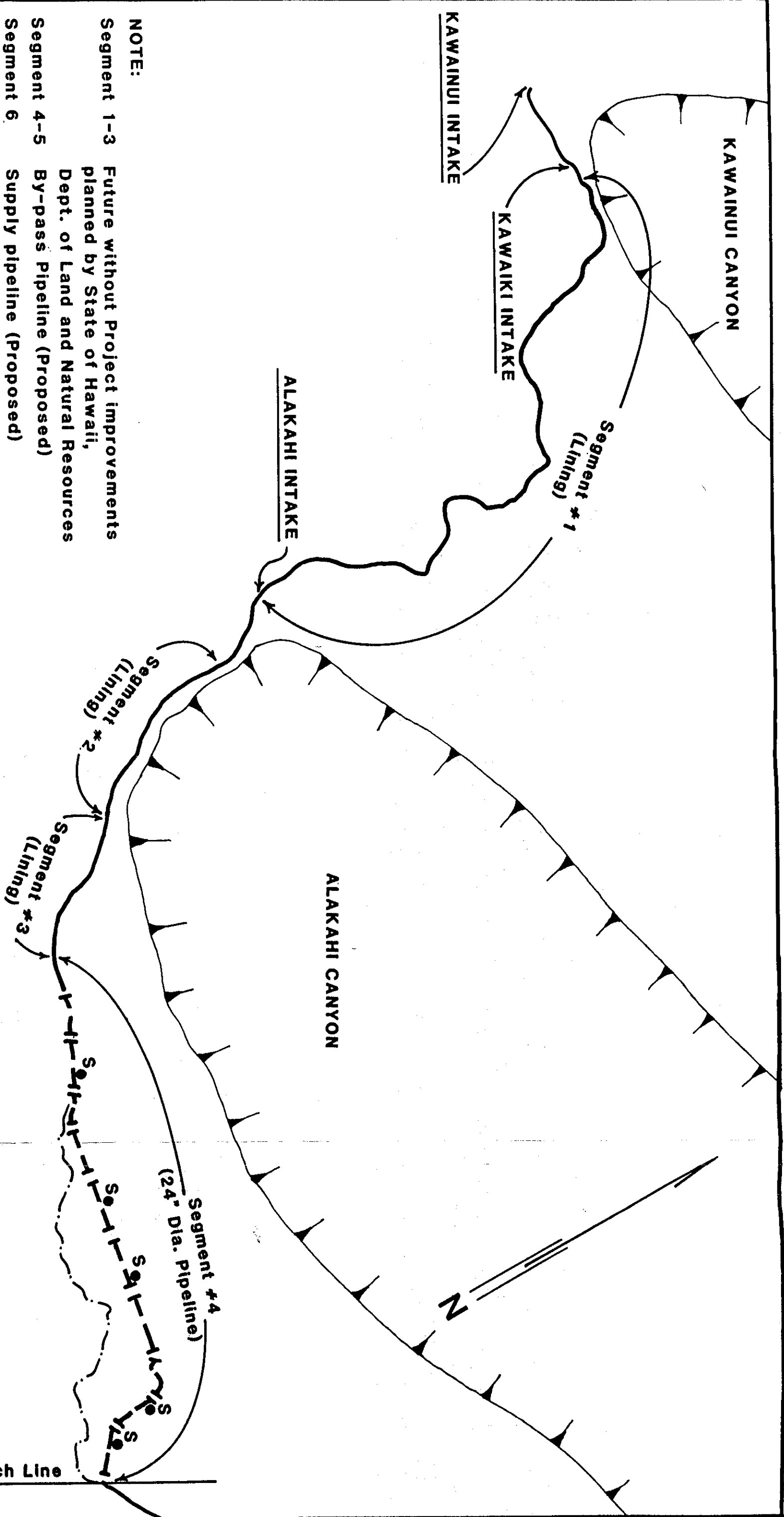
The lower end of Upper Hamakua Ditch and forest above the forest boundary are vegetated with this community. Though the understory is largely disturbed, the more or less intact canopy dominated by the native 'ohi'a provides habitat for forest birds and native invertebrates.

7. Stream community.—The stream community consists of the area along segment 5 in the natural stream bed to the east of a small waterfall. Although the course of the stream in segment 5 is through a forest dominated by exotic tree species, a handful of native species appear to be restricted to this habitat. Three members of the Lobelia family were found along the stream. These include an unidentified (because it was not blooming) and probably rare, large leafed Cyanea. Three patches of this plant were located: one just below the waterfall at the upstream end of segment 5, and two patches between the bridge below the waterfall and the Waimea intake. A few Cyanea pilosa were noted along steep stream banks below the waterfall, and a few patches of Lobelia hypoleuca are found along the eroded stream course. While patches of Lobelia occur in several places along the cliffs (pali) of the windward valleys, they are not common. A single patch of Phyllostegia vestida was also located just upstream from the Waimea intake. A single olona plant (Touchardia latifolia), an endemic shrub with large leaves and famous for its strong fiber which in the past was used for fishnets, was seen near the top of the waterfall.

8. Forest to 15+ m. of exotic trees with exotic species dominating the understory.—In the project area these forests have a canopy comprised of alder, Alnus nepalensis or paper bark, Melaleuca leucodendra along segment 5, and of sugi, Cryptomeria japonica at segments 1 and 4. The understory of these forests is also dominated by exotic species, primarily white ginger and palm grass. Native plants are virtually absent from these forests and it is unlikely that they support a native Hawaiian faunal community.

9. Exotic herbaceous and grass community found along roadsides, trails and in the pasture.—This vegetation which occurs along roads and trails is comprised almost exclusively of exotic species. Dense patches of white ginger occur along trails that have been sporadically maintained throughout the project area. Other conspicuous exotic species include the tall grass Paspalum urvillei. Lower statured alien herbs occur on roads and more frequently used trails with those species designated as exotic herbs or exotic grass or grasslike plant mostly restricted to these disturbed habitats. White ginger and the exotic palm grass also occur in the understory of the exotic forest at the end of Upper Hamakua Ditch and the exotic kahili ginger forms the understory south from the Waimea intake, both areas which have been disturbed in the past. Exotic grasses dominate the pasture vegetation south of the forest boundary at the Waimea II reservoir site.

These exotic-dominated vegetation types support few, if any native taxa. They are corridors and reservoirs for weedy species to be introduced into some of the more intact previously described vegetation types. Further, exotic vegetation is predicted to colonize sites disturbed by a project. Some of the species which have been introduced to the Kohalas along existing trails and roads have invaded communities, particularly when these communities have been slightly disturbed as by the activity of feral pigs.



- NOTE:**
- Segment 1-3 Future without Project improvements planned by State of Hawaii, Dept. of Land and Natural Resources
  - Segment 4-5 By-pass Pipeline (Proposed)
  - Segment 6 Supply pipeline (Proposed)

S<sub>o</sub> = Temporary Storage Area  
 for Construction Materials

# UPPER HAMAKUA DITCH

## WAIMEA - PAULILO WATERSHED

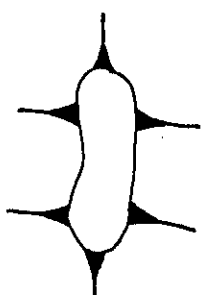
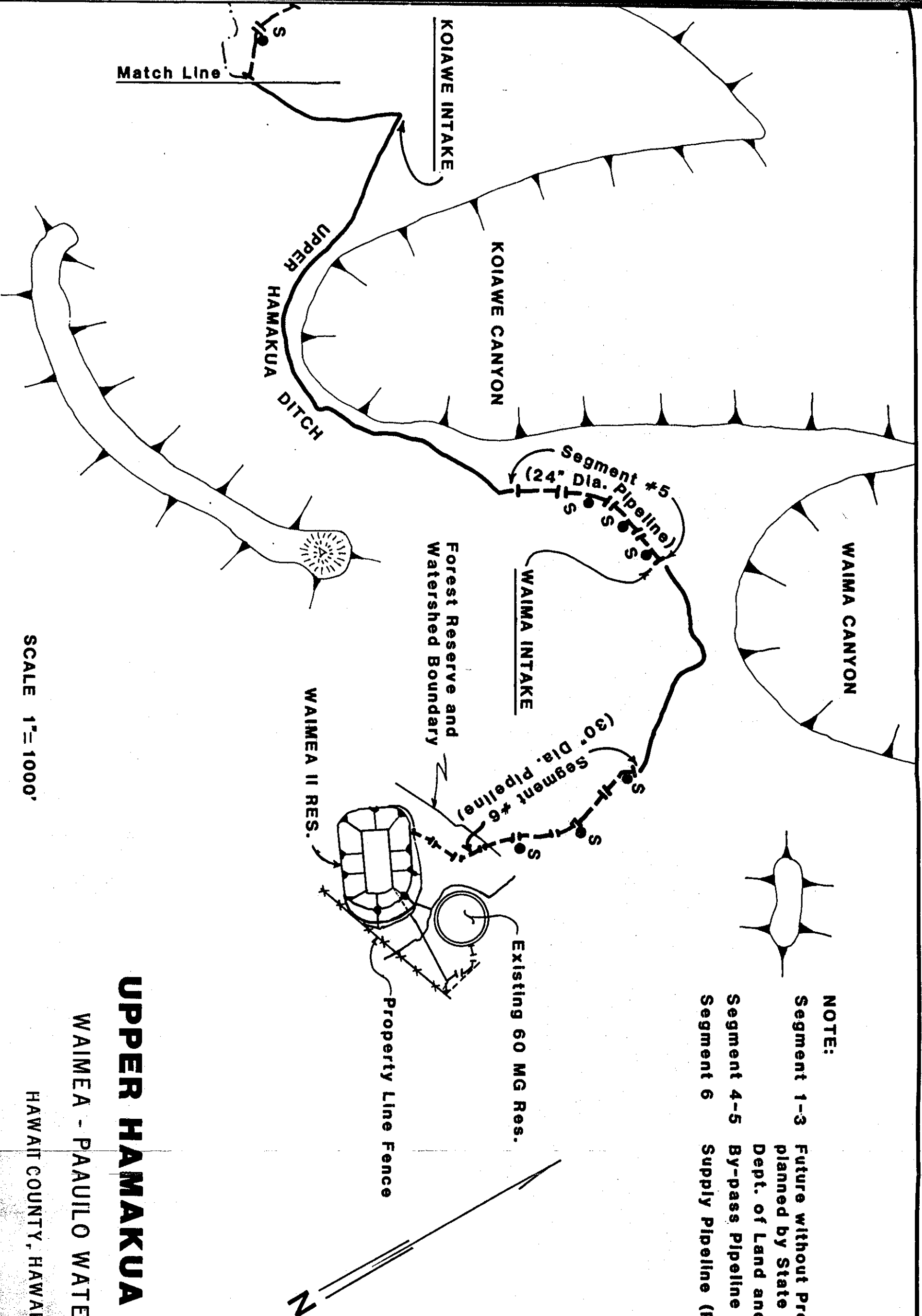
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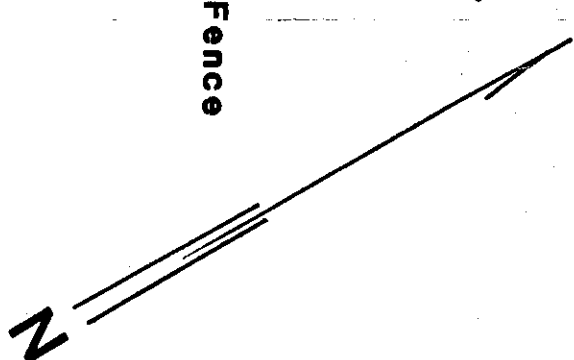
OCTOBER 1988

APPENDIX C-5 Sheet 1 of 2

Match Line



**NOTE:**  
 Segment 1-3 Future without Project Improvements planned by State of Hawaii, Dept. of Land and Natural Resources  
 Segment 4-5 By-pass Pipeline (Proposed)  
 Segment 6 Supply Pipeline (Proposed)



SCALE 1"=1000'

# UPPER HAMAKUA DITCH

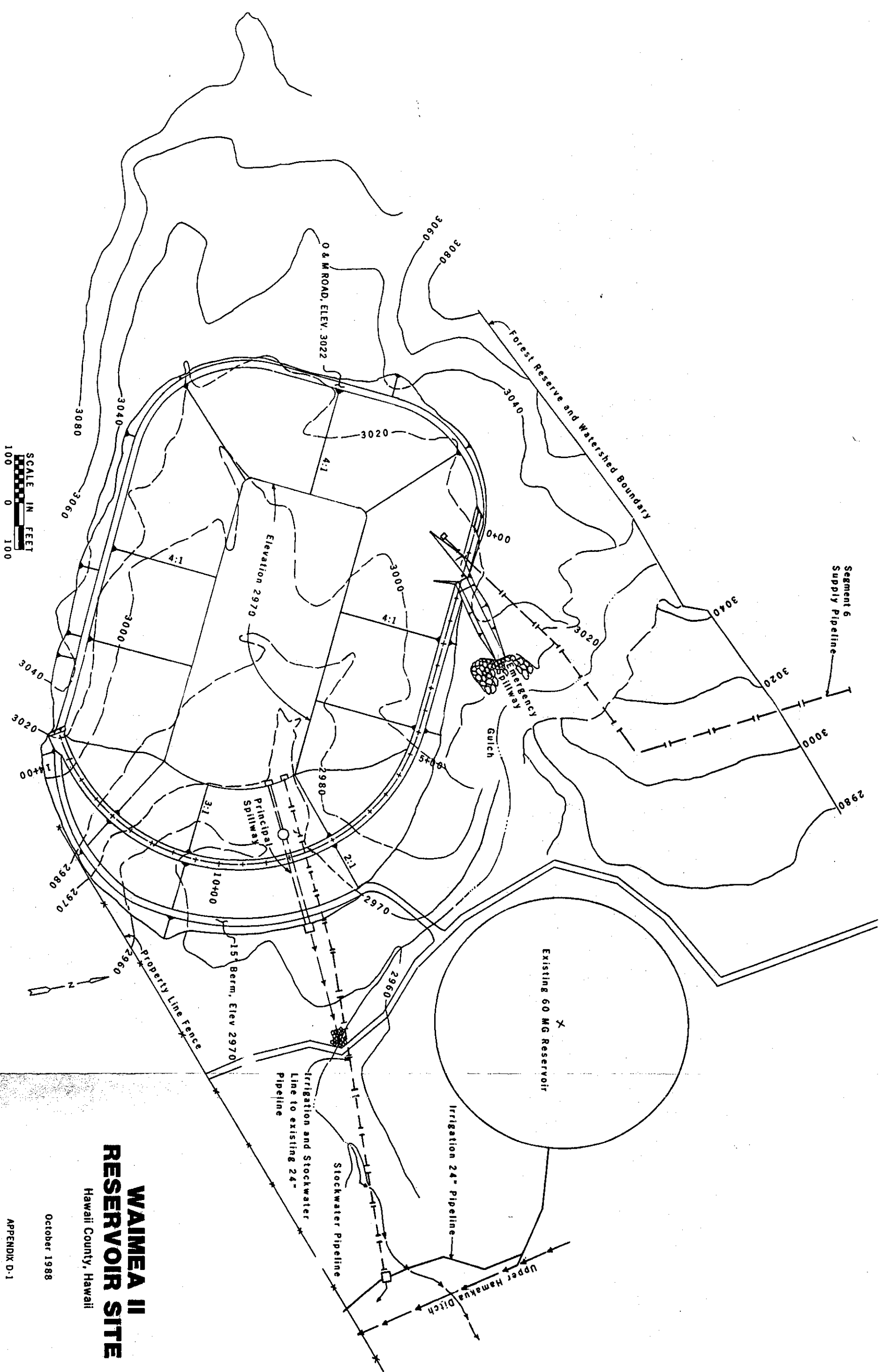
WAIMEA - PAULILO WATERSHED

HAWAII COUNTY, HAWAII

# APPENDIX D

## WAIMEA II DAM AND RESERVOIR DETAILS WITH BREACH INUNDATION MAP

- D-1 Waimea II Reservoir Site
- D-2 Preliminary Plans - Waimea II Dam
- D-3 Breach Inundation Map - Waimea II Dam

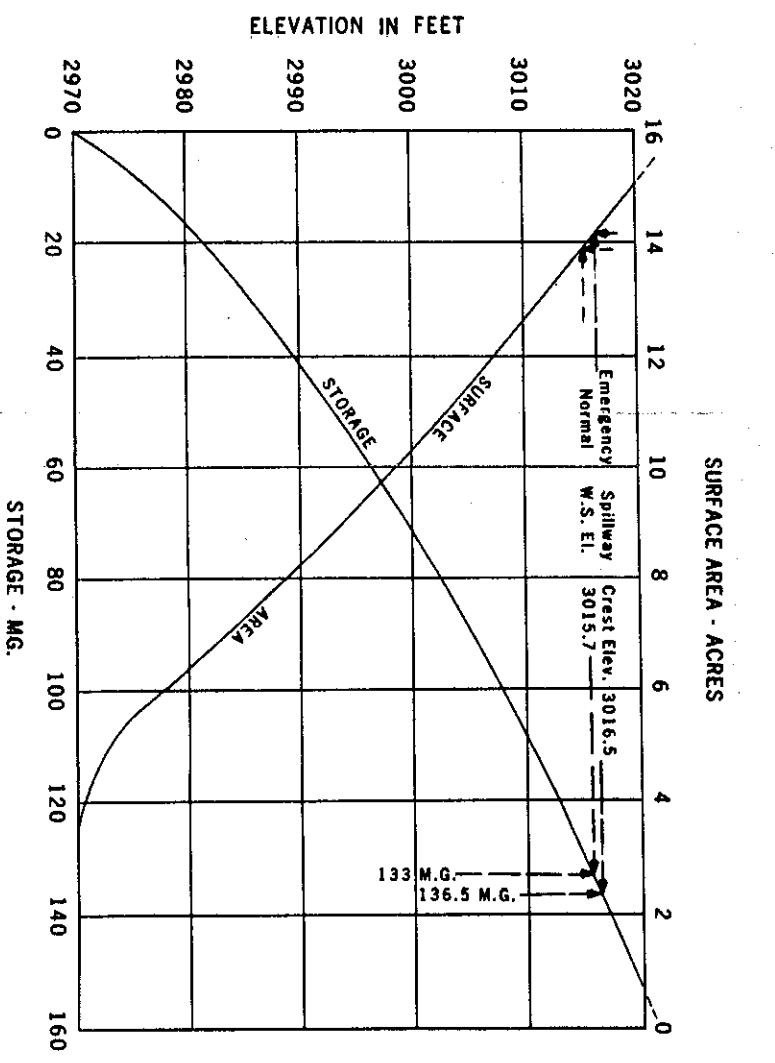
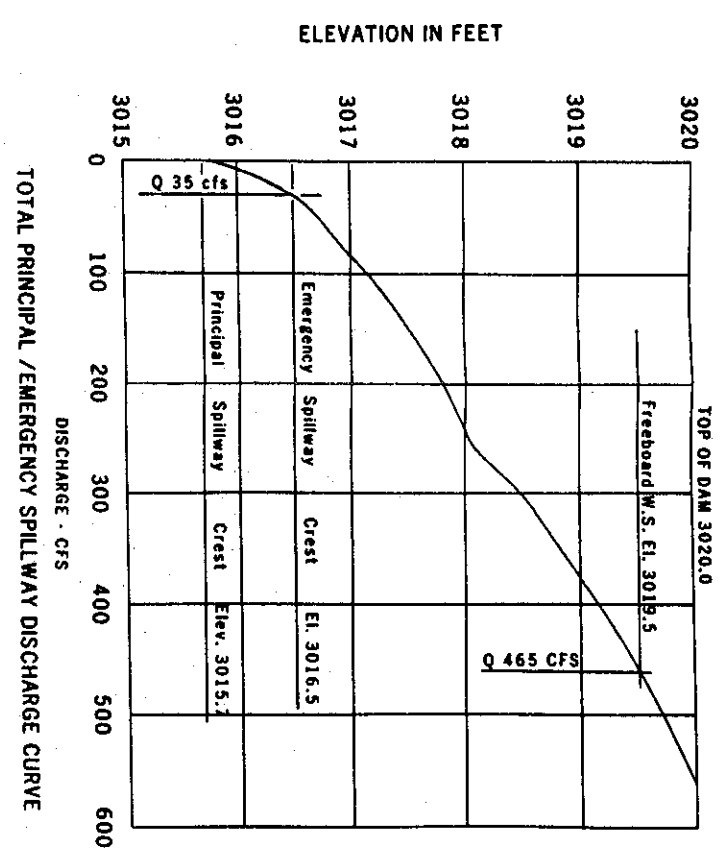
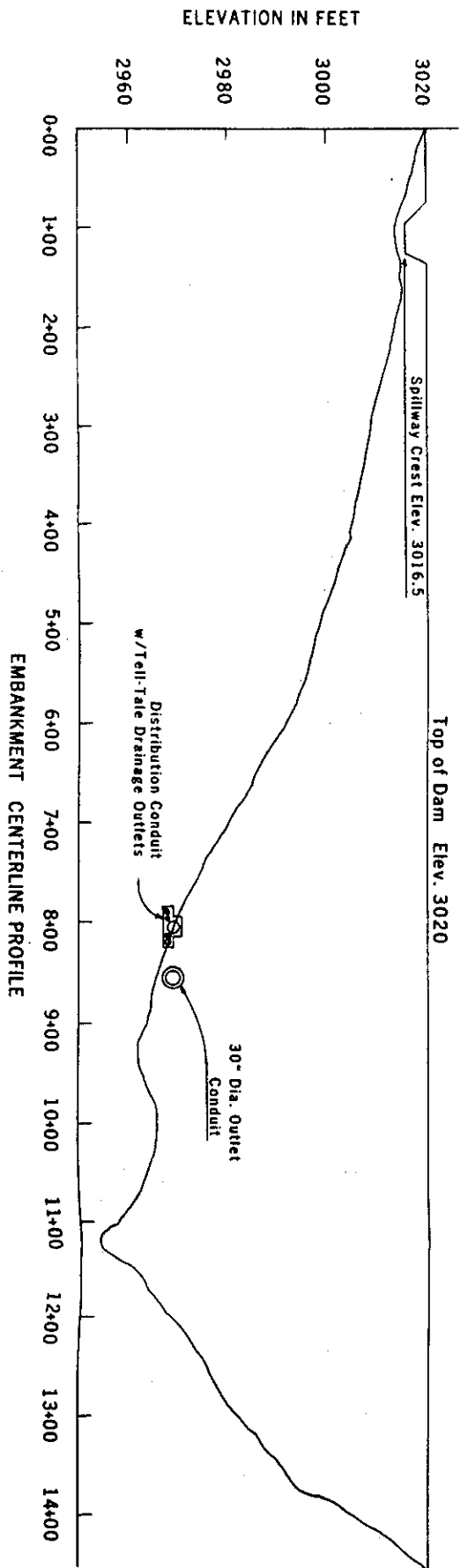
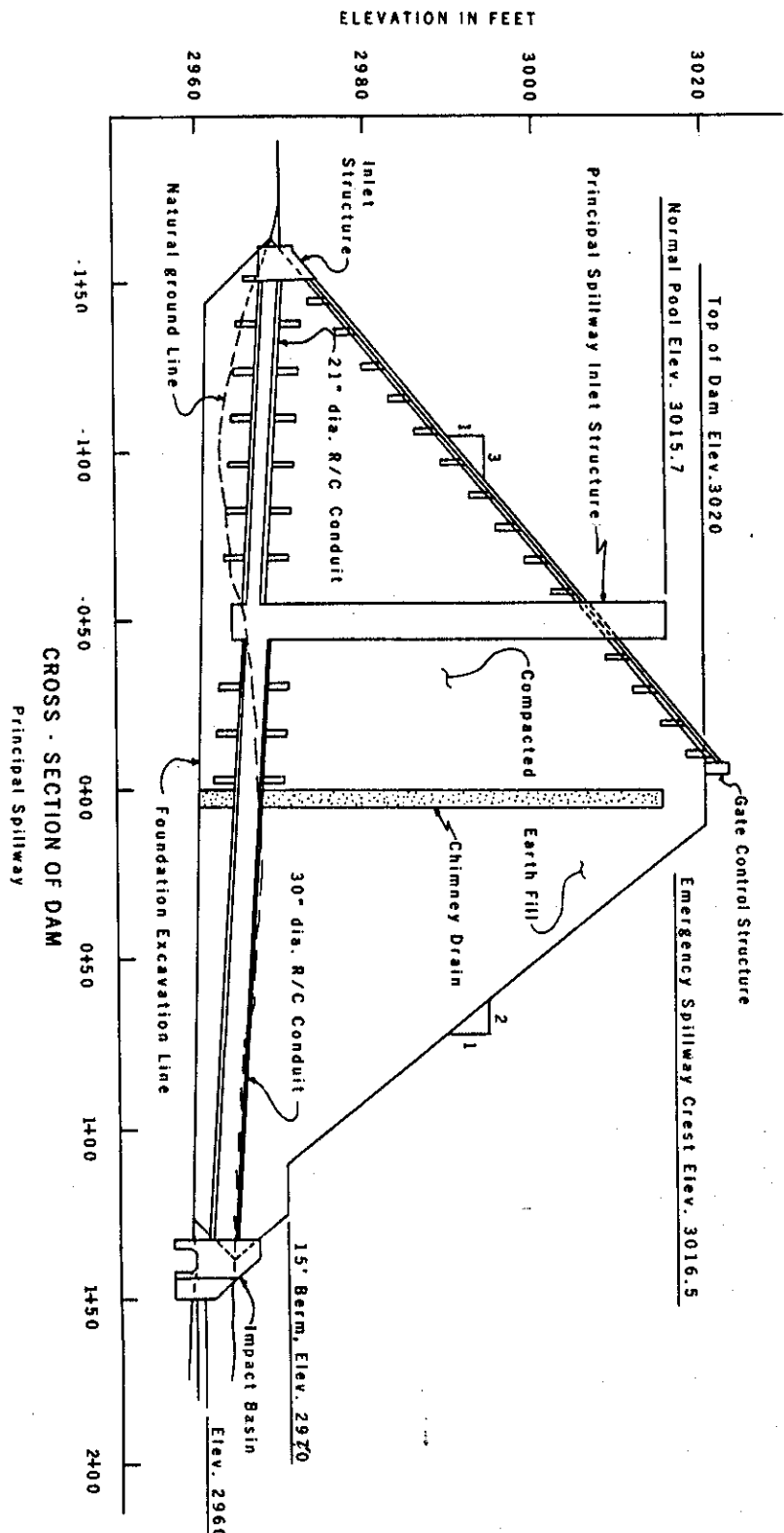
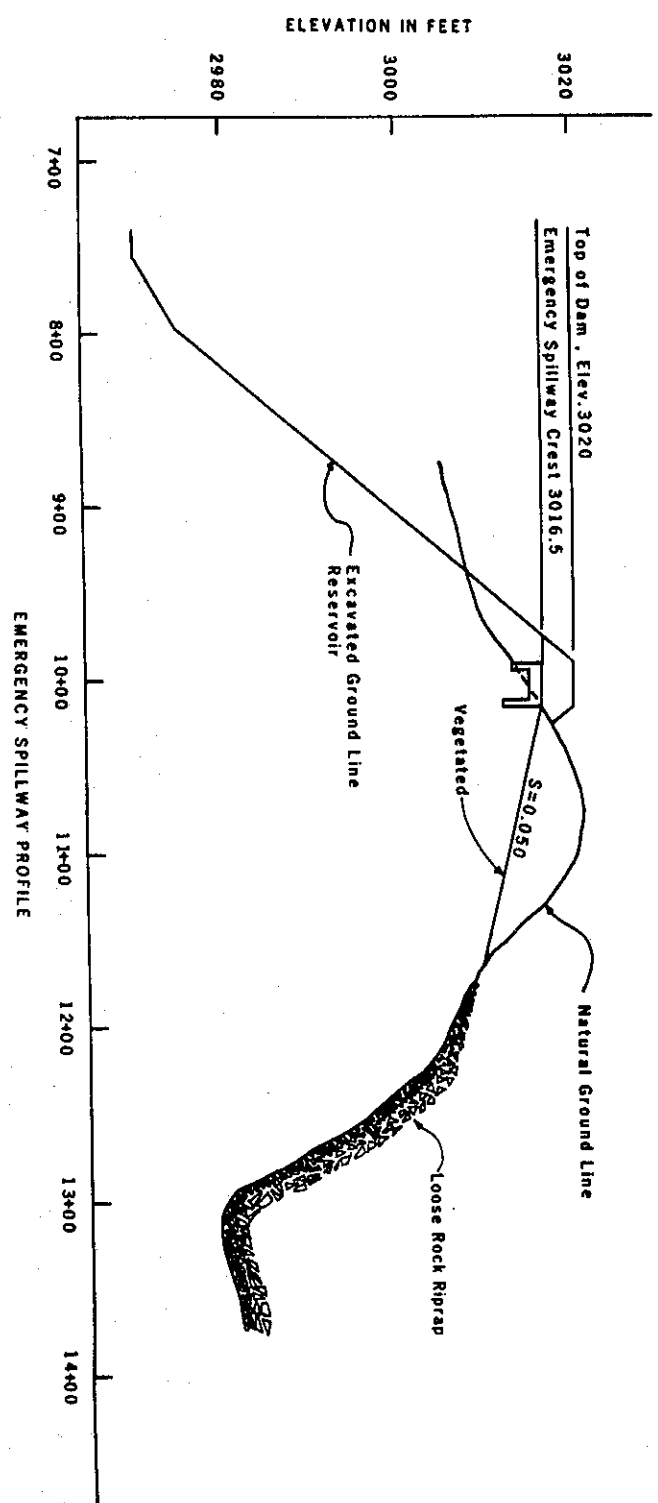


**WAIMEA II  
RESERVOIR SITE**  
Hawaii County, Hawaii

October 1988

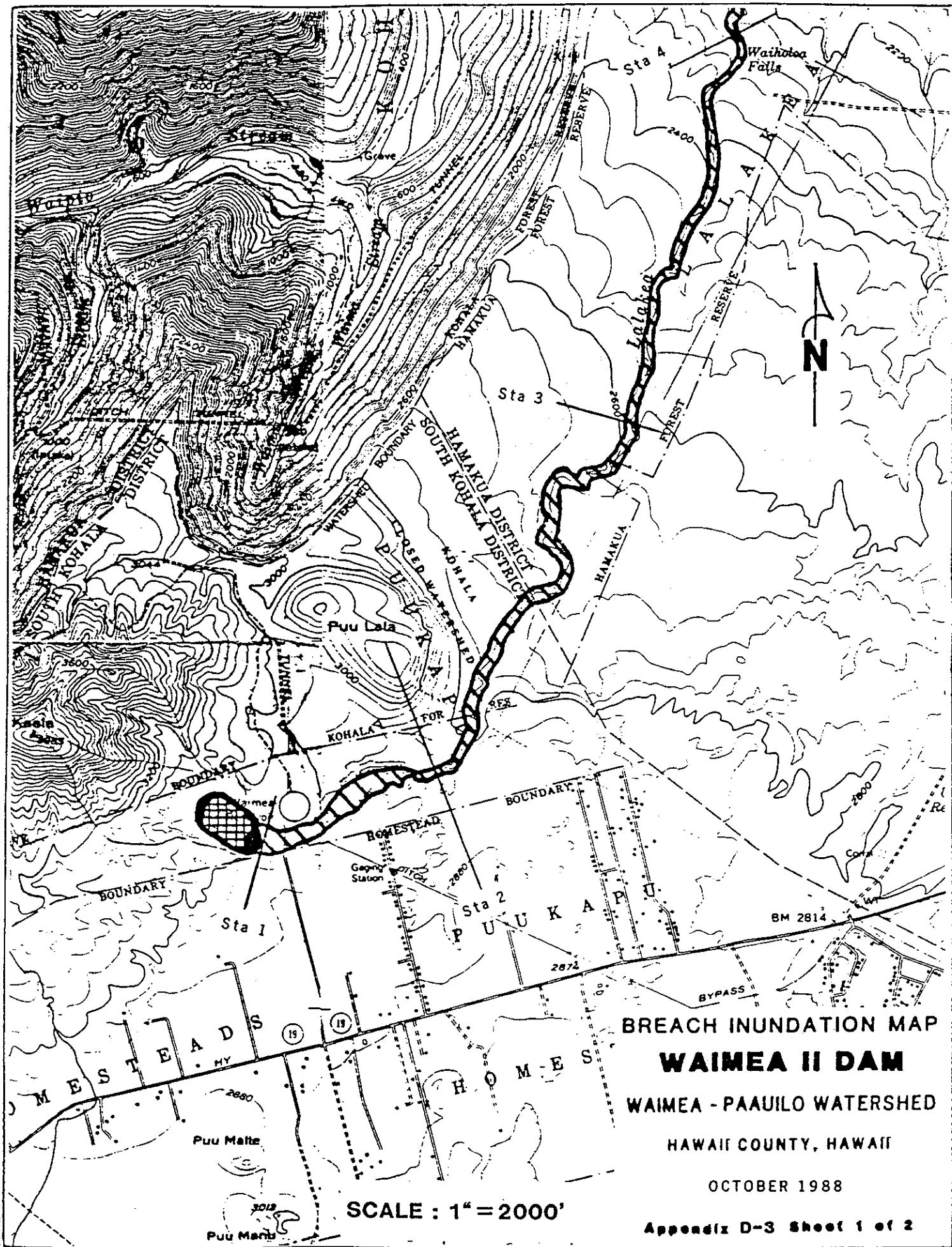
APPENDIX D-1





**WAIMEA II DAM**  
**WAIMEA - PAULILO WATERSHED**  
 HAWAII COUNTY, HAWAII

OCTOBER 1988  
 APPENDIX D-2

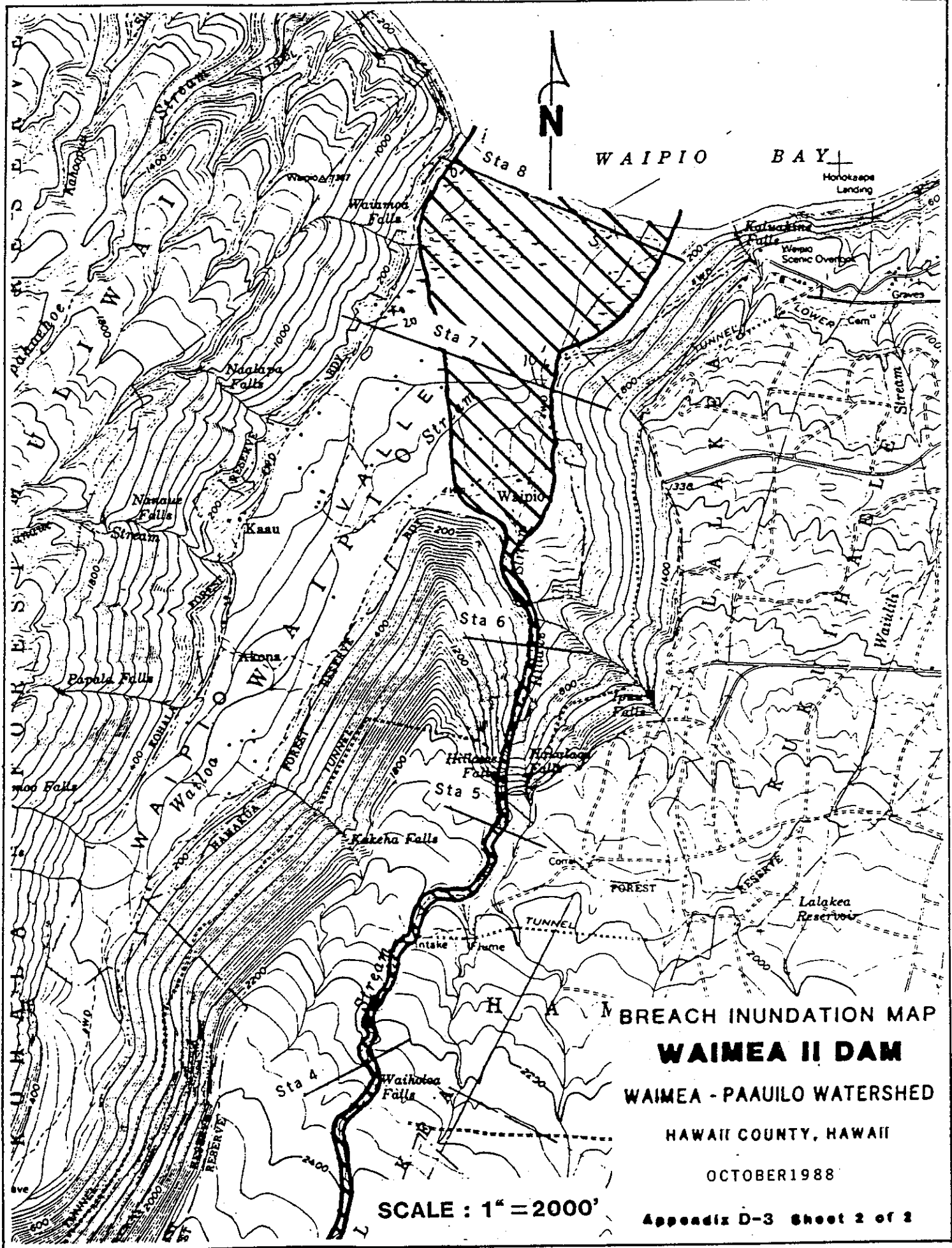


**BREACH INUNDATION MAP**  
**WAIMEA II DAM**  
 WAIMEA - PAAUILO WATERSHED  
 HAWAII COUNTY, HAWAII

OCTOBER 1988

SCALE : 1" = 2000'

Appendix D-3 Sheet 1 of 2



# APPENDIX E

## IRRIGATION DISTRIBUTION SYSTEM AND PROPOSED MAINLINE EXTENSIONS

E-1      Irrigation Distribution System

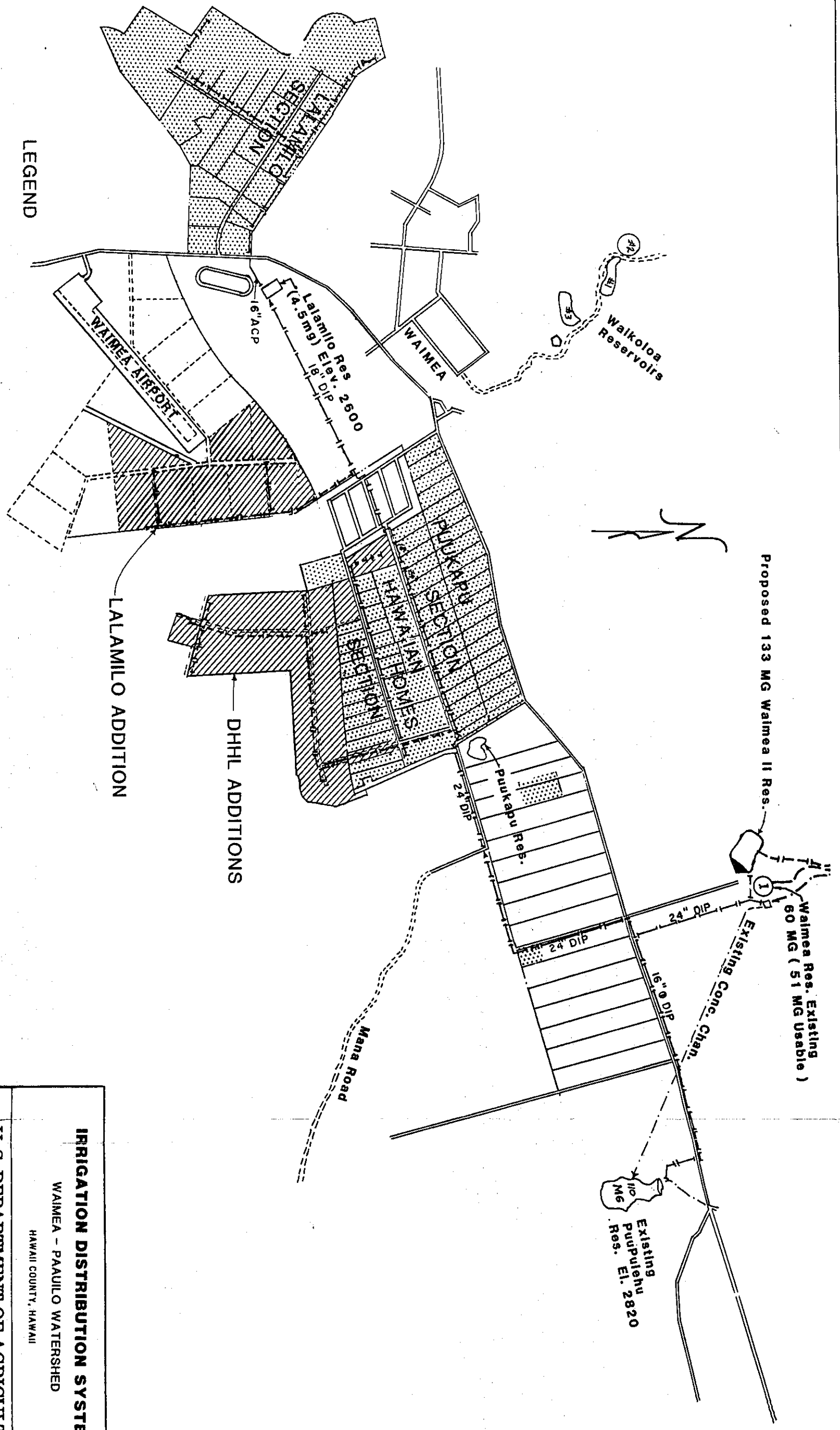
E-2      Proposed Mainline Extensions

Proposed 133 MG Waimea II Res.

Waimea Res. Existing  
60 MG ( 51 MG Usable )

Waikoloa Reservoirs

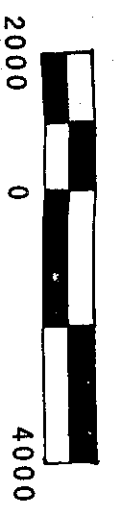
Existing Puipulehu Res. El. 2820



**LEGEND**

- Proposed Irrigation Pipeline
- Existing Irrigation Pipeline
- Existing Irrigated Area
- Planned Additional Irrigated Area

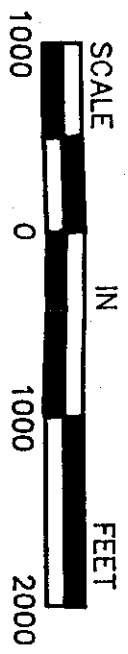
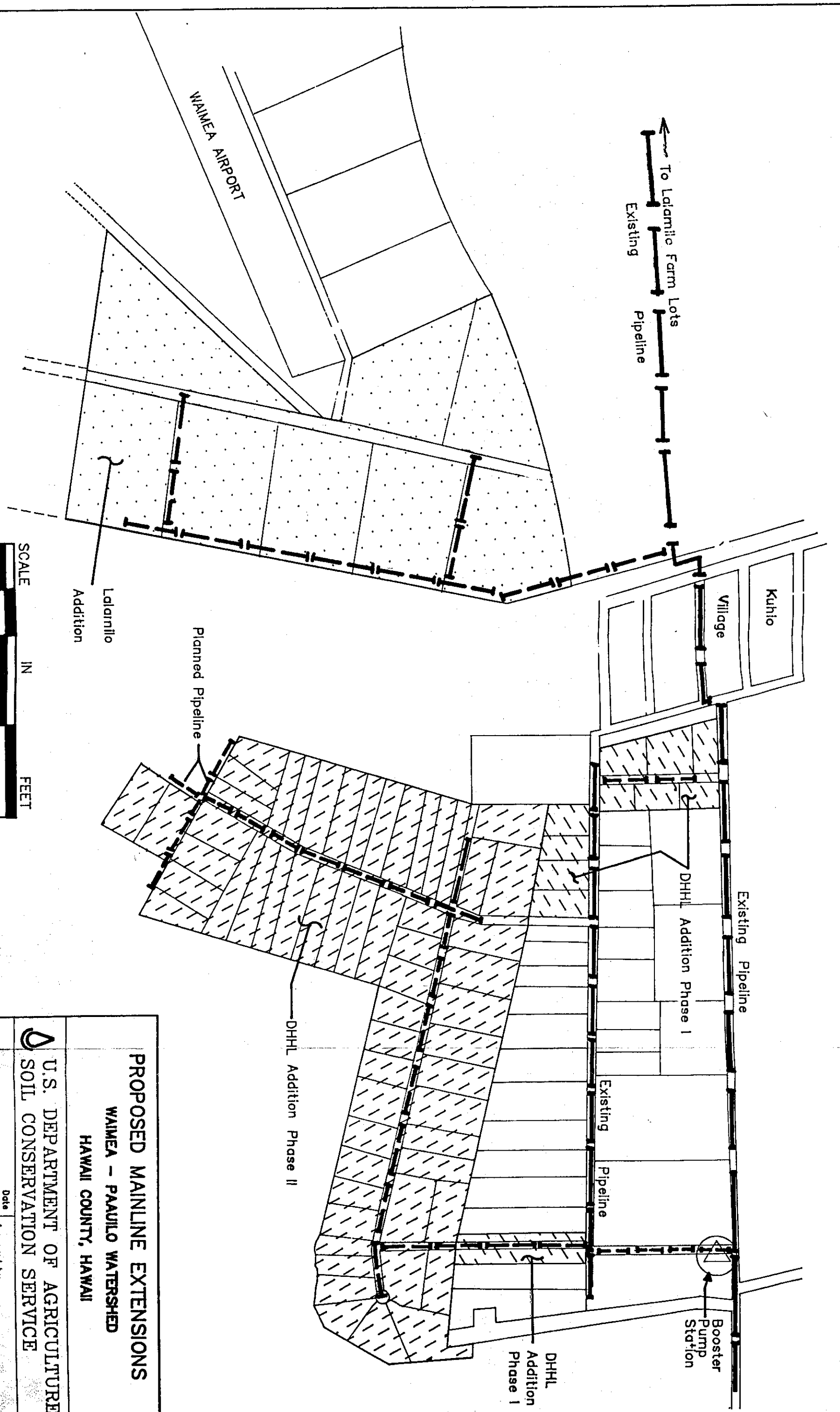
**SCALE IN FEET**



**U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE**

**IRRIGATION DISTRIBUTION SYSTEM**  
WAIMEA - PAUULO WATERSHED  
HAWAII COUNTY, HAWAII

Designed	Date	Approved by	Title
Drawn <b>E.B.A.</b>	<b>4-88</b>		
Traced		Sheet	Drawing No.
Checked <b>J.W.S.</b>	<b>5-88</b>	No. <b>1</b>	
		of <b>2</b>	



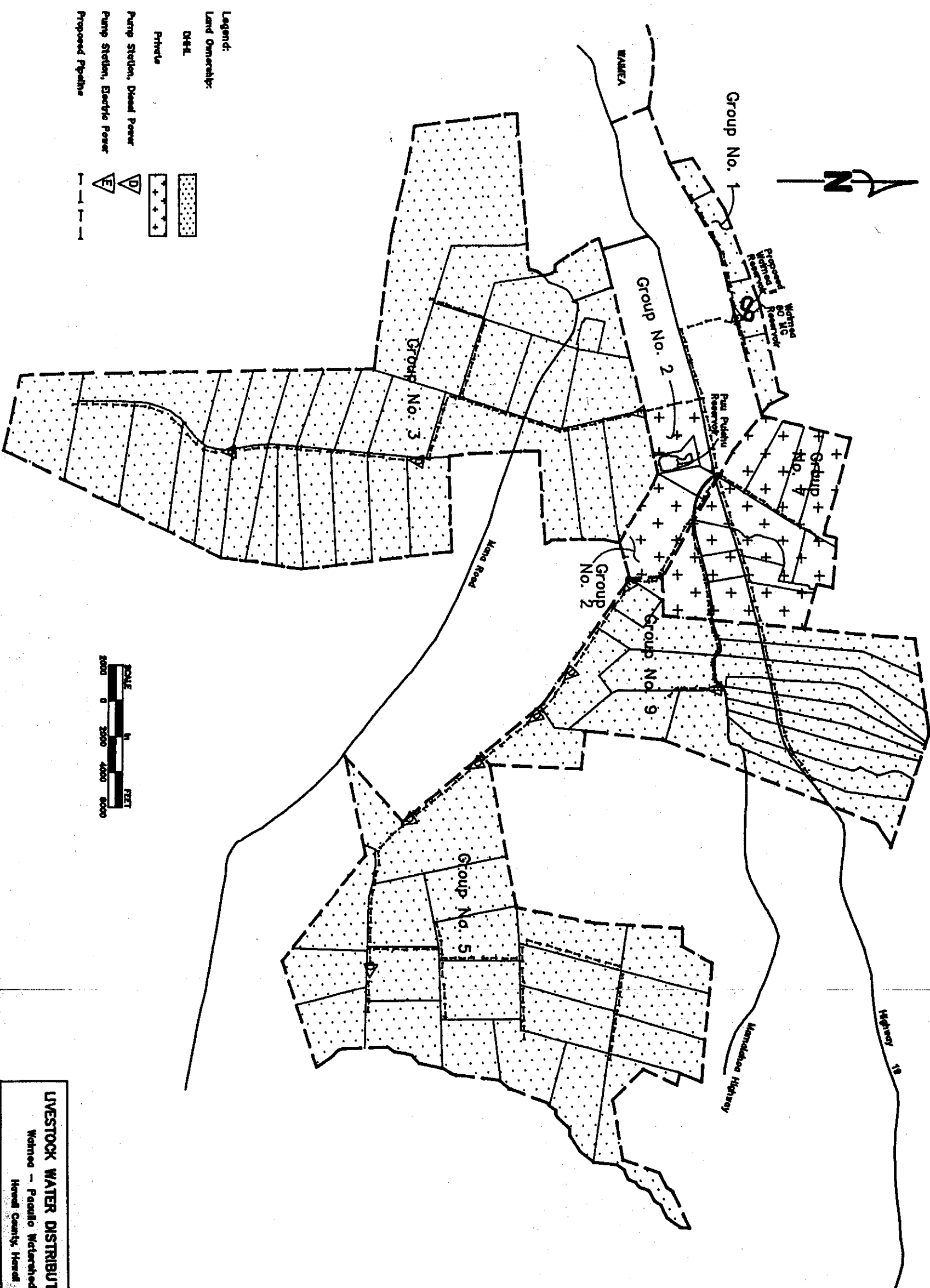
**PROPOSED MAINLINE EXTENSIONS**  
**WAIMEA - PAULILO WATERSHED**  
**HAWAII COUNTY, HAWAII**

**U.S. DEPARTMENT OF AGRICULTURE**  
**SOIL CONSERVATION SERVICE**

Designed	J.W.S.	Date	4-88
Drawn	E.B.A.	Approved by	
Traced	J.W.S.	Sheet No.	2
Checked	J.W.S.	Drawing No.	

# APPENDIX F

LIVESTOCK WATER DISTRIBUTION SYSTEM



**Legend:**

**Land Ownership:**

Private

Pump Station, Diesel Power

Pump Station, Electric Power

Proposed Pipelines



**LIVESTOCK WATER DISTRIBUTION SYSTEM**  
 Wahneka - Paul Pugh Watershed Project  
 Harrell County, Harrell

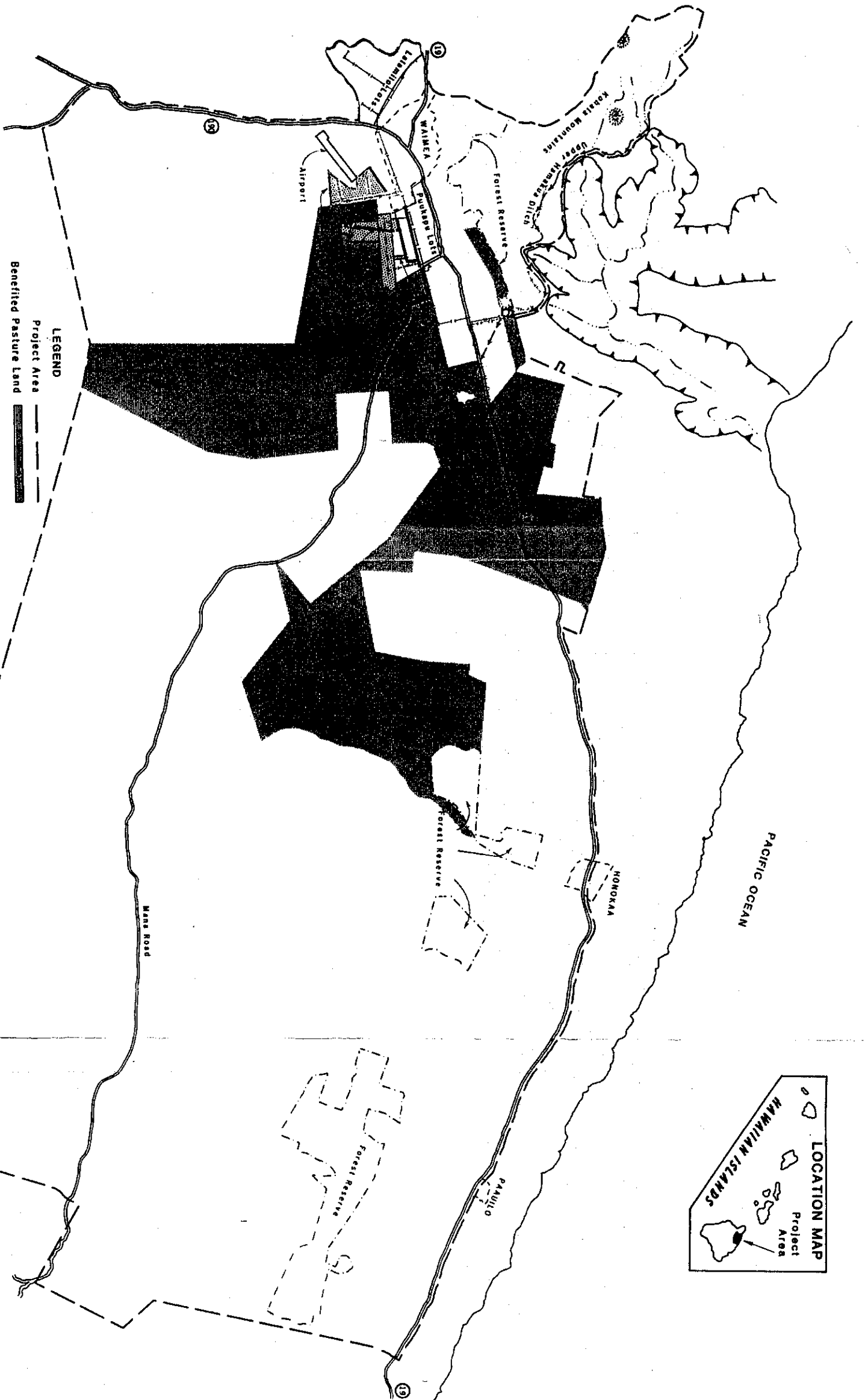
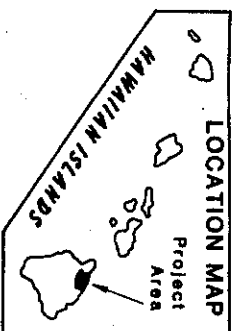
**U.S. DEPARTMENT OF AGRICULTURE**  
**SOIL CONSERVATION SERVICE**

Project	Approved by
Approved: F.H.G. BOY, EDA, 7-1-82	Approved by
Date: EDA, 12-82	Checked by
Drawn: F.H.G. JR.	Checked by
Scale: F.H.G. JR.	Checked by



# APPENDIX G

PROJECT MAP



- LEGEND**
- Project Area
  - Benefitted Pasture Land
  - Benefitted Irrigated Land
  - Existing Land
  - New Land
  - Urban Land
  - Forest Reserve
  - Streams
  - Proposed Reservoir
  - Existing Reservoir
  - Proposed Irrigation Pipeline
  - Existing Irrigation Pipeline
  - Proposed Stockwater Pipeline

**PROJECT MAP**  
**WAIMEA - PAULILO WATERSHED**

HAWAII COUNTY, HAWAII  
 September 1989