STATE OF HAWAII
DEPARTMENT OF PLANNING
AND ECONOMIC DEVELOPMENT

LAND USE COMMISSION

Room 104, Old Federal Bldg., 335 Merchant Street
Honolulu, Hawaii 96813 Telephone: 548-4611

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GORDAN Y. FURUTANI
Executive Officer

September 21, 1984

Ms. Letitia Uyehara, Director
Office of Environmental Quality Control
550 Halekauwila Street, Room 301
Honolulu, HI 96813

Dear Ms. Uyehara:

Subject: A83-554 - FARMS OF KAPUA, LTD.
Findings of Fact, Conclusions of Law, and Decision
and Order Accepting an Environmental Impact Statement

In accordance with Section 1:72, subsection C of the Regulations of the Environmental Quality Commission, we are filing a Notice of Acceptance of Environmental Impact Statement for a State Land Use District Boundary Amendment.

Sincerely,

GORDAN Y. FURUTANI
Executive Officer

GYF:gm
Attachment
cc: EQC w/attachment
Roy Takeyama w/attachment
Pa'apono and its individual members w/attachment
c/o Meredith Lenell

BEFORE THE LAND USE COMMISSION

OF THE STATE OF HAWAII

| | | |
|---|---|---|
| In the Matter of the Petition of | ) | |
| | ) | |
| FARMS OF KAPUA, LTD. | ) | DOCKET NO. A83-554 |
| | ) | |
| To Amend the Conservation Land Use District Boundary into the Agricultural Land Use District for Approximately 6,102 Acres at Kapua, South Kona, Hawaii, Tax Map Key: 8-9-06: Portion of Parcel 3 | ) | FARMS OF KAPUA, LTD. |

FINDINGS OF FACT, CONCLUSIONS OF LAW, AND DECISION AND ORDER ACCEPTING AN ENVIRONMENTAL IMPACT STATEMENT FOR A STATE LAND USE DISTRICT BOUNDARY AMENDMENT

BEFORE THE LAND USE COMMISSION

OF THE STATE OF HAWAII

| | | |
|---|---|---|
| In the Matter of the Petition of<br><br>FARMS OF KAPUA, LTD.<br><br>To Amend the Conservation Land Use District Boundary into the Agricultural Land Use District for Approximately 6,102 Acres at Kapua, South Kona, Hawaii, Tax Map Key: 8-9-06: Portion of Parcel 3 | ) | DOCKET NO. A83-554<br><br>FARMS OF KAPUA, LTD. |

FINDINGS OF FACT, CONCLUSIONS OF LAW AND DECISION AND ORDER ACCEPTING AN ENVIRONMENTAL IMPACT STATEMENT FOR A STATE LAND USE DISTRICT BOUNDARY AMENDMENT

The Land Use Commission of the State of Hawaii (Commission) having examined the Environmental Impact Statement (EIS) and the Revised Environmental Impact Statement (Revised EIS) filed by Petitioner Farms of Kapua, Ltd., a Hawaii limited partnership (the "Petitioner"), on February 21, 1984 and April 4, 1984, respectively, hereby makes the following Findings of Fact, Conclusions of Law, and Decision and Order:

## FINDINGS OF FACT

### DESCRIPTION OF AFFECTED PROPERTY AND PROPOSED DEVELOPMENT

1. Petitioner Farms of Kapua, Ltd. has petitioned the State Land Use Commission to reclassify 6,102 acres of land from the Conservation District at Kapua, South Kona, to the Agricultural Land Use District. Petitioner proposes to develop

a macadamia orchard, a controlled pasture area for cattle, an area for the research and development of alternate crops, and an area for aquaculture facilities, as components of a multi-agricultural development.

2. Petitioner proposes to cultivate macadamia on approximately 1,710 acres of land to approximately the 1000-foot elevation level. The proposed orchard will involve the clearing and/or grubbing of most of the area on the mauka portion of the subject property. A system of unpaved service roads will be developed to facilitate the cultivation and harvesting of the crop.

3. Petitioner proposes to plant approximately 2,472 acres between the macadamia orchard and the aquaculture facility, from approximately the 450-foot elevation to approximately the 150-foot elevation level with a combination of koa haole (leucaena) and guinea grass. This area has previously been planted in guinea grass. Petitioner proposes to pasture wean calves, acquired from other ranches, in this area.

4. Petitioner proposes to plant approximately 200 acres of the petition area in intensive cultivation of koa haole. Petitioner will plant, irrigate and harvest leucaena to be used as green chop for the cattle in the feedlot. Petitioner proposes to use another 200-acre area for the research and development of other possible crops to be cultivated at Kapua, such as aloe vera and crownflower.

5. Petitioner proposes to construct aquaculture farms in five 200-acre modules in an area below the 150-foot

elevation. Petitioner has not determined the actual siting of the modules, because Petitioner proposes to arrange the modules in a pattern which preserves the significant archaeological features of the coastline area. The aquaculture facilities will consist of a series of ponds and raceways, and common support facilities, such as a hatchery and laboratories.

6. The proposed project will include the on-site construction of a roadway system, irrigation water systems and agricultural improvements such as equipment storage sheds. Petitioner proposes to develop several wells within the macadamia orchard area. Petitioner's off-site improvements will include the extension of electrical and telephone lines and the resurfacing of existing access roads from Mamalahoa Highway. Petitioner also proposes to construct an electric substation for Hawaii Electric Light Company, Ltd. in order to provide power to the development.

7. Petitioner has assessed the impact of the proposed action on the environment; land use plans, policies and controls for the affected areas; flora and fauna; public services and facilities; water, archaeology; air quality; and drainage.

8. An archaeological field reconnaissance was conducted by Dr. Paul H. Rosendahl to verify the presence of sites of archaeological interest on the project area.

9. The greatest density and variety of archaeological remains were found in the northern coastal zone. A significant feature in the area is the slide of the Ahole Holua Complex.

This feature is regarded as one of the best preserved holua in the State.

10. In recognition of the concentration of archaeological sites in the northern coastal portion of the property, approximately 425 acres of the area is proposed to remain in the Conservation District.

11. After a reconnaissance survey of the project area, a total of 41 new sites have been designated. The archaeological remains identified within the project area are distinguished by their relatively good physical condition and high integrity.

12. Dr. Rosendahl recommends that further more detailed archaeological work be done and that the work be done in consultation with the developer, his archaeological consultant and the appropriate State and County representatives.

13. Dr. Craig J. Severance conducted a preliminary socio-cultural research of the impact of the proposed project on surrounding settlements.

14. Three potentially affected groups were identified. They include the families whose immediate ancestors are buried at Kapua and who were accustomed to utilizing parts of the project area for material resources, the Milolii Community and persons residing in South Kona.

15. Protection of historic sites and continued access to the Kapua Coastal Zone has been singled out as the probable social issues of greatest concerns.

16. Dr. Severance recommends that potential social

issues and concerns be addressed early in the development planning stage and through a series of open informational meetings.

17. A preliminary study of the potential sources of water for the proposed agricultural uses was conducted by John F. Mink.

18. Potable water requirements for the project is estimated to be 3,200 gallons per day. Water for the employees will be trucked in.

19. Petitioner estimates that its total average irrigation water demand will be 2,845 gallons per month, and that three wells may be required to satisfy the irrigation water demand.

20. One possible source of irrigation water is the Okoe Well located on State land. Petitioner has filed a request to lease water from this well with the Board of Land and Natural Resources.

21. Petitioner does not propose to develop any groundwater within 20 miles of the petition area. The nearest active wells are located in aquifers separate from the one underlying Kapua at Naalehu and Kealakekua.

22. Petitioner has identified the following probable adverse environmental effects which cannot be avoided and mitigation measures to minimize the impact:

a. Dust generation: The clearing and grubbing will be done in increments and immediately planted with crops to prevent dust generation.

b. Water consumption: The irrigation wells will be monitored for increased chloride level.

c. Vegetation removal: Any mammal and birds which were displaced by removal of vegetation will return when the crops are planted and mature.

d. Looting and vandalism of archaeological resources: A program for monitoring significant sites will be developed and implemented.

e. Demand on County protective services: employees of the Farms of Kapua will be trained to protect the property.

23. Petitioner has determined that the proposed action will result in the irreversible and irretrievable commitment of land, money, construction materials, manpower and energy.

24. Petitioner has identified the following alternatives to the proposed action:

a. Retain site in present condition.

b. Apply for a Conservation District Use Application.

c. Find another site.

d. Use as State natural, recreational and historic park.

The petition for Land Use District Boundary Amendment is the alternative that best meets Petitioner's objective for the development and use of the property.

PROCEDURAL MATTERS

25. Petitioner filed its Environmental Assessment with the Commission on June 16, 1983.

26. The Commission assessed the proposed actions and determined that the anticipated effects will not constitute a "signficiant effect" on the environment and issued a negative declaration on June 27, 1983.

27. Petitioner moved that the Commission withdraw its negative declaration and require Petitioner to submit an Environmental Impact Statement pursuant to Chapter 343, Hawaii Revised Statutes (HRS) on November 25, 1983, which the Commission did by Order dated December 12, 1983.

28. The Commission filed an EIS Preparation Notice with the Environmental Quality Commission on December 1, 1983; and on December 8, 1983, the Environmental Quality Commission published its EIS Preparation Notice.

29. Petitioner filed its EIS with the Commission on February 21, 1984 and filed its Revised EIS with the Commission on April 5, 1984.

30. On May 15, 1984, the Commission considered and voted unanimously to accept the Revised EIS.

CONCLUSIONS OF LAW

31. Petitioner's EIS and Revised EIS have satisfied the requirements of Section 1:42 of the Environmental Quality Commission's EIS Regulations.

32. The procedures for assessment, consultation process and the preparation of the EIS have been completed in accordance with the provisions of Chapter 343, Hawaii Revised Statutes and the Environmental Quality Commission's Regulations.

33. Pursuant to Chapter 343, Hawaii Revised Statutes, as amended, and the Rules and Regulations of the Environmental Qualtiy Commission, State of Hawaii, the State Land Use Commission concludes that the Petitioner has satisfied the criteria and procedures for the acceptance of an EIS.

## ORDER

IT IS HEREBY ORDERED that the Revised EIS submitted by Farms of Kapua in Docket Number A83-554 be and the same is hereby accepted pursuant to Chapter 343, Hawaii Revised Statutes and the Rules and Regulations of the Environmental Quality Commission.

Done at Honolulu, Hawaii, this 21st day of September, 1984, per motion and unanimous action of all Commissioners present on May 15, 1984.

LAND USE COMMISSION
STATE OF HAWAII

By _____
WILLIAM W. L. YUEN
Chairman and Commissioner

FILE COPY

# FARMS OF KAPUA

Ahupua'a of Kapua
South Kona, Hawaii

Tax Map Key: 8-9-06: 3

# REVISED ENVIRONMENTAL IMPACT STATEMENT

April, 1984

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, Hawaii 96813 • Phone (808) 533-4445

FILE COPY

# REVISED
# ENVIRONMENTAL IMPACT STATEMENT

## FARMS OF KAPUA

Ahupua'a of Kapua
South Kona, Hawaii

Tax Map Key: 8-9-06: 3

John Farias, Jr.
Farms of Kapua, Ltd.

Prepared by
Group 70, Planners

April 6, 1984

FILE COPY

REVISED
ENVIRONMENTAL IMPACT STATEMENT

APRIL 1984

| | |
|---|---|
| PROJECT: | FARMS OF KAPUA |
| LOCATION: | SOUTH KONA<br>ISLAND OF HAWAII<br>STATE OF HAWAII |
| APPLICANT: | FARMS OF KAPUA<br>615 PIIKOI STREET, SUITE 1510<br>HONOLULU, HAWAII 96814<br>CONTACT: JOHN FARIAS, JR.<br>TELEPHONE: (808) 521-2011 |
| ACCEPTING AUTHORITY: | LAND USE COMMISSION<br>STATE OF HAWAII |
| CONSULTANT: | GROUP 70<br>924 BETHEL STREET<br>HONOLULU, HAWAII 96813<br>CONTACT: FRANCIS S. ODA, AIA<br>TELEPHONE: (808) 533-4445 |

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## PART I: SUMMARY

Farms of Kapua, Ltd. is petitioning the State Land Use Commission to amend the Land Use Conservation District Boundary in Kapua, South Kona, to reclassify 6,102 acres of land into the Agriculture Land Use District. Approval of this boundary adjustment will allow the petitioner to create a macadamia orchard, a controlled pasture area for cattle, an area for research and development of alternative crops and aquaculture facilities, as components of a multi-agricultural development. The petition area is considered ideal for the planned agricultural projects because of its wind protected location, long southern exposure, evenly distributed rainfall and extensive size.

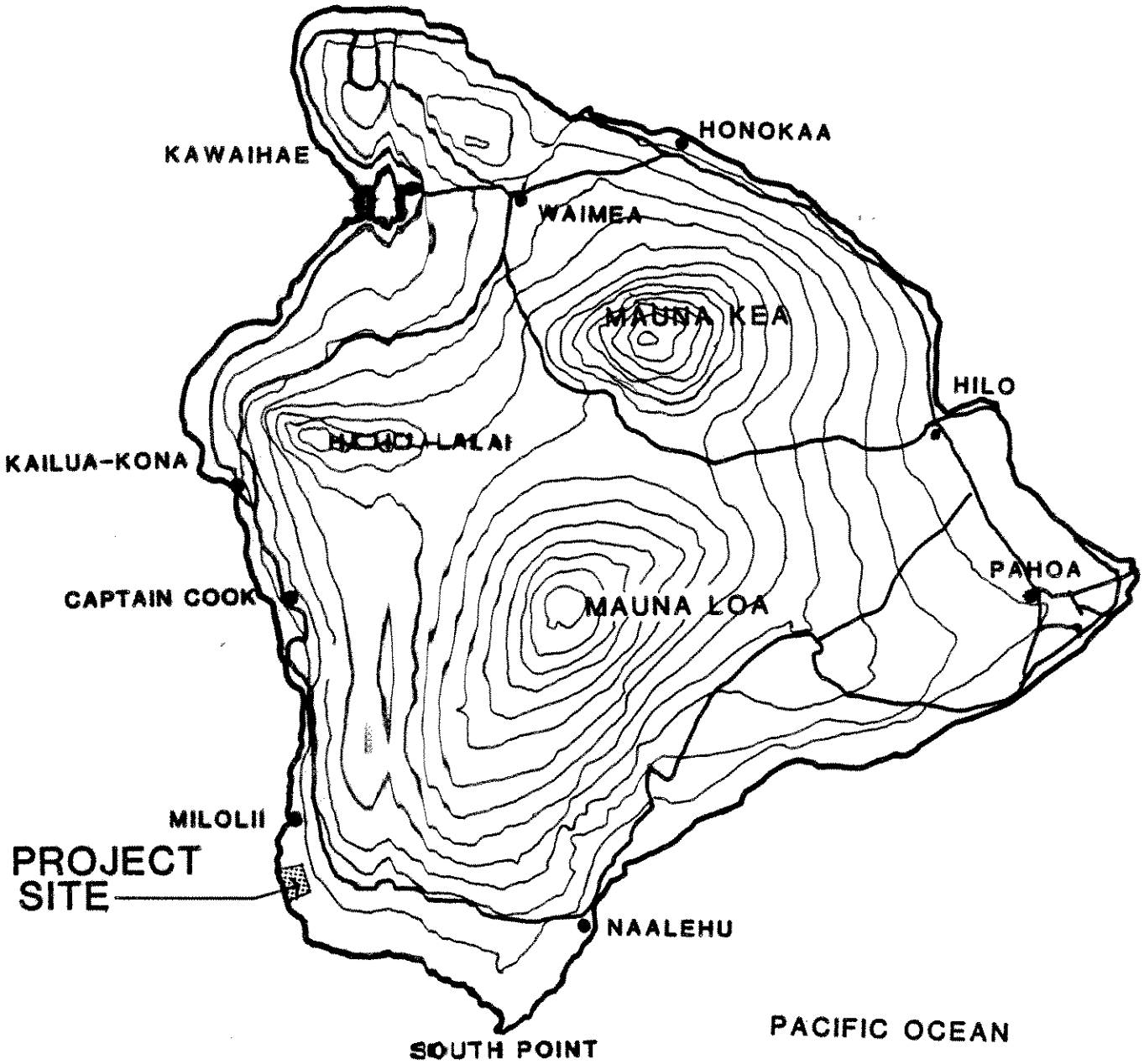
No construction is proposed within the offshore waters or within 300 feet of the shoreline. During the life of the project there will be no point discharge of human or animal wastes from the petition area directly into offshore waters.

The petitioner will generally maintain the present means of public access to the shoreline: from mauka portions of the site by permission only; and, unobstructed lateral access along the shoreline north and south of the project site.

The project will provide permanent employment for approximately 160 persons. It is expected that, wherever possible, those hired will be permanent residents of South Kona. Development of the project will expand the agricultural resources of South Kona.

Adverse or unavoidable environmental effects include: dust generation during site clearing activities, water consumption, vegetation removal, looting and/or vandalism of archaeological sites and demand on County protective services.

The major long-term gain of the proposed action is the broadening of the range of beneficial uses of the site (multi-agricultural uses) at the expense of the short-term, adverse or unavoidable effects described in the previous paragraph.




ISLAND OF HAWAII

0 8 32 MILES

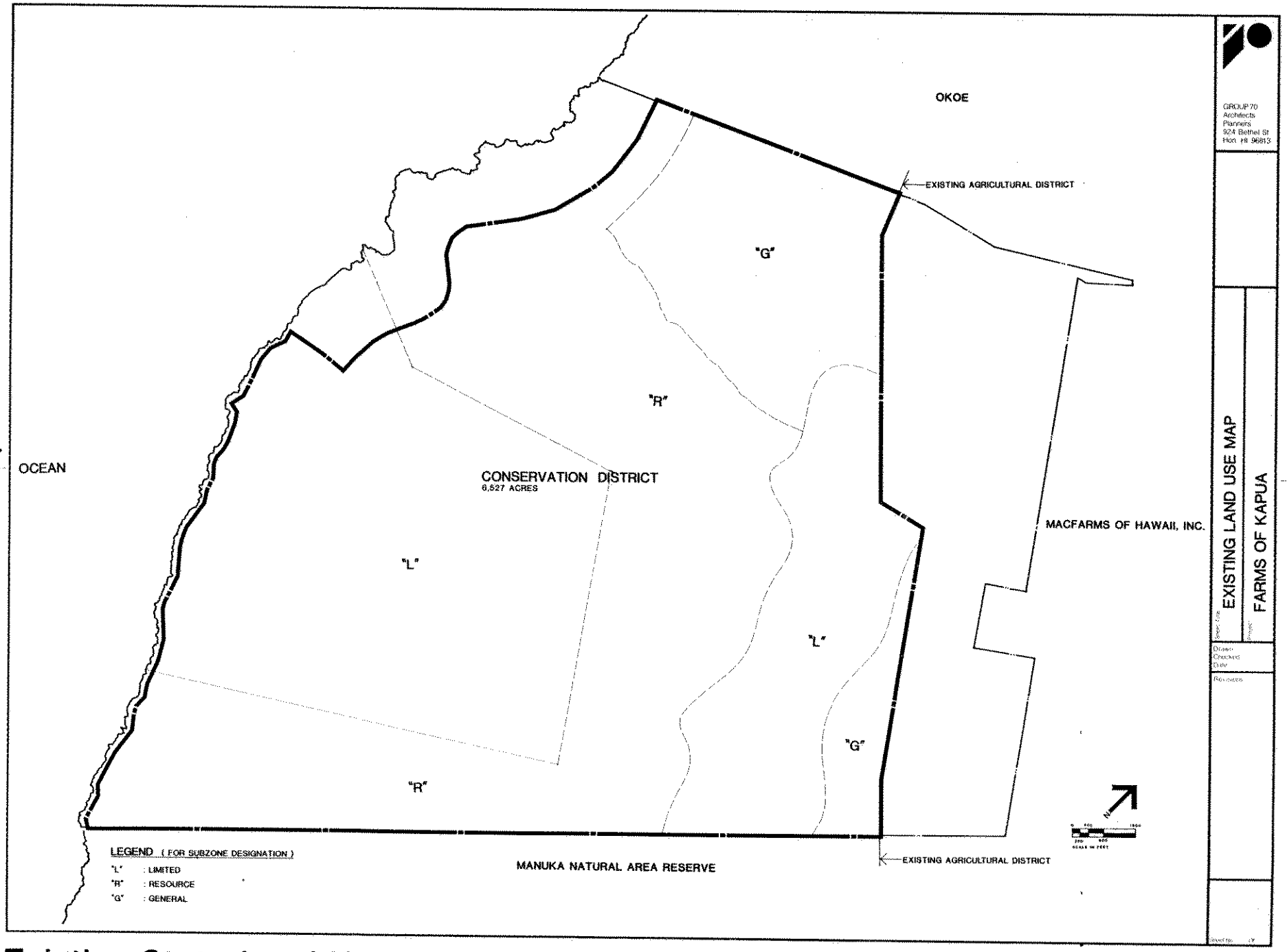
4 10

LOCATION MAP

# FARMS OF KAAPUA

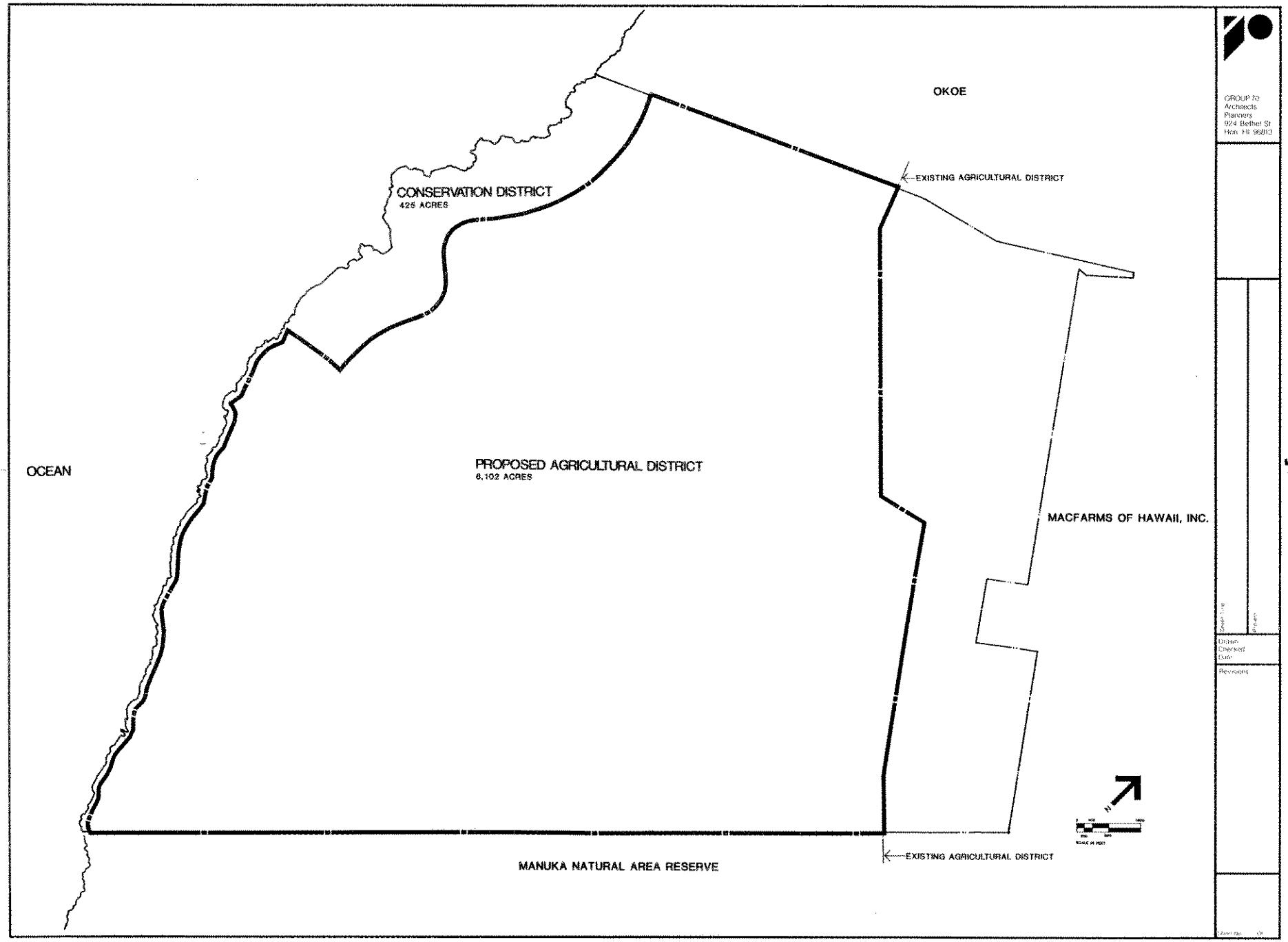


FIGURE 1




# Existing State Land Use Districts

FIGURE 2




# Proposed Boundary Changes

FIGURE 3

County Land Use Designations and Zoning - The Hawaii County General Plan Land Use Pattern Allocation Guide (LUPAG) Map shows an Open area along the coast with the rest of the area shown in Conservation. This conforms with the State Land Use designation. An application to amend the General Plan will follow the favorable resolution of the State Land Use District boundary amendment.

A 300 foot band along the coast is in the Special Management Area, no actions are proposed within this area. The parcel is zoned Open. The draft Kona Regional Plan does not include the petition area within its Conceptual Land Use Map.

## E. General Description of the Action's Technical, Economic, Social and Environmental Characteristics

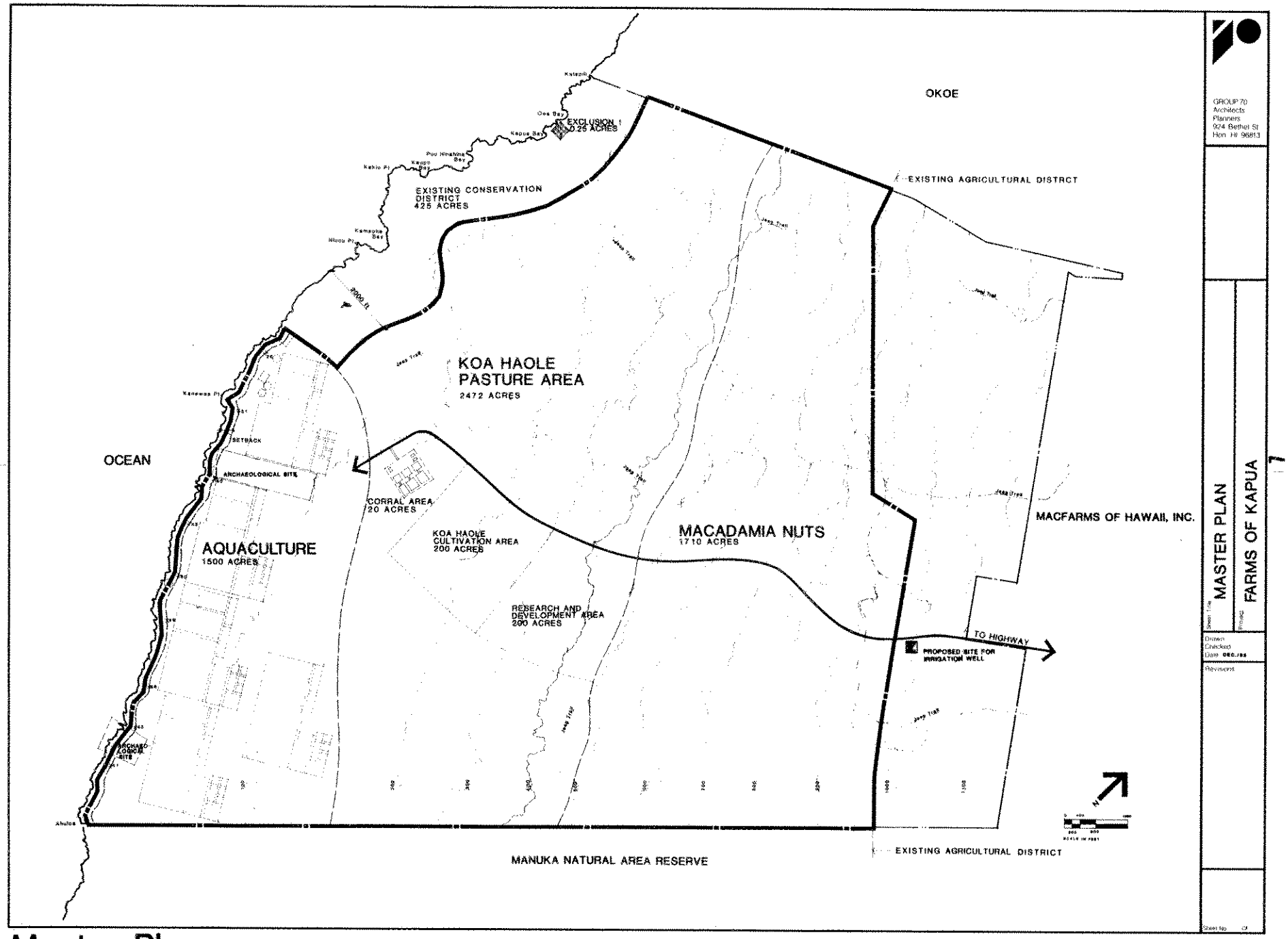
### 1. Technical Characteristics

The proposed Farms of Kapua project will involve a multi-agricultural use of the petition area, including: a macadamia orchard, a controlled pasture area for cattle, an area for the research and development of alternative crops and aquaculture facilities.

Macadamia will be cultivated on approximately 1,710 acres of land, on the mauka portion of the petition area (Figure 4). The proposed orchard will involve the clearing and grubbing of most of the vegetation within this area. In order to improve drainage and root penetration, some bulldozer ripping may be needed to break up areas covered with pahoehoe lava. The areas with a'a lava will require the addition of planting medium and fertilizer to planting holes. A system of unpaved service roads will be developed, to facilitate the cultivation and harvesting of the crop.

Approximately 2,472 acres between the macadamia orchard and the aquaculture facility (Figure 4) will be planted in a combination of koa haole (leucaena) and guinea grass. Wean calves, acquired from other ranches, will be placed in this area. The cattle would feed in this unirrigated pasture until reaching weights of 700-800 lbs., at which time they would enter the feedlot. The cattle would be in the feedlot for 90-120 days prior to marketing. As cattle are taken to the feedlot, replacement cattle for the unirrigated pastures would be purchased. Under normal weather conditions, once the entire area is developed, there would be approximately 600-700 weanlings on unirrigated 2,472 acre koa haole pasture area and 600-700 head in the feedlot. Manure from the cattle will be collected and used to supply some of the necessary nutrients to cultivate the Marine shrimp, the Brine shrimp and the Spirulina in the aquaculture facility.

Two hundred (200) acres of the petition area will be set aside (Figure 4) for the intensive cultivation of koa haole. Leucaena will be planted, irrigated and harvested here and used as green chop feed for the cattle in the feedlot.




# Master Plan

FIGURE 4

Another 200 acre area (Figure 4) is planned for the research and development of other possible crops to be cultivated in Kapua, such as aloe vera and crownflower.

The proposed aquaculture farms, which are planned in five 200-acre modules, will be sited in an area of approximately 1,500 acres below the 150 foot elevation and a minimum of 300 feet mauka of the shoreline. The actual siting of the modules is flexible and will be arranged in a pattern which preserves the significant archaeological features of the coastline area. One possible configuration is shown on Figure 4.

The aquaculture facilities will consist of a series of ponds and raceways, and common support facilities, such as a hatchery and laboratories. The construction of this facility will require some grading and excavation. A central water pumping facility will be built to pump brackish water from the ground into a reservoir and into the various ponds and raceways.

The proposed project will include the on-site construction of a roadway system, irrigation water systems and agricultural improvements such as equipment storage sheds. Roads within the property will be constructed by the petitioner to County standards. Several wells will be developed within the macadamia orchard between the 800 to 1,000-foot elevations. The proposed wells will be developed and financed by the petitioner to meet all Federal, State and County requirements.

The water distribution and storage system and cesspools will be private. They will be maintained by the Farms of Kapua, Ltd.

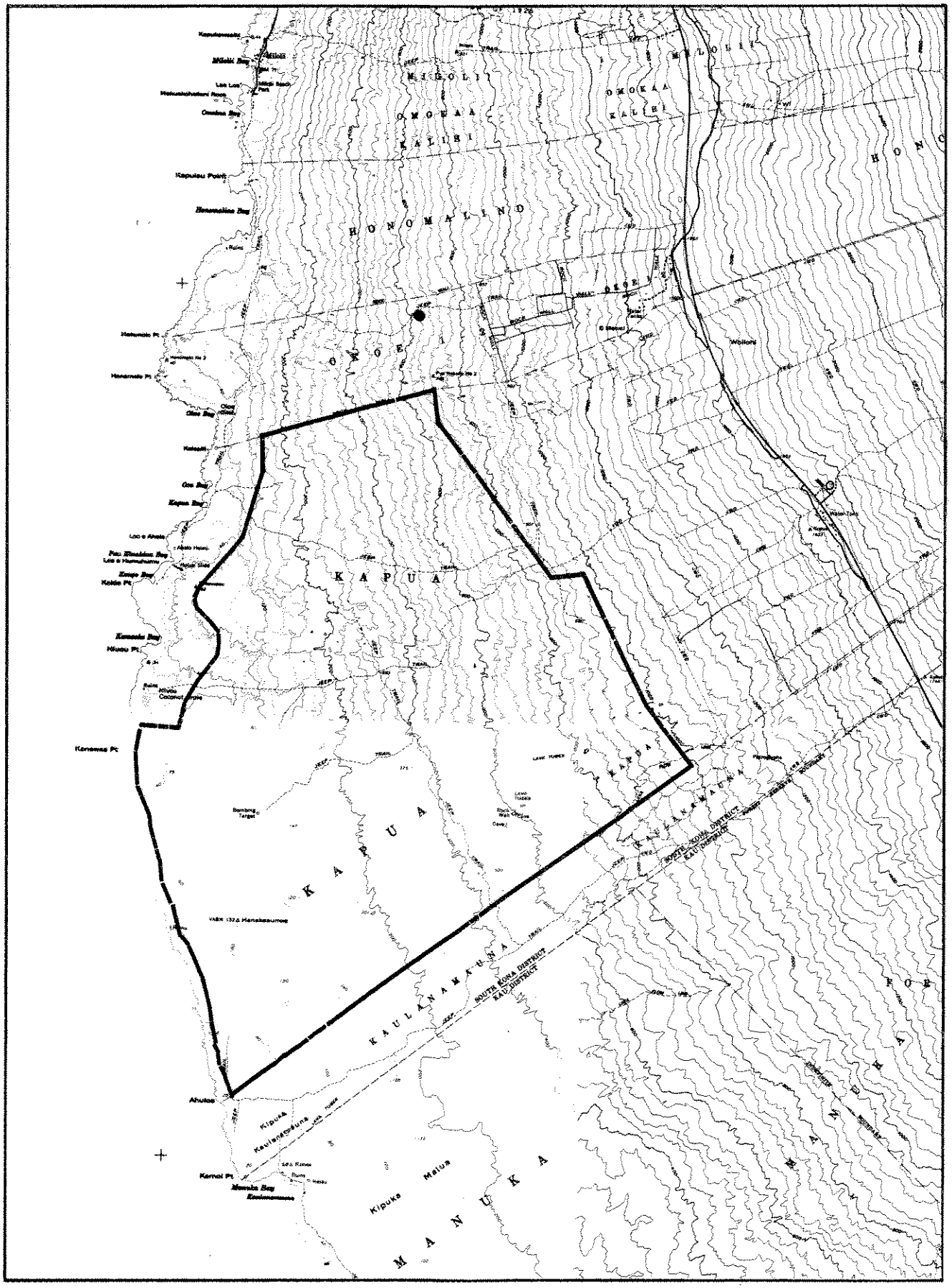
Off-site improvements will include the extension of electrical and telephone lines and the resurfacing of existing access roads from Mamalahoa Highway. Farms of Kapua, Ltd. will also construct an electric substation for Hawaii Electric Light Company in order to provide power to the development.

In addition, if the Board of Land and Natural Resources grants the use of the State's Okoe well (located on State land identified as T.M.K. [3rd Div.] 8-9-03: 83), approximately 13,000 linear feet of transmission lines, and a pump and controls at the well site, will need to be installed in order to bring the water to the petition area. The location of Okoe well is indicated on Figure 5.

## 2. Economic Characteristics

The project will provide direct, permanent employment for approximately 160 persons. It is expected that, wherever possible, those hired will be permanent residents of South Kona. Development of the project will expand the agricultural resources of South Kona.

The development will also result in a positive impact on the fiscal resources of the County of Hawaii. Additional revenues to government will also be generated in the form of licenses, permits and other fees. County




NORTH

# VICINITY MAP

FIGURE 5

● State's Okoe Well

## PART III: DESCRIPTION OF ENVIRONMENTAL SETTING AND THE PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

This section describes the existing conditions of various aspects of the environment, the proposed action and the impact of the proposed action that would affect the environment.

### A. Geology

#### 1. Existing Conditions

The island of Hawaii, the youngest and the largest of the Hawaiian Islands, is located on the southeast end of the archipelago. The island's total land area of 4,038 square miles was formed by five volcanoes: Mauna Kea, elevation 13,796 feet; Mauna Loa, elevation 13,677 feet; Hualalai, elevation 8,271 feet; Kohala, elevation 5,480 feet; and, Kilauea caldera, elevation 4,090 feet. Hualalai, Mauna Loa and Kilauea have been active in recent times.

Generally, areas to the south of Kuamo'o Point are susceptible to flows from Mauna Loa rather than Hualalai. The Mauna Loa shield has been built principally by eruptions along two rift zones that extend southeastward and east-northeastward from the Mokuaweoweo caldera. The volume of Mauna Loa, is on the order of 10,000 cubic miles, making it probably the largest volcanic mountain on earth. Although Mauna Loa has continued to erupt frequently during the 19th and first half of the 20th centuries, it must have grown to nearly its present size by the end of the Ice Age.

Within historical times, Mauna Loa has been volcanically active on 38 occasions between 1832 and 1975. Eight historical Mauna Loa lava flows have been situated within the North and South Kona Districts. Four major Mauna Loa flows (1859, 1919, 1926 and 1950) were extensive enough to reach the ocean. Two other flows (1851 and 1949) originating at the summit, extended westward toward Kealakekua. However, these flows terminated on the upper slopes of Mauna Loa above the 7,000 foot elevation, approximately 14 miles mauka of the shoreline.

The petition area is located on the basalts and olivine basalts of the present Mauna Loa shield, which are known as the Ka'u Volcanic Series. The Ka'u series is composed of a random succession of layers of pahoehoe, a'a and clinker, the upper strata of which are of relatively recent geologic age.[1]

## 2. Proposed Action

The proposed project will not affect the geological characteristics of the site or the surrounding area.

# B. Topography

## 1. Existing Conditions

In comparison to the advanced eroded character of the northeast slope of the island the Kona region is unscarred by the extensive development of stream or drainage channels.

The area of the proposed project extends from the coast through the broken lava terrain into the scattered forest at an elevation of approximately 1,000 feet, over a total average distance of 3.2 miles (Figure 6). Generally, most of the area between the shoreline and the 150 foot elevation contains slopes of up to 5%. The largest portion of the site has slopes averaging between 6% to 10%, interspersed with large areas of slopes of 11% to 15%. There are very few pockets on the petition area with slopes ranging from 16% to 25%.

The project's border includes approximately five miles of shoreline from Kalapili, just south of Okoe Bay, to Ahuloa (Figure 6). Small bays and inlets dot the northern portion of the coastline with reefs extending several hundred feet into the water. The southern portion consists primarily of bluffs of lava dropping off into the ocean.

The elevation gradient of the shoreline is greatest on the northern portion, and lessens southward along the coast. An elevation of 200 feet is reached approximately 2,000 feet inland from Okoe Bay, 3,000 feet inland of O'e'a Bay, 7,000 feet inland of Niuou Point and 7,000 to 8,000 feet from Kanewa'a Point and Ahuloa.[2]

## 2. Proposed Action

Proposed improvements for the macadamia orchard include minimal grading. No borrow material will have to be brought to the site.

Most of the 2,472-acre koa haole pasture will be rough bladed and rolled, preserving any healthy trees for shade and organic matter buildup. One pass by a large tractor (D7 or larger) with the blade adjusted to skim the surface, pulling a heavy 10 ton or heavier roller should be adequate for this area.

The 200-acre koa haole cultivation area and the 200-acre research and development area will be bladed and rolled to a higher degree than the 2,472-acre koa haole pasture (requiring possibly 2 or more rollings) to allow easy access of irrigation equipment and uniform growth. No ripping or moving of material is required.

expenditures for facilities and services are not expected to increase appreciably with the development of the proposed project as all of the basic infrastructure will be provided by the owners.

### 3. Social Characteristics

There are no people presently living on site. Therefore no one will be displaced by the implementation of the proposed action.

The petitioner will generally maintain the present means of public access to the shoreline: from mauka portions of the site by permission only; and, unobstructed lateral access along the shoreline north and south of the petition area.

### 4. Environmental Characteristics

No construction is proposed within the offshore waters or within 300 feet of the shoreline. During the life of the project there will be no point discharge of human or animal wastes from the petition area directly into offshore waters.

## F. Historic Perspective

In addition to 21 (3 inland and 18 coastal) previously recorded sites, a total of 41 new archaeological sites, 37 inland and 4 coastal, were designated during the archaeological reconnaissance survey of the Farms of Kapua area. The greatest density and variety of archaeological remains were found in the northern coastal zone which is not included in this petition (Figure 3). Strategic placement of the aquaculture facilities will preserve significant sites in the southern coastal area. The significance of the pre-contact uses of this area is undocumented at this time.

In recent years large portions of this area were grubbed and chain-dragged for the planting of guinea grass and koa haole. The site is currently being used for occasional grazing.

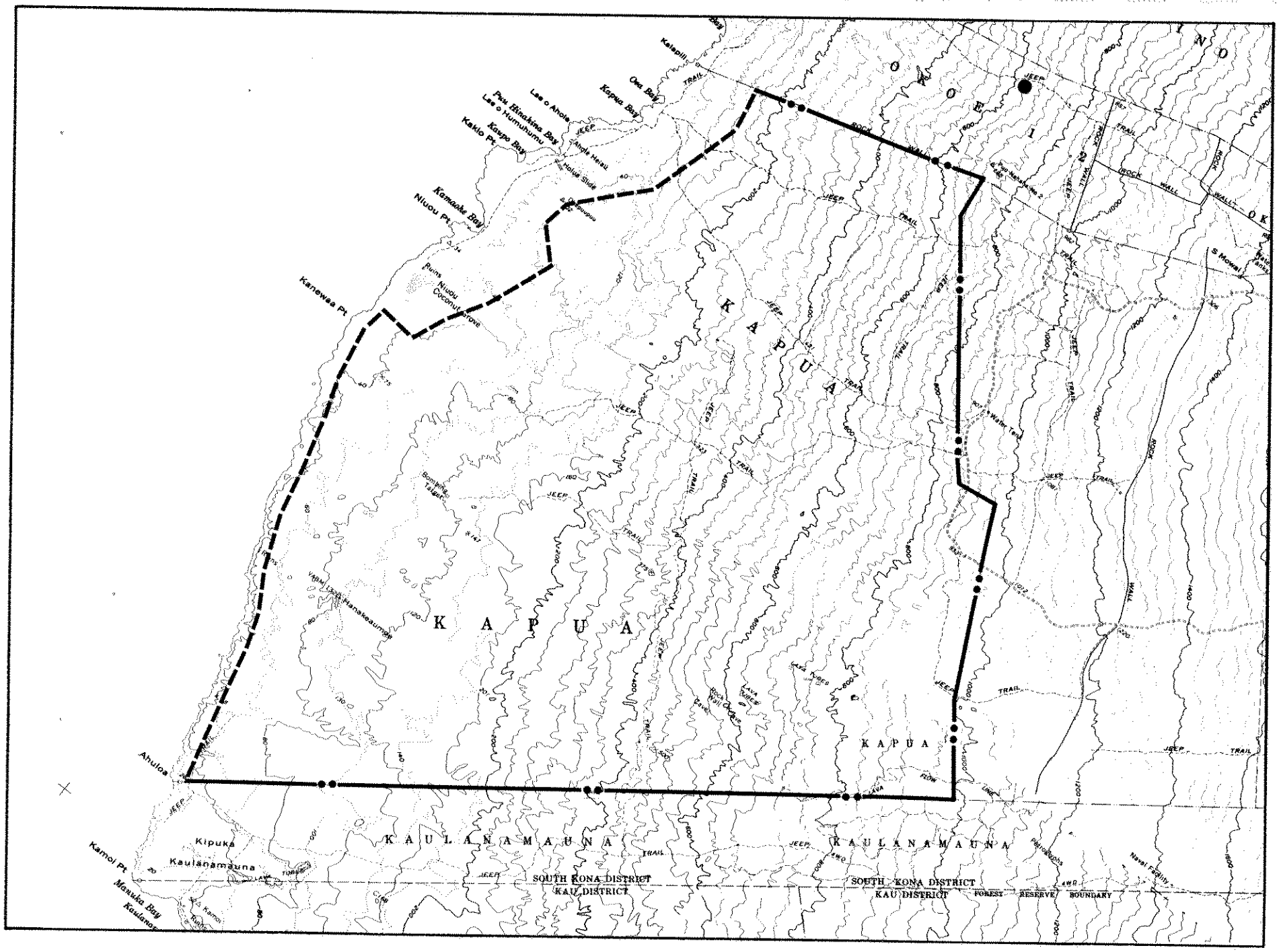
Between 1956 to 1970, the Navy subleased approximately 2,198 acres near Kauna Point for use as a bombing range (Figure 5). During this period only inert practice ordnance was used. The lease was terminated in 1970 and the Navy conducted a clean up of the range. However, unexploded ordnance has been seen in this area. There is ungoing communication between the petitioner and the Navy to remove the remaining materials.

## G. Use of Public Funds or Lands for the Action

No public funds or lands will be required for the action other than the use of the State's Okoe well, if granted.

## H. Phasing and Timing of the Action

As soon as all governmental approvals are secured, Farms of Kapua, Ltd. plans to roll and seed the 2,472 acre koa haole pasture area, in increments of approximately 400 acres per year, over six years. The macadamia area would be graded and planted, in increments of approximately 500 acres per year, over three years. As soon as source of water is developed, the 200 acre koa haole cultivation and the 200 acre research and development areas will be developed. One of the aquaculture modules will be developed within the first five years.




● State's Okoe Well

# TOPOGRAPHY MAP

FIGURE 6

N

SC 1" : 2800'

In the aquaculture area, rough grading and excavation will occur only within the individual 200 acre modules.

### 3. Impacts

Since the grading proposed is limited to the minimum required for the proposed agricultural uses, the alteration of the existing topography will be slight. There are no major waterways on site, and the proposed grading activities will not alter existing drainage conditions (i.e. percolation through the porous soils).

## C. Climate

### 1. Existing Conditions

The island of Hawaii lies in the path of the northeast trade winds and has an orographic (mountain-caused) rainfall pattern. The prevalence of trades accounts for the high annual rainfall of 75 to more than 300 inches on the windward (northeast) side of the island.

The Kona rainfall regime is unique in that the winter months are dry and the summer months are wet. The Kona rainfall pattern is influenced by Mauna Kea and Mauna Loa, which have elevations in excess of 13,000 feet. The peaks split and divert the northeastern tradewind inversion regime that normally exists between the 4,000 to 6,000 foot elevations over the Hawaiian Islands.

Similarly, the 8,271 foot peak of Hualalai blocks the rain-bearing tradewinds that are funneled through the saddle between Mauna Loa and Mauna Kea. As a result, the tradewinds do not reach most of the Kona district to bring orographic rainfall. In Kona, the temperature difference between the land and the ocean, especially in summer, tends to develop moderate on-shore seabreezes which generate convective type rain showers.[3]

There are no long-term rainfall data on-site. However, since in South Kona rainfall correlates strongly with elevation, adjustments in rainfall data from nearby stations can be used to estimate the rainfall on-site. The following description of rainfall was derived from John Mink's report, Water Supply for Farms of Kapua. His report is attached to the EIS as Appendix A.

Substantial records for standard gages at Manuka, two miles south of the petition area, and Opihihale, about seven miles north, are on file with the National Weather Service. The Manuka gage (State No. 2.0) is at an elevation of 1750 feet on the Belt Highway, and the Opihihale gage (State No. 24.1) is at 1270 feet, also on the highway. Rainfall at these stations shows similar distribution although the amounts differ because the gages are 500 feet apart in elevation. In South Kona rainfall correlates strongly with elevation and only weakly, if at all, with distance inland. Between Manuka and Napoopoo rainfall is very similar at

comparable elevations; north of Napoopoo it is significantly greater at these same elevations. Kapua lies in the relatively uniform belt between Manuka and Opihihale.

Mean monthly rainfall in inches at Manuka and Opihihale are given below to illustrate the similarity of distribution. The record of Manuka covers the period 1929-1966 while that for Opihihale is for 1955-1973. Means, not medians, are given.

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manuka | 4.10 | 4.47 | 5.75 | 5.49 | 6.45 | 5.17 | 4.74 | 5.66 | 5.81 | 4.66 | 3.67 | 3.61 | 59.05 |
| Opihihale | 4.68 | 2.43 | 3.85 | 3.51 | 4.22 | 3.67 | 4.45 | 4.22 | 4.61 | 3.53 | 3.78 | 3.27 | 46.62 |

The relevance of the Opihihale record as a surrogate for Kapua at 1200 feet can be tested by comparing the average annual rainfall to that at Manuka adjusted to 1270 feet elevation. The adjustment assumes linear increase in rainfall with elevation to at least the Manuka elevation of 1750 feet. These calculations indicate that Opihihale is representative of Kapua at about the 1200 feet level.

The secondary records within Kapua are at Kole Pen (State no. 2.18), Okoe (State no. 2.17) and Kapua (State no. 2.19). Kole Pen is within elevation of 920 feet, Okoe at 1590 feet, and Kapua at 1670 feet. None of data from these gages are reported in National Weather Service publications, nor had their records previously been printed in published reports of DLNR or the USGS. Monthly means for these stations are as follows (inches):

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kole Pen | 4.07 | 1.62 | 2.71 | 2.67 | 2.54 | 1.76 | 2.34 | 2.10 | 2.68 | 2.00 | 2.86 | 2.04 | 29.97 |
| Okoe | 5.50 | 2.43 | 4.43 | 4.79 | 4.99 | 3.50 | 4.01 | 3.64 | 4.69 | 3.78 | 4.56 | 2.56 | 50.03 |
| Kapua | 4.33 | 2.39 | 4.31 | 4.50 | 5.71 | 3.35 | 4.02 | 4.11 | 4.05 | 4.04 | 4.92 | 2.42 | 49.79 |

The above suggests that rainfall at 1000 feet in Kapua averages about 35 inches per year. At elevation 400 feet rainfall is about 25 inches.

The statistical dispersion of monthly rainfalls about their means is unusually tight. This means that extremely dry months are rare. The statistics suggest that devastating droughts are virtually absent in the Kapua region.

Temperature differences on the island of Hawaii also result chiefly from variations in elevation. In addition, leeward locations have slightly warmer and more variable temperatures than windward sites. The average range in temperature is greater over the course of a day than it is from season to season. Based on a standard change of 3.0°F for each 1,000 foot of elevation in the area, and using the recorded temperatures at the Kainaliu Station at the 1,500 foot elevation in Kona, it is estimated that the annual mean temperature at the 500 foot elevation is 72.6°F.

The Atlas of Hawaii characterizes the petition area as having light and variable winds.4

## 2. Proposed Action

The proposed project will not affect the climate of the site or the surrounding area.

# D. Soils

## 1. Existing Conditions

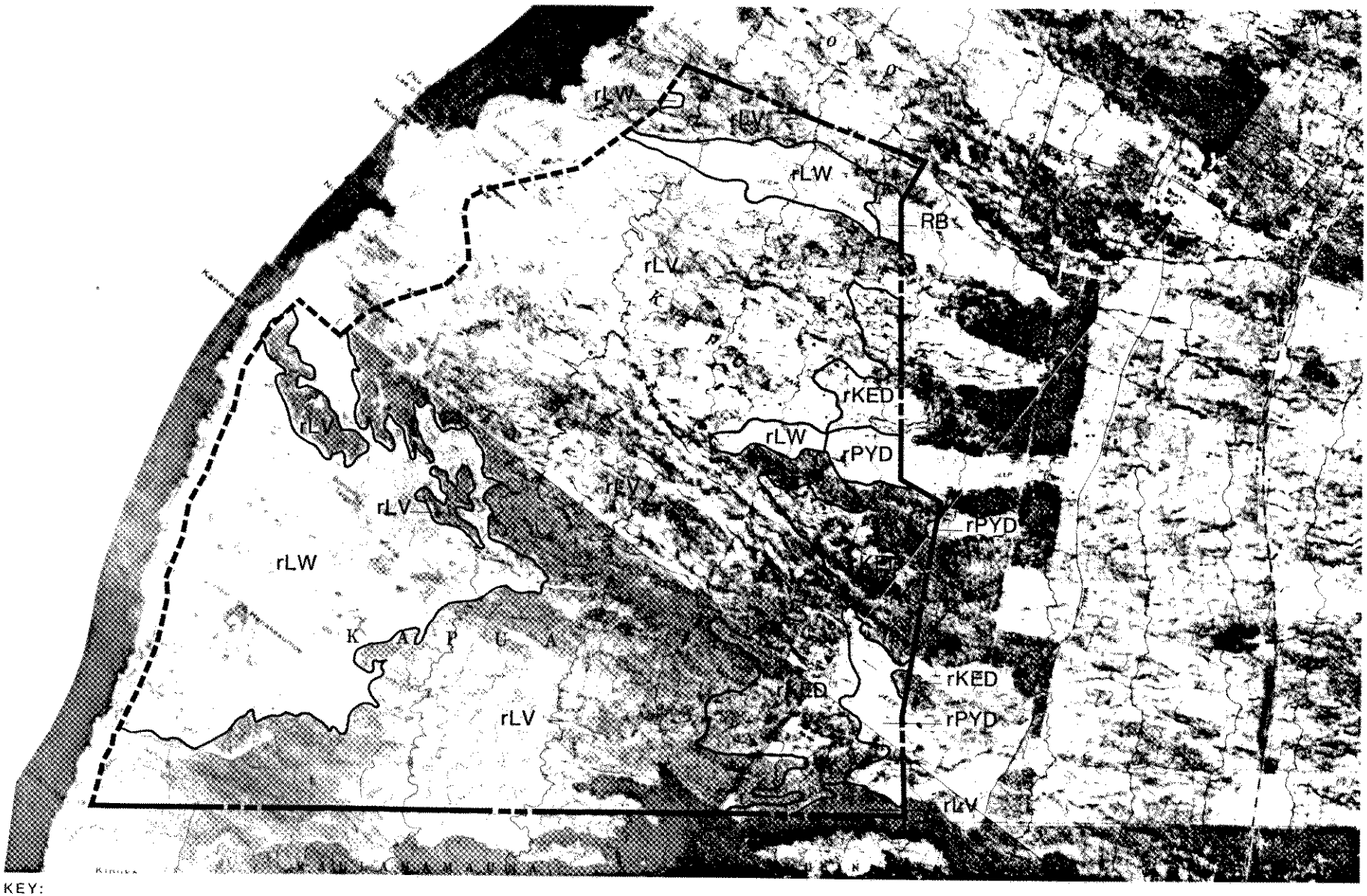
Geologically, the Kona District is quite young, being formed by recent prehistoric and historic lavas of Hualalai and Mauna Loa. Soils in Kona are generally shallow and exhibit a stony or rocky character. The absence of extensive erosion and weathering of these lavas into soil materials are due mainly to the climatological character of the region. The location of soil types on the petition area are shown in Figure 7, which contains information from the Soil Survey of Island of Hawaii, State of Hawaii, overlayed with U.S.G.S. contour lines. The following description of the soils on-site is based on the Soil Survey of Island of Hawaii, State of Hawaii, prepared by the U.S. Department of Agriculture, Soil Conservation Service, December 1973.

Kaimu Series - Kaimu extremely stony peat, 6 to 20 percent slopes (rKED). The Kaimu Series consists of well-drained, thin orgainc soils over a'a lava. The Kaimu extremely stony peat has a top layer consisting of three inches of peat underlain with fragmented a'a. Permeability is rapid, runoff is slow, and the erosion hazard is slight.

Punaluu Series - Punaluu extremely rocky peat, 6 to 20 percent slopes (rPYD). The Punaluu Series consists of well-drained, thin organic soils over pahoehoe lava. The Punaluu extremely rocky peat has a top layer consisting of black peat of 4 inches in thickness, underlain by pahoehoe bedrock. The topsoil is rapidly permeable and the under layer of pahoehoe is very slowly permeable, except for rapid movement of water through the cracks. Runoff is slow and the erosion hazard is slight.

Rough Broken Land (RB). This soil type is described by the Soil Conservation Service as a miscellaneous type consisting of very steep, preciptious land with slopes of 35 to 70 percent, broken by many intermittent drainage channels. Other than the steepness of slopes and probable erosion, the rough broken land is considered to be similar to that of the prevailing soil in the area, in this instance rKED. The rough broken land outlined in the petition area appears to have a much lesser degree of slope than indicated in the description given by the Soil Conservation Service.

Lava flows, A'a (rLV). This soil type designated as A'a Flows is similar to rKED, except that it occurs in lower rainfall areas and has essentially no soil covering.




KEY:

| | |
|---|---|
| rKED | Kaimu Extremely Stony Peat |
| rPYD | Punaluu Extremely Rocky Peat |
| RB | Rough Broken Land |
| rLV | Lava Flows, A'a |
| rLW | Lava Flows, Pahoehoe |

Based on Soil Survey of Island of Hawaii, State of Hawaii, USDA Soil Conservation Service

NORTH

- Soil Survey Map
- Site Plan

GROUP 70
Architects
Planners
Interior Designers
924 Bethel St
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**FIGURE 7**

Lava flows, Pahoehoe (rLW). This lava flow has a billowy, glassy surface, which is rough and broken in some areas, with the possibility of hammocks and pressure domes. Pahoehoe lava has no soil covering except in areas of heavier rainfall where trees have gained a foothold in cracks and crevices and a shallow level of humus has developed.

## 2. Proposed Action

Approximately 70 percent of the macadamia (in increments of 500 acres per year) will be graded. In addition, approximately 70 percent of the 200-acre research and development, 200-acre koa haole cultivation and 2,472-acre koa haole pasture (in increments of 400 acres per year) areas will be grubbed. The remaining 30 percent (a standard engineering consideration) of these areas is presumed to be unusable because of terrain, the preservation of significant archaeological sites or areas containing significant botanical specimens.

The portions of the proposed macadamia area which are covered with a'a lava, Kaimu Series and Punaluu Series soils require the clearing of existing vegetation, minimal grading and the excavation of planting holes. In order to improve drainage and root penetration in pahoehoe lava, some bulldozer ripping may be required.

Most of the 2,472-acre koa haole pasture is covered with a'a lava, with small islands of pahoehoe. This area will be rough bladed and rolled, preserving any healthy trees for shade and organic matter buildup. One pass by a large tractor (D7 or larger) with the blade adjusted to skim the surface, pulling a heavy 10 ton or heavier roller should be adequate for this area. Approximately half of the 200-acre koa haole cultivation area contains a'a lava, the other half, pahoehoe. This area and the 200-acre research and development area (which is almost completely covered with a'a lava) will be bladed and rolled to a higher degree (requiring possibly 2 or more rollings) than the 2,472-acre koa haole pasture. No ripping or moving of material is required in these areas.

Aquaculture activities within each of the five 200 acre modules, including the brackish water system, will occupy 160 acres. Rough grading and excavation will occur within the 160 acre areas. An additional 40 acres is alloted for roads (not all of this will be used).

Construction of the proposed project will also involve the excavation of holes for utility poles.

## 3. Impacts

Clearing and grubbing activities during construction will temporarily disturb the soil retention values of the existing vegetation, and expose the soils to erosional forces. Heavy construction equipment traffic along unpaved roads will lead to the generation of small dust particles. In addition, dust will be generated by the abrasive action of construction equipment on rocks.

The potential for soil erosion from wind is greater than from rain. However, as noted elsewhere, winds in the area are characterized as light and variable. Once construction is completed, the planted crops will assume the soil retention value of the existing vegetation.

As described in the Soil Survey of Island of Hawaii, State of Hawaii, U.S.D.A. Soil Conservation Service, most of these soils have been characterized as having slow runoff. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of soil erosion by surface runoff.

Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation area and 200 acre research and development area. The proposed irrigation of the above mentioned areas will not cause soil erosion because the proposed crops will retain the soils.

## E. Water Resources and Water Usage

### 1. Existing Conditions

In order to insure the availability of water for the proposed multi-agricultural uses of the site, a preliminary study of the potential sources of water was conducted by John F. Mink (Appendix A). His study is summarized below.

In this region, rainfall that is not evaporated and transpired by plants infiltrates into the ground to eventually accumulate as groundwater. The porous characteristic of the ground precludes the occurrence of surface runoff.

Groundwater reserves occur near sea level throughout the Kona region as a lens of fresh and brackish water afloat upon the denser mass of seawater. Recharge of this basal aquifer is primarily accomplished by rainfall infiltrating the highly permeable basaltic bedrock. The composition of the groundwater at low elevations near the shoreline is brackish. This is due to the porous rock which allows seawater to mix with the fresh water layers.

Although the groundwater resources of the site have not yet been tested, it is known that the annual average rainfall in the principal recharge zone for the aquifer beneath Kapua reaches 75 inches and over a large area, 50 to 75 inches. This suggests the presence of a sizeable groundwater resource, brackish and potable, on-site, since elsewhere in Hawaii, these conditions give rise to developable groundwater.

Furthermore, the State's Okoe well which is located about 3,000 feet north of the petition area has produced water that is stabilized at about 900 mg/l chloride at 700 gpm, which John F. Mink considers a favorable indication of the groundwater resources in the Kapua area. Okoe well lies 1.6 miles inland of the nearest coast. A comparable inland location within the petition area would be below the 400 foot elevation.

## 2. Proposed Action

Potable Water: Potable water requirements for employees of the macadamia orchard, feedlot and the aquaculture modules is estimated to be 3,200 gallons per day (160 employees consuming an average of 20 gallons per day). Water for the employees on site will be trucked in.

Irrigation Water: Supplemental irrigation requirements for the project would vary. The long term records of rainfall in the Kapua area show that extremely dry months are rare. Rainfall records for the last nineteen years show that no month was so dry that irrigation would have had to provide all the water required by the proposed crops. Some dependence on irrigation could be expected during occasional dry months, which might occur at any season of the year.

Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation and 200 acre research and development areas. Irrigation is not being proposed in the 2,472 acre koa haole pasture area. Research conducted by Harold F. Rice indicates that there are areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing.

Irrigation requirements by months, based on a moisture demand of 4.4 inches per month (Frank S. Scott Jr., Appendix E), have been computed by Mink for the historical record based on the Opihihale and Manuka rain gages and separately for the record at Kole Pen. The average deficit is estimated for Opihihale/Manuka at 1261 gpa/d, for Kole Pen at 1912 gpa/d. Estimates of the total average demands for irrigation, based on the least favorable record (Kole Pen) are given in Table 1. Irrigation rates for macadamia are assumed to be applicable to leuceana and other crops also.

Table 1

IRRIGATION WATER DEMAND

| CROP | ACRES | AVERAGE (gpad) | TOTAL AV. (mgd) | 10 PERCENT (gpad) | TOTAL (mgd) |
|---|---|---|---|---|---|
| Macadamia | 1710 | 1912 | 3.3 | 3481 | 6.0 |
| Leucaena | 200 | 1912 | 0.4 | 3481 | 0.7 |
| Other | 200 | 1912 | 0.4 | 3481 | 0.7 |
| TOTAL | 2110 | | 4.1 | | 7.4 |

Total average demand is equivalent to 2845 gpm. Assigning a yield of 1000 gpm to agricultural wells, three wells may be required to satisfy average demand. At the same yield, two to three additional wells may be needed to meet the ten percentile demand.

The wells can be drilled to correspond with planting and expansion of the orchard and koa haole area. These irrigation wells would be sited within the macadamia orchard between the 800 and 1,000 foot elevations, at locations consistent with acceptable water quality, and transmission and storage requirements. It is expected that the pump capacity of each of these wells will be approximately 1.4 MGD.

If one of these irrigation wells yields water of potable quality, it may be used as a standby source for potable water for employees.

One possible source of irrigation water is the Okoe well located on State land and identified as T.M.K. (3rd Div.) 8-9-03: 83 (Figure 6). The petitioner has submitted a request, pursuant to H.R.S. subsection 171-58, for the Board of Land and Natural Resources disposition of a State general lease of water from the Okoe well (currently idle), together with pump and pumpline easements as may be required, for the transmission of this water to the petition area. Approximately 13,000 linear feet of transmission lines, and a pump and controls will need to be installed in order to bring the water from this well to the site. Since the chloride content of the water from the Okoe well is higher than the macadamia can tolerate, it must be blended with less brackish water from another source before application. Salt tolerance is suspected to be higher for koa haole and cattle, therefore, water from Okoe well may be able to be used directly (unmixed) to satisfy the water requirements of these users.

Water for Cattle: Water requirements for cattle is estimated to 10,000 gallons per day (1,000 animal units [AU] consuming an average of 10 gallons per day). One AU is equivalent to one feedlot steer at 800 to 1,000 lbs. or two weanlings at 400 to 500 lbs. Water for the cattle will provided by resources on site.

Water for Aquaculture: To provide brackish water for the aquaculture facility, a central brackish water well and pumping system is proposed which will produce 6 MGD for the individual ponds and raceways.

Other Actions: No sewage injection areas above the underlying aquifer are proposed. Since the petition area is located makai of the County of Hawaii's "no pass" zone, the cesspools that are proposed for the project are not expected to have any impact on groundwater. They will be constructed according to the current regulations governing cesspools.

3. Impacts

While the sustainable yield of the aquifer below the site is unknown, study by John Mink suggests "that flow at the coastline is on the order of 6.0 MGD per mile. Within the property, total flow is between 8.0 and 18 MGD, and the most probable average is about 13 MGD. Not all of this flow is feasibly developable, however, sustainable yield on a continuous schedule is 6.0 to 7.0 MGD, but for periods of reasonable length, say three months or so, as much as twice the sustainable yield can be pumped without seriously affecting the quality of the yield." This is more than adequate for the water requirements of the proposed project.

The long term effects of pumping from the aquifer underlying the petition area can only be ascertained after the proposed wells are in operation over a period of time. No groundwater is being developed within 20 miles of the petition area. The nearest active wells at Naalehu and Kealakekua are not only distant but are also located in aquifers separate from the one underlying Kapua. No aquifers on the island of Hawaii have been designated as State Ground Water Control Areas.

## F. Natural Hazards

### 1. Existing Conditions

The entire island of Hawaii is located in Earthquake Zone 3 (on a scale of 0 - 5), which is the zone most prone to major damages from potential earthquake activity. The Ka'u District, located just south of the petition area, has been identified as the most earthquake prone area of the island.

Earthquakes and tsunamis are events which stem directly from fault activity. The Kealakekua and Kaholo faults are the only two fault zone systems which have been identified within the Kona region. Both systems are situated on the southwest flank of Mauna Loa, and more specifically, within the South Kona district. The Kaholo fault system runs parallel to the shoreline, below the 1,000 foot elevation, for approximately 16 miles, between Ki'ilae and Papa Bays.[5]

Historically, only the Kealakekua fault system has been significantly active, generating a major earthquake and two small tsunamis on August 21, 1951. As defined by Donal Mullineaux and Donald W. Peterson[6], the petition area is located in zone "E" on a scale of "A" to "F", with "F" being the area of highest susceptibility to damage from volcanic hazards.

According to the General Plan of the County of Hawaii, the nearest potential tsunami inundation zone is in the Milolii area, 3 to 4 miles north of the petition area.[7] Hawaii Institute of Geophysics (HIG 77-14) lists as tsunamis generated on the Kona coast, two definite, a third probable, and a fourth very doubtful, as well as two generated on the SE Puna-Kau coast that had significant runups on the Kona coast. There is, in addition, a Milolii tradition of a tsunami that does not fit any of the events listed in the HIG report. The Army Corps of Engineers has estimated the near-shore 100-year tsunami runup height in the Kapua vicinity as 7 or 8 feet.[8]

The property is not subject to flooding from the 100-year flood and is designated Zone C or area of minimal flooding, according to the Federal Flood Insurance Rate Map.[9] The petition area is not located within Zone V, which confirms that the area is not subject to coastal flooding or wave hazard.

## 2. Proposed Action

Minimal construction is planned for the petition area. The aquaculture facilities will be set back from the shoreline a minimum of 300 feet.

## 3. Impacts

The proposed aquaculture area will be constructed above the tsunami runup. The shoreline fronting the aquaculture area consists primarily of bluffs of lava dropping off into the ocean. In addition, elevations along 300 feet inland of the aquaculture area were studied (no development is proposed within this setback), and it was discovered that near the northern boundary of the aquaculture area, 300 feet inland, the elevation was approximately 26 feet. Proceeding south along the shoreline, elevations 300 feet inland average approximately 40 feet. This is well above the Corps of Engineers estimates for near-shore 100-year tsunami runup height of 7 or 8 feet. In the event of a storm warning, appropriate actions will be taken to secure the aquaculture products and facilities.

All construction work on the petition area will be subject to provisions of the "Uniform Building Code", which requires that all structures be designed and constructed to meet Zone 3 requirements. Should the area warrant additional disaster warning devices the County of Hawaii Civil Defense Agency would assume the responsibility of equipment installation.

# G. Coastal Water Quality and Marine Biology

## 1. Existing Conditions

The State of Hawaii Department of Health Water Quality Standards (Public Health Regulations, Chapter 37-A) classify waters in accordance with the uses which are to be protected. The offshore waters of the petition area have been categorized as Class AA by the Department of Health. The uses to be protected by Class AA waters are as follows:

> The uses to be protected in this class of waters are oceanographic research, the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, compatible recreation, and aesthetic enjoyment.
>
> It is the objective of this class of water that they remain in as nearly their natural, pristine state as possible, with an absolute minimum of pollution from any source. To the extent possible, the wilderness character of such areas shall be protected. No zones of mixing will be permitted in these waters.
>
> The classification of any water area as Class AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.

The following is a summary of the West Hawaii Coral Reef Inventory,[12] starting with the northernmost section:

Okoe Bay (Figure 6):

Okoe Bay is a small, moderately well protected embayment with a shallow and uneven bottom topography. The bottom is predominantly basalt pavement with very little rubble or sand cover. The shoreline consists mostly of sea cliffs 3 to 10 meters above sea level. There is a small green/black sand beach at Okoe Bay. Okoe Bay is one of the few semi-protected embayments on the South Kona coast. Its shallow shelf area is uncommon in this area of the coast where the rest of the shoreline drops off very rapidly.

Subtidal Invertebrates and Plants - The dominant hard coral type in Okoe Bay is *Porites lobata*. Massive colonies of the coral with diameters of up to 5 feet cover 40 - 80% of the bottom of the bay. Small branching coral, *Pocillopora meandrina*, occur on upper surfaces of basalt outcrops. Finger coral, *Porites compressa*, is also abundant. The most apparent echinoderms are the sea urchins, *Diadema paucispinum*, *Heterocentrotus mammillatus*, *Echinometra mathaei*, *Echinothrix calamaris* and *Tripneustes gratilla*.

Subtidal seaweed species are heavily grazed. Only the browns, *Sargassum* sp. and *Turbinaria ornata*, and several red algae such as *Galaxaura* spp. and *Jania* spp., are evident.

Subtidal fish - The most frequently encountered species at Okoe Bay were: *Chromis agilis*, *Ctenochaetus strigosus*, *Zebrasoma flavescens*, *Parupeneus multifisciatus*, *Mulloidichthys vanicoensis*, *Thalassoma duperrey*, *Naso Lituratus*, *Acanthurs nigrofuscus*, *Chromis verater* and *Acanthurus olivaceous*.

Intertidal organisms - Intertidal communities in the vicinity of proposed project range from those of moderately exposed sand beaches and rocky coasts to highly exposed open rocky coast communities.

There are few seaweed species and long stretches of coast along the petition area have no algal growth at all. The principal exposed coast species occuring in the area are: the green algae, *Ulva fasciata* and *Enteromorpha* spp.; the brown algae, *Giffordia* sp. (Ectocarpus), *Sargassum* sp. and *Turbinaria ornata*; and the red algae, *Ahnfeltia concinna*, *Amansia glomerata*, *Corallina* spp., *Porphyra* spp., *Desmia* sp., *Laurencia* spp., *Pterocladia capillacea* and *Pterocladia caerulescens*.

O'e'a Bay to Niuou Point (Figure 6):

There are two small bays, O'e'a and Kapu'a Bays, in the northern portion of this region. The bays lie within a tenth of a mile of each other, and are situated one-third mile south of Okoe Bay. Kama'ohe Bay, Pu'u Hinahina Bay and Kaupo Bay are open coast features.

Subtidal Invertebrates and Plants - O'e'a and Kapu'a bays support good coral growth. Fifty percent of the total bottom cover consists of living coral. Kama'ohe Bay has less than 1% coral cover, and Kapu'a Bay shows a low coral diversity with no unusual species. The echinoderms consist mostly of sea urchins, such as the Tripneustes gratilla, Echinothrix calamaris and Echinometra mathaei, with small numbers of starfish, Linckia spp.

Kapu'a Bay has a good assemblage of algal species. These include the green algae, Boodlea sp., Dictyosphaeria versluysii and Enteromorpha spp.: the brown algae, Colpomenia sinusoa, Dictyota spp., Sargassum sp., Sphacelaria sp. and Turbinaria ornata; and the red algae, Centroceras clavulatum, Galaxaura spp., Hypnea spp., Jania spp., Laurencia spp. and Liagora spp.

Subtidal Fish - The O'e'a Bay fish fauna consists of at least 59 species of moderate abundance and diversity. Frequently encountered species include: Chromis agilis, Chromis vanderbiliti, Thalassoma duperrey and Ctenochaetus strigosus. At Kapu'a Bay, two species characteristic of deep reefs were observed: Holocanthus arcuatus and Chaetodon miliaris.

Intertidal organisms - There are very few tidepools in this area, but one fronting Kapu'a Bay has a good assemblage of algal species.

Kanewa'a Point (Figure 6):

The coastline from Kanewa'a Point to points south consists of an irregular sea cliff ten to forty feet in height. There are no embayments or ponds in this section.

Subtidal Invertebrates and Plants - Coral cover along the coast is less than 1 - 5% except at Kanewa'a Point where the branching coral, Pocillopora meandrina covers up to 20% of the total bottom area. With the exception of crustose coralline algae, there are very few subtidal seaweed types present.

Subtidal Fish - The reef fish fauna off Kanewa'a Beach can be described as being both abundant and diverse. Of the approximately seventy-four species identified, the most frequently encountered species include: Myripristis berndti, Chromis agilis, Chromis vanderbiliti, Zebrasoma flavescens, Thalassoma duperrey and Ctenochaetus strigosus.

Intertidal Organisms - A moderate to heavy surge, rocky coast community occurs on the open coast. The intertidal community is dominated by mollusks, mainly Littorina spp., Nerita spp., Theodoxus spp., Vermetidae and the bivalve, Isognomon costellatum. Seaweed types included a variety of intertidal species, but there are long stretches of the cliff face without any algal growth at all.

Kamoi Point (Figure 6):

The area north and south of Kamoe Point (ending at Manuka Bay in the south) has an irregular 15 - 30' high sea cliff coastline. There are no ponds in this region.

Subtidal Invertebrates and Plants - There is excellent coral diversity at a site located approximately 1,500 feet north of Ahuloa. Maximum coral head diameter at this site ranges from 1 to 2 feet. There are few echinoderms in any location, and those that occur are mainly the sea urchins, Echinometra mathaei, Echinothrix diadema, plus a few sea cucumbers, Actinopyga mauritiana.

Coral cover between Niuou Coconut Grove to Ahuloa is less than 1 to 5%, except at Kanewa'a Point where the branching coral, Pocillopora meandrina, covers up to 20% of the total bottom area. The coral cover on cliff faces and rubble boulder bottoms from -15 feet to -30 feet is patchy, ranging from 5 to 20%. Corals in these communities are 1/2 to 1 inch in diameter. The deeper talus and cliff slopes are dominated by less than 5% cover of Porites lobata, with colony diameters to 2 feet. With the exception of crutose coralline algae, there are very few subtidal seaweed types present.

Subtidal Fish - The fishes near Ahuloa are abundant and diverse; this area is characteristic of undisturbed reef fish fauna. Forty-none reef fish species were recorded. Species identified include: Chromis agilis, Chromis vanderbiliti, Ctenochaetus strigosus, Chromis hanui, Chaetodon lunula, Sufflamen bursa, Naso lituratus, Parupeneus bifasciatus, Acanthurus olivaceous and Acanthurus guttatus. There are also many species of game fish in this area.

Intertidal Organisms - All intertidal communities in this region are exposed rocky coast types. The intertidal community is dominated by mollusks. Bivalves which are tolerant of fresh water are found in the tidepools as well as in the crevices of the pavement between boulders.

## 2. Proposed Action

No action is proposed on the shore or within offshore waters. During the life of the project there will be no point discharge of treated or untreated sewage, or discharge of effluent from the aquaculture facility directly into offshore waters. A 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback from the balance of the shoreline will be left in conservation. The anchialine ponds (Figure 8) will be left undisturbed.

### 3. Impacts

Implementation of the proposed project will not involve any direct physical or chemical modifications to the nearshore environment. Clearing and grubbing of the petition area will occur in approximate increments of 500 acres per year, over three years, in the macadamia orchard, and 400 acres per year, over six years, in the koa haole pasture area. Whenever a large enough portion of area is readied, it will be planted. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of runoff and soil erosion by surface water. There should be little erosion of soil from wind since the petition area experiences light and variable winds. Therefore, it is unlikely that the soils exposed during the proposed clearing and grubbing activities will impact ocean resources.

The anchialine ponds are located well within the area to be left in Conservation (the mauka boundary is 2,000 feet inland from the shoreline, from the northern boundary of the petition area to just north of Kanewaa Point). Therefore, the anchialine ponds, which are near the shoreline (Figure 8), will not be impacted by the nearest agricultural activities (koa haole pasture) located nearly 1,500 feet away. Since the anchialine ponds are located over a mile north of the aquaculture area boundary, and groundwater generally flows perpendicular to the coastline, the effect of pumping brackish water for the aquaculture facilities on anchialine ponds should be negligble.

The development will not affect wave stress conditions, which are the primary determinants of reef community structures.

## H. Vegetation

### 1. Existing Conditions

A botanical reconnaissance of the petition area, which was conducted by Kenneth M. Nagata, is attached to the EIS as Appendix B, and is summarized below.

The botanical survey revealed seven broad vegetation types: Scrub Grasslands; Koa Haole Thicket; Kiawe Forest; Coastal; Secondary Forest; Scrub and Native Forest and, Barren Lava with Ohia (Figure 9). In addition, many species observed alongside roads within the petition area are more common to typical roadside vegetation rather than to the specific vegetation type through which the roads traverse.

Much of the vegetation within the petition area consists of Scrub Grasslands dominated by fountain grass (Pennisetum setaceum) and Natal redtop (Rhynchelytrum repens). This vegetation type is characterized by open fields of grass, short stature shrubs of low to moderate density, and widely scattered trees 15 to 20 feet tall. Trees are more prevalent in the mauka than in the makai regions. Vast areas within this community type are nearly devoid of vegetation.

### 3. Impacts

The net result of the proposed planting of macadamia, koa haole, guinea grass, and as yet unspecified crops within the 200-acre research and development area should be one of replacing mostly exotic flora with other exotic vegetation. There should only be a brief period on any portion of the site when the soil retention values of the existing vegetative cover will be lost. By implementing the consulting botanist's recommendations to set aside the 20 acre preserve area, the only healthy rare and endangered trees found within the petition area would be preserved.

Manuka Natural Area Reserve (MNAR) is immediately south of the petition area. Concerns have been raised about the proposed planting of koa haole and guinea grass and their impact on the MNAR. To date, there is no known botanical survey that has been conducted in the Manuka Natural Area Reserve (MNAR). However, the area directly south of the petition area has been described in the Manuka Natural Area Reserve Management Plan - 1982 as follows: "From the coastline to about 4 miles mauka, the landscape is of barren lava fields with some grassland." Aerial infrared maps of the boundary between the MNAR and the petition area concurs with this description.

According to Nagata, koa haole is spread primarily by cattle and by man (through planting). Since the boundaries of the koa haole pasture area will be fenced, this would effectively prevent animals from straying into the MNAR and would halt the spread of koa haole attributable to cattle. The phasing of the koa haole pasture area will be in approximately 400 acre increments per year. Whenever a large enough portion of area is readied, aerial seeding will be conducted up to within 300 feet of the buffer to the MNAR. The boundaries of the planting area will be marked by flagman during seeding. The high density of koa haole seed will cause it to descend directly below the point of release from the plane. Because of the proposed fencing and the establishment of a buffer area, the chances of koa haole naturalization into the MNAR as a result of the proposed actions is anticipated to be equal to existing conditions. Guinea grass will be seeded by hand. While guinea grass seed can spread by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds. As noted in Appendix B, Guinea grass currently exists on site.

## I. Fauna

### 1. Existing Conditions

A biological reconnaissance of the petition area, which was conducted by Dr. Andrew J. Berger, is attached to the EIS as Appendix C, and is summarized as follows.

Berger states in his report that "Rarely during my field work in the Hawaiian Islands during the past 19 years have I seen such a poor habitat for birds and mammals as in the Kapua Farms petition area." While the

site may contain roosting sites of the Hawaiian (Hoary) bat Lasiurus cinereus semotus.[13], all of the remaining mammals found on the site are introduced species, and all of these are considered pests to man, his activities and products, and/or to native vegetation and fauna. Mammals presumed to inhabit the site include:

| Mammal | Scientific Name |
|---|---|
| Hawaiian Bat | Lasiurus cinereus semotus |
| Feral goat | Capra hircus |
| Feral pig | Sus scrofa |
| Domestic dog | Canis familiaris |
| Domestic cat | Felis catus |
| Indian mongoose | Herpestes auropunctatus |
| House mouse | Mus musculus |
| Polynesian rat | Rattus exulans |
| Norway rat | Rattus norvegicus |
| Roof rat | Rattus rattus |

Berger saw only two native birds, the Io and the Pueo, on or near the borders of the petition area. He sighted the Io at least one mile up slope from the upper boundary of the petition area. The Pueo was also seen, at an elevation of approximately 1,100 feet. Birds sighted during Berger's survey include:

| Introduced Bird | Scientific Name |
|---|---|
| Indian Black Francolin | Francolinus f. asiae |
| Spotted Dove | Streptopelia chinesis |
| Barred Dove | Geopelia striata |
| Skylark | Alauda arvensis |
| Japanese White-eye | Zosterops j. japonicus |
| Common Indian Myna | Acridotheres tristis |
| Warbling Silverbill | Lonchura malabarica cantans |
| Ricebird | Lonchura punctulata |
| Cardinal | Cardinalis cardinalis |
| House Finch | Carpodacus mexicanus frontalis |
| **Indigenous or Native Bird** | |
| Wandering Tattler | Heteroscelus incanus |
| Pacific Golden Plover | Pluvialis dominica fulva |
| **Endemic Bird** | |
| Hawaiian Hawk or Io | Buteo solitarius |
| Hawaiian Short-eared Owl or Pueo | Asio flammeus sandwichensis |

## 2. Proposed Action

Farms of Kapua, Ltd. plans to roll and seed the 2,472 acre koa haole pasture area, in increments of approximately 400 acres per year, over six years. The macadamia area would be graded and planted, in increments of approximately 500 acres per year, over three years. Therefore, the area cleared at any one year will represent only a portion of the total site. As soon as an area is cleared, it will be planted with the proposed agricultural crops.

## 3. Impacts

During site development, a portion of the existing vegetation will be removed, and it is anticipated that the mammals and birds (mostly introduced) which frequent the area being cleared will relocate to other areas on site. It is expected that these animals may return when the crops that are planted, mature enough to provide suitable food and shelter.

Berger states in his report that: "As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macadamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight."

It is the opinion of Berger that since the Io and the Pueo now forage over macadamia orchards, pasture land and other introduced vegetation on the Kona coast, the proposed action would have no adverse impact on these species.

# J. Historical/Archaeological Resources

## 1. Existing Conditions

An archaeological field reconnaissance was conducted by Dr. Paul H. Rosendahl from November 8 to 20, 1982, to verify the presence or absence of sites of archaeological interest, and in order to determine whether further study would be required prior to actual development of the project. The results of this survey, a historical documentary and an addendum report are attached to the EIS (Appendix D).

Survey coverage of the coastal portion of the project area included virtually 100% pedestrian coverage by an eight man team, of a zone extending inland from the shoreline to 1000 - 1500 feet inland, and from the northern boundary to the southern boundary of the petition area. Survey of the inland portion of the project area consisted of 100% coverage of selected discrete survey areas. The sampling strategy of the survey is described on page 6 of Rosendahl addendum report. These survey areas were selected so as to obtain representative samples of the project area in terms of both geographic distribution and environmental variation.

A total of 41 new sites (37 inland and 4 coastal) have been designated in addition to the 21 (3 inland and 18 coastal) previously recorded sites. In terms of overall distribution, sites and features tended to be more numerous in the northern portion of the project area, both coastal and inland parts.

The approximate inland limit of the northern coastal concentration of archaeological remains varies from 1,000 to 1,500 feet inland from the shoreline. Probably the greatest density and variety of archaeological remains were found in the northern coastal zone, which contained examples of virtually every type of site and feature, with the exception of definite agricultural features and the refuge cave. The best known feature in this area is the slide of the Ahole Holua Complex. This feature is regarded as one of the best preserved holua within the State.

In terms of both variety and density, fewer sites and features were identified in the various inland survey areas. Several kipukas containing concentrations of agricultural features were found. In several instances, the culturally utilized kipukas were physically linked to coastal habitation complexes by clearly defined foot trails.

Other inland sites contained intentionally modified and utilized caves which were included within different series of natural lava tube complexes that extended in generally mauka-makai orientations. Several of these caves contained structural modifications in the form of platforms, terraces, and walls, as well as probable cultural remains in the form of midden and artifacts.

The archaeological remains identified within the project area are distinguished by both their relatively good physical condition and their generally high integrity. With the exceptions of those in the inland cleared and grubbed areas, most of the sites and features appeared to have suffered little from modifications and/or damage subsequent to their original occupation and abandonment. The identified remains are evidence of both prehistoric and historic period occupation and utilization. A description of individual designated sites is included in the archaeological reconnaissance survey report (Appendix D).

It would appear that the level of information obtained from the reconnaissance survey is sufficient to provide a basis for defining the approximate inland limit of the coastal concentration of archaeological remains. This limit varies from 1,000 to 1,500 feet inland from the shoreline.

## 2. Proposed Action

Development of the proposed agricultural activities will involve soil disturbance of approximately 70 percent of the petition area. Roughly 425 acres of the northern coastal portion of the property is proposed to remain in Conservation in recognition of the concentration of archaeological sites located in that area (Figure 3).

### 3. Impacts

Since no construction or improvements, including roads, are proposed within the area to be left in the Conservation District, no direct impacts to archaeological sites in this area are expected.

The northern portion of the area designated for aquaculture has relatively more archaeological sites of significance, particularly within 1,500 feet of the shoreline. Specific siting of the aquaculture modules in not known at this time, however, information adequate for specific placement of facilities, with regard to the location of archaeological sites, as well as appropriate mitigation activities, would be available after the completion of intensive survey work that would be carried out prior to the specific placement of the modules. Careful placement of the aquaculture facilities, after the completion of an intensive survey, will preserve significant sites.

Specific facilities plans in regards to utilities would probably follow additional archaeological work in preliminary utility corridors chosen by the civil engineer. If any sites of significant archaeological value are found, then the archaeologist can make a recommendation in his cultural resources management plan whether preservation is necessary or if salvage excavation is appropriate. The final alignment of utility corridors would then be finalized. By following this process, there should be no adverse impacts to significant archaeological sites located near utility corridors. An archaeological survey of the corridor of the transmission lines from Okoe Well would be conducted after receiving the State's approval of use of the well.

Further archaeological reconnaissance survey will be conducted for any specific development areas within the petition area which were not covered in Rosendahl's earlier survey (1983). Upon completion of this latter task, intensive survey of significant sites identified would be conducted. The exact scope and scale of any further archaeological work in the petition area (intensive survey) will be worked out in consultation between the petitioner and the appropriate State and County representatives. Specific mitigation vs. preservation decisions will be made later, on the basis of intensive survey findings. It is likely that the decision will be made that some sites should undergo salvage excavation. This activity will result in the destruction of some of the sites, although this will be mitigated by the salvage study. These decisions are not required at this stage of the planning process (petition to amend the State Land Use boundary). If any unanticipated sites are encountered within the project area after the intensive level surveys are completed, the contractor will stop work and contact SHPO and the County Planning Department.

## K. Agriculture

### 1. Existing Conditions

The University of Hawaii Land Study Bureau, in its Detailed Land Classification - Island of Hawaii, 1965, rated the soils on the major

islands according to their productivity. Most of the soils on-site were given a master productivity rating of "E" (E259, E262, E287 and E319). The only agricultural activity that presently occurs on-site is occasional cattle grazing.

The Agricultural Lands of Importance to the State of Hawaii (ALISH) map which was jointly developed by the Soil Conservation Service, the University of Hawaii College of Tropical Agriculture and the State Departments of Agriculture, Planning and Economic Development, and Land and Natural Resources, has designated most of the site mauka of the 800 foot elevation as Other Important Agricultural Land. These are lands other than Prime or Unique Agricultural land that are also of statewide or local importance for agricultural uses. The lands makai of the 800 foot elevation were unclassified. It should be noted that the State Department of Agriculture has not prepared a map for approximately one-third of the petition area.

## 2. Proposed Action

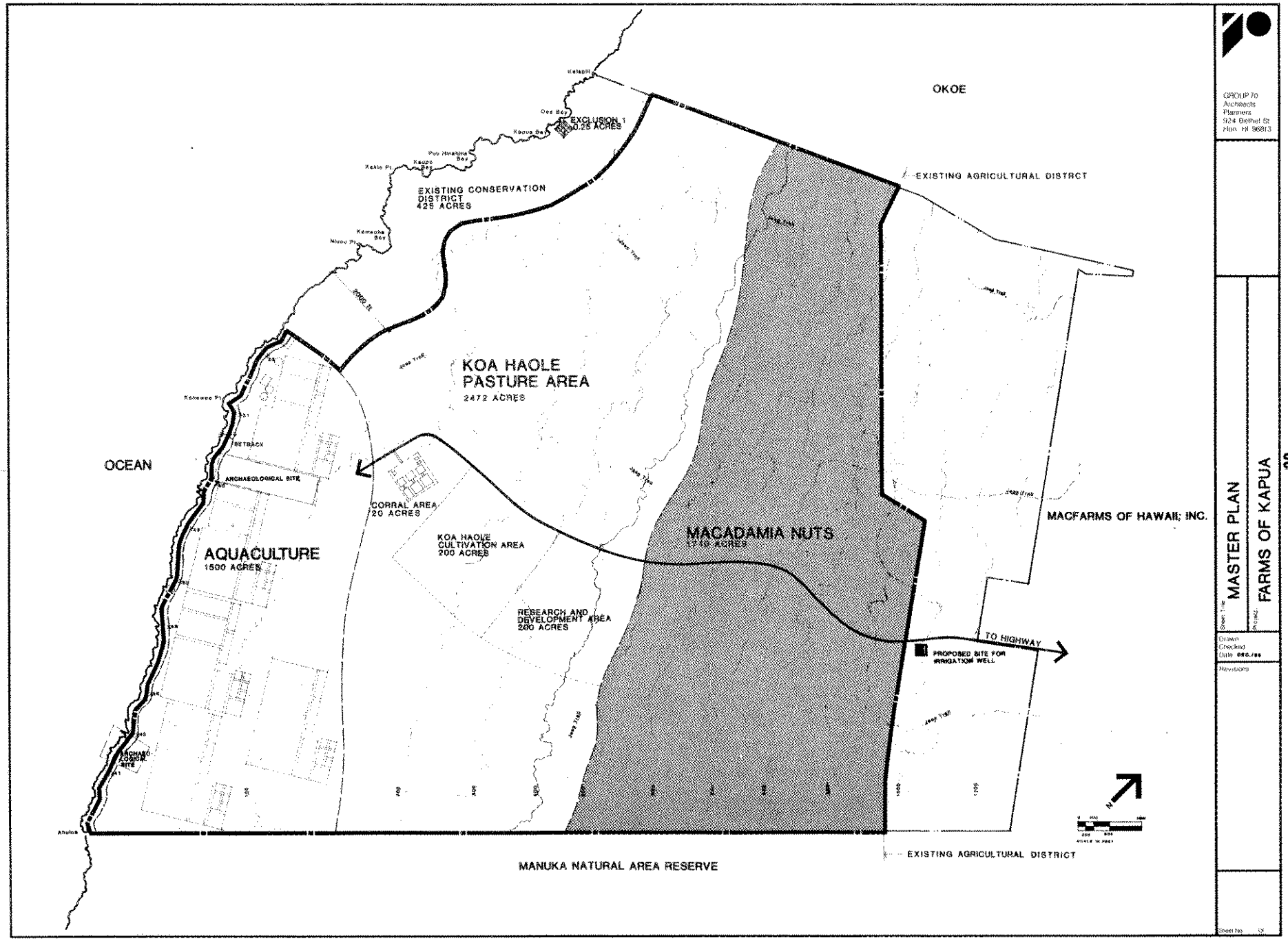
The proposed Farms of Kapua project will involve the multi-agricultural uses of the petition area, including: macadamia cultivation, pasture and cattle operations, and aquaculture.

Macadamia orchard (Figure 10): The agricultural feasibility of macadamia cultivation within the petition area was studied by Frank S. Scott, Jr. His findings are summarized below and is attached to the EIS (Appendix E).

Macadamia will be cultivated on approximately 1,710 acres of land, on the mauka portion of the parcel (Figure 10). Most of the macadamia area is covered with a'a lava (Figure 11). The areas with a'a lava can be used for macadamia production under appropriate culturing methods such as the addition of a planting medium and fertilizer to the planting holes. Soil or macadamia shells which have been composted will serve as the planting medium. These materials will be obtained from nearby farms. The next largest area is covered with Kaimu Series, which is well adapted to macadamia production. The Kaimu Series soil is interspersed with small islands of the Punaluu Series, which consists of rocky peat over pahoehoe, rough broken land and a'a with no soil covering. Most of the rough broken land to be used for macadamia cultivation can be leveled. Approximately equal in area covered by the Punaluu Series is pahoehoe lava. In order to improve drainage and root penetration in pahoehoe lava, bulldozer ripping is required. Whenever a large enough portion of area is readied, it will be planted.

A system of unpaved service roads will be developed, to facilitate the cultivation and harvesting of the crop.

Pasture and cattle operations: The development and management of the 2,472 acre koa haole pasture, the 200 acre koa haole cultivation and 20 acre feedlot areas has been studied by Harold F. Rice, Jr. His report is attached to this EIS (Appendix F) and summarized below.




# Proposed Macadamia Nuts Area

FIGURE 10

KEY:

| | |
|---|---|
| rKED | Kaimu Extremely Stony Peat |
| rPYD | Punaluu Extremely Rocky Peat |
| RB | Rough Broken Land |
| rLV | Lava Flows, A'a |
| rLW | Lava Flows, Pahoehoe |

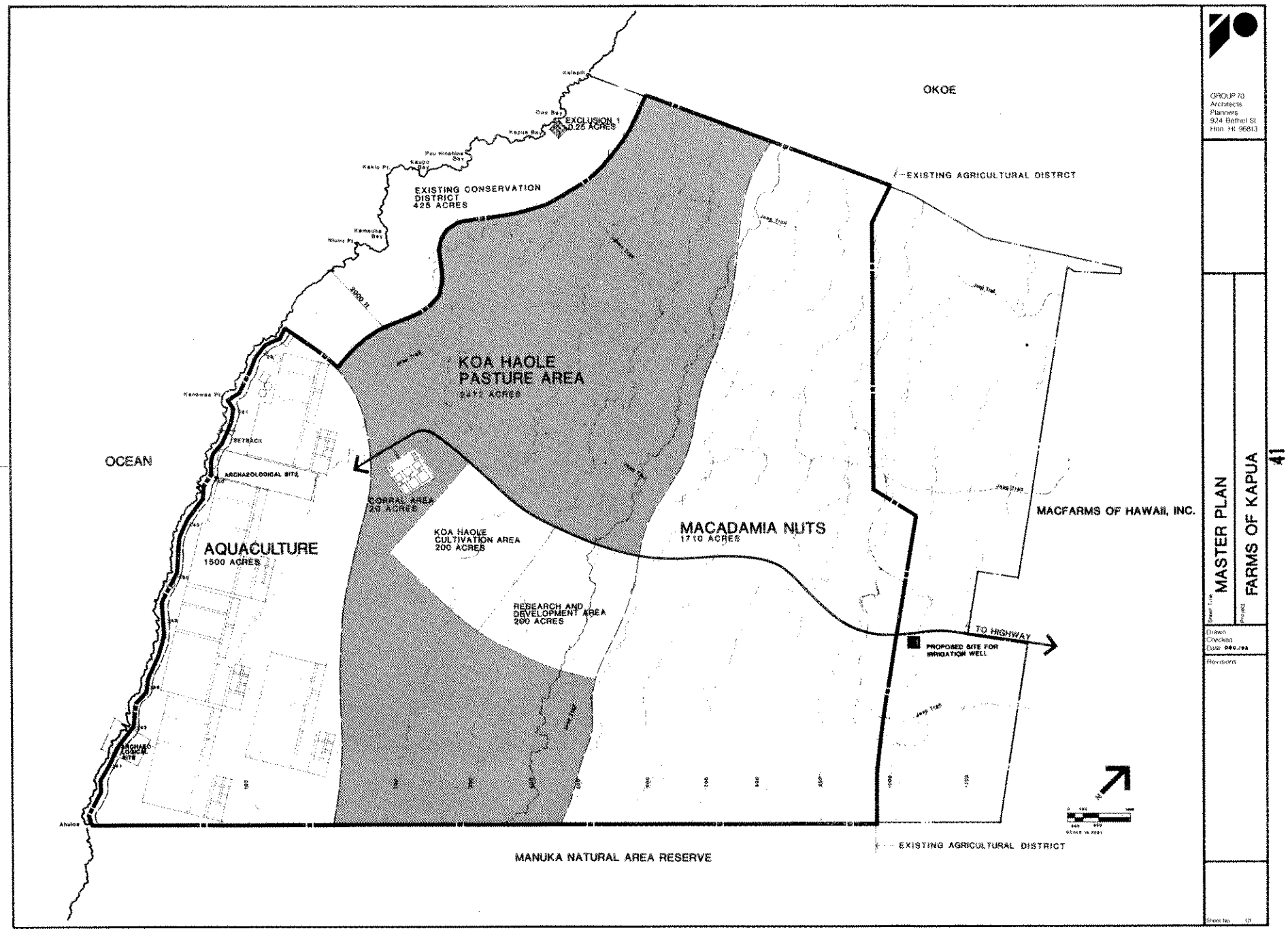
Based on Soil Survey of Island of Hawaii, State of Hawaii, USDA Soil Conservation Service

**FIGURE 11**

NORTH

- Master Plan
- Soil Survey Map
- Site Plan

GROUP 70
Architects
Planners
Interior Designers
924 Bethel St.
Honolulu 96813
PH(808)533 4445




# Proposed Koa Haole Pasture Area

FIGURE 12

Approximately 2,472 acres will be planted in koa haole and guinea grass to provide a balanced pasture grazing material for cattle (Figure 12). Most of this area is covered with a'a lava, with small islands of pahoehoe Figure 11). This area will be rough bladed and rolled, in increments of 400 acres per year, preserving any healthy trees for shade and organic matter buildup. One pass by a large tractor (D7 or larger) with the blade adjusted to skim the surface, pulling a heavy 10 ton or heavier roller should be adequate for this area.

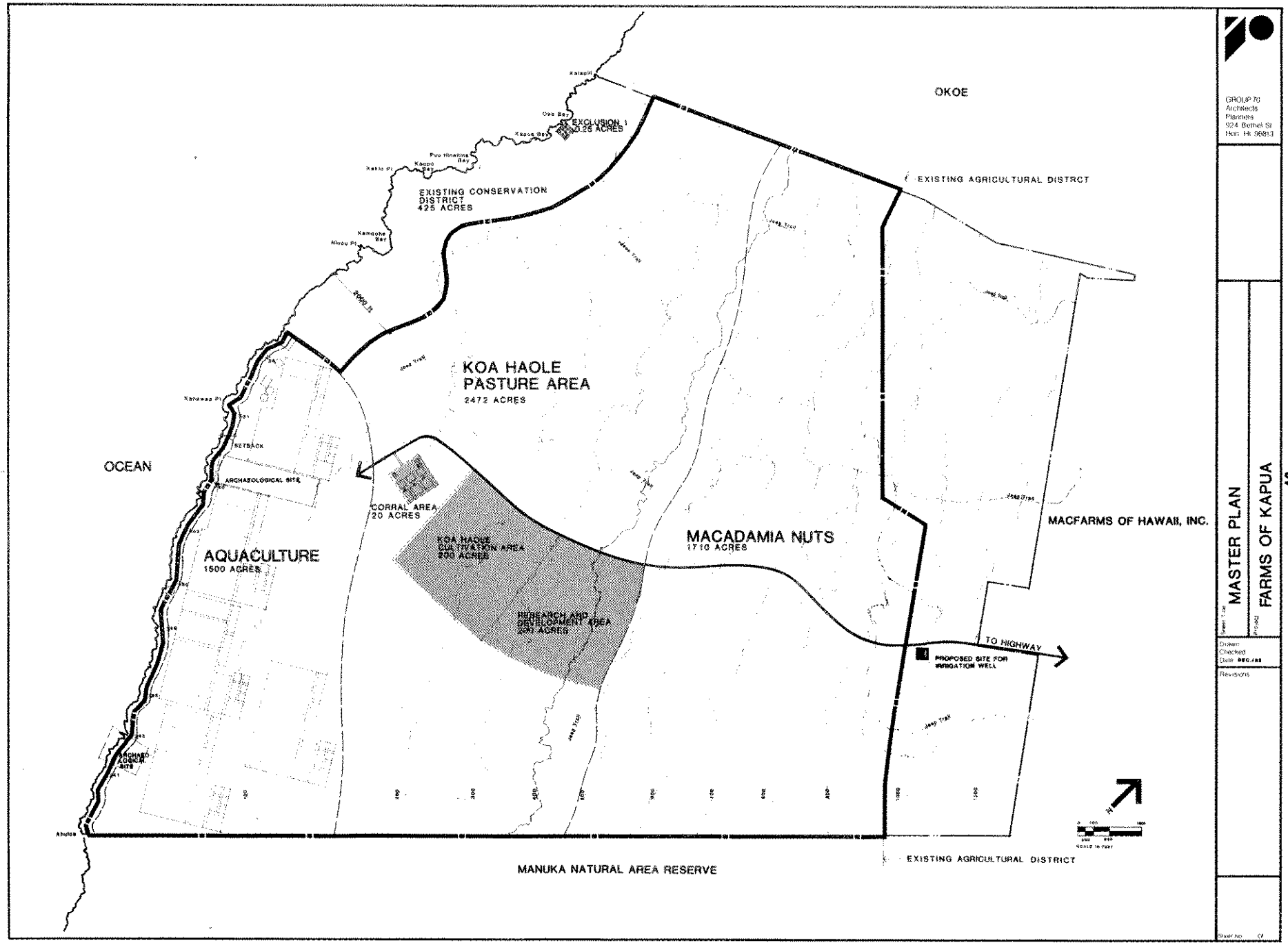
The pasture area will not be irrigated. Fences will be constructed to enable shifting the cattle from one area to another in order to allow unused pasture areas to regenerate.

A 200 acre section in the pasture and cattle operations area will be developed (after a source of water is developed) for the intensive cultivation of koa haole (Figure 13). The koa haole will be planted and irrigated in rows or hedges to allow mechanical forage harvesting. The koa haole will be used as green chop feed for cattle in the feedlot. Approximately half of the 200-acre koa haole cultivation area contains a'a lava, the other half, pahoehoe (Figure 11). This area will be bladed and rolled to a higher degree (requiring possibly 2 or more rollings) than the 2,472-acre koa haole pasture to allow easy access of irrigation equipment and uniform growth. No ripping or moving of material is required in this area.

Wean calves acquired from other ranches will be placed in the pastures of the unirrigated 2,472-acre koa haole area. The cattle would feed in the pastures until reaching weights of 700-800 lbs., at which time they would enter the 20 acre feedlot (Figure 13). The cattle would be in the feedlot for 90-120 days prior to marketing. As cattle are taken to the feedlot, replacement cattle for the unirrigated pastures would be purchased. In the event that a low rainfall period is encountered, the replacement of cattle would be delayed. Under normal weather conditions, once the entire area is developed, there would be approximately 600-700 weanlings on unirrigated pasture and 600-700 head in the feedlot. During drought conditions the cattle in the unirrigated pastures can be sold. The operation within the irrigated 200-acre koa haole cultivation area and feedlot are not affected by drought conditions and can continue to operate at full capacity.

Manure from the cattle in the feedlot will be used to supply some of the necessary nutrients to cultivate the Marine shrimp, the Brine shrimp and the Spirulina in the aquaculture facility.

Research and Development: Two-hundred (200) acres within the petition area will be set aside for research and development of alternative crops for (Figure 13). This area will be developed when an adequate source of water is developed. Possible crops to be investigated include aloe vera and crownflower. This area, which is almost completely covered with a'a lava (Figure 11) will require possibly 2 or more rollings. No ripping or moving of material is required.




# Corral, Koa Haole Cultivation, Research And Development Areas

FIGURE 13

Aquaculture (Figure 14): The potential for aquaculture development on the petition area has been studied by the Oceanic Institute. Their report is summarized below and is attached to the EIS (Appendix H).

The Oceanic Institute focused their study on economically feasible marine species because of the availability of brackish water on site. The species which have the primary potential for culture at the site are: Marine shrimp (Penaeus species), Mahimahi (Coryphaena), blue green algae (Spirulina), and Brine shrimp (Artemia). It should be noted that there is inherent flexibility in the choice of species to be cultivated in the aquaculture operations. Those species whose culture is possible because of the potential to append their culture to the cultivation of the primary species are: seaweeds, clams, mullet, baitfish and tilapia. Both the primary and secondary species were selected because they are complementary to one another, i.e. the tail water and waste products of one species can be used as nutrients for the other species. The proper assemblage of species provides the most efficient use of resources by taking advantage of free nutrient outputs (in the form of wastes).

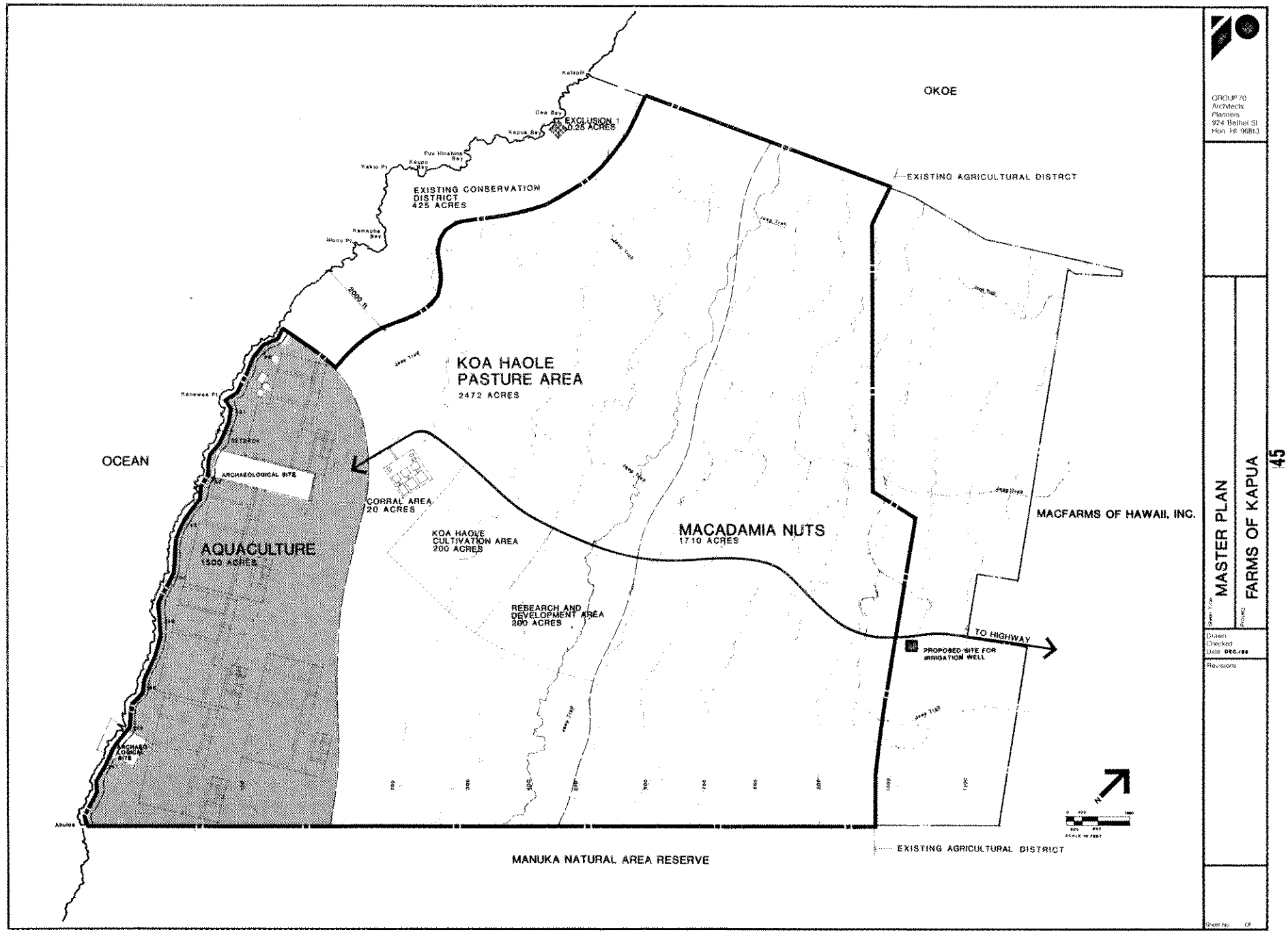
The aquaculture farms are to be developed in increments of approximately 200 acres (Figure 14). Each 200 acre increment will contain all of the various marine "crops" which will be used to sustain one another. The proposed aquaculture farms are to be integrated, providing opportunities for the sharing of costs of administrative offices, vehicles, technical skills, laboratory space, larval feed production, pumps, generators and security, among the various facilities (for each species).

Instead of developing a brackish water well and distribution system for each species, it is proposed that a central well and water pumping system be established. A well will be installed in this portion of the site to pump brackish water from the ground into a reservoir and into the various ponds and raceways, via a 3 foot wide by 2 foot deep open canal.

The Oceanic Institute has developed a comparison of costs between non-integrated and integrated systems. Integration has allowed reductions in construction from $8,549,000 to $8,029,800; in annual production costs of $3,083,450 to $2,275,875 while the total value of all production is $3,440,087. The overall return on production costs is 1.51.

The final effluent from the aquaculture facilities will be collected in open, unlined channels that will serve as culture troughs for seaweed, which will remove the water of most nutrients before it percolates into the underlying lava. The seaweed will purify the tailwater and will be harvested and used as feed for the Brine shrimp. It will also be harvested and sold for a variety of industrial and food uses.

Most of the aquaculture area is covered with pahoehoe lava (Figure 11). Aquaculture activities within each of the five 200 acre modules, including the brackish water system, will occupy 160 acres. Rough grading and excavation will occur within the 160 acre areas. An additional 40 acres is alloted for roads (not all of this will be used).




# Proposed Aquaculture Area

FIGURE 14

## 3. Impacts

The major impact of the proposed State Land Use Boundary amendment is increasing the agricultural potential of the petition area. Although the soils on site are not generally suited for most of the crops considered by the Land Study Bureau, the advantages of the site to macadamia are: the even distribution of rainfall throughout the year, making serious droughts rare in the Kapua region; the moderate temperatures; and, the location which is sheltered from the northeast tradewinds. The petition area is also considered ideal for aquaculture because of its long southern exposure, the large area available, the availability of brackish water on site and its location in the lee of Mauna Loa which shelters the site from the northeast tradewinds. In addition, as noted in Appendix F, there are areas in West Hawaii, at similar elevations, with similar rainfall and soils, which are vegetated with koa haole and are used for grazing. The proposed agricultural activities do not require soils of high productivity rating (ALISH and Land Study Bureau). Therefore, while the petition area may not have been previously considered adaptable for productive agricultural use (other than light grazing), approval of the petition would expand the agricultural potentials of the land.

Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation area and 200 acre research and development area. As described in the Soil Survey of Island of Hawaii, State of Hawaii, U.S.D.A. Soil Conservation Service, most of these soils have been characterized as having slow runoff. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of surface runoff. Therefore, it is unlikely that there will be any soil erosion from irrigation runoff.

No pesticide use is proposed within the petition area. The application of herbicides is proposed only in the macadamia area. Herbicide use is not being proposed in the 2,472 koa haole pasture area or in the 200 acre koa haole cultivation area. Although it is not anticipated at this time, the application of these materials may be used in the 200 acre research and development area. As previously described, the porous characteristic of the ground precludes the occurrence of surface runoff. The only other means of direct contact with ocean resources is by air. While herbicides can be carried by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds. Since these materials would be applied during non-windy days, it is unlikely that these materials would impact ocean resources. While the effect of the use of these materials on groundwater resources, within the petition area, are unknown, water from the proposed irrigation wells can be tested for these substances on a regular basis.

The impacts of the proposed cultivation of koa haole and guinea grass were addressed in section H. Vegetation.

Final waste water from the aquaculture system will be returned to the soil via infiltration ditches rather than via dispersion wells. The brackish water will be collected in a culture trough for seaweed which will remove any contaminants before the water infiltrates into the underlying lava. The ditch will be located below the 40 foot elevation, where infiltration of the brackish water will not have any adverse impacts to potable water sources.

The various proposed agricultural activities will, on occasion, require the use of trucks to transport supplies and harvested crops. It is expected that these trucks will schedule their trips to off-peak hours.

## L. Socio-Economic Characteristics

### 1. Existing Conditions

The 1980 population for North and South Kona was 19,662. This amounts to an increase of approximately 11,000 over the 1970 count, or a doubling of the population in 10 years. This rapid growth rate has not been matched in Kona over the last 80 years.[14]

The area of South Kona stretches from its northern boundary of Captain Cook to its southern boundary at the north side of Manuka Bay. It covers approximately 229 square miles or 146,560 acres. The population of the South Kona district decreased by 6.7% between 1960 and 1970; and increased by 47.7% between 1970 and 1980 to 5,914 people.[15]

According to the State of Hawaii Data Book 1983, roughly half of the population in South Kona resides in Captain Cook and Kealakekua, and the rest of the residents are scattered throughout the district.[16] At present, no one resides at the site.

Up until recent times, agriculture was the principal economic activity in the Kona area. In 1950, 1,258 workers were employed in some form of agricultural endeavor. Total employment in that year was 2,420 workers which supported a population of 7,330 persons. In 1960, 1,449 out of 3,859 workers were employed in agriculture, with a resident population of 8,743. During this latter period only 291 persons were employed in hotels.[17]

By 1970, the relative roles of the visitor industry and agriculture were completely reversed. The 1970 census reported that 333 workers were employed in agriculture and 659 persons were employed in the personal service sector, which includes hotel employment. Similarly, there were significant increases in employment in other visitor industry related fields such as retail, construction and transportation. Agricultural activity in Kona, though reduced, continues to play a role in Kona's economy, and contributes to the lifestyle and atmosphere of the communities. The Department of Labor and Industrial Relations, State of Hawaii gives the average unemployment rate for the South Kona District (Census Tract 213.00) in 1983 at 7.9%, or an average of 150 persons unemployed.[18]

The subject property, in its present state, does not provide any employment opportunities. Small areas of the petition area are visible from Mamalahoa Highway only intermittently. Its primary scenic value to the public is from boats offshore and from those travelling along the shoreline.

## 2. Proposed Action

The project involves the proposed multi-agricultural use of the site, including the development of: a macadamia orchard, a pasture and cattle operation and aquaculture facilities.

## 3. Impacts

Implementation of the proposed actions will expand the agricultural and economic value of the site and will have a positive impact on the State's goals (Hawaii State Plan) for economic growth and diversification. Sub-section 10 (a) specifically states: "Planning for the State's economy with regard to potential growth activities shall be directed towards achievement of the objective of development and expansion of potential growth activities that serve to increase and diversify Hawaii's economic base." In addition, sub-section 20 (b) states: "To achieve the potential growth activity objective, it shall be the policy of this State to: (2) encourage investment in economic activities that have the potential for growth, such as diversified agriculture, aquaculture . . ."

There will be a positive impact on the fiscal resources of the County of Hawaii if the proposed multi-agricultural use of the site is implemented. Macadamia nuts, an export product with proven success, will add to the export base of Hawaii County. In his report, Dr. Scott states that "It [macadamia] is an intensive crop which would provide an internal rate of return of 20.0 percent after land cost", and it is "one of the few crops for which the market is not a primary limiting factor." The proposed macadamia orchard "would have a reasonably good assurance of being able to market the output of macadamias from the estimated 2,000 to 4,000 acres which are ecologically adaptable to macadamia orchards." Dr. Scott has estimated that by 1990, approximately 26,000 acres would be required to supply the U.S. and Hawaii markets, plus an additional 21,000 acres for the rest of the world. Foreign plantings are minimal at present, but may pose serious competition to Hawaii in 20 years. "Planting at an early date would enhance the opportunity of Farms of Kapua to develop markets for macadamia products prior to serious competition from potential domestic and foreign producers".

As noted in Appendix G, over the years Hawaii's in-state production of beef has declined under pressure from mainland and New Zealand/Australian beef imports. In 1971 46% of the beef consumed in the state was produced in Hawaii. By 1981, only 30% of the beef consumed here was produced locally. The cattle produced on site are expected to contribute to an industry which has struggled for the last few years.

The viability of the pasture operation in this case does not rest entirely on the marketability of beef. The cattle will also provide the bulk of nutrients (in the way of manure) for Marine shrimp (Penaeus vannamei), Brine shrimp (Artemia) and Spirulina in one of the aquaculture modules and possibly supplement a few of the others. These species were specifically selected because they could be sustained by manure. Therefore, the pasture operation has a direct effect on at least one of the proposed aquaculture operations by significantly reducing the amount of manufactured feeds which must be imported from the mainland or Asia.

When the aquaculture facilities are operating, they will contribute fresh seafood products to Hawaii County's export base. It is expected the crops from the proposed aquaculture modules will be marketed on Oahu or on the mainland. It is unlikely that these products will compete with catch marketed by the fishermen of Milolii. In addition, the knowledge gained from establishing and running the facilities will add to the body of information needed to support and encourage aquaculture as an industry in Hawaii.

Long-term, direct on-site employment will be generated by the operation of the macadamia orchard, the pasture and cattle operations and the aquaculture facilities. The project will probably generate permanent employment for approximately 160 individuals which will bolster the waning employment in the Kona district in agricultural occupations. Job titles for the macadamia orchard and aquaculture area are found in their respective reports. It is expected that most of those hired for the proposed multi-agricultural activities will be from neighboring areas. The County of Hawaii Department of Research and Development states that: "The Farms of Kapua project would increase employment opportunities in South Kona, and thus provide some relief from the district's unemployment situation."[19] The hiring of South Kona residents will serve to minimize the impact of employees on off-site facilities, such as housing and schools.

At completion, the proposed development could be expected to generate greater property tax revenues per acre than are currently assessed. Additional revenues to the County will also be generated in the form of licenses, permits and other fees. County expenditures for facilities and services, on the other hand, are not anticipated to increase appreciably as a result of the development. The proposed project will provide all the basic infrastructure, such as the water and roadway systems, and will be maintained by the owners.

The proposed agricultural use of the site will not differ from the predominantly rural and agricultural lifestyle of the district. While the proposed action will intensify the use of the presently vacant lot, the proposed multi-agricultural uses will maintain the open space values of the site.

## M. Recreational Resources

### 1. Existing Conditions

According to the Guidelines and Standards for Public Access to the Shoreline, County of Hawaii, Planning Department, August 1981, there are 40.3 miles of shoreline in the Kona district, with 5 improved accesses and 59 trails and paths. The shoreline from Kalapili, just south of Okoe Bay, to Niuou Coconut Grove (Figure 6) can be reached by an ancient trail that parallels the shoreline from Honomalino Bay.[20] The Okoe Bay region can also be reached by an ancient trail from Highway 11 (Figure 6). Both of these trails cross private and State lands.

At Okoe Bay, there is an existing kiawe grove which is used for camping and picnicking. Swimming, shore fishing, throw-netting, gill-netting and snorkeling are occasional uses of Okoe Bay. Miloli'i bottom fishermen and trollers frequent the waters off this portion of the shoreline. Okoe Bay is an especially valuable refuge for boaters due to the scarcity of semi-protected embayments on the South Kona coast.

There is a jeep trail from the mauka portion of the property which extends to O'e'a Bay. Existing uses of the shoreline in this stretch include limu collecting from a few sites in the Kakio Point area. Limu eli'eli is collected on the shoreline between Kaupo and Pu'u Hinahina bays and nori is collected in the winter on the coastline between Kaupo and Niuou Coconut Grove (Figure 6).

The shoreline from Niuou Coconut Grove to Ahuloa (Figure 6) receives moderate to low use for limu picking, and most fishermen reach this area by boat. The Ahuloa area can also be reached from an ancient trail from Kealakekua, which is located approximately 3 1/2 miles south of the petition area. Diving in this stretch is considered exceptional and the area is suitable for nori picking in the winter.[21]

County parks and recreational facilities in the South Kona district, include: Hookena beach park; Milolii beach park (with facilities for camping, swimming, picnicking and fishing); Napoopoo beach park; Greenwell Park (lighted ballfield, community center, tennis and basketball/volleyball courts); lighted basketball and volleyball courts at Hookena School; Yano Memorial Community Center; Honaunau Boat Ramp; Honaunau Rodeo Arena; and Kona Swimming Pool.

The closest State facilities are: South Kona Forest Reserve (with a few hiking trails), Manuka State Park (with pavilions, restrooms, drinking water, picnic area and hiking trails); Kealakekua Bay State Underwater park; and, Hikiau Heiau Historic Site (with restrooms, drinking water and picnic area).

The City of Refuge National Historical Park (interpretive trails, fishing, swimming, snorkeling, diving, and picnicking) is the only federal facility in the South Kona district. The nearest large beach north of the petition area is Kalahiki Beach and the nearest large beach south, Green Sands Beach, near South Point.

2. Proposed Action

No actions are proposed along the shore and within the offshore waters. From 300 feet to 1/2 mile inland will be kept in Conservation (Figure 3).

3. Impacts

The petitioner will generally maintain the present means of public access to the shoreline: from mauka portions of the site by permission only; and, unobstructed lateral access from the shoreline north and south of the petition area. Those obtaining permission from the owners for access from the highway will be allowed to use the road which will extend to the aquaculture facility and the unpaved jeep road which continues through the aquaculture area to the coastline. In addition, the area contained within the 2,000 foot setback contains the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a.

Offshore recreational resources will not be directly affected by the project.

## N. Infrastructure

The civil engineering considerations of the proposed project were investigated by R.M. Towill. Their report is attached to this EIS (Appendix I) and is summarized in this section.

1. Water Distribution

a. Existing Conditions

The Hawaii County Department of Water Supply's South Kona System does not extend to the petition area.

b. Proposed Action

Potable water for the employees of the various facilities will be trucked in.

Irrigation wells will be drilled within the macadamia orchard area between the 800 - 1000' elevation. Transmission lines will be laid from the wells alongside the roadway down to the feedlot. The water transmission lines will be 12-inch PVC pipe. If permission is granted for the use of Okoe well, approximately 13,000 linear feet of transmission lines, and a pump and controls will need to be installed in order to bring water from the well to a mixing point within the petition area. It may also be possible to use the water from Okoe well, unmixed, for the irrigation of the 200 acre koa haole cultivation area and for cattle consumption.

The aquaculture facility requires 6 MGD of brackish water. A central pumping facility will be built to pump brackish water from the ground into a reservoir and into the various ponds and raceways. The irrigation and aquaculture systems will not cross-connect. In the event that an irrigation well is used as potable water supply, a separate distribution system would be installed.

c. Impacts

Installation of water transmission lines is not expected to have any negative impacts on the petition area, as the pipes will all be laid above ground, except at road crossings, where they will be buried. The effects of soil disturbance are described in section D. Soils. The proposed project will not be dependent on the County water system.

## 2. Sewage Disposal

a. Existing Conditions

There is presently no municipal sewage system which serves the South Kona district south of Kailua-Kona.[22] Residential units in the district rely primarily on cesspools for the disposal of sewage.

b. Proposed Action

Several cesspools will be constructed for sewage generated by employees of the aquaculture operation and the feelot. The cesspools will be typical of domestic cesspools used throughout the state and will be lined, should geologic conditions require it.

c. Impacts

The proposed project will not be dependent on County facilities for sewage disposal. A preliminary review of Chapter 57 of the State of Hawaii Public Health Regulations (Title 11, Department of Health, Chapter 57, Private Wastewater Treatment Works and Individual Wastewater Systems) by R.M. Towill Corporation indicates that cesspools are allowable for the project, provided that they are constructed in accordance with the regulations. The extremely low population of the petition area and the high permeability of the soil in the area present ideal conditions for cesspool use.

It is expected that one cesspool will adequately serve the domestic requirements of each aquaculture module. This is equal to 5 cesspools within 1500 acres. Cesspools will be located as per the spacing requirements specified in Chapter 57. The cesspools at the aquaculture farms will be sited a minimum of 300 feet from the shoreline and approximately 2,000 feet from each other. Approval of the proposed cesspools must be granted by the State Department of Health and the County of Hawaii Department of Public Works. Any effects of leaching from the proposed cesspools on the nutrient

levels in coastal waters will be mitigated through the strict observation of the Department of Health regulations on cesspools. In addition, irrigation wells on site will be monitored for any increases in nutrient or coliform levels.

Final waste water from the aquaculture system will be returned to the soil via infiltration ditches rather than via dispersion wells. The wastewater produced from the aquaculture modules is basically brackish water that has been cycled through the production units holding the various species. The wastes from one species is used as nutrients by the following species and in this way the water is filtered. The final wastewater contains no human contamination and consists basically of some remaining fecal matter from marine organisms, excess feed, and some algal and plant matter. The wastewater will be collected in a culture trough for seaweed, which will remove nutrients from the water before it infiltrates into the underlying lava. The culture troughs will be located above the 40 foot elevation, and a minimum of 300 feet from the shoreline. To ensure crop success and environmental quality, dry-run operations will be conducted before full-scale production is started. Constant monitoring of the quality of the water flowing throughout the aquaculture system should mitigate the pollution problems usually associated with wastewater disposal.

## 3. Solid Waste Disposal

### a. Existing Conditions

The County of Hawaii does not provide solid waste collection services in the area surrounding the petition area. However, refuse can be disposed of at a transfer station which is located in Miloli'i. There are also existing landfills in Ka'u and Kona, and the County is planning the construction of a new landfill in Kona.[23]

### b. Proposed Action

A private solid waste collection service will be used by the agricultural facilities.

### c. Impacts

The proposed project will not be dependent on County facilities for the collection of solid waste.

## 4. Drainage

### a. Existing Conditions

There is no drainage infrastructure on the petition area. Rapid natural drainage occurs due to the highly porous condition of the ground.

b. Proposed Action

The low rainfall and porous ground will negate the need for construction of a major drainage facilities (catch basins and drain lines).

## 5. Traffic and Roads

a. Existing Conditions

Access to the site is from Mamalahoa Highway, Route 19. Mamalahoa Highway is a two-lane, two-way highway and is the only major arterial serving the project area. From the highway there are two unimproved dirt roads which provide access to the interior of the site. From these roads extend several jeep roads.

The nearest stations where the State Department of Transportation conducts an occasional traffic count is located at the intersection of Mamalahoa Highway and Milolii Village Access Road (Station 5C) and the intersection of Mamalahoa Highway and South Point Road (Station 5B).[24]

Traffic on Mamalahoa Highway is very light in South Hawaii. Traffic counts taken at Station 5B by the State Highways Division on 31 March 1982 show that the 24 hour traffic count in the vicinity of the intersection at South Point Road is approximately 1187 vpd; AM peak hour traffic is 114 vph in both directions; and PM peak hour traffic is 139 vph in both directions.[25]

Traffic counts taken at Station 5C by the State Highways Division on 1 April 1982 show that 24-hour traffic count in the vicinity of the intersection at Milolii Village Access Road is approximately 906 vpd; AM peak hour traffic is 98 vph in both directions; and PM peak hour traffic is 73 vph in both directions.[26]

b. Proposed Action

A 60 ft. right-of-way with 20' pavement is proposed for construction from the mauka portions of the property to the aquaculture facility. The roadways through the aquaculture area and the macadamia orchard will be surfaced with crushed rock. The roadway system will be private, i.e. maintained by the Farms of Kapua.

c. Impacts

Approximately 160 workers will be commuting to the site. In addition to employee trips, trucks transporting macadamia nuts during harvest season, supplies, and, occasionally, cattle, will add to the traffic on the highway. It is expected that these trucks will schedule their trips to off-peak hours.

There is ample capacity on Mamalahoa Highway to assimilate the additional traffic expected from the area. Typically, under ideal conditions, a two-lane road such as Mamalahoa Highway can accommodate an hourly volume of 2,000 vehicles in both directions. At present, the peak hour traffic on the highway in the Kapua area is only 114 to 139 vph in both directions.

It is not expected that street improvements such as traffic lights and turning lanes on the highway will be needed to support the proposed project. Construction and maintenance of the proposed on-site roadway system will not require County funds or services.

### 6. Power and Telephone

#### a. Existing Conditions

Presently, commercial electrical power and telephone service are not available on site.

#### b. Proposed Action

Electrical and telephone lines will be extended from the existing lines running along Mamalahoa Highway to the petition area. The lines will be placed either alongside an existing roadway or within a power easement.

Within the petition area, the overhead lines will be supported by wooden utility poles spaced 230 to 250 feet apart. Installation of the poles will require the excavation of holes 7 to 7 1/2 feet deep, spaced 230 to 250 feet apart. The petitioner will construct an electrical substation, at his expense, for Hawaii Electric Light Company (HELCo), in order to provide power to the site.

#### c. Impacts

The excavation of the holes for the utility poles will result in temporarily exposing soils. The effects of soil disturbance are described in section D. Soils. After installation, utility poles and lines running mauka-makai would be visible from the boats offshore and from those travelling along the shoreline.

## O. Public Services

### 1. Protective Services

#### a. Existing Conditions

A police station, a three truck, 24-hour fire station, and an ambulance is located at the Captain Cook civic center complex. Captain Cook is located approximately 20 miles away from the petition

area. Under ideal conditions, the estimated response time to the site is 30 minutes.[27] In addition, the nearest hospital of the Hawaii County Hospital System, Kona Hospital, is located in Kealakekua.

b. Proposed Action

It is proposed that the site, which is currently vacant and unused, will be developed for a variety of agricultural uses.

c. Impacts

The property and lives associated with the macadamia orchard, cattle pasture area and aquaculture program may occasionally require protective services.

## 2. Schools

a. Existing Conditions

Students in the area surrounding the petition area within the South Kona Judicial District attend Hookena elementary/intermediate school, in Captain Cook.[28] The school provides education from kindergarten to the 8th grade. The enrollment in school year 1979-1980 was 280.

Konawaena Intermediate/High School in Kealakekua provides instruction for grades 7 thru 12.[29] In school year 1979-1980, the number of pupils was 1,242. There is a private elementary/intermediate school in Kealakekua: Kona Adventist School, and a private elementary /intermediate /high school in Kamuela: Hawaii Preparatory Academy. A campus of the University of Hawaii is located in Hilo. In addition, a regional library is located in Kealakekua.

b. Proposed Action

The proposed multi-agricultural use of the site is expected to generate employment for approximately 160 people.

c. Impacts

The children of employees of the project are not expected to adversely impact the schools of the area, since most of the employees are expected to be drawn from nearby areas. Since the nearest school is located several miles away, any noise generated during construction of the project should not affect school activites.

## PART IV: ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED AND MITIGATION MEASURES PROPOSED TO MINIMIZE IMPACT

This section summarizes any adverse and unavoidable impacts described in PART III. In addition, this section provides a description of any mitigation measures included in the proposed project that would reduce significant, unavoidable and adverse impacts to insignificant levels.

### A. Dust Generation

#### 1.0 Adverse Effect

Clearing and grubbing activities during construction will temporarily disturb the soil retention values of the existing vegetation, and expose the soils to erosional forces. Heavy construction equipment traffic along unpaved roads will also generate small dust particles. Soil will also be exposed during the excavation of holes for the utility poles. Although some fugitive dust will unavoidably be generated during construction, winds in the area are generally light.

During the proposed agricultural operations, some dust will be generated by vehicles traveling over unimproved agricultural roads. However, the amount of traffic generated by the proposed activities will be relatively light.

#### 2.0 Mitigation Measures

It is planned that the macadamia orchard will be developed in increments of approximately 500 acres per year. The 2,472 acre koa haole pasture will be developed in increments of approximately 400 acres per year. As soon as the irrigation wells are developed, the 200 acre koa haole cultivation area and the 200 acre research and development area will be developed as soon as the proposed irrigation wells are in operation. Compliance with Chapter 10 of the Hawaii County Code during grubbing and grading activities will mitigate soil erosion. As soon as an adequate area is cleared and grubbed, it will be planted. Once construction is completed, the planted crops will assume the soil retention value of the existing vegetation.

### B. Water Consumption

#### 1.0 Adverse Effect

Water use for the proposed uses is projected at 4,100,000 gallons per day. While some of the water used for the irrigation of the crops may percolate back into the aquifer, most of the water is irretrievable.

However, the sustainable yield of the area is estimated to be 6.0 to 7.0 MGD, this is more than adequate for the water requirements of the proposed project.

2.0 Mitigation Measures

As a precaution, the proposed irrigation wells will be monitored for chloride. An increase in the chloride level will be indicative of salt water intrusion and appropriate action (such as reducing or halting pumping) can be taken should this situation arise.

## C. Vegetation Removal

1.0 Adverse Effect

Most of the vegetation on site will be removed during the proposed clearing and grubbing activities. There will be a brief period when the soil retention values of existing vegetative cover will be unavoidably lost. The potential for soil erosion from wind is greater than from rain. However, as noted elsewhere, winds in the area are characterized as light and variable. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of soil erosion by surface runoff. Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation area and 200 acre research and development area. The proposed irrigation of the above mentioned areas will not cause soil erosion because the proposed crops will retain the soils.

When an area is cleared, it is anticipated that the mostly introduced fauna which frequent the area will relocate to nearby areas with cover.

2.0 Mitigation Measure

As mentioned in A. Dust Generation, the development of the project will occur in phased increments. The period during which a phased area lacks cover, and is exposed to soil erosion should be brief since most of it will be replanted with various proposed agricultural crops. The planted crops will assume the soil retention value of the removed vegetation.

It is expected that any mammals and birds (most of which are exotic, and/or adapted to agricultural lands) which were previously displaced will return when the crops are mature enough to provide suitable food and shelter.

## D. Looting and Vandalism of Archaeological Resources

1.0 Adverse Effect

With the identification and inventory of sites, there may be an increased possibility of looting and/or vandalism.

## 2.0 Mitigation Measure

A program for the monitoring of significant sites is proposed to mitigate the above adverse impact. The program would be included in a archaeological/historical resource management plan. This latter management plan would be developed after further archaeological reconnaissance surveys are conducted for any specific development areas which were not covered in Rosendahl's earlier survey (1983). These additional reconnaissance surveys would designate significant sites that would be intensively surveyed. The exact scope and scale of further archaeological work in the petition area (intensive survey) would be worked out in consultation between the petitioner and the appropriate State and County representatives. Specific mitigation vs. preservation decisions, and the development of a monitoring program will be made, on the basis of intensive survey findings.

It should be noted that the proposed agricultural activities will involve the employment of approximately 160 people on-site, who will provide a form of informal surveillance or monitoring of the area. Also, because of the control of mauka-makai access (by permission only), the existing means of access serves to control accessibility to identified sites.

# E. Demand on County Protective Services

## 1.0 Adverse Effect

There will be an unavoidable demand on County services for police, emergency and fire protection.

## 2.0 Mitigation Measures

Due to the distance from the nearest County of Hawaii Fire Department facility, fire fighting measures will be provided on site. A fire plan for the petition area will be developed in cooperation with the Fire Department. It is likely that employees of the Farms of Kapua will be trained and certified by the Fire Department, to protect the property on the petition area and to provide first aid.

## PART V: ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The construction and operation of the proposed project would involve the irretrievable commitment of certain natural and fiscal resources. Major resource commitments include land, money, construction materials, manpower and energy. The impacts of using these resources should, however, be weighed against the economic benefits to the residents of the County and State, and the consequences resulting from taking no action (PART VII, ALTERNATIVES TO THE PROPOSED ACTION).

Since only agricultural use is proposed for the site, the proposed action will keep the site in open space and will not represent a permanent, irreversible or irretrievable commitment of land.

The commitment of resources required to accomplish the project includes labor and materials, which are mostly unrenewable and irretrievable. Benefits will accrue to the State's agricultural industry. The operation of the project will also include the consumption of potable water and petroleum-generated electricity which also represents the irretrievable commitment of resources.

The loss of archaeological resources would be irreversible and irretrievable, if any significant sites were adversely impacted (beyond salvage study). Although no impacts to significant sites are expected during construction activities, there may be indirect impacts from looting and/or vandalism. The loss of these features would have an adverse effect on present and future generations to study the history and cultural significance of the region.

## PART VI: THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

Inherent in any intensification of land use is the trade-off between short-term gains at the expense of long-term losses and vice-versa. The implementation of this project is no exception.

The major short-term gain of the proposed action is the expansion of the State's Agricultural Land Use District boundaries. This gain would be at the expense of an equal loss of Conservation District lands. However, as previously noted in the examination of State Land Use Commission District Regulations, Standards for Determining District Boundaries (PART VIII), retaining the petition area in Conservation may represent a long-term loss, by narrowing the range of beneficial uses of the site. Prior to the State Land Use District designations, the use of the land was agricultural.

The major long-term gain of the proposed action is the broadening of the range of beneficial uses of the site (multi-agricultural uses) at the expense of the adverse and unavoidable effects outlined in PART IV.

A long-term loss would be experienced if any significant archaeological sites are looted and/or vandalized. This would hinder the ability of present and future generations to study the history and cultural significance of the region.

Approval of the petition will not foreclose future options in the manner that urban development would, as none of the proposed actions involve the committment of the site for the life of any structures. The proposed multi-agricultural uses would not alter the open space value of the site. In addition, the proposed action poses no long-term risks to health or safety.

## PART VII: ALTERNATIVES TO THE PROPOSED ACTION

### A. No Action Alternative

The no action alternative would be to retain the site in its present vacant condition. Present uses of the site include occasional grazing and fishing. No development would preclude most of the adverse and unavoidable environmental effects summarized in PART IV, although implementation of this alternative may present an adverse effect on significant archaeological sites. Archaeological sites may degenerate because the proposed preservation and monitoring programs would not be implemented.

Implementation of the no action alternative would not attain the objectives of the proposed action. As previously noted, the no action alternative would retain the petition area in Conservation, which may represent a long-term loss in productivity, by narrowing the range of beneficial uses of the site. The economic benefits of: employment for approximately 160 people, greater property tax revenues, and the diversification of economic activities would not be realized.

### B. Alternatives Which Could Feasibly Attain the Objectives of the Action

#### 1. Conservation District Use Application Alternative

This alternative involves seeking a Conservation District Use Application (CDUA) instead of the proposed amendment to the Land Use Conservation District Boundary in Kapua. The CDUA alternative will experience most of the adverse and unavoidable environmental effects summarized in PART IV.

Since large scale agricultural activities (as opposed to a smaller farm) are being proposed, implementation of this alternative would subvert the intent of the existing State Conservation Land Use designation.

In addition, the operation of the proposed project would be impractical within the constraints of the CDUA process. Specifically, the CDUA procedures for changes in the creation, location and/or operation of agricultural roads, wells, etc., make it inflexible and unfeasible for a serious agricultural operation. Although some agricultural activity is permitted in the Conservation District, it will be nearly impossible for the petitioner to obtain financing, since the proposed agricultural uses requires the sanction of an appropriate land use designation.

## 2. Alternative Site

Moving the proposed action to an alternative site is essentially the same as no action. The petitioner would have to acquire new property at a site which will more than likely have unique environmental characteristics. Thus, the construction of the proposed action at an alternative site will face differing environmental impacts, some of which will be less or more severe than the proposed action. The climatic conditions of the area are ideal for the proposed uses. No other known parcel of this size for multi-agricultural uses is available at this time. In addition, it should be noted that the petition area's immediate proximity to MacFarms of Hawaii, Inc.'s processing facility, represents an advantage over properties being used for macadamia cultivation, located elsewhere in the district.

## 3. State Natural, Recreational and Historic Park

In 1971, the State Division of Parks, Outdoor Recreation and Historic Sites proposed the creation of Natural, Recreational and Historic Park. The park would extend from the southern boundary of Manuka adjoining Kahuku to the northern boundary of Honomalino adjoining Kalihi. It was the intent of the State Division of Parks and Recreation to develop a primitive-type park to preserve the numerous archaeological features that were found in the area. It was proposed that controlled access to the park for hiking, hunting, fishing and camping would be by permit issued from the Hilo office of the State Division of Parks and Recreation. Since 1971, no action (funds for feasibility study were never released) has been taken on the park proposal. It has been learned from the State Division of Parks and Recreation,[30] that the development of this park has a low priority. The acquisition, development and management of the park would require funds which are not available to the State at this time. However, it was expressed that the Division of Parks and Recreation is interested in preserving access along the shoreline from Honomalino to Manuka. It is the intention of the petitioner to include some of the aspects of the Natural, Recreational and Historic Park proposal as part of the proposed activities within the petition area. As previously noted, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation, and the petitioner will maintain the present unobstructed lateral access along the shoreline, north and south of the petition area. In addition, preservation has not been ruled out for any significant archaeological sites found outside of the 425 acre area to be left in Conservation. Determinations of which sites deserve or are appropriate for preservation would be made on the basis of the findings of intensive survey work. The retention of significant historic sites outside of the Conservation District could be accomplished through a preservation program within the context of a archaeological/historical resource management plan. It is the petitioner's intent to prepare such a plan. Implementation of the Natural, Recreational and Historic Park alternative does not necessarily present an advantage over a private (petitioner's) cultural resource management program in the preservation and monitoring of significant archaeological sites.

## PART VIII: THE RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE POLICIES AND CONTROLS FOR THE AFFECTED AREA

Approval of the proposed petition to amend the Conservation Land Use District Boundary in Kapua, to reclassify approximately 6,102 acres of land into Agricultural District, will not be violative of Chapter 205, Section 205-2, Hawaii Revised Statutes nor will it be inconsistent with the Interim Statewide Land Use Guidance Policies (ISLUGP); the Hawaii State Plan; and, the interim State Functional Plans. It will also conform to the policies and guidelines of the State Coastal Zone Management Act (Chapter 205A HRS); Special Management Area Rules and Regulations of the County of Hawaii; the Hawaii County General Plan; and, the draft Kona Regional Plan.

### A. Chapter 205, Section 205-2, HRS - Land Use Commission

The proposed request is consistent with Chapter 205, Section 205-2 HRS, because "Agricultural districts shall include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities including but not limited to living quarters or dwellings, mills, storage facilities, processing facilities, and roadside stands for the sale of products grown on the premises; agricultural parts and open area recreational facilities."

### B. Interim Statewide Land Use Guidance Policies (ISLUGP)

The boundary amendment requested in this petition is consistent with the Land Use Commission's Interim Statewide Land Use Guidance Policies. For example, because the proposed project will provide employment opportunities, the petition recognizes the interim guidance policy which states that "preference shall be given to amendment petitions which will provide permanent employment, . . ." While the lands of the subject petition are designated in the County General Plan Land Use Pattern Allocation Guide (LUPAG) for Open Area along the shoreline, and Conservation for the remainder, it should be noted that the County made their designation in conformance with the higher State designation. An amendment to the General Plan will be requested following the favorable resolution of the State Land Use District boundary amendment.

The proposed amendment is necessary to accommodate agricultural development. Implementation of the project will not have significant adverse effects upon agricultural, natural, environmental, recreational, scenic, historic or other resources of the area. The petition does not involve the reclassification of the lands to Urban District.

## C. State Land Use Commission District Regulations, Standards for Determining District Boundaries

The following examination of the standards used in determining the boundaries for the Conservation District reveals that retaining the petition area in Conservation is not necessary.

"(a) Lands necessary for protecting watersheds, water sources and water supplies shall be included in this District except as otherwise provided for in other sections of these regulations."

No groundwater has been actively developed within 20 miles of the petition area, therefore, the site has no value in protecting any existing sources of water.

"(b) Lands susceptible to floods, and soil erosion, lands undergoing major erosion damage and requiring corrective attention by the State or Federal Government, and lands necessary for the protection of the health and welfare of the public by reason of the lands' susceptibility to inundation by tsunami and flooding, to volcanic activity and landslides may be included in this District."

The conservation lands on-site are not susceptible to flooding or soil erosion, and are not located in a potential tsunami inundation zone. The subject lands may be susceptible to damage from volcanic hazards. Other lands in South Kona which are more susceptible to volcanic hazard, however, are not included in the Conservation district.

"(c) Lands used for national or state parks may be included in this District.

(d) Lands used for national or state parks may be included in this District except as otherwise provided for in other sections of these regulations."

The Conservation District lands on the petition area are not used as a National or State park.

"(e) Lands necessary for providing and preserving parklands, wilderness and beach reserves, and for conserving natural ecosystems of endemic plants, fish and wildlife, for forestry, and other related activities to these uses shall be included in this District except as otherwise provided for in other sections of these regulations."

Retaining the petition area in Conservation is not necessary for the preservation of sites having unique physiographic or ecologic significance. The lands are not used for forestry, nor are they a critical habitat of any rare or endangered species. The subject parcel is not located within a restricted watershed or forest reserve.

"(f) Lands having an elevation below the maximum inland line of the zone of wave action, and marine waters, fish ponds and tide pools of the State shall be included in this District unless otherwise designated on the district maps. All offshore and outlying islands of the State of Hawaii are classified Conservation unless otherwise indicated."

No portion of the petition area has an elevation below the maximum inland line of the zone of wave action. The petitioner will retain a 300 foot band along the entire project coastline in Conservation.

"(g) Lands with topography, soils, climate or other related environmental factors that may not be normally adaptable or presently needed for urban, rural or agricultural use, shall be included in this District, except where such lands constitute areas not contiguous to the Conservation District."

While lands of the subject petition contain soils which have been considered not normally adaptable for productive agricultural use (by the Land Study Bureau and ALISH), the petitioner is proposing uses such as aquaculture and the cultivation of macadamia and leucaena, which do not require soils with greater master productivity ratings. Therefore, while previously the site may have not been considered normally adaptable for productive agricultural use (according to Land Study Bureau or ALISH designations), approval of the petition would expand the agricultural potentials of the petition lands and the Agriculture District boundaries.

(h) "Lands with a general slope of 20% or more which provide for open space amenities and/or scenic values shall be included in this District except as otherwise provided for in other sections of these regulations."

There are only a few pockets within the subject Conservation lands with slopes of 20% or more. The property provides occasional views from Mamalahoa Highway. The agricultural uses proposed for the project will not alter these views.

On the other hand, the petition is essentially in accordance with at least one of the State Land Use Commission's standards used to establish Agriculture District Boundaries, because "Lands with significant potential for grazing or for other agricultural uses shall be included in this District . . ." The site is ideal for aquaculture because of its long southern exposure, its location in the lee of Mauna Loa, which shelters the site from the northeast tradewinds, and the area available.

The site is also conducive to the growth of macadamia because of the moderate temperatures and the even distribution of rainfall throughout the year, making major droughts extremely rare in the Kapua region. When developed as proposed, the subject lands, which are adjacent to existing agricultural land, will have a high capacity for agricultural production.

## D. Hawaii State Plan

The boundary amendment, which would allow the proposed multi-agricultural uses of the presently undeveloped site, would be supportive of the Hawaii State Plan objectives and policies for the economy because it would increase the opportunities for an agricultural livelihood, and it would expand Hawaii's agricultural base, by increasing macadamia nut production, cultivating livestock, feed, food crops and aquaculture. Sub-section 10 (a) specifically states:

> "Planning for the State's economy with regard to potential growth activities shall be directed towards achievement of the objective of development and expansion of potential growth activities that serve to increase and diversify Hawaii's economic base."

And sub-section 20 (b) states:

> "To achieve the potential growth activity objective, it shall be the policy of this State to: (2) encourage investment in economic activities that have the potenital for growth, such as diversified agriculture, aquaculture . . ."

The proposed agricultural activities will also be supportive of the priority direction for population growth and distribution by generating employment on a neighbor island.

The project will be compatible with the State Plan objectives and policies for the physical environment in that it will provide adequate shoreline setback and beach access and protect Hawaii's historic and cultural sites.

## E. Interim State Functional Plans

Until the legislature adopts the necessary functional plans pursuant to Chapter 226, HRS, the Interim State Functional Plans delineate specific objectives, policies and implementing actions that would achieve the directions expressed in the State Plan. While most of the actions identified in the Interim Agriculture Functional Plan are intended for governmental agencies, it is felt that implementation of the proposed project will expand the inventory of productive agricultural land.

An archaeological field reconnaissance was conducted to identify sites of archaeological interest in conformance with the Interim State Historic Preservation Functional Plan objective for historic properties. In order to coordinate the archaeological survey with the interests of the State and County in inventorying all historic properties, the archaeologist, Dr. Rosendahl, has made copies of his report available to Wendall Kam, staff archaeologist with the State Historic Preservation Office, and Virginia Goldstein, staff planner and historic sites specialist in the Hawaii County Planning Department, and has maintained contact with Mr. Kam and Ms. Goldstein throughout the EIS process.

The proposed project will be compatible with the Interim State Recreation Plan objective for land use and planning because the intended multi-agricultural use of the site is compatible with the predominant agricultural lifestyle of the area, and the area's physical resources and recreational potential.

The project will conform to the objective of assuring adequate public access to lands and waters with recreational value, by providing lateral access along the shoreline, from the north to the south boundaries. The petitioner will also allow mauka-makai access to the shoreline from Mamalahoa Highway, by permission only.

The project conforms to the Interim State Water Resources Development Functional Plan objective of maintaining the long-term availability of fresh water supplies by: proposing the monitoring of the proposed wells for any increases in chloride content; not proposing the disposal of solid waste in a landfill on-site; and, not proposing the disposal of sewage via injection wells. Finally, the project will conform with this functional plan's objective of assuring the availability of water for agriculture by using nonpotable water for the irrigation of the proposed crops and brackish water for the aquaculture facility.

## F. Hawaii Coastal Zone Management Program

The objectives of the Hawaii Coastal Zone Management Program (Chapter 205A, HRS) are to protect valuable and vulnerable coastal resources such as coastal ecosystems, special scenic and cultural values and recreational opportunities. The objectives are also to reduce coastal hazards and to improve the review process for activities proposed within the coastal zone. The following are the objectives of the Hawaii Coastal Zone Management Program and an assessment of how the project relates to them:

1. "Provide coastal recreational opportunities accessible to the public."

   The proposed project will not alter the recreational activities normally associated with the shoreline fronting the site, such as diving, fishing and limu picking. Present means of access to the shoreline will not be altered.

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

   An archaeological reconnaissance of the site was conducted to verify the existence or absence of artifacts of cultural interest. No Conservation District boundary amendment is proposed for the northern coastal zone, where the greatest density and variety of archaeological remains were found.

It should be noted that preservation has not been ruled out for any sites found outside of the 425 acre area to be left in Conservation. Determinations of which sites deserve or are appropriate for preservation would be made on the basis of the findings of intensive survey work. The retention of significant historic sites outside of the Conservation District could be accomplished through a preservation program within the context of a archaeological/historical resource management plan. The possible need for this latter plan and the need for intensive level work was anticipated and described on pages 32 and 33 of Rosendahl's Archaeological Reconnaissance Survey Farms of Kapua. It is the petitioner's intent to implement these recommendations.

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

The coastal zone fronting the shoreline is not visible from Mamalahoa Highway. The project will involve the replacement of existing vegetation with the crops to be cultivated, and the construction of aquaculture facilities. These facilities will only be visible from boats off the coast and to those traveling along the shoreline.

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

No construction is proposed within the waters fronting the petition area. During the life of the project there will be no point discharge of treated or untreated sewage directly into offshore waters.

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

The site is considered ideal for aquaculture because of its long southern exposure, its location which is sheltered from the northeast tradewinds, and the large available area. The State has identified aquaculture as a desirable and important part of the State's economy.

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

The Flood Insurance Rate Map indicates that the entire site is in Zone C, or areas of minimal flooding. The petition area is not located within Zone V, which confirms the area is not subject to coastal flooding or wave hazard. The erosion hazard of the soils on-site are slight.

## G. Special Management Area Rules and Regulations of the County of Hawaii

The Special Management Area for Hawaii County extends 300 feet from the shoreline. No action is proposed within the boundaries of the SMA.

## H. General Plan Land Use Pattern Allocation Guide (LUPAG)

The revised LUPAG designates the site as: Open Area along the shoreline, and Conservation for the remainder. This conforms with the State designation. An application to amend the General Plan will follow the favorable resolution of the State Land Use District boundary amendment.

## I. Draft Kona Regional Plan

The draft Kona Regional Plan does not include the petition area within its Conceptual Land Use Map.

## PART IX: AN INDICATION OF WHAT OTHER INTERESTS AND CONSIDERATIONS OF GOVERNMENT POLICIES ARE THOUGHT TO OFFSET THE ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

The purpose of this section is to indicate that other interests and considerations of governmental policies, other than compliance with regulatory requirements associated with construction (listed in PART X), are thought to offset the adverse and unavoidable environmental effects of the proposed action, outlined in PART IV. One of the most significant ways in which the proposed action fulfills governmental policies, and therefore, is thought to offset any adverse effects, is through the satisfaction of the interim guidance policy which states that "preference shall be given to amendment petitions which will provide permanent employment. . ."

In addition, the proposed multi-agricultural uses of the presently undeveloped site, would be supportive of the Hawaii State Plan objectives and policies for the economy because it would increase the opportunities for an agricultural livelihood, and it would expand Hawaii's agricultural base, including aquaculture which is considered a "potential growth activity". The proposed project will also be supportive of the priority direction for population growth and distribution by generating employment on a neighbor island.

While the above countervailing benefits may be realized by the alternative of seeking a Conservation District Use Application (PART VII), as previously noted, it will nearly impossible for the petitioner to obtain financing, since the operation of all of the proposed multi-agricultural uses of the site would be impractical within the constraints of the CDUA process.

## PART X: LIST OF NECESSARY APPROVALS

Since the LUPAG designation for the parcel reflects the State Conservation Land Use District classification, a LUPAG designation of Extensive Agriculture and Orchard will be sought following the favorable resolution of the State Land Use Boundary. A change in the County Open zoning to Agricultural will also be sought at a later date.

It is anticipated that a Special Management Area permit (SMP) will not be required from the County of Hawaii prior to development.

Okoe well is on State land, and use of this well is contingent on obtaining a water license from the Department of Land and Natural Resources. It would also require other adjustments as well since the area of the well is under a revocable permit to Dillingham Investment Corporation for pasture purposes.

The following is a general list of approvals needed to complete the development of the project.

| Approval Needed | Approving Agency or Body |
|---|---|
| Amendment to Land Use Pattern Allocation Guide Map of County General Plan | County Planning Department/ County Planning Commission/ County Council |
| Rezoning | County Planning Department/ County Planning Commission/ County Council |
| Grubbing, Grading, Excavation and Stockpiling Permits | County Public Works Department |
| Approval of Private Sewage Disposal Systems | State Department of Health<br>County Department of Public Works |
| Use of Okoe Well | State Department of Land and Natural Resources |
| Well Drilling Permit | State Department of Land and Natural Resources |
| Water Systems Approvals | State Department of Health/ County Water Supply Department |
| Historic Sites Review | State Department of Land and Natural Resources/ County Planning Department |

| Approval Needed | Approving Agency or Body |
| --- | --- |
| Permit for Construction within State Highway Rights-of-way | State Department of Transportation, Highways Division |
| Electric Connection Approval | Hawaii Electric Light Company, Inc. |
| Telephone Connection Approval | Hawaiian Telephone Company |

## PART XI: AGENCIES, ORGANIZATIONS AND PERSONS WHO WERE SENT A COPY OF THE NOP

The EIS Notice of Preparation (NOP) was officially published in the Environmental Quality Commission (EQC) Bulletin on December 8, 1983. As of February 17, 1984, a total of 25 written comments were received; of this total, 6 required no response. The following agencies, organizations and persons recieved a copy(ies) of the NOP. Starred (*) individuals were sent copies of the NOP but were not deliverable by the U.S. Post Office. Double starred (**) individuals responded to the NOP, but did not require a response. Their letters are reproduced here. Triple starred (***) respondants made substantive written comments which required a written response; both their comments and our responses are included in this section. One letter was received after the EIS was filed (February 21, 1984) and is included in this section.

### FEDERAL

** 15th ABW/DEE, Hickam
Army - DAFE (Facilities Eng. - USASCH)
Navy
*** Soil Conservation Service
*** U.S. Army Corps of Engineers
U.S. Coast Guard
*** U.S. Fish & Wildlife Service

### STATE

Governor
Attorney General's Office
*** Department of Agriculture
** Department of Accounting and General Services
** Department of Defense
Department of Education
- Hilo Regional Library
- Kaimuki Regional Library
- Kailua-Kona Library
- Kaneohe Regional Library
- Kealakekua Library
- Lihue Regional Library
- Main Library
- Pearl City Regional Library
- Wailuku Regional Library

*** Department of Health
*** Department of Land & Natural Resources
** Division of State Parks
DLNR State Historic Preservation Officer

** Department of Planning & Economic Development
    DPED Library
    Land Use Commission
Department of Social Services and Housing
*** Department of Transportation
Environmental Quality Commission
Office of Environmental Quality Control
Office of Hawaiian Affairs
State Archives
State Energy Office
State Legislature
    Legislative Reference Bureau
    Representative Andrew Levin
    Senator Dante Carpenter
    Senator Anthony K.U. Chang
    Senator Gerald T. Hagino
    Senator Richard Henderson
    Senator Ann Kobayashi
    Senator Gerald K. Machida
    Senator Malama Solomon
University of Hawaii
***     Environmental Center (responded twice)
    Hamilton Library
    UH Hilo Library
***     Water Resources Research Center

COUNTY OF HAWAII

Mayor's Office
Corporation Counsel
County Council
Department of Parks and Recreation
*** Planning Department
Public Works Department
Research and Development
*** Water Supply Department

ORGANIZATIONS AND INDIVIDUALS

Lily Ahia
Kaipo Akaka
Annie Akiu
American Lung Association
Association of Hawaiian Civic Clubs, Hawaii Council
*** Audobon Society of Hawaii
Frank Belcher
Dr. William Bergin
*** Bishop Museum
* Captain Cook Community Association
Chamber of Commerce of Hawaii
Winifred Chang
Winona P. Char

Conservation Council for Hawaii
Friends of Kamoo Point
Hawaii County Taxpayer's Association
** Hawaii Electric Light Company
Hawaii Foundation for Diversified Agriculture
Hawaii Institute for Ecologically Sound Agriculture
Hawaii Island Chamber of Commerce
Hawaii Island Economic Development Board
Hawaii Tribune Herald
Hawaiian Telephone
Hawaii's Thousand Friends
Honest Environmental Citizens Against Progress
Honolulu Advertiser
Honolulu Star-Bulletin
James Juvik
Ka' Ohana O Ka Lae
*** Gilbert and Linda Kahele
Sarah Kahele
Samuel Kaluna
Herb Kane
Kona Chamber of Commerce
Kona Conservation Group
Kona Outdoor Circle
Life of the Land
Warren Matsumoto
Melvin Miranda
David Monfort
*** Na Ala Hele
Charles Nakea
Napoopoo-Keei-Honaunau Community Association
Nature Conservancy of Hawaii
George Newton
Shirley Ochmann
*** Pa'a Pono of Milolii, Inc.
David Campbell Penn (late reponse)
Public Access Shoreline Hawaii
David Roy
George Schattauer
Gordon Shigeura
Harry Shigeura
Jerry Shimoda
*** Sierra Club, Moku Loa Group
Rev. Leon Sterling
Sun Press
William Tagupa
Yoshitaka Takashiba
*** Universal Life Church
Rick Warshauer
West Hawaii Today
*** Wayne Westlake
D. Castle Wooley
Charles Young

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 15TH AIR BASE WING (PACAF)
HICKAM AIR FORCE BASE, HAWAII 96853

RECEIVED
DEC 13 1983
GROUP 70

REPLY TO ATTN OF: DEEV (Mr Yamada, 449-1831)

12 DEC 1983

SUBJECT: Notice of Preparation for Farms of Kapua Environmental Impact Statement (Your Ltr, 2 Dec 1983)

TO: State Dept of Planning and
Economic Development
Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, HI 96813

1. This office has reviewed the subject Notice of Preparation and has no comment relative to the proposed project.

2. We greatly appreciate your cooperative efforts in keeping the Air Force apprised of your project and thank you for the opportunity to review the document.

ROBERT M. OKAZAKI
Chief, Engrg & Envmtl Plng Div
Directorate of Civil Engineering

cc: Group 70
ATTN: Sheryl Seaman
924 Bethel Street
Honolulu, HI 96813

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United States Department of Agriculture
Soil Conservation Service
P.O. Box 50004
Honolulu, HI
96850

December 23, 1983

Gordan Y. Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

RECEIVED
DEC 28 1983
GROUP 70

Dear Mr. Furutani:

Subject: Notice of Preparation for Farms of Kapua Environmental Impact Statement

The above-mentioned document has been reviewed as requested. We feel the following concerns need to be addressed:

a. The soils should be verified in the field. Lava lands appear to extend from shoreline to the 600-foot elevation.

b. A close look should be given to the potential of lava lands supporting a guineagrass - ekoa plant community in an economically viable cattle operation.

We would appreciate the opportunity to review the draft EIS when prepared.

Sincerely,

FRANCIS C.H. LUM
State Conservationist

cc:
Group 70
924 Bethel Street
Honolulu, Hawaii 96813
Attn: Sheryl Seaman

The Soil Conservation Service is an agency of the Department of Agriculture

Kazu Ishihara AIA, Inc
Frank S Orda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

17 February 1984

Mr. Francis C.H. Lum
State Conservationist
United States Department of Agriculture
Soil Conservation Service
P.O. Box 50004
Honolulu, HI 96850

Dear Mr. Lum:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We appreciate the information provided. The EIS will include a map containing information from the Soil Survey of Island of Hawaii, State of Hawaii, overlayed with U.S.G.S. contour lines. For your information, the 400-foot elevation was chosen for the description of soils because of the proposed planting of macadamia between the 400-foot elevation to the mauka boundary of the petition area.

As stated in the NOP, a total of approximately 2,700 acres makai of the 400-foot elevation will be used for producing grazing material. Establishing haole koa and guinea grass will require some cultivation, such as rough land preparation and seeding. Eventually, soil will develop under the haole koa. Research conducted by the Farms of Kapua's consultant on pasture management, Harold F. Rice, indicates that there are areas in West Hawaii at similar elevations, on a'a and pahoehoe, with similar rainfall, which are vegetated with haole koa and are used for grazing. Furthermore, the viability of the pasture operation in this case does not rest entirely on the marketability of beef. The cattle will also provide nutrients (in the way of manure) for Marine shrimp (Penaeus vannamei), Brine shrimp (Artemia) and Spirulina in the aquaculture modules. These species were specifically selected because they could be sustained by manure. Therefore, the pasture operation has a direct effect on the proposed aquaculture operations by reducing the amount of manufactured feeds which must be imported from the mainland or Asia.





We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-4411

United States Department of the Interior

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

IN REPLY REFER TO:
ES
Room 6307

RECEIVED
DEC 30 1983

DEC 29 1983

GROUP 70

Mr. Gordon Furutani
Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

The Service has reviewed the Environmental Impact Statement (EIS) Preparation Notice for Farms of Kapua which was forwarded with your letter of December 2, 1983. The comments of our October 20, 1983 letter on the negative declaration (copy enclosed) remain valid and should be addressed in the EIS.

Although the EIS Preparation Notice has included descriptions of aquatic fauna within the project area, the EIS should also discuss potential secondary impacts of pond effluent leachate upon nearby anchialine ponds and upon nearshore water quality. We appreciate this opportunity to comment.

Sincerely,

Original signed by

William P. Kramer
Acting Project Leader
Office of Environmental Services

Enclosure

cc: Group 70
[illegible]
[illegible]
[illegible]

ES
Room 6307

OCT 20 1983

Mr. Gordan Furutani
Executive Officer
Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

The Service has reviewed the Land Use Commission's negative declaration for a State Land Use District Boundary Amendment on Kapua Farms, South Kona, Hawai'i. We have concerns regarding possible impacts of the proposed land use change upon native vegetation, erosion and drainage patterns. The proposed action includes reclassification of approximately 6,102 acres of Conservation Land Use District to Agriculture, construction of aquaculture facilities, roadways, irrigation systems, saltwater and freshwater well systems, establishment of pasturage for cattle, and cultivation of giant koa haole, Guinea grass and experimental crops.

Specific Comments

The EA includes a reconnaissance survey of flora and a cursory list of avifauna and mammals. We recommend that the list be expanded to include bats and aquatic fauna of achialine ponds present in the project area.

According to the Botanical Reconnaisance Report by Kenneth M. Nagata (EA, Appendix D), kauila (Colubrina oppositifolia) is located within the project site. C. oppositifolia is considered a candidate endangered species by the Federal government. As such, the tree has no legal standing; however, the Service is concerned about the survival of this species due to its low population levels and threats to its continued existence. This tree is known only from dryland forests of O'ahu and the island of Hawai'i. Even in areas where it is found, it is extremely rare, the largest known populations being a small stand at Pu'u Waawaa, South Kona.

Mr. Nagata noted that his botanical surveys were limited in scope and were conducted mainly along existing jeep roads. Thus, it is possible that additional trees exist in areas not surveyed. If stands of kauila trees are encountered during site preparation (clearing and grubbing) we suggest that they be protected.

We concur with the EA that the Hawaiian Hoary Bat, a listed endangered species (50 CFR 17.11 and 17.12), may be roosting and/or crossing the project site. Fujioka and Gon (In press, An unusual concentration of the Hawaiian Hoary Bat in the south Kona district, island of Hawaii. Journal of Mammology) recorded bats dispersing from roosting areas near 840m elevation in Kapua during 1977 surveys. Island-wide bat sightings suggest that bats may use roosting caves between sea level and 3050m elevation in the late summer months (Kepler, K. and M. Scott, in press, Distribution and behavior of the endangered Hoary Bat Lasiurus cinereus semotus in Hawaii). The archaeological study conducted for Farms of Kapua reports that several natural lava tube complexes (of the type used by bats) are present within the project site.

It is possible, therefore, that bats and bat roosting caves may occur within the project area makai of the highway. If roosting caves are encountered during site preparation, they must not be destroyed or modified. The Service recommends that a broad area surrounding the roosting cave(s) be left intact to avoid disturbing this Endangered species.

The EA describes several freshwater irrigation and central saltwater wells to be developed which will supply an estimated total of 8.16 MGD of water during non-drought conditions and 12.8 MGD during drought conditions. The fate of runoff from irrigated fields and discharge from aquaculture facilities is not clearly explained in the EA. We are concerned that percolation and leaching of enriched effluent and sediment-laden runoff water may contaminate anchialine ponds located just makai of the proposed aquaculture facilities.

The EA would be enhanced if it included a discussion of potential impacts to fish and wildlife resources and to water quality due to anticipated agricultural pesticide/herbicide use.

Please do not hesitate to contact us if you should have any questions regarding our comments.

Sincerely,

for H Peter A. Stine

William R. Kramer
Acting Project Leader
Office of Environmental Services

cc: HDAR
HDF&W
EPA, San Francisco
SCS, Honolulu

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

16 February 1984

Mr. William R. Kramer
Acting Project Leader
Office of Environmental Services
United States Department of the Interior
Fish and Wildlife Service
P.O. Box 50167
Honolulu, HI 96850

Dear Mr. Kramer:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your comments and offer the following responses:

1. Since the publication of the Preliminary Planning and Environmental Study for Farms of Kapua, please note that the cultivation of giant koa haole is no longer being proposed.

2. As requested, bats will be added to the list of animals that have been sighted or presumed to inhabit the petition area, in the EIS. In addition, a list of biota that have been found in the anchialine ponds will also be included.

3. Based on his earlier survey, Kenneth M. Nagata returned to Kapua to determine the extent of the native dry forest at the mauka boundary of the petition area, to ascertain the integrity of that forest and to seek out any rare and endangered species in that section. Mr. Nagata found a single kauila tree on an old a'a lava flow near the Kaulanamana flow. The tree is festooned with the parasistic kauna'oa-pehu. Two trees of Bobea timonioides are located nearby. Two individuals of halapepe (Pleomele sp.) were also discovered in the petition area. One of the halapepe was considered healthy and was located in a deep, steep-sided, collapsed lava tube. Mr. Nagata has recommended that approximately 20 acres, including the kauila and Bobea trees be set aside and managed as a preserve. The petitioner will implement his recommendation.

4. In his bird and mammal report that he prepared for the Farms of Kapua, Dr. Andrew J. Berger, consulting biologist, states that: "As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macadamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight."

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-14

5. The anchialine ponds have been located near Kapua Bay and Kaupo Bay. They are located well within the area to be left in Conservation (the mauka boundary is 2,000 feet inland from the shoreline, from the northern boundary of the petition area to just north of Kanewaa Point). The nearest ponds are located over a mile north from the aquaculture area boundary. Due to the direction of the lava flows mauka to makai, it is unlikely that effluent from the aquaculture facilities would travel in a northerly direction.

   Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation area and 200 acre research and development area. As described in the Soil Survey of Island of Hawaii, State of Hawaii, U.S.D.A. Soil Conservation Service, most of these soils have been characterized as having slow runoff. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of surface runoff. Therefore, it is highly unlikely that there would be any "sediment-laden runoff water", and that the anchialine ponds, which are near the shoreline, would be impacted by the nearest agricultural activities (koa haole pasture) located nearly 1,500 feet away.

6. No pesticide use is proposed within the petition area. The application of herbicides is proposed only in the macadamia area. Herbicide use is not being proposed in the 2,472 koa haole pasture area or in the 200 acre koa haole cultivation area. Although it is not anticipated at this time, the application of these materials may be used in the 200 acre research and development area. As previously described, the porous characteristic of the ground precludes the occurrence of surface runoff. The only other means of direct contact with ocean resources is by air. While herbicides can be carried by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds. Since these materials would be applied by hand, during non-windy days, it is unlikely that these materials would impact ocean resources.

   Mr. Berger states in his report that with the exception of the Hawaiian bat, all of the remaining mammals found on the site are introduced species, and all of these are considered pests to man, his activities and products, and/or to native vegetation and fauna. The only two species of endangered Hawaiian birds (the hawk and the owl) seen on or adjacent to the project site have adapted to the introduced vegetation on the island of Hawaii, primarily because of their feeding habits and the extent of their home range. Since the bats roost in caves or lava tubes during the day, it is highly unlikely that they would be





exposed to herbicide use. Only if the hawk and owl nest in the areas where these materials were used would these birds be directly affected.

As previously mentioned, the use of herbicides should have no impacts on coastal waters or the anchialine ponds because of the lack of surface runoff in the petition area. While the effect of the use of these materials on groundwater resources, within the petition area, are unknown, water from the proposed irrigation wells can be tested for these substances on a regular basis.

We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

DEPARTMENT OF THE ARMY
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
FT. SHAFTER, HAWAII 96858

JAN 06 1984
GROUP 70

December 29, 1983

Mr. Gordon Furutani, Executive Officer
Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Thank you for the opportunity to review the EIS preparation notice for Farms of Kapua, South Kona, Hawaii. The following comments are offered:

a. Any work in the ocean and tidal waters will need a Department of the Army permit.

b. The proposed site of the multi-agricultural project along the southwest coast of Hawaii is designated Zone C or area of minimal flooding, according to the Flood Insurance Study for the County of Hawaii prepared by the Federal Insurance Administration (FIA). There is minimal tsunami inundation along this portion of the southwest coast of Hawaii and therefore, no FIA flood hazard map was printed for this area.

Sincerely,

Kisuk Cheung
Chief, Engineering Division

Copy Furnished:

Group 70
924 Bethel St.
Honolulu, HI 96813
Attn: Sheryl Seaman

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

17 January 1984

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
Pacific Ocean Division, Corps of Engineers
Ft. Shafter, HI 96858

Dear Mr. Cheung:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We appreciate the information provided. We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

/tn
5552

State of Hawaii
DEPARTMENT OF DEFENSE
OFFICE OF THE ADJUTANT GENERAL
3949 Diamond Head Road
Honolulu, Hawaii 96816

HIENG

7 DEC 1983

Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Gentlemen:

Farms of Kapua

Thank you for providing us the opportunity to review the proposed project, "Farms of Kapua" Environmental Impact Statement.

We have completed our review and have no comments to offer at this time.

Yours truly,

JERRY M. MATSUDA
Major, HANG
Contr & Engr Officer

cc: Group 70

---

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

December 19, 1983

MEMORANDUM

TO: Mr. Gordon Furutani, Executive Director
Land Use Commission

FROM: Roy K. C. Sue, State Parks Administrator

SUBJECT: Notice of Preparation for Farms of Kapua EIS
Kapua, South Kona, Hawaii, TMK 8-9-06: 3

Thank you for your memorandum of December 2, 1983, requesting our review and comments on the EIS Notice of Preparation.

Please be advised that the State Historic Preservation Officer's comments will be submitted as a combined Department of Land and Natural Resources response in the near future.

ROY K. C. SUE

DEC 22 12 03 PM '83
LAND USE COMMISSION
STATE OF HAWAII

RECEIVED
DEC 25 1983
GROUP 70

GEORGE R. ARIYOSHI
GOVERNOR

JACK K. SUWA
CHAIRMAN, BOARD OF AGRICULTURE

SUZANNE D. PETERSON
DEPUTY TO THE CHAIRMAN

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96822

RECEIVED
DEC 27 1983
GROUP 70

December 23, 1983

MEMORANDUM

TO: Land Use Commission
State of Hawaii

SUBJECT: Notice of Preparation of EIS
Farms of Kapua
TMK: 8-9-06: 3 Kapua, South Kona, Hawaii
Acres: 6,102

The Department of Agriculture has reviewed the subject preparation notice and offers the following comments.

The subject document contains information that is substantially the same as that found in the "Preliminary Planning and Environmental Study for Farms of Kapua" submitted as an exhibit in the applicant's petition for an amendment to the State Land Use Conservation District Boundary (Docket No. A83-554). Therefore, our comments submitted earlier on the boundary amendment petition for the proposed project (see attached Memorandum to Department of Planning and Economic Development, dated October 11, 1983) essentially remain the same.

In summary, we have expressed concern on the following items:

(1) A market study would be helpful to ascertain the year 2000 domestic market demand for macadamia nuts, and the magnitude of nut yields that may be expected from competing foreign and domestic producers.

(2) Irrigation of the pasture area would be necessary to support optimal forage grass performance.

(3) What form of pasture management is to be instituted, inasmuch as the proposed cattle stocking rate is considered high for typical Big Island conditions?

(4) What evidence is there that the pasture operation will be economically viable?





(5) What procedures are to be taken to determine the amount of groundwater that can be safely and effectively withdrawn for irrigation use?

(6) How is the three-tiered agricultural operation to be managed?

The answers to these questions should further substantiate the merit of the overall undertaking.

Thank you for the opportunity to comment.

JACK K. SUWA, CHAIRMAN
Board of Agriculture

Attachment

cc: Group 70
Attention: Sheryl Seaman

October 11, 1983

MEMORANDUM

To: Mr. Kent M. Keith, Director
Department of Planning and Economic Development

Subject: Petition for an Amendment to the State Land Use District Boundaries
A83-594 (Farms of Kapua)
Conservation to Agricultural
Multi-Agricultural Project
TMK: 8-9-06: 3 Kapua, South Kona, Hawaii
6,102 acres

The Department of Agriculture has reviewed the subject petition and offers the following comments.

According to the petition, the applicant is seeking to reclassify approximately 6,102 acres of land from the Conservation District to the Agricultural District for the development of a multi-agricultural project consisting of a 1,500-acre aquacultural farm; a 2,472-acre controlled pasture, cultivated koa haole, research and research and development, and corral area; and the remaining area in macadamia tree cultivation.

References to the Soil Conservation Service Soil Survey, Land Study Bureau Detailed Land Classification, and Agricultural Lands of Importance to the State of Hawaii (ALISH) system are correct. It should be noted that the ALISH maps were jointly developed by the Soil Conservation Service, University of Hawaii College of Tropical Agriculture, and the State Departments of Agriculture, Planning and Economic Development, and Land and Natural Resources.

Our comments specifically address the petitioner's macadamia orchard and controlled pasture proposals. We understand that the Department of Land and Natural Resources will respond to the aquacultural farm proposal. We believe that all our comments can be satisfactorily addressed at the time of hearing, to lend further support to the petitioner's case. At a time when so many segments of our community are pessimistic about agriculture, it is commendable that an agricultural development project as large and innovative as this one is being considered at all.



Macadamia Orchard

As indicated on page 10 of Appendix G (Agricultural Feasibility: Macadamia Nuts: Farms of Kapua, by Frank S. Scott, Jr.; December, 1982) the projected 1990 U.S. and Hawaii market for macadamia nuts is considerable, although present and potential acres planted are slightly in excess of that required to meet this market. The proposed macadamia orchard, if planted in 1984, would begin to produce nuts sufficient for harvesting by about 1990 and would reach maturity at about the year 2000. Page 11 of Appendix G indicates that the market potential for macadamia nuts is expected to increase and that by planting the proposed orchard at an early date, markets for the nuts could be developed "... prior to serious competition from potential domestic and foreign producers".

The market demand for macadamia nuts by the year 2000 is speculative. The petition does not clearly indicate the demand for nuts by the year 2000 and what share of this market the proposed orchard could have. Unforeseen changes in demand as well as competition from other nut-producing areas may adversely impact the economic viability of the proposed macadamia orchard. A market study would have been helpful to ascertain the year 2000 domestic market demand for macadamia nuts, and what magnitude of nut yields may be expected from competing foreign and domestic producers.

According to the Farms of Kapua Errata Sheet for Appendix G (Letter from Roy Y. Takeyama dated September 27, 1983), the area proposed for macadamia cultivation is 1,836 acres out of a gross area of 2,051 acres. Exhibit 1 page 5, originally stated that approximately 1,710 acres would be for macadamia cultivation. Where are the remaining 274 acres located? Does this acreage include land which is in the Agricultural District between the area petitioned for reclassification and the Mac Farms of Hawaii border, as shown in Exhibit 1, Figure 4? The location of the macadamia orchard needs to be more clearly delineated, and the proposed uses for the area presently in the Agricultural District need to be clarified.

The errata sheet deletes without explanation the paragraph on page 15 of Exhibit G describing the farm size and cluster concept. Although homesites are not mentioned in either the petition or Exhibit 1, this paragraph based the economic analysis on 13 modules of 280 acres, each module consisting of 200 acres for macadmaia nuts, 10 acres for roads, and 70 acres for five-acre homesites. We therefore question the status of the cluster development as originally proposed, and whether there are any plans to introduce such a concept at a later date. Will the deletion of the cluster concept have an impact on the economic feasibility of macadamia nut production? If the cluster concept is not being considered, are there any plans to develop homesites on the property and if so, how many? How will investment capital be attracted to the 200-acre macadamia production units?

Controlled Pasture Operation

According to Exhibit 1 (pages 15 and 30), the 2,052-acre guinea grass and koa-haole pasture area will not be irrigated on a regular basis. The

estimated annual rainfall for the pasture area is approximately 30 to 35.2 inches (Appendix B, page 11). The Feed and Forage Industry Analysis (submitted to the Governor's Agriculture Coordinating Committee on September 14, 1983) indicates that guinea grass requires "... alternating wet and dry conditions, with annual rainfall of more than 40 inches". Since there is no plan to irrigate the pasture area, the grass may not perform optimally. Similarly, the koa-haole requires approximately 65 inches of rain annually for maximal forage yields (Appendix I, Leucaena Supplemental Report). Without pasture irrigation, perhaps only one-half of the maximal forage yields of koa-haole may be attainable.

It is not clear from the petition what form of pasture management system is to be instituted. The proposed stocking rate of 690 to 1,000 head of cattle on 2,052 acres of pasture is high for typical Big Island pasture conditions unless accomplished under a well-managed Savory cell system. This method of pasture management and those similar to it is labor intensive and requires extensive fencing. Most importantly, Savory systems demand a skilled manager capable of accurately assessing pasture growth and grazing intensity in order to adjust pasture rotation schedules.

Appendix H notes that Mainland and foreign imports of beef have been increasing while local production has been dropping. One of the major factors contributing to this dilemma is the inability of local producers to price their product competitively with imports. The economic viability of the pasture operation should be explored further at the time of hearing.

Water Supply

The irrigation demands of the macadamia orchard and koa-haole cultivated area during normal rainfall conditions will total over 2 million gallons per day (Exhibit 1, page 16). However, under drought conditions, about 6.3 million gallons per day would be required (Exhibit 1, page 15). Should the pasture area require irrigation, the total irrigation water demand would be greater. To meet this expected demand, the petitioner intends to tap the existing Okoe well, subject to approval by the Board of Land and Natural Resources (BLNR), and develop two to four deep irrigation wells on the property (Exhibit 1, page 15).

From the information provided, it appears that the water budget for the macadamia orchard and koa-haole field is adequate if the groundwater in the area is as abundant as hypothesized in Appendix B (Water Supply for Farms of Kapua, by John F. Mink), and if the use of brackish water from the Okoe well is approved. However, the sustainable yield of the aquifer below the site is unknown (Exhibit 1, pages 16 and 17), and use of water from the Okoe well has not been approved the the BLNR. The petitioner should clarify what procedures will be taken to determine the amount of groundwater that can be safely and effectively withdrawn for use.

A final concern is that the petition does not make clear how the overall three-tiered agricultural operation will be managed. All three operations will have dissimilar costs, capital requirements, markets, and so



forth. This issue should be addressed to ensure the maximum degree of success for this project, which has so many long-term future expectations.

The Department of Agriculture is supportive of innovative and large-scale efforts to develop diversified agriculture, such as proposed in this project. We believe that the questions which we have raised, when answered at the time of hearing, will further substantiate the merit of the overall undertaking.

Thank you for the opportunity to comment.

Jack K. Suwa

JACK K. SUWA
Chairman, Board of Agriculture

cc: Hawaii County Planning Department
Farms of Kapua

bcc: Paul Schwind

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

17 February 1984

Mr. Jack K. Suwa
Chairman, Board of Agriculture
State of Hawaii
Department of Agriculture
P.O. Box 22159
Honolulu, Hawaii 96822

Dear Mr. Suwa:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your letter of 23 December 1983 and offer the following responses:

1. As discussed with Paul Scwhind of your office, a market study to determine the national demand for macadamia in the year 2000 would not be feasible within the scope of this individual project. As noted in the "Agricultural Feasibility Macadamia Nuts Farms of Kapua" (Appendix G of the Technical Appendix for Farms of Kapua), Frank S. Scott, Jr. is aware of the potential market for macadamias and the potential competition from foreign plantings. He has recommended, therefore, that the proposed macadamia orchards be planted as soon as possible.

2. Research conducted by the Farms of Kapua consultant on pasture management, Harold F. Rice Jr., indicates that there are areas in West Hawaii at similar elevations, with similar rainfall and soil, which are not irrigated, which are vegetated with haole koa and are used for grazing.

3. Harold F. Rice Jr. has prepared a report on the proposed pasture development and management program. His report will be appended to the EIS.

4. Although there is and probably always will be a demand for Choice beef, an increasing number of health-conscious consumers are demanding lean beef. Of the 70% of beef that is imported from the mainland and New Zealand/Australia, 35% is ungraded beef. It is the petitioner's intent to capture some of this latter market.





The viability of the pasture operation in this case does not rest entirely on the marketability pf beef. The cattle will also provide the bulk of nutrients (in the way of manure) for Marine shrimp (Penaeus vannamei), Brine shrimp (Artemia) and Spirulina in one of the aquaculture modules and possibly supplement a few of the others. These species were specifically selected because they could be sustained by manure. Therefore, the pasture operation has a direct effect on the proposed aquaculture operations by reducing the amount of manufactured feeds which must be imported from the mainland or Asia.

5. As a precaution, the proposed irrigation wells and the State's Okoe well will be monitored for chloride. An increase in the chloride level will be indicative of salt water intrusion and appropriate action can be taken should this situation arise.

6. Actual management and operations of the macadamia orchards will be contracted with one of the nearby orchards. The operations in the macadamia area will be coordinated by Agricultural Concepts Inc. The pasture area will be managed by Farms of Kapua. Ms. Sally Rice, the Farms of Kapua manager, helped establish and manage an intensive grazing system at Kahuku Ranch for 15 years, where stocking rates exceeded those of any ranch in Hawaii. At her own ranch at Puuwaanahulu, Ms. Rice grows and fattens 60 head a year on 100 acres of a'a and pahoehoe, with an annual rainfall of 15 inches (12 inches in 1983). Marketing of the cattle will be the responsibility of Agricultural Concepts, Inc. Oceanic Institute will provide technical assistance to individual investor/operators of each of the five 200-acre aquaculture modules.

We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

RECEIVED
DEC 28 1983

DEC 27 1983 GROUP 70

(P)1984.3

Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Gentlemen:

Subject: Farms of Kapua
EIS Preparation Notice

We have reviewed the subject EIS Preparation Notice and have no comments to offer.

Thank you for the opportunity to review the EIS Preparation Notice.

Very truly yours,

RIKIO NISHIOKA
State Public Works Engineer

NS:jl
cc: Group 70

GEORGE R. ARIYOSHI
GOVERNOR

Wayne J. Yamasaki
DIRECTOR

DEPUTY DIRECTORS
Adam D. Vincent
JONATHAN K. SHIMADA, Ph.D
CHERYL D. SOON

**STATE OF HAWAII**
**DEPARTMENT OF TRANSPORTATION**
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813

IN REPLY REFER TO:
STP 8.9553

December 19, 1983

RECEIVED
DEC 29 1983

GROUP 70

LAND USE COMMISSION
STATE OF HAWAII
DEC 27 11 34 AM '83

Mr. Gordon Y. Furutani,
Executive Officer
Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Farms of Kapua
EIS Preparation Notice

Thank you for the opportunity to review the Farms of Kapua EIS Preparation Notice.

The hourly capacity of Mamalahoa Highway is less than the 2,000 vehicles stated on pg. 42. However, we do not anticipate any problems in accommodating the traffic from the proposal.

When construction plans for the access road are available, a permit allowing the connection to Mamalahoa Highway must be obtained from our Highways Division.

Very truly yours,

Wayne J. Yamasaki
Director of Transportation

---

Kazuo Ishihara AIA, Inc
Francis S Oda AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

4 January 1984

Mr. Wayne J. Yamasaki
Director of Transportation
State of Hawaii
Department of Transportation
868 Punchbowl Street
Honolulu, HI 96813

Dear Mr. Yamasaki:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We appreciate the information provided. In the EIS, the statement regarding the hourly capacity of Mamalahoa Highway (the second sentance of paragraph 6, page 42 of the NOP), will be revised to read: "Typically, under ideal conditions, a two-lane road such as Mamalahoa Highway can accommodate an hourly volume of 2,000 vehicles in both directions."

Also, the need for a Permit for Construction within State Highway Rights-of-ways will be noted in the section, "List of Necessary Approvals".

We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-4411

RECEIVED
JAN 05 1984
GROUP 70

JAN 4 1984

Mr. William W. L. Yuen, Chairman
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Yuen:

Thank you for notifying us that an environmental impact statement (EIS) is being prepared for the development of Kapua Farms. We have a number of concerns which the statement should address.

Aquatic Resources

With respect to the project's impact on aquatic resources, the following aspects ought to be covered:

1. Construction and site work activities (i.e., grading, erosion, debris, herbicides, fertilizers, pesticides);
2. Development of salt water and freshwater wells and use of 2.5 MGD of groundwater resources;
3. Use of cesspools;
4. Use of infiltration ditches to discharge aquaculture wastewater;
5. Potential escape of exotic species (such as marine shrimp) from the aquaculture facility;
6. Impact of project on existing routes (such as jeep trails) to the shoreline;
7. Aquatic resources and resource users to be potentially impacted by the project; and
8. Future development and expansion of the project.

The EIS should specify clearly what mitigative measures would be undertaken on each of the above points.



Recreation

Because of the potential for a shoreline wilderness and historic park in this area, we believe the EIS should explore retention of the shoreline areas in the Conservation District, as an alternative to the present proposal.

Historic Sites

Similarly, the retention of significant historic sites in the Conservation District should also be explored as an alternative. However, to achieve this would require that the reconnaissance survey be extended from the present sample area to cover the entire area proposed for development. It would require that the surveys be thorough enough for identification of significant sites and for recommendations to be made for mitigating impact on historic features.

Aquaculture

Apart from its shoreline location and the potential conflict with long term recreational use, the proposal to devote substantial acreage to aquaculture is worthy of comment.

The proposed site for the phased development of an integrated mariculture facility is excellent on the basis of its large land area, availability of seawater, annual insolation, and protection from trade winds. The proposed integrated mariculture facilities, incorporating marine shrimp, mahimahi, Spirulina, artemia, and seaweeds, represents state-of-the-art technology. Selected seaweeds will remove chemical pollutants resulting from "upstream" mariculture uses and result in an environmentally benign effluent. The local geology appears conducive to percolation of effluent waters into the underlying lava, thereby precluding ocean discharge.

The proposed phased development of the mariculture facilities, in increments of 200 acres, would allow some flexibility in planning and design activities to presumably minimize or eliminate disturbances to environmentally-sensitive areas.

The proposed reclassification and land use is consistent with the goals and objectives of the Hawaii State Plan. Sub-section 10 (a) states:

> "Planning for the State's economy with regard to potential growth activities shall be directed towards achievement of the objective of development and expansion of potential growth activities that serve to increase and diversify Hawaii's economic base."

Sub-section 20 (b) states:

"To achieve the potential growth activity objective, it shall be the policy of this State to: (2) encourage investment in economic activities that hav the potential for growth, such as diversified agriculture, aquaculture . . ."

We suggest that the EIS include discussion of these economic impacts: growth and diversification.

Water

Okoe well is on State land, and use of this well is contingent on obtaining a water license from this agency. It would also require other adjustments as well since the area of the well is under a revocable permit to Dillingham Investment Corporation for pasture purposes.

Any wells drilled to support the proposed development will require a drilling permit from this agency.

Natural Area

The EIS should take into account that the Manuka Natural Area Reserve is next to the proposed farm site. By way of mitigation, there should be some way to provide a buffer between the natural area and the developed farm. There should also be mitigation measures or controls to prevent aerial seeding or spraying from drifting into the natural area. Spray application methods should be explicitly stated including volume and frequency.

Sincerely,

SUSUMU ONO
Chairperson
and
State Historic Preservation Officer

cc: Group 70

Kazuo Ishihara AIA, Inc
Francis S Oda AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

17 February 1984

Mr. Susumu Ono
Chairperson and State Historic Preservation Officer
State of Hawaii
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Ono:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your comments and offer the following responses:

Aquatic Resources

1. Clearing and grubbing of the petition area will occur in approximate increments of 500 acres per year, over three years, in the macadamia orchard, and 400 acres per year, over six years, in the koa haole pasture area. Whenever a large enough portion of area is readied, it will be planted. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of runoff and soil erosion by surface water. There should be little erosion of soil from wind since the Atlas of Hawaii characterizes the petition area as having light and variable winds. Therefore, it is unlikely that there will be adverse impacts on coastal marine ecosystems by siltation.

   The application of herbicides is proposed only in the macadamia area. It is not being proposed in the 2,472 koa haole pasture area or in the 200 acre koa haole cultivation area. Although it is not anticipated at this time, the application of these materials may be used in the 200 acre research and development area. As previously described, the porous characteristic of the ground precludes the occurrence of surface runoff. The only other means of direct contact with ocean resources is by air. Since the petition area is characterized as having light and variable winds, and these materials would be applied by hand during non-windy days, it is unlikely that these materials would impact ocean resources.

   While the effect of the use of these materials in the petition area, on groundwater resources, are unknown, water from the proposed irrigation wells can be tested for these substances on a regular basis (annually).

2. The proposed irrigation wells and the State's Okoe well will be monitored for chloride. An increase in the chloride level will be indicative of salt water intrusion. Appropriate actions (such as reducing or halting pumping) can be taken should this situation arise.

3. The absence of any resident population and the high permeability of soil, are conditions which are considered ideal for sewage disposal by means of cesspools. Cesspools will be located as per the spacing requirements specified in Chapter 38 of the State of Hawaii Public Health Regulations. The cesspools at the aquaculture area will be sited a minimum of 300 feet from the shoreline and approximately 2000 feet from each other. The water from the proposed irrigation wells will be tested for coliform.

4. The wastewater produced from the aquaculture modules is basically brackish water that has been cycled through the production units holding the various species. The wastes from one species are used as nutrients by the following species and in this way the water is filtered. The final wastewater contains no human contamination and consists basically of minute quantities of fecal matter from marine organisms, excess feed, and some algal and plant matter. The wastewater will be collected in a culture trough for seaweed which will remove any contaminants from the water before it infiltrates into the underlying lava. Water in this trough can be tested on a regular basis to determine the filtering efficiency of the system.

5. Since the proposed aquaculture modules will be sited a minimum of 300 feet mauka of the shoreline and there will be no connection between the aquaculture modules to the shore, it is highly unlikely that any of the proposed species will escape into the ocean.

6. While the petitioner may alter the alignment of the existing mauka-makai jeep road(s) to the shoreline, they will maintain the present means of public access to the shoreline: from points mauka of the petition area by permission only; and, unobstructed lateral access along the shoreline, north and south of the petition area.

7. No action is proposed within 300 feet of the southern portion of the shoreline, and 2000 feet of the northern portion. During the life of the project there will be no point discharge of human or animal wastes from the project site directly into offshore waters. As previously mentioned, the proposed action





will not alter the present means of public access to the shoreline and therefore, should not impact resource users.

8. There are no plans for future development and expansion of the project other than what was described PART II, Section E. General Description of the Action's Technical, Economic, Social and Environmental Characteristics, of the NOP.

Recreation

1. As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the features of historical value that were found by the consulting archaeologist, Paul H. Rosendahl, in his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. As previously mentioned, the petitioner will maintain the present unobstructed lateral access along the shoreline, north and south of the petition area. We feel that retention of the above described shoreline areas in the Conservation District is in keeping with the expressed intent of S.R. 65 (1983).

Historic Sites

1. The retention of significant historic sites outside of the Conservation District could also be accomplished through a preservation program within the context of a archaeological/historical resource management plan. The possible need for this latter plan was anticipated and described by the consulting archaeologist, Paul H. Rosendahl, Ph.D., in the Archaeological Reconnaissance Survey of the Technical Appendix for Farms of Kapua.

   Also, it should be noted that in conversations with Rosendahl, DLNR Staff Archaeologist Wendell Kam indicated that completion of 100% reconnaissance survey coverage and subsequent intensive survey work did not necessarily have to be accomplished prior to the Final EIS; rather, such work could be projected as subsequent work in the EIS, and then be made conditions of subsequent development permits. Rosendahl reports that

Ms.Virginia Goldstein of the Hawaii County Planning Department has expressed a similar position.

Aquaculture

1. As noted elsewhere, we do not anticipate any potential conflict with long term recreational uses as a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation.

2. We concur with your assessment of the suitability of the site for aquaculture, and the flexibility available in siting the aquaculture modules.

3. As suggested, the EIS will include a discussion the economic impacts of aquaculture on growth and diversification.

Water

1. We appreciate the information provided on the requirements for use of Okoe Well. Please note that no drilling of wells on State lands is being proposed.

Natural Area

1. Since the boundaries of the koa haole pasture area will be fenced, this would effectively prevent animals from straying into the MNAR and would halt the spread of koa haole attributable to cattle. Furthermore, the petitioner proposes that there will be 300 foot buffer along the border of the MNAR, which will be left in its existing condition, unseeded and unimproved. The phasing of the koa haole pasture area will be in approximately 400 acre increments per year. Whenever a large enough portion of area is readied, aerial seeding will be conducted up to the 300 foot buffer to the MNAR. The boundaries of the planting area will be marked by flagman during seeding. Guinea grass will be seeded by hand. While seeds of the guinea grass may spread by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds. The exact volume and frequency of spray application methods are unknown at this time.





We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

# University of Hawaii at Manoa

Water Resources Research Center
Holmes Hall 283 • 2540 Dole Street
Honolulu, Hawaii 96822


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RECEIVED
JAN 09 1984
GROUP 70

6 January 1984

Mr. Gordon Furutani
Executive Officer
Land Use Commission
Old Federal Building, Rm. 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Subject: Environmental Impact Statement Preparation Notice, Farms of Kapua, South Kona, Hawaii, December 1983

We have reviewed the subject EISPN and offer the following comments:

1. In a zoning change of this magnitude (6,102 acres) an appropriate environmental question is, what will this land be used for if the applicant's proposed activities fail? Or more succintly, what will be the environmental impact if the applicant gets the zoning change but is unable to follow through on his plans? For example, a subsequent subdivision into small farm lots would have a very different environmental impact as compared to the petitioner's proposed activities.

2. In line with the above, a key issue to be addressed is, does the petitioner have the technical skills and entrepreunerial expertise to economically perform the proposed aquacultural, ranching, and macadamia nut operations? For it is this economic issue that relates directly to the all-around environmental impact of the proposal.

3. The low rainfall coupled with the extremely low moisture holding capacity of the ubiquitous lava rock, makes the necessity for irrigation a foregone conclusion on most of the subject property. Therefore, the EIS should cover the irrigation aspect in detail, including sources, salinity, application rates, etc. and how many acres of macadamia and pasture can actually be irrigated with the projected supplies.

4. A vegetation map in conjunction with the botanical survey would be very helpful in delineating ecological zones.

AN EQUAL OPPORTUNITY EMPLOYER



Thank you for the opportunity to comment. This material was reviewed by WRRC personnel.

Sincerely,

Edwin T. Murabayashi

Edwin T. Murabayashi
EIS Coordinator, WRRC

ETM:jmn

cc: Francis Oda, Group 70
Environmental Center

Kazuo Ishihara AIA, Inc
Frances S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G E Hong AIA Inc

17 February 1984

Mr. Edwin T. Murabayashi
EIS Coordinator
Water Resources Research Center
University of Hawaii
Holmes Hall 283
2540 Dole Street
Honolulu, HI 96822

Dear Mr. Murabayashi:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your comments and offer the following responses:

1. Should the proposed agricultural activities fail, either alternate crops would be cultivated or the use of the land would revert to existing uses (grazing). As in any other development, if the project fails, the investor experiences a loss.

2. The petitioner has the technical and entrepreunerial expertise to implement the proposed multi-agricultural activities. The Hawaii contact for Farms of Kapua is John Farias, Jr., former Chairman of the State Board of Agriculture. Mr. Farias has gathered together a knowledgable team of consultants for the various aspects of the proposed multi-agricultural activities. In addition, Mr. Farias, through his firm Agricultural Concepts, Inc., is managing a nursery in Punaluu, Oahu. The consultant on macadamia production is Frank S. Scott, Jr., an agricultural economist at the University of Hawaii at Manoa. The potential of the petition area for aquaculture was studied by Oceanic Institute. The consultant on pasture and cattle is Harold F. Rice, Jr. He is the owner of a ranch on 15,000 acres of leased lands and 2,000 head of cattle, partner in two other ranches, and is engaged in various other ranch and livestock services, including management consultant services. Ms. Sally Rice, manager of Farms of Kapua, helped establish and manage an intensive grazing system at Kahuku Ranch for 15 years, where stocking rates exceeded those of any ranch in Hawaii. At her own ranch at Puuwaanahulu, Ms. Rice grows and fattens 60 head a year on 100 acres of a'a and pahoehoe, with an annual rainfall of 15 inches (12 inches in 1983). Ms. Rice is also overseeing the development of a papaya farm in Kona.





3. Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation and 200 acre research and development areas. Irrigation is not being proposed in the 2,472 acre koa haole pasture area. Research conducted by Harold F. Rice Jr. indicates that there are areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing.

The expected demand and supply for water at Farms of Kapua was studied by John Mink and his report will also be appended to the EIS. Irrigation requirements by months, based on a moisture demand of 4.4 inches per month (Frank S. Scott Jr., Agricultural Feasibility of Macadamia Nuts Farms of Kapua, December 1982), have been computed by Mink for the historical record based on the Opihihale and Manuka rain gages and separately for the record at Kole Pen. The average deficit is estimated for Opihihale/Manuka at 1261 gpa/d, for Kole Pen at 1912 gpa/d. Estimates of the total average demands for irrigation, based on the least favorable record (Kole Pen) are given below. Irrigation rates for macadamia are assumed to be applicable to leuceana and other crops also.

| CROP | ACRES | AVERAGE (gpad) | TOTAL AV. (mgd) |
|---|---|---|---|
| Macadamia | 1710 | 1912 | 3.3 |
| Leucaena | 200 | 1912 | 0.4 |
| Other | 200 | 1912 | 0.4 |
| TOTAL | 2110 | | 4.1 |

Total average demand is equivalent to 2845 gpm. Assigning a yield of 1000 gpm to agricultural wells, three wells may be required to satisfy average demand.

An accurate determination of groundwater flow through Kapua is impossible because values for the parameters of the relevant equations are imprecise. However, analogy with similar Kona subsurface environments where some of these values have been refined suggests that flow at the coastline is at least of 6.0 mgd per mile. In the arid regions of North Kona and South Kohala, a thorough water balance study of the Water Resources Research Center at the University of Hawaii (B.Y. Kanehiro and F.L. Peterson, 1977, Groundwater Recharge and Coastal Discharge for the Northwest Coast of the Island of Hawaii: A Computerized Water Budget Approach: U.H. WRRC Technical Report TR-110)

indicated coastal discharge to likely be 6.38 mgd per mile and as much as 11.8 mgd per mile. This region does not experience rainfall as high as in Kapua. Within the petition area, total flow is between 8.0 and 18 mgd, and the most probable average is about 13 mgd. Not all of this flow is feasibly developable, however; sustainable yield on a continuous schedule is 6.0 to 7.0 mgd (total average demand is 4.1 mgd), but for periods of reasonable length (three months), Mink believes as much as twice the sustainable yield can be pumped without seriously affecting the quality of yield.

While the actual salinity of the water from the proposed irrigation wells is unknown, it is Mink's opinion that water of non-potable salinity (greater than 250 mg/l chloride) but fresh enough for agriculture and aquaculture exists less than four miles inland along the southern boundary of Kapua. Mink states that in the elevation range from 600 to 1000 feet, chloride content will probably be on the order of 500 to 700 mg/l at acceptable pumping rates. In 1980 the State drilled a well at Okoe (0953-01), about 3000 feet north of the Kapua boundary. The well produced water that stabilized at about 900 mg/l chloride at 700 gpm, a relatively good performance in view of the fact that the well lies only 1.6 miles inland of the nearest coast at Honomalino Bay. The comparable inland location in the mid portion of Kapua would be somewhat below elevation 400 feet.

Analyses based on data from other parts of Kona where hydrogeologic conditions resemble to an acceptable degree those at Kapua suggest that heads along a line through the center of the property increase as follows:

| Elevation (feet) | Distance from Coast (miles) | Head (feet) |
|---|---|---|
| 200 | 1.4 | 2.3 |
| 400 | 1.9 | 2.7 |
| 600 | 2.3 | 3.0 |
| 800 | 2.9 | 3.4 |
| 1000 | 3.4 | 3.6 |
| 1200 | 3.8 | 3.8 |

North of this center line distances from the coast to the same elevations are shorter and consequently heads at a given elevation are about 0.7 feet lower. South of it distances are slightly longer and heads are about 0.2 feet higher for the given elevations. Thus near the south boundary of Kapua the head at 1200 feet is calculated to be slightly over 4.0 feet.





4. As suggested, a vegetation map prepared by Kenneth M. Nagata, botanist, will be included in the EIS.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT
KAMAMANU BUILDING, 250 SOUTH KING ST., HONOLULU, HAWAII • MAILING ADDRESS: P.O. BOX 2359, HONOLULU, HAWAII 96804
GEORGE R. ARIYOSHI GOVERNOR
Kent M. Keith DIRECTOR
John R. Pingree DEPUTY DIRECTOR
Murray E. Towill

COPY

Ref. No. 8023

January 5, 1984

MEMORANDUM

TO: Mr. Gordon Y. Furutani, Executive Officer
Land Use Commission

FROM: Kent M. Keith, Director

SUBJECT: EIS Preparation Notice
Farms of Kapua, South Kona
Island of Hawaii

We have reviewed the subject preparation notice and have no comments to offer at this time.

Thank you for the opportunity to review the document.

cc: Group 70
Office of Environmental Quality Control

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

CHARLES G. CLARK
DIRECTOR OF HEALTH

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

In reply, please refer to:
EPHSD/SAN/DW

January 6, 1984

Ms. Sheryl Seaman
Group 70
924 Bethel Street
Honolulu, Hawaii 96813

Dear Ms. Seaman:

SUBJECT: EIS PREPARATION NOTICE FOR FARMS OF KAPUA, SOUTH KONA, HAWAII

This letter is in response to the Environmental Impact Statement preparation notice for the farms of Kapua, South Kona, Hawaii published in the December 8, 1983 edition of the EQC Bulletin. The Drinking Water Program would like to ensure that all pertinent issues related to or affecting the use of potable water be addressed in the environmental impact statement.

It is our understanding that the project consists of a 6,102 acre multi-agricultural project including a macadamia nut orchard, cattle pastures and corrals, and aquaculture facilities. A central water pumping facility to pump salt water from the ground into a reservoir and into various ponds and raceways is proposed to supply the aquaculture facility. Farms of Kapua also propose to develop several wells within the macadamia nut orchard. Potable and irrigation water systems will be constructed to supply the project with fresh water. Based on this understanding, the Drinking Water Program offers several comments.

Under the terms of Chapter 20, Title 11, Administrative Rules, a public water system is defined as a system serving 25 or more individuals at least 60 days per year or having a minimum of 15 service connections. Should the proposed water system qualify as a public water system, please be advised that Section 11-20-29 of Chapter 20 requires all new sources of potable water serving public water systems to be approved by the Director of Health prior to their use to serve potable water. Such approval is based primarily upon the satisfactory submission of an engineering report which adequately addresses all concerns as set down in Section 11-20-29. The engineering report must be prepared by a registered professional engineer and bear his or her seal upon submittal.

Section 11-20-30 requires that new or substantially modified distribution systems for public water systems be approved by the Director of Health. Such approval depends upon the submission of plans and specifications for the project prior to construction and the demonstration that the new or modified portions of the system are capable of delivering potable water in compliance to all maximum contaminant

levels as set down in Chapter 20 once the distribution system or modification is completed.

In the event that the proposed system is solely intended to serve irrigation or other nondomestic purposes, or if the proposed system will not serve the minimum number to qualify as a public water system as defined earlier, then the new system will not be subject to Chapter 20 requirements. However, if at some point in the future, the decision is made to use the water for potable purposes, or if the system expands to meet the minimum service population or number of service connections, the source and distribution system will be subject to all applicable terms and conditions of Chapter 20.

The existence of a potable water system, an irrigation system and a salt water system indicates a potential for cross-connection between the potable and nonpotable systems. Both the Department of Health and the Honolulu Board of Water Supply enforce regulations which help to protect against the existence of such cross-connections. We recommend that the irrigation and aquaculture systems be separate from the potable water system and care is taken to prevent backflow occurrences.

I hope this information will be useful to you. If you have any questions, contact the Drinking Water Program at 548-2235.

Sincerely,

Thomas E. Arizumi

THOMAS E. ARIZUMI
Supervisor
Drinking Water Program
Sanitation Branch
Environmental Protection and
Health Services Division

LB:dnn

Kazuo Ishihara AIA, Inc
Francis S. Oda AIA Inc
Robert K.L. Wong AIA Inc
Norman G.L. Hong AIA Inc

16 February 1984

Mr. Thomas E. Arizumi
Supervisor, Drinking Water Program
State of Hawaii
Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801

Dear Mr. Arizumi:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We appreciate the information provided on regulations regarding public water systems, however, please note that presently, only irrigation wells are being proposed. Only in the event that one of the irrigation wells yields water of potable quality, will the well be considered as a source for providing water for cattle and/or employees. The consulting engineer, R.M. Towill Corporation, is aware that in the event that the decision is made to use an irrigation well for potable purposes, or if the system expands to meet the minimum service population or number of service connections, the source and distribution system will be subject to all applicable terms and conditions of Chapter 20.

Furthermore, please be assured that the irrigation and aquaculture systems will not cross-connect. In the event that an irrigation well is used as potable water supply, a separate distribution system would be installed.

We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-4411

# University of Hawaii at Manoa

**Environmental Center**
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361


RECEIVED
JAN 11 1984
GROUP 70

January 6, 1984

PN:0028

Mr. Gordan Y. Furutani
Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Preparation Notice
Environmental Impact Statement
Farms of Kapua
Kapua, South Kona, Hawaii

The proposed "Farms of Kapua" project involves approximately 6,527 acres of land located within the Conservation Land Use District boundary, and proposes the creation of a 1,700 acre macadamia orchard, a 2,500 acre controlled pasture area for cattle, 200 acres of cultivated Koa haole, 200 acres of research and development of alternative crops, and a 1,500 acre aquaculture facility. A petition requests the reclassification of approximately 6,102 acres of Conservation District Lands to the Agricultural Land Use District. Four hundred twenty-five acres will remain in Conservation.

The Center does not normally review EIS documents at the Preparation Notice stage. However, due to the amount of interest in this particular project we have coordinated a review of possible specific areas of concern that the preparers of the Draft EIS should address. The Environmental Center's comments have been prepared with the assistance of Winona Char, Botany; Sheila Conant, General Science; Joseph Halbig, Geology-UH Hilo; Philip Helfrich, Hawaii Institute of Marine Biology; Matthew Spriggs, Anthropology; Jacquelin Miller, Lee Hannah, and Pamela Bahnsen, Environmental Center.

Fauna

It is stated on page 27 that, "Because of the mostly exotic vegetation on-site, there is little likelihood that the site provides habitats for native Hawaiian or endangered Hawaiian avifauna." This is a false assumption. It is highly likely that the Hawaiian Hawk or 'Io could inhabit this area since it has adapted quite well to changed environments. According to the updated (November 1983) listing of "Endangered and Threatened Animals and Plants of Hawaii," distributed by the Department of Land and Natural Resources, the 'Io is considered to be endangered by both the federal and state governments. It is also possible that the





Hawaiian Owl or Pueo, the 'Elepaio, and the 'Amakihi, which are all endemic to Hawaii, could have adapted to the "mostly exotic vegetation on-site." It is inappropriate to base conclusions regarding the presence or absence of avifauna on the results of a botanical survey. Thus we would suggest deletion or qualification of the following sentence, "During the botanical survey of the site, there were no observations of endangered Hawaiian avifauna". We suggest that a qualified ornithologist conduct an avifaunal study of the project area and that in particular a search for 'Io nests be conducted. The U.S. Fish and Wildlife should also be consulted. The 'Io utilize the same nests year after year and so if nests were located, the project's activities could possibly be coordinated so as not to disturb the 'Io's breeding activities.

The statement is made that, "If any of the species [Hawaiian (Hoary) Bat] is inhabiting the site, they would normally relocate to more suitable environs...." Evidence is not provided to support this statement. The Bat tends to have a home range to which they return and they may not relocate. It is also not known what habitat is "suitable" for the Hawaiian Bat.

The listing of birds "presumed to inhabit the site" should include the Hawaiian (Barn) Owl or Pueo and the Hawaiian Hawk or 'Io along with a number of game birds, such as the Ring-necked Pheasant and the California Quail.

The discussion (p. 28) of "Impacts" states that most species disturbed during land clearing operations will re-inhabit the area after crops are planted. The validity of this assumption is highly questionable. In the first place, adjacent undisturbed areas are likely to contain the sustainable populations of species for any particular habitat. Secondly, the new habitats to be created are sufficiently foreign to the pre-existing habitats to make them unacceptable to many of the previous inhabitants. The section on impacts should be expanded and the magnitude and significance (if any) of the gains or of the biota more quantitatively and accurately indicated.

The proximity of the planting of the Koa haole to the Manuka Natural Area Reserve and the proposed aerial seeding and fertilizing raises some concern as to the potential for impacts on the Reserve.

Vegetation

The botanical reconnaissance (Technical Appendix D) prepared for the Environmental Study (referred to on p. 26 of the EIS Preparation Notice) is preliminary in nature and was executed primarily along accessible areas, i.e., along or adjacent to existing jeep roads.

We note on page 4 of Appendix D that the botanist who conducted the reconnaissance survey clearly stated the limitations of the survey as follows:

> The intent of the survey was to obtain a general description of the flora in the project site. It is preliminary in nature and the existence of additional species not already listed on the Species Checklist cannot be precluded. Furthermore, because no systematic transect procedure was employed, and no quantitative data was obtained, the broad vegetation types are based on qualitative observations. The existence of smaller plant communities and sub-types is probable.

It would follow then, that a determination on the botanical environmental impacts cannot be conclusively stated. A more thorough botanical survey employing systematic transects and interpretation of recent aerial photographs for areas containing kipukas needs to be conducted and the findings addressed in the Draft EIS.

J.F. Rock, the noted Hawaiian botanist, in his Indigenous Trees of the Hawaiian Islands (1913) wrote that Kapua contained one of the few extremely rich dryland forests left on the island of Hawaii.

> Beside Kipuka Puaulu near the Volcano House, there are only two districts on Hawaii which possess an extremely rich and xerophilous flora, namely, Puuwaawaa in North Kona, and its rival Kapua in South Kona.

Kipukas with well-developed native elements are scattered throughout the rocky a'a. Even in this limited survey the botanist who conducted the reconnaissance reports pockets of remnant native forest especially in the upper elevation areas (900-1300 ft.) of the proposed project site. The archaeologist in his reconnaissance survey (Appendix E, page 13) also notes the "particularly distinctive Kipuka and a'a lava flows," as part of Kapua's vegetation patterns.

Although no officially listed endangered species of plants were found within the project site, several rare species such as Colubrina oppositifolia (kauila) and Canavalia hawaiiensis do occur on the site (page 3). If the Pleomele found in the study area should prove to be P. hawaiiensis (halapepe), then it is a species on the proposed list of endangered species. There is some possibility that Drypetes phyllanthoides (mehamehame), a proposed endangered species currently being reviewed by the U.S. Fish and Wildlife Service, may be present in the upper elevations of the study area. It has been collected from Kapua.

The Draft EIS should include a discussion of all the rare species found. Sensitive areas containing native plants should be identified and a discussion of the project's impacts on these areas and possible mitigating actions that may be incorporated to preserve these native species should be discussed in detail. The botanist's recommendations for preservation of a portion of the project site containing several rare native species (Appendix D, p. 24) should also be discussed.

It should be noted that one of the Significance Criteria (Section 1:31a.9.), as stipulated in the Environmental Quality Commission's Environmental Impact Statement Regulations, applies to actions that "substantially affect a rare, threatened or endangered species of animal or plant, or habitat." It is important to note that this criteria applies to "rare" or "threatened" species, and that the significance is not limited to species officially recognized as endangered.



There needs to be a complete discussion presented on the possible impacts of this project on the Manuka Natural Area Reserve. For example, the planting of 200 acres of Koa haole may have a serious impact on the Reserve due to its high potential for naturalization (i.e. spreading like a weed to the Reserve). The seed source and type of Koa haole to be used should be addressed.

A discussion of the mitigative measures that will be utilized to guard against exotic seeds being introduced into the Reserve's protected ecosystem should be included in the Draft EIS. The necessary land clearing activities for the Mac-nut planting or grass planting has the potential for stirring up seeds or propagules of exotic plant species which might then settle on the Reserve and become established. The potential impacts that may result of the proposed method for the Guinea grass seeding should also be addressed.

Historical/Archaeological Resources

The methodology utilized in determining that 425 acres will "remain in Conservation in recognition of the concentration of archaeological sites located in that area" should be discussed (p. 30). Many significant sites in the northern part of the property, mauka of this 425 acre reserve, are linked to sites in this reserve by trails and form together integrated complexes. Discussion should include the criteria utilized for not including sections of the northern part of the property and areas of the southern part in the vicinity of sites 9939, 9440, 3705, and 3706. Although inclusion of the later in the reserve area may entail deletion of one of the proposed aquaculture ponds, placement of ponds in the immediate vicinity of and between the sites, would seem to destroy their context as a linked series of site complexes. The extension of the reserve area would thus ensure that the proposed aquaculture feature would not impinge on these already known and significant archaeological sites. We note in relation to this that much of the aquaculture area has not been surveyed archaeologically. Hence, further discussion is needed regarding the placement of the aquaculture modules, with respect to preserving "the archaeological features of the coastline" (p. 8). Proper view corridors and buffer zones need to be addressed in relation to preservation of sites outside the reserve area.

We suggest that the Draft EIS address, as an alternative use, the incorporation of this makai area into a "State Natural Recreational and Historic Park at Kapua, Honomalino, Okoe, Kaulanamanua and Manuka" as recommended by DLNR, Division of State Parks (see attached memo of 12/10/71).

We note that approximately 75 percent of the property was not surveyed. Hence the statement, "that the archaeological remains are generally distributed, in terms of nature, density and significance, in an overall pattern congruent with and favorable to layout and scale of the project" may be inappropriate (p. 30). The lack of an intensive survey and test excavations makes it difficult to form a basis on which to formulate a decision (i.e. mitigation versus preservation). Discussion regarding sites such as the newly found refuge cave (Spriggs, 1983-appended) and other selected archaeological sites in relation to preservation should be addressed in the Draft EIS. Earlier concerns as to the adequacy of the archaeological survey of the area resulted in a field survey by our archaeological reviewer at the request of the Pa'a Pono Miloli'i. A copy of his field report is attached for your use and information in preparing the Draft EIS.

It is suggested that the archaeologist (Rosendahl) second recommendation be incorporated prior to the issuance of the Draft EIS, namely:

> ...immediate consultations should be held with the Hawaii County Planning Department to determine as specifically as possible the probable requirements to be imposed as permit conditions for S.M.A. and/or rezoning applications. In general, it can be anticipated that intensive archaeological survey work, including both detailed surface survey and test excavations, will be contained within these requirements. It is also considered quite probable that the Hawaii County Planning Department might require preparation of a written archaeological-historical resource management plan, including a combined research design and data recovery plan element, as an S.M.A. and/or rezoning condition. At the same time, the exact scope and scale of any such further archaeological work will depend to a large extent upon specific development plans and priorities. It can also be assumed that further archaeological reconnaissance survey will required for any specific areas within the project area under active development consideration, but which were not covered as part of the sample survey areas inspected during the initial reconnaissance survey work. (Technical Appendix E, p. 32)

On page 8, it is stated that "off-site improvements will include the extension of electrical and telephone lines and the resurfacing of existing access roads from Mamalohoa Highway" and that subject to approval "approximately 3,000 feet of transmission lines, and a pump and controls at the well site, will need to be installed in order to bring the water to the project site." The Draft EIS should include discussion of the possible impact these actions may have on archaeological resources as well as other environmental resources. Okoe contains many archaeological sites, including prehistoric field systems in its mauka area.

Water Resources and Usage

The preparation notice states (p. 17, para. 5) that John Mink considers the groundwater conditions found at the State Okoe well "a favorable indication of the groundwater resources in the Kapua area." It indicates that the Okoe well 1600 ft. inland from the shore produced 700 gpm (1 mgd) of water of 900 mg Cl/l, and notes that at this distance from the shore the ground elevation in Kapua is 400 ft. The notice also states (p. 18, para. 3) that the proposed macadamia orchard will require approximately 2.2 mgd for irrigation under average conditions, and 6.8 mgd during drought. It proposes (para. 4) that water from the Okoe well be used, but that additional water will be needed for blending because the chlorinity of the Okoe well water is too high for macadamia irrigation (para. 5). It proposes to get the additional water from 2 to 4 new wells at 800 to 1000 ft. elevations, suggesting a pump capacity of 1.4 mgd for each well. The notice later quotes (p. 19 last para.) estimates by Mink that the groundwater discharge at the coastline is 6 mgd/mi, or 8 to 18 mgd and probably about 13 mgd average along the Kapua coastline, a sustainable yield of 6 to 7 mgd within Kapua, and a safe yield double that for period of about 3 months.



The yield of the Okoe well suggests that the 2.2 mgd water needed for macadamia irrigation might be provided by 2 to 4 new wells, especially if the water they produced draft were augmented as suggested from the Okoe well. However, the preparation notice does not indicate what chlorinity is expectable in the water from the proposed new wells. According to John Mink (in Engineering Analysis for Farms of Kapua, June 1983, R.M. Towill Corp.) the chlorinity of wells drilled from elevations of 600 to 1000 ft. "will probably be on the order of 500 to 700 mg/l at acceptable pumping rates. The preparation notice does not indicate what the salinity tolerance of macadamia is, but if Mink is correct, the amount of water from the new wells to be mixed with that from that of the Okoe well would have to be many times that from the Okoe well if the mixed water were to have a chlorinity substantially less than 900 mg/l, and it would be impossible to obtain water with a chlorinity less than 500 mg/l even if no water from Okoe were used.

The preparation notice also states (p. 18, para. 3) that about 0.3 mgd irrigation water would be needed for maximum yield of leucaena, and that "the pasture area...may occasionally be irrigated if excess water is available from the wells." The EIS should show that there is a reasonable expectation that the combined macadamia, leucaena, and pasture irrigation demands can be met with respect to the combination of the quantity and quality and that the proposed "occasional" irrigation of pasture is reasonable economically.

The preparation notice holds out hope (p. 18, last para.) that one of the proposed new wells may yield potable water, and may be used as a source of water for the cattle and a standby source for the employees. The potability requirements for cattle and people are very different. It seems possible indeed that the salinity tolerance of the cattle is higher than that of macadamia if the Okoe well water cannot be tolerated by the macadamia. Mink's estimate provide no basis for expecting water meeting the standard for human consumption, 250 mg Cl/l, can be drawn from the proposed well.

Natural Hazards

The earthquake risk zone scheme to which reference is made (p. 20, para. 2) is the Uniform Building Code scheme in which there are 5 zones, not 4 as stated. (Zone 4 has been mapped only in California and Nevada.)

The preparation notice states (p. 20, para. 6) that: "There have been at least 5" locally generated tsunamis along the Kona Coast." Hawaii Institute of Geophysics HIG 77-14, lists as tsunamis generated on the Kona coast, two definite, a third probable, and a fourth very doubtful, as well as two generated on the SE Puna-Kau coast that had significant runups on the Kona coast. There is, in addition, a Milolii tradition of a tsunami that does not fit any of the events listed in the HIG report. The 1946 tsunami, mentioned in the notice as if locally generated, came from the Aleutian Islands.

The notice states that "...no measurable tsunami runups were recorded in this location for more recent tsunamis" (p. 20, para. 5). This is true, but only because no measurements have been made. The Corps of Engineers has estimated the near-shore 100-year tsunami runup height in the Kapua vicinity as 7 or 8 ft.

Aquaculture Wastewater

The notice states (p. 40, last para.) that the aquaculture wastewater will be disposed of by infiltration ditches, and that it will be "collected in an open ditch, which will serve as a culture trough for seaweed which will filter the water of any contaminants before it infiltrates into the underlying lava."

Seaweed will remove contaminants such as nutrients. However, the removal is not by filtration but by uptake. Considering the average infiltration capacity of the fresh lavas in the area, there is little question that areas can be found in which the approximate 6 mgd of salt wastewater (p. 19) can be disposed of as proposed. However, if the infiltration from the "open ditch-culture trough" is high, most of the nutrients may infiltrate before they can be taken up by the algae. The costs of disposal of the wastewater would thus be minimized but the nutrient removal also minimized. The effects of increases in nutrient concentration in the Class AA waters close to shore will be identical whether the increases result from surface or groundwater discharge. Hence it may be necessary to incur more than minimal costs for wastewater disposal in order to minimize the nutrient loads reaching the Class AA waters.

General Comments

The EIS should address the economic analysis that supports the requested land use change. Since the economic benefits are so important in determining the balance between conservation and development, the economic benefits would then be the basis for the justification of the transfer of the land from Convservation to Agriculture. The Land Use Commission should have that information available to them so that they can rationally evaluate the potential viability of the project. Should the project not prove economically viable, would the land be reclassified Conservation or subdivided into a farm development?

We also suggest that a discussion of the original rationale for classifying this area Conservation be included in the Draft EIS.

A map depicting the relationship between the archaeological sites, the sensitive vegetation areas, the proposed water wells, the proposed electric substation, the proposed project structures and areas, the Manuka Natural Reserve and the other abutting land uses would be a helpful addition in the Draft EIS.

We appreciate the opportunity to comment on this EIS Preparation Notice and hope you will find our comments useful in the preparation of the Draft EIS.

Yours truly,

Doak C. Cox
Director

Appendix

Enclosure



cc: OEQC
EQC
Group 70✓
Winona Char
Sheila Conant
Joseph Halbig
Philip Helfrich
Matthew Spriggs
Jacquelin Miller
Lee Hannah
Pamela Bahnsen

# University of Hawaii at Manoa

**Environmental Center**
**Crawford 317 • 2550 Campus Road**
**Honolulu, Hawaii 96822**
**Telephone (808) 948-7361**



RECEIVED
JAN 20 1984
GROUP 70


January 18, 1984

(PN:0028)

Mr. Gordan Y. Furutani
Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Preparation Notice
Environmental Impact Statement
Farms of Kapua
Kapua, South Kona, Hawaii

In our recent review of the assessment and preparation notice in the proposal to reclassify now-conservation land on Hawaii for the Farms of Kapua we commented on the tsunami hazard along the coast. We did not comment on the hazard associated with storm waves. In connection with the latter the following information on an event in January 1872 from Cox and Morgan "Local tsunamis and possible local tsunamis in Hawaii" (Hawaii Inst. of Geophys., HIG 77-14, 1977) may be of interest:

"The Hawaiian Gazette on 7 February carried accounts of damage on the island of Hawaii from southerly waves associated with a southerly gale... that commenced on Sunday the 22nd ult.' [The date and day of the week do not match. The event might have occurred on Sunday, 21 January or Monday, 22 January, 1872.] The reports included the following: 'The village of Kapua was visited by a tidal wave, which swept away several houses near the beach besides causing the damage. In the midst of so much destruction, it is fortunate that no lives were lost, although instances occurred where persons escaped in an almost miraculous manner."

Cox and Morgan commented that what was referred to as a "tidal wave" was clearly not a tsunami, but storm waves.

Yours truly,

Doak C. Cox
Director

AN EQUAL OPPORTUNITY EMPLOYER



cc: OEQC
Group 70
Winona Char
Sheila Conant
Joseph Halbig
Philip Helfrich
Matthew Spriggs
Jacquelin Miller
Lee Hannah
Pamela Bahnsen

Kazo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

17 February 1984

Dr. Doak C. Cox
Director
Environmental Center
University of Hawaii at Manoa
Crawford 317
2550 Campus Road
Honolulu, HI 96822

Dear Dr. Cox:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your letters of 6 January 1984, and 18 January 1984, and offer the following responses:

Fauna

1. As suggested, an avifaunal survey of the petition area has been conducted by Dr. Andrew J. Berger. Berger sighted the Io at least one mile up slope from the upper boundary of the petition area. The Pueo was also seen, at an elevation of approximately 1,100 feet. It is the opinion of Berger that since both species now forage over macadamia orchards, pasture land and other introduced vegetation on the Kona coast, the proposed action would have no adverse impact on these species.

2. In his bird and mammal report that he prepared for the Farms of Kapua, Berger states that: "As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macadamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight."

3. Berger did not see any Ring-necked Pheasant or California Quail during his avifaunal survey.

4. Berger states in his report that "Rarely during my field work in the Hawaiian Islands during the past 19 years have I seen such a poor habitat for birds and mammals as in the Kapua Farms petition area." While the site may contain roosting sites of the Hawaiian bat, all of the remaining mammals found on the site are introduced species, and all of these are considered pests to





man, his activities and products, and/or to native vegetation and fauna. As previously mentioned, Berger states that unless their roosting sites are damaged, the proposed activities would have no adverse effects on the bats. The two species of endangered Hawaiian birds (the hawk and the owl) seen on or adjacent to the project site have adapted to the introduced vegetation on the island of Hawaii, primarily because of their feeding habits and the extent of their home range.

There is unlikely to be any pristine habitats directly adjacent to the north and south of the petition area. The area directly south of the petition area has been described in the Manuka Natural Area Reserve Management Plan - 1982 as follows: "From the coastline to about 4 miles mauka, the landscape is of barren lava fields with some grassland." Aerial infrared photos of the boundary between the MNAR and the petition area concurs with this description. Review of infrared photos of the boundary to the north, indicate a similar habitat to the one provided by the petition area. As described in the previous paragraph, all of the birds and mammals found on site have appeared to have adapted to introduced vegetation.

5. The petitioner proposes that there will be 300 foot buffer along the border of the MNAR, which will be left in its existing condition, unseeded and unimproved. The phasing of the koa haole pasture area will be in approximately 400 acre increments per year. Whenever a large enough portion of area is readied, aerial seeding will be conducted up to within 300 feet of the buffer to the MNAR. Please note that at no point have we proposed to apply fertilizer by air.

Vegetation

1. Based on his earlier survey, Kenneth M. Nagata returned to Kapua to determine the extent of the native dry forest at the mauka boundary of the petition area, to ascertain the integrity of that forest and to seek out any rare and endangered species in that section. As a result of the reconnaissance conducted early in 1983 and through the aid of excellent infrared aerial photographs, the native dry forest was plotted on a black and white aerial photograph at the scale of 1:24,000. In areas devoid of native forest only spot surveys were made. All large groves of native vegetation below the contiguous forest were investigated. In the native forest, north-south transects were established approximately 50 meters apart. All significant ravines were surveyed.

2. In summary, Nagata found very little of the native dry forest actually extends into the petition area. The condition of this portion of the forest is regarded as poor and not the same rich forest of which Joseph Rock wrote in 1913.

3. Please note that Nagata's earlier survey extended beyond the mauka boundary of the petition area. There were only three small areas of native forest found within the petition area. Their approximate locations will be indicated in a general vegetation map of the site, which will be included in the EIS.

4. Nagata found a single kauila tree on an old a'a lava flow near the Kaulanamana flow. The tree is festooned with the parasistic kauna'oa-pehu. Two trees of Bobea timonioides are located nearby. Two individuals of halapepe (Pleomele sp.) were also discovered in the petition area. One of the halapepe was considered healthy and was located in a deep, steep-sided, collapsed lava tube. Nagata did not find any Drypetes phyllandthoides (mehamehame) during his latest survey. He has recommended that approximately 20 acres, including the kauila and Bobea trees be set aside and managed as a preserve. It is the petitioner's intent to comply with his recommendations.

5. Since the single kauila (Colobrina oppositifolia) and the three halapepe, which have been tentatively identified as (Pleomele aurea) were found in a gulch located approximately 2,440 feet from the mauka boundary of the petition area, a discussion of their preservation would be inappropriate for this EIS.

6. We note your interpretation of Section 1:31a.9. of the EIS Regulations.

7. To date, there is no known botanical survey that has been conducted in Manuka Natural Area Reserve (MNAR). However, as previously mentioned, the area directly south of the petition area has been described in the Manuka Natural Area Reserve Management Plan - 1982 as "barren lava fields with some grassland."

   According to Nagata, koa haole is spread primarily by cattle and by man (through planting). Since the boundaries of the koa haole pasture area will be fenced, this would effectively prevent animals from straying into the MNAR and would halt the spread of koa haole attributable to cattle. As stated earlier, the petitioner proposes a 300 foot buffer along the border of the MNAR, which will be left in its existing condition, unseeded and unimproved. The exact type of koa haole and seed source has not yet been determined. Because of the proposed fencing and





   the establishment of a buffer zone, the chances of koa haole naturalization into the MNAR as a result of the proposed actions is anticipated to be equal to existing conditions.

8. As noted in Nagata's earlier report, much of the petition area consists of sparse scrub grassland. As previously stated, fencing the boundaries of the koa haole pasture area would effectively halt the spread of grass seeds attributable to cattle. While the seeds of guinea and other grasses can spread by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds. Guinea grass will be seeded by hand. Therefore, the impact of land clearing and/or seeding on the naturalization of guinea grass in the MNAR through is likely to be no greater than presented by existing conditions. Guinea grass already exists on site.

Historical/Archaeological Resources

1. As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the sites previously recorded and most of the features that were found by the consulting archaeologist, Paul H. Rosendahl, during his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. The 300 foot setback allows unobstructed access along the shoreline. It is for these reasons that this area is proposed to be left in Conservation.

   With regard to not including sections of the northern inland area within the 425 acre area to be left in Conservation, it should be noted that preservation has not been ruled out for any sites found, on the basis of subsequent archaeological work, to deserve or be appropriate for preservation. Such determinations would be made on the basis of the findings of intensive survey work. The retention of significant historic sites outside of the Conservation District could be accomplished through a preservation program within the context of a archaeological/historical resource management plan. The possible need for this latter plan and the need for intensive level work was anticipated and described on pages 32 and 33 of Rosendahl's Archaeological Reconnaissance Survey Farms of

Kapua. It is the petitioner's intent to implement these recommendations.

We concur to the extent that specific siting of the proposed aquaculture modules is not indicated in the NOP, however, this is not appropriate for the current level of planning (petition to amend the Land Use Conservation District Boundary). Information adequate for specific placement of facilities, with regard to the location of archaeological sites, as well as appropriate mitigation activities, would be available after the completion of intensive survey work.

2. We will discuss the establishment of a park on the petition area in the section, ALTERNATIVES TO THE PROPOSED ACTION. We feel that retention of the above described shoreline areas in the Conservation District is in keeping with the expressed intent of S.R. 65 (1983). In addition, please note that the petitioner will generally maintain the present unobstructed lateral access along the shoreline, north and south of the petition area.

3. Such a statement concerning congruence and favorability would be inappropriate were one discussing the on-site placement of specific development facilities on the basis of reconnaissance survey findings alone; but as recommended on pages 32 and 33 of Rosendahl's Archaeological Reconnaissance Survey Farms of Kapua, intensive survey work is yet to be conducted. The determination made on the basis of the reconnaissance survey findings is appropriate, when it is realized that the level of specificity involved is very general. Specific mitigation vs. preservation decisions are not required at this stage of the planning process (petition to amend the State Land Use boundary). These decisions will be made later, on the basis of intensive survey findings.

   A response to Spriggs report is enclosed for your information.

4. The citation was taken out of context. Rosendahl's second recommendation specifically states that such consultations should be undertaken immediately after the State Land Use boundary change has been approved.

5. We concur that the potential for possible impacts could be mentioned in general terms. However, specific impacts cannot be evaluated until specific facilities plans have been prepared. Specific facilities plans in regards to utilities would probably follow additional archaeological work in preliminary utility corridors chosen by the civil engineer. If any sites of significant archaeological value are found, then the





archaeologist can make a recommendation in his cultural resources management plan whether preservation is necessary or if salvage excavation is appropriate. The final alignment of utility corridors would then be finalized. We feel by following this process, there should be no adverse impacts to archaeological sites. An archaeological survey of the corridor of the transmission lines from Okoe Well would be appropriate after receiving the State's approval of use of the well. Also, please note that the proposed extension of utility lines and resurfacing of existing access roads from Mamalahoa Highway would pass through the area occupied by MacFarms Inc. This area has already been substantially altered in the development and operation of macadamia orchards.

Water Resources and Usage

1. The expected chlorinity of the proposed wells will be discussed in the EIS. Experiments are about to commence on the salinity tolerance of macadamia and other crops at a site mauka of the petition area. If the chloride content of water from Okoe Well or from the proposed irrigation wells is greater than what can be tolerated by macadamia, then the use of water from these sources would be discontinued and well(s) may be drilled out of the petition area, probably at the 1200-foot elevation.
2. Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation area and 200 acre research and development area. Irrigation is not being proposed in the 2,472 acre koa haole pasture area. Research conducted by the Farms of Kapua consultant on pasture management, Harold F. Rice Jr., indicates that there are areas in West Hawaii at similar elevations (to the 2,472 acre koa haole pasture area), with similar rainfall, which are not irrigated, which are vegetated with haole koa and are used for grazing.

   The expected demand and supply for water at Farms of Kapua was studied by John Mink and his report will also be appended to the EIS. Irrigation requirements by months, based on a moisture demand of 4.4 inches per month (Frank S. Scott Jr., Agricultural Feasibility of Macadamia Nuts Farms of Kapua, December 1982), have been computed by Mink for the historical record based on the Opihihale and Manuka rain gages and separately for the record at Kole Pen. The average deficit is estimated for Opihihale/Manuka at 1261 gpa/d, for Kole Pen at 1912 gpa/d. Estimates of the total average demands for irrigation, based on the least favorable record (Kole Pen) are given below. Irrigation rates for macadamia are assumed to be applicable to leuceana and other crops also.

| CROP | ACRES | AVERAGE (gpad) | TOTAL AV. (mgd) |
|---|---|---|---|
| Macadamia | 1710 | 1912 | 3.3 |
| Leucaena | 200 | 1912 | 0.4 |
| Other | 200 | 1912 | 0.4 |
| TOTAL | 2110 | | 4.1 |

Total average demand is equivalent to 2845 gpm. Assigning a yield of 1000 gpm to agricultural wells, three wells may be required to satisfy average demand. Since the sustainable yield of the underlying aquifer is estimated to 6 to 7 mgd, there should be adequate water for the proposed agricultural activities.

3. We concur that the potability requirements for cattle and humans are different. According to Harold F. Rice, Jr., cattle can develop a very high tolerance for brackish water in a short period of time.

   For further clarification, the last paragraph on page 18 of the NOP can be reworded as follows: "If one of these irrigation wells yields water of potable quality, it may be used as a standby source for potable water for employees."

Natural Hazards

1. We appreciate the information provided. The EIS will incorporate this information. Please note that the shoreline fronting the aquaculture area consists primarily of bluffs of lava dropping off into the ocean. In addition, elevations along 300 feet inland of the aquaculture area were studied (no development is proposed within this setback), and it was discovered that near the northern boundary of the aquaculture area, 300 feet inland, the elevation was approximately 26 feet. Proceeding south along the shoreline, elevations 300 feet inland average approximately 40 feet. This is well above the Corps of Engineers estimates for near-shore 100-year tsunami runup height of 7 or 8 feet.

Aquaculture Wastewater

1. As suggested, the second sentence of the last paragraph, of page 40, will be revised to read: "The salt water will be collected in a culture trough for seaweed which will remove nutrients from the water before it infiltrates into the underlying lava."





2. The wastewater produced from the aquaculture modules is basically brackish water that has been cycled through the production units holding the various species. The wastes from one species are used as nutrients by the following species and in this way the water is filtered. The final wastewater contains no human contamination and consists basically of some remaining fecal matter from marine organisms, excess feed, and some algal and plant matter. The wastewater will be collected in a culture trough for seaweed, which will remove nutrients from the water before it infiltrates into the underlying lava.

   Please note that water from the seaweed culture trough can be tested for contaminants to check the efficiency of the system.

General Comments

1. The economic benefits of the proposed aquaculture, macadamia and cattle production activities were covered in appendices F, G and H of Exhibit 1, Volume 2, Land Use Commission Petition A83-554 and was available to the Commission. The information was provided so that the Commission would be able evaluate the potential viability of the project. If aspects of the proposed activities fail then an alternative agricultural use or crop will be tried. Two-hundred (200) acres of the petition area is proposed to be set aside for research and development. The experiments with crops in this area can provide the basis for agricultural development in areas of West Hawaii or in areas worldwide with similar environmental conditions.

2. Gordon Furutani, Executive Director of the Land Use Commission has been consulted regarding this matter. According to Mr. Furutani, research into the original rationale for classifying an area is conducted whenever a petition is filed. In some cases, the exact reasons for a land use designation is documented. In the case of the petition area, Mr. Furutani was unable to find any specific documentation.

3. The relationship between the proposed multi-agricultural uses of the petition area and archaeological sites, existing general vegetation zones, and neighboring areas will be shown on separate illustrations in the EIS. The engineering consultant's report will include figures showing the possible sites for the irrigation wells and the electrical substation. Indicating all of the requested information on one map would be confusing and illegible.

Letter of 18 January 1984

1. We appreciate the information provided. Unfortunately the account did not include an estimate of the runup height. It can be inferred from the account that only houses near the beach were swept away. According to conversations with long-time residents of the region, at one time, the beaches of Kapua, Oea and Okoe (all located within the 2,000 foot setback proposed to be kept in Conservation) were habitated. At Kapua, foundations of former houses are located within 100 feet of the shoreline. Note that no action is proposed within the Conservation area. As noted elsewhere, the shoreline fronting the aquaculture area consists primarily of bluffs of lava dropping off into the ocean. In the event of a storm warning, appropriate actions will be taken to secure the aquaculture products and facilities.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

Encl. (1)

COPY

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII

25 AUPUNI STREET • HILO, HAWAII 96720

December 9, 1983

RECEIVED
DEC 13 1983
GROUP 70

Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, HI 96813

EIS PREPARATION NOTICE
APPLICANT - FARMS OF KAPUA
TAX MAP KEY 8-9-06:03

The Department has no water system in the area.

Should the property be subdivided, requirements of our Rules and Regulations as well as our Standards for Water Systems shall be complied with.

H. William Sewake
Manager

DA

cc - Group 70, ATTENTION: MS. SHERYL SEAMAN

*Water brings progress*

Kazuo Ishihara AIA, Inc
Frances S Oda AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

4 January 1983

Mr. H. William Sewake, Mgr.
Department of Water Supply
County of Hawaii
25 Aupuni Street
Hilo, HI 96720

Dear Mr. Sewake:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We appreciate the information provided. We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-4111

PLANNING DEPARTMENT

25 AUPUNI STREET • HILO, HAWAII 96720
(808) 961-8288

COUNTY OF HAWAII

HERBERT T. MATAYOSHI
Mayor

SIDNEY M. FUKE
Director

DUANE KANUHA
Deputy Director

December 27, 1983

LAND USE COMMISSION
STATE OF HAWAII
DEC 30 11 40 AM '83

State Land Use Commission
Old Federal Building Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Gentlemen:

Notice of Preparation of an Environmental Impact Statement
Farms of Kapua, SLU Boundary Amendment
Conservation to Agriculture District

We have reviewed the subject preparation of notice for an Environmental Impact Statement covering the proposed macadamia nut farm, aquaculture project and cattle raising operations at Kapua, South Kona, Island of Hawaii.

We suggest that the EIS further detail the description of existing conditions and potential impacts in the subject areas of vegetation, historic sites and water resources.

These descriptions should include maps showing the areas surveyed and overlays of project uses over these maps. The discussions should include details of methodology or rationale for solution of survey areas.

The discussion of impacts to vegetation should include those indirect impacts which may result on the neighboring natural area reserve, as well as direct impacts to native vegetation in kipuka areas.

The EIS should also be carefully edited to assure that numbers (in terms of acreage, distances, etc.) and project description are consistent with those being proposed in the Land Use Boundary amendment petition.

We note a basic inconsistency between the preparation notice which essentially is an assessment that there will be impacts to the environment and the summaries of impacts to the various aspects of the environment e.g. vegetation, topography, etc. which note little or marginal impacts in all areas.



Should you have any further questions, please do not hesitate to contact Norman Hayashi of my staff at 961-8288.

Sincerely,

Duane Kanuha

SIDNEY FUKE
Director

VKG:lgv

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

16 February 1984

Mr. Sidney Fuke
Director
Planning Department
County of Hawaii
25 Aupuni Street
Hilo, HI 96720

Dear Mr. Fuke:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your comments and offer the following responses:

1. As suggested, we will include in the EIS, maps of the vegetation survey, archaelogical survey and possible well sites, with overlays of general project uses. Please note that because of the agricultural nature of the project, there is flexibility in the siting of wells, roadways, macadamia trees, haole koa, aquaculture facilities around significant historic sites, and rare and endangered plant species. The methodology and rationale for the vegetation and archaeological surveys, as well as the selection of well sites will be included in the consultant reports, which will be appended to the EIS.

2. According to the consulting botanist, Kenneth M. Nagata, koa haole is spread primarily by cattle and by man (through planting). Since the boundaries of the koa haole pasture area will be fenced, this would effectively prevent animals from straying into the MNAR and would halt the spread of koa haole attributable to cattle.

   The petitioner proposes that there will be 300 foot buffer along the border of the MNAR, which will be left in its existing condition, unseeded and unimproved. The phasing of the koa haole pasture area will be in approximately 400 acre increments per year. Whenever a large enough portion of area is readied, aerial seeding will be conducted up to the 300 foot buffer to the MNAR. The boundaries of the planting area will be marked by flagman during seeding. Guinea grass will be seeded by hand. While seeds of the guinea grass may spread by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds.





3. Based on his earlier survey, Kenneth M. Nagata returned to Kapua to determine the extent of the native dry forest at the mauka boundary of the petition area, to ascertain the integrity of that forest and to seek out any rare and endangered species in that section. In summary, he determined that very little of the native dry forest actually extends into the project site.

   Mr. Nagata found a single kauila tree on an old a'a lava flow near the Kaulanamana flow. The tree is festooned with the parasistic kauna'oa-pehu. Two trees of Bobea timonioides are located nearby. Two individuals of halapepe (Pleomele sp.) were also discovered in the petition area. One of the halapepe was considered healthy and was located in a deep, steep-sided, collapsed lava tube. Mr. Nagata has recommended that approximately 20 acres, including the kauila and Bobea trees be set aside and managed as a preserve. It is the petitioners intent to implement this recommendation.

4. As per your recommendation, every effort will be made to assure that acreage, distances, etc., are consistent with those being proposed in the petition to amend the Conservation Land Use District boundary.

5. As expressed to Ms. Virginia Goldstein of your department, please note that we voluntarily initiated the EIS process because of public interest in the petition, and not because the State Land Use Commission had decided that there were environmental impacts were not adequately addressed in the earlier assessment. The State Land Use Commission, after examining the environmental assessment filed by Farms of Kapua, concluded that "the effects of the proposed Land Use District Boundary Amendment and proposed action by the Petitioner will not constitute a significant effect upon the environment." Please note that the Land Use Commission granted a motion by the applicant to withdraw the previous Negative Declaration.

We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

HAWAII ELECTRIC LIGHT COMPANY, INC.
P. O. BOX 1027 HILO, HAWAII-96720

LIC 2
H-W/R

RECEIVED
DEC 21 1983
GROUP 70

December 19, 1983

Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Subject: Farms of Kapua EIS

Gentlemen:

We do not have any comments regarding the environmental effects of the proposed project. We want the opportunity to review the final draft of the EIS.

If there are any questions, please call us.

Very truly yours,

Alva K. Nakamura, Manager
Engineering Department

AKN:DT:bk

cc: Group 70

NA ALA HELE
P.O. BOX 1572
KEALAKEKUA, HI 96750

December 28, 1983

RECEIVED
DEC 30 1983
GROUP 70

TO: State of Hawaii Land Use Commission

FROM: Na Ala Hele

RE: EIS Notice of Preparation for Farms of Kapua

It is our understanding that an extensive Environmental Impact Statement will be forthcoming from Farms of Kapua.

In reaction to the brief section in the Notice of Preparation - J. Historical/Archaeological Resources:

1. The claim of "100% coverage" (p. 28) can be misleading, and it should be noted that Paul Rosendahl in the Archaeological Reconnaissance Survey for Farms of Kapua states that the surveyed sample is approximately 20-25% of the total project area. 100% pedestrian coverage of the shoreline to 1,000-1,500 feet inland was accomplished only in selected sample areas which were considered representative of the much larger whole.

   Also a 15% sampling of the inland project area was accomplished and only with caution should one conclude that the areas proposed for orchard and pasture are "relatively sparse in terms of substantial and significant archaeological sites" (p. 30). Rosendahl points out that "apparently very little survey work had ever been done in the more inland portions of the survey area prior to the present reconnaissance survey".

   Rosendahl describes the Reconnaissance Survey as "simply a pedestrian or walk-through survey--extensive rather than intensive in scope". It is only a preliminary evaluation revealing where further work should be done. Thus the level of information from Rosendahl's Reconnaissance Survey cannot be considered "sufficient" to preclude further survey and study of historic sites in the project area.

2. If any unanticipated sites are encountered within the project area, is the contractor or construction crew qualified to recognize historic sites prior to demolition? (p. 30). Shouldn't Intensive Archaeological Survey of historic sites be done prior to any construction activity?

3. It has been recognized that Kapua's archaeological sites are representative of the full range of Hawaiian prehistoric and historic cultural activities. The area has been so isolated that the sites are numerous, unique, well-preserved and have a high potential for adding to our understanding of Hawaii's rich cultural past.

   We disagree that "no impacts to archaeological sites in this area" can be expected (p. 30) just because no construction is proposed to take place

where sites appear to be concentrated. The increased accessibility of the area with improved roads and construction activity will definitely impact on our Hawaiian cultural resources. Once these resources are destroyed we forever lose the vast learning potentials delicately existing in Kapua.

It is not enough to leave the sites alone. They need to be surveyed, secured, supervised by a resident caretaker, and further protected by buffer zones between the Conservation and actively-used lands.

Could consideration be given in the Environmental Impact Statement study to a State Natural, Recreational and Historic Park (see Senate Resolution no. 65) coexisting with Farms of Kapua?

Mahalo for this opportunity to comment on the Farms of Kapua Project.

Sincerely,

Deborah Chang Abreu

Deborah Chang Abreu
President, NA ALA HELE

cc: Group 70 ✓
Aki Sinoto, Bishop Museum
Gil Kahele, Pa'a Pono of Miloli'i

Kazuo Ishihara AIA, Inc
Frances S Oda AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

17 February 1984

Ms. Deborah Chang Abreu
President
Na Ala Hele
P.O. Box 1572
Kealakekua, HI 96750

Dear Ms. Abreu:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We offer the following responses to your comments:

1. No "claim of 100% coverage" of the petition area was made in the NOP. Survey coverage of the coastal portion of the project area included virtually 100% pedestrian coverage by an eight man team, of a zone extending inland from the shoreline to 1000 - 1500 feet inland, and from the north boundary of Kapua to the south boundary. This statement was taken nearly verbatim from pages 9 and 11 of Rosendahl's Archaeological Reconnaissance Survey Farms of Kapua.

   We concur that it may have been inappropriate to conclude that the areas proposed for the macadamia orchard and controlled pasture are relatively sparse in terms of substantial and significant archaeological sites. This statement will not be included in the EIS.

   Further intensive level work was anticipated and recommended by Rosendahl on pages 32 and 33 of his report. It is the petitioner's intent to implement these recommendations, including those regarding "further survey and study of historic sites in the project area."

2. As stated on page 32 of the Archaeological Reconnaissance Survey Farms of Kapua, "further archaeological reconnaissance survey will [be] required for any specific areas within the project area under active development consideration, but which were not covered as part of the sample survey areas inspected during the initial reconnaissance survey work." Upon completion of reconnaissance survey work, the petitioner would have to either rely on contractor and/or construction crew recognition and notification, or utilize some program of archaeological monitoring. Furthermore, a program of intensive survey has been recommended by Rosendahl prior to any actual on-site construction activity.

3. Since intensive level survey work is proposed prior to construction activities, no direct impacts to archaeological sites are anticipated during the construction or operation of proposed activities. However, we concur that with the identification and inventory of sites (from increased archaeological work in the petition area, such as the Archaeological Reconnaissance Survey Farms of Kapua), there may be an increased possibility of indirect impacts from looting and/or vandalism. Accessibility to sites should not alter from existing conditions. As noted in the NOP, the petitioner will generally maintain the present means of public access to the shoreline: from points mauka of the petition area by permission only; and, unobstructed lateral access along the shoreline, north and south of the petition area. Because of the physical difficulty involved in access along the shoreline, and the control of mauka-makai access (by permission only), existing means of access serves to control accessibility to identified sites. Programs for the monitoring of sites would be included in a archaeological/historical resource management plan (page 32 of the Archaeological Reconnaissance Survey Farms of Kapua). The appropriate place for discussing both the various potential indirect or contingent impacts, and the alternatives for dealing with them, would be in the cultural resource management plan. We concur that the loss of archaeological resources would be irreversible and irretrievable, if any significant sites were adversely impacted. This will be stated in the EIS in the section, "Any Irreversible and Irretrievable Commitments of Resources".

We will discuss the establishment of a park on the petition area in the section, ALTERNATIVES TO THE PROPOSED ACTION. As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the features of historical value that was found by the consulting archaeologist, Paul H. Rosendahl, in his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. As previously mentioned, the petitioner will maintain the present unobstructed lateral access along the shoreline, north and south of the petition





area. We feel that retention of the above described shoreline areas in the Conservation District is in keeping with the expressed intent of S.R. 65 (1983).

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

B I S H O P  M U S E U M
1525 BERNICE STREET • P.O. BOX 19000-A • HONOLULU, HAWAI'I 96819 • (808) 847-3511

December 28, 1983

Mr. Gordan Y. Furutani
Executive Officer
Land Use Commission
Room 104, Old Federal Bldg.
335 Merchant Street
Honolulu, Hawai'i 96813

Dear Mr. Furutani:

Thank you for the review copy of the Farms of Kapua EIS Notice of Preparation. We are submitting herein our comments regarding specific points within pertinent sections of the document along with more generalized comments.

Comments (page/paragraph/line):

1/5/1,2 — The adverse impacts on the archaeological sites and their environmental context should be mentioned here. Also the loss of archaeological resources would be irreversible and irretrievable.

9/6/1 — The number of sites given here may be misleading or misunderstood by those unfamiliar with the archaeological resources in the subject area, since most of the sites are complexes or clusters of individual structures or features. Thus, a total of 54 sites involves hundreds of discrete structures or features, such as house sites, walls, platforms, mounds, trails, caves, etc.

8/2/3 & 9/6/3 — Figure 4, referred to in both sections, does not illustrate the spatial relationship between the aquacultural modules and any extant surface archaeological sites. Nor does the presently available data allow for the placement of the aquacultural modules in relation to preservation aims. The number, location, and extent of all sites, including possible subsurface components would have to be known in order to properly plan the placement of the aquacultural facilities. Are there enough 200-acre areas (size of each module) devoid of sites to permit such a patterning? If not, what mitigation procedures will be implemented in those areas? A considerably larger area will be impacted during the construction of each 200-acre module. This problem has not been addressed.



9/7/1 — The basis on which this statement of density and significance of sites in the proposed macadamia nut orchard area suffers from the same lack of data as the aquacultural area. Less than 25% sampling does not constitute an adequate basis on which to formulate an assessment of impact of the proposed agricultural development on the archaeological resources. The whole issue of subsurface features and component is markedly lacking, especially in the orchard areas where extensive clearing and grubbing is planned.

28/4,5/all — A reconnaissance survey cannot provide the kinds and level of data necessary to adequately assess the impacts of a massive development such as that proposed here, and definitely should not be the basis, even if only in part, for regulatory decisions such as the one pending for this project. The total area covered by the reconnaissance survey comprises less than 25% of the total project area.

28/5/3 — No evidence is given that the areas sampled were *representative* of either geographic distribution or environmental variation.

29/6/2 — How could the inland limit of the coastal concentration of archaeological remains be determined as 1000 to 1500 feet inland when the "100% pedestrian survey" only covered the same zone? (page 28, paragraph 5)

30/1/2 — The basis on which the 425 acre Conservation District boundaries were decided upon requires clarification, including specific site locational and boundary information.

30/2/all — Predictable indirect impacts on archaeological sites occur whenever an adjacent area is newly developed. The developers in this case must be held responsible for managing a resource that, though set in a Conservation District, is inseparable from the rest of the area.

30/3/all — This reviewer fails to see how such a determination can be made, especially from a professional standpoint, but also in view of the lack of complete data on the surface remains and the total lack of subsurface data. This reviewer has been involved in contract archaeology for over ten years and has yet to see a project in which the archaeological resources were distributed "in an overall pattern congruent with and favorable" to the proposed development.

30/4/all — See comments 8/2/3 & 9/6/3 on previous page.

30/5/1 This recommendation of not undertaking any further archaeological work until the boundary change is approved would be a dangerous precedent to set. Also, this is contrary to the philosophy and intent of historic preservation guidelines. The data presently lacking will have to be compiled and considered prior to an impact assessment in the decision making process.

30/5/3 This would be a naive and impractical course of action to allow. Past examples show that contractors frequently *do not* stop work to contact the SHPO simply because it is not in their or the developer's best interests to do so. This is especially true in outer island cases.

Are the equipment operators or the construction supervisors expected to identify those unanticipated sites or features? In this case, there may be a high probability of encountering "unanticipated" sites since an inventory was not completed.

45/PART IV Why aren't archaeological sites and features included in this section?

47/PART V Archaeological sites in their environmental context, as cultural resources, are *NON-RENEWABLE* resources. Once they are destroyed, they are gone forever.

48/PART VI What the loss of significant cultural resources would mean to future generations should be addressed here.

Some of the preceding specific comments and the following general comments are made on the basis of this reviewer's personal familiarity with the project area, Rosendahl's reconnaissance report, the original Negative Declaration document, and the preliminary planning study prepared by Group 70.

The Kapua project area (consisting of over 6,000 acres) is one of the few areas along this coast that contains vast areas that have been relatively undisturbed since the Hawaiian sites were abandoned, hence the area has a high potential to add to our understanding of past Hawaiian activities. Also, its geographic location between the intensively cultivated Kona field systems and the dry agriculturally marginal Ka'ū, affords a unique opportunity to study and preserve a representative archaeological sample of this region.

In order to properly assess the impact that the development will have on the archaeological resources, we need to know what resources are present and how they interrelate to one another. This can only be done through an Intensive Archaeological Survey, consisting of detailed mapping, written descriptions, photographic recording, and test excavations to provide chronological control and to determine the functions of sites.



Also, clearly, there is a need for a comprehensive overview and a listing of further archaeological work necessary, specific to the type of land alteration activities (excavations, grading, clearing, filling, etc.) planned for particular areas. For instance, in those pahoehoe areas possibly slated for clearing to plant macadamia nut trees, a number of sites, especially lava tubes, are known to contain human burials. And since there are potentially many more that have not been recorded, what course of action will be followed regarding these remains?

Since no mention is made of preservation beyond the coastal zone, we assume that none is being planned for other areas. We question this, because of the cursory level of work so far completed. We also question this from a resource management point of view, as we feel that representative features in other parts of the project area should probably be selected for preservation.

Finally, we would like to reiterate that our primary concern with this project is with the archaeological resources of the area. The inherent limitations of reconnaissance surveys, primarily the incomplete and cursory nature of data, precludes the application of reconnaissance findings as the sole basis for the decision making process. This is especially pertinent in the Kapua project area, since previously known, significant cultural resources abound in an extant Conservation District, which, as the subject document indicates, immediately following regulatory approval, will undergo extensive disturbance and destruction. Ideally, preservation is preferable, but where preservation is not feasible, every effort must be made to gather as much information as possible from these resources prior to their destruction. Combined with this, selected archaeological sites should be preserved for the education and enjoyment of present and future generations, and to provide a bank of archaeological resources for future researchers, who with more advanced techniques and technologies will be able to probe more deeply into Hawai'i's rich cultural past.

Sincerely,

Aki Sinoto /R

Aki Sinoto
Assistant Contract Manager
Department of Anthropology

AS/rc
xc: Group 70

Kazu Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

17 February 1984

Mr. Aki Sinoto
Assistant Contract Manager
Department of Anthropology
Bishop Museum
P.O. Box 19000-A
Honolulu, HI 96819

Dear Mr. Sinoto:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We offer the following responses to your comments. Direct references to your letter will be identified in the following manner: page/paragraph.

1/1 As stated on page 32 of the Archaeological Reconnaissance Survey Farms of Kapua, "further archaeological reconnaissance survey will [be] required for any specific areas within the project area under active development consideration, but which were not covered as part of the sample survey areas inspected during the initial reconnaissance survey work." Upon completion of reconnaissance survey work, the petitioner would have to either rely on contractor and/or construction crew recognition and notification, or utilize some program of archaeological monitoring. Furthermore, a program of intensive survey has been recommended by Rosendahl prior to any actual on-site construction activity. Since intensive level survey work is proposed prior to construction activities, no direct impacts to archaeological sites are anticipated during the construction or operation of proposed activities. With the identification and inventory of sites (from increased archaeological work in the petition area, such as the Archaeological Reconnaissance Survey Farms of Kapua), there may be an increased possibility of indirect impacts from looting and/or vandalism. Accessibility to sites should not alter from existing conditions. As noted in the NOP, the petitioner will generally maintain the present means of public access to the shoreline: from points mauka of the petition area by permission only; and, unobstructed lateral access along the shoreline, north and south of the petition area. Because of the physical difficulty involved in access along the shoreline, and the control of mauka-makai access (by permission only), existing means of access serves to control accessibility to identified sites. Programs for the monitoring of sites would be included in a archaeological/historical resource management plan (page 32 of the Archaeological Reconnaissance Survey Farms of Kapua). The appropriate place for discussing both the various potential indirect





or contingent impacts, and the alternatives for dealing with them, would be in the cultural resource management plan. We concur that the loss of archaeological resources would be irreversible and irretrievable, if any significant sites were adversely impacted.

1/2 It is correct that the exact number of every individual structure and feature was not indicated. In the EIS, reference will be made to Rosendahl's Archaeological Reconnaissance Survey Farms of Kapua, which in the descriptive comments on individual designated sites, generally give the approximate, if not exact, number of component major features comprising site complexes.

1/3 We concur to the extent that specific siting of the proposed aquaculture modules is not indicated in the NOP, however, this is not appropriate for the current level of planning (petition to amend the Land Use Conservation District Boundary). Information adequate for specific placement of facilities, with regard to the location of archaeological sites, as well as appropriate mitigation activities, would be available after the completion of intensive survey work that would be carried out prior to the specific placement of the modules. For your information, aquaculture activities of each module, including the brackish water system, will occupy 160 acres. An additional 40 acres is alloted for roads.

2/1 There is no general agreement within the professional archaeological community as to what constitutes an adequate sample. Each specific case must be considered on its own characteristics and requirements. In point of fact, there are several examples that might be cited in which a sample of approximately 10% is considered more than adequate for the reconnaissance survey level of investigation. As to the lack of subsurface testing, this is a task included within the scope of intensive survey work.

2/2 Reconnaissance survey is the appropriate level of study for general planning activities and decisions. In fact, it is the level required by a regulatory agency such as the State Land Use Commission for the making of that level of land use decisions; i.e., general land use planning. More specific land use planning is the jurisdiction of the County planning offices and agencies.

2/3 In the case of our reconnaissance survey report, it was stated that the survey areas comprising our sample were selected on the basis of geographic disribution and environmental variation. In order to clarify the reasons for selecting the sample survey areas and the reasoning why these areas can be considered representative in terms of a reasonable non-probablistic sample, a new figure presenting the distribution of vegetation types, substrate and areas previously altered by historic period land modification activities will be drafted. This figure will be appended to Rosendahl's report, which in turn will be attached to the EIS.

2/4 In general, the 1,000 to 1,500 foot inland coverage included a variable buffer zone on the inland side of the coastal survey area. Furthermore, as can seen on Figure 2 of the map in the reconnaissance survey report, several of the survey areas physically connected to and extended inland from the inland edge of the coastal zone survey area.

2/5 As recommended, the basis for deciding upon the boundaries of the Conservation District will be clarified in the EIS. The EIS will state that a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the sites previously recorded, and most of the features that were found by Rosendahl during his reconnaissance survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. The 300 foot setback allows unobstructed access along the shoreline. It is for these reasons that this area is proposed to be left in Conservation.

It should be noted that preservation has not been ruled out for any sites found outside of the 425 acre area to be left in Conservation. Determinations of which sites deserve or are appropriate for preservation would be made on the basis of the findings of intensive survey work. The retention of significant historic sites outside of the Conservation District could be accomplished through a preservation program within the context of a archaeological/historical resource management plan. The possible need for this latter plan and the need for intensive level work was anticipated and described on pages 32 and 33 of Rosendahl's Archaeological Reconnaissance Survey Farms of Kapua. It is the petitioner's intent to implement these recommendations.

2/6 Refer to response to 1/1.

2/7 The determination can certainly be supported, as a statement made of the basis of the reconnaissance survey findings, when it is realized that the level of specificity involved is very general. Such a statement concerning congruence and favorability would obviously be inappropriate were one discussing the on-site placement of specific development facilities on the basis of reconnaissance survey findings alone; but as has been pointed out repeatedly, intensive survey work must be conducted prior to such specific planning decisions.





2/8 Refer to response to 1/3.

3/1 We disagree with the statements made in this paragraph. To begin with, reconnaissance survey is already the level of study accepted as appropriate for such general land use planning decisions as State Land Use boundary change, and has been for several years. Secondly, reconnaissance survey level of study is the level deemed appropriate by federal guidelines for historic preservation work done in conjunction with general land use planning and decisions. As the federal guidelines state, it is only when the assessment of the potential impacts of site-specific facilities placement and specific definable on-site activities are required, that intensive survey level work is considered to be appropriate. Please note that on page 1 of Rosendahl's report that Rosendahl states that Ms. Virginia Goldstein, staff planner and historical sites specialist in the Hawaii County Planning Department and Mr. Wendell Kam, staff archaeologist with Hawaii State Historic Preservation Office were consulted in the preparation of the requirements of the archaeological reconnaissance survey. According to Rosendahl, both Ms. Goldstein and Mr. Kam have had opportunities to review Rosendahl's report, and on numerous occasions since then, have expressed that the reconnaissance-level survey is adequate for this level of planning (State Land Use Boundary Amendment).

3/2 It has never been recommended that decisions regarding the saving of sites should be left to on-site construction personnel. It has already been determined that 100% reconnaissance of areas not yet inspected will be required prior to any on-site development activities. Furthermore, provision will obviously be made for periodic monitoring of construction work for the possible exposure of previously unknown sites or features, and for the availablitiy of archaeological inspection immediately upon the discovery of any new sites or features. In addition, please note that development in the macadamia area will be phased in increments of 500 acres per year, and koa haole pasture, 400 acres per year. The aquaculture area will be developed in modules of 200 acres each. This will allow adequate reconnaissance survey (and if required, intensive survey and salvage or preservation) prior to construction activities.

3/4 As noted in the content requirements of the Environmental Quality Commission Environmental Impact Statement Regulations (section 1:42, f.), "This [section] should be a brief summary of any adverse impacts including those effects discussed in paragraph (e) [The probable impact of the proposed action on the environment] which are adverse and unavoidable under the proposed action." As noted in response to 1/1, since intensive level survey work is proposed prior to construction activities, no direct impacts to archaeological sites are anticipated during the construction or operation of proposed activities. However, there may be an

increased possibility of indirect impacts from looting and/or vandalism. It is our assessment that this is the only adverse impact to archaeological sites which may be unavoidable. The section in the EIS, "Any Probable Adverse Environmental Effects Which Cannot Be Avoided", will be revised accordingly.

3/5 As noted elsewhere, we concur that the loss of archaeological resources would be irreversible and irretrievable, if any significant sites were adversely impacted (beyond salvage study). This will be stated in the EIS in the section, "Any Irreversible and Irretrievable Commitments of Resources".

3/6 In the section, "The Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long Term Productivity, the EIS will mention that if any significant sites were adversely impacted, this would hinder the ability of future generations to study their cultural heritage.

3/8,9 We concur that with the statements that the petition area has the possibility of a very high potential archaeological research, interpretive, and cultural value, and "affords a unique opportunity to study and preserve a representative archaeological sample of this region." We also concur with the need to properly assess the impact that the land use change will have on archaeological resources. Our basic difference concerns the proper scheduling within the overall development sequence for the conduct of intensive survey work. The actual archaeological significance of the area remains to be determined through subsequent archaeological investigations carried out at the appropriate time within the overall development sequence.

4/1,2 The specific needs of the kinds of archaeological work mentioned here are to be determined on the basis of subsequent intensive survey, and would be discussed within the context of cultural resource management planning. The same response applies to the discussion of specific site preservation work. As noted elsewhere, preservation has not been ruled out for any sites found outside of the 425 acre area to be left in Conservation. Such concerns are the provenience of a cultural resource management plan.

4/3 We note your difference in opinion as to the level of archaeological study that is appropriate for the present level of development planning. Refer to response to 2/2.

It is not true that "...immediately following regulatory [State Land Use Commission] approval, [the Kapua project area] will undergo extensive disturbance and destruction" since many more governmental





approvals (including those regarding archaeological requirements) must be sought first. As noted in response to 3/2, development will be phased in increments, after all the necessary archaeological work is conducted.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

Encl. (1)

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

SUSUMU ONO, CHAIRMAN
BOARD OF LAND & NATURAL RESOURCES

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

February 14, 1984

Dr. Paul Rosendahl
P. O. Box 504
Kurtistown, HI 96760

Dear Dr. Rosendahl:

Subject: Review and Comment
Archaeological Reconnaissance Survey
Farms of Kapua
Kapua, South Kona, Hawaii
TMK: 8-9-06: 3

Thank you for your letter of January 23, 1984 to Wendell Kam, Staff Archaeologist, requesting our review of the subject reconnaissance survey.

Our review of the reconnaissance survey has resulted in the conclusion that it presents an adequate approach to the identification of cultural resources in the subject parcel. It is our further understanding that this survey represents an initial investigation toward a more extensive reconnaissance survey and/or intensive survey of the parcel which will also include detailed mapping and subsurface testing (where warranted) of all areas impacted by the proposed development. As stated in your cover letter, the completion of this work is contingent upon the approval of the State Land Use Boundary Change petition for the project.

As stated in the subject document's Scope of Work (1982:2), a reconnaissance survey is simply a pedestrian, or walk-through, survey--extensive rather than intensive in scope--conducted to determined the presence or absence of archaeological resources within a specified project area. A reconnaissance survey (1) permits a preliminary evaluation of archaeological resources, and (2) facilitates formulation of realistic recommendations and estimates for such further archaeological work as might be necessary or appropriate.

Therefore, we view this subject document as a preliminary investigation into the cultural resources of the project area.



This document represents the initial phase of an archaeological program which will expand into an extensive reconnaissance survey, and, possibly, intensive survey and/or mitigation (including a cultural resource management plan).

The specific tasks performed in the subject document included an archaeological background research, preliminary historical documentary research, preliminary socio-cultural research, reconnaissance survey field work (selected sampling), and data analysis. The continuation of these tasks, to completion, will result in an adequate investigation of the cultural resources in the project area.

Should you have any further questions, please contact Mr. Kam at 548-7460.

Sincerely yours,

Ralston H. Nagata
Acting State Parks Administrator

cc: V. Goldstein, Hawaii County
Planning Department

*For the Protection of Hawaii's Native Wildlife*

# HAWAII AUDUBON SOCIETY

P.O. BOX 22832
HONOLULU, HAWAII 96822

RECEIVED
JAN 06 1984
GROUP 70

December 27, 1983

Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Subject: EIS Notice of Preparation, Farms of Kapua, South Kona, Hawaii

Gentlemen:

We are pleased that the possibly significant environmental impacts of the Farms of Kapua development have been recognized and that the Land Use Commission has withdrawn the Negative Declaration with regard to the boundary amendment petition submitted by the sponsors of that project. We believe the EIS to be prepared should address the following matters:

1. According to the EIS Notice of Preparation, a botanical survey of the project area has been completed and will be appended to the EIS; we presume that this appendix will be included in the documents made available to public reviewers of the EIS. We note, however, that the only mention of a zoological survey of the land area of the project site is a reference to observations of birds made during the botanical survey. The EIS should fully document the claim that native birds are absent from the site and should discuss any other impacts upon the native fauna of the region. The EIS Notice of Preparation mentions the presence in the project area of kipuka and lava tubes, features likely to support relictual native plants and animals.

2. The EIS should fully address possible adverse impacts of the Farms of Kapua development upon the adjacent Manuka Natural Area Preserve (MNAR) and other nearby areas that may now support native plant and animal communities. Of particular concern is the extent to which development will encourage the spread of exotic plants within the MNAR. The proposed aerial seeding of koa haole and guinea grass may disseminate these aggressive exotic plants in areas of the MNAR now occupied by native plant communities. Cattle pastures should be adequately fenced to prevent animals from straying into the MNAR.

3. The applicant proposes to use water of non-potable salinity for irrigation of agricultural crops. The EIS should address the possible long-term hazards of salt build-up in soil resulting from irrigation with brackish water.

4. The EIS should discuss possible adverse impacts on coastal marine ecosystems of siltation resulting from increased soil erosion caused by clearing and grubbing of existing vegetation.

We thank you for this opportunity to comment on the Notice of Preparation for the Farms of Kapua EIS.

Sincerely,

Carl C. Christensen

Carl C. Christensen, Chairman
Conservation Committee

cc: Group 70

Kazuo Ishihara AIA, Inc
Francis S. Oda AIA, Inc
Robert K.T. Wong AIA, Inc
Norman G.L. Hong AIA, Inc

16 February 1984

Mr. Carl C. Christensen
Chairman, Conservation Committee
Hawaii Audubon Society
P.O. Box 22832
Honolulu, HI 96822

Dear Mr. Christensen:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We offer the following responses to your comments:

1. As stated on page 26 of the NOP, a botanical reconnaissance of the petition area will be appended to the Environmental Impact Statement (EIS). In addition, Dr. Andrew J. Berger has conducted an avifaunal survey and his report will also be appended to the EIS. Berger sighted only two native birds, the Io and the Pueo, on or near the borders of the petition area. He sighted the Io at least one mile up slope from the upper boundary of the petition area. The Pueo was also seen, at an elevation of approximately 1,100 feet. It is the opinion of Berger that since both species now forage over macadamia orchards, pasture land and other introduced vegetation on the Kona coast, the proposed action would have no adverse impact on these species.

   Berger states in his report that "Rarely during my field work in the Hawaiian Islands during the past 19 years have I seen such a poor habitat for birds and mammals as in the Kapua Farms petition area." While the site may contain roosting sites of the Hawaiian bat, all of the remaining mammals found on the site are introduced species, and all of these are considered pests to man, his activities and products, and/or to native vegetation and fauna. As previously mentioned, Berger states that unless their roosting sites are damaged, the proposed activities would have no adverse effects on the bats.

   While Berger and Nagata did not extend their field study to lava tubes, some of these features have been identified by Dr. Rosendahl, in his archaeological survey. If these caves or lava tubes are left intact, it is likely that any present relictual native plants and animals will be left undisturbed.





2. To date, there is no known botanical survey that has been conducted in Manuka Natural Area Reserve (MNAR). However, the area directly south of the petition area has been described in the Manuka Natural Area Reserve Management Plan - 1982 as follows: "From the coastline to about 4 miles mauka, the landscape is of barren lava fields with some grassland." Aerial infrared maps of the boundary between the MNAR and the petition area concurs with this description.

   There is unlikely to be any pristine habitats directly adjacent to the north of the petition area. Review of infrared photos of the boundary to the north, indicate a similar habitat to the one provided by the petition area. As stated earlier, all of the birds and mammals found on site have appeared to have adapted to introduced vegetation.

   According to Nagata, koa haole is spread primarily by cattle and by man (through planting). Since the boundaries of the koa haole pasture area will be fenced, this would effectively prevent animals from straying into the MNAR and would halt the spread of koa haole attributable to cattle. The petitioner proposes a 300 foot buffer along the border of the MNAR, which will be left in its existing condition, unseeded and unimproved. The phasing of the koa haole pasture area will be in approximately 400 acre increments per year. Whenever a large enough portion of area is readied, aerial seeding will be conducted up to within 300 feet of the buffer to the MNAR. The boundaries of the planting area will be marked by flagman during seeding. The high density of koa haole seed will cause it to descend directly below the point of release from the plane. Because of the proposed fencing and the establishment of a buffer zone, the chances of koa haole naturalization into the MNAR as a result of the proposed actions is anticipated to be equal to existing conditions. Guinea grass will be seeded by hand. While guinea grass seed can spread by wind, it should be noted that the Atlas of Hawaii characterizes the petition area as having light and variable winds. Guinea grass currently exists on site.

3. It is the opinion of Frank S. Scott Jr. (macadamia consultant) and John Mink (consulting hydrologist) that since the soils on the petition area are porous, natural rainfall will leach the soil of any salts that would accumulate from using water of non-potable salinity for irrigation. Salt build-up is more common to clay soils. Futhermore, Mink states that salt accumulation in soils in Hawaii from irrigation has never been documented.

4. Clearing and grubbing of the petition area will occur in approximate increments of 500 acres per year, over three years, in the macadamia orchard, and 400 acres per year, over six years, in the koa haole pasture area. Whenever a large enough portion of area is readied, it will be planted. With relatively low and evenly distributed rainfall, the porous characteristic of the ground precludes the occurrence of runoff and soil erosion by surface water. There should be little erosion of soil from wind since the petition area experiences light and variable winds. Therefore, it is unlikely that there will be adverse impacts on coastal marine ecosystems by siltation. The various crops will provide ground cover and will reduce the amount of area exposed to soil erosion.

We look forward to your comments on the Environmental Impact Statement.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

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GROUP 70

December 29, 1983

Land Use Commission
State of Hawaii
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

RE: Comments on Notice of Preparation for Farms of Kapua Environmental Impact Statement

Dear Land Use Commission,

Pa'a Pono of Milolii, Inc., is extremely interested in assuring that all the environmental effects of Farms of Kapua's large-scale project will be addressed. Much of the Environmental Impact Statement preparation notice and the Proposal and Technical Appendices are merely conclusions with no facts and figures to support these conclusions. The following are a few of the concerns for which we request a response from Farms of Kapua.

## I. Present Land Use Design and Zoning

The Environmental Impact Statement (EIS) should address Hawaii County General Plan Use Pattern Allocation Guide (LUPAG), Agricultural Lands of Importance to the State of Hawaii (ALISH), and the State General Plan. For the subject area, LUPAG indicates an open area along the coast with the rest of the area being Conservation. According to Hawaii Revised Statutes (HRS) Section 205-16.1, land use amendment shall be approved only if there are no significant adverse effects upon...natural, environmental, recreational, scenic, historic or other resources. The General Plan shows this area to be open and conservation. Farms of Kapua must justify changing the present governmental assessment of this



area that it is to remain an open area because of its natural beauty and great historic and cultural significance.

## II. Geology of the Area

The EIS should address the possibility or probability of lava flows from Mauna Loa striking the project areas as opposed to lava flows striking alternative areas such as the Keahole area in Kona. (Land exchange as an alternative will be subsequently discussed.)

Much of the topography of the project area is extremely rough and irregular, caused by successive precipitous flow margins and lava flows. The land contains large flow channels and levees, lava tubes and skylights (collapsed portions). (This topography consists of the land above 150 feet.) The EIS must address the considerable engineering and construction problems with grading this area for roads, irrigation systems and site preparation for agriculture and aquaculture.

Much of the lower and middle slopes consist of pahoehoe lava flows (some with an a'a overburden). These regions contain numerous large and small lava tubes. The EIS should address how cesspool and aquaculture infiltration ponds will be sealed so that liquid wastes will not be conducted into the ocean via the lava tubes.

According to page 6 of the EIS Notice of Preparation, macadamia nuts will be cultivated on approximately 1710, which will involve clearing and grubbing of most of the vegetation. Yet on page 14 of the same document, it is stated that alteration of the existing topography will be slight. The EIS should address the change of topography which will occur from bulldozing approximately 1700 acres. Also, The EIS should address the cost of land preparation considering the aforementioned problems with the rough topographic features of this area.

## III. Climate

The EIS Preparation Notice (pages 14-15) has erred considerably in its climate section, particularly with regard to rainfall. It claims that "there are no long-term rainfall data on-site," and that data from nearby stations at Opihihale (median rainfall 43.3 inches, 1270 feet elevation, 7 miles north, Station No. 24.1) and Manuka (median rainfall 56.2 inches, 1750 feet elevation, 2 miles south, Station No. 2.0) suggest rainfall at 400 feet elevation is 35 inches. No rationale is supplied.

No mention is made of the rainfall map and data from the project site found in Circular C-88, "Median Rainfall, State of Hawaii," published in 1982 by the Division of Water and Land Development (DOWALD), State Department of Land and Natural Resources. Circular C-88 tables include summary data from Kole Pen (median rainfall 25.7 inches, 920 feet elevation, Station No. 2.18), located in the middle of the proposed Farms of Kapua macadamia nut orchards, and from Okoe (median rainfall 46.7 inches, 1590 feet elevation, Station No. 2.17), located immediately to the north of the site. Additional data are on file at the DOWALD office in Honolulu, from stations located in the Mac Farms orchards in Kapua (just mauka of the proposed orchards) at 1300 feet elevation (mean annual rainfall 1968-1972, 29.0 inches) and at the 1500 foot elevation (mean annual rainfall 1967-1979, 35.6 inches). These last two stations' data are also included as "Appendix C" to Frank Scott's "Agricultural Feasibility, Farms of Kapua" report (EIS Preparation Notice, reference item 18).

Also available from DOWALD are computer printouts for rain gauges that provide month-by-month data for the record periods of each station, such as the records for Opihihale Station listed in Appendix C (item 18). The EIS should incorporate the cited 1982 rainfall map and data tables for the aforementioned stations closest to the project area rather than speculate on the rainfall using readings from stations too far away to be reasonable. Only with proper rainfall figures can



reasonable estimates be made for water deficits and irrigation needs of the planned macadamia nut orchards and haole koa area.

Proper records are also necessary to evaluate the occurrence of droughts in the Kapua area, an important consideration of agriculture on marginal lands. One such analysis is "Drought Frequency, Kapua, South Kona, Hawaii" by John Mink, November 12, 1983. Unfortunately, he used the DOWALD printout for the Opihihale Station rather than the Kole Pen Station on-site. His conclusions ("severe droughts are infrequent in South Kona but ordinary droughts, perhaps better called dry periods, are expectable [sic] annually") may apply to Opihihale, but have no relevance to the project area other than to indicate that the Opihihale Station location is much better suited to agriculture than the proposed project site.

Using the same methodology described by Mink and the data from Kole Pen at Kapua (attached), a very much different picture emerges. The data are from essentially the same record period, 1956-1975, and include 237 months of records. Mink's method: "For droughts to exist, subnormal monthly rainfalls must persist for three months or more. Two levels of drought are considered, ordinary drought in which rainfall lies between the 50 percentile (median) and 25 percentile levels and severe drought in which rainfall is less than the 25 percentile level." The median (50 percentile) annual rainfall at Kole Pen is 25.72 inches, and median monthly rainfall, a twelfth, is 2.14 inches. The 25 percentile annual rainfall is 22.48 inches, and the monthly 25 percentile is 1.87 inches.

During the 1956-1975 period 16 "severe droughts" occurred, each from 3 to 7 months in length. "Severe droughts" were in occurrence 26% of the time (62 months of the 237 months). The occurrence of "ordinary droughts" is even greater.

Of those 237 months at Kole Pen, 47, or 20%, of the months experienced less than 1 inch of rain. Kole Pen is at 920 feet elevation, in the upper to middle elevations of the proposed orchards, and the lower orchards and haole koa areas get

even less rainfall than the 25.7 inches (median) at Kole Pen. The EIS should address the significance of these rainfall figures and explain the discrepancies with Mink's figures.

A study of the attached monthly rainfall data table, Kole Pen, reveals that only 29 of the 237 months (12.2%) have monthly rainfall equal to or greater than the 4.4 inches per month (equivalent to 52.8 inches per year) that Frank Scott has indicated are needed for macadamia nut growth. A more plausible monthly water demand figure of 5.5 inches (equivalent to 66 inches per year) was met in only 18 (7.6%) of the months. The water deficits need to be met by irrigation, and the water needs are much higher than indicated in either the EIS Preparation Notice or in the supporting documents referenced therein. The high occurrence of drought noted above indicates that the considerable normal water demands can be expected to be much exceeded a quarter of the time for periods up to 7 months long. Such periods of excessive sustained pumping demand could negatively affect the groundwater quality, and the EIS needs to accurately and credibly assess this situation and to present all data and calculations to public scrutiny. The groundwater is a public resource and its quality needs to be protected from abuse.

## IV. Water Resources and Water Usage

The EIS Preparation Notice, page 39, cites the total water pumping capacity of the County's South Kona water system (3 wells at Keei) as 1.58 MGD (million gallons per day) and its "safe capacity" as 0.86 MGD or 54% or its "total." As the rainfall in the watershed above Keei is no less than that above Kapua, the EIS needs to explain how Farms of Kapua can expect to get 1.4 MGD from each of the two to four planned wells (EIS Preparation Notice, page 18), nearly three times the total well capacity of the County wells? For the two to four wells, this 2.8 to 5.6 MGD (or up to 6.8 MGD during droughts, also cited on page 18) or 1.8 to 4.3 times the total capacity of the South Kona County water system, and 3.3 to 7.9 times its "safe capacity."



How can the Farms of Kapua project expect to pump this much water, much less the amount actually needed, when the real water requirements for irrigating macadamia nuts plus the additional haole koa irrigation needs have yet to be accurately determined? If long term potable water production is a goal, shouldn't the "safe capacity" water extraction rates be practiced? Is there any chance that Mac Farms at Kapua or other users at Honomalino or Okoe (where the State's brackish well is located) might want or plan to drill wells into the same aquifer? Couldn't overdraft from Farms of Kapua wells jeopardize the aquifer shared by adjacent private and State landowners? Letters from adjacent landowners stating their feelings on the local aquifer joint use and potential jeopardy to quality should be included in the EIS. These questions need good, substantiated answers in the EIS if the project proposal is to have any credibility. Additionally, water consumption of cattle in dry areas is two to three times the amount cited on page 19.

The EIS Preparation Notice (page 18) claims that "about 320,000 gallons per day" are necessary to provide good yields from the proposed 200 acres of irrigated haole koa, while figures in Dr. Brewbaker's report (Reference Item 21, page 3) support calculations of nearly twice that amount, as well as suggesting that reducing the irrigation supplement from 40 inches to 20 inches per year will reduce yields by 50%. The EIS should clarify the contradictions utilizing data and calculations. Page 18 of the EIS Preparation Notice also suggested irrigation of the large pasture area, but did not provide logistic details or costs. This also should be clarified in the EIS.

## V. Natural Hazards

The EIS Notice of Preparation refers to the project area as prone to earthquakes. The EIS should address 1) how the aquaculture ponds will be resistant to earthquake activity, and 2) whether there are other areas in Kona that are less

susceptible to damage from volcanic hazards using the Mullineaux and Peterson report. The EIS should illustrate the volcanic hazards by including the specific hazard maps of the study.

## VI. Coastal Water Quality and Marine Biology

The offshore waters are categorized as Class AA waters. The EIS Notice of Preparation states there will be no point discharge of sewage or discharge of effluent into the offshore water. The EIS needs to address the abundance of lava tubes which in effect will provide conduits for direct discharge into offshore waters. Also, the EIS should address the probably biological pollution of Class AA waters by the escape from aquaculture effluent percolation ponds/trenches of exotics such as algai Eucheuma (a foreign limu) and fish Tilapia. If either of these organisms get into the offshore waters, the fishing grounds may be adversely affected (as has happened at Kaneohe Bay with Eucheuma and to much of Hawaiian waters with Taape).

The EIS should also address the use of pesticides associated with the agricultural project and its effects on the anchialine pools and shoreline reef communities. The pesticides could be transported via lava tubes and normal groundwater movement.

## VII. Vegetation

Kenneth Nagata's botanical reconnaissance noted the presence of considerable fountain grass. The EIS should address the role of fountain grass in displacing other plant species, including pasture forage species, the resulting impact on potential carrying capacity of the proposed pasture areas, and any planned mitigating measures.

Mr. Nagata's preliminary reconnaissance survey was limited to jeep roads, and thus most of the project area was not surveyed. Although Nagata's report neglected to mention which



jeep roads were travelled and how much time was spent in the field, it is obvious from the report that the survey was inadequate to meet the needs of an EIS in addressing the impacts of clearing the majority of the existing vegetation and describing adequately the occurrence and distribution of the considerable native vegetation at Kapua. A more thorough field study needs to be done to address the impacts on the vegetation of the area.

## VIII. Fauna

There has been neither an EIS faunal field survey nor citation of other reports on the area. All species listed in the EIS Preparation Notice were "presumed to inhabit the site." The assumption that on-site animals will simply "relocate to other areas" is ecologically unsound.

The project proposes to clear considerable acreages of existing vegetation and replace it with managed agricultural species. The impacts on existing fauna are enormous and need to be described by the EIS. For example, what are the impacts of bulldozing on roosting and breeding sites of the endangered 'Ope'ape'a (Hawaiian Bat) and 'Io (Hawaiian Hawk), and what effects will pesticide use on the project site have on the food supplies of both species?

## IX. Historical/Archaeological Resources

The archaeological field reconnaissance conducted by Dr. Rosendahl was too incomplete to assess the historical and archaeological significance of the area. The survey covered a very small percentage of the mauka area of the project (15%). Even in the survey areas, Rosendahl did not number or indicate the location of all the sites recorded. Rosendahl basically discards what he calls "minor" features in the report. Non-inclusion of these minor sites results in a distortion of the density and significance of archaeological remains in the inland zones. Eighty-five percent of the area was not even surveyed

for sites. The area must have 100% coverage so that sites can be preserved throughout the project area. A much more complete survey needs to be completed where these features are numbered as specific sites.

A field trip of the project area was completed by Matthew Spriggs, Department of Anthropology, University of Hawaii, Manoa, in December 1983. His observations are attached hereto as Exhibit B and incorporated by reference. This report should be appended to the EIS and his concerns should be addressed. One of Mr. Spriggs' conclusions is that Rosendahl's reconnaissance survey report lacks any synthesis of the evidence relating to prehistoric and historic use of Kapua. Given the limits of Rosendahl's survey, it is impossible to evaluate the importance of the project area in archaeological terms. A much more comprehensive field study and analysis should be done in the project area before any land use boundary amendment can be made.

Even in Rosendahl's limited survey, 33 new sites were discovered in addition to 21 previously recorded sites. This is obviously an area rich in historic sites. The EIS must address specifically what procedures will be followed in selection of sites to be preserved and the actual preservation measures. For example, when the bulldozers commence operation, is it expected that a bulldozer operator will be able to spot a site and halt all operations while the site is inspected? Obviously, this is practically and economically impossible. The EIS should address the possible effects of proposed blasting (EIS Preparation Notice, page 32) on archaeological sites.

Nobody has spoken to the community of Milolii to assess the sociological and cultural impact such a project may have on the community. Nor has anyone spoken to the Native Hawaiians about the oral history of the area or the present cultural significance of the sites to them.

The historical and cultural significance of the sites at Kapua should be analyzed in the context of the proposed State Historical Park. This park was supported by numerous individuals and groups islandwide. Therefore, the historical and cultural



significance of this area in terms of a State Park should be discussed with the interested groups.

The Environmental Quality Commission (EQC) Regulations, 1:42, require that a historic perspective be addressed. The Regulations also require a description of environmental setting including a description of the environment in the vicinity of the action from a local and regional perspective. These issues cannot be addressed without direct contact with the Milolii community.

## X. Macadamia Nut Cultivation

The EIS needs to resolve and correct the contradictions, inconsistencies and inadequacies presented in Frank Scott's feasibility analysis of macadamia nut culture at Kapua (Item 18 in the EIS Preparation Notice list of references, "Agricultural Feasibility, Farms of Kapua"). The following considerations need to be placed in factual and logical consideration.

1. Frank Scott assumes 1982 market prices of $.90 a pound for macadamia nuts (reference item 18, page 36) in his estimates of financial returns and amortization tables and calculated a 26-year break-even point (reference item 18, page 37) for the proposed orchards at Kapua. As 1983 prices for macadamia nuts were in the $.60 to $.75 per pound range (due to an oversupply of nuts), how will the economic feasibility of the orchards be affected?

2. Frank Scott's economic analysis predicts "an internal rate of return of 17.3%" for macadamia nuts, but did not allow for the economic effects of reduced yields in the proposed Farms of Kapua orchards due to (a) growth and yield reductions of trees grown on pahoehoe lava, ripped or not (Gordon Shigeura, Land Use Commission Hearing, October 26, 1983; Dr. Phillip Ito, George Schattauer, Dale Anderson, all personal communication); (b) the negative effects of high temperatures on flowering and fruit set in the lower elevation orchards due to the advected heat load from the heated lava plains below (having

"a long southern exposure"); (c) periodic, prolonged droughts which would cause irrigation demands in excess of the safe pumpage capacities of the proposed wells; (d) the use of brackish irrigation water, which causes yield reduction in all six tree crops listed in the 1977 Maas and Hoffman article cited by Scott (the salinity of the Okoe well water proposed for use at Kapua causes 16-28% reduction in yields in all six trees for which data were available).

3. Frank Scott admits that foreign macadamia nut plantings will "pose serious competition to Hawaii in 20 years."

4. In Hawaii, won't orchards planted in ideal site conditions of soil and rainfall and thus having little or no expenses for site preparation and irrigation be in a much better financial position to face competitive price drops than those with a burden of considerable additional production costs to make up for? In fact, won't orchards from Ahuloa to Ola'a, planted on abandoned cane land, have these plus additional advantages of local labor forces and existing agricultural infrastructure?

5. Past and current experience show that marginal cane, pineapple and pasture lands have been the first to be uneconomically competitive with foreign production and are to be the first to be abandoned. The high costs of site preparation and irrigation make the proposed Farms of Kapua orchards marginal relative to most other Hawaii orchards lacking these considerable expenses.

6. The estimates of expensive irrigation water needs of proposed macadamia nuts on the Farms of Kapua property are grossly underestimated. The expenses of daily irrigation needs and the number of irrigation wells needed to supply these needs (without damaging the basal water lens from overpumping) are not realistically dealt with in Frank Scott's analysis. Errors that need to be clarified in the EIS include: (a) Scott cites 35-43 inches of rainfall in the proposed orchard area (400-1250 feet elevation), while the 1982 rainfall maps (Circular C-88, DOWALD, State of Hawaii) shows the actual range in this area to be 22-32 inches per year, and a rain gauge with 20 years of record at 920



feet elevation in the middle of the proposed orchards to have a median rainfall of 25.7 inches per year. (b) Scott claims macadamia nut water requirements to be 52.8 inches per year (4.4 inches per month), while most agronomists and macadamia nut growers on the Big Island point to 60-70 inches of rain to be the lower limits for good yields (Gordon Shigeura, Land Use Commission Hearing, October 26, 1983; Dr. Tung Liang, Dale Anderson, George Schattauer, Dr. Phillip Ito, all personal communication). (c) Scott's analysis did not take into account the additional "leaching requirement" of water use needed to flush down the salts which accumulate in the soil to harmful amounts when brackish irrigation water and fertilizers are used. The existing rainfall is not sufficient to leach these salts, as well-developed soils found in similar rainfall regimes show horizons enriched with salts left behind when evapotranspiration exhausts soil moisture. (d) Scott's descriptions of proposed orchard areas' soils (summarized in the EIS Preparation Notice) are not an accurate description of those soils present on the site, as anyone who has walked the area can see. Except for the far mauka (Agriculture zoned) part of the proposed orchard area and a few kipukas, the soil cover for most of the proposed orchard area is very thin and quite discontinuous or non-existent. Such soils lack moisture storage needed to retain water from rainfall and, expecially in the pahoehoe areas, do not have much fine material, nutrients or space for roots. Therefore, water consumption in these areas will be higher than that calculated by Scott.

7. In Scott's analysis (reference item 18, page 15) he states, "The economic feasibility analysis for macadamias is based on economic models of 200 acres in size which would be cooperatively owned by 14 investors, each of whom would have a five-acre homesite in a cluster arrangement surrounded by the macadamia farm. Each module consists of 280 acres, including the 200-acre macadamia farm, 70 acres in five-acre homesites and 10 acres in roadways." He goes on to estimate that between the mauka boundary with Mac Farms and the 150-foot elevation, 18 280-acre modules could be accommodated (18 modules x 14 homesites

per module = 252 homesites). How many modules can be accommodated between the mauka boundary and the 400-foot lower limit of the proposed macadamia orchard? As such homesite accommodation is not allowed in the existing Conservation District zoning of the proposed project area (while orchards per se are a permitted use in the Conservation District), is the desire to include homesites the reason for the application to change the land-zoning from Conservation to Agriculture? What effects would the deletion of the proposed homesites have on Scott's economic feasibility analysis cited above? The EIS should explain these unanswered questions.

8. Scott (reference item 18, page 14) gives figures for irrigation water consumption "during occasional periods of drought which may last for as long as three weeks in the mauka area and five weeks in the makai area." He cites a "maximum daily water requirement" of 14,400,000 gallons per day for the area between the mauka border with Mac Farms and the 150-foot elevation, and also a reduced "supplemental requirement of 2.300 gallons per acre per day in the area between Mac Farms and the 400-foot elevation, at some risk of tree damage and low production." 2,300 gallons per acre per day for the proposed 1710 acres above the 400-foot elevation amounts to 3,933,000 gallons per day irrigation demand, still with tree and yield damage. The EIS should indicate what the irrigation water use during such drought periods will be for the proposed orchard area above the 400-foot elevation taking into consideration (a) "maximum daily water requirement" (so as to avoid the "risk of tree damage and low production"), (b) the actual 22-32 inches per year rainfall rather than Scott's estimated 35-43 inches per year rainfall, (c) the realistic 60-70 inches per year requirements of macadamia nuts, and (d) the calculated additional "leaching requirement." As the County Department of Water Supply charge of 73¢ per 1000 gallons of agricultural water is probably an underestimate of the cost of private water development and production, the EIS should provide an analysis of water costs on site and provide a realistic evaluation of irrigation water costs during "normal" rainfall years and during drought years,



including the drilling of enough wells to meet the maximum needs during drought periods. As Scott's economic analysis of costs and returns (reference item 18, page 20) cited water costs as 40¢ per 1000 gallons, but the more realistic cost figures should be substituted in Scott's economic analysis and appropriate adjustments be made to his cost and amortization tables and the break-even point.

This part addresses "Water Resources and Water Usage" pp. 18-19. In the EIS Preparation Notice, page 39 cites the total water pumping capacity of the county's South Kona water system (3 wells at Keei) as 1.58 MGD (million gallons per day) and its "safe capacity" as 0.86 MGD o4 54% of its "total." As the rainfall in the watershed above Keei is no less than that above Kapua the EIS needs to explain how Farms of Kapua can expect to get 1.4 MGD from each of the two to four planned wells (EIS Preparation Notice, p. 18) nearly three times the total well capacity of the County wells? For the two to four wells, this 2.8 to 5.6 MGD (or up to 6.8 MGD during droughts, also cited on p. 18) or 1.8 to 4.3 times the total capacity of the South Kona county water system, and 3.3 to 7.9 times its "safe capacity." How can the Farms of Kapua expect to pump this much water, much less the amount actually needed, when the real water requirements for irrigating macadamia nuts plus the additional haole koa irrigation needs? If long term potable water production is a goal, shouldn't the "safe capacity" water extraction rates be practiced? Is there any chance that Mac Farms at Kapua or other users at Honomalino or Okoe (where the State's brackish well is located) might want or plan to drill wells jeopardise the aquifer shared by adjacent private and State landowners? Letters from adjacent land owners stating their feelings on the local aquifer joint use and potential jeopardy to quality should be included in the EIS. These questions need good, substantiated answers in the EIS if the project proposal is to have any credibility. Additionally, water consumption of cattle in dry areas is two to three times the amount cited on page 19.

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"Agricultural Feasibility, Farms of Kapua" report (EIS Preparation Notice Reference item 18).

Also available from DOWALD are computer printouts for rain gauges that provide month-by-month data for the record periods of each station, such as the records for Opihihale Station listed in Appendix C (item 18). The EIS should incorporate the cited 1982 rainfall map and data tables for the aforementioned stations closest to the project area rather than speculate on the rainfall using readings from stations too far away to be reasonable. Only with proper rainfall figures can reasonable estimates be made for water deficits and irrigation needs of the planned macadamia nut orchards and haole koa area.

Proper records are also necessary to evaluate the occurence of droughts in the Kapua area, an important consideration of agriculture on marginal lands. One such analysis is "Drought Frequency, Kapua, South Kona, Hawaii" by John Mink, 12 November 1983. Unfortunately, he used the DOWALD printout for the Opihihale station rather than the Kole Pen Station on-site. His conclusions ("severe droughts are infrequent in South Kona but ordinary droughts, perhaps better called dry periods, are expectable (sic) annually") may apply to Opihihale, but have no relevance to the project area other than to indicate that the Opihihale Station location is much better suited to agriculture than the proposed project site.

Using the same methodology described by Mink and the data from Kole Pen at Kapua (attached) a very much different picture emerges. The data are from essentially the same record period, 1956-1975, and include 237 months of records. Mink's method: "For droughts to exist, subnormal monthly rainfalls must persist for three months or more. Two levels of drought are considered, ordinary drought in which rainfall lies between the 50 percentile (median) and 25 percentile levels and severe drought in which rainfall is less than the 25 percentile level." A study of the attached monthly rainfall data table, Kole Pen, reveals that only 29 of the 237 months (12.2 per cent) have monthly rainfall equal to or less than the 4.4 inches per month (equivalent to 52.8 inches per year) that Frank Scott has indicated are needed doe macadamia nut growth. A more plausible monthly water demand

figure of 5.5 inches (equivalent to 66 inches per year) was met on only 18 (7.6%) of the months. The water deficits need to be met by irrigation, and the water needs are much higher than indicated in the EIS Preparation Notice.

During the 1956-1975 period sixteen "severe droughts" occurred, each from 3-7 months in length. "Severe droughts" were in occurrence 26% of the time (62 months of the 237 months). The occurrence of "ordinary droughts" is even greater.

Of those 237 months at Kole Pen, 47, or 20%, of the months experienced less than one inch of rain. Kole Pen is at 920 feet elevation, in the upper to middle elevations of the proposed orchards, and the lower orchards and haole koa areas get even less rainfall than the 25.7 inches (median) at Kole Pen. The EIS should address the significance of these rainfall figures and explain the discrepancies to Mink's figures.

XII. Controlled Pasture Area

The EIS Preparation Notice, page 32, states that proposed pasturage could support a maximum of one animal per two acres without a supplemental irrigation system. There are no facts or figures to support this conclusion. The EIS should cite production figures from Kona ranches having similar soil and rainfall as Kapua. The EIS Preparation Notice states that approximately 690 head of cattle will produce enough manure for one module of agriculture. Even using the unverified figure the proposed pasturage could 875-1000 head of cattle. Therefore, only one aquaculture module could be supported by manure. How are the other four aquaculture modules going to obtain the nutrient input other than by means of importing expensive feeds? Also, how is this manure going to be collected if the cattle are not confined in the corral? If they are confined, how to they consume the forage in the grazing area?

Farms of Kapua have tried to set up a system whereby various agricultural projects are interdependent, thereby making the aquaculture economy viable. Any imbalance in the system will affect the economic feasilibity of the aquaculture. The EIS should incorporate well-documented figures for product in the controlled pasture, cultivated leucaena, and manure collection components of the integrated system. There should be feed conversion figures



and maximum sistained yield for each component.

There should be figures for the various contingencies -- what if there is not enough pasturage for the cattle? What if there is not enough manure for the aquaculture agriculture facility? What are the additional costs if the integrated system is not workable? What affect will a drought have on the pasture growth (and subsequently manure production)?

XIII. Aquaculture

The EIS should explain how the aquacultural facilities will be constructed without affecting the existing historical sites. Are there going to be back-up electrical generation facilities adequate to supply power for pumping should there be a power outage? The following questions need to be answered:

How are the ponds actually going to be constructed? Will they be constructed on the surface of concrete or synthetic materials? Or will they be excavated and sealed? What effect will blasting and excavation have on historical sites and shoreline fisheries? Which of the proposed species are now in successful commercial production? What are the other aquaculture facilities in the State? Are they commercially successful? Why, or why not? What will be done to waste material? (For example, 38% of harvested P. Monodon is waste. Figures in Farms of Kapua aquaculture feasibility study indicate that this would amount to 60 tons of waste per year per module.) The study cites a 30% mortality rate for P. Monodon. What happens to the bodies of the dead shrimp?

The Farms of Kapua proposal states that plankton will be a supplemental food source for the shrimp. How will the plankton be provided if the salt water is being pumped?

XIII. Socio-Economic Characteristics

The EIS Preparation Notice speaks about agriculture and tourism as principal economic activities. This completely leaves out the major socio-economic activity in the community of Milolii which is fishing. Most of the people in the Milolii community are self-employed fishermen. How will the Farms of Kapua development benefit these fishermen? The Preparation Notice states the project will probably generate permanent employment for 80 individuals. What are the specific job descriptions?

The EIS Preparation Notice states that the project for cattle production will contribute to an industry which has been struggling. Why has the industry been struggling? Why will production of this beef be able to compete with foreign markets where other ranches have been unable to do so?

XIV. Recreation

The area is now used as a recreational area for the local people living nearby. It is presently a quiet, undistrubed, beautiful landscape where families go to picnic, fish, pick opihi, bike in an unspoiled land. The project will adversely affect this recreational use of the area. The people of South Kona and specifically Milolii whould give their input on whether or not recreational resources will be affected by the project.

XV. Adverse Environmental Effects

Aside from the adverse environmental effects stated in pages 45-46, the EIS must address the adverse effects to the community of South Kona, Milolii in particular. This community is extremely unique in that it is one of the last native Hawaiian fishing communities in the entire State of Hawaii. The only way the impact on this community can be assessed is by speaking to the representatives of the community itself.

XVI. Irreversable and Irretrievable Commitments or Resources

The EIS Preparation Notice addresses this area in two paragraphs. The full EIS should address the loss of 1) fauna (there is an assumption in Farms of Kapua's assessment that the hoary bat will relocate -- what is the factual basis for this conclusion?), 2) flora (e.g. native pili grassland community, cassia, gaudichaudii, and nototrichium sandwicensis), 3) historical culture and archeological sites, 4) open, natural land. These potential losses are ones which cannot be reconstructed. Once gone, they are lost forever. It is the loss of these natural and cultural resources which must be scrupulously addressed in the EIS. The EIS must address the mitigation measures for all these potentially significant losses.



XVII. Alternatives

The EIS Preparation Notice states that an alternate is acquiring a Conservation District Use Application (CDUA). The notice states this would be impractical. There is no factual basis as to why this would be impractical. Further, the notice mentions that it would be impossible for the petitioner to obtain financing, "since the proposed agricultural uses requires the sanction of appropriate land use." What does this mean? How is Farms of Kapua going to get financing at all?

An alternative site is a viable alternative. Why not find a site which does not have the great amount of historical and acheological sites in the area? The aquaculture project may be viable at Keahole, Kona, Hawaii area. There may be a possibility of a land exchange in the State of Hawaii. The site is not "ideal" for multi-aquaculture use. The ground is lava rock; there is inadequate water; much of the adjacent Milolii community objects to the development. (Another alternative is to begin in the macadamia nut project and wait to develop the lower portions of the land. Most of the historical sites and potential adverse effects occur on the lower slopes of the project area.)

An important reason for seeking an alternative site is that the Hawaiian Senate has passed a resolution in 1983 for a State Historical Park for a large majority of the project area. This would be of great benefit to the entire State of Hawaii. This benaficial use of the land should be addressed.

XVIII. Issues Not Addressed

According to EQC, EIS Regulations 1:42, 6.5, the EIS must include phasing a timing of action. This is a very large scale project. A detailed timetable should be set forth in the EIS. EIS Regulations 1:42, 6.7 states that there should be an historical perspective -- this must be addressed in the EIS.

There is no cost-benefit analysis in the EIS Preparation Notice. There is no detailed audit account of the financing in Farms of Kapua/s proposal. These financial considerations should be fully disclosed.

The EIS should address the issue of what are the plans for the land should the agricultural use fail. This project is

S.KEY#: 2.18 NAME:KOLE PEN OBS:PUUPAAWAA RANCH

LATITUDE: 19 8 30 LONGITUDE: 155 52 42 ELEV: 920 FEET

PERIOD OF RECORD 1956 - 1975 READ: OTHER

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 10.60 | 4.40 | 7.31 | 8.55 | 5.46 | 4.50 | 5.65 | 4.75 | 4.40 | 6.70 | 9.93 |
| 75% | 6.17 | 3.00 | 3.00 | 3.59 | 3.24 | 2.50 | 3.10 | 2.90 | 3.79 | 2.41 | 3.63 |
| MED | 3.49 | 1.10 | 2.38 | 2.76 | 2.48 | 1.67 | 2.23 | 1.93 | 2.84 | 1.65 | 1.8[illegible] |
| 25% | 1.88 | 0.49 | 1.22 | 1.43 | 1.34 | 0.95 | 1.27 | 0.97 | 1.71 | 1.11 | 1.23 |
| MIN | 0.05 | 0.02 | 0.04 | 0.16 | 0.53 | 0.04 | 0.28 | 0.65 | 1.00 | 0.36 | 0.5[illegible] |
| COV | 53 | 72 | 43 | 43 | 41 | 45 | 42 | 50 | 38 | 37 | 47 |
| AVG | 4.07 | 1.62 | 2.71 | 2.67 | 2.54 | 1.76 | 2.34 | 2.10 | 2.68 | 2.00 | 2.6[illegible] |
| CDV | 71 | 85 | 76 | 75 | 59 | 53 | 61 | 57 | 40 | 72 | 5[illegible] |
| YRS | 19 | 20 | 19 | 20 | 20 | 20 | 20 | 19 | 20 | 20 | 2[illegible] |

DATA:

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | - 6.85 | - 3.96 | - 2.25 | - 3.07 | - 3.02 | - 3.07 | - 3.00 | - 3.78 | - 1.49 | - 4.12 | - 9.9[illegible] |
| 1957 | - 1.93 | - 1.53 | - 3.40 | - 2.00 | - 2.19 | - 2.00 | - 1.75 | - 2.90 | - 1.95 | - 3.33 | - 1.[illegible] |
| 1958 | - 0.21 | - 1.93 | - 3.40 | - 2.18 | - 2.82 | - 2.79 | - 3.35 | - 4.75 | - 2.00 | - 2.31 | - 1.2[illegible] |
| 1959 | - 9.53 | - 1.83 | - 3.32 | - 2.15 | - 2.75 | - 1.64 | - 2.90 | MISS | - 1.63 | - 1.10 | - 5.[illegible] |
| 1960 | - 0.05 | - 1.05 | - 2.42 | - 1.52 | - 2.47 | - 1.70 | 1.18 | 1.99 | 3.93 | 1.99 | 1.67 |
| 1961 | 3.03 | 0.49 | 3.08 | 3.39 | 1.79 | 2.23 | 2.94 | 1.47 | 1.65 | 6.70 | 3.5[illegible] |
| 1962 | - 3.49 | - 0.39 | - 2.59 | - 3.14 | - 3.31 | - 1.15 | - 4.48 | - 0.97 | - 2.93 | - 1.27 | - 0.5[illegible] |
| 1963 | - 5.00 | - 0.19 | - 7.31 | - 6.31 | - 5.36 | - 2.36 | - 5.65 | - 2.42 | - 4.04 | - 1.65 | - 1.1[illegible] |
| 1964 | - 2.79 | - 0.29 | - 4.12 | - 3.67 | - 5.17 | - 2.96 | - 2.58 | - 1.99 | - 1.91 | - 2.44 | - 3.0[illegible] |
| 1965 | - 5.25 | - 3.06 | - 2.20 | - 3.63 | - 3.66 | - 2.54 | - 3.13 | - 3.76 | - 4.13 | - 2.00 | - 6.41 |
| 1966 | - 1.75 | - 3.17 | - 2.38 | - 1.48 | - 1.27 | - 0.59 | - 1.12 | - 2.80 | - 3.35 | - 1.65 | - 1.62 |
| 1967 | - 1.82 | - 1.29 | - 6.75 | - 3.55 | - 2.65 | - 4.50 | - 4.25 | - 1.45 | - 3.45 | - 1.30 | - 3.67 |
| 1968 | - 6.17 | - 2.82 | - 2.35 | - 3.53 | - 0.67 | - 1.25 | - 1.58 | - 3.25 | - 4.40 | - 1.24 | - 1.70 |
| 1969 | - 6.25 | - 1.15 | MISS | - 0.75 | - 2.50 | - 0.40 | - 2.00 | - 1.43 | - 1.08 | - 0.90 | - 1.03 |
| 1970 | - 3.59 | - 0.80 | - 0.25 | - 1.70 | - 0.75 | - 0.42 | - 1.83 | - 2.45 | - 1.00 | - 0.75 | - 1.60 |
| 1971 | -10.00 | - 0.40 | - 1.22 | - 0.40 | - 1.31 | - 0.04 | - 0.35 | - 0.85 | - 2.75 | - 1.07 | - 2.72 |
| 1972 | - 4.85 | - 3.68 | - 5.67 | - 1.41 | - 0.53 | - 0.92 | - 0.28 | - 0.70 | - 3.01 | - 0.36 | - 0.75 |
| 1973 | MISS | - 0.02 | - 0.04 | - 0.65 | - 1.95 | - 1.15 | - 0.31 | - 0.95 | - 3.42 | 1.93 | - 4.55 |
| 1974 | - 1.65 | - 0.20 | - 2.95 | - 3.46 | - 4.89 | - 2.35 | - 2.46 | - 1.26 | - 3.90 | - 2.82 | - 2.55 |
| 1975 | - 2.47 | - 4.40 | - 3.32 | - 2.37 | - 1.56 | - 1.04 | - 1.54 | - 0.65 | - 2.03 | - 1.13 | - 2.05 |

highly experimental and its chances of success may be small. If the project is economically unfeasible, what will Farms of Kapua do to the land? How will they pay their investors back? If the land has failed in agriculture, how will the investors recoup their dollars other than residential sub-divisions?

Dated 1/4/82

MEREDITH LENELL, Attorney for
PA'A PONO OF MILOLII, INC.

# A Field Trip to the "Farms of Kapua" Property, Kapua, Kona, Hawai'i Island

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December 1983

## Introduction

Kapua was visited between 9 and 11 December 1983 in an access organized by Mr. Gil Kahele of Pa'a Pono Miloli'i, a Hawai'i based community group. Also present on the access were other members of Pa' Pono, as well as Volcano residents Rick Warshauer and Holly McEldowney. For part of the access archaeologists Melinda Sue Allen and Kanalei Shun were also present.

The trip was organized by P'a Pono Miloli'i who had expressed concern about the adequacy of the previous archaeological reconnaissance of the property carried out by Paul Rosendahl, Inc. ("Archaeological Reconnaissance Survey, Farms of Kapua Project Area, Land of Kapua, South Kona, Island of Hawaii." Prepared for Farms of Kapua, Ltd., March 1983). Areas visited were generally those not covered in Rosendahl's survey but which Pa'a Pono thought might well have significant sites in them. Some sites previously recorded by Rosendahl were relocated to allow orientation in relation to the Survey map provided with the original reconnaissance report. The area which is to be kept within the Conservation District as containing a particularly dense concentration of significant archaeological sites was not visited, and our visit concentrated on the mauka and southern portions of the property.

The method used in our inspection was that of walk-through reconnaissance, with usually 3-4 people spread out within sight of one another traversing a particular area. Coverage was not intensive and

recording of sites was brief and superficial. In areas of pahoehoe flows where many lava tubes and bubbles were seen, by no means every one was looked at. Where sites were not visited personally by the author, location details are only general and verbal descriptions given by other "team" members were relied upon.

The inspectionn allowed location and description of some sites outside Rosendahl's survey area. Thus I hope that this report may help fill in gaps in our knowledge of site distribution on Kapua and help in planning further archaeological work there. In addition some sites within Rosendahl's survey area which might have been missed in the original survey were described. The might is used because Rosendahl did not number or indicate the location of all sites recorded during the original survey, and the author has not yet had time to examine the original field notes, an offer which was made by Paul Rosendahl.

On page 12 of his survey report, Rosendahl states, "Several of the survey areas revealed scatterings of archaeological features--generally rather minor features, but few or no well-defined sites. In these instances, general survey area notes pertaining to the general nature, density, and distribution of these features were made, but no specific site numbers were designated." On page 25 further details are given:

"At least a scattering of archaeological features was found in virtually every survey area inspected. In most cases, these features consisted principally of minor agricultural features--such as clearings (for planting), stone clearing mounds, rough terraces, stone alignments, modified bedrock outcrops, and low, piled stone windbreaks. These minor



agricultural features often with associated crude residential shelter features, probably represented component elements of larger, more extensive agricultural and residential/agricultural complexes...for additional comments, the original field records of the reconnaissance survey should be consulted."

One of the criticisms made by the UH Environmental Center in its review of the Preliminary Planning and Environmental Study/Negative Declaration, Farms of Kapua, Kapua, South Kona, Hawaii (Appendix E of which is Rosendahl's Report) was that non-inclusion of these "minor" features in the report and on the survey map distorts the density of archaeological remains in the inland zone. The review strongly suggested that these features or complexes of such features be numbered as sites and that the general areas where these features exist be further surveyed. There are more sites within surveyed areas than are indicated in the report but on the information given it is not possible to evaluate their significance, nor their location.

In this report the different areas inspected and the sites recorded are described. Location on the map is at best only very approximate. Using Rosendahl's survey as a basis, and with the additional information recorded during the current survey, a tentative model of prehistoric land use of the Farms of Kapua property is formulated. Finally comments on Rosendahl's original survey report are made as well as recommendations for improving it as part of the EIS preparation.

Archaeological Survey Inspection

The initial survey sweep involved moving makai from an old concrete military observation post on the central N-S jeep trail at about the 400 foot elevation, in the vicinity of a lava flow channel. Most of the sweep was across a'a and the channel became less and less distinct. A small patch of flat, vegetated pahoehoe was examined at the makai end of the sweep, about 30m from a mauka-makai jeep trail leading to the vicinity of site 3705. A small cairn was found here (location 1), possibly a trail marker (elevation c. 150-200 foot). The sweep then moved south across the jeep trail and a'a ridge to an area of pahoehoe flows and a prominent a'a and pahoehoe ridge. Between the ridges in an area of lava bubbles another cairn was located (location 2), possibly another trail marker (c. 175 foot elevation). Several bubbles in the area were investigated but none contained any signs of human occupation except an occasional piece of ordnance. About 100m mauka of this cairn at about the 200 foot elevation was a very large refuge cave with associated petroglyphs (location 3). This cave was known to Mr. Gil Kahele who had learned about it from older residents of Miloli'i. This was by far the most important site noted during the inspection, a refuge cave of very high research, interpretive and cultural value. It was not recorded in Rosendahl's survey, being slightly to the north of survey area A11.

The cave appears to be part of an extensive lava tube system which also includes sites 9936, 9933, 3705, 9915, 3706 and possibly 9940. These do not however constitute a continuous cave because of roof falls.



The cave entrance is in a collapsed lava sink and petroglyphs are found makai of the entrance on the sink "lip", one of the petroglyphs apparently of a man and woman making love.

The cave entrance has a double fortification and is one of the most complex refuge cave fortifications known to me in Hawai'i. The entrance, partially collapsed, has been artificially narrowed, permitting only single file access. This was accomplished by walling up both the floor and sides of the cave entrance. A right-angled turn after the narrow entrance brings one down two terraces into a chamber perhaps 8m long and the natural width of the tube (approximately 6m). The mauka end of the chamber is again walled up. On the natural floor of the chamber and on the terraces are traces of shell midden and kukui nuts. On the floor are at least two piles of rounded, water-worn slingstones. There are further terracing and platforms within the chamber. Entry to the mauka portion of the tube is along the right wall-again entry is restricted by walling to single file and another right angled turn has to be made. Wooden upright poles in place may have supported a roof over this part of the entrance, thus further restricting access. A roll of thick (fencing?) wire was found at this point. At this second fortified entrance the rest of the cave width is blocked nearly to the roof, with a "window" at the top to allow observation of those entering the first chamber. Behind the blocking wall is a high observation terrace. On it is a large waterworn stone. Midden and ash piles lie on the natural floor of the tube in the vicinity of the second entrance. The length of the tube is a few hundred meters. It is generally barren of signs of occupation although a drop

down to a side "blind" tube is terraced with a one meter high retaining wall. Mauka of this, one has to climb up a large pile of roof fall which gives access to a higher level of the tube. The main tube at its mauka end is walled up fully but a side tube to the right allows exit. In this side tube were located several interesting features (see sketch map) including two upright stones about 2-1/2m apart supported by a circle of stones, probably a shrine, at least two firepits with ash and opihi shell, other ash and shell scatters and fragments of a gourd which may have been set to collect any water dripping from the roof. The exit is disguised and allows only one person at a time to crawl out with some bodily contortion. Outside and adjacent, but hidden behind boulders, is a flat terrace, presumably a guard or lookout post under the overhang of a partially collapsed sink. Another lava tube entrance was nearby but there was no time to investigate it.

Within 30m on the northern side of the ridge is a 2m high platform terrace with a vertical entrance on the top which leads nowhere--a "decoy" entrance for the tube. Other areas of arranged rocks in the area may represent other decoy entrances. This tube (probably in the proposed koa haole cultivation or research area should most certainly be protected and preserved.

Proceeding makai, the inspection noted no sites until the vicinity of site 9934 (a probable burial platform) was reached. In an area about 50m mauka of this feature a C-shaped shelter was located (location 4) incorporating two upright stones. Directly adjacent to the north a shallow depression approved to have been covered with a layer of stones



and may be a "stone-mulched" planting area. There were other similar areas nearby as well as at least two probable planting mounds. Around 9934 were more mounds and cleared areas. 3705 tube shelter is nearby. We seem to have an occupation and dryland agriculture in this area of otherwise fairly barren terrain.

From 9933 a transect south was made. Several other lava tubes were noted in this area but not investigated in detail. Immediately mauka of one of these on an area of pahoehoe were up to 100 mounds (location 5). No habitation debris was noted in this tube. These mounds could be agricultural (for gourds?), burials, or may be associated with recent military use. This area is within the bombing range at about 900 foot elevation.

Our next survey sweep was initially south along the N-S road starting at the 400 foot elevation from the concrete observation platform. The first pahoehoe area encountered was the top of Rosendahl's A11 survey area. This area has many lava bubbles and short tube segments adjacent to the large lava flow channel of the A11 survey area. Adjacent to the jeep trail several lava tubes were investigated. Only one (immediately adjacent to the jeep trail) showed signs of human use (location 6) (see sketch map). Immediately makai of a "skylight" entrance was an ash deposit, immediately mauka the floor was paved with flat pahoehoe slabs across the three meter width of the tube. Mauka again there was a cleared floor area, also probably for sleeping. Little midden was evident and it would appear to represent a temporary shelter perhaps along a trail. Moving south towards Rosendahl's survey area K-7 was an

area of barren a'a. Starting at the road, perhaps 500m north of K-7 was located an old mauka-makai paved trail across the a'a (location 7). This was followed only part way down, but may be the same trail as was encountered more makai on the lower edge of the investigated a'a flow.

The next large pahoehoe flow and flow channel after K-7 includes site 9904 mauka of the road. It was followed makai by teams both north and south of it. North of the channel the teams sighted trail segments often paved (location 8) which may be continuations of the trail sighted at location 7. Associated with one trail segment was a lava shelter with a cleared, probable sleeping area. Otherwise the lava tubes and bubbles of the area showed no signs of occupation. No signs of occupation including trails were sighted in the barren a'a south of this flow channel.

Just after the grasscovered pahoehoe was reached, an agricultural area (location 9) was located around a low rise. It consisted of C-shaped windbreaks of pahoehoe slabs (see sketch map) against the rise on its south, east, and west sides. On the west (makai) side a terraced platform 3 x 2m was found, paved with smaller stones. This was interpreted as the platform for a terraced field shelter. From here a sweep was made towards coastal Site 2147. The transect crossed the edge of Rosendahl's K-10 survey area. As 2147 was approached many of the collapsed lava tubes exhibited signs of modification for agricultural use (location 10) in the form of rearranged stones on the sink floor forming a "stone mulch", excavated holes with windbreak walls around them, as well as other windbreaks of piled rocks. These are evidently associated with a secondary agricultural focus for the village site 2147.



The next sweep was from 2147 north along the coast, covering the area inland to the K-10 survey boundary. Further features were located in the coastal area surveyed by Rosendahl but none certainly outside it. These features were associated with 2147 or were trails leading mauka-makai or along the coast. The area of coastal settlement appears larger than is indicated in Rosendahl's survey map showing 2147. In location 11, for instance, a house platform with slab-lined hearth and associated terraced activity areas was located about 500m north of the "red hill" within 2147 and perhaps 50m from the ocean. About 75m mauka of this on a small rise was a c-shaped structure (location 12) with two or three pieces of branch coral. Adjacent were areas of rough terracing and paving. A line of cairns, presumably delimiting a trail extended some distance mauka. A military road marked by cairns is in the vicinity but is not associated with this particular line of cairns.

In the vicinity of and north of location 12, further evidence of agriculture in the form of modified collapsed lava bubbles was found as well as one small sink about 2m deep, perhaps 4m in diameter with midden, coral lumps, etc., on the floor--presumably a temporary field shelter.

From a position about 3-400m south of Site 3775 the transect narrowed and cut diagonally towards 3705. Many large tubes were seen during this sweep, at least one (approximate position location 13) with deteriorating (bombed) terraced platforms outside its entrancce.

Site 9936 was visited in company with Ms. Allen who had originally located this site. Two other significant nearby features--both lava bubble shelters had also been recorded by Allen and merit designation by

a separate site cluster member. One in particular appears to have potential for important subsurface deposits. These should have been noted in Rosendahl's site description.

The final surveyed areas were near the mauka property boundary, both south and north of thee main road into the property. Much of this area, the makai extension of a now-destroyed more intensive agricultural zone, has been dragged/grubbed except ridge toes which tend to be devoid of soil. Thick lantana made survey difficult. Some rough slope modification features were noted even in these areas however. One ridge and adjacent swale with soil deposit (location 14) south of the road gave some indication of what may have already been largely destroyed in the area. It appears to be a house site with surrounding wall and a possible historic burial feature, with associated agricultural mounds and walls (see sketch map).

The road area near the lower gate at the mauka end of the property shows a bulldozed midden scatter in its dragged area (location 15). Moving north along the fenceline about 100m a substantial mauka-makai (cattle?) wall was encountered but not followed.

Part of Lot 7 outside the Conservation zone but still within the Farms of Kapua property was investigated. Only areas immediately adjacent to the N-S fenceline road were checked, particularly areas with kukui nut trees. Three areas north and south of the property entrance road showed areas of rough terracing for planting on stony ridge sides (locations 16, 17, 18) and a small 3 x 2m enclosure (location 16). This Lot 7 area and Lot 13B to the south would seem to have considerable



potential for archaeological remains. Immediately mauka of Lot 7 was the area of Kapua where several LCA's were awarded in what appears to have been an intensively cultivated inland zone. Nearly all of this was bulldozed to make way for the macadamia plantation, leaving only its lower edges within the Farms of Kapua property as evidence for this land use pattern.

## Kapua Land Use

Evidence from Rosendahl's survey and the new information collected in this report allow a tentative prehistoric land use model to be put forward. There are evidently three main zones:

1. Coastal occupation and associated dry land agriculture.
2. Generally barren lower slopes with occasional agricultural kipuka and temporary occupations. Zone of trails (generally mauka-makai) with associated temporary shelters and refuge caves. This zone may be considerably more extensive in the southern half of the property.
3. Intensive inland agricultural zone (only lower edges present, mostly bulldozed in project area) with permanent occupation. Appears to be a southern extension of the Kona field system.

## Comments on Rosendahl's Survey Report

There are several main areas of concern here. One, the selective numbering of sites and site complexes, has already been discussed. It is only necessary to reiterate that this gives a distorted picture of site distribution and density. Of further information on these unnumbered

sites and their placement on the survey map should be a high priority for the EIS.

Further discussion is needed in the "Survey Methodology and Procedures" section of the archaeological report on how the inland survey areas were selected, apart from the presence of sites on aerial photographs. It is unclear what methodology was used which ensures that the samples truly are "representative" of the density of inland sites. It is questionable whether a sample of 14.6% of the inland area and the way the areas surveyed were chosen allow us to make valid general statements about site distribution, density and significance in the inland zone. Reference to discussion of appropriate survey methods and survey size in the professional literature would seem necessary at this point. Very little of the central portion of the property was examined and yet general statements about relative site density in the north, central and southern portions are made. This seems questionable in the light of the percentage of area surveyed. It would seem that reconnaissance level survey of the whole property should be required before such general statements can be made with any real basis, or at least survey of a considerably larger and more representative portion of the property.

The archaeological survey map as presented is a confusing document with differing contour intervals in different sections. Particularly in the north it is so crowded as to be unusable. I suggest using standardized contour intervals and as well as this general map, providing detailed maps of individual survey areas. Vegetation and substrate maps



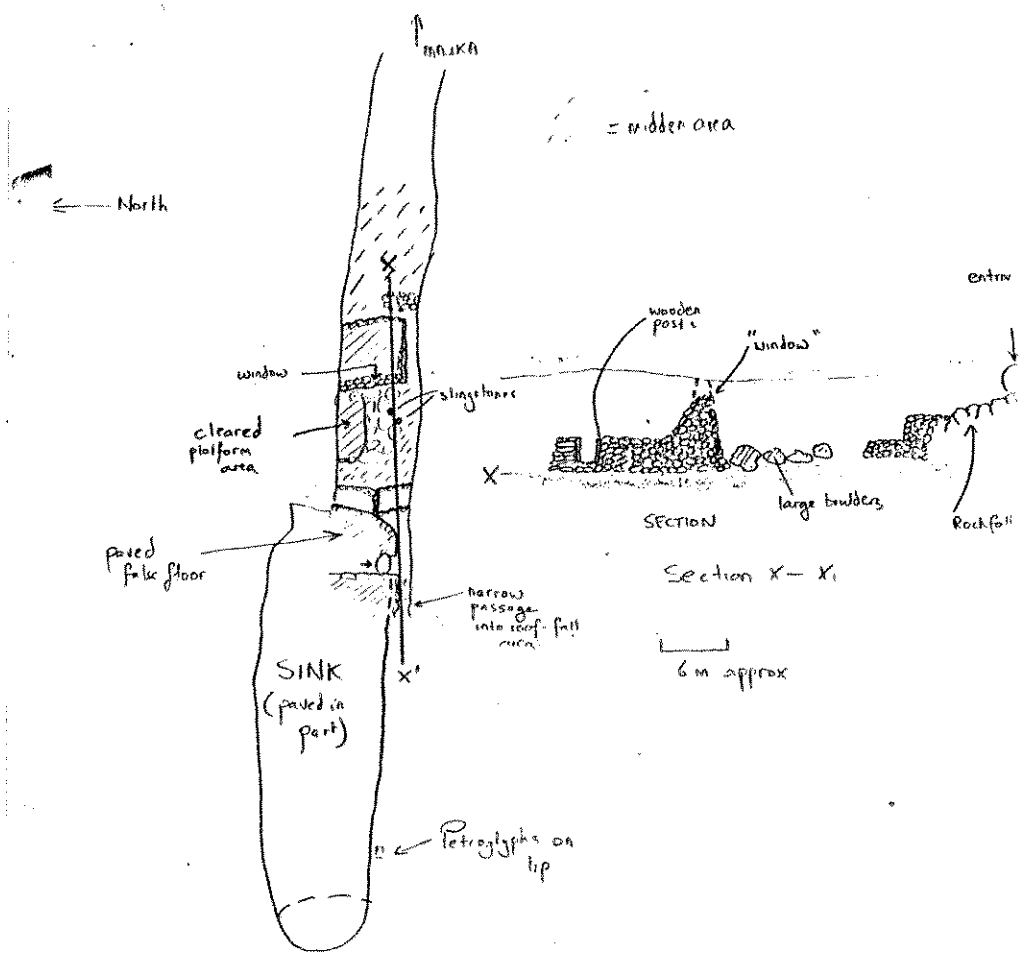
would be most useful in evaluating archaeological potential for different areas. In addition the grubbed/dragged areas should be located on a map, after having been ground truthed. It appears that generally only "swales" or low flatter areas were grubbed and a'a ridges in between were not touched.

Rosendahl's section on site significance points out that such designations are only tentative at this stage. Even so, some of the designations appear questionable. It is strange that no inland sites are considered of great interpretive significance. "Preservation value" is discussed as referring" to the need to conserve an adequate and representative sample of the archaeological resource base for future uses" (p. 28). However, no recommendations are made to preserve any sites outside of the coastal zone--surely for an "adequate and representative sample of the archaeological resource base" some mauka areas, particularly of combined agricultural and residential complexes should be preserved.

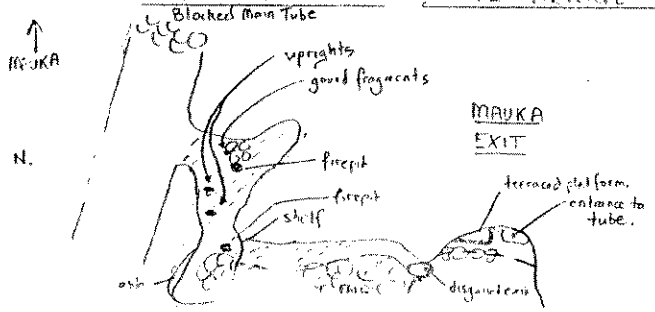
In the report "cultural value" is defined as referring to "the potential for preservation and promotion of cultural and ethnic identity and values." Only one site is listed as having "high cultural" significance and two others as possibly having in one case "moderate" cultural value, and in another simply "cultural value". Surely this does not exhaust the known sites in the area which are of cultural significance to the Hawaiians. Several families who lived on the property until the 1930s and other Miloli'i residents have strong cultural associations with the sites of this area. Some have relatives

buried on the property. In preparation for the EIS a large effort should be made to elicit information from Native Hawaiians about the significance of these sites to them, as well as what is probably a rich oral history concerning the area. Until this is done the true significance of many of the Kapua sites cannot be adequately evaluated.

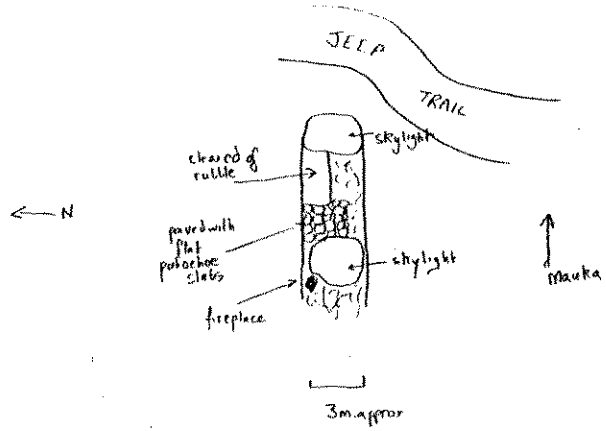
The reconnaissance survey report lacks any synthesis of the different lines of evidence relating to prehistoric and historic use of Kapua. Sites are described but without context and so it is not possible to evaluate the importance of this area in archaeological terms on the basis of the work as presented. The descriptions of early European travellers to the area such as Ellis seem to be contradicted by the archaeological evidence presented such as high status residential and other sites on the coast. Why is it that (according to Rosendahl) sites are concentrated in the north of the property both makai and mauka? Sites which in themselves may not seem very important, such as the residential and agricultural features located in the mauka area during this inspection take on greater significance when it is realized that the rest of the mauka portion of Kapua has already been bulldozed and these remnant sites are all that is left. An overview of the evidence so far recovered should be given in the EIS.



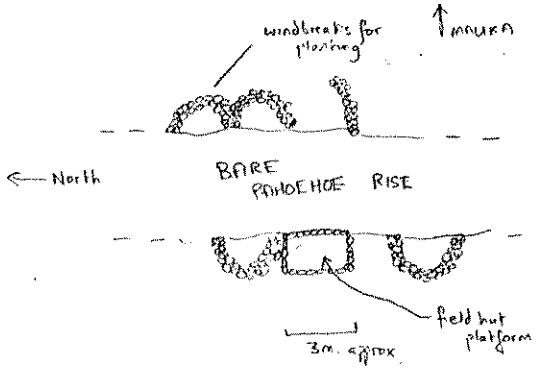

LOCATION THREE — LARGE REFUGE CAVE – MAKAI ENTRANCE




AS 1983

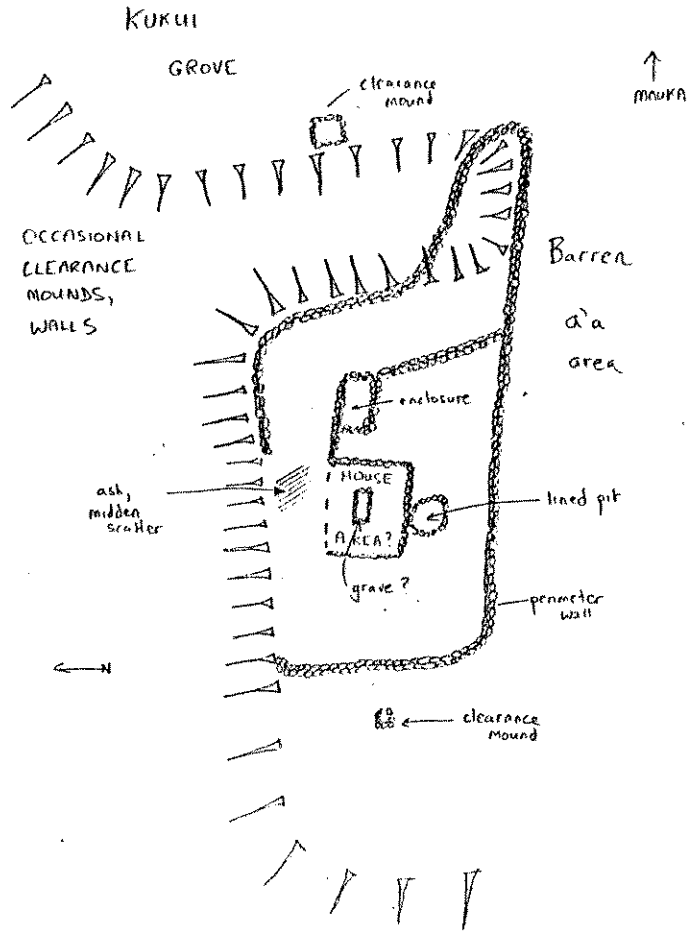



LOCATION SIX — TEMPORARY SHELTER IN TUBE



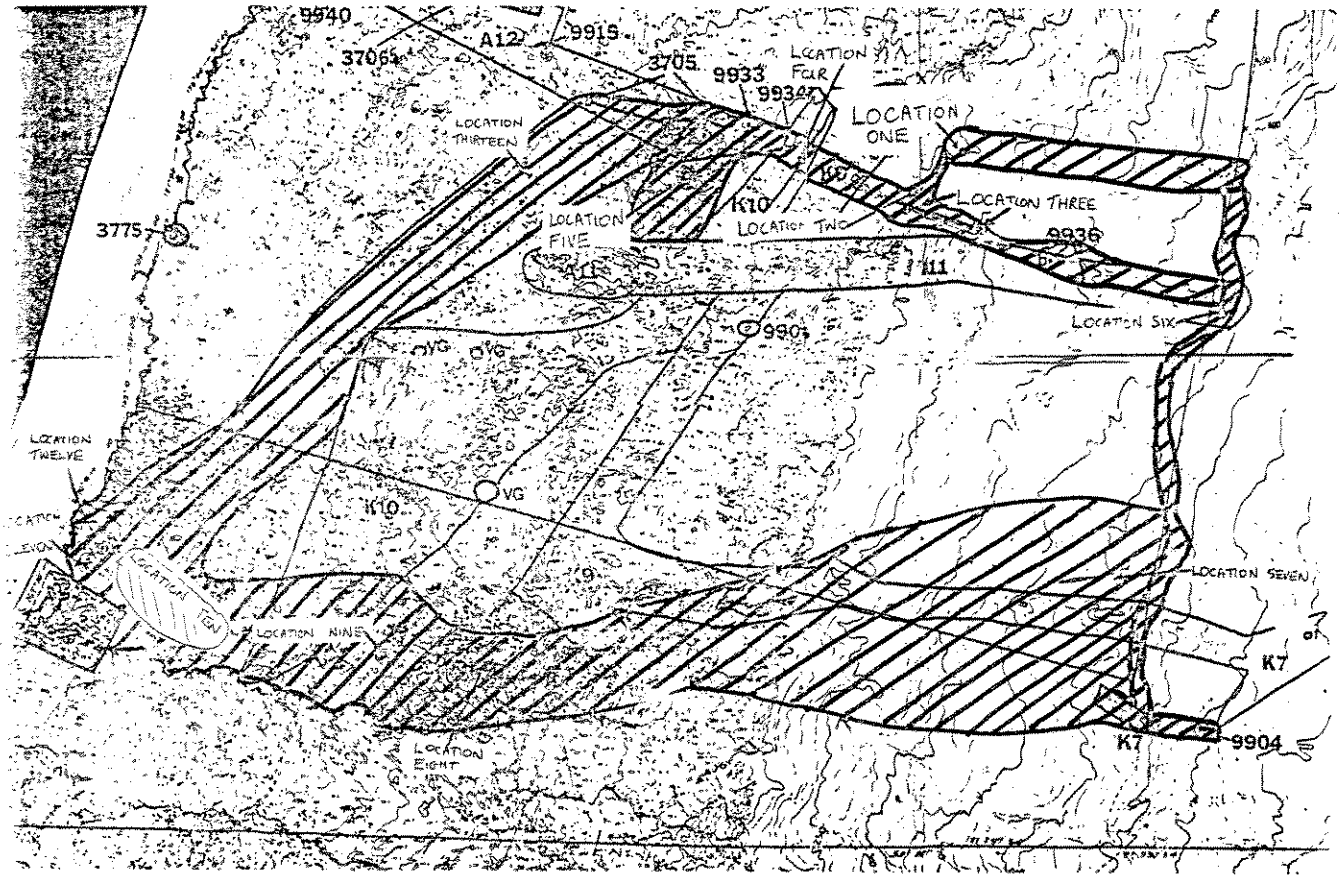

PART OF LOCATION NINE — AGRICULTURAL COMPLEX

MS 1983




LOCATION FOURTEEN — HOUSE SITE ?

MS 1983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3706
A12
9915
3705
9933
9934
LOCATION FOUR
LOCATION ONE
LOCATION THIRTEEN
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LOCATION FIVE
K10
LOCATION TWO
LOCATION THREE
9936
A11
LOCATION SIX
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LOCATION TEN
LOCATION NINE
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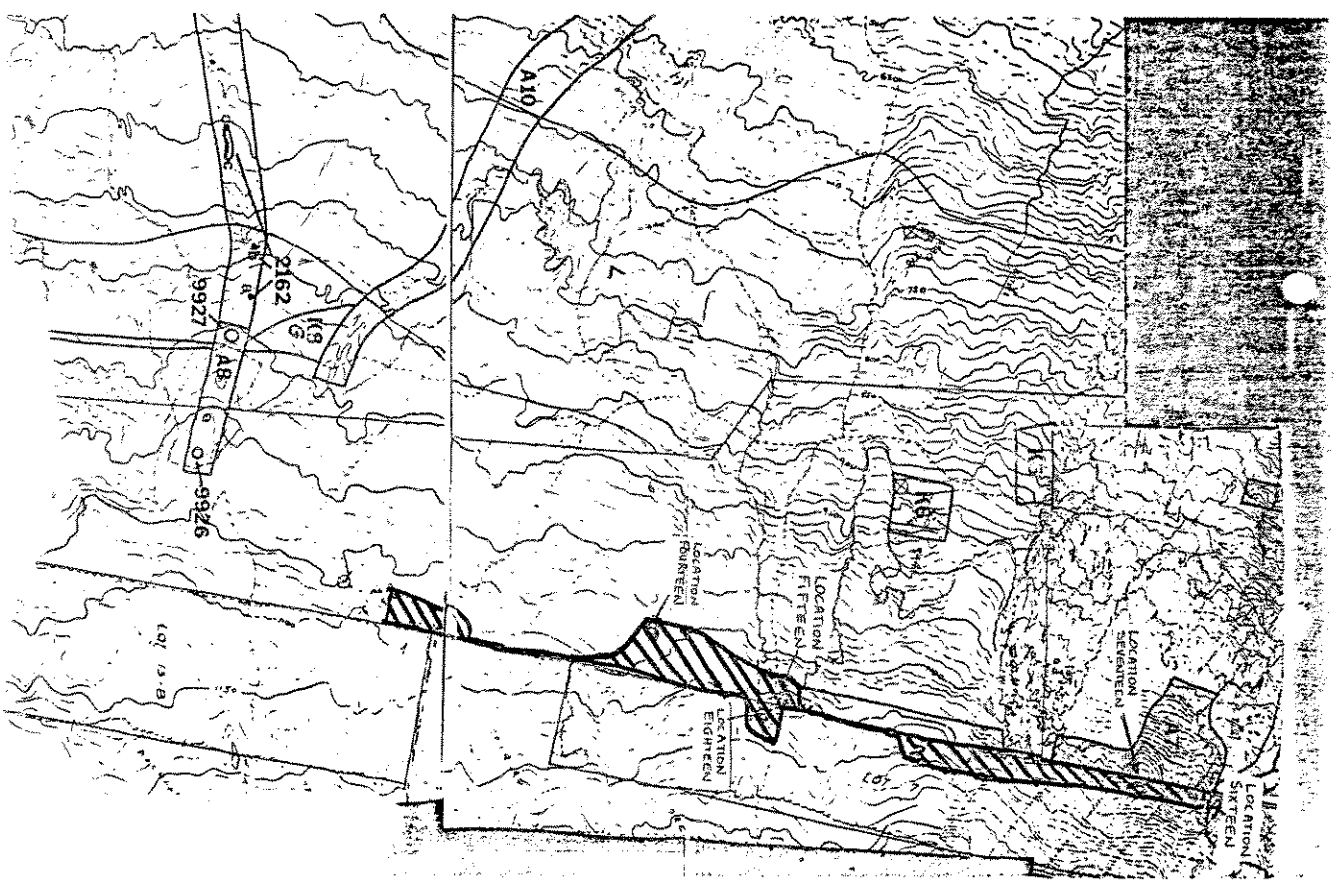
LOCATION EIGHT


A10
2162
9927
A8
9926
LOCATION FOURTEEN
LOCATION FIFTEEN
LOCATION EIGHTEEN
LOCATION SEVENTEEN
LOCATION SIXTEEN

Kazuo Ishihara AIA, Inc
Frances S Oda AIA Inc
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17 February 1984

Pa'a Pono of Milolii, Inc.
c/o Ms. Meredith Lenell, Esq.
P.O. Box 861
Captain Cook, HI 96704

Gentlepersons:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We offer the following responses to your comments. Direct references to your letter will be identified in the following manner: page/paragraph.

1/2 to 2/1 The EIS will include a discussion of the General Plan Land Use Pattern Allocation Guide (LUPAG) and Agricultural Lands of Importance to the State of Hawaii (ALISH) designations. It should be noted that the LUPAG designation is in conformance with the higher State Land Use designation. The original rationale behind the State Conservation District designation has been investigated. Gordon Furutani, Executive Director of the Land Use Commission was consulted regarding this matter. According to Mr. Furutani, research into the original rationale for classifying an area is conducted whenever a petition is filed. In some cases, the exact reasons for a land use designation is documented. In the case of the petition area, Mr. Furutani was unable to find any specific documentation. An amendment to the General Plan will be requested following the favorable resolution of the State Land Use District boundary amendment.

While lands of the subject petition contain soils which have been considered not normally adaptable for productive agricultural use (in ALISH), the petitioner is proposing uses such as aquaculture and the cultivation of macadamia and koa haole, which do not require soils with greater master productivity ratings. Therefore, while previously the site may have not been considered normally adaptable for productive agricultural use (according to the ALISH designation), approval of the petition would expand the agricultural potentials of the petition lands and the State Agriculture District boundaries.

2/2 The land exchange will not be discussed as an alternative to the proposed State Land Use Boundary Amendment, since the State has not offered lands for such an exchange or has not established the park since 1971 (S.R. 261). Therefore, it would not be appropriate to discuss the "probability of lava flows from





Loa striking the project areas as opposed to lava flows striking alternative areas such as the Keahole area in Kona" in the EIS.

2/3 to 2/4 Approximately 70 percent of the macadamia (in increments of 500 acres) will be graded. In addition, approximately 70 percent of the 200-acre research and development, 200-acre koa haole cultivation and 2,472-acre koa haole pasture (in increments of 400 acres) areas will be grubbed. The remaining 30 percent (a standard engineering consideration) of these areas may be needed for the construction of roads, or the preservation of significant archaeological sites or areas containing significant botanical specimens. The activities of each aquaculture module, including the brackish water system, will occupy approximately 160 acres. An additional 40 acres is alloted for roads (although not all of this will be used).

Proposed improvements for the macadamia orchard include minimal grading of the irregular terrain. No borrow material will have to be brought to the site.

Only one pass by a large tractor (D7 or larger) with the blade adjusted to skim the surface, pulling a heavy 10 ton or heavier roller for the 2,472-acre koa haole pasture area is recommended by Harold F. Rice, Jr., the consultant on pasture managment. The 200-acre koa haole cultivation and the 200-acre research and development area will be bladed and rolled to a higher degree (requiring possibly 2 or more rollings). No ripping or moving of material is required. In the aquaculture area rough grading will occur only within the individual 200 acre modules.

2/4 Cesspools will be located as per the spacing requirements specified in Chapter 38 of the State of Hawaii Public Health Regulations. The cesspools at the aquaculture area will be sited a minimum of 300 feet from the shoreline (at an elevation of 40+ feet) and approximately 2000 feet from each other. Please note that the wastewater from the aquaculture modules will be collected in a culture trough for seaweed, which will remove nutrients from the water before it infiltrates into the underlying lava.

2/5 Please refer to response to 2/3. Note that approximately 70% of the 1,710 acre macadamia area will be graded. The consulting engineer, R.M. Towill, has estimated the total cost of grading (70% of 1,710 acre macadamia area) and grubbing (70% of 200 acre research and development area, 200 acre koa haole cultivation area and 2,472 acre koa haole pasture) to be $2,000,000.

3/1 to 5/2 We appreciate the information on the availability of data from nearby stations (State Department of Land and Natural Resources, Division of Water and Land Development publication Circular C-88, "Median Rainfall State of Hawaii)". This latter publication was made available to the public after moisture deficits for the proposed macadamia orchards in Kapua were modeled by interpolating rainfall averages at Opihihale and Manuka (John Mink, Water Supply for Farms of Kapua). Please note that none of these gages are reported in National Weather Service publications, nor had their records previously been printed in published reports of DLNR or the USGS.

Unfortunately, C-88 does not provide average rainfalls for any of the rain gages. All statistics and isohyetal maps are cast in terms of medians, which is the mid-level of rainfall accumulation per unit time. Please note that the analysis in the NOP employs average rainfall by months, while your comments are based on medians. These values are not identical. For example, average rainfall at Kole Pen is 30 inches per year, while the median is just 25.7 inches. The median does not give the total quantity of water that falls as rain. Hydrologic balances are computable from averages but not from medians, unless the frequency distribution is perfectly normal, in which case the average and median are identical. (For this reason, the median rainfall map included in DOWALD Report C-88 [1982] will not be reproduced in the EIS.) Thus, only a weak correspondence exists between the statistical methodology and interpretation presented in the NOP and the one presented in your letter.

There is no standard definition of drought. In the broadest sense, drought is an extended interval during which less than normal rainfall occurs in a region. Therefore, a drought at Opihihale implies drought in South Kona. Absolute values of rainfall at a particular site are irrelevant in the drought concept. Nevertheless, Mink's memo (Drought Frequency, Kapua, South Kona, Hawaii, 11/12/83) has been revised to include drought statistics derived from the Kole Pen data and is attached to this letter. Preliminary analysis shows the frequency and duration to be virtually the same as at Opihihale.

Again, the comments to your letter do not reflect the same methodology used in Mink's memo in your assessment of drought frequency at Kole Pen. Mink uses the median and 25 percentiles for each month; while you use averages of these percentiles, equally apportioned to each month, instead of the actual percentiles for each month. Preliminary analysis employing Mink's drought model for Kole Pen indicates the occurrence of five severe droughts (8.4% of the time) in the 20 years of record of Kole Pen, which differs from your analysis of 16 severe droughts, 25% of the time.





5/3 to 6/2 The sustainable yield of the Keei water system was improperly cited in the NOP. To avoid confusion this information will be not be included in the EIS. Other areas of Kona provide more realistic water production data. For instance, in North Kona at Keauhou, one station has been constructed to produce 4 mgd. The most recently drilled Keei well (no. 2653.01, elev. 822, completed 1978) was successfully tested at 1.1 mgd.

Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation and 200 acre research and development areas. Irrigation is not being proposed in the 2,472 acre koa haole pasture area. Research conducted by Harold F. Rice indicates that there are areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing.

The expected demand and supply for water at Farms of Kapua was studied by John Mink and his report will also be appended to the EIS. Irrigation requirements by months, based on a moisture demand of 4.4 inches per month (Frank S. Scott Jr., Agricultural Feasibility of Macadamia Nuts Farms of Kapua, December 1982), have been computed by Mink for the historical record based on the Opihihale and Manuka rain gages and separately for the record at Kole Pen. The average deficit is estimated for Opihihale/Manuka at 1261 gpa/d, for Kole Pen at 1912 gpa/d. Estimates of the total average demands for irrigation, based on the least favorable record (Kole Pen) are given below. Irrigation rates for macadamia are assumed to be applicable to leuceana and other crops also.

| CROP | ACRES | AVERAGE (gpad) | TOTAL AV. (mgd) | 10 PERCENT (gpad) | TOTAL (mgd) |
|---|---|---|---|---|---|
| Macadamia | 1710 | 1912 | 3.3 | 3481 | 6.0 |
| Leucaena | 200 | 1912 | 0.4 | 3481 | 0.7 |
| Other | 200 | 1912 | 0.4 | 3481 | 0.7 |
| TOTAL | 2110 | | 4.1 | | 7.4 |

Total average demand is equivalent to 2845 gpm. Assigning a yield of 1000 gpm to agricultural wells, three wells may be required to satisfy average demand. At the same yield, two to three additional wells will be needed to meet the ten percentile demand.

An accurate determination of groundwater flow through Kapua is impossible because values for the parameters of the relevant equations are imprecise. However, analogy with similar Kona subsurface environments where some of these values have been refined suggests that flow at the coastline is at least of 6.0 mgd per mile. In the arid regions of North Kona and South Kohala, a thorough water balance study of the Water Resources Research Center at the University of Hawaii (B.Y. Kanehiro and F.L. Peterson, 1977, Groundwater Recharge and Coastal Discharge for the Northwest Coast of the Island of Hawaii: A Computerized Water Budget Approach: U.H. WRRC Technical Report TR-110) indicated coastal discharge to likely be 6.38 mgd per mile and as much as 11.8 mgd per mile. This region does not experience rainfall as high as in Kapua. Within the petition area, total flow is between 8.0 and 18 mgd, and the most probable average is about 13 mgd. Not all of this flow is feasibly developable, however; sustainable yield on a continuous schedule is 6.0 to 7.0 mgd (total average demand is 4.1 mgd), but for periods of reasonable length (three months), Mink believes as much as twice the sustainable yield can be pumped without seriously affecting the quality of yield.

To date, no comments reflecting concern over the use of the aquifer have been recieved from the State or adjacent landowners. They will have another opportunity to express their opinions on this matter during the EIS public review period.

6/3 to 7/1 Ultimately, no structure can built to withstand severe earthquake activity, however, please note that the aquaculture ponds will be lined with plastic, not concrete. It is not appropriate for the EIS to address "whether there are other [emphasis added] areas in Kona that are less suceptible to damage from volcanic hazards using the Mullineaux and Peterson report", therefore, the map will not be reproduced in the EIS.

7/2 The wastewater produced from the aquaculture modules is basically brackish water that has been cycled through the production units holding the various species. The wastes from one species are used as nutrients by the following species and in this way the water is filtered. The final wastewater contains no human contamination and consists basically of some remaining fecal matter from marine organisms, excess feed, and some algal and plant matter. The wastewater will be collected in a culture trough for seaweed, which will remove nutrients from the water before it infiltrates into the underlying lava.

7/3 No pesticides are proposed to be used on site.





7/4 Please note that guinea grass, not fountain grass, is proposed to be planted in the pasture areas. It is the opinion of the consultants on pasture management and vegetation, Rice and Nagata, respectively, that guinea grass will successfully compete against fountain grass. Rice further maintains that contrary to what most ranchers thought some years ago, fountain grass, under modern management, is now considered of value in the establishment of rocky areas for pasture by increasing organic matter. With cross-fencing and rapid rotation of large groups of cattle, the fountain grass can be grazed prior to the stage at which it becomes unpalatable. Furthermore, tests at Keaumoku by Clarence Garcia with the University of Hawaii Extension Service indicated that the application of small amounts of magnesium fertilizer will make the grass palatable.

7/5 to 8/1 Based on his earlier survey, Kenneth M. Nagata returned to Kapua to determine the extent of the native dry forest at the mauka boundary of the petition area, to ascertain the integrity of that forest and to seek out any rare and endangered species in that section. In summary, Nagata found very little of the native dry forest actually extends into the petition area.

8/2 An avifaunal survey of the petition area has been conducted by Dr. Andrew J. Berger. His report will be appended to the EIS.

8/3 Berger states in his report that "Rarely during my field work in the Hawaiian Islands during the past 19 years have I seen such a poor habitat for birds and mammals as in the Kapua Farms petition area." While the site may contain roosting sites of the Hawaiian bat, all of the remaining mammals found on the site are introduced species, and all of these are considered pests to man, his activities and products, and/or to native vegetation and fauna. As previously mentioned, Berger states that: "As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macadamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight." The two species of endangered Hawaiian birds (the hawk and the owl) seen on or adjacent to the project site have adapted to the introduced vegetation on the island of Hawaii, primarily because of their feeding habits and the extent of their home range.

As previously noted, no pesticides are proposed to be used on site.

8/4 to 9/1 There is no general agreement within the professional archaeological community as to what constitutes an adequate sample. Each specific case must be considered on its own characteristics and

requirements. In the case of our reconnaissance survey report, it was stated that the survey areas comprising our sample were selected on the basis of geographic disribution and environmental variation.

The amount and detail of data collected during reconnaissance survey field work (and thus contained within the original field records) is generally more extensive than presented in the descriptive report on a survey. Please be assured that the "minor" features identified during the reconnaissance survey were not "discarded." These features were treated in a qualitative, rather than, quantitative manner. This is considered acceptable for the reconnaissance survey level, though not for subsequent more intensive survey work. It is assumed that anyone conducting subsequent intensive survey field work will inspect and study the available field records of the prior reconnaissance survey. As noted on page 13 of Rosendahl's report and as Spriggs notes on page 2, paragraph 2, Rosendahl has offered Spriggs and other qualified researcher to review the original field notes.

Reconnaissance survey is the appropriate level of study for general planning activities and decisions. In fact, it is the level required by a regulatory agency such as the State Land Use Commission for the making of that level of land use decisions; i.e., general land use planning. More specific land use planning is the jurisdiction of the County planning offices and agencies.

9/2 Our response to Spriggs report is enclosed. At this point it can be said that the synthesis that Spriggs refers to would definitely be appropriate at the intensive survey level of study, but not necessarily at the reconnaissance level.

9/3 The specific procedures for the selection of sites for preservation, preservation measures must await the findings of intensive survey work, and the preparation of a cultural resource management plan based on those intensive survey findings. This was anticipated and noted on page 32 of Rosendahl's report. And again, these activities are inappropriate to the present level of the planning.

Blasting, once proposed as a last resort in the preparation of land for macadamia cultivation, is no longer being proposed anywhere on site.

9/4 We disagree with the statements made in this paragraph. Pages 3, 26, and Appendix III of Rosendahl's report demonstrates that preliminary work along these lines has been accomplished, and that subsequent more socio-cultural research, including informant interview work has been recommended.





9/5 to 10/1 As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the features of historical value that was found by the consulting archaeologist, Paul H. Rosendahl, in his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. As previously mentioned, the petitioner will maintain the present unobstructed lateral access along the shoreline, north and south of the petition area. We feel that retention of the above described shoreline areas in the Conservation District is in keeping with the expressed intent of S.R. 65 (1983).

10/2 As suggested, what is known of the historic perspective will be addressed and a description of the environment in the vicinity of the action from a local and regional perspective will be inlcluded in the EIS. We note your opinions on this matter.

10/4 For the 25-year planning horizon in his analysis, Dr. Scott considers a price of 90 cents per pound (in-shell, 18% moisture content) more realistic than current lower prices (resulting from a temporary oversupply). This is particularly true in view of the fact that Dr. Scott did not inflate the net returns during the 25-year amortization period. Had he programmed a price of 75 cents the first year and inflated net returns at 6 percent annually, the break-even could be expected much sooner.

10/5 to 11/1 In more refined determinations of the economic viability of macadamias for Farms of Kapua, Dr. Scott is currently assuming a 6 percent inflation rate, but a plateau yield of only 5,000 pounds per acre. On this basis, he has computed an internal rate of return of 20.0 percent, as compared to 17.3 percent under the higher price, higher yield scenario, with no inflation. The maximum yield per acre of 5,000 pounds, which he has programmed in the more recent study, amounts to only 71 percent of an expected 7,000 per acre yield under more optimal conditions. In the earlier study, a maximum yield per acre of 5,850 pounds was assumed.

Dr. Scott's research indicated that temperatures between the 400 and 950 foot elevations at Kapua would not pose a problem in flowering and fruit set.

As noted elsewhere, we disagree with your analysis, that there will be "periodic, prolonged droughts which would cause irrigation demands in excess of the safe pumpage capacities of the proposed wells" (see response to 5/3 to 6/2). Please note that the use of Okoe well is contigent on State approval, and its use would be considered supplementary to the proposed irrigation wells to be drilled on site.

11/2 to 11/4 Macadamia orchards located in more ideal locations will, of course, have a comparative advantage, but this does not render production at Kapua economically unfeasible.

11/5 to 12/1 Although none of the subject gages (recently reported in Circular C-88) are reported in National Weather Service publications, nor had their records previously been printed in published reports of DLNR or the USGS, Scott has revised his report to incorporate this data. His revised report will be appended to the EIS.

(a) In consideration of this data, Scott will revise supplemental water requirements in his report. The range of 22 to 32 inches will be considered the natural rainfall base.

(b) Indicated water requirements of 4.4 inches per month relate to drip irrigation requirements, not rainfall. This requirement has been determined by commercial producers who are using drip irrigation. This assumes uniform distribution. Assuming some seasonality in rainfall, this does not contradict that natural rainfall of 60 to 70 inches may be required for lower limits for good yields in Kona.

(c) Scott's analysis, which is based on the direct use (unmixed with less brackish) of water from Okoe well, assumed that natural rainfall (based on earlier determinations) plus 110 percent of supplemental irrigation requirements might provide adequate leaching of salt. These assumptions were preliminary and not intended to be conclusive. However, according to John Mink, while brackish water has been used for irrigation in Hawaii on soils with less porosity, a case of salt accumulation in soil has yet to be documented.

(d) Scott's description of soils is based entirely on "Soil Survey of Island of Hawaii" issued by the Soil Conservation Service in December, 1973. The EIS will include a map containing information from the Soil Survey of Island of Hawaii, State of Hawaii, overlayed with U.S.G.S. contour lines. Most of the macadamia area is covered with a'a lava. The areas with a'a lava can be used for macadamia production under appropriate





culturing methods such as the addition of a planting medium and fertilizer to the planting holes. Soil or macadamia shells which have been composted will serve as the planting medium. These materials will be obtained from nearby farms. The next largest area is covered with Kaimu Series, which is well adapted to macadamia production. The Kaimu Series soil is interspersed with small islands of the Punaluu Series, which consists of rocky peat over pahoehoe, rough broken land and a'a with no soil covering. Approximately equal in area covered by the Punaluu Series is pahoehoe lava. In order to improve drainage and root penetration in pahoehoe lava, some bulldozer ripping may be required.

12/2 to 13/1 Scott prepared two reports; one was prepared purely the purposes of planning and the other for a rezoning request based on a "final" plan. The preliminary planning report was erroneously included as Appendix "G" in Exhibit 1, Volume 2 of the Technical Appendix for Farms of Kapua. Please note that the cluster concept is no longer being proposed. The report relating to the rezoning request, which should have been included, does not address the cluster concept. The latter report (revised) will be appended to the EIS.

13/2 to 14/1 The water requirement as discussed here relates to the incorrect report and not to the report concerned with the request for rezoning. Scott's cost estimate for irrigation water is not based on an engineering study of actual water cost, which still must be determined, but is a rough estimate, based on prior research, to obtain a cost estimate for irrigation water in the budget analysis. Water cost will be adjusted upward in the final analysis, reflecting both probable cost and quantity increases. This additional water cost would of course, have some effect on the profitability of the macadamia enterprise, but would not render it infeasible.

14/2 Please refer to response to 5/3 to 6/1.

15/1 Please refer to response to 6/2.

15/2 Please refer to response to 3/1.

15/3 to 16/1 Please refer to response to 3/2.

16/2 Please refer to response to 3/3 to 4/1.

16/3 Please refer to response to 4/2.

16/4 to 17/1 Please refer to response to 4/3.

17/2 Please refer to response to 4/4.

17/3 Please refer to response to 4/5 to 5/1.

17/4 As previously noted, there are other areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing. A successful example of intensive pasture management is Kapua Farms manager Sally Rice's ranch at Puuwaanahulu. There she grows 60 head a year on 100 acres of a'a and pahoehoe with an annual rainfall of 15 inches (12 inches in 1983).

It is correct that it has been estimated that the manure from 690 head of cattle per year may be required for one aquaculture module, if manure is used as the sole source of nutrients. However, the viability of the the remaining aquaculture modules do not rest on the use of manure. The consultant's report on the aquaculture program includes the cost of manufactured feeds in its production costs and concludes that the overall return on production cost is estimated at 1.51.

There will be approximately 600 to 700 head in the feedlot at any one time. While the exact details of manure collection, storage and transportation at the proposed feedlot are as yet undecided, elsewhere manure has been removed daily by mechanical scrappers and deposited in enclosed, concrete lined trenches. The trenches lead to an enclosed screening system that separates solids from liquids. The liquids will be applied to the pasture areas, and the solids will be transported by trucks for use in the aquaculture modules.

Part of the 200 acre koa haole cultivation area will be harvested to provide feed for the cattle in the feedlot. Harvesting would be by a green chop cutter which blows the cut forage into a feeding wagon that follows the cutter. When the wagon is full, it would be disconnected and towed to the feedlot.

17/5 to 18/1 A study on potentials for aquaculture production within the petition area has been prepared by Oceanic Institute and will be appended to the EIS. The report states that it is the combination of favorable environmental conditions and the availability of a large area of land that will make aquaculture production within the petition area viable. The report includes the cost of manufactured feeds in its production costs and concludes that the overall return on production cost is estimated at 1.51.

18/2 A pasture development and management plan has been developed by Harold F. Rice, Jr. and will be appended to the EIS. He states that under normal weather conditions, once the entire





pasture area is developed, there would be approximately 600-700 weanlings on the 2,472 acre unirrigated pasture and 600-700 head in the feedlot. During drought conditions the cattle in the unirrigated pastures can be sold. Please note that the operation of the irrigated 200-acre koa haole cultivation area and feedlot will not be affected by drought conditions and can continue to operate at full capacity.

18/3 The specific siting of the proposed aquaculture modules, with regard to the location of archaeological sites, as well as appropriate mitigation activities, would be available after the completion of intensive survey work.

Two emergency generators are proposed to provide electricity in the event of a power shortage.

18/4 The site of each pond and raceway will be graded and will be lined with a plastic liner. Blasting will not be required for grading.

Except for the mahimahi, all of the proposed primary species, Marine shrimp, blue-green algae and brine shrimp have been successfully, commercially produced. An analysis of the failures in aquaculture operations in the State will be found on pages 6 and 7 of the report prepared by Oceanic Institute.

Any waste material from shrimp production will be collected and sold as feed.

18/5 The production of bacteria, photoplankton, zooplankton (the diet of the marine shrimp) will be enhanced by the addition of fertilizer or manure to the water.

18/6 We concur that the major economic activity in Milolii is fishing, however, note the comment regarding the principal economic activities of agriculture and the visitor industry is related to the greater Kona area.

It is unlikely that the activities within the petition area will benefit or hurt the fishermen of Milolii. It is expected the crops from the proposed aquaculture modules will be marketed on Oahu or on the mainland. Specific job descriptions for employment at the aquaculture modules are not available at this time, however, job titles are included in the report prepared by Oceanic Institute. This report will be appended to the EIS.

19/1 A description of the State beef cattle industry has been prepared by John Farias, Jr., and will be appended to the EIS.

19/2 Residents of South Kona (including those from Milolii), have had ample opportunity to "give their input on whether or not recreational resources will be affected by the project" during the consultation period prior to filing the EIS. They will have another opportunity for comments during the public review period of the EIS.

19/3 Refer to response to 19/2.

19/4 We concur that the loss of native fauna and flora, historical and archaeological sites, and open land would be irreversible and irretrievable, if any of these resources were adversely impacted. As previously noted, Berger states that unless their roosting sites are damaged, the proposed activities would have no adverse effects on the bats. The two species of endangered Hawaiian birds (the hawk and the owl) seen on or adjacent to the project site have adapted to the introduced vegetation on the island of Hawaii.

Also, Nagata found very little of the native dry forest actually extends into the petition area. Nagata found a single kauila tree on an old a'a lava flow near the Kaulanamana flow. The tree is festooned with the parasistic kauna'oa-pehu. Two trees of Bobea timonioides are located nearby. Two individuals of halapepe (Pleomele sp.) were also discovered in the petition area. One of the halapepe was considered healthy and was located in a deep, steep-sided, collapsed lava tube. He has recommended that approximately 20 acres, including the kauila and Bobea trees be set aside and managed as a preserve, and the petitioner intends to implement with his recommendation.

None of the proposed activities will change the open space character of the petition area. As noted above, the characterization of the petition area as "natural" or pristine is debatable.

As stated on page 32 of the Archaeological Reconnaissance Survey Farms of Kapua, "further archaeological reconnaissance survey will [be] required for any specific areas within the project area under active development consideration, but which were not covered as part of the sample survey areas inspected during the initial reconnaissance survey work." Upon completion of reconnaissance survey work, the petitioner would have to either rely on contractor and/or construction crew recognition and notification, or utilize some program of archaeological monitoring. Furthermore, a program of intensive survey has been recommended by Rosendahl prior to any actual on-site construction activity. Since intensive level survey work is proposed prior to construction activities, no direct impacts to archaeological sites are anticipated during the construction or operation of proposed activities. However, there may be an





increased possibility of indirect impacts from looting and/or vandalism. It is our assessment that this is the only impact to archaeological sites which may be unavoidable. The loss of historical and archaeological sites would be irreversible and irretrievable, if any of these sites were adversely impacted (beyond salvage). This will be stated in the EIS in the section, "Any Irreversible and Irretrievable Commitments of Resources".

20/1 Since large scale agricultural activities (as opposed to a smaller farm) are being proposed, the CDUA process is impractical in this case because it subverts the intent of the State Land Use designations. In addition, the CDUA procedures for changes in the creation, location and/or operation of agricultural roads, wells, etc., make it inflexible and unfeasible for a serious agricultural operation.

20/2 Refer to response to 2/2.

20/3 Refer to response to 9/5 to 10/1.

20/4 Phasing and timing of the proposed agricultural activities will be described in the EIS. Also, refer to response to 10/2.

20/5 The Environmental Quality Commission Environmental Impact Statement Regulations do not require a cost benefit analyis or "detailed audit account", therefore the EIS will not include these items.

20/6 to 21/1 Should the proposed agricultural activities fail, either alternate crops would be cultivated or the use of the land would revert to existing uses (grazing). As in any other development, if the project fails, the investor experiences a loss.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

Encl: (2)

Kazu Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA, Inc

16 February 1984

Mr. Matthew Spriggs
Department of Anthropology
University of Hawaii at Manoa
P.O. Box 19000-A
Honolulu, HI 96819

Dear Mr. Spriggs:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We offer the following in response to the direct comments on Rosendahl's report, which begin on page 11 of Spriggs' Field Inspection Report, December 1983. Responses regarding the main body of Spriggs' report follow immediately after. Direct references to Spriggs' report will be identified in the following manner: page/paragraph.

Page 11, Comments on Rosendahl's Survey Report:

11/3 to 12/2 The amount and detail of data collected during reconnaissance survey field work (and thus contained within the original field records) is generally more extensive than presented in the descriptive report on a survey. It is assumed that anyone conducting subsequent intensive survey field work will inspect and study the available field records of the prior reconnaissance survey. As noted on page 13 of Rosendahl's report and as Spriggs notes on page 2, paragraph 2, Rosendahl has offered Spriggs and other qualified researchers to review the original field notes. Since interest has been shown in the sites that were not indicated in the original archaeological site and survey area location map, it will be revised to indicate the quantity of archaeological sites that were not assigned formal designations (in the original map). Also, short descriptive summaries will be provided for each survey area covered. The information to be included would cover vegetation cover, terrain and the nature and density of both major and minor archaeological features.

The comments concerning the supposed inadequacy of the reconnaissace survey sampling fail to acknowledge that probablistic sampling is neither the only, nor necessarily better, sampling strategy to be used. In a reconnaissance survey situation, probablistic sampling should probably be used only when nothing is known about the survey project area. In instances where some level of knowledge is available concerning the presence of previously recorded sites, or the likely distribution of sites, it is much more reasonable and generally more productive to adopt a non-probablistic sampling





strategy, given the local environmental setting. This is what was done in the case of the reconnaissance survey work within the petition area. Admittedly, the representative quality of a non-probablistic sample is more difficult to evaluate, at least in any quantative manner, but this difficulty does not invalidate the non-probablistic sample obtained. It does mean that the basis for selection of sample areas, the criteria by which the sampling universe was stratified, should be made clear. In the case of our reconnaissance survey report, it was stated that the survey areas comprising our sample were selected on the basis of geographic disribution and environmental variation. In order to clarify the reasons for selecting the sample survey areas and the reasoning why these areas can be considered representative in terms of a reasonable non-probablistic sample, a new figure presenting the distribution of vegetation types, substrate and areas previously altered by historic period land modification activities will be drafted. This figure will be appended to Rosendahl's report, which in turn will be attached to the EIS.

12/3, 13/1 The map presented as Figure 2 of the reconnaissance survey report is certainly adequate for that level of study, but not for an intensive survey. In order to present the data on the map in a clearer fashion, the archaeological site and survey area location map will be redrafted.

13/2 to 14/1 It should be noted that the designations were qualified as being only tentative and made on the basis of the reconnaissance survey findings alone. Preservation is a strategy for dealing with sites found to have significant research, interpretive, and/or cultural value. Determination and documentation of the significance of specific sites is dependent upon the completion of intensive survey level work. Therefore, specific recommendations for site preservation are an aspect of subsequent work. The fact that no recommendations for the preservation of inland sites or areas was made in the reconnissance survey report certainly does not mean that such recommendations would not be made during the subsequent archaeological work that will be conducted.

We concur that numerous sites, both already identified and other new ones, would be found to have cultural value after informant work (recommended in Appendix 3 of Rosendahl's report) has been carried out in the local community, as part of subsequent intensive survey level work.

14/2 We expect that a synthetic analysis would obviously comprise an important aspect of subsequent intensive survey level work.

Main body of Spriggs' report

2/2 As far as can be determined, Spriggs did not find anything that would not be predicted on the basis of Rosendahl's earlier reconnaissance survey findings (Spriggs' inspection comprised of a reconnaissance-level survey inspection primarily of areas outside of those covered during Rosendahl's reconnaissance survey). This suggests that Rosendahl's sample was, in fact, reasonably representative. The single, new, unique site reported by Spriggs, the refuge cave seen in his Location Three, was already known to local informants. The fact that Rosendahl's earlier sampling did not find the refuge cave does not mean that the sampling method was somehow inadequate; sampling is conducted to provide the basis for generalizing upon the probable composition of the total population of the sample universe.

3/2 Refer to responses to 11/3 to 12/2

4/1 Although Rosendahl and Mr. Kahele have spoken on numerous occasions, and Rosendahl has offered to accompany Mr. Kahele to Kapua at a mutually convenient time, the existence of the large refuge cave was never mentioned. If this cave is known to the older residents of Miloli'i, then it is likely that its existence would have been made known during the subsequent local informant work that was recommended in Rosendahl's reconnaissance survey report (Appendix 3). The discovery of the site does not imply an oversight on Rosendahl's part, for the cave is located outside of the areas covered during Rosendahl's reconnaissance survey. Without more intensive survey work, the purported "very high research, interpretive and cultural value" of the site is still to be demonstrated and documented.

4/2 While the refuge cave is contained within the same lava flow as sites 9936, etc., it does not necessarily (or geologically) follow that they ever constituted contiguous components of a single "extensive lava tube system."

5/2 It is difficult to determine from the statement regarding the refuge cave its relative complexity in comparison to refuge cave sites that have been identified by other archaeologists. Also, it appears somewhat inconsistent to characterize the tube as being "...generally barren of signs of occupation...", after describing numerous features and other evidence of occupation in the immediately preceeding sentences.

6/2 If the lava tube described here does have significant archaeological value (whether research, interpretive, or cultural), it would have been identified during the subsequent reconnaissance survey of this as yet unsurveyed area. Also, any significant values





would have been, and still are to be, determined and documented on the basis of subsequent intensive survey work.

9/1 It should be pointed out that a reconnaissance survey is not necessarily supposed to identify every single site and feature within a survey area. Features that are overlooked or inadvertently included within an inappropriate site complex, would be correctly identified during subsequent intensive survey work.

10/2 While the inland most portion of the project area has been extensively modified in historic times, and undoubtedly there were archaeological sites present that were destroyed, no basis is provided for the statement that the most inland portion of the project area was once "...the makai extension of a now-destroyed more intensive agricultural zone." The prior significance of the area as an intensive agricultural zone has not been documented.

11/2 Spriggs' model for prehistoric Kapua land use, is remarkably similar to the generalized aboriginal Hawaiian land use model that has been commonly and widely used by archaeologists working in Hawaii for the last 15 years. Refer to the previous paragraph regarding the "Intensive inland agricultural zone".

For your information, Tables 3 and 4 will be updated with the information provided in the Spriggs inspection report for the additional sites identified during his field reconnaissance of December 1983.

Very truly yours,

Sheryl Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

DROUGHT FREQUENCY
KAPUA, SOUTH KONA, HAWAII

No single definition adequately describes the concept of a drought. To the farmer, drought exists when moisture available to plants becomes depleted and is not replenished, while for the climatologist drought occurs when subnormal rainfall persists over an arbitrarily selected continuous period. The climatologist's view is easier to deal with because it depends on just two variables--rainfall and time. The month is usually the time unit employed because monthly tabulations of rainfall are readily available, and an interval of about 30 days is long enough for most people to become aware of rainfall conditions. The definitions and remarks that follow are based on the climatological approach to drought, that is, deficit monthly rainfall over an arbitrarily selected minimum number of consecutive months.

For drought to exist, subnormal monthly rainfalls must persist for three months or more. Two levels of drought are considered, ordinary drought in which rainfall lies between the 50 percentile (median) and 25 percentile levels and severe drought in which rainfall is less than the 25 percentile level. The 50 percentile level means that 50 percent of the time rainfall is greater than the given value and 50 percent of the time it is less; the 25 percentile level means that 75 percent of the time rainfall is greater than a given value and 25 percent of the time it is less. The Opihihale rain gage (24.1) is used and as one of the index stations because it is a standard National Weather Service Station and Kole Pen (2.18) is used as another. The period of record examined for Opihihale is the 19 years for 1955 through 1973, and for Kole Pen, the 20 years from 1956 through 1975.

During the 19 years at Opihihale, 17 droughts occurred of which 13 were ordinary and 4 severe. A total of 69 months was involved, or 30.3 percent of all months. Severe droughts, none of which exceeded three months in duration, accounted for a total of 12 months, or 5.3 percent of the time, while ordinary droughts occupied 25 percent of the time. Thus the probability of any consecutive three month period having rainfall at 25 percent or less than normal is one in twenty and that of having rainfall lying between 50 and 25 percent of normal is one in four. This can be generalized by stating that in every year an ordinary drought is expectable but that only once in five years is a severe drought expectable. Ordinary droughts are common and perhaps should not be considered droughts at all. Severe droughts, on the other hand, are potentially destructive, but fortunately their probability of occurrence is low.

Of the total number of droughts in the Opihihale record, 11 lasted for only three months, one for four months, three for five months, one for six months, and one for 11 months (in 1973). Thus, 35 percent of all droughts were greater than three months long, yet nevertheless drought extensions beyond three months took up only eight percent of the time.

For the 20 year record at Kole Pen, 17 droughts, the same number as at Opihihale, occurred. Twelve were ordinary and five severe, also about the same distribution as Opihihale. A total of 65 months was involved, or 27.4 percent of all months. Severe droughts, two of which lasted five months, accounted a total of 20 months, or 8.4 percent of the time, while ordinary droughts occupied 19 percent of the time. The probability of any consecutive three month period having rainfall of 25 percent or less of normal is one in sixteen and that of having rainfall lying between 50 and 25 percent of normal is one in six. This can be generalized by stating that in every 1.5 years an ordinary drought is expectable but that only once in four years is a severe drought expectable. The concordance of the statistics between Opihihale and Kole Pen suggests that droughts in South Kona are regional in extent.

In conclusion, it may be stated that severe droughts are infrequent in South Kona, but ordinary droughts, perhaps better called dry periods, are expectable about annually.

UNIVERSAL LIFE CHURCH
KONA LIGHT – BOX 879, KEALAKEKUA, HAWAII. 96750. (808)322-9056
URBAN LIGHT – 1588 FELL ST. SAN FRANCISCO, CA. 94117. (415)563-1216

RECEIVED
JAN 06 1984
GROUP 70

MINISTERS:
KEALOHA RON GRAY Ph.D
SUNDANCE MOUNTAIN

January 2, 198

Land Use Commission
Room 104, Old Federal Building
335 Merchant St.
Honolulu, Hawaii 96813

Dear Land Use Commissioners:

My comments are the Farms of Kapua EIS Notice of Preparation are:

1. Possible Toxic Spray Contamination of underground water.
In an earlier report they proposed to put two pounds of atrazine, two gallons of roundup and one half gallon of paraquat on each acre of mac nuts annually. So on their planned 1700 acres they will put annually 3400 pounds of atrazine, 3400 gallons of roundup and 850 gallons of paraquat On page 16 of the EIS they say at the bottom of the page "the high permeability of the soils will allow adequate infiltration of water." I remember the pineapple growers telling us not to worry about toxic sprays, and now our underground water is contaminated on Oahu and Kuaui and possibly Maui. Let us learn from past experience or we are certain to commit the same errors. Do not let anyone spray toxic chemicals on the soil!

2. Certain destruction of ancient Hawaiian burial sites.
They plan to bull doze the land for mac nuts and some of the 200 acres for koa haole, and some of the 1500 acres of aquaculture. So some 3400 acres may be bulldozed. This will destroy Hawaiian burial sites and interfere with their religious practice, which violates their first amendment constitutional rights.

3. A better Alternative use would be a wilderness park.
A wilderness park has been approved by the Hawaii Senate and is widly supported. A wilderness park is not even considered in the EIS Part VII on alternatives. Isiah, chapter 5, verse 8 says "Woe unto those who lay house to house and field to field so that one cannot find silence in the midst of the earth." We must create wilderness parks!

Sincerely,

Ron Gray

SPIRITUAL GROWTH, HOLISTIC HEALTH, ENVIRONMENTALISM, CULTURAL INTEGRATION

Kazuo Ishihara AIA, Inc
Francis S. Oda AIA, Inc
Robert K.L. Wong AIA, Inc
Norman G.L. Hong AIA, Inc

16 February 1984

Mr. Ron Gray
Universal Life Church
Box 879
Kealakekua, HI 96750

Dear Mr. Gray:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your comments and offer the following responses:

1. As a normal procedure, the proposed irrigation wells will be monitored for chloride and at regular intervals (annually), water from the wells could also be tested for herbicides.

2. We disagree with the statement, "Certain destruction of ancient Hawaiian burial sites." Please note that because of the agricultural nature of the project, there is flexibility in the siting of wells, roadways, macadamia trees, haole koa, aquaculture facilities around significant historic sites.

3. We will discuss the establishment of a park on the petition area in the section, ALTERNATIVES TO THE PROPOSED ACTION. As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the features of historical value that was found by the consulting archaeologist, Paul H. Rosendahl, in his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. The petitioner will generally maintain the present unobstructed lateral access along the shoreline, north and south of the petition area. We feel that retention of the above described shoreline areas in the

Mr. Ron Gray
Farms of Kapua
16 February 1984



Conservation District is in keeping with the expressed intent of S.R. 65 (1983).

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

Sierra Club
moku loa group
Hawai'i Chapter
P.O. Box 1137, Hilo, HI 96720

6 January 1984

RECEIVED
JAN 09 1984
GROUP 70

Environmental Quality Commission
550 Halekauwila St., Rm. 301
Honolulu, Hi. 96813

Dear Sirs:

I am writing in response to the EIS Preparation Notice for the proposed Farms of Kapua project. The Moku Loa Group of the Sierra Club hereby requests to be a consulted party in the EIS process and to receive copies of appropriate correspondence.

At this point in time we have a list of concerns that we feel the EIS needs to cover, and we will provide lists of other concerns as the situations arise. We do hope that all claims, expectations and conclusions expressed in the EIS will be backed up therein with supportive documentation, appropriate arithmatic calculations and logical rationale.

The EIS should contain throughout a clear economically-based substantiation of all aspects of the proposed operation, as the questionable economic feasibility of the project is of great concern to many people for several reasons:

1) Should the project fail, the permanent sacrifice of existing resources and values (archaeological and cultural resources, the proposed State Park, the wilderness values, the shoreline and near-shore fishing resources, the native vegetation, the jeopardy to valuable ground water, etc.)will have been for nought.

2) Should the project fail after gaining a change to agricultural zoning, the people of South Kona will be faced with the likelihood of an extensive and expensive subdivision in its stead. Such a happening will cause much economic and social hardship to the rural and mostly local people in South Kona and Ka'u, as land values and tax assessments will rise sharply and force many to abandon their land and existing livelihoods (farming, fishing,retirement).

3) In a global economic environment of limited macadamia nut market and expanding foreign competition, such a capital-intensive project on such submarginal lands will be one of the first to fail.

4) Ongoing conversion of abandoned cane lands on this and other Hawaiian islands to extensive macnut orchards in areas having good soil, adequate moisture, available agricultural labor and unions, and



pre-existing cane field roads, provides a formidable local competition to proposed orchards in submarginal agricultural conditions.

All of the aforementioned concerns need to be thoroughly addressed in the EIS.

The EIS should use existing rainfall data from on-site stations (see State Division of Water and Land Development reports and records). It should also incorporate a reproduction of the latest median rainfall map (1982, DOWALD report C-88). This map shows the rainfall on-site to be about 20-30 inches a year. The monthly rainfall data should be combined with substantiated monthly water demand figures for each irrigated crop and irrigated acreage to come up with a realistic total agricultural water demand. Using these figures plus considerable extra allowance for the common and often prolongued droughts in Kona, the total demand of the area's aquifer from this project alone can be estimated.

This demand plus potential public and private groundwater withdrawls for the area should be compared with substantiated estimates of the total safe groundwater withdrawl potential of the area. Both public and private groundwater demand in Kona has been growing rapidly in amount and area serviced over the last decade, and this project's demands should be compatible with future public and other private needs so as not to damage the quality of groundwater by overdraught. These concerns need to be adequately dealt with in the EIS.

The EIS needs to correct the errors in the Preparation Notice regarding soils. Examination of the reference cited reveals that:

1) below 600' elevation, all the land is mapped as barren lava flows (rLV, rLW and RB);

2) between 600' and 800', only about a third of the area has any soil (rKED) and the rest is rLV, rLW and RB;

3) above 800' elevation is where the soil is (only 5-10% of the area is rLV or RB).

The topography of the landscape is rough enough to require extensive bulldozing and grading for the macnut and leucaena areas, and the EIS should give realistic costs for this, including the deep ripping needed for pahoehoe areas. Where will the soil come from that will be put in planting holes - the mauka Farms of Kapua lands now serving as watershed forest?

The EIS should clarify the vagueness of the cattle operation portion of the proposed project with realistic figures. Residents of the area say that fewer than 200 cattle can be grazed on the project area, and each past operator has removed the cattle to other pastures during dry periods. The cattle also graze only in the upper areas that have soil and where leucaena was able to establish itself following

seed spreading in the 1950's, and where the proposed orchards will be — not in the barren lava flows below the 400' elevation lower limit of proposed macnuts. The proposed 690-1,000 head of cattle (EIS Preparation Notice) to be grazed on 2,500 acres works out to 3.5 - 4.5 acre per head, which is comparable to the stocking rates of the better pastures in South Kona, i.e. those with soil and 40-60 inches of rain. What will be done to the arid, barren and rugged lava flows in the proposed pasture area to make them achieve the claimed yields? The EIS should explain this and provide substantiated forage yields and conversion figures to head-of-cattle on an annual basis. Will the cattle in the corrals be the same cattle as those in the unirrigated pastures? How long will they be resident in the corrals?

The vegetation description in the EIS Preparation Notices indicates a dominance by fountain grass. This unpalatable grass is fostered by fires and physical disturbance and has taken over countless acres of previously usable pasture land by displacing forage plants, ruining the pasture. No substantial acreages have ever been reclaimed, but thousands of acres of infested, former pasture have been sold off for real estate development. The EIS needs to adjust its cattle carrying capacity estimates to reflect fountain grass as well as the other unfavorable conditions on-site. Will any proven mitigative measures be taken?

As the manure from corralled cattle will be the major feed for the aquaculture project, good linkage between the cattle operation and the aquaculture operation should be substantiated in the EIS, using realistic production and conversion figures. The report by Farms of Kapua consultant, Oceanics Institute, ("Estimates of production using manure as the source of fertilizer for different crops", undated) indicates that one aquaculture module will require 7,530 tons of manure from 690 head of cattle per year. The EIS should incorporate such figures and explain where the feed for the other four modules will come from and adjust the consultant's economic analysis for aquaculture accordingly. How will the manure be collected, stored and transported? Are there any health considerations associated with manure storage and use? What will become of the massive amounts of non-consumable portions of the manure? Will it plug waste water infiltration ditches, be extracted and stored, or what? What will be the forage production (tons/acre/year) for the controlled pasture area and for the irrigated leucaena area? The EIS should also provide reasonable and well-substntiated forage consumption figures by the cattle in both pasture and leucaena-fed corral situations.

The EIS should tally by project area the amount of acres that will be bulldozed, grubbed, cleared or otherwise surface-disturbed. Observation of orchard and pasture areas mauka and adjacent to the proposed project area suggests that all orchard and pasture acres will be disturbed, and the 200 acre leucaena and 200 acre "experimental" area will need the same. How much of the aquaculture acreage will



not be disturbed? It appears that about 3,500 - 4,000 acres will be the minimum disturbed, plus much more if the pasture area is made suitable for forage growth and cattle access.

The EIS should consider these extensive landscape modifications as irretrievable committments of natural and cultural resources, and address the consequences accordingly. What effects will these committments have on the extensive and significant archaeological and cultural resources of the area?

Once initiated, what effects would these committments have on the State Park proposed in the Manuka-Kaulanamauna-Kapua-Okoe-Honomalino area? This park has been supported by numerous community groups and agencies and by two resolutions from the State Legislature (1971 and 1983). It was approved by the State Department of Land and Natural Resources in 1971, but not totally established. In combination with the recently established State Natural Area Preserve in Manuka and Kaulanamauna, the park would extend from 5,200 feet elevation down to the ocean, and from the ocean back mauka to 400-500 feet in the Kapua, Okoe and Honomalino ahupua'a. The scale and rich variety of this park would rival that of the National Parks in Hawaii, and be much richer in archaeological resources. The EIS should address the completion of this park as a viable alternative to the initiation of all but the macnut portions of the Farms of Kapua project, and the negative impact upon the park if the project goes through. The EIS should also consider as an alternative an exchange of lands or development easements for the non-macnut part of the proposed development. Such an exchange would allow both the continuation of the state park at Kapua and the development of the cattle, aquaculture and experimental crops operations by the developers at some other location.

The EIS should legibly show on a standard topographic map base, the locations of all the archaeological sites seen on all surveys (both numbered and unnumbered sites) as well as the areas covered in the archaeological surveys. The sites should be evaluated as to significance by impartial archaeologists and be so evaluated in the context of preservation in the state park.

The EIS should use tax appraisal records for the area to indicate what effects on land values and taxes the development will have. These should include projected appreciations due to the land improvements and resales during the total development period of the proposed Farms of Kapua project. These land and tax appreciations should be compared with likely appreciations if the land use were as a park instead.

The EIS should evaluate the potential compatibility of the aquaculture with the "Class AA Waters" occurring off the project area's coast. The six million gallons a day of aquaculture effluent will be enriched by nutrients, contaminated with foreign organisms (including

Tilapia fish and the runaway algae Eucheuma), and bearing a high sediment load. The chemical and physical nature of these effluent waters needs to be included in the EIS. What measures will be taken to ensure that the proposed 10,000 feet of infiltration ditches (planned for effluent disposal) will not leak into pristine offshore waters via the numerous small and large lava tubes and spaces between lava flows? What effects will such leakages and biological contaminants have on the edible limu, opihi and nearshore fisheries that the nearby villagers at Milolii depend on for the livelihood?

The Eis should include a timetable of development. It should also provide a complete list of permits needed or possibly needed. It should list all potential standards for water quality (potable, marine, etc.) that the project should have to be in compliance with.

As orchards, aquaculture and grazing are all permitted uses in the (existing) conservation district zoning, the EIS should explain why the proposal calls for rezoning to agriculture. The land does not seem to qualify for agriculture: the County Plan has it zoned Conservation and Open, the State Land Study Bureau designation is "E"(for "Very Poor") for agriculture, and the ALISH evaluation considered only the portion above 800 feet elevation as agricultural land. The EIS should review all of the above. The EIS should incorporate the Land Use law descriptions of Conservation District land and the Title 13 descriptions of the existing subzones, and explain why these designations are not appropriate .

Thank you very much for the opportunity to provide direction in your preparation of the Farms of Kapua EIS. We look forward to the opportunity to review the draft EIS.

Yours truly,

Rick Warshauer

Rick Warshauer
Conservation Chairman
Moku Loa Group, Sierra Club

Please reply to: Rick Wars_hauer
P.O. Box 192
Volcano, Hawaii 96785

cc: Group 70
Land Use Commission

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

17 February 1984

Mr. Rick Warshauer
Conservation Chairman
Moku Loa Group, Sierra Club
P.O. Box 192
Volcano, HI 96785

Dear Mr. Warshauer:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We offer the following responses to your comments. Direct references to your letter will be identified in the following manner: page/paragraph.

1/3 The economic benefits of the proposed aquaculture, macadamia and cattle production activities are covered in reports prepared by Oceanic Institute, Frank S. Scott, Jr. and John Farias, Jr., respectively. These reports will be appended to the EIS.

1/4,5 In the event that the proposed macadamia orchards fail, then other crops will be cultivated, or the land will return to grazing, as have other agricultural lands elsewhere in the state that were once intensively cultivated.

For your information, the consulting biologist, botanist and archaeologist, (Mssrs. Kenneth M. Nagata, Dr. Andrew J. Berger, and Dr. Paul Rosendahl, respectively) have found that large areas of the petition area to be already extensively modified.

1/6-2/2 We note your assessment on the feasibility of the proposed macadamia orchard. This assessment differs from the one reached by the consultant on macadamia, Dr. Frank S. Scott, Jr.

2/3 We appreciate the information on the availability of data from nearby stations (State Department of Land and Natural Resources, Division of Water and Land Development publication Circular C-88, "Median Rainfall State of Hawaii)". This latter publication was made available to the public after moisture deficits for the proposed macadamia orchards in Kapua were modeled by interpolating rainfall averages at Opihihale and Manuka (John Mink, Water Supply for Farms of Kapua). Please note that none of these gages are reported in National Weather Service publications, nor had

their records previously been printed in published reports of DLNR or the USGS.

The EIS will present the data from Manuka, Opihihale and Kole Pen. The rainfall map included in DOWALD Report C-88 (1982) will not be reproduced in the EIS because it presents rainfall data in terms of medians, which is the mid-level of rainfall accumulation per unit time. Hydrologic balances are computable from averages but not from medians, unless the frequency distribution is perfectly normal, in which case the average and median are identical.

The expected demand and supply for water at Farms of Kapua was studied by John Mink and his report will also be appended to the EIS. His findings are summarized as follows:

To expand the moisture deficit model originally based on Opihihale, a similar model was derived employing the Kole Pen data. The period of record is 1956 through 1975, for which the values are given in the DLNR printout for 237 months of the total of 240 months. The moisture deficits will be given in Table 1 of Mink's report. Deficits for each month were computed as the difference between macadamia orchard demand of 4.4 inches per month and the actual reported monthly rainfall. Surplus moisture is indicated by parentheses. Included with the tabulation are statistics of the deficit distribution.

At Kole Pen the distribution shows that no irrigation will be necessary about 13 percent of the time. About one third of the time the irrigation requirement would be less than 1.5 inches per month. The average annual deficit will be 25.7 inches, which reduced to a daily basis amounts to 1912 gallons per acre.

Placing sole reliance on the Kole Pen record as the index of rainfall in the Kapua lands proposed for macadamia, supplemental irrigation requirements will be as follows:

| AV. DEFICIT (in/yr) | AV. DEFICIT (gpad) | 10 PERCENTILE Deficit (in/mos) | 10 PERCENTILE Deficit (gpad) |
|---|---|---|---|
| 25.7 | 1912 | 3.9 | 3481 |

The ten percentile exceedance level is chosen as the limit to which all deficits should be met. Thus only ten percent of the time would trees suffer insufficient moisture. In no period of the record did the deficit equal or exceed the ten percentile level for three or more consecutive months.





Irrigation is proposed only in the macadamia orchard and the 200 acre koa haole cultivation and 200 acre research and development areas. Irrigation is not being proposed in the 2,472 acre koa haole pasture area. Research conducted by Harold F. Rice, the consultant on pasture management, indicates that there are areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing.

Estimates of the total average and ten percentile exceedance demands for irrigation are given below. Irrigation rates for macadamia are assumed to be applicable to leucaena and other crops also.

| CROP | ACRES | AVERAGE (gpad) | TOTAL AV. (mgd) | 10 PERCENT (gpad) | TOTAL (mgd) |
|---|---|---|---|---|---|
| Macadamia | 1710 | 1912 | 3.3 | 3481 | 6.0 |
| Leucaena | 200 | 1912 | 0.4 | 3481 | 0.7 |
| Other | 200 | 1912 | 0.4 | 3481 | 0.7 |
| TOTAL | 2110 | | 4.1 | | 7.4 |

Total average demand is equivalent to 2845 gpm. Assigning a yield of 1000 gpm to agricultural wells, three wells may be required to satisfy average demand.

2/4 An accurate determination of groundwater flow through Kapua is impossible because values for the parameters of the relevant equations are imprecise. However, analogy with similar Kona subsurface environments where some of these values have been refined suggests that flow at the coastline is at least of 6.0 mgd per mile. In the arid regions of North Kona and South Kohala, a thorough water balance study of the Water Resources Research Center at the University of Hawaii (B.Y. Kanehiro and F.L. Peterson, 1977, Groundwater Recharge and Coastal Discharge for the Northwest Coast of the Island of Hawaii: A Computerized Water Budget Approach: U.H. WRRC Technical Report TR-110) indicated coastal discharge to likely be 6.38 mgd per mile and as much as 11.8 mgd per mile. This region does not experience rainfall as high as in Kapua. Within the petition area, total flow is between 8.0 and 18 mgd, and the most probable average is about 13 mgd. Not all of this flow is feasibly developable, however; sustainable yield on a continuous schedule is 6.0 to 7.0 mgd (total average demand is 4.1 mgd), but for periods of

reasonable length (three months), Mink believes as much as twice the sustainable yield can be pumped without seriously affecting the quality of yield.

2/5 We appreciate the information provided. The EIS will include a map containing information from the Soil Survey of Island of Hawaii, State of Hawaii, overlayed with U.S.G.S. contour lines. For your information, the 400-foot elevation was chosen for the description of soils because of the proposed planting of macadamia between the 400-foot elevation to the mauka boundary of the petition area.

2/6 Approximately 70 percent of the macadamia (in increments of 500 acres) will be graded. In addition, approximately 70 percent of the 200-acre research and development, 200-acre koa haole cultivation and 2,472-acre koa haole pasture (in increments of 400 acres) areas will be grubbed. The remaining 30 percent (a standard engineering consideration) of these areas may be needed for the construction of roads, or for the preservation of significant archaeological sites or areas containing significant botanical specimens.

Most of the macadamia area is covered with a'a lava. The areas with a'a lava can be used for macadamia production under appropriate culturing methods such as the addition of a planting medium and fertilizer to the planting holes. Soil or macadamia shells which have been composted will serve as the planting medium. These materials will be obtained from nearby farms. The next largest area is covered with Kaimu Series, which is well adapted to macadamia production. The Kaimu Series soil is interspersed with small islands of the Punaluu Series, which consists of rocky peat over pahoehoe, rough broken land and a'a with no soil covering. Approximately equal in area covered by the Punaluu Series is pahoehoe lava. In order to improve drainage and root penetration in pahoehoe lava, bulldozer ripping is required.

Most of the 2,472-acre koa haole pasture is covered with a'a lava, with small islands of pahoehoe. This area will be rough bladed and rolled, preserving any healthy trees for shade and organic matter buildup. One pass by a large tractor (D7 or larger) with the blade adjusted to skim the surface, pulling a heavy 10 ton or heavier roller should be adequate for this area.

Approximately half of the 200-acre koa haole cultivation area contains a'a lava, the other half, pahoehoe. This area and the 200-acre research and development area (which is almost completely covered with a'a lava) will be bladed and rolled to a higher degree (requiring possibly 2 or more rollings) than the 2,472-acre koa





haole pasture to allow easy access of irrigation equipment and uniform growth. No ripping or moving of material is required. A large tractor can do 5 acres a day. Total cost for grading and grubbing is estimated to be $2,000,000.

2/7 to 3/1 New cattle, usually wean calves from other ranches, will be acquired as the unirrigated 2,472-acre koa haole pastures reach maximum growth, normally after January. The cattle would feed in the pastures until reaching weights of 700-800 lbs., at which time they would enter the feedlot. The cattle would be in the feedlot for 90-120 days prior to marketing. As cattle are taken to the feedlot, replacement cattle for the unirrigated pastures would be purchased. In the event that a low rainfall period is encountered, the replacement of cattle would be delayed. Under normal weather conditions, once the entire area is developed, there would be approximately 600-700 weanlings on unirrigated pasture and 600-700 head in the feedlot. During drought conditions the cattle in the unirrigated pastures can be sold. The operation within the irrigated 200-acre koa haole cultivation area and feedlot are not affected by drought conditions and can continue to operate at full capacity.

Rice estimates that upwards of 80,000 plants per acre (15 lbs. of seed) should yield with irrigation (200-acre area) approximately 50 to 60 tons of fresh forage per acre per year. In the unirrigated pasture, he estimates the yield will be approximately 20 tons of forage per acre per year.

An animal eats approximately 13% of its body weight per day on pasture. Therefore, a 500 lb. calf eats 65 lbs./day or 18,250 lbs. per year. Twenty (20 tons) of forage per acre per year equals 1.6 head per acre per year. Allowing for dry conditions, this would amount to 1 head at 500 lbs. on 2 acres.

As previously noted, there are other areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing. A successful example of intensive pasture management is Kapua Farms manager Sally Rice's ranch at Puuwaanahulu. There she grows 60 head a year on 100 acres of a'a and pahoehoe with an annual rainfall of 15 inches (12 inches in 1983).

3/2 We note your position on fountain grass. It is the opinion of the consultants on pasture management and vegetation, Rice and Nagata, respectively, that guinea grass will successfully compete against fountain grass. Guinea grass is proposed to be planted in the pasture areas. Rice further maintains that contrary to what most ranchers thought some years ago, fountain grass, under modern

management, is now considered of value in the establishment of rocky areas for pasture by increasing organic matter. With cross-fencing and rapid rotation of large groups of cattle, the fountain grass can be grazed prior to the stage at which it becomes unpalatable. Furthermore, tests at Keaumoku by Clarence Garcia with the University of Hawaii Extension Service indicated that the application of small amounts of magnesium fertilizer will make the grass palatable.

3/3 It is correct that it has been estimated that the manure from 690 head of cattle per year may be required for one aquaculture module, if manure (and the wastes from the various species) is used as the sole source of nutrients. However, the viability of the the remaining aquaculture modules do not rest on the use of manure. The consultant's report on the aquaculture program includes the cost of manufactured feeds in its production costs and concludes that the overall return on production cost is estimated at 1.51.

While the exact details of manure collection, storage and transportation at the proposed feedlot are not yet decided, elsewhere manure has been removed daily by mechanical scrappers and deposited in enclosed, concrete lined trenches. The trenches lead to an enclosed screening system that separates solids from liquids. The liquids will be applied to the pasture areas, and the solids will be transported by trucks for use in the aquaculture modules. The frequent removal of wastes (twice daily) and the observation of sanitation practices should mitigate health considerations such as odor and flies.

It is expected that there will be no remnants of the manure after it passes through the proposed aquaculture system.

Estimated forage production yields and forage consumption rates were provided in response to 2/7 to 3/1.

3/4 to 4/1 As noted elsewhere, approximately 70 percent of the macadamia (in increments of 500 acres), 200-acre research and development, 200-acre koa haole cultivation and 2,472-acre koa haole pasture (in increments of 400 acres) areas will be graded or grubbed. For your information, aquaculture activities of each module, including the brackish water system, will occupy approximately 160 acres. An additional 40 acres is alloted for roads (although not all of this will be used). This information will be provided in the EIS.

4/2 The loss of archaeological resources would be irreversible and irretrievable, <u>if</u> any significant sites were adversely impacted. As stated on page 32 of the <u>Archaeological Reconnaissance</u>





<u>Survey Farms of Kapua</u>, "further archaeological reconnaissance survey will [be] required for any specific areas within the project area under active development consideration, but which were not covered as part of the sample survey areas inspected during the initial reconnaissance survey work." Upon completion of reconnaissance survey work, the petitioner would have to either rely on contractor and/or construction crew recognition and notification, or utilize some program of archaeological monitoring. Furthermore, a program of intensive survey has been recommended by Rosendahl prior to any actual on-site construction activity. Since intensive level survey work is proposed prior to construction, no direct impacts to archaeological sites are anticipated during the construction or operation of proposed activities. With the identification and inventory of sites (from increased archaeological work in the petition area, such as the <u>Archaeological Reconnaissance Survey Farms of Kapua</u>), there may be an increased possibility of indirect impacts from looting and/or vandalism. Accessibility to sites should not alter from existing conditions. As noted in the NOP, the petitioner will generally maintain the present means of public access to the shoreline: from points mauka of the petition area by permission only; and, unobstructed lateral access along the shoreline, north and south of the petition area. Because of the physical difficulty involved in access along the shoreline, and the control of mauka-makai access (by permission only), existing means of access serves to control accessibility to identified sites. Programs for the monitoring of sites would be included in a archaeological/historical resource management plan (page 32 of the <u>Archaeological Reconnaissance Survey Farms of Kapua</u>).

The value of the petition area as an existing pristine habitat for native fauna or flora has not been documented. In his bird and mammal report that he prepared for the Farms of Kapua, Dr. Andrew J. Berger, consulting biologist, states that with the exception of the Hawaiian bat, all of the remaining mammals found on the site are introduced species, and all of these are considered pests to man, his activities and products, and/or to native vegetation and fauna. The only two species of endangered Hawaiian birds (the hawk and the owl) seen on or adjacent to the petition area, have adapted to the introduced vegetation on the island of Hawaii, primarily because of their feeding habits and the extent of their home range. Berger also states that: "As long as any <u>present, actual</u> roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macadamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight."

Based on his earlier survey, Kenneth M. Nagata returned to Kapua to determine the extent of the native dry forest at the mauka boundary

of the petition area, to ascertain the integrity of that forest and to seek out any rare and endangered species in that section. In summary, he determined that very little of the native dry forest actually extends into the project site. Therefore, the proposed actions will not result in the irreversible or irretrievable commitment of natural resources.

4/3 We will discuss the establishment of a park on the petition area in the section, ALTERNATIVES TO THE PROPOSED ACTION. As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the features of historical value that was found by the consulting archaeologist, Paul H. Rosendahl, in his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. As previously mentioned, the petitioner will maintain the present unobstructed lateral access along the shoreline, north and south of the petition area. We feel that retention of the above described shoreline areas in the Conservation District is in keeping with the expressed intent of S.R. 261 (1971) and S.R. 65 (1983).

The "exchange of lands or development easements for the non-macnut part of the proposed development" will not be discussed as an alternative to the proposed State Land Use Boundary Amendment, since the State has not offered lands for such an exchange or has not acted to establish the park since 1971 (S.R. 261).

4/4 In the EIS, reference will be made to Rosendahl's Archaeological Reconnaissance Survey Farms of Kapua, which in the descriptive comments on individual designated sites, generally give the approximate, if not exact, number of component major features comprising site complexes. In order to present the data on the map in a clearer fashion, the archaeological site and survey area location map will be redrafted. Please note that on page 1 of Rosendahl's report that Rosendahl states that Ms. Virginia Goldstein, staff planner and historical sites specialist in the Hawaii County Planning Department and Mr. Wendell Kam, staff archaeologist with Hawaii State Historic Preservation Office were consulted in the preparation of the requirements of the archaeological reconnaissance survey. According to Rosendahl, both Ms. Goldstein and Mr. Kam have had opportunities to review Rosendahl's report, and on numerous occasions since then, have expressed that the report and the level of work is adequate for this level of planning (State Land Use Boundary Amendment).





4/5 It would be impossible to project "appreciations due to the land improvements and resales during the total development period of the proposed Farms of Kapua project" based on tax appraisals. Please note that actual sales, and not tax appraisals indicate appreciation of property.

4/6 to 5/1 The wastewater produced from the aquaculture modules is basically brackish water that has been cycled through the production units holding the various species. The wastes from one species are used as nutrients by the following species and in this way the water is filtered. The final wastewater contains no human contamination and consists basically of some remaining fecal matter from marine organisms, excess feed, and some algal and plant matter. The wastewater will be collected in a culture trough for seaweed, which will remove nutrients from the water before it infiltrates into the underlying lava. The water in the trough can be tested for nutrient levels on a regular basis to monitor the efficiency of the system.

Since the aquaculture ponds and raceways will be lined with plastic, the water will not be able to erode the lava and no sediments will be generated. Therefore, a "high sediment load" is not expected.

5/2 The general development plan of the proposed agricultural development is as follows. In the 2,472 acre koa haole pasture area, 400 acres per year, over six years, would be rolled and seeded. The macadamia area would be graded and planted, in increments of 500 acres per year, over three years. As soon as irrigation wells are developed, the 200 acre koa haole cultivation and the 200 acre research and development areas will be developed. It is expected that one of the aquaculture modules will be developed within the first five years.

A list of permits required for the project will be included in the EIS, in the section, "List of Necessary Approvals". Please note that since construction or point discharge of human or animal wastes from the petition area directly into offshore waters is not being proposed, permits regarding marine water quality will not be required.

5/3 The EIS will include a discussion of the General Plan Land Use Pattern Allocation Guide (LUPAG) designation. It should be noted that the General Plan Land Use Pattern Allocation Guide designation is in conformance with the higher State Land Use designation. The orignial rationale behind the State Conservation District designation has been investigated. Gordon Furutani, Executive Director of the Land Use Commission was consulted regarding this matter. According to Mr. Furutani, research into the

original rationale for classifying an area is conducted whenever a petition is filed. In some cases, the exact reasons for a land use designation is documented. In the case of the petition area, Mr. Furutani was unable to find any specific documentation.

The EIS will include a discussion of the ALISH and Land Study Bureau designations. While lands of the subject petition contain soils which have been considered not normally adaptable for productive agricultural use (according to ALISH and Land Study Bureau), the petitioner is proposing uses such as aquaculture and the cultivation of macadamia and koa haole, which do not require soils with greater master productivity ratings. Therefore, while previously the site may have not been considered normally adaptable for productive agricultural use (according to the ALISH designation), approval of the petition would expand the agricultural potentials of the petition lands and the State Agriculture District boundaries.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

1414 Keneki Place
Hilo, Hawaii 96720
January 7, 1984

MR. William W. L. Yuen, Chairman
State Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

JAN 12 ...

GROUP 70

SUBJECT: Notice of Preparation for Farms of Kapua Environmental Impact Statement

Your attention is called to Part VII: Alternatives To The Proposed Action and under said Part, Alternatives A.(No Action Alternative) and B.(Alternatives Which Could Feasibly Attain Objectives Of The Action) are proposed. I respectfully submit that Alternative C.(State Natural Recreational And Historic Park) be given serious consideration as another viable alternative. Further, I am enclosing, for inclusion into the Final Environmental Impact Statement among other things, Senate Resolution No. 65(Twelfth Legislature, 1983) and a copy of Mr. Sunao Kido's(then Chairman and Member of the State Board of Land and Natural Resources) letter, dated December 10, 1971, both documents proposing a State Park. I submit that the creation of a State Natural Recreational and Historic Park on a portion of this application is a viable alternative and written response to this proposal is requested from the applicant, Farms of Kapua.

In reference to Part III, Section J.(Historical/Archeological Resources), it states, in part, "A total of 33 new sites(29 inland and 4 coastal) were discovered in addition fo 21(3 inland and 18 coastal) previously recorded sites." (a) Will these new sites be recorded on the State and National Historic Register? (b) Which qualified and knowledgable agency or person(s) determine the significance of these sites? (c) What measures in terms of budget, preservation, and restoration be provided for and accorded these sites? (d) Will there be a further in-depth and extensive oral history be done with people who have lived or presently live in the immediate adjoining areas? Responses to the above questions is requested.

Hanoli Kamana'o,
Gilbert Kahele
Gilbert Kahele

cc: Group 70
924 Bethel Street
Honolulu, HI 96813
Attention: Ms. Sheryl Seaman

(To be made one and seven copies)
THE SENATE
TWELFTH LEGISLATURE, 19 83
STATE OF HAWAII

S.R. NO. 65

Plans clusters of houses aqua marina

# SENATE RESOLUTION

REQUESTING FURTHER ACTION ON THE DESIGNATION OF A STATE NATURAL RECREATIONAL AND HISTORIC PARK AT KAPUA, HONOMALINO, OKOE, KAULANAMAUNA, AND MANUKA DISTRICTS IN SOUTH KONA AND KA'U, ISLAND OF HAWAII.

WHEREAS, the Senate of the 1971 State Legislature adopted Senate Resolution No. 267, "Requesting the Department of Land and Natural Resources to Authorize the Feasibility Study Relating to the Creation of a State Natural Recreational and Historic Park in the Areas of Kapua or Kauna, Honomalino, Okoe and Manuka in South Kona and Ka'u, Island of Hawaii"; and

WHEREAS, Senate Resolution No. 267 requested the Department of Land and Natural Resources (DLNR) to report back to the Senate thirty days prior to the convening of the Regular Session of 1972; and

WHEREAS, the DLNR Division of State Parks submitted a request to the Board of Land and Natural Resources on December 10, 1971, for approval to create a Honomalino state natural recreational and historic park in this area, and the Division of State Parks cited diverse archaeological findings unearthed during a survey of the area, and stated that many other field trips and studies of the area had been made by the Association of Hawaiian Civic Clubs, the Bishop Museum, the Consolidated Clubs of Kona, the Mayor and County Council of Hawaii, the County Planning Department, and the Kona Hawaiian Civic Club; and

WHEREAS, the Division of State Parks cited its desire to create a "primitive type" park which would not require capital improvements but which would provide for controlled access to the park and for the excavation and preservation of some archaeological sites; and

WHEREAS, the area of the proposed state park is state conservation land with the exception of a portion owned by the Bishop Estate; and

S.R. NO. 65

WHEREAS, the Board of Land and Natural Resources, during its board meeting of December 10, 1971, voted unanimously for adoption of the concept of a primitive-type park in the general location shown on the map attached to the Division of State Parks submittal; however, no further action has been taken since 1971; now, therefore,

BE IT RESOLVED by the Senate of the Twelfth Legislature of the State of Hawaii, Regular Session of 1983, that the Department of Land and Natural Resources is requested to renew its plans to create an Honomalino state park with minimal improvements but preserving the significant archaeological sites in the area; and

BE IT FURTHER RESOLVED that the Department investigate the acquisition of the privately owned portion of the proposed state park; and

BE IT FURTHER RESOLVED that the Department submit a report to the Legislature on its progress in developing the Honomalino state park thirty days prior to the convening of the Regular Session of 1984; and

BE IT FURTHER RESOLVED that a certified copy of this Resolution be transmitted to the Chairperson of the Board of Land and Natural Resources.

OFFERED BY: Yoshio Ige Carl Dentes
Leslie Kondo
A. Leimeaner Akana

3/29/83

S-1093

STANDING COMMITTEE REPORT NO. 944

Honolulu, Hawaii 4/19, 1983

Honorable Richard S. H. Wong
President of the Senate
Twelfth State Legislature
Regular Session of 1983
State of Hawaii

Sir:

RE: S.R. No. 65

Your Committee on Ecology, Environment and Recreation, to which was referred S.R. No. 65, entitled:

"SENATE RESOLUTION REQUESTING FURTHER ACTION ON THE DESIGNATION OF A STATE NATURAL RECREATIONAL AND HISTORIC PARK AT KAPUA, HONOMALINO, OKOE, KAULANAMAUNA, AND MANUKA DISTRICTS IN SOUTH KONA AND KA'U, ISLAND OF HAWAII",

begs leave to report as follows:

The purpose of this resolution is to request the Department of Land and Natural Resources to renew its plans to create Honomalino state park with minimal improvement, to preserve the significant archaeological sites in the area, and to investigate the acquisition of the privately owned portion of the proposed state park.

Your Committee finds that the request for creation of the Honomalino state park was initiated in 1971 by the Department of Land and Natural Resources Division of State Parks, and the concept was adopted by the Board of Land and Natural Resources the same year. However, no further action on this project has been taken.

Your Committee on Ecology, Environment and Recreation concurs with the intent and purpose of S.R. No. 65 and recommends its adoption.

Respectfully submitted,

Anthony K. K. Chang
ANTHONY K. K. CHANG, Chairman

Gerald T. Hagino
GERALD T. HAGINO, Vice-Chairman

SMA-Y019

GERALD K. MACHIDA, Member

MALAMA SOLOMON, Member

ANN KOBAYASHI, Member

SMA-Y019

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of State Parks
Honolulu, Hawaii

December 10, 1971

Board of Land and Natural Resources
Honolulu, Hawaii

Gentlemen:

SUBJECT: Approval to Create A State Natural Recreational and Historic Park at Kapua, Honomalino, Okoe, Kaulanamanua and Manuka Districts in South Kona and Kau, Island of Hawaii.

In a resolution unanimously adopted at the convention of February 6, 1971, the Association of Hawaiian Civic Clubs, supported by evidences produced by the Bishop Museum, requested the wholehearted support of the Governor to ask the Members of the Board of Land and Natural Resources to establish a State Natural Recreational and Historic Park in the above named areas.

Much time and effort has been expended conducting field trips and studies in the areas of the above named subject by the following groups:

1. Association of Hawaiian Civic Clubs
2. Bishop Museum
3. Consolidated Clubs of Kona
4. The Mayor and Members of the Council of the County of Hawaii
5. The Planning Department of the County of Hawaii
6. The Kona Hawaiian Civic Club with the Lt. Governor of Hawaii
7. The Division of State Parks, Outdoor Recreation and Historic Sites

On the basis of these many field trips, studies and surveys, the Division of State Parks, Outdoor Recreation and Historic Sites, respectfully requests the Board of Land and Natural Resources to create a Natural Recreational and Historic Park in the area bounded in green on the attached map. The park would extend from the southern boundary of Manuka adjoining Kahuku to the northern boundary of Honomalino adjoining Kalihi. The mauka or eastern boundary would be the Forest Reserve line. All of the bounded area is zoned Conservation and is State-owned except for the entire Kapua District, which is owned by the Bernice P. Bishop Estate. There is no doubt that much valuable historic, cultural and archaeological sites were uncovered during the above mentioned field trips, studies and surveys.

It is the intent of the Division of State Parks to adopt a concept of a primitive type park. Controlled access to the park would be by permit issued from the Hilo office, be it for hiking, hunting, fishing or camping. No improvements are expected especially to the main dirt road leading from Mamalahoa Highway. The immediate necessity would be the posting of signs and of boundary markers. A survey and possibly some excavation of the more important sites would be planned for the near future. In the meantime, the existing rules and regularions of the Division of Fish and Game with the soon to be adopted rules and regulations of the Division of State Parks shall prevail. This would develop a compatible program for this area between the two Divisions.

Approval by this Board would indicate concurrence with SR No. 267/71, which requested and authorized the Board of Land and Natural Resources to conduct a feasibility study to create a State Natural Recreational and Historic Park in this particular area. SR No. 267/71 also requested that the Board submit its findings to the Senate, thirty days prior to the convening of the Regular Session, 1972.

ITEM E-3

By approving the above named subject, the Board, in essence, would concur with the intent and purpose of SR No. 267/71 and based on the findings of the already named agencies and groups, eliminate the necessity of submitting the requested study to the Senate of the Regular Session, 1972. The action of the Board would thus be reported to the Senate as a matter of record on SR No. 267/71.

Respectfully submitted,

J. M. SOUZA, JR.
State Parks Administrator
Division of State Parks

RECOMMENDED FOR APPROVAL:

SUNAO KIDO, Chairman and Member
Board of Land and Natural Resources

Att.

HISTORIC SITES IN THE HONOMALINO TO MANUKA AREA

The Division of State Parks has now completed an archaeological site survey of the area of South Kona and Ka'u from Honomalino to Manuka. The statewide inventory and survey team spent 46 man-days in this area inventorying archaeological sites in accordance with the Division's statewide inventory procedures. This meant that only sites previously known or recorded were processed; no attempt was made to conduct original site surveys although new sites were recorded when observed.

The previous work in this area consisted of (1) walk-through survey done by John Reinecke in 1930, (2) work done by Dr. K. P. Emory in 1932, and (3) more recent work by Mrs. Violet Hansen in 1965 and 1969. Mr. George Schattauer also provided a great deal of information about sites that had not been previously recorded, and, many of these were included in this inventory.

Historical Background

The earliest known written account of this area is that of Archibald Menzies in 1794, who recorded his travels through the area as he journeyed toward South Point for his ascent of Mauna Loa (Menzies 1920). He and his party spent the night at Honomalino Village where they were given 200 coconuts for their journey. They observed fishing canoes returning in the evening and the "trading" of fish for nails and bits of iron. Menzies complained that the only water available was brackish and not suitable for their drinking, although the Hawaiians were accustomed to it. He says that they had to send four or five miles upland for good water.

When Menzies and his party left Honomalino Village, he noted that the land they then passed was "a dreary tract of the most rugged rocks of lava scattered here and there with some fisherman's huts" (p. 178).

They next landed at Manuka Village, most likely at what we have recorded as site number 2152. After spending the night, they journeyed southward again, describing the countryside they passed as dreary lava tracts.

The next description of this region comes from the pen of the Reverend William Ellis in 1823, when he came through the area on his way entirely around Hawaii Island (Ellis 1963). He seems to echo, and to amplify, the impressions of Menzies on the barreness of the area. Ellis' party also spent the night at Honomalino Village where they had trouble getting fresh water and food. The next morning, they travelled to Kapua Village. At Kapua, they had to hire a man to go about seven miles inland for fresh water, but complained that he brought back only a single calabash of fresh water. The party then continued on down the coast, and Ellis remarked:

"Nothing can exceed the barren and solitary appearance of this part of the island, not only from the want of fresh water, but from the rugged and broken tracts of lava of which it appears to be entirely composed." (Ellis 1963: 125).

Ellis then summarized his impressions of South Kona as follows: "... the south part (of Kona) presents a most inhospitable aspect. The population is thin, consisting principally of fishermen, who cultivate but little land, and that at the distance from five to seven miles from the shore." (Ellis 1963: 126).

Ellis then describes their entry into Ka'u district at Kaulanamauna: "On entering it (Ka'u), the same gloomy and cheerless desert of rugged lava spread itself in every direction from the shore to the mountains. Here and there at distant intervals, they passed a lonely house, or a few wandering fishermen's huts, with a solitary shrub, or species of thistle, struggling for existence among the crevices in the blocks of scoriae and lava. All

besides was 'one vast desert, dreary, bleak, and wild'".

Ellis' party next spent the night at Keawaiki, probably at what we have recorded as site number 2161. Again, Ellis complains about the fresh water problem and the fact that all they had was what they brought with them. They evidently had to build themselves a windscreen of lava blocks for the evening.

Physical Setting

The physical setting remains much as reported by Menzies and Ellis; if anything, it is somewhat more barren and rugged owing to recent flows of aa lava. Today, vegetation does grow along the coastal areas, particularly in pahoehoe kipukas, behind sand beach areas, and in some sections of older aa lava. However, this vegetation is generally dry-adapted species such as kiawe and others indicative of vegetation zone "A" in Hawaii (Baker 1965:3). Inland, the vegetation changes from grasses through lantana to trees such as ohia and lama. However, and very significant in terms of this report, certain regions extending right down to the coast have lantana and other vegetation growth indicative of vegetation zone "B" which requires wetter climatic conditions than zone "A". The point of this discussion is that although the coastline is generally barren, rugged and dry, there are a number of kipukas and other areas where the local conditions differ dramatically enough to support vegetation requiring higher rainfall. The same appears to be the case for the upland areas, for certain areas continue to be quite barren and inhospitable while others are in vegetation zone "$C_1$", which has been recognized in Kona and Kohala as the area where the most intense Hawaiian agriculture took place. This zone does occur less than "five to seven" miles from the shore in a number of areas.

In essence, then, it is dangerous to generalize on the climatic



and vegetational conditions in this area, for it is locally quite variable. The range, in terms of Hawaiian cultural factors, would be from areas where living would have been, indeed, very bleak and marginal, through areas where living would have been rather pleasant, particularly inland.

In terms of the fresh water problem, numerous wells and underground water sources were noted along the coastline during this survey, all providing water that would have been potable to people accustomed to brackish water. Thus, although water was a problem to Menzies and Ellis, it was not necessarily so for the Hawaiian population.

Survey Summary

Having entered this area with the historical background given in Menzies and Ellis, it came as a surprise to find a wealth of archaeological sites in the region. We had indications of numerous sites from others who had visited the area recently, but could not account in the beginning for the discrepancy between this information and the early descriptions of Menzies and Ellis.

Within the site complexes marked on the attached map were found:

92 house sites
8 kuleana walled areas
2 heiau
3 holua slides
4 petroglyph areas
40 walled enclosures
8 shrines (ko'a)
11 shelter caves
22 grave platforms (puoa)
17 trails

8 wells/cave with water

1 refuge cave

1 goat trap

10 platforms, function unknown

5 cairns (ahu)

1 massive stone wall

1 burial cave

4 ili ili floored areas

8 cleared flat places in aa flows

Obviously, then, there was much more cultural activity in this area than was recognized by Menzies and Ellis. As can be seen on the site map, most of these sites lie along the coastline. This, however, is an artifical clustering for it is the result of the statewide inventory procedure of inventorying known and previously recorded sites, rather than attempting original field surveys. Virtually all early recording done in this area was only for the coastal areas; primarily because for years, little emphasis was given in Hawaiian archaeology to inland agricultural sites. A look at the site map will show that sites are located inland, and these plotted were merely the "top of the iceberg" for the inland region was evidently intensively used by the Hawaiians. Numerous well made trails, both of steppingstones and cleared paths in aa, lead from the coast into this inland area. An extensive matrix of walls, house platforms, cave shelters, and other remains was plotted by the field party as an example of what lies in this upland area (site number 2162).

In addition, it was quite surprising to find evidence at the 1,200 foot elevation of Okoe 1-2, of a field system similar to that described for the area from Honaunau to Kailua (Newman 1970: 118-137). Although not noted



from the jeep roads leading through this elevation zone elsewhere in the Honomalino to Manuka area, it is quite likely that this field system extends through much of the area. A field system like this consists of an interconnecting network of low earthen and rock ridges bordering flat field plots, in which would have been planted sweet potatoes, dryland taro, and possibly ti and breadfruit. The amount of work required to establish such a field system must have been tremendous and necessitated a fairly large and stable population.

Goat Problem

It is quite clear that a major wildlife management problem is developing in this area with the increasing goat population. A rough estimate of the population in this area would be about 1,000 goats. This population seems to range from at least the 1,000 foot elevation down to the coastline, and is concentrated in the more fertile and better watered "oases" and kipukas. There are, for example, probably almost 50 ~~kipukas~~ goats around Manuka Bay itself.

It is our understanding that since hunting pressures have eased in this area, the goats have made a remarkable population recovery from a previous low population. However, it would appear that the population has now increased almost to the carrying capacity of the area. It is quite likely that within the next one to two years, the goats will be forced to either move out of these areas or many will starve or succumb to disease. This is evident because virtually all greenery has been stripped from the haole koa by the goats.

The goat population is of special interest to archaeologists for they are damaging a number of archaeological sites by cutting the midden deposits with their sharp hooves. In terms of parklands, the goats are also creating problems by destroying vegetation which relieves the rather bleak

landscape--and which is in the process of forming soils that would make the land more hospitable. Should heavy rains ever occur in this area, erosion will be greatly increased owing to the stripping of the vegetation and the disruption of the soil surface by hooves.

We strongly urge, therefore, that this goat population be brought to a lower level through controlled hunting. We would emphasize controlled hunting because of problems of historic site preservation. As soon as the general public is allowed unrestricted access to this area, the risks of artifact looters vandalizing sites to get artifacts for their collections, or for sale will greatly increase. Yet, the goat population is also visibly damaging sensitive archaeological sites at this time. The solution to this dilemma would seem to be to allow hunters to enter this area on a permit system wherein records are kept of who was in the area on what days. In addition, it will be essential that the area be patrolled periodically by personnel who can spot check the sites likely to be looted. If this is done, it would be hoped that the danger of site destruction by both goats and artifact hunters can be minimized.

Conclusion

On the basis of this initial information about the possible intensive and extensive use of the upland area for agriculture, coupled with the elaborate nature of certain of the coastal site complexes where heiau and holua slides were found, the Division would be prepared to challenge the picture painted by Menzies and Ellis of Hawaiian use of this area.

Although the coastline does appear bleak, it is broken sufficiently to allow intensive settlement of certain coastal areas, particularly kipukas. Furthermore, since Menzies and Ellis were apparently judging population on the basis of visible grass houses, they probably missed the evidence found



for an intensive use of natural shelters in pahoehoe by these coastal peoples. In other words, not only did the Hawaiians live in grass houses clustered around "oases" in the rugged coastline, but they lived in comfortable and cool shelter caves through much of the remainder, particularly in pahoehoe kipukas.

Recommendations

Strictly in terms of the archaeological values present, this Honomalino to Manuka area is worthy of being set aside as protected park land. The area would be noteworthy in showing the ecological adaptation made by the ancient Hawaiians to what, in European eyes, would have been a most inhospitable land. It would compare to the value of Lapakahi in thus showing the interaction between man and nature in ancient Hawaii, but would not particularly overlap the Lapakahi area which is somewhat more hospitable and thus a different aspect of culture history. The area has high research potential in providing a full range of sites from which such information could be extracted. Once this research potential has been realized by intensive survey work and excavations, the resulting information could be used to develop a very full interpretive picture of Hawaiian life in an area such as this.

The only reservation the Division has about putting this area into park use would be that increased public access may endanger a number of sites by artifact looters. This will always be a problem with any area, for some segments of the population are going to continue to attempt to dig out sites for private collections or for the sale of artifacts. This can be avoided to a great degree in this case by providing for adequate research excavations prior to the entry of the general public into the area. Once the sensitive sites have been excavated, then there will remain only those

sites that would be difficult to damage by vandalism or artifact collectors.

The other caution that must be made is that the present survey by the Division statewide inventory team must not be considered to be the definitive survey, for the limitations of this survey in merely inventorying previously recorded sites have been pointed out. In particular, an intensive survey of the upper portions of the area should be carried out as soon as possible. In the interim, it is the Division's suggestion that the proposed boundaries of the park be pushed inland as far as possible to accommodate these complexes of upland sites.



## REFERENCES CITED

Baker, H. L. and others

1965 Detailed Land Classification--Island of Hawaii. Land Study Bureau Bulletin Number 6. Honolulu.

Ellis, William

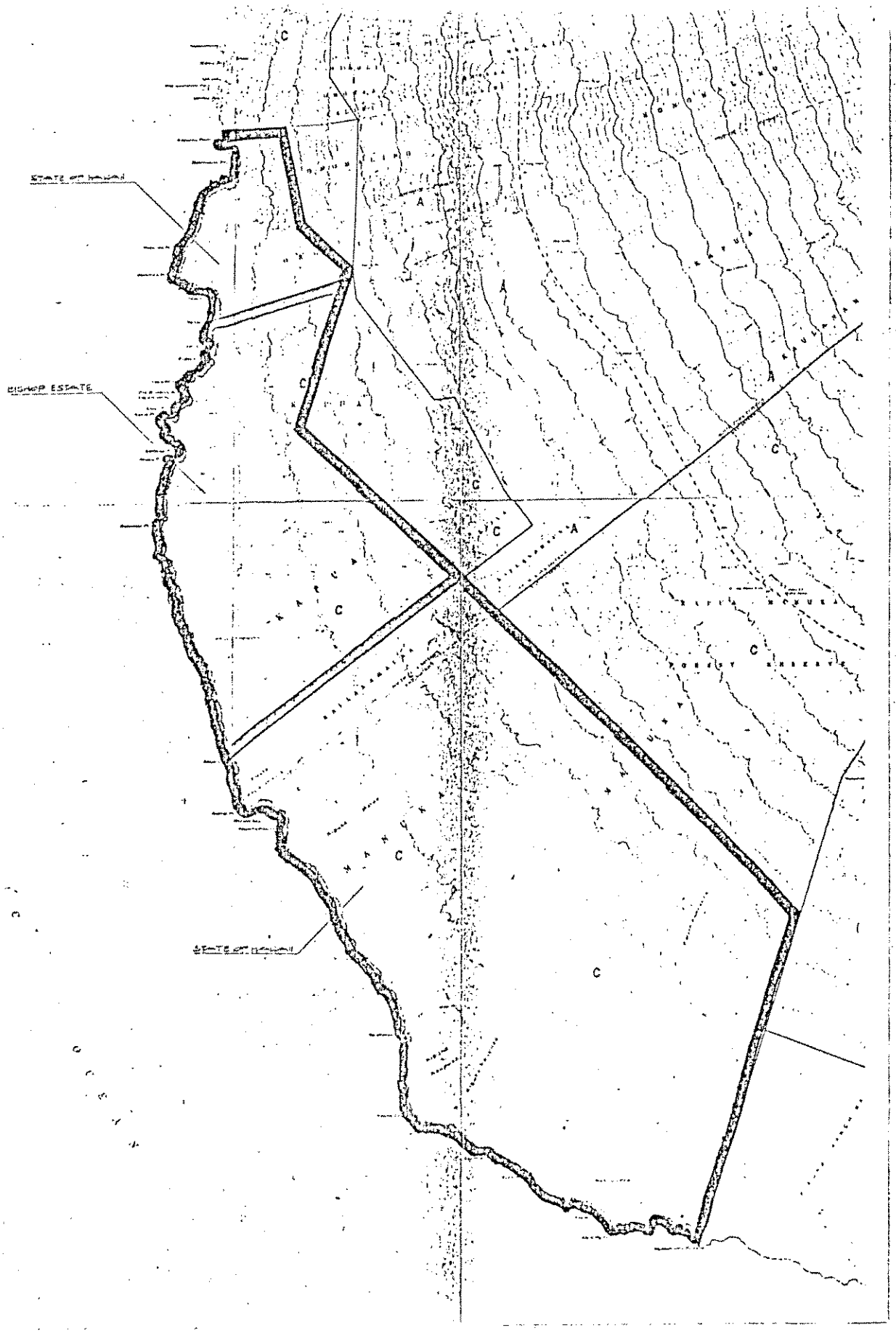
1963 Journal of William Ellis. Advertiser Publishing Company, Honolulu (Reprint of the 1827 edition.)

Menzies, Archibald

1920 Hawaii Nei 128 Years Ago. Honolulu.

Newman, T. Stell

1970 Hawaiian Fishing and Farming on the Island of Hawaii in A.D. 1778. Division of State Parks, Department of Land and Natural Resources. Honolulu.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Kaz Ishihara AIA, Inc
Francis S Oda AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

16 February 1984

Mr. Gilbert Kahele
1414 Keneki Place
Hilo, HI 96720

Dear Mr. Kahele:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We have reviewed your comments and offer the following responses:

1. We will discuss the establishment of a park on the petition area in the section, ALTERNATIVES TO THE PROPOSED ACTION. As described in the NOP, a 2,000 foot setback in the northern half of the shoreline, and a 300 foot setback in the balance of the shoreline will be left in Conservation. The area contained within the 2,000 foot setback contains most of the features of historical value that was found by the consulting archaeologist, Paul H. Rosendahl, in his preliminary survey of the site. This area also contains all of the anchialine ponds that were described by J.A. Maciolek and R.E. Brock in the Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974. In addition, the beaches which are most frequently used for camping and fishing, Kapua, Niuo'u, Kaupo and Oe'a, are located in this area. The petitioner will generally maintain the present unobstructed lateral access along the shoreline, north and south of the petition area. We feel that retention of the above described shoreline areas in the Conservation District is in keeping with the expressed intent of S.R. 65 (1983).

2. Preparation of State and National Historic Register nomination forms would be an appropriate part of intensive survey work that would be required during the rezoning application process.

3. Site significance would be determined in consultation with staff of both the State Historic Preservation Office and the Hawaii County Planning Department.

4. The measures in terms of budget, preservation, and restoration for these sites would be addressed in a cultural resource management plan. This latter plan was mentioned by Rosendahl in the Archaeological Reconnaissance Survey Farms of Kapua.





5. On page 3, and in Appendix III of Rosendahl's report, additional social-cultural research is recommended. The petitioner intends to comply with his recommendations.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

P.O. Box 70
Volcano, HI. 96785
January 20, 1984

Sheryl Seaman
Group 70
Architects and Planners
924 Bethel Street
Honolulu, HI. 96813

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JAN 24 1984
GROUP 70

RE: Farms of Kapua, EIS Notice of Preparation

Written comments regarding environmental effects of the proposed action.

According to the EIS Notice of Preparation, Farms of Kapua, Dec. 1 1983:

> "Between 1956 to 1970, the Navy subleased approximately 2,198 acres near Kauna Point for use as a bombing range. During this period only inert practice ordnance was used. Following termination of the lease in 1970, the Navy received authorization to reenter the property for the purpose of removing hazardous ordnance."

There appears a discrepancy here between "inert practice ordnance" and the removing of "hazardous ordnance" by the Navy. If the bombs were inert, why were they hazardous? It is highly doubtful that inert bombs were used at the Kapua bombing range especially during the 50s and early 60s.

It is also highly unlikely that the Navy conducted a thourough unexploded ordnance clearance that included the entire 2,198 acre range, nor the surrounding nearshore water or the portions mauka of the target where bombs would have landed had they missed their target.

Nor is it likely that the Navy did any subsurface survey and clearance. As recent reports disclose, bomb disposal units were required recently to clear unexploded ordnance at Waikane on the windward side of Oahu. These were bombs from World War II that erosion has gradually pushed to the surface. Erosion since 1970 may have exposed many more bombs left at Kapua that would cause considerable hazard during the contruction and operational phase of the proposed aquacultural facility.

It is strongly suggested that the U.S. Navy be required to return to the bombing range at Kapua for further survey and possible clearance of unexploded ordnance. This new Navy survey report should be included in the EIS.

Included also in the EIS should be the previous 1970 U.S. Navy survey of the Kapua target zone including, but not limited to, information such as dates of operation, number of bombs dropped during the 14-year operation, the type of ordnance, the scope of the clearance, exact area surveyed for unexploded ordnance, and the results of their ordnance clearing operation.



It is only the aforementioned methods that one can adequately determine and judge the true potential environmental impact and threat to human health posed by this previous Navy bombing of the area. This information might preclude aquaculture development in the area specified altogether.

Sincerely,

W.K. Westlake

Wayne K. Westlake

cc: William W.L. Yuen, Chairman
Land Use Commission

enclosures: "Dud Rocket Shells Posing Hazard in Waikane Valley" by Harold Morse, Honolulu Star-Bulletin, Jan. 5, 1984

"Digging Up Trouble" Honolulu Advertiser, Jan. 5, 1984

"Hunting For Old Shells" Honolulu Advertiser, Jan. 21, 1984

**EXPLOSIVE PROBLEM**—U.S. Marines ordnance experts will be in Waikane Valley for the next few weeks ridding the area of ordnance such as the 3.5-inch bazooka rocket shown by Chief Warrant Officer David Lindsey. —Star-Bulletin Photo by Dean Sensui.

# Dud Rocket Shells Posing Hazard in Waikane Valley

By Harold Morse
*Star-Bulletin Writer*

Thousands of bullets from small arms and a large number of 3.5-inch rockets in various stages of disintegration were found by about eight newsmen and 13 Marines who took a hike up a Waikane Valley hillside yesterday.

The old Waikane Valley Impact Site, inspected yesterday by reporters and cameramen, originally was leased by the federal government as a military training area during World War II. It was so used until 1976 when the lease expired and the land was returned to private use.

Marines at that time, August 1976, collected some 25,000 pounds of scrap, including about 40 live rounds which they exploded.

The impact site evidently was used as a maneuver area, too. Expended blank cartridges are strewn about.

More unexploded ordnance was discovered recently, and Kaneohe Marines are involved in another surface-clearing operation at the site which is expected to take several weeks.

THE PROPERTY belongs to the Kamaka family. Tor Kamaka, vice president of the family enterprise, said yesterday that the parcel totals 187 acres and has been in the family a number of generations.

Kamoialii Peak towers as the highest land elevation in the area.

Alfred Morita, a Kamaka cousin and family consultant on the board of directors, said extensive taro cultivation took place on the land some years ago.

Kamaka said the family wants to branch out into different types of diversified agriculture to go along with banana growing now in progress. Prawns and catfish inhabit a mountain stream newsmen crossed yesterday, Kamaka said.

The family also wants to have a ti leaf operation and operate a non-profit Keikei Village, containing authentic Hawaiian structures, to help perpetuate Hawaiian culture, he said.

THE VILLAGE would be on acreage closer to Kamehameha Highway, Kamaka said.

Marine Col. Thomas McKeown of Camp Smith, project coordination officer for Waikane Valley, said erosion and other natural causes have exposed additional ordnance since the 1976 clearing operation.

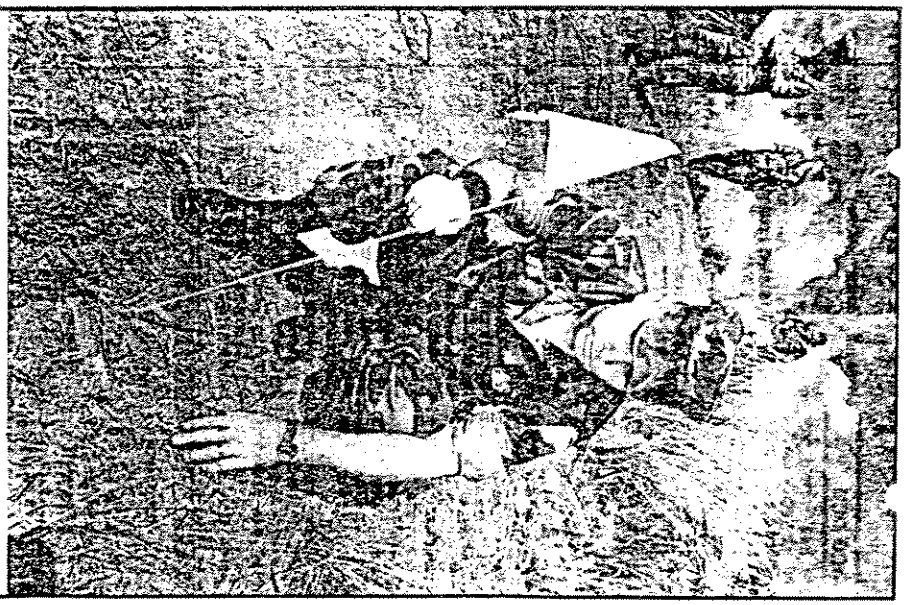
Master Sgt. Gerald L. Watts, an explosives ordnance disposal specialist based at Kaneohe Marine Corps Air Station, said most of the small-arms bullets were 7.62mm slugs, probably from machine guns fired from a ridge across the valley.

The 3.5-inch rockets were fired from anti-tank weapons known as bazookas. Some of the rocket rounds fired were practice rounds and others were live, the Marines said.

The live ones that failed to explode are dangerous and should not be touched, they said.

Although the property involved is relatively isolated, such individuals as hunters and hikers should avoid the area because of the danger of accidental detonation of unexploded rounds, the Marines warned.

SB 1-5-84



Advertiser photo by Gregory Yamamoto

## Digging up trouble

Chief Warrant Officer 2 Stephen Negahnquet points out potentially dangerous unexploded ordnance recently found in Waikane Valley in Kahaluu. Military explosives experts made a tour of the area yesterday and will begin clearing it later this week. People who know of such material are encouraged to contact the Honolulu Police Department by phoning 911. A military explosives disposal team will pick up and properly dispose of the munitions, no questions asked, a military spokesman said. The site was originally leased by the federal government as a military training area from World War II to 1976. The area was cleared at that time, but erosion has exposed additional ordnance. Officials are asking hunters and hikers to stay away from the isolated area until the operation, which is expected to last several weeks, is complete.

Adv 1-5-84

UPI photo

## Hunting for old shells

Navy personnel search the underbrush of the canyon in the San Diego community of Tierrasanta for old ammunition. The site was a military firing range during World War II. Two 8-year-old boys were killed in December when playing with a live shell they found in the area. Their deaths led to an intensive sweep the past four days. The search yielded more than a dozen shells, including live tank and bazooka rounds.

HA 1-21-84

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

16 February 1984

Mr. Wayne K. Westlake
P.O. Box 70
Volcano, HI 96785

Dear Mr. Westlake:

SUBJECT: Farms of Kapua EIS Notice of Preparation

We share your concerns regarding the potentially hazardous nature of the unexploded ordnance left by the Navy during their tenure of 1956 to 1970. Enclosed please find numerous correspondance between representatives of the Farms of Kapua and the Navy. Note that the petitioner has made a formal request for the Naval Explosive Ordnance Team to enter the former bombing site, on at least two occasions. Inclusion of a report of the 1971 survey in the EIS would be moot, as exposed ordnance has already been reported. Please be assured that we will continue to make effort necessary towards removal of these items, in order safely implement the proposed activities.

Very truly yours,

Sheryl B. Seaman

Sheryl B. Seaman, AIA

cc: Land Use Commission
John Farias
Roy Takeyama

Encl. (5)

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-4411

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, D.C. 20350

IN REPLY REFER TO

22 AUG 1980

Dear Mr. Brown,

This is in response to your letters of June 10 and August 5, 1980, in which you request a copy of License NOy(R)-50959 covering the Navy's former bombing range at Kauna Point on the island of Hawaii and an acknowledgement of cancellation, deactivation, and cleanup of the range.

Enclosed are the requested documents relating to the license and its termination.

Following termination of lease NOy(R)-50959 on December 31, 1970, the Navy received authorization to reenter the Kauna Point land for the purpose of removing, insofar as possible, hazardous ordnance. In 1971, a thorough surface sweep of the Kauna Point range was done, utilizing explosive ordnance disposal personnel. It is estimated that 90% of the hazardous ordnance was neutralized or removed. The remaining estimated 10% was either buried or was then inaccessible because of the extremely rough lava terrain.

In the intervening nine years, it is possible that wind or water erosion, or both, may have exposed on the surface of the ground, items of hazardous ordnance which were not visible to the ordnance-clearance personnel in 1971. Such hazardous ordnance could consist of smoke marking charges (which were used as part of nonexplosive practice bombs to indicate where the bombs landed) and/or unburned rocket motors. A smoke marker resembles a 10 gauge shotgun shell. If detonated, it has the potential of injuring a person. The unburned propellent, rocket motor, is a gray cylinder, closed on each end, from 30 to 40 inches long and two to five inches in diameter. The rocket motor could be a fire hazard and considered dangerous.

In the event that you should find any ordnance which might be hazardous as described above on the former Kauna Point range, it is requested that you contact:

Naval Explosive Ordnance Team (Hawaii area)
Telephone: 684-8115/684-8116

471-7411 military info
Explosive ord. Team
684-8115

RECEIVED

Parenthetically, it should be noted that no explosive ordnance was ever used at the Kauna Point range. The foregoing information regarding hazardous ordnance is provided to advise you that there nevertheless may be some risk to people present upon that land today.

I trust that this information satisfies the purposes of your inquiry.

Sincerely,

P. H. Speer

P. H. SPEER
Rear Admiral, USN
Assistant Deputy Chief of Naval Operations (Air Warfare)
By direction of the Chief of Naval Operations

Mr. Lonnie Brown
1221 Kapiolani Boulevard, Suite 1031
Honolulu, HI 96814

Encls

AGRICULTURAL CONCEPTS, INC. 615 Piikoi Street, Suite 1510, Honolulu, Hawaii 96814 · (808) 521-2011

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OCT 05 1982
GROUP 70

September 10, 1982

Naval Explosive Ordnance Team
(Hawaii Area)
Barbers Point Naval Air Station
Ewa Beach, Hawaii 96706

Gentlemen:

Attached is a copy of a letter from Rear Admiral P.H. Speer to Mr. Lonnie Brown dated August 22, 1980 regarding the former Kauna Point range on the Big Island. Previous attempts to reach the ordnance team through the telephone numbers supplied in Admiral Speer's letter have proved unsuccessful.

I represent Farms of Kapua, which recently acquired the Kapua lands on which the Kauna Point range is located.

We have been on the property and find potentially hazardous ordnance to be visible. As instructed by the enclosed correspondence, we hereby request the removal of all such ordnance from the Kauna Point range.

Please advise.

Sincerely,

John Farias, Jr.
President

Enclosure

cc: S.D. Zuckerman
Sally Rice
Lonnie Brown

AGRICULTURAL CONCEPTS, INC. 615 Piikoi Street, Suite 1510, Honolulu, Hawaii 96814 · (808) 521-2011

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OCT 19 1982
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October 15, 1982

Rear Admiral P.H. Speer, USN
Assistant Deputy Chief of Naval
Operations (Air Warfare)
Department of the Navy
Office of the Chief of Naval Operations
Washington, D.C. 20350

Dear Sir:

On September 10, 1982, we wrote to the Naval Explosive Ordnance Team (Hawaii Area) regarding the former Kauna Point bombing range, copy enclosed.

Your letter of August 22, 1980 to Mr. Lonnie Brown is also enclosed.

To date, we have not received a reply. We would appreciate a response or advisement.

Sincerely,

John Farias, Jr.
President

Enclosures

cc: Senator Daniel K. Inouye (w/encl)
Senator Spark M. Matsunaga (w/encl)
S.D. Zuckerman
Roy Takeyama, Esq.

FOV
SS.

8215

Rcvd 10/19/83

RECEIVED
OCT 21 1983

DEPARTMENT OF THE NAVY
COMMANDER IN CHIEF
UNITED STATES PACIFIC FLEET
PEARL HARBOR, HAWAII 96860

GROUP 70

IN REPLY REFER TO:
FFI-1
5800
Ser 03J/9748
17 OCT 1983

Roy Y. Takeyama, Esquire
Century Square, Suite 3404
1188 Bishop Street
Honolulu, Hawaii 96813

COPY FOR YOUR INFORMATION

XC: SDZ
Dai.F
S.R.
10/19

Dear Mr. Takeyama:

This letter is in response to your telephone request of September 21, 1983 for information regarding the Navy's former bombing range at Kauna Point, which is now owned by your client, Farms of Kapua.

The Navy subleased the Kauna Point property from 1956 to 1970, and utilized it as a bombing range. During this period only inert practice ordnance was used. Although this ordnance contained no high explosives, some potentially hazardous material was present consisting of smoke marking charges and rocket motors. The marking charges resemble 10 gauge shotgun shells; if detonated they could cause injury. The propellant for the rocket motors is a gray cylinder, closed on each end, from 30 to 40 inches long and two to five inches in diameter. Should unburned propellant remain, it could be a fire hazard and should be considered dangerous.

Following termination of the lease in 1970, the Navy received authorization to reenter the property for the purpose of removing, insofar as possible, hazardous ordnance. In 1971 a thorough surface sweep was conducted, utilizing explosive ordnance disposal personnel. It is estimated that 90 percent of the hazardous material was removed or neutralized. The remaining estimated 10 percent was either buried or was then inaccessible because of the extremely rough lava terrain.

In the intervening 12 years, water and/or wind erosion may have exposed hazardous material which was not visible in 1971. Should any potentially hazardous items be discovered it is requested that your clients contact Explosive Ordnance Disposal Group One (Telephone: 684-6233). Arrangements can then be made for Navy personnel to go to the site and remove or destroy the hazardous material.

I trust that this information satisfies the purposes of your inquiry.

Sincerely,

T. R. KINNEBREW
Deputy Commander in Chief
U.S. Pacific Fleet and
Chief of Staff

RECEIVED OCT 19 1983

cc: J. Farias 10/19/83

---

ROY Y. TAKEYAMA
ATTORNEY
A LAW CORPORATION
CENTURY SQUARE
SUITE 3404
1188 BISHOP STREET
HONOLULU, HAWAII 96812

(808) 526-2416

October 18, 1983

Lieutenant Hammond
Naval Base
Staff Judge Advocate's
Office
Box 012
Honolulu, Hawaii 96860

Dear Lt. Hammond:

Through numerous correspondences with P.H. Speer, Rear Admiral, USN and B.C. McCaffree, Jr., Commodore, USN, Farms of Kapua, situated at Kauna Point on the Island of Hawaii, has been repeatedly reassured that the Naval Explosive Ordinance Team would be discharged should any ordinance be found on this land. The purpose of this letter is to give you notice that numerous hazardous ordinances were sighted recently by Dr. Paul Rosendahl and his survey team while conducting an archaeological reconnaissance survey of the Kapua area. Dr. Rosendahl reported these ordinances to be located near the coastal area on the northern boundary of the Farms of Kapua property, approximately 2,400-2,500 feet from shore.

Please deploy the proper ordinance disposal group to the Kauna point site immediately. An increased amount of activity is taking place at this site, and these potentially hazardous ordinances should be disposed of as soon as possible to avoid possible injuries.

Thank you for your cooperation in this matter. If you have any questions, feel free to call me at 526-2416.

Sincerely,

ROY Y. TAKEYAMA
Attorney

cc: J. Farias

RECEIVED OCT 19 1983

typical of that vegetation type. Occasionally, however, a species generally restricted to the roadsides in most of the site was observed as an element of a specific vegetation type. Such examples are large-fruited gomphocarpus and false mallow which are also found along the coastal areas, West Indian sage (Salvia occidentalis) which is an element in the Koa-haole Thicket and Scrub Grassland and garden spurge which is also common in coastal areas and in the Kiawe Forest. Typically roadside species include Santa Maria (Parthenium hysterophorus), spiny amaranth (Amaranthus spinosus), Bermuda grass (Cynodon dactylon), partridge pea (Cassia leschenaultiana) and Henry's crabgrass (Digitaria adscendens).

## RARE AND ENDANGERED SPECIES

There are only five Hawaiian plant species that have been officially designated as Endangered Species and are thus protected by federal and state laws. None of these were found in the project site. However, at least one, Colubrina oppositifolia, that is unofficially considered rare and endangered is present. Three vines of Canavalia hawaiiensis were discovered in the lama-alahe'e forest near the mauka boundary between the main gate and the northeast gate. It has been collected several times in the North Kona and South Kona Districts but according to Fosberg and Herbst (1975) it is "Depleted, much less common over all or most of its range than formerly, the depletion directly or indirectly the result of human activities". A single healthy kauila (Colubrina oppositifolia) was found in a gulch in the northeast corner of the project site, makai of the jeep road. It is widely distributed from the Puu Waawaa-Huehue area in North Kona where it reaches its best development to the land of Kapua where even since the days of Joseph Rock, it has been considered very rare. Kauila is so rare today that it appears on every listing of significantly rare species. The Smithsonian report (1974) listed it as "Endangered" and Fosberg and Herbst (1975) considered it "Very Rare", "total population low", and "Endangered, in considerable danger of disappearance". In 1976 it was proposed by the U.S. Fish and Wildlife Service as a candidate for official listing as and Endangered Species persuant to the Endangered Species Act of 1973 (Anon. 1976). It was re-listed by the USFWS in 1980 (Anon. 1980) as a taxon for which the service has sufficient information on hand to support its being listed as Endangered or Threatened (Category 1). Also discovered in that same gulch were three halapepe trees which have been tentatively determined as Pleomele aurea. Because it was not in flower at the time of the survey, it is not definitely known whether it is the long-flowered P. aurea or the short-flowered P. hawaiiensis. The tentative determination is based on leaf and fruit characters. Pleomele aurea was listed by Fosberg and Herbst (1975) as "Depleted", and "Endangered" and by the Smithsonian Institution as "Endangered". It was proposed for official designation by the USFWS in 1976 but in the re-evaluation and re-listing its status was downgraded to Category 3C, "Taxa that have proven to be more abundant or widespread than was previously believed and/or those that are now subject to any identifyable threat" (Anon. 1980). Pleomele hawaiiensis has been similarly listed except that in the 1980 re-evaluation it was retained in the critical Category 1.



## LIMITATIONS OF THE SURVEY

The intent of the survey was to obtain a general description of the flora in the project site. It is preliminary in nature and the existence of additional species not already listed on the Species Checklist cannot be precluded. Furthermore, because no systematic transect procedure was employed, and no quantitative data was obtained, the broad vegetation types are based on qualitative observations. The existence of smaller plant communities and sub-types is probable.

## RECOMMENDATIONS

At least one species considered to be rare and endangered, and another of possible significance were discovered in the gulch near the northeast corner of the project site. Although the floor of the gulch is largely choked with exotic vegetation such as lantana, the existence of these species behooves some measure of conservation. In addition, 10 fine specimens of a variety of the sandalwood, Santalum paniculatum were found in close proximity to the kauila and halapepe. According to the most recent treatment of the Hawaiian sandalwoods (Stemmermann, 1980), the two varieties of S. paniculatum are distinguished primarily by the color on the undersides of the leaves. The var. paniculatum has leaves with pale undersides but the var. pilgeri has leaves with undersides not conspicuously pale. The varieties are very closely related and some intergrading occurs. Although var. pilgeri is more typical to the Kapua region, the individuals observed have pale undersides of the leaves and have thus been determined as S. paniculatum var. paniculatum.

It is therefore recommended that the portion of the gulch makai of the jeep road be considered as a preserve and properly managed as such. No wild seedlings of kauila have ever been observed but it has been successfully propagated by various botanic gardens. It is hoped that seedlings of kauila, halapepe as well as other native species within the project site could be re-established in this preserve. Finally, herbarium specimens of the halapepe should be made during the flowering season (perhaps April-June) to verify its identification.

KAPUA FARMS

BOTANICAL RECONNAISSANCE

## INTRODUCTION AND METHODS

The project site encumbers approximately 7000 acres in the land of Kapua, South Kona District, Hawaii Island between approximately 1100-1300' elevation and sea level. It is bounded by an extensive macadamia nut farm on the northeast, the ocean on the west and also by terrain and vegetation similar to that in the project site. Because of the preliminary nature of the survey and the expanse of the site, the reconnaissance was executed primarily through the use of a four-wheel drive vehicle and existing jeep roads. Species recorded are primarily those observed from these roads. In addition, several walk-through forays averaging several hundred yards were conducted whenever appropriate.

## VEGETATION

The vegetation has been mapped and classified by Ripperton and Hosaka (1942) as their Zone B. It is typically a lowland scrub type consisting mainly of lantana (Lantana camara), cactus (Opuntia megacantha) and koa-haole (Leucaena leucocephala) with ilima (Sida fallax) and 'uhaloa (Waltheria americana) in more exposed sites. Annuals such as Spanish needle (Bidens pilosa), false mallow (Malvastrum coromandelianum) and cocklebur (Xanthium saccharatum) may become common during the rainy season. Kiawe (Prosopis pallida) is dominant in coastal areas on the leeward side of the islands.

The botanical reconnaissance revealed that the vegetation differs dramatically from that of the Ripperton and Hosaka report. Six broad vegetation types were recognized in the project area, each blending into one another forming a continuum.

Scrub Grasslands (SG)
Much of the vegetation in the project site consist of a sparse scrub grassland dominated by fountain grass (Pennisetum setaceum) and Natal redtop (Rhynchelytrum repens). This vegetation type is characterized by open fields of grass and short stature shrubs of low to moderate density and widely scattered trees 15-20 feet tall. The trees are more prevalent in the mauka than in the makai regions. Numerous species were recorded in this community but most were present only in small numbers. The common shrubs include pluchea (Pluchea odorata), 'uhaloa, lantana and ilima. Spurflower (Plectranthus parviflorus) is also commonly found. Scattered throughout the area but in smaller numbers are indigo (Indigofera suffruticosa), broomsedge (Andropogon virginicus), molassasgrass (Melinis minutiflora), 'ihi (Portulaca cyanosperma) and Boston fern (Nephrolepis exaltata). The widely scattered trees are mostly lama (Diospyros ferrea var. pubescens), Christmas berry (Schinus terebinthifolius) and kiawe. Several individuals of maiapilo (Capparis sandwichiana var. zoharyi) and pua-kala (Argemone glauca), three sandalwood trees (Santalum paniculatum) 15-20 feet tall and a single maua (Xylosma hawaiiense var. hillebrandii) were also observed. Vast areas within this community type are nearly devoid of vegetation.



Koa-haole Thicket (KHT)
Another extensive vegetation type is a koa-haole thicket in which koa-haole, lantana and Guinea grass (Panicum maximum) are the dominant elements. Scattered kiawe, Christmas berry, ihi, Cassia bicapsularis and Japanese lovegrass (Eragrostis tenella), and in the mauka region, remnant lama, 'ūlei (Osteomeles anthyllidifolia) and alahe'e (Canthium odoratum) are occasionally found. Ilima, 'uhaloa and Natal redtop are present in small numbers. Also included within the Koa-haole Thicket is a prominent gulch in the northeast portion of the project site. Elements of the vegetation type are found in the gulch (eg lantana) but atypical species such as honohono (Commelina diffusa), currant tomato (Lycopersicon pimpinellifolium) and Pipturus hawaiensis are also present. The Koa-haole Thicket serves as the primary pasture for the cattle in the area.

Kiawe Forest (KF)
Some areas are dominated by open kiawe forests up to 25-30' tall. Despite the open canopy, the understory in many areas is relatively sparse. Lantana, koa-haole, Guinea grass, 'uhaloa, Cassia bicapsularis, balsam apple (Momordica charantia var. pavel), Japanese lovegrass and garden spurge (Euphorbia hirta) comprise the shrub and herb layers. Where moisture is more readily available the understory consists of dense stands of koa-haole and lantana.

Coastal (C)
The coastline vegetation is relative sparse and many of the typical strand species are absent. Groves of kiawe grow where groundwater and some soil are present. Associated with kiawe are such atypical coastal species as Cassia bicapsularis, lantana, Japanese lovegrass, garden spurge, balsam apple, false mallow, large-fruited gomphocarpus (Gomphocarpus physocarpus); Madagascar periwinkle (Catharanthus roseus) and currant tomato. Kou (Cordia subcordata), hala (Pandanus sp.), naupaka kahakai (Scaevola taccada var. sericea), pa'ū-o-hi'iaka (Jacquemontia sandwicensis), pohuehue (Ipomoea brasiliensis) and alena (Boerhavia diffusa) are also found along the coast.

Secondary Forest and Scrub (SFS) and Native Forest (NF)
The vegetation in the mauka areas down to approximately the 900' elevation level consist largely of secondary forest and scrub and remnant native forest. In the past large tracts were grubbed and chain-dragged resulting in dense secondary scrub dominated by Christmas berry, lantana, Guinea grass and kauna'oa-pehu (Cassytha filiformis). Also abundant are guava (Psidium guajava), huehue-haole (Passiflora suberosa), koali-'awania (Ipomoea congesta) and Cassia bicapsularis. Peperomia leptostachya is common and groves of kukui (Aleurites moluccana) are present in this area. Remnant individuals or clusters of lama and alahe'e up to 30' tall and 'ūlei can be found among the secondary growth. Where the native forest was left intact, the lama and alahe'e form closed-canopied forests up to 40' tall (NF). Few other species are found in the native forest. 'Ūlei, huehue (Cocculus ferrandianus) and lauae (Microsorium scolopendrium) were occasionally recorded and a single maua was seen. Lantana and Guinea grass are also present in small numbers, generally in exposed sites such as those created by fallen trees.

Roadside (R)
Many species in the project site are more common to the roadsides than to the specific vegetation type through which the road traverses. Although these species may also be found away from the road, they are not considered to be

APPENDIX B

# KAPUA FARMS
# BOTANICAL RECONNAISSANCE
# (1983)
# and
# MAUKA BOUNDARY, FARMS OF KAPUA
# BOTANICAL SURVEY
# (1984)

By
KENNETH M. NAGATA
Botanist

TABLE 2

KAPUA MOISTURE DEFICIENCY ELEV. 400 FT.

(Rainfall at elevation 400 based on Opihihale)

Deficiency in rainfall by months = 4.4" - actual rainfall

( ) = surplus

| YEAR | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANNUAL DEFICIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | 3.1 | (1.6) | 1.2 | 0.8 | 2.3 | 0.5 | 0.6 | (0.2) | 0 | 2.0 | 3.2 | 0.2 | 13.9 |
| 1956 | (3.6) | 1.5 | 0.2 | 1.4 | (0.1) | 2.4 | 0.1 | 1.4 | 2.4 | 1.5 | (7.3) | 3.6 | 14.5 |
| 1957 | (0.4) | 2.4 | 2.9 | 1.7 | 1.7 | 1.2 | 1.7 | 1.6 | 2.7 | 1.1 | 1.7 | 3.1 | 21.8 |
| 1958 | 4.2 | 3.7 | 0.6 | 3.6 | 1.2 | 1.8 | 0 | (0.2) | 1.9 | 0.6 | 4.1 | 2.6 | 24.3 |
| 1959 | (4.6) | 2.4 | 2.5 | 2.3 | 1.7 | 2.0 | (1.6) | 2.0 | 1.5 | 1.5 | 0.6 | 3.2 | 19.7 |
| 1960 | 3.9 | 2.4 | 2.7 | 3.1 | 2.5 | 0.4 | 3.1 | 2.4 | 2.0 | (0.3) | 3.4 | 0.2 | 26.1 |
| 1961 | 2.5 | 2.7 | 1.0 | 1.1 | (1.1) | 1.2 | 0.8 | 0.8 | 1.4 | (1.1) | (3.0) | 2.6 | 14.1 |
| 1962 | 2.2 | 3.7 | 0.1 | 2.2 | (0.1) | 1.7 | 0.9 | 2.4 | 2.0 | 2.9 | 3.0 | 2.0 | 23.1 |
| 1963 | 0.1 | 3.5 | (0.2) | (2.3) | (1.2) | (1.5) | (0.4) | 2.1 | 0.3 | 3.3 | 2.8 | 3.1 | 15.2 |
| 1964 | 2.3 | 3.0 | (2.4) | 0.6 | 1.5 | 1.5 | (1.3) | 0.4 | 1.1 | 1.2 | 1.6 | (3.1) | 13.2 |
| 1965 | 1.6 | 2.0 | 2.7 | 0.8 | 0.2 | 1.0 | 0.9 | (0.9) | 0.7 | 2.8 | (1.5) | 2.8 | 15.5 |
| 1966 | 2.4 | 0.6 | 1.4 | 2.3 | 1.0 | 2.4 | 2.8 | 1.9 | 0.6 | 2.2 | 1.5 | 2.6 | 21.7 |
| 1967 | 2.3 | 2.6 | (0.7) | 1.6 | 0.3 | (0.7) | (2.4) | (1.5) | (4.4) | 0.5 | 3.4 | 1.6 | 12.3 |
| 1968 | 0 | 2.8 | 2.2 | 0.1 | 2.0 | 2.5 | 1.7 | 0.7 | (2.0) | 2.0 | 1.7 | (3.7) | 15.7 |
| 1969 | (0.5) | 2.9 | 2.1 | 2.1 | 2.5 | 0.7 | 0.7 | (0.6) | 2.4 | 1.1 | 4.0 | 2.7 | 21.2 |
| 1970 | 1.5 | 3.5 | 3.1 | 1.7 | 2.4 | 2.9 | 0.7 | 3.5 | 1.1 | 2.8 | 0.3 | 2.8 | 26.3 |
| 1971 | (5.3) | 2.0 | 3.7 | 2.4 | 1.6 | 3.3 | 1.9 | 1.8 | 0.6 | 2.3 | 2.0 | 2.4 | 24.0 |
| 1972 | (0.2) | 2.1 | 0.9 | 2.8 | 2.4 | 2.9 | 2.8 | (0.9) | 2.6 | 2.3 | 2.0 | 1.7 | 22.5 |
| 1973 | 3.2 | 2.8 | 1.3 | 2.9 | 2.4 | 3.1 | 2.4 | 1.7 | 1.5 | 3.2 | 2.0 | 2.0 | 28.5 |
| MAX | 4.2 | 3.7 | 3.7 | 3.6 | 2.5 | 3.3 | 2.8 | 3.5 | 2.7 | 3.3 | 4.1 | 3.6 | 28.5 |
| MED | 1.6 | 2.6 | 1.3 | 1.7 | 1.6 | 1.8 | 0.7 | 1.4 | 1.4 | 2.0 | 2.0 | 2.6 | 21.2 |
| Total Deficit /n | 1.5 | 2.5 | 1.5 | 1.8 | 1.4 | 1.7 | 1.1 | 1.2 | 1.3 | 1.8 | 2.0 | 2.1 | 19.7 |

DEFICIT DISTRIBUTION

| Class (in.) | No. | Exceedance Percentile |
|---|---|---|
| ≤ 0 | 38 | 83.3 |
| 0.1-0.5 | 16 | 76.3 |
| 0.6-1.0 | 23 | 66.2 |
| 1.1-1.5 | 24 | 55.7 |
| 1.6-2.0 | 36 | 39.9 |
| 2.1-2.5 | 36 | 24.1 |
| 2.6-3.0 | 28 | 11.8 |
| 3.1-3.5 | 18 | 3.95 |
| 3.6-4.0 | 7 | 0.88 |
| 4.1-4.5 | 2 | 0 |
| n = 228 | | |

TABLE I

KAPUA MOISTURE DEFICIENCY, ELEV. 1150 FT.

(RAINFALL OPIHIHALE 2: Elev. 1270 ft.)

Deficiency in rainfall by months = 4.4" - actual rainfall

( ) = surplus

| YEAR | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANNUAL DEFICIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | 2.8 | (3.2) | (0.3) | (0.2) | 1.7 | (0.6) | (0.5) | (1.4) | (1.2) | 1.4 | 2.9 | (1.0) | 9.1 |
| 1956 | (5.7) | 0.7 | (1.0) | 0.8 | (1.3) | 1.9 | (1.1) | 0.6 | 1.8 | 0.7 | (10.5) | 3.4 | 9.9 |
| 1957 | (1.7) | 1.8 | 2.5 | 1.0 | 0.9 | 0.3 | 0.9 | 0.8 | 2.2 | 0.2 | 0.9 | 2.8 | 14.3 |
| 1958 | 4.1 | 3.5 | (0.4) | 3.4 | 0.3 | 1.1 | (1.2) | (1.5) | 1.3 | (0.4) | 4.0 | 2.1 | 19.8 |
| 1959 | (7.0) | 1.9 | 2.0 | 1.7 | 0.9 | 1.3 | (3.2) | 1.4 | 0.6 | 0.7 | (0.4) | 2.9 | 13.4 |
| 1960 | 3.7 | 1.9 | 2.2 | 2.7 | 2.0 | (0.7) | 2.8 | 1.9 | 1.3 | (1.6) | 3.1 | (1.0) | 21.6 |
| 1961 | 2.0 | 2.2 | 0.1 | 0.2 | (2.6) | 0.3 | (0.2) | (0.2) | 0.6 | (2.6) | (5.0) | 2.1 | 7.5 |
| 1962 | 1.6 | 3.5 | (1.1) | 1.6 | (1.3) | 0.9 | (0.1) | 2.0 | 1.3 | 2.5 | 2.6 | 1.3 | 17.3 |
| 1963 | (1.1) | 3.2 | (1.5) | (4.1) | (2.7) | (3.1) | (1.7) | 1.5 | (0.8) | 3.0 | 2.3 | 2.8 | 12.8 |
| 1964 | 1.7 | 2.6 | (4.3) | (0.5) | 0.7 | 0.7 | (2.8) | (0.7) | 0.2 | 0.3 | 0.7 | (5.1) | 6.9 |
| 1965 | 0.8 | 1.4 | 2.0 | (0.2) | (1.0) | 0.1 | (0.1) | (2.3) | (0.3) | 2.2 | (3.1) | 2.2 | 8.7 |
| 1966 | 1.8 | (0.5) | 0.6 | 1.7 | 0.1 | 1.9 | 2.2 | 1.2 | (0.4) | 1.6 | 0.7 | 2.1 | 13.9 |
| 1967 | 1.7 | 2.1 | (2.1) | 0.8 | (0.8) | (2.1) | (4.3) | (3.2) | (6.8) | (0.6) | 3.1 | 0.8 | 8.5 |
| 1968 | (1.2) | 2.2 | 1.6 | (1.1) | 1.4 | 2.0 | 1.0 | (0.4) | (3.8) | 1.3 | 0.9 | (5.9) | 10.4 |
| 1969 | (1.9) | 2.5 | 1.5 | 1.6 | 1.6 | (0.3) | (0.3) | (2.0) | 1.8 | 0.2 | 3.9 | 2.0 | 15.1 |
| 1970 | 0.7 | 3.2 | 2.8 | 0.8 | 1.9 | 2.5 | (0.3) | 3.2 | 0.2 | 2.2 | (0.8) | 2.2 | 19.7 |
| 1971 | (7.9) | 1.5 | 3.5 | 1.9 | 0.8 | 3.0 | 1.2 | 1.1 | (0.4) | 1.7 | 1.4 | 1.9 | 18.0 |
| 1972 | (0.6) | 1.5 | 0 | 2.2 | 1.8 | 2.5 | 2.3 | (2.4) | 2.0 | 1.7 | 1.3 | 0.8 | 16.1 |
| 1973 | 2.9 | 2.2 | 0.4 | 2.5 | 1.8 | 2.8 | 2.0 | 1.0 | 0.7 | 2.9 | 1.4 | 1.3 | 21.9 |
| MAX | 4.1 | 3.5 | 3.5 | 3.4 | 2.0 | 3.0 | 2.8 | 3.2 | 2.2 | 3.0 | 4.0 | 3.4 | 21.9 |
| MED | 1.6 | 2.1 | 0.4 | 1.0 | 0.9 | 1.1 | 0 | 0.6 | 0.6 | 1.4 | 1.3 | 2.1 | 13.9 |
| Total Deficit /n | 1.5 | 2.0 | 1.1 | 1.2 | 0.8 | 1.1 | 0.7 | 0.8 | 0.7 | 1.2 | 1.5 | 1.6 | 14.2 |

DEFICIT DISTRIBUTION

| Class (in.) | No. | Exceedance Percentile |
|---|---|---|
| ≤ 0 | 74 | 67.5 |
| 0.1-0.5 | 14 | 61.4 |
| 0.6-1.0 | 30 | 48.3 |
| 1.1-1.5 | 22 | 38.6 |
| 1.6-2.0 | 36 | 22.8 |
| 2.1-2.5 | 23 | 12.7 |
| 2.6-3.0 | 15 | 6.14 |
| 3.1-3.5 | 10 | 1.75 |
| 3.6-4.0 | 3 | 0.44 |
| 4.1-4.5 | 1 | 0 |
| n = 228 | | |

## APPENDIX 2

### Expected Moisture Deficits in Kapua
### Elevation 400 feet to 1200 feet
(Based on National Weather Service Long Term Rainfall Records at Opihihale and Manuka)

The closest site to the proposed Kapua macadamia orchards for which a long term record of rainfall exists is Manuka (State Rain Gage No. 2.0), about two miles along the highway to the south at elevation 1750 feet. The nearest one to the north is at Opihihale (State No. 24.1), on the highway seven miles away at 1270 feet. The rainfall between the two stations appears to be relatively uniform in distribution with respect to elevation. North of Napoopoo rainfall is sharply higher at the same elevations as at Opihihale and Manuka. To the east of Manuka the Kau climatic conditions prevail.

South Kona stations between Napoopoo and Manuka for which a rainfall record is given in "An Inventory of Basic Water Resources Data: Island of Hawaii: State of Hawaii DLNR Report R34, 1970" are as follows:

| Station | Location | Elevation (feet) | Av. Annual Rainfall (inches) |
|---|---|---|---|
| 2.0 | Manuka | 1750 | 59.05 |
| 24.1 | Opihihale 2 | 1270 | 47.74 |
| 25.0 | Pahoehoe | 1000 | 50.62 |
| 25.7 | Pahoehoe Ranch | 1100 | 45.57 |
| 27.0 | Honaunau | 1089 | 44.17 |
| 28.0 | | | |
| (28.1) | Napoopoo | 395 | 38.25 |

These stations, located over a coastal reach of 26 miles, indicate that rainfall is strongly correlated with elevation in this portion of South Kona. On the basis of these records, average annual rainfall at 1000 feet is about 45 inches and at 400 feet about 35 to 40 inches. These approximations are applicable to Kapua.

Reliable records of rainfall along the coast south of Napoopoo don't exist, or are difficult to find, but isohyetal maps suggest that average coastal rainfall is no lower than 20 inches per year and probably is somewhat more. Thus the average rain in Kapua from shore to elevation 1150 feet ranges from 20 inches to nearly 50 inches. For convenience the Opihihale monthly rainfall record is employed as representative of the inland boundary of the Kapua orchards. The Opihihale record is taken from the National Weather Service as given in Scott (ref. cited) and covers the 19 years



period 1955 through 1973. The average for this period was 46.6 inches, about an inch less than the 12 year period (1955 through 1966) given in DLNR Report R34. An alternative model employing the Kole Pen rainfall record is given in Appendix 1.

Rainfall at the 400 feet elevation, both monthly and annual, was computed as a proportion of that at Opihihale on the basis of elevation and of a 30 inch rainfall at the coast. The annual average of 35.2 inches is somewhat lower than the Napoopoo average of 38.5 inches at elevation 395 feet. The average in Kapua between elevations 400 and 1150 feet is taken as 40.9 inches.

Moisture deficits for the 1150 feet and 400 feet levels in Kapua are given in Tables 1 and 2. Deficits for each month were computed as the difference between macadamia demand of 4.4 inches per month and recorded monthly rainfall. Surplus moisture is indicated by parentheses. Included with the tabulation are statistics of the deficit distribution. At the 1150 feet level the distribution shows that no irrigation will be necessary about one third of the time, while at the 400 feet level irrigation will not be needed about one fifth of the time. For more than half the months the irrigation requirement will not exceed one inch per month at 1150 feet and about 1.5 inch per month at 400 feet.

The maximum deficit in the 228 months of record was 4.2 inches at 400 feet and 4.1 inches at 1150 feet; in no month would irrigation have to provide the full demand of 4.4 inches. Every month gets measureable rainfall, a condition of considerable importance to agriculture.

TABLE I

KAPUA MOISTURE DEFICIENCY

(RAINFALL KOLE PEN: Elev. 920 ft.)

Deficiency in rainfall by months = 4.4" - actual rainfall

( ) = surplus

| YEAR | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANNUAL DEFICIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | (2.5) | 0.4 | 2.1 | 1.3 | 1.4 | 1.3 | 1.4 | 0.6 | 2.9 | 0.3 | (5.6) | 3.0 | 14.7 |
| 1957 | 2.4 | 2.9 | 4.0 | 2.4 | 2.2 | 2.4 | 2.6 | 1.5 | 2.4 | 1.1 | 2.8 | 3.3 | 30.0 |
| 1958 | 4.2 | 3.4 | 1.4 | 4.2 | 1.6 | 1.6 | 1.0 | (0.4) | 2.4 | 2.1 | 3.0 | 2.8 | 27.7 |
| 1959 | (5.1) | 2.6 | 4.1 | 2.2 | 1.6 | 2.8 | 1.5 | miss | 2.8 | 3.3 | (1.5) | 3.6 | 24.5 |
| 1960 | 4.3 | 3.3 | 1.5 | 2.9 | 1.9 | 2.7 | 3.2 | 2.4 | 1.4 | 2.4 | 2.7 | 0.8 | 29.5 |
| 1961 | 1.4 | 3.9 | 1.3 | 1.0 | 2.7 | 2.0 | 1.5 | 2.9 | 2.7 | (2.3) | 0.9 | 2.4 | 22.7 |
| 1962 | 0.9 | 3.9 | 1.8 | 1.3 | 1.1 | 3.2 | (0.1) | 3.4 | 1.5 | 3.1 | 3.9 | 3.0 | 27.1 |
| 1963 | (0.6) | 4.2 | (2.9) | (1.9) | (1.5) | 2.0 | (1.3) | 2.0 | 0.4 | 2.7 | 3.3 | 3.2 | 17.8 |
| 1964 | 1.6 | 3.5 | 0.3 | 0.7 | (0.8) | 1.3 | 1.8 | 2.4 | 2.5 | 2.0 | 1.3 | 0.9 | 18.3 |
| 1965 | (0.9) | 1.3 | 2.2 | 0.8 | 0.7 | 1.9 | 1.3 | 0.6 | 0.3 | 2.4 | (2.0) | 4.3 | 15.8 |
| 1966 | 2.6 | 1.2 | 2.0 | 2.9 | 3.1 | 3.8 | 3.3 | 1.6 | 1.0 | 2.7 | 2.8 | 3.8 | 30.8 |
| 1967 | 2.5 | 3.1 | (2.4) | 0.7 | 1.7 | (0.1) | 0.1 | 2.8 | 0.9 | 2.6 | 0.7 | (0.1) | 15.1 |
| 1968 | (1.8) | 1.6 | 2.0 | (4.2) | 3.8 | 3.3 | 2.8 | 1.1 | 0 | 3.2 | 2.7 | (3.7) | 20.5 |
| 1969 | (1.9) | 3.2 | miss | 3.6 | 1.9 | 4.0 | 2.4 | 2.9 | 3.3 | 3.5 | 3.4 | 4.3 | 32.5 |
| 1970 | 0.8 | 3.6 | 4.1 | 2.7 | 3.6 | 4.0 | 2.6 | 1.9 | 3.4 | 3.6 | 2.8 | 2.0 | 35.1 |
| 1971 | (6.2) | 4.0 | 3.2 | 4.0 | 3.4 | 4.4 | 4.0 | 3.5 | 1.6 | 3.3 | 1.7 | 3.5 | 36.6 |
| 1972 | (0.5) | (1.3) | (1.3) | 3.0 | 3.9 | 3.5 | 4.1 | 3.7 | 1.3 | 4.0 | 3.6 | 3.1 | 30.2 |
| 1973 | miss | 4.4 | 4.4 | 3.7 | 2.4 | 2.8 | 4.1 | 3.4 | 0.5 | 2.5 | (0.2) | (1.6) | 28.2 |
| 1974 | 2.7 | 4.2 | 1.9 | 0.9 | (0.5) | 2.1 | 1.9 | 3.1 | 0.5 | 1.6 | 1.8 | 4.3 | 25.0 |
| 1975 | 1.9 | 0 | 2.1 | 2.0 | 2.8 | 3.0 | 2.9 | 3.7 | 2.4 | 3.3 | 2.3 | 4.4 | 30.8 |
| MAX | 4.3 | 4.4 | 4.4 | 4.2 | 3.9 | 4.4 | 4.1 | 3.7 | 3.4 | 4.0 | 3.9 | 4.4 | 36.6 |
| MED | 0.9 | 3.3 | 2.0 | 2.2 | 1.9 | 2.8 | 2.4 | 2.8 | 1.6 | 2.7 | 2.7 | 3.3 | 27.7 |
| Total Deficit /n | 1.3 | 2.7 | 2.0 | 2.0 | 2.0 | 2.6 | 2.1 | 2.3 | 1.7 | 2.5 | 2.0 | 2.6 | 25.7 |

DEFICIT DISTRIBUTION

| Class (in.) | No. | Exceedance Percentile |
|---|---|---|
| ≤ 0 | 31 | 86.9 |
| 0.1-0.5 | 8 | 83.5 |
| 0.6-1.0 | 17 | 76.4 |
| 1.1-1.5 | 23 | 66.7 |
| 1.6-2.0 | 28 | 54.9 |
| 2.1-2.5 | 24 | 44.7 |
| 2.6-3.0 | 36 | 29.5 |
| 3.1-3.5 | 31 | 16.5 |
| 3.6-4.0 | 23 | 6.8 |
| 4.1-4.4 | 16 | 0 |

## APPENDIX 1

### Moisture Deficit Model: Kole Pen Rain Gage

Subsequent to having modeled moisture deficits for the proposed macadamia orchards in Kapua by interpolating rainfall averages at Opihihale and Manuka (see Appendix 2), the State Department of Land and Natural Resources published Circular C-88, "Median Rainfall State of Hawaii", which includes records for two rain gages closer to the Kapua area. These gages are Kole Pen at elevation 920 feet and Okoe at elevation 1590 feet. A third gage, Kapua at elevation 1670 feet, is included in the computer printout at DLNR. None of these gages are reported in National Weather Service publications, nor had their records previously been printed in published reports of DLNR or the USGS.

Unfortunately, C-88 does not provide average rainfalls for any of the rain gages. All statistics and isohyetal maps are cast in terms of medians, which is the mid-level of rainfall accumulation per unit time. Hydrologic balances are computable from averages but not from medians, unless the frequency distribution is perfectly normal, in which case the average and median are identical. At Kapua the frequency distribution is not normal, even on an annual basis for which normality might be expected. The average and median rainfall for the Kapua gages are as follows:

| Gage | State No. | Average (in/yr.) | Median (in/yr) |
|---|---|---|---|
| Kole Pen | 2.18 | 30.0 | 25.7 |
| Okoe | 2.17 | 50.0 | 46.7 |
| Kapua | 2.19 | 50.0 | |

To expand the moisture deficit model originally based on Opihihale, a similar model was derived employing the Kole Pen data. The period of record is 1956 through 1975, for which the values are given in the DLNR printout for 237 months of the total of 240 months. The moisture deficits are given in Table 1. Deficits for each month were computed as the difference between macadamia orchard demand of 4.4 inches per month and the actual reported monthly rainfall. Surplus moisture is indicated by parentheses. Included with the tabulation are statistics of the deficit distribution.

At Kole Pen the distribution shows that no irrigation will be necessary about 13 percent of the time. About one third of the time the irrigation requirement would be less than 1.5 inches per month. The average annual deficit will be 25.7 inches, which reduced to a daily basis amounts to 1912 gallons per acre.



Placing sole reliance on the Kole Pen record as the index of rainfall in the Kapua lands proposed for macadamia, supplemental irrigation requirements will be as follows:

| AV. DEFICIT (in/yr) | AV. DEFICIT (gpad) | 10 PERCENTILE Deficit (in/mos) | 10 PERCENTILE Deficit (gpad) |
|---|---|---|---|
| 25.7 | 1912 | 3.9 | 3481 |

(In the above, ten percentile exceedance means that the deficit equal to or greater than that listed will occur only 10 percent of the time.)

The ten percentile exceedance level is chosen as the limit to which all deficits should be met. Thus only ten percent of the time would trees suffer insufficient moisture. In no period of the record did the deficit equal or exceed the ten percentile level for three or more consecutive months.

Estimates of the total average and ten percentile exceedance demands for irrigation are given below. Irrigation rates for macadamia are assumed to be applicable to leucaena and other crops also.

| CROP | ACRES | AVERAGE (gpad) | TOTAL AV. (mgd) | 10 PERCENT (gpad) | TOTAL (mgd) |
|---|---|---|---|---|---|
| Macadamia | 1710 | 1912 | 3.3 | 3481 | 6.0 |
| Leucaena | 200 | 1912 | 0.4 | 3481 | 0.7 |
| Other | 200 | 1912 | 0.4 | 3481 | 0.7 |
| TOTAL | 2110 | | 4.1 | | 7.4 |

Total average demand is equivalent to 2845 gpm. Assigning a yield of 1000 gpm to agricultural wells, three wells may be required to satisfy average demand. At the same yield, five or six wells will be needed to meet the ten percentile demand.

In the Appendix, irrigation requirements by months, based on a moisture demand of 4.4 inches per month, have been computed for the historical record based on the Opihihale and Manuka rain gages and separately for the record at Kole Pen. The results may be summarized briefly as follows:

Required Supplemental Irrigation
Kapua Farms Macadamia Orchard

| Elevation (feet) | Average Deficit (in./yr.) | Average Deficit (gpa/d) | 10 Percentile Exceedance (in./mos.) | 10 Percentile Exceedance (gpa/d) | Maximum Deficit (in./mos.) |
|---|---|---|---|---|---|
| Opihihale - Manuka | | | | | |
| 400 | 19.7 | 1466 | 3.0 | 2671 | 4.2 |
| 1100 | 14.2 | 1056 | 2.5 | 2226 | 4.1 |
| Average | 17.0 | 1261 | | | |
| Kole Pen | | | | | |
| 900 | 25.7 | 1912 | 3.9 | 3481 | 4.4 |

(In the above, ten percentile exceedance means that the deficit equal to or greater than that listed will occur only ten percent or less of the time.)

The ten percentile exceedance level is chosen as the limit to which all deficits should be met. Thus only ten percent of the time would the trees suffer insufficient moisture. Only once in the 19 years of record at Opihihale and not once at Kole Pen did the deficit equal or exceed the ten percentile level for three consecutive months.

Estimates of the total average and the ten percentile exceedance demands based on the least favorable record (Kole Pen) can be calculated for macadamia plantings as follows:

Irrigation Demand for Macadamia
(Kole Pen)

| Use | Number and Unit | Average Rate/Unit (gpd) | Total Average Demand (mgd) | 10 Percentile Rate/Unit (gpd) | Total 10 Percentile Demand (mgd) |
|---|---|---|---|---|---|
| Orchard | 1710 acres | 1912 | 3.3 | 3481 | 6.0 |



The total average demand for macadamias is equivalent to 2290 gpm. Assuming the agricultural wells 1000 gpm each, three wells may be required to satisfy average demand. At the same rates, four to five wells may be needed to meet the ten percentile demand.

Satisfying only the average demand, which is approximately the same as the median demand (See Appendix), means that 50 percent of the time a residual moisture deficit will exist in spite of irrigation. This deficit would not be destructive but might affect yields. Thus it would be prudent to have more than the three wells that may be needed for the average demand. A moisture deficit over only ten percent of the time might not measurably affect yields, and for this reason at least four wells are desirable.

## Well Construction and Equipment Costs

Current costs of drilling and outfitting wells are as follows (estimates provided by drilling contractors):

Drilling (16 inch bore).....$350/ft.
Casing (12 inch dia.).....$50/ft.
Testing.....$400/hr.
Pump (700 to 1000 gpm set at 1200 ft.)
and Controls.....$350,000
Miscellaneous (power, etc.).....$ 50,000

The cost of each irrigation well will be approximately:

Drilling: 1050 x 350.....$367,500
Casing: 1010 x 50..... 50,500
Testing: 24 x 400..... 9,600
Pump and Controls..... 350,000
Miscellaneous..... 50,000
Total.....$827,600

The above likely overstates rather than understates expected costs. Nevertheless, developing groundwater with deep wells is expensive. Two wells would cost a total of about $1,700,000 while the desired four would cost about $3,400,000.

Cost of pumping will be substantial. Assuming cost per kilowatt hour in South Kona is ten cents (which is the approximate average cost on Hawaii), operating cost of lifting 1000 gpm of water 1000 feet to the surface into a storage reservoir at this elevation will be about $.40/1000 gallons. A rough calculation of the cost of the well at 12 percent interest for 25 years assigns another approximately $.32/1000 gallons. The total estimated cost of $.72/1000 gallons is less than the county charges. This total, however, does not include storage and transmission costs. A final cost would more likely be about $.80/1000 gallons.

| Elevation (feet) | Distance from Coast (miles) | Head (feet) |
|---|---|---|
| 200 | 1.4 | 2.3 |
| 400 | 1.9 | 2.7 |
| 600 | 2.3 | 3.0 |
| 800 | 2.9 | 3.4 |
| 1000 | 3.4 | 3.6 |
| 1200 | 3.8 | 3.8 |

North of this center line distances from the coast to the same elevations are shorter and consequently heads at a given elevation are about 0.7 feet lower. South of it distances are slightly longer and heads are about 0.2 feet higher for the given elevations. Thus near the south boundary of Kapua the head at 1200 feet is calculated to be slightly over 4.0 feet.

An accurate determination of groundwater flow through Kapua is impossible because values for the parameters of the relevant equations are imprecise. However, analogy with similar Kona subsurface environments where some of these values have been refined suggests that flow at the coastline is at least of 6.0 mgd per mile. In the arid regions of North Kona and South Kohala, a thorough water balance study of the Water Resources Research Center at the University of Hawaii (B.Y. Kanehiro and F.L. Peterson, 1977, Groundwater Recharge and Coastal Discharge for the Northwest Coast of the Island of Hawaii: A Computerized Water Budget Approach: U.H. WRRC Technical Report TR-110) indicated coastal discharge to likely be 6.38 mgd per mile and as much as 11.8 mgd per mile. Thisregion does not experience rainfall as high as in Kapua. Within the petition area, total flow is between 8.0 and 18 mgd, and the most probable average is about 13 mgd. Not all of this flow is feasibly developable, however; sustainable yield on a continuous schedule is 6.0 to 7.0 mgd, but for periods of reasonable length, say three months or so, as much as twice the sustainable yield can be pumped without seriously affecting the quality of yield. Pumping in excess of sustainable yield for short periods is common practice in basal aquifers of Hawaii (J.F. Mink, 1982, State of the Groundwater Resources at Southern Oahu, Honolulu Board of Water Supply.

## Groundwater Development

No groundwater is being developed within 20 miles of Kapua. The nearest active wells are near Naalehu in Kau and northward in South Kona toward Kealakekua. These wells are not only distant but are located in aquifers either separate or remote from the one underlying Kapua. The State well at Okoe is idle but can produce inferior quality agricultural water.



To extract groundwater, deep wells will have to be drilled. Cost of drilling wells and fitting them with pumps and controls is considerable, and thus to promote economic feasibility the fewest number of wells needed for efficient satisfaction of irrigation demands should be planned. The Appendix addresses this necessity by providing a "Moisture Deficit" model in which monthly deficits are computed as the deficiency of rainfall to meet macadamia tree requirements of 4.4 inches of water.

The irrigation wells can be placed within the macadamia orchards at sites consistent with acceptable water quality and transmission and storage requirements. As a first estimate, locations between the 800 and 1000 feet elevation contours would offer a reasonable compromise among quality, initial and operating costs, and engineering factors. A likelihood exists that at least one of these wells, the one nearest the southern boundary, would yield water of potable quality.

The moisture deficit model states that for average conditions, a total of three wells may be required, but for drought situations, a total of four to five wells may be necessary to satisfy the irrigation requirements of the proposed macadamia orchards, the 200-acre koa haole cultivation area, and the 200-acre research and development area. The irrigation wells can be drilled to match planting and expansion of the orchards. The pump capacity of each irrigation well will be about 1000 gpm.

The State well at Okoe can be used in combination with water from the project's first irrigation well to irrigate initial plantings. This arrangement would delay drilling of subsequent irrigation wells for a short time. To put the Okoe well in service, however, a pump and controls will have to be installed and 3000 feet of transmission line laid from the well site to the northern boundary of Kapua. The cost of this approach in comparison with the cost of drilling two new irrigation wells should be worked out before a final decision is made to use the Okoe well.

## Plan of Development

As currently planned, the sector of Kapua from elevation 400 feet to the boundary of the existing agricultural district at about 1000 feet will be planted to approximately 1710 acres of macadamia trees. The 1710 acres of orchard will be irrigated by the agricultural wells, possibly with some contribution from the Okoe well.

rainfall correlates strongly with elevation and only weakly, if at all, with distance inland. Between Manuka and Napoopoo rainfall is very similar at comparable elevations; north of Napoopoo it is significantly greater at these same elevations. Kapua lies in the relatively uniform belt between Manuka and Opihihale.

Mean monthly rainfall in inches at Manuka and Opihihale are given below to illustrate the similarity of distribution. The record of Manuka covers the period 1929-1966 while that for Opihihale is for 1955-1973. Means, not medians, are given.

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manuka | 4.10 | 4.47 | 5.75 | 5.49 | 6.45 | 5 17 | 4.74 | 5.66 | 5.81 | 4.66 | 3.67 | 3.61 | 59.05 |
| Opihihale | 4.68 | 2.43 | 3.85 | 3.51 | 4.22 | 3.67 | 4.45 | 4.22 | 4.61 | 3.53 | 3.78 | 3.27 | 46.62 |

The relevance of the Opihihale record as a surrogate for Kapua at 1200 feet can be tested by comparing the average annual rainfall to that at Manuka adjusted to 1270 feet elevation. The adjustment assumes linear increase in rainfall with elevation to at least the Manuka elevation of 1750 feet. These calculations indicate that Opihihale is representative of Kapua at about the 1200 feet level.

The secondary records within Kapua are at Kole Pen (State no. 2.18), Okoe (State no. 2.17) and Kapua (State no. 2.19). Kole Pen is within elevation of 920 feet, Okoe at 1590 feet, and Kapua at 1670 feet. None of data from these gages are reported in National Weather Service publications, nor had their records previously been printed in published reports of DLNR or the USGS. Monthly means for these stations are as follows (inches):

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kole Pen | 4.07 | 1.62 | 2.71 | 2.67 | 2.54 | 1.76 | 2.34 | 2.10 | 2.68 | 2.00 | 2.86 | 2.04 | 29.97 |
| Okoe | 5.50 | 2.43 | 4.43 | 4.79 | 4.99 | 3.50 | 4.01 | 3.64 | 4.69 | 3.78 | 4.56 | 2.56 | 50.03 |
| Kapua | 4.33 | 2.39 | 4.31 | 4.50 | 5.71 | 3.35 | 4.02 | 4.11 | 4.05 | 4.04 | 4.92 | 2.42 | 49.79 |

The above suggests that rainfall at 1000 feet in Kapua averages about 35 inches per year. At elevation 400 feet rainfall is about 25 inches.

The statistical dispersion of monthly rainfalls about their means is unusually tight. This means that extremely dry months are rare. The statistics suggest that devastating droughts are virtually absent in the Kapua region.

The rainfall that is not evaporated and transpired by plants infiltrates into the ground to eventually accumulate as groundwater. Essentially no surface runoff of rainfall escapes to the sea.



## Groundwater Occurrence

The groundwater potential of the Kapua region is broadly known but has not been investigated in any detail. Evidence exists that suggests the presence of a sizeable groundwater resource ranging from very brackish near the coast to potable several miles inland. In the principal recharge zone annual average rainfall reaches 75 inches and over a large area the average lies between 50 and 75 inches. Elsewhere in Hawaii these conditions give rise to developable groundwater.

Subsurface geology is favorable for groundwater accumulation and flow. Fresh water occurs as a lens floating on salt water, a condition which imposes strict constraints on how the fresh water can be successfully extracted. As a general rule, salinity of groundwater is a function of head (water table elevation above sea level), while head is a function of distance inland. A head of about four feet is required to guarantee fresh water production at economically acceptable pumping rates. Based on the scanty available data and by analogy with measurements elsewhere in South Kona, a head of four to five feet occurs four or more miles inland along the southern boundary of Kapua.

Water of non-potable salinity (greater than 250 mg/l chloride) but fresh enough for agriculture and aquaculture exists at lower elevations. In the elevation range from 600 to 1000 feet chloride content will probably be on the order of 500 to 700 mg/l at acceptable pumping rates. From elevation 400 to 600 feet it likely will rise to about 1000 mg/l, and between the coast and 400 feet it may reach several thousand mg/l. In water holes a few hundred feet inland of Kapua Bay a total salinity of 5000 mg/l (2700 mg/l chloride) has been reported (J.A. Maciolek, R.E. Brock, 1974, Aquatic Survey of the Kona Coast Ponds, Hawaii Island: Univ. Hawaii Sea Grant AR 74 04).

In 1980 the State drilled a well at Okoe (0953-01), about 3000 feet north of the Kapua boundary. The well produced water that stabilized at about 900 mg/l chloride at 700 gpm, a relatively good performance in view of the fact that the well lies only 1.6 miles inland of the nearest coast at Honomalino Bay. The comparable inland location in the mid portion of Kapua would be somewhat below elevation 400 feet.

Analyses based on data from other parts of Kona where hydrogeologic conditions resemble to an acceptable degree those at Kapua suggest that heads along a line through the center of the property increase as follows:

WATER SUPPLY

FOR

FARMS OF KAPUA

Prepared for

Farms of Kapua

By

JOHN F. MINK

Hydrologist

February, 1984

## Environment

Kapua lies in South Kona on the southwestern flank of Mauna Loa. It is underlain by basalts and olivine basalts of the Kau volcanic series, the upper strata of which are of relatively recent geologic age. The Kau series is composed of a random succession of layers of pahoehoe, aa and clinker, the characteristic rock types of shield volcanoes. Few of the layers are more than ten feet thick or several hundred feet wide. A few discontinuous ash and cinder beds may occur among the lavas, but they are neither common nor extensive enough to interfere with the water bearing character of the basalts.

Surface features of the area depend upon average annual rainfall. Where the average exceeds about 40 inches per year but is less than about 60 inches the natural growth is scattered forest; above 50 inches the forest begins to close; and below 40 inches sparse grass and sporadic shrubs dominate. The 25 inch isohyet is about coincident with the 400 feet topographic contour, the 40 inch about with the 1200 feet contour, and the 20 inch isohyet is estimated to lie along the coast. A relatively well developed soil has formed above the 40 inch isohyet and a somewhat thinner, less uniform one between 30 and 40 inches. Below the 25 inch isohyet weathering has not been sufficient to generate recognizable soil. Here the landscape consists of irregular, broken lava flows. Near the coast certain salt tolerant plants whose roots reach to brackish groundwater survive in favorable locations.

The petition area extends from the seacoast through the broken lava terrain into the scattered forest at approximately 1000 feet elevation over a total average distance of 3.2 miles. The slope of six percent is typical of the flanks of recent Hawaiian volcanoes like Mauna Loa.

## Rainfall

Records of rainfall at Kapua in the elevation reach between 900 and 1600 feet were recently published in Circular C-88 of the State Department of Land and Natural Resources. Unfortunately, C-88 does not provide average rainfalls for any of the rain gages. All statistics and isohyetal maps are cast in terms of medians, which is the mid-level of rainfall accumulation per unit time. Hydrologic balances are computable from averages but not from medians, unless the frequency distribution is perfectly normal, in which case the average and median are identical. A more substantial record for standard gages at Manuka, two miles south of the petition area, and Opihihale, about seven miles north, are on file with the National Weather Service. The Manuka gage (State No. 2.0) is at an elevation of 1750 feet on the Belt Highway, and the Opihihale gage (State No. 24.1) is at 1270 feet, also on the highway. Rainfall at these stations shows similar distribution although the amounts differ because the gages are 500 feet apart in elevation. In South Kona

# APPENDIX A

# WATER SUPPLY
# FOR
# FARMS OF KAPUA
# (Revised 1984)

By
JOHN F. MINK
Hydrologist

18. H. Stuart Kearns, Jr., Department of Research and Development, County of Hawaii, EIS public review letter, Hilo, Hawaii, 23 March 1984.

19. Ibid.

20. County of Hawaii, Public Access to the Shoreline, prepared by: a joint venture of Hiroshi Kasamoto, Inc. and P. Yoshimura, Inc., R.M. Towill, base maps, September 1979, Sheet 27.

21. West Hawaii Coral Reef Inventory, p. 391.

22. Duenna Nakanishi, County of Hawaii Public Works Department, Sewers and Sanitation Bureau, telephone conversation, 17 November 1982.

23. Ibid.

24. State of Hawaii Department of Transportation, Traffic Survey Data Book, Highway P-8, 1983.

25. Ibid.

26. Ibid.

27. Officer Riveira, County of Hawaii Police Department, Captain Cook Station Kona District, telephone conversation, 17 November 1982.

28. Ed Matsushige, State of Hawaii Department of Education, telephone conversation, 19 November 1982.

29. Ibid.

30. William Gorst, State Department of Land and Natural Resources, Division of Parks and Recreation, telephone conversation, 17 November 1982.

## REFERENCES AND FOOTNOTES


1. Gordon A. MacDonald and Agatin Abbott, Volcanoes in the Sea, University of Hawaii Press, Honolulu, Hawaii, 1970.

2. U. S. Army Corps of Engineers, West Hawaii Coral Reef Inventory, prepared by Ron S. Nolan and Daniel P. Cheney, Contract DAW C84-80-C-0003, 1981, p. 377.

3. County of Hawaii, Draft Kona Regional Plan, prepared by Department of Planning, Hilo, Hawaii, 1982, p. 44.

4. Department of Geography, University of Hawaii, Atlas of Hawaii, University of Hawaii Press, Honolulu, Hawaii, 1983.

5. Draft Kona Regional Plan, p. 25.

6. Donal Mullineaux and Donald W. Peterson, "Volcanic Hazards on the Island of Hawaii", Open-file report 74-239, 1974.

7. Draft Kona Regional Plan, p. 30.

8. Doak C. Cox, Environmental Center, University of Hawaii at Manoa, NOP consultation letter, Honolulu, Hawaii, 6 January 1984.

9. Kisuk Cheung, Department of the Army, Pacific Ocean Division, NOP consultation letter, Honolulu, Hawaii, 29 December 1983.

10. West Hawaii Coral Reef Inventory.

11. J.A. Maciolek and R.E. Brock, Aquatic Survey of the Kona Coast Ponds, Hawaii Island, Sea Grant Advisory Report 74-04, 1974

12. West Hawaii Coral Reef Inventory.

13. Raymond J. Kramer, Hawaiian Land Mammals, Charles E. Tuttle Co., 1971, p. 60.

14. Draft Kona Regional Plan, p. 78.

15. State of Hawaii Department of Planning and Economic Development, State of Hawaii Data Book, December 1983, p. 19.

16. Ibid, p. 20.

17. Draft Kona Regional Plan, p.78.

# OEQC BULLETIN

George R. Arlyoshi
Governor

Letita N. Uyehara
Interim Director

Office of Environmental Quality Control
550 Halekauwila St., Rm. 301, Honolulu, Hawaii Ph.(808)548-6915

Volume I | February 23, 1984 | No. 02




## REGISTER OF CHAPTER 343, HRS DOCUMENTS

### EIS PREPARATION NOTICE

The following proposed action has been determined to require an environmental impact statement. Anyone can be consulted in the preparation of the EIS by writing to the listed contacts. 30 days are allowed for requests to be a consulted party.

KAAHUMANU PROJECT, HONOLULU, OAHU, City and County of Honolulu Dept. of Housing and Community Development

The proposed action is to develop a mixed use complex on the City-owned Kaahumanu Parking Facility and District Court sites. The proposed development would include a 400-600 room executive hotel to accommodate business persons, other compatible commercial uses, a community events center, and a mini-conference center. The Kaahumanu Parking Facility (TMK: 2-1-2:16, 20 and 56) is 61,142 sq. ft. in area and is bounded by Queen, Bethel and Merchants Sts. The District Court site (TMK: 2-1-2:24 and 26) consists of 28,771 sq. ft. and is bounded by Nuuanu Ave., Nimitz Hwy., Bethel and Merchant Sts. The affected site properties, totaling 89,913 sq. ft. (2.06 acres) is zoned B-4 (Central Business District).

Contact: Mr. Toshiaki Kimura
Department of Housing and Community Development
City and County of Honolulu
Honolulu Municipal Building
650 South King Street, 5th Floor
Honolulu, Hawaii 96813

Deadline: March 24, 1984.

### NEGATIVE DECLARATIONS

The following are Negative Declarations or determinations made by proposing or approving agencies that certain proposed actions will not have significant effects on the environment and therefore do not require EIS's (EIS Reg. 1:4p). Publication in the Bulletin of a Negative Declaration initiates a 60-day period during which litigation measures may be instituted. Copies are available at 25 cents per page upon request to the Office. Written comments should be submitted to the agency responsible for the determination (indicated in project title). The Office would appreciate a copy of your comments.

OAHU

PAUOA ELEMENTARY SCHOOL NEW ENTRANCE TO PARKING LOT, PAUOA, OAHU, Dept. of Accounting and General Services for the Dept. of Education

### ENVIRONMENTAL IMPACT STATEMENTS

EIS's listed in this section are available for review at the following public depositories: Office of Environmental Quality Control; Legislative Reference Bureau; Municipal Reference and Records Center (Oahu EIS's); Hamilton Library; State Main Library and the Kaimuki, Kaneohe, Pearl City, Hilo, Kahului and Lihue Regional Libraries. Statements are also available at State Branch Libraries that are in proximity to the site of a proposed action (indicated by project description).

Comments on the following EIS's may be sent to: 1) the accepting authority; and 2) the proposing agency. Please note the deadline date for submitting written comments on the EIS.

FARMS OF KAPUA, SOUTH KONA, HAWAII, Farms of Kapua/State Land Use Commission

Farms of Kapua, Ltd., is requesting an amendment to the Conservation Land Use District boundary in Kapua, South Kona, Hawaii. Approx. 6,527 acres are located within the Conservation Land Use District boundary. This petition requests the reclassification of approx. 6,102 acres of Conservation District Lands to the Agricultural Land Use District. The petitioner intends to develop a multi-agricultural project including a 1,710 acre macadamia orchard, a 2,472 acre controlled pasture area for cattle, 200 acres of cultivated koa haole, a 20 acre corral, 200 acres for research and development of alternative crops, and a 1,500 acre area for aquaculture development. The project will be known as "Farms of Kapua". The petition area is identified as TMK: 8-9-06:3 (portion), situated within the ahupua'a of Kapua, in South Kona, Hawaii. It is located in the southernmost portion of the South Kona District, 20 miles south of Captain Cook and 20 miles northwest of South Point. The petition area is bounded by approx. five miles of coastline to the west. Directly south is Kaulanamauna Kipuka, which is part of the greater Manuka Natural Area Reserve. The site is bounded on the east by the Agriculture Land Use District. Further east lies MacFarms of Hawaii, Inc.'s 3,000-acre macadamia orchards, processing plant and headquarters and Mamalahoa Hwy.

This EIS is available for review at the Kailua-Kona, Kealakekua, and UH-Hilo Campus Libraries.

Deadline: March 24, 1984.

KALUANUI WELLS, KOOLAULOA, OAHU, City and County of Honolulu Board of Water Supply

Previously published February 8, 1984.

This EIS is available for review at the Kahuku Community-School Library.

Deadline: March 9, 1984.

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR INCREMENT I, EWA MARINA COMMUNITY, HONOULIULI, EWA, OAHU, M.S.M. and Associates, Inc./City and County of Honolulu Dept. of Land Utilization

Previously published February 8, 1984.

This EIS is available for review at the Ewa Beach Community-School Library.

Deadline: March 9, 1984.

EIS'S SUBMITTED FOR ACCEPTANCE. The following EIS's have been submitted for acceptance and contain comments and responses made during the review and response period.

RENOVATION OF UPPER HAMAKUA DITCH AND CONSTRUCTION OF ACCESS ROADS, SOUTH KOHALA, HAWAII, Dept. of Land and Natural Resources, Division of Water and Land Development

Kazuo Ishihara AIA, Inc
Frances S Odani AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

7 March 1984

David Campbell Penn
44-403 Kaneohe Bay
Kaneohe, HI 96744

Dear Mr. Penn:

SUBJECT: Farms of Kapua EIS Notice of Preparation

Enclosed is a copy of the letter that was sent to you providing instructions for written comments during the consultation period. The consultation period was extended for a period over 30 days in order to allow for your comments to be used in the the preparation of the EIS and to be incorporated into the document. The period for public consultation has passed, and the Environmental Impact Statement was filed with the Land Use Commission and the Office of Environmental Quality Control on 21 February 1984. However, you will have another opportunity to provide written comments during the EIS public review period (see attached photocopy of the 23 February 1984 OEQC Bulletin). Please note that the deadline for written public review comments is 24 March 1984. Enclosed, is a copy of the EIS for your review and comments.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission
Stephen Zuckerman
John Farias
Roy Takeyama
Sally Rice

Encl. (3)

Kazuo Ishihara AIA, Inc
Frances S Odani AIA, Inc
Robert K L Wong AIA, Inc
Norman G L Hong AIA, Inc

7 January 1984

Mr. David Campbell Penn
41-020 Alaihi
Waimanalo, HI 96795

Subject: Farms of Kapua Notice of Preparation

Dear Mr. Penn:

As per your letter of 6 January 1984, a copy of the EIS Notice of Preparation for the Farms of Kapua is enclosed. As noted in 1:41 of the Environmental Impact Statement Regulations, you have a period of thirty (30) days in which to make written comments regarding the environmental effects of the proposed action.

Very truly yours,

Sheryl Seaman, AIA

VS:dl

p. 48. PART VI

Limiting the further extension of Agricultural Land Use District boundaries is a long-term and short-term gain which preserves a unique Hawaiian land district in the face of encroaching development throughout the islands.

Expansion of the Agricultural Land Use District boundaries is a long-term and short-term loss which expands the future options for inappropriate uses of the area. Particular impacts of the proposed action are outlined above; in the short-term it will alter the open space value of the area and in the long-term it will pose significant risks to the continuation of local Hawaiian health, safety, spirit, and culture.

p. 49. NO ACTION ALTERNATIVE

Present uses of the area also include hunting, gathering, and spiritual/cultural practices.

p. 51. LIST OF NECESSARY APPROVALS

The SMA use permit process should be followed for the propsed action because:

1. The SMA area extends a minimum of 300 feet from the shore. Aquaculture development is planned within 100 feet of the shore.

2. According to SMA Rules and Regulations(County of Hawaii) development includes:

i. Placement or erection of any solid or liquid waste material or any gaseous, liquid, solid, or thermal waste.

ii. Grading

iii. Change in intensity of use.

iv. Change in intensity of use of water, and of the ecology related thereto.

v. Construction of structures.

The proposed action incorporates all pf the definitions of development.

The SMA use permit process should also be followed when (SMA Rules 9.4(10)c):

Use, activity, and operations is part of a larger project , whose cumulative impact may have adverse environmental or ecological effect on the SMA.

This definition of development is fulfilled by the proposed action. It is part of a larger operation occurring within an Agricultural Land Use District, whose impacts will have particular adverse effects upon the social well-being of local citizens.

The proposed action does not conform to the stipulations of shoreline setback as set out in HRS 205:A(29), with particular regard to 7.1., Removal of materials, and 7.2., Prohibiting structures.

Lands of Kapue should remain within the Conservation Land Use District because they fulfill the function of providing wilderness and beach reserves, and that of conserving natural ecosystems(people too!). Areas within the 20% slope or more designation provide open space amenities and scenic, cultural, and psychic values, which need not be disturbed.

Thank you again for the opportunity to comment upon this Notice.

reason of creating structures and landscapes which are not a part of the naturally occuring environment. Also by reason of noise and exhausts emanating from business operations. Disruption of the coastal landscape will significantly alter the natural, pristine state of the area , as well as altering its wilderness character.

p. 26. VEGETATION

What was the extent of the botanical reconnaisance( % total area covered)?

Eradication of existing vegetation will deprive local citizens of certain plants ( kiawe, ferns, medicinal plants) which are utilized for fuel, medecine, and other cultural practices of crucial social significance.

p. 27. FAUNA

Would the territoriality of bats and the existence of established populations influence the mobility and relocation of the Kapua population?

p. 29. HISTORICAL/ARCHAEOLOGICAL RESOURCES

how do the location and significance of discovered sites relate to the history and tradition of Kapua?

What was the highest elevation covered by the survey?

Impact to sites outside the Conservation District will adversely effect the cultural/spiritual value of sites within the District, because of the interrelationships previously mentioned. How can the archaeological remains be distributed congruent to the project, when they were created hundreds of years before FOK existed? It seems that Rosendahl's analysis puts the cart before the horse.

All sites in the area are significant. Salvage archaeology, suggested in the proposed action, will have severe impacts upon this significance. The Bishop Museum does not have room to store, much less to exhibit, the crates of material already "salvaged". This practice constitutes a selfish taking of a natural resource, which loses a great deal of its significance and interpretive value when removed from its native habitat. Most importantly this practice disturbs the flows of psychic energies and compromises family-oriented spiritual practices of local citizens. This is a highly significant social effect of the proposed action.

p. 34. AGRICULTURE

The application of herbicides and fertilizers is dangerous to workers and to the entire ecosystem. (see Rachel Carson, Silent Spring)

p. 37. RECREATIONAL RESOURCES

Open space values of the site will not be maintained, due to alteration of the landscape and compounded social problems resulting from diruption of psychic harmonies(as previously mentioned).

p. 40. SEWAGE DISPOSAL

What will be the effects of aquacultural waste waters upon the marine environment?

p. 43. POWER AND TELEPHONE

Utility lines and poles will have a negative impact upon the visual aesthetics of the area.

p. 45. PART IV

Added to your list of probable adverse environmental impacts which cannot be avoided should be those as discussed above. Mitigation measures proposed to minimize these impacts could only be a complete reformulation of the proposed action, one which more satisfactorially accounts for the rights and aspirations of the historical children of these lands.

p. 47. IRREVERSIBLE COMMITMENTS AND IRRETREIVABLE RESOURCES

The propsed action represents an irreversible commitment to:

1. Alteration of coastal features
2. Alteration of the existing landscape
3. Salvage Archaeology (whose evils are mentioned above)
4. Loss or destruction of cultural and natural resources
5. Adversely affecting the social welfare of the community and of the state
6. Adversely affecting sociological activities.
7. Removing 6102 acres of conservation land from the State inventory

The propsed action would cause the following resources to become irretreivable:

1. Cultural resources
2. Spiritual resources
3. Scenic resources

Feb. 23, 1984.

RECEIVED
FEB 22 1984
GROUP 70

To: Group 70
From: Dave Penn
Re: EIS-Kapua

To whom it may concern,

Thank you for the opportunity to comment upon the EIS Notice of Preparation for the Farms of Kapua (FOK) Project. The Notice arrived promptly , although I did not receive a written request or instructions for my comments, Please accept them at this time.

Sincerely,

Dave Penn

44-402 Kamehameha Hwy.
Kaneohe, HI

p. 1. SUMMARY:

Other adverse or unavoidable environmental impects include-

1. Noise
2. Visual pollution
3. Disruption of animal habitats
4. Disruption of historically/culturally/spiritually significant areas
5. Disruption of drainage patterns
6. Exhaust from trucks and other machinery
7. Disruption of the relationship of local citizens with their natural environment

These are highly significant long-term effects of the proposed action.

p. 9. SOCIAL CHARACTERISTICS

The area is presently used by local citizens for hunting,gathering, and spiritual practice. Thus a significant portion of people's lives is involved with the site. The proposed action will displace these uses and their benefits to society.

p.9. HISTORIC PERSPECTIVE

Over what % of the total area were survey activities conducted? I think it mentioned 20 % in Rosendahl's report. For the remaining 80% of the area, we could expect the same amount of "sites" as was found in the other 1/5. In adopting the historical perspective, we must be wary of "site specificity". Hawaiian land use was grounded in an intricate system of ecological relationships, ultimately focusing upon psychic unity. We must similarly view recognized historic/cultural sites as part of a network of forces which distingcish a unique area and its people. Using this framework for analysis;

1. The interpetive and spiritual value of coastal sites is disturbed by the prescence of aquaculture facilities.

2. Previous grubbing and chain-dragging of the proposed macadamia orchard does not make the area less significant. To what extent was this particular area surveyed?

3. Does FOK plan to futher restore the Kauna Point area? Did the Navy, following 1970, remove materials other than hazrdous ordinance ( spent material )?

p. 21. COASTAL WATER QUALITY

The proposed action will impinge upon the aesthetic enjoyment of Class AA waters by

## LITERATURE CITED


Anon. 1974. Report on Endangered and Threatened Plant Species of the United States. Smithsonian Institution. 200 pp.

Anon. 1976. Endangered and Threatened Species: Plants. Federal Register. 41(117): 24524-24572.

Anon. 1980. Endangered and Threatened Wildlife and Plants: Review of Plant Taxa for Listing as Endangered or Threatened Species. Federal Register. 45(242): 82480-82569.

Fosberg, F.R. & D. Herbst. 1975. Rare and Endangered Species of Hawaiian Vascular Plants. Allertonia. 1(1): 1-72.

Ripperton, J.C. & E.Y. Hosaka. 1942. Vegetation Zones of Hawaii. HAES Bull. 89. Honolulu. 60 pp.

Stemmermann, L. 1980. Observations of the Genus Santalum (Santalaceae) in Hawaii. Pacific Science. 34(1): 41-54.

St. John, H. 1973. List and Summary of the Flowering Plants in the Hawaiian Islands. Pacific Tropical Botanical Garden. Memoir No. 1. 519 pp.

Wagner, W. Unpublished checklist of Pteridophyta.


## SPECIES CHECKLIST

Families are arranged alphabetically in three groups - Pteridophyta, Monocotyledonae, and Dicotyledonae. Genera and species are arranged alphabetically within each family. Taxonomy of the pteridophytes follow that of Wagner's unpublished list. The common names for the ferns are the commonly-accepted ones. Taxonomy, common names and the status of the Angiosperms follow that of St. John (1973).

### EXPLANATION OF SYMBOLS

Species Status:

- E - Endemic to the Hawaiian Islands, ie. occuring naturally nowhere else in the world.
- I - Indigenous, ie. native to the Hawaiian Islands but also occuring naturally elsewhere.
- X - Exotic, ie. plants introduced after the Western discovery of the islands.
- P - Polynesian introductions; plants introduced before the Western discovery of the islands.

Vegetation Types:

- SG - Scrub Grassland
- KHT - Koa-haole Thicket
- KF - Kiawe Forest
- C - Coastal
- SFS - Secondary Forest and Scrub
- NF - Native Forest
- R - Roadside

SPECIES CHECKLIST

| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPES SG | KHT | KF | C | SFS | MF | R |
|---|---|---|---|---|---|---|---|---|---|
| PTERIDOPHYTA | | | | | | | | | |
| Adiantaceae | | | | | | | | | |
| Doryopteris decora Brack. | Desert doryopteris, iwaiwa | E | x | x | | | | | |
| Davalliaceae | | | | | | | | | |
| Nephrolepis exaltata (L.) Schott | Boston fern | I | x | | | | x | x | |
| Polypodiaceae | | | | | | | | | |
| Microsorium scolopendrium (Burm.) Copel. | Laua'e | X | x | x | | | x | x | |
| MONOCOTYLEDONAE | | | | | | | | | |
| Amaryllidaceae | | | | | | | | | |
| Agave americana L. | Century plant | X | | x | | | | | |
| Commelinaceae | | | | | | | | | |
| Commelina diffusa Burm. f. | Honohono | X | | x | | | | | |
| Gramineae | | | | | | | | | |
| Andropogon virginicus L. | Broomsedge | X | x | | | | x | | x |
| Cynodon dactylon (L.) Pers. | Bermuda grass | X | | | | | | | x |
| Digitaria adscendens (HBK) Henr. | Henry's crabgrass | X | | | | | | | x |
| Eragrostis tenella (L.) Beauv. ex R. & S. | Japanese lovegrass | X | x | x | x | x | | | |
| Melinis minutiflora Beauv. | Molassesgrass | X | x | | | | x | | |
| Panicum maximum Jacq. | Guinea grass | X | | x | | | x | | |
| Pennisetum setaceum (Forsk.) Chiov. | Fountaingrass | X | x | | | x | | | |
| Rhynchelytrum repens (Willd.) C.E. Hubb. | Natal redtop | X | x | x | | | | | |
| Liliaceae | | | | | | | | | |
| Pleomele aurea (H. Mann) N.E. Br. | Halapepe | E | | x | | | | | |
| Palmae | | | | | | | | | |
| Cocos nucifera L. | Coconut | P | | | | x | | | |
| Pandanaceae | | | | | | | | | |
| Pandanus sp. | Hala | I? | | | | x | | | |
| DICOTYLEDONAE | | | | | | | | | |
| Amaranthaceae | | | | | | | | | |
| Amaranthus spinosus L. | Spiny amaranth | X | | | | | | | x |
| Nototrichium sandwicense (Gray in Mann) Hbd. | Kulu'ī | E | | x | | | | | |
| Anacardiaceae | | | | | | | | | |
| Schinus terebinthifolius Raddi | Christmas berry | X | x | x | | | x | x | |
| Apocynaceae | | | | | | | | | |
| Catharanthus roseus (L.) G. Don | Madagascar periwinkle | X | x | x | | x | | | |



| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPES SG | KHT | KF | C | SFS | MF | R |
|---|---|---|---|---|---|---|---|---|---|
| Araliaceae | | | | | | | | | |
| Reynoldsia sandwicensis Gray | 'Ohe'ohe makai | E | | | | | | x | |
| Asclepiadaceae | | | | | | | | | |
| Asclepias curassavica L. | Milkweed, butterfly weed | X | | | | | | | x |
| Gomphocarpus physocarpus E. Mey. | Large-fruited gomphocarpus | X | | | | x | | | x |
| Boraginaceae | | | | | | | | | |
| Cordia subcordata Lam. | Kou | P | | | | x | | | |
| Cactaceae | | | | | | | | | |
| Opuntia megacantha Salm-Dyck | Prickly pear | X | | x | | | | | |
| Capparidaceae | | | | | | | | | |
| Capparis sandwichiana var. zohari Deg. & Deg. | Maiapilo | E | x | | | | | | |
| Caricaceae | | | | | | | | | |
| Carica papaya L. | Papaya | X | | x | | | x | | |
| Chenopodiaceae | | | | | | | | | |
| Chenopodium album L. | Pigweed | X | | | | x | | | |
| Compositae | | | | | | | | | |
| Ageratum conyzoides L. | Ageratum | X | | | | | | | x |
| Bidens pilosa L. var. minor (Bl.) Sherff | | X | | | | | | | x |
| B. pilosa L. var. pilosa | Spanish needle | X | | | | | | | x |
| Erigeron bonariensis L. | Hairy horseweed | X | | | | | | | x |
| Parthenium hysterophorus L. | Santa Maria | X | | | | | | | x |
| Pluchea odorata (L.) Cass. | Pluchea | X | x | x | | | x | | |
| Sonchus oleraceus L. | Sow thistle | X | | | | | | | x |
| Convolvulaceae | | | | | | | | | |
| Ipomoea brasiliensis (L.) Sweet | Pohuehue | I | | | | x | | | |
| I. congesta R. Br. | Koali-'awahia | I | x | x | | | x | x | |
| Jacquemontia sandwicensis Gray | Pa'ū-o-hi'iaka | E | | | | x | | | |
| Crassulaceae | | | | | | | | | |
| Kalanchoe pinnata (Lam.) Pers. | Air plant | X | | x | | | | | |
| Cucurbitaceae | | | | | | | | | |
| Momordica charantia var. pavel Crantz | Balsam apple | X | x | x | x | x | x | | |
| Ebenaceae | | | | | | | | | |
| Diospyros ferrea var. pubescens (Skottsb.) Fosb. | Lama | E | x | x | | | x | x | |
| Euphorbiaceae | | | | | | | | | |
| Aleurites moluccana (L.) Willd. | Kukui | P | | x | | | x | | |
| Euphorbia hirta L. | Garden spurge | X | | | | | x | | x |
| Ricinus communis L. | Castor bean | X | | | | | | | x |
| Flacourtiaceae | | | | | | | | | |
| Xylosma hawaiiense var. hillebrandii (Wawra) Sleumer | Maua | E | x | | | | | x | |

| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPES SG | KHT | KF | C | SFS | MF | R |
|---|---|---|---|---|---|---|---|---|---|
| Goodeniaceae | | | | | | | | | |
| Scaevola taccada var. sericea (Vahl.) St. John | Naupaka-kahakai | I | | | | x | | | |
| Labiatae | | | | | | | | | |
| Hyptis pectinata (L.) Poit. | Comb hyptis | X | | | | | | | x |
| Ocimum gratissimum L. | | X | | | | x | | | |
| Plectranthus parviflorus Willd. | Spurflower | X | x | | | | | | |
| Salvia occidentalis Sw. | West Indian sage | X | x | x | | | | | x |
| Lauraceae | | | | | | | | | |
| Cassytha filiformis L. | Kauna'oa | I | | x | | | x | | |
| Leguminosae | | | | | | | | | |
| Acacia farnesiana (L.) Willd. | Klu | X | x | | | | | | |
| Canavalia hawaiiensis Deg. Deg. & Sauer | | E | | | | | | x | |
| Cassia bicapsularis L. | | X | x | x | x | x | x | | |
| C. leschenaultiana DC. | Partridge pea | X | | | | | | | x |
| Ceratonia siliqua L. | Carob | X | | x | | | | | |
| Crotalaria mucronata Desv. | | X | | | | | | | x |
| Desmodium canum (Gmel.) Schinz & Thell. | Spanish clover | X | | | | | | | x |
| D. intortum var. pilosiuschulum (DC.) Fosb. | | X | | | | | | | x |
| Erythrina sandwicensis Deg. | Wiliwili | E | x | x | | | | | |
| Indigofera suffruticosa Mill. | Indigo | X | x | x | x | | | | |
| Leucaena leucocephala (Lam.) de Wit | Koa-haole | X | | x | x | x | x | x | |
| Prosopis pallida (Humb. & Bonpl. ex Willd.) HBK. | Kiawe | X | x | x | x | x | | | |
| Loranthaceae | | | | | | | | | |
| Korthalsella cylindrica (v. Tiegh.) Engler | | E | | | | | | x | |
| Malvaceae | | | | | | | | | |
| Malvastrum coromandelianum (L.) Garcke | False mallow | X | | | | x | | | x |
| Sida fallax Walp. | Ilima | I | x | x | | | x | | |
| S. spinosa L. | Prickly sida | X | | | | | | | x |
| Menispermaceae | | | | | | | | | |
| Cocculus ferrandianus Gaud. | Huehue | E | x | | | | x | x | |
| Myoporaceae | | | | | | | | | |
| Myoporum sandwicense ssp. St. Johnii Webster | Naio | E | x | | | x | | | |
| Myrtaceae | | | | | | | | | |
| Metrosideros collina ssp. polymorpha (Gaud.) Rock | 'Ōhi'a-lehua | E | | | | | | x | |
| Psidium cattleianum Sabine | Strawberry guava | X | | | | | x | | |
| P. guajava L. | Guava | X | | x | | | x | x | |
| Nyctaginaceae | | | | | | | | | |
| Boerhavia diffusa L. | Alena | I | | | | x | | | |



| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPE SG | KHT | KF | C | SFS | MF | R |
|---|---|---|---|---|---|---|---|---|---|
| Oxalidaceae | | | | | | | | | |
| Oxalis corniculata L. | Yellow wood sorrel | X | | | | | | | x |
| Papaveraceae | | | | | | | | | |
| Argemone glauca Pope | Pua-kala | E | x | x | | | | | |
| Passifloraceae | | | | | | | | | |
| Passiflora foetida L. | Scarlet-fruited passionflower | X | x | | | | x | | |
| P. suberosa L. | Huehue-haole | X | | x | | | x | | |
| Piperaceae | | | | | | | | | |
| Peperomia leptostachya H. & A. | | I | x | x | | | x | | x |
| Portulacaceae | | | | | | | | | |
| Portulaca cyanosperma Egler | 'Ihi | E | x | x | | | | | |
| Rhamnaceae | | | | | | | | | |
| Colubrina oppositifolia Brongn. ex Mann | Kauila | E | | x | | | | | |
| Rosaceae | | | | | | | | | |
| Osteomeles anthyllidifolia Lindl. | 'Ūlei | E | x | x | | | x | x | |
| Rubiaceae | | | | | | | | | |
| Canthium odoratum (Forst. f.) Seem. | Alahe'e | I | x | x | | | x | x | |
| Morinda citrifolia L. | Noni | P | x | | | x | | | |
| Santalaceae | | | | | | | | | |
| Santalum paniculatum H. & A. var. paniculatum | Sandalwood | E | x | x | | | | | |
| Sapindaceae | | | | | | | | | |
| Cardiospermum halicacabum | Balloon vine | X | | | | x | | | x |
| Dodonaea eriocarpa var. hosakana Sherff | A'ali'i | E | x | x | | | x | | |
| Scrophulariaceae | | | | | | | | | |
| Verbascum thapsus L. | Common mullein | X | | | | | | | x |
| Solanaceae | | | | | | | | | |
| Capsicum annuum L. | Red pepper | X | | x | | | | | |
| Lycopersicon pimpinellifolium Mill. | Currant tomato | X | | x | | x | | | |
| Solanum sodomeum L. | Apple of Sodom | X | | x | | | | | |
| Sterculiaceae | | | | | | | | | |
| Waltheria americana L. | 'Uhaloa | I | x | x | x | x | | | |
| Urticaceae | | | | | | | | | |
| Pipturus hawaiensis Levl. | | E | | x | | | | | |
| Verbenaceae | | | | | | | | | |
| Lantana camara L. | Lantana | X | x | x | x | x | x | x | |
| Stachytarpheta cayennensis (L.C. Rich.) Vahl | Cayenne vervain | X | | | | | | | x |

MAUKA BOUNDARY, FARMS OF KAPUA
BOTANICAL SURVEY
Kenneth M. Nagata

## OBJECTIVES

The objectives of the survey were to determine the extent of the native dry forest at the mauka (east) boundary of the project site, to ascertain the integrity of that forest and seek out any rare and endangered species in that section of the site. The mauka boundary extends from a 700 foot elevation in the north, diagonally to an 850 foot elevation approximately half-way through the site where it angles sharply to approximately 950 feet. The boundary then follows a nearly straight line to the southern boundary at approximately a 1000 foot elevation.

## SURVEY AREA

Only the vegetation just within the mauka boundary of the project site was surveyed. Areas of exotic vegetation were spot-surveyed, the contiguous native forest was surveyed in detail and larger pockets of native vegetation makai of the forest were surveyed down to approximately an 800 foot elevation. As the native forest only occurred in the sourthern section of the boundary line, only this section was surveyed in detail. The area of detailed survey is probably 300-400 acres. This study does not preclude the existence of rare and endangered species makai of the intensive survey area. However, the previous survey and examination of infrared aerial photographs indicate that the presence of such species, makai of this survey area, is highly unlikely.

## METHODS

As a result of the reconnaissance conducted early in 1983 and through the aid of excellent infrared aerial photographs, the native dry forest was plotted on a black and white aerial photograph at the



scale of 1:24,000. In areas devoid of native forest only spot surveys were made. All large groves of native vegetation below the contiguous forest were investigated. In the native forest, north-south transects were established approximately 50 meters apart. All significant ravines were surveyed. Field glasses and an altimeter proved to be invaluable aids during the survey.

## RESULTS AND DISCUSSION

For convenience the mauka boundary was divided into north and south sections. The north section is that region north of the sharp diagonal between 850 and 950 foot elevations. South of this was regarded as the southern section. There was virtually no native forest in the northern section which was not dominated by grazed koa haole (Leucaena leucocephala) thickets and lantana (Lantana camara) scrub. Several common native species were scattered in small to moderate numbers in this area; 'ala'ala-wai-nui (Peperomia leptostachya), 'ihi (Portulaca cyanosperma), 'ilima (Sida fallax) and 'uhaloa (Waltheria americana) were the most common. Two pockets of remnant native vegetation were surveyed. These consisted of clusters of lama (Diospyros ferrea var. pubescens) and alahe'e (Canthium odoratum) trees, but the shrub layer was completely dominated by koa haole and lantana.

Lama-alahe'e native forests were found in three sections in the southern portion above the 900 foot elevation. Except for the more recent a'a flows there can be no doubt that the native forest once dominated the entire landscape. However, extensive areas have been grubbed, cattle were allowed to graze freely and secondary species such as Christmas berry (Schinus terebinthifolius), guinea grass (Panicum maximum) and lantana have since become established throughout the region. Even in the native forest, these exotic species have become so entrenched that no portion of the remaining

native dry forest in the project site can be considered pristine. Intrusion by exotic species can generally be described as severe. The canopy cover of lama and alahe'e was generally less than 60% but even when it approached 90%, the understory was completely dominated by either Christmas berry, lantana or guinea grass or a combination of these species. Very few other native species were found in the native forest; these included: naio (Myoporum sandwicense subsp. St.-Johnii), huehue (Cocculus ferrandianus), 'ūlei (Osteomeles anthyllidifolia), 'ohe (Reynoldsia sandwicensis), māmane (Sophora chrysophylla var. ovata), and Pittosporum monae. In addition, several individuals of an 'ākia (Wikstroemia sp.) and two halapepe (Pleomele sp.). These, however, were sterile and proper identification was not possible. Abundant in all vegetation types was the aggressive, indigenous parasite, kauna'oa-pehu (Cassytha filiformis).

Below the 900 foot elevation, the character of the native vegetation was one of scattered trees and small pockets of lama and alahe'e amid expanses of secondary scrub consisting mostly of lantana, Christmas berry and guinea grass, and dense thickets of lantana and Christmas berry. Several 'iliahi (Santalum paniculatum) trees were found in this zone. In terms of incursion by exotic species, the condition of these native pockets was poor. A significant pocket, however, was found on an old a'a flow adjacent to the Kaulanamana flow at approximately a 900 foot elevation. It consists of widely scattered clusters of lama and alahe'e trees and several 'ohe, mamane, and naio. In addition, a single kauila (Colubrina oppositifolia) and two Bobea timonioides were found. Native species accounted for probably less than 30% of the total vegetational cover, with kaua'oa-pehu accounting for much of it.

In summary, very little of the native dry forest actually extends into the project site. The condition of this portion of the forest is regarded as poor; it simply is not the same rich forest of which



Joseph Rock wrote in 1913. One cannot judge the entire forest in the region by this small portion, however. This makai portion of the forest has been subject to extensive disturbence. In portions mauka of the boundary which have been relatively free of such activities the forest may be relatively intact.

## RARE AND ENDANGERED SPECIES

A single kauila tree was discovered between the 900 and 960 foot elevations on an old a'a flow dominated by Christmas berry, lantana, guava (Psidium guajava) and kauna'oa-pehu near the Kaulanamana flow. It is approximately 30 feet in height and is festooned with the parasitic kauna-oa-pehu. It is possible that the parasite may eventually cause the decline of this tree. Although mamane, 'ohe, 'ulei, and naio as well as lama and alahe'e also inhabit the area, the vegetational cover afforded by these scattered native trees is almost negligible. Small clusters of native trees occur in this region but the understory is completely exotic. Kauila was considered "Endangered" in the report on rare and endangered species by the Smithsonian Institution (1974). Fosberg and Herbst (1975) in their assessment of the rare Hawaiian species, considered it "Very Rare", "total population low" and "Endangered, in considerable danger of disappearance". In 1976 it was proposed by the U.S. Fish and Wildlife Service as a candidate for official listing as an Endangered Species pursuant to the Endangered Species Act of 1973 (Anon. 1976). It was re-listed by USFWS in 1980 (Anon. 1980) as a taxon for which the service has sufficient information on hand to support its being listed as Endangered or Threatened (Category 1).

In the same a'a flow at approximately an 800 foot elevation, two trees of Bobea timonioides were also discovered approximately 300 feet apart. The trees were 20-25 in height and free of kauna'oa-pehu. Bobea timonioides was considered "Endangered" and its distribution "very local, found only or principally in one or

more restricted areas" by Fosberg and Herbst. The Smithsonian report listed it as "Endangered" and in 1976 it was prosposed for endangered status by USFWS. In 1980 it was re-listed by the agency in their high priority Category 1.

Two individuals of halapepe (Pleomele sp.) were discovered in the project site. Both specimens as well as the specimen near the north boundary which was discovered in the earlier reconnaissance were sterile. Thus, although all three are of the same taxon, positive identification is yet unavailable. The northern specimen is in a gulch well outside the present project site and is thus excluded from the present discussion. One healthy specimen 15 feet tall was observed in a deep, steep-sided collapsed lava tube approximately 2000 feet north of the Kaulanamana flow at approximately 960 feet elevation. Several Pipturus sp. trees and Dioscorea cf. bulbifera also occur in the pit. The second halapepe is a poor, declining specimen eight feet tall just at the boundary line half-way down the southern section. It is situated in the lama-alahe'e forest with a dense understory of lantana and Christmas berry. It is possible that these are Pleomele hawaiiensis, a species that was listed by the Smithsonian report as "Endangered" and by Fosberg and Herbst as "Depleted, much less common over all or most of its range than formerly, the depletion directly or indirectly the result of human activities". It was proposed for endangered status by the USFWS in 1976 and in its re-evaluation in 1980 it was placed in Category 1.

## RECOMMENDATIONS

If the Pleomele proves to be the rare P. hawaiiensis, the steep, collapsed lava tube and the healthy specimen within should be preserved. The second specimen and the forest in which it inhabits are in such poor condition that in situ preservation is probably unfeasible. Attempts should be made to vegetatively propagate it and subsequent re-establishment in a designated preserve is recommended.



Ideally, preservation of an ecosystem is more desirable than fencing off individual trees. The a'a flow which serves as the habitat for the kauila and the Bobea is conveniently situated adjacent to the Kaulanamana flow on the southern boundary of the project site. Preservation of all or most of that habitat might have been feasible and justified if the vegetation was indicative of a pristine condition. In reality, the ecosystem is severely disturbed and native species account for an extremely small proportion of the total vegetation cover. It is therefor recommended that approximately 20 acres of that habitat including the kauila and Bobea trees be set aside and managed as a preserve. It is further recommended that some management program be established to prevent the further decline of the kauila and of the preserved ecosystem.

## LITERATURE CITED


Anon. 1974. Report on Endangered and Threatened Plant Species of the United States. Smithsonian Institution. 200pp.

Anon. 1976. Endangered and Threatened Species: Plants. Federal Register. 41(117): 24524-24572.

Anon. 1980. Endangered and Threatened Wildlife and Plants: Review of Plant Taxa for Listing as Endangered or Threatened Species. Federal Register. 45(242): 82480-82569.

Fosberg, F.R. & D. Herbst. 1975. Rare and Endangered Species of Hawaiian Vascular Plants. Allertonia. 1(1): 1-72.

St. John, H. 1973. List and Summary of the Flowering Plants in the Hawaiian Islands. Pacific Tropical Botanical Garden. Memoir No. 1. 519 pp.

Wagner, W. Unpublished Checklist of Pteridophyta.




## SPECIES CHECKLIST

Families are arranged alphabetically in three groups - Pteridophyta, Monocotyledonae, and Dicotyledonae. Genera and species are arranged alphabetically within each family. Taxonomy of the pteridophytes follow that of Wagner's unpublished list. The common names for the ferns are the commonly-accepted ones. Taxonomy, common names and the status of the Angiosperms follow that of St. John (1973).

### EXPLANATION OF SYMBOLS

Species Status:

- E - Endemic to the Hawaiian Islands, ie. occuring naturally nowhere else in the world.
- I - Indigenous, ie. native to the Hawaiian Islands but also occuring naturally elsewhere.

Vegetation Types:

- KHT - Koa-haole Thicket
- SFS - Secondary Forest and Scrub
- NF - Native Forest
- BLO - Barren Lava with scattered Ohia

Abundance Rating:

- A - Abundant, generally the major or dominant element in an area.
- C - Common, generally distributed throughout a given area in large numbers.
- O - Occasional, generally distributed throughout a given area in small numbers.
- U - Uncommon, observed uncommonly but more than 10 times in a given area.
- R - Rare, observed 2-10 times in a given area.

CHECKLIST OF NATIVE SPECIES ALONG MAUKA BOUNDARY

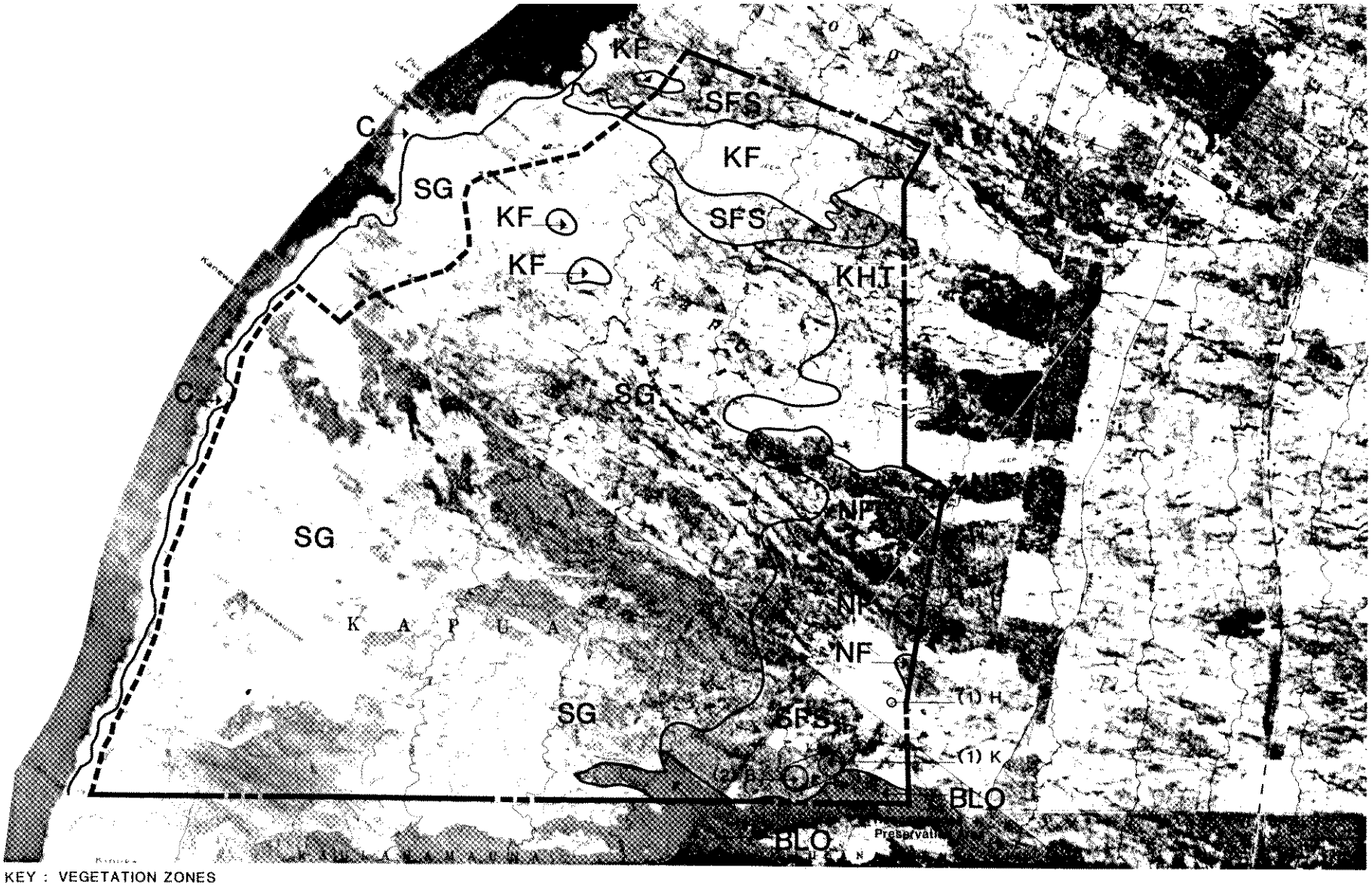
| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPES KHT | SFS | NF | BLO |
|---|---|---|---|---|---|---|
| PTERIDOPHYTA | | | | | | |
| Adiantaceae | | | | | | |
| Doryopteris decora Brack. | Desert doryopteris, iwa iwa | E | R | O | | |
| Davalliaceae | | | | | | |
| Nephrolepis exaltata (L.) Schott | Boston fern | I | R | U | U | U |
| MONOCOTYLEDONAE | | | | | | |
| Liliaceae | | | | | | |
| Pleomele sp. | Halapepe | E | | R | R | |
| DICOTYLEDONAE | | | | | | |
| Amaranthaceae | | | | | | |
| Nototrichium sandwicense (Gray in Mann) Hbd. var. sandwicense | Kulu'i | E | | R | | |
| Araliaceae | | | | | | |
| Reynoldsia sandwicensis Gray | 'Ohe | E | R | O | R | |
| Convolvulaceae | | | | | | |
| Ipomoea congesta R. Br. | Koali-'awania | I | O | O | R | |
| Ebenaceae | | | | | | |
| Diospyros ferrea var. pubescens (Skottsb.) Fosb. | Lama | E | U | O | A | |
| Lauraceae | | | | | | |
| Cassytha filiformis L. | Kauna'oa-pehu | I | U | A | A | |

CHECKLIST OF NATIVE SPECIES ALONG MAUKA BOUNDARY

| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPES KHT | SFS | NF | BLO |
|---|---|---|---|---|---|---|
| DICOTYLEDONAE (cont.) | | | | | | |
| Leguminosae | | | | | | |
| Erythrina sandwicensis Deg. | Wiliwili | E | U | | | |
| Sophora chrysophylla var. ovata Chock | Māmane | E | | O | U | |
| Malvaceae | | | | | | |
| Sida fallax Walp. | 'Ilima | I | C | O | U | |
| Menispermaceae | | | | | | |
| Cocculus ferrandianus Gaud. | Huehue | E | O | O | O | |
| Myoporaceae | | | | | | |
| Myoporum sandwicense subsp. St. Johnii Webster | Naio | E | U | O | O | |
| Myrtaceae | | | | | | |
| Metrosideros collina subsp. polymorpha (Gaud.) Rock | 'Ōhi'a-lehua | E | U | U | | U |
| Piperaceae | | | | | | |
| Peperomia leptostachya H. & A. | Ala'ala-wai-nui | I | O | U | U | |
| Pittosporaceae | | | | | | |
| Pittosporum monae Rock ex St. John | ** | E | | | R | |
| Plumbaginaceae | | | | | | |
| Plumbago zeylanica L. | 'Ilie'e | I | R | | | |
| Portulacaceae | | | | | | |
| Portulaca cyanosperma Egler | 'Ihi | E | C | O | R | |
| Rhamnaceae | | | | | | |
| Colubrina oppositifolia Brongn. ex Mann | Kauila | E | | R | | |

CHECKLIST OF NATIVE SPECIES ALONG MAUKA BOUNDARY

| SCIENTIFIC NAME | COMMON NAME | STATUS | VEGETATION TYPES KHT | SFS | NF | BLO |
|---|---|---|---|---|---|---|
| DICOTYLEDONAE (cont.) | | | | | | |
| Rosaceae | | | | | | |
| Osteomeles anthyllidifolia Lindl. | 'Ūlei | E | U | O | O | |
| Rubiaceae | | | | | | |
| Bobea timonioides (Hook. f.) Hbd. | ** | E | | R | | |
| Canthium odoratum (Forst. f.) Seem. | Alahe'e | I | U | C | A | |
| Santalaceae | | | | | | |
| Santalum paniculatum H. & A. | 'Iliahi | E | R | O | | |
| Sapindaceae | | | | | | |
| Dodonaea eriocarpa var. hosakana Sherff | A'ali'i | E | R | O | | |
| Sterculiaceae | | | | | | |
| Waltheria americana L. | 'Uhaloa | I | C | O | | |
| Thymeliaceae | | | | | | |
| Wikstroemia sp. | 'Ākia | E | | | R | |
| Urticaceae | | | | | | |
| Pipturus sp. | ** | E | | R | | |




KEY : VEGETATION ZONES

| | |
|---|---|
| SG | Scrub Grasslands |
| KHT | Koa Haole Thicket |
| KF | Klawe Forest |
| C | Coastal |
| SFS | Secondary Forest and Scrub |
| NF | Native Forest |
| BLO | Barren Lava with Scattered Ohia |

Rare and Endangered Specimens

| | |
|---|---|
| H | Halapepe |
| K | Kauila |
| B | Bobea |

NORTH

- Vegetation Map
- Site Plan

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APPENDIX C

# FARMS OF KAPUA
# SOUTH KONA, HAWAII
# BIRD AND MAMMAL REPORT
# (1984)

By
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Biologist

FARMS OF KAPUA
SOUTH KONA, HAWAII
BIRD AND MAMMAL REPORT

By Andrew J. Berger

This report was prepared for Farms of Kapua in accordance with instructions received from Group 70. My field investigation of the Kapua site was conducted on December 27 and 28, 1983.

After studying this generally unsuitable habitat for wildlife, I decided to entitle this a Bird and Mammal Report. This decision was based on the fact that there are no endemic amphibians or land reptiles in the Hawaiian Islands. All, therefore, have been introduced by man. None are of any significance for an environmental impact study. In fact, the bullfrog (Rana catesbeiana), introduced from North America as early as 1867, is a serious predator on the newly hatched ducklings of the endangered Hawaiian Duck or Koloa (Anas wyvilliana). Nine species of geckos (family Gekkonidae) and skinks (family Scincidae) occur on Hawaii; all are insect eaters (McKeown, 1978). They are irrelevant to an environmental impact statement, in part, because they adapt well to urban and rural areas, and because all are introduced species.

## The Habitat

Rarely during my field work in the Hawaiian Islands during the past 19 years have I seen such a poor habitat for birds and mammals as in the Kapua Farms petition area. In addition to the extensive areas that are covered by virtually barren lava, the vast majority of the plants are introduced species, as documented in the Botanical Report by Mr. Kenneth Nagata. The section that had previously been planted to koa-hoale (Leucaena leucocephala) and that then served as pasture land for cattle was heavily grazed. I saw a dozen cattle during my studies.

## The Birds

There are three different groups of birds in the Hawaiian Islands: introduced, indigenous or native, and endemic.

I. Introduced Birds
More than 170 species of exotic birds have been introduced to the Hawaiian Islands by man since 1796 (Berger, 1981). I identified the following on and adjacent to the project site.

A. Order Galliformes
a. Family Phasianidae, Pheasants, Quails, Francolins.
1. The Indian Black Francolin, Francolinus f. asiae. The Black Francolin is native to northern India and Nepal, where the bird is called the Black Partridge. The State Division of Fish and Game imported about 750 Black Francolin from India during the period from 1959 to 1962; these birds were released on Kauai, Molokai, Maui, and Hawaii. An additional 116 birds from mainland game farms were imported by the owners of the Puuwaawaa Ranch on Hawaii and released there between 1959 and 1962; these birds apparently did not establish a breeding colony (Lewin, 1971). The Black Francolin, however, is now well established on the Big Island, and during past work on the island, I have seen it from near sea level to an elevation of approximately 5,700 feet. I did not see any Black Francolin during my two days of field work, but they have been sited near the upper water trough, elevation about 1,280 feet.

B. Order Columbiformes
a. Family Columbidae, Pigeons and Doves
2. Lace-necked or Spotted Dove, Streptopelia chinesis. This Asian dove was introduced to the Hawaiian Islands at an early date; the exact date apparently is unknown, but the birds are said to have been very common on Oahu by 1879 (Caum, 1933). The species is now common to abundant on all of the main islands and, like the other doves in Hawaii, is classified as a game bird. This dove occurs where rainfall exceeds 100 inches per year, but the highest densities are found in drier areas where such introduced plants as koa-haole and kiawe (Prosopis pallida) are dominant plants. Schwartz and Schwartz (1949), for example, found densities as great as 200 birds per square mile on Molokai.

The Spotted Dove is common in residential areas, in kiawe thickets, and in pasture and agricultural lands. I saw these doves from sea level to the upper boundary of the project site.

3. Barred Dove or Zebra Dove, Geopelia striata. This small dove is said to have been introduced to Hawaii sometime after 1922 (Bryan, 1958). It has been a remarkably successful introduction and

it is now abundant on all of the main islands. Schwartz and Schwartz (1949) estimated densities as great as 400 to 800 birds per square mile in some areas on Oahu and Molokai. One study of the food habits of this dove in Hawaii revealed that the diet consists of 97 percent seeds and other plant materials; the 3 percent animal matter included several species of beetles, weevils, and wireworm larvae. The doves contract intestinal roundworks and tapeworms from the insects in their diet and Kocan and Banko (1974) reported on Barred Doves on Hawaii that were infected with trichomonas; this parasite has "catastropic" effects on doves in North America.

This is one of the most common birds in the project area, and I found them in the kiawe groves at sea level and at higher elevations.

C. Order Passeriformes

a. Family Alaudidae, Larks

4. Skylark, Alauda arvensis

The first Skylarks were brought to Hawaii from England in 1865. Henshaw (1904) wrote that the introduction of the Skylark to Oahu had been "a great success," and that some birds had been released on the windward side of Hawaii, "but their fate is at present unknown." The Skylark is now rare on Oahu but is an abundant species on Hawaii, being found from near sea level (e.g., at South Point) to above tree line, especially on Mauna Kea. I saw three Skylarks along the jeep road in the grasslands at lower elevations.

b. Family Zosteropidae, White-eyes and Silver-eyes

5. Japanese White-eye, Zosterops j. japonicus. This race of the white-eye is native to the main islands of Japan from Honshu to Kyushu and the islands lying between Japan and Korea. The first Japanese White-eyes (Mejiro) were released on Oahu by the Territorial Board of Agriculture and Forestry in 1929 (Caum, 1933). At least 252 White-eyes were released on the island of Hawaii during June 1937 (Berger, 1975b).

The White-eye presents an example par excellence of the success of introduced birds. It now occurs on all of the main islands, is found from sea level to tree line on Maui and



Hawaii, and inhabits very dry areas (e.g., Kawaihae) and those having 300 or more inches or rainfall per year. There is virtually no habitat in Hawaii that is not occupied by the Japanese White-eye; I believe it to be the most abundant song bird in the Hawaiian Islands.

White-eyes eat insects, nectar, soft fruits, the pulp of berries, and buds, so that they can be a serious threat to farmers. The California State Department of Agriculture is greatly concerned about the accidental release of a related species (Bray-backed White-eye, Z. palpebrosa) at San Diego. Two pairs escaped in 1973 or 1974; 150 offspring have been captured since then. "Estimates of the potential loss in soft-fruit crops, should white-eyes even begin to multiply rapidly and establish large populations, run as high as $2 million a year" (Audobon Magazine, September 1982).

I found White-eyes at all elevations in the project area, from the kiawe thickets at sea level to the uppermost region of the area.

c. Family Sturnidae, Starlings and Mynas

6. Common Indian Myna, Acridotheres tristis.

This myna is native to Sri Lanka, India, West Pakistan, Nepal, and adjacent regions. The Myna was introduced from India "in 1865 by Dr. William Hillebrand to combat the plague of army worms that was ravaging the pasture lands of the islands. It has spread and multiplied to an amazing extent; reported to be abundant in Honolulu in 1879, it is now extremely common throughout the territory" (Caum, 1933). The Myna is common to abundant in lowland areas of the inhabited islands, being most common in residential areas and in the vicinity of houses and barns in rural areas. I have seen Mynas sitting on the backs of cattle at South Point as well as at elevations of 7,500 feet on Mauna Kea. However, I found them only in the kiawe thickets at sea level in the project area.

d. Family Ploceidae, Weaverbirds and their Allies

7. Warbling Silverbill, Lonchura malabarica cantans

This Silverbill is native to Africa, being found from Senegal to western and southern Sudan (Traylor, 1968). The Silverbills have been characterized as being "pre-eminently desert birds."

There are no published records of the Warbling Silverbill as having been released in the Hawaiian Islands (Bryan, 1958; Berger, 1981). It is assumed that cage birds were released, on the Puuwaawaa Ranch, probably during the 1960s. I first discovered this silverbill near Kawaihae on March 22, 1972 (Berger, 1975a). Later observations have revealed that large populations have become established on the leeward slopes of the Kohala Mountain, Mauna Kea (including Pohakuloa), and Hualalai. Silverbills are seed eaters and, with the other seed eaters in Hawaii, will make the harvesting of small grain crops virtually impossible on the island of Hawaii (see Spotted Munia and House Finch). I saw one small flock.

8. Spotted Munia or Ricebird, Lonchura punctulata
This Asian species was brought to Hawaii by Dr. William Hillebrand about 1865 (Caum, 1933). Caum wrote that the Ricebird "feeds on the seeds of weeds and grasses and does considerable damage to green rice." Rice is no longer grown in Hawaii, but the Ricebird has recently become a serious pest by eating the seeds of sorghum. The Ricebird is another abundant species on all of the islands, and it is tolerant of both very dry and very wet habitats. The birds tend to be nomadic during the nonbreeding season, moving over large areas in search of seeds. The birds are prolific, nesting in every month of the year. I saw several small flocks of Ricebirds flying over the project site.

e. Family Fringillidae, American Sparrows and Buntings.

9. Cardinal, Cardinalis cardinalis
The Cardinal also is called the Kentucky Cardinal, Virginia Cardinal, and Red Cardinal. Cardinals were released several times on Kauai, Oahu, and Hawaii between 1929 and 1931. On Hawaii it occurs from sea level to at least 7,500 feet on Mauna Kea. It inhabits very dry areas and those with a high annual rainfall. It is a common species in the project site at higher elevations and I found Cardinals in both of the kiawe thickets at sea level.

10. House Finch, Carpodacus mexicanus frontalis
This seed-eating finch is native to western North America. Birds were first brought to Hawaii



"prior to 1870" (Caum, 1933). It is now an abundant species on all of the islands, in residential and rural areas, and in the high ranch and open forest lands on Maui and Hawaii.

Because of their fondness for papaya, the bird is called the Papayabird in Hawaii. Despite this liking for soft fruits, however, House Finches are primarily seed eaters, frequently also eating flower buds. When experimental crops of sorghum were planted in former sugarcane land at Kohala in 1972, Spotted Munias and House Finches destroyed 50 tons of grain from a plot that was expected to produce 60 tons. I saw several flocks of House Finches at elevations above 650 feet.

II. Indigenous or Native Birds
These are birds whose total range in the Pacific Basin includes Hawaii; these are the seabirds and the migratory shorebirds and ducks that spend only their nonbreeding season in the islands.

A. Order Charadriiformes

a. Family Scolopacidae, Sandpipers, Curlews, and Snipe

1. Wandering Tattler, Heteroscelus incanus
This shorebird nests in Alaska and northwestern British Columbia. This species is a regular winter resident in the Hawaiian Islands. The birds usually are seen along beaches and reef flats, and I saw one bird along the beach at the sand dune area.

b. Family Charadriidae, Plovers

2. Pacific Golden Plover, Pluvialis dominica fulva
This subspecies nests in Siberia and in arctic America. It, too, is a very common winter resident, being found from sea level to at least 10,000 feet elevation on the island of Hawaii. During their winter stay in Hawaii, these plovers inhabit lawns in residential areas, golf courses, pastures, shorelines, and open mountain areas. I saw one plover along the shore and several others along the jeep road at high elevations.

III. Endemic Birds
These are birds that are unique to Hawaii. They are not found in any other part of the world. Of these unique Hawaiian birds, more than 85 percent are extinct or

threatened with extinction, or are endangered. One entire family of birds is endemic to the Hawaiian Islands, the Hawaiian Honeycreepers (Family Drepanididae). There is no habitat suitable for the honeycreepers within, or anywhere near, the project site. I saw two species of endemic birds during the two days of my field study.

A. Order Falconiformes

a. Family Accipitridae, Hawks

1. Hawaiian Hawk or Io, Buteo solitarius

The Io occurs on the slopes of Mauna Loa, on both the windward and Kona coasts, and less commonly on Mauna Kea. It is now classified as an endangered species, although recent studies suggest that there is a good population on Hawaii. I did not see a hawk on or over the project site, but on December 27, I saw one bird soaring high in the air at approximately the elevation of the main highway, that is, more than a mile above the upper boundary of the project area.

b. Family Strigidae, Typical Owls

2. Hawaiian Short-eared Owl or Pueo, Asio flammeus sandwichensis

The Pueo is a permanent resident on all of the main islands in the chain. The birds are found from sea level to at least 8,000 feet on Mauna Kea, and the birds are tolerant of wide climatic conditions. The Pueo is not classified as an endangered species by the Federal Fish and Wildlife Service but has recently been so classified by the State Division of Forestry and Wildlife. The Pueo differs from most other owls in that it is diurnal as well as nocturnal in habits; hence, they are seen much more often that is the introduced, nocturnal Barn Owl. I saw one Pueo at an elevation of 1,100 feet on December 28.

## The Mammals

I. Endemic Mammals

The only endemic Hawaiian land mammal is the Hawaiian bat (Lasiurus cinereus semotus), a subspecies of the American hoary bat. The Hawaiian bat is found primarily on the island of Hawaii, where it has been seen from sea level to 13,200 feet (Tomich, 1969; Kramer, 1971). It occurs in Hilo, I have seen it along the Stainback Highway, and it is especially common in Kona, south to South Point.



Bats are primarily nocturnal in habits, emerging from their daytime roosts at dusk. I did not extend my field studies to dusk because I felt confident that if bats roost on the project site they do so either in lava tubes or in caves. Most of these sites already have been identified and mapped by Dr. Rosendahl in his "Archaeological Reconnaissance Survey, Farms of Kapua, March 1983"; for example, Site nos. 10-71-2162, 3705, and 3706, which are lava tube complexes or lava tube cave shelters. Any or all of these sites that are deemed of significance archeologically would be preserved and protected during the preparation of the area for farming or ranching. If these actual or potential bat roosting caves or tubes are left intact, none of the proposed uses (i.e., macadamia orchard, pasture, koa haole plantation; aquaculture) of the land would have any significant impact on the bat pouplation.

II. Introduced Mammals

All of these introduced species have proven highly detrimental to man, his buildings, products, agricultural products and/or to the native forests and their birdlife. None, therefore, are of concern as far as detrimental effects resulting from the proposed use of the land by Farms of Kapua.

Some of these mammals were first brought to the Hawaiian Islands by Captains Cook and Vancouver. Feral cattle, goats (Capra hircus), sheep (Ovis aries), and pigs (Sus scrofa) have been destroying the Hawaiian endemic forests since 1800, and they continue to cause damage to this day. Inasmuch as the proposed project site already is a real wasteland, composed predominantly of lava flows and introduced plants, the effects caused by any goats that may move into the area now undoubtedly would be insignificant. Their entry into the area after development begins would have to be controlled.

With the possible exception of the house mouse (Mus musculus), all of the smaller introduced mammals prey on birds and their eggs. These small mammals include the roof or black rat (Rattus rattus), Polynesian rat (Rattus exulans), Norway rat (Rattus norvegicus), small Indian mongoose (Herpestes auropunctatus), feral cat (Felis catus), and feral dog (Canis familiaris). I saw several mongooses. I did not attempt to trap the nocturnal rodents because their presence is irrelevant to an environmental impact statement for this project because all are introduced mammals and because all are pestiferous animals.

## Summary and Conclusions

1. Because there are no endemic amphibians or land reptiles in the Hawaiian Islands, those that are present in the project area are introduced species. All are insignificant with respect to an environmental impact assessment.

2. The Hawaiian bat is an endangered endemic species of mammal. As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macdamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight.

3. All of the remaining mammals found on the site are introduced species, and all are serious pests to man, his activities and products, and/or to native vegetation and fauna. The species of rats prey on ground nesting and even tree nesting birds, and the rats and the mouse cause great damage to agriculture as well as to homes and industrial plants. The mongoose also is a predator on birds, both introduced and endemic. The feral goats cause great destruction to vegetation, both introduced and native. If it were possible to eliminate all of these introduced and destructive mammals it would be a great boon for the islands. Their presence, therefore, is irrelevant to an environmental impact assessment.

4. The two species of endangered Hawaiian birds (the hawk and the owl) seen on or adjacent to the project site have adapted to the introduced vegetation on the island of Hawaii, primarily because of their feeding habits and the extent of their home range. The owl apparently eats mostly rodents; the hawk catches rodents, small birds, and insects. Although no intensive field studies of the hawk and owl have yet been published, it is probable that the hawk ranges over several square miles in its search for food; the owl's home range presumably is somewhat smaller. In both cases, however, the proposed activities in the project area certainly would have no adverse effects on these Hawaiian birds, that already inhabit ranch land and orchards at higher elevations on the Kona coast.

5. In his letter to Kent Keith, Susumu Ono, Chairman of the Department of Land and Natural Resources (September 21, 1983) wrote: "We also suggest that the proposed aquaculture development will concentrate shorebird populations. Problems may be anticipated with herons in particular." I doubt that this will prove to be a serious problem, in part, because personnel of the State Division of Forestry and Wildlife counted only nine Black-crowned Night Herons



on the entire island of Hawaii during their semiannual waterbird count held on July 27, 1983. I doubt that there will be a concentration of migratory shorebirds at the aquaculture facilities, largely because of their feeding and foraging habits.

6. In summary, I can see absolutely no biological reason for not changing the classification of the land from conservation to agriculture.

## Literature Cited


Berger, A.J. 1975a. The Warbling Silverbill, a new nesting bird in Hawaii. Pacific Science, 29:51-54.

---------- 1975b. The 1929 and 1936 "Buy-A-Bird" campaigns on Hawaii. Elepaio, 36:40-44.

---------- 1981. Hawaiian Birdlife, 2nd edition. University of Hawaii Press, Honolulu, 260 pp.

Bryan, H.J., Jr. 1958. Check Life and Summary of Hawaiian Birds. Books About Hawaii, Honolulu.

Caum, E.L. 1933. The exotic birds of Hawaii. Occ. Papers Bernice P. Bishop Museum, 10:1-55.

Henshaw, H.W. 1904. Complete list of the birds of the Hawaiian Possessions, with notes on their habits. Thrum's Hawaiian Almanac and Annual, 1904:113-145.

Kocan, R.M., and W. Banko. 1974. Trichomoniasis in the Hawaiian Barred Dove. Jour. Wildlife Diseases, 10:359-360.

Kramer, R.J. 1971. Hawaiian Land Mammals. Charles E. Tuttle, Co., Rutland, Vermont.

Lewin, Victor. 1971. Exotic game birds of the Puu Waawaa Ranch, Hawaii. Jour. Wildlife Management, 35:141-155.

McKeown, Sean. 1978. Hawaiian Reptiles and Amphibians. Oriental Publishing Co., Honolulu.

Schwartz, C.W., and E.R. Schwartz. 1949. The game birds in Hawaii. Board of Commissioners of Agriculture and Forestry, Honolulu.





Tomich, P.Q. 1969. Mammals in Hawaii. Bernice P. Bishop Museum Special Publ. No. 57, Honolulu.

Traylor, M.A. 1968. Family Estrildidae, in Check-list of Birds of the World, pages 368-369, vol. 14. Museum Comparative Zoology, Cambridge, Mass.

APPENDIX D

# ARCHAEOLOGICAL RECONNAISSANCE SURVEY
# FARMS OF KAPUA PROJECT AREA
# (1983)
# and
# ADDENDUM REPORT
# (1984)

By
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Report Ms.73-120782

# ARCHAEOLOGICAL RECONNAISSANCE SURVEY

# FARMS OF KAPUA PROJECT AREA

# LAND OF KAPUA, SOUTH KONA

# ISLAND OF HAWAII

by

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## INTRODUCTION

### BACKGROUND

At the request of Mr. John Farias, Jr. and Mr. Francis Oda--development consultants for Farms of Kapua Ltd., Paul H. Rosendahl, Ph.D., Inc. carried out an archaeological reconnaissance survey program at the 7400 acre (±) Farms of Kapua project area in the Land of Kapua, South Kona District, Island of Hawaii. The basic purpose of this program is to provide information on the archaeological-historical and socio-cultural aspects of the Farms of Kapua development sufficient for successful application to the State Land Use Commission for the desired change in the location of the existing Conservation District boundary within the project area.

This archaeological reconnaissance survey program comprises the initial phase (Phase I) of a recommended four-phase program formulated to address the various archaeological-historical and socio-cultural aspects of the Farms of Kapua development overall. This program was outlined in a meeting of October 2, 1982 to Mr. Farias and Mr. Oda, and to Mr. Roy Takeyama, attorney for the development. The goal of the recommended four-phase program is to accomplish levels of work and to provide amounts of information both adequate for and appropriate to specific stages in the general development sequence. The four phases of work and their relationship to the various stages of the general development sequence can be summarized as follows:

| Program Phase | General Development Stage |
|---|---|
| I - Archaeological Reconnaissance Survey | Land Use Boundary Change (State) |
| II - Intensive Archaeological Survey and Testing | S.M.A. Permit and Rezoning (County) |
| III- Archaeological-Historical Resource Management Plan | Any on-site development activity (within the development area overall) |
| IV - Archaeological-Historical Resource Management Activities | Any specific on-site parcel developments and/or as desired |

The specific tasks of the first phase of the recommended overall program--the archaeological reconnaissance survey phase now completed and reported on here--were formulated on the basis of discussions both with development representatives Mr. Farias, Mr. Oda, and Mr. Takeyama, and with Ms. Virginia Goldstein--



staff planner and historical sites specialist in the Hawaii County Planning Department, and Mr. Wendell Kam--staff archaeologist with the Hawaii State Historic Preservation Office. The subsequent three phases of the recommended program--which were not dealt with during the initial archaeological reconnaissance survey program reported on here--will eventually have to be defined in terms of specific tasks, levels of effort, and costs on the basis of the cumulative results of each immediately preceding phase work.

### SCOPE OF WORK

The basic purpose of the reconnaissance survey was to identify--to discover and locate on available maps--any sites or features of possible archaeological significance. A reconnaissance survey is simply a pedestrian, or walk-through, survey--extensive rather than intensive in scope--conducted to determine the presence or absence of archaeological resources within a specified project area. Reconnaissance survey indicates the general variety of archaeological remains present, and the basic density and distribution of such remains. A reconnaissance survey (1) permits a preliminary evaluation of archaeological resources, and (2) facilitates formulation of realistic recommendations and estimates for such further archaeological work as might be necessary or appropriate. Such further work could include intensive survey--detailed recording of sites and features, and selected test excavations; and possibly subsequent mitigation--salvage or research excavations, interpretive planning, and/or preservation of sites and features with significant research, interpretive, cultural, and/or preservation values.

The specific tasks performed as part of the initial phase of the recommended program--the archaeological reconnaissance survey phase--included the following five items.

#### Archaeological Background Research

Archaeological background research was directed at a familiarization with all prior relevant archaeological research conducted within and immediately adjacent to the project area. This task consisted primarily of a critical review of available archaeological reports and records. As part of the background research, a one-day preliminary on-site inspection of the project area was made.

Preliminary Historical Documentary Research

Preliminary historical documentary research was carried out by a qualified professional historical researcher, Ms. Carol L. Silva. The specific purposes of this preliminary work were two-fold: a) to determine the location, nature, content, and relevance of available documentary references (books, maps, journals, and other materials); and b) to assess the potential for subsequent, more intensive historical research that would be appropriate to the second phase of the recommended overall program (Phase II - Intensive Archaeological Survey and Testing).

Preliminary Socio-Cultural Research

Preliminary socio-cultural research was carried out by a qualified professional cultural anthropologist, Dr. Craig J. Severance (University of Hawaii-Hilo Campus). The specific purpose of this preliminary work was to prepare a critical summary of, and plan for addressing, relevant socio-cultural issues--issues relating to the potential real and perceived impacts of the Farms of Kapua development upon local cultural lifestyles--that will undoubtedly be raised as the development project progresses. This task consisted of two basic aspects: a) a review of available and relevant anthropological, ethnographic, and ethnohistoric references; and b) limited field work within the local Milolii community in order to assess the potential for subsequent informant work that would be appropriate to the second phase (Phase II) of the recommended overall program.

Reconnaissance Survey Field Work

Reconnaissance survey field work consisted of variable intensity coverage of a carefully selected sample of the Farms of Kapua project area. Stratified on the basis of both natural environmental factors and previously recorded archaeological sites, this sample comprised--as anticipated--an overall net coverage of approximately 20-25% of the total project area.

Data Analysis and Reports

Analysis of data recovered during the field work commenced upon completion of the field work. Both a Preliminary and a Final Report were prepared for submission. The Preliminary Report (letter report of November 29, 1982 [Report Ms.73-112682]) was a short progress report which summarized (a) relevant project



background, (b) field work completed and findings, (c) preliminary conclusions and evaluations of findings, and (d) tentative recommendations for the scope and scale of such further work as found to be necessary or appropriate. The Final Report--as presented here--includes (a) a description of survey findings, (b) interpretation and evaluation of these findings, and (c) recommendations for such further work as found to be necessary or appropriate. Such further work constitutes the general objectives and tasks of the second phase (Phase II) of the recommended four-phase program for addressing the various archaeological-historical and socio-cultural aspects of the Farms of Kapua development overall.

DESCRIPTION OF PROJECT AREA

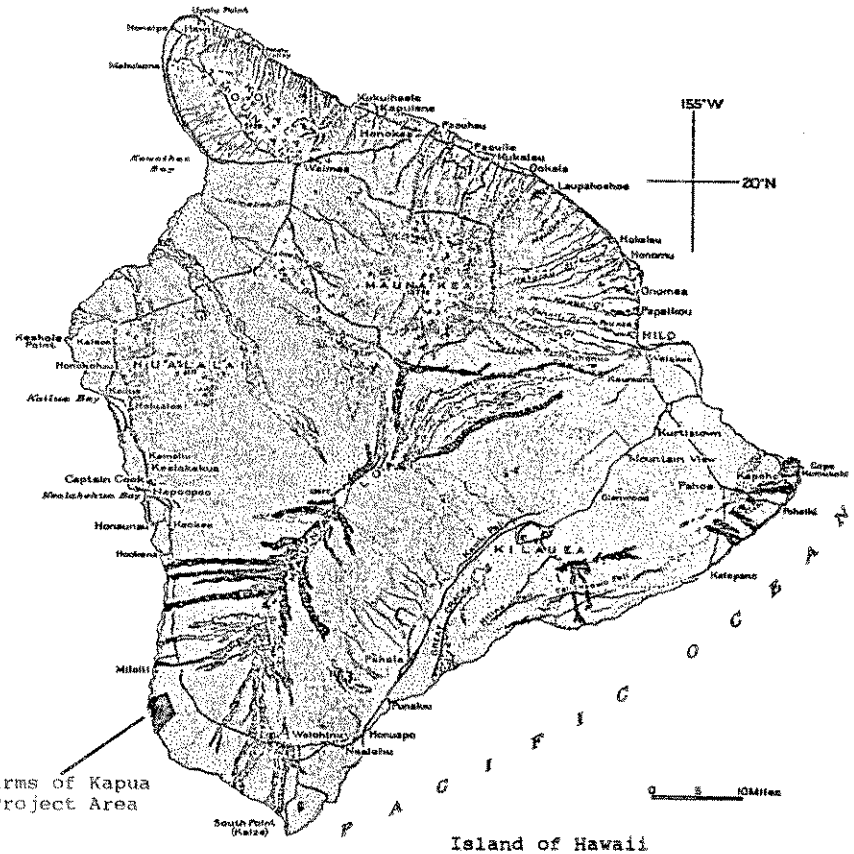
The Farms of Kapua project area consists of approximately 7400 acres located in the Land of Kapua, South Kona District, Island of Hawaii (TMK:3-8-9-06:Por.3,19; 3-8-9-11:01,10) (Fig.1). A portion of L.C.Aw.9971:30 to W.P. Leleiohoku, the project area comprises the entire seaward portion of the Land of Kapua, which is situated near the South Kona-Kau District boundary--Kapua being the first large land unit within South Kona. The inland (eastern) limits of the project area are located c. 1.1 miles seaward of the Mamalahoa Highway (Hawaii Island Belt Road). For the most part, the more inland portion of the project area has been used in recent years for grazing cattle, while the more seaward portion has been largely unused. Until the late 1930s, a few local families still resided along the northernmost coastal section of the project area. A major section of the central seaward portion of the project area was utilized by the U.S. Navy as a bombing target range until about the mid-1960s.

The Farms of Kapua project area is bound on the north side by the Land of Okoe 1-2, on the east (inland) end by a fenceline demarcating the approximate limits of the existing macadamia nut orchards, on the south side by the Land of Kaulanamauna, and on the west (seaward) end by the Pacific Ocean. Roughly rectangular in plan view--except for the irregular coastline forming the western end, the project area has the following approximate dimensions: north side, 4.36 miles (7.01 km.); east (inland) end, 2.78 miles (4.48 km.); south side, 4.09 miles (6.59 km.); and west (seaward) end, 2.23 miles (3.60 km.). In overall elevation, the project area rises from sea level to approximately 1,100 ft. along the inland end.

The physical environmental characteristics of the project area conform to the general description of the Kona sector given

Figure 1.

PROJECT LOCATION MAP






in the Hawaii Island-Detailed Land Classification Bulletin of the State Land Study Bureau:

> This area is characterized by lava flows and a diverse climate; climate changes rapidly over short distances. The lava lands have very little soil material...except in pockets of a few acres.... The lands are heavily vegetated, except for the more recent lava flows and drier areas along the coast. The lava flows become progressively more barren toward the south.... The climate is characterized by (1) a dry period in the winter and rainy period during the summer (opposite to areas exposed to trade winds), (2) close correlation between changes in rainfall and temperature and changes in elevation, (3) lack of strong winds, and (4) clear mornings but cloudy and rainy afternoons and evenings (Baker et al. 1965:5).

The following more specific information and comments on the local environmental setting are based on a limited number of references (Baker et al. 1965; Downs, Hay, and Thompson 1982; Hawaii State-Department of Land and Natural Resources 1970; Stearns and MacDonald 1946; and U.S.-Department of Agriculture 1973), study of available aerial photographs (black-and-white, color infra-red), and on-site observations.

The terrain of the project area is generally rugged, though overall gently sloping in aspect except for localized very broken terrain, such as aa lava flows. The shoreline of the northern portion of the project area includes several small bays and coves with sand or coral cobble beaches, while the shoreline of the central and southern portions consist primarily of low rocky cliffs. Rainfall varies with elevation, with annual totals ranging from less than 40 inches near the coast to more than 60 inches at the inland limits of the project area. Mean annual temperature for the project area is approximately 75°F.

The geological base of the project area is comprised of Late Pleistocene and Recent Mauna Loa basaltic lava flows of the Kau Volcanic Series. Both aa and pahoehoe flows are present. No historic period flows are found within the project area, though it is possible that some of the flows present--particularly some of the aa flows--are relatively late prehistoric in age. The aa and pahoehoe flows of the seaward and central inland portions of the project area are generally poorly weathered and exhibit little or no soil development. The only exception to this general situation are the several kipuka of varied size, especially in the northern portion of the project area, which have shallow accumulations of soil atop older pahoehoe bedrock.

Two principal soils are present in the inland portions of the project area. Kaimu extremely stony peat (6-20% slope) is representative of the Kaimu soil series of well-drained, thin organic soils which have developed over aa lava bedrock. Punaluu extremely rocky peat (6-20% slope) is representative of the Punaluu soil series of well-drained, thin organic soils which have developed over pahoehoe lava bedrock.

With the exception of the most inland limits of the project area, the vegetation consists predominantly of introduced exotic species of grasses, shrubs, and trees. Major portions of the project area--especially the relatively barren coastal and south-central portions--are basically lowland grasslands comprised mainly of guinea grass (Panicum maximum Jacq.) and fountain grass (Pennisetum setaceum (Forsk.) Choiv.), scattered shrubs such as lantana (Lantana camera L.) and the native 'ilima (Sida fallax Walp.), and occasional specimens and small stands of kiawe (Prosopis pallida (Humb. and Bonpl. ex Willd.) HBK) and koa-haole (Leucaena glauca (L.) Benth.). Along the shoreline in the central and northern coastal areas are several moderate to dense stands of kiawe--an indication of the presence of shallow ground water sources. Other components of these circumscribed oasis-like areas are coconut palms (Cocos nucifera L.), hala (Pandanus odoratissimus L.f.), and hau (Hibiscus tiliaceus L.). The various kipuka in the northern portion of the project area have a characteristic vegetation comprised primarily of kiawe, lantana, koa-haole, and 'ilima.

The inland portion of the project area--particularly the central part--is characterized by a variable density cover comprised primarily of koa-haole and grasses. Further inland--along the eastern limits of the project area, the vegetation cover becomes moderately to extremely dense, and is comprised primarily of introduced Christmas-berry (Schinus terebinthius Raddi) and native 'ohi'a (Metrosideros collina (Forst.) Gray subsp. polymorpha (Gaud.) Rock), with lesser numbers of other native trees such as lama (Diospyros sp.), alahe'e (Canthium odoratum (Forst.) Seem.), and kukui (Aleurites moluccana (L.) Willd.).

Major sections of the more inland portion of the project area seem to have been extensively modified in recent historic times--most likely by chain-dragging and/or bulldozer grubbing for preparation of improved pasture for cattle. On the basis of observed ground surface modifications and vegetation distribution patterns, it appears that this land surface modification activity extended down to approximately 900 ft. elevation, and possibly as far down as 800 ft. elevation in some areas.



PREVIOUS ARCHAEOLOGICAL WORK IN PROJECT AREA

During his 1906 survey of heiau on Hawaii Island, J.F.G. Stokes of the Bishop Museum apparently passed through the coastal portion of Kapua. His manuscript report (Stokes n.d.) mentions that he was told of a heiau supposedly present at Kapua--Heiau of Kalawahine, but that he did not actually find any structural evidence of such a site.

J.E. Reinecke, during his 1930 survey for Bishop Museum of sites along the coast of West Hawaii Island (Reinecke n.d.) recorded fourteen sites (Site No.69 thru 82). His manuscript report provides only very short descriptions of most of these sites, as he did not appear to have spent much time at all at Kapua.

In 1932, K.P. Emory and E.H. Bryan of Bishop Museum carried out a more thorough archaeological survey of sites at Kapua--those along the coast between the Okoe boundary and Kaupo Bay--in conjunction with the land survey and mapping done for the land owner Bishop Estate, by H.K. Keppeler (Emory n.d.; Keppeler, Emory, and Bryan 1932). The resulting map (Bishop Estate Map No.2525) depicts many of the archaeological sites situated in the northern coastal portion of the Kapua project area, and includes several of the local place names.

During the years 1963 -1969, Bishop Museum Field Associate Mrs. V. Hansen made several field trips through Kapua and the adjacent lands recording archaeological sites (Hansen n.d.). She recorded numerous sites along the coastal area of Kapua, and in the process assigned many individual site numbers using the Bishop Museum site designation system.

In 1970, Emory compiled an inventory of known Hawaii Island sites in the Kona and Kau Districts, and at Anaehoomalu, for the Hawaii County Planning Department (Emory 1970). This work was based on existing Bishop Museum site records, and apparently did not involve any field inspection--at least not for the sites at Kapua. In his description of Kapua sites, Emory (1970:19-23) took the existing Bishop Museum site numbers, and reassigned new Hawaii Register of Historic Places (H.R.H.P.) site numbers--often incorporating several previously designated sites (up to thirteen) into single large site complexes.

As part of the Statewide Inventory of Historic Places, staff archaeologists for the State Historic Preservation Office inspected previously recorded sites at Kapua in 1971. They assigned several new H.R.H.P. site numbers, generally replacing those assigned by Emory by dividing up the sites into groupings or complexes more appropriate on the basis of spatial associations. Twenty-one sites and site complexes were designated--eighteen

coastal and three inland. These H.R.H.P. sites and site complexes are listed in the subsequently referenced Tables 2 and 3 (Site Nos. 1994 to 3775, non-consecutive), and their locations indicated on Figure 2 (at end). Individual site record files are available for inspection at the Historic Sites Section-Division of State Parks in Honolulu. H.R.H.P. site file information for Kapua was recently summarized by then staff archaeologist Ms. Patricia Beggerly in a letter to Kapua developers (April 25, 1980). For convenience, a copy of this concise summary has been appended to the present report (Appendix I).

In general, consideration of the past archaeological work done within the area of the present reconnaissance survey project at Kapua indicated the presence of numerous, well-preserved archaeological sites along the immediate coastal section. The wide range of formal and functional types of sites present appeared representative of the full range of Hawaiian cultural activities during both the prehistoric and historic periods of occupation. Apparently very little survey work had ever been done in the more inland portions of the survey area prior to the present reconnaissance survey reported here.

## SURVEY METHODOLOGY AND PROCEDURES

A preliminary on-site inspection of the project area for purposes of familiarization and field work planning was made on November 3, 1982, in the company of the local representative of Farms of Kapua Ltd., Ms. Sally Rice. Formal reconnaissance survey field work was carried out at Kapua during the period November 8-20, 1982 by an eight-man field team under the direct supervision of Field Director Mr. Michael W. Kaschko and Field Supervisor Ms. Melinda Sue Allen. Project Director and Principal Investigator Dr. Paul H. Rosendahl was present in the field on November 8, 10, 13-15, and 19-20. During the entire field work period, personnel stayed at a base camp established and maintained on the beach at Kapua Bay by Travel/Camp Inc. of Hilo.

A total of approximately 752 man-hours of labor were expended to conduct the archaeological reconnaissance field work. Of this total, approximately 116 man-hours were expended in the identification and evaluation of previously recorded and newly found sites situated within the immediate coastal area, while approximately 636 man-hours were expended in the reconnaissance of the selected sample portions of the inland area.

Individual survey areas are summarized in Table 1 in terms of approximate acreage and formally designated sites situated within each survey area. The location and general extent of each survey area is shown on Figure 2 (at end). Survey coverage of the coastal portion of the project area included virtually



Table 1.

SUMMARY OF SURVEY AREAS
FARMS OF KAPUA PROJECT AREA

| Survey Area | Approximate Acreage | Designated Sites in Survey Area# |
|---|---|---|
| Coastal Zone+ | 677.2 ac. | 1994, 1995, 1996, 1997, 1998, 1999, 2133, 2134, 2135, 2136, 2141, 2142, 2143, 2144, 2145, 2147, 3707, 3775, 9912, 9937, 9938, 9939, 9940 |
| A-1 | 12.1 | 9931 |
| A-2 | 6.2 | 9909 |
| A-3 | 1.4 | 9921 |
| A-4 | 14.0 | 9901*, 9922 |
| A-5 | 11.8 | 9901*, 9923 |
| A-6 | 16.4 | 9901*, 9924, 9925 |
| A-7 | 34.7 | none designated |
| A-8 | 10.7 | 9926, 9927 |
| A-9 | 29.4 | 9914 |
| A-10 | 78.5 | none designated |
| A-11 | 90.0 | 9936 |
| A-12 | 73.2** | 3705, 3706, 9915, 9933, 9934 |
| K-1 | 10.0 | 9901*, 9907 |
| K-2 | 16.5 | 9901* |
| K-3 | 5.1 | 9901*, 9902 |
| K-4 | 8.9 | 9903 |
| K-5 | 7.3 | none designated |
| K-6 | 8.0 | 9941 |
| K-7 | 71.3 | 2162, 9904 |
| K-8 | 20.9 | 9905 |
| K-9 | 145.5 | 9906 |
| K-10 | 147.4 | none designated |

Table 1. (Continued)

| Survey Area | Approximate Acreage | Designated Sites in Survey Area# |
|---|---|---|
| K-11 | 12.5 | 9910 |
| K-12 | 49.4*** | 9908 |
| V-1 | 38.6 | 9911, 9913, 9928 |
| V-2 | 86.0 | 9929, 9930 |
| | 1661.3 acres++ | Total designated sites = 56 |

# Hawaii Register of Historic Places Site No. 50-10-XX-____

+ Inland limits of coastal zone vary from c. 1000' to 1500' from shoreline. Average of 1250' used in calculation.

* Site extends over areas A-4, A-5, A-6, K-1, K-2, and K-3.

** Includes 19.5 acres within Coastal Zone survey area.

*** Includes 2.2 acres within Coastal Zone survey area.

++ Total excluded 21.7 acres of Survey Area A-12 (19.5) and Survey Area K-12 (2.2) already included within Coastal Zone survey area.

Survey Area Coverage of Project Area

22.45% of total project area (approx.)

$$\frac{1661.3}{7400} = 22.45\%$$

100% of Coastal Zone survey area (approx.)

14.64% of inland portion of project area (approx.)

$$\frac{948.1}{6722.8} = 14.6\%$$



100% pedestrian coverage of a zone extending inland from the shoreline to 1000-1500 feet inland, and from the north boundary of Kapua to the south boundary. Survey coverage of the inland portion of the project area consisted of virtually 100% pedestrian coverage of selected discrete survey areas. These survey areas, which varied considerably in dimensions and overall size, were selected so as to obtain representative samples of the project area in terms of both geographic distribution and environmental variation.

As an initial objective, a total areal sample of 15-20% of the project area overall was anticipated. Actual field work conditions affecting the size of the discrete survey areas and the relative intensity of coverage varied as a function primarily of vegetation cover density and geological nature of the ground surface. As indicated in the note at the end of Table 1, sample coverage of the total project area turned out to be somewhat more than 20%. This coverage included 100% coverage of the coastal zone survey area, and a sampling of approximately 15% of the remaining inland portion of the project area.

In the course of the archaeological reconnaissance survey field work, a total of 27 discrete survey areas--including the coastal zone--were designated and covered. With the exception of the coastal zone survey area, which was divided into several sections for logistical reasons, each individual survey area was covered by a four-man field survey crew. Crew members carried out sweeps of variable width through each survey area, with the distance between crew members appropriate to the terrain and vegetation cover so as to obtain as close as possible to 100% coverage of each survey area.

All previously identified H.R.H.P. sites were located and compared to their record forms, with additions and modifications being made directly on the form copies as appropriate. Newly found sites were recorded and assigned H.R.H.P. site numbers from a series of blank numbers obtained from the Historic Sites Section-Division of State Parks in Honolulu (series 9001-10000). Field recording of new sites generally consisted of a short written description on a standardized survey record form, 35 mm. black-and-white photographs, and a scaled plan view sketch map. Brass washer site markers were placed at both previously recorded and new sites to facilitate accurate recognition of sites in the course of any future archaeological work. Several of the survey areas revealed scatterings of archaeological features--generally rather minor features, but few or no well-defined sites. In these instances, general survey area notes pertaining to the general nature, density, and distribution of these features were made, but no specific site numbers were designated.

Field work was greatly facilitated by the use of several sets of recent aerial photographs. A series of 1"=1500' (±) scale color infra-red contact prints provided a general understanding of project area vegetation patterns, distribution of geological features--particularly distinctive kipuka and aa lava flows, and the location of roads and trails that traversed the project area. A series of 1"=200' scale color infra-red enlargements was especially useful in the selected of individual survey areas to be covered in the field. Many of the newly identified archaeological sites were initially noted on these enlargements, and were subsequently verified through on-ground inspection. Field survey crews used 1"=400' scale black-and-white enlargements during field work for actual plotting of survey area limits and individual site locations. Field location plots were also simultaneously transferred onto field copies of a 1"=500' scale topographic map that had been prepared earlier by the commercial firm of R.M. Towill (Honolulu) from the same negatives used to prepare the 1"=400' scale enlargements.

All records and materials generated by the reconnaissance survey project are currently deposited in the main office of Paul H. Rosendahl, Ph.D., Inc. at Kurtistown, Island of Hawaii, and will be made available to qualified researchers who wish to inspect them.



## RECONNAISSANCE SURVEY FINDINGS

In the course of the archaeological reconnaissance survey field work, a total of 27 discrete survey areas--including the coastal zone--were designated and covered. The variety of different functional site and feature types encountered during the field work is outlined in Table 2.

### DESIGNATED SITES

All previously recorded H.R.H.P. sites within the project area--a total of 21, including 18 coastal and 3 inland sites--were identified, inspected, and evaluated. A total of 35 new sites were also designated--30 inland sites and 5 coastal sites. Both previously recorded H.R.H.P. sites and newly designated sites are summarized in Table 3, on the basis of H.R.H.P. site number, survey area provenience, inferred functional site type, approximate overall size, relative overall physical condition, and relative integrity (estimated extent of any post-original modification). The locations of both previously recorded and newly designated sites are shown in Figure 2 (at end). In terms of gross quantitative summary, the major functional site categories were represented among the 56 designated sites according to the following distribution: residential features--12, residential complexes--25, agricultural complexes--5, residential/agricultural complexes--2, burial features--2, foot trails--2, ceremonial features--4, and holua slide, refuge cave, historic camp site, and function unknown--1 each.

Sites 1994 through 3775 (non-consecutive) are those previously designated and recorded during the Statewide Inventory of Historic Places in 1971. Summary information on these sites is presented in the previously referenced Appendix I (at end). Sites 9901 through 9941 (non-consecutive) are newly designated sites identified and recorded during the present reconnaissance survey field work. The following more specific comments on the 56 designated sites--both previously recorded and newly designated--have been abstracted from the relevant individual H.R.H.P. record forms and the present reconnaissance survey record forms.

Site 1994 - Residential Complex (Kalapili Point Complex)

Approximately 30(+) component features, including paved and gravel-lined foot trails, residential platforms, walled enclosures, burial platforms, and cairns; both prehistoric and historic period occupation indicated.

Table 2.

SUMMARY OF FUNCTIONAL SITE AND FEATURE TYPES
FARMS OF KAPUA PROJECT AREA

RESIDENTIAL FEATURES

- Walled shelters
- Walled structures (other than shelters)
- Terraces
- Platforms
- Caves

RESIDENTIAL COMPLEXES

(comprised of multiple residential features)

AGRICULTURAL COMPLEXES

Major features - Walled enclosures (pens)
Gardens (enclosed and naturally defined)

Minor features - Clearings, mounds, terraces, alignments, modified outcrops, and windbreaks

RESIDENTIAL/AGRICULTURAL COMPLEXES

BURIAL FEATURES (individual and complexes)

- Mounds
- Platforms
- Modified outcrops

BRACKISH WELLS/SPRINGS

FOOT TRAILS

- Paved (waterworn stones, lava slabs)
- Gravel-lined

CEREMONIAL FEATURES (individual and complexes)

- Heiau
- Shrines (structures and caves)

HOLUA SLIDE

REFUGE CAVE

HISTORIC ROAD/CART TRAIL

HISTORIC CAMP SITE

WALLS

CAIRNS

FUNCTION UNKNOWN



Table 3.

SUMMARY OF DESIGNATED SITES
FARMS OF KAPUA PROJECT AREA

| Site No.* | Survey Area | Site Type/Designation | Dimensions (sq.m.) | Site Condition | Site Integrity |
|---|---|---|---|---|---|
| 1994 | CZ** | Residential complex | 46,800 | G* | Unaltered |
| 1995 | CZ | Possible shrine or heiau | 196 | G | Part. alt. |
| 1996 | CZ | Residential complex | 120,000 | F/G | Part. alt. |
| 1997 | CZ | Residential complex | 60,000 | F/G | Part. alt. |
| 1998 | CZ | Residential complex | 20,000 | F | Unaltered |
| 1999 | CZ | Shrine complex | 764 | G | Part. alt. |
| 2133 | CZ | Heiau complex (Ahole Heiau) | 2,000 | F/G | Part. alt. |
| 2134 | CZ | Holua slide complex | 9,000 | G | Part. alt. |
| 2135 | CZ | Burial complex | 2,200 | G | Unaltered (?) |
| 2136 | CZ | Residential complex | 2,560 | F | Part. alt. |
| 2141 | CZ | Residential complex | 864 | G | Unaltered |
| 2142 | CZ | Residential complex | 200 | G | Unaltered |
| 2143 | CZ | Circular structure (function unknown) | 25 | E | Unaltered |
| 2144 | CZ | Enclosure (residential?) | 46 | G | Part. alt. |
| 2145 | CZ | Residential complex (shelters) | 400 | G | Unaltered (?) |
| 2147 | CZ | Residential complex | 75,000 | F/G | Part. alt. |
| 2162 | K-7 | Residential complex (principally caves) | 100,000 | F | Unaltered (?) |
| 3705 | A-12 | Refuge cave | 40,000 | G | Part. alt. |
| 3706 | A-12 CZ | Residential complex (principally caves) | 960,000 | G | Part. alt. |
| 3707 | CZ | Residential complex | 10,000 | F/G | Part. alt. |
| 3775 | CZ | Heiau (Kapua Heiau) | 374 | F | Part. alt. (?) |
| 9901 | K-1,2,3 A-4,5,6 | Residential/agricultural complex | 298,500 | P/F/G | Part. alt./ Unaltered |
| 9902 | K-3 | Residential or heiau complex | 200 | G | Unaltered |
| 9903 | K-4 | Residential feature (cave) | 130 | G | Part. alt. |
| 9904 | K-7 | Residential feature (cave) | 60 | G | Part. alt. |
| 9905 | K-8 | Residential complex | 4,125 | F/G | Unaltered |
| 9906 | K-9 | Residential complex | 300 | F/G | Part. alt. |
| 9907 | K-1 | Residential or heiau complex | 1,280 | F/G | Unaltered |
| 9908 | K-12 | Historic camp site | --- | - | Unaltered (?) |

Table 3. (Continued)

| Site No.* | Survey Area | Site Type/Description | Dimensions (sq.m.) | Site Condition | Site Integrity |
|---|---|---|---|---|---|
| 9909 | A-2 | Agricultural complex | 27,000 | P/F/G | Part. alt. |
| 9910 | K-11 | Residential complex | 250 | -- | -- |
| 9911 | V-1 | Residential complex | --- | -- | -- |
| 9912 | CZ | Residential complex | 360 | -- | -- |
| 9913 | V-1 | Paved trail with associated structural features | --- | F/E | Unaltered |
| 9914 | A-9 | Paved trail | --- | E | Unaltered |
| 9915 | A-12 | Residential feature (cave) (seaward extension of 3705) | --- | G | Unaltered |
| 9921 | A-3 | Walled enclosure | 270 | F | Part. alt. |
| 9922 | A-4 | Residential complex | 400 | F | Unaltered |
| 9923 | A-5 | Residential complex | 300 | F/G | Unailtered |
| 9924 | A-6 | Walled shelter | 80 | G | Unaltered |
| 9925 | A-6 | Residential/agricultural complex | 250 | G | Unaltered |
| 9926 | A-8 | Residential feature (cave) | 300 | F/G | Unaltered (?) |
| 9927 | A-8 | Residential feature (cave) | 480 | G | Part. alt. |
| 9928 | V-1 | Residential complex (shelters) | 300 | G | Unaltered |
| 9929 | V-2 | Residential complex | 100 | F | Unaltered |
| 9930 | V-2 | Residential complex (possible agricultural) | 250 | F/G | Unaltered |
| 9931 | A-1 | Agricultural complex | 37,000 | P/F | Unaltered (?) |
| 9933 | A-12 | Residential feature (cave) | 300 | G | Unaltered |
| 9934 | A-12 | Platform (burial?) | 20 | G | Unaltered |
| 9935 | A-11 | Residential feature (cave) | 80 | F | Unaltered |
| 9936 | A-11 | Residential complex (caves) | 3,000 | G | Unaltered (?) |
| 9937 | CZ | Residential complex | 600 | F/G | Unaltered |
| 9938 | CZ | Residential feature (cave) | 100 | G | Unaltered |
| 9939 | CZ | Walled shelter | 48 | F | Unaltered |
| 9940 | CZ | Cave | 150 | G | Unaltered |
| 9941 | K-6 | Walled enclosure | 300 | F | Unaltered (?) |

* Hawaii Register of Historic Places Site No. 50-10-XX-____

** CZ = Coastal zone

\+ P=poor, F=fair, G=good, E=excellent



Site 1995 - Ceremonial Feature (Stone Wall Structure with Platform)

Massive raised stone structure--a walled platform, suspected to be either a shrine or small heiau.

Site 1996 - Residential Complex (Oea Bay Complex)

Approximately 40(+) component features, including paved and gravel-lined foot trails, walled enclosures, walls, residential platforms, burial platforms, a well, cairns, and a possible shrine; both prehistoric and historic period occupation indicated.

Site 1997 - Residential Complex (Kapua Bay Complex)

Undetermined number of component features (possibly 40-50+), including walled enclosures, residential platforms, foot trails, burial platforms, walls, cave shelters, wells, terraces, walled shelters, cairns, and ceremonial features (possibly three heiau); both prehistoric and historic period occupation indicated.

Site 1998 - Residential Complex (Kapua Complex #1)

Approximately 7(+) component features, including foot trails, residential platforms, walled enclosures, a cairn, and a burial platform; one walled enclosure possibly a small shrine; prehistoric occupation indicated, historic period uncertain.

Site 1999 - Ceremonial Feature Complex (Religious Complex)

Approximately 5(+) component features, including walled enclosures (3) and platforms (2) inferred to be shrines; additional terrace and walled shelters nearby; prehistoric occupation indicated.

Site 2133 - Ceremonial Feature Complex (Lae o Ahole Complex)

Approximately 12 component features, including platforms, foot trails, burial platforms, a walled enclosure, a wall, wells or springs, and a natural lava upthrust (possible shrine); principal feature is large platform identified as Ahole Heiau; prehistoric occupation indicated.

Site 2134 - Holua Slide Complex (Ahole Holua Complex)

Approximately 10 component features, including terraces and platforms, paved foot trails, a walled enclosure, and the holua slide; principal feature is the massive, very well-preserved holua slide; one platform possibly a small shrine; prehistoric occupation indicated.

Site 2135 - Burial Complex

Uncertain number of component features, including at least three burial platforms, a paved foot trail, low terraces, and a walled enclosure; prehistoric occupation indicated.

Site 2136 - Residential Complex (Kaupo Bay Complex)

Approximately 20(+) component features, including walled residential structures and platforms, walled enclosures, paved foot trails, wells or springs, walls, and several small, walled shelters; both prehistoric and historic period occupation indicated.

Site 2141 - Residential Complex (Kapua Complex #2)

Approximately 10 component features, including walled residential enclosures, residential platforms, cairns (piled coral included), and areas of scattered water-worn pebbles and cobbles; one walled enclosure inferred to be a small shrine; prehistoric occupation indicated.

Site 2142 - Residential Complex (Habitation Units)

Approximately 5 component features, including a walled residential enclosure and platform, walled shelter, and cairns; numerous shallow natural depressions in the immediate vicinity appear to be intentionally filled with basalt cobbles; prehistoric occupation indicated.

Site 2143 - Function Unknown (Circular Structure)

Single component site; unique feature constructed of stacked, thin slabs of pahoehoe lava, with numerous coral pebbles and small cobbles stuck into the wall fabric; period uncertain, but probably prehistoric (?).

Site 2144 - Walled Enclosure

Three component features, including walled enclosure, a cairn, and a crude cobble-filled platform with low wall; upright pahoehoe lava slabs used in enclosure construction; period uncertain, but probably prehistoric.

Site 2145 - Residential Complex (Shelter Complex)

Four component features, including a crude platform, a small walled enclosure, and two natural shelter caves; prehistoric occupation indicated.



Site 2147 - Residential Complex (Habitation Complex)

Approximately 20 component features, including walled residential enclosures and platforms, walled shelters, possible burial platforms, and walls; both prehistoric and historic period occupation indicated.

Site 2162 - Residential Complex (Lava Tube Complex)

At least 6 component features, including four (or more) cave shelters, a larger residential cave (possibly a refuge cave), and a walled enclosure; additional cave shelters and walls said to be in general area; prehistoric occupation indicated.

Site 3705 - Refuge Cave (Lava Tube Cave Shelter)

Extensive cave system with multiple entrances; entrances are partially walled and terraced; prehistoric occupation indicated.

Site 3706 - Residential Complex (Lava Tube Complex)

Extensive cave system (Site 3705 possibly part of this system); several cairns and/or possible burial platforms present around sinkhole entrance; several interior features, including cairns and low platforms (possibly burial features); upright lava slabs associated with one wall-like feature suggests possible shrine; prehistoric occupation indicated.

Site 3707 - Residential Complex (Niuou Complex)

Approximately 10(+) component features, including foot trails, residential platforms (or terraces), a probable burial platforms, a large walled enclosure, and walls; prehistoric occupation indicated.

Site 3775 - Ceremonial Feature (Kapua Heiau)

Large single component site; quite isolated, with no other features found in the vicinity; situated at edge of sea cliff; prehistoric occupation indicated.

Site 9901 - Residential/Agricultural Complex

Large complex situated in major kipuka; exhibits virtually full range of component features; physically connected by foot trail to coastal habitation areas; further study likely to permit definition of several inter-related sub-complexes; prehistoric occupation indicated, with possible historic period occupation also.

Site 9902 - Residential or Ceremonial Complex

Five component features, including large terrace with internal alignments and fireplace, a walled enclosure, a walled shelter, a small platform, and a small terrace; large terrace possibly heiau; situated within Site 9901; prehistoric occupation indicated.

Site 9903 - Residential Feature

Large shelter cave with internal features (low terraces, boulder alignments, and fireplaces); apparently rich cultural deposit; prehistoric occupation indicated.

Site 9904 - Residential Feature

Distinctive shelter cave formed by natural lava arch; several rough terraces on seaward side; prehistoric occupation indicated.

Site 9905 - Residential Complex

Approximately 5 component features, including walled residential enclosure, several rough terraces and/or cleared areas, and short foot trail segments; additional small walled shelter nearby; all features situated atop and at edge of rough aa lava flow; both prehistoric and historic period occupation indicated.

Site 9906 - Residential Complex

Approximately 4 component features, including modified bedrock outcrop shelter (with associated petroglyph), residential platform, walled shelter, and residential terrace with fireplace; prehistoric occupation indicated.

Site 9907 - Residential or Ceremonial Complex

Approximately 6 component features, including several terraces, a low walled enclosure, and a paved foot trail; situated atop prominent knoll; possibly heiau site; prehistoric occupation indicated.

Site 9908 - Historic Camp Site

Situated adjacent to boundary wall extending between Land of Kapua and Land of Okoe 1-2; site possibly associated with construction of wall and/or fenceline along wall.



Site 9909 - Agricultural Complex

Small kipuka containing variety of minor agricultural features (clearings, modified bedrock outcrops, stone alignments); prehistoric occupation indicated.

Site 9910 - Residential Complex

Uncertain number of component features, but several rough terrace features with surface midden present; situated atop knoll; heavily overgrown.

Site 9911 - Residential Complex

Uncertain number of component features, but several walled shelters, cairns, and modified bedrock outcrops; possibly associated with foot trail (Site 9913); prehistoric occupation indicated.

Site 9912 - Residential Complex

Approximately 6(+) walled shelters situated at seaward end of foot trail; abundant midden; prehistoric occupation indicated.

Site 9913 - Paved Foot Trail With Associated Features

Paved foot trail extending inland-seaward between coastal site complex (Site 2136) and inland kipuka (Survey Area V-2); features along trail include cairns, modified bedrock outcrops (shelters), and cleared areas; prehistoric occupation indicated.

Site 9914 - Foot Trail

Paved foot trail extending inland from coastal site complex (Site 3707); prehistoric occupation indicated.

Site 9915 - Residential Feature

Cave with interior features (low terraces)and fair amount of midden and portable artifact material; possibly a seaward extension of previously identified refuge cave (Site 3705); prehistoric occupation indicated.

Site 9921 - Agricultural (?) Enclosure

Rubble wall encloses small, rocky kipuka; possible minor agricultural features inside enclosure; probably prehistoric occupation indicated.

Site 9922 - Residential Complex

Three component features, including large terrace with partial enclosing wall, and two smaller open terraces; contained within Site 9901; prehistoric occupation indicated.

Site 9923 - Residential Complex

Six component features, including terraces (2), walled shelters (2), gravel-lined foot trail, and possible burial feature (filled mound-like pahoehoe blister); situated at edge of kipuka (Survey Area A-5) with scattered minor agricultural features; contained within Site 9901; prehistoric occupation indicated.

Site 9924 - Residential Feature

Walled shelter at base edge of aa lava flow; interior fireplace, and possible paving; contained within Site 9901; prehistoric occupation indicated.

Site 9925 - Residential/Agricultural Complex

Residential terrace, with associated cupboard feature and numerous minor agricultural features, including mounds (24) and terraces (2); contained within Site 9901; prehistoric occupation indicated.

Site 9926 - Residential Feature

Sinkhole cave with interior terraces (2) and short wall segment; prehistoric occupation indicated.

Site 9927 - Residential Feature

Cave with several interior features, including low terraces, mounds, fireplace, and small circular stone alignments; presence of metal barrel bands suggests use of cave for catchment of water dripping from ceiling; prehistoric and historic period occupation indicated.

Site 9928 - Residential Complex

Cluster of small walled shelters (6-7) along paved foot trail (Site 9913); prehistoric occupation indicated.

Site 9929 - Residential Complex

Cluster of small features associated with paved foot trail; features include cairns, terraces, walls,



modified bedrock outcrops, and a possible platform; features generally poorly defined; prehistoric occupation indicated.

Site 9930 - Residential Complex

Several crude terraces(3-5, poorly defined) situated along the base of an aa lava flow; prehistoric occupation indicated.

Site 9931 - Agricultural Complex

Small kipuka containing a variety of minor agricultural features; paved foot trail extends seaward to habitation complex (Site 1994), while gravel-lined foot trail leads inland from inland end of kipuka; prehistoric occupation indicated.

Site 9933 - Residential Feature

Sinkhole cave with interior features (wall and terrace); prehistoric occupation indicated.

Site 9934 - Platform

Single component site; possible burial feature; central depression with several upright slabs at edge; possibly historic period feature.

Site 9935 - Residential Feature

Sinkhole cave with interior terraces (3); prehistoric occupation indicated.

Site 9936 - Residential Complex

Cluster of connected sinkhole caves with interior features, including terraces, platforms, and possibly paved areas; possible burial feature (platform); prehistoric occupation indicated.

Site 9937 - Residential Complex

Approximately 7 component features, including walled shelters (3), wall, cairn, modified bedrock outcrop, and terrace; prehistoric occupation indicated.

Site 9938 - Residential Feature

Cave situated at side of large, shallow sink; terrace at entrance; abundant midden and portable artifact materials; prehistoric occupation indicated.

Site 9939 - Residential Feature

Walled shelter; somewhat deteriorated condition; probable prehistoric occupation indicated.

Site 9940 - Residential Feature

Shelter cave; possible rough terrace near entrance; associated midden and artifact materials; prehistoric occupation indicated.

Site 9941 - Walled Enclosure

Large walled enclosure with several interior features, including small enclosures and modified bedrock outcrops; possibly agricultural and/or residential feature; currently used as cattle enclosure; both probable prehistoric and historic period occupation indicated.

COMMENT ON SURVEY AREAS

At least a scattering of archaeological features was found in virtually every survey area inspected. In most cases, these features consisted principally of minor agricultural features--such as clearings (for planting), stone clearing mounds, rough terraces, stone alignments, modified bedrock outcrops, and low, piled stone windbreaks. These minor agricultural features, often with associated crude residential shelter features, probably represented component elements of larger, more extensive agricultural and residential/agricultural complexes. The approximate acreage of each survey area, and the designated sites present within various of the survey areas, are listed in the previously cited Table 1. Further comments on individual survey areas will not be presented here; for additional comments, the original field records of the reconnaissance survey should be consulted.



PRELIMINARY HISTORICAL DOCUMENTARY RESEARCH

Preliminary historical documentary research was carried out by Ms. Carol L. Silva, and her report has been included here as Appendix II. Her research was restricted in scale, and concentrated on the more readily available published and archival resources in an attempt to determine the potential for subsequent more extensive historical research. Her report contains references from mythological literature, a brief historical sketch of the general Kapua area of South Kona, specific historical references to the Land of Kapua, information regarding land records for the historic period prior to 1900, a note on cartographic sources, and several recommendations for additional historical research that would appear to be useful for understanding the significance of the archaeological-historical sites found within the Farms of Kapua project area.

PRELIMINARY SOCIO-CULTURAL RESEARCH

Preliminary socio-cultural research was carried out by Dr. Craig J. Severance, and his report has been included here as Appendix III. His research was quite restricted in both scope and scale, and concentrated on the identification of potentially major socio-cultural issues and concerns that will most likely have to be dealt with as the Farms of Kapua development progresses. His report briefly discusses the need for addressing community concerns, identifies several specific probable concerns of various segments of the local community that are likely to be affected by the proposed development at Kapua, and offers several recommendations for subsequent socio-cultural research intended to deal in a productive manner with the various concenrs of the local community.

## CONCLUSION

### DISCUSSION

The variety, distribution, and density of sites and features encountered during the reconnaissance survey of the 27 discrete survey areas varied considerably. In terms of general overall distribution, sites and features tended to be more numerous in the northern portion of the project area--both coastal and inland parts, rather than in the central or southern portions. Probably the greatest density and variety of archaeological remains were found in the coastal zone, which contained examples of virtually every type of site and feature--with the exception of definitely identified agricultural features and the refuge cave.

Sites and features identified in the various inland survey areas were more restricted in terms of both variety and density. Several kipuka containing concentrations of agricultural features were found. In several cases, residential features comprised integral components. In several instances, the culturally utilized kipuka were physically linked to coastal habitation complexes by clearly defined foot trails. The second major kind of inland sites were intentionally modified and/or utilized caves which were included within different series of natural lava tube complexes that extended in generally inland-seaward orientations. Several of these caves contained structural modifications in the form of platforms, terraces, and walls, as well as portable cultural remains in the form of midden and artifacts.

The varied archaeological remains identified within the project area are distinguished by both their relatively good physical condition and their generally high integrity. Most of the sites and features appeared to have suffered little from modifications and/or damage subsequent to their original occupation and abandonment. The identified remains evidence both prehistoric and historic period occupation and utilization. The nature and distribution of the archaeological remains are not uniform. In terms of variety, the coastal zone exhibits a considerably wider range of site and feature types than do the different inland survey areas. In terms of distribution, the northern portion of the project area--both the coastal and inland parts--contains a greater density of remains than do either the central or southern portions of the project area.

As an overall assessment of the reconnaissance survey results, it would appear that the level of information obtained is sufficient to support the anticipated application to the State Land Use Commission for the desired change in the existing



Conservation District boundary within the project area. Based on the results of the archaeological work completed to date, it is felt that a relatively good working knowledge and understanding of the nature, distribution, and density of the archaeological remains present within the Farms of Kapua project area has been obtained. Particularly important is the basis now for defining the approximate inland limit of the coastal concentration of archaeological remains. This limit varies from c. 1000 to 1500 feet inland from the shoreline.

### EVALUATIONS

The significance of archaeological remains can be defined in terms of potential research, interpretive, cultural, and/or preservation values. Research value refers to the potential of archaeological resources for producing information useful in the understanding of culture history, past life-ways, and cultural processes at the local, regional, and inter-regional levels of organization. Interpretive value refers to the potential of archaeological resources for public education and recreation. Cultural value, within the general framework for significance evaluation used here, refers to the potential of archaeological resources for the preservation and promotion of cultural and ethnic identity and values. Preservation value refers to the need to conserve an adequate and representative sample of the archaeological resource base for future uses.

To attempt evaluation of the significance of archaeological resources on the basis of a preliminary assessment such as a reconnaissance survey is generally somewhat premature. Occasionally it is possible at even a preliminary level of study, such as that of a reconnaissance survey, to evaluate the significance of specific sites or features when their research, interpretive, cultural, and/or preservation values are obvious. In most instances, however, it is necessary first to conduct more inensive survey, often including test excavations, to determine and document the significance of specific archaeological remains.

Based on the findings of the reconnaissance survey field work, it is possible to offer tentative, preliminary assessments of the potential archaeological significance of the 56 designated sites that were identified and inspected. The nature and relative degree of significance for these sites are listed in Table 4. It will be noted that the full range of archaeological significance, in terms of research, interpretive, and cultural values, are exhibited by the identified remains in varying degrees. For the most part, the nature and degree of significance assigned to the previously recorded H.R.H.P. sites has been taken from their individual H.R.H.P. site record forms. The nature and degree of

Table 4.

SUMMARY OF SITE EVALUATIONS AND RECOMMENDATIONS
FARMS OF KAPUA PROJECT AREA

| Site No.* | Site Type/Description | Significance** Degree and Nature | Preliminary Recommendations General | Est. Man-days |
|---|---|---|---|---|
| 1994 | Residential complex | Mod. Res./Mod. Int. | Int.Sur.# | Valuable-SR## |
| 1995 | Possible shrine or heiau | High Res./Mod. Int. | " | Valuable-SR |
| 1996 | Residential complex | High Res./High Int. | " | Valuable-SR |
| 1997 | Residential complex | High Res./High Int. | " | Valuable-SR |
| 1998 | Residential complex | Mod. Res./Mod. Int. | " | Valuable-SR |
| 1999 | Shrine complex | High Res./High Int. High Cultural | " | Valuable-SR |
| 2133 | Heiau complex (Ahole Heiau) | Mod. Res./High Int. | " | Valuable-SR |
| 2134 | Holua slide complex | High Res./High Int. | " | Valuable-SR (also National Reg.) |
| 2135 | Burial complex | High Res./Mod. Int. Mod. Cultural (?) | " | Reserve-SR |
| 2136 | Residential complex | High Res./Mod. Int. | " | Valuable-SR |
| 2141 | Residential complex | Mod. Res./Mod. Int. | " | Reserve-SR |
| 2142 | Residential complex | Mod. Res./Mod. Int. | " | Reserve-SR |
| 2143 | Circular structure (function unknown) | High Res./Mod. Int. | " | Valuable-SR |
| 2144 | Enclosure (residential?) | Min. Res./Min. Int. | " | Marginal |
| 2145 | Residential complex (shelters) | High Res./Min. Int. | " | Valuable-SR |
| 2147 | Residential complex | Mod. Res./High Int. | " | Valuable-SR |
| 2162 | Residential complex | Mod. Res./Min. Int. | " | Reserve-SR (?) |
| 3705 | Refuge cave | Mod. Res./Mod. Int. | " | Reserve-SR |
| 3706 | Residential complex (principally caves) | High Res./High Int. | " | Valuable-SR |
| 3707 | Residential complex | Mod. Res./Poor Int. | " | Reserve-SR |
| 3775 | Heiau (Kapua Heiau) | High Res./Mod. Int. | " | Valuable-SR |
| 9901 | Residential/agri-cultural complex | Mod. Res./Min. Int. | " | to be determined |
| 9902 | Residential or heiau complex | High Res./Mod. Int. Cultural (?) | " | 20 |
| 9903 | Residential feature (cave) | High Res./Mod. Int. | " | 25- |
| 9904 | Residential feature (cave) | Mod. Res. | " | 12 |



Table 4. (Continued)

| Site No.* | Site Type/Description | Significance** Degree and Nature | Preliminary Recommendations General | Est. Man-days |
|---|---|---|---|---|
| 9905 | Residential complex | Mod. Res. | Int. Sur.# | 12 |
| 9906 | Residential complex | Mod. Res. | " | 20 |
| 9907 | Residential or heiau complex | Mod. Res. | " | 16 |
| 9908 | Historic camp site | --- | " | to be determined |
| 9909 | Agricultural complex | Mod. Res. | " | to be determined |
| 9910 | Residential complex | --- | " | to be determined |
| 9911 | Residential complex | --- | " | to be determined |
| 9912 | Residential complex | --- | " | to be determined |
| 9913 | Paved trail with assoc. structural features | Min. Res. | " | to be determined |
| 9914 | Paved trail | Min. Res. | " | to be determined |
| 9915 | Residential feature (cave) | Mod. Res. | " | to be determined |
| 9921 | Walled enclosure | Min. Res. | " | 2 |
| 9922 | Residential complex | Mod. Res. | " | 2 |
| 9923 | Residential complex | Mod. Res. | " | 4 |
| 9924 | Walled shelter | Mod. Res. | " | 2 |
| 9925 | Residential/agri-cultural complex | High Res. | " | 10 |
| 9926 | Residential feature (cave) | Mod. Res. | " | 4 |
| 9927 | Residential feature (cave) | High Res. | " | 8 |
| 9928 | Residential complex (shelters) | Mod. Res. | " | 8 |
| 9929 | Residential complex | Min. Res. | " | 6 |
| 9930 | Residential complex (possible agricultural) | Mod. Res. | " | 6 |
| 9931 | Agricultural complex | Min. Res. | " | 6 |
| 9933 | Residential feature (cave) | Min. Res. | " | 4 |
| 9934 | Platform (burial?) | Mod. Res. | " | 2 |
| 9935 | Residential feature (cave) | Mod. Res. | " | 3 |
| 9936 | Residential complex (caves) | High Res. | " | 8 |
| 9937 | Residential complex | Min. Res. | " | 3 |
| 9938 | Residential feature (cave) | High Res. | " | 8 |
| 9939 | Walled shelter | Min. Res. | " | 2 |

Table 4. (Continued)

| Site No.* | Site Type/Description | Significance** Degree and Nature | Preliminary Recommendations General | Est. Man-days |
|---|---|---|---|---|
| 9940 | Cave | Min. Res. | Int. Sur.# | 4 |
| 9941 | Walled enclosure | Min. Res. | " | 2 |

* Hawaii Register of Historic Places Site No. 50-10-XX-____

** Significance Evaluation
1. Nature of significance--assesses potential value in terms of one or more of the following categories: research value, interpretive value, cultural value, and preservation value.
   a. Research (Res.) value refers to the potential for producing information useful in the understanding of culture, history, past life-ways, and/or cultural processes at the local, regional, and/or inter-regional levels of organization.
   b. Interpretive (Int.) value refers to the potential for public education and recreation.
   c. Cultural value refers to the potential for preservation and promotion of cultural and ethnic identity and values.
   d. Preservation value refers to the need to conserve an adequate and representative sample of the archaeological resource base for future use.
2. Degree of significance--high value, moderate (Mod.) value, minimal/limited (Min.) value, and little/no value.

\# Int. Sur.= Intensive Survey

## Sites 1994-3775 were previously recorded during the Statewide Inventory and their status on the State Register (SR) -- Hawaii Register of Historic Places is presented.

The following information was taken from these site forms:
a. approximate area
b. site condition
c. site integrity
d. significance
e. evaluation (Hawaii Register of Historic Places status)



significance assigned to the newly identified sites found during the present reconnaissance survey were tentatively determined on-site during the field work and subsequently reviewed upon completion of the field work.

The preliminary evaluations presented in Table 4 apply only to the 56 designated sites within the project area. Other archaeological features encountered within the various survey areas can be generally regarded individually as being of lesser significance, with their potential value primarily for archaeological research purposes, and/or as possibly associated components related to one of the 56 designated sites.

## RECOMMENDATIONS

At this point, several tentative general recommendations can be made concerning the archaeological-historical aspects of the Farms of Kapua development project. First of all, no further archaeological work of any kind should be undertaken until the final report on the reconnaissance survey has been reviewed by the State Historic Preservation Office and the Hawaii County Planning Department, and until the State Land Use Commission has granted approval of the desired change in the Conservation District boundary. Secondly, assuming that the land use boundary change is approved, immediate consultations should be held with the Hawaii County Planning Department to determine as specifically as possible the probable requirements to be imposed as permit conditions for S.M.A. and/or rezoning applications. In general, it can be anticipated that intensive archaeological survey work, including both detailed surface survey and test excavations, will be contained within these requirements. It is also considered quite probable that the Hawaii County Planning Department might require preparation of a written archaeological-historical resource management plan, including a combined research design and data recovery plan element, as an S.M.A. and/or rezoning condition. At the same time, the exact scope and scale of any such further archaeological work will depend to a large extent upon specific development plans and priorities. It can also be assumed that further archaeological reconnaissance survey will required for any specific areas within the project area under active development consideration, but which were not covered as part of the sample survey areas inspected during the initial reconnaissance survey work.

Preliminary recommednations regarding further archaeological work at specific sites identified during the present reconnaissance survey are also listed in Table 4. A general recommendation for intensive survey--including detailed recording and selected test excavations--has been made for all 56 designated sites. It will

be noted, however, that approximate man-day estimates for the labor required to carry out the intensive survey work have been made only for most of the newly found sites, and not for the previously recorded H.R.H.P. sites. The scope and scale of further work at these latter sites should best be worked out in consultation with the staff archaeologist for the State Historic Preservation Office. Such consultation could perhaps best take the form of an on-site field inspection and evaluation trip. In all cases, it is strongly recommended that the specific scope and scale of any further archaeological work be worked out in consultation between the developer and his archaeological consultant, and the appropriate State and County representatives.



## REFERENCES CITED

Baker, H.L., T. Sahara, T.M. Ryan, E.T. Murabayashi, A.Y. Ching, F.N. Fujimura, and I. Kuwahara

1965 Detailed Land Classification - Island of Hawaii. L.S. Bulletin No.6. Land Study Bureau, University of Hawaii. Honolulu, Hawaii.

Downs, B., D. Hay, and G.E. Thompson

1982 The Lands of Kapua: Interpretation of Aerial Photography in Archaeological Reconnaissance. Research paper prepared for Geography 472. University of Hawaii-Hilo.

Emory, K.P.

n.d. Kona Field Notes [1932]. Department of Anthropology, Bishop Museum.

1970 Inventory of Archaeological and Historical Sites in the Districts of Kona and Ka'u and in Anaehoomalu, South Kohala, Island of Hawaii. Departmental Report Series 70-12. Anthropology Department, Bishop Museum.

Hansen, V.

n.d. Field Notes [1963-1969]. Department of Anthropology, Bishop Museum.

Hawaii State-Department of Land and Natural Resources, Division of Water and Land Development

1970 An Inventory of Basic Water Resources Data: Island of Hawaii. Report R34. Honolulu, Hawaii.

Keppeler, H.K., with K.P. Emory and E.H. Bryan

1932 Map of a Portion of Kapua, South Kona, Hawaii: Beach from Okoe Boundary to Kaupo Bay. B.P. Bishop Estate Map No.2525.

Reinecke, J.E.

n.d. Survey of Sites on West Hawaii. (Section 9: Survey of Hawaiian Remains, Honaunau to Ka'u Line.) Manuscript [1930]. Anthropology Department, Bishop Museum.

Stearns, H.T., and G.A. MacDonald

1946 Geology and Ground-Water Resources of the Island of Hawaii. Bulletin 9. Hawaii Division of Hydrography.

Stokes, J.F.G.

n.d. Survey of Heiaus of Hawaii. Manuscript [1919]. Anthropology Department, Bishop Museum.

United States-Department of Agriculture, Soil Conservation Service

1973 Soil Survey of Island of Hawaii, State of Hawaii.



## APPENDIX I.

Historic Sites Section-Division of State Parks letter of April 25, 1980, summarizing available information on file in the records of Hawaii Register of Historic Places sites present at Kapua.

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

RECEIVED
SEP 20 1982
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CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

April 25, 1980

File Archaeological Sites Kapua

Subject: TMK 8-9-06:3 6 19

As per your telephone conversation with our archaeologist, Patricia Beggerly, on April 16, 1980, we are sending you herewith information regarding archaeological sites on the property you are proposing to develop on the Island of Hawaii.

Site No. 10-65-1994--Kalapili Point Complex

This site complex includes Reinecke's (1930) site #69, as well as Bishop Museum sites no. HA-C2-35 and C2-36, which are portions of Emory's (1970) site 50-10-65-3709. This grouping of 3709 includes too much space and too many units for convenient handling.

Kalapili Point Complex seems to be the focus of a number of trails which connect it internally and to units nearer the bay. The group of features is clustered and apparently integrated; it is also typical of aa flow building techniques and forms. This was a small village settlement.

The complex is located on a rough aa flow and consists of a series of platforms and enclosures linked by a maze of stepping-stone trails. All are built of rough aa fragments with smaller fragments used as flooring on tops of the platforms and on the bottoms of most of the enclosures. From appearances, there is a mixture of living platforms and puoa, or burial platforms. Several have obvious fire hearths in their upper surfaces. A number of cairns (ahu) are scattered about without any apparent pattern. A line of platforms lie near a trail that is about one meter wide and paved with fragments of aa, not stepping-stones.



Site No. 10-65-1995--Stone Wall Structure With Platform

This rather massive structure lies just inland of the coastal jeep road and on the aa lava flow just south of Kapua Bay. The function is uncertain but it may have been a house platform as suggested by Emory or, more likely, a religious shrine or small heiau.

The structure should have high interpretive value though this is limited by the relative inaccessibility of the area. Research potential should be moderate to high. Historical material research might allow clearer assessment of function. The paucity of midden materials, the massive construction and continuous walls without formal openings argue against a house site. Similar structures in Kona, however, have been strewn with midden and evidently were house platforms. The raised platform inside might indicate a shrine as would the massiveness; no uprights were present, however. The seaward platform below the structure was certainly a habitation site because of the firehearth.

This structure is valuable because of its condition and its interpretive value despite its distance from easily traveled roads.

Site No. 10-65-1996--Oea Bay Complex

Oea Bay is a shallow indentation into the rocky coastline and has a small sandy beach area. Lying behind the beach and to the north and south are at least four habitation areas, as well as a number of enclosures. Trails lead inland from these features, probably to inland agricultural areas. The best features are closest to the bay; in the aa lava flow are other features but these are rather rudely built. It would appear that this was a contiguous settlement area which probably continued down into recent history, or at least into the 20th century, to judge from the few historic materials present. However, little in the way of historic midden or artifacts was seen.

The Oea Bay Complex has high research potential because of the habitation units, several of which have fairly deep midden deposits. Its interpretive potential is high for most are readily visible as old ruins to visitors. An interesting and educational interpretation of the complex could be developed through additional archaeological and historical research.

Site No. 10-65-1997--Kapua Bay Complex

Kapua Bay is a small indentation in the coastline with a rather minor sandy beach bordered on both sides by bleak rocky outcrops jutting into the sea. The gully and slough are forested by kiawe and the kiawe extends north along the coast to Oea Bay. Inside the arm formed by the gully and slough is a rough aa lava flow which is covered by a number of cultural features.

It is hard, if not impossible, to see a cultural discontinuity between the Oea and Kapua Bay complexes. If anything, Kapua Bay appears to have been more heavily utilized, particularly in historic times. The cultural features are in good condition in general and their functional diversity and evidence of sub-surface open cultural deposits make the area valuable for research. When this research potential is coupled with firm possibility of historic written documentation, the interpretive potential for the complex is enhanced.

Site No. 10-65-1998--Kapua Complex #1

On the seaward edge of the aa flow just south of Kapua Bay is a complex of enclosures, flat areas in the aa, and platforms. Beginning about 30 m south of Complex 1997 and adjacent to the jeep road is a platform 8 x 8 x 1.5 m high. Faces of stacked aa chunks were once evidently vertical, but are now generally sloping owing to rock fall. On the north central portion of the top is a scatter of 'ili'ili and a firehearth of water-worn rocks inset into the surface. Midden is also present on the platform surface.

There should be good research potential here and the interpretive potential should also be moderate to good. For example, if the unit described above is a pao as stated by the informant to Dr. Emory, it should be possible to illustrate another form of shrine.

Site No. 10-65-1999--Religious Complex

In the aa flow some 125 m south of 50-10-65-1995 is a cluster of shrines. Beginning at the north end, there is a small enclosure. The walls on three sides are about 0.75 m high, while on the seaward or west side there is only a low alignment about 0.25 m high. The interior is of clinker aa fragments and there are a few pieces of coral scattered on the surface. About 6 m south is a slightly larger enclosure, in good condition. Flooring is of



small aa fragments again and on top of this floor is a roughly defined raised rectangular platform in the rear. This platform is defined by water-worn stones holding a fill of large aa fragments. Another 5 m to the southwest, on top of a natural rise, a rough enclosure, 5 x 6 m, has been built. In generally deteriorated condition, this enclosure has walls averaging about 1 m in height, a flooring of small aa fragments and what appears to be the remains of a small pedestal platform in the center of the east wall. To seaward of this enclosure is a small rough platform built of aa rubble. The seaward (west) side of the platform has a facing of about 0.75 m, and the eastern edge flares into the naturally rising ground. Ten meters to the south again is a massive platform that must once have been very impressive.

The prime function of this complex seems to have been religious in nature and herein lies its significance. This is the first such cluster of allied religious features seen on the Kona coast although numerous individual shrines have been seen. While outside the confines of this complex, there are at least two other religious function structures nearby to the south.

Site No. 10-65-2133--Lae o Ahole Complex

This complex is located near Lae o Ahole Point and is contiguous to 50-10-65-1999 on the north and to 50-10-65-2134 on the south. Its inland or eastern boundary is approximately 200 m from the sea or where the aa flow rises in steep slope.

Just to the south of 50-10-65-1999 and about 8 m from the coastal jeep road is a rectangular platform built of large water-worn rock. 40 m east of the above platform and about 50 m south of it is another platform. Almost due south about 15 m from the previous platform lies another platform, just under the beginning of the kiawe area. It is built on the NE side of a pahoehoe outcrop, using this outcrop as one edge and built up to the level of it elsewhere. Almost contiguous to this enclosure, but a bit south and west, is yet another feature of uncertain function. Two trails lead inland from this area. The northernmost of these, a smoothed aa type, is marked by water-worn stepping-stones from the hau thicket to about 5 m inland. The hau thicket was impenetrable so origin of the trail is unknown. The second trail emerges from the southern edge of the thicket and goes inland also. Coral paving pieces mark a sub-trail which again disappears into the hau thicket.

About 15 m north of Ahole heiau is a well-made stacked aa wall. At one time this wall may have been attached to the heiau itself but only minimal traces of such connection now remain. The existing portion of the wall is about 50 m long in a generally E-W direction. It is tumbled in places and has a present maximum height of 1.5 m. Faced on two sides, it has a rubble core fill. Function is uncertain.

This area, in combination with 50-10-65-1999, appears to be the religious center for Kapua ahupuaa; there is little evidence of habitation here. While Ahole heiau is disrupted, enough remains for possible stabilization/reconstruction. Interpretive potential is high for this complex itself but increases with the addition of the shrines of 50-10-65-1999.

Site No. 10-65-2134--Ahole Holua Complex

To the south of Lae o Ahole Complex, 50-10-65-2133, this group of sites is located on the aa bluff inland of Puu Hinahina Bay. It is dominated by the massiveness of Ahole holua and indeed the smaller features near the slide may very well be functionally dependent upon this main feature.

The slide itself consists of a steeply sloping sliding ramp (ca. 60 m long) and a runway (2.5 m wide. ca. .5 m high on the eastern or top end of the slide). The runway is almost exactly 23 m long and is covered with stones approximately 30 cm in diameter. An alignment of water-worn stones and a rise in height of approximately 30 cm marks the beginning of the slide itself. Aside from these water-worn stones, the rest of the slide surface and facing is constructed with aa stones of varying size. The slide surface is about .5 m wider than the runway (6.25 m on each side) and is finished with quite small aa fragments. The height of the slide varies to make a smooth steep slope. The first meter or so from the top is fairly flat; the next 31 m are steeply sloping, at least 1:3. The next 15 m form a very steep slope 5':11'. The last 20 m are again flat and the surfaces change to 'ili'ili and coral with only small amounts of aa strewn about.

Its condition is excellent; if there is any destruction, it is only at the lower end where reported high seas and kiawe growth may have altered it and ruts in the slide area may have been made by goats in the area.

On the aa bluff to the north of the holua are large numbers of what appear to be the gallery terraces described by Violet Hansen and Kenneth Emory. Of these, at least 8 separate structures



(platforms, walls, stepping-stone trails, shelters, and walled enclosures) could be counted. These are situated in such a manner as to present a good view of the slide and it is not improbable that these features were used for just that function. The surface of the entire area between these features is covered with the "popcorn and peanuts" of the day--opihi, cowrie, pipipi, and conus together with kukui nut shells, animal bone and coconut fragments. These do not seem to occur in very deep layers signifying, perhaps, a temporary rather than permanent use of the area. The limits of the separate features are in some cases, difficult to distinguish and it seems more logical to consider the area as a whole than as individual units.

This is one of the best preserved holua on Hawaii Island, and within the entire state. A holua of this magnitude and elegance indicates the complexity of ancient Hawaiian culture wherein large labor forces could be marshalled to produce a luxury structure dedicated to a recreational use by the higher ranking Hawaiians.

The creation of a proper slide, with its required slope (much like that of a western ski jump), flatness of top, and proper length to ensure both sled speed and a deacceleration area, are indicative of the highly developed skills of the ancient Hawaiians in stonework engineering.

In summary, the Ahole Holua complex is of great value.

Site No. 10-65-2135--Burial Complex

This complex is located between Ahole holua on the north and Punawai o Kaupo on the south.

There are at least three puoa (burials) on top of the aa bluff from which the holua descends. Two of these are rectangular in shape while the third is circular. Beneath the bluff is a zone of barren, broken aa lava with many extrusions; seaward of this is a rocky, coral strewn shore and beach area.

In the interim broken aa zone there are a number of cultural features. Among these are several cleared places in the aa whose function is uncertain. A number of shelters utilizing the extrusions in their construction are within this area also. A low stone wall enclosure group may represent a habitation area.

Site No. 10-65-2136--Kaupo Bay Complex

This complex consists of seven house sites, two pens, kuleana walls, stepping-stone trails and two wells; all cluster around Kaupo Bay. These units were mapped in 1932 by Hebert Keppeler and the pertinent portion of that overall Kapua map is included here. They were visited again in 1965 and described by Violet Hansen of Bishop Museum.

While not the most spectacular complex, nor the most carefully constructed of its kind, the Kaupo Bay complex does offer good research potential because of its fairly deep midden deposits and the unusual coral piles.

Site No. 10-75-2141--Kapua Complex 2

This complex of istes includes Bishop Museum site nos. C2-15, A-I and is a portion of the Bishop Museum assigned no. 50-10-71-3708. This cluster has geographical and, apparently, social integrity and coherence; it has, therefore, been separated out of the larger number.

This habitation area is located on the pahoehoe flow 50 m inland behind the rocky pahoehoe shore line. Some white sand is present in the interim zone though in pockets rather than in a continuous band.

This appears to be a family complex complete with shrine. Research potential should be moderate to good.

Site No. 10-75-2142--Habitation Units

This feature, described by Reinecke (1930) as a "pen and shelter", is in fact, a house enclosure with a interior platform. This platform is set off by an alignment of water-worn pahoehoe and filled with 'ili'ili of water-worn pebbles and a little coral. Shell midden is scattered throughout the enclosure and there is a concentration of an ashy deposit in a depression in the pahoehoe "floor" of the enclosure.



Site No. 10-71-2143--Circular Structure.

On a slight promontory at the seaward edge of a large aa lava flow is an excellently constructed circular feature. In overall shape, it is like a hollow cylinder set on end. The outside height is about 1½ m and its overall diameter is about 2½ m. The inside diameter is some 1¼ m and the circular hole is 2 m deep. Lying immediately behind is a huge, almost vertical lava slab, but it is not part of the construction.

Site No. 10-71-2144--Enclosure

This feature is called a house site by Hansen (1965) but function appears less certain to the staff. Formally, it is a four-sided walled enclosure without an opening. Roughly built, the pahoehoe chunk walls are 0.5 - 0.75 m high, faced two sides but are not filled. Upright slabs are used in the east wall while about mid-way of the north wall is a huge block of extruded material projecting almost 1.0 m into the enclosure and ca. 2 meters in height.

Site No. 10-71-2145--Shelter Complex

This group of sites is located along the seaward fringe of an aa bluff immediately behind the coastal pahoehoe and about 15 m seaward of 50-10-71-2144.

The complex includes platforms, enclosures, work areas and shelter coves.

Site No. 10-71-2147--Habitation Complex

This complex of sites includes those features numbered by Bishop Museum as 50-10-71-3703 and 50-10-71-3750. Since there is considerable spatial isolation between this cluster and those north and south on this coast it is assumed that they have some social integrity as a group.

A long, rude and often ephemeral wall or alignment arcs from the aa flow near the end of the jeep road out across the pahoehoe in a sweeping curve toward the sea. On the shore in front of this flat enclosed area is a littoral spatter cone. The most inland portion of the wall is about 100-125 m inland of the littoral cone. The complex includes enclosures, platforms, walled shelters, and house sites.

Research potential in this cluster of sites is quite high. There are both pahoehoe and aa flow areas occupied here and research may indicate correlations and/or differences between the two adaptive areas. The underlying fireplace at the historic period house could provide a continuity picture of utilization of a habitation site.

Site No. 10-71-2162--Lava Tube Complex

This complex includes a number of walls and shelter caves spread over quite a large area and only briefly inspected. More detail survey of this zone should be undertaken.

This midzone appears to have been extensively used by the Hawaiians at least as a refuge area.

Site No. 10-71-3705--Lava Tube Cave Shelter

The inland entrance to this refuge cave is located near the end of the jeep road. The seaward entry is about 1 mile away and slightly to the southwest of the upland entry.

Site No. 10-71-3706--Lava Tube Complex

A large and complex system of lava tubes lies seaward of the U.S. Navy bombing target in Kapua. The complex probably extends over a distance of almost one square kilometer. It is possible that #3705, inland of the target, is part of this system. Many of the tubes are in excess of 5 m in diameter, with some chambers being 10-20 m across. The complex is easily spotted on stereo air photos. It lies in an area of pahoehoe higher than that lying to the north and has innumerable round holes (collapsed portions of tubes) visible.

Site No. 10-71-3707--Niouou Complex

This site consists of a trail, grinding holes, burials, platforms and house sites. Remains of a coconut grove are nearby.



Site No. 10-71-3775--Kapua Heiau

On the seaward edge of a pahoehoe flat are the remains of a heiau. This heiau is walled on 3 sides (north, east and south) and may have had a wall on the west side although it is now absent except for wall stubs at each end of the west side.

The heiau is constructed of a rubble filled interior and stacked, core-filled walls. The fill is of aa fragments, small pahoehoe slabs, some water-washed basalt, and a little pocillopora coral. In the northeast corner is a depression and the center has the remnants of what was once a built up platform but now so deteriorated it is difficult to be sure.

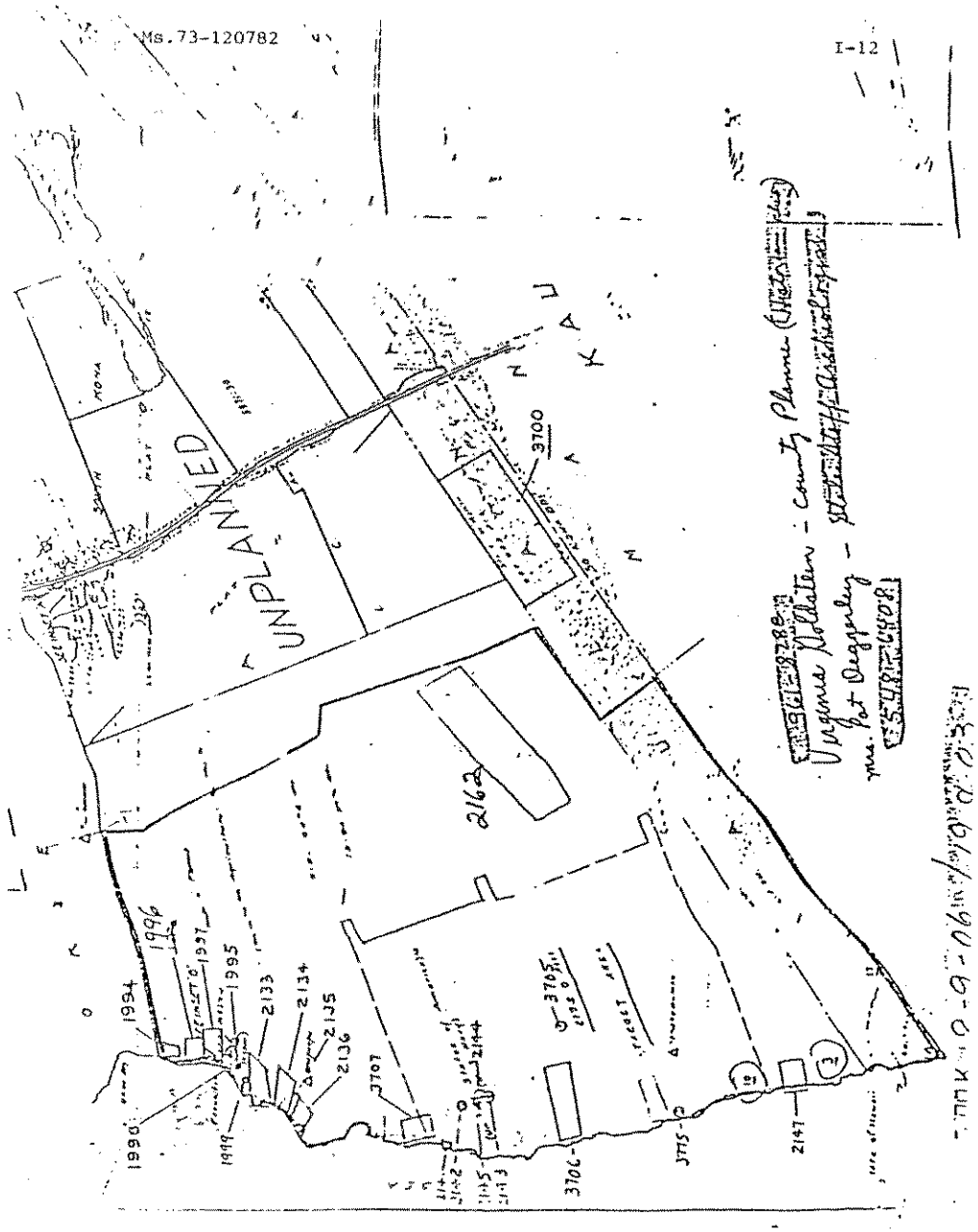
The walls were constructed by laying an inner and outer course of pahoehoe slabs horizontally on top of one another and then filling the core with small rubble. It would appear that the walls were built first and then the rubble for the interior laid down.

The condition is fair, owing to rockfall from the walls. The northern wall no longer retains vertical facing but is now rounded.

This heiau is significant in being so isolated on an exceedingly barren stretch of coastline. Its construction is quite similar to site number 2143, a heiau north of Kailua-Kona. It would thus have research potential for these are the only two examples of this techniques of construction yet seen.

Sincerely yours,

Ralston Nagata, Director
Historic Sites Section






APPENDIX II.

PRELIMINARY HISTORICAL DOCUMENTARY RESEARCH:

FARMS OF KAPUA PROJECT AREA
LAND OF KAPUA, SOUTH KONA
ISLAND OF HAWAII

by

Carol L. Silva
Historical Researcher

Introduction

It is the intent of this preliminary search primarily to establish the existance of historical documentation relative to the project area and to survey those sources which are immediately available.

A sampling of specific mythological, cultural and historical information has been assembled from the writings of native historians, from missionary and travellers' accounts, land records and cartographic sources.

MYTHOLOGY

Kapua is initially encountered in mythological literature in the legend of Kalaehina. Two abstracts of the story provided by Martha W. Beckwith are included here along with the complete formal text as it appears in the Fornander Collection of Hawaiian Folk-lore.

> "The younger brother of Kalaepuni can throw a canoe into the sea as if it were a spear, and split wood with his head. He proves his worth by getting six canoes for his brother out of a place where they were stuck, in the uplands of Kapua, South Kona, Hawaii. He makes a conquest of the island of Maui; its king, Kamalalawalu, flees and hides himself when Kalaehina defies his taboo. There he rules until Kapakohana, the strong usurper of Kauai, wrestles with him and pushes him over the cliff Kaihalulu and kills him." (Beckwith, 1918:368)

> "Legend of Kalaehina (Kalaikini, Kaleikini)
>
> "(a) Kalae-hina is so strong that he can throw a canoe into the sea as easily as if it were a spear, tear up trees by the roots, and split wood with his head. When the six canoes which his brother is building at Kupua (sic) in South Kona get stuck at the place called Na-wa'a-ho'okui in bringing them down to the sea, he hits on a plan to deliver five of them by sea from a different landing while he himself brings the sixth along on his back by the upper road. His brother therefore sends him to kill the chiefs of Maui and seize the rule from Kamalalawalu. At Kauiki in Hana the chief is found holding competitive sports and Kalae-hina enters the games. When the chief sees how strong the new champion is he runs away and hides at Wai-anapanapa.
>
> "Kalae-hina becomes ruling chief over Maui and gets such a great name for strength that the men who work for him are silent from fear. Kapakohana, who has superseded Ola on Kauai because of his strength, comes to test himself with Kalae-hina. They wrestle and Kapakohana manages to push his antagonist over the cliff Kai-halulu and drown him in the sea, after which feat he cuts out his jawbone and exhibits it to the people." (Beckwith, 1970:421-2)



"Chapter II. Relating to Kalaehina:

"We can see in the above story that Kalaepuni must have been a very brave and fearless man and also that he was very powerful. In this chapter we will speak of his younger brother Kalaehina.

"Before the death of Kalaepuni at Keanapou, on Kahoolawe, and while he was still king of Hawaii in place of Keawenuiaumi, he ordered the people from one end of Kona to the other to go with Kalaehina and haul down canoes at Kapua, a place in South Kona next to Kau. In this expedition Kalaehina was placed in charge. There were as many canoes as there were minor districts in Kona. When they arrived at the place where the canoes were lying, there were six of them, there being six minor districts in Kona, Kalaehina then said to the people: 'Ye servants of my older brother, Kalaepuni, hear me: the district that will get its canoe down to the shore first, its people shall be the favorites of Kalaepuni.'

"Upon hearing this the people of the respective districts then began to haul the canoes until they came to a cliff about six yards high at a place called Nawaahookui where all six canoes got stuck fast, not one being able to get down to the beach. Therefore the people left the canoes where they were and returned to Kalaepuni. When Kalaepuni saw the people he asked: 'Where are the canoes?' Kalaehina replied: 'We hauled them until we could not get them past a certain place by a cliff and we have left them there all stuck fast.' When Kalaepuni heard this he became very angry at his younger brother and said to him: 'Did I not put you over all men? Why did you not make them carry out my orders? You must therefore go and haul them down by yourself. The rest of the people shall not go to assist you, and if you will not be able to get the canoes down you shall be a sacrifice for the temple.'

"When Kalaehina heard the command given him by his older brother he was much frightened, for he believed that he was unable to get the canoes down. He, however, began to study the matter and all that night and the next day he spent in making plans as to how to overcome this most difficult matter. After at last hitting on a plan he went up to the place where the canoes were lying, took a look at them and proceeded to Kau. When he arrived in Kau he deceived the people, saying: 'Ye people of Kau, the king, Kalaepuni has given me orders to tell you to go and haul the canoes down to the beach.' When the people heard this they all started for Kapua. Upon arriving at the place, the people lifted up the canoes, carried them to a place from where they could be dragged to the beach and placed in the sea; five of them were then paddled to Keauhou, where Kalaepuni was stopping, while Kalaehina followed behind with the other canoe on his back, coming by the upper road to Kainaliu. When Kalaepuni saw this he praised his younger brother for being so strong.

"When the day of celebration of Kalepuni arrived the king displayed his brother's strength in the presence of all the people. Kalaehina took up one of the six canoes and threw it into the sea as though it was a spear, without much effort. A few days after this Kalaehina saw the king's chief steward chopping firewood, he picked up a stick of wood and struck it with his head, breaking the stick into small bits, thus making the hard ohia appear as nothing.

"When Kalaepuni saw how strong Kalaehina, his brother, was, he said: 'My younger brother, we are indeed fortunate because of our great strength. I have become king of Hawaii through my

great strength, now I think it well of you to go to Maui and kill all the offspring of the chiefs of that island so that you can reign in place of Kamalalawalu.' Kalaehina agreed to this request of his brother. At the close of the kapu days set apart for the sacrifices of the temple in Hawaii he set sail for Maui.

"When Kalaehina arrived at Hana, Maui, the people at the time were engaged in games of strength and skill of the king of Maui, Kamalalawalu, at the hill of Kauwiki. Great crowds of people were gathered and the kapu sticks separating the king's palace from the people were put up. When Kalaehina saw them, he took them down and boldly entered into the place reserved for the king. When Kamalalawalu the king saw these doings of Kalaehina he ordered the people to jump on Kalaehina and kill him. As the people were about to place their hands on him, he swept them off their feet as though they were but ants, killing a large number of them. At sight of this great strength, Kamalalawalu was so afraid that he escaped to a pool of water at Waianapanapa which lies in Honokolani, Hana, and this pool of water is there to this day.

"Kalaehina then became the king of Maui and he reigned in the place of Kamalalawalu. This fact was reported from Hawaii to Niihau and his great strength and succession as king of Maui was the one topic of conversation." (Fornander, 1918-1919:204-6)

A footnote accompanies the text in explanation of the place name Nawaahookui: "The name indicates the incident, 'canoes stuck fast.'"

Another folk-tale which involves the area, though only briefly, is one entitled "The Despotic Chiefs of Kau".

"2. Koihala

"An irresolute chief was Ko-i-ha-la. When the chief was visiting in Ko-na, he despatched a messenger to Ka-u with the order for food to be prepared and taken to Wai-ahu-kini, there to meet him. When all was in readiness, the servants bore it to Wai-ahu-kini. As they sat awaiting his appearance, they saw the chief's canoe heading for Kai-li-kii, so they took up the food again and went on to the place where they expected him to land. Not so! when they got to Kai-li-kii he was heading for Ka-pu-a.

"Again the men shouldered the food and followed toward the mountain, but as they reached Ka-pu-a they perceived the chief heading for Ka-alu-alu and they immediately proceeded thither.

"By this time they were hungry and tired and they therefore agreed to watch and, if the chief did not arrive shortly, to eat the food themselves. The chief delayed landing, simply sitting idly in the canoe and gazing at the men. So the servants ate the food that had been prepared and then they filled with stones the ti-leaf packets in which the fish had been wrapped and the empty calabashes of vegetable food. The chief, seeing these things, paddled furiously until he reached Ka-alu-alu. Hence has arisen the proverb, 'Kau ino auwaa o Kaalualu,' that is, 'The canoes arrive hurriedly at Ka-alu-alu.' Hastening up the beach to the spot where the men sat he cried, 'Say! let us eat! let the chief eat!' --- 'Yes, indeed!' answered the servants. 'Here is vegetable food and fish!' Whereupon they stoned the despotic chief to death." (Green, 1926:89)



Somewhat pertinent to the discussion of the mythology of the area are references to the land of Kapalilua. Although not specifically defined in the literature examined to date, it appears that Kapalilua was a general appellation incorporating several districts in South Kona near the Kau border; its exact boundaries could not readily be determined.

Following is a quick listing of references encountered in which the name Kapalilua occurs:

"...Kapalilua, South Kona..."
"...Kona Kapalilua, at the boundary of Kau and Kona..."
"...Papa, at Kapalilua..."
"...Honokua in Kapalilua..."
"...Okoe, Kapalilua..."
"...Okoe 1, Kapalilua, South Kona..."
"...Okoe 2, Kapalilua..."
"...Kapua, Kapalilua..."
"...Kapuakou, Kapalilua, Hawaii..."

Kapua's inclusion within this broader land area is significant enough to merit additional study of available references to Kapalilua in general.

Two mythological references appear in the Fornander Collection; the first is taken from the "Story of Lonoikamakahiki" and the second is a portion of a chant of the winds of Hawaii, extracted from the "Legend of Kuapakaa".

"Kamalalawalu dispatched his own child Kauhiokalani, otherwise known as Kauhiakama, for Hawaii instructing him thus: 'You go to learn the number of people there are on Hawaii, and on your return report to me.'

"In accordance with the wish of Kamalalawalu, Kauhiokalani, otherwise known as Kauhiakama, sailed for Hawaii. He arrived at Kohala at a landing place for canoes known as Puakea. Having arrived there, the canoes were put ashore and he began his itinerary along the coast of Kohala until he reached Kawaihae. On his journey he found very few people.

"Kauhiakama thence travelled on from there to Kona Kapalilua, at the boundary of Kau and Kona, not meeting many people. He continued on until he made the circuit of Hawaii, without seeing a great many people. At Kapaau, Kohala, on his homeward journey, there was congregated a large concourse of people at the athletic grounds called Hinakahua, it being customary for the people to gather together at this place for athletic contests.

"Kauhiakama remarked: 'I thought Hawaii had more people, but not so; it is only noted as being a large island, but as to the inhabitants there are very few. If the people on the route of my travel were only as numerically large as the people of this place, it would be something, but I find it is not so.'

"Kauhiakama, having observed the population of Kohala during this circuit, returned to Maui. Upon arrival there, Kamalalawalu asked him: 'How is Hawaii?' Kauhiakama replied: 'Kohala is depopulated; the people are only at the beach, because during my circuit of Hawaii I did not find a large number of them. I first arrived at Kohala, then traveled along its shore until Kawaihae was reached and did not meet a solitary man. At the place of my landing, however, I met a few, not exceeding forty, perhaps, and at Kawaihae there were some places with few men. I proceeded from Kawaihae through Kona to a part of Kau, all the way not meeting many people. That is the most desolate place, composed of nothing but clinkers...." (Fornander, 1916-1917:334-6)

"Kuapakaa said to his father: 'The men are advising the king to go on.' Pakaa said to the boy: 'Call out for the winds of Hawaii.'

"The Winds of Hawaii.
"There they are! There they are! There they are!
The apaapaa is of Kohala,
The naulu is of Kawaihae,
The kipuupuu is of Waimea,
The olauniu is of Kekaha,
The pili-a is of Kaniku,
The ae is of Kiholo,
The pohu is of Kona,
The maaakualapu is of Kahaluu,
The pilihala is of Kaawaloa,
The kehau is of Kapalilua,
The puahiohio is of Kau,
The hoolapa is of Kamaoa,..." (Fornander, 1918-1919:92)

BRIEF HISTORY OF THE AREA

In an effort to foster a proper, clearer perspective of the Kapua district in terms of the whole Kapalilua land area, general historical information relative to Kapalilua precedes the more specific data focussing on Kapua.

The native historian S. M. Kamakau records several episodes in which Kapalilua figures during the period of civil warfare prior to Kalaniopuu's dominance of the island of Hawaii:

"It was in 1754 that Keawe-'opala succeeded to the chieftainship over the island, with the chiefs and all his relatives placed under him. A number of the chiefs, however, who were deprived of their lands murmured against him and put up a fight against him, among them some of his own relatives such as Ke'e-au-moku, Keawe-poepoe, and Ku-mai-ku; but because of the number of his supporters the battle went against them. This fight was called Kai-omo and Moku-kohekohe because the coast was so well defended that there was no place to land, and the battle had to be carried on at sea.

"A canoe arrived from Kekaha and brought word to Ke'e-au-moku that Ka-lani-'opu'u was at Kapalilua /in south Kona/ and was coming to make war against Keawe-'opala. Ke'e-au-moku



therefore made up his mind to join forces with Ka-lani-'opu'u, and at Honomalino in Kapalilua Ke'e-au-moku came to offer his support to Ka-lani-'opu'u. When Keawe-'opala heard that Ke'e-au-moku had thus given his support to Ka-lani-'opu'u, he made ready his forces with Ka-moho-'ula as their leader, a famous fighter and skillful in maneuvering a battle. He sent his forces into South Kona by the east side of Hualalai, on the slope of Pae, and from thence to Kuapehu. Between Ke'ei and Honaunau lay the battlefield...." (Kamakau, 1961:78)

Kamakau goes on to tell us that not only was Kalaniopuu victorious in gaining dominion of the island of Hawaii, he also acquires Hana and Kipahulu, Maui through conquest. It is at this time, he says, that many of the Hawaii chiefs choose to reside in these Maui districts. One such chief is the afore-mentioned Keeaumoku.

At the time of Cook's visits, the following was noted:

"...At the time when Ka-lani-'opu'u returned to Hawaii to see Captain Cook, called Lono, all the chiefs returned with him to Hawaii, and Ke'e-au-moku also left Hana, went to live at Honokua in Kapalilua, and later moved westward with his wife and children to Honomalino and Miloli'i." (Kamakau, 1961:385)

"During the war between Ka-lani-'opu'u and Ka-hekili, between the years 1777 and 1779, the parents of Ka-'ahu-manu /Keeaumoku and Namahana/ went to Hawaii with their whole household and company of attendants and followed in the rear of Ka-lani-'opu'u's army, together with the twin half brothers of Ke'e-au-moku. /These were/ Ka-me'e-ia-moku and Ka-manawa, who had the same father (Keawe-poepoe) but different mothers, Ku-ma'ai-ku being the mother of Ke'e-au-moku and Ka-noena of the twins. Keawe-a-heulu also belonged to their company. His estates were the lands of Kapalilua, Ka'awaloa, and Kealakekua;..." (Kamakau, 1961:310)

Another native historian, John Papa Ii, relates the following incident subsequent to the death of Kalaniopuu:

"Following the days of mourning for Kalaniopuu, the chiefs of Kau suggested a division of districts, giving three to Kamehameha and three to Kiwalao. Kamehameha was to have Hamakua, Kohala, and Kona, and Kiwalao was to have Kau, Puna, and Hilo. The chiefs of Kau asked Kamehameha for South Kona also, where they could go and enjoy tranquility. When Kamehameha agreed, it was decided to deposit Kalaniopuu's corpse at Hale o Keawe in Honaunau, South Kona.

"Kamehameha was agreeable to everything that was said in Kau, feeling a deep respect for his older cousin Kiwalao. After everything was settled, Kamehameha departed for his own land at Halawa, Kohala. However, the chiefs of Kau changed their minds and wanted the remains of Kalaniopuu to go to Pa o Umi in Kailua, North Kona, so that more Kona lands would belong to them, and more calm places in which to live. This disturbed the chiefs of Kona, and so Kekuhaupio, who had been to Kau and had heard what was said, hastened to Kohala to bring Kamehameha to Keei before the arrival of the

Kau chiefs in Kona. He left to hurry on his journey, for part of Keei belonged to him and to some of the other chiefs.

"When the company from Kau reached Kapalilua in Kona with the corpse of Kalaniopuu, they heard that Kamehameha had arrived at Keei. That was probably the reason why the corpse was not taken to Kailua but to Honaunau, as they had originally agreed...." (Ii, 1973:13)

Another version of the same event is given in "The Prophecies of Keaulumoku" found in Kalakaua's Legends and Myths of Hawaii:

"A few months before the death of Kalaniopuu, Kahekili, learning of the failing health of his old opponent, prepared for the recovery of the district of Hana, which had been for nearly forty years under Hawaiian rule. Marching into the district and investing the fortress of Kauwiki, he finally reduced it by cutting off its water-supply, and Eastern Maui again became a part of the dominions of the moi of Maui. This occurred about the time of the death of Kalaniopuu.

"But what became of Keeaumoku and his family, whose home for years had been among the hills of Hana? Learning of the meditated invasion of the district, and unwilling to trust himself to the mercy of Kahekili, Keeaumoku fled with his family to the almost barren island of Kahoolawe, where he lived in seclusion until after the fall of Kauwiki and death of Kalaniopuu, when he boldly returned to Hawaii, quietly settled on his old and inalienable estates at Kapalilua, in South Kona, and awaited the development of events, which he plainly perceived were repidly and irresistibly tending toward wide-spread revolution and disorder.

...

"The mourning for Kalaniopuu continued for many weeks, and rumors unsatisfactory to the Kona chiefs were afloat concerning the new moi's proposed division of the lands subject to royal apportionment. Preparations for the burial of the bones of the deceased king were finally completed. In double canoes, one of them bearing the corpse of his royal father, Kiwalao set sail with a large party of chiefs, warriors and retainers for Honaunau. There it was his purpose to deposit the remains in the neighboring burial-place of Hale-a-Keawe, sacred to the ashes of Hawaiian kings, and then proceed with the redivision of such of the lands of the kingdom as were at his disposal.

"When off Honokua the second day, Keeaumoku came down from Kapalilua and boarded the fleet. His avowed purpose was to wail over the body of Kalaniopuu. His return to Hawaii had become generally known, and Kiwalao regarded with a curiosity not unmixed with suspicion the warring and impetuous chief, who had been first the friend and then the enemy of his father, and who had suddenly emerged at a critical moment full-armed from the obscurity of years.

"Hastening to Kehaha (sic), where his brothers, Kameeiamoku and Kamanawa, with Kamehameha, Kekuhaupio and other chiefs, were in council, Keeaumoku informed them that the destination of Kiwalao was Kailua, which place he would proceed to occupy after depositing the royal remains at Honaunau. This information, he declared, was given to him by one of Kiwalao's attendants.



"Not doubting the truth of Keeaumoku's story, and believing it to be the purpose of Kiwalao to occupy the entire district of Kona, which embraced lands not subject to royal disposal, the assembled chiefs moved with their followers and occupied quarters in the neighborhood of Honaunau...." (Kalakaua, 1888:361-2)

An account of Kamehameha in Kapalilua was set down by Kamakau in this way:

"Fishing was the occupation of Kamehameha's old age at Kailua. He would often go out with his fishermen to Kekaha off Ka'elehuluhulu and when there had been a great catch of aku or 'ahi fish he would give it away to the chiefs and people, the cultivators and canoe makers. If word was brought that 'ahi were plentiful at Kalae, off went the chief to the 'ahi fishing, and he fished also at Kaulana, Ka'iliki'i, Pohue, Na-pu'u-o-Pele, Kapalilua, and at other places along the coast...." (Kamakau, 1961:203)

A final reference documents something of the hospitality shown to a traveller in 1843:

"In 1843 came a report of a fight in Kau between the Protestants and the adherents of the Pope. The government ordered Ii to go there on the first ship to Hilo. So, in the first month of the year, Ii left Kamamalu with the teachers. By the time he reached Kau the disturbance was over. The participants in the fight were tried by Ii, and the people there turned to righteousness in our Lord Jesus.

"Ii was told that the women of western and eastern Kau planned to journey back and forth every week. He had a pleasant meeting with one company of traveling women and accompanied them to the place where they encamped. They looked at the Bible together and each read a verse. Ii left them all at Kahuku, as they were going home. The women of Kapalilua also gave Ii help until he reached Kahakuwai in Kainaliu, North Kona, where Kuakini raised coffee." (Ii, 1973:168-9)

SPECIFIC HISTORICAL REFERENCE TO KAPUA

A glimpse of the district of Kapua in 1823 is provided by the English missionary William Ellis:

"...about five in the afternoon landed at Kapua, a small and desolated-looking village, on the south-west point of Hawaii, and about twenty miles distant from Kalahiti. Here we had the canoe drawn up on the beach until our companions should arrive.

...

"Early the next morning the party at Honomalino proceeded to Kapua, and about eight a.m. joined those who had slept there.

"A Barren And Desolate Country.

"At this place we hired a man to go about seven miles into the mountains for fresh water; but he returned with only one calabash

full; a very inadequate supply, as our whole company had suffered much from thirst, and the effects of the brackish water we had frequently drank since leaving Honaunau.

"Nothing can exceed the barren and solitary appearance of this part of the island, not only from the want of fresh water, but from the rugged and broken tracts of lava of which it appears to be entirely composed.

"Unwilling to spend the Sabbath in the desolate and almost forsaken village of Kapua, we prepared for a long day's journey, as we knew of no village before us containing more than five or six houses for nearly thirty miles' distance.

"Before we left Kapua, we were so favoured as to procure water enough to fill our canteens, and about 10 a.m. resumed our journey. Messrs. Thurston, Bishop and Goodrich, walked on by the sea-side. About noon they reached Kaulanamauna, and shortly after left Kona, and entered Kau.

"A General Description Of Kona.

"Kona is the most populous of the six great divisions of Hawaii, and being situated on the leeward side, would probably have been the most fertile and beautiful part of the island, had it not been overflowed by floods of lava....

"The northern part, including Kairua, Kearake'kua, and Honaunau, contains a dense population; and the sides of the mountains are cultivated to a considerable extent; but the south part presents a most inhospitable aspect. The population is thin, consisting principally of fishermen, who cultivate but little land, and that at the distance of from five to seven miles from the shore." (Ellis, 1963:124-6)

The following description of a steamer off the Kapua coast was jotted by an English woman in the early 1860's:

"They had pulled all night against the prevailing sea breeze from Kapua, a little below Milolii...

"A few hours sailing along the lava-girt coast brought us to Kapua, where we landed and took some food. But the sea breeze afterward set in, and we were obliged to give up the attempt to proceed. After three and a half hours struggling against wind and current we put in to another village, named Honomalino, where a house was immediately given up to us." (Korn, 1958:63-4)

A single reference to the holua slide in Kapua was found in an article entitled "The Kona Coast", written in 1920 by A. S. Baker:

"Although the slide (holua) at Keauhou is the most interesting one in existence, long, massive, and well built, yet there is a short one at Ahole, some four miles south of Milolii. Slight remains of a heiau just back of the north end of the village of Milolii may be seen, and a couple of kuulas (fish heiaus) are passed enroute, by the trail, or one may comfortably visit the slide by canoe, with views of beautiful coral and colored fishes if one has a water-telescope. Though very ancient, the slide still has a good 'top dressing,' as we say of the roads, or smooth surface of fine stone. It is very short; a level approach of 75



feet, eight feet wide, and an incline of 200 feet, from eight feet wide at the start to twenty feet wide at the end on the shore. In one place it is built up ten feet high for just a short distance." (Baker, 1920:80)

A rapid scan through the Henry Kekahuna Collection revealed virtually nothing on the area. A single note offering an explanation of the naming of the district was located in File 43:

"Ka-pu'a. (Pu'a, - a kind of big tree.)" (Kekahuna, n.d., mss.)

## LAND RECORDS

### Mahele Awards

The Indices of Awards, which lists the original claimants and parcel acreages given during the Great Mahele, indicate that 9 separate claims were registered and awarded for the area of Kapua.

The whole of the ahupuaa was awarded to W. P. Leleiohoku who received a total of 14,240 acres. Leleiohoku was an heir of Kuakini (who was the son of Keeaumoku and the governor of the island of Hawaii); he was the husband first of Nahienaena and then of Princess Ruth Keelikolani.

The 8 claims that were awarded within Leleiohoku's ahupuaa ranged from 1.37 to 4.67 acres in size; 6 of the parcels measured between 2 and 3.36 acres.

As each parcel awarded during the Mahele required registration and as testimony for each had to be received by the Land Commission, a typescript translation of these original documents in Hawaiian accompanies this report (Appendix A). Often descriptions of the house-lot, agricultural plots, vegetation, boundaries and origin of ownership are given. This specific kind of data has usefulness both to the archaeologist and to the historian alike.

### Land Documents

The Land File at the Hawaii State Archives yielded the following references to documents relative to Kapua:

Kapua & Lehoulaiki., Land of, in Kona, Hawaii no date

"In list of lands, showing that R.P. 6853, was issued to Leleiohoku, by name only on Land Claim No. 9971, on above land, in Kona, Hawaii."

Kapua, Ahupuaa of no date

"In list showing that above Ahupuaa in Kona Hawaii was set /aside/ to Wm. P. Leleiohoku, in the division made between the

King & the said Leleiohoku."

Kapua, Land of, (Kona, Hawaii) no date
"Re. the Leleiohoku Estate."

Kapua, Land of, in Kona, Hawaii 1850 May 27
"In re. division of lands between the Hawaiian Govt. & the heirs of W. P. Leleiohoku, showing that the above land was granted to said heirs, which was sanctioned by the Privy Council on May 27, 1850. Duplicate copy attached."

Kapua, Ahupuaa of, in S. Kona, Hawaii 1866 Apr. 25
"In report by J. H. Kalaiheana showing that the above ahupuaa belongs to Keelikolani."

Kapua, Land of 1871 Nov. 6
"In letter from W. T. Martin to C. T. Gulick stating that the owners of the land of Kahuku & the above desires to have the boundaries of said lands defined - That there are living at this time, certain Hawaiians who know the boundaries of said lands - Desires that the boundaries be settled at once, for if delayed, these old natives may die &c.
P.S. See also Int. Dept. Bk. 10 p.582"

Kapua, Land of 1873 Jan. 29
"In letter from W. T. Martin to the Estates of Kamehameha V & Keelikolani asking that the above land be leased to W. T. Martin & Co. for 10 years at an yearly rental of $200 beginning on April 1st or July 1st 1873 & to pay all Govt. taxes assessed thereon."

Kapua, Land of 1873 Feb. 1
"In letter from R. A. Lyman to the Commissioner of Crown Lands stating that the Governess of Hawaii owns the above land adjoining the land of Kahuku."

Kapua, Lands in 1873 May 24
"In letter from Min. of Interior to H. N. Greenwell, forwarding the following Royal Patents for lands in the above tract
See pages 246 & 247 of the above Letter Book
ALLODIAL TITLES.
No. 4349 Kapa $5.00
" 3677 Kama $5.00"

A few other document references exist which have not been included in this enumeration due to the uncertainty of whether the document involved refers to Kapua in Kohala, or Kahaluu, No. Kona, South Kona or Waimanalo, Oahu.

A check was made of the actual Land Commission Award and Royal Patent documents of parcels awarded in Kapua. For <u>each</u> parcel, some kind of documentation exists either in the form of crude maps, boundary descriptions or text. Several documents are fragile and very faded and all are written in Hawaiian except for one document dated 1876 which proves to be Ruth Keelikolani's Boundary Certificate of



Kapua Ahupuaa. This Certificate is apparently the result of the three 1873 letters in the Land File referenced earlier.

CARTOGRAPHIC SOURCES

No registered maps of the Kapua area could be found on file at the State Survey office. An unregistered copy of a 1932 Bishop Estate map (#2525) plotting in detail a portion of the ahupuaa was seen there. Bishop Estate was contacted and a copy of the map was requested and received.

Copies of current Tax Maps of the area depict the location of each of the original Land Commission Awards; some detail of nearly all of the parcels are included in insets. These Tax Maps have been included in this preliminary report for reference purposes.(See Appendix B)

Another unregistered shell-line drawing was also recently seen at the Survey office. As none of the land parcels were shown or delineated, a more in-depth study of the map was deferred for the present. This particular map, dated 1909, does have research potential in that place names were plotted - these were located mainly along the shore. Additional research time is needed to first ascertain where copies may be obtained and then to conduct an examination of the data the map provides.

RECOMMENDATIONS

Additional research hours should be expended toward the in-depth study of land documents; special emphasis should be placed on the translation of the original L.C.A. and R.P. records. Closer attention should also be given to each article of correspondence referenced in the Land File index. Probates of the original parcel owners, should they exist, need to be examined for any relative data contained therein.

The afore-mentioned shell-line map as well as cancelled Tax Maps of the area require special study and a list of place names should be developed.

These are priority recommendations; of a secondary nature, additional work should be done in gathering more historical and literary accounts and descriptions of the area.

## BIBLIOGRAPHY


Baker, Albert S.
1920 "The Kona Coast". Hawaiian Almanac And Annual For 1921. Honolulu: T. G. Thrum.

Beckwith, Martha Warren
1970 Hawaiian Mythology. Honolulu: University of Hawaii Press.

1918 The Hawaiian Romance Of Laieikawai. Washington: Government Printing Office.

Board of Commissioners to Quiet Land Titles
1929 Indices of Awards. Honolulu: Territory of Hawaii.

Ellis, Rev. William
1963 Journal of William Ellis. Honolulu: Advertiser Publishing Company, Ltd.

Fornander, Abraham
1916-1917 Fornander Collection of Hawaiian Antiquities and Folklore. Vol. 4. Honolulu: Bishop Museum Press.

1918-1919 Fornander Collection of Hawaiian Antiquities and Folklore. Vol. 5. Honolulu: Bishop Museum Press.

Green, Laura
1926 Folk-tales From Hawaii. Poughkeepsie, New York: Vassar College.

Hawaii State Archives
n.d. Land File index

n.d. Native Register Vol. 4 (typescript)

n.d. Native Register Vol. 8 (typescript)

n.d. Native Testimony Vol. 8 (typescript)

Ii, John Papa
1973 Fragments of Hawaiian History. Honolulu: Bishop Museum Press.

Kalakaua, His Hawaiian Majesty
1888 Legends and Myths. New York: Charles L. Webster & Company.

Kamakau, Samuel M.
1961 Ruling Chiefs of Hawaii. Honolulu: Kamehameha Schools Press.

Kekahuna, Henry P.
n.d. Private Collection located in the Hawaii State Archives.

Korn, Alfons L.
1969 The Victorian Visitors. Honolulu: University of Hawaii Press.


Respectfully submitted Carol L. Silva
Date November, 1982



## APPENDIX A.

Copies of transcript translations from selected Land Commission testimonies.

No. 9968 Lauwalu Laie, Feb. 7, 1848 Page 502

To the Land Commissioners, Greetings: I, Lauwalu am a claimant of land at Laie. In the 'ili of Naualoli is one lo'i. In the 'ili of Kumupali is one lo'i. My land claims were from Kauaiamano and Paakahi. Because they are so scattered it is not practical to tell you their boundaries.

LAUWALU

---

Molokai
No. 9969 Laniheleua Dec. 6, 1848

Greetings to you, the Land Commissioners: I hereby state to you that one half of Kamiloloa is for me, on the Island of Molokai.

LANIHELEUA

---

Maui
No. 9970 G. Laanui Feb. 12, 1848

Hear ye, ye Land Commissioners: I hereby tell you of my land on the island of Maui at Lahaina. The Ahupua'a of Uhai, which has been divided into one-third parts.

G. LAANUI

---

No. 9971 Wm. P. Leleiohoku Honolulu, Feb. 14, 1848

The Land Commissioners, Greetings: I hereby state on this paper, and on the attached paper, all my claims for land, from Hawaii to Kauai, genuine claims for land, and house lot claims. Here are the claims for 'Aina maoli /lands genuinely owned/:

The Lands of Wm. P. Leleiohoku Page 503

| The Lands | Type of Land | | District | Island |
|---|---|---|---|---|
| 1. Hookena | Ahupua'a | | Kona | Hawaii |
| 2. Kiloa | " | no award | " | " |
| 3. Honokohauiki | " | | " | " |
| 4. Kaumalumalu | " | | " | " |
| 5. Lauhulu | " | no award | " | " |
| 6. Auhaukeae | " | Kekauonohi | " | " |
| laid off _____ | | page 614 v.10 | | |
| 7. Moeauoa | " | | " | " |
| 8. Lehuulaiki Do | " | | " | " |
| Halepohaku, Halelau, Pahipa | | - Kailua, Waimea | | |
| 9. Kapua | " | | " | " |
| 10. Hilea | " | L. Kamehameha | Kau | " |
| 11. Kahilipali | " | | " | " |
| 12. Kahuku Do | " | no award | " | " |
| 13. Puaaloa (none) | " | Palaa | Puna | " |
| 14. Kikala | " | | Hilo | " |
| 15. Waikoloa | " | | Hamakua | " |
| 16. Honopue Do Honopueo | " | none | " | " |



The Lands of Wm. P. Leleiohoku Page 503

| The Lands | Type of Land | District | Island |
|---|---|---|---|
| 17. Kaiwiki | Ahupua'a | Hamakua | Hawaii |
| 18. Paalaea | " | " | " |
| 19. Niulii | " | Kohala | " |
| 20. Awalua Do | " none | " | " |
| Lot at Iole Two | | | |
| 21. Poepoe | " | " | " |
| 22. Puanui | " | " | " |
| 23. Hukiaa Do | " none | " | " |
| 24. Kealahewa Do | " to Kaoanaeha | " No.8595B | " |
| 25. Kapaa Do | " to Kale Davis | " 8522B | " |
| 26. West half of the District of Hamakua poko (none) | | | Maui |
| 27. Napuumaile Do | " none | Hamakualoa | " |
| 28. Hanawana Do | " to Kanui H.K. No.5250 | " | " |
| of Kaiko | | | |
| 29. Kuiaha | " | " | " |
| 30. Puako Do | " none | Lahaina | " |
| 31. Aki 2 | " Kekauonohi | " | " |
| 32. Kamalo Kaamola | " No.9971 | Kona | Molokai |
| 33. Punaluu | | Koolau poko | " |
| | The Minutes of P. Council May 27, 1850 | | |

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| | | | |
|---|---|---|---|
| 34. Punalau | " | Koolau loa | Oahu |
| 35. Kaakopua | a mahina /farm/ | Honolulu | " |

Those are my lands -- some Ahupua'as and the 'ilis in them and the half of the district of Hamakua-Poko. The 'ilis and the leles of these ahupua'as and the leles and 'ilis which are in the lands of others, and their lihis and places which were wrongly transferred to someone else, and the ones wrongfully entered by those with no right thereto, and the things denied in the nature of the rights of the natives, that is my share for which my claims are presented to you. The lihi places which were taken in by the King and the chiefs in order to benefit the populace and the Government are conveyed, if they truly are needed by the Government and all the people, then my directions to you shall be void, but an explanation should be given me to enable me to release these lihis outside of my land and district boundaries. But, if these lihis are taken by someone in order to enrich the occupant, or the Government, perhaps, it shall be possible to quiet the title and return it to me, as in my Document which Describes Lihis, to be issued hereafter; on this paper only you shall investigate the claims which I am here stating. The Lihi Leles and the claims for lihi and mahina and ko'ele, and the lihis from upland to sea, and the fishing grounds, perhaps, and all the rights which pertain to these lands, are what I hereby ask for,

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to quiet title and award to me, excepting the Government's ko'eles which are not attached; if however the Government's Po'alua is not also changed, and the ko'eles which enrich it, without being for the benefit of the populace, and if some words opposing these claims are not reinvestigated, then, consider me, without my having to ask, in the way that I am now quieting title. All the land has been surveyed on its boundaries for the exact separation of the division, and the payment of the commutation has been made. This is also for the Government and the Government will pay for its survey if it passes to its share, if not, however, it is not possible to divide up the Government's Third. The witnesses of these claims are the populace who well know of my occupancy, and also the King's Mahele Book, which is well known. These lands are for myself and for ourselves and my heirs and representatives and we shall be able to work on these claims when our time shall come to substantiate them. I am, respectfully, your obedient servant,

WM. P. LELEIOHOKU

Here are the house lot claims and the sites, some claims for land on Hawaii, Maui, and here on Oahu. They are numbered as follows: No. 1 "Hulihee Lot and the house within" at Kona, Hawaii. No. 2 House lot for Tailor Shop at Keopu, Kona, Hawaii. No. 3 Lot at Kaaipuhi. No. 4 A lot at Niumalu. No. 5 Kalakeakua Lot. No. 6. Puuloa Lot at Lanihau. No. 7 Lot occupied by Laioha. No. 8 House site at a place called the Fort, of the Island of Hawaii,



with five houses in it. No. 9 Lot in Kahaluu. No. 10 Papaula Lot at Honuaula. No. 11 Papa, house site at Honuaula. No. 12 Lot for Naluana. No. 13 Kaualomalie Lot at Honaunau. No. 14 Waioha, house lot at Honaunau. No. 15 Lot at Holualoa. No. 16 Lot at Hianaloli. No. 17 House site mauka of Kainaliu. No. 18 Lot at Kuapehu, Kaawaloa. No. 19 Some house sites, named Kaaipu in Kawaihae, Kohala. No. 20 Kaaeao is the name, at Kalaeone in Kawaihae. No. 21 House site named Poohuai. No. 22 House site in the middle of the commoners' land. No. 23 Kamakahonu Lot in Waimea. No. 24 Kaaihapuu at Puako. No. 25 Two house lots at Iole. No. 26 House site at Niulii, Kohala. No. 27 Lot at Waipio, Hamakua. No. 28 Lot at Kamaoa, Kau. No. 29 Three lots at Kahilipali, Kau. No. 30 Lot at Keopu, Kaluapaa. No. 31 Lot at Kalamaunu. No. 32 Lot occupied by Loe, Kailua. No. 33 Lot to Umiokalani at Kailua. No. 34 Lot occupied by Kamauoha. No. 35 Lot at Pakina in Kau, occupied by Laanui. No. 36 House lot at Kuhua, Lahaina, Maui. No. 37 House lot occupied by Kahinu in Honolulu. No. 38 Parcel of land named Pakaka occupied by Jimo Hobisona /James Robinson/ No. 39 Kaaihee on the east of the kula of Kahua, a lele of Kalawahine, seaward of Makiki. Your obedient servant,

WM. P. LELEIOHOKU

---

No. 9976 Lono Koolauloa, Feb. 8, 1848

To the Land Commissioners: I hereby state my claims to you:





'ilis of land. Haleolono is the name of one and Kauhiaina is another. Palaueka is the name of the ahupua'a -- Kauhiaina is there. Haleolono is in the ahupua'a of Kaumalumalu.



KEOHOAEAE

---

No. 7912 Kaniu Kailua, January 31, 1848

Greetings to the Land Commissioners: I hereby state my claim for land in the ahupua'a of Waiaha 2. The name of the 'ili is Kauailoa. This 'ili is bounded by Pahukauila on the north, Haleuwaawaa on the south, Punaio on the west, and Makaihuwaa on the east.

KANIU

---

No. 7916 Kahueai Kailua, January 31, 1848

Greetings to the Land Commissioners: I hereby state my claim for land in the ahupua'a of Puaa 2. The name of the 'ili is Ohiki and it is 200 fathoms by 13 fathoms. A single kihapai at Ohiki 3 is 50 fathoms by 15 fathoms. A kihapai at Kamuku 1 is 8 fathoms by 5 fathoms.

KAHUEAI

---

No. 7926 Kanahele

Greetings to the Land Commissioners: I hereby petition for my house lot at Kalaoa 5 on Hawaii, in the ahupua'a of Leleiohoku in Kailua. It is 528 feet by 396 feet. That is the size of my house lot, for your information, O Land Commissioners.

KANAHELE

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No. 7927 Kama

Here is my 'ili, received from Namaielua, extending from the sea to the upland where taro is grown. There are 10 mala ofsweet potatoes, 4 mala of taro, 1 of pumpkin. My "jump" kihapais from Nooluo /?/ are 6 mala of taro. I also have a house lot which is 58 in circumference.
Kapalilua, South Kona KAMA

---

No. 7929 KaalauaHi Kalihi, Hawaii, 4 Feb. 1848 

Greetings to the Honorable Commissioners: I hereby state my claim for 3 'ili of land in the ahupua'a of Kalihi. They were given me by the konohiki, Kaee. From his own mouth he gave me the right, to pass on to my children -- that is my claim.

KAALAUAHI

No. 7930 Kapu

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Here are my 2 mo'o. Haleolono is one and Lihiiki is another. On the south is the sea, on the north is the forest. 2 mala of taro and 9 of sweet potatoes are in Haleolono 'ili. 13 mala of sweet potatoes are in the mo'o of Lihiiki. Those are my "jump" kihapais. 1 mala of sweet potatoes is in the mo'o of Kawaehonua. I have a "jump" kihapai from Kaaumoana, 2 mala of sweet potatoes in the mo'o of Luape.
Okoe 1, Kapalilua, South Kona KAPU

---

No. 7931 Kaaumoana

Here is my claim, an ahupua'a,* from Keana. 3 mala of taro, 7 of sweet potatoes, 1 of wauke, 5 of lauhala. The /kind of/ tree which I may take is the ulei. My house lot is 60 by 40, a circumference of 200.
Okoe 1, Kapalilua, South Kona KAAUMOANA

*In the Native Testimony, claimant is said to have an 'ili.

---

No. 7932 Kaluna

Here is my 'ili of land, received from Kaaumoana, named Luahana, from the upland forest to the sea. On the north is the forest, on the south is the sea. There are 10 mala of sweet potatoes and 1 of taro. I have a "jump" kihapai, received from Ulunui, of 2 mala of sweet potatoes at Kuloli. I have a "jump" kihapai received from Lukehi at Honomalino for 3 mala of taro. Also, at the seashore, I have 8 coconut trees in my lot. I have a "jump" kihapai named Kaneehonua, received from Kalimakuhi, 7 lauhala trees.
Kapalilua, District 3 KALUNA

---

No. 7934 Kapa

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Here is my 'ili of land, received from Namaielua. The mo'o is Kailiohia. My cultivated kihapai are: 10 mala of sweet potatoes, 1 of taro, 1 of gourd, 2 of lauhala. Here are my "jump" kihapais: in the mo'o named Ahole are 4 mala of sweet potatoes and 1 of taro. Another "jump" kihapai is in Haleola, with 3 mala of sweet potatoes. The house lot is 22 by 16, a circumference of 76.
Kapua, Kapalilua, District 3 KAPA

---

No. 7935 Kui

Here is my claim for an ahupua'a,* from Nakookoo. On the south is the sea, on the north is the forest. The /kind of/ tree which I may take is the kukui. There are 9 mala of sweet potatoes, 2 of gourd, 1 of coffee, 1 of taro, and 5 of lauhala.
Okoe 2, Kapalilua, District 3 KUI

*In the Native Testimony, claimant has an 'ili.



No. 7938 Kaikeleaukai

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Greetings to the Land Commissioners: I hereby petition for my house lot in the ahupua'a of Kalaoa 4 /held by/ Kaainoa, in Kailua, Hawaii. The length is 990 feet, the width is 264 feet. That is it, for your information, O Land Commissioners.
KAIKELEAUKAI

---

No. 7939 Kanahele

Greetings to the Land Commissioners: I hereby petition for my 'ili of land in the middle of the ahupua'a of Kalaoa 5, of Leleiohoku, in Kailua, Hawaii. My land is as follows: On the north is Haleolono, on the east is Kalulu, on the south is Kaholo Two, on the west is Keahole. That is it.
KANAHELE

---

No. 7940 Kaaua

Here is my 'ili of land received from Namaielua. The mo'o is Kipu, in

Page 517

a large 'ili from the upland to the sea. My cultivated kihapais are: 8 mala of sweet potatoes, 5 of taro, 2 of lauhala, 3 of gourd. My "jump" kihapai are 1 mala of sweet potatoes in the mo'o of Puhinahi. At Puuhinahine, received from Namaielua, are 3 mala of sweet potatoes, 1 of lauhala, and also a house lot.
Kaua, Kapalilua, District 3 KAAUA

---

No. 7941 Kaelemakule

Here are my mo'os, received from Kai. Their names are Halekamahine and Lihiiki. On the south is the sea, on the north is the forest. There are 9 mala of sweet potatoes, 3 of taro, 1 of gourd, and 2 of lauhala. My "jump" kihapai is at Kapua, received from Kopa, 1 mala of taro. The house lot is 30 by 20, a circumference of 100.
Okoe, Kapalilua, District 3 KAELEMAKULE

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No. 7951 Kanewa Wahine Puaa 2, Kailua, Hawaii, Feb. 8, 1848

To the Honorable Land Commissioners: Here is my claim, with my keiki, Kekiaipuu. There are 2 'ili in the Kamukus. The length of the 2 'ili is 1625 /fathoms/ and the width is 30 fathoms.
KANEWA WAHINE

---

No. 7953 Kuahine Kailua, February 14, 1848

Greetings to the Land Commissioners: I hereby state my land claim in the ahupua'a of Auhaukeae 2. There are two 'ili. Iliiloa 1 is the name of one, and the other 'ili is named Puhau -- it is an 'ili stretched far out from inland to the sea. A pauku of land makai of the highway is named Kealaehu. A kihapai in the ahupua'a of Auhau-

No. 10369 Ninauaiwi Kawanui, Kona, Hawaii Page 591

Greetings to the Land Commissioners: I have an 'ili of land, Kapukalua

Page 592

is the name. That is my claim for which I petition you. This land claim is for me, Ninauaiwi. I have a lot claim also, at the seashore, however, it has not been measured. Within this lot are lauhala trees I planted. This is in Kawanui. I have 2 orange trees, mauka.

NINAUAIWI

---

No. 10375 Nune

Petition for a mo'o in Hookena, which was received from Nikakai. There are 10 kihapai of taro and 2 of sweet potatoes. This mo'o extends from the sea to the forest. 1 kihapai of taro at Kahookiwikiwi was received from Kuailohia. I have 1 kihapai of sweet potatoes, received from Nune.

WAIAU, the one who has the mo'o

---

No. 10376 Naea

This house lot is on the Island of Hawaii, District 3, ahupua'a of Keei. It is 237 feet in circumference.

NAEA

---

No. 10378 Nuhi

Here is my claim in the ahupua'a of Kalahiki, received from Kinimaka. The kihapais I cultivate are: 11 mala of taro and 1 mala of bananas. At Pahoa, an 'ili kupono, are 5 mala of taro and 1 of sweet potatoes. At Puuloaiki is 1 mala of taro. At Hooneenui are 2 mala of sweet potatoes. Here are the boundaries of Kalahiki, my ahupua'a /in which he lives/: the koa wa'a /zone where large koa trees suitable for canoe making grow/ is on the north, the sea is on the south, Waea /ahupua'a/ is on the south, and Kauhako /ahupua'a/ is on the west. There is 1 house lot.

NUHI

---

No. 10379 Namakelua

An explanation to you, the Land Commissioners: Kealaehu is the name of this place. Mauka it is 4200 feet, on the east, it adjoins Kiilae, on the west side it adjoins Honaunau, to the aki* and back. That is how it is demarcated here at the sea, for your information, the commissioners for land and house lots.

*Sedge or bulrushes.

NAMAKELUA

---

No. 10380 Naluhielua Kapuakou, Kapalilua, Hawaii Page 593

I have a house lot, 80 fathoms by 60 fathoms, also 2 mo'o, received from Lanai, with 4 kihapai of taro, 1 mala of bananas and 3 mala of sweet potatoes.

NALUHIELUA



No. 10523 J. Kawahie Palaoa 4, Kona, Hawaii Page 597

Hear ye, ye Land Commissioners: I have taken a pauku, named Paloaloa, of the 'ili of Kaiwiholehole. It is mauka in the forest. That is my message to you, the commissioners to quiet land titles.

JOHN NAWAHIE

---

No. 10527 Namaielua Kapua, Kapalilua, Hawaii

Here is my claim in the ahupua'a of Kapua, received from Leleiohoku. These are the mala I cultivate: 6 mala of taro, 8 of sweet potatoes, 2 of bananas, 2 of sugar cane, 2 of lauhala, 10 of gourd, 1 of uhi yam. These are boundaries of Kapua: the sea is on the south and the koa wa'a /zone of large koa trees/ is on the north. There is one fish pond and one house lot, 70 in circumference.

NAMAIELUA

---

No. 10528 Nahulu Kapua, South Kona, District 3

Here is my 'ili of land, received from Namaielua, at Puuhinahina, a small mo'o. From the sea to inland there are 4 mala of sweet potatoes, 8 mala of taro and a mala of bananas.

NAHULU

---

No. 10529 Nuhi

Greetings to the Commissioners to quiet house lot titles: I hereby petition for my house lot claim in the ahupua'a of Leleiohoku, Honokohau, in Kailua here on Hawaii. It measures 44 fathoms in length by 9 fathoms in width, that is the nature of my house lot.

NUHI

---

No. 10530 Naolulo

Here is my 'ili, received from Namaielua. The name of the mo'o is Kauleokalani -- it is a small land area. From the upland taro culture zone to the kula sweet potato zone, there are 9 mala of sweet potatoes, 5 of taro, 2 of sugar cane, 1 of bananas, 1 of arrowroot, and 1 of lauhala. My "jump" kihapai, received from Namaielua, is 1 mala of watermelon.

Kapua, South Kona, District 3 NAOLUA /sic/

---

No. 10558 Olopana Kealia, Hawaii Page 598

Greetings to the Land Commissioners: I, Olopana, hereby petition you for my own claim -- a mo'o in the ahupua'a of Kealia 1. A house lot is 27 by 10. Those are my own claims. Furthermore, there is a mala in the Ma'u*, far in the upland.

OLOPANA

---

No. 10560 Opunui Keokea, South Kona, Hawaii

Greetings to the Land Commissioners: I hereby tell you of my land claim, as follows: Keokea is the ahupua'a and Uhai is the konohiki from whom I received my 'ili of land named Kamuku. It extends from the highway to Kealaehu. There are 5 kihapai of taro and 6 of sweet potatoes. In the 'ili named Papuaaiki I have 6 kihapai of taro and 1 of sweet potatoes, received from Kalaikuiha.

OPUNUI

---

*See Translator's Notes re Land Zones in Kona.

No. 10839 Popoki

Kaia and Kaheleaulani sworn the have seen his ili Waipio of Puueo ahupuaa, from his grandparents in 1819, no objections.
Konohiki boundaries surround this land.

---

No. 10572 Pamaikanui

Kaia and Kaheleaulani sworn they have seen his ili section Pualoalo 2 in Puueo ahupuaa from Kaumaumanui in 1819.
The konohiki's land surrounds this land.

---

No. 10377 Nika

Kaia and Kaheleaulani sworn they have seen the ili Kukuilolo in Puueo ahupuaa, from Kaumaumanui in 1847, the land is surrounded by the konohiki's land.

---

No. 8773 Kauwa 29 Nov. 1849 Pg. 503

Laanui and Kalaikoa sworn they have seen his ili section Kaiakekua of Manuka ahupuaa, from Puhi in 1819, no objections to him.
The konohiki's land surrounds this land.

---

No. 10681 Palanalelo

S. Laanui and Kauwa sworn they have seen his ili Lamakulua of Manuka ahupuaa from Puhi in 1819, no one objected to Palanalelo.
The konohiki's boundaries surrounds this land.

---

No. 9096 Kaiama (deceased) Opulua (w) HEIR

Kaelemakule and Ikipaalanea sworn they have seen Kaiama's land of one section consisting of 3 taro kiahpais, 1 sugar can kihapai, 1 potato kihapai, 1 olona kihapai in Ahualoa ili of Kahilipahinui ahupuaa. Kalua gave this land in 1819 no oppositions.
It is bounded by the land of the konohiki.

---

No. 8767 Kaikai

Kapena sworn he has seen his land section.
Section 1 - Panohiku ili in Makaka ahupuaa. Land from Kapuaakini in1836.
Section 2 - 4 taro kihapais and houselot in Peapea ili of Makaka ahupuaa and this land was given at Kalapuna in 1845, no objections.
The konohiki's land is on all sides.

---

No. 10527 Namaielua 7 Dec. 1849 Pg. 504

Kona, Ahuole and Kaolelo sworn they have seen:
Section 1 - Haleola ili of Kapua ahupuaa and was from Lanai in 1819.
Section 2 - Kahihi lili of Puuhinahina.
Section 3 - Taro and sugar can kihapai in kaule ili.
Section 4 - House lot in Kailiohia ili with 2 houses. Land from Kanai in 1819, no disputes.



No. 10527 Namaielua (con't.)

| | | |
|---|---|---|
| Section 1 - | Mauka | Nahulu and Nahuhielua |
| | K | Konohiki |
| | K | Sea |
| | K | Naohele's land |
| Section 2 | MKKK | Konohiki's land is on all sides. |
| Section 3 | MKKK | Konohiki's land is on all sides. |
| Section 4 | MKKK | Konohiki's land is on all sides. |

---

No. 10528 Nahulu

Alinokane and Kaolelo sworn they have seen his ili Puuhinahina of Kapua ahupuaa from Lanai in 1819, no one objected.
Boundaries are:

| | |
|---|---|
| MKK | Konohiki |
| K | Naluhielua |

---

No. 7934 Kapa

Ahuole and Kaolelo sworn they have seen his ili Kailiohia of Kapua ahupuaa from Lanai in 1819, no objections to him.
Boundaries are:

| | |
|---|---|
| M. | Kaluhielua's land |
| K. | Namaielua's land |
| K. | Sea |
| K. | Land of Namaielua |

---

No. 7927 Kama

Ahuole and Kaolelo sworn they have seen the ili of Haleola in Kapua ahupuaa, it is from Namaielua in 1819.
MKKK Konohiki on all sides.

---

No. 10530 Naolulo 7 Dec. 1849 Pg. 505

Ahuole and Kaolelo sworn they have seen his ili Kauleokalani of Kapua ahupuaa it was given by Lanai in 1819, no one objections to him.
Boundaries are:
MKKK Konohiki on all of the sides.

---

No. 7940 Kaawa

Ahuole and Kaolelo sworn theyhave his ili Kipea of Kapua ahupuaa, no disputes.

| | |
|---|---|
| Mauka | Konohiki |
| K. | Naolulo |

---

No. 7940 B Kaiowalu

Kaia and Kelualinaole sworn they have seen his land of an ili section of Kuiki and Lamakulua in Manuka ahupuaa, this was given by Puhi in 1819, and is surrounded by the land of the konohiki, no objections. Keawe wrote this claim.

---

No. 7940 C Keliiainaole

Kaia and Kaiawalu sworn they have seen Kaneio wrtie this claim and it is an ili Kononihonua in manuka ahupuaa. It was given by Puhi in 1819, the land of the konohiki surrounds this land.

---

No. 7940 D Kaia 7 Dec. 1849 Pg. 506

Kaiawalu and Keliiainsole sworn they have seen his land, Keamia had written the claim. It is the land ili section Kamilo of Manuka, Puhi had given in 1819. No one has objected and it is surrounded by the land of the konohiki.

---

No. 8751 Kuhea

Kaiowalu and Keliiainaole sworn they have seen his land - the ili Elelu in Manuka ahupuaa which Puhi had given in 1819, no one has objected. It is surrounded by the land of the konohiki.

---

No. 7991 Puni

Kui and Kekulu sworn they have seen his land.
Section 1 - Ili Kaopa in Okoe 2 ahupuaa from Kui in 1829.
Section 2 - Ili Halanolanui, where on is a house lot, no objections.
Land surrounded by the land of the konohiki.

---

No. 7941 Kailemakule

Kui sworn that he has seen Kaimakoi's ilis Lihiiki and Haleokamahina in Okoe ahupuaa. Kui had given this landin 1829, no one had objected. It is surrounded by the land of the konohiki.

---

No. 7936 Kainakekoi

Kui sworn he has seen Kainakekoi's ili Halanolaaiki in Okoe ahupuaa which he himself had givenin 1829, this land is surrounded by the land of the konohiki.

---

No. 10120 Mahoe 7 Dec. 1849 Pg. 507

Kui sworn he has known that Mahoe has six taro kihapais in the ili of Halaulaanui of Okoe ahupuaa, he had given this land to Mahoe in 1840, no one objected. It is surrounded by the land of the konohiki.

---

No. 7935 Kui

Puni and Kekulu sworn he has seen his ili land in Puhala of Okoe 2 ahupuaa. Naihe had given this land in 1819, no one had objected. It is surrounded by the land of the konohiki.

---

No. 10269 Mahiai

Kaaumoana sworn he has seen Mahiai's section in Opuomakaula in Okoe 1 and he had given him this land in 1840, no one had objected. It is surrounded by the land of the konohiki

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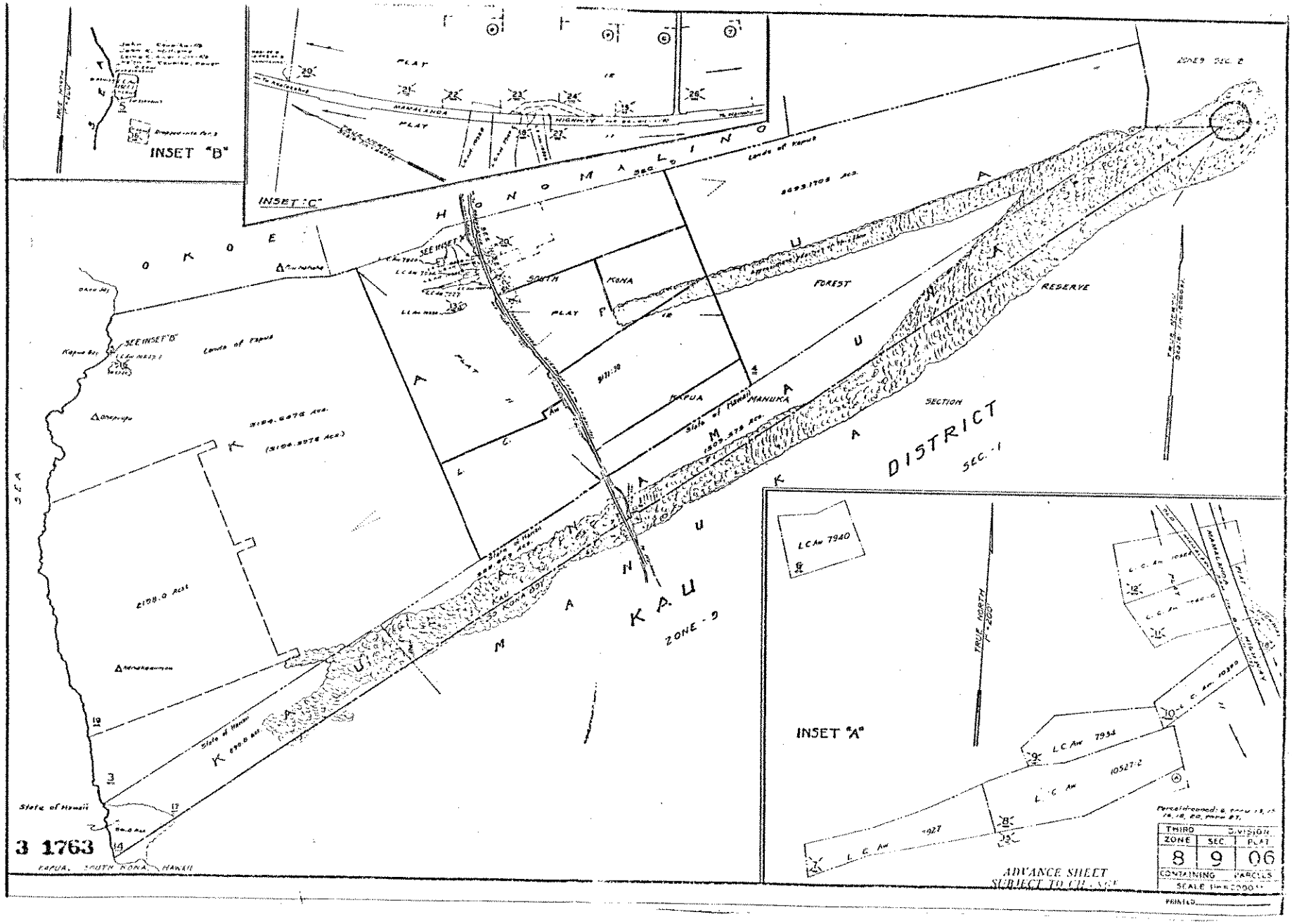
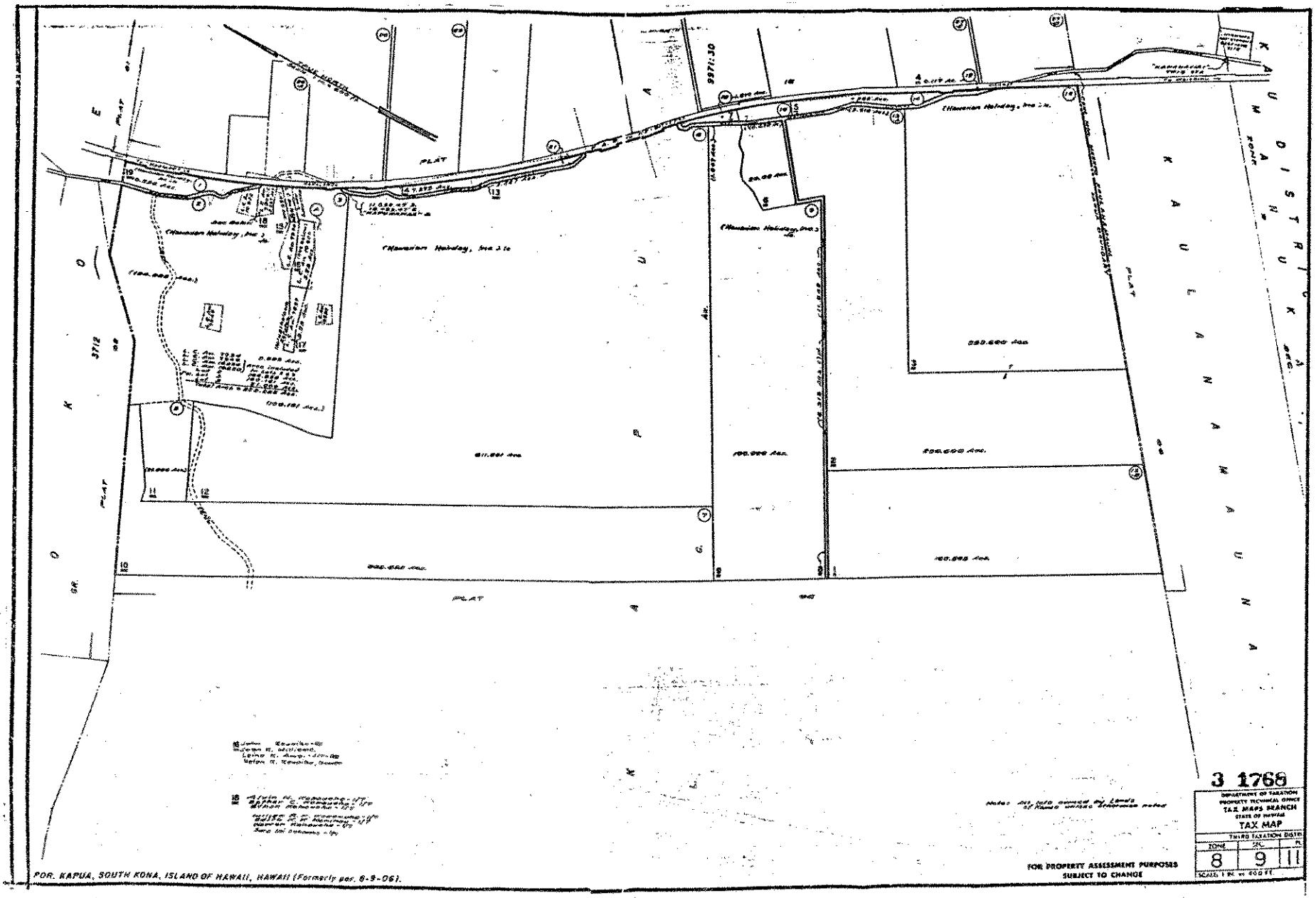
Native Testimony v.8 3



APPENDIX B.

Copies of Tax Maps for Land of Kapua Project Area.


INSET "B"
INSET "C"
INSET "A"
OKOE
HONOMALINO
KAU
MANUKA
DISTRICT
SEC. 1
ZONE - 9
SOUTH KONA
FOREST
RESERVE
SECTION
KAPUA
MANUKA
SEE INSET "B"
Lands of Kapua
State of Hawaii
KAPUA, SOUTH KONA, HAWAII
3 1763
L.C.Aw 7940
L.C.Aw 7934
L.C.Aw 10527:2
L.C.Aw 7927
TRUE NORTH
ADVANCE SHEET
SUBJECT TO CHANGE
THIRD DIVISION
ZONE 8
SEC. 9
PLAT 06
CONTAINING PARCELS
PRINTED



KAUDISTRICK
KAULANAMAUNA
KAPUA
KONA
PLAT
3712
9971:30
Hawaiian Holiday, Inc.
3 1768
DEPARTMENT OF TAXATION
PROPERTY TECHNICAL OFFICE
TAX MAPS BRANCH
STATE OF HAWAII
TAX MAP
THIRD TAXATION DISTR.
ZONE
SEC.
PL.
8
9
11
SCALE 1 IN. = 400 FT.
FOR PROPERTY ASSESSMENT PURPOSES
SUBJECT TO CHANGE
POR. KAPUA, SOUTH KONA, ISLAND OF HAWAII, HAWAII (Formerly por. 8-9-06).

APPENDIX III.

PRELIMINARY SOCIO-CULTURAL RESEARCH:

FARMS OF KAPUA PROJECT AREA
LAND OF KAPUA, SOUTH KONA
ISLAND OF HAWAII

by

Craig J. Severance, Ph.D.
Cultural Anthropologist



## INTRODUCTION

This report is a very brief and preliminary overview of cultural and social issues and concerns that may develop within the affected populations as a result of the proposed Farms of Kapua Project. The report is limited to potential sociocultural issues and makes no attempt to consider economic impacts or concerns. The report will outline the activities undertaken by the consultant in preparation of the report, and give a brief background to social impact assessment and the need for addressing community concerns. It will then give a brief review of possible concerns of various potentially affected groups. Finally, it will discuss the potential for further social research within the Milolii and South Kona populations, and outline a plan for such work as a way of assessing and addressing social and cultural concerns.

The work was begun by discussing the Milolii Community with other social researchers who had experience with Hawaiian communities and by seeking names of potential informants and references to ethnographic and ethnohistoric literature relating to the area. It was ascertained that a team of anthropology and psychology graduate students from the University of Southern California had spent a summer in Milolii in the early 1970's and that a female graduate student in anthropology was to have begun fieldwork there about the same time. Attempts to trace the names and any publications of such individuals have been unsuccessful so far and a search of Dissertation Abstracts continues. A number of the social researchers queried suggested that the Milolii community might be sensitive about outside researchers, but others noted the general openness of the community. An informal interview was arranged with Mona Kahele, a member of the Pa'a Pono o Milolii, a community organization on November 13, 1982 and the open-ended interview was conducted jointly by myself and Margaret L. K. Rosendahl. Potential informants were identified and the Kapua beach areas were visited. A brief literature review of the concepts and

methodologies of varieties of cultural and social issues assessment was subsequently conducted and the ethnohistoric literature search was continued.

## THE NEED FOR ADDRESSING COMMUNITY CONCERNS

The need for addressing socio-cultural impacts and concerns is implicit in the National Environmental Protection Act and explicit in certain related Federal and State Regulations. There has only recently developed a clearly agreed upon methodology and means of determining when social impact assessment is required to assess social costs and benefits of a proposed project and to choose between alternative plans. Most social impact assessments are done by outside researchers as part of a broader environmental impact assessment of relatively large scale projects or projects with projected major Impacts. They generally include a survey or mini-survey of potentially affected communities and/or populations to establish baseline data on attitudes, lifestyles, and measures of community vitality, cohesiveness and economic viability (Bowles, 1981). Scenarios of possible impacts are generated with the expectation that monitoring of impacts will take place if or as the project develops.

In my opinion, the Proposed Farms of Kapua Project does not require a full-scale social impact assessment at the present time, but serious attention must be given to potential social issues and concerns early in the planning stage. This attention must be directed at establishing open communication between the affected individuals and communities and the developers. It is a basic principle of social change that people will tend to resist changes about which they feel a lack of information or about which they have had little say or input. There is thus a potential for strong resistance to the proposed project among segments of the Milolii community and the larger South Kona population. Open communication between the proposed project developers and community members must take place in order for social issues and community concerns to be incorporated into the planning process. Community based planning philosophies assume that potentially affected community members are a valuable resource in providing information on their lifestyles, and social and visual environments and in projecting scenarios on how these may be changed by proposed developments. There is even a partially successful model for having Hawaiian Community



Organizations do medium-scale impact assessments on their own communities or populations. (Puna Hui Ohana, 1982). Some form of social and cultural issues assessment will probably be required later on in the permitting process, particularly at the County level. Careful attention to community concerns should reduce possible community resistance to the project that could influence the overall permitting process.

## POSSIBLE CONCERNS OF POTENTIALLY AFFECTED GROUPS

For the purposes of this brief report there are three potentially affected groups to be mentioned. Potentially most adversely affected are those families and their descendents who lived at Kapua into the late 1940's. These are primarily the Kahele and Kaupiko families and descendents of any other families whose immediate ancestors are buried at Kapua and who were accustomed to utilizing parts of the uplands to gather net-dyeing plants, medicinal plants and other material resources. Some members of these families are active in Pa'a Pono o Milolii, a community organization that is interested in protecting and preserving knowledge of historic sites in the area and in maintaining full public access to the beach and coastal area. Members of this group include a number of potential informants who could provide information relating to historic graves, to the use and function of known sites and to the names and religious significance of natural rocks and features. Any activities or development in the coastal area that disturbs historic sites (including archeological testing of possible grave sites) or restricts public access can be expected to be strongly resented and resisted by members of this group. Some members of the group have publically requested that any development that may occur at Kapua be restricted to the mauka area leaving a coastal buffer strip of substantial width.

The second potentially adversely affected group is the Milolii community itself. This community should be thought of as including the full-time residents of the village as well as those who live mauka but have camps or customary access to the village. The degree of community cohesiveness, vitality and economic viability can only be assessed by survey work, informant work and limited participant observation. Disturbance of or restricted access to the coastal area of Kapua, restricted access to ajacent mauka

areas for plant collecting or increased traffic through Milolii village may adversely affect and be resented by some members of the community. Economic opportunities may, however, be welcomed by some members of the community.

The third potentially adversely affected population consists of those persons residing in South Kona or in the state as a whole who may fish or hike the shoreline south of Milolii and who have customary or potential future access by boat or by land to the Kapua area. This population includes commercial and recreational fishermen, campers and hikers and any others who might land at Kapua by boat or who might hike the shoreline trails. They may be affected by the visual pollution of developments visible from the shoreline or offshore as well as by any restriction of access.

All three groups may be affected to some degree by changes in power and water use or need or by changes in land values and taxation rates. Obviously, the most observable potential effects and possible issues and concerns may arise within the first two populations, although any concerns that may arise among the third population will need to be addressed.

A very tentative listing and ranking of potential issues and concerns is set forth below. It is drawn primarily from a general familiarity with the impacts and issues caused by similar developments. It would have to be refined and reworked by future socio-cultural work among the populations before it was relied upon for assessing alternative plans. A primary issue and concern, particularly for groups one and two above is protection of historic sites and any natural features that may have historic site value. This protection could easily include the encouragement or support for recording and publishing information related to sites through a organization such as the Pa'a Pono o Milolii. The sites and related information appear to be clustered primarily in the coastal area but every effort should be made to assess and protect any trails, planting areas or other sites of significance in the mauka area.

The second major issue is restriction of access and the potentially related issue of increased traffic through Milolii village itself. All three groups are potentially affected here, although the first two groups have the greatest claim to customary access. Again, while customary access



may appear to be an issue primarily in the coastal buffer zone, access to inland areas for gathering of plant materials may become an issue. This includes mauka areas in the project area itself as well as mauka areas ajacent to the project area closer to Milolii. If mauka-makai road improvements are made within the project area, it is strongly recommended that public access be maintained or granted. If consideration is given to any future developments of horizontal road connections between Milolii village and/or the Milolii road and the Kapua area, it is strongly recommended that full consideration be given to the attitudes and expressed wishes and needs of groups one and two above.

Protection of historic sites and continued access to the Kapua coastal zone have been singled out here as the probable potential social issues of greatest concern. The additional issues noted above are potential future concerns, but the size of their impact and the relative sensitivity of the three groups can only be estimated from further socio-cultural baseline work and from a clear set of proposed development plans that indicate location and scale of development. It should be recognized that additional unpredictable issues can always arise in relation to any development in Hawaii.

## PLAN FOR ADDRESSING POTENTIAL FUTURE CONCERNS

First, as a general recommendation, a series of open informational meetings between representatives of the developers and representatives of Pa'a Pono o Milolii and the Milolii community should be held before plans and their alternatives become finalized. Such meetings should make it clear that concerns of the affected communities and populations will be given serious consideration as development plans progress. Such meetings should also make it clear that the developers are not witholding information about the status and finality of any alternate plans. Some guarantee of historic sites protection and continued customary access should be made.

The potential for future informant regarding historic sites and customary access to the Kapua area for fishing and gathering is substantial. It is recommended that a qualified ethnohistorian and archeologist work closely with

the Pa'a Pono o Milolii and any other appropriate knowledgeable persons, particularly where named and/or natural features of historic significance should be recorded and protected.

Should limited to medium scale social impact assessment be considered necessary or be made a condition of any required permit, it is recommended that the consultant services of a trained (M.A. level) cultural anthropologist, sociologist and/or community psychologist be obtained. Such an individual(s) should work closely with the community and use selected trainable members of the community as a resource for self-assessment. Here, a much smaller version of the Puna Hui Ohana (1982) model may be appropriate although the pitfalls of that model should be recognized. The research program must establish a socio-cultural baseline through limited participant observation, an adequate sample of informant interviews, and one or more minisurveys (Finsterbusch and Wolf, 1977; Finsterbusch, 1980). The research program should provide some measure of community vitality and cohesiveness, of economic viability, and of degree of customary recreational and subsistence use of the Kapua area. It should also include a series of questions in the minisurvey instrument or instruments designed to establish baseline attitudes toward the Kapua area, the proposed Farms of Kapua Project, and other possible future developments in the South Kona area. The establishment of such a baseline is a necessary part of the generally agreed upon methodology of social impact assessment. Such a baseline allows a monitoring of any changes should or as the development takes place. Such minisurveys could be extended to a small random sample of the larger South Kona Community. Within the Milolii community itself, such minisurveys could most effectively and efficiently be done by training a few residents as research assistants.



## REFERENCES CITED

Bowles, Roy T.
1981 Social Impact Assessment in Small Communities. Toronto: Butterworth's and Company.

Finsterbusch, K.
1980 Understanding Social Impacts. Beverly Hills: Sage Publications.

Finsterbusch, K. and Wolf, C. P.
1977 The Methodology of Social Impact Assessment. Stroudsburg, Pa.: Dowden, Hutchinson and Ross.

Puna Hui Ohana
1982 "Assessment of Geothermal Development Impact on Aboriginal Hawaiians". Report Prepared for U.S. Department of Energy under Contract No. DE-FC-03-79ET-27133.

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Report Ms.108-021084

# ADDENDUM REPORT:

## ADDITIONAL ARCHAEOLOGICAL INPUT ENVIRONMENTAL IMPACT STATEMENT (E.I.S.) PREPARATION

ARCHAEOLOGICAL RECONNAISSANCE SURVEY
FARMS OF KAPUA PROJECT AREA
LAND OF KAPUA, SOUTH KONA
ISLAND OF HAWAII
(1983)

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## PREFACE

The present addendum to the previously submitted report on the archaeological reconnaissance survey of the Farms of Kapua project area conducted in 1982 (Rosendahl 1983) has been prepared to provide additional archaeological input for the preparation of an Environmental Impact Statement for the Farms of Kapua development. It has been prepared by Principal Archaeologist Dr. Paul H. Rosendahl, with the assistance of Project Field Director Mr. Michael W. Kaschko and Project Field Supervisor Ms. Melinda Sue Allen. Ms. Allen developed the vegetation map presented here as Figure 1, and prepared the descriptions of the vegetation community types presented in the Vegetation Map section. Working from the field records of the 1982 reconnaissance survey project, Ms. Allen and Mr. Kaschko produced short descriptive summaries of the individual survey areas and descriptions of the eight newly designated sites presented here in the Survey Notes and the Additional Designated Sites sections respectively. The revised site and survey area location map presented here as Figure 2 was drafted by Ms. Margaret L. K. Rosendahl on the basis of information provided by Ms. Allen and Mr. Kaschko.

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## INTRODUCTION

This Addendum Report has been prepared for Farms of Kapua Ltd. in order to provide additional archaeological input for the preparation of an Environmental Impact Statement (E.I.S.). This E.I.S. will be submitted to the Hawaii State Land Use Commission in conjunction with a petition for amendment of the existing Land Use Conservation District Boundary in Kapua, South Kona District, Island of Hawaii.

An archaeological reconnaissance survey of the Farms of Kapua project area was carried out for Farms of Kapua Ltd. in November 1982 by Paul H. Rosendahl, Ph.D., Inc. The findings of this survey, along with reports on preliminary historical documentary and socio-cultural research, were presented in the original survey project report (Rosendahl 1983) submitted to Farms of Kapua Ltd. in March 1983. This report has subsequently been examined and commented upon by several public and private agencies, offices, and organizations, as well as various individuals. The comments of these groups and individuals have been reviewed and response made to Farms of Kapua Ltd.

The original reconnaissance survey report (Rosendahl 1983) was found adequate by both the Hawaii County Planning Department and the State Department of Land and Natural Resources-Historic Sites Section with regard to the level of archaeological study both sufficient and appropriate for State Land Use petitions. That is, the reconnaissance survey report is adequate in terms of its specific original purpose. At the same time, the report needs the inclusion of additional information, and the clarification of certain points in some instances, in order to answer several questions raised by various reviews and thereby make it adequate for the E.I.S. being prepared for submission to the State Land Use Commission.

The basic problem that needs to be recognized is the lack of congruence between the general level of feasibility study and planning at which the Farms of Kapua development currently stands, and the more specific level of planning and evaluation that the requirements of an E.I.S. presume. The difficulty lies with the existing State law which can require the preparation of an E.I.S. in conjunction with a land use boundary amendment petition. There is a definite and obvious difference between the general level of study appropriate for a State land use change decision, and the more specific level of study appropriate for an E.I.S. This difference is reflected in the difference between the level of archaeological study represented by a reconnaissance survey, and that of an intensive survey.

Thus, while the original reconnaissance survey report is fully adequate for its original land use change petition purpose, it is somewhat less adequate for its subsequent E.I.S. purpose.

With this situation in mind, it was recommended to Farms of Kapua Ltd. that additional archaeological input be provided to supplement the original reconnaissance survey report, thereby providing an acceptable level of information that would satisfy the E.I.S. requirements with regard to the State Land Use Commission--without needing to conduct additional archaeological field work first. With this basic purpose in mind, the present Addendum Report was prepared. It constitutes a supplement to be addended to the original reconnaissance survey report, and therefore the information contained within that report will not be repeated here.

The specific tasks undertaken in order to provide the additional archaeological input contained within the present Addendum Report were the following:

1. Draft a new map which would present important environmental data concerning distribution of substrate, vegetation types, and areas previously altered by historic period land modification activities. This information would help to explain the specific archaeological survey areas selected for field investigation, and to indicate why they can be considered representative in terms of the sampling strategy utilized;

2. Clarify and justify the non-probablistic sampling strategy used in conducting the reconnaissance survey field work;

3. Revise and redraft the archaeological site and survey area location map to make the information more obvious, and to include such additional data as important place names and existing access roads and trails;

4. Prepare short descriptive summaries for each survey area examined. These would include information on the terrain and vegetation encountered, and on the general nature and density of both the major and minor archaeological features identified; and

5. Update the various tables of data presented in the original reconnaissance survey report. The resulting Addendum Tables would present additional information derived from the review of the field records carried out in order to prepare the short descriptive survey area summaries mentioned above.



## VEGETATION MAP

The vegetation map presented here as Figure 1 (at end) has been constructed from the following sources of information: (a) the botanical survey report and vegetation map prepared for Farms of Kapua by Kenneth M. Nagata (1983); (b) analysis of available black-and-white (1965, 1"=2000' scale approx.) and color infra-red (1982, 1"=1500' scale approx.) aerial photographs; and (c) data collected during the archaeological reconnaissance survey conducted in 1982. Much of the latter information was collected in the form of specific survey area notes.

This vegetation map has been prepared to accomplish the following major purposes:

1. Show the relationship of vegetation areas to the specific survey areas that were examined;

2. Indicate the portions of the project area that have been mechanically altered in the historic recent past;

3. Show the lowland *kipuka* that would have been suitable for aboriginal Hawaiian dryland cultivation; and

4. Indicate the location and extent of relatively unweathered lava flows.

It should be noted that all of the information contained within the vegetation map was taken into consideration during the selection of specific survey areas that were examined during the archaeological reconnaissance survey field work carried out in 1982.

A total of nine major vegetation types were recognized. These types are defined below. A specific coastal strand type has not been distinguished, as in most cases it would correlate with the patches of coastal Kiawe Forest.

### Kiawe Forest

This vegetation type is dominated by *kiawe* (*Prosopis pallida*), with a variable understory of one or more of the following: *koa-haole* (*Leucaena leucocephala*), lantana (*Lantana camara*), and Christmasberry (*Schinus terebinthifolius*). The Kiawe Forest is concentated in *kipuka* in the elevation range of 50 to 300 ft., and along the immediate coast in areas were sub-surface fresh water is present.

Grasslands

The Grasslands vegetation type differs from Scrub Grasslands in that the substrate is an older pahoehoe lava flow, and the grass component of the vegetation is more pronounced. It has been observed that the native pili (Heteropogon contortus) is one of the more common species of grass present within the area of the vegetation type (R. Warshaur, personal communication to M. S. Allen, December 1983). 'Uhaloa (Waltheria americana) and 'ilima (Sida sp.) are also present.

Scrub Grasslands

This vegetation type covers a large portion of the project area below the elevation of 600 ft. At lower elevations, this type consists of sparsely distributed grasses, 'uhaloa, and 'ilima. At higher elevations, the type includes more scrubs and occasional solitary trees such as lama (Diospyros ferrea), wiliwili (Erythrina sandwicensis), alahe'e (Canthium odoratum), sandalwood (Santalum sp.), and Christmasberry.

Native Forest

In addition to the three areas of Native Forest identified by Nagata (1983), three other remnants of lama-alahe'e forest were identified during the archaeological survey. As reported by Nagata, the understory is predominantly exotic species, and the general condition of the forest is poor. Occasional patches of candlenut (kukui) (Aleurites moluccana) are found within these areas.

Koa-Haole Thicket

These areas consist of dense koa-haole with few other species. For the most part, the areas of Koa-Haole Thicket correlate with areas which have been mechanically altered.

Secondary Forest and Scrub

These areas include several vegetation communities of predominantly exotic species. The boundaries for this vegetation type are based largely on the distribution map prepared by Nagata (1983). Christmasberry, lantana, and guinea grass (Panicum maximum) are common components. A large portion of this vegetation type area at the southern end of the project area has been mechanically altered, as was obvious on both the black-and-white and the color infra-red aerial photographs. Other portions of this vegetation type may also have been mechanically altered, but this was not obvious from either the aerial photographs or from ground survey.



Barren Lava With Scattered Ohia

This vegetation type is confined to the Kaulanamauna Flow along the south end of the project area. The scattered 'ohi'a-lehua (Metrosideros collina subsp. polymorpha) occur either as scattered solitary specimens or in small clusters.

Secondary Grasslands

Two small areas of predominantly guinea grass were identified near the inland boundary of the project area.

Hau Grove

A single grove of hau (Hibiscus tiliaceus) was found at the coast in the vicinity of the Lae o Ahole Complex (site 2133). Also present within this grove were some hala (Pandanus), kiawe, coconut (Cocos nucifera), and kou (Cordia subcordata).

## SAMPLING STRATEGY

The location and extent of individual survey areas are shown on Figures 1 and 2 (at end). Survey coverage of the coastal portion of the project area included virtually 100% pedestrian coverage of a zone extending inland from the shoreline to 1000-1500 feet inland (average width c. 1250 ft.), and from the north boundary of the project area to the south boundary.

Survey coverage of the inland portion of the project area consisted of virtually 100% pedestrian coverage of selected discrete survey areas. Varying considerably in dimensions and overall size, these inland survey areas were selected so as to obtain representative samples of the project area in terms of both geographic distribution and environmental variation. Figure 1 illustrates how this objective was achieved, by showing the distribution of the 26 discrete inland survey areas in relation to the different vegetation community types. These different vegetation community types are good indicators of local environmental variation.

As an initial objective, a total areal sample of 15-20% of the project area overall was anticipated. The size of individual survey areas and the relative intensity of coverage varied primarily as a function of vegetation type and density, and the general terrain. These factors are summarized for the individual survey areas in the Survey Area Notes section of this report. Actual sample coverage of the total project area was somewhat more than 20% (approx. 22.45%). This included essentially 100% coverage of the coastal zone survey area, and a sampling of approximately 15% of the inland portion of the project area.

In order to sample the inland portion of the project area, a simple non-probablistic sampling strategy was utilized, instead of a more formal probablistic one. It should be noted that probablistic sampling is neither the only, nor necessarily the better, sampling strategy available. In a reconnaissance survey situation, probablistic sampling should be used only when little or nothing is known about the area under study. In instances where a fair amount of knowledge is available concerning the presence of previously recorded sites, or the likely distribution of sites--given the local environmental setting, it is often more reasonable and more productive to adopt a non-probablistic sampling strategy.

This is what was done in the case of the reconnaissance survey work in the Farms of Kapua project area. While the representativeness of a non-probablistic sample is admittedly more difficult to evaluate--at least in any quantitative manner, this limitation does not invalidate the non-probablistic sample



obtained. It does mean that the basis for the selection of sample areas--the criteria by which individual survey areas are selected and defined--should be made clear. In the case of the reconnaissance survey of the inland portion of the Farms of Kapua project area, the individual survey areas comprising the sample examined were selected on the basis of geographic distribution and local environmental variation--as demonstrated by Figure 1 and the information contained within the summaries of the individual survey area presented later in this addendum report.

The findings of the more recent field inspection carried out by Spriggs (Spriggs 1983) suggests that the non-probablistic sample obtained by the earlier reconnaissance survey was, in fact, reasonably representative. Spriggs' inspection comprised a reconnaissance-level inspection of areas primarily outside of those covered during the earlier reconnaissance survey. So far as can be determined, Spriggs did not find anything that would not have been predicted on the basis of the findings of the earlier reconnaissance survey. The single new, unique site reported by Spriggs--the refuge cave seen in his Location three--was already known to local informants. Furthermore, the fact that the earlier reconnaissance survey did not find the refuge cave does not mean that the sampling method was somehow inadequate. Sampling is not carried out to find unique sites; it is meant to provide the basis for generalizing upon the probable composition of the total site population of a survey area. And finally, it is most likely that all of the new sites identified by Spriggs during his inspection of areas not previously examined would have been found during subsequent reconnaissance survey of those areas.

## REVISED SITE AND SURVEY AREA LOCATION MAP

The revised archaeological site and survey location map is presented here as Figure 2 (at end). The map has been redrafted to avoid the visual confusion caused by the density of contour lines present in the original map. That map had been prepared by superimposing the archaeological data onto a sepia copy of an existing topographic map of the project area. The revised map also includes the location of newly designated sites, several place names of importance, and several trails and jeep roads. The revised site and survey location map has also served as the base map for the vegetation map (Figure 1, at end) discussed previously.

## SURVEY AREA NOTES

Individual survey area locations are shown on both Figures 1 and 2 (at end). For each designated survey area, a variety of field observations were made. General environmental data concerning local terrain and substrate, dominant vegetation components, and other prominant characteristics were recorded. Several of the survey areas had scatterings of archaeological features--often rather minor features, but few or no well-defined sites. In these instances, information pertaining to the general nature, density, and distribution of these features was recorded in the survey area notes, but no specific site numbers were designated. The following pages summarize the general information collected for the designated survey areas.

Each individual survey area summary indicates the approximate acreage and the range in elevation above sea level to the nearest 50-ft. contour. General information is given concerning the terrain and substrate of each survey area, as well as the nature of the vegetation present. The major vegetation type for the survey area is given, supplemented by more detailed notes as appropriate.

Ground surface visibility and overall archaeological feature density are described in relative terms. Ground surface visibility is directly related to the nature and density of the vegetation cover. Overall feature density reflects the number of features actually observed, and in no way compensates for any limitations of surface visibility. Taken together, these two categories of information provide a reasonable indication of the principal environmental constraints in each specific survey area, and how these might have affected both the accuracy and completeness of site and feature identifications.

Additional comments briefly describe the various kinds of archaeological features encountered within the individual survey areas, and their general distribution. These comments often include information concerning both formally designated sites, and the range of other features not assigned or included within formal designations.



## SURVEY AREA: COASTAL ZONE

Area: 677.2 ac. Elev. Range: 0-100 ft.

Terrain/Substrate: largely exposed, barren aa and pahoehoe substrate; northern portion of area has numerous small sandy beaches edging small coves with adjacent kiawe groves, and frequently associated brackish water ponds.

Vegetation: Scrub Grasslands, Grasslands, and Kiawe Forest; mostly open barren areas, with vegetation pockets in the northern portion of the area.

Ground Surface Visibility: fair (in northern portion) to excellent (in southern portion).

Designated Sites: (23); 1994-1999, 2133-2136, 2141-2145, 2147, 3707, 3775, 9912, 9937-9940.

Overall Feature Density: moderate (in southern portion) to high (in northern portion).

Comments:

Many of the recorded sites along the coast are associated with the cove and beach locations and/or the small pockets of vegetation that indicate the presence of a subsurface lens of brackish water. Other recorded sites are associated with various topographic features, such as lava tube cave systems and aa ridges. The general distribution of sites appears more or less continuous in the northern portion of the coastal zone survey area, while in the southern portion the sites appear to be more scattered or discontinuous.

SURVEY AREA: A-1

Area: 12.1 ac. Elev. Range: 50-150 ft.

Terrain/Substrate: kipuka surrounded by barren aa; substrate is moderately weathered aa with occasional soil pockets.

Vegetation: Kiawe Forest; kiawe canopy with koa-haole, lantana, and 'ilima understory.

Ground Surface Visibility: fair.

Designated Sites: (1); 9931.

Overall Feature Density: low to moderate.

Comments:

Site complex 9931 corresponds to the entire survey area. The dryland agricultural features present consist of modified outcrops, stone mounds, cleared natural terraces, and possible planting holes. All archaeological features are poorly defined, and sometimes difficult to differentiate from natural formations.

The kipuka is connected to coastal site complex 1994 by a steppingstone foot trail. Just inside the kipuka, the trail crosses a small gulch by means of a causeway built up to a height of 1.2 meters.



SURVEY AREA: A-2

Area: 6.2 ac. Elev. Range: 100-200 ft.

Terrain/Substrate: small kipuka surrounded by barren aa; substrate is moderately weathered aa with occasional soil pockets.

Vegetation: Kiawe Forest; kiawe canopy with koa-haole, lantana, and 'ilima understory.

Ground Surface Visibility: fair.

Designated Sites: (1); 9909.

Overall Feature Density: low.

Comments:

Site complex 9909 corresponds to the entire survey area. The dryland agricultural features consist of modified outcrops, a three meter long alignment, and a few single stone alignments around pockets of soil. Several clear soil areas (no stones) with no associated structural features may also be cultural modifications.

## SURVEY AREA: A-3

Area: 1.4 ac. Elev. Range: 100-150 ft.

Terrain/Substrate: small kipuka surrounded by barren aa; substrate is moderately weathered aa; a large bedrock outcrop c. two meters in height lies within the kipuka; some soil present at north end of outcrop.

Vegetation: Kiawe Forest; kiawe canopy with Christmasberry, koa-haole, lantana, and 'ilima understory.

Ground Surface Visibility: good.

Designated Sites: (1); 9921.

Overall Feature Density: low.

Comments:

Site 9921 corresponds to the entire survey area. The kipuka is surrounded by a low stone wall which incorporates natural outcrop features. With the exception of a stone cairn at the north end, no other cultural modifications were noted within the enclosure.



## SURVEY AREA: A-4

Area: 14.0 ac. Elev. Range: 150-250 ft.

Terrain/Substrate: portion of a large kipuka surrounded by barren aa; substrate is moderately weathered aa with occasional soil pockets of variable size.

Vegetation: Kiawe Forest; kiawe canopy with a dense understory of lantana.

Ground Surface Visibility: poor.

Designated Sites: (2); 9901, 9922.

Overall Feature Density: moderate.

Comments:

Site complex 9901 includes this survey area and several others. Within the area of Survey Area A-4, the dryland agricultural features present consist primarily of soil pockets that probably were intentionally cleared of stones. Some of these clearings are partially enclosed by low stone walls.

## SURVEY AREA: A-5

Area: 11.8 ac. Elev. Range: 250-400 ft.

Terrain/Substrate: portion within *kipuka* has moderately weathered aa substrate, while portion outside *kipuka* is barren aa.

Vegetation: Kiawe Forest; *kiawe* canopy with thick undergrowth of lantana and *koa-haole* within *kipuka*; occasional *Erythrina* trees outside on otherwise barren aa.

Ground Surface Visibility: fair within *kipuka*; excellent outside.

Designated Sites: (2); 9901, 9923.

Overall Feature Density: low.

Comments:

Except for site complex 9923 on the edge of the *kipuka*, no archaeological features were observed on the adjacent aa. The overall density of agricultural modifications within the *kipuka* appears to be less than in Survey Area A-4. At site 9923, a stone wall extends roughly south from the *kipuka* edge into the *kipuka* for an undetermined distance.



## SURVEY AREA: A-6

Area: 16.4 ac. Elev. Range: 400-500 ft.

Terrain/Substrate: generally stony ground with pockets of soil.

Vegetation: mixed Kiawe Forest and Koa-Haole Thicket;some *kiawe* with dense cover of tall *koa-haole* and occasional areas of lantana.

Ground Surface Visibility: fair to good.

Designated Sites: (3); 9901, 9924, 9925.

Overall Feature Visibility: moderate.

Comments:

Agricultural/habitation site complex 9925 consists of a somewhat discrete concentration of stone mounds, cleared areas, and possible planting terraces with associated habitation features on the adjacent ridge to the north. Site 9924 is an isolated C-shaped shelter.

The rest of the survey area is included within site complex 9901. The dryland agricultural features found in this portion consist of stone mounds, modified outcrops, and a few terraces.

SURVEY AREA: A-7

Area: 34.7 ac. Elev. Range: 1000-1150 ft.

Terrain/Substrate: most of area consists of weathered aa, with very little soil; northernmost strip, within the Secondary Grassland and Scrub, is grubbed pahoehoe.

Vegetation: Native Forest and Secondary Grasslands; canopy predominantly candlenut, with alahe'e and lama in the lower tree layer; some Christmasberry and lantana also noted; guinea grass dominant in the grubbed northern strip.

Ground Surface Visibility: variable (poor to good); particularly poor in the area with cover of guinea grass.

Designated Sites: (2); 9916, 9917.

Overall Feature Density: low.

Comments:

Site 9916 is a historic road designated as a site because it appeared to be more substantial than a recent jeep trail. The only other feature (9917) noted was an apparent cultural deposit containing volcanic glass, ceramic fragments, and marine shell that was found in December 1983 in a burned area. Other unidentified deposits could be present in this area, as it was densely vegetated at the time of the initial reconnaissance survey in November 1982.

Within the Native Forest area, no definite cultural modifications or features were identified. Some crude stone mounds and possibly modified outcrops might have been cultural in origin. The butt portion of a large, quadrangular basalt adze was collected from the surface in the northern section of the Native Forest area, but the artifact was not associated with any distinct archaeological feature. Given the ambiguous nature of the possible modifications noted within the Native Forest area, it was decided not to assign any site designation until more intensive survey work is undertaken.



SURVEY AREA: A-8

Area: 10.7 ac. Elev. Range: 950-1050 ft.

Terrain/Substrate: pahoehoe with thin to moderate soil mantle.

Vegetation: Secondary Forest and Scrub; thick Christmasberry, lantana, and guava scrub, with dense grass in places; occasional patches of lama; sinkhole vegetation includes mamaki, bitter yam, lantana, and candlenut.

Ground Surface Visibility: poor to fair.

Designated Sites: (2) 9926, 9927.

Overall Feature Density: low.

Comments:

The survey area is centered on a line of lava tube collapses or sinkholes. Two were inaccessible. Two (9926, 9927) contained cultural modifications. No sites were observed between the sinks, or in the immediate vicinity of the sinks; however, the thick vegetation may have obscured any archaeological features.

## SURVEY AREA: A-9

Area: 29.4 ac. Elev. Range: 0-300 ft.

Terrain/Substrate: gently sloping pahoehoe.

Vegetation: Scrub Grasslands; sparsely vegetated with scattered 'ilima and 'uhaloa scrub and grasses; occasional solitary trees.

Ground Surface Visibility: excellent.

Designated Sites: (1); 9914.

Overall Feature Density: low.

Comments:

The survey area includes a lava flow channel about one mile inland of the jeep road and the coastal portion of the Niuou Trail (sea level to 200 ft. elevation). No sites were found inland of the trail, or along the trail, until it nears the Niuou Complex site (3707).



## SURVEY AREA: A-10

Area: 78.5 ac. Elev. Range: 300-950 ft.

Terrain/Substrate: pahoehoe with variable thickness soil mantle.

Vegetation: Secondary Forest and Scrub, Scrub Grasslands; variable cover, with inland end characterized by lama forest; vegetation in gulch thick, with lantana, kauna'oa-uka, and scattered Christmas-berry and lama trees; downslope area characterized by 'ilima, guava, 'a'ali'i, and scattered alahe'e.

Ground Surface Visibility: poor to fair.

Designated Sites: none.

Overall Feature Density: none.

Comments:

No archaeological features were found in this area. The area was originally inspected because of the possibility of agricultural features occurring in the gulch. Examination of aerial photographs indicated that the upper portion of the survey area (650-950 ft. elevation) has been mechanically altered.

SURVEY AREA: A-11

Area: 90.0 ac. Elev. Range: 100-400 ft.

Terrain/Substrate: pahoehoe.

Vegetation: Grasslands; grass with occasional lantana, 'uhaloa, and 'ilima.

Ground Surface Visibility: good to excellent.

Designated Sites: (3); 9920, 9935, 9936.

Overall Feature Density: low.

Comments:

The survey area followed a line of lava tube collapses. The tube system is distinct from the one which contains sites 3705 and 3706, although it is possible that there is a connecting subsurface tube. The possibility for subsurface archaeological features within this system is substantial. Many, though not all, of the tube entrances were explored.



SURVEY AREA: A-12

Area: 73.2 ac. Elev. Range: 0-150 ft.

Terrain/Substrate: pahoehoe.

Vegetation: Grasslands; grasses with scattered 'ilima, 'uhaloa, and Pluchea.

Ground Surface Visibility: excellent.

Designated Sites: (6); 3705, 3706, 9915, 9933, 9934, 9940.

Overall Feature Density: high.

Comments:

This survey area centered on the lava tube system which contains sites 3705 and 3706. Although ground visibility was excellent, additional subsurface features within the tube system may exist.

## SURVEY AREA: K-1

Area: 10.0 ac. Elev. Range: 50-150 ft.

Terrain/Substrate: portion of seaward extension of large *kipuka* surrounded by barren aa; substrate is moderately weathered aa; rocky and uneven ground surface; soil pockets.

Vegetation: Kiawe Forest; *kiawe* canopy with dense understory of lantana, *koa-haole*, and grasses.

Ground Surface Visibility: fair.

Designated Sites: (3); 9901, 9907, 9932.

Overall Feature Density: moderate.

Comments:

Much of the surface area of this survey area appears to have had some degree of surface modification for dryland agriculture, including such features as clearings and stone piles and mounds. A historic inland-seaward extending trail (site 9932) appears to run the full length of this survey area.



## SURVEY AREA:K-2

Area: 16.5 ac. Elev. Range: 150-200 ft.

Terrain/Substrate: portion of *kipuka*, bordered by barren aa to the south; substrate consists of moderately weathered aa and pahoehoe; soil pockets.

Vegetation: Kiawe Forest; *kiawe* canopy with dense understory of lantana, *koa-haole*, *'ilima*, and grasses.

Ground Surface Visibility: poor.

Designated Sites: (2); 9901, 9932.

Overall Feature Density: moderate.

Comments:

There is generally less surface modification than noted in Survey Area K-1, although the features appear to be similar dry-land agricultural features. A segment of a probable historic trail (site 9932) is present, as well as a long section of an inland-seaward extending stone wall.

SURVEY AREA:K-3

Area: 5.1 ac. Elev. Range: 350-400 ft.

Terrain/Substrate: central portion of large kipuka; substrate consists of moderately weathered aa; some soil pockets.

Vegetation: Kiawe Forest; kiawe canopy with fairly dense understory of lantana, koa-haole, and 'ilima.

Ground Surface Visibility: fair.

Designated Sites: (2); 9901, 9902.

Overall Feature Density: moderate.

Comments:

A possible remnant of a historic trail is present at the base of the slope, just north of site 9902. This feature might represent an inland continuation of another trail (site 9932) identified some distance seaward. Site complex 9901, a habitation and/or ceremonial complex, was probably associated with the prehistoric use--presumably for dryland cultivation--of this portion of the kipuka designated as site 9901.



SURVEY AREA: K-4

Area: 8.9 ac. Elev. Range: 900-1050 ft.

Terrain/Substrate: pahoehoe; large lava channel (collapsed lava tube).

Vegetation: Secondary Forest and Scrub; fairly dense cover of grasses, koa-haole, and lantana, with some candlenut.

Ground Surface Visibility: poor.

Designated Sites: (1); 9903.

Overall Feature Density: moderate.

Comments:

Just seaward of site 9903, a stacked stone wall extends across the lava channel. At the inland end of the survey area is a roughly stacked terrace retaining wall--possibly agricultural--situated on the sloping side of the channel. It appears likely that at least portions of this collapsed lava tube were used for cultivation.

SURVEY AREA: K-5

Area: 7.3 ac. Elev. Range: 850-900 ft.

Terrain/Substrate: well-weathered aa.

Vegetation: Koa-Haole Thicket; dense koa-haole and grasses.

Ground Surface Visibility: poor.

Designated Sites: none.

Overall Feature Density: low.

Comments:

Only two or three possibly modified outcrop features--rough rock piles against bedrock outcrops--were noted in this survey area. Much of the area appears to have been altered during recent times.



SURVEY AREA: K-6

Area: 8.0 ac. Elev. Range: 900-950 ft.

Terrain/Substrate: moderately weathered aa substrate; undulating ground surface, with areas of exposed aa boulders and cobbles.

Vegetation: Koa-Haole Thicket; dense cover of koa-haole, with few kiawe and alahe'e.

Ground Surface Visibility: fair.

Designated Sites: (1); 9941.

Overall Feature Density: moderate.

Comments:

Site complex 9941, a large stone walled enclosure containing dryland cultivation features, comprises the full extent of this survey area. The enclosure appears to have been used historically as a cattle enclosure. This site may be the rainfall station referred to as Kole Pen.

SURVEY AREA: K-7

Area: 71.3 ac. Elev. Range: 450-950 ft.

Terrain/Substrate: pahoehoe; collapsed lava tube channel.

Vegetation: Secondary Forest and Scrub, and Scrub Grasslands; more inland portion has thick, high grass, with koa-haole, lantana, and some Christmasberry and lama; gradual transition seaward to low scrub, primarily of grasses, lantana, 'ilima, and scattered kiawe.

Ground Surface Visibility: poor to fair.

Designated Sites: (2); 2162, 9904.

Overall Feature Density: moderate.

Comments:

Given the relatively dense vegetation cover, it is possible that small and inconspicuous tube openings may have been missed. In the case of the larger lava tubes, the interior extents were not always fully examined.



SURVEY AREA: K-8

Area: 20.9 ac. Elev. Range: 900-1050 ft.

Terrain/Substrate: moderately weathered aa, and surface of barren aa flow.

Vegetation: Secondary Forest and Scrub, and Barren Lava with Scattered Ohia; very heavy cover of thick grass, with lantana, Christmasberry, and lama, on weathered aa.

Ground Surface Visibility: poor in heavily vegetated area; good on aa flow.

Designated Sites: (1); 9905.

Overall Feature Density: low.

Comments:

The northern portion of this survey area exhibits evidence of land suface alteration by means of systematic chain-dragging.

SURVEY AREA: K-9

Area: 145.5 ac. Elev. Range: 150-450 ft.

Terrain/Substrate: inland portion is lava tube channel (collapsed lava tube); seaward portion is well-weathered pahoehoe.

Vegetation: Scrub Grasslands and Grasslands; inland portion has low scrub cover of grasses, lantana, and *'ilima*; seaward portion cover mostly grass, with some low lantana and *'ilima*.

Ground Surface Visibility: fair to good.

Designated Sites: (2); 9906, 9942.

Overall Feature Density: low.

Comments:

No obvious cultural remains were found in the various caves examined along the lava tube channel. The old pahoehoe grasslands portion of the survey area contained scattered military ordnance on the surface, as well as several old bombing targets. Site 9942 probably is the same subsequently noted by Spriggs (1983) during his inspection and referred to as Locations 7 and 8.



SURVEY AREA: K-10

Area: 147.4 ac. Elev. Range: 100-150 ft.

Terrain/Substrate: flat, well-weathered pahoehoe, with scattered patches of thin soil.

Vegetation: Grasslands; low grass cover.

Ground Surface Visibility: good.

Designated Sites: none.

Overall Feature Density: low.

Comments:

Three or four locations were noted that could have been natural volcanic glass sources (surface chill glass) and/or small natural bedrock shelters; however, no definite cultural remains were found in association. Two or three natural depressions (small sinks) in the pahoehoe exhibited some rough clearing of surface rubble from the interior. Though not very distinctive, these may represent minor agricultural features.

SURVEY AREA: K-11

Area: 12.5 ac. Elev. Range: 750-800 ft.

Terrain/Substrate: well-weathered old aa substrate; undulating surface.

Vegetation: Secondary Forest and Scrub; heavy cover of high grass, lantana, Christmasberry, and *kiawe*, with some candlenut and *wiliwili*.

Ground Surface Visibility: poor.

Designated Sites: (1); 9910.

Overall Feature Density: moderate.

Comments:

This survey area appears to contain possible agricultural features, including clearings and piled stone mounds, although the heavy vegetation makes it difficult to determine the extent of these features.



SURVEY AREA: K-12

Area: 49.4 ac. Elev. Range: 50-950 ft.

Terrain/Substrate: inland portion is well-weathered aa flow; seaward portion is barren aa.

Vegetation: Secondary Forest and Scrub, and Scrub Grasslands; inland portion has dense cover of high grass, with lantana, Christmasberry, *lama*, and *kiawe*; seaward portion has open scattering of grasses.

Ground Surface Visibility: poor in inland portion; excellent in seaward portion.

Designated Sites: (2); 9908, 9943.

Overall Feature Density: low.

Comments:

This survey area consists of a long transect extending along virtually the entire northern boundary of the project area.

## SURVEY AREA: V-1

Area: 38.6 ac. Elev. Range: 50-500 ft.

Terrain/Substrate: pahoehoe; sloping in inland portion.

Vegetation: Scrub Grasslands; sparsely vegetated, with scattered 'ilima and 'uhaloa; occasional solitary trees in inland portion; seaward portion cuts through small kipuka with kiawe canopy.

Ground Surface Visibility: excellent.

Designated Sites: (2); 9913, 9928.

Overall Feature Density: low.

Comments:

No archaeological remains were noted in the inland portion of this survey area. The seaward portion cuts through a small kipuka (Survey Area V-2) which had scattered agricultural features. The seaward end of the survey area centers on a foot trail (site 9913), associated with which are two possible rest areas, three cairns, and site 9928.



## SURVEY AREA: V-2

Area: 86.0 ac. Elev. Range: 100-250 ft.

Terrain/Substrate: small kipuka with moderately well-weathered aa substrate with soil pockets; surrounded by barren aa.

Vegetation: Kiawe Forest; kiawe canopy with understory of lantana, 'uhaloa, and grass; cover is not continuous as in other coastal kipuka survey areas; open patches of exposed aa between clumps of kiawe.

Ground Surface Visibility: good.

Designated Sites: (4); 9918, 9919, 9929, 9930.

Overall Feature Density: moderate to high.

Comments:

Site 9919 refers to the entire V-2 survey area. The dryland agricultural features consist primarily of modified outcrops, crude terraces, cleared areas, and short wall segments. Site 9918 is a foot trail connecting the kipuka with the coastal area, while sites 9929 and 9930 are small residential complexes within the larger agricultural complex.

## ADDITIONAL DESIGNATED SITES

Review of the reconnaissance survey field records during preparation of the preceeding Survey Area Notes revealed an additional eight features and feature complexes which could be regarded as formal sites. These eight have now been assigned H.R.H.P. sites numbers, and their locations have been plotted on the revised survey area and site location map (Fig. 2).

Addendum Tables 1, 2, 3, and 4 summarize the appropriate additions to be made to the tables presented in the original report of the reconnaissance survey. The newly designated sites are listed in Table 1 according to specific survey area provenience. Table 2 lists the additional new type of residential site represented among the eight additional designated sites. Table 3 summarizes the additional sites according to survey area location, site type, dimensions (where available), condition, and integrity. Table 4 summarizes the preliminary evaluations of and recommendations for the additional designated sites according to significance (degree and nature), and estimated man-days of labor for the intensive survey work recommended as the appropriate next level of archaeological study. Following these addendum tables are short descriptions of the individual additional designated sites.

Spriggs' (1983) field inspection report was consulted in an attempt to correlate his described archaeological locations with previously designated sites and survey areas. Where his observations seem to apply to certain archaeological features recorded during the reconnaissance survey, appropriate notation has been added to the specific survey area notes and/or individual site descriptions. No attempt has been made, however, to incorporate specific information from Spriggs' report into the addendum tables. For the most part, the sites and features reported by Spriggs appear to be situated outside of the areas covered during the original reconnaissance survey. Furthermore, the level of descriptive recording is somewhat less than that of the reconnaissance survey, and the exact locations of many of these new sites are uncertain. It would be inappropriate to attempt to describe and assess the significance of the features identified by Spriggs without first inspecting them in the field in order to record and evaluate them in a manner consistent with the methods and criteria used during the original reconnaissance survey.



Addendum Table 1.

**SUMMARY OF SURVEY AREAS**
**FARMS OF KAPUA PROJECT AREA**

| Survey Area | Designated Sites |
|---|---|
| A-7 | 9916, 9917 |
| A-11 | 9920 |
| K-1 | 9932 |
| K-2 | 9932 |
| K-9 | 9942 |
| K-12 | 9943 |
| V-2 | 9918, 9919 |

Addendum Table 2.

**SUMMARY OF FUNCTIONAL SITE AND FEATURE TYPES**
**FARMS OF KAPUA PROJECT AREA**

RESIDENTIAL FEATURES

Habitation deposit

Addendum Table 3.

SUMMARY OF DESIGNATED SITES
FARMS OF KAPUA PROJECT AREA

Site 9916
Survey Area: A-7
Site Type: Historic road
Dimensions: ---
Condition: Fair Integrity: Partially altered

Site 9917
Survey Area: A-7
Site Type: Habitation deposit
Dimensions: c. 3 sq. meters (exposed)
Condition: Poor/Fair Integrity: Part. alt.

Site 9918
Survey Area: V-2
Site Type: Trail and associated features
Dimensions: ---
Condition: Good Integrity: Unaltered

Site 9919
Survey Area: V-2
Site Type: Agricultural complex
Dimensions: 86 sq. meters
Condition: Fair Integrity: Unaltered

Site 9920
Survey Area: A-11
Site Type: Residential complex (cave)
Dimensions: ---
Condition: Good Integrity: Unaltered

Site 9932
Survey Area: K-1,2
Site Type: Historic trail
Dimensions: ---
Condition: Fair/Good Integrity: Part. alt.

Site 9942
Survey Area: K-9
Site Type: Trail segments
Dimensions: ---
Condition: Good Integrity: Unaltered

Site 9943
Survey Area: K-12
Site Type: Wall (boundary wall)
Dimensions: ---
Condition: Good/Excellent Integrity: Unaltered



Addendum Table 4.

SUMMARY OF SITE EVALUATIONS AND RECOMMENDATIONS
FARMS OF KAPUA PROJECT AREA

Site 9916
Site Type: Historic road
Significance: Mod. Res./Min. Int.
Recommendations: Int. Survey (2 man-days)

Site 9917
Site Type: Habitation deposit
Significance: Mod. Res./Min. Int.
Recommendations: Int. Survey (4 man-days)

Site 9918
Site Type: Trail and associated features
Significance: Mod. Res./Min. Int.
Recommendations: Int. Survey (to be determined)

Site 9919
Site Type: Agricultural complex
Significance: Mod. Res./Mod. Int.
Recommendations: Int. Survey (to be determined)

Site 9920
Site Type: Residential complex (cave)
Significance: High Res./Min. Int.
Recommendations: Int. Survey (4 man-days)

Site 9932
Site Type: Historic trail
Significance: Mod. Res./Min. Int.
Recommendations: Int. Survey (4 man-days)

Site 9942
Site Type: Trail segments
Significance: Mod. Res.
Recommendations: Int. Survey (4 man-days)

Site 9943
Site Type: Wall (boundary wall)
Significance: Mod. Res./Mod. Int.
Recommendations: Int. Survey (4 man-days)

SITE DESCRIPTIONS

Site 9916 - Historic Road

Historic road or cart trail, or possibly a more recent jeep track; roadbed is approximately two meters wide, and is defined by small pebbles and cobbles; road sides are bordered by rough rubble alignments and crude sections of wall; road extends seaward, and may continue into the kipuka associated with site 9901.

Site 9917 - Habitation Deposit

A dark, charcoal-rich cultural deposit with an areal exposure of two-to-three square meters; surface portable remains include fragments of volcanic glass and ceramics, and marine shell midden; site is situated on a rise, near the edge of the adjacent candlenut-lama forest to the south.

Site 9918 - Trail With Associated Features

Foot trail leading into agricultural complex designated as site 9919; small lava bubble shelter associated with trail contains several large pieces of gourd; small terrace also located nearby.

Site 9919 - Agricultural Complex

Complex of dryland agricultural features situated within a grove of kiawe; component features include terraces, modified outcrops, cleared areas, and wall segments; some of the terraces might also have functioned as residential and/or crop storage features.

Site 9920 - Residential Complex

Complex originally designated as site 9936-b on earlier reconnaissance survey site location map; complex consists of two shelter caves--one with a moderate soil deposit, and the other with a cache of cowrie shell octopus lures; a cairn of stacked pahoehoe slabs is located in the vicinity.

Site 9932 - Historic Trail

Inland-seaward extending trail; appears as a shallow depression in ground, c. 1.5 meters wide and cleared of stones; visible intermittently through Survey Areas K-1 and K-2; trail appears to be one identified on 1932 Bishop Estate map (Keppeler, Emory, and Bryan 1932) as "Main Trail to Upper Kapua and Okoe".



Site 9942 - Trail Segments

Three distinct trail segments; all three probably parts of same foot trail; generally c. one meter wide; portions paved with pahoehoe steppingstones; small built-up ramp across shallow depression noted; trails segments mentioned by Spriggs (1983) as his Locations 7 and 8 are possibly sections of this same inland-seaward extending trail.

Site 9943 - Wall (Boundary Wall)

Long stone wall extending along the north side of the project area; probably the boundary wall between the land units (ahupua'a) of Kapua and Okoe; wall generally 1.0 to 1.5 meters high, constructed of stacked boulders; some roughly core-filled sections; remains of two-strand barbed wire fence along part of the wall; previously designated site 9908, a historic camp site, possibly associated with construction of the wall and/or fence.

## REFERENCES CITED

Keppeler, H. K., with K. P. Emory and E. H. Bryan

1932 Map of a Portion of Kapua, South Kona, Hawaii: Beach from Okoe Boundary to Kaupo Bay. B. P. Bishop Estate Map No.2525.

Nagata, K. M.

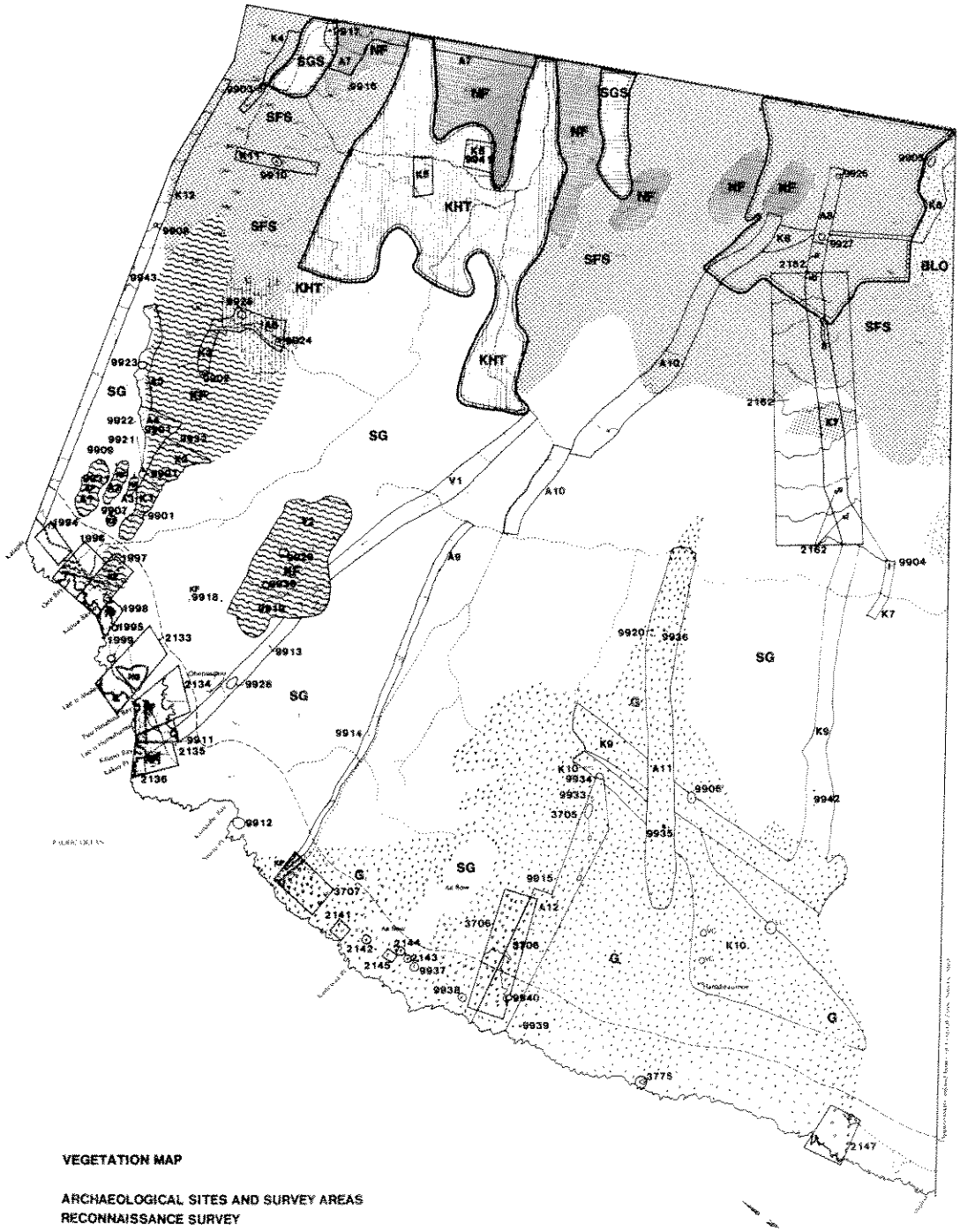
1983 Kapua Farms Botanical Reconnaissance. Prepared for Farms of Kapua Ltd.

Rosendahl, P. H.

1983 Archaeological Reconnaissance Survey, Farms of Kapua Project Area, Land of Kapua, South Kona, Island of Hawaii. Report Ms.73-120782. Prepared for Farms of Kapua Ltd.

Spriggs, M.

1983 A Field Trip to the "Farms of Kapua" Property, Kapua, Kona, Hawai'i Island. Report appended to University of Hawaii-Environmental Center letter of January 6, 1984 commenting on Farms of Kapua E.I.S. Notice of Preparation.




**VEGETATION MAP**

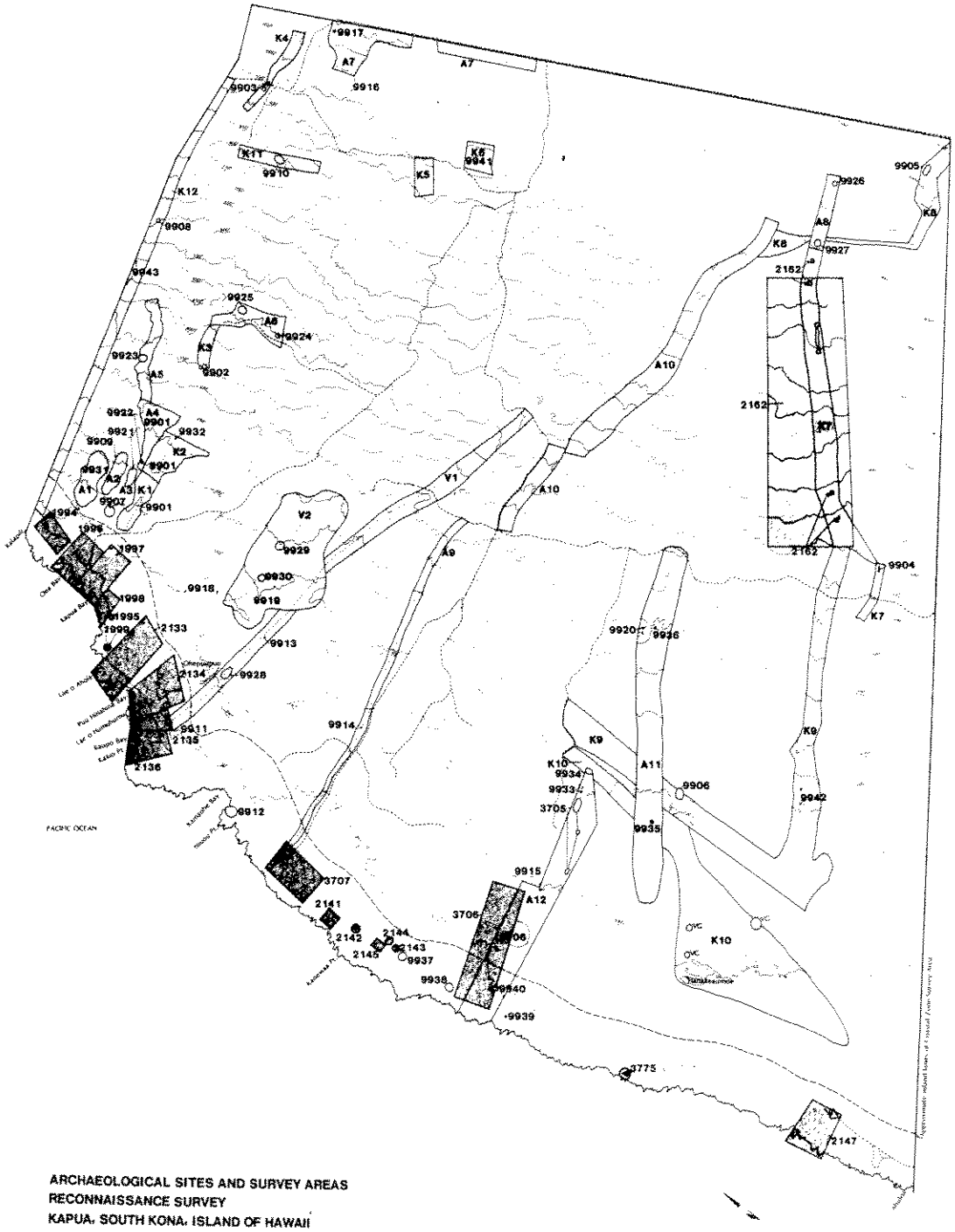
**ARCHAEOLOGICAL SITES AND SURVEY AREAS**
**RECONNAISSANCE SURVEY**
**KAPUA, SOUTH KONA, ISLAND OF HAWAII**

PHRI 82-73 November 1982
(Revised February 1984 PHRI 84-108)

| | |
|---|---|
| SG | Scrub grasslands |
| G | Grasslands |
| KF | Klaive forest |
| HG | Hau grove |
| NF | Native forest |
| KHT | Koa-hoole thicket |
| SFS | Secondary forest and scrub |
| SGS | Secondary grasslands |
| BLO | Barren lava with scattered ohia |
| | Approximate limits of mechanically altered areas |

3775
A/K/V

Report Ms 108-021084 Fig. 1




ARCHAEOLOGICAL SITES AND SURVEY AREAS
RECONNAISSANCE SURVEY
KAPUA, SOUTH KONA, ISLAND OF HAWAII

PHRI 82–73 November 1982
(Revised February 1984 PHRI 84–108)

3775
A/K/V

APPENDIX E

# AGRICULTURAL FEASIBILITY OF MACADAMIA CULTIVATION FARMS OF KAPUA (Revised 1984)

By
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Agricultural Economist

# Agricultural Feasibility

Farms Of Kapua

# Phase I

Prepared for
Agricultural Concepts, Inc.

by
Frank S. Scott, Jr.
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Revised
January 1984

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A Feasibility Study for
Macadamia Nuts
FARMS OF KAPUA

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## SUMMARY AND CONCLUSIONS

This report investigates the agroeconomic feasibility of macadamia nut production at Farms of Kapua in the area extending mauka from the 400-foot elevation to the area currently zoned for agriculture (varying from 800 to 1,000 feet elevation).

The feasibility of macadamia production is based on four criteria, consisting of (1) ecological adaptation; (2) sales potential; (3) comparative economic advantage; and (4) intensity of production.

### Ecology

Ecological conditions are generally favorable to macadamia production in the area. The predominant soil types are the Kaimu Series in the mauka section and a'a lava flows in the makai section of the subject land parcel. The Kaimu soils are interspersed with large islands of the Punaluu Series, consisting of extremely rocky peat over pahoehoe, rough broken land and a'a with no soil covering. Kaimu soils are well adapted to macadamia production and the interspersed soils could be used for macadamia production with appropriate preparation and cultural practices. Temperatures are favorable to macadamia production, with mean highs and lows expected to have no adverse effects on yield from the 400-foot elevation to the MacFarms border.



Wind is not considered a serious problem in this area, although occasional storms could be expected to result in some tree damage.

The estimated mean annual rainfall of 30.0 inches at the mauka border 1,000 feet would permit macadamia production, but supplemental irrigation would be required during dry periods for maximum yield. Macadamia trees would be expected to undergo severe stress without irrigation at the 400-foot elevation, where mean annual rainfall is estimated at 27.5 inches. Mean supplemental irrigation requirements for optimal macadamia production in the area specified are estimated at 2.5 acre inches per month, ranging from 2.0 inches during the wetter months to 3.0 inches during the drier months. For optimal production, the irrigation system would need a delivery capacity of 4,000 gallons per acre per day to accommodate extended dry periods.

Initial investigation indicates the need for providing quality irrigation water as a basis for obtaining viable macadamia production in the subject area. The Okoe well, which is being considered as a source of irrigation water for Farms of Kapua has a total salt content of 1,780 mg/liter and a chloride content of 920 mg/liter, both of which exceed the estimated salt tolerance for macadamia production at 80 percent yield when converted to accumulated salts in the soil. Research on plant response to salts generally assumes organic soils and primary dependence upon irrigation. There is reason to believe that the high salt content of the water may be better tolerated at Farms of Kapua, where irrigation requirements are projected at only 57 percent of total water requirements, where the mean annual rainfall of 28.8 inches would provide substantial leaching, and where the porous a'a with very little soil would not be expected to contribute significantly to the concentration of salts.

## Sales Potential

There is sales potential in the foreseeable future for the output of an estimated 1,197 acres of macadamias in the area of Farms of Kapua between the 400-foot elevation and the border of the area currently zoned for agriculture. The U.S. Mainland market potential for macadamias in 1990 has been estimated at 32,200,000 pounds as compared with estimated current marketings of less than 6,000,000 pounds, including macadamias taken home from Hawaii by visitors. A potential market for macadamias equivalent to that of the U.S. Mainland has been projected for the rest of the world. Approximately 26,000 acres would be required to supply the U.S. and Hawaii markets, plus 21,000 acres for the rest of the world. Hawaii plantings amounted to 15,800 acres in 1983 and an estimated additional 15,000 acres is expected to be planted in Hawaii within the next 10 years. Foreign plantings are minimal at present, but may pose serious competition to Hawaii in 20 years.

## Economic Viability

A mature macadamia orchard of 16 years or more in age in the project area is projected to provide a net return per acre to land and risk before land cost of $2,564 at 1982 input-output prices. An estimated annual land charge of $300 per acre would reduce this to $2,264. Internal rate of return at a projected 5 percent rate of inflation over a 25-year period from orchard start-up is projected at 23.0 percent before land cost and 20.0 percent with land costs treated as an annual cash lease of $300, plus the present value of land at the 25-year amortization period.

Under good management, including appropriate supplemental irrigation, macadamia production at Farms of Kapua would be competitive with other well managed orchards in Hawaii.

## Conclusions

The study indicates that macadamia production would provide an economically viable enterprise at Farms of Kapua for the area extending from the 400-foot elevation to the area currently zoned



for agriculture, providing a satisfactory source of irrigation water is obtainable. This crop probably exceeds all other crops in satisfying the four feasibility criteria used in the analysis. It is one of the few crops for which the market is not a primary limiting factor. It is an intensive crop which would provide an internal rate of return of 20.0 percent after land cost, based on the assumptions in the analysis. The macadamia orchard also constitutes an esthetic landscape which is important in a development such as Farms of Kapua.

Because of the high salt concentration of Okoe well from which a source of irrigation water is proposed, search for a purer source of water is suggested. If this alternative cannot be realized, gradual development of macadamia orchards makai from the area currently zoned for agriculture is suggested. This would permit research on macadamia growth response to irrigation water from the Okoe well, which in turn could provide a guide to the feasibility of expanding to zones of lower rainfall.

## INTRODUCTION

This report investigates the feasibility of macadamia nut production on Farms of Kapua in the area extending from the 400-foot elevation to the boundary of the area presently zoned for agriculture. This area contains 1,710 acres, of which 70 percent or 1,197 acres is considered adaptable to macadamia production.

Appropriate criteria for crop selection indicate that macadamia nut production constitutes the most feasible agricultural enterprise for this area.

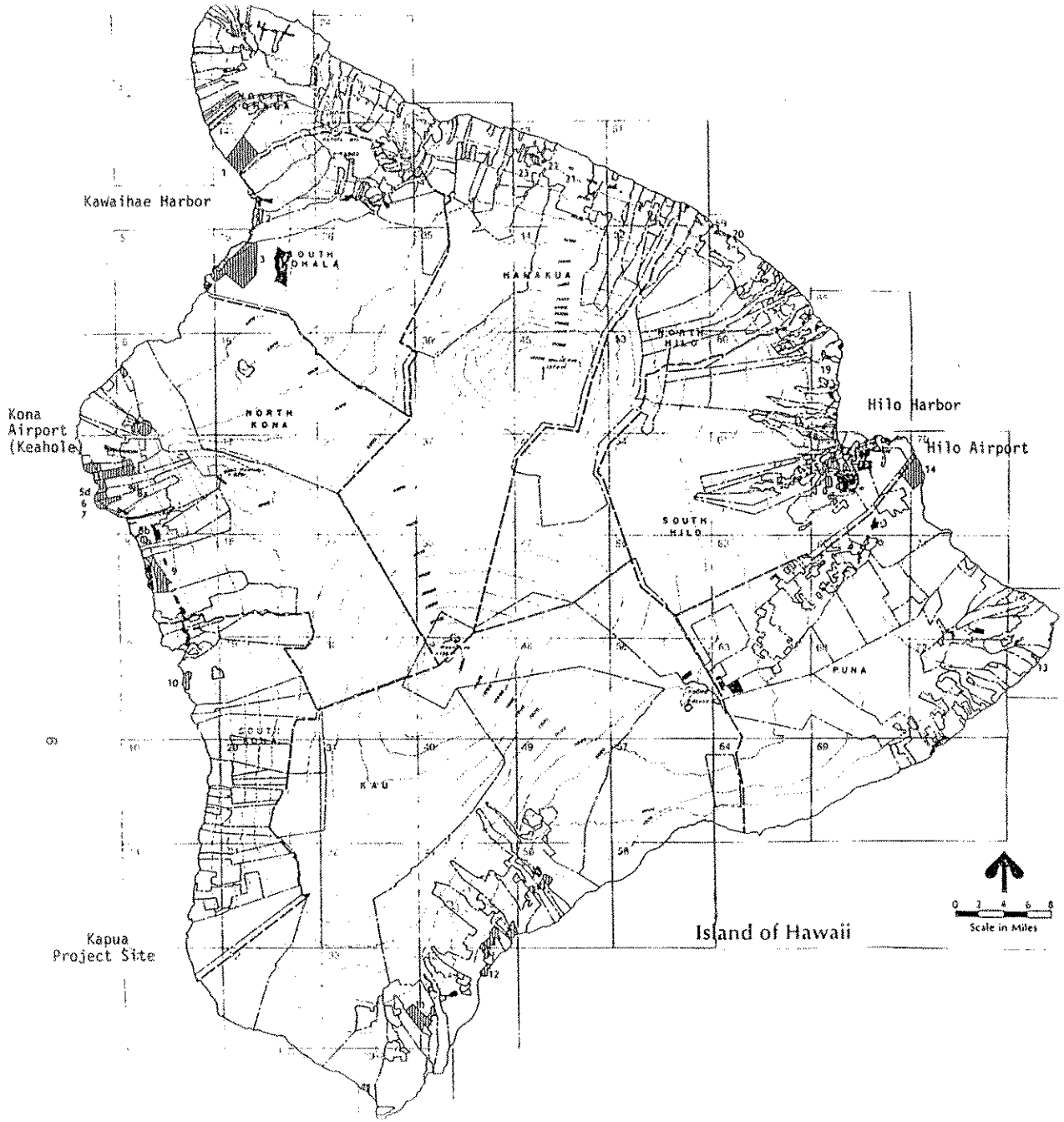
Macadamias were selected as the most feasible crop for the subject area based on the following criteria:

(1) Ecological Adaptation. Ecological factors are soil fertility, soil depth, drainage, water retention, slope, wind, temperature, sunlight, precipitation, insects, weeds and diseases.

(2) Sales Potential. The quantity of a product ecologically adapted to the project area which could be successfully marketed, either locally or as an export crop.

(3) Cost Feasibility. This includes excess of returns over costs and the ability to compete price-wise and quality-wise with other existing or potential production areas.

(4) Intensity of Production. The magnitude of net income per acre is crucial to crop viability on high value agricultural land.


Kawaihae Harbor
Kona Airport (Keahole)
Hilo Harbor
Hilo Airport
Kapua Project Site
Island of Hawaii
NORTH KONA
SOUTH KOHALA
HAMAKUA
NORTH HILO
SOUTH HILO
PUNA
SOUTH KONA
KAU
Scale in Miles

## SOILS AND TOPOGRAPHY

### Section Between 400 and 900 Feet Elevation

Soil capability classifications in the analysis are based on "Soil Survey of Island of Hawaii, State of Hawaii," issued by the U.S.D.A. Soil Conservation Service in December, 1973. Since most of the conservation zone programmed for macadamia production is situated between 400- and 900-feet elevation, soil descriptions are limited to this area.

The predominant soil types throughout the area between 400- and 900-feet elevation consist of rKED soil of the Kaimu Series in the mauka section and rLV (a'a lava flows) in the makai section. The central and south sections of the area are interspersed with islands of rPYD soil of the Punaluu Series. There is a small pocket of rLW (Pahoehoe lava flows) in the extreme central makai section of this area. A strip of RB (rough broken land) is located near the north boundary.

Descriptions and capability potentials for macadamias of the various soil series and subseries in the 400- to 900-foot zone are as follows:

Kaimu Series. Kaimu extremely stony peat, 6 to 20 percent slopes (rKED). The Kaimu Series consists of well-drained, thin organic soils over a'a lava. The Kaimu extremely stony peat has a top layer consisting of three inches of peat underlain with fragmented a'a. The pH of the topsoil is neutral. Permeability is rapid, runoff is slow and the erosion hazard is slight. Kaimu extremely stony peat is classified as VIIs (severe limitations) because of its shallow and stony characteristics which prevent cultivation. Macadamia nuts and other orchard crops are adaptable to this soil type. Slopes are moderate and topography would not limit orchard production efficiency.



Punaluu Series. Punaluu extremely rocky peat, 6 to 20 percent slopes (rPYD). The Punaluu Series consists of well-drained, thin organic soils over pahoehoe lava. The Punaluu extremely rocky peat has a top layer consisting of black peat of four inches in thickness underlain by pahoehoe bedrock. The pH of the topsoil is medium acid. The topsoil is rapidly permeable and the underlayer of pahoehoe is very slowly permeable, except for rapid movement of water through the cracks. Runoff is slow and the erosion hazard is slight. The soil is given a low classification of VII because of the shallow characteristics of the topsoil and rocky characteristics of the underlayer which prevent cultivation. Similar type land is used for macadamia production in other areas of Kona, thus indicating the probable feasibility of its use for the same purpose on Kapua lands. Substantial ripping and possible blasting is suggested to break up the pahoehoe to improve drainage and root penetration. Slopes are not excessive for macadamia production.

Rough Broken Land (RB). This soil type is described by the Soil Conservation Service as a miscellaneous type consisting of very steep, precipitous land with slopes of 35 to 70 percent, broken by many intermittent drainage channels. Other than the steepness of slopes and probable erosion, the rough broken land is considered to be similar to that of the prevailing soil in the area, in this instance rKED. The rough broken land outlined in the project area appears to have a much lesser degree of slope than indicated in the description given by the Soil Conservation Service. It appears that most of this area could be levelled and low areas filled in at the time the project is cleared and ripped. It could then be planted to macadamias.

Lava Flows, A'a (rLV). The soil type designated as A'a Lava Flows is similar to rKED, except that it occurs in lower rainfall areas and has essentially no soil covering. This soil

type can be used for macadamia production under appropriate cultural methods, including addition of soil to the planting holes, adequate irrigation and adequate fertilization. Some levelling and ripping may be required prior to planting macadamias.

Lava Flows, Pahoehoe (rLW). This lava flow has a billowy, glassy surface, which is rough and broken in some areas, with the possibility of hammocks and pressure domes. Pahoehoe lava has no soil covering except in areas of heavier rainfall where trees have gained a foothold in cracks and crevices and a shallow level of humus has developed. Pahoehoe flows are given the lowest agricultural capability subclass of VIIIs.

## SALES POTENTIAL

Approximately 9,540,000 pounds of kernels were processed from the 38,160,000 pounds of in-shell macadamias marketed in Hawaii in 1983(6). It is estimated that somewhat over 50 percent of this quantity was sold in Hawaii. A substantial, but undetermined, amount of macadamias were consumed elsewhere in the form of take-home gifts purchased by Hawaii visitors and out-shipments as gifts by Hawaii residents (15,16). Most of the remainder was sold to the U.S. Mainland, although substantial quantities were also sold to foreign countries, particularly to Japan, Canada and Western Europe. U.S. imports of macadamias from foreign countries amounted to approximately 540,000 pounds of kernels in 1982.

Research conducted by the writer indicates a 1990 U.S. Mainland market potential of not less than 32,200,000 pounds of kernels. The fact that the U.S. currently consumes close to 50 percent of the world output of commercial tree nut production might indicate a probable potential world market potential of 64,400,000 pounds of shelled macadamias in 1990.



At expected yields per acre from existing plantings in full bearing in Hawaii, approximately 26,000 acres of macadamias would be required to supply the combined 1990 market potential for Hawaii and the U.S. Mainland of 39,200,000 pounds of kernels.

The Hawaii Agricultural Reporting Service reported 15,800 acres in macadamia orchards in 1983, of which 10,600 acres were in full or partial bearing. Additional plantings in progress plus potential plantings in Hawaii for the next 10 years are estimated at 15,000 acres. This would bring total acreage to a level slightly in excess of that required to meet the projected 1990 market potential for Hawaii and the U.S. Mainland. None of this additional acreage would be in full bearing by 1990, however, since macadamia trees are estimated to reach full maturity at approximately 16 years of age, depending upon variety, ecology, cultural practices and planting density. Hence, by the time the projected plantings reach full bearing, the market potential would be expected to have increased. Also, it is estimated that the world market potential for macadamias in 1990 would require the output from 21,500 acres, although an undetermined amount of this would be supplied by foreign countries.

Macadamia plantings are being increased in several foreign countries, primarily in Australia and in various countries in Africa, Central America and South America. However, the development of varieties, propagation of nursery stock and orchard development are slow processes and serious threat to Hawaii producers is not expected for perhaps 20 years.

The above analysis indicates that Farms of Kapua would have reasonably good assurance of being able to market the output of macadamias from the estimated 2,000 acres which are ecologically adaptable to macadamia orchards within the conservation zone and in the mauka areas of Farms of Kapua, which are presently zoned for agriculture. Planting at an early date would enhance the opportunity of Farms of Kapua to develop markets for macadamia products

prior to serious competition from potential domestic and foreign producers.

## TEMPERATURE

Research on climatic adaptability of macadamias is inconclusive and there is some disagreement among scientists on this issue. There is general agreement that yield is seriously reduced under sustained average daily minimum temperatures of less than 57 degrees and in excess of 69 degrees during the winter season at the time of blossoming. Research by Dr. Shigeru Nakata of the University of Hawaii indicates a very serious reduction in the cumulative number of racemes during a 97-day period of controlled temperatures from 390 racemes at a daily minimum of 64.4°(F.) to 250 racemes at a daily minimum of 59.0° to 160 racemes at a daily minimum of 53.6°. The reduction in raceme count to 50 percent of the expected count or 390 racemes at approximately 57° would seriously reduce yield. High minimum daily temperatures during flowering also had an adverse effect and an accumulative raceme count of only 10 was attained at a minimum daily temperature of 69.8° in Dr. Nakata's experiment.

University of Hawaii scientists involved in cultural research on macadamias indicate that macadamia yield is also affected by an average daily maximum temperature in excess of 85.0 degrees.

Both daily minimum and daily maximum temperatures are indicated to be within acceptable levels for macadamia flowering and fruit set in the subject area of Farms of Kapua.

Average daily minimum temperatures in the section of Farms of Kapua between the 400-foot and 900-foot elevations would not pose a problem in macadamia flowering, based on Dr. Nakata's research. Average daily low temperatures for January, February and March at the 400-foot elevation at Kapua are estimated at 62.7°, 65.2° and 63.0°, respectively based on recorded data at Napoopoo, which is



the closest station located at the same elevation (Appendix B). Adjustment of median daily minimum temperatures recorded at Opiihale at 1,300 feet elevation to the 900-foot level at Farms of Kapua provides daily lows of 57.8°, 58.0° and 59.0° for January, February and March, respectively.

Based on the Napoopoo recordings, the estimated average daily maximum temperatures at the 400-foot level of Kapua for August and September are 84.8° and 84.7°, respectively. Adjustment of average daily maximum temperatures recorded at the 1,300-foot elevation at the Opiihale station to the 900-foot elevation at Farms of Kapua provides average daily maximum temperatures of 81.2 and 82.4 degrees for August and September, respectively.

## RAINFALL AND IRRIGATION

A mature macadamia orchard at Kapua is estimated to require 4,000 gallons per acre per day under full dependence on drip irrigation at orchard maturity. Water requirements assume an adequate amount of humus for water retention as now exists in the upper elevations of the subject zone. Adequate humus would be expectd to develop in the drier areas by the time the orchards attain maturity in water requirements. Natural rainfall in this area at elevations of 1,000 feet or less is inadequate for macadamia production. Estimated average annual rainfall, based on recorded and approximated data on the project site varies from 30.0 inches at the 920-foot elevation (Kole Pen) to 27.5 inches at the 400-foot elevation (estimated mean at 400-foot isohyet converted from median by multiplier of 1.165 to conform with mean-median relationship at Kole Pen, Circular C88, DOWALD, Reference 7). Based on these data the average annual rainfall for the section of Kapua between the 400 and 900 feet elevations is estimated to approximate 28.8 inches. The annual rainfall in this area is fairly uniform, with recordings dropping below 87 percent of the median only 25 percent of the time. The rainfall is also fairly uniform from month to month,

with a median of 2 to 3 inches per month for January, March, April, May, July and September and 1 to 2 inches per month for each of the other months. It is estimated that supplemental irrigation requirements per acre would approximate 2.0 acre-inches per month during the wetter six months of the year and 3.0 acre-inches per month during the drier six months. This would constitute an average annual supplemental irrigation requirement of 30 acre-inches for mature trees. It is assumed that the natural rainfall would be sufficient to leach out any accumulation of salts from the irrigation water. An analysis of the probable effects of saline irrigation water on macadamia production is presented in Appendix A.

Supplemental irrigation requirements would, as evidenced by the rainfall data, vary from year to year and full dependence on irrigation could be expected during occasional dry months, which might occur at any season of the year.

## WIND

Wind damage to macadamias is not a regular occurence in the area of Kapua, but occasional storms result in severe damage, including blowing down of trees. Windbreaks would partially reduce these losses, but there is indication that the cost of planting and care of windbreaks and the land area required for them may not be justified. Even with windbreaks it is expected that trimming and occasional replanting would be required. A more conclusive answer on the economic feasibility of windbreaks requires further study.



## PRODUCTION AND MARKETING SPECIFICATIONS

### Farm Size

A 200-acre unit was selected as a basic model for farm size because of the availability of input-output data for this size of unit and because it is large enough to efficiently utilize buildings and equipment, including mechanical harvesters. Multiples of the 200-acre unit under common management would be expected to provide some increase in economy of scale.

### Buildings and Equipment

The budget analyses for each 200-acre farm enterprise is designed to optimize production practices through the most appropriate combination of labor and equipment.

Table 1 shows a full inventory of buildings and equipment for a macadamia orchard in production. Buildings and equipment required for harvesting and post-harvest operations are not scheduled for purchase until required at the appropriate level in orchard development, during the 7th and 8th years.

### Production Inputs

Chemical, labor and machinery use requirements for fertilizing, weed control and rat control are based on practices reported by farmers in Kona and in pertinent other macadamia producing areas on the Island of Hawaii. This information is supplemented and refined with data obtained by scientists and extension specialists at the University of Hawaii.

### Spacing and Yield

Since it is indicated that the saline irrigation water being considered for use at Kapua would have some retarding effect on growth of trees, resulting in 90 percent of potential yield, a planting density of 64 trees per acre is programmed in the budget analysis. This compares to a density of 50 trees or less per acre on most farms in Kona, but 70 or more trees per acre on some farms

Table 1. Buildings and Equipment, 200-Acre Macadamia Farm

| Item | Cost | Expected Life (years) | Depreciation (10% salvage value) | Interest 12% ÷ 2 | Depreciation & Interest |
|---|---|---|---|---|---|
| Bldg., Equip. & Storage, 2000 sq. ft. @ $10 | $ 20,000 | 20 | $ 900 | $ 1,200 | $ 2,100.00 |
| Bldg. for Huskers 2000 sq. ft. | 20,000 | 20 | 900 | 1,200 | 2,100.00 |
| Drying Sheds 2000 sq. ft. @ $6 | 12,000 | 20 | 540 | 720 | 1,260.00 |
| Truck, dump, 2-ton | 15,000 | 10 | 1,350 | 900 | 2,250.00 |
| Pickup, 3/4-ton | 10,000 | 10 | 900 | 600 | 1,500.00 |
| Tractor, 50 hp 2 @ $18,000 | 36,000 | 10 | 1,620 | 2,160 | 3,780.00 |
| Trailer, 2 @ $1,000 | 2,000 | 10 | 180 | 120 | 300.00 |
| Huskers, 4 @ $3,500 | 14,000 | 10 | 1,260 | 840 | 2,100.00 |
| Power Sprayers, 200-gallon, 2 @ $2,000 | 4,000 | 10 | 360 | 240 | 600.00 |
| Knapsack Sprayer, 2 @ $200 | 400 | 10 | 36 | 24 | 60.00 |
| Harvester (Shaker) | 70,000 | 10 | 6,300 | 4,200 | 10,500.00 |
| Leaf Remover | 4,000 | 10 | 360 | 240 | 600.00 |
| Irrigation System | 120,000 | 8 | 13,500 | 7,200 | 20,700.00 |
| Miscellaneous Equip. | 4,000 | 10 | 360 | 240 | 600.00 |
| Total, 200 Acres | 331,400 | | | | 53,850.00 |
| 1 Acre | 1,657 | | | | 269.25 |



in Kona and elsewhere on the Island of Hawaii. A somewhat greater spacing between rows than within rows is suggested to facilitate harvesting.

A per acre yield for mature orchards of 90 percent of that realized under good management in Kona is budgeted for Kapua to take into consideration the probable effect of the slightly saline irrigation water on yield. Accelerated levels of production are assumed during the earlier bearing years, however, to reflect yields expected from optimal production practices and the favorable climate between the 400- and 900-foot elevation, and possibly lower.

## Harvesting

The 200-acre farm is large enough to utilize one mechanical harvester, which substantially reduces costs of harvesting in relation to full dependence on hand harvesting. Nevertheless, because macadamias mature over an extended period of time, only 45 percent of the nuts are scheduled for harvest by shaker and the remainder are hand harvested. The potential for mechanical harvesting is based on data provided by the macadamia industry and agricultural engineers at the University of Hawaii. The shaker is designed to unload in-husk nuts into trucks and trailers for immediate transport to husking facilities.

## Husking and Drying

Four Tengan huskers are required at the time the 200-acre orchard approaches full production. One large husker would not significantly increase efficiency and the use of more than one husker permits incremental additions of huskers as the orchard matures.

## Processing

The feasibility analysis carries the macadamia operation to the stage of in-shell nuts. Aggregation of the output from a multiple of 200-acre units would be expected to provide sufficient economy of scale for a processing plant at Kapua for converting

macadamias at least to the raw kernel stage and probably into processed consumer products.

Labor and Management Requirements

Labor and management requirements for macadamia production at Farms of Kapua for the area analyzed in this report are shown in Table 2.

Labor requirements include both field and skilled labor combined. One man-unit is standardized for this analysis at 2,080 hours or 240 8-hour days annually. Labor requirements increase from 1.00 man-unit per 200-acre model (5.99 man-units for the 1,197 acres designated for macadamia production) during year 1 to 11.60 and 67.03 man-units, respectively, during year 16 at orchard maturity.

Management requirements are computed at 7 percent of costs other than land for years 1 to 6 and 7 percent of gross revenue for years 7 to 16. Hourly requirements are determined by evaluating management cost at $10 per hour. Estimating management costs at a given percentage of costs or gross revenues is the procedure currently in use by the USDA in computing costs of production for agricultural crops. Based on the methodology specified, management requirements are estimated at 0.20 man-units for the 200-acre model and 1.20 man-units for the entire area designated for macadamia production during year 1. This gradually increases to 3.40 and 20.35 man-units, respectively, for year 16.

Total manpower requirements for labor and management combined for the 1,197 acres designated for macadamias amount to 87.38 man-units for year 16 at orchard maturity. Programming of longer days or more days of work per year would, of course, somewhat reduce the actual number of people required to operate the macadamia enterprise.



Table 2. Labor and Management Requirements for Macadamias Per Acre Parcel, Per 200-Acre Unit and for the 1,197-Acre Farms of Kapua [a/]

| Year | Labor Requirements, Man-Units | | | Management Requirements, Man-Units | | |
|---|---|---|---|---|---|---|
| | Per Acre | For 200-acre unit | For 1,197 acres | Per Acre [c/] | For 200-acre unit | For 1,197 acres |
| 1. [b/] | 0.005 | 1.000 | 5.985 | 0.001 | 0.200 | 1.197 |
| 2. | 0.005 | 1.000 | 5.985 | 0.001 | 0.200 | 1.197 |
| 3. | 0.006 | 1.200 | 7.182 | 0.002 | 0.400 | 2.394 |
| 4. | 0.006 | 1.200 | 7.182 | 0.003 | 0.600 | 3.591 |
| 5. | 0.008 | 1.600 | 9.576 | 0.003 | 0.600 | 3.591 |
| 6. | 0.008 | 1.600 | 9.576 | 0.003 | 0.600 | 3.591 |
| 7. | 0.024 | 4.800 | 28.728 | 0.004 | 0.800 | 4.788 |
| 8. | 0.033 | 6.600 | 39.501 | 0.008 | 1.600 | 9.576 |
| 9. | 0.039 | 7.800 | 46.683 | 0.010 | 2.000 | 11.970 |
| 10. | 0.044 | 8.800 | 52.668 | 0.012 | 2.400 | 14.364 |
| 11. | 0.048 | 9.600 | 57.456 | 0.014 | 2.800 | 16.758 |
| 12. | 0.050 | 10.000 | 59.850 | 0.015 | 3.000 | 17.955 |
| 13. | 0.052 | 10.400 | 62.244 | 0.016 | 3.200 | 19.152 |
| 14. | 0.053 | 10.600 | 63.441 | 0.016 | 3.200 | 19.152 |
| 15. | 0.054 | 10.800 | 64.638 | 0.016 | 3.200 | 19.152 |
| 16. | 0.056 | 11.200 | 67.032 | 0.017 | 3.400 | 20.349 |

a/ Source: Tables 4 to 19

b/ Not including orchard establishment, most of which is contracted.

c/ Management requirements computed at 10 percent of costs other than land and 7 percent of gross revenue for years 7 to 16.

## ORCHARD ESTABLISHMENT AND DEVELOPMENT COSTS

Table 3 itemized the per acre orchard establishment costs for the 200-acre macadamia farm. It assumes that land clearing will be done by contract, and pre-planting, weed control, layout and digging of basins, planting and fertilizing will be done by Farms of Kapua.

Orchard development cost for this analysis is equal to the cumulative investment costs through the 6th year, during which time no commercial production of nuts is assumed. During the 7th year, current revenue approximates current costs, thus terminating the development period.

## COSTS AND RETURNS

Costs and returns per acre for the 200-acre orchard are budgeted each year through maturity at year 16 to reflect the progressive growth of the orchard and to provide data for amortization tables and measures of profitability (Tables 4 - 19).

Annual net returns are computed to reflect four factor-input scenarios. These are:

1. Net Returns to Labor, Management, Land and Risk;
2. Net Returns to Management, Land and Risk;
3. Net Returns to Land and Risk; and
4. Residual Net Returns to Risk after costing all factors of production, including land.



Table 3. Orchard Establishment Cost Per Acre, 200-Acre Macadamia Farm

| Item | Quantity | Unit | Cost/Unit | Total |
|---|---|---|---|---|
| Land clearing & ripping (contract) | | | | $ 1,400.00 |
| Pre-planting, weed control | | | | |
| Material - Roundup (2 applications) | 0.75 | gallons | $ 70.00 | 52.50 |
| Tractor (fuel & oil) | 4.00 | hours | 5.25 | 21.00 |
| Labor (tractor driver) | 4.00 | hours | 6.50 | 26.00 |
| Layout & dig basins | | | | |
| Tractor (fuel & oil) | 8.00 | hours | 5.25 | 42.00 |
| Labor (tractor driver) | 8.00 | hours | 6.50 | 52.00 |
| Labor (layout & misc.) | 6.00 | hours | 4.50 | 27.00 |
| Planting | | | | |
| Nursery stock | 64.00 | trees | 8.00 | 512.00 |
| Pickup (hauling materials) | 3.00 | hours | 4.00 | 12.00 |
| Labor (pickup driver) | 3.00 | hours | 6.50 | 19.50 |
| Labor (planting) | 5.00 | hours | 4.50 | 22.50 |
| Fertilizer | | | | |
| Material 10-10-10 (1/4 lb. per tree) | 16.00 | pounds | 0.15 | 2.40 |
| Labor | 2.00 | hours | 4.50 | 9.00 |
| Total Cost Per Acre | | | | $ 2,197.90 |

Table 4. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 1

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| ORCHARD ESTABLISHMENT COST | | | $ | $ |
| Labor | | | | 156.00 |
| Contract | | | | 1,400.00 |
| Other | | | | 641.90 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Irrigation | | | | |
| Water | 100.00 | 1,000 gallons | 0.80 | 80.00 |
| Labor | 0.50 | hours | 4.50 | 2.25 |
| Fertilizing | | | | |
| 16-16-16 | 64.00 | pounds | 0.19 | 12.16 |
| Pickup | 0.25 | hours | 4.25 | 1.06 |
| Labor, pickup driver | 0.25 | hours | 6.50 | 1.63 |
| Labor, field | 2.00 | hours | 4.50 | 9.00 |
| Indirect labor | 3.00 | hours | 4.50 | 13.50 |
| Interest on operating capital (12% / 2) | | | | 147.90 |
| Depreciation & interest on buildings & equipment a/ | | | | 152.40 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 2,556.92 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | (2,556.92) |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 2,765.30 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (2,765.30) |
| Management Charge (7% of costs other than land) | | | | 193.57 |
| TOTAL COSTS EXCEPT LAND | | | | 2,958.87 |
| NET RETURNS TO LAND & RISK | | | | (2,958.87) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (3,258.87) |

a/ Storage building, pickup, one tractor, one power sprayer, two knapsack sprayers, irrigation system and $2,000 miscellaneous equipment only. All other buildings and equipment purchased at beginning of years 7 or 8.



Table 5. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 2

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| ITEMIZED COSTS | | | $ | $ |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Irrigation | | | | |
| Water | 200.00 | 1,000 gallons | 0.80 | 160.00 |
| Labor | 0.50 | hours | 4.50 | 2.25 |
| Fertilizing | | | | |
| 16-16-16 | 100.00 | pounds | 0.19 | 19.00 |
| Pickup | 0.50 | hours | 4.25 | 2.13 |
| Labor, pickup driver | 0.50 | hours | 6.50 | 3.25 |
| Labor, field | 2.00 | hours | 4.50 | 9.00 |
| Indirect labor | 3.00 | hours | 4.50 | 13.00 |
| Interest on operating capital (12% / 2) | | | | 21.37 |
| Depreciation & interest on buildings & equipment a/ | | | | 152.40 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 476.40 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | (476.40) |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 523.65 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (523.65) |
| Management Charge (7% of costs other than land) | | | | 36.66 |
| TOTAL COSTS EXCEPT LAND | | | | 560.31 |
| NET RETURNS TO LAND & RISK | | | | (560.31) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (860.31) |

a/ Storage building, pickup, one tractor, one power sprayer, two knapsack sprayers, irrigation system and $2,000 miscellaneous equipment only. All other buildings and equipment purchased at beginning of years 7 or 8.

Table 6. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 3

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| ITEMIZED COSTS | | | $ | $ |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Irrigation | | | | |
| Water | 300.00 | 1,000 gallons | 0.80 | 240.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 250.00 | pounds | 0.19 | 47.50 |
| Pickup | 1.00 | hours | 4.25 | 4.25 |
| Labor, pickup driver | 1.00 | hours | 6.50 | 6.50 |
| Labor, field | 2.00 | hours | 4.50 | 9.00 |
| Indirect labor | 4.00 | hours | 4.50 | 18.00 |
| Interest on operating capital (12% / 2) | | | | 28.64 |
| Depreciation & interest on buildings & equipment a/ | | | | 152.40 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 634.29 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | (634.29) |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 658.29 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (658.29) |
| Management Charge (7% of costs other than land) | | | | 46.08 |
| TOTAL COSTS EXCEPT LAND | | | | 704.37 |
| NET RETURNS TO LAND & RISK | | | | (704.37) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (1,004.37) |

a/ Storage building, pickup, one tractor, one power sprayer, two knapsack sprayers, irrigation system and $2,000 miscellaneous equipment only. All other buildings and equipment purchased at beginning of years 7 or 8.



Table 7. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 4

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| ITEMIZED COSTS | | | $ | $ |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Irrigation | | | | |
| Water | 400.00 | 1,000 gallons | 0.80 | 320.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 300.00 | pounds | 0.19 | 57.00 |
| Pickup | 1.00 | hours | 4.25 | 4.25 |
| Labor, pickup driver | 1.00 | hours | 6.50 | 6.50 |
| Labor, field | 3.00 | hours | 4.50 | 13.50 |
| Indirect labor | 5.00 | hours | 4.50 | 22.50 |
| Interest on operating capital (12% / 2) | | | | 34.55 |
| Depreciation & interest on buildings & equipment a/ | | | | 152.40 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 689.70 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | (689.70) |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 762.70 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (762.70) |
| Management Charge (7% of costs other than land) | | | | 53.39 |
| TOTAL COSTS EXCEPT LAND | | | | 816.09 |
| NET RETURNS TO LAND & RISK | | | | (816.09) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (1,116.09) |

a/ Storage building, pickup, one tractor, one power sprayer, two knapsack sprayers, irrigation system and $2,000 miscellaneous equipment only. All other buildings and equipment purchased at beginning of years 7 or 8.

Table 8. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 5

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| ITEMIZED COSTS | | | $ | $ |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Irrigation | | | | |
| Water | 500.00 | 1,000 gallons | 0.80 | 400.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 375.00 | pounds | 0.19 | 71.25 |
| Pickup | 2.00 | hours | 4.25 | 8.50 |
| Labor, pickup driver | 2.00 | hours | 6.50 | 13.00 |
| Labor, field | 4.00 | hours | 4.50 | 18.00 |
| Indirect labor | 5.00 | hours | 4.50 | 22.50 |
| Interest on operating capital (12% / 2) | | | | 41.12 |
| Depreciation & interest on buildings & equipment a/ | | | | 152.40 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 794.77 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | (794.77) |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 878.77 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (878.77) |
| Management Charge (7% of costs other than land) | | | | 61.51 |
| TOTAL COSTS EXCEPT LAND | | | | 940.28 |
| NET RETURNS TO LAND & RISK | | | | (940.28) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (1,240.28) |

a/ Storage building, pickup, one tractor, one power sprayer, two knapsack sprayers, irrigation system and $2,000 miscellaneous equipment only. All other buildings and equipment purchased at beginning of years 7 or 8.



Table 9. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 6

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| ITEMIZED COSTS | | | $ | $ |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Irrigation | | | | |
| Water | 600.00 | 1,000 gallons | 0.80 | 480.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 425.00 | pounds | 0.19 | 80.75 |
| Pickup | 2.00 | hours | 4.25 | 9.00 |
| Labor, pickup driver | 2.00 | hours | 6.50 | 13.00 |
| Labor, field | 4.00 | hours | 4.50 | 18.00 |
| Indirect labor | 5.00 | hours | 4.50 | 22.50 |
| Interest on operating capital (12% / 2) | | | | 46.49 |
| Depreciation & interest on buildings & equipment a/ | | | | 152.40 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 889.64 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | (889.64) |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 973.64 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (676.84) |
| Management Charge (7% of costs other than land) | | | | 68.15 |
| TOTAL COSTS EXCEPT LAND | | | | 1,041.79 |
| NET RETURNS TO LAND & RISK | | | | (1,041.79) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (1,341.79) |

a/ Storage building, pickup, one tractor, one power sprayer, two knapsack sprayers, irrigation system and $2,000 miscellaneous equipment only. All other buildings and equipment purchased at beginning of years 7 or 8.

Table 10. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 7

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 1350.00 | pounds | $ 0.90 | $ 1215.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 700.00 | 1,000 gallons | 0.80 | 560.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 500.00 | pounds | 0.19 | 95.00 |
| Pickup | 2.00 | hours | 4.25 | 8.50 |
| Labor, pickup driver | 2.00 | hours | 6.50 | 13.00 |
| Labor, field | 4.00 | hours | 4.50 | 18.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | | hours | 4.25 | |
| Truck & trailer | | hours | 4.50 | |
| Labor, shaker operator | | hours | 6.50 | |
| Labor, truck driver | | hours | 6.50 | |
| Labor, field (hand harvesting) | 20.00 | hours | 4.50 | 90.00 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 3.00 | hours | 2.50 | 7.50 |
| Labor, husker operator | 3.00 | hours | 4.50 | 13.50 |
| Sorting, labor (250# in-shell per hour) | 5.00 | hours | 4.50 | 22.50 |
| Indirect labor | 9.00 | hours | 4.50 | 40.50 |
| Interest on operating capital (12% / 2) | | | | 62.93 |
| Depreciation & interest on buildings & equipment a/ | | | | 216.75 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1089.43 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 125.57 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1328.43 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | (113.43) |
| Management Charge (7% of gross revenue) | | | | 85.05 |
| TOTAL COSTS EXCEPT LAND | | | | 1413.48 |
| NET RETURNS TO LAND & RISK | | | | (198.48) |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | (498.48) |

a/ Prior to purchase of shaker.

Table 11. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 8

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 2700.00 | pounds | $ 0.90 | $ 2430.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 800.00 | 1,000 gallons | 0.80 | 640.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 600.00 | pounds | 0.19 | 114.00 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 4.00 | hours | 4.50 | 18.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 2.00 | hours | 4.50 | 9.00 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 2.00 | hours | 6.50 | 13.00 |
| Labor, field (hand harvesting) | 22.50 | hours | 4.50 | 101.25 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 6.50 | hours | 2.50 | 16.25 |
| Labor, husker operator | 6.50 | hours | 4.50 | 29.25 |
| Sorting, labor (250# in-shell per hour) | 11.00 | hours | 4.50 | 49.50 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 76.80 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1289.55 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 1140.45 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1625.80 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 804.20 |
| Management Charge (7% of gross revenue) | | | | 170.10 |
| TOTAL COSTS EXCEPT LAND | | | | 1795.90 |
| NET RETURNS TO LAND & RISK | | | | 634.10 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 334.10 |

Table 12. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 9

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 3300.00 | pounds | $ 0.90 | $ 2970.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 750.00 | pounds | 0.19 | 142.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 27.50 | hours | 4.50 | 123.75 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 8.00 | hours | 2.50 | 20.00 |
| Labor, husker operator | 8.00 | hours | 4.50 | 36.00 |
| Sorting, labor (250# in-shell per hour) | 13.00 | hours | 4.50 | 58.50 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 83.43 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1352.93 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 1617.07 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1743.18 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 1226.82 |
| Management Charge (7% of gross revenue) | | | | 207.90 |
| TOTAL COSTS EXCEPT LAND | | | | 1951.08 |
| NET RETURNS TO LAND & RISK | | | | 1018.92 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 718.92 |

Table 13. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 10

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 4000.00 | pounds | $ 0.90 | $ 3600.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 900.00 | pounds | 0.19 | 171.00 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 33.00 | hours | 4.50 | 148.50 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 10.00 | hours | 2.50 | 25.00 |
| Labor, husker operator | 10.00 | hours | 4.50 | 45.00 |
| Sorting, labor (250# in-shell per hour) | 16.00 | hours | 4.50 | 72.00 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 88.16 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1395.66 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 2204.34 |
| TOTAL COSTS EXCEPT MANAGEMENT & LABOR | | | | 1828.66 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 1773.34 |
| Management Charge (7% of gross revenue) | | | | 252.00 |
| TOTAL COSTS EXCEPT LAND | | | | 2080.66 |
| NET RETURNS TO LAND & RISK | | | | 1513.34 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 1213.34 |

Table 14. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 11

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 4500.00 | pounds | $ 0.90 | $ 4050.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 1050.00 | pounds | 0.19 | 199.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 38.00 | hours | 4.50 | 171.00 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 11.00 | hours | 2.50 | 27.50 |
| Labor, husker operator | 11.00 | hours | 4.50 | 49.50 |
| Sorting, labor (250# in-shell per hour) | 18.00 | hours | 4.50 | 81.00 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 92.30 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1432.30 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 2617.70 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1910.30 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 2139.70 |
| Management Charge (7% of gross revenue) | | | | 283.50 |
| TOTAL COSTS EXCEPT LAND | | | | 2193.80 |
| NET RETURNS TO LAND & RISK | | | | 1856.20 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 1556.20 |

Table 15. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 12

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 4950.00 | pounds | $ 0.90 | $ 4455.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 1050.00 | pounds | 0.19 | 199.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 41.00 | hours | 4.50 | 184.50 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 12.00 | hours | 2.50 | 30.00 |
| Labor, husker operator | 12.00 | hours | 4.50 | 54.00 |
| Sorting, labor (250# in-shell per hour) | 20.00 | hours | 4.50 | 90.00 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 94.07 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1436.57 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 3018.43 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1941.57 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 2513.43 |
| Management Charge (7% of gross revenue) | | | | 311.85 |
| TOTAL COSTS EXCEPT LAND | | | | 2253.42 |
| NET RETURNS TO LAND & RISK | | | | 2201.58 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 1901.58 |

Table 16. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 13

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 5150.00 | pounds | $ 0.90 | $ 4635.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 1050.00 | pounds | 0.19 | 199.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 43.00 | hours | 4.50 | 193.50 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 13.00 | hours | 2.50 | 37.50 |
| Labor, husker operator | 13.00 | hours | 4.50 | 58.50 |
| Sorting, labor (250# in-shell per hour) | 21.00 | hours | 4.50 | 94.50 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 95.60 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1440.60 |
| NET RETURNS TO LABOR, MANAGEMENT. LAND & RISK | | | | 3194.40 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1963.60 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 2671.40 |
| Management Charge (7% of gross revenue) | | | | 324.45 |
| TOTAL COSTS EXCEPT LAND | | | | 2288.05 |
| NET RETURNS TO LAND & RISK | | | | 2346.95 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 2046.95 |

Table 17. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 14

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 5250.00 | pounds | $ 0.90 | $ 4725.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 1050.00 | pounds | 0.19 | 199.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 44.00 | hours | 4.50 | 198.00 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 14.00 | hours | 2.50 | 35.00 |
| Labor, husker operator | 14.00 | hours | 4.50 | 63.00 |
| Sorting, labor (250# in-shell per hour) | 21.00 | hours | 4.50 | 94.50 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 95.99 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1437.49 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 3287.51 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1964.99 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 2760.01 |
| Management Charge (7% of gross revenue) | | | | 330.75 |
| TOTAL COSTS EXCEPT LAND | | | | 2295.74 |
| NET RETURNS TO LAND & RISK | | | | 2429.26 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 2129.26 |

Table 18. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 15

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 5350.00 | pounds | $ 0.90 | $ 4815.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 20.00 | pounds | 0.60 | 12.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 1050.00 | pounds | 0.19 | 199.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 45.00 | hours | 4.50 | 202.50 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 14.00 | hours | 2.50 | 35.00 |
| Labor, husker operator | 14.00 | hours | 4.50 | 63.00 |
| Sorting, labor (250# in-shell per hour) | 21.00 | hours | 4.50 | 94.50 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 96.26 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1448.26 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 3366.74 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1980.26 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 2834.74 |
| Management Charge (7% of gross revenue) | | | | 337.05 |
| TOTAL COSTS EXCEPT LAND | | | | 2317.31 |
| NET RETURNS TO LAND & RISK | | | | 2497.69 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 2197.69 |

Table 19. Annual Costs and Returns Per Acre, 200-Acre Macadamia Farm, Year 16

| Item | Quantity | Unit | Cost/Unit | Cost/Acre |
|---|---|---|---|---|
| GROSS RETURNS | 5450.00 | pounds | $ 0.90 | $ 4905.00 |
| ITEMIZED COSTS | | | | |
| Weed Control | | | | |
| Roundup (2 applications) | 1.00 | gallons | 70.00 | 70.00 |
| Atrazine (1 application) | 2.00 | pounds | 4.00 | 8.00 |
| Paraquat (1 application) | 0.50 | gallons | 45.00 | 22.50 |
| Tractor & sprayer (4 applications) | 4.00 | hours | 5.25 | 21.00 |
| Labor, tractor driver | 4.00 | hours | 6.50 | 26.00 |
| Rat Control | | | | |
| Materials | 30.00 | pounds | 0.60 | 18.00 |
| Labor | 2.00 | hours | 4.50 | 9.00 |
| Irrigation | | | | |
| Water | 825.00 | 1,000 gallons | 0.80 | 660.00 |
| Labor | 1.00 | hours | 4.50 | 4.50 |
| Fertilizing | | | | |
| 16-16-16 | 1050.00 | pounds | 0.19 | 199.50 |
| Pickup | 3.00 | hours | 4.25 | 12.75 |
| Labor, pickup driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field | 6.00 | hours | 4.50 | 27.00 |
| Leaf Removal | | | | |
| Tractor & leaf remover | 1.00 | hours | 5.25 | 5.25 |
| Labor, tractor driver | 1.00 | hours | 6.50 | 6.50 |
| Harvesting | | | | |
| Shaker (2 times) | 3.00 | hours | 4.25 | 12.75 |
| Truck & trailer | 3.00 | hours | 4.50 | 13.50 |
| Labor, shaker operator | 3.00 | hours | 6.50 | 19.50 |
| Labor, truck driver | 3.00 | hours | 6.50 | 19.50 |
| Labor, field (hand harvesting) | 46.00 | hours | 4.50 | 207.00 |
| Husking & drying | | | | |
| Husker (750# unhusked/hour) | 15.00 | hours | 2.50 | 37.50 |
| Labor, husker operator | 15.00 | hours | 4.50 | 67.50 |
| Sorting, labor (250# in-shell per hour) | 22.00 | hours | 4.50 | 99.00 |
| Indirect labor | 10.00 | hours | 4.50 | 45.00 |
| Interest on operating capital (12% / 2) | | | | 97.85 |
| Depreciation & interest on buildings & equipment | | | | 269.25 |
| TOTAL COSTS EXCEPT LABOR, MANAGEMENT & LAND | | | | 1425.35 |
| NET RETURNS TO LABOR, MANAGEMENT, LAND & RISK | | | | 3479.65 |
| TOTAL COSTS EXCEPT MANAGEMENT & LAND | | | | 1997.85 |
| NET RETURNS TO MANAGEMENT, LAND & RISK | | | | 2907.15 |
| Management Charge (7% of gross revenue) | | | | 343.35 |
| TOTAL COSTS EXCEPT LAND | | | | 2341.20 |
| NET RETURNS TO LAND & RISK | | | | 2563.80 |
| Land Charge | | | | 300.00 |
| NET RETURNS TO RISK | | | | 2263.80 |

At this stage in the analysis it is necessary to assume a market value for the land in order to determine the effect of land cost on economic viability of macadamia production. For this purpose, the market value of the undeveloped land is estimated at $6,000 per acre. It is also necessary to assume an appropriate annual land charge for budget analysis. Annual charges for farmland are lower than would be obtained by applying the current discount rate to the market value, since part of the returns from the investment in land are expected to result from its increase in real value over time. The University of Illinois and Purdue University have recently published comprehensive research reports on cash rents for agricultural land, which are pertinent to this analysis. The Purdue study indicated that 1980 cash lease rents paid by farmers amounted to 4.3 and 5.9 percent of the market value of farmland. The Illinois study indicated cash rents amounting to 3 percent of the market value of farmland during the same year. Based on this information, an annual charge of 5 percent of the assumed market value of land determined to be feasible for macadamia production at Kapua ($300) is indicated in the budget analysis.

Production output of macadamias is priced at a projected price at time of orchard establishment of 90 cents per pound in-shell basis. An interest rate of 12% for six months each year is imposed on operating costs. This is considered a more realistic rate for the long run than the current 15%.

Since no revenue is realized until the 7th year, expenses during the first six years are considered orchard development costs. Total cost during the first year before land cost amounts to a substantial $2,958.77 per acre, including the cost of orchard establishment (Table 4). Annual per-acre costs then decline to $560.31 during the second year and gradually increase to $1,041.79 during the 6th year (Tables 5 to 9).



An annual gross return per acre of $1,215.00 is realized during the 7th year, resulting in a net return to land and risk, before land cost, of ($198.48) (Table 10). Application of an annual land charge of $300 leaves a residual net return to risk of ($498.48).

As the yield of nuts increases, annual net returns to land and risk gradually increase to $3,362.31 per acre during year 16 (Table 19), at which time the orchard is considered to have reached full maturity. Application of the $300 land charge leaves a residual net return per acre of $2,263.80. Inasmuch as improved varieties of macadamia have been developed fairly recently, no conclusive data have been recorded with respect to the age of eventual decline of the trees. The limited amount of data available indicate that predominant varieties will maintain full bearing for 35 years or more. Hence the comparatively high costs of orchard development can be amortized over a long period of time, thus contributing to the attractiveness of the investment.

## MEASURES OF INVESTMENT PROFITABILITY

### Internal Rate of Return

Internal rate of return is considered the most appropriate method for determining profitability of an orchard enterprise. Internal rate of return is the discount rate which makes the present value of the cash flow equal to zero.

The internal rate of return per acre for the 200-acre macadamia enterprise before land cost, based on an amortization period of 25 years and allowing for an additional 10 years of full productivity of the orchard after that time is 23.0% (Table 20).

When a $300 land charge is imposed annually as a cash cost but offset by the present market value of the land at year 25 ($6,000 inflated annually at 5%), the internal rate of return is reduced to 20.0 percent (Table 21).

Table 20. Net Cash Flow Per Acre and Internal Rate of Return, Before Land Cost

| Year | Building & Equipment Costs | Operating Costs | Total Cash Costs | Current Returns | Net Cash Flow (non-inflated) | Net Cash Flow (5% inflation) | Present Value @23% |
|---|---|---|---|---|---|---|---|
| 1 | $ 882.00 | $2,465.00 | $3,347.00 | $ 0.00 | $(3347.00) | $(3347.00) | $(2721) |
| 2 | | 356.13 | 356.13 | 0.00 | (356.13) | (373.94) | (247) |
| 3 | | 477.25 | 477.25 | 0.00 | (477.25) | (526.41) | (283) |
| 4 | | 575.75 | 575.75 | 0.00 | (575.75) | (666.14) | (291) |
| 5 | | 685.25 | 685.25 | 0.00 | (685.25) | (833.26) | (296) |
| 6 | | 774.75 | 774.75 | 0.00 | (774.75) | (989.36) | (286) |
| 7 | 197.50 | 1048.75 | 1246.25 | 1215.00 | (31.25) | (41.91) | (10) |
| 8 | 525.00 | 1280.00 | 1805.00 | 2430.00 | 625.00 | 880.00 | 168 |
| 9 | 600.00 | 1390.50 | 1990.50 | 2970.00 | 979.50 | 1447.70 | 225 |
| 10 | 52.50 | 1471.25 | 1523.75 | 3600.00 | 2076.25 | 3222.34 | 407 |
| 11 | 182.00 | 1548.75 | 1730.75 | 4050.00 | 2319.75 | 3781.19 | 388 |
| 12 | | 1578.25 | 1578.25 | 4455.00 | 2876.75 | 4925.00 | 411 |
| 13 | | 1598.75 | 1598.75 | 4635.00 | 3036.25 | 5465.25 | 371 |
| 14 | | 1612.25 | 1612.25 | 4725.00 | 3112.75 | 5883.10 | 324 |
| 15 | | 1639.75 | 1639.75 | 4815.00 | 3175.25 | 6302.87 | 282 |
| 16 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 6592.77 | 240 |
| 17 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 7071.07 | 209 |
| 18 | 525.00 | 1673.25 | 2198.25 | 4905.00 | 2706.75 | 6219.13 | 150 |
| 19 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 7794.98 | 153 |
| 20 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 8149.93 | 130 |
| 21 | 260.00 | 1673.25 | 1933.25 | 4905.00 | 2971.75 | 7904.86 | 102 |
| 22 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 9026.28 | 95 |
| 23 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 9478.72 | 81 |
| 24 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 9953.79 | 69 |
| 25 | | 1673.25 | 1673.25 | 4905.00 | 3231.75 | 10,451.48 | 59 |
| Remaining value of orchard after 25th year | | $48,431.00 | | | | | 274 |
| NET PRESENT VALUE | | | | | | | 44 |
| INTERNAL ECONOMIC RATE OF RETURN | | | | | | | 23%[a/] |

a/ Rounded to one decimal point; thus net present value varies slightly from zero.



Table 21. Net Cash Flow Per Acre and Internal Rate of Return, After Annual Land Charge of $300 Per Acre

| Year | Building & Equipment Costs | Operating Costs | Total Cash Costs | Current Returns | Net Cash Flow (non-inflated) | Net Cash Flow (5% inflation) | Present Value @20% |
|---|---|---|---|---|---|---|---|
| 1 | $ 882.00 | $2,765.00 | $3,647.00 | $ 0.00 | $(3647.00) | $(3647.00) | $(3039) |
| 2 | | 656.13 | 656.13 | 0.00 | (656.13) | (689.00) | (478) |
| 3 | | 777.25 | 777.25 | 0.00 | (777.25) | (857.00) | (496) |
| 4 | | 875.75 | 875.75 | 0.00 | (873.75) | (1012.00) | (488) |
| 5 | | 985.25 | 985.25 | 0.00 | (985.25) | (1198.00) | (481) |
| 6 | | 1074.25 | 1074.25 | 0.00 | (1074.25) | (1372.00) | (459) |
| 7 | 197.50 | 1348.75 | 1546.25 | 1215.00 | (331.25) | (444.00) | (124) |
| 8 | 525.00 | 1580.00 | 2105.05 | 2430.00 | 325.00 | 458.00 | 107 |
| 9 | 600.00 | 1690.50 | 2290.50 | 2970.00 | 679.50 | 1006.00 | 195 |
| 10 | 52.50 | 1771.25 | 1823.75 | 3600.00 | 1776.25 | 2756.00 | 445 |
| 11 | 182.00 | 1848.75 | 2030.75 | 4050.00 | 2019.75 | 3293.00 | 443 |
| 12 | | 1878.25 | 1878.25 | 4455.00 | 2576.75 | 4412.00 | 495 |
| 13 | | 1898.75 | 1898.75 | 4635.00 | 2736.25 | 4925.00 | 460 |
| 14 | | 1912.25 | 1912.25 | 4725.00 | 2812.75 | 5317.00 | 414 |
| 15 | | 1939.75 | 1939.75 | 4815.00 | 2875.25 | 5707.00 | 370 |
| 16 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 6110.00 | 330 |
| 17 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 6415.00 | 289 |
| 18 | 525.00 | 1973.25 | 2498.25 | 4905.00 | 2406.75 | 5529.00 | 208 |
| 19 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 7072.00 | 221 |
| 20 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 7427.00 | 194 |
| 21 | 260.00 | 1973.25 | 2233.25 | 4905.00 | 2671.75 | 7108.00 | 155 |
| 22 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 8189.00 | 148 |
| 23 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 8600.00 | 130 |
| 24 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 9031.00 | 114 |
| 25 | | 1973.25 | 1973.25 | 4905.00 | 2931.75 | 9482.00 | 99 |
| Remaining value of orchard after 25th year, 20% discount rate | | | | | | $53,727.00 | 566 |
| Value of land at 25th year, 20% discount rate | | | | | | 19,404.00 | 203 |
| NET PRESENT VALUE | | | | | | | 21 |
| INTERNAL ECONOMIC RATE OF RETURN | | | | | | | 20.0%[a/] |

a/ Rounded to one decimal point; thus net present value varies slightly from zero.

## BIBLIOGRAPHY


1. Atkinson, J.H., Indiana Land Values and Cash Rents, Purdue Farm Management Report, Cooperative Extension Service, Purdue University, August, 1980, pp. 1-4.

2. Gustafson, Don, In San Diego, Development Costs Rise Slightly, AVOCADO GROWER, Volume 6, No. 7, July 1982, pp. 28-30.

3. Hamilton, R.A., and E.T. Fukunaga, Growing Macadamia Nuts in Hawaii Bulletin 121, Hawaii Agricultural Experiment Station, University of Hawaii, January 1959, 51 pp.

4. Hathorn, Scott Jr., and Terry H. Mikel, 1980 Arizona Citrus Crop Budgets - Yuma Mesa Valencias, Department of Agricultural Economics, University of Arizona, April 1980, 56 pp.

5. Hawaii Agricultural Reporting Service, Hawaii Macadamia Nuts - Annual Summary, Hawaii Department of Agriculture in Cooperation with USDA, January 1984.

6. Hawaii Agricultural Reporting Service, Statistics of Hawaiian Agriculture, 1982, Hawaii Department of Agriculture in Cooperation with USDA, July 1983, 100 pp.

7. Hawaii, State of, Median Rainfall - State of Hawaii, Circular C88, Division of Water and Land Development, Department of Land and Natural Resources, June 1982, 44 pp.

8. Keeler, Joseph T. and Wen-Yuan Huang, Computerized Cost Budgets for Bananas, Avocados, Papayas, Guava, Greenhouse Tomatoes and Anthuriums - 1978, Department of Agricultural Resource Economics, University of Hawaii Agricultural Experiment Station, 1978 (unpublished).

9. Keeler, Joseph T. and E.T. Fukunaga, The Economic and Horticultural Aspects of Growing Macadamia Nuts Commercially in Hawaii, Agricultural Economics Bulletin No. 27, Hawaii Agricultural Experiment Station, University of Hawaii, June 1968, 47 pp.

10. Kirpes, Daniel J. and Raymond J. Folwell, Establishment and Production Costs In a 25-Acre Grape Vineyard, Extension Bulletin 0875, Washington State University, May 1981, 16 pp.

11. Maas, E.V. and G.J. Hoffman, Crop Salt Tolerance - Current Assessment, Journal of Irrigation and Drainage Division, American Society of Civil Engineers, June 1977, pp. 115-134.

12. Ott, Gene, Paul Trujillo and Palemon Martinez, Costs and Returns of Apple Production in Northern New Mexico, 400 N-6, Cooperative Extension Service, New Mexico State University, June 1978, 12 pp.





13. Reed, A.D. and L.A. Horel (compiled by) Orchard Development Costs, Leaflet 2717, Division of Agricultural Services, University of California, Revised October 1977, 56 pp.

14. Reiss, Franklin Jr. and Edward N. Ballard, William H. Brink and William R. Harryman, Farm Lease Practices in Three South-Central Illinois Counties in 1980, AE-4491, Department of Agricultural Economics, June 1980, 45 pp.

15. Scott, Frank S. Jr., Galal Osman and Maurice Kanda, Characteristics of Consumer Demand for Roasted Macadamia Nuts, HITAHR Research Series, University of Hawaii (in press).

16. Scott, Frank S. Jr., Galal Osman and Maurice Kanda, Characteristics of Consumer Demand for Chocolate-Coated Macadamia Nuts, HITAHR Research Series, University of Hawaii (in press).

17. Scott, Frank S. Jr., Walter P. Thompson and Russ Smith, Agricultural Feasibility, Mokuleia Homesteads 325-Lot Subdivision, Molukeia Homesteads, January 1982, 182 pp.

18. Scott, Frank S. Jr., and Herbert K. Marutani, Economic Viability of Small Macadamia Nut Farms in Kona, Research Series 009, Hawaii Institute of Tropical Agriculture and Human Resources, University of Hawaii, January 1982, 41 pp.

19. Scott, Frank S. Jr., Agricultural Feasibility and Enivronmental Impact - Waiahole Valley Agricultural Park, M&E Pacific, May 1980, 47 pp.

20. Scott, Frank S. Jr., The Economic Feasibility of Establishing a Macadamia Nut Industry in Costa Rica, FAO Project COS/72/012, Food and Agriculture Organization of the United Nations, Rome, Italy, September 1975, 40 pp.

21. Scott, Frank S. Jr., Economic Potentials of Agricultural Enterprises in Kona, Donald Wolbrink and Associates, Inc., Honolulu, October 1974, 57 pp.

22. Scott, Frank S. Jr. and M.A. Chaudhary, A Current Evaluation of the Market for Macadamia Nuts, Hawaii Farm Science, University of Hawaii, 20(1), January 1971, pp. 10-11.

23. Scott, Frank S. Jr., The Market for Macadamia Nuts, An Economic Analysis, Agricultural Economics Report 82, Hawaii Agricultural Experiment Station, University of Hawaii, January 1969, 15 pp.

24. Scott, Frank S. Jr., Irrigation Requirements and Salt Water Tolerance of Macadamias, Farms of Kapua, Farms of Kapua, November 10, 1982, 5 pp.

25. Scott, John T. Jr., Returns to Land in the Corn Belt, AE-448, Department of Agricultural Economics, University of Illinois, August 1977, 21 pp.

26. Snyder, Darwin P., Enterprise Analysis - A Guide for Determining Fruit Crop Costs and Returns, A.E. Ext. 76-5, Department of Agricultural Economics, New York State College of Agriculture and Life Sciences, Cornell University, March 1976, 28 pp.

27. USDA Soil Conservation Service, Soil Survey of Island of Hawaii, State of Hawaii, USDA Soil Conservation Service in Cooperation with University of Hawaii Agricultural Experiment Station, December 1973.



# APPENDIX A

## Irrigation Requirements and Salt Water Tolerance of Macadamias

FARMS OF KAPUA
PHASE I

## Irrigation Requirements and Salt Water Tolerance of Macadamias
## FARMS OF KAPUA

Frank S. Scott, Jr.
Revised January 1984

This report investigates irrigation water requirements for macadamia production at Farms of Kapua and possible tolerances of macadamias to salt concentrations in irrigation water from the Okoe well.

### Rainfall Availability and Irrigation Requirements

Natural rainfall at Farms of Kapua ranges from an estimated mean of 40 inches at the 950-foot elevation to 27.5 inches at the 400-foot elevation. Total annual rainfall is fairly uniform, with rainfall dropping below 90% of the mean only 25 percent of the time. The area between 950 and 400 feet elevation is estimated to average 2.5 inches in January, March, April, May, June and September and 1.5 inches during the remaining 6 months. Mean monthly rainfall ranges from 1.2 inches in January to 3.5 inches in September at the 400-foot elevation and from 2.3 inches in December to 4.5 inches in July at the mauka border.

Natural rainfall at an estimated mean of 28.8 inches annually would provide an average of 2.4 acre-inches per month. Considering seasonal and weekly irregularities in rainfall distribution, an effective mean delivery of 1.9 acre-inches per month is estimated. The estimated mean monthly requirement of 4.4 acre-inches would thus require a mean supplemental irrigation of 2.5 acre-inches per month or 2,300 gallons per acre per day. This amounts to 57 percent of total water requirements for macadamia production. Infrequent droughts may occur during any month of the year, except May and September, during which time full dependence on irrigation would require an estimated 4,000 gallons of water per day.

### Chemical Analysis of Okoe Well

The Okoe well, from which irrigation water might be obtained for macadamia production at Farms of Kapua, has an analysis of 1,780 mg/l of total dissolved salts and 920 mg/l of chloride (Table 1). This compares with a chloride concentration of only 34 mg/l at the Kahaluu well in Kona. Both the concentration of total salts and the chloride content would reduce the yield of macadamias by an undetermined amount.



Table 1. Chemical Analysis of Okoe Well [a/]

| Chemical | mg/l | |
|---|---|---|
| Total Hardness | 340.00 | |
| Chloride | 920.00 | (25.95 Meq/l) |
| Sodium | 510.00 | |
| Sulfate | 160.00 | |
| Magnesium | 56.00 | |
| Silica | 36.00 | |
| Calcium | 42.00 | |
| Potassium | 21.00 | |
| Alkalinity | 45.00 | |
| Nitrogen | 0.84 | |
| Fluoride | 0.40 | |
| Manganese | 0.00 | |
| Iron | 0.00 | |
| Total Disolved Salts (Solids) | 1,780.00 | (2.78 ECw or mmhos/cm) |

a/ Source: United States Geological Survey

### Salt Tolerances of Macadamias

The only research which has been conducted on salt tolerance of macadamias consists of demonstration plots under the supervision of Dr. Samir El-Swaify of the Department of Agronomy and Soil Science of the University of Hawaii. This research has been discontinued because of lack of funds and conclusive results have not been realized. The limited evidence available suggests that macadamia trees have a salt tolerance between sensitive and moderately sensitive as related to the scale shown in Figure 1 of the attached article by Maas and Hoffman (7). This suggested salt tolerance for macadamias is somewhat less sensitive than that of almonds, oranges, peaches, and plums but considerably more sensitive than for olives (see attachment by Maas and Hoffman, pp. 122-124).

## Application of Salt Tolerance Guidelines to Macadamias

The threshold for total concentration of soluble salts in the soil permitting 100% yield for macadamias (at an assumed value of one-third of the distance from sensitive to moderately sensitive) is 2.0 millimhos per/cm or 1,280 mg/l in clay or loam soil. On this basis, a concentration of total salts of 4.0 millimhos per/cm or 2,560 mg/l would permit a macadamia yield of 80 percent of potential as determined by Maas and Hoffman (7, see attachment, Figure 1).

Salinity concentration in the soil exceeds that of the irrigation water because of concentration of salts. The salinity concentration in organic (clay or loam soils), with almost complete dependence on irrigation water during the growing season, is considered to be 3.8 times that of the irrigation water, but may vary considerably due to other factors, such as permeability, slope, and the extent of leaching (5). Conditions would be quite different from this at Farms of Kapua due to rapid drainage through the porous a'a lava and the fact that only supplemental irrigation water would be required.

An analysis of rainfall data applicable to the area mauka of the 400-foot elevation at Farms of Kapua indicates that natural rainfall would provide 43 percent of the water requirement for macadamias, with the deficit to be provided with supplemental irrigation water. Thus there would be a very substantial leaching with pure water which would be expected to keep the salt concentration in the root zone at a minimum. It is probably reasonable to assume, therefore, that the salt concentration in the soil for macadamia production at Farms of Kapua may not exceed twice the level of that in the irrigation water. On this basis, a total salt concentration in the irrigation water of 1,280 parts/million would be tolerable for macadamias. The total concentration of 1,780 mg/l of dissolved salts in the Okoe well thus exceeds the indicated tolerable level.

Much of the literature on salt tolerances of plants relates to total salt concentration, but high concentrations of individual elements, such as chloride in this case, may pose special problems. The chloride concentration of 920 mg/l in the Okoe well is obviously excessive, but may still be acceptable for macadamia production, considering the porousness of the soil, the very substantial leaching that would result from natural rainfall, and the fact that irrigation water would provide only 45 percent of total water requirements. Irrigation water from the McMahan Ranch near San Diego, which is used in salt-sensitive avocado orchards, has a chloride concentration of 280 parts/million which would result in a concentration of 1,064 mg/l in organic (clay or loam) soil at the indicated 3.8:1 ratio for these types of soils (10). A doubling of the 920 parts per million of chloride in the Okoe well water to reflect soil concentration would result in 1,840 mg/l of chloride in the soil at Farms of Kapua, thus far exceeding chloride concentration in soils irrigated by McMahan Ranch water.



The State of California Water Resources Control Board uses guidelines developed by the University of California for interpretation of water quality. These guidelines indicate that specific toxicity, such as chloride, affects only sensitive crops (1). Relative to this, Fireman and Hayward state that the total concentration of soluble salts, rather than their chemical nature, is mainly responsible for the harmful effects of saline soils on crop growth (4). Specified tolerances for sensitive crops are as follows: less than 142 mg/l of chloride in the irrigation water poses no problem; 142 to 354 mg/l of chloride poses an increasing problem; and in excess of 354 mg/l poses a severe problem.

Application of the indicated severe tolerance level of 354 mg/l in the irrigation water would amount to a chloride concentration in organic (clay or loam) soils at the 3.8 ratio of 1,345 mg/l. At the suggested 2:1 ratio of soil to water salt concentration at Kapua, the chloride concentration of 920 mg/l in irrigation water from Okoe well would amount to a concentration of 1,840 parts per million in the a'a soil. Since these guidelines relate to chloride tolerance for sensitive crops and chloride poses a problem only for sensitive crops, there may be reason for some adjustment in applying the guidelines to macadamias, which are indicated to be slightly less sensitive than tree crops labeled as sensitive. The chloride content of the Okoe well, although higher than the maximum allowed by the guidelines, might be a tolerable maximum for macadamias under conditions of good drainage and excessive leaching, plus dilution of salts by rain water.

Conversion of the 1,780 mg/l of total dissolved salts and 920 mg/l of chloride in the Okoe well to an acceptable level in the soil concentration at Kapua would only be possible with a multiplier of 1.39 for total dissolved salts and 1.46 for chloride. There are no data to support this contention, since research in irrigating macadamias with saline water on a'a soil has been discontinued without realizing even preliminary results.

## Summary and Conclusions

Information available at this time does not permit a conclusive determination of the feasiblity of using Okoe well water for supplemental irrigation of macadamias at Farms of Kapua. This can be conclusively determined only after trial demonstrations at the project site. This research would serve the purpose of determining the precise sensitivity of macadamias to total dissolved salts and to chloride plus the ratio of salt concentration in irrigation water to that in the soil under the unique conditions at Kapua.

A reasonable approach to expedite the project if no source of water other than that from Okoe well is obtainable, would be to initially plant macadamias only in the mauka area of Farms of Kapua, where natural rainfall, although inadequate for optimal production, is indicated to be sufficient for at least marginal

production and tree survival. If early tests in irrigating young macadamia trees are encouraging, macadamia production might then be gradually extended makai.

A better alternative would be to obtain better quality irrigation water from another source, providing that the cost is not prohibitive for macadamia production. This water, if available, might provide the only source of irrigation water or it could be used for diluting the salt content of water from the Okoe well.

## References


1. Ayers, Robert S. and Roy L. Branson, U.C. Guidelines for Interpretation of Agricultural Water Quality, California Agriculture, Volume 31, Number 6, May 1977, page 25.

2. Borst, George, Irrigation Water Quality in Relation to Root Rot, AVOCADO GROWER, Volume II, Number 7, July 1978, pp. 22-24.

3. Donahue, Roy L., Raymond W. Miller and John C. Shickluna, Soils -- An Introduction to Soils and Plant Growth, Fourth Edition, Prentice-Hall, Inc., 1977, pp. 370-393.

4. Fireman, Milton and H.E. Hayward, Irrigation Water and Saline and Alkaline Soils, The Yearbook of Agriculture - Water, 1955, pp. 321-327.

5. Hoffman, G.T., E.V. Maas, Jewell L. Meyer, Terry Pritchard and Donald Lancaster, Soil Tolerance of Corn in the Delta, California Agriculture, Volume 33, Numbers 11 and 12, November - December, 1979, pp. 11-12.

6. Irrinews, Salinity Control in the Lower Colorado River Basin, International Irrigation Information Center, Box 8500, Ottawa KIG 3H9, Canada, No. 15, April 1979, pp. 1-2.

7. Maas, E.V. and G.J. Hoffman, Crop Salt Tolerance - Current Assessment, Journal of Irrigation and Drainage Division, American Society of Civil Engineers, June 1977, pp. 115-134.

8. Mink, John F., Salinity of Irrigation Water at Kapua, Memorandum, November 3, 1982.

9. Moore, C.V., J.H. Snyder and Peter Sun, Effects of Colorado River Water Quality and Supply on Irrigated Agriculture, Water Resources Research, Volume 10, No. 2, April 1974, pp. 137-144.

10. Tourney, Jim, Farm Pond Cuts Water, Nitrogen Costs for Ramona Avocado Grove, AVOCADO GROWER, Volume 6, No. 9, September 1982, pp. 34-38.

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# Crop Salt Tolerance—Current Assessment[a]

By E. V. Maas[1] and G. J. Hoffman,[2] M. ASCE

## Introduction

Crop salt tolerance has usually been expressed as the yield decrease expected for a given level of soluble salts in the root medium as compared with yields under nonsaline conditions (7,20,26,28,61,152). However, salt tolerance is a relative value based upon cultural conditions under which the crop was grown. Salt tolerance lists published by the U.S. Salinity Laboratory (7,26,28,152) represent relative tolerances when crops are grown under conditions simulating recommended cultural and management practices for commercial production. Absolute tolerances that reflect predictable inherent physiological responses by plants cannot be determined because many interactions among plant, soil, water, and environmental factors influence the plant's ability to tolerate salt. Useful quantitative salt tolerance data must account for these interacting factors and be based upon appropriate measures of soil salinity and plant response.

A literature review reveals that a myriad of experimental procedures have been used for determining salt tolerance. Experiments have been conducted in soil, sand, and water cultures; in fields, small plots, greenhouses, and growth chambers; and under nearly every conceivable environmental condition. Salination methods vary as do ways of measuring and reporting salinity levels in the root medium. Likewise, plant response to salinity has been measured in several ways and at various stages of growth and development. In many experiments, important variables were either not controlled or not measured or reported.

Despite these problems, we have attempted to compile and normalize all

Note.—Discussion open until November 1, 1977. Separate discussions should be submitted for the individual papers in this symposium. To extend the closing date one month, a written request must be filed with the Editor of Technical Publications, ASCE. This paper is part of the copyrighted Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR2, June, 1977. Manuscript was submitted for review for possible publication on August 18, 1976.

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available salt tolerance data from the past 30 yr to present our best current assessment of the salt tolerance of agricultural crops. Included are only those data correlating plant response to the total soluble salts in the root medium. Sodic soil conditions, specific ion toxicities, and nutritional effects are not considered herein, but, if present, they must be taken into account.

## Plant Response to Salinity

Although salinity affects plants in many ways physiologically, overt injury symptoms seldom occur except under extreme salination. Salt-affected plants usually appear normal, although they are stunted and may have darker green leaves which, in some cases, are thicker and more succulent. Woody species are an exception since toxic accumulations of Cl or Na may cause leaf burn, necrosis, and defoliation. Most herbaceous plants do not exhibit leaf injury symptoms even though some accumulate Cl and Na to levels as high as those causing injury in woody species. Occasionally, nutritional imbalances caused by salinity produce specific nutrient-deficiency symptoms.

The most common salinity effect is a general stunting of plant growth. As salt concentrations increase above a threshold level both the growth rate and ultimate size of most plant species progressively decrease. Not all plant parts are affected equally, however, and any correlation between growth response and soil salinity must take this into account. Top growth is often suppressed more than root growth (17,47,64,120). Salinity also increases the leaf-stem ratio of alfalfa, thereby influencing forage quality (94).

The only agronomically significant criterion for establishing salt tolerance is the commercial crop yield. Too often vegetative growth response to salinity is not a reliable guide for predicting fruit or seed production. Grain yields of rice (131) and corn (102) may be greatly reduced without appreciably affecting straw yield. With some other crops, e.g., barley, wheat, cotton and some tolerant grasses, seed or fiber production are decreased much less than vegetative growth [15, unpublished U.S. Salinity Laboratory (USSL) data]. For root crops, storage-root yields may be decreased much more than that of tops or fibrous roots (15,96).

Although most plants respond to salinity as a function of the total osmotic potential of soil water without regard to the salt species present (24), some herbaceous plants and most woody species are susceptible to specific ion toxicities. Because of these toxicities, yield losses of fruits and nuts are generally greater than those predicted from osmotic effects alone. Detailed data on Cl and Na tolerances of these crops are not available but tolerable levels causing yield reductions of 10% or less are published (27,132).

In some cases, salinity induces nutritional imbalances or deficiencies causing decreased growth and plant injury for which osmotic effects alone cannot account (25,44). Blossom-end rot of tomato and pepper (64,78), blackheart of celery (77), and internal browning of lettuce (25) are all symptoms of Ca deficiency which may occur in saline soils characterized by high sulfate and low Ca levels. Magnesium deficiencies, also caused by high sulfate levels, have been observed on several varieties of table grapes (65).

Obviously, the relationship between osmotic potential of the soil solution and crop yield is invalid under conditions in which specific ion effects are

significant. Accordingly, corrections must be made for the additional detrimental effects.

### Methods of Salinity Measurement

The parameter chosen to relate salinity to plant tolerance must correlate closely with plant growth and yield. Without specific ion effects, growth reduction is primarily related to the osmotic potential of the soil solution in the root zone (44). Osmotic potential can be measured directly by freezing-point depression, vapor-pressure osmometers, or thermocouple psychrometers, as is often done for sand and solution culture studies; but generally these methods have not been adopted for soils.

The most common method of measuring soil salinity is to determine the electrical conductivity of saturation extracts, $EC_e$, from the active root zone. Electrical conductivity, EC, is directly related to the concentration of soluble salts in the soil solution and within limits of osmotic potential $\psi_o$ by the relationship, $\psi_o = -0.36$ EC. Using $EC_e$ was recommended because the saturation percentage is easily and reproducibly determined in the laboratory and is related to the field-moisture range of soils varying widely in texture (152). For many soils, the soluble salt concentration of the soil solution at field capacity is about twice that at saturation. Nevertheless, salinity measurements obviously would be more reliable if made on soil solutions in the field-moisture range.

Some recent developments in instrumentation now permit direct determinations of electrical conductivity of soil water $EC_{sw}$. Two devices that allow rapid, reliable, and nondestructive measurements are salinity sensors and four-electrode probes. Salinity sensors permit in-situ measurement of $EC_{sw}$ at a given location in a soil profile (129,143). They function throughout the range of soil matric potential normally encountered in irrigated fields and respond adequately to salinity changes in the soil solution typically found in the field (157). The four-electrode probe can also be used for assessing in-situ soil salinity but requires a knowledge of water content, temperature, soil texture and cation-exchange-capacity. Rhoades and Ingvalson (142) suggested that the relationship between soil conductivity and soil salinity be determined for each soil type at a known water content and soil temperature. Once this relationship is established, no further soil samples or laboratory analyses are required. In field practice, they recommend measuring soil conductivity just after an irrigation when water content is reasonably reproducible. The method is simple, rapid, and can be used for diagnosis, survey, and management practices (141).

As important as measuring the primary parameter to which the plant responds, is knowing where and when to make the measurement. Salt distribution in the soil usually varies in both space and time. Depending upon leaching fraction, salinity profiles may be rather uniform and change relatively little with depth or they may be highly nonuniform with salinities varying from concentrations approximately that of the irrigation water near the soil surface to concentrations many times higher at the bottom of the root zone. As a result of evapotranspiration and drainage, the salt concentration also changes with time between irrigations; consequently, irrigation frequency influences the magnitude of these changes. To minimize the ambiguity of interpreting results from nonuniform salinity profiles, the salt tolerance data derived at this Laboratory (26,28,152) were

obtained from experiments in artificially salinized field plots where salinity was maintained essentially uniform with depth throughout the root zone by irrigating with different saline waters at high leaching fractions.

Applying these data to field conditions, where salinity distribution is neither uniform nor constant, requires knowledge of plant response to salinity that varies with time and depth. Several studies support the hypothesis that plants respond to the mean salinity of the root zone (53,54,106,146,147). Ingvalson, Rhoades, and Page (98) found that alfalfa yields correlated better with time-integrated $EC_{iw}$ than with the mean $EC_e$. Others studies indicate that the effective salinity level must be weighted in favor of the least saline zone. Lunin and Gallatin (113) found that salination of up to two-thirds of the root zone with synthetic sea water had little effect on corn and tomato growth. Water uptake increased from nonsaline zones and decreased as salinity in saline zones increased. In another zonal salination experiment, Bingham and Garber (50) reported similar results for corn salinized with NaCl and concluded that plants can tolerate excessive salinity levels if an adequate part of the root zone is relatively salt free.

Bernstein and Francois (41), in a comprehensive leaching-requirement study, found that alfalfa responded primarily to a weighted-mean salinity based upon the amount of water absorbed with depth in the root zone. Because water uptake is inversely related to salt concentration, more water is absorbed from the upper root zone and consequently, the weighted-mean salinity is influenced far more by the concentration of the irrigation water than by the higher concentration of the drainage water.

If the response of all plants is governed primarily by the salinity of the irrigation water rather than the average soil salinity, salt tolerance data obtained from uniform salinity profiles could be applied directly to nonuniform conditions by using soil water salinities measured in the zones of maximum water uptake.

## Factors Influencing Salt Tolerance

Perhaps the most difficult task in assessing crop salt tolerance is accounting for the many factors that may influence the plant's response to salinity. Although the following sections present the salt tolerance of many crops as a simple function of $EC_e$, the relationship does not always hold. Salt tolerance depends upon many plant, soil, water, and environmental variables. Hopefully, an analysis of these interacting variables will caution both those using these data and those conducting salt tolerance investigations.

### Plant Factors

Stage of Growth.—Salinity affects plants at all stages of development and, for some crops, sensitivity varies from one growth stage to the next. Cereal crops seem particularly variable. Several studies show that rice is tolerant during germination, becomes very sensitive during early seedling growth, and then becomes increasingly more tolerant with maturation (100,131,133,134). Some disagreement exists as to the sensitivity of rice during the flowering stage; Pearson and Bernstein (134) found that rice becomes sensitive again during pollination and fertilization, whereas Kaddah, et al. (103,104) did not. Barley,

wheat, and corn are also more sensitive to salinity during emergence and early seedling growth than during germination and later stages of growth and grain development (14,15,102). In contrast, sugar beet and safflower and relatively sensitive during germination (18,70,71). Soybean tolerance may increase or decrease from germination to later growth depending upon variety (2). Of course, separating effects due to growth stage from those due to duration of salination is important. The data of Lunin, Gallatin, and Batchelder (114), Kaddah and Fakhry (101), Kaddah and Ghowail (102), and Meiri and Poljakoff-Mayber (120) showed that plant response was directly related to duration of exposure to salinity. Most USSL salt tolerance data were obtained from salinity treatments imposed after seedlings were established in nonsaline plots and do not necessarily apply to germination and early seedling stages.

**Varieties and Rootstocks.**—Varietal differences, while not common, must be considered in evaluating crop salt tolerance. In studies conducted over the past 30 yr at USSL (26,28,152), significant varietal differences were found for bermudagrass (see also Ref. 158), bromegrass, and birdsfoot trefoil. Recently, varietal differences among several other crops have been reported by other investigators. The tolerance of rice varieties varies widely according to Akbar, Yabuno, and Nakao (5) and Datta (60). Youngner, Lunt and Nudge (159) found substantial differences among varieties of creeping bentgrass in their response to saline nutrient solutions. Variation may also exist among cultivars of barley (79) and wheat (151). Although most known varietal differences occur among species within the grass family (Gramineae), some variation has been noted among the legumes (Leguminosae). Besides birdsfoot trefoil, varieties of soybean (2) and of berseem clover (121) respond differently to salinity. Varieties of many crops today are developed from a much more diverse genetic base than in the past and this may lead to greater variability.

Rootstock differences are an important factor in the salt tolerance of fruit tree and vine crops. Fruit crops are not only sensitive to salinity per se but are particularly susceptible to toxic effects of Na and Cl. Varieties and rootstocks that differ in the absorption and transport of these ions have different salinity tolerances. Cooper (58,59) found that the salt tolerance of avocado, grapefruit, and orange is closely related to the Cl accumulation properties of the rootstocks. Similar effects of rootstocks on salt accumulation and tolerance have been reported for stone-fruit trees (35). Large differences in the salt tolerance and grape varieties have been linked with rootstock effects on Cl accumulation (36,65,81,145).

## Soil Factors

**Fertility.**—Apparent salt tolerance may vary with soil fertility. The types of salinity-fertility interactions affecting interpretations of salt tolerance data have been illustrated by Bernstein, Francois, and Clark (43). Crops grown on infertile soils generally have abnormally high apparent salt tolerance as compared with crops grown on fertile soils because yields on nonsaline soil are severely limited by inadequate fertility (111,139,140). Because salinity is not the limiting variable governing growth, the data are of limited value. Obviously, proper fertilization would increase absolute yields even though apparent relative salt tolerance is

decreased. Salt tolerance data may be desired for suboptimal conditions, however, where fertilizers are either uneconomical or unavailable.

Published lists of crop salt tolerances based on data from USSL (7,26,28,152) were obtained under optimum fertility for nonsaline conditions. Unless salinity causes specific nutritional imbalances, additional fertilization generally has little effect or reduces salt tolerance. Apparent decreases in salt tolerance with excess N applications have been reported for corn and cotton (105), rice (127), wheat (110,127), and spinach (109). No significant change in relative salt tolerance was found for bean (112) or millet, berseem clover, and corn (138,140), when excess N was applied. Bernstein, et al. (43) concluded from sand culture studies that high N levels do not increase the salt tolerance of wheat, barley, corn, or six vegetable crops (garden beet, broccoli, cabbage, carrot, lettuce, and onion).

Rarely, if ever, are P levels excessive in soil, even with heavy applications because P is adsorbed or precipitated in the soil. High P levels in sand or water cultures, however, may aggravate salt injury and decrease salt tolerance. Bernstein, et al. (43) reported a decrease in the salt tolerance of corn grown in sand cultures at soluble P levels of 16 mg/l and 64 mg/l as compared with 1.6 mg/l. The high P level (16 mg/l-24 mg/l) in the water culture study of Torres and Bingham (151) may account for the decreased salt tolerance they reported for wheat. In soil, most studies have verified that excess P applications have no effect on salt tolerance (69,105,110,112). Ravikovitch and coworkers (138,139,140), however, observed that high P levels can influence salt tolerance for some crops.

Fewer studies have been conducted on the influence of excessive K levels on salt tolerance, but high K levels do not seem to have a significant effect (43,111,139).

Soil Water and Aeration.—Immediately after irrigation, soil water content is maximum and soluble salt concentration is minimal. As water is lost from the soil by evaporation and crop transpiration, most of the salts are excluded by the plant and left behind in a reduced volume of soil water. The drier the soil becomes before the next irrigation, the higher the average salt concentration for the irrigation cycle. Since plants tend to respond to the sum of the osmotic potential of the soil solution and the soil matric potential, the more saline the soil water, the more frequent the irrigations must be to minimize plant water stress. Also, since osmotic potential is such a large factor in saline soils, the available water in a given soil generally decreases as salinity increases. Frequent irrigation minimizes the influence of soil matric potential in salt tolerance studies. Matric potential, of course, is not a factor in properly irrigated water and sand-culture studies. However, extrapolating the data obtained under steady salinity conditions in these cultures to fluctuating soil water contents in the field can be a major source of error.

Another problem in evaluating salt tolerance studies conducted on field soils may develop from a shallow water table. Deep-rooted plants may extract water from a shallow water table and, depending upon the quality of water, plants may respond much differently than expected from salinity levels in the soil profile.

Excessive irrigation can cause poor soil aeration, particularly in fine-textured soils. Low oxygen levels have intereacted with salinity to affect shoot growth of tomato (10) and wheat germination (3).

### Environmental Factors

Climate may significantly influence plant response to salinity. Temperature, atmospheric humidity, and air pollution have markedly influenced salt tolerance. Many crops seem less salt-tolerant when grown under hot dry conditions than under cool humid ones. On the other hand, air pollution increases the apparent salt tolerance of oxidant sensitive crops. Since all crops are not equally affected, these environmental factors must be considered when assessing salt tolerance.

Magistad and coworkers (118) found that relative yields of alfalfa, bean, beet, carrot, cotton, onion, squash, and tomato were depressed more in warm than in cool climates. Ahi and Powers (4) found similar results for alfalfa, strawberry clover, and saltgrass. The salt tolerance of bean grown in a cool climate is significantly higher than when grown under hot conditions (95). High atmospheric humidity tends to increase the salt tolerance of some crops (95,96,97). High humidity generally benefits salt-sensitive crops more than tolerant crops because increases in salt tolerance result in greater yield increases.

A strong interaction between the effects of ozone, a major air pollutant, and salinity has been found in pinto bean, garden beet, and alfalfa. At ozone concentrations often prevalent in several agricultural areas, alfalfa yields may be increased by maintaining moderate but not detrimental salinity levels (94). Salinity also reduced ozone damage in pinto bean and garden beet, but effects are beneficial at salinity and ozone levels too high for economical production (93,126). These initial results indicate that the salinity-ozone interaction is commercially important for leafy vegetable and forage crops. Because some crops are affected more by air pollutants when grown under nonsaline rather than saline conditions, such crops may seem more salt-tolerant in areas with high air pollution.

### Salt Tolerance Evaluations

Our current evaluation of the relative salt tolerance of agricultural crops is given in Table 1. The alphabetical crop list provides two essential parameters sufficient for expressing salt tolerance: (1) The maximum allowable salinity without yield reduction below that of the nonsaline control treatment; and (2) the percent yield decrease per unit salinity increase beyond the threshold. All the salinity values are reported as $EC_e$, in millimhos per centimeter at 25° C, and rounded to two significant digits. A qualitative salt tolerance rating is also given for quick relative comparisons among crops. These ratings are defined by the boundaries shown in Fig. 1. The literature references upon which these evaluations are based are also listed in Table 1.

The information for preparing this salt tolerance list was obtained by reviewing: (1) Salinity related references listed in the Bibliography of Agriculture from 1950–1975; (2) all available published and unpublished information at the USSL including the Laboratory's Collaborators' Reports; (3) the references listed in individual salt tolerance papers; and (4) results requested from research personnel in the western United States. Generally, only those papers reporting measurements of both root-media salinity and crop yield were considered. Unfortunately, growth response had to be used for some tree and vine crops because of the lack of yield data. Experiments without adequate control of the factors influencing

TABLE 1.—Salt Tolerance of Agricultural Crops

| Crop (1) | Salinity[a] at initial yield decline (threshold), *A* (2) | Yield decrease per unit increase in salinity beyond threshold, *B* (3) | Salt tolerance rating[b] (4) | References (5) |
|---|---|---|---|---|
| Alfalfa *Medicago sativa* | 2.0 | 7.3 | MS | 41, 46, 53, 56, 75, 94 |
| Almond[c] *Prunus dulcis* | 1.5 | 19 | S | 35, 57 |
| Apple *Malus sylvestris* | — | — | S | 99 |
| Apricot[c] *Prunus Armeniaca* | 1.6 | 24 | S | 35, 57 |
| Avocado[c] *Persea americana* | — | — | S | 13, 82 |
| Barley (forage)[d] *Hordeum vulgare* | 6.0 | 7.1 | MT | 63, 84 |
| Barley (grain)[d] *Hordeum vulgare* | 8.0 | 5.0 | T | 15, 84 |
| Bean *Phaseolus vulgaris* | 1.0 | 19 | S | 31, 95, 118, 125, 128 |
| Beet, garden[e] *Beta vulgaris* | 4.0 | 9.0 | MT | 43, 96, 118 |
| Bentgrass *Agrostis palustris* | — | — | MS | 159 |
| Bermudagrass[f] *Cynodon Dactylon* | 6.9 | 6.4 | T | 39, 40, 108 |
| Blackberry *Rubus* spp. | 1.5 | 22 | S | 66 |
| Boysenberry *Rubus ursinus* | 1.5 | 22 | S | 66 |
| Broadbean *Vicia Faba* | 1.6 | 9.6 | MS | 17 |
| Broccoli *Brassica oleracea botrytis* | 2.8 | 9.2 | MT | 29, 43 |
| Bromegrass *Bromus inermis* | — | — | MT | 119 |
| Cabbage *Brassica oleracea capitata* | 1.8 | 9.7 | MS | 29, 43, 128 |
| Canarygrass, reed *Phalaris arundinacea* | — | — | MT | 119 |

TABLE 1.—*Continued*

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| Carrot<br>*Daucus Carota* | 1.0 | 14 | S | 32, 43, 107, 118, 128 |
| Clover, alsike, ladino, red, strawberry<br>*Trifolium* spp. | 1.5 | 12 | MS | 11, 39, 75, 144 |
| Clover, berseem<br>*T. alexandrinum* | 1.5 | 5.7 | MS | 9, 16, 139, 140 |
| Corn (forage)<br>*Zea Mays* | 1.8 | 7.4 | MS | 85, 138, 139 |
| Corn (grain)<br>*Zea Mays* | 1.7 | 12 | MS | 30, 102 |
| Corn, sweet<br>*Zea Mays* | 1.7 | 12 | MS | 30 |
| Cotton<br>*Gossypium hirsutum* | 7.7 | 5.2 | T | 22, 23, 38 |
| Cowpea<br>*Vigna unguiculata* | 1.3 | 14 | MS | 139 |
| Cucumber<br>*Cucumis sativus* | 2.5 | 13 | MS | 128, 137 |
| Date<br>*Phoenix dactylifera* | 4.0 | 3.6 | T | 72, 73, 74 |
| Fescue, tall<br>*Festuca elatior* | 3.9 | 5.3 | MT | 54, 55 |
| Flax<br>*Linum usitatissimum* | 1.7 | 12 | MS | 89 |
| Grape[e]<br>*Vitis* spp. | 1.5 | 9.6 | MS | 81, 124, 150 |
| Grapefruit[e]<br>*Citrus × paradisi* | 1.8 | 16 | S | 86, 91, 135 |
| Hardinggrass<br>*Phalaris tuberosa* | 4.6 | 7.6 | MT | 55 |
| Lemon[e]<br>*Citrus limon* | — | — | S | 64 |
| Lettuce<br>*Lactuca sativa* | 1.3 | 13 | MS | 19, 43, 128 |
| Lovegrass[g]<br>*Eragrostis* spp. | 2.0 | 8.4 | MS | 39 |
| Meadow Foxtail<br>*Alopecurus pratensis* | 1.5 | 9.6 | MS | 55 |
| Millet, Foxtail<br>*Setaria italica* | — | — | MS | 139 |
| Okra<br>*Abelmoschus esculentus* | — | — | S | 6, 122, 130 |
| Olive<br>*Olea europaea* | — | — | MT | 48, 150 |
| Onion<br>*Allium Cepa* | 1.2 | 16 | S | 33, 43, 96, 128 |

TABLE 1.—*Continued*

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| Orange | | | | |
| *Citrus sinensis* | 1.7 | 16 | S | 51, 83, 92, 136 |
| Orchardgrass | | | | |
| *Dactylis glomerata* | 1.5 | 6.2 | MS | 55, 156 |
| Peach | | | | |
| *Prunus Persica* | 1.7 | 21 | S | 35, 57, 88 |
| Peanut | | | | |
| *Arachis hypogaea* | 3.2 | 29 | MS | 147 |
| Pepper | | | | |
| *Capsicum annuum* | 1.5 | 14 | MS | 21, 128, U[h] |
| Plum[c] | | | | |
| *Prunus domestica* | 1.5 | 18 | S | 35, 57 |
| Potato | | | | |
| *Solanum tuberosum* | 1.7 | 12 | MS | 34 |
| Radish | | | | |
| *Raphanus sativus* | 1.2 | 13 | MS | 96, 128 |
| Raspberry | | | | |
| *Rubus idaeus* | — | — | S | 66 |
| Rhodesgrass | | | | |
| *Chloris Gayana* | — | — | MS | 1, 76 |
| Rice, paddy[d] | | | | |
| *Oryza sativa* | 3.0 | 12 | MS | 68, 123, 131, 154 |
| Ryegrass, perennial | | | | |
| *Lolium perenne* | 5.6 | 7.6 | MT | 55 |
| Safflower | | | | |
| *Carthamus tinctorius* | — | — | MT | 70 |
| Sesbania[d] | | | | |
| *Sesbania exaltata* | 2.3 | 7.0 | MS | 23 |
| Sorghum | | | | |
| *Sorghum bicolor* | — | — | MT | U |
| Soybean | | | | |
| *Glycine Max* | 5.0 | 20 | MT | 2, 45, 46 |
| Spinach | | | | |
| *Spinacia oleracea* | 2.0 | 7.6 | MS | 109, 128 |
| Strawberry | | | | |
| *Fragaria* spp. | 1.0 | 33 | S | 67, 128 |
| Sudangrass | | | | |
| *Sorghum sudanense* | 2.8 | 4.3 | MT | 54 |
| Sugarbeet[e] | | | | |
| *Beta vulgaris* | 7.0 | 5.9 | T | 52, 155 |
| Sugarcane | | | | |
| *Saccharum officinarum* | 1.7 | 5.9 | MS | 42, 62, 149 |
| Sweet potato | | | | |
| *Ipomoea Batatas* | 1.5 | 11 | MS | 80, U |
| Timothy | | | | |
| *Phleum pratense* | — | — | MS | 144 |

TABLE 1.—*Continued*

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| Tomato | | | | |
| Lycopersicon Lycopersicum | 2.5 | 9.9 | MS | 49, 87, 166, 148 |
| Trefoil, Big *Lotus uliginosus* | 2.3 | 19 | MS | 11, 12 |
| Trefoil, Birdsfoot narrowleaf[i] *L. corniculatus tenuifolium* | 5.0 | 10 | MT | 11, 12 |
| Vetch, common *Vicia sativa* | 3.0 | 11 | MS | 139 |
| Wheat[d,j] *Triticum aestivum* | 6.0 | 7.1 | MT | 8, 15, 90 |
| Wheatgrass, crested *Agropyron desertorum* | 3.5 | 4.0 | MT | 37 |
| Wheatgrass, fairway *A. cristatum* | 7.5 | 6.9 | T | 37 |
| Wheatgrass, slender *A. trachycaulum* | — | — | MT | 119 |
| Wheatgrass, tall *A. elongatum* | 7.5 | 4.2 | T | 37 |
| Wildrye, Altai *Elymus angustus* | — | — | T | 119 |
| Wildrye, Beardless *E. triticoides* | 2.7 | 6.0 | MT | 55 |
| Wildrye, Russian *E. junceus* | — | — | T | 119 |

[a]Salinity expressed as $EC_e$, in millimhos per centimeter at 25° C.

[b]Ratings are defined by the boundaries in Fig. 1.

[c]Tolerance is based on growth rather than yield.

[d]Less tolerant during emergence and seedling stage. $EC_e$ should not exceed 4 mmho/cm or 5 mmho/cm.

[e]Sensitive during germination. $EC_e$ should not exceed 3 mmho/cm for beet and sugarbeet.

[f]Average of several varieties. Suwannee and Coastal are about 20% more tolerant, and Common and Greenfield are about 20% less tolerant than the average.

[g]Average for Boer, Wilman, Sand, and Weeping varieties. Lehmann seems about 50% more tolerant.

[h]Unpublished USSL data.

[i]Broadleaf birdsfoot trefoil seems less tolerant than narrowleaf.

[j]Tolerance data may not apply to new semidwarf varieties.

Note: Col. 2 given in millimhos per centimeter; Col. 3 given in percent per millimho per centimeter.

salt tolerance and papers that failed to mention these factors were not considered in the salt tolerance evaluations. Some crops listed in Table 1 have only a qualitative salt tolerance rating because of insufficient data for quantitative evaluation. For ease in interpretation, all salinity values were converted to the

same measure, $EC_e$, and all yield data were placed on a relative basis with the yield of the control treatment assigned a value of 100%.

After evaluating the data for the various crops it became apparent that, in general, yield was not decreased significantly until a threshold salinity level was exceeded, and that yield decreased approximately linearly as salinity increased beyond the threshold. With some crops, e.g., bean, onion, clover, and pepper, yield approached zero asymptotically; with a few others, yields decreased linearly as salinity increased to a point above which the plants died and yields dropped sharply to zero. These deviations from linearity are of little concern, however, because they occur only in the lower part of the curve where yields are commercially unacceptable. Nevertheless, salinity values may be extrapolated for zero yield to estimate the maximum salinities that plants can tolerate for calculating leaching requirements (41,153).

To obtain the numerical evaluations presented in Table 1, least-squares linear equations were fit to the data for each experiment for values beyond the threshold salinity. In some cases, inclusion or exclusion of data required subjective

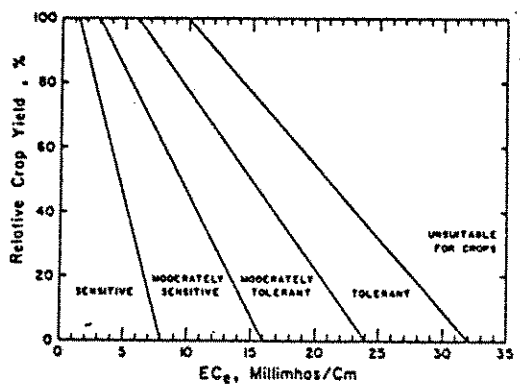



FIG. 1.—Divisions for Classifying Crop Tolerance to Salinity

judgment. When more than one experiment was considered for determining the salt tolerance of a crop, the slope and intercept values for the various experiments were averaged. Because the salinity range studied in some experiments was poorly chosen, data from some experiments could only be used to establish threshold salinities and from others only to determine slope. From the average regression coefficients, the salinity levels at initial yield decline and the yield decrease per unit salinity increase were computed. Relative yield, $Y$, for any given soil salinity exceeding the threshold, $EC_e > A$, can be calculated by

$$Y = 100 - B(EC_e - A) \quad (1)$$

in which $A$ = the salinity threshold, in millimhos per centimeter; and $B$ = the percent yield decrease per unit salinity increase. For example, alfalfa yields decrease approximately 7.3% per mmho/cm when the soil salinity exceeds 2.0 mmho/cm; therefore, at a soil salinity of 5.4 mmho/cm, the relative yield, $Y = 100 - 7.3(5.4 - 2.0) = 75\%$.

Division boundaries for the salt tolerance ratings defined in Fig. 1 were chosen to approximate the family of linear curves that represent the majority of the crops reported. Four divisions were labeled to correspond with previously published terminology ranging from sensitive to tolerant. With few exceptions the linear salt tolerance curves for each crop remained within one division. Where the linear salt tolerance curve for a crop crossed division boundaries, the crop was rated based on its tolerance at the lower salinity levels where yields are commercially acceptable.

A comparison of our salt tolerance evaluations with previously published data from USSL (26,28) revealed no major changes among the crops even though many evaluations included new and additional experimental data. Only the tolerance of garden beet and bermudagrass changed significantly and both seem less tolerant than previously reported. The threshold salinities of field corn, grape, and spinach dropped slightly as compared with extrapolated values from Bernstein's evaluations (28); whereas threshold salinities of cotton, soybean, and wheat increased about 1 mmho/cm. Several new crops were added to the list but quantitative evaluations of a few others were not included because substantiating data were lacking.

The accuracy and reliability of these evaluations are no better than the data used to make them and can only be refined by further observation, experimentation, and continued improvement of our experimental techniques. Hopefully, these comments will promote well-conducted and controlled experiments that will provide additional salt tolerance data to improve and expand this list.

## Summary

An extensive literature review of all available salt tolerance data was undertaken to evaluate the current status of our knowledge of the salt tolerance of agricultural crops. In general, crops tolerate salinity up to a threshold level above which yields decrease approximately linearly as salt concentrations increase. Our best estimate of the threshold salinity level and yield decrease per unit salinity increase is presented for a large number of agricultural crops. The methods of measuring appropriate salinity and plant parameters to obtain meaningful salt tolerance data and the many plant, soil, water, and environmental factors influencing the plant's ability to tolerate salt are examined.

# APPENDIX B

Temperature Recordings at Stations
Closest to

FARMS OF KAPUA
PHASE I

MINIMUM TEMPERATURE **** ISLAND OF HAWAII

STATION NO. 24.1 LOCATION - OPIHIMALE 2 ELEVATION 1300 FT UNITS - DEGREES F

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | LOW | HIGH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | ***** | ***** | ***** | ***** | ***** | ***** | 63.5 | 65.4 | 62.7 | 63.0 | ***** | ***** | ***** | 62.7 | 65.4 |
| 1957 | 57.9 | 54.7 | 56.3 | 58.6 | 60.9 | 62.1 | 62.9 | 64.2 | 63.8 | 62.5 | 61.5 | 59.1 | 60.4 | 54.7 | 64.2 |
| 1958 | 54.4 | 55.6 | 56.6 | 59.1 | 61.3 | 62.0 | 62.9 | 64.5 | 63.5 | 61.7 | 60.7 | 56.3 | 59.9 | 54.4 | 64.5 |
| 1959 | 59.4 | 57.5 | 58.0 | 60.9 | 61.3 | 61.9 | ***** | ***** | ***** | ***** | 61.3 | 58.0 | ***** | 57.5 | 61.9 |
| 1960 | 56.0 | 56.4 | 57.5 | 59.5 | 61.3 | 62.6 | 62.3 | 63.8 | 62.7 | 63.1 | 59.3 | 57.5 | 60.2 | 56.0 | 63.8 |
| 1961 | 56.4 | 58.7 | 58.3 | 59.3 | 62.3 | 62.0 | 62.1 | 63.6 | 62.2 | ***** | 58.7 | 57.2 | ***** | 56.4 | 63.6 |
| 1962 | 57.1 | 55.9 | 56.7 | 59.2 | 61.6 | 62.4 | 62.0 | 62.8 | 62.3 | 61.5 | 59.3 | 57.5 | 59.9 | 55.9 | 62.8 |
| 1963 | 55.8 | 57.4 | 59.6 | 60.9 | 61.5 | 62.4 | 62.8 | 63.9 | 63.8 | 61.8 | 58.9 | 58.3 | 60.6 | 55.8 | 63.9 |
| 1964 | 57.8 | 54.9 | 57.8 | 59.7 | 59.8 | 63.2 | 61.1 | 59.7 | 61.7 | 60.9 | 60.1 | 59.2 | 59.7 | 54.9 | 63.2 |
| 1965 | 57.3 | 53.1 | 55.9 | 59.3 | 62.5 | 61.7 | 62.1 | 62.0 | 62.6 | 61.3 | 61.6 | 57.0 | 59.7 | 53.1 | 62.6 |
| 1966 | 54.8 | 57.9 | 57.6 | 57.8 | 61.0 | 62.1 | 62.2 | 63.4 | 61.7 | 62.1 | 60.8 | 58.0 | 59.9 | 54.8 | 63.4 |
| 1967 | 56.2 | 57.3 | 59.6 | 59.3 | ***** | 62.9 | 64.4 | 64.3 | 63.4 | 61.5 | 59.5 | 58.7 | ***** | 56.2 | 64.4 |
| 1968 | 56.8 | 57.8 | 60.6 | 60.2 | 61.9 | 62.6 | 63.6 | 64.1 | 64.3 | 63.3 | 61.1 | 59.8 | 61.3 | 56.8 | 64.3 |
| 1969 | 56.7 | 59.0 | 57.3 | 60.2 | 61.2 | 62.6 | 63.7 | 63.3 | 62.8 | 61.1 | 59.5 | 58.0 | 60.4 | 56.7 | 63.7 |
| 1970 | 57.3 | ***** | 56.9 | 58.9 | 62.0 | 62.9 | 62.1 | 64.1 | 61.7 | 62.0 | 60.8 | 56.8 | ***** | 56.8 | 64.1 |
| 1971 | 57.3 | 56.8 | 58.0 | 60.2 | 59.6 | 60.6 | 63.0 | 61.9 | 61.9 | 60.3 | 59.5 | 56.4 | 59.6 | 56.4 | 63.0 |
| 1972 | 56.3 | 55.2 | 57.4 | 60.3 | 59.7 | 63.1 | 64.3 | 63.9 | 63.0 | 62.3 | 59.4 | 56.7 | 60.1 | 55.2 | 64.3 |
| 1973 | 56.8 | 54.7 | 57.8 | 57.3 | 59.2 | ***** | 63.4 | 63.6 | 62.2 | 61.6 | 60.5 | 58.1 | ***** | 54.7 | 63.6 |
| 1974 | 59.0 | 56.9 | 59.0 | 61.2 | ***** | ***** | 62.3 | 63.8 | 63.1 | 62.6 | 59.3 | 58.5 | ***** | 56.9 | 63.8 |
| 1975 | 57.1 | 57.9 | 57.6 | 59.2 | 60.3 | 61.5 | 60.4 | 61.9 | 61.0 | 60.8 | 58.8 | 57.1 | 59.5 | 57.1 | 61.9 |
| 1976 | 55.5 | 56.1 | 57.3 | 57.2 | 59.3 | 59.8 | 60.5 | 61.1 | 61.5 | 59.4 | 57.1 | 55.4 | 58.3 | 55.4 | 61.5 |
| 1977 | 55.4 | 60.9 | 61.1 | 62.1 | 62.3 | 60.2 | 61.9 | 62.1 | 60.8 | 60.3 | 61.9 | 58.9 | 60.7 | 55.4 | 62.3 |
| 1978 | 56.1 | 55.1 | 56.7 | 59.7 | 62.7 | 63.9 | 64.5 | 65.1 | 63.6 | 62.8 | 60.4 | 57.4 | 60.7 | 55.1 | 65.1 |
| MEAN | 56.6 | 56.6 | 57.8 | 59.5 | 61.0 | 62.1 | 62.6 | 63.2 | 62.5 | 61.7 | 60.0 | 57.7 | 60.0 | | |
| S.D. | 1.2 | 1.7 | 1.3 | 1.2 | 1.0 | 1.0 | 1.1 | 1.3 | 0.9 | 1.0 | 1.1 | 1.0 | 0.6 | | |
| LOW | 54.4 | 53.0 | 55.9 | 57.1 | 59.1 | 59.8 | 60.4 | 59.6 | 60.8 | 59.4 | 57.0 | 55.4 | 58.3 | | |
| HIGH | 59.4 | 60.9 | 61.0 | 62.0 | 62.6 | 63.9 | 64.5 | 65.4 | 64.3 | 63.3 | 61.9 | 59.8 | 61.3 | | |
| MEDIAN | 56.7 | 56.8 | 57.5 | 59.4 | 61.3 | 62.2 | 62.5 | 63.6 | 62.6 | 61.6 | 59.9 | 57.7 | 60.0 | | |
| YEARS | 22 | 21 | 22 | 22 | 20 | 20 | 22 | 22 | 22 | 21 | 22 | 22 | 15 | | |

MAXIMUM TEMPERATURE **** ISLAND OF HAWAII

STATION NO. 24.1 LOCATION - OPIHIHALE 2 ELEVATION 1300 FT UNITS - DEGREES F

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | LOW | HIGH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | ***** | ***** | ***** | ***** | ***** | ***** | 77.7 | 80.3 | 78.6 | 78.7 | ***** | ***** | ***** | 77.7 | 80.3 |
| 1957 | 75.0 | 73.0 | 73.5 | 75.6 | 75.6 | 77.1 | 78.0 | 80.0 | 80.2 | 79.5 | 78.3 | 76.4 | 76.8 | 73.0 | 80.2 |
| 1958 | 74.4 | 75.5 | 75.8 | 75.9 | 75.8 | 76.9 | 78.2 | 79.8 | 80.0 | 78.4 | 78.0 | 76.0 | 77.1 | 74.4 | 80.0 |
| 1959 | 76.6 | 74.4 | 76.3 | 76.0 | 77.1 | 78.0 | ***** | ***** | ***** | ***** | 77.3 | 74.5 | ***** | 74.4 | 78.0 |
| 1960 | 74.5 | 74.6 | 75.7 | 76.7 | 77.3 | 77.8 | 79.0 | 80.4 | 79.6 | 79.1 | 77.4 | 76.2 | 77.4 | 74.5 | 80.4 |
| 1961 | 76.4 | 76.4 | 76.5 | 75.8 | 76.7 | 77.0 | 78.2 | 78.9 | 78.9 | ***** | 76.6 | 74.5 | ***** | 74.5 | 78.9 |
| 1962 | 75.4 | 75.0 | 76.6 | 76.2 | 76.5 | 76.7 | 77.6 | 78.8 | 78.2 | 78.5 | 77.1 | 74.5 | 76.8 | 74.5 | 78.8 |
| 1963 | 74.9 | 76.3 | 77.0 | 76.8 | 76.3 | 77.1 | 78.3 | 78.4 | 78.6 | 79.1 | 78.2 | 76.5 | 77.3 | 74.9 | 79.1 |
| 1964 | 75.6 | 75.0 | 74.8 | 74.7 | 76.5 | 78.1 | 80.0 | 79.5 | 78.6 | 78.8 | 77.5 | 77.5 | 77.2 | 74.7 | 80.0 |
| 1965 | 75.8 | 73.8 | 75.2 | 76.7 | 77.2 | 76.8 | 78.0 | 78.3 | 78.5 | 78.9 | 77.7 | 74.7 | 76.8 | 73.8 | 78.9 |
| 1966 | 73.3 | 74.4 | 75.5 | 76.6 | 77.9 | 79.4 | 79.5 | 81.1 | 81.0 | 80.2 | 78.7 | 76.8 | 77.9 | 73.3 | 81.1 |
| 1967 | 74.7 | 74.7 | 77.2 | 78.1 | 79.5 | 78.6 | 81.9 | 80.7 | 80.2 | 79.9 | 76.9 | 76.4 | 78.2 | 74.7 | 81.9 |
| 1968 | 75.3 | 77.0 | 76.3 | 78.2 | 80.3 | 79.5 | 81.4 | 81.0 | 81.4 | 81.5 | 79.6 | 76.5 | 79.0 | 75.3 | 81.5 |
| 1969 | 74.3 | 75.4 | 77.0 | 77.0 | 77.8 | 78.8 | 78.6 | 78.9 | 78.2 | 77.6 | 76.9 | 74.6 | 77.1 | 74.3 | 78.9 |
| 1970 | 75.5 | ***** | 75.3 | 76.5 | 78.0 | 77.9 | 78.2 | 80.1 | 77.9 | 78.7 | 76.5 | 75.2 | ***** | 75.2 | 80.1 |
| 1971 | 74.1 | 75.7 | 75.0 | 75.4 | 75.8 | 77.4 | 78.5 | 80.0 | 76.5 | 77.0 | 75.1 | 73.9 | 76.3 | 73.9 | 80.0 |
| 1972 | 72.5 | 73.5 | 77.3 | 74.9 | 76.4 | 76.1 | 78.3 | 79.9 | 79.9 | 79.1 | 76.4 | 74.9 | 76.6 | 72.5 | 79.9 |
| 1973 | 74.8 | 73.4 | 75.6 | 75.5 | 75.4 | ***** | 78.9 | 78.7 | 78.1 | 78.3 | 77.6 | 75.8 | ***** | 73.4 | 78.9 |
| 1974 | 76.3 | 75.1 | 75.9 | 75.9 | ***** | ***** | ***** | 80.9 | 81.0 | 81.0 | 78.9 | 77.8 | ***** | 75.1 | 81.0 |
| 1975 | 75.6 | 75.6 | 75.5 | 75.1 | 74.7 | 75.8 | 78.2 | 78.8 | 80.0 | 79.0 | 78.9 | 77.8 | 77.1 | 74.7 | 80.0 |
| 1976 | 76.4 | 76.2 | 75.0 | 75.3 | 74.7 | 75.8 | 77.5 | 80.2 | 81.9 | 81.7 | 79.3 | 77.9 | 77.7 | 74.7 | 81.9 |
| 1977 | 77.8 | 77.9 | 77.8 | 77.2 | 78.1 | 77.9 | 80.8 | 81.5 | 82.4 | 82.1 | 78.8 | 79.8 | 79.3 | 77.2 | 82.4 |
| 1978 | 77.8 | 78.5 | 77.1 | 78.6 | 79.6 | 79.9 | 80.5 | 81.5 | 80.6 | 80.6 | 79.7 | 77.5 | 79.3 | 77.1 | 81.5 |
| MEAN | 75.3 | 75.3 | 75.9 | 76.3 | 77.0 | 77.6 | 78.9 | 79.8 | 79.5 | 79.4 | 77.8 | 76.1 | 77.5 | | |
| S.D. | 1.2 | 1.4 | 1.0 | 1.0 | 1.5 | 1.1 | 1.2 | 0.9 | 1.4 | 1.3 | 1.0 | 1.4 | 0.9 | | |
| LOW | 72.5 | 73.0 | 73.5 | 74.6 | 74.6 | 75.8 | 77.5 | 78.3 | 76.5 | 77.0 | 76.1 | 73.9 | 76.2 | | |
| HIGH | 77.8 | 78.5 | 77.8 | 78.6 | 80.3 | 79.9 | 81.9 | 81.5 | 82.4 | 82.1 | 79.6 | 79.8 | 79.3 | | |
| MEDIAN | 75.3 | 75.1 | 75.8 | 76.0 | 76.6 | 77.6 | 78.3 | 80.0 | 79.7 | 79.1 | 77.6 | 76.3 | 77.2 | | |
| YEARS | 22 | 21 | 22 | 22 | 21 | 20 | 21 | 22 | 22 | 21 | 22 | 22 | 17 | | |

MAXIMUM TEMPERATURE **** ISLAND OF HAWAII

STATION NO. 28. LOCATION - NAPOOPOO ELEVATION 600 FT UNITS - DEGREES F

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | LOW | HIGH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1919 | 78.3 | 78.3 | 78.8 | 78.7 | 78.9 | 78.0 | 77.1 | 81.5 | 85.3 | 83.7 | 83.7 | 83.1 | 80.4 | 77.1 | 85.3 |
| 1920 | 84.4 | 83.7 | ***** | ***** | ***** | ***** | 84.9 | 85.5 | 86.1 | 84.5 | 81.7 | 79.9 | ***** | 79.9 | 86.1 |
| 1921 | 78.8 | 80.6 | 82.1 | 83.7 | 84.1 | 85.2 | 86.5 | 86.5 | 86.2 | 84.9 | 81.8 | 80.1 | 83.4 | 78.8 | 86.5 |
| 1922 | 78.6 | 79.0 | 82.2 | 82.8 | 83.3 | 83.9 | 85.3 | 85.3 | 85.7 | 84.5 | 83.1 | 80.7 | 82.9 | 78.6 | 85.7 |
| 1923 | 80.0 | 81.4 | 83.6 | 87.5 | ***** | ***** | 84.6 | 86.1 | 88.4 | 85.5 | 80.9 | 78.8 | ***** | 78.8 | 88.4 |
| 1924 | 77.2 | 79.0 | 81.3 | 82.5 | 82.4 | 82.9 | 83.6 | 84.3 | 83.8 | 83.7 | 82.8 | 80.5 | 82.0 | 77.2 | 84.3 |
| 1925 | 79.6 | 80.9 | 82.0 | 81.7 | 81.9 | 84.1 | 84.0 | 86.3 | 84.4 | 83.9 | 82.0 | 81.8 | 82.7 | 79.6 | 86.3 |
| 1926 | 80.9 | 80.5 | 81.9 | 82.7 | 83.3 | 83.9 | 85.4 | 85.3 | 86.2 | 84.8 | 83.6 | 82.6 | 83.4 | 80.5 | 86.2 |
| 1927 | 80.2 | 82.4 | 82.4 | 83.6 | ***** | 80.3 | 79.8 | 81.7 | 80.4 | 79.5 | 79.1 | 76.7 | ***** | 76.7 | 83.6 |
| 1928 | 76.8 | 75.2 | 76.9 | 77.9 | 78.6 | 77.7 | ***** | 84.6 | 84.9 | 82.7 | 80.8 | 78.6 | ***** | 75.2 | 84.9 |
| 1929 | 77.6 | 78.8 | 81.3 | 82.0 | 82.5 | 83.0 | 84.9 | 85.2 | 85.0 | 83.3 | 81.7 | 79.6 | 82.1 | 77.6 | 85.2 |
| 1930 | 78.7 | 80.2 | 81.7 | 82.4 | 83.4 | 83.2 | 85.7 | 85.8 | 85.7 | 84.1 | 81.9 | 80.2 | 82.7 | 78.7 | 85.8 |
| 1931 | 78.3 | 77.9 | 79.4 | 81.3 | 82.9 | 84.7 | 83.8 | 85.5 | 84.9 | 83.5 | 81.0 | 79.0 | 81.8 | 77.9 | 85.5 |
| 1932 | 79.4 | 79.1 | 80.5 | 81.7 | 82.1 | 83.1 | 84.3 | 83.8 | 83.6 | 81.9 | 81.0 | 78.8 | 81.6 | 78.8 | 84.3 |
| 1933 | 77.8 | 77.9 | 79.2 | 80.9 | 81.1 | 80.0 | 82.5 | 81.9 | 82.1 | 81.1 | 79.9 | 80.2 | 80.4 | 77.8 | 82.5 |
| 1934 | 79.4 | 79.4 | 80.8 | 82.0 | 83.2 | 83.9 | 85.2 | 85.1 | 85.1 | 83.9 | 82.2 | 81.0 | 82.6 | 79.4 | 85.2 |
| 1935 | 79.9 | 79.4 | 80.1 | 81.4 | 82.5 | 83.4 | 84.4 | 85.0 | 84.5 | 82.5 | 81.6 | 80.5 | 82.1 | 79.4 | 85.0 |
| 1936 | 79.9 | 79.6 | 80.3 | 81.9 | 82.2 | 85.9 | 85.3 | 86.5 | 85.9 | 84.5 | 82.3 | 79.8 | 82.8 | 79.6 | 86.5 |
| 1937 | 77.7 | 76.5 | ***** | 83.3 | 83.0 | 83.7 | ***** | ***** | ***** | ***** | 87.1 | 86.7 | ***** | 76.5 | 87.1 |
| 1938 | 78.4 | ***** | 78.0 | 79.5 | ***** | ***** | ***** | 90.0 | 90.2 | 91.4 | 89.2 | 88.2 | ***** | 78.0 | 91.4 |
| 1939 | ***** | ***** | ***** | ***** | ***** | 79.3 | 81.3 | 83.2 | 82.6 | 82.3 | 80.2 | 80.4 | ***** | 79.3 | 83.2 |
| 1940 | 81.6 | 82.8 | 82.6 | 83.4 | 84.3 | 83.5 | 85.5 | 86.5 | 85.7 | 86.8 | 85.0 | 83.3 | 84.2 | 81.6 | 86.8 |
| 1941 | 83.3 | 81.5 | 79.6 | 80.8 | 81.1 | 83.4 | 85.1 | 87.7 | 86.5 | 85.0 | 85.4 | 82.9 | 83.5 | 79.6 | 87.7 |
| 1942 | 83.0 | 82.3 | 79.9 | 80.2 | 83.1 | 82.8 | ***** | 85.7 | 85.9 | 86.9 | 86.0 | 84.2 | ***** | 79.9 | 86.9 |
| 1943 | 81.9 | 82.8 | 80.1 | 82.5 | 83.0 | 83.0 | 85.2 | 81.9 | 84.9 | 85.2 | 84.4 | 83.0 | 83.2 | 80.1 | 85.2 |
| 1944 | 82.2 | 81.4 | 81.0 | 82.0 | 81.1 | 81.6 | 84.5 | 83.6 | 84.1 | 84.4 | 84.7 | 81.5 | 82.7 | 81.0 | 84.7 |
| 1945 | 81.8 | 81.8 | ***** | ***** | 82.3 | 82.5 | 84.1 | 84.2 | 84.1 | 85.5 | 84.7 | 83.5 | ***** | 81.8 | 85.5 |
| 1946 | 82.7 | 80.5 | 81.9 | 80.2 | 81.0 | 82.9 | 85.7 | 87.3 | 83.5 | 84.3 | 83.7 | 81.6 | 82.9 | 80.2 | 87.3 |
| 1947 | 79.7 | 83.4 | 81.9 | 83.3 | 82.5 | 83.6 | 84.8 | 86.0 | 86.0 | 85.6 | 83.8 | 81.8 | 83.5 | 79.7 | 86.0 |
| 1948 | ***** | 81.3 | 81.6 | 83.1 | 82.6 | 82.7 | 83.5 | 85.0 | 84.4 | 83.6 | 81.1 | 79.7 | ***** | 79.7 | 85.0 |
| 1949 | 78.9 | 79.1 | 79.1 | 78.3 | 79.8 | 80.0 | 82.0 | 82.4 | 82.6 | 82.1 | 80.7 | 80.3 | 80.4 | 78.3 | 82.6 |
| 1950 | 79.9 | 81.0 | 82.2 | 80.7 | 80.5 | 80.5 | 82.3 | 84.7 | 84.5 | 84.4 | 83.0 | 80.9 | 82.0 | 79.9 | 84.7 |
| 1951 | 81.8 | 80.9 | 80.2 | 81.6 | 82.0 | 82.7 | 83.8 | 83.7 | 83.7 | 83.3 | 81.4 | 80.5 | 82.1 | 80.2 | 83.8 |
| 1952 | 78.8 | 79.7 | 80.0 | ***** | 80.6 | 80.5 | 82.6 | 83.5 | 82.5 | 83.9 | 82.2 | 80.3 | ***** | 78.8 | 83.9 |
| 1953 | 80.2 | 80.3 | 80.8 | 81.5 | 81.7 | 81.4 | 82.4 | 83.5 | 82.6 | 82.5 | 80.7 | 78.7 | 81.4 | 78.7 | 83.5 |
| 1954 | 79.6 | 81.5 | 80.7 | 83.0 | 82.5 | 82.8 | 83.9 | 84.6 | 84.2 | 83.6 | 82.8 | 80.8 | 82.5 | 79.6 | 84.6 |
| 1955 | 79.8 | 78.2 | 79.2 | 80.8 | 80.2 | 79.7 | 81.3 | 81.8 | 81.9 | 81.2 | 81.4 | ***** | ***** | 78.2 | 81.9 |

MINIMUM TEMPERATURE **** ISLAND OF HAWAII

STATION NO. 28. LOCATION - NAPOOPOO ELEVATION 400 FT UNITS - DEGREES F

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | LOW | HIGH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1919 | 65.4 | 65.3 | 65.9 | 67.8 | 67.7 | 69.1 | 69.4 | 71.3 | 72.4 | 73.0 | 69.7 | 69.2 | 68.8 | 65.3 | 73.0 |
| 1920 | 70.4 | 67.3 | ***** | ***** | ***** | ***** | 70.2 | 70.0 | 69.3 | 67.9 | 66.5 | 66.2 | ***** | 65.2 | 70.4 |
| 1921 | 64.8 | 62.8 | 64.9 | 66.6 | 66.9 | 69.7 | 69.8 | 69.9 | 68.9 | 68.5 | 65.9 | 65.3 | 67.0 | 62.8 | 69.9 |
| 1922 | 62.7 | 61.9 | 63.3 | 64.7 | 66.4 | 66.7 | 68.2 | 68.3 | 69.5 | 70.2 | 70.1 | 70.8 | 66.9 | 61.9 | 70.8 |
| 1923 | 69.5 | 65.7 | 67.4 | 70.0 | ***** | ***** | 71.7 | 70.5 | 71.6 | 69.0 | 68.5 | 66.3 | ***** | 65.7 | 71.7 |
| 1924 | 63.7 | 65.4 | 65.0 | 67.1 | 67.0 | 68.5 | 68.9 | 69.2 | 69.1 | 67.7 | 67.5 | 65.5 | 67.0 | 63.7 | 69.2 |
| 1925 | 65.3 | 65.3 | 64.7 | 64.3 | 65.4 | 68.0 | 68.1 | 69.6 | 67.8 | 66.8 | 64.8 | 64.6 | 66.2 | 64.3 | 69.6 |
| 1926 | 63.9 | 65.0 | 63.8 | 64.7 | 67.0 | 67.3 | 67.8 | 67.5 | 67.3 | 66.8 | 65.7 | 67.0 | 66.3 | 63.8 | 67.8 |
| 1927 | 69.3 | 72.9 | 74.2 | ***** | ***** | 69.6 | 70.2 | 70.7 | 68.9 | 68.9 | 68.2 | 66.3 | ***** | 66.3 | 74.2 |
| 1928 | 64.4 | 63.0 | 66.3 | 67.9 | 69.8 | 68.7 | 70.1 | 71.5 | 70.2 | 70.0 | 68.2 | 66.1 | 68.0 | 63.0 | 71.5 |
| 1929 | 64.5 | 64.6 | 66.9 | 67.7 | 68.5 | 69.9 | 70.5 | 69.7 | 70.3 | 69.7 | 68.6 | 65.7 | 68.0 | 64.5 | 70.5 |
| 1930 | 63.4 | 65.4 | 65.4 | 67.0 | 67.4 | 67.8 | 69.5 | 72.3 | 71.5 | 69.0 | 68.8 | 67.4 | 67.9 | 63.4 | 72.3 |
| 1931 | 66.4 | 65.7 | 65.4 | 65.2 | 67.2 | 69.5 | 68.3 | 69.7 | 69.6 | 69.4 | 66.8 | 64.1 | 67.3 | 64.1 | 69.7 |
| 1932 | 64.6 | 63.4 | 64.3 | 65.2 | 65.0 | 65.8 | 67.1 | ***** | ***** | 69.9 | 69.2 | 66.6 | ***** | 63.4 | 69.9 |
| 1933 | 65.4 | 64.6 | 65.5 | 65.6 | 67.6 | 67.6 | 68.7 | 67.9 | 67.1 | 67.3 | 66.1 | 66.8 | 66.7 | 64.6 | 68.7 |
| 1934 | 65.6 | 65.4 | 65.9 | 66.2 | 67.3 | 68.2 | 68.8 | 70.4 | 69.1 | 68.8 | 68.4 | 66.9 | 67.6 | 65.4 | 70.4 |
| 1935 | 65.5 | 66.3 | 66.5 | 67.1 | 68.7 | 69.3 | 70.4 | 70.8 | 70.7 | 68.5 | 66.4 | 65.9 | 68.0 | 65.5 | 70.8 |
| 1936 | 64.6 | 63.4 | 64.5 | 66.5 | 66.8 | 68.3 | 68.5 | 70.2 | 68.1 | 67.5 | 66.0 | 64.1 | 66.5 | 63.4 | 70.2 |
| 1937 | 62.8 | 62.6 | 65.1 | 67.8 | 67.9 | 69.2 | ***** | ***** | ***** | ***** | 69.4 | 68.6 | ***** | 62.6 | 69.4 |
| 1938 | 66.3 | 64.9 | 66.9 | 68.6 | 68.4 | 67.7 | ***** | 69.2 | 69.4 | 70.7 | 67.9 | 67.2 | ***** | 64.9 | 70.7 |
| 1939 | ***** | ***** | ***** | ***** | ***** | 63.3 | 64.0 | 65.1 | 64.4 | 64.4 | 62.8 | 61.9 | ***** | 61.9 | 65.1 |
| 1940 | 60.7 | 61.4 | 61.8 | 63.5 | 64.3 | 68.4 | 64.6 | 65.8 | 64.4 | 64.3 | 63.2 | 61.5 | 63.7 | 60.7 | 68.4 |
| 1941 | 60.6 | 58.8 | 59.0 | 59.9 | 60.8 | 62.2 | 62.4 | 64.5 | 63.5 | 62.6 | 62.0 | 57.9 | 61.2 | 57.9 | 64.5 |
| 1942 | 57.3 | 57.4 | 56.5 | 57.4 | 61.2 | 68.4 | 67.0 | 67.0 | 65.4 | 65.0 | 64.8 | 62.9 | 62.5 | 56.5 | 68.4 |
| 1943 | 62.2 | 61.8 | 61.0 | 63.3 | 64.1 | 65.1 | 65.4 | 63.2 | 64.5 | 64.2 | 62.4 | 61.2 | 63.2 | 61.0 | 65.4 |
| 1944 | 60.0 | 60.9 | 61.4 | 63.1 | 63.4 | 64.8 | 66.0 | 65.1 | 65.3 | 64.8 | 63.6 | 61.7 | 63.3 | 60.0 | 66.0 |
| 1945 | 61.0 | 61.9 | ***** | ***** | 63.2 | 64.3 | 64.4 | 63.8 | 62.5 | 61.9 | 61.7 | 59.6 | ***** | 59.6 | 64.4 |
| 1946 | 58.8 | 58.1 | 58.9 | 58.5 | 59.2 | 61.1 | 61.9 | 62.3 | 61.5 | 60.1 | 58.2 | 56.4 | 59.6 | 56.4 | 62.3 |
| 1947 | 53.7 | 55.8 | 55.6 | 56.8 | 58.0 | 58.8 | 59.5 | 59.6 | 59.4 | 57.9 | 56.4 | 53.6 | 57.1 | 53.6 | 59.6 |
| 1948 | ***** | 61.0 | 63.1 | 64.4 | 65.7 | 66.2 | 66.3 | 66.9 | 65.9 | 65.1 | 62.5 | 59.6 | ***** | 59.6 | 66.9 |
| 1949 | 58.2 | 62.2 | 60.4 | 61.6 | 63.0 | 64.6 | 63.9 | 65.9 | 64.9 | 64.5 | 62.3 | 62.1 | 62.8 | 58.2 | 65.9 |
| 1950 | 61.6 | 62.3 | 62.5 | 61.8 | 62.8 | 65.5 | 65.2 | 66.0 | 65.7 | 65.4 | 63.7 | 60.9 | 63.6 | 60.9 | 66.0 |
| 1951 | 60.5 | 60.8 | 59.9 | 59.9 | 61.7 | 64.7 | 65.4 | 64.9 | 64.7 | 65.2 | 62.8 | 61.0 | 62.6 | 59.9 | 65.4 |
| 1952 | 60.5 | 59.2 | 60.0 | ***** | 61.6 | ***** | ***** | ***** | ***** | 66.8 | 65.2 | 63.3 | ***** | 59.2 | 66.8 |
| 1953 | 60.1 | 62.8 | 62.4 | 62.0 | 64.1 | 64.5 | 64.1 | 64.3 | 62.7 | 62.2 | 61.0 | 59.3 | 62.5 | 59.3 | 64.5 |
| 1954 | 58.8 | 58.8 | 58.2 | 60.6 | 61.0 | ***** | ***** | 67.9 | 66.6 | 64.9 | 64.2 | 60.3 | ***** | 58.2 | 67.9 |
| 1955 | 59.7 | 58.3 | 59.6 | 61.9 | 62.0 | 63.0 | 62.1 | 61.6 | 64.3 | 65.1 | 65.0 | ***** | ***** | 58.3 | 65.1 |
| 1956 | 63.1 | 62.2 | 62.8 | 62.9 | 64.6 | 64.7 | 64.6 | 66.4 | 65.2 | 65.4 | 63.1 | 60.6 | 63.8 | 60.6 | 66.4 |
| 1957 | 60.0 | 57.0 | 58.3 | 61.3 | 60.7 | 62.4 | 63.3 | 64.5 | 64.4 | 63.2 | 62.3 | ***** | ***** | 57.0 | 64.5 |
| 1958 | 57.8 | 58.0 | 57.8 | 59.0 | 59.9 | 61.5 | 61.8 | 62.7 | 62.0 | 60.9 | 60.1 | 62.6 | 60.3 | 57.8 | 62.7 |
| 1959 | 63.9 | 63.5 | 63.9 | 64.9 | 64.9 | 65.2 | 66.4 | 65.9 | 65.7 | 64.8 | 63.7 | ***** | ***** | 63.5 | 66.4 |
| 1960 | 60.6 | 60.4 | 60.8 | 62.4 | 63.7 | 64.7 | 66.2 | 67.6 | 66.5 | 66.3 | 64.6 | ***** | ***** | 60.4 | 67.6 |

MAXIMUM TEMPERATURE **** ISLAND OF HAWAII

STATION NO. 7. LOCATION - KIOLAKAA ELEVATION 1050 FT UNITS - DEGREES F

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | LOW | HIGH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | ***** | ***** | 76.3 | 78.0 | 78.7 | 79.0 | 78.6 | 79.0 | 79.1 | 78.3 | 78.3 | 74.1 | ***** | 76.1 | 79.1 |
| 1917 | 75.2 | 77.4 | 74.6 | 76.6 | 77.3 | 78.0 | 80.1 | 80.0 | 83.5 | 82.0 | 81.8 | 78.0 | 78.7 | 74.6 | 83.5 |
| 1918 | 77.7 | 74.9 | 75.3 | 74.8 | 77.6 | 79.6 | 80.2 | 80.5 | 82.2 | 82.0 | 80.9 | 78.1 | 78.6 | 74.8 | 82.2 |
| 1919 | 76.3 | 77.4 | 76.1 | 79.6 | 78.3 | 77.9 | 81.0 | 81.4 | 81.4 | 80.8 | 79.1 | 80.3 | 79.1 | 76.1 | 81.4 |
| 1920 | 78.5 | 78.2 | 78.1 | 77.2 | 78.6 | 80.4 | 79.9 | 81.1 | 81.0 | 81.5 | 80.2 | 78.0 | 79.4 | 77.2 | 81.5 |
| 1921 | 73.1 | 77.1 | 77.5 | 78.0 | 79.0 | 79.7 | 81.2 | 80.6 | 79.6 | 80.5 | 80.0 | 79.2 | 78.8 | 73.1 | 81.2 |
| 1922 | 76.3 | 75.1 | 77.4 | 78.7 | 79.4 | 80.6 | 82.2 | 80.9 | 83.1 | 81.8 | 80.9 | 80.5 | 79.7 | 75.1 | 83.1 |
| 1923 | 74.9 | 77.4 | 77.2 | 77.6 | 78.9 | 80.6 | 81.6 | 83.0 | 82.3 | 82.4 | ***** | 78.9 | ***** | 74.9 | 83.0 |
| 1924 | 79.4 | 79.2 | 77.8 | 76.2 | 77.3 | 78.6 | 80.1 | 80.1 | 81.8 | 80.7 | 80.9 | 79.1 | 79.3 | 76.2 | 81.8 |
| 1925 | 79.7 | 79.9 | 77.7 | 77.6 | 78.8 | 80.5 | 82.1 | 81.1 | 82.7 | 81.7 | 80.4 | 81.4 | 80.3 | 77.6 | 82.7 |
| 1926 | 80.2 | 79.5 | 80.7 | 80.0 | 80.2 | 81.5 | 84.5 | 83.2 | 83.3 | 83.8 | 81.5 | 78.0 | 81.4 | 78.0 | 84.5 |
| 1927 | 76.5 | 80.6 | 77.2 | 77.0 | 78.2 | 79.1 | 81.4 | 80.2 | 79.9 | 79.8 | 80.8 | 74.3 | 78.7 | 74.3 | 81.4 |
| 1928 | 75.7 | 77.2 | 79.7 | 78.7 | 78.2 | 79.6 | 79.2 | 80.0 | 80.0 | 80.4 | 80.4 | 78.2 | 78.9 | 75.7 | 80.4 |
| 1929 | 78.2 | 76.8 | 76.3 | 76.0 | 78.6 | 79.5 | 80.0 | 82.5 | 82.5 | 83.1 | 81.6 | 79.2 | 79.5 | 76.0 | 83.1 |
| 1930 | 78.9 | 80.3 | 78.2 | 76.7 | 77.1 | 78.2 | 80.6 | 79.1 | 79.8 | 81.0 | 81.5 | 79.0 | 79.2 | 76.7 | 81.5 |
| 1931 | 78.2 | 77.8 | 78.5 | 79.5 | 79.4 | 80.2 | 80.7 | 81.6 | 81.2 | 80.4 | 80.1 | 79.0 | 79.7 | 77.8 | 81.6 |
| 1932 | 77.1 | 76.6 | 76.7 | 76.9 | 76.6 | 77.5 | 80.5 | 81.4 | 79.3 | 78.7 | 77.3 | 75.7 | 77.9 | 75.7 | 81.4 |
| 1933 | 73.7 | 74.6 | 74.8 | 74.7 | 75.1 | 75.1 | 77.5 | 78.6 | 79.9 | 79.4 | 79.6 | 79.1 | 76.8 | 73.7 | 79.9 |
| 1934 | 75.9 | 78.2 | 78.2 | 76.6 | 79.2 | 78.0 | 80.2 | 83.0 | 82.7 | 83.3 | 79.5 | 77.7 | 79.4 | 75.9 | 83.3 |
| 1935 | 78.5 | 77.4 | 76.7 | 75.8 | 77.9 | 78.4 | 79.6 | 80.7 | 81.1 | 80.2 | 78.8 | 77.1 | 78.5 | 75.8 | 81.1 |
| 1936 | 76.5 | 78.0 | 76.2 | 77.9 | 79.1 | 79.6 | 80.8 | 80.7 | 80.8 | 80.7 | ***** | ***** | ***** | 76.2 | 80.8 |
| 1937 | 75.8 | 76.0 | 74.4 | 77.0 | 77.3 | 79.7 | 80.4 | 80.3 | 80.2 | 80.2 | 79.9 | 79.8 | 78.4 | 74.4 | 80.4 |
| 1938 | 76.7 | 78.4 | 78.5 | 77.7 | 78.5 | 77.9 | 79.1 | 80.0 | 79.1 | 82.2 | 78.8 | 79.0 | 78.8 | 76.7 | 82.2 |
| 1939 | 77.5 | 76.4 | 75.4 | 76.3 | 76.8 | 75.6 | 79.0 | 80.4 | 80.3 | 79.3 | 77.1 | 79.3 | 77.8 | 75.4 | 80.4 |
| 1940 | 82.3 | 81.5 | 78.7 | 79.3 | 80.6 | 79.9 | 82.2 | 80.5 | 78.9 | 78.4 | ***** | 79.5 | ***** | 78.4 | 82.3 |
| 1941 | 79.7 | 77.4 | 77.0 | 78.4 | 78.4 | 80.4 | 80.6 | 81.5 | 80.7 | 79.0 | 80.1 | 78.0 | 79.3 | 77.0 | 81.5 |
| 1942 | 81.8 | 81.6 | 75.7 | 75.9 | 79.4 | 79.5 | 82.2 | 82.8 | 82.5 | 82.5 | 82.5 | 80.9 | 80.6 | 75.7 | 82.8 |
| 1943 | 77.2 | 77.0 | 75.8 | 79.4 | 78.9 | 77.6 | 80.2 | 80.5 | 79.7 | 80.5 | 81.2 | 79.5 | 79.0 | 75.8 | 81.2 |
| 1944 | 78.7 | 77.9 | 78.5 | 77.1 | 76.9 | 77.0 | 77.6 | 78.6 | 79.3 | 79.3 | 78.2 | 76.4 | 78.0 | 76.4 | 79.3 |
| 1945 | 77.5 | 78.4 | 76.0 | 76.0 | 77.4 | 77.1 | 78.2 | 80.2 | 80.1 | 79.7 | 78.6 | 77.4 | 78.0 | 76.0 | 80.2 |
| 1946 | 76.5 | 74.7 | 76.1 | 76.6 | 79.6 | 81.2 | 80.6 | 80.8 | 81.5 | 80.1 | 80.9 | 75.6 | 78.7 | 74.7 | 81.5 |
| 1947 | 75.9 | 79.3 | 75.7 | 77.7 | 76.7 | 79.0 | 80.5 | 81.1 | 79.9 | 81.2 | 79.4 | 78.4 | 78.7 | 75.7 | 81.2 |
| 1948 | 77.1 | 77.4 | 76.3 | 76.6 | 76.4 | 77.5 | 78.3 | 79.3 | 82.1 | 80.6 | 77.2 | ***** | ***** | 76.3 | 82.1 |
| 1949 | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** |
| 1950 | ***** | ***** | 76.1 | 76.1 | 77.1 | ***** | 78.5 | 78.7 | 78.6 | 79.8 | 79.1 | 76.5 | ***** | 76.1 | 79.8 |
| 1951 | 75.6 | 74.7 | 75.3 | 75.8 | 76.4 | 78.7 | 80.0 | 78.9 | 79.9 | ***** | ***** | 74.6 | ***** | 74.6 | 80.0 |
| 1952 | 72.6 | 74.9 | ***** | ***** | ***** | 78.5 | 79.1 | 79.5 | 80.1 | 81.4 | 78.4 | ***** | ***** | 72.6 | 81.4 |
| 1953 | ***** | 78.1 | 76.4 | 76.7 | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | 76.4 | 78.1 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN | 77.2 | 77.6 | 76.8 | 77.2 | 78.1 | 78.8 | 80.2 | 80.6 | 80.8 | 80.7 | 79.8 | 78.2 | 78.9 |
| S.D. | 2.1 | 1.8 | 1.6 | 1.5 | 1.2 | 1.6 | 1.6 | 1.2 | 1.3 | 1.3 | 1.6 | 1.7 | 0.9 |
| LOW | 72.6 | 74.6 | 74.6 | 74.6 | 75.1 | 75.1 | 77.5 | 78.6 | 78.6 | 78.3 | 77.1 | 74.5 | 76.8 |
| HIGH | 82.5 | 81.6 | 80.6 | 80.0 | 80.6 | 81.5 | 84.5 | 83.1 | 83.5 | 83.8 | 82.5 | 81.4 | 81.5 |
| MEDIAN | 77.1 | 77.4 | 76.5 | 77.0 | 78.3 | 79.0 | 80.1 | 80.5 | 80.5 | 80.6 | 80.0 | 78.4 | 78.8 |
| YEARS | 34 | 35 | 36 | 36 | 35 | 35 | 36 | 34 | 36 | 35 | 32 | 33 | 28 |

MINIMUM TEMPERATURE **** ISLAND OF HAWAII

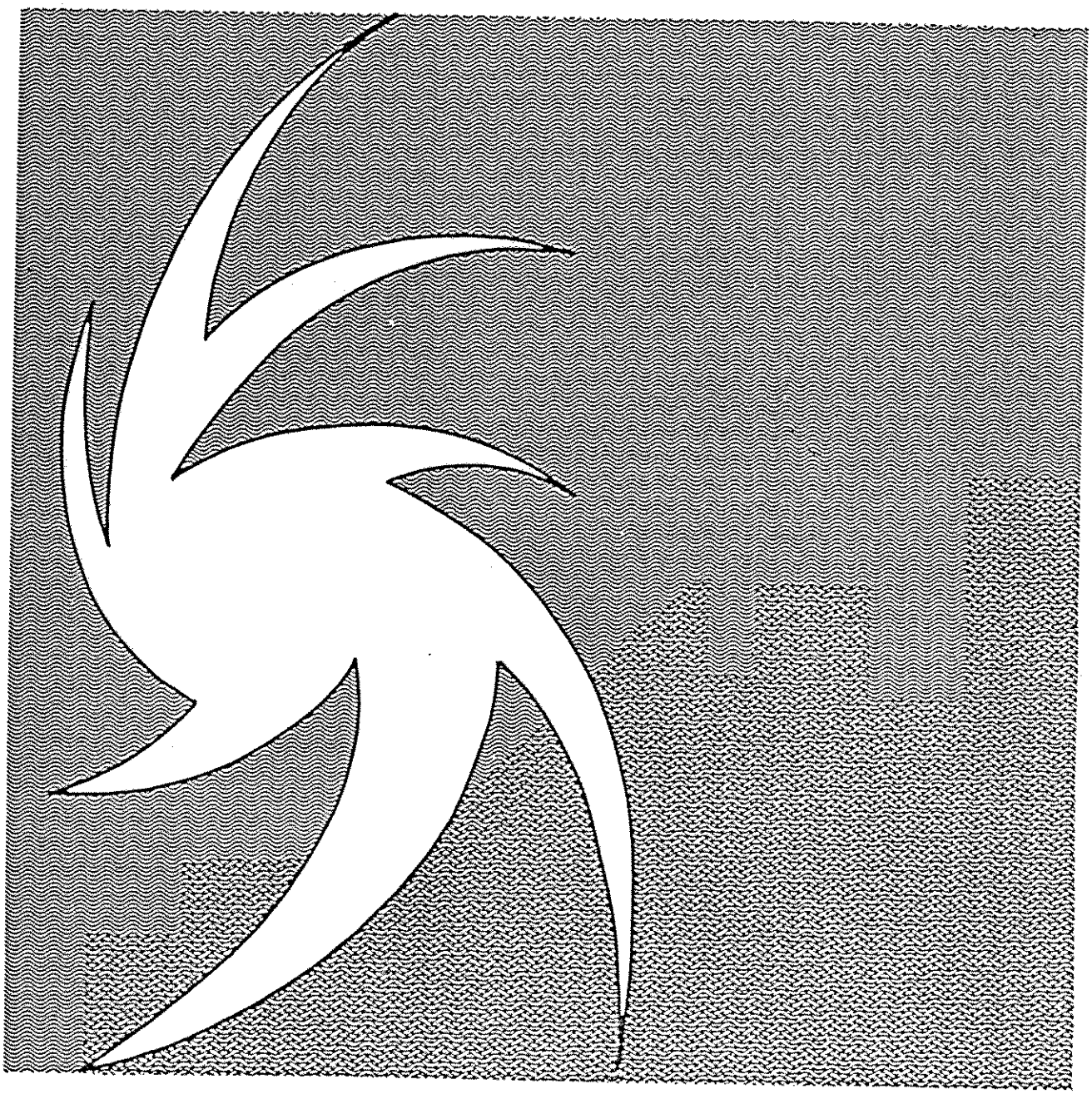
STATION NO. 7. LOCATION - KIOLAKAA ELEVATION 1050 FT UNITS - DEGREES F

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | LOW | HIGH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | ***** | ***** | 62.0 | 63.0 | 63.2 | 63.8 | 67.2 | 63.9 | 64.1 | 64.6 | 62.8 | 60.8 | ***** | 60.8 | 67.2 |
| 1917 | 59.2 | 57.8 | 60.2 | 61.1 | 63.0 | 64.1 | 64.1 | 64.4 | 64.7 | 64.5 | 63.1 | 62.1 | 62.4 | 57.8 | 64.7 |
| 1918 | 61.0 | 60.0 | 59.8 | 63.2 | 64.4 | 64.3 | 65.7 | 65.1 | 65.7 | 65.6 | 64.4 | 61.9 | 63.4 | 59.8 | 65.7 |
| 1919 | 58.0 | 60.1 | 60.1 | 61.8 | 61.8 | 63.8 | 64.1 | 65.2 | 64.6 | 64.6 | 62.6 | 61.3 | 62.3 | 58.0 | 65.2 |
| 1920 | 60.4 | 58.8 | 58.7 | 60.8 | 62.7 | 63.6 | 64.5 | 65.5 | 64.5 | 63.3 | 62.4 | 63.5 | 62.4 | 58.7 | 65.5 |
| 1921 | 62.3 | 60.8 | 58.8 | 61.6 | 62.4 | 64.3 | 64.8 | 64.2 | 64.2 | 63.8 | 60.2 | 62.2 | 62.5 | 58.8 | 64.8 |
| 1922 | 59.7 | 59.4 | 59.7 | 61.8 | 63.0 | 63.9 | 65.0 | 65.5 | 64.7 | 63.8 | 62.3 | 61.6 | 62.5 | 59.4 | 65.5 |
| 1923 | 60.7 | 59.8 | 60.2 | 62.3 | 62.6 | 63.4 | 64.8 | 65.7 | 65.9 | 64.5 | ***** | 61.8 | ***** | 59.8 | 65.9 |
| 1924 | 56.8 | 61.6 | 59.8 | 61.9 | 62.4 | 62.6 | 64.1 | 64.4 | 64.7 | 64.5 | 62.1 | 62.6 | 62.3 | 56.8 | 64.7 |
| 1925 | 60.5 | 59.8 | 59.8 | 60.0 | 61.2 | 64.4 | 64.3 | 65.2 | 65.2 | 64.3 | 63.6 | 61.7 | 62.5 | 59.8 | 65.2 |
| 1926 | 59.7 | 59.8 | 60.1 | 60.3 | 63.5 | 64.8 | 65.9 | 66.5 | 65.8 | 64.3 | 63.3 | 62.9 | 63.1 | 59.7 | 66.5 |
| 1927 | 62.0 | 60.6 | 62.7 | 63.1 | 64.1 | 64.5 | 65.9 | 64.3 | 64.4 | 63.8 | 63.7 | 62.1 | 63.4 | 60.6 | 65.9 |
| 1928 | 60.1 | 58.5 | 59.9 | 61.3 | 62.3 | 62.5 | 63.6 | 65.1 | 64.9 | 64.3 | 63.7 | 61.9 | 62.4 | 58.5 | 65.1 |
| 1929 | 58.7 | 58.8 | 61.5 | 62.6 | 64.0 | 64.8 | 66.5 | 65.9 | 66.1 | 65.3 | 63.6 | 60.8 | 63.2 | 55.7 | 66.5 |
| 1930 | 59.8 | 59.2 | 61.0 | 61.3 | 62.9 | 64.4 | 65.5 | 67.1 | 67.1 | 64.5 | 64.5 | 61.6 | 63.2 | 59.2 | 67.1 |
| 1931 | 59.8 | 60.3 | 60.9 | 60.6 | 62.6 | 65.1 | 65.0 | 66.0 | 65.7 | 65.3 | 62.2 | 59.9 | 62.8 | 59.8 | 66.0 |
| 1932 | 61.8 | 60.8 | 61.7 | 61.4 | 61.4 | 62.6 | 65.6 | 64.3 | 64.0 | 64.3 | 63.2 | 61.7 | 62.7 | 60.8 | 65.6 |
| 1933 | 60.9 | 60.7 | 59.0 | 59.2 | 62.5 | 62.3 | 62.0 | 62.0 | 63.4 | 63.8 | 61.4 | 62.4 | 61.6 | 59.0 | 63.8 |
| 1934 | 60.4 | 58.6 | 60.0 | 59.4 | 62.9 | 64.6 | 65.7 | 67.0 | 66.4 | 65.4 | 65.0 | 63.1 | 63.2 | 58.6 | 67.0 |
| 1935 | 59.7 | 59.5 | 60.7 | 61.1 | 62.9 | 63.8 | 64.7 | 63.6 | 65.0 | 65.2 | 63.4 | 62.3 | 62.7 | 59.5 | 65.2 |
| 1936 | 61.0 | 60.4 | 60.6 | 62.0 | 63.4 | 63.6 | 64.5 | 65.8 | 65.4 | 65.8 | 63.3 | 62.0 | 63.1 | 60.4 | 65.8 |
| 1937 | 60.9 | 61.2 | 62.1 | 62.6 | 64.0 | 63.3 | 65.3 | 65.7 | 64.4 | 63.6 | 63.3 | 60.8 | 63.2 | 60.8 | 65.7 |
| 1938 | 61.6 | 62.2 | 63.7 | 64.1 | 63.3 | 65.1 | 64.5 | 64.7 | 64.9 | 65.2 | 62.4 | 62.7 | 63.7 | 61.6 | 65.2 |
| 1939 | 60.1 | 61.3 | 60.0 | 61.4 | 62.9 | 62.6 | 64.5 | 65.3 | 64.4 | 64.2 | 62.6 | 61.8 | 62.6 | 60.0 | 65.3 |
| 1940 | 60.2 | 60.4 | 61.7 | 63.7 | 65.3 | 64.8 | 66.3 | 66.8 | 64.6 | 64.7 | 65.6 | 61.0 | 63.8 | 60.2 | 66.8 |
| 1941 | 61.1 | 60.5 | 60.5 | 63.3 | 63.4 | 64.7 | 65.3 | 66.4 | 66.2 | 66.0 | 63.3 | 63.0 | 63.6 | 60.5 | 66.4 |
| 1942 | 60.6 | 59.4 | 60.0 | 62.5 | 64.3 | 65.5 | 66.6 | 67.2 | 66.3 | 65.8 | 64.4 | 65.6 | 63.8 | 59.4 | 67.2 |
| 1943 | 62.1 | 60.4 | 60.4 | 62.1 | 63.9 | 64.6 | 65.0 | 65.1 | 64.8 | 64.6 | 62.6 | 62.3 | 63.2 | 60.4 | 65.1 |
| 1944 | 61.5 | 59.7 | 61.0 | 63.0 | 62.2 | 64.1 | 64.9 | 64.5 | 64.5 | 63.4 | 63.8 | 59.8 | 62.7 | 59.7 | 64.9 |
| 1945 | 60.0 | 60.7 | 61.6 | 62.4 | 63.4 | 65.3 | 64.3 | 65.5 | 64.5 | 63.6 | 63.5 | 60.5 | 62.9 | 60.0 | 65.5 |
| 1946 | 61.0 | 61.4 | 62.2 | 61.0 | 61.2 | 64.7 | 66.7 | 65.9 | 65.4 | 65.8 | 62.1 | 61.5 | 63.2 | 61.0 | 66.7 |
| 1947 | 58.2 | 58.1 | 61.1 | 62.5 | 62.3 | 64.1 | 65.6 | 65.9 | 64.9 | 64.4 | 63.0 | 60.5 | 62.5 | 58.1 | 65.9 |
| 1948 | 58.2 | 56.8 | 61.8 | 61.9 | 63.2 | 63.8 | 64.3 | 65.4 | 65.4 | 64.8 | 63.6 | ***** | ***** | 56.8 | 65.4 |
| 1949 | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** |
| 1950 | ***** | ***** | 59.7 | 62.1 | 66.5 | ***** | 65.5 | 65.9 | 66.1 | 64.4 | 62.1 | 58.6 | ***** | 58.6 | 66.5 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 60.0 | 60.8 | 62.7 | 61.1 | 61.7 | 63.0 | 67.7 | 64.1 | 63.3 | ***** | ***** | 62.9 | ***** | 60.0 | 67.7 |
| 1952 | 62.5 | 60.6 | ***** | ***** | ***** | 65.2 | 64.1 | 65.4 | 64.5 | 63.6 | 65.1 | ***** | ***** | 60.6 | 65.4 |
| 1953 | ***** | 61.1 | 61.1 | 59.9 | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | ***** | 59.9 | 61.1 |
| MEAN | 60.3 | 59.9 | 60.7 | 61.7 | 63.0 | 64.0 | 65.1 | 65.2 | 65.0 | 64.5 | 63.1 | 61.7 | 62.9 | | |
| S.D. | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 0.8 | 1.0 | 1.0 | 0.8 | 0.7 | 1.0 | 1.0 | 0.5 | | |
| LOW | 56.8 | 56.8 | 58.6 | 59.1 | 61.1 | 62.3 | 62.0 | 62.0 | 63.3 | 63.3 | 60.1 | 58.5 | 61.6 | | |
| HIGH | 62.5 | 62.1 | 63.6 | 64.1 | 66.5 | 65.5 | 67.6 | 67.1 | 67.1 | 66.0 | 65.6 | 63.5 | 63.8 | | |
| MEDIAN | 60.4 | 60.3 | 60.5 | 61.8 | 62.9 | 64.1 | 65.0 | 65.4 | 64.8 | 64.5 | 63.3 | 61.8 | 62.8 | | |
| YEARS | 34 | 35 | 36 | 36 | 35 | 33 | 36 | 36 | 36 | 35 | 34 | 34 | 30 | | |

CLIMATOGRAPHY OF THE UNITED STATES NO. 20

# Climate of Kainaliu, Hawaii



noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA SERVICE / NATIONAL CLIMATIC CENTER ASHEVILLE, N.C. APRIL 1978

LATITUDE N19 32
LONGITUDE W155 56

# CLIMATOLOGICAL SUMMARY

MEANS AND EXTREMES FOR PERIOD 1931-1979

KAINALIU T3.2 MI
ELEVATION 1500

| MONTH | TEMPERATURE (°F) MEANS: DAILY MAXIMUM | DAILY MINIMUM | MONTHLY | EXTREMES: RECORD HIGHEST | YEAR | DAY | RECORD LOWEST | YEAR | DAY | MEAN NUMBER OF DAYS: MAX. 90° AND ABOVE | MAX. 32° AND BELOW | MIN. 32° AND BELOW | MIN. 0° AND BELOW | PRECIPITATION TOTALS (INCHES): MEAN | GREATEST MONTHLY | YEAR | GREATEST DAILY | YEAR | DAY | SNOW, SLEET: MEAN | MAXIMUM MONTHLY | YEAR | GREATEST DEPTH | YEAR | DAY | MEAN NUMBER OF DAYS: .10 or MORE | .50 or MORE | 1.00 or MORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 76.3 | 58.6 | 67.3 | 85 | 54 | 31 | 49 | 45 | 30 | 0 | 0 | 0 | 0 | 5.30 | 19.03 | 71 | 6.05 | 59 | 18 | .0 | | | | | | 7 | 3 | 1 |
| FEB | 76.5 | 58.4 | 67.5 | 85+ | 54 | 1 | 48 | 62 | 22 | 0 | 0 | 0 | 0 | 3.05 | 9.51 | 55 | 2.91 | 53 | 27 | .0 | | | | | | 6 | 2 | 1 |
| MAR | 76.7 | 59.1 | 67.9 | 85+ | 54 | 3 | 52 | 58 | 15 | 0 | 0 | 0 | 0 | 4.66 | 14.49 | 61 | 5.20 | 51 | 14 | .0 | | | | | | 6 | 3 | 1 |
| APR | 77.0 | 60.1 | 68.6 | 84 | 54 | 30 | 53+ | 66 | 21 | 0 | 0 | 0 | 0 | 5.54 | 12.06 | 63 | 5.84 | 68 | 11 | .0 | | | | | | 11 | 3 | 1 |
| MAY | 77.1 | 61.4 | 69.3 | 85+ | 66 | 20 | 54 | 56 | 30 | 0 | 0 | 0 | 0 | 6.71 | 11.30 | 61 | 2.40 | 51 | 7 | .0 | | | | | | 14 | 5 | 1 |
| JUN | 77.2 | 62.7 | 70.0 | 85+ | 54 | 2 | 57 | 53 | 21 | 0 | 0 | 0 | 0 | 6.36 | 13.51 | 51 | 2.51 | 51 | 13 | .0 | | | | | | 15 | 4 | 1 |
| JULY | 78.6 | 63.0 | 70.9 | 89 | 54 | 26 | 58+ | 62 | 6 | 0 | 0 | 0 | 0 | 8.06 | 13.99 | 55 | 3.44 | 72 | 9 | .0 | | | | | | 14 | 5 | 2 |
| AUG | 79.4 | 63.8 | 71.6 | 89 | 54 | 12 | 58 | 63 | 1 | 0 | 0 | 0 | 0 | 7.43 | 13.08 | 65 | 5.03 | 56 | 6 | .0 | | | | | | 13 | 5 | 1 |
| SEPT | 79.8 | 63.4 | 71.6 | 86+ | 57 | 22 | 58 | 65 | 4 | 0 | 0 | 0 | 0 | 7.16 | 15.38 | 74 | 5.00 | 74 | 3 | .0 | | | | | | 14 | 4 | 2 |
| OCT | 79.9 | 62.6 | 71.3 | 87+ | 51 | 13 | 58+ | 65 | 26 | 0 | 0 | 0 | 0 | 5.29 | 10.51 | 51 | 4.42 | 74 | 14 | .0 | | | | | | 10 | 3 | 1 |
| NOV | 78.6 | 61.4 | 70.1 | 85+ | 55 | 9 | 56+ | 64 | 18 | 0 | 0 | 0 | 0 | 3.96 | 11.40 | 56 | 3.08 | 56 | 16 | .0 | | | | | | 7 | 2 | 1 |
| DEC | 77.0 | 59.5 | 68.3 | 85+ | 57 | 1 | 50 | 68 | 29 | 0 | 0 | 0 | 0 | 3.31 | 8.29 | 68 | 2.67 | 68 | 18 | .0 | | | | | | 6 | 2 | 1 |
| YEAR | 77.8 | 61.2 | 69.6 | 89+ | 54 | AUG 12 | 48 | 62 | FEB 22 | 0 | 0 | 0 | 0 | 64.97 | 19.03 | JAN 71 | 6.05 | JAN 59 | 16 | .0 | .0 | 00 | .0 | 50 | | 127 | 41 | 14 |

+ ALSO ON EARLIER DATES

## FREEZE PROBABILITIES

PROBABILITY OF LATER DATE IN SPRING (MO/DA) THAN INDICATED

| TEMP | .10 | .20 | .30 | .40 | .50 | .60 | .70 | .80 | .90 |
|---|---|---|---|---|---|---|---|---|---|
| 32 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 28 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 24 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 20 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 16 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |

0/ 0 PROBABILITY OF OCCURRENCE OF THRESHOLD TEMP IS LESS THAN INDICATED PROBABILITY

PROBABILITY OF EARLIER DATE IN FALL (MO/DA) THAN INDICATED

| TEMP | .10 | .20 | .30 | .40 | .50 | .60 | .70 | .80 | .90 |
|---|---|---|---|---|---|---|---|---|---|
| 32 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 28 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 24 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 20 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |
| 16 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 | 0/ 0 |

0/ 0 PROBABILITY OF OCCURRENCE OF THRESHOLD TEMP IS LESS THAN INDICATED PROBABILITY

PROBABILITY OF LONGER THAN INDICATED FREEZE FREE PERIOD (DAYS)

| TEMP | .10 | .20 | .30 | .40 | .50 | .60 | .70 | .80 | .90 |
|---|---|---|---|---|---|---|---|---|---|
| 32 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 |
| 28 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 |
| 24 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 |
| 20 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 |
| 16 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 | >365 |

## PRECIPITATION WITH PROBABILITY EQUAL OR LESS THAN

| LVL | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 0.59 | 0.24 | 1.04 | 1.46 | 2.66 | 2.71 | 4.00 | 3.94 | 3.65 | 2.19 | 0.87 | 1.11 |
| 0.10 | 0.99 | 0.44 | 1.46 | 2.36 | 3.47 | 3.29 | 4.67 | 4.18 | 4.25 | 2.67 | 1.23 | 1.43 |
| 0.20 | 1.73 | 0.83 | 2.14 | 3.13 | 4.32 | 4.09 | 5.59 | 5.06 | 5.06 | 3.35 | 1.81 | 1.92 |
| 0.30 | 2.47 | 1.25 | 2.76 | 3.77 | 5.01 | 4.75 | 6.32 | 5.77 | 5.70 | 3.91 | 2.33 | 2.34 |
| 0.40 | 3.25 | 1.72 | 3.37 | 4.39 | 5.67 | 5.37 | 7.00 | 6.43 | 6.29 | 4.44 | 2.85 | 2.74 |
| 0.50 | 4.13 | 2.25 | 4.03 | 5.02 | 6.33 | 6.00 | 7.67 | 7.09 | 6.86 | 4.97 | 3.40 | 3.16 |
| 0.60 | 5.17 | 2.89 | 4.77 | 5.74 | 7.04 | 6.67 | 8.39 | 7.76 | 7.50 | 5.55 | 4.04 | 3.63 |
| 0.70 | 6.43 | 3.69 | 5.62 | 6.51 | 7.85 | 7.44 | 9.20 | 8.50 | 8.21 | 6.21 | 4.76 | 4.14 |
| 0.80 | 8.13 | 4.80 | 6.73 | 7.30 | 8.88 | 8.42 | 10.21 | 9.40 | 9.10 | 7.05 | 5.72 | 4.80 |
| 0.90 | 11.09 | 6.67 | 8.66 | 9.23 | 10.46 | 9.91 | 11.74 | 11.12 | 10.42 | 8.33 | 7.35 | 5.94 |
| 0.95 | 13.76 | 8.52 | 10.25 | 10.51 | 11.88 | 11.25 | 13.10 | 12.48 | 11.61 | 9.49 | 8.70 | 6.81 |

MEDIAN PRECIPITATION AMOUNTS (0.50 PROBABILITY LEVEL) IN THIS TABLE DIFFER FROM THE MEANS SHOWN IN THE ABOVE TABLE BECAUSE OF THE METHOD USED IN MAKING THE COMPUTATIONS. THESE VALUES WERE DETERMINED FROM THE INCOMPLETE GAMMA DISTRIBUTION WHOSE CURVE HAS BEEN FOUND TO GIVE BEST FITS TO PRECIPITATION CLIMATOLOGICAL SERIES.

STATION: 51 2751 — MAX TEMP — KAINALIU 73.2, HI

| YR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 79.8 | 79.1 | 79.9 | 79.8 | 79.6M | 78.8 | 81.6 | 81.8 | 82.1 | 82.3 | 80.2 | 78.4 | 80.2M |
| 52 | 77.7 | 79.6 | 79.1 | 79.3 | 79.1 | 78.4 | 81.4 | 80.0 | 79.4 | 81.5 | 79.3 | 78.0 | 79.4 |
| 53 | 78.0 | 76.5 | 79.5 | 78.6 | 78.2 | 78.5 | 78.9 | 81.3 | 82.6 | 82.0 | 80.9 | 78.4 | 79.6 |
| 54 | 79.8 | 81.8 | 79.6 | 83.0E | 82.3E | 81.0 | 83.3 | 82.6 | 82.4 | 81.6 | 79.7 | 78.1 | 81.2E |
| 55 | 76.3 | 75.6 | 74.7 | 77.8 | 75.9 | 73.2 | 76.2 | 76.4 | 76.9 | 77.3 | 77.3 | 74.7 | 76.2 |
| 56 | 75.2 | 74.9 | 74.7 | 74.8 | 75.3 | 76.2 | 77.1 | 79.8 | 78.8 | 78.8 | 76.7 | 77.2 | 76.4 |
| 57 | 74.9 | 73.5 | 74.3 | 77.1 | 75.8 | 77.3 | 78.2 | 80.1 | 81.7 | 80.9 | 80.1 | 77.5 | 77.6 |
| 58 | 76.6 | 78.0 | 74.4 | 76.8 | 74.1 | 76.8 | 79.7 | 80.3 | 81.4 | 79.5 | 74.9 | 77.8 | 78.2 |
| 59 | 76.9 | 76.2 | 77.6 | 77.0 | 76.7 | 77.7 | 78.1 | 79.2 | 80.9 | 79.6 | 74.3 | 75.9 | 77.8 |
| 60 | 73.9 | 75.8 | 76.9 | 77.1 | 77.1 | 76.9 | 79.4 | 78.9 | 79.7 | 79.8 | 79.0 | 77.2 | 77.8 |
| 61 | 77.3 | 77.6 | 76.5 | 75.3 | 76.1 | 76.0 | 78.4 | 79.1 | 78.7 | 79.4 | 77.8 | 75.7 | 77.3 |
| 62 | 75.4 | 76.0 | 76.1 | 76.3 | 75.4 | 75.7 | 76.9 | 77.8 | 77.9 | 78.6 | 77.7 | 75.7 | 76.7 |
| 63 | 75.5 | 77.3 | 76.6 | 77.1 | 77.0 | 77.2 | 76.2 | 77.9 | 79.8 | 80.1 | 79.5 | 77.4 | 77.7 |
| 64 | 77.0 | 76.2 | 76.6 | 76.8 | 75.8 | 77.6 | 78.1 | 79.2 | 78.8 | 79.1 | 77.9 | 77.5 | 77.2 |
| 65 | 76.4 | 76.6 | 76.0 | 77.2 | 77.3 | 76.9 | 76.1 | 78.7 | 79.6 | 80.5 | 78.7 | 75.4 | 77.4 |
| 66 | 75.9 | 74.6 | 74.3 | 76.9 | 78.1 | 77.3 | 78.5 | 80.3 | 80.4 | 80.4 | 78.7 | 78.0 | 78.0 |
| 67 | 76.3 | 75.9 | 77.2 | 78.1 | 76.8 | 79.2 | 80.4 | 80.7 | 81.1 | 81.2 | 78.7 | 76.6 | 78.7 |
| 68 | 76.4 | 77.2 | 77.0 | 77.7 | 79.1 | 79.3 | 79.8 | 81.3 | 81.3 | 81.6 | 81.3 | 78.1 | 79.2 |
| 69 | 76.1 | 76.2 | 77.4 | 76.5 | 77.4 | 77.9 | 79.3 | 79.4 | 79.3 | 79.5 | 78.8 | 77.2 | 77.8 |
| 70 | 77.5 | 77.2 | 77.4 | 76.9 | 78.2 | 78.0 | 78.5 | 79.4 | 79.4 | 79.3 | 78.4 | 77.6 | 78.1 |
| 71 | 76.0 | 76.0 | 76.5 | 75.0 | 75.3 | 76.6 | 76.7 | 78.0 | 77.9 | 78.1 | 76.7 | 76.1 | 76.4 |
| 72 | 73.8 | 76.3 | 76.1 | 73.5 | 76.0 | 76.3 | 78.0 | 79.5 | 79.1 | 79.6 | 77.9 | 76.1 | 76.9 |
| 73 | 76.0 | 75.1 | 76.6 | 75.9 | 76.0 | 75.6 | 77.6 | 77.7 | 78.9 | 78.6 | 78.1 | 76.7 | 76.9 |
| 74 | 76.8 | 76.4 | 76.4 | 76.4 | 76.8 | 77.2 | 78.1 | 78.5 | 79.2 | 78.9 | 77.9 | 77.2 | 77.5 |
| 75 | 75.4 | 75.3 | 76.4 | 75.9 | 72.8 | 76.1 | 75.4 | 77.1 | 78.8 | 77.5 | 77.5 | 75.7 | 75.6 |
| SUM | 1908.7 | 1913.0 | 1917.9 | 1934.8 | 1924.6 | 1929.9 | 1965.7 | 1983.2 | 1994.6 | 1996.3 | 1966.1 | 1924.0 | 1946.0 |

STATION: 51 2751 — MIN TEMP — KAINALIU 73.2, HI

| YR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 57.6 | 58.3 | 59.1 | 58.1 | 61.0M | 62.9 | 63.5 | 63.6 | 63.6 | 64.2 | 61.2 | 59.1 | 61.0M |
| 52 | 58.6 | 57.0 | 59.3 | 57.5 | 59.2 | 62.1 | 61.7 | 62.9 | 62.8 | 62.6 | 61.3 | 57.7 | 60.1 |
| 53 | 56.7 | 58.7 | 58.4 | 54.2 | 60.3 | 61.1 | 61.7 | 62.4 | 62.3 | 61.5 | 58.8 | 58.6 | 59.9 |
| 54 | 57.8 | 58.0 | 58.9 | 59.5 | 61.0E | 64.2E | 62.5 | 64.3 | 63.1 | 61.3 | 61.7 | 59.6 | 60.9E |
| 55 | 58.0 | 57.8 | 57.4 | 59.3 | 60.5 | 61.7 | 61.0 | 61.4 | 61.0 | 60.3 | 59.3 | 59.5 | 59.8 |
| 56 | 60.7 | 59.6 | 60.1 | 60.7 | 62.7 | 62.9 | 62.9 | 64.4 | 63.6 | 63.6 | 61.8 | 59.2 | 61.8 |
| 57 | 58.8 | 55.8 | 56.5 | 59.5 | 60.4 | 62.4 | 63.2 | 63.6 | 63.9 | 62.7 | 61.4 | 60.0 | 60.7 |
| 58 | 55.8 | 57.6 | 57.7 | 60.0 | 61.1 | 63.3 | 64.1 | 65.9 | 64.2 | 63.3 | 62.4 | 58.9 | 61.2 |
| 59 | 61.4 | 59.3 | 60.9 | 61.9 | 62.5 | 62.9 | 64.1 | 65.1 | 65.3 | 62.9 | 62.3 | 60.0 | 62.3 |
| 60 | 57.2 | 57.6 | 59.0 | 59.8 | 61.5 | 63.0 | 62.0 | 63.7 | 63.0 | 63.0 | 59.9 | 56.3 | 60.7 |
| 61 | 57.5 | 59.8 | 59.1 | 60.1 | 61.5 | 61.7 | 61.9 | 63.5 | 62.4 | 63.4 | 61.1 | 59.2 | 61.0 |
| 62 | 59.3 | 57.1 | 59.5 | 59.9 | 61.6 | 62.0 | 62.0 | 62.3 | 62.1 | 60.7 | 59.3 | 56.9 | 60.2 |
| 63 | 56.4 | 58.5 | 59.9 | 60.4 | 60.2 | 60.9 | 61.4 | 62.6 | 64.3 | 62.9 | 60.5 | 60.3 | 60.7 |
| 64 | 59.8 | 57.6 | 59.1 | 60.5 | 60.2 | 63.0 | 62.6 | 62.6 | 62.3 | 61.6 | 60.6 | 59.9 | 60.8 |
| 65 | 58.0 | 55.0 | 57.5 | 60.7 | 62.8 | 62.3 | 62.5 | 62.8 | 63.1 | 62.6 | 62.6 | 58.0 | 60.7 |
| 66 | 56.1 | 58.5 | 59.4 | 57.8 | 60.6 | 62.0 | 62.4 | 62.7 | 63.3 | 64.0 | 63.0 | 60.4 | 60.8 |
| 67 | 58.3 | 59.1 | 60.4 | 60.5 | 62.5 | 63.0F | 64.5 | 64.2 | 63.6 | 62.4 | 62.5 | 61.8 | 61.9E |
| 68 | 60.0 | 61.2 | 62.7 | 62.7 | 64.2 | 64.9 | 65.0 | 66.2 | 64.3 | 63.3 | 64.1 | 62.2 | 63.7 |
| 69 | 59.0 | 61.5 | 59.6 | 61.7 | 62.6 | 63.9 | 65.6 | 64.9 | 64.6 | 62.8 | 61.6 | 60.0 | 62.2 |
| 70 | 60.2 | 58.4 | 59.1 | 61.0 | 63.4 | 63.8 | 63.7 | 65.1 | 63.7 | 63.7 | 62.7 | 60.0 | 62.1 |
| 71 | 60.1 | 59.8 | 60.1 | 61.5 | 61.0 | 62.3 | 63.8 | 62.7 | 62.3 | 61.7 | 60.7 | 59.4 | 61.5 |
| 72 | 58.7 | 58.0 | 59.9 | 60.7 | 61.2 | 63.4 | 63.0 | 64.7 | 63.6 | 63.9 | 61.9 | 58.9 | 61.6 |
| 73 | 58.6 | 57.6 | 59.7 | 59.5 | 60.0 | 61.5 | 62.7 | 63.9 | 63.6 | 63.1 | 62.1 | 59.8 | 61.0 |
| 74 | 61.6 | 59.6 | 60.9 | 61.9 | 62.4 | 63.7 | 63.6 | 64.2 | 63.9 | 63.7 | 61.7 | 60.7 | 62.3 |
| 75 | 59.0 | 59.5 | 59.1 | 60.1 | 61.1 | 62.8 | 62.9 | 63.8 | 63.1 | 62.5 | 61.2 | 59.4 | 61.2 |
| SUM | 1464.6 | 1465.3 | 1479.1 | 1503.5 | 1535.3 | 1567.9 | 1576.1 | 1593.9 | 1585.6 | 1569.9 | 1535.6 | 1487.8 | 1529.9 |

STATION: 51 2751 — AVERAGE TEMPERATURE — KAINALIU 73.2, HI

| YR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 68.7 | 68.7 | 69.0 | 69.0 | 70.3M | 70.9 | 72.4 | 72.7 | 72.9 | 73.3 | 70.7 | 68.8 | 70.6M |
| 52 | 68.2 | 68.3 | 69.7 | 68.4 | 69.2 | 70.3 | 71.4 | 71.5 | 71.1 | 72.1 | 70.3 | 67.9 | 69.8 |
| 53 | 67.7 | 68.6 | 69.5 | 68.4 | 69.3 | 69.8 | 70.3 | 71.9 | 72.4 | 71.8 | 69.9 | 68.5 | 69.8 |
| 54 | 68.2 | 69.9 | 69.9 | 71.3E | 71.8E | 72.6F | 72.9 | 73.6 | 72.8 | 71.5 | 70.7 | 68.9 | 71.1E |
| 55 | 67.3 | 66.7 | 67.1 | 68.6 | 69.2 | 67.5 | 68.6 | 68.9 | 69.0 | 68.9 | 68.5 | 67.1 | 68.0 |
| 56 | 68.0 | 67.2 | 67.4 | 67.8 | 69.0 | 69.6 | 70.0 | 72.1 | 71.2 | 71.2 | 69.3 | 68.2 | 69.3 |
| 57 | 66.8 | 66.7 | 65.4 | 68.3 | 68.1 | 69.9 | 70.7 | 71.9 | 72.4 | 71.8 | 70.8 | 68.8 | 69.2 |
| 58 | 66.2 | 67.7 | 67.2 | 68.4 | 69.6 | 70.2 | 71.9 | 73.2 | 72.8 | 71.4 | 70.7 | 68.4 | 69.7 |
| 59 | 69.2 | 67.8 | 69.5 | 69.5 | 69.6 | 70.3 | 71.1 | 72.2 | 73.2 | 71.3 | 70.4 | 68.0 | 70.1 |
| 60 | 65.5 | 66.7 | 68.0 | 68.5 | 69.3 | 70.0 | 70.7 | 71.3 | 71.4 | 71.4 | 69.5 | 67.8 | 69.3 |
| 61 | 67.4 | 68.7 | 67.4 | 67.7 | 68.8 | 68.9 | 70.2 | 71.3 | 70.6 | 71.6 | 69.5 | 67.5 | 69.2 |
| 62 | 67.6 | 66.6 | 67.5 | 68.1 | 68.5 | 68.9 | 69.5 | 70.2 | 70.0 | 69.7 | 68.5 | 66.3 | 68.4 |
| 63 | 66.2 | 67.9 | 68.3 | 68.8 | 68.6 | 69.1 | 69.9 | 70.3 | 71.7 | 71.5 | 69.8 | 68.9 | 69.3 |
| 64 | 67.4 | 66.8 | 66.7 | 67.7 | 69.0 | 70.3 | 70.3 | 70.9 | 70.6 | 70.4 | 69.3 | 68.7 | 69.0 |
| 65 | 67.2 | 66.8 | 66.8 | 69.0 | 70.1 | 69.6 | 70.3 | 70.8 | 71.3 | 71.6 | 70.7 | 66.7 | 69.1 |
| 66 | 66.0 | 66.6 | 67.5 | 67.4 | 69.4 | 69.7 | 70.5 | 71.5 | 71.9 | 72.2 | 70.9 | 69.2 | 69.4 |
| 67 | 67.3 | 67.5 | 68.8 | 69.5 | 70.7 | 71.1 | 72.5 | 72.5 | 72.4 | 71.8 | 70.6 | 69.1 | 70.3 |
| 68 | 68.2 | 69.3 | 69.9 | 70.2 | 71.7 | 72.2 | 72.4 | 73.8 | 73.8 | 73.5 | 72.7 | 70.2 | 71.5 |
| 69 | 66.1 | 68.9 | 68.5 | 69.1 | 70.0 | 70.9 | 72.4 | 72.2 | 72.0 | 71.2 | 70.2 | 68.6 | 70.0 |
| 70 | 68.9 | 67.8 | 68.3 | 68.0 | 70.8 | 70.9 | 71.0 | 72.3 | 71.6 | 71.5 | 70.6 | 68.8 | 70.1 |
| 71 | 67.1 | 67.9 | 68.3 | 68.3 | 68.2 | 69.5 | 70.5 | 70.4 | 70.1 | 69.9 | 68.7 | 67.8 | 68.9 |
| 72 | 66.3 | 66.2 | 67.8 | 68.1 | 68.6 | 69.9 | 71.5 | 72.1 | 71.3 | 71.8 | 69.9 | 67.5 | 69.3 |
| 73 | 67.3 | 66.4 | 68.1 | 67.7 | 68.0 | 68.6 | 70.2 | 70.8 | 71.3 | 71.0 | 70.2 | 68.3 | 69.0 |
| 74 | 69.2 | 68.0 | 68.9 | 69.2 | 69.6 | 70.5 | 70.9 | 71.4 | 71.6 | 71.3 | 69.8 | 68.8 | 70.0 |
| 75 | 67.2 | 67.4 | 68.8 | 67.0 | 67.0 | 68.5 | 69.2 | 70.5 | 70.7 | 70.0 | 69.4 | 67.6 | 68.4 |
| SUM | 1687.2 | 1687.1 | 1699.7 | 1714.8 | 1731.3 | 1749.7 | 1771.5 | 1790.3 | 1790.9 | 1783.7 | 1751.6 | 1706.6 | 1738.8 |

# APPENDIX C

Rainfall Recordings at Stations
Closest to

FARMS OF KAPUA
PHASE I

S.KEY#: 2.17 NAME:UKOE OBS:PUUWAAWAA RANCH

LATITUDE: 19 10 12 LONGITUDE: 155 52 5 ELEV: 1590 FEET

PERIOD OF RECORD 1956 - 1975 READ: OTHER

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 18.40 | 6.65 | 14.45 | 11.23 | 13.74 | 7.79 | 10.17 | 5.95 | 8.25 | 12.60 | 14.40 | 6.20 | 83.86 |
| 75% | 7.95 | 4.02 | 5.00 | 7.24 | 7.29 | 4.52 | 5.07 | 4.63 | 6.27 | 4.84 | 5.95 | 4.00 | 63.99 |
| MED | 5.03 | 1.95 | 3.70 | 3.55 | 4.57 | 3.32 | 3.37 | 3.47 | 4.92 | 2.06 | 3.46 | 2.40 | 46.71 |
| 25% | 2.68 | 1.07 | 1.90 | 2.22 | 2.29 | 1.09 | 2.41 | 3.02 | 2.55 | 2.25 | 2.12 | 1.10 | 35.33 |
| MIN | 0.20 | 0.04 | 0.17 | 0.86 | 1.15 | 0.62 | 0.20 | 1.08 | 1.53 | 0.95 | 0.40 | 0.10 | 26.01 |
| COV | 50 | 58 | 45 | 53 | 52 | 41 | 37 | 21 | 42 | 37 | 47 | 57 | 29 |
| AVG | 5.50 | 2.43 | 4.43 | 4.79 | 4.99 | 3.50 | 4.01 | 3.64 | 4.69 | 3.78 | 4.56 | 2.56 | 50.03 |
| CDV | 78 | 72 | 78 | 70 | 65 | 59 | 62 | 37 | 45 | 70 | 79 | 73 | 33 |
| YRS | 19 | 20 | 19 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 19 | 17 |

S.KEY#: 2.18 NAME:KOLE PEN OBS:PUUWAAWAA RANCH

LATITUDE: 19 8 30 LONGITUDE: 155 52 42 ELEV: 920 FEET

PERIOD OF RECORD 1956 - 1975 READ: OTHER

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 10.60 | 4.40 | 7.31 | 8.55 | 5.86 | 4.50 | 5.65 | 4.75 | 4.40 | 6.70 | 9.95 | 8.05 | 45.99 |
| 75% | 6.17 | 3.00 | 3.08 | 3.59 | 3.24 | 2.50 | 3.10 | 2.90 | 3.79 | 2.41 | 3.63 | 3.23 | 39.57 |
| MED | 3.49 | 1.10 | 2.38 | 2.26 | 2.48 | 1.67 | 2.23 | 1.98 | 2.84 | 1.65 | 1.87 | 1.35 | 25.72 |
| 25% | 1.88 | 0.48 | 1.22 | 1.43 | 1.34 | 0.95 | 1.27 | 0.97 | 1.71 | 1.11 | 1.29 | 0.66 | 22.48 |
| MIN | 0.05 | 0.02 | 0.04 | 0.18 | 0.53 | 0.04 | 0.28 | 0.65 | 1.00 | 0.36 | 0.54 | 0.00 | 17.59 |
| COV | 53 | 72 | 43 | 43 | 41 | 45 | 42 | 50 | 38 | 37 | 47 | 66 | 28 |
| AVG | 4.07 | 1.62 | 2.71 | 2.67 | 2.54 | 1.76 | 2.34 | 2.10 | 2.68 | 2.00 | 2.86 | 2.04 | 29.97 |
| CDV | 71 | 85 | 76 | 75 | 59 | 63 | 61 | 57 | 40 | 72 | 82 | 105 | 30 |
| YRS | 19 | 20 | 19 | 20 | 20 | 20 | 20 | 19 | 20 | 20 | 20 | 20 | 17 |

KEY#: 2.19 NAME:HALEPIULA (1670) OBS:PUUWAAWAA RANCH

TITUDE: 19 8 36 LONGITUDE: 155 51 0 ELEV: 1670 FEET

RIOD OF RECORD 1956 - 1966 READ: OTHER

MPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | 10.71 | 6.21 | 9.33 | 8.85 | 10.59 | 6.48 | 5.35 | 6.45 | 6.27 | 9.10 | 12.33 | 5.20 | 70.13 |
| X | 5.54 | 3.39 | 5.89 | 6.19 | 6.78 | 4.65 | 5.18 | 5.73 | 4.85 | 5.48 | 10.34 | 3.64 | 60.25 |
| D | 4.08 | 1.90 | 3.45 | 4.23 | 6.35 | 3.00 | 4.27 | 3.91 | 3.90 | 3.38 | 2.81 | 2.06 | 52.63 |
| X | 2.58 | 0.94 | 2.85 | 1.80 | 4.00 | 1.84 | 3.09 | 2.60 | 2.89 | 2.26 | 1.54 | 1.34 | 37.42 |
| N | 0.10 | 0.50 | 1.25 | 0.75 | 2.56 | 1.38 | 0.98 | 1.53 | 2.54 | 0.94 | 0.18 | 0.31 | 33.21 |
| V | 36 | 57 | 35 | 55 | 26 | 43 | 25 | 37 | 25 | 42 | 74 | 46 | 23 |
| G | 4.33 | 2.39 | 4.31 | 4.50 | 5.71 | 3.35 | 4.02 | 4.11 | 4.05 | 4.04 | 4.92 | 2.42 | 49.79 |
| V | 74 | 73 | 52 | 58 | 40 | 48 | 33 | 40 | 31 | 63 | 91 | 67 | 26 |
| S | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 9 |

KEY#: 2.20 NAME:KAHUKU SHED 3 OBS:KAHUKU RANCH

TITUDE: 19 10 4 LONGITUDE: 155 41 6 ELEV: 5100 FEET

RIOD OF RECORD 1920 - 1974 READ: MONTHLY

MPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | 23.70 | 16.95 | 12.50 | 22.02 | 9.73 | 8.11 | 10.57 | 21.05 | 10.34 | 10.24 | 14.62 | 21.50 | 69.16 |
| X | 8.51 | 5.95 | 5.82 | 4.73 | 4.33 | 4.00 | 4.21 | 4.77 | 4.22 | 5.07 | 5.71 | 4.72 | 59.70 |
| D | 4.70 | 2.64 | 3.35 | 2.87 | 3.24 | 2.50 | 2.63 | 3.37 | 3.00 | 3.13 | 3.05 | 3.16 | 45.38 |
| X | 1.53 | 1.04 | 2.09 | 2.23 | 2.26 | 1.42 | 1.55 | 1.75 | 2.22 | 2.02 | 1.45 | 1.14 | 36.76 |
| N | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.58 | 0.87 | 0.00 | 0.00 | 23.00 |
| V | 70 | 70 | 47 | 36 | 31 | 48 | 46 | 46 | 31 | 43 | 59 | 61 | 24 |
| G | 5.48 | 3.81 | 4.33 | 4.27 | 3.39 | 2.87 | 3.10 | 3.92 | 3.53 | 4.01 | 3.94 | 3.94 | 46.99 |
| V | 90 | 97 | 67 | 86 | 52 | 64 | 70 | 90 | 61 | 61 | 85 | 102 | 27 |
| S | 52 | 53 | 51 | 53 | 53 | 53 | 53 | 52 | 53 | 52 | 53 | 52 | 47 |

S.KEY#: 2.30 NAME:HOOPUALOA UPPER OBS:DOMKOWICZ BYS

LATITUDE: 19 12 48 LONGITUDE: 155 51 18 ELEV: 2425 FEET

PERIOD OF RECORD 1903 - 1912 READ: DAILY

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 9.72 | 10.00 | 7.60 | 16.89 | 10.29 | 13.90 | 12.12 | 14.04 | 10.11 | 11.38 | 6.79 | 9.55 | 84.84 |
| 75% | 6.36 | 5.04 | 5.03 | 6.32 | 8.01 | 9.69 | 7.59 | 9.44 | 9.26 | 6.73 | 4.27 | 3.45 | 65.37 |
| MED | 2.95 | 2.74 | 3.40 | 4.24 | 5.82 | 4.85 | 3.67 | 5.65 | 5.93 | 4.96 | 1.94 | 2.52 | 57.51 |
| 25% | 1.27 | 0.77 | 1.18 | 3.52 | 3.09 | 2.52 | 2.54 | 3.97 | 3.25 | 2.85 | 1.34 | 1.40 | 47.07 |
| MIN | 0.14 | 0.42 | 0.54 | 2.73 | 2.53 | 1.77 | 1.81 | 3.20 | 2.26 | 1.65 | 0.87 | 0.40 | 35.19 |
| COV | 67 | 73 | 62 | 29 | 35 | 59 | 50 | 41 | 40 | 40 | 52 | 42 | 16 |
| AVG | 3.86 | 3.39 | 3.45 | 5.79 | 5.98 | 6.09 | 5.26 | 7.10 | 6.18 | 5.29 | 2.85 | 2.98 | 56.58 |
| COV | 82 | 90 | 67 | 75 | 40 | 69 | 65 | 53 | 50 | 58 | 69 | 90 | 20 |
| YRS | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 9 | 7 |

S.KEY#: 2.40 NAME:HOOPULOA LOWER OBS:EDWARDS EH

LATITUDE: 19 12 0 LONGITUDE: 155 52 18 ELEV: 1650 FEET

PERIOD OF RECORD 1897 - 1905 READ: DAILY
LESS THAN 10 YEARS OF DATA

S.KEY#: 2.40 NAME:HOOPULOA LOWER OBS:EDWARDS EH

LATITUDE: 19 12 0 LONGITUDE: 155 52 18 ELEV: 1650 FEET

PERIOD OF RECORD 1897 - 1905 READ: DAILY
LESS THAN 10 YEARS OF DATA

S.KEY#: 2.50 NAME:KAPUA OBS:KAHUKU RANCH

LATITUDE: 19 12 31 LONGITUDE: 155 45 42 ELEV: 6000 FEET

PERIOD OF RECORD 1953 - 1973 READ: MONTHLY

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 18.60 | 23.50 | 9.00 | 13.40 | 13.25 | 16.70 | 7.00 | 11.00 | 9.25 | 9.00 | 12.00 | 9.75 | 79.25 |
| 75% | 6.40 | 4.20 | 4.65 | 6.15 | 6.63 | 6.00 | 5.00 | 5.82 | 6.63 | 4.03 | 9.00 | 5.20 | 65.05 |
| MED | 3.05 | 2.90 | 2.97 | 3.40 | 4.60 | 2.00 | 4.20 | 4.00 | 3.90 | 2.50 | 1.50 | 2.82 | 54.20 |
| 25% | 1.63 | 1.50 | 2.00 | 2.25 | 3.43 | 1.22 | 2.50 | 2.65 | 2.31 | 1.20 | 0.90 | 1.11 | 35.67 |
| MIN | 0.00 | 0.00 | 0.35 | 0.00 | 0.60 | 0.60 | 0.60 | 0.75 | 0.30 | 0.30 | 0.15 | 0.10 | 29.75 |
| COV | 60 | 47 | 40 | 46 | 32 | 66 | 33 | 37 | 48 | 54 | 82 | 65 | 29 |
| AVG | 5.05 | 3.88 | 3.33 | 4.49 | 5.26 | 3.92 | 3.91 | 4.25 | 4.13 | 3.03 | 4.32 | 3.22 | 52.43 |
| CDV | 98 | 133 | 66 | 68 | 60 | 107 | 47 | 60 | 65 | 69 | 101 | 79 | 31 |
| YRS | 20 | 19 | 16 | 19 | 18 | 18 | 19 | 17 | 20 | 19 | 19 | 20 | 19 |

S.KEY#: 2.21 NAME:PAPA OBS:PUUWAAWAA RANCH

LATITUDE: 19 12 20 LONGITUDE: 155 50 20 ELEV: 2600 FEET

PERIOD OF RECORD 1959 - 1972 READ: OTHER

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 21.12 | 7.50 | 17.77 | 15.00 | 13.96 | 13.45 | 12.40 | 12.41 | 12.55 | 14.90 | 16.35 | 6.85 | 110.46 |
| 75% | 9.90 | 5.32 | 9.57 | 10.16 | 13.05 | 8.53 | 9.35 | 8.59 | 10.38 | 8.70 | 8.45 | 5.99 | 94.10 |
| MED | 5.55 | 4.00 | 5.42 | 7.11 | 6.60 | 3.40 | 5.68 | 6.20 | 6.60 | 5.02 | 4.01 | 3.78 | 81.11 |
| 25% | 3.99 | 1.78 | 2.93 | 6.06 | 4.25 | 3.07 | 3.47 | 4.79 | 4.39 | 2.89 | 2.55 | 1.99 | 52.01 |
| MIN | 0.40 | 0.40 | 0.00 | 2.05 | 1.89 | 0.36 | 2.20 | 1.05 | 2.22 | 1.45 | 1.20 | 0.85 | 37.88 |
| COV | 43 | 50 | 49 | 25 | 51 | 47 | 46 | 28 | 40 | 50 | 54 | 50 | 29 |
| AVG | 7.38 | 3.77 | 6.49 | 7.54 | 7.90 | 5.54 | 6.29 | 6.63 | 7.28 | 6.15 | 5.57 | 3.78 | 76.40 |
| COV | 73 | 59 | 81 | 46 | 55 | 73 | 53 | 47 | 46 | 62 | 78 | 57 | 33 |
| YRS | 13 | 13 | 14 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 13 | 12 | 11 |

S.KEY#: 2.22 NAME:FURLKA OBS:PUUWAAWAA RANCH

LATITUDE: 19 11 31 LONGITUDE: 155 49 34 ELEV: 3200 FEET

PERIOD OF RECORD 1958 - 1975 READ: OTHER

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 19.17 | 7.58 | 10.32 | 9.77 | 11.57 | 9.72 | 7.70 | 6.82 | 8.38 | 7.82 | 11.30 | 6.86 | 74.91 |
| 75% | 7.51 | 3.66 | 5.32 | 5.79 | 7.50 | 4.19 | 5.38 | 5.18 | 5.62 | 4.09 | 6.00 | 3.96 | 58.68 |
| MED | 4.14 | 2.53 | 3.18 | 4.29 | 4.72 | 2.83 | 3.98 | 2.61 | 4.42 | 3.13 | 3.23 | 1.91 | 46.35 |
| 25% | 2.87 | 1.64 | 1.77 | 3.26 | 3.37 | 1.71 | 2.59 | 1.81 | 3.44 | 1.63 | 1.75 | 0.97 | 35.66 |
| MIN | 0.85 | 0.03 | 0.00 | 1.00 | 1.57 | 0.58 | 0.65 | 0.06 | 1.77 | 0.00 | 0.70 | 0.31 | 29.40 |
| COV | 45 | 38 | 50 | 28 | 38 | 42 | 35 | 48 | 24 | 43 | 55 | 61 | 24 |
| AVG | 5.03 | 2.74 | 3.89 | 4.72 | 5.37 | 3.38 | 4.00 | 3.43 | 4.63 | 2.98 | 4.26 | 2.51 | 49.42 |
| COV | 78 | 66 | 77 | 46 | 51 | 72 | 51 | 57 | 39 | 64 | 80 | 76 | 28 |
| YRS | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 16 | 17 | 17 | 17 | 18 | 15 |

S.KEY#: 2.24 NAME:KAU OBS:WINFORD GARDENS

LATITUDE: 19 6 42 LONGITUDE: 155 47 55 ELEV: 2360 FEET

PERIOD OF RECORD 1966 - 1968 READ:
LESS THAN 10 YEARS OF DATA

S.KEY#: 2.25 NAME:RESERVOIR (2940) OBS:PUUWAAWAA RANCH

LATITUDE: 19 9 49 LONGITUDE: 155 49 31 ELEV: 2940 FEET

PERIOD OF RECORD 1966 - 1975 READ: OTHER

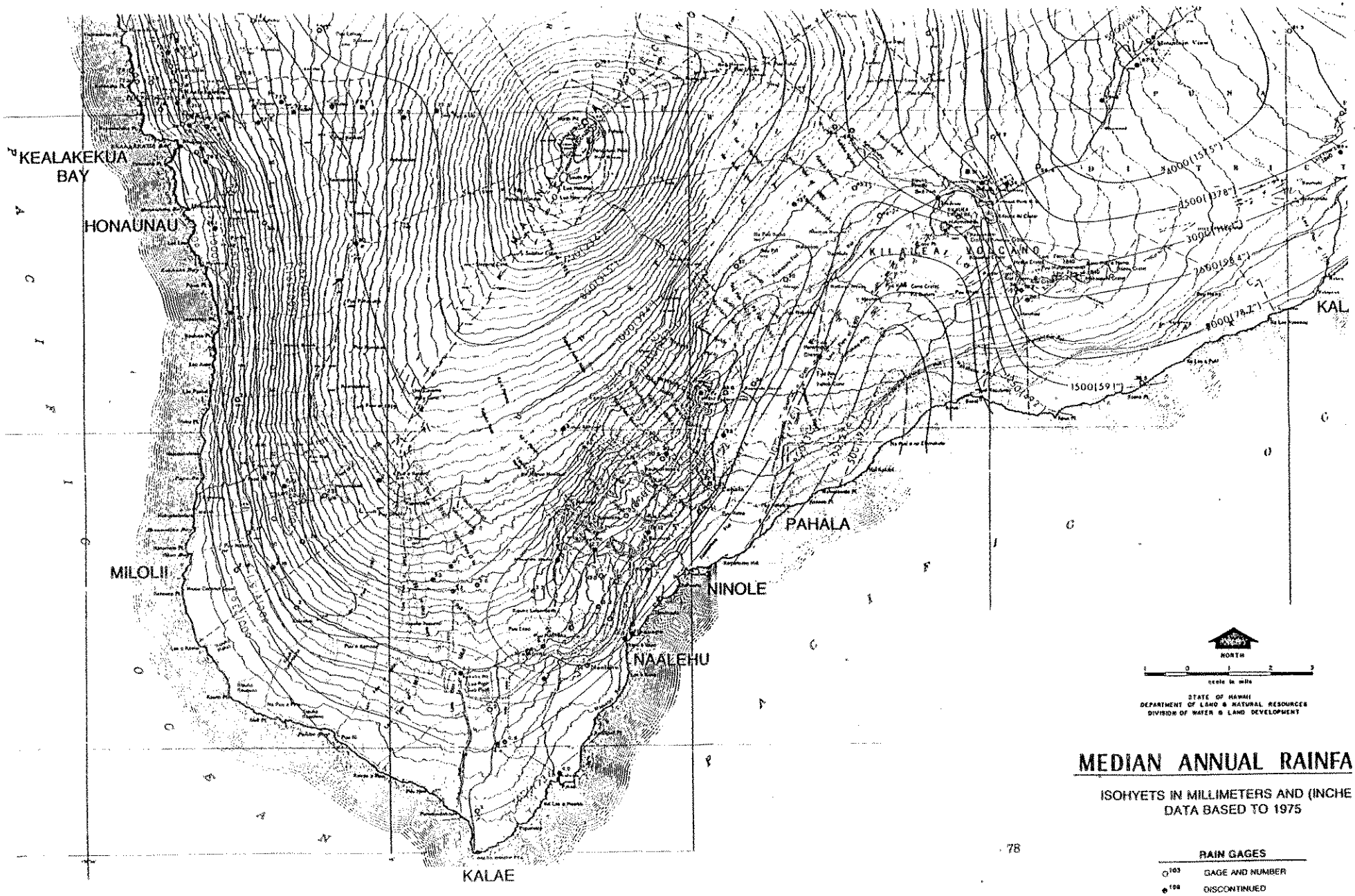
COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 14.30 | 5.79 | 7.60 | 8.95 | 5.98 | 8.35 | 5.75 | 5.65 | 8.73 | 2.80 | 4.66 | 7.10 | 56.91 |
| 75% | 6.93 | 5.29 | 5.50 | 4.33 | 4.95 | 3.93 | 4.54 | 3.95 | 5.55 | 2.67 | 4.21 | 4.43 | 49.16 |
| MED | 3.70 | 1.73 | 2.29 | 3.20 | 2.80 | 1.84 | 2.57 | 2.39 | 4.28 | 2.43 | 3.50 | 1.61 | 40.81 |
| 25% | 3.06 | 0.68 | 1.61 | 1.52 | 1.65 | 0.77 | 1.80 | 1.47 | 3.14 | 1.47 | 1.98 | 0.56 | 27.11 |
| MIN | 1.15 | 0.11 | 0.85 | 0.54 | 1.11 | 0.22 | 0.40 | 0.74 | 2.40 | 0.93 | 0.15 | 0.15 | 24.85 |
| COV | 39 | 77 | 55 | 48 | 50 | 67 | 43 | 46 | 28 | 29 | 36 | 77 | 29 |
| AVG | 5.13 | 2.77 | 3.34 | 3.32 | 3.15 | 2.80 | 3.00 | 2.66 | 4.65 | 2.11 | 3.10 | 2.43 | 39.35 |
| COV | 81 | 83 | 74 | 71 | 56 | 97 | 58 | 63 | 42 | 34 | 49 | 97 | 29 |
| YRS | 8 | 9 | 9 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 10 | 10 | 8 |

S.KEY#: 2.26 NAME:CASTLE OBS:PUUWAAWAA RANCH

LATITUDE: 19 13 42 LONGITUDE: 155 46 54 ELEV: 2600 FEET

PERIOD OF RECORD 1967 - 1975 READ: OTHER
LESS THAN 10 YEARS OF DATA


KEALAKEKUA BAY
HONAUNAU
MILOLII
KALAE
NAALEHU
NINOLE
PAHALA
KILAUEA VOLCANO
4000(157.5")
3500(137.8")
3000(118.1")
2500(98.4")
2000(78.7")
1500(59.1")
NORTH
scale in mile
STATE OF HAWAII
DEPARTMENT OF LAND & NATURAL RESOURCES
DIVISION OF WATER & LAND DEVELOPMENT
MEDIAN ANNUAL RAINFA
ISOHYETS IN MILLIMETERS AND (INCHE
DATA BASED TO 1975
RAIN GAGES
GAGE AND NUMBER
DISCONTINUED

STATION: 51 2751 — TOTAL PRECIPITATION — KAINALIU 73.2, HI

| YR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 4.27 | 5.71 | 12.59 | 6.97 | 7.14 | 13.31 | 8.89 | 8.75 | 7.37 | 10.51 | 5.48 | 2.95 | 93.75 |
| 52 | 8.55 | 3.89 | 4.52 | 5.28 | 6.31 | 8.14 | 6.31 | 3.47 | 8.24 | 2.86 | 4.43 | 2.33 | 64.33 |
| 53 | .37 | 8.24 | 5.60 | 5.15 | 8.73 | 7.90 | 8.79 | 5.03 | 5.96 | 6.07 | .92 | 6.07 | 68.83 |
| 54 | 2.74 | .88 | 6.29 | 2.42 | 8.93 | 7.77 | 9.29 | 6.83 | 7.27 | 3.37 | 2.45 | 4.32 | 63.33 |
| 55 | 2.02 | 9.51 | 2.38 | 2.16 | 6.91 | 8.92 | 13.99 | 7.36 | 9.96 | 2.38 | 2.16 | 6.89 | 74.66 |
| 56 | 10.50 | 2.94 | 5.55 | 4.09 | 9.12 | 6.17 | 12.24 | 10.47 | 6.70 | 4.79 | 11.40 | 2.99 | 92.16 |
| 57 | 4.92 | 2.90 | 2.71 | 1[.07 | 8.63 | 4.36 | 7.98 | 7.94 | 3.64 | 6.21 | 3.19 | 2.26 | 64.33 |
| 58 | .46 | .10 | 6.32 | 3.01 | 5.33 | 4.10 | 5.76 | 10.13 | 4.32 | 9.45 | .33 | 2.41 | 52.14 |
| 59 | 14.64 | 2.92 | 2.35 | 6.32 | 7.12 | 3.80 | 9.62 | 9.36 | 3.50 | 3.57 | 6.36 | 2.23 | 70.19 |
| 60 | .76 | 2.01 | 3.73 | 5.97 | 9.29 | 6.13 | 2.69 | 7.27 | 8.08 | 6.33 | 1.01 | 3.79 | 57.10 |
| 61 | 2.22 | 2.79 | 14.49 | 7.12 | 11.50 | 6.55 | 6.63 | 8.27 | 6.15 | 6.20 | 8.16 | 2.37 | 80.43 |
| 62 | 6.03 | .56 | 3.66 | 4.58 | 10.74 | 6.11 | 9.44 | 5.13 | 7.65 | 4.32 | 3.80 | 2.39 | 65.11 |
| 63 | 4.27 | 2.91 | 9.29 | 12.08 | 6.94 | 9.37 | 9.46 | 11.89 | 12.56 | 2.36 | 2.35 | 3.48 | 86.96 |
| 64 | 2.02 | .27 | 7.21 | 7.00 | 4.97 | 6.55 | 7.76 | 9.63 | 9.09 | 5.26 | 2.67 | 7.80 | 70.85 |
| 65 | 2.17 | 1.49 | 2.15 | 4.62 | 6.47 | 6.50 | 9.00 | 13.08 | 8.64 | 2.92 | 8.04 | 1.07 | 64.15 |
| 66 | 2.38 | 3.54 | 3.33 | 1.63 | 3.86 | 4.55 | 7.76 | 5.07 | 4.38 | 5.93 | 7.00 | 1.12 | 50.53 |
| 67 | 1.84 | 3.71 | 5.67 | 5.30 | 6.26 | 6.32 | 10.66 | 10.89 | 6.92 | 3.30 | 4.93 | 4.79 | 72.81 |
| 68 | 3.96 | 4.25 | 2.05 | 10.96 | 5.07 | 4.31 | 9.24 | 7.16 | 6.07 | 3.98 | 2.01 | 6.29 | 69.35 |
| 69 | 6.37 | 1.08 | 1.13 | 3.47 | 6.12 | 3.84 | 6.39 | 7.90 | 6.38 | 2.63 | 3.00 | 3.49 | 54.30 |
| 70 | 3.33 | 1.46 | .99 | 6.30 | 2.05 | 4.71 | 5.68 | 5.67 | 5.68 | 4.24 | 4.04 | 1.80 | 43.96 |
| 71 | 19.03 | .90 | 1.99 | 6.31 | 2.97 | 2.15 | 8.51 | 2.36 | 8.38 | 3.08 | 3.86 | 3.32 | 63.32 |
| 72 | 8.16 | 6.43 | 6.89 | 5.07 | 6.90 | 5.99 | 11.27 | 5.79 | 5.15 | 6.39 | 1.44 | 3.91 | 65.61 |
| 73 | 4.04 | .09 | 2.07 | 1.80 | 1.81 | 1.96 | 3.75 | 3.86 | 6.48 | 6.39 | 2.31 | 3.63 | 40.19 |
| 74 | 9.67 | 3.11 | 3.40 | 6.47 | 6.47 | 10.84 | 5.18 | 5.10 | 15.38 | 10.40 | 3.83 | 1.11 | 80.96 |
| 75 | 3.19 | 6.16 | 2.54 | 9.86 | 9.91 | 6.66 | 5.46 | 6.73 | 6.78 | 6.45 | 3.43 | 2.95 | 61.54 |
| SUM | 132.53 | 75.87 | 116.99 | 134.41 | 147.79 | 159.05 | 199.91 | 185.76 | 176.91 | 132.29 | 99.02 | 87.84 | 1674.17 |

STATION: 51 2751 — TOTAL SNOWFALL — KAINALIU 73.2, HI

| SEASON | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | SEASON |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50-51 | | | | | | | .0 | .0 | .0 | .0 | .0 | .0 | |
| 51-52 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 52-53 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 53-54 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 54-55 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 55-56 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 56-57 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 57-58 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 58-59 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 59-60 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 60-61 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 61-62 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 62-63 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 63-64 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 64-65 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 65-66 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 66-67 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 67-68 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 68-69 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 69-70 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 70-71 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 71-72 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 72-73 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 73-74 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 74-75 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 75-76 | .0 | .0 | .0 | .0 | .0 | .0 | | | | | | | |
| SUM | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

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USCOMM—NOAA—ASHEVILLE 400

STATION: SI 2751 KAINALIU 73.2 TOTAL PRECIPITATION

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 4.27 | 5.71 | 12.50 | 6.97 | 7.14 | 11.31 | 8.89 | 8.75 | 7.37 | 10.51 | 5.48 | 2.85 | 93.75 |
| 1952 | 8.55 | 3.89 | 4.52 | 5.28 | 6.51 | 8.14 | 6.31 | 3.47 | 8.24 | 2.88 | 4.43 | 2.33 | 64.55 |
| 1953 | .37 | 8.24 | 5.60 | 5.15 | 8.75 | 7.90 | 6.79 | 1.03 | 5.96 | 6.07 | .92 | 6.07 | 68.85 |
| 1954 | 2.74 | .88 | 6.28 | 2.62 | 8.93 | 7.77 | 9.39 | 6.83 | 7.27 | 5.37 | 2.45 | 4.52 | 65.05 |
| 1955 | 2.02 | 9.51 | 2.38 | 2.16 | 6.91 | 8.92 | 13.99 | 7.56 | 9.96 | 2.38 | 2.18 | 6.89 | 74.86 |
| 1956 | 10.50 | 2.94 | 5.55 | 9.09 | 9.12 | 6.17 | 12.24 | 10.67 | 6.70 | 4.79 | 11.40 | 2.99 | 92.16 |
| 1957 | 4.92 | 7.90 | 2.71 | 11.07 | 8.65 | 4.38 | 7.98 | 7.94 | 3.84 | 4.21 | 3.19 | 2.24 | 64.03 |
| 1958 | .46 | .10 | 6.52 | 3.01 | 5.33 | 4.10 | 5.78 | 10.15 | 4.32 | 9.43 | .53 | 2.41 | 52.14 |
| 1959 | 14.64 | 2.92 | 2.35 | 4.52 | 7.12 | 3.80 | 9.62 | 9.36 | 3.50 | 3.57 | 6.56 | 2.23 | 70.19 |
| 1960 | .76 | 2.01 | 3.75 | 5.97 | 9.29 | 6.15 | 2.69 | 7.27 | 8.08 | 6.33 | 1.01 | 3.79 | 57.10 |
| 1961 | 2.22 | 2.79 | 14.49 | 7.17 | 11.40 | 6.55 | 4.63 | 8.27 | 6.13 | 6.20 | 8.16 | 2.37 | 80.43 |
| 1962 | 6.03 | .56 | 3.66 | 4.58 | 10.74 | 6.11 | 9.44 | 5.13 | 7.65 | 4.82 | 3.80 | 2.59 | 65.11 |
| 1963 | 4.27 | 2.91 | 9.29 | 12.08 | 6.94 | 9.37 | 9.46 | 11.89 | 12.56 | 2.36 | 2.35 | 3.48 | 86.96 |
| 1964 | 2.62 | .27 | 7.21 | 7.00 | 4.97 | 6.55 | 7.78 | 9.63 | 9.09 | 5.26 | 2.67 | 7.80 | 70.85 |
| 1965 | 2.17 | 1.49 | 2.15 | 4.62 | 6.47 | 6.50 | 9.00 | 13.08 | 8.64 | 2.92 | 8.04 | 1.07 | 66.15 |
| 1966 | 2.38 | 3.54 | 3.33 | 1.63 | 3.06 | 4.55 | 7.76 | 5.07 | 4.38 | 5.93 | 7.00 | 1.12 | 50.55 |
| 1967 | 1.84 | 3.71 | 5.67 | 5.30 | 6.26 | 8.32 | 10.68 | 10.89 | 6.92 | 3.50 | 4.93 | 4.79 | 72.81 |
| 1968 | 5.96 | 4.25 | 2.05 | 10.96 | 5.07 | 4.31 | 9.24 | 7.16 | 6.07 | 3.98 | 2.01 | 8.29 | 69.35 |
| 1969 | 8.37 | 1.08 | 1.13 | 3.47 | 6.12 | 3.84 | 6.39 | 7.90 | 6.38 | 2.63 | 3.00 | 3.69 | 54.00 |
| 1970 | 3.35 | 1.46 | .98 | 4.33 | 2.05 | 4.71 | 5.68 | 5.67 | 5.68 | 4.24 | 4.04 | 1.80 | 43.96 |
| 1971 | 19.03 | .90 | 1.95 | 6.31 | 2.97 | 2.15 | 8.51 | 2.56 | 8.38 | 3.08 | 3.86 | 3.32 | 63.02 |
| 1972 | 8.16 | 4.45 | 4.89 | 3.07 | 4.90 | 5.99 | 11.27 | 5.79 | 5.15 | 6.59 | 1.44 | 3.91 | 65.61 |
| 1973 | 4.04 | .09 | 2.07 | 1.80 | 1.81 | 1.96 | 3.75 | 3.86 | 6.48 | 8.39 | 2.31 | 3.63 | 40.19 |
| 1974 | 9.67 | 3.11 | 3.40 | 6.47 | 6.47 | 10.84 | 5.18 | 5.10 | 15.38 | 10.40 | 3.83 | 1.11 | 80.96 |
| 1975 | 3.19 | 6.16 | 2.56 | 3.86 | 9.91 | 6.66 | 5.46 | 6.73 | 4.78 | 6.45 | 3.43 | 2.35 | 61.54 |
| 1976 | 1.18 | 3.75 | 6.17 | 6.64 | 7.75 | 9.62 | 8.33 | 5.18 | 4.42 | 3.89 | .80 | 3.11 | 60.84 |
| 1977 | .35 | .62 | 6.87 | 6.06 | 5.44 | 3.54 | 5.74E | 3.76E | 1.23 | 3.95 | .56 | 1.26 | 39.38E |
| 1978 | .47 | .68 | 3.36 | 5.41 | 6.59 | 10.67 | 5.93 | 9.09 | 13.19 | 3.58 | 3.76 | 2.13 | 65.61 |
| 1979 | 2.36 | 7.13 | 1.14 | 9.10 | 14.68 | 6.51 | 8.81 | 9.68 | 11.34 | 5.97 | 2.97 | 1.91 | 81.80 |
| 1980 | 12.69 | 1.52 | 8.04 | 3.00 | 3.93 | 11.07 | 8.99 | 10.19 | 10.93 | 4.80 | 1.87 | 3.11 | 80.34 |
| SUM | 149.53 | 89.57 | 142.57 | 168.82 | 206.14 | 200.46 | 237.71 | 274.66 | 220.02 | 154.48 | 108.98 | 99.16 | 2007.14 |
| NO YRS | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| MEAN | 4.98 | 2.99 | 4.75 | 5.63 | 6.87 | 6.68 | 7.92 | 7.49 | 7.33 | 5.15 | 3.63 | 3.31 | 66.73 |
| EXT HI | 19.03 | 9.51 | 14.49 | 12.08 | 14.68 | 13.31 | 13.99 | 13.08 | 15.38 | 10.51 | 11.40 | 8.29 | 93.75 |
| EXT LO | .35 | .09 | .98 | 1.63 | 1.81 | 1.96 | 2.69 | 2.56 | 1.23 | 2.36 | .53 | 1.07 | 39.38E |
| EST | | | | | | | 1 | 1 | | | | | 2 |

STATION: 51 1665 HONAUNAU 27 TOTAL PRECIPITATION

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNTOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | .27 | .74 | 3.17 | 1.57 | 2.25 | 2.23 | 2.61 | 1.06 | 2.15 | 2.12 | 1.16 | .44 | 20.37 |
| 1952 | 2.62 | 1.35 | 3.39 | 2.97 | 3.14 | 2.43 | 1.41 | .81 | 4.46 | 3.96 | .90 | .11 | 24.05 |
| 1953 | .06 | 6.56 | 5.46 | 5.27 | 9.62 | 4.79 | 7.47 | 4.31 | 4.67 | 2.09 | .87 | 2.29 | 53.46 |
| 1954 | 2.18 | .72 | 4.59 | 3.60 | 7.19 | 7.36 | 2.33 | 4.82 | 5.01 | 3.87 | 1.37 | 3.15 | 46.19 |
| 1955 | 2.14 | 5.32 | .47 | 2.75 | 4.12 | 8.87 | 8.93 | 4.15 | 2.91 | 3.60 | .98 | 6.21 | 50.15 |
| 1956 | 4.33 | 2.08 | 3.03E | 3.19 | 2.93 | 2.68 | 3.65 | 2.16 | 2.46 | 1.41 | 3.13 | .58 | 31.63E |
| 1957 | 1.59 | 2.24 | .66 | 2.42 | 3.25 | 1.89 | 3.01 | 4.80 | 2.61 | 3.34 | 2.83 | 2.98D | 31.62D |
| 1958 | .07 | 1.00 | 5.55 | 1.35 | 5.82 | 5.66 | 5.79 | 7.27 | 3.91 | 2.79 | 1.95 | 1.25 | 42.41 |
| 1959 | 6.50 | 3.34 | 1.20 | 6.20 | 4.03 | 2.10 | 4.01 | 6.04 | 2.31 | 2.08 | 1.36 | 1.03 | 41.00 |
| 1960 | .77 | 2.00 | 2.47 | 3.00 | 3.99 | 6.23 | 1.18 | 3.73 | 4.26 | 1.78 | .47 | 2.06 | 31.94 |
| 1961 | 1.85 | 1.78 | 3.34 | 2.34 | 3.20 | 3.45 | 2.95 | 3.69 | 5.02 | 14.88 | 2.97 | 1.09 | 46.56 |
| 1962 | 2.00 | 1.32 | 2.02 | 1.09 | 7.48 | 4.02 | 4.96 | 2.02 | 6.58 | 3.59D | 2.14D | 2.46 | 40.48D |
| 1963 | 6.59 | 1.14 | 2.20 | 6.70 | 6.93 | 7.95 | 3.26 | 6.75 | 2.35 | 1.12 | 1.00 | 1.19 | 47.18 |
| 1964 | 1.29 | .40 | 7.69 | 7.45 | 1.74 | 2.56 | 3.24 | 5.34 | 2.21 | 5.73D | 2.09D | 7.13D | 46.97D |
| 1965 | 2.69 | 2.93 | 3.06 | 5.34 | 9.66 | 9.48 | 8.34 | 10.81 | 7.67 | 4.09 | 8.27 | 1.24 | 73.57 |
| 1966 | 2.73 | 3.89 | 2.91 | 5.00 | 2.10 | 1.53 | 5.91 | 4.06 | 8.23 | 7.97 | 3.16 | 2.16 | 49.65 |
| 1967 | 3.47 | 4.69 | 8.22 | 6.01 | 4.94 | 6.82 | 13.61 | 7.41 | 4.45 | 7.27 | 4.94 | 3.24 | 75.07 |
| 1968 | 5.75 | 3.60 | 3.15 | 7.02 | 2.01 | 3.50 | 4.88 | 7.08 | 10.15 | 2.68 | 2.92 | 6.14 | 59.28 |
| 1969 | 7.25 | 1.24 | 2.48 | 5.32 | 6.37 | 7.30 | 9.44 | 13.51 | 7.22 | 5.40 | 3.43 | 3.29 | 68.25 |
| 1970 | 4.04 | 1.43 | 1.39 | 5.65 | 5.45 | 3.55 | 5.39 | 5.05 | 9.25 | 7.11 | 8.78 | .19 | 57.28 |
| 1971 | 15.40 | 1.50 | 4.11 | 4.26 | 6.26 | 3.43 | 7.43 | 3.69 | 10.20 | 5.12 | 5.33 | 5.13 | 71.86 |
| 1972 | 7.78 | 2.66 | 4.27 | 3.52E | 4.00E | 3.36E | 7.91E | 5.70 | 7.56 | 2.39 | .87 | 2.44 | 52.46E |
| 1973 | 1.62 | .32 | 2.03 | .54 | 2.94 | 2.79 | 3.14 | 3.66 | 6.26 | 6.26 | 2.64 | 3.26E | 35.46E |
| 1974 | 9.22 | 7.30 | 6.08 | 5.42 | 10.41 | 13.11 | 5.54 | 5.23 | 9.10 | 11.02 | 3.59 | 3.55 | 89.57 |
| 1975 | 3.92 | 6.16 | 2.69 | 4.65 | 7.36 | 5.85 | 5.85 | 5.69 | 3.75 | 6.90 | 3.10 | 2.88 | 58.80 |
| 1976 | 3.29 | 4.66 | 6.07 | 12.04 | 8.16 | 7.47 | 6.79 | 3.48 | 4.64 | 4.33 | 1.15 | 2.04 | 64.12 |
| 1977 | .25 | 1.43 | 7.40 | 8.20 | 5.07 | 1.97E | 2.57E | 17.31 | 1.26 | 3.79 | 1.91 | 1.65 | 52.81E |
| 1978 | .81 | .43 | 4.55E | 4.87E | 8.25 | 13.40 | 7.88 | 9.85 | 7.50E | 5.11E | 3.48 | 2.71 | 68.84E |
| 1979 | 2.22 | 3.56 | .46 | 6.50 | 5.18 | 7.37 | 7.80 | 7.41 | 8.62E | 4.99E | 3.21 | .73 | 62.25E |
| 1980 | 9.15 | 2.43 | 9.43 | 4.14 | 4.90 | 6.05 | 4.00 | 7.51E | 6.75V | 5.40 | 2.68 | 3.09 | 65.53E |
| SUM | 111.84 | 82.22 | 113.54 | 138.68 | 160.05 | 155.60 | 161.28 | 174.80 | 164.12 | 142.19 | 82.68 | 75.71 | 1562.71 |
| NO YRS | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| MEAN | 3.73 | 2.74 | 3.78 | 4.62 | 5.34 | 5.19 | 5.38 | 5.83 | 5.47 | 4.74 | 2.76 | 2.52 | 52.10+ |
| EXT HI | 15.40 | 7.56 | 9.43 | 12.04 | 10.41 | 13.40 | 13.61 | 17.31 | 10.20 | 14.88 | 8.78 | 7.13D | 89.57 |
| EXT LO | .06 | .32 | .46 | .54 | 1.74 | 1.53 | 1.14 | .81 | 1.26 | 1.12 | .47 | .11 | 20.37 |
| EST | | | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 4 | 2 | 3 | 22 |

S.KEY#: 24.10 NAME:OPIHIKAO 2 OBS:TRUMAN LORNA

LATITUDE: 19 16 24 LONGITUDE: 155 52 36 ELEV: 1300 FEET

PERIOD OF RECORD 1955 - 1975 READ: DAILY

COMPUTED STATISTICS:

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAX | 12.33 | 7.61 | 8.65 | 8.45 | 7.05 | 7.46 | 8.65 | 7.55 | 11.16 | 7.02 | 14.89 | 10.25 | 64.09 |
| 75% | 6.20 | 3.37 | 5.11 | 4.42 | 5.69 | 4.85 | 5.55 | 5.85 | 5.00 | 4.51 | 4.22 | 3.53 | 55.40 |
| MED | 3.66 | 2.46 | 3.96 | 3.51 | 3.69 | 3.51 | 4.49 | 3.63 | 3.80 | 3.11 | 3.14 | 2.25 | 43.30 |
| 25% | 2.51 | 1.93 | 2.19 | 2.56 | 2.64 | 2.21 | 3.17 | 2.91 | 3.06 | 2.34 | 1.62 | 1.80 | 38.45 |
| MIN | 0.34 | 0.86 | 0.94 | 0.96 | 2.35 | 1.36 | 1.63 | 1.20 | 2.20 | 1.41 | 0.38 | 1.00 | 29.77 |
| COV | 42 | 30 | 40 | 27 | 37 | 37 | 27 | 34 | 24 | 32 | 44 | 33 | 18 |
| AVG | 4.68 | 2.93 | 3.85 | 3.51 | 4.22 | 3.67 | 4.45 | 4.22 | 4.61 | 3.33 | 3.78 | 3.27 | 46.62 |
| COV | 71 | 62 | 49 | 47 | 38 | 46 | 42 | 41 | 55 | 43 | 98 | 76 | 22 |
| YRS | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |

DATA:

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | 1.59 | 7.61 | 4.10 | 4.36 | 2.71 | 4.97 | 4.92 | 5.83 | 5.60 | 3.00 | 1.49 | 5.35 | 51.66 |
| 1956 | 10.14 | 3.73 | 3.40 | 3.75 | 5.72 | 2.47 | 5.50 | 3.83 | 2.57 | 3.68 | 14.89 | 1.00 | 62.65 |
| 1957 | 6.09 | 2.58 | 1.92 | 3.41 | 3.43 | 4.07 | 3.48 | 3.63 | 2.21 | 4.21 | 3.54 | 1.63 | 40.25 |
| 1958 | 0.34 | 1.94 | 4.82 | 0.96 | 4.09 | 3.34 | 5.61 | 5.90 | 3.12 | 4.81 | 0.38 | 2.25 | 36.56 |
| 1959 | 11.41 | 2.46 | 2.41 | 2.60 | 3.47 | 3.07 | 7.57 | 3.00 | 3.75 | 3.70 | 4.77 | 1.53 | 49.73 |
| 1960 | 0.71 | 2.53 | 2.20 | 1.67 | 2.37 | 5.13 | 1.63 | 2.54 | 3.08 | 5.98 | 1.33 | 5.43 | 34.60 |
| 1961 | 2.43 | 2.18 | 4.34 | 4.20 | 7.32 | 4.13 | 4.62 | 4.63 | 3.80 | 7.02 | 9.38 | 2.33 | 56.08 |
| 1962 | 2.79 | 0.86 | 5.47 | 2.80 | 5.67 | 3.51 | 4.48 | 2.44 | 3.05 | 1.90 | 1.76 | 3.13 | 37.85 |
| 1963 | 5.47 | 1.21 | 5.91 | 8.45 | 7.05 | 7.46 | 6.10 | 2.91 | 5.19 | 1.41 | 2.05 | 1.61 | 54.71 |
| 1964 | 2.68 | 1.75 | 8.65 | 4.94 | 3.68 | 3.68 | 7.15 | 5.99 | 4.18 | 4.13 | 3.60 | 9.49 | 59.02 |
| 1965 | 3.55 | 3.91 | 2.18 | 4.55 | 5.40 | 4.32 | 4.49 | 6.66 | 4.67 | 1.96 | 7.47 | 1.97 | 50.23 |
| 1966 | 2.59 | 4.86 | 3.60 | 2.71 | 4.31 | 2.47 | 2.00 | 3.19 | 4.83 | 2.79 | 3.68 | 2.25 | 39.48 |
| 1967 | 2.73 | 2.33 | 6.47 | 3.59 | 5.20 | 6.54 | 8.65 | 7.55 | 11.16 | 4.99 | 1.27 | 3.61 | 64.09 |
| 1968 | 5.63 | 1.98 | 2.80 | 5.53 | 2.97 | 2.42 | 3.44 | 4.75 | 8.17 | 3.11 | 3.45 | 10.25 | 54.50 |
| 1969 | 6.31 | 1.90 | 2.88 | 2.93 | 2.38 | 4.73 | 4.73 | 6.37 | 2.57 | 4.19 | 0.50 | 2.19 | 41.58 |
| 1970 | 3.66 | 1.19 | 1.56 | 3.51 | 2.50 | 1.00 | 4.71 | 1.20 | 4.15 | 2.01 | 5.19 | 2.03 | 33.62 |
| 1971 | 12.33 | 2.49 | 3.54 | 2.52 | 3.59 | 1.36 | 3.17 | 3.23 | 4.80 | 2.67 | 2.98 | 2.54 | 43.03 |
| 1972 | 5.03 | 2.44 | 4.39 | 2.13 | 2.55 | 1.92 | 2.14 | 6.75 | 2.23 | 2.68 | 3.14 | 3.45 | 39.06 |
| 1973 | 1.49 | 2.14 | 1.96 | 1.31 | 2.53 | 1.55 | 2.35 | 1.44 | 3.72 | 1.51 | 3.01 | 3.08 | 29.77 |

HAWAII RAINFALL
(INCHES)

| STATE KEY NO. | GAGE NAME | RECORD YEARS | ANNUAL MEDIAN | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | KALAE | 22 | 17.4 | 1.9 | 0.5 | 1.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.7 | 0.3 | 0.6 | 1.3 | 1.3 |
| 2.00 | MANUKA | 47 | 56.2 | 4.0 | 3.2 | 5.1 | 5.0 | 5.4 | 4.0 | 4.1 | 4.1 | 5.5 | 3.7 | 3.2 | 3.1 |
| 2.13 | 100 ACRES | 17 | 45.2 | 3.4 | 2.5 | 3.4 | 4.6 | 5.1 | 2.9 | 3.7 | 3.1 | 4.4 | 3.2 | 2.9 | 2.0 |
| 2.17 | OKOE | 17 | 46.7 | 5.0 | 1.9 | 3.7 | 3.6 | 4.6 | 3.3 | 3.4 | 3.5 | 4.9 | 2.9 | 3.5 | 2.4 |
| 2.18 | KOLE PEN | 17 | 25.7 | 3.5 | 1.1 | 2.4 | 2.3 | 2.5 | 1.7 | 2.2 | 2.0 | 2.8 | 1.6 | 1.9 | 1.4 |
| 2.20 | KAHUKU SHED 3 | 47 | 45.4 | 4.7 | 2.6 | 3.4 | 2.9 | 3.2 | 2.5 | 2.6 | 3.4 | 3.0 | 3.1 | 3.1 | 3.2 |
| 2.21 | PAPA | 11 | 81.1 | 5.6 | 4.0 | 5.4 | 7.1 | 6.6 | 3.4 | 5.7 | 6.2 | 6.6 | 5.0 | 4.0 | 3.8 |
| 2.22 | FURLKA | 15 | 46.4 | 4.1 | 2.5 | 3.2 | 4.3 | 4.7 | 2.8 | 4.0 | 2.6 | 4.4 | 3.1 | 3.2 | 1.9 |
| 2.50 | KAPUA | 10 | 54.2 | 3.1 | 2.8 | 3.0 | 3.4 | 4.6 | 2.0 | 4.2 | 4.0 | 3.9 | 2.5 | 1.5 | 2.8 |
| 3.00 | SOUTH PT CORRAL | 26 | 22.9 | 3.5 | 1.7 | 2.9 | 1.5 | 0.8 | 0.5 | 0.8 | 0.8 | 0.7 | 1.2 | 2.3 | 2.6 |
| 3.10 | KAHUKU 2 MAKAI | 21 | 45.3 | 5.4 | 3.3 | 3.8 | 3.1 | 3.4 | 2.5 | 2.8 | 3.5 | 3.0 | 2.9 | 3.3 | 3.8 |
| 3.20 | KAHUKU SHED 1 | 53 | 52.0 | 4.9 | 3.0 | 4.1 | 3.4 | 3.5 | 3.5 | 3.1 | 3.9 | 3.6 | 3.8 | 3.7 | 3.3 |
| 3.30 | KFALAKDA | 16 | 77.4 | 7.1 | 5.3 | 5.4 | 5.9 | 6.9 | 6.1 | 5.6 | 7.0 | 6.1 | 5.6 | 5.2 | 5.9 |
| 4.10 | KAHUKU RCH HSE | 55 | 41.3 | 4.6 | 2.2 | 3.4 | 2.4 | 1.9 | 2.1 | 2.4 | 2.4 | 2.3 | 3.0 | 2.5 | 3.2 |
| 4.40 | KAMADA (1000) | 14 | 32.7 | 3.2 | 1.8 | 1.9 | 2.3 | 1.7 | 0.7 | 1.0 | 1.3 | 1.8 | 1.4 | 2.9 | 2.5 |
| 4.90 | KAALUALU | 12 | 24.8 | 4.0 | 1.1 | 1.1 | 2.4 | 0.6 | 0.1 | 0.2 | 0.1 | 0.1 | 0.5 | 1.2 | 2.1 |
| 5.00 | KAMADA-P RANCH | 43 | 35.5 | 4.8 | 2.8 | 3.0 | 2.4 | 2.0 | 1.9 | 2.3 | 2.7 | 2.1 | 2.8 | 3.2 | 3.4 |
| 6.00 | KIOLAKAA ACF | 45 | 73.9 | 6.0 | 4.6 | 6.0 | 4.8 | 5.2 | 4.6 | 4.8 | 5.2 | 5.4 | 5.6 | 6.0 | 4.6 |
| 7.00 | KIOLAKAA-HAYSELD | 38 | 53.3 | 5.9 | 2.7 | 4.8 | 2.6 | 2.9 | 2.6 | 2.7 | 3.1 | 3.6 | 3.8 | 3.4 | 4.1 |
| 10.00 | MOUNTAIN HOUSE | 52 | 133.2 | 10.6 | 7.8 | 9.3 | 10.4 | 12.6 | 12.0 | 11.0 | 12.3 | 14.0 | 12.3 | 10.4 | 7.4 |
| 11.00 | MAKINO | 37 | 79.6 | 7.7 | 4.7 | 6.0 | 5.3 | 5.4 | 5.1 | 3.9 | 6.1 | 5.4 | 5.9 | 7.1 | 6.1 |
| 12.00 | KAALA IKI | 37 | 63.7 | 5.1 | 4.2 | 5.8 | 3.7 | 4.1 | 3.1 | 2.7 | 4.1 | 4.1 | 5.1 | 5.6 | 5.5 |
| 12.10 | HILEA | 48 | 36.0 | 2.4 | 2.6 | 4.3 | 2.1 | 1.6 | 0.9 | 1.1 | 1.5 | 2.0 | 2.4 | 3.0 | 2.6 |
| 12.12 | FIELD 715 | 18 | 57.8 | 6.7 | 3.3 | 4.0 | 4.3 | 3.9 | 3.0 | 2.2 | 3.8 | 4.3 | 5.9 | 6.2 | 4.6 |
| 12.70 | FIELD 656 | 10 | 93.6 | 9.6 | 4.8 | 6.2 | 7.7 | 7.5 | 7.0 | 4.2 | 7.4 | 8.0 | 8.8 | 12.4 | 6.0 |
| 12.90 | FIELD 850 | 14 | 116.2 | 10.0 | 5.8 | 9.9 | 9.5 | 10.8 | 8.1 | 5.9 | 9.2 | 9.3 | 8.5 | 8.4 | 6.9 |
| 13.00 | WAIUBATA | 35 | 50.4 | 5.2 | 3.4 | 5.7 | 2.6 | 2.3 | 1.7 | 1.6 | 2.3 | 2.6 | 4.1 | 4.8 | 4.9 |
| 13.20 | FIELD 435 | 17 | 79.0 | 8.9 | 4.5 | 4.9 | 6.2 | 5.7 | 3.9 | 3.6 | 4.7 | 5.0 | 7.1 | 6.6 | 5.7 |
| 13.80 | KAALA IKI ASTRIP | 12 | 89.3 | 9.2 | 4.8 | 6.6 | 5.9 | 6.4 | 4.6 | 3.7 | 4.9 | 5.6 | 5.6 | 10.8 | 5.9 |
| 14.00 | NAALEHU | 86 | 46.2 | 4.7 | 2.8 | 4.5 | 2.1 | 2.0 | 1.2 | 1.5 | 2.3 | 2.3 | 3.1 | 3.7 | 4.4 |
| 14.10 | HONUAPO 25 | 12 | 29.6 | 0.9 | 1.2 | 4.4 | 1.2 | 0.8 | 0.4 | 0.9 | 1.7 | 1.3 | 1.3 | 3.9 | 2.1 |
| 15.00 | HONUAPO | 34 | 34.4 | 4.0 | 2.9 | 3.9 | 1.9 | 1.2 | 0.6 | 0.7 | 1.6 | 1.4 | 2.0 | 3.5 | 2.9 |
| 16.00 | MOAULA TUNNEL | 19 | 124.9 | 6.5 | 6.0 | 10.0 | 10.8 | 11.5 | 10.0 | 8.5 | 10.5 | 12.0 | 10.1 | 7.3 | 6.0 |
| 17.00 | MOAULA RES | 64 | 92.0 | 6.8 | 5.9 | 6.9 | 6.4 | 7.0 | 5.5 | 5.0 | 6.1 | 7.0 | 7.7 | 6.8 | 6.3 |
| 18.00 | MOAULA | 55 | 43.3 | 5.0 | 3.4 | 3.8 | 2.5 | 1.9 | 1.3 | 1.0 | 1.6 | 1.9 | 3.2 | 3.9 | 3.1 |
| 20.00 | ALILI TUNNEL 2 | 12 | 128.4 | 8.0 | 12.0 | 10.5 | 8.5 | 10.0 | 9.0 | 7.5 | 8.3 | 11.4 | 10.0 | 10.5 | 7.5 |
| 20.10 | ALILI TUNNEL 1 | 33 | 117.0 | 8.6 | 8.0 | 10.5 | 10.0 | 10.0 | 7.2 | 7.0 | 8.6 | 10.0 | 9.5 | 10.0 | 8.0 |
| 20.20 | ALILI | 19 | 116.2 | 8.6 | 6.4 | 9.5 | 10.7 | 8.9 | 7.1 | 5.8 | 9.1 | 8.3 | 9.1 | 8.7 | 8.4 |
| 21.00 | PAHALA | 84 | 43.6 | 3.9 | 4.0 | 3.9 | 2.0 | 1.8 | 1.0 | 0.9 | 1.7 | 2.1 | 2.9 | 4.2 | 3.3 |
| 22.00 | KEAIWA | 33 | 59.5 | 6.5 | 4.9 | 5.1 | 3.9 | 3.5 | 2.4 | 2.1 | 2.7 | 3.3 | 5.0 | 3.8 | 4.1 |
| 22.10 | KEAIWA CAMP | 23 | 65.9 | 5.2 | 4.9 | 5.5 | 4.6 | 4.4 | 2.0 | 2.0 | 2.6 | 3.7 | 4.2 | 8.0 | 5.1 |
| 24.10 | OPIHIHALE 2 | 21 | 43.3 | 3.7 | 2.5 | 4.0 | 3.5 | 3.7 | 3.5 | 4.5 | 3.6 | 3.8 | 3.1 | 3.1 | 2.3 |
| 25.00 | PAHOEHOE | 17 | 49.9 | 3.4 | 2.8 | 3.9 | 4.1 | 5.2 | 5.1 | 4.7 | 4.6 | 5.4 | 4.4 | 2.6 | 1.9 |
| 25.10 | KALAHIKI (750) | 10 | 41.1 | 1.5 | 1.8 | 3.5 | 2.5 | 4.7 | 3.6 | 4.4 | 5.1 | 3.5 | 4.4 | 3.2 | 2.5 |
| 25.70 | PAHOEHOE RANCH | 19 | 45.4 | 3.3 | 1.9 | 3.4 | 3.9 | 3.5 | 3.4 | 4.5 | 4.2 | 3.6 | 3.0 | 1.9 | 2.9 |

HAWAII RAINFALL
(INCHES)

| STATE KEY NO. | GAGE NAME | RECORD YEARS | ANNUAL MEDIAN | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26.00 | TAKASHIDA | 36 | 78.7 | 3.8 | 3.7 | 5.9 | 6.7 | 8.2 | 8.6 | 8.0 | 6.8 | 6.5 | 5.4 | 4.5 | 3.5 |
| 26.10 | TANK FIELD | 18 | 66.1 | 3.9 | 3.2 | 5.0 | 5.7 | 5.3 | 5.6 | 6.4 | 7.2 | 4.9 | 4.1 | 2.6 | 3.1 |
| 26.20 | KEALAKEKUA | 57 | 60.6 | 3.3 | 2.2 | 4.0 | 4.0 | 6.0 | 5.6 | 6.5 | 6.7 | 6.7 | 5.3 | 3.4 | 2.7 |
| 27.00 | HONAUNAU | 38 | 47.0 | 2.4 | 2.0 | 3.0 | 3.4 | 4.9 | 4.7 | 5.1 | 5.1 | 4.4 | 3.7 | 2.8 | 1.9 |
| 28.00 | NAPOOPOO | 35 | 42.1 | 2.8 | 1.8 | 2.7 | 3.1 | 3.6 | 3.5 | 3.9 | 4.1 | 4.1 | 3.4 | 2.4 | 2.2 |
| 28.10 | NAPOOPOO 16 | 37 | 34.5 | 2.1 | 1.2 | 1.9 | 2.1 | 3.1 | 3.2 | 3.0 | 3.4 | 3.5 | 2.9 | 1.7 | 2.2 |
| 28.20 | KEEI MIDDLE RD | 16 | 53.2 | 3.9 | 2.1 | 2.9 | 4.3 | 4.1 | 3.5 | 5.4 | 5.9 | 5.3 | 3.8 | 2.7 | 2.8 |
| 29.00 | KAAWALOA | 34 | 56.1 | 3.3 | 2.7 | 4.1 | 3.8 | 4.9 | 5.1 | 5.8 | 6.3 | 6.2 | 4.8 | 2.7 | 2.7 |
| 29.10 | KEALAKEKUA-DAVIS | 24 | 66.1 | 3.5 | 2.4 | 3.8 | 4.1 | 5.9 | 6.1 | 6.8 | 8.7 | 8.0 | 6.2 | 3.6 | 2.1 |
| 29.20 | KALUKALU | 10 | 58.6 | 4.1 | 1.8 | 2.8 | 4.9 | 6.7 | 6.5 | 5.3 | 6.1 | 5.5 | 5.5 | 3.1 | 3.3 |
| 29.50 | KANAKAMELAI | 19 | 39.5 | 2.3 | 2.0 | 2.9 | 3.2 | 4.6 | 4.1 | 4.0 | 3.3 | 3.4 | 2.6 | 2.1 | 1.7 |
| 29.80 | UNDULI (1600) | 15 | 61.8 | 3.9 | 2.6 | 3.0 | 4.3 | 6.1 | 4.2 | 6.4 | 6.8 | 6.5 | 4.8 | 2.8 | 2.5 |
| 29.90 | MALUKALU | 13 | 68.8 | 4.8 | 2.0 | 4.6 | 5.6 | 6.2 | 6.7 | 8.2 | 6.2 | 8.1 | 4.1 | 3.3 | 2.1 |
| 35.00 | WOOD VALLEY TUNN | 14 | 161.7 | 9.5 | 8.8 | 16.0 | 12.0 | 12.0 | 10.5 | 10.5 | 10.5 | 14.5 | 15.5 | 10.5 | 9.8 |
| 35.10 | KEAIWA RESERVIOR | 20 | 113.9 | 9.0 | 6.0 | 9.0 | 10.6 | 10.0 | 6.1 | 5.6 | 8.9 | 8.4 | 9.8 | 10.2 | 8.4 |
| 35.60 | WOOD VALLEY | 21 | 83.9 | 6.4 | 5.2 | 6.9 | 6.6 | 6.7 | 3.4 | 2.9 | 4.3 | 5.7 | 6.9 | 7.2 | 5.6 |
| 36.00 | KAPAPALA | 89 | 60.5 | 6.0 | 5.1 | 6.1 | 3.4 | 3.6 | 1.7 | 1.8 | 2.8 | 3.4 | 4.6 | 5.0 | 3.7 |
| 37.00 | PAKAO | 46 | 59.6 | 6.2 | 5.1 | 6.1 | 6.5 | 4.6 | 2.5 | 3.6 | 4.9 | 4.4 | 6.0 | 3.9 | 3.4 |
| 38.00 | AINAPO | 50 | 69.7 | 7.0 | 5.6 | 7.1 | 5.6 | 6.0 | 2.0 | 2.8 | 3.7 | 4.5 | 5.8 | 5.1 | 4.5 |
| 38.10 | MAUNALOA (6700) | 20 | 58.2 | 4.9 | 4.3 | 7.2 | 5.3 | 3.3 | 0.5 | 1.9 | 2.8 | 2.7 | 2.8 | 6.0 | 4.5 |
| 39.10 | MAUNA LOA UPPER | 20 | 18.6 | 1.6 | 1.1 | 2.1 | 1.1 | 1.4 | 0.4 | 0.9 | 1.0 | 1.3 | 1.2 | 1.6 | 1.9 |
| 43.10 | MAUNAIU | 49 | 51.2 | 5.6 | 4.6 | 5.0 | 3.4 | 2.4 | 0.8 | 1.1 | 2.0 | 2.7 | 3.6 | 4.6 | 4.1 |
| 43.20 | PAHUA MINI | 22 | 37.7 | 3.5 | 3.1 | 3.9 | 3.0 | 2.1 | 1.0 | 1.3 | 3.1 | 3.3 | 3.8 | 2.1 | 1.7 |
| 44.00 | OMAIKEA | 49 | 43.1 | 3.9 | 3.4 | 4.7 | 2.2 | 1.4 | 0.3 | 0.7 | 1.5 | 2.0 | 2.8 | 3.5 | 3.4 |
| 45.10 | MAUNA LOA (5500) | 22 | 50.5 | 4.4 | 3.5 | 5.7 | 4.6 | 2.6 | 0.3 | 1.6 | 2.1 | 2.2 | 2.6 | 5.4 | 5.1 |
| 51.00 | KILAUEA N RIM | 16 | 84.4 | 8.2 | 7.0 | 8.9 | 6.2 | 5.4 | 2.2 | 2.9 | 3.2 | 3.2 | 4.3 | 9.5 | 8.1 |
| 51.40 | VOLCANO HOUSE | 21 | 86.6 | 7.2 | 7.9 | 10.0 | 6.8 | 6.0 | 3.5 | 4.4 | 4.8 | 5.2 | 6.5 | 9.2 | 7.4 |
| 51.50 | VOLCANO FARM LOT | 12 | 123.3 | 12.6 | 6.7 | 11.5 | 14.6 | 8.2 | 4.4 | 7.1 | 6.3 | 5.9 | 5.3 | 12.0 | 14.6 |
| 52.00 | HALEMAUMAU | 42 | 50.9 | 6.3 | 3.4 | 4.8 | 3.0 | 1.8 | 0.7 | 1.1 | 1.3 | 1.3 | 2.2 | 4.6 | 4.4 |
| 52.10 | UWEKAHUNA | 27 | 65.7 | 8.1 | 5.9 | 6.0 | 4.4 | 2.6 | 0.9 | 1.3 | 2.0 | 1.8 | 2.8 | 7.9 | 5.6 |
| 54.00 | HAWAII NAT PK HQ | 61 | 102.2 | 9.0 | 6.3 | 10.3 | 8.3 | 6.1 | 3.9 | 4.5 | 5.0 | 4.9 | 5.8 | 9.6 | 10.0 |
| 54.10 | OHIANLANI DAIRY | 23 | 125.9 | 15.4 | 11.6 | 14.5 | 9.3 | 8.6 | 5.8 | 7.0 | 7.3 | 5.2 | 9.1 | 10.9 | 12.2 |
| 54.20 | GLENWOOD-HELBUSH | 10 | 184.1 | 14.2 | 7.5 | 16.1 | 16.7 | 10.1 | 5.9 | 10.1 | 14.5 | 13.0 | 13.9 | 13.8 | 12.1 |
| 54.40 | 26 MILES | 23 | 154.0 | 10.9 | 10.0 | 15.2 | 15.2 | 10.9 | 7.6 | 9.5 | 9.4 | 6.9 | 8.9 | 19.4 | 11.2 |
| 58.00 | AINAHOU | 32 | 81.9 | 10.1 | 9.1 | 10.0 | 4.4 | 3.3 | 2.0 | 2.1 | 2.1 | 1.8 | 3.3 | 8.7 | 10.5 |
| 58.10 | AINAHOU MAKAI | 28 | 77.6 | 9.4 | 6.3 | 9.7 | 3.8 | 2.9 | 1.1 | 1.2 | 2.4 | 1.6 | 2.9 | 7.7 | 9.2 |
| 58.20 | AINAHOU STL TK | 11 | 83.6 | 12.3 | 6.0 | 10.6 | 10.0 | 5.4 | 2.0 | 2.6 | 2.4 | 3.2 | 5.8 | 8.3 | 11.5 |
| 65.00 | PAHOA | 64 | 146.8 | 11.2 | 9.1 | 13.5 | 11.9 | 10.1 | 8.3 | 10.5 | 9.9 | 9.6 | 10.6 | 14.3 | 14.7 |
| 66.00 | KAPOHO UPPER | 21 | 122.2 | 10.0 | 7.2 | 12.4 | 7.0 | 7.5 | 6.4 | 7.8 | 9.3 | 8.0 | 8.4 | 12.1 | 14.9 |
| 66.10 | LAVA TREE PARK | 16 | 141.5 | 13.4 | 11.3 | 12.6 | 10.9 | 10.5 | 6.8 | 11.1 | 9.0 | 6.9 | 9.2 | 14.7 | 11.9 |
| 67.00 | KAMAILE | 25 | 105.3 | 11.7 | 7.4 | 11.5 | 7.0 | 5.6 | 5.0 | 5.8 | 6.5 | 7.1 | 7.1 | 10.7 | 11.8 |
| 67.50 | HAYHALALEKAI | 30 | 82.9 | 7.9 | 7.4 | 7.4 | 4.7 | 4.4 | 3.8 | 5.1 | 4.0 | 4.3 | 5.9 | 9.0 | 8.6 |
| 68.00 | HOLUALOA BEACH | 52 | 27.5 | 1.5 | 1.2 | 1.6 | 2.1 | 2.4 | 2.3 | 2.4 | 2.2 | 2.3 | 1.8 | 1.5 | 1.5 |
| 68.10 | MIDDLE HOLUALOA | 39 | 43.1 | 2.7 | 1.7 | 2.6 | 2.9 | 4.1 | 4.4 | 4.4 | 4.6 | 3.9 | 3.1 | 2.3 | 2.1 |
| 68.20 | LANIHAU | 37 | 74.8 | 3.8 | 3.5 | 5.7 | 5.7 | 5.1 | 8.0 | 7.1 | 6.4 | 6.8 | 5.6 | 4.0 | 2.9 |

RAIN READINGS FROM GEORGE SCHATTAUER

KAPUA, HAWAII

June 14, 1982

| | 1,300' Elevation | 1,500' Elevation |
|---|---|---|
| 1967 | n/a | 49.42" |
| 1968 | 44.16" | 50.17" |
| 1969 | 23.42" | 29.61" |
| 1970 | 21.74" | 27.95" |
| 1971 | 29.43" | 36.31" |
| 1972 | 26.23" | 34.02" |
| 1973 | 12.64"* | 28.83" |
| 1974 | n/a | 39.51" |
| 1975 | n/a | 35.02" |
| 1976 | n/a | 31.48" |
| 1977 | n/a | 25.36" |
| 1978 | n/a | 28.28" |
| 1979 | n/a | 53.26" |
| 1980 | n/a | 23.25"** |

* Readings taken for 9 months only

** Readings taken through July 2

Rainfall Per Month (Inches)

| | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|
| January | 5.01 | 6.50 | 3.02 | 14.53 | 8.92 | 1.77 |
| February | 2.10 | 0.98 | 1.47 | 0.83 | 2.02 | 0.27 |
| March | 1.93 | 3.66 | 0.41 | 0.87 | 5.07 | 1.58 |
| April | 10.09 | 2.48 | 3.86 | 2.98 | 2.93 | 0.55 |
| May | 1.53 | 4.12 | 2.25 | 2.64 | 0.65 | 2.26 |
| June | 1.60 | 1.66 | 3.20 | 1.19 | 1.49 | 1.26 |
| July | 3.20 | 1.81 | 2.54 | 2.02 | 1.95 | 0.57 |
| August | 3.60 | 2.79 | 1.78 | 1.23 | 1.43 | 1.81 |
| September | 5.30 | 1.61 | 2.25 | 4.81 | 3.89 | 4.11 |
| October | 1.02 | 2.43 | 2.85 | 0.57 | 0.85 | n/a |
| November | 2.52 | 0.95 | 2.95 | 2.70 | 2.24 | n/a |
| December | 12.27 | 0.62 | 1.37 | 1.94 | 2.58 | n/a |

APPENDIX F

# PASTURE DEVELOPMENT AND MANAGEMENT PROGRAM FOR FARMS OF KAPUA (1984)

By
HAROLD F. RICE, Jr.
Rancher

## PLAN FOR PASTURE DEVELOPMENT

### Unirrigated Koa Haole Pasture Area (2,472 acres)

#### Site Preparation

400 acres a year over 5 years will be developed to unirrigated pasture. These areas will be rough bladed and rolled, preserving any healthy trees for shade and organic matter buildup. A minimum of tractor work is required. One pass by a large tractor (D7 or larger), with the blade adjusted to skim the surface, and pulling a 10 ton or heavier roller should be adequate. No ripping or moving of material is required for the pasture areas. A large tractor can do 5 acres a day at $85 an hour.

#### Seeding

Common and improved varieties of ekoa and Guinea grass will be planted immediately after a rainy period (January). The ekoa (scarified and innoculated with the proper bacteria) will be seeded by airplane on windless days. The boundaries will be marked by flagmen during seeding. The seeding will be done by professionals that are very accurate. The high density of ekoa seed will cause it to descend directly below the point of release from the plane.

Grass seeding will not be done by air. The new plantings (ekoa and grasses) will be fertilized with super phosphate and potash. The areas worked will be fenced into 50 acre paddocks to increase the buildup of organic matter (manure) and fertility until the pasture is well established.

#### Management

No pasture can achieve maximum production until a heavy concentration of stock in combination with legumes can be built up. The management of the unirrigated pastures will be one of intense, rapid rotation. This increases the fertility of the pasture by the constant replacement of manure and urine and encourages the highest forage yields. This contrasts with management practices of the past, where the objective concentrated almost entirely on the cattles' welfare, rather than considering the maximum growth of forage as an equal objective.



### Irrigated Koa Haole Cultivation Area (200 acres)

#### Site Preparation

This area can be develped as soon as water for irrigation is available. This area will be bladed and rolled to a higher degree than the larger, 2,472 acre koa haole pasture area to allow for easy access of irrigation equipment and uniform growth. This area would require possibly 2 more rollings than the larger pasture area. Again, no ripping or moving of material is required.

#### Planting, Cultivation and Harvesting

Improved varieties of seed developed by the University of Hawaii, probably K8, K6, K28, will be planted in rows, with adequate spacing to allow access for irrigation and harvesting. The plantings would be made by a ground seeder. Cuttings should start when the plants reach 5 feet in height. During the spring and summer months the koa haole can be harvested or grazed every 6 to 8 weeks.

Harvesting would be by a green chop cutter which blows the cut forage into an attached feeding wagon. When the wagon is full, it would be disconnected and towed to the feedlot.

Cattle will follow the harvesting of forage, to clean up the leaves below the level of cutting. This procedure is important in order to continue organic buildup in the soil and to precondition the cattle for the feed corrals. Irrigation would follow after the cattle.

### Control of Vegetation

Ekoa seed is heavy so it cannot be carried by average winds; it has to be carried by livestock or man. It is also a very hard seed so that it will not establish naturally unless there is some moisture. It will germinate and grow if the seed is treated or passes through the ruminant of livestock. The pastures at Kapua will be fenced on the boundaries with conventional fencing and electric outrigger line so cattle will not spread the seed. Since there will be an intense rotation of cattle through the pastures, the grasses will be grazed before the seeds reach maturity. The intensive management procedures for grazing and harvesting will prevent plants within the system from seeding and spreading.

## CATTLE MANAGEMENT

### Feedlot

The 20 acre site for the feedlot corrals, feed storage bunkers and working facilities will be built as the unirrigated and irrigated pastures come into production. Pen sizes and contours will take into consideration the operation of manure collection. Large healthy kiawe trees in the site area will be preserved for shade.

### Management

To enhance the development of the pastures at the onset and to best utilize the forage after establishment, the purchasing, grazing and marketing of cattle should be flexible. This is accomplished by purchasing the best bargains available, usually wean calves from other ranches.

The acquisition of new cattle should be made as the unirrigated pastures come into maximum growth, normally just after the first good rains of the year. The cattle would feed in the pastures until reaching weights of 700-800 lbs., at which time they would enter the feedlot (or a number of them would follow green chop cutter/harvesting operation in the 200 acre koa haole cultivation area). The cattle would be in the feedlot for 90-120 days prior to marketing. As cattle are taken to the corrals, replacement cattle for the unirrigated pastures would be purchased. In the event that a low rainfall period is encountered, the replacement of cattle would be delayed. Under normal weather conditions, once the entire area is developed, there would be approximately 600-700 weanlings on unirrigated pasture and 600-700 head in the feedlot. During drought conditions the cattle in the unirrigated pastures can be sold. The operations within the irrigated 200-acre koa haole cultivation area and the feedlot are not affected by drought conditions and can continue to operate at full capacity.

### Forage Requirements

An animal eats approximately 13% of its body weight per day on pasture. Therefore, a 500 lb. calf eats 65 lbs./day or 18,250 lbs. per year (University of Hawaii Research Bulletin 166). Twenty (20) tons of forage per acre per year equals 1.6 head per acre per year. Allowing for dry conditions, this would amount to 1 head at 500 lbs. on 2 acres.



### Economic Viability (1984 $)

| | |
|---|---|
| Purchase 400 lb. wean calf (38¢/lb.) | $152.00 |
| One year's interest at $12\frac{1}{2}$% | 19.00 |
| One ton of feed in feedlot | 250.00 |
| Out of pocket costs | $421.00 |

400 lb. weaner gains 1 lb./day for 270 days;
enters feedlot weighing 670 lbs.;
gains 3.4 lbs/day
for 90 days in feedlot (315 lbs.)
and is marketed at 985 lbs.
A dressing percentage of 55%
yields a 542 lb. carcass.
At $1.11, the carcass grosses:

| | |
|---|---|
| Gross | $601.62 |

| | |
|---|---|
| Gross | $601.62 |
| Minus out of pocket costs | -$421.00 |
| Net (not including overhead) | $180.62 |

## COMPARISON OF RANCHES WITH KOA HAOLE PASTURE

There are other areas in West Hawaii at similar elevations, with similar rainfall and soils, which are not irrigated, which are vegetated with haole koa and are used for grazing. This information is provided below:

Farms of Kapua - proposed Koa Haole Pasture
- Elevation: 400 ft. to 150 ft.
- Rainfall: 25.7 in. (Kole Pen-elevation 900 ft.)
- Soil: Rocky, a'a and pahoehoe
- Carrying capacity: (proposed) 1 AU* to 4 acres on unirrigated pasture

Paahoehoe Ranch (Magoons) Kalae
- Elevation: 1000 ft. to sea level
- Rainfall: 25 in. at 800 ft. elevation, 10 in. at the beach
- Soil: Rocky, a'a and pahoehoe
- Carrying capacity: 1 AU to 2 acres

McCandless Ranch - Hookena
- Elevation: 1000 ft. to sea level
- Rainfall: 45 in. at 1000 ft., 25 in. at 600 ft, 20 in. at the beach.
- Soil: Rocky, a'a and paahoehoe
- Carrying capacity: 1 AU to 2 acres

Thomas Okuna Ranch - Honuapo
- Elevation: 200 ft. to sea level
- Rainfall: 25.6 in. at 200 ft. elevation
- Soil: Rocky, a'a and paahoehoe
- Carrying capacity: 1 AU to 2 acres

Kahuku Ranch - Kamaoa
- Elevation: 500 ft.
- Rainfall: 32.7 in. at 1000 ft. and 22.9 in. at 500 ft. elevation
- Soil: Very rocky, a'a
- Carrying capacity: 1 AU to 2 acres

Kaula Ili - Puuwaanahulu
- Elevation: 2,500 ft.
- Rainfall: 15 in.
- Soil: Pahoehoe
- Carrying capacity: 1 AU to 2 acres



Kaupo Ranch - Nuu
- Elevation: 1000 ft. to sea level
- Rainfall: 30 in. at 1000 ft., 20 in. at 500 ft., 10 in. at beach
- Soil: Very rocky, a'a and pahoehoe
- Carrying capacity: 1 AU to 2 acres

* 1 AU = 2 weanlings
3/4 AU = 1 yearling to feeder (700-800 lbs.)
1 AU = 1 feedlot steer (800-1,000 lbs.)

It is my opinion that the growing and grazing of ekoa, as proposed by Farms of Kapua between the 100 to 800 foot elevation, is economically viable.

# APPENDIX G

## HAWAII BEEF CATTLE INDUSTRY
(Revised 1984)

By
AGRICULTURAL CONCEPTS, INC.

AGRICULTURAL CONCEPTS, INC. 615 Piikoi Street, Suite 1510, Honolulu, Hawaii 96814 • (808) 521-2011

February 16, 1984

Mr. Francis Oda, AIA
GROUP 70
924 Bethel Street
Honolulu, HI 96813

Re: Hawaii Beef Cattle Industry

Dear Francis:

The Hawaii beef cattle industry has been a struggling industry for many years.

When the meat industry aggressively pursued marketing of U.S. beef under a USDA grain fed labeling program in the 1950's, the Hawaiian range fed beef could not compete in the marketplace here in Hawaii. Portion controlled cuts were preferred by restaurants. Instead of the cooks cutting pieces out of primal (larger) cuts they would just throw out a precut and weighed piece, cook and serve.

Quality also was a problem with Hawaiian range fed beef - basically older animals, therefore tougher meat.

The creation of the Hawaii Meat Company feedlot some years ago helped to stabilize the problem by feeding Hawaiian animals to USDA standards and the Hawaii beef found its niche in the Hawaiian marketplace.

However, the ever increasing pressure for Mainland and New Zealand/Australian beef continued to drive our in-state production down.

In 1971 Hawaii imported 23,900,000 pounds of Mainland beef, 16,500,000 pounds from New Zealand and Australia, and produced 34,000,000 pounds in-state. This amounted to 46% of what we consumed.

By 1976, Mainland imports were up to 39,900,000 pounds, foreign imports up to 20,400,000 pounds and Hawaii production dropped to 32,300,000 pounds, or 35% of total consumption.

The 1981 figures reflect a still increasing Mainland portion of 45,600,000 pounds imported, with foreign imports dropping to 16,500,000 pounds and Hawaii's in-state production still dropping to 28,700,000 pounds, or 30% of total consumption.



It became apparent a few years ago to leaders of the State government that Hawaii should do everything it can to first increase the production of feed and forage and increase the production of beef. This became one of the goals of the State administration. We still adhere to that goal today and the project of Kapua can help in achieving this goal by producing 600-700 head of cattle.

Further, while there has been talk and studies done years ago regarding manure as a source of food for aquaculture, only recently has The Oceanic Institute been successful in determining feed conversions of manure to shrimp.

It is likely that the animals would also receive some grain either on site or elsewhere, and sold as "short-fed" cattle which produces a leaner animal and incidentally, is better for your health than the fattier, high-cholesterol imported beef. Although there is and always will be a demand for choice beef, an increasing number of health conscious consumers are demanding lean beef. Safeway Stores recognized this trend when it began its "Safeway Lean Beef" promotion a few years ago. It is the petitioner's intent to capture some of this growing market.

Please call if you have any questions.

Many thanks,

John Farias, Jr.

John Farias, Jr.
President

cc: Roy Takeyama, Esq.

APPENDIX H

# KAPUA FARMS
# AQUACULTURE POTENTIAL STUDY
(Revised 1984)

By
OCEANIC INSTITUTE

THE

OCEANIC INSTITUTE

KAPUA FARMS

AQUACULTURE POTENTIAL STUDY

Submitted to:

Agricultural Concepts, Inc.
Honolulu, Hawaii

January 1983

MAKAPUU POINT
WAIMANALO, HAWAII 96795
(808) 259-7951

FARMS OF KAPUA

AQUACULTURE POTENTIAL STUDY

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## INTRODUCTION

This report will define the potential options for aquaculture on the Farms of Kapua site, located near the southerly terminus of the South Kona District, Island of Hawaii. It will be limited to marine species and will only consider those aquacultural activities that can be pragmatically considered on a commercial basis. This of course implies that the ultimate design of large scale facilities must conform to the particular nature of the subject site, both in terms of its advantages and limitations.

Objectives. Our primary objective is to carry out aquaculture activities that achieve the greatest production and income at the least cost. This is achieved by selecting combinations of species which are complementary to one another, i.e. where the water and waste products of one species cultured can contribute substantially to the conditions required for the growth of other species. The proper assemblage of species (with respect to their needs for food, water quality, etc.) provides the maximum opportunity for the most efficient use of resources.

The method of approach involves, first, a careful evaluation of the site; second, an analysis of the economics of producing independently each species selected, *a priori*, defining the economic, technical, social, and ecological

problems that may occur; third, an analysis of the economics of integrated production of a variety of species, taking advantage of the free nutrient outputs from the culture of one or more species for the benefit of other species, thus reducing costs of production. In an ecological sense, an integrated system can also serve as a means of cleansing used water before discharge, thus minimizing the social costs of the aquaculture system devised.

## I. NATURE OF SITE

The subject property, known as Farms of Kapua, is located on the leeward side of the island of Hawaii--more specifically, in the southernmost part of the South Kona District. It is approximately 20 miles northwest of South Point, approximately 20 miles south of Captain Cook, and approximately 38 miles south of Kailua Village.

The parcels comprising the Farms of Kapua contain at least 6,102 acres, beginning at an elevation of approximately 1,200 feet and sloping gradually to the sea. The upper 1200 acres are zoned, unplanned agriculture and are being used for cattle grazing as an interim use. The owners contemplate developing farms, focusing on macadamia nut trees. The property immediately mauka of this area contains MacFarms of Hawaii's mature macadamia nut tree orchards, processing plant, and headquarters. There are two other smaller orchards in the same vicinity.



The property applicable for aquaculture use is bound by the coastline, containing approximately five miles of ocean frontage. The northern portion of the coastline is dotted with small bays and inlets, with reefs extending several hundred feet into the water, and the southern portion is predominantly bluffs of lava dropping off to the ocean.

Some of the most interesting archeological ruins we have viewed are concentrated on the most northerly portion of the coast near Kapua Bay. An example is a Holua Slide that appears to be in good condition. There are very few observable historical sites in the southerly portion of the property, which one would expect because of the inhospitable nature of the terrain in that area. In discussing the scope of our services, the client and we decided that consideration of aquaculture in the Kapua Bay area of sensitive archeological sites should be deferred. We, therefore, have focused our evaluation on the balance of the property.

In terms of climate, the entire Kapua area during most of the year is ideal for aquaculture. The property is situated in the lee of Mauna Loa, protecting it from the prevailing winds of the east and north.

During the winter months, Kona winds from the west may disrupt the calm water of this area. Evidence of past storms still remains as demonstrated by masses of coral fragments and rocks strewn on some of the beaches. However,

during the majority of the year the waters off Kapua remain very calm.

Because of its location on the southerly portion of the west coast of the island of Hawaii, the property has a long, warming sun. These factors of long sun and little wind contribute to a warmer average water temperature throughout the year than would occur in other parts of Hawaii. Warm water is an important ingredient in most saltwater aquaculture endeavors.

It is not coincidental that the area off Milolii, the last of the old traditional Hawaiian fishing villages, has been one of the most productive fisheries throughout Hawaii (apparently the combination of ocean currents and topography of the Big Island at this location create conditions that favor fishing). Milolii is situated just to the north of the subject property.

In the ocean the food chain begins from the most basic phytoplankton, the initial protein food source for sea life. In aquaculture systems the process is reversed.

In an artificial sense, this is the task of the aquaculture planner, i.e., supplying an optimal habitat for controlled growth of sealife. The conditions at Kona present the prerequisites for beginning aquaculture. If one does not have warm seawater, one must spend the dollars to boost the water temperature. If one does not have quality



water, one is limited to the kind of product that will grow in a given location.

Kapua represents the ideal characteristics for water temperature - 78° F to 82° F (25.5°C to 27.75°C) average range throughout the year - plus pollutant free water.

Another important factor in evaluating the potential for a site is topography, especially the relationship between site elevations and tidal levels. The main constraint in master planning for a saltwater aquaculture program is cost of supplying water. This major element of cost will vary from site to site. Clearly, the flatter the land and the closer it is to sea level, the lower will be the cost of bringing water to the site. A project such as the one contemplated here would require a well on site and then use of that water for raceways or ponds. Alternatively, one could pump water from the sea as OTEC has done. Regardless of the approach taken, the higher one must pump the water, the more the system itself will cost, and the greater the operating costs of supplying water will be. As the value of the crop increases, the higher an elevation the aquaculture developer can locate his aquaculture system. As a general guideline, we recommend not locating the ponds or raceways above a 150 foot elevation contour line. Support facilities are not so restricted and can be located at any elevation, but preferably contiguous to the operations.

The ideal soil for aquaculture is a clay loam mix that permits grading out ponds easily and compacting the surface to minimize leakage of water. The Kapua area has a'a lava and big pockets of pahoehoe lava. Such conditions will increase the initial capital costs of setting up the aquaculture program, but the expense of grading and using butyl or other forms of plastic covering on the bottom of ponds is not prohibitive. Many scientists argue that, for a commercial scale aquaculture operation, it would be preferable for such lining. The lining can be cleaned and sterilized, which is a periodic requirement for preventing the formation and spread of viruses and other diseases -- a major risk in any aquaculture venture.

A major advantage we found in reviewing the site is the area available. Very few sites in Hawaii exist that will permit multiple aquaculture use and/or users. The more concentrated an area becomes, focusing entirely on aquaculture, the more efficient and productive it will become. First, the infrastructure costs including roads, power, and water can be spread to the various users. Second, staffing, managing, modes of transportation of supplies into the area, distribution of product from the site, marketing, etc. can be shared on a cooperative basis, reducing the costs of each aquaculture use. Third, the problem of not being capable of developing an aquaculture system large enough to take advantage of economies of scale can be alleviated. Most



projects in Hawaii have not become economically viable because the developer did not create a large enough project and marketing program. Fourth, the cost of land to the aquaculture user should be minimized because the subject site is isolated from the major developed areas of Hawaii. Fifth, an opportunity exists to intelligently develop a Master Plan that not only will be attractive and not imperil the environmental, social, and cultural assets of the area, but also will be economically sound. Many aquaculture developers have made no attempt to program aquaculture in a planning mode, but simply locate their facilities on small parcels which meet their needs in locations that are adequate.

We believe a probable minimum of 1,000 acres is available and useable for aquaculture operations, with a probable maxmimum of approximately 1,500 acres.

In general, we can state that the Kapua site encompasses most of the preconditions of economically viable aquaculture uses.

## II. ANALYSIS OF SELECTED SPECIES

The selection of species for aquaculture requires integrating a combination of factors: the physical requirements for culturing the species, (i.e. temperature, salinity, water flow etc.) production costs, facilities, feed, labor, electricity, the value of the product, size of the market, shipment costs, etc. Ultimately, the choice of

species for Kapua will depend on the characteristics of the species and the mode of production. As stated above, the physical environment at Kapua has mixed benefits: the constant warm tropical climate, and clean, unpolluted sea water contribute uniquely to the cultivation of marine species. The sparseness of nutrients in the water may require fertilizer for cultivation of some species, but creates unique opportunities to integrate agriculture and aquaculture, using agricultural waste as alternatives to expensive fertilizer. Because of this, the species we have selected, and the methods of production envisioned, are responsive to the unique conditions of the location. For these reasons, only a limited number of species and certain methods of production can be considered.

Identification of Species. Initially, a large number of species were screened for potential aquaculture activities at Kapua. Due to various factors, including economics of production, facilities cost, requirements for fresh water, limited market, etc., many species were eliminated from the list. In contrast, opportunities to make use of previously used water, to utilize nutrients contained in tail water from other culture systems, and the potential to use manure produced from agriculture activities on site, make it possible to culture some species economically as part of an integrated system which could not be considered for independent culture. Species selected for this project



fall into two categories: 1) Primary Species - those which have primary potential for culture at the site and are considered as primary objectives; and 2) Secondary Species - those whose culture is possible because of opportunities to append their culture to systems that have previously been targeted as Primary Species for culture.

The Primary Species identified for Kapua are - Marine Shrimp (*Penaeus* species), Mahimahi (*Coryphaena*), Blue Green Algae (*Spirulina*), and Brine Shrimp (*Artemia*). The Secondary Species are seaweeds, oysters, clams, mullet and tilapia.

The approaches we have taken to planning these activities have been to present an evaluation of the individual species by discussing the issues that are most relative to production on the site at Kapua, to provide descriptions of the production aspects of culturing the various species, develop an integrated plan for aquaculture at Kapua; and provide a conceptual scheme for land use for the aquaculture activities.

## III. EVALUATION OF AQUACULTURE OPTIONS

The following is an evaluation of the various options for aquaculture at Kapua. For brevity, we have summarized the production costs and yields of each of the individual endeavors involved. Treatment of the details involved in developing the summaries are found in later sections of this report.

As mentioned previously, the real opportunities for cost reduction and profit are developed when the entire site with the combined culture of the species is viewed as one system. In this case requirements for administration, vehicles, high level technical skills, laboratory space - lab equipment, larval feed production, pumps, generators, security, etc. can be integrated and applied to the comprehensive venture. When this is done, the integrated activities can be treated as one large business to calculate the operating costs.

The combined value of all of the products produced on site can be accumulated to calculate the return on operating expenses.

## AN INTEGRATED PLAN FOR KAPUA

In the integration planning of the Primary and Secondary Species, it was apparent that certain items were amenable to reduction in initial construction costs or production costs, or both.

The items consolidated consisted of the following: (See Integration Summary Sheet)

1. Brackish Water Development and Distribution

Instead of each separate aquaculture facility having its own brackish water well, pumps, stand-by emergency generator and electrical system, piping, valving and distribution system, it is proposed that a central water pumping facility be established. This is relatively simple,



as all water flows through each facility in turn with only minor exceptions.(see Figure 1 showing Water Flow Through Facilities),

The integrated Brackish Water System will consist of the following components, designed to provide 6 million gallons per day (24 hours):

| | |
|---|---|
| Reservoir, 300,000 gals. 200' x 40' x 5' | $ 17,000 |
| Wells - 2 at $22,000 | 44,000 |
| Pumps - 3 at $15,000 (2,500 gpm) | 45,000 |
| Pump House/Generator Building 200 ft² x $25 | 5,000 |
| Emergency Generator (2) - 75 kw at $30,000 | 60,000 |
| Fencing 1200' x $15 | 18,000 |
| Main Water Distribution Canal 4000' x $6 | 24,000 |
| Engineering and Construction Management | 19,500 |
| Contingency | 42,500 |
| Brackish Water System Construction TOTAL | $275,000 |

2. Brackish Water Disposal System. It is recommended that final waste water from the aquaculture system be returned to the soil via infiltration ditches rather than via dispersion wells. It has been estimated that the final effluent from the tilapia facility will be collected in approximately 10,000 feet of open ditch. This ditch will serve as the culture trough for seaweed and will clean the water of any contaminants before it seeps into the underlying lava.

The construction cost of this facility will be borne by the seaweed facility and there will be no cost for water disposal to other facilities with the exception of their own pond or raceway drainage channels.

3. Central Laboratory. The planned laboratories will be combined into one, either in the mahimahi or shrimp facility. This will allow for fewer (but better qualified) technicians, more expensive equipment and supplies and the elimination repetitive operations (such as water analysis each facility).

4. Personnel. A top-management team is put in to operate the entire aquaculture effort, consisting of:

(1) General Manager

(1) Assistant General Manager

(1) Technical Coordinator



This allows the individual facilities to relinquish their managers and some of the technicians. Also, due to labor pooling, some laborer reductions are possible.

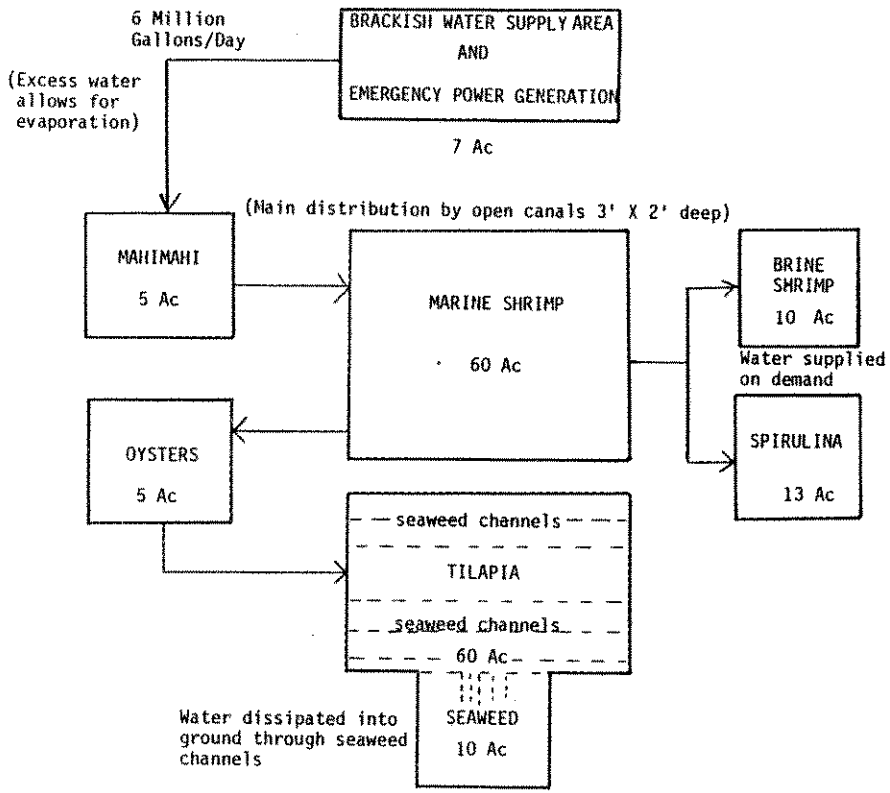
As may be seen from the attached Summary Sheets, Figure 2, integration has allowed reductions in construction from $ 8,549,500 to $ 8,029,800 ; in annual production costs of $ 3,083,450 to $ 2,275,875 while the total value of all production is $ 3,440,087 . The overall return on Production Costs is 1.51 .

The above are the major items that initially appear to give the largest advantages in cost reduction. As the cost estimates are very rough and not meant to be definitive, additional reductions may be possible when the exact criteria for each aquaculture facility is established and the preliminary engineering and economic feasibility studies are conducted.

FIGURE 1

FARMS OF KAPUA

WATER FLOW THROUGH FACILITIES




Summary:

| | # of Acres |
|---|---|
| Brackish Water System | 7 |
| Mahimahi Facility | 5 |
| Shrimp Facility | 60 |
| Oyster Facility | 5 |
| Tilapia Facility | 60 |
| Brine Shrimp Facility | 10 |
| Algae Facility | 13 |
| Aquaculture Total: | 160 |
| Circulation (Roads, etc.) @ 25% | 40 |
| Site Total: | 200 |

| | SHRIMP FACILITY | | MAHIMAHI FACILITY | | [illegible] FACILITY | | [illegible] FACILITY | | OYSTER/CLAM FACILITY | | SEAWEED FACILITY | | BRACKISH WATER FACILITY | | MANAGEMENT PERSONNEL | | OVERALL SUMMARY | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED | NON-INTEGRATED | INTEGRATED |
| 1. Facility Construction Costs | 6,240,000 | 5,879,000 | 550,000 | 481,500 | 224,000 | 198,000 | 509,500 | 471,000 | 801,000 | 606,300 | 125,000 | 119,000 | NA | 275,000 | ----- | ----- | 8,549,500 | 8,029,800 | | |
| 2. Annual Production Costs | 1,723,950 | 1,006,375 | 526,000 | 379,500 | 149,000 | 105,000 | 214,500 | 175,500 | 393,000 | 258,500 | 77,000 | 58,000 | NA | 163,000 | ----- | 130,000 | 3,083,450 | 2,275,875 | | |
| 3. Annual Value of Crop | 2,249,337 | 2,249,337 | 700,000 | 700,000 | 15,750 | 15,750 | 88,000 | 88,000 | 306,000 | 306,000 | 81,000 | 81,000 | NA | ---- | ----- | ----- | 3,440,087 | 3,440,087 | | |
| 4. Construction Costs Savings | ---- | 361,000 | ---- | 168,500 | ----- | 26,000 | ----- | 38,500 | ----- | 194,700 | ----- | 6,000 | ----- | ------ | ----- | ----- | --- | 519,700 | | |
| 5. Production Cost Savings | ---- | 727,575 | ---- | 146,500 | ----- | 44,000 | ----- | 39,000 | ------ | 134,500 | ----- | 19,000 | ----- | ------ | ----- | ----- | --- | 1,110,575 | | |
| 6. Return on Operating Expenses | 1.30 | 2.24 | 1.33 | 1.84 | 0.11 | 0.15 | 0.41 | 0.50 | 0.78 | 1.18 | 1.05 | 1.40 | | | | | 1.12 | 1.51 | | |
| 7. | | | | | Note: "Held in abeyance pending further analysis" | | | | | | | | | | | | | | | |

8. Notes

1. Reduce Construction & Equipment duplication:
   $361,000
2. Reduce Salaries by combining certain supervisory personnel. Integrating feeds.
   $727,575

1. Reduce from construction: Water Supply System $168,500
2. Reduce Salaries:
   Gen. Mgr.(1) $30,000
   Hatch. Tech.(1) 15,000
   Laborer (1) 12,000
   57,000
   Pumping Costs 89,500
   146,500

Remove from construction:
Storage $1,000
Lab 10,000
Well 5,000
Pump 8,000
$26,000

Reduce Salaries:
Mgr. (1) $25,000
Techn. (1) 15,000
Electricity 4,000
$44,000

1. Remove:
   Water Supply $35,000
   Energy 3,500
   $38,500
2. Reduce Salaries:
   Mgr. (1) $20,000
   Electricity 10,000
   Truck 4,000
   Contingency 5,000
   $39,000

Remove from construction costs:
Water System $160,000
Hatchery (due to consolidation) 18,200
1 Algal Tank & plumbing 16,000
$194,700

Reduce Salaries:
Gen. Mgr. (1) 30,000
Techn. (1) 15,000
Pumping Costs 89,500
$134,500

1. Remove from construction:
   Laboratory $5,000
   Contingency 1,000
   $6,000
2. Manager 5,000
   Labor (1) 12,000
   Contingency 2,000
   $19,000

Add to construction costs:
Pumping & General Facility $275,000

Add to Production costs:
Personnel Operators (2) 25,000
Pump Costs 110,000
Gen. Ops. 10,000
Fuel 5,000
Maint. 13,000
$163,000

1. Add to Salaries:
   General Mgr. (1) $50,000
   Asst. Mgr. (1) 35,000
   Tech. Coor. (1) 45,000
   $130,000

EGRATION SUMMARY SHEET

FIGURE 2

## IV. MARINE SHRIMP FARMING

### Background

Shrimp farming is practiced to various degrees in many parts of the world. Shrimp farming uses the hatchery techniques developed by the Japanese more than 20 years ago. Recently the breeding of shrimp in captivity has made it possible to extend shrimp farming to areas of the world where suitable conditions are encountered.

Shrimp is the most valuable seafood commodity in the United States. Approximately 500 million pounds of shrimp are sold in the U.S. annually, more than 50% of which is supplied by imports. Demand for shrimp, as indicated by price, has risen approximately 4-fold since 1967. Natural stocks are unlikely to provide for future demands. As a result, a major opportunity for a shrimp aquaculture industry exists. The problem is to find locations in the United States where shrimp farming can be carried out at a scale that will allow a significant profit.

The requirements for shrimp farming are an abundance of warm, unpolluted seawater, available land, and breeding stock of suitable shrimp species. There are few locations in the United States where these criteria are met (3). Hawaii is one of the few locations in the United States where land, climate and enviromental conditions present an optimistic outlook for a large-scale, year-round shrimp



aquaculture industry. The climatic conditions at Kapua are among the best in Hawaii for shrimp farming.

Since June 1976, the State of Hawaii Aquaculture Planning Program, under the auspices of the State Department of Planning and Economic Development and in cooperation with the University of Hawaii Sea Grant College Program, has been investigating the economic potential of aquaculture for the State of Hawaii. Of the more than 70 species evaluated, marine shrimp has been shown to have the largest, most stable, and well-defined market. If a successful and economically viable culture can be demonstrated in Hawaii, it will become a significant new industry for the State.

The market price for shrimp, after reaching a low of less than $3.00 per pound in 1980, rose to more than $6,00 per pound wholesale during the winters of 1979 and 1982. The future market for shrimp is very strong.

### DEVELOPMENT OF A SHRIMP FARM AT KAPUA

Shrimp farming involves breeding and spawning shrimp in captivity, rearing larvae to a size suitable for stocking into a nursery system, growing post-larval shrimp to a size which allows them to be stocked into a final production system, (i.e., ponds or raceways); and lastly, rearing the juvenile shirmp to a marketable size (see Figures 4 and 5 ).

FIGURE 3

**Prices**

Unlike Japan, the United States shrimp prices continued moving upward during February and March 1981. For example, the 26/30 count Chicago wholesale price quotes for Gulf brown shrimp were $4.60 to $4.75 per pound in early

**UNITED STATES SHRIMP PRICES**

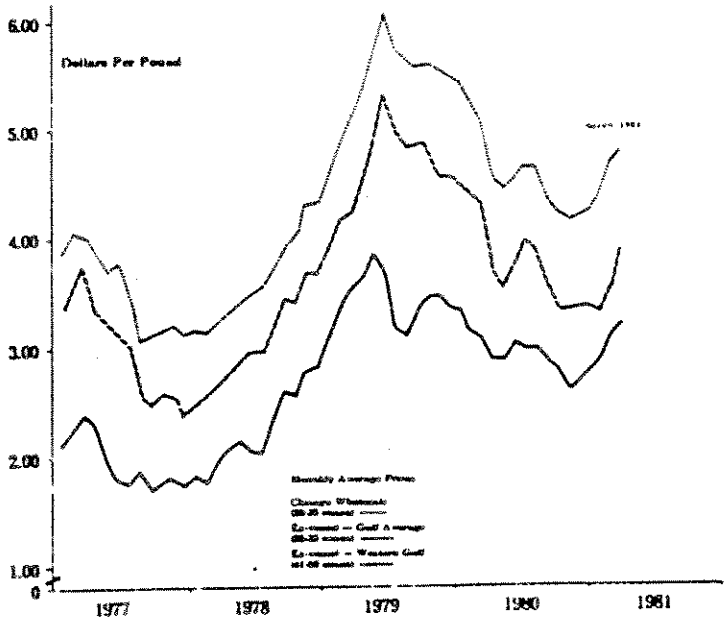
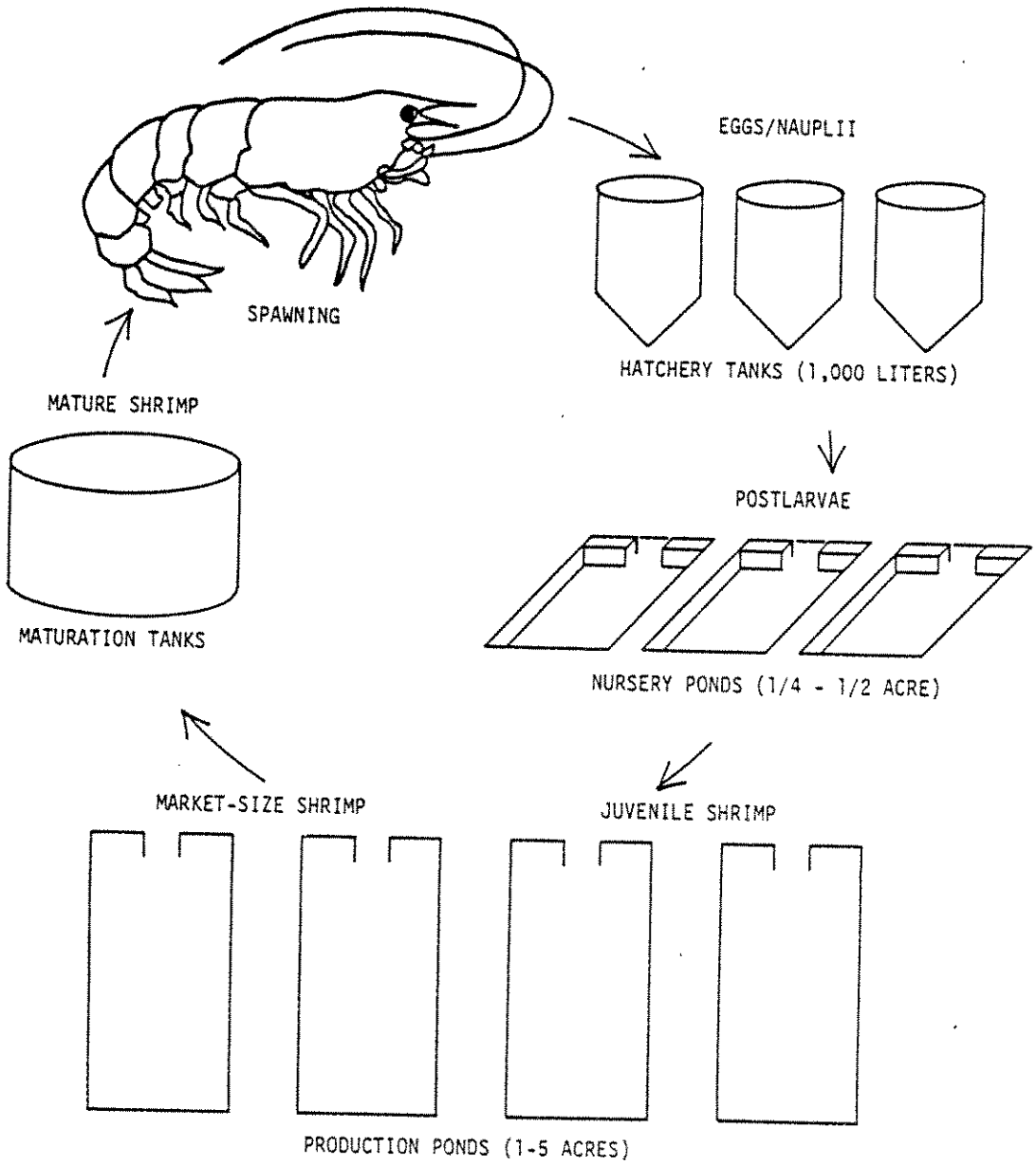


FIGURE 4

STEPS IN THE SHRIMP PRODUCTION CYCLE



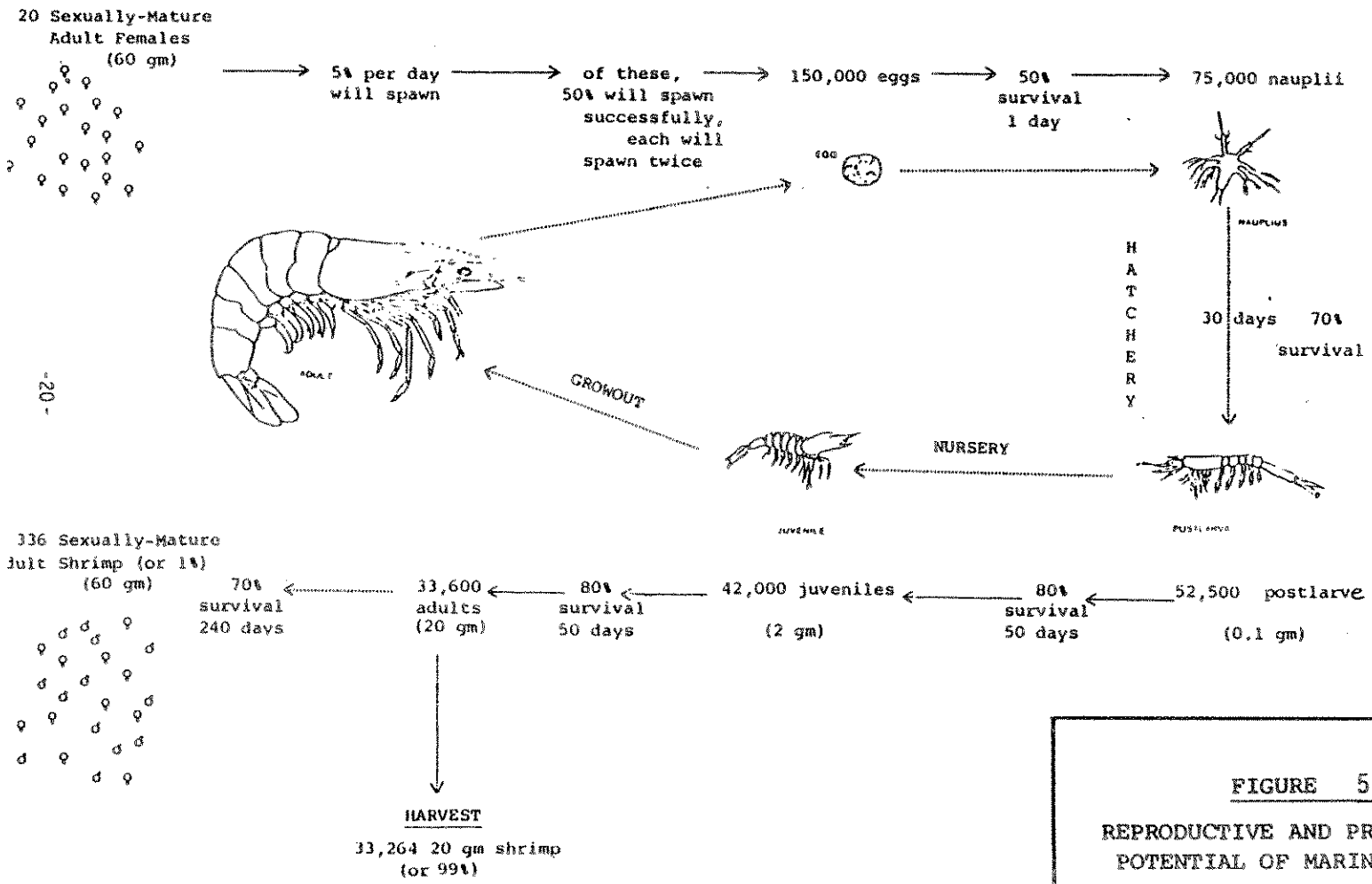



FIGURE 5

REPRODUCTIVE AND PRODUCTION POTENTIAL OF MARINE SHRIMP

Operating the breeding facility and hatchery requires the services of highly trained technically skilled individuals, while the nursery and grow-out phases could be handled by technicians who with proper supervision may only require a few months of training to be efficient on the job.

Options for farming shrimp include intensive and extensive systems, involving, respectively, more or less managerial inputs. For the shrimp farm at Kapua, the following systems are developed, compared and evaluated:

A. Extensive Culture System Assumptions (P. vannamei, P. stylirostris):

1. 20 acres of production ponds (of 1 acre each) can produce:
2. 60,000 lbs. whole shrimp/year (3000 lbs./acre x 20 acre)
3. At a food conversion ratio of 3:1, then 60,000 lbs. of shrimp/year require 180,000 lbs of feed.
4. At $5.00/lb. market price tails per harvest = $3,100 x 55 harvests = $170,500/year.

If 60,000 lbs. shrimp (whole) per 20 acres/year is possible, 62% tail recovery = 37,200 lbs of tails that can be produced. At $5.00/lb, 37,200 lbs = $186,000/20 acres/year.

At 45 tails/lb this = 1,674,000 shrimp harvested/year. If mortality is 20% in ponds, then 2,092,500 shrimp/year must be stocked.



If 20 one-acre ponds are harvested 2.75 times/year, then 55 ponds can be harvested/year (approx. ± 1 per week).

Each one acre pond can produce 1,860 lbs of tails/yr (45 tails/lb) or 620 lbs of tails (45/lb) every four months.

620 lbs of tails (45/lb)/pond/crop = 27,900 shrimp or @ a 20% mortality rate 34,875 shrimp stocked/pond (1 acre) 55 times/year or 4.58 times/month (approx. 1 per week).

B. Intensive Culture System Assumptions (P. vannamei, P. stylirostris):

1. 1 acre of production raceways can produce:
2. 60,000 lbs whole shrimp/year (20,000 lbs/acre x 2.75 crop/year)
3. At a food conversion ratio of 3:1, then 60,000 lbs of shrimp/year require 180,000 lbs of feed.
4. At $5.00/lb market price x 635 lbs tails per harvest x $3,175 x 60 harvest = $190,5000/year.

If 60,000 lbs shrimp (whole)/acres/year is possible, then 62% tail recovery = 38,440 lbs of tails that can be produced. 38,440 lbs x $5.00/lb = $192,200/year/acre.

Therefore, at 45 tails/lb this = 1,729,800 shrimp harvested/year.

If mortality is 30% in raceways, then 2,471,143 shrimp/year must be stocked.

If 22 raceways are harvested 2.75 times/year, then 60.5 raceways can be harvested/year (approx. 1 per week).

Each 2,000 ft.$^2$ raceways can produce 1,747 lbs. tails (45 tails/lb/ year) or 635 lbs tails (45/lb) every 4 months)

635 lbs. tails (45/lb) raceway/crop = 28,587 shrimp, or at 30%, 40,839 shrimp stocked/raceway (60 times/year (± 1 per week)

C. Intensive Culture System (Taiwanese Tiger shrimp, P. monodon):

1. 20 acres of production ponds (of 0.5 acre each) an produce:

2. 315,040 lbs whole shrimp/year (7876 lbs/0.5 acre x 40 units)

3. At a food conversion ratio of 2:1, then 315,040 lbs of shrimp/year require 630,080 lbs of feed.

4. At $7.50/lb market price x 1,403 lbs of tails per harvest = $7,015 x 139 harvest = $1,462,627.50/year

If 315,040 lbs shrimp (whole/20 acres/year is possible, then 62% tail recovery = 195,325 lbs of tails that can be produced. At $7.50/lb, 195,325 lbs = $1,464,937.50/20 acres/year.

At 45 tails/lb this = 8,789,625 shrimp harvested/year.

If mortality is 30% in ponds, then 12,556,607 shrimp/year must be stocked.

If 40 one-half acre ponds are harvested 3.48 times/year, then ± 139 ponds can be harvested/year (approx. 2.67 per week).

Each one-half acre pond can produce 4,883 lbs of tails/year @ 45 tails/lb) or, 1,403 lbs. of tails (45/lb) every 105 days.

1,403 lbs of tails (45/lb.)/pond/crop = 63,142.2 shrimp or @ a 30% mortality rate, 90,203 shrimp stocked/pond (0.5 acre) 139 times/year or 11.58 times/month (approx. ± 2/week).



D. Intensive Culture System assumptions (Kunuma - ebi, P. japonicus):

1. 1 acre of production raceways (0.25 each acre) can produce 20,000 lbs of whole shrimp/year

2. At a food conversion ratio of 2.5:1, then 50,000 pounds of feed are required.

3. At $20.00/lb market price x 20,000 pounds of whole shrimp = $400,000 per year.

If 20,000 lbs shrimp (whole/acre of 0.05 ac. raceways) is possible, then at 28/lb, 560,000 shrimp are harvested each year.

Assuming 30% mortality in raceways, then 800,000 shrimp/year must be stocked.

Grow-out summary of shrimp stocks required:

| Growout System | # Shrimp Stocked/Year |
|---|---|
| Extensive Pond Culture (P. vannamei/P. stylirostris) | 1,674,000 |
| Intensive Racway Culture (P. vannamei/P. stylirostris) | 1,096,071 |
| (P. japonicus) | 800,000 |
| Intensive Pond Culture (P. monodon) | 8,789,625 |
| Total stocks required | 12,359,696 |

Nursery

If, 12,359,696 shrimp/year are stocked into these systems, then at a 20% mortality rate 15,449,620 shrimp must be stocked into the nursery per year.

Each nursery crop requires about 60 days (including 10 days for maintenance). For this reason, the total yearly chrimp to be stocked into the nursery is divided by six. Therefore 2,574,936 post-larval shrimp must be produced for the nursery by the hatchery six times per year.

0.25 Acre Concrete Pond

With an 80% yield stocked at a density of 200,000/0.25 acre concrete nursery pond, this requires 13 (true 12.04) ponds for the nursery system.

Each pond can produce 1,200,000 shrimp/year (6 harvests x stocking density of 200,000). Therefore, 13 ponds can produce 15,600,000 shrimp/ year with 1.2 ponds providing 240,000 shrimp/week (233,409 shrimp required/week).



IV. Hatchery

If 14,449,620 post-larval shrimp are stocked into the nursery/year, then the hatchery must stock (@ a 50% survival rate) 28,899,240 nauplii/year or 2,908,270/month,

If 400,000 Nauplii can be put in one 4000 liter tank (100 Nauplii/l) Then: 8 (True = 6.02) x 4000 l tanks could service the entire operation.

8 x 4000 liter algae tanks could feed those hatchery tanks at a density of 100,000 cells/ml./day, and 8 x 100 liter Artemia tanks could provide enough brine shrimp to feed the latter stages of larval development.

If 320 imported breeders are needed initially for the broodstock facility, then at a 30% mortality in transit rate, 458 (true 457.14) breeders are required.

## SHRIMP FARM CONSTRUCTION COSTS

### I. Grow-out Facilities

| | | Units | Size | Cost/Unit | Total |
|---|---|---|---|---|---|
| | **Extensive System** | | | | |
| a. | Ponds (on lava) | 20 | 1 acre | 50,000 | 1,000,000 |
| b. | Pumps | 1 | 1200 gpm | 12,000 | 12,000 |
| c. | Well (saltwater) | 1 | 12" x 50' | 500/ft. | 25,000 |
| d. | Well (dispersion) | 1 | 12" x 50' | 500/ft. | 25,000 |
| e. | Plumbing | 20 | -- | 5,000/pond | 100,000 |
| f. | Building | 1 | 40' x 40' | 20/ft² | 32,000 |
| | | | Sub Total | | 1,194,000 |
| | **Intensive System** | | | | |
| a. | Raceways | 22 | 20' x 100' x 3' | 18,000 | 396,000 |
| b. | Pumps | 1 | 1200 gpm | 12,000 | 12,000 |
| c. | SME preparation | 1 | 44,000 ft² | 30,000/acre | 30,000 |
| d. | Wells (saltwater) | 1 | 12" x 50' | 500/ft | 25,000 |
| e. | Wells (dispersion) | 1 | 12" x 50' | 500/ft | 25,000 |
| f. | Plumbing | 22 | -- | 3,000/raceway | 66,000 |
| | | | Sub Total | | 554,000 |
| | **Taiwanese System** | | | | |
| a. | Ponds (on lava) | 40 | 0.5 acre | 51,000 | 2,040,000 |
| b. | Pumps | 1 | 1200 gpm | 12,000 | 12,000 |
| c. | Well (saltwater) | 1 | 12" x 50' | 500/ft, | 25,000 |
| d. | Well (dispersion) | 1 | 12" x 50' | 500/ft | 25,000 |
| e. | Plumbing | 40 | -- | 5,000/pond | 200,000 |
| | | | Sub Total | | 2,302,000 |



### II. Nursery Facilities

| | | | | |
|---|---|---|---|---|
| Nursery Ponds | 13 | 0.25 acre | 30,000 | 390,000 |
| Plumbing Ponds | 13 | -- | 3,000/pond | 39,000 |
| Air Blower | 2 | -- | 1,200 | 2,400 |
| Fiberglass Tanks | 10 | 20' Diameter | 3,000 | 30,000 |
| Plumbing (Tanks) | 10 | -- | 100/Tank | 1,000 |
| Site Preparation (Tanks) | 1 | 0.3 acre | 30,00/acre | 10,000 |
| | | Sub Total | | 472,400 |

### III. Hatchery Facilities

| | Units | Size | Cost/Unit | Total |
|---|---|---|---|---|
| Building | 1 | 50' x 100' | 20/ft² | 100,000 |
| Larval rearing tanks | 8 | 4000 l | 1200 | 9,600 |
| Algae tanks | 8 | 4000 l | 1200 | 9,600 |
| Artemia tanks | 8 | 100 l | 200 | 1,600 |
| Plumbing | -- | -- | 4000 | 4,000 |
| Air Blower | 2 | -- | 1200 | 2,400 |
| Misc. Equipment | -- | -- | -- | 6,000 |
| Electrical Installation | -- | -- | 4000 | 4,000 |
| | | Sub Total | | 137,200 |

Broodstock Management Facility

| | | | | |
|---|---|---|---|---|
| Building | 1 | 50' x 50' | 20/ft² | 50,000 |
| Broodstock Tanks | 4 | 16' diameter | 500 | 2,000 |
| Air Blower | 1 | -- | 1200 | 1,200 |
| Plumbing | -- | -- | 4000 | 4,000 |
| Electrical Installation | -- | -- | 4000 | 4,000 |
| Imported Broodstock | 458 | 60g | 15.00 | 6,800 |
| | | Sub Total | | $68,000 |

Construction Cost Summary

| | |
|---|---|
| Production Facilties | |
| Extensive | $1,194,000 |
| Intensive (*P. japonicus*) | 554,000 |
| Intensive (*P. Monodon*) | 2,302,000 |
| Nursery Facilities | 472,400 |
| Hatchery Facilities | 137,200 |
| Broodstock Management Facility | 68,000 |
| Engineering and construction | 472,000 |
| Management | $1,040,400 |
| Total Construction Cost | $6,240,000 |



PRODUCTION COSTS

I. Labor Requirements for Shrimp Farm

| | Annual Costs |
|---|---|
| **A. Administrative** | |
| 1 General Manager | $40,000 |
| **B. Broodstock and Hatchery** | |
| 1 Manager | $30,000 |
| 1 Broodstock Technician | $15,000 |
| 3 Hatchery Technicians | 45,000 |
| **C. Grow-out** | |
| 1 Manager | $32,000 |
| 1 Production Technician | 18,000 |
| 4 Technicians | 60,000 |
| **D. Maintenance** | |
| 1 Maintenance Specialist | $20,000/yr |

II. Technicians Required

| System | Acres | @ $12,000/yr Technicians |
|---|---|---|
| Raceway | 1 | 5 |
| 1 Acre ponds | 20 | 3 |
| 1/2 Acre ponds | 20 | 4 |

III. Feed Costs

The cost of feed is dependent on three factors:

1. The species grown
2. Mode of production selected.
3. The food conversion ratio in that system.

The option of using manure as a fertilizer eliminates totally the use of feed, ultimate production is limited to approximately 3,500 lbs/acre/year.

In contrast, raceway production of the same shrimp can yield up to 80,000 lbs/acre/year. However, approximately 3 lbs of feed per 1 lb of shrimp are required.

Each species has differing nutritional requirements in the feed. The provision for protein in feeds is the most costly item in feed formulation. The cost of feed delivered in Hawaii may vary from $0.25/lb for the raceway production of Mexican white shrimp which require approximately 20% protein, to as much as $2.00/lb. for feeding the Kuruma prawn which requires up to 60% protein in its diet.

As mentioned above, the amount of feed depends on the system, for some species can be produced equally well with feed or just fertilizer.

The term "intensive" refers to production in highly managed production using feed, while "extensive" refers to production in a more natural environment in large ponds using manure as an alternative to more costly feeds.

Feed Conversion

Feed conversion refers to the number of pounds of dry weight of feed required to produce harvestable wet weight of shrimp. (e.g. 3:1)

It should be noted that in cases where only shrimp tails are sold, only about 62% of the product is marketed. However, feed conversion is always expressed with the number of whole products harvested.



Feed Costs

In general, the per pound cost of feed delivered in Hawaii can be estimated on the basis of % protein contained in the feed. For every % protein, the per ton cost of feed delivered in Hawaii can be calculated by multiplying by $20. For example, a feed containing 20% protein would cost $400/ton or 20¢/pound.

At present, shrimp feed is not manufactured in Hawaii, thus costs for feeds with proprietary formulations may be inflated many times more than their actual worth, with shipping fees contributing to the cost of feed.

Work in progress at the Oceanic Institute and at the University of Hawaii is expected to produce cost effective shrimp feeds in the near future; thus feed costs to be used in estimating production costs at Kapua will be based on the estimated cost of feed as a result of work carried out in Hawaii during the next year.

## SPECIES FEED REQUIREMENTS AND COSTS

| System | *P. japonicus* Intensive | *P. monodon* Intensive | *P. stylirostris** *P. vannamei* Intensive | Extensive |
|---|---|---|---|---|
| Production Unit Size | 0.05 Acre | 0.5 Acre | 0.05 Acre | 1 Acre |
| Area (total acres) | 1 Acre | 20 Acres | 1 Acre | 20 Acres |
| Production/Acre | 20,000 lbs. | 15,000 lbs. | 60,000 lbs | 3,000 lb |
| Food Conversion Ratio | 2.5:1 | 2:1 | 2.5:1 | -- |
| Feed Costs/lb. | $1.25 | $0.60 | $0.60 | $0.05 |
| Total Feed Costs | $62,500 | $378,000 | $90,000 | $3,000 |

* Species Interchangeable depending on the time of the production year.

** This represents the cost/pound of production to obtaining, transporting and distributing manure.

### IV Fertilizer

Due to the relatively pristine environment of the Kapua area and the cleanliness of the waters which will supply the operation, it will be necessary to add fertilizer containing phosphate and nitrate to the one acre and one-half acre ponds to improve the natural productivity of those ponds.

By doing so, an enhanced production of aquatic organisms (bacteria, photoplankton, zooplankton, etc.) will provide a supplementary diet for the shrimp thus, improving the food conversion factor. In certain cases manure can totally substitute for fertilizer.



### Fertilizer Costs

Assumptions: $10/Acre/Crop $10 x # Acres x # Harvests
30 lbs/acre/crop

| | P. Monodon (0.5 Acre) | P. vannamei P. stylirostris (1.0 Acre) |
|---|---|---|
| Cost/Crop/AC | $ 10 | $ 10 |
| # Crops/yr | 70 | 55 |
| Cost/yr/AC | 700 | 550 |

### Power and Fuel Costs

Fuel costs represent the alternative of using available resources of commercial electricity or for cost of own generators for:

Pumping Water

Providing electricity for operations, administration, breeding, hatchery

Pumping Air for Intensive Systems

Fuel/Power = $75,000

### Misc. Administration (operating costs)

| | |
|---|---|
| Communications and Office Supplies | $ 4,000/yr |
| Truck lease (2) | 6,000/mo |
| Freshwater | 1,000/yr |
| | $11,000 |

## Summary of Labor Costs

4 Separate Systems

| | Japonicus | Monodon | Vannamei or Stylirostris Intensive | Extensive |
|---|---|---|---|---|
| ADMINISTRATION | | | | |
| 1 General Mgr. | | 40,000 | 40,000 | 40,000 |
| BROODSTOCK/HATCHERY | | | | |
| 1 Manager | 30,000 | 30,000 | 30,000 | 30,000 |
| 1 Broodstock Tech. | 15,000 | 15,000 | 15,000 | 15,000 |
| 3 Hatchery Tech. | 45,000 | 45,000 | 45,000 | 45,000 |
| Sub Total | 90,000 | 130,000 | 130,000 | 130,000 |
| MAINTENANCE | | | | |
| 1 Maint. | 20,000 | 20,000 | 20,000 | 20,000 |
| GROW-OUT | | | | |
| 1 Manager | 32,000 | 32,000 | 32,000 | 32,000 |
| Technicians | (5) 60,000 | (4) 48,000 | (5) 60,000 | (3) 36,000 |
| Sub Total | 92,000 | 80,000 | 92,000 | 68,000 |
| Total | 202,000 | 230,000 | 242,000 | 218,000 |



## Summary of Annual Nursery Grow-Out Costs

Four Separate Systems

| | Japonicus | Monodon | Stylirostris, Vanname: Intensive | Extensive |
|---|---|---|---|---|
| Salaries | $202,000 | $230,000 | $242,000 | $218,000 |
| Feed | 62,500 | 378,000 | 90,000 | 3,000 |
| Fertilizers | -- | 700 | -- | 550 |
| Power/Fuel | 75,000 | 75,000 | 75,000 | 30,000 |
| Artemia | 4,800 | 4,800 | 4,800 | 4,800 |
| Misc. Admin. | 11,000 | 11,000 | 11,000 | 11,000 |
| Total | $344,300 | $699,500 | $422,800 | $267,350 |

## Summary Annual Broodstock/Hatchery Operating Costs

(Same For All Four Systems)

| | |
|---|---|
| Salaries | $130,000 |
| Artemia Costs | 4,800 |
| Utilities | 7,500 |
| Miscellaneous Administatration | 3,000 |
| Miscellaneous Supplies | 3,000 |
| | $148,300 |

## Annual Shrimp Production and Value

| | Japonicus | Monodon | Vannamei or Intensive | Stylirostris Extensive |
|---|---|---|---|---|
| Total lbs. produced/yr | 20,000 | 315,040 | 60,000 | 60,000 |
| % recovery | 100% | 62% | 62% | 62% |
| lbs. produced | 20,000 | 195,325 | 38,440 | 38,440 |
| Value/lb. | $20.00 | $7.50 | $5.00 | $5.00 |
| Value of Product | 400,000 | 1,464,937 | 192,200 | 192,200 |

Comparing costs for each of the four shrimp production systems vs. the total value of product gives the following:

| | | | | |
|---|---|---|---|---|
| Total Production Costs | 344,300 | 699,500 | 422,800 | 267,350 |
| vs | | | | |
| Total Value of Product | 400,000 | 1,464,937 | 192,200 | 192,200 |
| Ratio of Product Value to Production Costs | 1.16 | 2.09 | 0.45 | 0.72 |



## Recommended Shrimp Production Mix

From this analysis it is obvious that the best return on a combined production system would be production as follows:

| | | |
|---|---|---|
| A. | Hatchery (for all systems) | $248,300 |
| B. | Japonicus Intensive (Raceways) | 344,300 |
| C. | Monodon in one-half AC ponds | 699,500 |
| D. | Stylirostris/Vanamei in 1 Ac. ponds | 267,350 |
| | Total Annual Operating Costs | $1,559,450 |
| | Total Annual Value all Shrimp Production | $2,249,337 |
| | Total Shrimp Farm Construction Costs | $6,240,000 |

## V. MAHIMAHI PRODUCTION

### Introduction

Commercial production of mahimahi has not yet been achieved. However, advances in experimental programs have provided data which suggest that commercial production may be feasible. The aspect of the program defined below is based on technology developed at the Oceanic Institute in a program supported by Sea Grant (with federal government funds) during the period 1978 to 1980.

Mahimahi has been selected as a primary species for Kapua because of the special circumstances encountered, relative to water quality, temperature and the need to select species whose culture can be combined into an integrated system that makes optimal use of the available resources. Since mahimahi requires very clean water and a reasonably rapid flow, the systems used to cultivate the fish yield very high quality water which may be used to cultivate other species.

Since shrimp culture is one of the most promising aquaculture opportunities, and pumping costs are a significant part of the production costs in the Kapua shrimp production program, we have estimated the sea water requirements for the shrimp farm and sized a mahimahi production system to make primary use of the water that will then supply the shrimp activities. The water passes from



the pump through the mahimahi production facility and on to the shrimp production units and then on to other uses (see Figure 1).

### DEVELOPMENT OF MAHIMAHI CULTURE TECHNOLOGY

#### History

Development of the dolphin fish, or mahimahi (*Coryphaena* sp.) as an aquacultural species began in a program at the Oceanic Institute in Hawaii to study the cultivation of fish in ocean cages. However, mahimahi subsequently evolved into a very exciting aquacultural species with possibilities extending far beyond its original purpose. Since the capture and successful acclimation of the first pair of wild fish to culture conditions in 1979, considerable progress has been made in developing mahimahi for aquaculture.

#### Evolution of Culture Technology

Initial success in the capture and controlled spawning of mahimahi allowed preliminary larval rearing studies, and techniques were developed to produce viable spawnings with minimal reliance on physical manipulation. These trials were essential to understanding the particular needs of mahimahi larvae for food, water quality, and other rearing conditions. The preliminary trials contributed valuable data to subsequent successful rearing trials. Early in

1980, a small group of mahimahi was reared completely through the larval stage to adulthood.

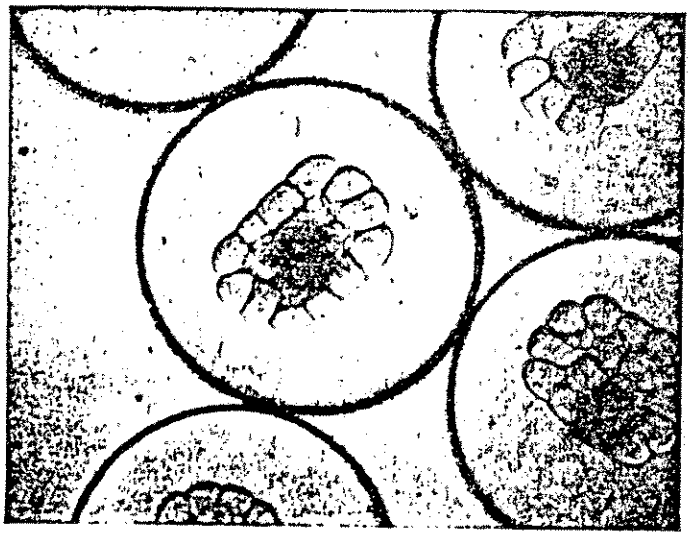
First generation fish grew rapidly in small circular tanks, and provided invaluable preliminary data on growth rates, food conversion ratios, maturation, and possible production rates. Juvenile fish, 40 days old (1" long), grew to almost three pounds (20" long) in only 90 days. These fish were fed an average of nine pounds of feed each to reach this weight, thus giving a food conversion ratio equal to 3:1 (wet weight of feed required to wet weight of fish produced). However, using dry pelletized feed, this conversion ratio approaches 2:1. At the age of only five months, these first generation fish reached sexual maturity. With their spawning, the life cycle of mahimahi was closed and thus effectively controlled.

The offspring of the first generation laboratory-reared mahimahi were also cultured. Significant improvements in larval survival rates were achieved, and the resulting juvenile fish (second generation) matched the growth and food conversion rates of their parents.

The second generation fish also reached sexual maturity during their fifth and sixth months, and their spawning yielded viable third generation larvae.

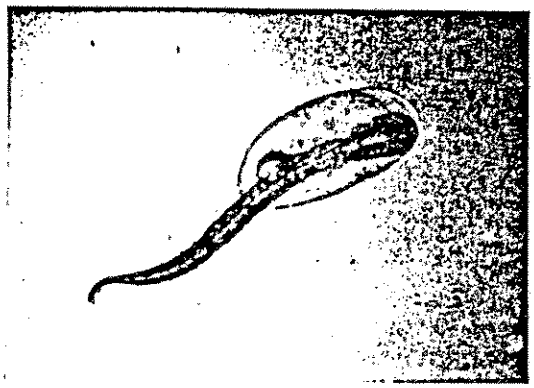
Thus, considerable progress has been made in a short period with mahimahi, and results indicate that the

FIGURE 6



First 40 days of growth

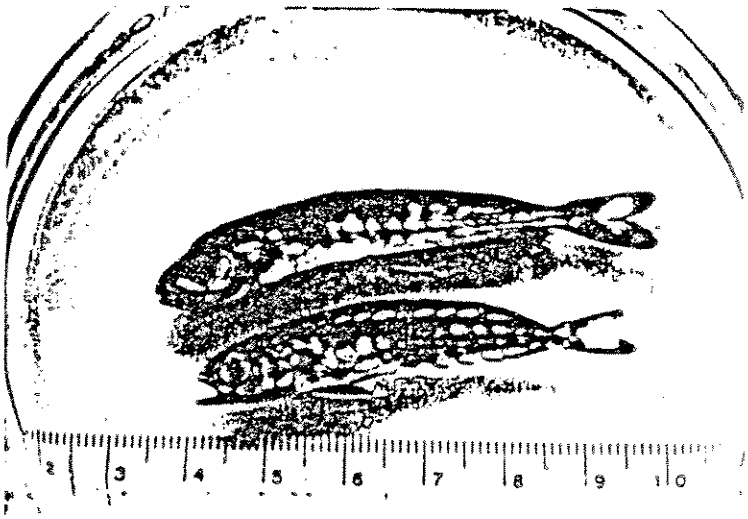
Mahimahi eggs begin dividing 2 hours after fertilization.



Free-swimming larvae emerge 40 days after fertilization.

Juvenile mahimahi at 30 days.

Juvenile mahimahi at 40 days (length in centimeters).



excellent aquacultural properties of this fish make it commercially feasible.

### Commercial Qualities of Mahimahi

As a candidate for aquaculture, mahimahi has demonstrated a number of advantages that favor commercial development -- fast growth, efficient feed conversion, wide temperature and salinity tolerances, and an extended spawning season. Growth rates of mahimahi in the wild have been reported to be as high as 1.1 pounds per month. Growth rates of captive mahimahi are even greater; oceanarium fish reach growth rates of 3.3 pounds per month. Adult fish are tolerant of temperature ranges of 15° to 29°C (59°F to 84°F), and salinity ranges of 16 to 34 parts per thousand. The spawning season for mahimahi in warm oceans is prolonged (9 months) and sexual maturity occurs very early in life (5 months).

These biological factors, together with mahimahi's excellent palatability and high market value, all combine to make this fish a very promising species for commercial development.

## MARKET POTENTIAL

### Local Market Potential

Mahimahi is widely recognized as a valuable seafood with significant markets in Hawaii as well as other areas of the world. Currently, the demand for mahimahi in the state



of Hawaii alone is over 6,000,000 pounds per year, and continues to rise. Of this total, only about 3% is caught fresh by local fishermen, due to its seasonality, while the remainder must be imported as frozen fillets from foreign countries. Increasing demand for this premium fish by both island residents and the large tourist industry has resulted in a consistently high market value. Thus, the market potential for locally-produced fresh mahimahi is considered excellent. Furthermore, since the west coast is only hours away from Hawaii by air, it may constitute additional markets for fresh mahimahi.

### Salability

Commercial farm production of mahimahi will prove superior to either the fresh, wild-caught, or the imported frozen fillets. This can be accomplished through controlled quality, and a continuous, reliable supply to the consumer. Marketing and taste tests have already been carried out at several major hotels in Honolulu. The results have demonstrated that the quality of cultivated mahimahi is clearly equal or superior to that of wild-caught animals in taste, texture, and amount of usable meat. Wild-caught mahimahi are typically very lean, compared to cultured mahimahi. In addition, the yield of fillet to the total weight of cultured mahimahi is up to 60%, as compared to 40% to 50% in wild-caught fish.

At present, consumers are accustomed to large mahimahi fillets because traditionally, only large fillets have been available. The farm-fresh product could either be prepared and served whole at one to two pounds, (similar to baked or stuffed trout or young salmon), or be served in the traditional fillet form. Thus, the market potential in Hawaii for farm fresh mahimahi looks extremely attractive.

MAHIMAHI REARING

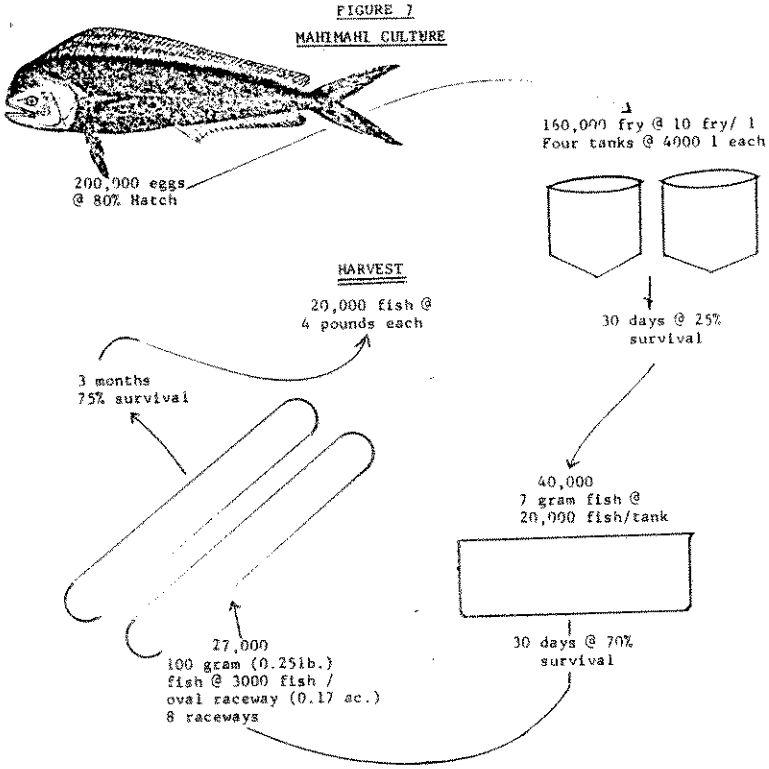
The process of rearing mahimahi involves the following steps: 1) obtaining breeding stocks; 2) establishing them in captivity; 3) spawning the fish; 4) collecting the eggs; 5) carrying out larval rearing; and 6) growing the fish to market size. The approach we have taken envisions a market for a 4-5 pound fish which is produced in three steps: hatchery, nursery, and production units. The system we propose will involve maintaining broodstock in holding tanks, collecting eggs, hatching eggs and rearing larvae in 4,000 liter hatching tanks, rearing small fish in 20 feet diameter (942 $ft^3$ or 30 ton) tanks. The fish are raised to 1/4 pound or 100 grams and then stocked into 1/6 acre production tanks.

The water requirements for the shrimp activities with excess pumping capacity to handle emergencies are about 5 million gallons per day or about 4,000 gallons per minute. Thus we have designed a mahimahi production system to use 4,000 gallons per minute of sea water.



FIGURE 7

MAHIMAHI CULTURE



A 1/6 acre oval production tank for the mahimahi rearing is approximately 120' x 60' x 8' deep, with a water volume of 275,000 gallons. Using 8 tanks (with 6 in production at any one time), and with the recommended water exchange rate of 300% per day (24 hours), will require 4,950,000 gallons per day. This will also fulfill the shrimp farm requirement.

It should be noted that, although water depth in the tank is 6 feet for technical reasons, the fish effectively use only the top 3 feet of the tanks, or approximately 16,500 cubic feet per tank.

PRODUCTION SYSTEM

To estimate the production capacity, we multiply 132,000 cu. ft. of water, .37 pounds of fish per cubic foot and get approximately 50,000 pounds of fish per crop from an acre of production tanks, with a weight of 4 pounds per fish. This is approximately 12,000 fish. Knowing this information, it is possible to define the number and size of the units in the system, and estimate the construction and operating costs.

Constructing tanks of the size estimated above, which are approximately 1/6 of a surface acre, each tank would yield 2,000 fish every 3 months. Assuming about 70% survival, about 3,000 fish will be stocked into each tank every 3 months.



NURSERY SYSTEM

Prior to being placed in the production tanks, fish are taken from the hatchery at a weight of 7 grams and reared to 1/4 pound or 100 grams in 20 ft. diameter nursery tanks. This tank contains about 942 cu. ft. of water or 7,000 gallons. Fish are stocked into the system at about two 7 gram fish per gallon or 14,000 fish per tank. We need to produce about 20,000 fish to stock the production system. With 70% survival in the nursery, we must stock the nursery system with 28,000 fish. This will require two 20 ft nursery tanks. Two additional tanks are provided for expansion.

The Hatchery requirements are defined by defining the system required to produce 28,000 7 gram fish to stock the nursery. In the hatchery about 25% of the fish will survive. This means the system must be stocked with about 120,000 larvae. The larvae are reared in 4,000 liter tanks at a density of 10 larvae per liter. This requires 12,000 liters or 4 tanks in the hatchery.

In the hatchery fish need live food. This includes small organisms called rotifers or copepods (zooplankton). These must be cultured to provide for larval feeding. Four food tanks must be maintained, and each harvested to 20% daily as one new tank is started every four days a total of six tanks are required for food production.

As fish get older, they require larger feed. Brine

shrimp cysts (Artemia) are hatched and provided live to the larvae. Approximately 14 cans of brine shrimp are required for each hatchery production (which requires one month). As fish get larger, they are fed small live tilapia (harvested from the tilapia system).

Juvenile fish are removed from the hatchery at 0.015 pounds (or about 7 grams) and transferred to the 20 ft. nursery tanks.

## Broodstock

One female fish can produce up to 200,000 eggs in a spawn. To insure producing fertilized eggs at all times, it is recommended that six male and six female fish of about 15 pound size be maintained. This is accomplished by holding a stock of 3 pairs in each of two twenty foot diameter tanks with an egg collection device attached. Two additional tanks are provided for expansion.



## COSTS FOR MAHIMAHI FACILITY

| | |
|---|---|
| **Broodstock Tanks:** | |
| Tanks (4) 20' diam. @ 3,000 ea. | $12,000 |
| Foundation and site preparation | 1,000 |
| | $13,000 |
| **Hatchery** | |
| Butler type building | 16,000 |
| 20 x 40 @ $20/ft. | |
| Tanks | |
| Larval rearing tanks (4) @ $800/ea | 3,200 |
| Plankton tanks (6) @ 800/ea | 4,800 |
| Brine shrimp (2) 1000 l @ 200/ea | 400 |
| Plumbing - 1 @ $5,000 | 5,000 |
| Blower (1) and air distribution | 2,500 |
| Lab Equipment | 7,500 |
| Total | $39,400 |
| **Nursery** | |
| Tanks (4) 20 ft. diameter @ 3,000 | 12,000 |
| Site and foundation preparation - 1/4 acre | 7,000 |
| Plumbing and equipment | 5,000 |
| Sub Total | 24,000 |
| **Production Tanks** | |
| 1/6 Acre - 7,500 sq. ft. surface | |
| area tanks - 8 ft. deep (8) @ $24,400 | $195,000 |
| plumbing (8) @ $2,000 | 16,000 |
| 4 HP blower (2) @ $2,000 | 4,000 |

| | | |
|---|---|---|
| Office - 15 x 15 | 225 | |
| Feed storage - 10 x 20 | 200 | |
| Laboratory - 10 x 20 | 200 | |
| | 625 sq. ft. @ $20 | 12,500 |
| | Sub Total | $227,500 |

| | |
|---|---|
| **Water Distribution** | |
| Canals | 6,720 |
| Piping | 2,400 |
| Values | 2,400 |
| Drainage | 7,320 |
| | 18,840 |
| **Water Supply System** | |
| Reservoir | 21,500 |
| Wells (2) @ 22,000 | 44,000 |
| Pumps (3) @ 2,500 gpm x 15,000 | 45,000 |
| Pump house and generator building | 5,000 |
| Emergency generator | 35,000 |
| Fencing | 18,000 |
| Sub Total | $168,500 |

| | |
|---|---|
| **Construction Cost Summary** | |
| Broodstock Tanks | 13,000 |
| Hatchery | 39,400 |
| Nursery | 24,000 |
| Production Tanks (8) complete | 227,500 |
| Water Distribution and Drains | 18,840 |
| Water Supply System and Emergency power generator | 168,500 |
| Engineering and Construction Mgmt. | 50,000 |
| Contingency | 107,760 |
| Total | $650,000 |



## ANNUAL PRODUCTION COSTS FOR MAHIMAHI FACILITY

| | |
|---|---|
| **Broodstock aquisition** | |
| 24 Fish @ $200 (one time cost) | $ 4,800 |
| **Salaries** | |
| General Manager | 25,000 |
| Broodstock Maturation Hatchery Manager | 30,000 |
| Hatchery Technicians (3) @ $15,000 | 45,000 |
| Laborers (4) @ $12,000 | 48,000 |
| | $163,000 |

| | |
|---|---|
| **Feed** | |
| Feed for production system (Fish production = 50,000 pounds per crop - 40% protein feed at 40¢ per pond - feed conversion 2:1) 50,000 x (2) x 3.5 crops = 350,000 pounds of feed @ 40¢ | $140,000 |
| Brine Shrimp - 100 cans @ $25 | 2,500 |
| Algae + fertilizer | 3,000 |
| Total | $145,500 |

Pumping Costs -

Pumping rate = $.15/HP/HR.

Pumping cost 2 x 50 HP x .15 x 20 hrs x 365 days

| | |
|---|---|
| Total | $109,500 |
| Freezer Storage | 5,000 |

Miscellaneous

| | |
|---|---|
| Hatchery and Laboratory supplies | $ 10,000 |
| Office supplies | 2,000 |
| Truck lease | 4,000 |
| Maintenance | 7,000 |
| Water | 1,000 |
| Electricity | 6,000 |
| | $30,000 |

Production Yield

The system as it is defined with one acre of ponds will produce 50,000 pounds of mahi per crop in 3 months. However, due to the time required for cleaning, etc., we will assume only 3.5 crops per year or 175,000 @ $4.00 per pound for fresh fish. The system should thus generate $700,000 annually.



Estimates of Returns on Production Expenses

Major Operating Costs

| | |
|---|---|
| Salaries | 163,000 |
| Stock Acquisition | 4,800 |
| Feed | 145,500 |
| Pumping Costs | 109,500 |
| Freezer Storage | 5,000 |
| Miscellaneous | 30,000 |
| Contingency @ 15% | 68,700 |
| Total Operating Costs | $526,500 |

Annual Production Income

| | |
|---|---|
| Crop Value | $700,000 |
| Production Costs | 526,500 |
| Return on Production Costs | 1.33 |
| Total Facility Construction Costs | $650,000 |

## VI. BRINE SHRIMP AND SPIRULINA

### Introduction

The costs of feed represent a substantial part of the costs of production in aquaculture. The systems we have described for marine shrimp and mahimahi require the importation of expensive feeds from the mainland or Japan. If we produce feeds in Hawaii, or are better able to produce feed ingredients at Kapua, we will have unique opportunities to improve the profitability of the program. It is not generally recognized that aquaculture techniques can be used to cultivate organisms that can be used as feeds or feed ingredients for aquatic species. Two species which have this potential are brine shrimp and Spirulina. These species, cultivated in aquatic systems, can be cultivated using manure as a source of nutrients, and produce a very high-quality meal that can substitute as a source of protein in formulating feeds for shrimp, mahimahi, and even chickens and pigs.

As a means of demonstrating the production potential per acre of these sources of protein, comparing them with land-based production systems for soybeans is useful.



PROTEIN PRODUCTION PER ACRE:
SOYBEANS, BRINE SHRIMP, SPIRULINA

| Species | Production of Dry weight Product/Acre | %Protein | Protein Per Acre |
|---|---|---|---|
| Soybeans | 5 tons | 40% | 2 tons |
| Brine Shrimp | 9 tons | 55% | 5 tons |
| Spirulina | 20 tons | 80% | 16 tons |

Brine shrimp is produced in a highly saline condition (70-90 ppt) and does very well at temperatures above 30°C. Spirulina grows well in 10-15 ppt salinity and thrives at temperatures above 35°C. The Kona region on Hawaii is one of the unique locations in Hawaii where these conditions are met.

The challenge in these programs is to produce enough product to provide ingredients for feed formulation for the needs of the shrimp and mahimahi feeds. It should be noted that there is a limited market for dry Spirulina and brine shrimp product. As an important component of health food, Spirulina sells for $30.00 per pound wholesale, and as much as $70.00 per pound retail. There is a limited market for brine shrimp meal at $30/pound.

Brine shrimp cysts (or live nauplii) are required for the cultivation of mahimahi and shrimp larvae. The brine shrimp system can generate these products as a free by-product.

An additional motivation and justification for the cultivation of Spirulina and brine shrimp protein is the fact it is one of the foundation elements in developing an animal feeds industry in Hawaii. Feed ingredients which

contain the highest amount of protein are the most expensive elements in animal feed (based on total composition of the feed). The value of feed ingredients increases, based on the percentage of protein contained in the ingredient. Figure 8 shows the cost of various ingredients delivered in Hawaii, plotted with respect to percent protein in the feed. Based on percent composition of dry weight, we have placed brine shrimp (50 - 60% protein) and Spirulina (65 - 85% protein) on this graph. Based on their protein composition, these substances may be worth $15 to $20, and $20 to $24, per hundred pounds respectively, as average feed ingredients.

In practice, the actual value of a feed ingredient is based on the kind and relative concentrations of the amino acids in the protein, as well as the kinds and amounts of other elements such as lipids, vitamins, carbohydrates and minerals contained in the meal. Spirulina (Table 1) and brine shrimp (Table 2), are known to have the quality and quantity of amino acids that are suitable for animal feeds. The most critical measure of the value of a feed ingredient is the performance of the animal which is being provided with the formulated feed, such as its food conversion and



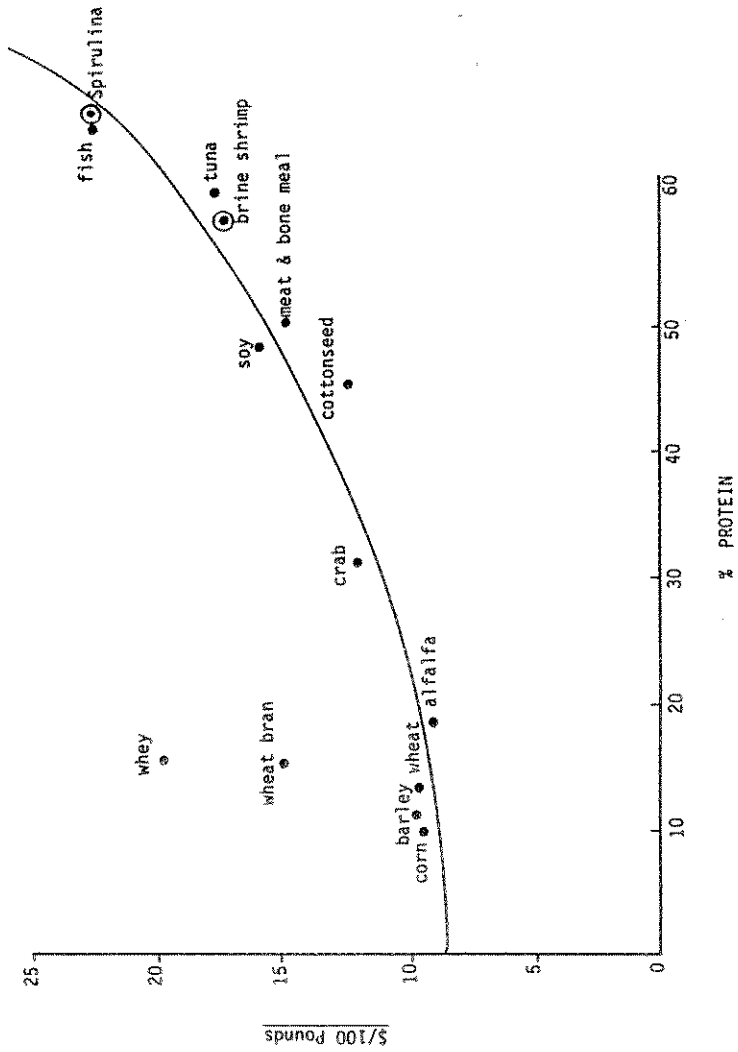



FIGURE 8 : Relationship Between Cost of Feed Ingredients Delivered in Hawaii and Percentage of Protein

TABLE 1

# CHEMICAL ANALYSIS OF SPIRULINA

| CHEMICAL COMPOSITION | |
|---|---|
| Moisture | 7.0% |
| Ash | 9.0% |
| Proteins | 71.0% |
| Crude fiber | 0.9% |
| Xanthophylls | 1.80g/kg of product |
| Carotene | 1.90g/kg of product |
| Chlorophyll a | 7.60g/kg of product |

| TOTAL ORGANIC NITROGEN | 13.35% |
|---|---|
| Nitrogen from Proteins | 11.36% |
| Crude Protein (%N x 6.25) | 71.0% |

| ESSENTIAL AMINOACIDS | |
|---|---|
| Isoleucine | 4.13% |
| Leucine | 5.80% |
| Lysine | 4.00% |
| Methionine | 2.17% |
| Phenylalanine | 3.95% |
| Threonine | 4.17% |
| Tryptophan | 1.13% |
| Valine | 6.00% |

| NON-ESSENTIAL AMINOACIDS | |
|---|---|
| Alanine | 5.82% |
| Arginine | 5.98% |
| Aspartic Acid | 6.43% |
| Cystine | 0.67% |
| Glutamic Acid | 8.94% |
| Glycine | 3.46% |
| Histidine | 1.08% |
| Proline | 2.97% |
| Serine | 4.00% |
| Tyrosine | 4.60% |

| VITAMINS | | | |
|---|---|---|---|
| Biotin (H) | average | 0.4 | mg/kg |
| Cyanocobalamin ($B_{12}$) | average | 2 | mg/kg |
| d-Ca-Pantothenate | average | 11 | mg/kg |
| Folic Acid | average | 0.5 | mg/kg |
| Inositol | average | 350 | mg/kg |
| Nicotinic Acid (PP) | average | 118 | mg/kg |
| Pyridoxine ($B_6$) | average | 3 | mg/kg |
| Riboflavine ($B_2$) | average | 40 | mg/kg |
| Thiamine ($B_1$) | average | 55 | mg/kg |
| Tocopherol (E) | average | 190 | mg/kg |

| MOISTURE | 7.0% |
|---|---|
| ASH | 9.0% |
| Calcium (Ca) | 1,315 mg/kg |
| Phosphorus (P) | 8,942 mg/kg |
| Iron (Fe) | 580 mg/kg |
| Sodium (Na) | 412 mg/kg |
| Chloride (Cl) | 4,400 mg/kg |
| Magnesium (Mg) | 1,915 mg/kg |
| Manganese (Mn) | 25 mg/kg |
| Zinc (Zn) | 39 mg/kg |
| Potassium (K) | 15,400 mg/kg |
| Others | 57,000 mg/kg |

| STEROLS | |
|---|---|
| Cholesterol | 325 mg/kg |
| Sitosterol | 196 mg/kg |
| Dihidro 7 Cholesterol, Cholesten 7 ol 3, Stigmasterol, others | 97 mg/kg |
| | 32 mg/kg |

| NUTRITIONAL VALUE | | |
|---|---|---|
| Protein Efficiency Ratio (PER) of 2.2 to 2.6 (74-87% that of casein) | | |
| Net Protein Utilization (NPU) of 53 to 61% (85-92% that of casein) | | |
| Digestibility of 83 to 84% | | |
| Available Lysine | average | 85% |
| NITROGEN FROM NUCLEIC ACIDS | | 1.99% |
| Ribonucleic Acid (RNA) RNA = N × 2.18 | | 3.50% |
| Deoxyribonucleic Acid (DNA) DNA = N × 2.63 | | 1.00% |

| CAROTENOIDS | | 4,000 mg/kg |
|---|---|---|
| α Carotene | | traces |
| β Carotene | average | 1,700 mg/kg |
| Xanthophylls | average | 1,000 mg/kg |
| Cryptoxanthin | average | 556 mg/kg |
| Echinenone | average | 439 mg/kg |
| Zeaxanthin | average | 316 mg/kg |
| Lutein and Euglenamone | average | 289 mg/kg |

| TOTAL LIPIDS | | |
|---|---|---|
| Fatty Acids | | 7.0% |
| | | 5.7% |
| Lauric ($C_{12}$) | | 229 mg/kg |
| Myristic ($C_{14}$) | | 644 mg/kg |
| Palmitic ($C_{16}$) | | 21,141 mg/kg |
| Palmitoleic ($C_{16}$) | | 2,035 mg/kg |
| Palmitolinoleic ($C_{16}$) | | 2,565 mg/kg |
| Heptadecanoic ($C_{17}$) | | 142 mg/kg |
| Stearic ($C_{18}$) | | 353 mg/kg |
| Oleic ($C_{18}$) | | 3,009 mg/kg |
| Linoleic ($C_{18}$) | | 13,784 mg/kg |
| γ Linolenic ($C_{18}$) | | 11,970 mg/kg |
| α Linolenic ($C_{18}$) | | 427 mg/kg |
| Others | | 699 mg/kg |
| Insaponifiable | | 1.3% |
| Sterols | | 325 mg/kg |
| Titerpen alcohols | | 800 mg/kg |
| Carotenoids | | 4,000 mg/kg |
| Chlorophyll a | | 7,600 mg/kg |
| Others | | 150 mg/kg |
| 3-4 Benzypyrene | | 3.6 mg/kg |

| TOTAL CARBOHYDRATES | | 16.5% |
|---|---|---|
| Ramnose | average | 9.0% |
| Glucane | average | 1.5% |
| Phosphoryled cyclitols | average | 2.5% |
| Glucosamine and muramic acid | average | 2.0% |
| Glycogen | average | 0.5% |
| Sialic acid and others | average | 0.5% |

Reference: Hill, Christopher. Imprisoned Light. Journal of Nutritional Microbiology. Boulder Creek, California. Page 2.

TABLE 2

CHEMICAL ANALYSIS ARTEMIA SALINA

Composition of Lyophilized Brine Shrimp

| Constituent | % Dry Weight |
|---|---|
| Moisture, %[a,b] | 90 |
| Protein, % from total amino acids[b] | 43 |
| Protein, % Kjeldahl method[c] | 58 |
| Crude fat, % ether extract[c] | 5.1 |
| Crude fat, % methanol-chloroform[b] | 19.3 |
| Cholesterol[b] | 0.46 |
| Fiber[c] | 3.5 |
| Ash[c] | 20.6 |
| Carotenoid index[b] | |
| Fresh live brine shrimp | 20.6 |
| Freeze dried brine shrimp | 0.27 |

[a]Moisture expressed as percent of wet weight of sample before lyophilization.

[b]Analysis from this laboratory.

[c]Analysis from commercial laboratory.

Vitamins and Vitamin-Like Substances in Brine Shrimp[a]

| Constituent | mg/g, dry weight |
|---|---|
| Biotin | 0.001 |
| Choline chloride | 6.10 |
| Folic acid (bound) | 0.007 |
| Niacin (bound) | 0.130 |
| Pantothenic acid | 0.068 |
| Pyridoxine HCl | 0.008 |
| Inositol | 1.20 |
| Riboflavine | 0.017 |
| Thiamine | 0.127 |
| Vitamin $B_{12}$ | 0.003 |
| Vitamin A[b] | 6650 |

[a]Analyses from commercial lab.

[b]Vitamin A is expressed as international units per gram.

Mineral Content of Brine Shrimp[a]

| Constituent | % dry weight |
|---|---|
| Copper | 0.001 |
| Magnesium | 0.222 |
| Iron | 0.275 |
| Calcium | 0.100 |
| Phosphorus | 0.930 |
| Manganese | 0.013 |
| Potassium | 0.832 |
| Sodium | 5.11 |
| Zinc | 0.008 |

[a]Analyses from commercial lab.

TABLE 2 (Cont'd)

CHEMICAL ANALYSIS ARTEMIA SALINA

Amino Acid Composition of Brine Shrimp (g/100 g of Protein)[a]

| Amino Acid | Brine Shrimp |
|---|---|
| Leu | 8.0 |
| Ile | 5.3 |
| Lys | 7.6 |
| Thr | 4.6 |
| Trp | 1.0 |
| Val | 5.4 |
| Met | 2.7 |
| Phe | 4.7 |
| His | 1.8 |
| Arg | 6.5 |
| Ala | 6.9 |
| Asp | 9.2 |
| Cys | 2.2 |
| Glu | 14.2 |
| Gly | 5.3 |
| Pro | 5.2 |
| Ser | 4.8 |
| Tyr | 4.5 |

Fatty Acid Analysis (a) of Lipid Fractions (b) from Artemia salina

| Fatty Acid | Total Sample | Fraction 1 | Fraction 2 | Fraction 3 | Fraction 4 | Fraction 5 |
|---|---|---|---|---|---|---|
| 14.0 | 1.4 | 1.5 | 3.7 | 1.5 | 1.9 | 2.9 |
| 14:1 | 2.3 | 2.9 | 5.6 | 2.8 | 0.2 | 0.6 |
| 15:0 | 0.7 | 0.8 | 1.4 | 0.8 | 0.5 | 1.7 |
| 15:1 | 0.8 | 1.5 | 1.5 | 1.6 | 5.9 | 0.8 |
| 16:0 | 13.5 | 12.9 | 20.5 | 13.2 | 8.7 | 18.3 |
| 16:1 | 13.8 | 16.3 | 24.2 | 16.2 | 7.8 | 11.2 |
| 17:0 | 1.3 | 1.2 | 1.2 | 1.1 | 0.6 | 1.1 |
| Iso 17:0 | | 1.3 | 0.6 | 0.2 | 1.7 | |
| 17:1 | 0.9 | 0.5 | 0.5 | 0.5 | 0.4 | 1.1 |
| Iso 17:1 | | 0.3 | 0.5 | 0.4 | | |
| 18:0 | 5.9 | 4.9 | 4.1 | 4.6 | 5.2 | 6.2 |
| 18:1 | 35.6 | 31.7 | 23.5 | 29.7 | 27.8 | 31.6 |
| 18:2 | 6.2 | 6.5 | 4.6 | 6.0 | 5.5 | 3.8 |
| 20:0 | 2.0 | 2.3 | 2.4 | 2.8 | 1.5 | 1.1 |
| 20:1 | 0.1 | 0.1 | 0.7 | 1.0 | 0.7 | 0.7 |
| 20:3[c] + 20:4 | 2.2 | 1.0 | | 1.5 | 7.9 | 1.4 |
| Iso 20:3 + 20:4 | | | | 1.6 | 1.4 | 0.8 |
| 20:5 | 12.0 | 13.4 | 4.9 | 13.1 | 20.8 | 17.5 |

[a]Also found in all fractions and total sample, in amounts less than 1% were: 10:0, 11:0, 12:0, 12:1, 13:0. Fatty acid 19:0 was found in small amounts in all samples except fraction 2.

[b]Expressed as percent of total fraction.

[c]Column used did not separate 20:3 from 20:4

Reference: Gallahger, M. and W. Duane Brown, 1975. Composition of San Francisco Bay Brine Shrimp (Artemia salina). Agriculture and Food Chemistry Vol.23, No.4, Page 630.

growth rate. There is substantial information to suggest that these products have excellent performance as feed ingredients.

Hawaii currently imports 80% of its chickens, 80% of its beef and 60% of its pork products. Hawaii imports the feed or the feed ingredients for 20% of the chicken and 40% of the pork that is produced in the islands. In addition, we also import the feed or the ingredients for the egg industry. Though not significant, Hawaii also uses imported sources of protein for pigs and rabbits, and feeds for other animals.

At present, the state of Hawaii annually imports approximately 27,000 tons of protein feed ingredients such as cottonseed products, fish meal, meat and bone meal, and soybean meal. The average percent of protein in these feed ingredients is about 50% (Figure 1). At an average price of $15.00 per hundred pounds, the state imports more than eight million dollars worth of protein feed ingredients annually. In addition, each year Hawaii imports more than 10,000 tons of formulated feeds for poultry, swine and small animals, containing an average of 18% protein. If products grown in Hawaii were substituted for the soybean meal, meat and bone meal, and cottonseed meal, it would account for about 24% of the required feed ingredients (approximately 2,000 tons), or about $600,000 worth of product annually. Therefore, we can estimate that, based on present consumption, an industry in



Hawaii which produced high-protein feed ingredients would have a market for about 8.5 million dollars worth of product. Naturally, this assumes that dried meal of adequate quality and quantity could be provided to the feed industry at a cost of about $25 per 100 pounds.

To help understand the impact of developing ingredients locally on feed costs (and hence the livestock and aquaculture industries), we have tabulated a typical marine shrimp, pig, poultry and Kuruma shrimp diet using imported ingredients, and have calculated the cost of the resultant diet (Table 3). The values used in the computation are based on current wholesale feed prices.

Marine shrimp feed costs $17.30 per 100 pounds, while pig and poultry feeds cost $14.23 per 100 pounds and $17.26 per 100 pounds, respectively. The Kuruma prawn diet cost of $2.27 per pound is based on the actual cost paid by a firm currently growing Kuruma shrimp. Based on the amino acid and biochemical composition of Spirulina and brine shrimp (Table 1 and 2), we have designed three hypothetical diets using these commodities (Table 3). It is possible to achieve a 14-30% reduction in feed costs due to the reduction of imported ingredients for marine shrimp, poultry and swine diets (Table 3). Calculating the cost of each of the ingredients in these diets and subtracting the summed values from the cost of the feed using imported ingredients only (Table 3), shows that the relative worth of Spirulina

Table 3 and brine shrimp would be from $17 to $43 for 100 pounds in marine shrimp, poultry and swine diets (Table 4). For the Kuruma shrimp diet, the value is nearly $5000 for 100 pounds (Table 4). If large scale production at Kapua is successul, the cost of the Kuruma shrimp diet will be reduced by almost 72%.

With a local demand for 27,000 tons of protein feed ingredients, (estimating production per surface acre ranging from 5-9 tons dry weight for brine shrimp, to 14-20 tons dry weight for *Spirulina*,) we could envision 2,000 acres in production. This could result in new employment opportunities as well as the potential to provide economic improvement in the existing aquaculture programs. The area of Kapua should be reserved to meet these needs.

As with all plant crops, a significant percentage of the cost of production is the cost of fertilizer, or the nitrogen, phosphorus and potassium. As is the case with feed ingredients, the cost of the fertilizer, combined with the cost of shipping it to Hawaii, represents a major element in the cost of growing *Spirulina* or brine shrimp (which eat algae or other cellular material). An average algae producing system may require 12.9 tons of dry matter per acre/year. The cost of required commercial fertilizer delivered in Hawaii would be about $2,000/year/acre. Therefore $2,000 of fertilizer would be eliminated.



TABLE 3

Ingredients, Percent Composition and Price of Poultry, Swine, Marine Shrimp and Kuruma Shrimp Feeds.

| Ingredient | Poultry | Swine | Marine Shrimp *Penaeus stylirostris* | Kuruma Shrimp + *Penaeus japonicus* |
|---|---|---|---|---|
| Corn | 60 | 70 | | |
| Soybean | 20 | 17 | 20 | 10 |
| Meat and Bone | 7 | 7 | | |
| Cottonseed | 7 | 5 | | |
| Wheat | | | 32 | |
| Crab Meat | | | 20 | |
| Shrimp Meal | | | | 20 |
| Fish Meal | | | 10 | |
| Tuna Meal | | | 20 | |
| Yeast | | | | 18 |
| Squid Meal | | | | 45 |
| Fat | 5 | | | |
| Fish Oil | | | 4 | 3 |
| Vitamins | 0.5 | 0.5 | 1 | 1 |
| Minerals and Salts | 0.5 | 0.5 | 1 | 1 |
| Binders | | | 2 | 2 |
| % Protein (Calculated) | 22 | 26 | 33 | 59 |
| Cost ($/100 lbs.calc.)* | $15.06 | $11.03 | $14.10 | - |
| Shipping costs ($/100 lbs) | 3.20 | 3.20 | 3.20 | - |
| Total ($/100 lbs) | $18.26 | $14.23 | $17.30 | $227.00** |
| % of Cost as Shipping | 17.5% | 22.5% | 18.5% | |

* Based on 1982 Commodity Prices, California
** Actual price reference: Jim Sweeney, IKKO, Hawaii
\+ Hypothetical Formulation since diet is purchased and is proprietary

TABLE 4

Ingredients, Percent Protein and Relative Cost of Poultry, Swine, Marine Shrimp and Kuruma Shrimp Diets which include *Spirulina* and *Artemia*.

| Ingredient | Poultry | Swine | Marine Shrimp (*Penaeus stylirostris*) | Kuruma Shrimp (*Penaeus japonicus*) |
|---|---|---|---|---|
| Corn | 65 | 65 | | |
| Soybean | 4 | 5 | | 5 |
| Meat and Bone | 4 | 4 | | |
| Cottonseed | 6 | 5 | | |
| Wheat | | | 45 | |
| Crab Meal | | | 14 | |
| Shrimp Meal | | | | 5 |
| Squid Meal | | | | 35 |
| Yeast | | | | 11 |
| *Spirulina* | 5 | 10 | 15 | 15 |
| *Artemia* | 10 | 10 | 15 | 20 |
| Fat | 5 | | | |
| Fish Oil | | | 7 | 5 |
| Vitamins | 0.5 | 0.5 | 1 | 1 |
| Minerals and Salts | 0.5 | 0.5 | 1 | 1 |
| Binders | | | 2 | 2 |
| % Protein (Calculated) | 23 | 26 | 29 | 59 |
| Costs without *Spirulina* and *Artemia* | 9.15 | 8.20 | 8.03 | 48.90 |
| Shipping Costs | 2.72 | 2.56 | 2.24 | 3.20 |
| Total ($/100 lbs) | $11.87 | $10.76 | $10.27 | $52.10 |
| Cost Difference (Table 3 - Table 4 values) Value of *Spirulina* and ($/100 lbs) | 6.39 | 3.47 | 7.03 | 174.90 |
| *Artemia* ($/100 lbs) | 43 | 17 | 23 | 500 |



Waste products available from feed lots are known for their content of nitrogen and phosphorus. A ton of cow manure may contain up to 10 pounds of nitrogen and 2 pounds of phosphorus. Poultry manure may have as much as 20 lbs/ton of nitrogen and 16/lbs/ton of phosphorus. Since cow manure has previously been used for *Spirulina* culture, it may be very effective in reducing production costs. Similar results have been observed with brine shrimp. Manure from the feed lot will be incorporated into the system.

## Brine Shrimp Production Process

The process of brine shrimp farming involves developing 1 acre ponds about 3 ft. deep. The ponds would have sloping sides of about 45° to assist in collection of cysts. Ponds are filled with sea water, and the salinity is increased to 20 ppt by evaporation. The high salinity favors the growth of algae that serve as food for brine shrimp, and eliminate predators which would eat brine shrimp. Algae is then inoculated into the ponds, and when cultures are dense enough, brine shrimp cysts are hatched and inoculated into the pond. The shrimp grow and reproduce, and consume the algae. Eventually the brine shrimp increase in number to the point where the algae are close to being depleted faster than they can reproduce. At this point, substantial adult brine shrimp are harvested using an automatic device (a paddle wheel that lifts a brine shrimp to a harvest basin).

By harvesting at the proper rate, the system stays in equilibrium. Production of approximately 90 tons of wet brine shrimp per acre/year have been achieved in California. This is about 9 tons dry weight of product.

By selectively harvesting brine shrimp of proper size, we hope to supply hatchery needs for mahimahi, marine shrimp, and other species in an integrated program. Brine shrimp are dried in the sun much like the drying of sludge in concrete tanks (20 x 20), where the wet product is placed during hot days.



BRINE SHRIMP FACILITY

| | No. Units | Size | Cost | Total |
|---|---|---|---|---|
| Ponds | 10 | 0.5 acre | 10,000 | 100,000 |
| Pumps | 1 | 500 gpm | 8000 | 8,000 |
| Well | 1 | 8" x 29 ft, | $250/ft | 5,000 |
| Site Preparation | 11 | Acres | 1000 Ac | 11,000 |
| Buildings | | | | |
| Storage | | | | 6,000 |
| Laboratory | | | | 15,000 |
| Engineering and Construction Mgmt | | | | 14,500 |
| Equipment | | | | |
| Laboratory | | | 5,000 | |
| Brine Shrimp Collection 11 @ 2,000 | | | 22,000 | |
| Blowers - 2 @ 4,000 | | | 8,000 | |
| Total | | | | |
| Contingency | | | 29,500 | |
| Total | | | $224,000 | |

## BRINE SHRIMP FARM
## PRODUCTION COSTS

| | | |
|---|---|---|
| Salaries | | |
| Manager (1) | $25,000 | $25,000 |
| Technician (2) | 15,000 | 30,000 |
| Labors (3) | 12,000 | 36,000 |
| Fertilizer | | 1,800 |
| Electricity | | 8,000 |
| Cysts | | 5,000 |
| Miscellaneous | | 2,000 |
| Office | | 2,000 |
| Truck Lease | | 4,000 |
| Water (fresh) | | 1,000 |
| Freezer Space | | 15,000 |
| Contingency | | 19,200 |
| | | $149,000 |



Value of Crop - Brine Shrimp

| | |
|---|---|
| 5A x 9t/Ac/yr x $350 = | $ 15,750 |
| Total Annual Production Costs | 149,000 |
| Total Annual Crop Value | 15,750 |
| Return on production costs | 0.11 |
| Total Facility Construction Costs | $224,000 |

## Spirulina Production Process

Spirulina grows in brackish water containing high levels of nutrients, nitrates, phosphastes and other elements. The growth is favored by a high pH, which can be achieved in part with lime and the addition of carbon dioxide, which provide carbon for plant growth. Agitation (such as a paddle wheel mixer) or aeration is required to help the algae in solution.

The physical environment is similar to those used for culturing Penaeus monodon, and consits of 1/2 acre ponds approximately 3 ft. deep containing 2 feet of culture media. Provision of adequate amounts of carbon as carbonate or carbon dioxide is the most difficult step. If the carbon dioxide is produced commercially, this process is expensive. The carbon is supplied from stack gas produced by the burning of the rapidly grown in haole koa trees which would be harvested and replanted on the grazing land and the opportunities for significant costs savings would be developed.

Spirulina is harvested by draining 20% of the pond volume daily and replacing it with new growth media . The production of Spirulina would depend on using the brackish water available from the well for the culture media.



## Spirulina Construction Costs

| | No. Units | Size | Cost | Total |
|---|---|---|---|---|
| Ponds | 20 | 0.5 acre | 10,000 | 200,000 |
| Pumps | 20 | 5 gpm | 200 | 4,000 |
| Blowers | 2 | 10 Hp | 6,000 | 12,000 |
| Site Preparation | 10 Ac | | 2,000 | 20,000 |
| Plumbing and Ditches | 4s | | | 12,000 |
| Carbon dioxide Production System (Burner) | | | | 30,000 |
| Filtration Plant | | | | 40,000 |
| Buildings | | | | |
| Laboratory Stock Culture | | | | 20,000 |
| Storage | | | | 10,000 |
| Centrifuge | | | | 10,000 |
| Dryer | | | | 10,000 |
| Water Supply | | | | |
| Well | 1 | | 20,000 | 20,000 |
| Pump | 1 | | 10,000 | 10,000 |
| Pipes and Valves | | | L/S | 5,000 |
| Engineering and Construction Mgmt. | | | | 40,000 |
| Contingency | | | | 66,500 |
| | Construction Total | | | $509,500 |

## Spirulina Production Costs

| | | |
|---|---|---|
| Salaries | | |
| Manager (1) | $30,000 | $ 30,000 |
| Technician (2) | 15,000 | 30,000 |
| Laborers (4) | 12,000 | 48,000 |
| Fertilizer | | 25,000 |
| Chemicals | | 10,000 |
| Fuel | | 12,000 |
| Electricity | | 25,000 |
| Miscellaneous Office Supplies | | 2,000 |
| Truck Lease | | 4,000 |
| Fresh Water | | 500 |
| Subtotal | | 186,500 |
| Contingency 15% | | 28,000 |
| | | $214,500 |

### Value of Crop - Spirulina

| | |
|---|---|
| 10 A x 20 t/Ac/yr x $440 = | $ 88,000 |
| Total annual production cost | 214,500 |
| Total annual crop value | 88,000 |
| Return on production costs | 0.41 |
| Total facility construction costs | 509,500 |



## VII. Secondary Species Systems

Secondary species systems would not normally be considered for culture; however, because of their characteristics of consuming by-products from other systems or flourishing on wastes from primary production systems, they are included in this project. Species in this category include:

Oysters and clams which consume the phytoplankton and bacteria produced in the shrimp and mahimahi tank and pond culture.

Seaweed (Gracilaria) which consume waste nutrients from other systems at low concentration.

Tilapia, which flourish in nutrient-rich water with nutrients provided by animal manure.

Mullet (baitfish) which grow well in nutrient-enriched pond as do tilapia.

### A. Oysters and Clams

Oysters and clams are filter feeders. They thrive on a variety of single-celled algae, bacteria, and other particulate matter. Warm water favors oyster and clam growth. A marketable size oyster or clam may be grown under the conditions encountered at Kapua in less than a year in contrast with 2 to 4 years in more temperate locations.

## State of the Art for Culture

Species. A number of bivalve mollusc species (oysters and clams) are presently grown throughout the world using both extensive and intensive systems. Among the most frequently cultured oysters are the flat oyster (*Ostrea edulis*), the Pacific oyster (*Crassostrea gigas*) and the American oyster (*C. virginica*). At the present time, most of the economically important clam species are harvested from natural stocks. However, several types have been cultured, principally the asari (*Tapes japonica*) and the quahog or hard clam (*Mercenaria mercenaria*).

Those cultured bivalve species generally inhabit coastal or brackish water environments. After spending a few days to a few weeks in a free swimming larval stage, young oysters attach themselves to hard substrates, while clams bury themselves in sand or mud bottoms. Both oysters and clams are filter feeders; that is, they remove particulate organic matter and microscopic algae from the surrounding water by an internal filtering apparatus. This mode of feeding can cause shellfish to concentrate pathogens and toxic substances if they are present in the water or food material. Spawning times for both groups show a high degree of dependence on water temperatures, with spawning initiated when water temperatures warm to a certain level. Oysters, under natural environmental conditions, may take several years to attain market size. However, this time may be



reduced to one year if temperatures and feeding conditions are optimal.

Hatchery technology. Controlled spawning and hatchery methods for the production of seed oysters and clams are well established. Government and commercial oyster and clam hatcheries utilize similar techniques. In the case of oysters, broodstock (e.g., *C. virginica*) are maintained in the hatchery at 50°F (10°C) until they are needed for spawning. In order to condition the broodstock for spawning, the temperature of the adults, paired in glass trays, is slowly raised to 64°F (18°C) or more for a period of two to four weeks. The temperature is then raised to 77°F (25°C) to initiate spawning. These techniques allow controlled year-round production of oyster and clam seed.

Newly hatched larvae are transferred to rearing tanks. Oyster larvae are fed microscopic algae (phytoplankton). Some hatcheries prefer feeding pure algal cultures (one species), while others prefer separating out the naturally-occurring algae in seawater by centrifugation. Both oyster and clam larvae become bottom-living juveniles after about 100 days, depending on species and water temperature. Some hatcheries provide culch-material consisting of adult oyster shells, rocks, etc., on which the oyster larvae can settle. Recently, however, "culchless" or "free" spat (settled oysters) have been produced by providing screens or sheets of metal for more economic transporting and handling

(Bardach et al., 1972). Several commercial hatcheries on the mainland can now provide seed stock on demand to various locations around the world.

Growout technology. Growout techniques for oysters and clams range from seeding natural beds in coastal waters to intensive land-based systems. Seeding natural oyster beds in coastal waters is practiced extensively in Japan. The seed comes either from hatcheries (as described above) or is collected from coastal habitats where natural reproduction occurs, thereby thinning the natural population and increasing survival. Seed oysters are cultured to market size in Japan using "off-bottom" culture techniques which suspend many animals from rafts and/or lines. Yields from this raft and lone-line culture can be as high as 29,200 lbs/acre/yr (26,000 kg/ha/yr) of shelled meat.

In the mainland United States, oyster seed (attached to a substrate) is distributed onto beds in coastal waters. Typical yields from this "on-bottom" culture technique are between 10 to 110 lbs/acre/yr (10 to 100 kg/ha/yr) of shelled meat with no active management and 5,620 lbs/acre/yr (5,000 kg/ha/yr) of shelled meat with management, i.e., thinning, predator control, etc.

Private interests in Hawaii are attempting to demonstrate the economic feasibility of the technology-intensive, land-based culture of oysters and clams. This system, practiced by the Kahuku Seafood Plantation is based on the



sluice or raceway culture of oysters in trays supported by the production of food algae in ponds. Under Hawaii conditions, market size can be attained in seven to nine months. Preliminary calculations for an intensive system similar to the ones undergoing demonstration in Hawaii indicate that 21,650 pounds (9,820 kg) of oyster meat could be harvested per algal production acre per year.

Clam seed is collected from densely concentrated natural sand or mud bottom beds, or produced by hatcheries. The culture of clams in trays is being carried out in various places around the U.S. (including Hawaii), but the principal method of clam culture is still "on-bottom."

## Market Characteristics and Opportunities

Supply and demand. There is an established market for oyster products on a world, national and local basis. In 1975, worldwide oyster consumption was 770,000 metric tons round weight. The United States consumed about 60 percent of this figure, or about 454,000 metric tons. Annual local consumption in Hawaii for the years 1972-1975 ranged between 500,000 and 550,000 pounds (226,800 and 249,480 kg). In 1976, consumption dropped by 21 percent to 435,000 pounds (197,300 kg), all of which was imported [foreign imports were 294,600 pounds (133,630 kg), and domestic imports were 140,000 pounds (63,500 kg)].

The demand for oysters in the United States has stabilized, despite increases in the population. Expanding the

market for oysters will require improvements in product forms, year-round availability, quality control, and market development activities primarily by the industry itself.

World and mainland supplies of clams are generally dependent on harvesting natural stocks. World production is dominated by Japan and the United States, which combined to account for 80 percent of the total world clam landings in 1972. Japanese production fluctuated between 673 million and 582 million pounds (305,273 and 263,995 mt), round weight, between the years 1965 and 1972. U.S. clam production, however, ranged between 80 million and 125 million pounds (36,290 and 56,700 mt) from 1969 to 1974.

Japan and the U.S. are also the major world consumers of clams. In 1972, Japanese consumption reached 568 million pounds (257,645 mt), while the U.S. total was 503 million pounds (228,160 mt). U.S. per capita clam consumption ranks third in the world at 2.41 pounds per person per year (1.09 kg/person/yr), behind Japan [5.36 pounds (2.43 kg)] and Malaysia [6.01 pounds (2.73 kg)].

The outlook for Mainland domestic landings of clams suggests substantial export markets may exist. Landings of several economically-important species have declined recently, due to natural and man-made stresses on nearshore clam habitats. Furthermore, if a large Hawaii supply of clams could be available on a year-round basis, a local processing plant may be needed. Such activities would not only provide



employment, but would reduce the possibility of saturating the local market as well.

Product forms and distribution. Oysters are sold in fresh, frozen and processed forms. Fresh and frozen oyster products, which make up the largest portion of sales, can be found raw in the shell, shucked and placed on the half-shell, and frozen. Processing is generally for the steamed, canned or shucked, breaded and frozen forms. Substantial numbers of oysters are used in soups, chowders and stews.

The largest segment (about 70 percent) of the Hawaii oyster market is the restaurant trade. The most popular form sold is fresh oysters on the half-shell for appetizers. Frozen breaded forms are usually deep-fried and served as an entree item. Home consumers, who account for about 30 percent of local sales,, prefer the fresh in-shell and shucked forms. Approximately 40 percent of Oahu's population consumes oysters annually.

Clams are available to the consumer in a wide variety of forms. Fresh or frozen forms may be sold in-shell or shucked. Frozen forms may also be sold as specialty items-breaded, raw or cooked, strips, stuffed, deviled or in cakes, patties, burgers, croquettes or sticks. Clams may also be processed into cocktails, chowders, and juices, and are also available as animal food, and used as bait. The most popular type for processing are surf clams. Hard and soft shell clams are most often sold in-shell.

U. S. frozen clam meat production in 1974 was over 8,500,000 pounds (3,855,600 kg). Institutions are the largest consumers of frozen products, consuming 82 percent of the total frozen poundage, and handling 81.4 percent of the total retail dollar value, or $21 million in 1975. The market is now expanding.

Price. The majority of domestic imports are shipped into Hawaii from the East Coast, although the amount coming from the Pacific Northwest is steadily increasing. Wholesale prices in Hawaii for fresh, imported, in-shell oysters range between $0.20 to $0.50 a piece including transportation costs. Retail prices range from $0.25 to $0.80 apiece. The commercial oyster producers in Hawaii recently began marketing their product. Their fresh, in-shell oysters were sold wholesale for between $0.10 and $0.20 each, and retailed in supermarkets for $0.25 to $0.50 each. Preliminary calculations suggest that export markets, e.g., the mainland U.S., could be opened if production costs could be reduced to approximatly $0.05 per oyster.

Total canned clam production has declined from 3.58 million standard cases in 1973 to 2.8 million cases in 1976. This may be attributed to a decline in clam landings for 1976 - particularly landings of surf clams. In 1976, canned clams represented a $46.4 million industry of which whole and minced clams comprised 57.1 percent, and the specialties category comprised 12.1 percent.



All clams consumed in Hawaii are presently imported (40 percent from the Mainland U.S.A. and 60 percent from foreign sources). Domestic imports are mainly in the fresh, in-shell or fresh/frozen in-shell forms, while the foreign trade is primarily in the processed form. The average price of all forms of clams has dropped from $0.50 per pound ($1.10/kg) in 1974 to $0.36 per pound ($0.79/kg) in 1976. This may reflect a shifting in consumer demand from fresh, in-shell clams to processed clams, rather than an overall decrease in prices.

Fresh clams in Hawaii are priced at $1.50 to $2.00 per pound ($3.31 to $4.41/kg). Restaurants and supermarkets presently prefer processed forms which can be kept in inventory longer. An evaluation of price data indicates mainland marketing of fresh or frozen in-shell clams could be carried out by Hawaii entrepreneurs if wholesale prices were approximately $0.75 a pound ($1.65/kg).

## Oyster and Clam Production Facility
### Construction Costs

**Hatchery**

| | |
|---|---|
| Site Preparation | 4,000 |
| Building 20 x 20 @ $20 | 8,000 |
| Plumbing | 6,000 |
| Hatching tanks (8) 1000 l @ 300 | 2,400 |
| Algae culture tanks (6) 400 l @ 800 | 6,000 |
| Lab Equipment | 6,000 |
| Miscellaneous | 2,000 |
| Total | $34,400 |

**Algal Tanks**

| | |
|---|---|
| 6 lined tanks @ 1/4 Ac @ $15,000 | $90,000 |
| Plumbing @ 1000 | 6,000 |
| Total | $96,000 |

**Oyster Trenches**

| | |
|---|---|
| 2 trenches 40' x 100' x 5' @ 87,000 w/plumbing & recirc pumps | 174,000 |
| 1 water distr system and drainage system L/S | 120,000 |
| 1 Electrical L/S | 40,000 |
| 1 handling bldg. 20' x 40' x $20 | 16,000 |
| Total | 350,000 |

**Water Supply**

| | |
|---|---|
| 2 wells 150' x 12" @ 22,00 | 44,000 |
| 3 pumps 2500 @ 15,000 | 45,000 |
| Piping, Valves, & C | 40,000 |
| Pump house 10 x 10 x 15 | 1,000 |
| 1 Emergency Generator | 30,000 |
| Total | 160,000 |



| | |
|---|---|
| Engineering and Construction Management 10% | 61,000 |
| Contingency 20% | 133,500 |
| Total | $194,500 |
| Total For Facility | 801,000 |

## Oyster and Clam Annual Production Costs

| | |
|---|---|
| Salaries | |
| General Manager | 40,000 |
| Hatchery Manager | 30,000 |
| Technicians (3) @ 15,00 | 45,000 |
| Laborers (5) @ 12,000 | 60,000 |
| Feed | 5,000 |
| Pumping Costs | |
| 100 HP x $.15 x 20 hrs. x 365 days | 109,500 |
| Supplies | |
| Hatchery | 10,000 |
| Grow-out | 15,000 |
| Truck Lease | 7,500 |
| Truck Maintenance and Ops. | 7,200 |
| Fresh Water | 2,000 |
| Electricity | 6,500 |
| Administration Misc. | 5,000 |
| Contingency | 50,300 |
| | $393,000 |



## Annual Value of Oyster Crop

It is reasonable to expect an output per trench of 85,000/month. The market price for oysters is variable but $0.15 each at the facility is reasonable.

2 trenches x 85,000/mo. x 12 mos. x $0.15 = 306,000

| | |
|---|---|
| Annual Crop Value | $306,000 |
| Annual Production Costs | 393,000 |
| Return on Operating Costs | 0.78 |
| Total Facility Construction Costs | 801,000 |

B. Seaweed

Gracilaria Culture. Seaweed farming is a developing field. Microscopic algae (seaweeds) grow attached to substrate and are very efficient at removing nutrients from waters that pass through their culture systems. It is envisioned that seaweeds will be cultivated in trenches in which the waste water from the farm is transported to the dispersion field. Seaweeds (Gracilaria and other species) serve as important sources of carragheenans which are used as binders in cosmetics, ingredients for milk shakes, etc. This product may also be used for local consumption as a food source. Protected yields of seaweed are about 90 dry - tons of material per mile of canal per year.

General supply and demand. Although precise figures are difficult to obtain, the total value of the world seaweed crop and its related industries is estimated to be between $1 billion (Naylor, 1976) and $20 billion annually. In 1973, the "first-hand value" of the world seaweed crop was approximately $765 million for approximately 1.17 million wet tons (1.06 million mt). Approximately 95% of this value was obtained from the sale of semi-processed (e.g., dried, powdered, etc.), edible products in Japan, Korea and Taiwan. Seaweeds for industrial purposes (e.g., food additives) are generally sold in a simple dried and unprocessed state and account for the greater part of the balance ($25 million). Algae used in animal feeds and fertilizers make up the remainder - a mere fraction of the value of edible seaweed.

Direct human consumption. The major world markets for edible seaweeds are located in Japan, Korea and Taiwan, as tastes and traditions in these countries have contributed to the development of a dietary preference for seaweeds. Seaweeds of greatest economic importance are *Porphyra*, *Undaria*, and *Laminaria*. There have been a few attempts at introducing marine algal products to the western world (e.g., seaweed soups), but these have met with limited success.

Seaweeds can be consumed in a wide variety of product forms. *Porphyra* (commonly known as nori) is used in soups,



sauces, salads, and sandwiches, and as a condiment. Nori cultivation accounts for over 40 percent of the volume, and 56 percent of the value of the total aquaculture production of Japan. *Laminaria* and *Undaria* (wakame) are used in soups, sauces, salads, teas, garnishes, vegetable dishes, coated candy, and pills as a source of Vitamin C.

To date, there are no commercial aquaculture enterprises culturing algae for the Hawaii market. However, several species of edible algae are collected and consumed in significant quantities. Fresh *Gracilaria* (or ogo) is harvested from the wild and retails in local supermarkets for $1.30 to $1.80 a pound ($2.87 to $3.97/kg). Ogo is used as an appetizer, salad or snack, and vegetable side dish, alone or in combination with rice or raw fish. One preliminary market analysis indicates that there is sufficient local demand to utilize an additional 316,000 pounds (143,338 kg) per year. Processed and packaged orphyra is imported from the Far East.

Industrial additives. Industrial use of seaweed extracts (marine colloids) is the fastest developing area of the algae industry today. Seaweed extracts of economic importance are algaes, carrageenans, furcellarans and algins. Extracts are being utilized in an ever-increasing array of processes and food and non-food products including milk, ice cream, dresssing, soups, beverages (beer), leather manufacturing, photographic chemicals, pharmaceuticals,

cosmetics, textiles, paper products, rubber explosives, and paints. Although each type of gel possess unique characteriastics, they all basically function to stabilize, suspend, emulsify or thicken.

The total world production of marine colloids in 1974 was 32,700 tons (29,685 metric tons) worth approximately $300 million. This was comprised of (1) agar, 7,500 tons (6,808 metric tons) at $86.25 million; (2) carrageenan, 8,0o00 tons (7,262 mt) at $93.6 million; (3) furcellaran, 1,200 tons (1,089 mt) at $42.96 million and growth rate of this industry at 10 to 20 percent with the wholesale value of the U.S. gel market alone totaling between $68 and $100 million per year. The principal consumers and processors of algae and its derivatives are the U.S., Canada, Japan and Europe.

Extensive wild populations do not exist in Hawaii, but the state has several indigenous and exotic species of algae that may prove valuable for colloids and aquaculture appears to be a means of exploiting these species. Valuable species include Gracilaria spp., Chondrus spp. and Eucheuma spp. Both Chrondrus and Eucheuma produce carrageenans which are marketed in two biochemically distinct forms: IOTA and KAPPA. IOTA carrageenan has a high world demand, and may sell for as much as $1,000 per dry ton ($1,100 per dry metric ton) wholesale. Researchers at the Univeristy of Hawaii are responsible for the rapid development of Eucheuma



farming in the Philippines. They suggest that oppotunities exist for the commercial culture and processing of Eucheuma in Hawaii. The state can functiôn both as a source of farmed algae and a location for processing colloids for the Pacific.

## Seaweed System
## Construction Costs

| | Units | Size | Unit/Costs | Total |
|---|---|---|---|---|
| Production trenches | 1f | 10,000 | $6 | 60,000 |
| Drying Beds | 5f | 2,000 | 5 | 10,000 |
| Storage Building | 1 | 20X20 | $20/sq ft. | 8,000 |
| Laboratory | 1 | 20x20 | $25/sq. ft. | 10,000 |
| Miscellaneous Supplies | | | | 2,000 |
| Harvesting Equipment | | | | 6,000 |
| Engineering | | | | 9,000 |
| | | | | 105,000 |
| Contingency | | | | 20,000 |
| | Total | | | $125,000 |

## Seaweed System
## Production Costs

| | | |
|---|---|---|
| Salaries | | |
| Manager/Technician (1) | $20,000 | 20,000 |
| Labor (3) | 12,000 | 36,000 |
| Truck Lease | | 4,000 |
| Maintenance | | 5,000 |
| Vehicle Maintenace and Ops. | | 3,000 |
| Supplies | | 2,000 |
| Contingency | | 7,000 |
| Total | | $77,000 |

### Annual Value of Crop - Seaweed

900 T of wet seaweed per mile of ditch per year may be expected. This will be dried to produce 90 t/mile.
90t x 2 miles x $450/t = 81,000



| | |
|---|---|
| Total annual production costs | $ 77,000 |
| Total annual crop value | 81,000 |
| Return an production costs | 1.05 |
| Total Facility Construction Cost | 125,000 |

## C. TILAPIA

Tilapia is a desirable fish in several respects: 1) it may feed upon phytoplankton, as do clams and oysters mentioned earlier; 2) tilapia will also eat larger, particulate matter; 3) tilapia grow very rapidly; 4) they are very hardy; 5) they are good to eat (and are considered a delicacy by the Chinese); 6) they grow under a wide variety of conditions. Tilapia of several species have attracted the attention of aquaculturists around the world during recent years. A recent variety has been developed in which about half of the offspring are a red-to-pink color. Fish of this color are especially prized as edible products. In addition, the possibility may exist for the red variety to serve as an acceptable bait in the currently bait-limited billfish fishing industry in waters off the island of Hawaii.

Because tilapia are very hardy and because they will readily consume and grow well on a wide variety of matter, they would serve as an ideal scavenger in the tail-water of the integrated aquaculture operation. It is proposed that tilapia be cultured in the principal drainage ditch for the farm, and in a 30-acre pond integrated into the canal. Nutrient-rich water entering the pond will then proceed to the seaweed ditches and final dispersal.

Income from tilapia has not been calculated in this study, as initially all production of this fish will be used as mahimahi feed.

# APPENDIX I

## ENGINEERING ANALYSIS
## FOR
## FARMS OF KAPUA
## (Revised 1984)

By
R.M. TOWILL CORPORATION

# ENGINEERING ANALYSIS

# FOR

# FARMS OF KAPUA

# SOUTH KONA, HAWAII

Prepared For:

Agricultural Concepts, Inc.
615 Piikoi Street, Suite 1510
Honolulu, Hawaii 96814

FEBRUARY 1984

Prepared By:

R. M. Towill Corporation
677 Ala Moana Boulevard, Suite 1016
Honolulu, Hawaii 96813

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# SECTION 1
# INTRODUCTION AND SCOPE

## 1.1 PROJECT DESCRIPTION

The "Farms of Kapua" is a multi-agricultural project proposed for the southernmost portion of the South Kona District, TMK: 8-9-06, Parcel 3. The development includes a macadamia nut orchard area, a 200-acre koa haole cultivation area, a koa haole pasture area (2,472 acres), a 200-acre research and development area and an aquaculture area. Detailed description of the development is contained in the Farms of Kapua EIS Preparation Notice prepared by Group 70, Planners.

## 1.2 PURPOSE

The purpose of this report is to present the civil engineering considerations necessary to procure an amendment to the Land Use District Boundary in Kapua, South Kona, Hawaii, from conservation district to agricultural district. Detailed description of the site is outlined in the Farms of Kapua EIS Preparation Notice prepared by Group 70, Planners.

## 1.3 SCOPE

The scope of this report is to provide preliminary civil engineering concepts of roadway development, water supply development, sewage treatment and disposal methods, drainage and grading, power procurement and the budgetary cost estimate for these items. The extent of effort is such that it satisfies the requirement to procure the desired amendment.

## SECTION 2
## ROADWAYS AND RIGHT-OF-WAYS

### 2.1 GENERAL DESCRIPTION

The project site is situated makai of the Mamalahoa Highway as shown on Figure 1. There is presently no paved access to the project site. The proposed project development will require an access road from the Mamalahoa Highway through the macadamia nut orchard to the aquaculture facility.

### 2.2 PROPOSED ROADWAY IMPROVEMENTS

#### 2.2.1 Access from Mamalahoa Highway

There is an access road proposed from the Mamalahoa Highway through the agricultural areas to the aquaculture facility. This road will be paved similar to Collector Streets.

Collector Streets, as defined in the County of Hawaii Ordinance, are streets supplementary to the arterial street system which is a means of intercommunication between this system and smaller areas used to some extent for through traffic and to some extent for access to abutting properties. The Collector Streets are streets having a 60-foot right-of-way with 20-foot pavement. The paved road extends through to the aquaculture facility and is approximately 28,000 lineal feet as shown on Figure 1. A typical cross section of a paved roadway is shown on Figure 2. This roadway is not intended to be dedicated to the County.

### 2.3 ESTIMATED COST

The approximate unit cost for the construction of the paved roadway is $100 per linear feet. The length of the paved roadway is 28,000 lineal feet. At the unit cost of $100 per lineal feet, the total cost of paved roadway is $2,800,000.

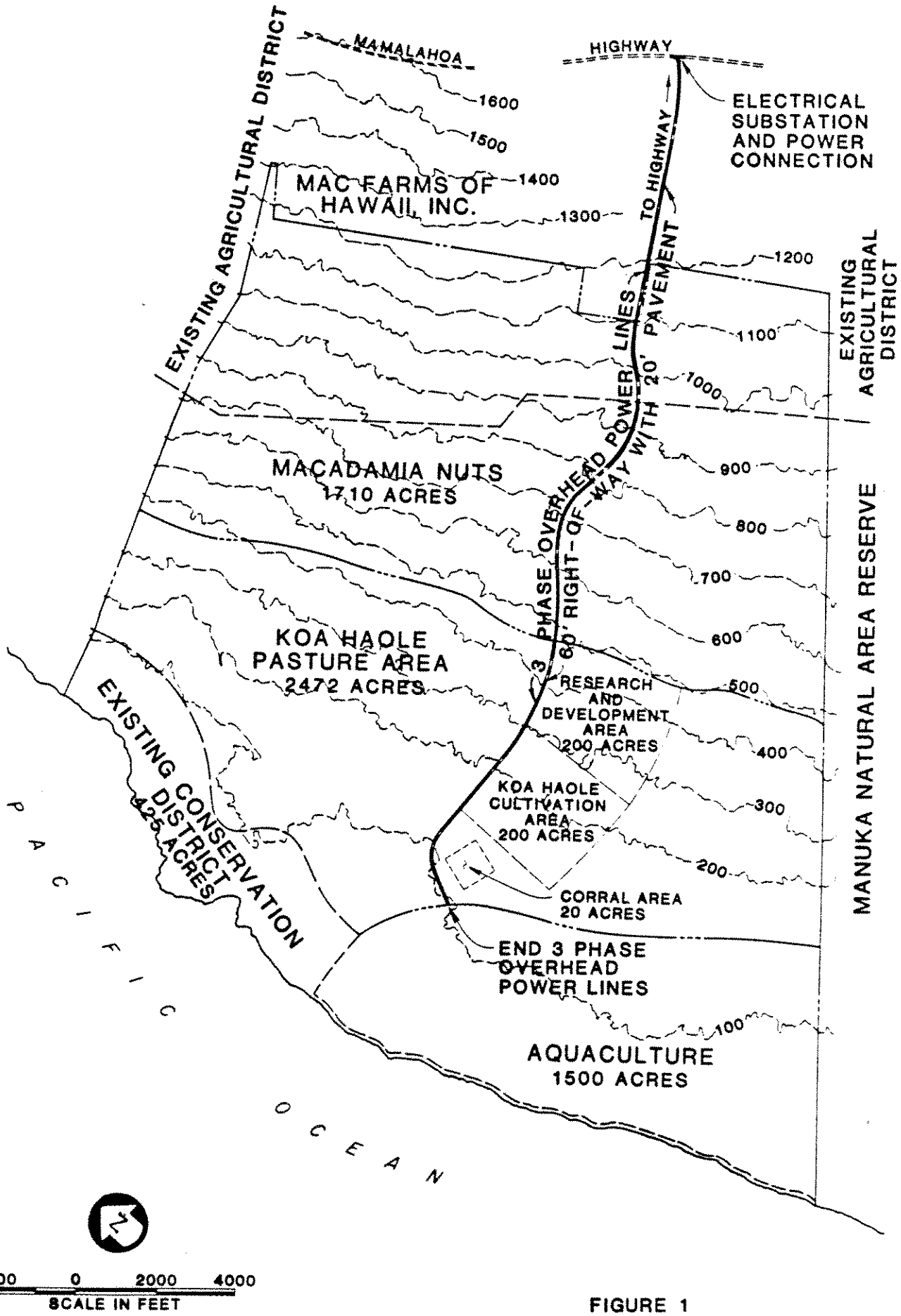


FIGURE 1

R. M. TOWILL CORPORATION

ROADWAY AND POWERLINE LAYOUT

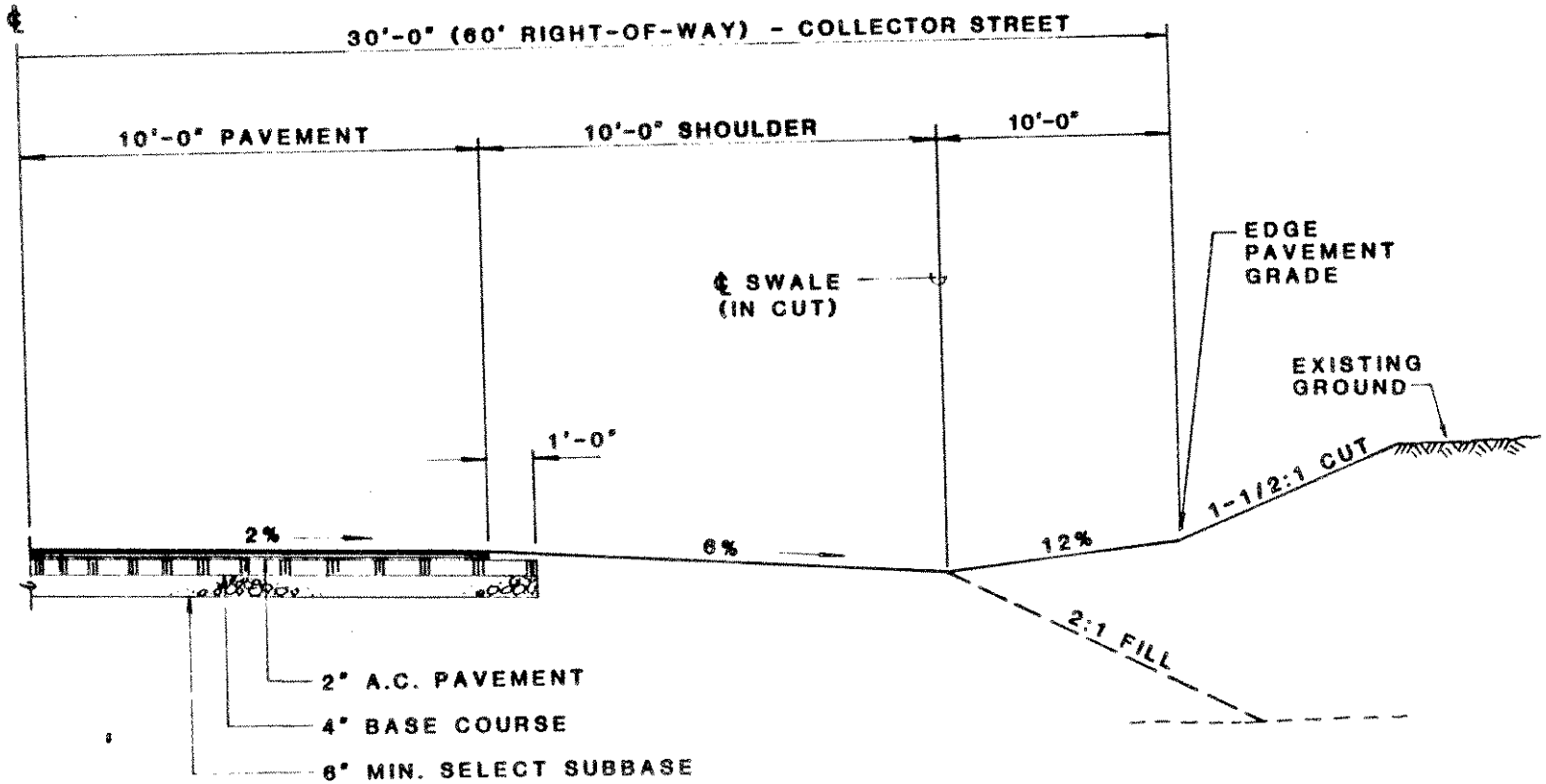


FIGURE 2

**TYPICAL CROSS-SECTION**

## SECTION 3
## GRADING AND DRAINAGE

### 3.1 GENERAL DESCRIPTION

The project site is presently unimproved with the entire area ungraded. There are no major waterways on site that require major drainage facilities (catch basins and drain lines). A detailed description of the terrain and vegetation of the site is outlined in the Farms of Kapua EIS Preparation Notice prepared by Group 70, Planners.

### 3.2 PROPOSED GRADING CONCEPT

#### 3.2.1 Macadamia Nut, 200-Acre Cultivated Koa Haole and 200-Acre Research and Development Areas

The extent of the grading and drainage improvements to be done in the macadamia nut orchard area includes the grading of the existing irregular terrain such that high mounds are cut and the material used to fill the depressions, and the addition of drainage facilities consisting of roadside swales, pipe culverts and on site swales if necessary.

The grading should be done such that there is no need to bring in any borrow material. Grading for the macadamia orchard will be phased in 500-acre increments over 6 years. Grading for the 200-acre Research and Development and the 200-acre Koa Haole Cultivation areas shall be done in a single increment after the irrigation system for these areas are in place. Approximately 70 percent of the entire area shall be graded such that macadamia nuts or other crops can be cultivated. All large rocks and boulders exposed while grading shall be buried. The remaining 30 percent of land is presumed to be needed for preservation of archaeological/historical sites or areas containing significant botanical specimens.

The grading shall be done to permit proper drainage of rainfall runoff. Areas containing archaeologically significant items shall be avoided and only critical gulches that may concentrate runoff at a specific area shall be filled to alleviate the problem. The low rainfall and porous condition of the ground will negate the need for construction of a major drainage



system. Runoff from roadways shall be conveyed by swales located along side the road as shown on Figure 2 and directed off the pavement. Where necessary, culverts will be installed.

#### 3.2.2 Koa Haole Pasture Area

There are no improvements proposed in this area except for clearing and grubbing and minimal grading to provide access for irrigation trucks used for watering the plants. Improvements are to be done in 400-acre increments over 6 to 7 years. Access roads will be provided on an as needed basis.

#### 3.2.3 Aquaculture Facility Area

No grading will be done with the initial development of the project. Clearing and grubbing, minor leveling of mounds and refined grading may be done as each of the five 200-acre aquaculture modules is developed. Any archaeological/historic sites will not be disturbed during grading.

### 3.3 ESTIMATED COST

The cost for rough grading (or clearing and grubbing) the project site is based on an average cost per acre. The cost per acre of the rough grading as described in Section 3.2.1 is estimated from past experience at $1,400. At 1,477 acres of grading (70 percent of the total area of 2,110 acres in the macadamia nut, koa haole cultivation and research and development areas), the total cost for grading is $1,772,400. Clearing and grubbing the koa haole pasture area at $136 per acre for 1,730 (70 percent of 2,472) acres would cost approximately $235,280.

The cost of drainage improvements includes only the cost of culverts, since the swales are considered a part of roadway construction. The estimated amount of culverts required is 5 at $5,000 per culvert. The total cost of culverts is $25,000. The total cost of grading and drainage is approximately $2,032,700.

## SECTION 4
## IRRIGATION WATER SUPPLY DEVELOPMENT

### 4.1 GENERAL DESCRIPTION

The water development plan for this project includes only irrigation water requirements. Potable water will not be provided for this project. The absence of any potable water system in the vicinity dictates that water requirements for the workers of the macadamia nut orchard and the aquaculture facility may be provided by catchments and/or hauled in by water trucks and stored in reservoirs or tanks.

The irrigation water is provided in this project by three irrigation wells located on site, with the possible supplement of water from the existing Okoe Well (approximately 1.0 mgd), with distribution lines running adjacent to the main roadways as shown on Figure 3. Pumps, motors and controls are also required at the Okoe Well sites in the event it is used.

### 4.2 WATER SYSTEM REQUIREMENTS

#### 4.2.1 Irrigation Well Requirements

The irrigation requirements for 1,710 acres of macadamia nut is 1,912 gpd/acre based on "Water Supply for Farms of Kapua" prepared by John F. Mink, groundwater hydrologist, for Farms of Kapua. The area to be irrigated includes the macadamia nut orchard area and 400 acres of koa haole cultivation, and research and development. This is a total requirement of 34.0 mgd or 2,800 gpm.

#### 4.2.2 Distribution Requirements

The distribution requirements for this study are limited to the roadways in the areas makai of the irrigation wells, as shown on Figure 3. The distribution system should be sized such that it may carry the 10 percent demand requirement (3,481 gpd/acre) should it be necessary.

### 4.3 PROPOSED DEVELOPMENT CONCEPT

#### 4.3.1 Well Development

The absence of any water system in the vicinity necessitates the development of a water source in the area. As recommended by John F. Mink,

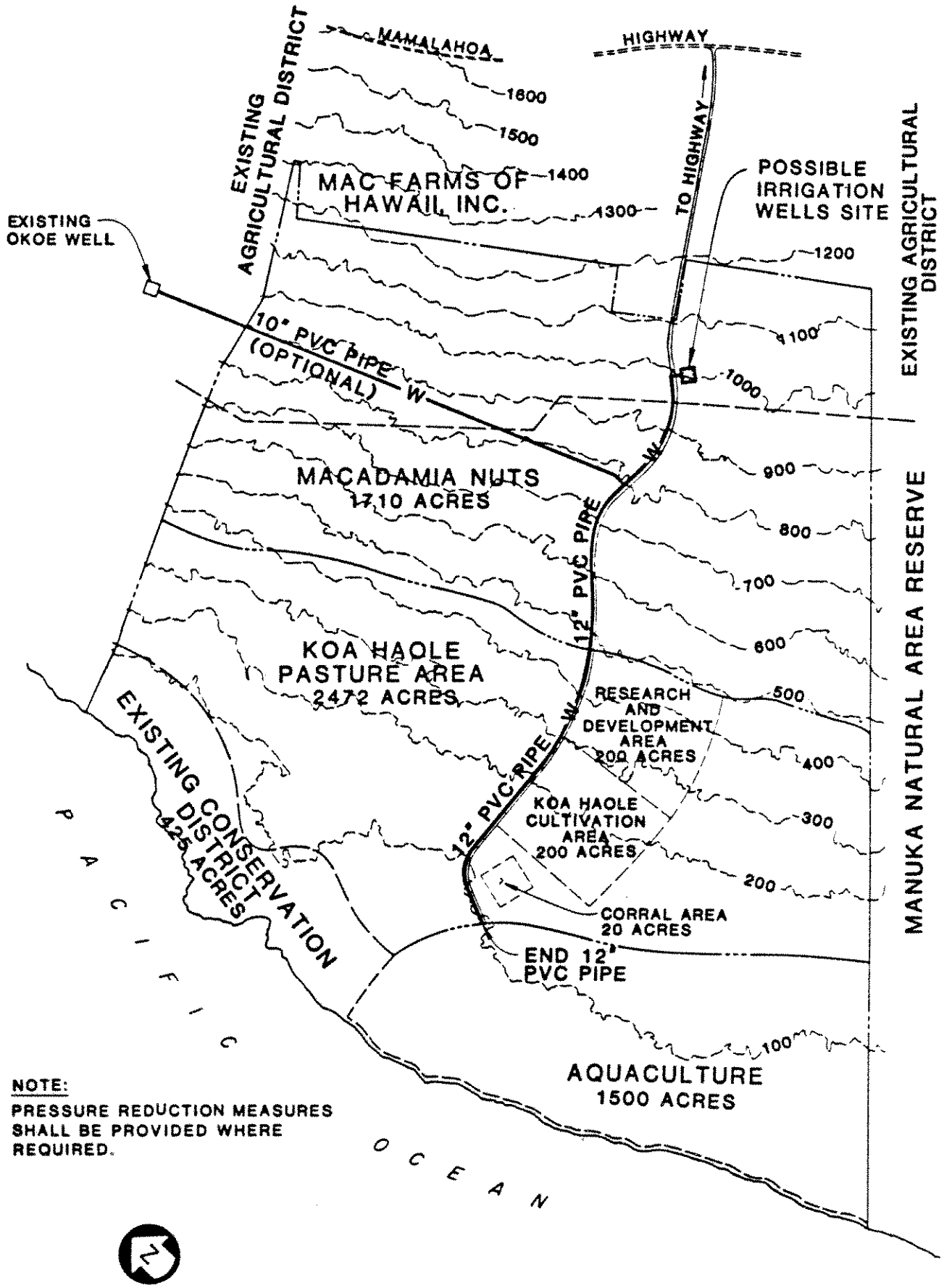


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FIGURE 3

IRRIGATION WATER SYSTEM LAYOUT

the 12-inch diameter irrigation water wells are to be developed in the area between the 800 and 1,000-foot elevations. A possible site for the wells is shown on Figure 3 (see attached).

The wells should be pumped at approximately 1,000 gpm each. The location may be anywhere in the macadamia farm area. Based on the irrigation water requirement of 2,800 gpm, three (3) irrigation wells must be developed initially, with an additional one (1) to two (2) well(s) in the future to satisfy the 10 percentile demand. The 3,000 gpm total (not including water from Okoe Well) is adequate to handle water requirements for the macadamia nut orchard, 200-acre koa haole cultivation area and 200-acre research and development area. It is recommended that the latter one (1) to two (2) well(s) be developed on an as needed basis. The type of irrigation system in the macadamia nut orchard shall be drip irrigation.

### 4.3.2 Distribution Requirements

The irrigation water distribution system shall include the piping network providing water for the areas adjacent to the roadways. A layout of the system is shown on Figure 3. The transmission line extends from the well site through the roadway in the area and down to the aquaculture facility. Pressure reduction measures shall be incorporated as necessary in the system. No storage reservoir is required.

The irrigation pipes shall be 12-inch PVC to transport the 10 percent water demand should it be required. The pipe shall be exposed except at street crossings where adequate protection from traffic shall be provided. The class of the PVC pipe shall be such that it is resistant to exposure to sunlight.

## 4.4 ESTIMATED COST

The breakdown of the irrigation water system is shown on Table 1. The total cost for the irrigation system is approximately $4,000,000.



TABLE 1

IRRIGATION SYSTEM COST

| | | |
|---|---|---|
| Well Development Cost, 3 @ $900,000 | = | $2,700,000 |
| Distribution System | | |
| 18,400 LF of 12" PVC Pipe @ $16/LF | = | 294,400 |
| Well Pumps, Motor & Controls | = | 200,000[1] |
| 13,000 LF of 10" PVC Pipe @ $14/LF | = | 182,000[1] |
| Installation (35% of $676,400) | = | 236,700 |
| | | $3,613,100 |
| 10% Contingency & Misc. Expenses | = | 361,300 |
| | | $3,974,400 |
| SAY | = | $4,000,000 |

[1]These items are to be eliminated should Okoe Well not be used as a supplemental water supply.

## SECTION 5

## SEWAGE COLLECTION, TREATMENT AND DISPOSAL

### 5.1 GENERAL DESCRIPTION

There are presently no sewage collection, treatment and disposal system in the area. The closest centralized system is in Naalehu in Kau and in Keauhou, Kona. Connection to either of these sewer systems is economically unfeasible. The construction of a centralized system with a sewage treatment plant would be extremely expensive from a construction and maintenance standpoint. Because of the nature of the development, a centralized system is not recommended from an economic as well as environmental standpoint.

### 5.2 METHOD OF SEWAGE COLLECTION, TREATMENT AND DISPOSAL

#### 5.2.1 Agricultural Development

The recommended method of sewage disposal is by cesspools. The absence of any permanent resident population, high permeability of the soil in the area, and the absence of a potable water well are ideal conditions for cesspool use at the cattle pen area for workers.

The rules and regulations governing the use of cesspools are outlined in Chapter 38 of the State of Hawaii, Public Health Regulations. Chapter 57 will soon replace Chapter 38 as the governing regulation and also contain cesspool requirements. Both Chapters 57 and 38 are similar and allow the use of cesspools for this project provided they are constructed in accordance with the regulations.

The requirements in Chapters 38 and 57 are basically construction methods and spacing requirements. Spacing constraints are shown on Table 2. Construction of cesspools should be 6 feet minimum diameter and should be lined if the geologic condition requires it. Details on cover construction, depth and inlet pipe locations are in the regulations and are typical of domestic cesspools used throughout the State.



#### 5.2.2 Aquaculture Facility

The low domestic wastewater volume (sewage) produced at the aquaculture facility will be disposed of by cesspools. Several cesspools may be necessary for the entire facility.

The wastewater produced from the aquaculture facility operation is basically brackish water that has been cycled through the aquaculture production units. This wastewater contains no human contamination and consists basically of fecal matter from marine organism, excess feed, and other algal and plant matter. Because the water in the area is classified as Class AA, no discharge into the ocean is permitted regardless of treatment.

The recommended method of disposal proposed by a previous study of the aquaculture facility by the Oceanic Institute is by percolation ditches or ponds. It is important to note that the ponds or ditches must be man-made, not a natural pond or body of water.

The exact area required for the percolation ditches has not been determined. The estimated flow of wastewater is 6.0 mgd. The porous ground characteristic in the area should be excellent for disposing of the wastewater by percolation within the area provided for the facility.

### 5.3 ESTIMATED COST

The average cost of cesspool construction based on previous experience is approximately $6,000 each. The cost of domestic sewage disposal at the agriculture areas and aquaculture facility is to be included as part of the facility development. The number of cesspools will be dependent on the size of the initial increment of construction and will be in accordance with the current regulations governing cesspools. The excavation and transmission pipe costs for the marine wastewater percolation ponds have not been determined in this study.

TABLE 2

MINIMUM HORIZONTAL DISTANCES FROM CESSPOOL

(Distances in Feet)

| | |
|---|---|
| Wall line of any roof structure or building | 10 |
| Property line | 9 |
| Stream, the ocean at mean sea level, pond, lake | 50 |
| Large trees | 10 |
| Seepage pit | 18 |
| Other Cesspools | 18 |



SECTION 6

POWER (TELEPHONE) PROVISION

## 6.1 GENERAL DESCRIPTION

The closest source of power in the area is the 69 KV overhead power lines along the Mamalahoa (Belt) Highway. The closest substation is at Hookena in South Kona. Power is required at the water well sites, and the aquaculture facility.

## 6.2 PROPOSED POWER PROVISION

It recommended that the power supply be three-phase type and be transmitted by overhead lines. The lines should run within the road right-of-way and/or power easements. Connection may be made at the Mamalahoa Highway at the junction of the southernmost entry road as shown on Figure 2. A substation should be constructed to provide 12.49 KV distribution lines. Power lines should be provided on all the roadways to the aquaculture facility. Figure 2 shows the proposed power line layout.

Three-phase power supply is recommended because of the large motors at the well site and the aquaculture facility. Overhead lines will be supported by wooden utility poles which will also support telephone lines. Poles are to be spaced 230 to 250 feet apart.

## 6.3 ESTIMATED COST

The budgetary estimate of the overhead lines is approximately $2,600 per pole. The normal distance between poles is 230 to 250 feet. Based on these costs, the unit cost for overhead power lines is approximately $12.00 per lineal foot. At 23,050 lineal feet of power line, the total cost is approximately $276,600. The cost of a substation is approximately $150,000. Total cost for the power system is approximately $426,600. This cost does not include facility hookups, but only the installation of the main transmission line as shown on Figure 2.

## SECTION 7
## COST ESTIMATE SUMMARY

The following table is a summarization of cost (to the closest $50,000) developed in the study.

| | Item | Cost |
|---|---|---|
| 1. | Roadway Construction | $ 2,800,000 |
| 2. | Grading and Drainage | $ 2,050,000 |
| 3. | Irrigation Water System (3 wells) | $ 4,000,000 |
| 4. | Power Requirements | $ 450,000 |
| | TOTAL | $ 9,300,000 |
| | SAY | $ 9,300,000 |

# APPENDIX J

## AGENCIES, ORGANIZATIONS AND PERSONS WHO WERE SENT A COPY OF THE EIS; WRITTEN COMMENTS RECEIVED DURING THE PUBLIC REVIEW PERIOD; and RESPONSES

EIS PUBLIC REVIEW PERIOD
(23 FEBRUARY - 24 MARCH 1984)

## AGENCIES, ORGANIZATIONS AND PERSONS WHO WERE SENT A COPY OF THE EIS

The EIS was officially filed with the Land Use Commission and the Environmental Quality Commission on February 21, 1984. It was published in the Office of Environmental Quality Control (OEQC) Bulletin on February 23, 1984. The deadline for submitting written comments on the EIS was March 24, 1984. As of April 3, 1984, a total of 25 written comments were received; of this total, 12 required no response. The following agencies, organizations and persons recieved a copy(ies) of the EIS. Double starred (**) individuals responded to the EIS, but did not require a response. Their letters are reproduced here. Triple starred (***) respondants made substantive written comments which required a written response; both their comments and our responses are included in this section.

### Federal

** 15th ABW/DEE, Hickam
Army - DAFE (Facilities Eng. - USASCH)
** Navy
** Soil Conservation Service
** U.S. Army Corps of Engineers
** U.S. Coast Guard
** U.S. Fish & Wildlife Service
*** U.S. Geological Survey

### State

*** Department of Agriculture
** Department of Accounting and General Services
** Department of Defense
Department of Education
- Hilo Regional Library
- Kaimuki Regional Library
- Kailua-Kona Library
- Kaneohe Regional Library
- Kealakekua Library
- Lihue Regional Library
- Main Library
- Pearl City Regional Library
- Wailuku Regional Library

Department of Hawaiian Homes Lands
** Department of Health
*** Department of Land & Natural Resources
DLNR State Historic Preservation Officer
*** Department of Planning & Economic Development
- DPED Library
- Land Use Commission

Department of Social Services and Housing
** Department of Transportation
*** Office of Environmental Quality Control
Office of Hawaiian Affairs
State Archives
** State Energy Office
State Legislature
- Legislative Reference Bureau

University of Hawaii
- Environmental Center
- Hamilton Library
- Marine Options Program
- UH Hilo Library
- *** Water Resources Research Center

### County of Hawaii

Department of Parks and Recreation
*** Planning Department
*** Public Works Department
*** Research and Development
** Water Supply Department

### Organizations and Individuals

American Lung Association
*** Audobon Society of Hawaii
Bishop Museum
Hawaii Electric Light Company
Hawaii Island Economic Development Board
Hawaii Tribune Herald
Honolulu Advertiser
Honolulu Star-Bulletin
Gilbert Kahele
*** Na Ala Hele
Pa'a Pono of Milolii, Inc.
*** David Campbell Penn
Sierra Club, Moku Loa Group
Sun Press
Universal Life Church
*** Rick Warshauer
West Hawaii Today

U.S. Department of Transportation
United States Coast Guard

Commander (dpl)
Fourteenth Coast Guard District

Prince Kalanianaole
Federal Building
300 Ala Moana Blvd.
Honolulu, Hawaii 96850
Phone: (808) 546-2861

11000
Serial No. 4/030
27 February 1984

RECEIVED
FEB 29 1984
GROUP 70

Mr. Gordan Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

The Fourteenth Coast Guard District has reviewed the Environmental Impact Statement (EIS) for the Farms of Kapua and has no objection or constructive comments to offer at the present time.

Sincerely,

J. E. SCHWARTZ
Commander, U. S. Coast Guard
District Planning Officer
By direction of Commander,
Fourteenth Coast Guard District

Copies to: (1) Farms of Kapua
(2) AIA Group 70

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 15TH AIR BASE WING (PACAF)
HICKAM AIR FORCE BASE, HAWAII 96853

RECEIVED
MAR 7 1984
GROUP 70

5 MAR 1984

REPLY TO ATTN OF: DEEV (Mr Yamada, 449-1831)

SUBJECT: Environmental Impact Statement for the Farms of Kapua

TO: Ms Letitia Uyehara, Interim Director
Office of Environmental Quality Control
550 Halekauwila Street, Room 301
Honolulu, HI 96813

1. This office has reviewed the subject EIS and has no comment relative to the proposed project.

2. We greatly appreciate your cooperative efforts in keeping the Air Force apprised of your project and thank you for the opportunity to review the document. The EIS is returned for your file.

ROBERT M. OKAZAKI
Chief, Engrg & Envmtl Plng Div
Directorate of Civil Engineering

1 Atch
EIS

cc: Mr Gordon Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, HI 26813

Mr John Farias, Jr.
Farms of Kapua
605 Piikoi Street, Suite 1510
Honolulu, HI 96814

Mr Francis S. Oda, AIA
Group 70
924 Bethel Street
Honolulu, HI 96813

HEADQUARTERS
NAVAL BASE PEARL HARBOR
BOX 110
PEARL HARBOR, HAWAII 96860

IN REPLY REFER TO:
002B:WKL:jam
Ser 313

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MAR 9 1984
GROUP 70

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MAR 1984

Mr. Gordan Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Environmental Impact Statement
Farms of Kapua

The EIS for the Farms of Kapua has been reviewed and the Navy has no comments to offer.

Thank you for the opportunity to review the EIS.

Sincerely,

M. M. DALLAM
CAPTAIN, CEC U. S. NAVY
FACILITIES ENGINEER
BY DIRECTION OF THE COMMANDER

Copy to:
Mr. John Farias, Jr.
Farms of Kapua
605 Piikoi Street, Suite 1510
Honolulu, Hawaii 96814

✓Mr. Francis S. Oda, AIA
Group 70
924 Bethel Street
Honolulu, Hawaii 96813

United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
P.O. Box 50166
Honolulu, Hawaii 96850

March 20, 1984

RECEIVED
MAR 22 1984
GROUP 70

Mr. Gordon Furutani
Executive Officer
Land Use Commissioner
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Subject: Environmental Impact Statement, Farms of Kapua, South Kona, Hawaii, February 1984

We have reviewed the subject environmental impact statement regarding water resources in the Kapua Farms area and the action proposed in providing water for the farms.

The excellent report by John F. Mink on water supply for the farms, which is appended to the statement, indicates the existence in the Kapua area of a sizable ground-water resource that ranges from very brackish to fresh depending on the distance from the shore. The report emphasizes, however, that the resource has not been investigated in detail in Kapua and points out the high cost of drilling and equipping wells in the area.

In view of uncertantities in locations of ground water suitable in both quantity and quality for the farms and of the high cost of installation of production wells, perhaps consideration should be given to investigation of methods of exploration and testing that would give reasonably definitive information on the best sites for drilling.

Thank you for the opportunity to examine the statement.

Sincerely,

Stanley F. Kapustka
District Chief

cc: John Farias, Jr.
Francis S. Oda

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Stanley F. Kapustka
District Chief
United States Department of the Interior
Geological Survey
Water Resources Division
P.O. Box 50166
Honolulu, HI 96850

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Kapustka:

We thank you for your letter of 20 March 1984 and offer the following responses. Although the groundwater resource at Kapua has not been investigated in detail, John F. Mink considers his report provides adequate information on which to proceed with specific siting and installing of wells. The state-of-the-art in estimating resources is such that the current practice is to drill a well that serves both exploratory and development purposes. This is the accepted practice of the City and County of Honolulu Board of Water Supply among others. In addition, please note that Mink has testified before the Land Use Commission that he has no record of failure in terms of predicting the availability or non-availability of water for development, in his capacity over the years as consultant to various water developers.

Very truly yours,

Sheryl B. Seaman, AIA

cc: Land Use Commission

DEPARTMENT OF THE ARMY
PACIFIC OCEAN DIVISION, CORPS OF ENGINEERS
FT. SHAFTER, HAWAII 96858

REPLY TO ATTENTION OF

March 20, 1984

RECEIVED MAR 23 1984 GROUP 70

Mr. Gordon Furutani
Executive Officer
Land Use Commission
Old Federal Building
Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Thank you for the opportunity to review and comment on the Environmental Impact Statement for Farms of Kapua. Our letter dated December 29, 1983 included in the EIS reflects our concerns. We have no further comments.

Sincerely,

Kisuk Cheung
Chief, Engineering Division

Copy Furnished:

Mr. John Farias, Jr.
Farms of Kapua
605 Piikoi Street
Suite 1510
Honolulu, Hawaii 96814

Mr. Francis Oda, AIA
Group 70
924 Bethel Street
Honolulu, Hawaii 96813

United States Department of Agriculture
Soil Conservation Service
P.O. Box 50004
Honolulu, Hawaii
96850

RECEIVED MAR 24 1984 GROUP 70

March 23, 1984

Mr. Gordan Furutani
Executive Officer
Land Use Commission
Old Federal Bldg., Room 104
335 Merchant St.
Honolulu, HI 96813

Dear Mr. Furutani:

Subject: Environmental Impact Statement for Farms of Kapua
Ahupua'a of Kapua, South Kona, Hawaii

We reviewed the subject environmental impact statement and have no comments to make.

Thank you for the opportunity to review this document.

Sincerely,

FRANCIS C.H. LUM
State Conservationist

cc:
Mr. John Farias, Jr.
Farms of Kapua
605 Piikoi St., Suite 1510
Honolulu, HI 96814

Mr. Francis S. Oda, AIA
Group 70
924 Bethel St.
Honolulu, HI 96813

The Soil Conservation Service is an agency of the Department of Agriculture

United States Department of the Interior

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

IN REPLY REFER TO:
ES
Room 6307

MAR 27 1984

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MAR 28 1984
GROUP 70

Mr. Gordon Furutani
Executive Officer, Land
Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Re: EIS, Farms of Kapua
South Kona, Hawaii

Dear Mr. Furutani:

We have reviewed the subject Environmental Impact Statement (EIS) and have no additional comments to offer. We appreciate this opportunity to comment.

Sincerely,

William R. Kenney

for Ernest Kosaka
Project Leader
Office of Environmental Services

cc: Mr. John Farias, Jr., Farms of Kapua
Mr. Francis s. Oda, Group 70
NMFS-WPPO
HDF&W
HDAR
EPA, San Francisco

CONSERVE AMERICA'S ENERGY

*Save Energy and You Serve America!*

FEB 21 1984

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GROUP 70 (P)1102.4

Mr. Gordan Furutani
Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Subject: Environmental Impact Statement
for Farms of Kapua, South Kona, Hawaii

We have reviewed the subject environmental impact statement and have no comments to offer.

Thank you for the opportunity to review the environmental impact statement.

Very truly yours,

RIKIO NISHIOKA
State Public Works Engineer

/lm
cc: Mr. John Farias, Jr.
Mr. Francis S. Oda, AIA

---

State of Hawaii
DEPARTMENT OF DEFENSE
OFFICE OF THE ADJUTANT GENERAL
3949 Diamond Head Road
Honolulu, Hawaii 96816

RECEIVED FEB 29 1984

GROUP 70

HIENG

Mr. Gordan Furutani, Executive Director
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Farms of Kapua

Thank you for providing us the opportunity to review the proposed project, "Farms of Kapua" Environmental Impact Statement.

We have completed our review and have no comments to offer at this time.

Yours truly,

signed

JERRY M. MATSUDA
Major, HANG
Contr & Engr Officer

cc: Farms of Kapua
Group 70 ✓
OEQC w/EIS

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

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

RECEIVED
MAR 20 1984
GROUP 70

MAR 14 1984

LAND USE COMMISSION
STATE OF HAWAII
MAR 15 3 55 PM '84

Mr. Gordan Y. Furutani
Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Thank you for the opportunity to comment on the environmental impact statement (EIS) for the Kapua Farms petition. We have a few concerns to express.

Aquaculture Technology

The species of choice are, for the most part, high-value, readily-marketed products with excellent export potential. Production of high-value products offer the profit margins needed to attract investment capital. Moreover, the phased development strategy is an appropriate way to proceed with the commercialization of new technologies.

The proposed integrated aquaculture system represents state-of-the-art technology, inasmuch as waste products of one component of the system are fuel for the next component of the system. An integrated system therefore yields several benefits: wastewater disposal and associated potential environmental pollution problems are minimized, and production economics are favored by a potentially-significant reduction in feed costs to all downstream components of the system. Similarly, required nutrient levels in the system are the result of waste products and by-products of the culture system, and not from imported or fossil-fuel derived fertilizer. The proposed culture system would also offer the necessary economies of scale to realize maximum profit potential, hence success.

Aquatic Resources

Surveys of coastal waters near the project site in October 1971 by the Division of Fish and Game revealed abundant and diversified reef fauna.



We suggest the EIS cover in detail the potential impacts of the project on coastal marine resources and on anchialine ponds found nearby. A number of specific concerns (8) were identified in our January 4, 1984 letter to Mr. William W. L. Yuen. The applicant's consultants responded to some of our concerns in a letter of February 17, 1984, and in the draft EIS. However, the following concerns, some shared with other agencies commenting (Part IX), remain to be addressed:

1. Effects of reducing the groundwater resources on anchialine ponds and coastal waters;

2. Effects of leaching from cesspools and troughs for disposal of aquacultural effluent on the nutrient levels in coastal waters;

3. Security measures to prevent the theft and transport of exotic and diseased aquacultural species.

With respect to construction and site work activities, the following precautionary measures are recommended to minimize potential for adverse effects to the nearby aquatic environment:

1. Construction and site work should be scheduled for periods of minimum rainfall;

2. Lands denuded of vegetation should be protected as quickly as possible from erosion (through replanting or other means);

3. Precautionary measures proposed by the applicant (such as use of no pesticides within the petition area and herbicide use only by hand application, during non-windy days, within only the proposed macadamia orchards and research-and-development area) should be required; and

4. Construction materials, petroleum products, human wastes, debris and landscaping substances (herbicides and fertilizers) should be prevented from falling, flowing, and leaching into coastal waters.

Historic Sites

Our records indicate that the Ahole Holua Complex (site #2134), a site listed on the National Register of Historic Places, and many other cultural features listed on the Statewide Archaeological Inventory, are located within the subject parcel.

We concur that Rosendahl's March 1983 archaeological reconnaissance is adequate for the purpose of the State Land Use Boundary Amendment Petition, and further archaeological work will be done prior to the developer's impact on any area within the parcel.

The EIS states:

> "Further archaeological reconnaissance survey will be conducted for any specific development areas within the petition area which were not covered in Rosendahl's earlier survey (1983). Upon completion of this latter task, intensive survey of significant sites identified would be conducted. The exact scope and scale of any further archaeological work in the petition area (intensive survey) will be worked out in consultation between the petitioner and the appropriate State and County representatives. Specific mitigation vs. preservation decisions will be made later, on the basis of intensive survey findings. These decisions are not required at this stage of the planning process (petition to amend the State Land Use boundary). If any unanticipated sites are encountered within the project area after the intensive level surveys are completed, the contractor will stop work and contact the State Historic Preservation Officer and the County Planning Department." (EIS, 1984:37)

Recreation

One of the alternatives (B.2) on page 63 of the EIS provides unobstructed lateral access along the entire shoreline of the petition area, together with a 300 foot or 2,000 foot conservation district shoreline setback. We concur with this alternative. Another concern is that, wherever feasible, public access also be provided to archaeological features of public interests which are located outside the 425-acre area left in the Conservation District.

We also recommend that unimpeded public access to Oea Bay via an ancient mauka-makai trail (noted in County of Hawaii's Inventory of Public Access to the Shoreline, 1979) be maintained, consistent with a 1980 court decision affirming public right to use ancient and traditional trails (news reports attached).

Site

Although the geology at the Kapua site may result in higher land clearing and facility construction costs, provision of butyl pond liners will virtually eliminate pond water losses on the porous lava. Geological considerations aside, the Kapua area is well-endowed with the natural and climatic resources necessary for successful commercial aquacultural production.


MAR 14 1984

It would appear the site offers excellent potential for seawater or brackishwater well development. It is our understanding that extensive brackish groundwater resources are known to exist throughout the entire South Kona region. Provision for a commercial saltwater culture system would also tend to reduce development pressure on the area's freshwater resources and any potential concern for water resource adequacy and allocation.

Water

Okoe well is on State land, and use of this well is contingent on obtaining a water license from this agency. It would also require other adjustments as well since the area of the well is under a revocable permit to Dillingham Investment Corporation for pasture purposes.

Any wells drilled to support the proposed developments will requre a drilling permit from this agency.

Sincerely,

SUSUMU ONO
Chairperson
and
State Historic Preservation Officer

Attachments

HSB 10/16/80

# Ka'u Tradition Wins in Shore Access Case

By Llewellyn Stone Thompson
*Big Island Correspondent*

HILO — Circuit Judge Ernest Kubota has ruled that a private landowner in the Ka'u district must allow the public access to the shoreline by way of four traditionally used routes to the seacoast and along the coast.

Kubota rendered the decision in a case in which five Ka'u residents and the Sportsmans Club of Ka'u brought a class action suit against landowner Matsuhei "Thomas" Okuna after Okuna blocked access to the shoreline and had large numbers of people arrested for trespassing in the 1970s.

The case was the first in Hawaii in which members of the public took an access case to trial and won recognition of the right to access, said attorney Benjamin Gaddis of the Legal Aid Society which represented the plaintiffs.

THE CASE involved a question of access to Kawa Bay, consisting of a black sand beach backed by lava fields, located five miles northeast of Naalehu.

Kawa Bay had been used since ancient times for fishing and surfing, with access always available to the public, according to witnesses at the non-jury trial of the case in May.

The bay is also the site of Keeku heiau or temple, used for human sacrifices in ancient times, according to Kubota's findings of fact.

As early as 1955 but increasing in the mid-1970s, landowner Okuna began denying access to the bay, Kubota determined.

During a 2½-year period beginning in 1976, Okuna had 50 people arrested for trespassing on his property, police testified during the trial.

Kubota's ruling ordered continued public access by four trails, including the 3-foot-wide "Ancient Walking Trail," sometimes called the William Ellis trail, and the 15-foot-wide Government Road. These two trails parallel the shoreline.

KUBOTA ALSO ordered access by two other trails running from the mountains to the sea: a 10-foot-wide path called Corral Gate Road and a 3-foot-wide path called Hilea trail.

Kubota granted the access because the roads and trails had been in continuous use since ancient times, Gaddis said, and the ruling does not automatically ensure access by other trails which may not have been in continuous usage, he said.

The question of access to another Big Island coastal site, Kauanoa Beach at the Mauna Kea Beach Hotel at Kawaihae, was settled out of court with the hotel, Gaddis said.

HA 10/16/80

# Public wins access to shore through ancient Ka'u trails

By Hugh Clark
*Advertiser Big Island Bureau*

HILO — A Big Island judge ruled this week that Hawaii's residents must have access to the shoreline and the mountains under the doctrine of ancient Hawaiian custom.

The ruling in a class-action case in 3rd Circuit Court reopens old avenues to the shoreline of Ka'u and is expected to have statewide implications on public access — if the decision is not overturned by the Hawaii Supreme Court.

Judge Ernest Kubota, recognizing the traditions of ancient Hawaiian movement along the shoreline and from the mountains to the sea, signed a judgment in the 4-year-old case on Tuesday.

He awarded the Sportsman's Club of Ka'u and five of its members four different routes to Kawa Bay and to inland areas above the only major surfing site on the Big Island's south coastline.

In so doing, Kubota recognized the plaintiffs as a "class" — which means that they represented "all residents of the state of Hawaii," according to his ruling.

Equally important in the decision was the ruling that ancient Hawaiian custom, as determined by testimony by expert witnesses, including two anthropologists, can be used as a basis for determining access to the shoreline.

Ancient Hawaiians never recognized private property as barriers in their movements along the shoreline to fish and travel. Today's landowners cannot bar travel now if the property is on ancient trails or paths created by the Hawaiian monarchy, according to the judgment.

Under Hawaii legal procedures, the Kubota ruling will not bind other courts in the state unless the decision is appealed and upheld by the intermediate or supreme courts.

But Kubota has created a precedent in his own courtroom for future public access disputes that may be litigated, involving the ancient trails or the King's Highway.

The decision stemmed from a jury-waived trial Kubota conducted for a week in May after the Legal Aid Society of Hawaii brought the suit against Ka'u rancher Matsuhei "Thomas" Okuna.

Lead counsel Ben Gaddis said the case was the first dealing with the public-access question to come to trial in Hawaii's courts and to result in a formal conclusion.

The dispute began in the early 1970s, when Okuna began denying access to hunters, fishermen and surfers because he said there were gates damaged and instances of malicious mischief.

In a two-year span prior to the suit, Okuna had about 50 Ka'u residents arrested for trespassing.

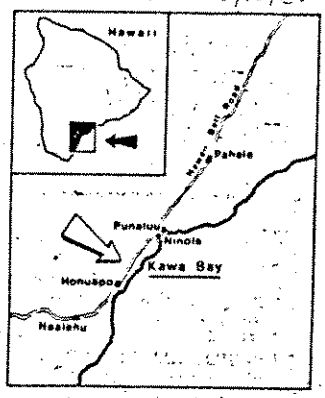
Under the judgment Kubota signed Tuesday, the right to access becomes permanent in 10 days unless Okuna appeals the decision to the Hawaii Supreme Court.

The decision took more than four months to draft after Kubota ruled in favor of the sportsmen's group and Henry Barba, Balbino Salmasan, Ernest Buyuan, Ralph Dedman and Pele Hanoa, individuals who specifically had been denied access to Kawa Bay and its black-sand beach.

Star witnesses in the week-long trial were two 93-year-olds who lived in Ka'u all their lives — William Meinecke and Louie Cruz. They testified about the traditions and history of the vast but sparsely settled district, which is bigger than the

See Ka'u on Page A-4 (over)

HA 10/16/80




# Ka'u trails

from page one

island of Oahu.

Kubota ruled on the basis of the old-timers' testimony and that of anthropologists William Bonk of the University of Hawaii at Hilo and Marion Kelly of the Bishop Museum.

The first access recognized in the ruling is the "ancient walking trail" — known also as Ellis Trail, named for the Rev. William Ellis, the English missionary and explorer, who charted the Big Island in his 1823 expedition. The trail is described as a 3-foot-wide pedestrian easement just behind the shoreline.

The judge also awarded a 15-foot-wide "pedestrian, equestrian and wagon easement" some distance back from the shore. It is known in the case as the "government road" — but is better known as the King's Highway, a pathway around the island that was constructed in the mid-1800s by Hawaii's monarchy.

The two mauka-makai routes the plaintiffs secured in the judgment are:

- A 10-foot-wide vehicular and pedestrian path along the "Corral Gate Road."
- A 3-foot-wide pedestrian easement along an ancient course known as Hulea Trail, named for an ancient village in Ka'u.

The four routes reopen public access to Kawa Bay, a picturesque and prehistoric point in Ka'u about midway from Punaluu or Ninole on the north to Honuapo on the south.

The case began five years ago, when Gaddis was invited to give a public talk on access rights to a group of Ka'u residents involved in an adult education project.

The attorney was greeted by more than 100 angry fishers, surfers and hunters who wanted their access to the shoreline restored. Three suits followed.

The later ones against the state and lessees of the state were settled out of court in negotiations or by stipulation, but the 1976 Kawa Bay case proved to be the precedent-setter.

In addition to the recreational access, the decision will allow Hawaiians to reach Keeku Heiau, a 13th- to 15th-century Luakini heiau dedicated to the god Lono, according to the court ruling.

Keeku was regarded as having "great significance" in ancient times because of priests "who performed human sacrifices and other ceremonies which drew persons to Kawa Bay from the entire district of Ka'u," the judge said.

Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Susumu Ono
Chairperson and State Historic Preservation Officer
State of Hawaii
Department of Land and Natural Resources
P. O. Box 621
Honolulu, HI 96809

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Ono:

We have reviewed your letter of 14 March 1984 and offer the following responses:

Aquaculture Technology

We concur with your comments regarding the potential of the site for successful aquaculture development, especially given the proposed planning for an integrated aquaculture system.

Aquatic Resources

1. According to conversation with John Mink, the effect of pumping brackish water for the aquaculture facilities on anchialine ponds and coastal waters should be negligible. Generally, groundwater flows perpendicular to the coastline. Therefore, it is unlikely the pumping of brackish water in the aquaculture area would affect the nearest anchialine ponds located a mile away. Also, please note that the proposed aquaculture activities involve the use of brackish water and its eventual disposal by infiltration. Most of the water pumped would be returned. Any loss of brackish water will be by evaporation.

2. It is expected that one cesspool will adequately serve the domestic requirements of each aquaculture module. This is equal to 5 cesspools within 1500 acres. Any effects of leaching from the proposed cesspools on the nutrient levels in coastal waters will be mitigated through the strict observation of the Department of Health regulations on cesspools (Title 11, Department of Health, Chapter 57, Private Wastewater Treatment Works and Individual Wastewater Systems). Approval of the proposed cesspools must be granted by the State Department of Health and the County of Hawaii Department of Public Works.





The integrated aquaculture system and the disposal of its effluent via seaweed culture troughs was proposed in order to yield brackish water that is nearly as nutrient-free as when it is first pumped out. The quality of the water that passes through the system will be monitored not only to minimize the effects of disposal (infiltration), but also to avoid the overabundance of nutrients in any of the ponds or raceways. Nutrient overload will have an adverse effect on the aquaculture crops. Robert Shleser of the Oceanic Institute has testified before the Land Use Commission that to ensure crop success and environmental quality, dry-run operations will be conducted before full-scale production is started. Constant monitoring of the quality of the water flowing throughout the aquaculture system should mitigate the pollution problems usually associated with wastewater disposal.

3. It is proposed that security personnel will be present on site during non-working hours to prevent theft and transport of exotic and diseased species.

Construction and Site Work Activities

1. Since rainfall is relatively low and evenly distributed throughout the year, it is expected that scheduling construction and site work during periods of lowest rainfall will not be necessary. However, it is expected that the petitioner will halt work during high wind and/or stormy conditions.

2. Soils exposed during construction and site work will be replanted as soon as possible, not only to minimize soil erosion, but also in order for the petitioner to yield a return on his investment in land and improvements.

3. Since the filing of the EIS, we have learned that herbicides will not only be applied by hand sprayers, but also mechanically. Mechanical applicators are usually towed behind tractors or pick up trucks which travel between the rows of trees. The herbicides are applied only for the ground between the rows. Frank S. Scott, Jr., the macadamia production consultant, has stated that the application of herbicides in macadamia orchards by existing means has not resulted in any adverse impacts. In fact, the herbicides used are usually diluted enough so that its accidental application on macadamia tree trunks does not result in tree loss. We concur that the other precautionary measures proposed by the petitioner (as described in your letter) should be required and implemented.

4. We concur that construction materials, petroleum products, human wastes, debris, herbicides and fertilizers should be required from entering into coastal waters.

Letter to Susumu Ono
3 April 1984
RE: Farms of Kapua Environmental Impact Statement
Page three (3)

Historic Sites

We note your statement regarding the adequacy of Rosendahl's March 1983 archaeological reconnaissance for the purpose of the State Land Use Boundary Amendment Petition. This information will be provided in the revised EIS.

Recreation

1. We note your comment regarding public access to archaeological features of interest which are located outside of the 425 acre Conservation area. Actual feasiblity for public access to these sites would be determined during the preparation of a cultural resources management plan and appropriate means of access could be recommended in the plan.

2. According to the articles provided, the 1980 ruling does not automatically ensure unimpeded access to other trails which may not have been in continuous usage. If continuous use of the ancient mauka-makai trail (as noted in Inventory of Public Access to the Shoreline) is documented, then allowing public access along this trail would be consistent with the 1980 decision. Please note that the petitioner will generally maintain the present means of public access to the shoreline from mauka portions of the site, i.e. by permission only. According to Sally Rice, manager of Farms of Kapua, no one has been denied access, if permission was requested.

Site

Your opinion that the site is conducive to aquaculture production is shared by the Oceanic Institute, the petitioner's consultants in this field.

Water

The information provided on Okoe well will be provided in the revised EIS.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission



RECEIVED
MAR 24 1984
GROUP 70

STP 8.9786

March 21, 1984

Mr. Gordon Furutani,
Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Farms of Kapua
Environmental Impact Statement
TMK: 8-9-06:3

Thank you for providing the Farms of Kapua environmental impact statement for our review.

The statement adequately addresses our concerns for the area.

Very truly yours,

Wayne J. Yamasaki
Director of Transportation

KYA:ko

cc: John Farias, Jr., Farms of Kapua
Francis Oda, AIA, Group 70
HWY-H
STP(KYA)

University of Hawaii at Manoa

Water Resources Research Center
Holmes Hall 283 • 2540 Dole Street
Honolulu, Hawaii 96822

RECEIVED
MAR 24 1984
GROUP 70

23 March 1984

Mr. Gordon Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

SUBJECT: Draft Environmental Impact Statement, Farms of Kapua, Ahupua'a of Kapua, South Kona, Hawaii, February 1984

We have reviewed the subject DEIS and offer the following comments:

1. As expressed in our letter to the earlier EIS Preparation Notice, we continue to be concerned about the economic feasibility of the proposed macadamia and cattle operations. The current Draft EIS does not allay those concerns. We feel that much more detailed information is needed on these endeavors.

2. In both macadamia and ranching, water quality and quantity plays a key role because given the relatively dry site environs, neither endeavor will be viable without irrigation. Some of our concerns are expressed below with reference to Appendix A, "Water Supply for Farms of Kapua":

a. The use of rainfall data from gages located outside and some distance from the region under question is unnecessary and may be misleadin computing the water budget, since adequate data are available from Kole Pen, a very representative site within the region. Use of data from outside the region (Opihihale 2) and adjusting by the elevation/rainfall relationship, presumes that isohyets and elevation contours are parallel in the region which they are not. The result is a possible overestimation of rainfall for Kapua.

b. The calculation of water deficits does not address the question of water holding capacity within the root zone. Because of the thinness of existing soils and their high permeability, it is likely that only a fraction of rainfall is effective in meeting crop water demands. This is especially true in a dry region such as Kapua where rainfall is sporadic.





c. Use of mean rather than median rainfall to estimate available water may be inappropriate for agricultural applications since heavy rainfalls, which skew the distribution (and increase the mean over the median) are often largely lost to the plants due to rapid infiltration.

d. In Appendix A, a value of 4.4"/month is assumed as the water use requirement of macadamia trees. This figure was obtained from Appendix E where 4000 gallons per acre per day is given as the water requirement for a mature macadamia orchard at Kapua. This important figure is unsubstantiated and appears to be significantly in error on the low side. Based on potential evaporation rates for a similar area on O'ahu (comparable elevation, radiation, temperature, and rainfall) water requirements at Kapua probably range from about 4.4"/month in December to more than 8"/month in July, averaging 6.3"/month (T.W. Giambelluca, "Water balance of the Pearl Harbor—Honolulu basin, Oahu, Hawaii, 1946-1975", UH WRRC Tech. Rep. No. 151, 1983). Similarly, Macadamia Nut Industry Analysis Number 2 (College of Tropical Agriculture and Human Resources, UH, 1981) estimated macadamia water requirements to be 6.1"/month under irrigated conditions.

e. The Appendix A estimates of total groundwater flux (8 to 18 mgd) and developable groundwater (6 to 7 mgd) are based partially on the study of groundwater in the arid North Kona and South Kohala regions by Kaneshiro and Peterson ("Groundwater recharge and coastal discharge for the northwest coast of the island of Hawaii: A computerized water budget approach", UH, WRRC Tech. Rep. No. 110, 1977). In that study an average daily flux of 6.38 mgd/mile of coastline is estimated. Although this region (N. Kona/S. Kohala) is drier than the Kapua area, its recharge area may be larger and/or wetter than Kapua's. In fact, there is evidence that the flux at N. Kona/S. Kohala is greater than that at Kapua based on the groundwater gradient. In Appendix A the head at Kapua is estimated to be 3.8 ft at 3.8 miles inland and 3.0 ft at an elevation of 600' (2.3 miles from the coast). For N. Kona/S. Kohala, Kaneshiro and Peterson found the head to be 5' at 3.8 miles from coast and 600' elevation. This comparison casts some doubt on the extrapolation of the 6.38 mgd/mile figure from W. Kona/S. Kohala to Kapua unless evidence of different hydrogeologic conditions can be shown.

f. The quality (chlorinity level) of the groundwater extractable at Kapua may be brought under considerable question. The state well at Okoe, less than 1 mile from the Kapua boundary and at a similar elevation, produced water with 900 mg/l chloride (too saline for irrigation without dilution) at a pumping rate of about 1 mgd. The proposed Kapua wells will have a 1.4 mgd capacity. What assurances are there that sufficient amounts of fresh water are available for irrigation?

g. Summary. On several counts, the feasibility of the macadamia portion of this proposed project has been brought under question in terms of water requirements. The Appendix A estimates of effective rainfall may be too high and the estimated average water requirements too low. Both have the effect of biasing estimated irrigation requirements on the low side. The amount of developable groundwater for use in irrigation is

also questionable. This is certainly the least known of the water variables and estimates could be in error in either direction. However, some evidence suggests that the estimates given in Appendix A are too high. Given the range of uncertainty is the amount of available water and the apparent size of the water requirement, more information must be brought forward to substantiate the feasibility of growing macadamia nuts at Kapua.

3. In the EIS's reply to our letter (Part XI) Puu Anahulu ranch (mis-spelled Puuwaanahulu) is presented as a comparable cattle pasturage. Puu Anahulu is an old weathered cinder cone with considerable soil material and therefore much greater moisture holding capacity. We would therefore suggest that infact they are not comparable sites. The nonsoil aa and pahoehoe areas of Puu Anahulu ranchlands are vegetated by fountain grass, a noxious unpalatable pest having virtually negligible grazing value. This same fountain grass is found in the middle to lower elevations of Kapua on comparable aa and pahoehoe lands.

4. Irrigation water will be brackish. Without much fine particle soil, the sites moisture holding capacity will be extremely limited, possibly to the extent that moisture will only constitute a film on the rock surfaces. In essence then as the water evaporates the dissolved salts will become concentrated and affect plant roots negatively. Macadamia has low to moderate salt tolerance similar to many common vegetables, which has to be taken into account.

In order to reduce the salt concentration in the root zone, it is common practice to over-irrigate to wash the salt out. It should be pointed out that this salt from irrigation will percolate down to the basal water table and make it saltier.

5. We would call your attention to the letters from Pa'a Pono of Milolii and Moku Loa Group which expresses many similar concerns about the water, macadamia, and cattle operation, which we feel were not adequately addressed.

Thank you for the opportunity to comment. This material was reviewed by WRRC personnel.

Sincerely,

Edwin T. Murabayashi

Edwin T. Murabayashi
EIS Coordinator

ETM:jm

cc: John Faria
Francis Oda, Group 70
Env. Center, UH

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Edwin T. Murabayashi
EIS Coordinator
University of Hawaii at Manoa
Water Resources Research Center
Holmes Hall 283
2540 Dole Street
Honolulu, HI 96822

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Murabayashi:

We have reviewed your letter of 23 March 1984 and offer the following responses:

1. The EIS and its appendicies show a level of detail which should be sufficient for you to assess economic feasibility appropriate to this level of planning. This information has been sufficient to allay the business concerns of the owners as indicated by their committment of their financial resources to purchasing the land and undertaking the project.

2. Your comments regarding water quality and quantity were reviewed by John F. Mink and were incorporated into the responses that follow:

   a. Please note that a moisture deficit model based on Kole Pen was included in Appendix A, Water Supply for Farms of Kapua. This was provided in response to comments provided during the EIS consultation period. Mink disagrees that the data from Kole Pen is "adequate". As noted on page 2 of his report, data from the Kole Pen gage was not reported in National Weather Service publications, nor had their records previously been printed in published reports by DLNR or the USGS.

   b. We concur that existing soils are thin, however, the addition of planting medium will increase the retention of moisture. Also, please note that it expected that the full moisture requirement is only required at the ninth year of orchard maturity, when additional soil will have developed (organic breakdown of fallen leaves, etc.).

Mink disagrees with your statement that rainfall in Kapua can be characterized as "sporadic". Rainfall is either continuous or sporadic. There is nowhere in Hawaii where rainfall is continuous for any length of time, and certainly not for an entire year. It is true, however, that while rainfall is relatively low, that it is evenly distributed and that extremely dry months are rare.

c. Mink disagrees that the use of median data is more appropriate than mean data in estimating water availability for agriculture. The use of mean is the standard statistical procedure in computing hydrological balances.

d. Based on research on water requirements conducted for avocados in California and for macadamias at C. Brewer's Ka'u orchard, Dr. Frank S. Scott, Jr., has determined that a mature macadamia orchard requires 4,000 gallons of water per acre per day under full dependance on drip irrigation. Scott estimates that a mature macadamia tree at 64 trees per acre requires an irrigation radius of 42 feet. This amounts to approximately 15 times the 30 gallon weekly requirements indicated at Ka'u orchard for young trees requiring an estimated 3 1/2 foot radius. This converts to a weekly requirement of 450 gallons per mature tree or 28,800 gallons per acre at 64 trees per acre or approximately 4,000 gallons per acre per day. Avocado trees in the hot desert area between San Diego and Riverside, have been found to require a mean of 0.142 acre inches of water per day with full dependance of irrigation during May to September. The 0.142 acre inch daily requirement converts to 0.994 per acre inches per week or 3,905 gallons per acre per day per day. This compares favorably with Scott's estimate of 4,000 gallons per acre day at Kapua.

The water requirements for macadamias as indicated in MIA page 7 are not based on research findings, but constitute suggested possible water needs. No conclusive research has been released publicly on the water requirements for macadamias. HITAHR (Hawaii Institute of Tropical Agriculture and Human Resoures) had established a project on water requirements via Mac Farms, but this project is now under the jurisdiction of Mac Farms. The duration of the research has been too short to provide conclusive evidence on the water requirements for macadamia.

The irrigation requirement suggested in MIA p. 7 B.1.c. assumes complete coverage of the grounds such as for vegetable production, and is not based on conclusive research on macadamia requirements. Orchard requirements for drip irrigation are much less than for crops requiring complete coverage of the land area and for heavy water users such as bananas.





Most Kona macadamia orchards are in the 40 to 60 inch rainfall zone. Scott has surveyed 120 macadamia farms, most of which were in Kona, during the past 4 years. Scott has found that farmers with good cultivation practices obtain yields of up to 7,500 pounds per acre annually in the rainfall zone specified above.

Frank S. Scott, Jr. is a member of the Macadamia Nut Industry Analysis group and is responsible for much of the narrative on marketing and economic viability. Scott did not consider it appropriate to include the Macadamia Nut Industry Analysis Number 2 (MIA) as an appendix to his report since the MIA is simply considered a planning document for identifying and prioritizing research needs. The document attempts to identify the current status of problems based on findings, observations and options. Thus, it is a planning document and action plan and should not be considered as a research report.

e. Your comments regarding disagreements with Mink's reference to Kanehio and Peterson (Groundwater Recharge and Coastal Discharge for the Northwest Coast of the Island of Hawaii: A Computerized Water Budget Approach, UH WRRC Technical Report No. 110, 1977) appear to be based on the questionable assumptions that the N. Kona/S. Kohala water "recharge area may be larger and/or wetter than Kapua's". A preliminary review of data indicates that the N. Kona/S. Kohala area is not wetter and is certainly smaller than the Kapua recharge area. Mink maintains that flow within the petition area is greater than in the N. Kona/S. Kohala area.

f. Mink finds fault with your assumption that the location of the "state well at Okoe, less than 1 mile from the Kapua boundary and at a similar elevation" (emphasis added), indicates that wells installed at the same elevation within the petition area will yield water of equal chloride content. As noted in Mink's report, head is a function of distance inland. In fact, Mink noted that since Okoe well is located only 1.6 miles inland, the water yielded was of relatively good quality. Please note that the proposed irrigation wells are expected to be installed at the 1000 foot elevation, approximately 3.2 miles inland.

No assurances can be made that there are sufficient amounts of water on site for irrigation. However, please note that John F. Mink is a recognized expert in this field and he has no record of failure in terms of predicting the availability or non-availability of water for development in his capacity over the years as consultant to various water developers.

g. Mink disagrees with the comment regarding the need for more information (testing) to substantiate the availability of irrigation water for macadamia production. While there is an element of risk in any development of water resources, the state-of-the-art in estimating resources is such that the current practice is to drill a well that serve both exploratory and development purposes. This is the accepted practice of the City and County of Honolulu Board of Water Supply among others. Requiring years of exploratory analysis would represent an undue burden on the petitioner.

3. We concur that there is relatively more soil material on parts of the Puu Anahulu cinder cone. However, both Harold F. Rice, Jr., the pasture consultant, and Sally Rice, the manager of the Puu Anahulu ranch, maintain that soil conditions in the pasture area of the latter ranch, five years ago (prior to intensive managment by Sally Rice), were comparable to existing soil conditions in the area proposed for pasture development at Farms of Kapua. Please refer to page 5 of Appendix F, Pasture Development and Management Program for Farms of Kapua (1984) for additional ranches in West Hawaii with comparable rainfall and soils to the proposed pasture area.

   Please refer to page 5 of our response to Mr. Warshauer (17 February 1984), item 3/2, regarding the value of fountain grass for pasture management.

4. It is the opinion of Scott and Mink that since the soils on the petition area are porous, natural rainfall will leach the soil of any salts that would accumulate from using water of non-potable salinity for irrigation. Salt build-up is more common to clay soils. Furthermore, Mink states that salt accumulation in soils in Hawaii from irrigation has never been documented.

5. Since your letter does not identify the concerns expressed in the consultation letters from Pa'a Pono of Milolii and the Sierra Club, Moku Loa Group, regarding water, macadamia and cattle operations that you feel were not adequately addressed, it is difficult for us to provide you with the additional information that would allay your concerns.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission



GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
550 HALEKAUWILA STREET
ROOM 301
HONOLULU, HAWAII 96813

Letitia N. Uyehara
Director

TELEPHONE NO.
548-6915

March 23, 1984

MAR 26 1984

GROUP 70

Mr. John Farias, Jr.
Farms of Kapua
605 Piikoi Street, Suite 1510
Honolulu, Hawaii 96814

Dear Mr. Farias:

We offer the following comments to your Farms of Kapua Environmental Impact Statement.

Aquaculture

The EIS should disclose the depth and volume of each aquaculture pond. Also required is discussion on how the aquaculture ponds will be drained, where the drained water will go, and if disposed into the nearshore waters, the impacts of the drained water on that marine environment.

If fish or mollusks not indigenous to Hawaii are proposed to be raised in the aquaculture ponds, the EIS should provide information on these species.

Feedlot

According to the information provided in the EIS, manure from cattle will be used to supply some of the nutrients required to raise shrimp. If all the manure will not be used to provide nutrients, the EIS should discuss how the remaining manure will be disposed.

Thank you for providing us the opportunity of reviewing your project.

Sincerely,

Letitia N. Uyehara
Director

cc: Group 70
LUC

Francis S. Oda AIA Inc
Robert K. L. Wong AIA Inc
Norman G. E. Hong AIA Inc

3 April 1984

Letitia N. Uyehara
Director
State of Hawaii
Office of Environmental Quality Control
550 Halekauwila Street, Room 301
Honolulu, HI 96813

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Ms. Uyehara:

We have reviewed your letter of 23 March 1984 and offer the following responses:

Aquaculture

1. The approximate dimensions, volume and number of ponds per module for each of the species are as follows:

| Species | Pond dimensions | Water volume* | Number of ponds |
|---|---|---|---|
| Mahimahi | 120'x 60'x 8' deep | 275,000 gal. | 8 |
| Marine Shrimp extensive system | 1 ac. x 3' deep | 978,924 gal. | 20 |
| Marine Shrimp intensive system | 20'x 100'x 3' deep | 44,946 gal. | 22 |
| Marine Shrimp Taiwanese system | 0.5 ac. x 3' deep | 489,462 gal. | 40 |
| Brine Shrimp | 0.5 ac. x 3' deep | 326,308 gal. | 10 |





| Species | Pond dimensions | Water volume* | Number of ponds |
|---|---|---|---|
| Spirulina | 0.5 ac. x 3' deep | 163,154 gal. | 20 |
| Oyster | 40'x 100'x 5' deep | 149,819 gal. | 2 |

* Water will not necessarily be filled to the top of the various ponds.

** Seaweed and Tilipia will be cultivated in the brackish water disposal system

2. A description of the flow of water through the integrated aquaculture system and its disposal was provided on page 44 of the EIS. The impacts of the aquaculture effluent was described on pages 52 and 53 of the EIS.

3. Descriptions of the proposed species were included in Appendix H of the EIS.

Feedlot

In the event that all of the manure produced in the feedlot is not used to provide nutrients for the aquaculture facility, the remainder will be applied to the 2,472 acre koa haole pasture area to facilitate organic buildup.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

GEORGE R. ARIYOSHI
GOVERNOR

JACK K. SUWA
CHAIRMAN, BOARD OF AGRICULTURE

SUZANNE D. PETERSON
DEPUTY TO THE CHAIRMAN

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96822

March 23, 1984

RECEIVED
MAR 28 1984
GROUP 70

MEMORANDUM

To: Mr. Gordan Furutani, Executive Officer
Land Use Commission

Subject: Environmental Impact Statement (EIS) for
Farms of Kapua
Farms of Kapua, Ltd.
TMK: 8-9-06: 3 South Kona, Hawaii
Acres: 6,102

The Department of Agriculture has reviewed the subject Draft Environmental Impact Statement and offers the following comments.

The Draft EIS provides new information which clarifies portions of the proposed three-tiered agricultural operation. Our concerns on the Preparation Notice (see Memorandum from Department of Agriculture to Land Use Commission, dated December 23, 1983) have been largely addressed.

2,472-acre Pasture Area

As proposed, the pasture area is to be situated between the aquaculture facilities and the macadamia nut orchard segments of the proposed project. Elevation ranges from about 150 feet to 500 feet. The pasture area will be established in six, 400-acre phases. Situated within this pasture area will be a 200-acre intensively cultivated leucaena field, and a 200-acre agricultural research and development area.

The net usable pasture area is approximately 1,730 acres after deleting the 30 percent of the gross area which may be unusable because of terrain, archaeological sites, and significant botanical specimens (EIS, page 19). Upon completion of pasture preparation (approximately six years), approximately 600-700 weanlings at 400-500 pounds each will be rapidly rotated in a pasture management scheme which will utilize 50-acre paddocks (EIS, Appendix F, page 1).

The pasture will be seeded with guinea grass and koa haole. Average annual rainfall is up to 25 inches (EIS, page 16). According to the letter from Group 70 to the Moku Loa Group of the Sierra Club dated February 17, 1984, the forage yield from this pasture (unirrigated) is estimated to be 20 tons/acre/year, which would allow a stocking rate of approximately one animal unit (2 weanlings) per four acres of pasture (EIS, Appendix F, page 5-6).





We understand that the maintenance and continuation of an intensive pasture operation requires personnel highly experienced in intensive pasture management and the availability of supplemental irrigation water during poor growing conditions. University of Hawaii experts generally agree that cultivated leucaena would make a good green chop for the feedlot cattle.

The Department of Agriculture believes that an agricultural feasibility study on the scale of that prepared for the macadamia nut portion of the project would have been helpful in determining the long-term viability of the pasture operation. We note that the discussion of economic viability (Appendix F, page 4) is limited to out-of-pocket costs for purchase and feed of weanlings, and does not cover capital, land, labor and management costs of pasture development.

1,710-acre Macadamia Nut Orchard

The irrigation requirements for the macadamia trees will be approximately 6.0 million gallons per day (MGD). This represents a level of moisture that would result in the trees having insufficient moisture ten percent of the time. This level of irrigation may not measurably affect yields (EIS, Appendix A, page 6-7).

We note that the macadamia orchard operation will be contracted with one of the nearby orchards (letter from Group 70 to Department of Agriculture dated February 17, 1984).

1,500-acre Aquaculture Facility

We have no comments to offer on this proposal other than that we note that the manure from the feedlot operation will be used as a nutrient supplement for the shrimp and algae in the aquaculture facility.

Irrigation Water Supply

The total irrigation water demand at the 10 percent moisture deficit level for the macadamia orchard and the cultivated leucaena and research and development areas is approximately 7.4 MGD. The EIS states that groundwater is to be used although the sustainable yield and quality of the aquifer below the site is unknown (EIS, page 21, 22). The development of this water source is critical to the successful establishment and maintenance of the macadamia orchard and feedlot segment of the pasture operation.

We note that the proposed irrigation wells and the Okoe well will be monitored for chloride content, and that appropriate action will be taken if chloride levels increase (letter from Group 70 to Department of Agriculture, dated February 17, 1984).

The Department of Agriculture remains supportive of innovative and large-scale efforts to develop diversified agriculture, such as proposed in this project. The resolution of uncertainties in water sources and pasture development costs will help to ensure its long-term success.

Thank you for the opportunity to comment.

JACK K. SUWA
Chairman, Board of Agriculture

cc: Mr. John Farias, Jr.
Mr. Francis S. Oda, AIA, Group 70

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Jack K. Suwa
Chairman, Board of Agriculture
State of Hawaii
Department of Agriculture
P.O. Box 22159
Honolulu, HI 96822

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Suwa:

We thank you for your letter of 23 March 1984 and offer the following in response to your expressed uncertainties regarding the availability of water for irrigation and pasture development costs.

Although the groundwater resource at Kapua has not been investigated in detail, John F. Mink considers his report provides adequate information on which to proceed with specific siting and installing of wells. The state-of-the-art in estimating resources is such that the current practice is to drill a well that serves both exploratory and development purposes. This is the accepted practice of the City and County of Honolulu Board of Water Supply among others. In addition, please note that Mink has testified before the Land Use Commission that he has no record of failure in terms of predicting the availability or non-availability of water for development, in his capacity over the years as consultant to various water developers.

Generally, the petitioner does not share your uncertainties regarding pasture development costs. The petitioner feels that on the basis of the reports prepared, by Harold F. Rice, Jr. (Appendix F of the EIS) among others, a sufficient return can be made on the substantial effort in time and money required to plan, secure the necessary land use approvals and to develop the project.

We concur that the implementation of the project will be beneficial to the State plans for agricultural activities, and to the State's economy in general.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

RECEIVED
MAR 29 1984
GROUP 70

CHARLES G. CLARK
DIRECTOR OF HEALTH

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

In reply, please refer to:
EPHSO-SS

March 26, 1984

MEMORANDUM

To: Mr. Gordan Furutani, Executive Officer
Land Use Commission

From: Deputy Director for Environmental Health

Subject: Environmental Impact Statement (EIS) for Farms of Kapua, S. Kona, Hawaii

Thank you for allowing us to review and comment on the subject EIS. On the basis that the project will comply with all applicable Administrative Rules, please be informed that we do not have any objections to this project.

We realize that the statements are general in nature due to preliminary plans being the sole source of discussion. We, therefore, reserve the right to impose future environmental restrictions on the project at the time final plans are submitted to this office for review.

MELVIN K. KOIZUMI

cc: Mr. John Farias, Jr.
Mr. Francis S. Oda

---

GEORGE R. ARIYOSHI
GOVERNOR

RECEIVED
MAR 29 1984
GROUP 70

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
550 HALEKAUWILA STREET
ROOM 301
HONOLULU, HAWAII 96813

FEB 23 1984

Letitia N. Uyehara
Interim Director

TELEPHONE NO.
548-6915

Rec'd at OEQC March 27

March 23, 1984
Returning - No Comm
Takashi Yoshihara
Energy Program Adm
DPED

February 21, 1984

Dear Reviewer:

Attached for your review is an Environmental Impact Statement (EIS) that was prepared pursuant to Chapter 343, Hawaii Revised Statutes and the Rules and Regulations of the Environmental Quality Commission:

TITLE: Farms of Kapua

LOCATION: South Kona, Hawaii

CLASSIFICATION: Applicant Action

Your comments or acknowledgment of no comments on the EIS are welcomed. Please submit your reply to the accepting authority or approving agency:

Mr. Gordan Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Please send a copy of your reply to the proposing party:

| | | |
|---|---|---|
| Mr. John Farias, Jr. | | Mr. Francis S. Oda, AIA |
| Farms of Kapua | AND | Group 70 |
| 605 Piikoi Street, Suite 1510 | | 924 Bethel Street |
| Honolulu, Hawaii 96814 | | Honolulu, Hawaii 96813 |

Your comments must be received or postmarked by: March 24, 1984

If you have no further use for this EIS, please return it to the Office of Environmental Quality Control.

Thank you for your participation in the EIS process.

DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT
KAMAMALU BUILDING, 250 SOUTH KING ST, HONOLULU, HAWAII
MAILING ADDRESS: P.O. BOX 2359, HONOLULU, HAWAII 96804

GEORGE R. ARIYOSHI, GOVERNOR
KENT M. KEITH, DIRECTOR
JOHN R. PINGREE, DEPUTY DIRECTOR
MURRAY E. TOWILL, DEPUTY DIRECTOR

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C O P Y

Ref. No. 9082

March 28, 1984

RECEIVED
APR 2 1984
GROUP 70

MEMORANDUM

TO: Gordan Furutani, Executive Officer
Land Use Commission

FROM: Kent M. Keith, Director

SUBJECT: Farms of Kapua EIS, South Kona, Island of Hawaii

We have reviewed the subject environmental impact statement and have the following comments to make.

The issue of public access to the shoreline should be clarified. The EIS states on p. 51 that the Petitioner will generally maintain the present mode of public access to the shoreline. Access from the mauka portions of the site will be by permission only and there will be unobstructed lateral access along the shoreline north and south of the petition area. Since the mauka-makai access through the subject project to the shoreline will be via an improved private road, the EIS should note what criteria will be used to grant such public access.

The EIS states on p. 36 that development of the proposed agricultural activities will involve soil disturbance of approximately 70% of the petition area. It also states that further archaeological reconnaissance will be conducted for specific development areas which were not covered in the earlier field survey. In addition, an intensive survey of significant sites is proposed. Since the area petitioned for reclassification is abundant in historical resources, additional information to determine their significance is important. The proposed survey will help to better identify potential impacts of the project. The EIS should also give an indication as to how specific mitigation and preservation decisions will be implemented. Due to the nature of the terrain most of the sites may not be visible during mechanical clearing operations (bulldozing).

The petition (Exh. 1, p. 56) stated that the aquaculture facility would require 6 MGD of salt water. The EIS dated February 1984 (p. 51) states that 6 MGD of brackish water will be required. This discrepancy should be clarified. The EIS proposes to return the wastewater from the aquaculture



operation to the ground via infiltration ditches and proposes to monitor the efficiency of the system by testing the water in the culture troughs. The discussion on p. 52-53 implies that infiltration ditches and culture troughs are the same. The EIS should indicate measures to be taken in the event that the system is found to be inefficient.

With respect to coastal ecosystems, we note that there are no point source discharges proposed for the project. In an area of highly permeable soils, however, coastal ecosystems can be affected by non-point sources of pollution, such as cesspools, cattle manure disposal, and aquaculture effluent disposal. Since the EIS is not specific with regard to the number, type, and location of cesspools; methods for treating and locations for disposing cattle manure; and the chemical nature and locations for disposing of aquaculture effluents; it is difficult to determine the project's consistency with the policies of Hawaii's CZM law, Chapter 205A, Hawaii Revised Statutes, at this time.

In general, while we find that many Coastal Zone Management (CZM) concerns are addressed, the absence of detailed site development plans precludes a thorough assessment. We trust that should the petition for reclassification be approved, the issues discussed previously will be resolved so as to assure that subsequent permits and approvals will be consistent with CZM objectives and policies.

Thank you for the opportunity to comment on this document.

cc: Mr. John Farias, Jr.,
Farms of Kapua
✓ Mr. Francis S. Oda, AIA
Group 70

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G C Hong AIA Inc

3 April 1984

Kent M. Keith
Director
State of Hawaii
Department of Planning and Economic Development
P.O. Box 2359
Honolulu, Hawaii 96804

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Keith:

Although your your memorandum was postmarked six days after the end of the public review period for the EIS, we have reviewed your comments and offer the following responses:

1. According to Sally Rice, manager of Farms of Kapua, no one has been denied access to the shoreline from mauka portions of the site, if permission had been requested. It is anticipated that this existing system will continue to be implemented. In the event that public access to the site increases to the point that there is vandalism and/or looting of significant archaeological sites or agricultural crops, then some additional form of control limiting the number of people on-site would have to be implemented. Permission for access would then probably be granted on an advance reservation, "first come, first serve" basis.

2. We concur that additional information is important to determine the significance of archaeological features on site, however, please note that Ralston H. Nagata, Acting State Parks Administrator has written to Dr. Paul Rosendahl, that the work concluded for the EIS "presents an adequate approach to the identification of cultural resources in the subject parcel." Furthermore, Nagata states that "This document represents the initial phase of an archaeological program which will expand into an extensive reconnaissance survey, and, possibly, intensive survey and/or mitigation (including a cultural resource management plan)." As noted in the EIS, further archaeological reconnaissance survey will be conducted for any specific development areas within the petition area which were not covered in Rosendahl's earlier survey (1983). Since development of the petition area will occur in increments of 500 acres per year in the macadamia area, 400 acres per year in the koa haole pasture area and 200 acres per aquaculture module,





further reconnaissance survey can be phased accordingly, prior to development.

Upon completion of the additional reconnaissance surveys, intensive survey of significant sites identified would be conducted. The exact scope and scale of intensive survey will be worked out in consultation between the petitioner and the appropriate State and County representatives. Specific mitigation (salvage) vs. preservation decisions will be made during the preparation of cultural resource management plan, on the basis of intensive survey findings and consultations with the County of Hawaii Department of Planning and the State of Hawaii Historic Preservation Office.

Please note that prior to development, sites determined to be preserved will be clearly marked so as to be identifiable to bulldozer operators. Other sites, which have been deemed relatively insignificant or in a condition beyond preservation, will have been documented on maps and described in documents, and/or will have undergone salvage archaeology.

3. Since the publication of Exhibit 1 of the petition, it has been verified the aquaculture facility will utilize brackish water.

As noted in Appendix H, the seaweed culture troughs will serve as the infiltration ditches for the aquaculture effluent. The integrated aquaculture system and the disposal of its effluent via seaweed culture troughs was proposed in order to yield brackish water that is nearly as nutrient-free as when it is first pumped out. The quality of the water that passes through the system will be monitored not only to minimize the effects of disposal (infiltration), but also to avoid the overabundance of nutrients in any of the ponds or raceways. Nutrient overload will have an adverse effect on the aquaculture crops. Robert Shieser of the Oceanic Institute has testified before the Land Use Commission that to ensure crop success and environmental quality, dry-run operations will be conducted before full-scale production is started. Constant monitoring of the quality of the water flowing throughout the aquaculture system should mitigate the pollution problems usually associated with wastewater disposal.

4. Manure from the cattle in the pasture area will not be collected, treated and disposed. However, please note that the pasture area is located 2,000 feet from the shoreline at its closest point, at an elevation of 40 feet. It is unlikely that the manure from 600-700 weanlings over 2,472 acres would have an adverse effect on coastal ecosystems.

It is proposed that the cattle manure from the feedlot will be used as a source of fertilizer for the aquaculture facilities. The disposal of the aquaculture effluent is described in item 3 of our letter.

It is expected that one cesspool will adequately serve the domestic requirements of each aquaculture module. This is equal to 5 cesspools within 1500 acres. Any effects of leaching from the proposed cesspools on the nutrient levels in coastal waters will be mitigated through the strict observation of the Department of Health regulations on cesspools (Title 11, Department of Health, Chapter 57, Private Wastewater Treatment Works and Individual Wastewater Systems). Construction requirements are described in section 11-57-09 of Chapter 57 and include that each cesspool: must be at least seven foot in outside diameter; must have a minimum sidewall of at least 10 feet below the inlet pipe; and, must have the inlet pipe(s) at least five feet above the groundwater table's highest known level. Approval of the proposed cesspools must be granted by the State Department of Health and the County of Hawaii Department of Public Works.

We hope that the information provided above assists your reconsideration of the proposed multi-agricultural project in relation to CZM objectives and policies. We would appreciate any further comments that could benefit the planning of the project. Also, please be assured that any future concerns can be expressed to the appropriate agencies during the application for subsequent permits and approvals.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

COPY

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720

March 1, 1984

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MAR 5 1984
GROUP 70

Mr. Gordon Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, HI 96813

ENVIRONMENTAL IMPACT STATEMENT (EIS)
APPLICANT - FARMS OF KAPUA
TAX MAP KEY 8-9-06:03

We have no comments to the EIS at this time. The Department of Water Supply does not operate any water system in the area.

We are returning the EIS as requested.

H. William Sewake
Manager

CS

Enc.

cc - Mr. John Farias, Jr. (w/o enc.)
Mr. Francis S. Oda, AIA (w/o enc.)

*...Water brings progress...*

COPY

PLANNING DEPARTMENT
25 AUPUNI STREET

COUNTY OF HAWAII
HILO, HAWAII 96720

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MAR 23 1984
GROUP 70

March 21, 1984

Mr. Gordon Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Dear Mr. Furutani:

Draft EIS - Farms of Kapua

We have reviewed the subject draft EIS and submit the following comments.

Page 6 notes a 300-foot band along the coast designated as the Special Management Area. Please be advised that the SMA extends 500 feet inland.

In terms of the archaeological resources, the EIS should also assess the probability of finding other sites in areas not surveyed including the probable density and kinds of sites likely/not likely to exist.

The discussion of impacts to archaeological sites on page 37 notes "By following this process, there should be no adverse impacts to archaeological sites." If the statement was meant only to apply to utility corridors it might be correct. If, however, the statement was meant to apply to other areas, then we think it is not correct.

While a cultural resources management plan may be drawn, the intent of that plan is not only to specify which sites do get preserved and how, but also for those sites not specified for preservation to outline the appropriate measures for mitigating the



adverse impact of the eventual destruction of those sites. It is neither correct nor realistic to assume that no sites will be destroyed; salvage excavations in and of themselves do assume the destruction of some sites and this should clearly be acknowledged in the EIS.

Should you have any questions, please do not hesitate to contact Norman Hayashi or Virginia Goldstein of my staff at 961-8288.

Sincerely,

Sidney M Fuke

SIDNEY FUKE
Planning Director

VKG:ds

cc: John Farias, Jr.
Francis S. Oda

Kazu Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Sidney Fuke
Planning Director
Planning Department
County of Hawaii
25 Aupuni Street
Hilo, HI 96720

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Fuke:

We have reviewed your letter 21 March 1984 and offer following responses to your comments:

1. The information you provided on the inland limits of the SMA boundary conflicts with the information provided by one of your staff members. Originally, we sent a letter to your department requesting a summary of the land use controls of the project site. We recieved a written reponse which was dated 29 November 1982. Attached with this latter letter was a map indicating the approximate boundary of the SMA. On 10 March 1983, we asked for a verbal confirmation of the inland boundary of the SMA. We were informed that the SMA boundary is 300 feet inland from the shoreline. We would appreciate a written verification of the SMA boundary within the petition area.

   If the inland limit of the SMA is 500 feet, it appears that the Special Management Area Rules and Regulations of the County of Hawaii, Section 9.4, B. does not define the proposed aquaculture activities as "development" within the SMA. If required, however, the application of the SMP would follow the favorable resolution of the State Land Use Boundary and County zoning amendments.

2. Other than the information provided on page 36 of the EIS, we cannot provide estimates on the probability of locating other sites, their density, etc. in the areas not surveyed. Please note that further archaeological reconnaissance surveys will be conducted for any specific development areas within the petition area which were not covered in Rosendahl's earlier survey (1983).





3. For further clarification, the sentence in question will be revised to read: "By following this process, there should be no adverse impacts to significant archaeological sites near utility corridors."

4. The EIS does not state that no sites will be destroyed. However, for further clarification we will state in the revised EIS that salvage excavations involve the destruction of some sites.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

HERBERT T. MATAYOSHI, MAYOR
H. STUART KEARNS, JR.
Director

DEPARTMENT OF RESEARCH AND DEVELOPMENT
COUNTY OF HAWAII • 34 RAINBOW DRIVE • HILO, HAWAII 96720 • TELEPHONE (808) 961-8366

March 23, 1984

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MAR 24 1984
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Mr. Gordon Furutani
Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, Hawaii 96813

Reference: Farms of Kapua

The County of Hawaii's Department of Research and Development supports the Farms of Kapua application because of the economic benefits it would bring to the district of South Kona.

The Department of Labor and Industrial Relations, State of Hawaii gives the average unemployment rate for the South Kona District (Census Tract 213.00) in 1983 at 7.9%, or an average of 150 persons unemployed. The Farms of Kapua project would increase employment opportunities in South Kona, and thus provide some relief from the district's unemployment situation.

Thank you for your consideration of these comments.

H. Stuart Kearns Jr.
H. STUART KEARNS, JR.
DIRECTOR

cc: Mayor's Office
Mr. John Farias, Jr.
Mr. Francis S. Oda

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

H. Stuart Kearns, Jr.
Director
Department of Research and Development
County of Hawaii
34 Rainbow Drive
Hilo, HI 96720

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Kearns:

We have reviewed your letter of 23 March 1984 and we appreciate the information provided on the South Kona district's unemployment situation. This information and your department's assessment that the positive impacts that the proposed project would have on employment within the district, will be included in the revised EIS.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

GROUP 70 • Architects • Planners • Interior Designers • 924 Bethel Street • Honolulu, HI 96813 • Phone (808) 533-444

HERBERT T. MATAYOSHI
Mayor
EDWARD K. HARADA
Chief Engineer
ARTHUR T. ISEMOTO
Deputy Chief Engineer

# DEPARTMENT OF PUBLIC WORKS

COUNTY OF HAWAII - 25 AUPUNI STREET - HILO, HAWAII 96720 - TELEPHONE (808) 961-8321

March 23, 1984

RECEIVED
MAR 26 1984
GROUP 70

Mr. Gordon Furutani, Executive Officer
Land Use Commission
Old Federal Building, Room 104
335 Merchant Street
Honolulu, HI 96813

SUBJECT: FARMS OF KAPUA
SOUTH KONA, HAWAII
TAX MAP KEY: 8-9-6:3

We have reviewed the Environmental Impact Statement (EIS) for the subject project and our comments/concerns are:

1. Grubbing and grading of large areas (magnitude of several thousand acres) for agricultural operations are proposed. Compliance with Chapter 10 (formerly Ordinance No. 168) of the Hawaii County Code will be required in controlling soil erosion and sedimentation.

2. Reference: Appendix I - Engineering Analysis

   An access road is proposed from the Mamalahoa Highway through the agricultural areas to the aquaculture facility. This 28,000 lineal feet access road, consisting of a 20-ft. wide pavement with a 60-ft. right-of-way, is not intended to be dedicated to the County and remain forever private. The EIS is silent on both possible subdivision of lands, as well as road improvements, should subdivision of lands occur.

   Specifically, should subdivision of land occur, will the collector road still remain private? And, will the requisite subdivision roads also remain private? The Department of Public works requests clarification by the developer on both questions.

for EDWARD HARADA
Chief Engineer

cc: John Farias Jr., Farms of Kapua
Francis Oda, Group 70
County Planning Director

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Edward Harada
Chief Engineer
Department of Public Works
County of Hawaii
25 Aupuni Street
Hilo, HI 96720

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Harada:

We have reviewed your letter of 23 March 1984 and offer the following responses:

1. We appreciate the information provided. This information will be incorporated into the revised EIS.

2. No subdivision of lands is being proposed within the petition area. Also, as stated in the EIS, the proposed roadway system will be private, i.e. built and maintained by the petitioner.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

*For the Protection of Hawaii's Native Wildlife*

# HAWAII AUDUBON SOCIETY

P.O. BOX 22832
HONOLULU, HAWAII 96822

6 March 1984

Land Use Commission
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813

Subject: Environmental Impact Statement, Farms of Kapua

Gentlemen:

Our comments on the document under review concern Part III of the EIS, "Description of environmental setting and probable impact of the proposed action on the environment."

1. The EIS reports (p. 32) the presence in the project area of two individuals of Bobea timonoides and of a single "healthy" kauila tree (identified in the Consultant's report, Appendix B of the EIS, as Colubrina oppositifolia) as well as two individuals of halapepe (Pleomele sp.) and other native plants. The EIS states that "Nagata [the botanical consultant] has recommended that approximately 20 acres (Figure 9), including the kauila and Bobea trees be set aside and managed as a preserve. It is the petitioner's intent to implement this recommendation." Agricultural use of this area would be inconsistent with the petitioner's expressed intent to manage these approximately twenty acres as a preserve. Accordingly, we believe that the State Land Use Commission should retain this area within the Conservation District and should exclude it from any parcel of land to be transferred to the Agriculture District.

2. We note also that p. 3, Appendix B, "Kapua Farms Botanical Reconnaissance" identifies Pleomele aurea as a "Depleted" or "Endangered" species, while P. hawaiiensis is a Category 1 species as determined by the U. S. Fish and Wildlife Service. The same report states that Canavalia hawaiiensis, another rare or endangered species, is also present within the project area. We believe that areas identified in Figure 9 of the EIS as "Native Forest" (code "NF") as well as any other areas containing these or other rare native plant species should also be retained within the Conservation District.

3. In the report entitled "Mauka Boundary, Farms of Kapua Botanical Survey", the botanical consultant recommends that "some management program be established to prevent the further decline of the kauila and of the preserved ecosystem." Does petitioner intend to implement this recommendation, and if so, how?

4. In her 16 February 1984 response to Hawaii Audubon Society's 27 December 1983 comments on the EIS Preparation Notice for this project (correspondence reproduced in Part XI of the EIS), petitioner's consultant states that a 300 foot buffer zone will be retained along the common border of the project area and the adjacent Manuka Natural Area Reserve. We believe the State Land Use Commission should ensure the preservation of such a buffer zone by retaining this area within the Conservation District and excluding it from any parcel of land to be transferred to the Agriculture District.

5. The petitioner's zoological consultant notes (p. 34) that "the site may contain roosting sites of the Hawaiian (Hoary) Bat Lasiurus cinereus semotus." He further states (p. 35) that "As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities . . . . would have absolutely no effect on the bats, which obtain their insect food in flight." According to Group 70's 16 February 1984 response to Hawaii Audubon Society's comments on the EIS Notice of Preparation (both are reproduced in the EIS), the petitioner's zoological consultant "did not extend [his] survey to lava tubes", possible roosting sites for bats. If such roosting sites are not identified in advance of preparation of the area for farming and ranching, it will be impossible to ensure that "present, actual" roosting sites are preserved. Accordingly, we believe such sites should be identified prior to any change in land use district boundaries so that the sites and a broad buffer area surrounding them may be retained within the Conservation District.

We thank you for this opportunity to comment on the EIS for this project.

Sincerely,

Carl C. Christensen

Carl C. Christensen
Conservation Chairman

cc: Group 70

Robert K.L. Wong AIA Inc
Norman G.L. Hong AIA Inc

3 April 1984

Carl C. Christensen
Conservation Chairman
Hawaii Audubon Society
P.O. Box 22832
Honolulu, Hawaii 96822

Dear Mr. Christensen:

Subject: Farms of Kapua Environmental Impact Statement

We have reviewed your letter of 6 March 1984 and offer the following responses:

1. We disagree that the agricultural use of the petition area would be inconsistent with the management of the proposed preservation area. The botanical consultant, Kenneth M. Nagata, recommended the 20 acre preserve in order to provide a buffer between the kauila, Bobea specimens and the proposed macadamia cultivation in that area. Please note that the retention of the proposed preservation area within the Stat Conservation District in itself would not necessarily result in assuring the survival of the subject specimens. The petitioner will manage the preserve by mechanically removing vines from the specimens and controlling nearby christmas berry trees and lantana shrubs. If the proposed preservation area is left in the Conservation District, it is unlikely that the Department of Land and Natural Resources will provide management in the manner previously described.

2. Based on Nagata's assessment that the native dry forest within the petition area as "poor", we disagree with your contention that these areas should be retained within the State Conservation District.

   Please note that Nagata's earlier reconnaissance survey extended beyond the petition area to the 1100 - 1300 foot elevation. The Canvalia hawaiiensis vines were discovered mauka of the petition area.

3. The proposed management of the specimens within the preserve area was described in the first paragraph. In addition, Nagata recommends that the specimens be monitored on a quarterly basis. The petitioner intends to implement the recommended management program.



4. We note your opinion that 300 foot buffer zone along the southern boundary of the petition area should be retained within the State Conservation District.

5. According to the archaeological consultant, Paul H. Rosendahl, Ph.D., nearly all of the lava tubes and caves (potential roosting sites for bats) would be identified during the reconnaissance level survey of all areas to be developed, which has not yet been undertaken. Present, actual roosting sites would probably be preserved because it would not be to the petitioner's benefit to intentionally destroy any lava tubes or caves. Destruction of these features would change the topography of the proposed development areas and would make agricultural use of these areas more difficult.

   We note your opinion on the retention of roosting sites and buffer zones within the State Conservation District. Please note that Andrew J. Berger, Ph.D., states on page 9 of his report (Appendix C) that: "As long as any present, actual roosting sites (in lava tubes or caves) of the bat are preserved, the proposed activities (macadamia nut orchard, koa haole planting, pasturing of cattle, and aquaculture facilities) would have absolutely no adverse effects on the bats, which obtain their insect food in flight."

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

• Architects • Planners • 924 Bethel Street • Honolulu HI 96813 • Phone

March 22, 1984

To: Group 70
From: Dave Penn
Re: EIS Draft Kapua

To whom it may concern,

Thank you for the opportunity to comment upon the Draft Eis for the Farms of Kapua (FOK) Project. My previous comments on the EIS Notice of Preparation apparently were not received in time for inclusion in the Draft EIS. I have enclosed another copy of these comments, as well as additional comments upon the Draft EIS.

Sincerely,

Dave Penn

RECEIVED
MAR 24 1984
GROUP 70

SUMMARY

p. 1) The propsed action does not broaden the range of beneficial uses for the parcel as a conservation district.

p. 8) The Draft EIS does not adequately adress the effect of the propsed action's water consumption on the present and future rights of surrounding users to the area's water supply.

The exact location of the aquaculture modules must be shown for an adequate assessment of impacts to be made.

p. 10) Social Characteristics: serious displacements of natural and psychic energies will occur as a result of the proposed action. Existing uses by local populations will be adversely affected.

Historic Perspective: The significance of pre-contact uses does not need to be documented; it is inherent in Hawaiian spirit and tradition.

All military waste must be removed from the area.

p. 24) Coastal Water Quality: An absolute minimum of any quantity(i.e. pollution) is zero. Therefore the proposed action does not meet the State Public Health Regulations regarding Class AA waters. The maximum extent possible for protection of the wilderness character of these waters is afforded by keeping the area within the Conservation District.

p. 36) Archaeological Resources: The level of information retained from the reconnaisance survey is not sufficient to determine the upper limit of concentration of remains. It is not clear why decisions on mitigation and preservation are delayed. The EIS should adress all aspects of the propsed action. Mitigation and preservation measures themselves may create other adverse impacts on environmental quality. Any development of the area will impinge upon the interpretive values of cultural sites.

p. 44) A more complete analysis of the ecology of the aquaculture effluents is needed.

p. 46) The application of herbicides is hazardous to workers and to the natural environment

p. 49) The proposed agricultural use is of a larger scale than is found in the local area, and will add to the problems of competitive growing and marketing of the smaller farmers.

p. 51) It is not clear what the effect of drilling irrigation wells will be upon the level

of adjacent wells and water tables.

p. 59) More explanation of the mitigation- preservation decision process and the attendant monitoring program is needed.

p. 60) Most importantly, the proposed action will have adverse effects upon the actual practice of the living culture in the region.

p. 62) No Action Alternative: Productivity should not be measured strictly in economic terms. The no action alternative preserves the productive aspects of the area most important for the social well-being of area residents.

p. 63) All sites are appropriate for preservation. If you didn't put it there, you have no right to remove it.

p. 64) The propsed action will have significant adverse effects on area resources.

p. 65) Protection of water resources implies preservation of water resources. There is not sufficient knowledge of the aquifer system at present to allow extensive development of a finitely limited resource.

Preservation of the ecosystem includes that of people and their culture. This area is a critical habitiat of an endangered species, the native Hawaiian Hawaiian.

p. 67) The extent of preservation of cultural resources cannot be determind without the presentation of a detailed site plan for the aquaculture facilities.

p. 69) Again, the minimization of adverse impacts upon the coastal ecosystem occurs when the area remains within the conservation district.

p. 73) What are the criteria for determination of inclusion and response to comments? All comments received should be included in the EIS.

Comments on the Comments

Mr. Suwa of the Department of Agriculture concurs that the sustainable yield of the aquifer below the site is unknown.

The BLNR attachment on the proposed park supports Sprigg's hypothesis of an extension of the Kona field system.

Regarding Nagata's Mauka Boundary Botanical Survey, the analysis of infrared photos is not a sound criteria for evaluating the presence of rare or endangered species.

My primary concern regarding the proposed action is that salvage archaeolngy will occur where sites are deemed to be of minor importance. Nowhere in the Draft EIS is there made an adequate corralation between the historical and legendary accounts of the area and its actual historic features. No attempt is made to interpret the existing phenomenon as a manifestation of a complex and unoque social system. Impacts upon any sites within the project area are significant because they disturb the physical and spiritual linkages common to any Hawaiian land division. The Bishop Museum does not have room to store, much less to exhibit, the crates of material already "salvaged". This practice constitutes a selfish taking of a natural resource, which loses all of its significance to practitioners of Hawaiian culture and most of its educational or interpretive value when it is removed from its native habitat. This practice disturbs the flows of psychic energies and compromises family-oriented spiritual practices of local citizens.

As a citizen of Hawaii, I remain wholeheartedly opposed to the proposed change in land use district boundary for the Farms of Kapua project.

Sincerely,

Dave Penn

Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

David Campbell Penn
44-403 Kaneohe Bay Drive
Kaneohe, HI 96744

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Penn:

Although your letter of 23 February 1984 was sent after the EIS was filed, we will reproduce it and our response in PART XI (Agencies, Organizations and Persons Who Were Sent a Copy of the NOP) of the revised EIS. We offer the following responses to your letter of 22 March 1984:

1. Examination of the standards used in determining the boundaries for the Conservation District reveals that the "beneficial uses for the parcel as a conservation district" is minimal. Please refer to our discussion of the standards in PART VIII, section C of the EIS.

2. Surrounding landowners have had ample opportunity to comment on the proposed consumption of water, however, to date, none have expressed concerns regarding their present and future rights of the area's water supply.

3. We disagree that the exact siting of aquaculture modules is necessary in order to assess environmental impacts. Please note that we have described the anticipated site-related impacts of the proposed aquaculture modules, such as soil disturbance, in PART III, sections D, J and K of the EIS.

4. We note your assertion that "serious displacements of natural and psychic energies will occur as a result of the proposed action". The latter conditions and the degree and scope of "existing uses by local populations" are repeatedly referred to in your letter, but are never succinctly described (number of people involved, exact uses, duration of use, necessity of the site for the use, etc.). Please note that we have yet to recieve a letter from nearby residents on the site's "natural and psychic energies" or "existing uses" since the EIS process began. Unless these conditions are documented, described or identifiable to us, it is difficult for us to assess the impacts





of the proposed State Land Use Boundary amendment on these conditions and users.

5. We note your opinion that the significance of pre-contact uses of the site need not be documented, however, unless it is documented, it is impossible to assess the impact of the proposed activities on the cultural significance of the site.

6. We concur that all hazardous, unexploded ordnance should be removed from the petition area. Please refer to our response to Wayne K. Westlake (PART XI of the EIS).

7. We disagree with your assessment that the proposed action will not meet the State of Hawaii Department of Health Water Quality Standards regarding Class AA waters. The Department of Health was a consulted party during the preparation of the EIS, and has had an opportunity to review the EIS and has not shared your opinions on this matter. As stated in the EIS, no construction is proposed within the offshore waters or within 300 feet of the shoreline. During the life of the project there will be no point discharge of human or animal wastes from the petition area directly into offshore waters. Also, please note that Chapter 37-A of the Public Health Regulations state that the classification of any water area as Class AA shall not preclude (emphasis added) other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.

8. The statement is taken out of context, the entire sentence reads: "It would appear that the level of information obtained from the reconnaissance survey is sufficient to provide a basis for defining the approximate inland limit of the coastal concentration of archaeological remains. This limit varies from 1,000 to 1,500 feet inland from the shoreline." Please note that this statement has not been questioned by the County of Hawaii Planning Department or the State of Hawaii Historic Preservation Office.

   We note your concerns regarding the level of archaeological work conducted. We refer you to the Notice of Preparation consultation letter we received from the Bishop Museum, our response and a letter from the Acting State Parks Administrator, Ralston H. Nagata. These letters are found in PART XI of the EIS.

9. The integrated aquaculture system and the disposal of its effluent via seaweed culture troughs is proposed in order to yield brackish water that is nearly as nutrient-free as when it is first pumped out. The quality of the water that passes

through the system will be monitored not only to minimize the effects of disposal (infiltration), but also to avoid the overabundance of nutrients in any of the ponds or raceways. Nutrient overload will have an adverse effect on the aquaculture crops. Robert Shleser of the Oceanic Institute has testified before the Land Use Commission that to ensure crop success and environmental quality, dry-run operations will be conducted before full-scale production is started. Constant monitoring of the quality of the water flowing throughout the aquaculture system should mitigate the pollution problems usually associated with wastewater disposal.

10. Herbicides are hazardous to workers and to the environment if general, safe application procedures are not observed. Frank S. Scott, Jr., the macadamia production consultant, has stated that environmental problems with the application of herbicides in macadamia orchards by existing means has never been documented. In fact, the herbicides used are usually diluted enough so that its accidental application on macadamia tree trunks does not result in tree loss.

11. As described in PART III, section L. Socio-Economic Impacts, there is adequate demand for macadamia, beef and aquaculture products statewide and for export. It is expected that this demand is great enough to accomodate the proposed crops without adversely affecting smaller farmers in the area and attractive enough for individuals to start new small farms.

12. Drilling irrigation wells in itself will not have any negative impacts on adjacent wells and water tables.

13. As noted on the same page you refer to (page 59), the exact scope and scale of further archaeological work in the petition area would be worked out in consultation between the petitioner and the appropriate State and County representatives. The specific elements for the monitoring of significant sites and specific mitigation vs. preservation decisions will be included in an archaeological/historical resource management plan. It is expected that this plan will be required by the County of Hawaii during our attempt to either obtain a LUPAG redesignation or rezoning (upon favorable resolution of the State Land Use District boundary).

14. Please refer to item 4 of this letter.

15. "The productive aspect of the area most important for the social well-being of area residents" is difficult to identify, quantify or even understand.

16. We note your opinions on preservation.





17. We disagree with your assessment that the proposed action will have significant adverse effects on area resources. Please refer to the discussion in PART VIII, section C of the EIS. In this section we examine the standards used in determining the boundaries for the Conservation District. Generally, these standards are used to weigh the value of land for its natural resources.

18. Although the groundwater resource at Kapua has not been investigated in detail, John F. Mink considers his report provides adequate information on which to proceed with specific siting and installing of wells. In addition, Mink has testified before the Land Use Commission that he has no record of failure in terms of predicting the availability or non-availability of water for development, in his capacity over the years as consultant to various water developers. Please note that the petition area is located makai of the County's "no pass zone" or principal groundwater recharge area.

19. We question your use of the term "critical habitat " in your assertion that the petition area "is a critical habitiat [sic] of an endangered species, the native Hawaiian Hawaiian". We also question your reference to people of Hawaiian ancestry as an "endangered species", as intended by the Endangered Species Act as Amended by Public Law 97-304.

20. We concur that the extent of the preservation of cultural resources cannot be determined without detailed site plans for the aquaculture modules. As noted in PART III, section J, specific siting of the aquaculture modules in not known at this time, however, information adequate for specific placement of facilities, with regard to the location of archaeological sites, as well as appropriate mitigation activities, would be available after the completion of intensive survey work that would be carried out prior to the specific placement of the modules. Careful placement of the aquaculture facilities, after the completion of an intensive survey, will preserve significant sites.

21. Please refer to item 7 of this letter.

22. All letters received during the consultation period were included in the EIS. All written comments were responded to. We did not reply to a letter which stated that they did not have any comments.

23. Mr. Suwa's comments (11 October 1983) were taken out of context. Mr. Suwa used that statement to ask for clarification of procedures that will be taken to determine the amount of groundwater that can be safely and effectively withdrawn for use. Please note that it is stated in the EIS, that as a precaution, the proposed irrigation wells will be monitored for chloride. An increase in the chloride level will be indicative of salt water intrusion and appropriate action (such as reducing or halting pumping) can be taken should this situation arise. In addition, please refer to item 18 of this letter.

24. Please refer to page 4, items 11/2, 10/2 of our response (16 February 1984) to Spriggs consultation comments (PART XI of the EIS) regarding his hypothesis of the Kona field system.

25. It is not stated in Nagata's report that the evaluation of the presence of rare or endangered species was based on the analysis of infrared photos. The infrared photos and an earlier reconnaissance (1983), were used to plot the native dry forest on an aerial photo, for use in surveying all significant ravines, and the contiguous forest and all large groves of native vegetation below it.

26. Please refer to item 13 of this letter. We expect that a synthetic analysis of the cultural significance of the petition area would obviously comprise an important aspect of subsequent intensive level survey work (as described in PART III, section J of the EIS).

27. Your opposition to the petition to amend the State Land Use Conservation District Boundary in Kapua, South Kona is noted.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

NA ALA HELE
P.O. BOX 1572
KEALAKEKUA, HI 96750

RECEIVED
MAR 24 1984
GROUP 70

March 22, 1984

State of Hawaii
Land Use Commission
Room 104, Old Federal Bldg.
335 Merchant St.
Honolulu, HI 96813

Re: Comments on Farms of Kapua's Environmental Impact Statement

Dear Sirs:

If the Farms of Kapua Ltd. reclassification request is granted, the petitioner should be required by the State of Hawaii to complete a "cultural resource management plan" which would result from intensive archaeological survey. That plan should be required to provide for:

1. Archaeological monitoring during construction activity without sole reliance on a construction crew's untrained eye to detect previously unidentified historic sites, and
2. A resident caretaker who would monitor historic sites in an effort to prevent "irreversible and irretrievable" loss of State cultural resources due to looting and/or vandalism.

Study of historic Hawaiian trails could advance our fundamental understanding of the daily lifestyles of ancient Hawaiians. We urge that trails of significance and sturdy construction be guaranteed preservation beyond the 300-2,000 foot shoreline setbacks.

Na Ala Hele has a primary interest in historic Hawaiian trail documentation and preservation. In our West Hawaii field experience we have been impressed by the quality of stonework found in many Kapu'a and Okoe trails. The permanency and artful manner in which the huge waterworn stones ('ala) were placed and the sheer manpower required in their construction far surpass that found in trails in other West Hawaii districts. So little is known about Hawaiian trails it is fascinating to speculate why the Kapu'a-Okoe trails were built so sturdily, for what purposes, and by whom.

We recommend that documentation of trail routes, their manner of construction and destinations be addressed in future archaeological survey in order that trails worthy of further analysis can be identified and preserved.

Sincerely,

Deborah Chang Abreu

Deborah Chang Abreu
President, Na Ala Hele

cc: ✓Group 70
Office of Hawaiian Affairs

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Deborah Chang Abreu
President
Na Ala Hele
P.O. Box 1572
Kealakekua, HI 96750

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Ms. Abreu:

We have reviewed your letter of 22 March 1984 and offer the following responses to your comments:

1. As noted on page 32 of Rosendahl's report (1983), requirement of a cultural resource management plan is anticipated to be required by the County Planning Department during LUPAG redesignation or rezoning applications (upon favorable resolution of the State Land Use District boundary). It is anticipated that the County Planning Department, and not the State of Hawaii Historic Preservation Office, will be the lead agency in guiding the preparation of the cultural resource managment plan. Of course the Historic Preservation Office will be consulted in specifying the scope and scale of any future archaeological work within the petition area. Your recommendations for archaeological monitoring during construction and the provision of a resident caretaker will be taken into consideration in preparing the management plan.

2. We concur that the study of historic Hawaiian trails has significant value in understanding the lifestyle of the pre-contact Hawaiians. We also concur that future archaeological surveys include the documentation of trail routes. As with other significant archaeological features, specific mitigation vs. preservation plans for trails of significance or "sturdy construction", would be outlined in the cultural resource management plan.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission

SIERRA CLUB-Moku Loa Group
Conservation Chair
P.O. Box 192
Volcano, Hawaii 96785
March 23, 1984

RECEIVED
MAR 27 1984
GROUP 70

Mr. Gordon Furutani, Executive Officer
Land Use Commission
Old Federal Bldg., Rm. 104
335 Merchant Street
Honolulu, Hawaii 96813

Subject: Farms of Kapua, Draft EIS Comments.

Dear Sir:

This letter provides some specific comments on the EIS with regards to several points of importance discussed within the draft EIS. Additionally, we would like to state that the EIS has done very little to incorporate numerous very valid concerns expressed by a number of reviewers into the body of the document. Many substantive questions were ignored, others answered in a nonsensical manner, and overall there has been a "whitewash" of concerns raised by reviewers in many EIS opinions, statements and conclusions unsubstantiated by facts, calculations and logic.

Such flippant treatment of reviewer concerns does little to provide an aire of credibility to the document, nor does it provide the reader with the feeling of confidence in the numerous possible discretionary responses to stated problems and concerns by the developers. In short, if the developers take reviewer concerns lightly in the documents displayed to regulatory agencies, the public and concerned agencies alike should not have faith in any mitigative promises or options the developer proposes or regulatory agencies allow.

A few of our many concerns are stated below:

(1) Noticeably absent from the bibliography of EIS Appendix E, Dr. Scott's "Agricultural Feasibility of Macadamia Cultivation, Farms of Kapua" (1984), is the "Macadamia Nut Industry Analysis Number 2" (March 25, 1981), submitted to the State of Hawaii Agriculture Coordinating Committee by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Also absent from Dr. Scott's report and the EIS are a number of facts about the macadamia nut industry that have direct bearing on the proposed Farms of Kapua project. Accordingly, ten pages of the document are herein supplied as 'Attachment A' to this correspondence, and to these will specific points be addressed as "MIA-page number". Note also that an updated "Analysis Number 3" is in draft form, and it continues to support the facts cited herein.



(2) Water Needs of Mac Nuts (MIA-p. 7) - Mac nuts grown on porous 'a'a type soil require at least 80-100 inches of rainfall annually, but if irrigation is used to supplement rainfall, a total of 73 inches is required: (0.20 in./day) (365 days/year) = 73 in./year = 6.1 in./mo. This is also stated as a requirement of 5500 gal/acre/day for combined rain-and-irrigation. The total requirement of water for the 2110 acres of irrigated crops is (5500 gal/acre/day) (2110 acres) = 11.6 million gal/day. The rainfall (Kole Pen data) supplies 4.1 mgd = (25.7 in/year) (27,147 gal/ac-in)/(365 days/year). Therefore, (11.6 mgd - 4.1 mgd) = 7.6 mgd needs to be supplied by irrigation, on the average, and much more in drier years.

(3) Moisture Deficits (See Attachment B) - This table was constructed to show the month-by-month moisture deficit (to be met by irrigation) using (a) 1956-1975 median rainfall data from the Kole Pen station at 920 feet elevation in the proposed orchard area, and (b) the 6.1 in./mo. = 73 in./yr total irrigation-plus-rainfall moisture requirement for macadamia as cited in MIA-pg. 7. The average annual deficit of 44.3 inches is the amount of moisture needed that must be supplemented by irrigation to meet the orchard's needs. This value is much greater than those which Mink "calculated" in the EIS, "Water Supply for Farms of Kapua" (Feb. 1984): 25.7 in. in Table (p. 10), 14.2 in. in Table I (p. 13), and 19.7 in. in Table II (p. 14).

(4) Irrigation Requirements and Cost (See Attachment C) - This table is derived from Attachment B and provides an idea of the irrigation requirements for the proposed development, as based on the 1956-1975 Kole Pen rain records. The average supplemental requirement for 2110 irrigated acres is 6.95 mgd. Using the water cost figures in the EIS (Scott, Table 4, p. 21), the cost of the water each year will be $2.02 million dollars on the average. These figures are considerably higher than those which can be derived from Scott's moisture deficits above:

44.3 in deficit → 6.95 mgd → $2.03 million;
25.7 in deficit → 4.03 mgd → $1.18 million;
14.2 in deficit → 2.22 mgd → $0.65 million;
19.7 in deficit → 3.09 mgd → $0.90 million.

(5) Such a financial burden needs to be honestly evaluated in the economic feasibility analysis of the project. This unavoidable cost burden on Farms of Kapua orchards

greatly reduces their competitive abilities when both foreign and local, unirrigated, production force nut prices down to levels that make high-cost fields unprofitable to sustain. At this point in time such conditions can be predicted if the lessons learned in our sugar, pineapple and cattle industries will be heeded, and the Land Use Commission, the county governments, and investors all look at what is best for sustaining competitive agriculture for Hawaii's future. All must try to avoid the social and taxpayer burden following collapses of extensive agri-businesses and subsequent job and tax revenue losses, as has happened when Kohala and Puna sugar plantations failed.

(6) Predictable insect pest problems (MIA-pp. 12-13). The Koa seedworm is identified as a major pest of mac nuts and uses as an alternate host koa haole. Koa haole is presently growing on much of the acreage proposed for mac nuts and can be expected to sprout up from residual seeds after land clearing. The large acreage of cattle forage bordering the orchards will also provide a permanent reservoir for these pest insects that cannot be sprayed by insecticides. The EIS claimed that no insecticides will be used in the orchards. The masses of pest insects associated with the forage areas and orchard weeds may prove to be too much for biological controls.

(7) Weeds (MIA-p. 16). Also predictable as a problem are weeds. The present and proposed distribution of guinea grass (a "major problem weed") is about the same as that of koa haole. This situation predisposes the orchards to weed problems and will make considerable use of herbicides a necessity on over 1700 acres. What impact might this mass of herbicides have on the growth of algae in the aquaculture ponds. Herbicides, as well as salts, will be leached out of the soil and carried down into the brackish groundwater up-gradient of the aquaculture project's brackish wells.

(8) Paragraphs (5), (6) and (7) illustrate that "integrated agriculture" schemes propose significant economic and environmental problems as well as cost efficiency. These problems are predictable, and may well influence the economic viability of the Farms of Kapua proposal.

(9) Labor (MIA-p. 9). Paragraph 1-(a) points out that Mac Farms (at Kapua) has had to bus in labor. If additional jobs (and demand for labor) are created by the proposed Farms of Kapua project, will this mean that additional busing of workers will be required? The project purports to create jobs, but are the jobs needed in the Kapua area if laborers have to be brought in?



Providing more mac nut-type jobs in the Kapua area by approval of the project may be compounding an existing problem. A better solution would be for the Land Use Commission to deny the proposed land zoning change and to suggest that mac nut orchard development be directed to other parts of the island that are already zoned for agriculture and where laborers may be available. Puna, Kohala and Hamakua are much better areas for directing mac nut development, as both the lands (well-watered soil, zoned Agriculture) and the availability of recently-unemployed agricultural workers will make mac nut development on these lands more economically feasible and socially responsible than on the lands of Kapua. The EIS and government agencies all need to deal rationally with these judgments and consider the long-term implications. These issues should not be ignored or dealt with flippantly.

(10) The Moku Loa Group of the Sierra Club has long been a supporter of the well-being of Hawaii's agricultural interests as well as the rational use of the Island's natural resources and has prepared these comments with both in mind. The future enjoyment of these resources, especially the non-renewable resources like archaeological and cultural remains and native biota, depend on wise decision-making today. The agencies and societies making these decisions depend on accurate and comprehensive documentation and evaluation to do what is best for both the future as well as the present. Please make the final draft of the EIS worthy of the stakes.

Sincerely,

Rick Warshauer

Rick Warshauer

3 attachments

cc: Group 70

Attachment A

AGRICULTURAL INDUSTRY ANALYSIS

THE STATUS, POTENTIAL, AND PROBLEMS OF HAWAIIAN CROPS

# MACADAMIA NUT INDUSTRY ANALYSIS NUMBER 2

Submitted to the

State of Hawaii
Agriculture Coordinating Committee

March 25, 1981

Editorial Responsibility: Dr. C. L. Chia
Dr. N. P. Kefford
Mr. W. T. Harada

College of Tropical Agriculture
and Human Resources
University of Hawaii at Manoa



## I. PREFACE

As a step towards marshalling the resources available in the State of Hawaii for the development of the macadamia nut industry in an orderly and optimally successful fashion, representatives of the macadamia nut industry, Governor's Agriculture Coordinating Committee, U.S. Fish and Wildlife Services, Department of Planning and Economic Development, Department of Land and Natural Resources, Department of Hawaiian Home Lands, Hawaii Farm Bureau Federation, County of Hawaii, the College of Tropical Agriculture and Human Resources of the University of Hawaii at Manoa, and the College of Agriculture at U.H. Hilo have worked together to prepare this Industry Analysis and Action Plan which is a reasoned assessment of the industry.[1]

The analysis considers all of the elements that constitute the macadamia nut industry. One such element is an assessment of the potential of the industry in Hawaii. Other elements are assessed in terms of this potential, bottlenecks in the achievement of the potential are identified, and the requirements to relieve each bottleneck are defined. From this base, an action plan is developed in which the units of the community best able to accept responsibility for relieving bottlenecks and the resources required are specified. In the action plan, the bottlenecks are presented in the order of priority determined by the industry.

In order to identify current potentials and bottlenecks of the industry, this analysis and action plan will need to be revised periodically.

---

[1]The people who contributed are:

Ellen Farmer (CTAHR)
W. T. Kirschbaum (CTAHR)
Dick Phillips (Industry)
Elnora Huyck (CTAHR)
Masao Nakamura (Industry)
Lloyd Garrett (DOA)
S. Foss (Industry)
Ian G. Morison (CTAHR)
Yoshiko Hall (GACC)
C. L. Chia (CTAHR)
George Nagai (Industry)
Wen-hsiung Ko (CTAHR)
Donald Shintaku (Industry)
David Rietow (Industry)
Ed Kanahele (DHHL)
Charles Yasuda (DOA)
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Paul Schwind (DOA)
William Sakai (UH-Hilo)
Roy Nishimoto (CTAHR)
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Alan Yamaguchi (Industry)
Hiroshi Ooka (Industry)
Dickey Hitta (Farm Bureau)
Calvin Lee (DPED)
Robert Chuck (DLNR)
David Fellows (USFWS)
Mike Nagao (UH-Hilo)
Frank Haramoto (CTAHR)
I-Pai Wu (CTAHR)
Richard Hamilton (CTAHR)

3/9/81

c. Although Hawaii Revised Statutes Section 171-37 limits State land leases for intensive agricultural uses to 35 years, the lease term can be up to 45 years for tree-crop orchards, 55 years if extensive expenditures are required, and 75 years if the lessee is required to reside on the premises. Department of Land and Natural Resources (DLNR), Land Management Division, should be consulted as to applicability of these provisions to the development of specific macadamia orchards.

d. The DOA statistics show that the acreage in crop has increased from 8,690 in 1969 to 13,400 in 1980. Further increase in acreage is expected.

e. With land leased from the State, growers may pay as low as $5-$10 per acre per year for the first few years, but will have to share a percentage of gross sales. Other land can be leased for $30 to $120 per acre per year, plus lease purchase. Fee Simple land costs between $2,000 and $8,000 per acre. Land with mature trees sell $10,000 to $20,000 per acre.

f. The Panaewa Agricultural Park on which construction began in the fall of 1980 is planned to include 6 lots of 20 acres in size for orchard use, 20 lots of 10 acres in size for orchard or nursery use, and 110 acres for the University of Hawaii at Hilo farm laboratory. There has been much interest expressed in the acquisition of land for macadamia. More agricultural parks are desirable; it may be the only way for many small growers to get into the business.

g. Some former sugarcane lands in Honokaa, Kohala, Hilo, Kau, and Wailuku are now being used for macadamia. Macadamia may be a good alternative for other sugarcane lands that go out of production.

h. The possibility of bringing more private lands into macadamia production should be investigated.

2. Bottlenecks

a. Insufficient supply of suitable land at reasonable cost for expansion of the macadamia nut industry (for small and large growers and for new and present growers).

Overall priority 15

(1) Impact if this Bottleneck is (is not) Eliminated

(a) If the high cost of land purchase can be replaced with low annual lease arrangement, the rate of return will be more favorable. In some areas, land costs are so high that it is uneconomical to grow macadamia.



B. Water

1. Analysis

a. If macadamia is grown on porous a'a type soil, at least 80-100 inches of rainfall is required.

b. If macadamia is grown on soil, at least 60 inches of rainfall is required.

(365 day)(0.20 in/day) = 73 in/yr = 6.1'/mo

c. If rainfall is insufficient, irrigation would be required. Whether macadamia is grown in regular soil or a'a type soil, the trees should receive about 0.20 inch of water per day from rainfall and/or irrigation (5,500 gal./acre/day).

d. Lack of adequate water is depressing growth and yield in some areas. These areas would benefit greatly if water sources were developed to allow irrigation.

e. Mauna Loa Macadamia Nut Corporation is developing its own water sources and irrigation facilities in Kau.

f. In Kona, growers who use municipal water for irrigation have to pay $0.61 per 1,000 gal. This rate is based on agricultural use.

g. The State has recently completed the drilling and testing of an exploratory well on State land in South Kona near Honomalino at an elevation of 849 feet. Results indicate the well can produce 750 gallons per minute of brackish water (800 ppm chloride).

h. A cooperative irrigation experiment between Mac Farms of Hawaii and CTAHR is now being conducted on Mac Farms' orchard. The experiment was installed in an area (lower elevation) which receives insufficient rainfall. Water is being applied through a micro-jet system at 6 different rates (4, 8, 12, 16, 20, and 24 gals. per tree per day) with adjustments being made for rainfall. Yield data will be collected and correlated with water application rate.

i. Mac Farms of Hawaii and CTAHR are in the process of initiating another cooperative irrigation experiment in an area with higher rainfall (higher elevation). The effect of irrigation as a supplement to rainfall on yield will be studied.

j. The Hamakua agricultural water study commenced in April, 1979 (contact the Soil Conservation Service for further details).

k. If irrigation water is required, macadamia should be grown where water is available or where the cost of pumping water will not be prohibitive.

l. A great deal of the arid, low elevation belt of the Big Island has ground water that is not potable, but may be of sufficient quality for irrigation. There are large abandoned areas in Honomalino which may be revived by irrigation. However, the salinity tolerance of macadamia and the effect of salinity on yield and quality of nuts have not been determined.

C. Labor

1. Analysis

a. The lack of sufficient and qualified labor in some areas, particularly for harvesting, presents a problem. Mauna Loa Macadamia Nut Corp. and Mac Farms of Hawaii are both busing workers from other areas to their orchards in Kau and Honomalino. A partial solution may be attained through maximizing recovery and by shortening the harvest season. However, shortening the harvest season may be good for the large growers, but may not be desirable for the small growers and processors.

b. The existing labor laws do not allow families to undertake contract harvesting of macadamia nuts. Contract harvesting of macadamia nuts appears to have advantages for both the families in need of income and the industry.

c. There is insufficient housing for laborers in macadamia production areas.

d. Labor-saving mechanical harvesting systems have been developed for large growers or groups of cooperating growers. Mechanical harvesting systems for small growers are being tried experimentally in the field.

e. Mauna Loa Macadamia Nut Corp. and Mac Farms of Hawaii have developed mechanical harvesting systems and are continuing to improve them.

f. The ground pick-up and shaking systems presently being used need further improvements.

g. The Honomalino farm is using a form of shake harvesting.

h. Since the labor problems are related to harvesting, the labor problem is also dealt with under harvesting as a harvesting problem.

2. Bottlenecks

a. State and Federal laws restrict the industry from hiring families on contracts to harvest macadamia nuts. (There appear to be advantages for the families in need of income and for the industry.) Insufficient housing for laborers in macadamia production areas.

Overall priority 16

(1) Impact if this Bottleneck is (is not) Eliminated

(a) If the existing laws are amended, families will be able to undertake contract harvesting of macadamia nuts. A family of five may earn as much as $150 per day (3,000 lbs. harvested at 5¢ per lb.).



E. Insect Control

1. Analysis

a. Broad mite, black citrus aphid, Hawaiian thrips and koa seedworm are pests of macadamia. Yields have been shown to decrease by more than 20% when insect damage is severe. The first three species cause blossom drop and nut drop. Long-legged red ant occurs in large numbers in certain orchards on Hawaii but does not appear to be a serious problem.

b. Growers must be careful that their spray programs do not kill pollinators.

c. Generally, only big growers spray chemicals to control insects.

d. Chemicals registered for insect control in macadamia nut orchards are listed below (I = insecticide; M = miticide):

| Insecticide | Rate/Acre | Effective Against |
|---|---|---|
| (1) Sulfur | 15 lbs. | Broad mites |
| (2) Endosulfan (I) (Thiodan) | 1-1/3 to 2 qts. | Broad mites, koa seedworm, stinkbug |
| (3) 6-methyl-1, 3-dithiolo (4,5-6) quinoxalin-2-one (m) (F) (Morestan) | 1 to 8 lbs. | All mites |
| (4) Malathion (I) (wettable powder) | 4 to 60 lbs. | Aphids, stinkbug |
| (5) Malathion (I) (Emulsifiable concentrate) | 1-1/2 to 24 pts. | Aphids, stinkbug |
| (6) Phosalone (I) (M) (Zolone) | 4 to 8 pts. | Aphids |
| (7) Plictran (M) | 8 to 24 oz. | All mites |

e. Research needed for registration is being conducted on Orthene to control thrips and aphids. Current studies on Orthene include aerial spraying. This is the final year of data collection. Registration could take another 3 or 4 years.

f. The mere presence of insect pests should not be considered a problem. There is a need to determine the economic threshold to justify spraying. One large grower has established a monitoring program for insect pests and has developed methods to determine when it is economical to spray for mites.

g. Research is needed to determine the feasibility of using integrated pest management on macadamia. The industry is interested in biological control of insects since, as a practice, the method is less expensive and labor-consuming than chemical control. The successful effort to control the stinkbug is a good example of biological control.

h. The industry is cooperating to establish broad mite predators and to evaluate the effectiveness of the predators.

i. Many natural predators of aphids are established in Hawaii.

j. Koa seedworm is a problem only in areas where heavy growth of koa haole occurs. Biological control agents for the koa seedworm already occur in Hawaii and are probably providing a fair amount of control.

k. It would be better to try for lure control of Hawaiian thrip because biological control would be very difficult.

l. The feasibility of developing integrated insect control programs should be investigated.

m. It is very important to maintain surveillance for new insect pests of macadamia since serious pests of the crop are known to occur elsewhere.

2. Bottlenecks

a. The industry needs improved economical control of broad mite, Hawaiian flower thrips, black citrus aphid, and koa seedworm.

Overall priority 19

(1) Impact if this Bottleneck is (is not) Eliminated

(a) If effective insect control is not achieved, the industry will continue to suffer some yield reductions. In severe instances, yields have been shown to decrease by more than 20%.

(2) Action Required and Agency Responsible for Eliminating this Bottleneck

(a) Evaluate the effectiveness of the three broad mite predators that have been released.

CTAHR and Industry

(b) Determine the economic threshold for broad mite and Hawaiian flower thrip damage. Develop lure control of the Hawaiian flower thrip.

CTAHR and Industry

(c) Investigate the aphid problem.

Industry and CTAHR

(d) Educate growers on monitoring orchards for mites, thrips, and aphids. The monitoring program will allow growers to bring in predators and to spray when necessary. Help industry develop an integrated pest management system.

DOA, Industry, CTAHR

(e) Find candidate biological control agents for koa seedworm.

DOA



G. Weed Control

1. Analysis

a. The major problem-weeds are buttonweed and Guinea grass. Other weeds are guava, lantana, and koa haole.

b. Weeds are normally more of a problem in the early years of orchard establishment.

c. The herbicides registered for use in macadamia nut orchards are: Aatrex at 2-1/2 to 5 lbs. per acre, Dowpon or Basfapon at 5 to 10 lbs. per acre, Karmex at 2-1/3 to 5 lbs. per acre, Paraquat CL plus surfactant at 1 to 2 qts. per acre, and Princep 80 W at 2-1/2 to 5 lbs. per acre, and Roundup at 1 to 5 qts. per acre.

d. The pre-emergence herbicides (Aatrex, Karmex, and Princep) are inherently weak on some grass species.

e. Buttonweed is apparently somewhat tolerant to Aatrex.

f. Karmex is somewhat injurious to macadamia under shallow a'a soil conditions if not properly used.

g. The post-emergence herbicides, Dowpon and Paraquat, are somewhat ineffective on buttonweed and Guinea grass, especially in a very mature growth stage. Roundup provides good to excellent post-emergence control of these weeds.

h. Roundup is good for controlling lantana. It could be effective on guava, but a better application method using a mixture of Roundup and a growth regulator must be tried. There is a possibility of effectively controlling koa haole with Roundup.

i. In CTAHR studies with another crop in Waiakea, Ronstar (Rhodia, Inc.) provided excellent control of buttonweed. Toxicology problems are stalling registration of this product.

j. A new product, Devrinol, could provide pre-emergence control of grasses. HITAHR is currently collecting residue samples of this product.

k. HITAHR is also working with Surflan, a pre-emergence herbicide which has shown excellent control of buttonweed. This product has possibilities for use with established orchards as well as young orchards or nurseries.

l. The use of Dalapon at increased rates is being investigated by Mauna Loa Macadamia Nut Corp. to control mature Guinea grass.

m. The feasibility of developing integrated weed control programs should be investigated.

(b) Update macadamia cost of production information.

Industry, CTAHR

(c) Investigate potential markets for macadamia nuts and update and refine the research on U.S. market potential of macadamia nuts.

CTAHR, Industry, Hawaii County Research and Development

(d) Conduct surveys to determine the characteristics of consumer demand more fully.

Industry, CTAHR

(e) Publish statistics on the macadamia products exported to foreign countries.

Industry and U.S. Department of Commerce

(NOTE: The industry must submit a request to the Department of Commerce for a SIC number (Standard Industrial Classification Number) so that the trade statistics will show macadamia nut data separate from the current category of other nuts.)

(f) Publish statistics on the macadamia products shipped to the U.S. Mainland.

Industry, DOA

O. Public Policies and Regulations

1. Analysis

a. The industry recently has been involved in a fight to deny a request from Malawi to include macadamia nuts within the Generalized System of Preferences. Approval of Malawi's petition would have made Malawi eligible for preferential duty-free treatment. The industry needs the continued cooperation of the Farm Bureau, government agencies, and Hawaii's Congressional Delegation to oppose requests such as the one from Malawi that would be damaging to Hawaii's macadamia nut industry.

b. The industry has a difficult time keeping up with changes in government regulations.

c. OSHA, EPA, etc., have many policies and regulations that affect the macadamia nut industry. The public policies and regulations that affect the industry should be compiled and updated periodically.

d. The industry is concerned that the importation of macadamia planting materials and nuts will bring serious macadamia pests to Hawaii.

Attachment B

(surplus) ; All figures in inches

6.1"/mo. = macadamia water needs

KOLE PEN MOISTURE DEFICIENCY

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | (0.8) | 2.1 | 3.8 | 3.0 | 3.1 | 5.0 | 3.1 | 2.3 | 4.6 | 2.0 | (3.9) | 4.7 | 31.[illegible] |
| 1957 | 4.1 | 4.6 | 5.7 | 4.1 | 3.9 | 4.1 | 4.5 | 3.2 | 4.1 | 2.8 | 4.5 | 5.0 | 50.[illegible] |
| 1958 | 5.9 | 5.1 | 3.1 | 5.9 | 3.2 | 3.3 | 2.7 | 1.3 | 4.1 | 3.8 | 4.9 | 4.5 | 47.[illegible] |
| 1959 | (3.4) | 4.3 | 5.8 | 3.9 | 3.3 | 4.5 | 3.2 | — | 4.5 | 5.0 | 0.2 | 5.3 | 40.[illegible] |
| 1960 | 6.0 | 5.0 | 3.2 | 4.6 | 3.6 | 4.4 | 4.9 | 4.1 | 3.1 | 4.1 | 4.4 | 2.5 | 49.[illegible] |
| 1961 | 3.1 | 5.6 | 3.0 | 2.7 | 4.3 | 3.9 | 3.2 | 4.6 | 4.4 | (0.6) | 2.6 | 4.1 | 41.[illegible] |
| 1962 | 2.6 | 5.5 | 3.5 | 3.0 | 2.8 | 4.9 | 1.6 | 5.1 | 3.2 | 4.8 | 5.6 | 4.7 | 47.[illegible] |
| 1963 | 1.1 | 5.9 | (1.2) | (0.2) | 0.2 | 3.7 | 0.4 | 3.7 | 2.1 | 4.4 | 5.0 | 4.9 | 31.[illegible] |
| 1964 | 3.3 | 5.2 | 2.0 | 2.4 | 0.9 | 3.1 | 3.5 | 4.1 | 4.2 | 3.7 | 3.0 | 2.6 | 38.[illegible] |
| 1965 | 0.2 | 3.0 | 3.9 | 2.5 | 2.4 | 3.6 | 3.0 | 2.3 | 2.0 | 4.1 | (0.3) | 6.0 | 33.[illegible] |
| 1966 | 4.3 | 2.9 | 3.7 | 4.6 | 4.8 | 4.5 | 5.0 | 3.3 | 2.5 | 5.1 | 4.5 | 5.5 | 51.[illegible] |
| 1967 | 4.2 | 4.8 | (0.7) | 2.4 | 3.9 | 1.6 | 1.8 | 4.6 | 2.6 | 4.8 | 2.4 | 4.5 | 37.[illegible] |
| 1968 | (0.1) | 3.3 | 3.7 | (2.5) | 5.5 | 5.0 | 4.5 | 2.8 | 1.7 | 4.9 | 4.4 | (2.0) | 35.[illegible] |
| 1969 | (0.2) | 4.9 | — | 5.3 | 3.6 | 5.7 | 4.1 | 4.7 | 5.0 | 5.2 | 5.1 | 6.0 | 49.6 |
| 1970 | 2.5 | 5.3 | 5.8 | 4.4 | 5.3 | 5.7 | 4.3 | 3.6 | 5.1 | 5.3 | 4.5 | 3.7 | 55.[illegible] |
| 1971 | (4.5) | 5.7 | 4.9 | 5.7 | 5.1 | 6.1 | 5.7 | 5.2 | 3.3 | 4.1 | 3.4 | 5.2 | 54.[illegible] |
| 1972 | 1.2 | 2.4 | 0.4 | 4.7 | 5.6 | 5.2 | 5.8 | 5.4 | 3.1 | 5.7 | 5.3 | 4.8 | 49.6 |
| 1973 | — | 6.1 | 6.1 | 5.4 | 4.1 | 4.9 | 5.8 | 5.1 | 2.2 | 4.2 | 1.5 | 0.1 | 45.5 |
| 1974 | 4.4 | 5.8 | 3.6 | 2.6 | 1.2 | 3.8 | 3.6 | 4.8 | 2.2 | 3.3 | 3.5 | 6.0 | 44.8 |
| 1975 | 3.6 | 1.7 | 3.8 | 3.7 | 4.5 | 4.7 | 4.6 | 5.5 | 4.1 | 5.0 | 4.0 | 6.1 | 51.3 |

1956–1975 Average = 44.[illegible]

## Attachment C

| Year | (in/d) Deficit: mean Annualized Daily Portion | (g/d) mean Annualized Daily Need per acre | (mgd) (ditto) per 1710ac | (mgd) (ditto) per 2110ac | At 80¢/1000g water costs for 2110 irrigated acres: per day ($) | per year (million $) |
|---|---|---|---|---|---|---|
| 1956 | 0.087 | 2362 | 4.04 | 4.98 | 3984 | 1.45 |
| 1957 | 0.138 | 3332 | 5.70 | 7.01 | 5608 | 2.05 |
| 1958 | 0.131 | 3163 | 5.41 | 6.65 | 5320 | 1.94 |
| 1959 | 0.110 | 2656 | 4.54 | 5.59 | 4472 | 1.63 |
| 1960 | 0.137 | 3719 | 6.36 | 7.82 | 6256 | 2.28 |
| 1961 | 0.114 | 3095 | 5.29 | 6.51 | 5208 | 1.90 |
| 1962 | 0.129 | 3502 | 5.99 | 7.37 | 5896 | 2.15 |
| 1963 | 0.086 | 2335 | 3.99 | 4.91 | 3928 | 1.43 |
| 1964 | 0.104 | 2823 | 4.83 | 5.94 | 4752 | 1.73 |
| 1965 | 0.092 | 2498 | 4.27 | 5.25 | 4200 | 1.53 |
| 1966 | 0.140 | 3801 | 6.50 | 7.99 | 6392 | 2.33 |
| 1967 | 0.102 | 2769 | 4.73 | 5.82 | 4656 | 1.70 |
| 1968 | 0.098 | 2660 | 4.55 | 5.60 | 4480 | 1.64 |
| 1969 | 0.136 | 3692 | 6.31 | 7.77 | 6216 | 2.27 |
| 1970 | 0.152 | 4126 | 7.06 | 8.68 | 6944 | 2.53 |
| 1971 | 0.149 | 4045 | 6.92 | 8.51 | 6808 | 2.48 |
| 1972 | 0.136 | 3672 | 6.31 | 7.77 | 6216 | 2.27 |
| 1973 | 0.125 | 3393 | 5.80 | 7.14 | 5712 | 2.08 |
| 1974 | 0.123 | 3339 | 5.71 | 7.02 | 5616 | 2.05 |
| 1975 | 0.141 | 3828 | 6.55 | 8.05 | 6440 | 2.35 |
| Average 1956-75 | 0.121 | 3285 | 5.62 | 6.95 | 5544 | 2.02 |

$$\frac{(\text{Annual Deficit in/yr})(27{,}147\ \text{gal/ac-in})(2110\ \text{ac})}{(365\ \text{days/yr})} = \text{total daily water needs (mgd)}$$

$$\frac{(44.3\ \text{in/yr})(27{,}147\ \text{g/ac-in})(2110\ \text{ac})}{(365\ \text{days/yr})} = 6.95\ \text{mgd} = \text{average total daily water needs}$$

$$(6.95\ \text{mgd})(365\ \text{day/yr})(\$0.80/1000\ \text{gal}) = \$2.03\ \text{million/yr}$$ for average irrigation water costs

Kazuo Ishihara AIA, Inc
Francis S Oda AIA Inc
Robert K L Wong AIA Inc
Norman G L Hong AIA Inc

3 April 1984

Rick Warshauer
P.O. Box 192
Volcano, HI 96785

SUBJECT: FARMS OF KAPUA ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Warshauer:

We have reviewed your letter of 23 March 1984 and offer the following response to your opening statements. Please note that the EIS included all letters received during the consultation period and their written responses. Any concerns expressed by a consulted party is available to the reader for review. Since your letter does not identify the specific issues from unidentified consulted parties, which you feel have not been adequately addressed in our responses, it is impossible for us to satisfactorily respond to your generalizations in your first paragraph. Specific responses to your comments follow.

1. As you are well aware, Frank S. Scott, Jr. is a member of the Macadamia Nut Industry Analysis group and is responsible for much of the narrative on marketing and economic viability in the Macadamia Nut Industry Analysis Number 2 (MIA). Scott did not consider it appropriate to include the MIA as an appendix to his report since the MIA is simply considered a planning document for identifying and prioritizing research needs. The document attempts to identify the current status of problems based on findings, observations and options. Thus, it is a planning document and action plan and should not be considered as a research report.

2. The water requirements for macadamias as indicated in MIA page 7 are not based on research findings, but constitute suggested possible water needs. No conclusive research has been released publicly on the water requirements for macadamias. HITAHR (Hawaii Institute of Tropical Agriculture and Human Resoures) had established a project on water requirements via Mac Farms, but this project is now under the jurisdiction of Mac Farms. The duration of the research has been too short to provide conclusive evidence on the water requirements for macadamia.

The statement that a'a soil requires 80 - 100 inches of rainfall probably emanated from Hilo and does not relate to Kona (MIA p. 7 B.1.a.). Most Kona macadamia orchards are in the 40 to 60 inch rainfall zone. Scott has surveyed 120 macadamia farms, most of which were in Kona, during the past 4 years. Scott has found that farmers with good cultivation practices obtain yields of up to 7,500 pounds per acre annually in the rainfall zone specified above.

Orchard requirements for drip irrigation are much less than for crops requiring complete coverage of the land area and for heavy water users such as bananas. The irrigation requirement suggested in MIA p. 7 B.1.c. assumes complete coverage of the grounds such as for vegetable production, and is not based on conclusive research on macadamia requirements.

Based on research on water requirements conducted for avocados in California and for macadamias at C. Brewer's Ka'u orchard, Scott has determined that a mature macadamia orchard requires 4,000 gallons of water per day under full dependance on drip irrigation. Scott estimates that a mature macadamia tree at 64 trees per acre requires an irrigation radius of 42 feet. This amounts to approximately 15 times the 30 gallon weekly requirements indicated at Ka'u orchard for young trees requiring an estimated 3 1/2 foot radius. This converts to a weekly requirement of 450 gallons per mature tree or 28,800 gallons per acre at 64 trees per acre or approximately 4,000 gallons per acre per day. Avocado trees in the hot desert area between San Diego and Riverside, have been found to require a mean of 0.142 acre inches of water per day with full dependance of irrigation during May to September. The 0.142 acre inch daily requirement converts to 0.994 per acre inches per week or 3905 gallons per acre per day per day. This compares favorably with Scott's estimate of 4,000 gallon per acre day at Kapua.

Scott maintains that he has made a concerted effort to approximate irrigation water requirements for Farms of Kapua as a basis for the EIS statement. Pending approval of zoning for agriculture, field tests would be initiated to determine water requirements more conclusively. Scott considers his preliminary estimates sufficient for the rezoning request.

As noted in our response to the Sierra Club Moku Loa Group consultation letter, Scott notes that the Kole Pen mean of 27.5 inches is more appropriate than the use of the median of 25.7 for determining supplemental irrigation requirements in budget analyses. John F. Mink, consulting hydrologist, concurs with this.





3. Please refer to item 2. The irrigation requirement figure cited from the MIA report is not appropriate for the petition area.

4. This comment is based on the assumptions made in items 2 and 3 of your letter and is therefore not applicable.

5. Scott disagrees with the contention that macadamia are not viable for Farms of Kapua because of the cost of irrigation. This disadvantage simply converts to a lower value of the orchard and the orchard land. The law of comparative advantage states that producing areas with lesser absolute advantages should produce those crops for which the least disadvantage exists. Macadamias fall into this category for Farms of Kapua. Another consideration is that the climate in the Farms of Kapua area zone is more ideal for macadamia production than for some areas with heavier rainfall, but with more potential for problems with disease, insects, weeds, and wind. Thus the greater cost of irrigation would likely to be partially offset by other advantages over other areas with heavier rainfall. The crucial consideration is whether macadamias are projected to be economically viable at Farms of Kapua at projected input-output prices. This has been determined by Scott to be positive.

6. The koa seedworm has been identified as a minor, not major pest of macadamias. The koa seedworm has been identified as a problem only by one, or at most, a few producers. As stated in MIA, biological control agents already prevail and probably provide a fair amount of control. Furthermore, all koa would be controlled in the macadamia orchards.

7. Scientists at the University of Hawaii, who are specialists in herbicide use, have indicated to Scott that the herbicides proposed are absorbed by the weeds and are non-residual. They indicate no evidence that the chemicals recommended having even polluted streams or shorelines in Hawaii.

8. Please refer to items 5, 6 and 7 of this letter. We disagree with your assertion that these conditions are expected at the petition area and will influence the economic viability of proposed activities.

9. The Department of Labor and Industrial Relations, State of Hawaii gives the average unemployment rate for the South Kona District (Census Tract 213.00) in 1983 at 7.9%, or an average of 150 persons unemployed. The County of Hawaii Department of Research and Development has written that: "The Farms of Kapua project would increase employment oppportunities in South Kona, and thus provide some relief from the district's unemployment situation." This letter will be included in APPENDIX J of the revised EIS.

10. We share your concern regarding the need to provide an accurate base of information on which to evaluate land use decisions. Please note that the petitoner requested the Land Use Commission to withdraw a previous Negative Declaration and prepared the EIS in accordance with Chapter 343, Hawaii Revised Statutes.

Very truly yours,

Francis S. Oda, AIA

cc: Land Use Commission