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BENJAMIN J. CAYETANO
Governor of Hawaii

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OFC. OF ENVIRONMENTAL
QUALITY CONTROL

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

P. O. Box 621
Honolulu, Hawaii 96809

JUN 15 1995

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MICHAEL D. WILSON
Board of Land and Natural Resources

Deputy Director
GILBERT COLOMA-AGARAN

Aquaculture Development
Aquatic Resources
Boating and Ocean Recreation
Bureau of Conveyances
Conservation and Environmental Affairs
Conservation and Resources Enforcement
Forestry and Wildlife
Historic Preservation
Land Management
State Parks
Water and Land Development

REF:OCEA:RS

In reply, please refer
to FILE NO.: HA-2092A

MEMORANDUM

TO: Mr. Gary Gill, Director
Office of Environmental Quality Control

FROM: Michael D. Wilson, Chairperson Gilbert S. Coloma-Agaran
Board of Land and Natural Resources

SUBJECT: Document for Publication in the OEQC Bulletin Final Environmental Assessment for Conservation District Use Application HA-2092A for Amendment 1 - Two Accessory Shade Houses, Amendment 2 - Anchialine Pond Management Plan, and Amendment 3- Battery Storage Facility

The above mentioned proposed use requires an environmental assessment in accordance with Title 11, Chapter 200 of the Environmental Impact Statement Administrative Rules. The Department has determined that a Negative Declaration should be issued based upon the final environmental assessment.

Please feel free to call me or Roy Schaefer of our Office of Conservation and Environmental Affairs, at 587-0377, if you have any questions.

6/22 Dean Yamamoto
LMTC re: comment letters
6/23 Roy Schaefer -
on rec 1 month. asked
Charlene to check. She
will c/B

44

1995-07-08-~~OA~~HI-FEA-Bakken Conservation District Use Permit

JUL 8 1995

Rec'd 6/16/95

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C. FREDERICK SCHUTTE
(1921-1988)

WRITER'S DIRECT DIAL NUMBER:

April 26, 1995

RECEIVED
'95 APR 26 PM 3:30
DLNR
OCEA

VIA HAND DELIVERY

Office of Environmental Quality Control
220 South King Street, Suite 400
Honolulu, Hawaii 96813

Attention: Jayan/Nancy

Re: Earl E. Bakken and Doris J. Bakken
TMK No. (3) 7-1-2-3
Environmental Assessment for CDUA Nos. HA-2092-A1, HA-2092 A2 and HA-2092 A3

Gentlemen:

Pursuant to your request, we have consolidated the three Environmental Assessments originally attached to the above-mentioned CDUAs into one Environmental Assessment. We are enclosing four (4) copies of the consolidated Environmental Assessment. We are also enclosing four (4) copies of the three CDUAs previously submitted. If you should have any questions, please do not hesitate to call me.

Very truly yours,

Dean T. Yamamoto
for
CADES SCHUTTE FLEMING & WRIGHT

521-9343

Enclosures

cc: Mr. Roy Schaeffer, DLNR (w/copy of EA)
Planning Department, County of Hawaii (w/copy of EA)
Roy A. Vitousek III, Esq. (w/copy of EA)

BEFORE THE BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

In the Matter of the Conservation District Use Application of EARL E. BAKKEN and DORIS J. BAKKEN Individually and as Trustees of THE BAKKEN RESIDENCE TRUST AGREEMENT. To Amend the Conservation District Use Permit issued for Kiholo Bay, North Kona, Hawaii, State of Hawaii, Tax Map Key No.: (3) 7-1-2-3	)

Final

ENVIRONMENTAL ASSESSMENT
FOR CDUA NOS. HA-2092 A1, HA-2092 A2 & HA-2092 A3

EXHIBITS 1 THROUGH 9

CADES SCHUTTE FLEMING & WRIGHT
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Telephone: 329-5811

Attorneys for Applicants
Earl E. and Doris J. Bakken Individually and
Trustees of the Bakken Residence Trust

Final ENVIRONMENTAL ASSESSMENT

(1) Identification of applicant or proposing agency:

Earl E. and Doris J. Bakken individually and as Trustees of the Bakken Residence Trust Agreement are the applicants. The Bakken Residence Trust is the fee owner of the parcel of land identified by TMK No.: (3) 7-1-2-3, which is located at Kiholo, North Kona, Hawaii. They are applying for the following amendment to CDUA HA-11/6/87-2092:

(a) To construct two shade houses;

(b) To institute and implement a pond management program for the anchialine ponds including the placement of sterile grass carp and sterile awa to reduce the algae growth; and

(c) To initiate the process of supplementing their power system at their property at Kiholo Bay through the use of a battery inverter and heat recovery system.

(2) Identification of approving agency, if applicable:

Department of Land and Natural Resources is the approving agency for the CDUA.

(3) Identification of agencies consulted in making assessment:

Department of Land and Natural Resources, State Historic Preservation Division and Na Ala Hele, the Department of Health, and a submittal of a Special Management Area Use Permit Assessment to the County of Hawaii Planning Department.

The project is within the Special Management Area, but not within the shoreline setback.

(4) General description of the action's technical, economic, social, and environmental characteristics:

The proposed action will not affect the economic, social or environmental characteristics of the subject area.

Two Shade Houses

The applicants propose the construction of two shade houses, comprised of a wooden frame and shade cloth, of 20' x 32' x 15' and 10' x 15' x 15', for the growth and maintenance of outdoor landscaping and interior plants.

The shade houses will be constructed in a heavily vegetated area. The shade houses will not affect the view plane from either mauka or makai.

Pond Management Program

The applicants created a series of man-made anchialine ponds surrounding their single family residence, which are used as a source of raw water supply for their on-site reverse osmosis system. This system provides the applicants with their potable water source.

The Board approved the development of the pond system, subject to the following conditions:

1. That prior to the development of additional ponds, all nonnative fauna should be eliminated from the existing anchialine pond in an acceptable manner, subject to approval from the Division of Aquatic Resources;

2. That the existing pond should be left intact;

3. That each pond should be distinct, with no artificial means of interconnection;

4. That the applicant affirm that no artificial "seeding" of flora and fauna be undertaken. The ponds are to be left to naturally assemble a habitat inherent in a typical anchialine pond;

5. That the ponds should have a depth at mean low level tide of no more than twenty (20) inches; and

6. That the applicant inform the Office of Conservation and Environmental Affairs and the Division of Aquatic Resources should any contamination of the ponds occur.

Prior to the development of the property, there was one anchialine pond present, which was shallow, with water being restricted to one small low-lying area during low tides and badly overgrown with the encroachment of surrounding vegetation. The substratum was mud. This pond was apparently created by a previous owner of the property and was not inventoried by Maciolek and Brock (1974). In the late '80s, the biota of the pond was dominated by koi and mosquito fish. Mud and these exotic fish were eliminated from this pond. (See description of Pond 4-Brock report, Exhibit 6.)

The ponds located on the subject property provide habitat for native anchialine species; the exception to this is in Pond 2, where the predatory aholehole have

driven the usual crustacean fauna from the lighted portions of the pond. (The aholehole colonized the pond by natural means.) This pond is also located in more sandy substrata which may affect the movement of crustacea.

No unusual anchialine species were found in any of the water features on the subject property and all of the species encountered are common in West Hawaii anchialine biotope. (See Brock-Exhibit 6.)

Following the construction of the ponds, a green alga became established and created a near-continuous mat across the surface of two ponds. (See Exhibit 7.) The herbivorous native shrimp Halocardinia ruba appeared in both Ponds 1 and 2 with greatest numbers in Pond 1, but it did not control the algae in either pond. The applicants released two species, grass carp and milkfish [awa], which were sterilized prior to their release in these ponds and because they are herbivorous to control the algae. These fish were obtained under a permit from the State of Hawaii Department of Aquaculture. (See Exhibit 8.)

Dr. Richard Brock evaluated the ponds and has prepared a pond management plan for the anchialine ponds. (See Exhibit 6.)

Battery Inverter System/Heat Recovery System

The proposed structure will be built over existing water tanks and supported on six (6) new concrete columns replacing those which currently support the roof structure built above the two existing water tanks. Naupaka which currently grows in this area will, within a short period of time, screen the new structure, therefore not affecting the view plane that runs makai-mauka. The new structure will be directly makai of the existing garage/powerhouse and will follow the same architectural lines. Excavation will take place in the filled area surrounding the existing concrete columns in order to replace these columns with new ones of higher strength and increase the bearing capacity of the footings.

The solar photovoltaic panels for the solar electric system will be mounted on the flat roof of the powerhouse. The mounting angle proposed is nearly horizontal and the panels will be barely visible from the ground as there is a full parapet wall around the perimeter of the flat roof area.

A new conduit will be run between the new equipment room and the new inverter located in the existing garage.

This conduit will be routed overhead along the support structure for the solar panels and require no excavation. It will not be visible away from the powerhouse. Three additional electrical conduits will also be run between the powerhouse and the residence. These conduits will follow the same path proposed for the heat recovery piping described below.

One of the goals of the project is thermal energy recovery. Applicants propose to recover substantial waste heat from the generator water jacket, which will be used to serve heating needs at the residence. The most straightforward use of this recovered heat is to heat the swimming pool. Initial calculations indicate that thermal energy recovered from the generator operation will be sufficient to completely displace the current method of heating the pool.

Insulated supply and return piping will be run between the garage/powerhouse and the house on the surface of the ground. Stairways leading from the garage/powerhouse to the lower level of the property will be restructured to accommodate the crossing of the pipes. Once through this structure, the pipes will run on the surface through dense landscaped vegetation, crossing above the anchialine pond. A chasing will be built to conceal the pipe where it crosses above the pond on the southwest side of the house before reentering dense landscape vegetation adjacent to the house.

The major on-site construction tasks required to complete this battery/inverter system are the construction of the new utility space as an addition to the existing powerhouse, the installation and connection of the DC-to-AC inverter, the installation and connection of the battery storage bank, the installation and connection of the rooftop solar modules and the installation of either a solar-operated composting toilet (Biolet with NSF approval) or a standard toilet and laundry tub. The waste pipes for the standard toilet would run along side the heat recovery pipes and tie into the existing waste lines under the guest wing of the house.

(5) Summary description of the affected environment, including suitable and adequate location and site maps:

Two Shade Houses

The proposed location for the shade houses, is an area surrounded by vegetative growth. The shade cloth will help to minimize the visual impact of the shade houses. Additional landscaping around the shade houses, will further reduce the visual impact of the structure. The shade houses will be used for growing and maintaining

native and rotational plants for the residence and for landscaping. (See Exhibits 3 & 4.)

Pond Management Program

The pond management program is a means in which the integrity of the anchialine ponds can be maintained with appropriate checks and balances and supervision by Dr. Richard Brock.

Battery Inverter System/Heat Recovery System

The proposed battery storage building and related improvements will be located on the applicants' private property at Kiholo Bay, North Kona, Hawaii. (See Exhibits 1 & 2.) The property is developed as a single-family residence as approved by the Board of Land and Natural Resources on April 22, 1988 (HA-11/6/87-2092).

The proposed facility will be located on fill land adjacent to the existing garage. The site is currently utilized for water tanks and the proposed structure will be built above the water tanks in place of the existing wood roof structure. There is a long, narrow man-made pond on the west and northwest sides of the site, landscaped rock and soil fill on the north and south sides and the existing garage on the east side.

The applicants' property is surrounded by State-owned lands except where it borders on another private property on the north side. The portion of the State property makai of the applicants' property consists of a pebble and sand area with a grove of mature coconut palm trees and the pebble and sand shoreline area. Mauka and south of the applicants' property is an exposure of pahoehoe lava with varying densities of kiawe and other vegetation typical of the arid environment of the Kekaha district.

The building that is proposed to house the battery inverter system will replace the existing wood roof structure which currently covers the water tanks. This new structure will be supported on six (6) new concrete columns replacing the six (6) existing columns which presently support the existing roof structure. Excavation will take place in the fill immediately surrounding the existing concrete columns in order to replace these existing columns and increase the bearing capacity of the existing footings. All excavation will take place in the fill. A buffer zone will be created (in accordance with the pond management plan developed by Dr. Brock) around the anchialine ponds to avoid construction debris falling into the ponds and to maintain the integrity of the ponds. The battery

storage building will be constructed makai of the existing garage and powerhouse. The proposed building follows the general architectural design of the existing garage. With the growth of naupaka (see Exhibit 9), the visual impact from makai of the property will be negligible. The new addition will not be seen from mauka of the property since it will be obscured by the present garage. (See Exhibit 9.)

(6) Identification and summary of major impacts and alternative considered, if any:

Two Shade Houses

The proposed shade houses are designed as uninhabitable accessory buildings. The walls of the shade houses are designed to be of shade cloth that will be tied to the steel framework (prefabricated trusses). The shade cloth walls are meant to be "breakaway walls" when subjected to abnormally high tides or wave action. The steel structure is a prefabricated kit made by Conley's Manufacturing and Sales. It consists of six (6) steel arches. Each end of each arch shall be inserted into a 6" diameter PVC sleeve that is imbedded into the ground two (2) feet. (See Exhibit 5.) (The ground in question is comprised of fill, which was previously authorized by the BLNR.) Sand will be tamped into the void to secure the arch.

Base course will be utilized for the floor of the shade houses. The impacted area will be approximately 640 square feet (20' x 32' x 15') and 150 square feet (10' x 15' x 15').

The proposed location of the shade houses is to the north of the residence and north of the leach field in a heavily vegetated area. (See Exhibit 4.)

Utilizing on site shade houses will assist in the acclimation of rotational house plants and assist in the growth of native plants which the applicants intend to plant on their property.

The proposal consists exclusively of utilization of private property. The proposal will not alter the coastline. The proposed will not have any negative impact the coastal ecology. The proposal will not result in the loss of valuable natural, cultural, or recreational resources of this shoreline property or coastal area. Based on the aforementioned, it is clear that the impacts on coastal ecological systems will be negligible and are not anticipated to be significantly adverse.

Noise and dust released in the atmosphere are common occurrences associated with construction; in particular, noise will be generated by machinery utilized in construction. Actions to mitigate noise caused by equipment involve the proper functioning of the equipment and the attachment of noise-muffling devices if required. Also restricting the operation of noise-emitting equipment to normal working (daytime) hours should prevent the bulk of airborne noise and vibration disturbances to nearby residents and beach users. Dust and other airborne particulate generated by construction activities will be minimized by applications of sprinkled water and approved liquids which prevent wind-generated dust and particulate pollution to be released within the atmosphere.

Construction activities are not expected to create disturbances to the quality or balance of the offshore waters' ecosystem. No alteration of the shoreline is envisioned; protective measures to minimize and prevent siltation will be implemented.

Based on the size of the proposed project, impacts, if any, will be minimal. Construction will be occurring on private property and the public will not be inconvenienced. It is expected that all probable short-term, adverse impacts brought on by the construction are either insignificant or relatively minor and appear controllable by incorporating acceptable mitigative measures and actions.

Short-term impacts, beneficial and adverse, would generally result from construction-related activities. These impacts are of short duration and should last no longer than the duration of the construction phase, which is relatively short considering the simplicity of the design of the shade houses.

Pond Management Program

The major impact of approving the anchialine pond management program designed by Dr. Richard Brock is to minimize the potential for negative impacts to resident aquatic biota.

The no-action option is not feasible in as much as the anchialine ponds require "management" in order to preserve the resident aquatic biota and improve the anchialine features of the ponds.

Battery Inverter System/Heat Recovery System

Several alternatives to the proposed action were considered including storing the batteries under the house.

This would require the construction of a slab under the guest wing of the house with a chain link fence built around the slab for safety. Conduit would have to be under the existing driveway and in the fill surrounding the driveway in a depth of approximately 12". Options reviewed either had the conduit then crossing over the ponds or through the ponds.

Although considered, locating the batteries under the house and running conduit from the house to the garage/ power house was more costly and would require excavation in the fill surrounding the ponds.

The proposed battery inverter system and accompanying powerhouse and heat recovery system will not remove or impose restrictions on existing access routes to the shoreline or similar shoreline recreational areas. The proposal consists exclusively of utilization of private property. The proposal will not alter the coastline. The proposed will not impact the coastal ecology. The proposal will not result in the loss of valuable natural, cultural, or recreational resources of this shoreline property or coastal area. Based on the aforementioned, it is clear that the impacts on coastal ecological systems will be negligible and are not anticipated to be significantly adverse.

Noise and dust released in the atmosphere are common occurrences associated with construction; in particular, noise will be generated by machinery utilized in construction. Actions to mitigate noise caused by equipment involve the proper functioning of the equipment and the attachment of noise-muffling devices if required. Also restricting the operation of noise-emitting equipment to normal working (daytime) hours should prevent the bulk of airborne noise and vibration disturbances to nearby residents and beach users. Dust and other airborne particulate generated by construction activities will be minimized by applications of sprinkled water and approved liquids which prevent wind-generated dust and particulate pollution to be released within the atmosphere.

Construction activities are not expected to create disturbances to the quality or balance of the offshore waters' ecosystem. No alteration of the shoreline is envisioned; protective measures to minimize and prevent siltation will be implemented.

Based on the size of the proposed project, impacts, if any, will be minimal. Construction will be occurring on private property and the public will not be inconvenienced. It is expected that all probable short-term,

adverse impacts brought on by the construction are either insignificant or relatively minor and appear controllable by incorporating acceptable mitigative measures and actions.

Short-term impacts, beneficial and adverse, would generally result from construction-related activities. These impacts are of short duration and should last no longer than the duration of the construction phase.

The no-action alternative was considered but rejected in view of the fact that the applicants' goal is to reduce the amount of liquefied petroleum utilized and their desire to utilize natural energy.

(7) Proposed mitigation measures, if any:

Two Shade Houses and Battery Inverter System/Heat Recovery System

Noise and dust released in the atmosphere are common occurrences associated with any construction although due to the nature of the proposed work, very limited machinery will be utilized; in particular, noise will be generated by machinery utilized in construction. Actions to mitigate noise caused by equipment involve the proper functioning of the equipment and the attachment of noise-muffling devices if required. Also restricting the operation of noise-emitting equipment to normal working (daytime) hours should prevent the bulk of airborne noise and vibration disturbances to nearby residents and beach users. Dust and other airborne particulate generated by construction activities will be minimized by applications of sprinkled water and approved liquids which prevent wind-generated dust and particulate pollution to be released within the atmosphere.

Construction activities are not expected to create disturbances to the quality or balance of the offshore waters' ecosystem. No alteration of the shoreline is envisioned; protective measures to minimize and prevent siltation will be implemented.

The use of dark green shade cloth and landscaping the area around the shade houses will minimize any visual impact. The shade houses are designed to be constructed in an area that is not visible from makai of the property.

Pond Management Program

None, the applicant proposes adopting the Anchialine Pond Management Plan prepared by Dr. Richard Brock.

(8) Determination:

Applicants submit that an Environmental Assessment is not required.

§11-200-8 Exempt classes of action states that Chapter 343, Hawaii Revised Statutes, states that a list of classes of actions shall be drawn up which, because they will probably have minimal of no significant effect on the environment, shall generally be exempted from the preparation of an environmental assessment. Applicants' proposal is an action that is exempt.

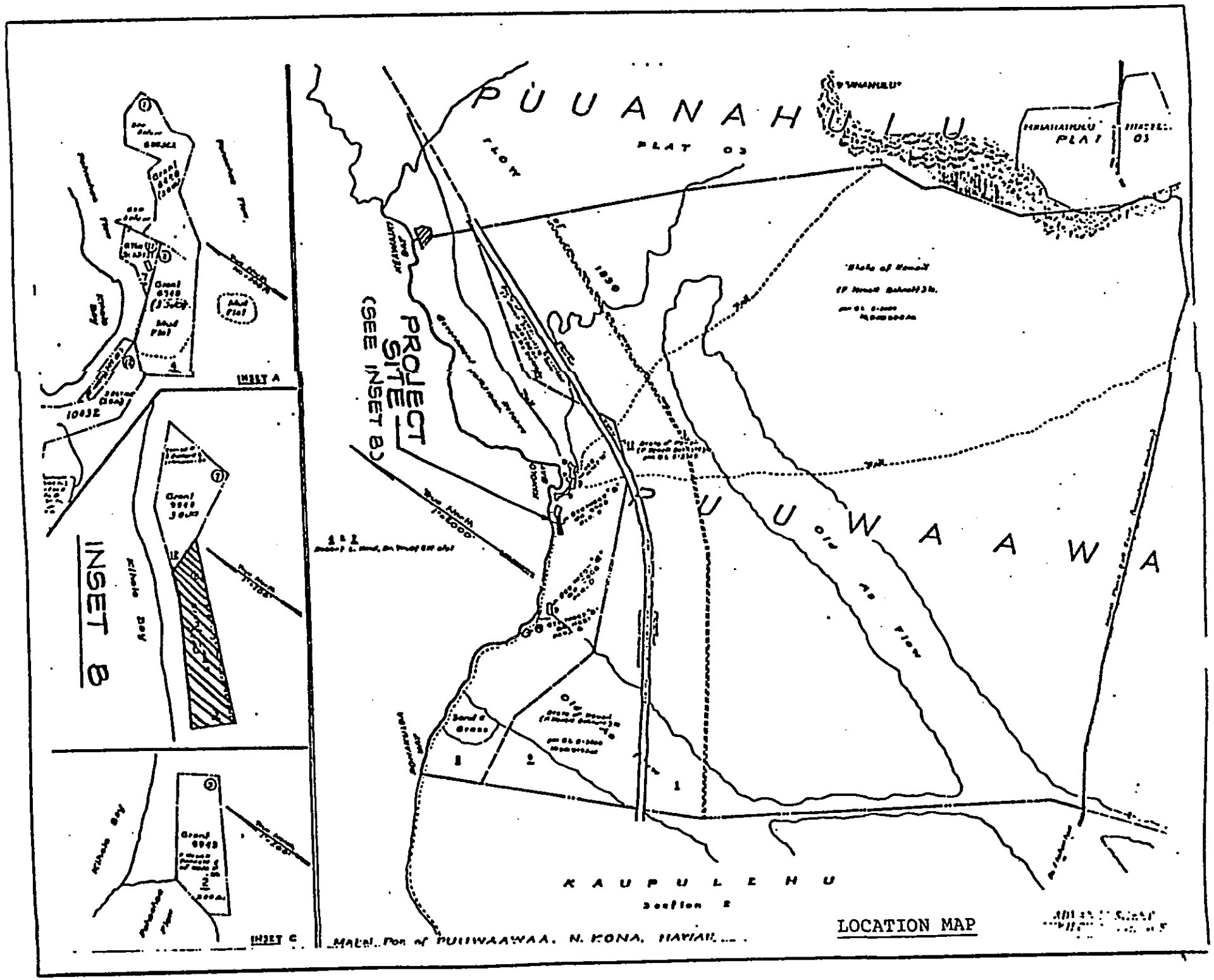
Following receipt of the CDUA for the applicants' property to construct a single family residence with amenities at Kiholo Bay, on TMK: 7-1-2: 3, then Chairperson William Paty informed the agents of the applicant on December 2, 1987 that:

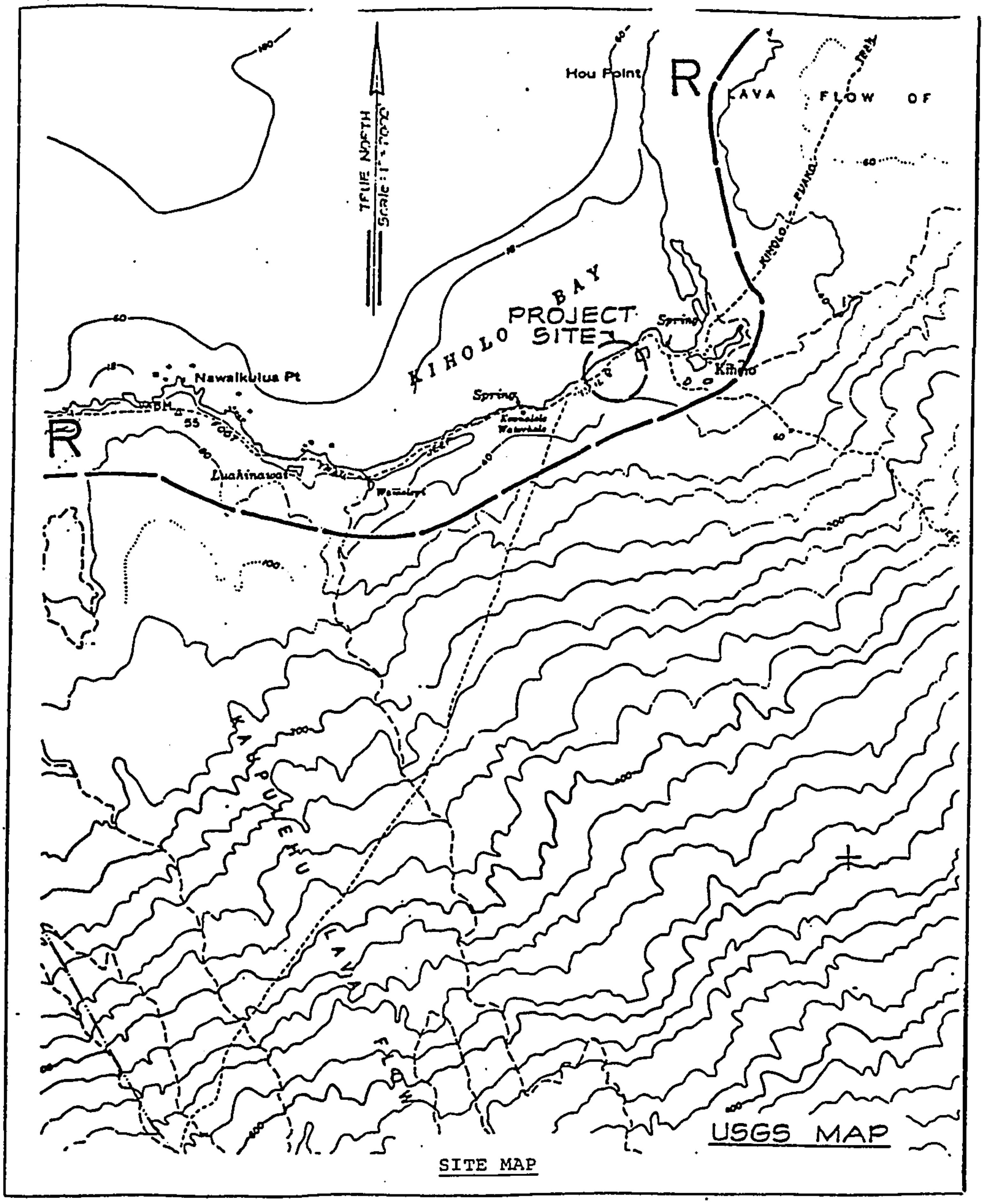
> ...In conformance with Title 11, Chapter 200, of the Administrative Rules, a negative declaration was determined for the proposed action.

In light of the fact that the proposed uses are minor appurtenant structures and an improvement to the existing family residence (shade houses) or the proposed uses have minimal or no significant effect on the environment, a negative declaration should apply.

SCHEDULE OF EXHIBITS

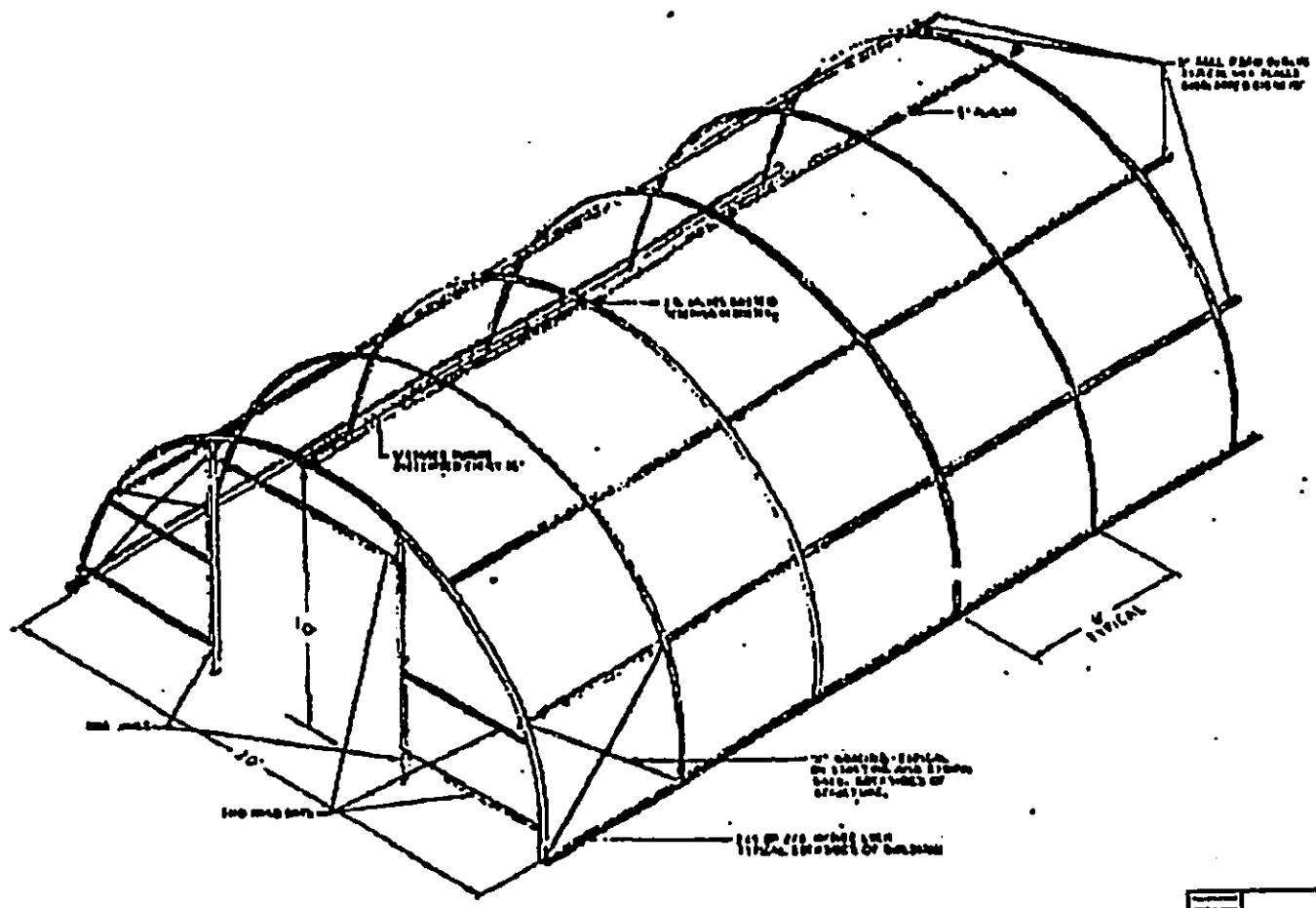
EXHIBIT 1	Location Map
EXHIBIT 2	Site Map
EXHIBIT 3	Elevations for Shade Houses
EXHIBIT 4	Site Plan for Shade Houses
EXHIBIT 5	Section of Prefabricated Shade Houses
EXHIBIT 6	Dr. Brock's Anchialine Pool Management Plan
EXHIBIT 7	Photographs of Ponds
EXHIBIT 8	Permit from Agriculture Department, State of Hawaii
EXHIBIT 9	Photographs of Proposed Battery Storage Building and Proposed Building Elevations


PUUANAHULU
PLAT 03
PROJECT SITE
(SEE INSET B)
INSET A
INSET B
INSET C
KAUPULEHU
Section 2
LOCATION MAP



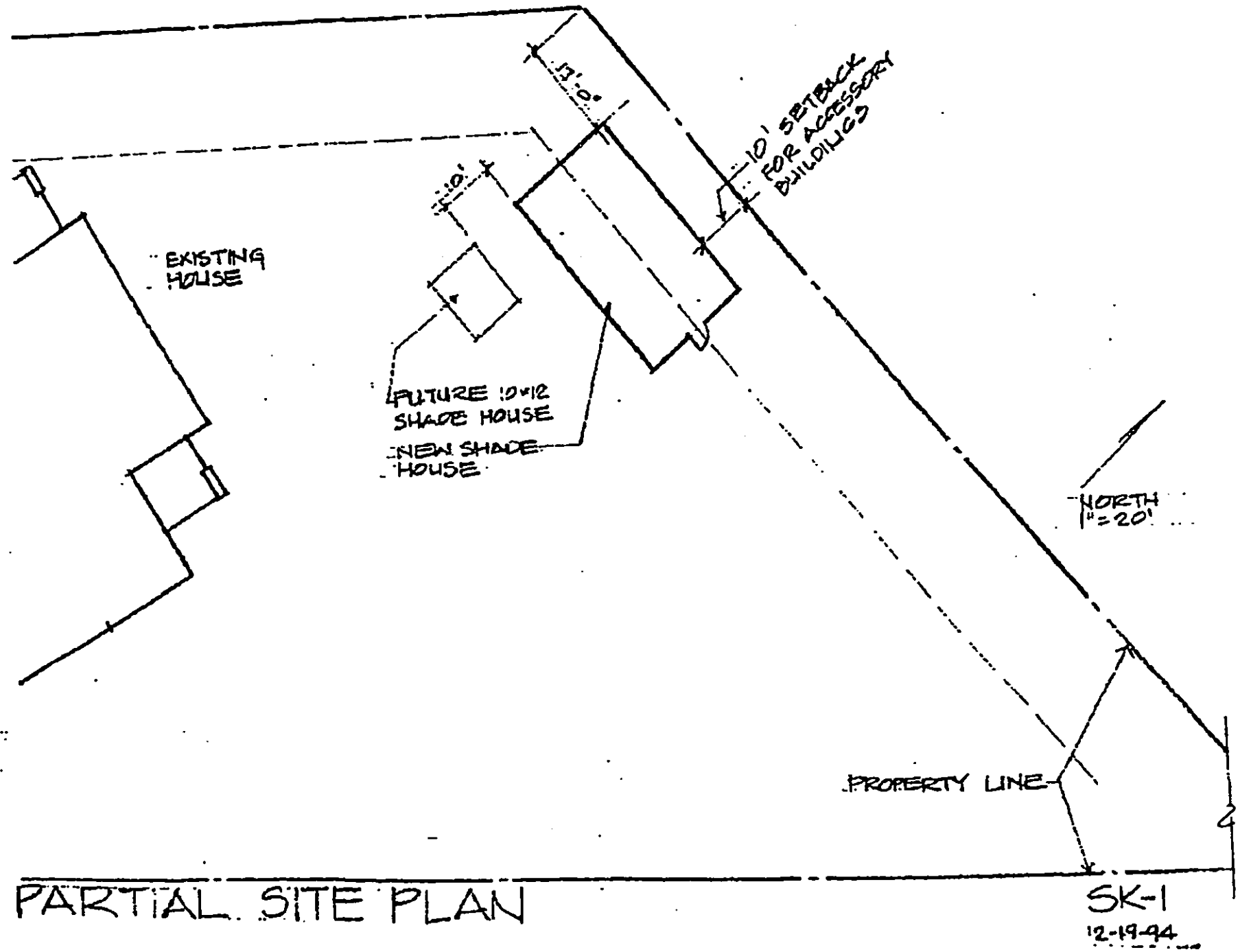
Hou Point
LAVA FLOW OF
KIHOLO-PUAKO TRAIL
TRUE NORTH
KIHOLO BAY
PROJECT SITE
Spring
Kiholo
Nawaikulua Pt
Spring
Luahinewai
Kaupulehu Lava Flow
R
R
USGS MAP

SITE MAP



SHADEHOUSE
ELEVATIONS

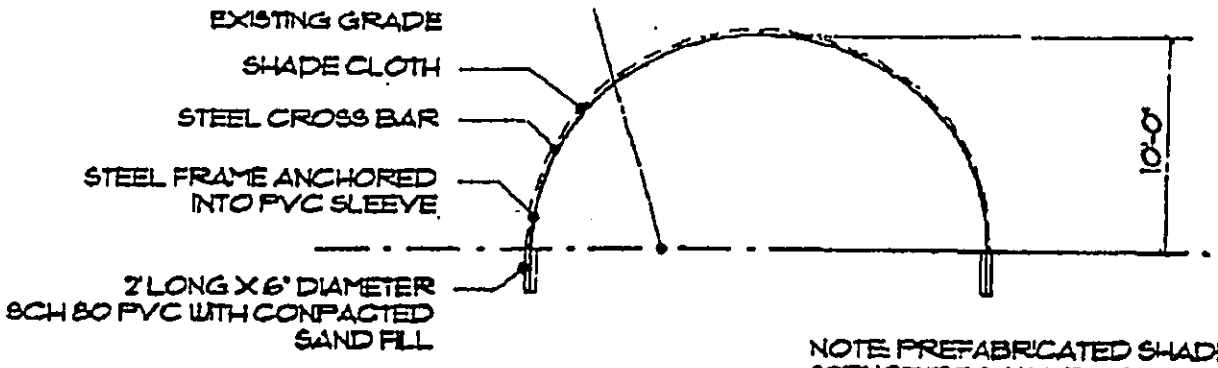
STRUCTURAL MASTER



PARTIAL SITE PLAN

SK-1

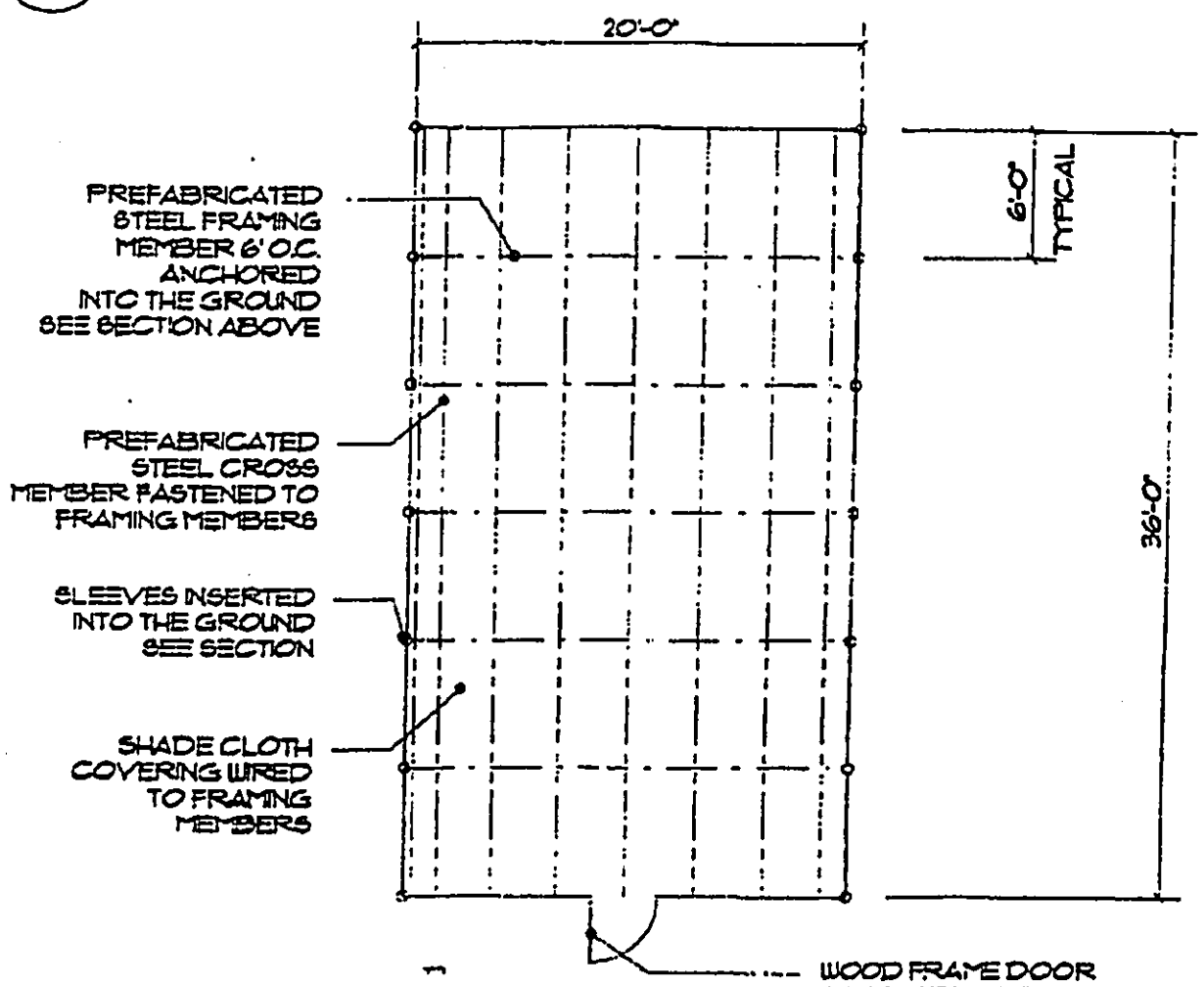
12-19-94



NOTE: PREFABRICATED SHADE HOUSE STRUCTURE SHALL BE 20 X 36 CONLEY KIT AS SUPPLIED BY GREEN HOUSE SPECIALTISTS

A SECTION

1/8" = 1'-0"



B PLAN

1/8" = 1'-0"

SHADE HOUSE

BAKKEN RESIDENCE
CLEMSON LAM, ARCHITECT, AIA

SK-1

12-14-94

ANCHIALINE POOL MANAGEMENT PLAN

KIHOLO BAY, NORTH KONA, HAWAII

TMK: (3) 7-1-2:3

Prepared For:

Cades Schutte Fleming & Wright
75-150 Hualalai Road, Suite B-303
Kailua-Kona, Hawaii 96740

By:

Richard E. Brock, Ph.D.
Environmental Assessment Co.
1820 Kihi Street
Honlulu, Hawaii 96821

July 1994

EAC Rept. No. 94-03

1.1 INTRODUCTION

A. Purpose

With any coastal development there exists the potential for negative impacts to occur to resident aquatic biota. Hawaii Revised Statues, Chapter 205-A as well as the County of Hawaii Special Management Area Rules and Regulations recognize the potential for impact to occur to aquatic species with coastal development and have been enacted to preserve, protect and where possible, to restore the natural resources of coastal zone areas. These regulations are the basis for which the County of Hawaii and the Hawaii State Department of Land and Natural Resources is requiring developers in the coastal zone area to institute programs to insure the protection of aquatic species present on or adjacent to their project sites.

A private residence situated on 3 acres at Kiholo Bay, North Kona, Hawaii (TMK 3/7-1-2:03) was constructed in 1989-1990. Part of the landscaping for this residence called for the development of water features. Accordingly, two anchialine pools and a well (for fire fighting purposes) were developed.

A preliminary inventory of the aquatic resources in these water features carried out in December 1993 and April 1994 noted several species characteristic of the Hawaiian anchialine fauna. Anchialine pools are a unique ecological resource being restricted to highly porous substrates such as recent lavas or limestone adjacent to the sea. These pools are defined as having measurable salinities, undergo tidal fluctuations yet have no surface connections with the sea. They typically harbor a characteristic assemblage of organisms, some of which are not known from any other habitat.

Anchialine pools have been reported from the Red Sea, on islands situated in the tropic Indian, Pacific and Atlantic Oceans. Locations with the most numerous anchialine sites are in Fiji, the Ryukyus and Hawaii. In terms of a statewide resource, Hawaii Island has the largest number of anchialine pools. The majority of these ponds occur along the West Hawaii coast from Kawaihae to Kailua-Kona; about 420 pools have been surveyed in this area. A conservative estimate places the total number of anchialine pools on Hawaii Island at about 600-650 ponds (Brock 1985) and statewide the number probably does not exceed 750 pools. Three preserves exist protecting portions of this resource: Ahihi-Kinau, Maui and Manūka, Hawaii under the State Natural Area Reserve System as well as the Waikoloa Anchialine Pond Preservation Area (or WAPPA) under University of Hawaii management.

The presence of anchialine species on the subject property

and the interest of the owners in insuring that these resources are adequately protected has prompted the development of an anchialine pool management plan, thus this document has been written to fulfill this need.

B. Background Information

Because of recent coastal development along the Kona shoreline, anchialine resources have become a focus of attention by permit agencies, conservationists and the general public. As noted above, anchialine pools harbor a distinct assemblage of organisms some of which are found nowhere else. Anchialine pool organisms fall into two classes, i.e., epigeal and hypogeal species (sensu Maciolek 1983). The epigeal fauna is comprised of species that require the well-illuminated (sunlit) part of the anchialine system. Most of these species are found in other Hawaiian habitats albeit individuals from anchialine systems frequently show ecotype (morphological) variations. The hypogeal organisms occur not only in the illuminated part of the system but also in the interconnected watertable below. These species are primarily decapod crustaceans, some of which are known only from the anchialine habitat.

The Hawaiian anchialine pool ecosystem is dominated by a characteristic assemblage of organisms including crustaceans (shrimps and amphipods), fishes, mollusks, a hydroid, sponges, polychaetes, tunicates, aquatic insects, algae and aquatic macrophytes. Most striking are a number of red-pigmented caridean shrimp species. These shrimps, as well as many other co-occurring faunal components, utilize the anchialine pond habitat and the rock interstices leading to the underlying brackish watertable. Depending on pond depth, many of the shrimp species display a tidally linked migration, emerging from the rock interstices with the incoming tide to feed in the pond, and later returning via the interstices to the subterranean labyrinth with the falling tide (Fricke and Fricke 1979). The most characteristic species in Hawaiian anchialine systems is the red-pigmented caridean shrimp known as opae'ula or Halocaridina rubra.

Over the last twenty years exotic fishes have become established in most West Hawaii anchialine pools. Unlike native fishes, many exotics (tilapia and topminnows) are able to complete their lifecycles in the anchialine habitat. These fishes prey on and exclude native hypogeal shrimp which are usually a dominant faunal component. Maciolek and Brock (1974) found exotic fishes in 15 percent of the pools surveyed in 1972 on the West Hawaii coast; thirteen years later OI Consultants (1985) noted exotic fishes in 46 percent of the ponds examined and more recently unpublished surveys by the U.S. Army Corps of Engineers as well

as this author suggest that outside of the WAPPA fewer than 10 percent of the West Hawaii anchialine pools remain free of exotic fishes.

More life history information is available for Halocaridina rubra or opae'ula than for any of the other anchialine species. Opae'ula feed on detritus, benthic diatoms, phytoplankton, filamentous algae, vascular plant tissue (Wong 1975) and when available, animal tissue. Halocaridina rubra feed by plucking the substratum with bristled chelae; midwater and surface film feeding is accomplished by using the chelae and bristles as plankton filters. Opae'ula have been maintained in small sealed containers for years; presumably, under these conditions they are capable of utilizing bacterial films.

Ponds with sufficient illumination must represent significant points of high benthic productivity relative to the watertable below. Sunlight and dissolved nutrients provide the necessary ingredients for this productivity. Many of the shrimp species appear to take advantage of these loci of food resources (ponds). With pond obliteration as through burial or senescence (slow natural infilling), the total productivity within a given section of the watertable would also be significantly reduced; this suggests that the carrying capacity of the habitat with respect to these hypogeal species would be significantly lower with such obliteration. Hypogeal species would probably not entirely disappear; however, other epigeal species (crustaceans, fishes, mollusks and flora) dependent on the illuminated high productivity part of the anchialine system would not survive.

C. Status of the Anchialine Resources at the Kiholo Bay Subject Property

The owners of the subject parcel are very interested in the conservation and enhancement of the natural resources present on the property. This interest lead to the development of additional anchialine habitat on the property as well as the clearing of excess sedimentary material and unwanted exotic fish in the badly degraded anchialine pool that was present prior to any development. Originally, anchialine habitat occupied less than 0.5 percent of the property; since completion of the project, these water exposures now cover 4.5 percent of the property.

Prior to the development of the subject property, there was one anchialine pool present. This pool was shallow with water being restricted to one small low-lying area during low tides and it was badly overgrown with the encroachment of surrounding vegetation. The substratum was evidently mud. In their inventory of the Kona coast anchialine pool resource, Maciolek and

Brock (1974) did not find or sample this pool. Apparently the biota of the pool in the late 1980's was dominated by two exotic fish species, the koi (Cyprinus carpio) and mosquito fish (family Poeciliidae).

The unwanted exotic fishes were eliminated from this pool. Much of the mud has been removed from the bottom of this pool thereby increasing the depth and area over which water is present through the tidal cycle. In its present configuration, it has a surface area of approximately $57m^2$ which represents the maximal horizontal extent of the pond at peak high tide prior to the development of the site. This pool is referred to as Pond 4 below.

The inventories of 23 December 1993 and 7 April 1994 examined all four water exposures present on the property. The aquatic biota of these pools was sampled by simple visual means; species seen and their relative abundances are given below. Also collected was a series of seven water quality samples. The water quality parameters that were evaluated are specific criteria designated for "open coastal waters" by the Department of Health in Title 11, Chapter 54, Amended Administrative Rules for Water Quality Standards. These criteria include ammonia nitrogen, nitrate+nitrite nitrogen, total nitrogen, orthophosphorus, total phosphorus, chlorophyll-a and nephalometric turbidity. Also collected were samples for the non-specific criteria including temperature, pH and salinity as well as the nutrient silica for each location. Water samples were filtered in the field held on ice until returned to the laboratory later on the day of collection for processing. The analytical procedures followed those given in Standard Methods (1985) with modifications according to Strickland and Parsons (1972).

The two largest pools present on the property were constructed at the time the property was developed in 1989-90. The first of these is located on the southern end of the site at a more inland (mauka) location. This pool (hereafter Pond 1) is irregularly shaped, is approximately 6 x 23m in dimensions and has a surface area of about $170m^2$. Pond 1 is situated in a pahoehoe substrate with a considerable amount of sand along the seaward (makai) side; the mean depth is about 60cm. Pond 1 is used as a source of water for the residence on the property; approximately 4,000 to 5,000 gallons (15 to $19m^3$) of low salinity water are drawn daily for domestic and irrigation purposes. Pond 2 is much more elongate (about 71m or 235 feet long) and about 4m wide with a general orientation paralleling the shoreline of Kiholo Bay. This pool has a surface area of approximately $315m^2$ ($3,397\ ft^2$) and a mean depth of about 45cm. Brine (i.e., more saline water) from the reverse osmosis system for the production of freshwater is placed back into Pond 2 with no evident change

in the salinity of this pool (see Table 1 below). The third water exposure examined in this study is a well which was developed for fire fighting purposes; it is situated on the northern end of the property. The well is aproximately circular and has a diameter of about 1.2m; the distance from the top of the well to the water's surface is about 1.4m and the depth is close to 1m. The badly degraded anchialine pool on the property was cleared of fish and excess sediment removed. Today, this pond has a surface area of about $57m^2$ and a maximum depth of about 60cm.

The results of the water chemistry analyses are given in Appendix A. These results show the concentrations of all parameters to be in the usual range for undisturbed Kona coast groundwater (see Brock et al. 1987, Brock and Kam 1992). The well (sample no. 6) data for nitrate nitrogen, ammonia nitrogen and orthophosphate are all low suggesting that the sewage system for the property is working well. This system uses a small "leach field" of banana trees, and other plants situated within 20m of the well. An elevation in the concentration of ammonia and nitrate would be a signal that a problem may be occurring; this is not the case.

The usual suite of anchialine species are present in the well. The two common hypogeal shrimp species (Halocaridina rubra and Metabetaeus lohena) are abundant. Halocaridina rubra was estimated to occur at a density of 150 shrimp/$0.1m^2$ and Metabetaeus lohena at a density of 7/$0.1m^2$. The other anchialine species seen in the well include the common anchialine red amphipod (unidentified).

Aquatic biota in Pond 1 include the tahitian prawn (Macrobrachium lar), the o'opu akupa (Eleotris sandwicensis) and again, the two anchialine shrimp, Halocaridina rubra and Metabetaeus lohena as well as the unidentified red amphipod. Other anchialine species present were the ubiquituous brackish water snail (Melania sp.) and the characteristic cyano-bacteria algal (Schizothrix) mat. The Schizothrix mat is comprised of a complex of many benthic species; besides the characteristic orange hue present over the rocky substrate of the pool, the mat fixes carbonate materials (Bailey-Brock and Brock 1993). Also present in this pond are 8 milkfish or awa (Chanos chanos) and approximately 30 grass carp (Ctenopharyngodon idellus) as well as the introduced waterboatman beetle (Trichocorixa reticulata) and dragonfly nymphs (Anax sp.).

The inventory of Pond 2 again noted the tahitian prawn, the o'opu akupa, approximately 290 milkfish or awa and 70 grass carp. Also present were at least 24 aholehole (Kuhlia sandvicensis) and the snail (Melania sp.). Both the small crustaceans (native

shrimps and amphipods) as well as the insects (waterboatmen and dragonfly nymphs) were not seen in this pool probably because of the presence of predatory aholehole.

The biota of the original anchialine pool (Pond 4) is dominated by small red amphipods and at least one additional amphipod species is present along with the snail (Melania sp.) as well as dragonfly nypmhs (Anax sp.). No Halocaridina rubra were seen in Pond 4 during our survey, but as often is the case, the presence or absence of these shrimp is related to tide state. Thus H. rubra is expected to be encountered in this pond on occasion. The presence of numerous amphipods suggests that there are no major crustacean predators present in this pool; usually predatory fish in an anchialine pool will prey on amphipods as well as native shrimp. This pone is reportedly subject to periodic algal growth which is removed manually by maintenance workers.

No unusual anchialine species were found in any of the water features on the subject property and all of the species encountered are common in the West Hawaii anchialine biotope.

Two of the fish species (grass carp and milkfish) were intentionally released into Ponds 1 and 2 after their construction to control the growth of algae. According to maintenance personnel, soon after the construction of the two ponds a green alga became established and created a near-continuous mat across the surface of the two pools. The herbivorous native shrimp Halocaridina rubra appeared in both Ponds 1 and 2 with greatest numbers in Pond 1, but it did not control the algae in either pool. The grass carp and awa were sterilized prior to their release in these pools and because they are herbivorous, they have cleared up the algae (see Appendix B for further discussion).

Human occupation of the Kiholo area extends back to prehistoric times as suggested by the presence of archaeological sites located mauka of the subject parcel. Occupation of the area has probably been a near continuous event up through modern times. The important fishpond(s) at Kiholo destroyed by the lava flow of 1859 as well as the use of Kiholo as a loading area for the interisland shipping of cattle attest to the importance of the area through the historic period (Clark 1985). Many of the ponds in the Kiholo area have been modified or used by humans for the holding and/or raising of fish in the past and the impact of these uses are still evident in some Kiholo ponds (e.g., the fishponds at the north end of the bay).

The pools located on the subject property are providing habitat for native anchialine species; the exception to this is Pond 2 where predatory aholehole have driven the usual crustacean fauna from the lighted portions of the pool. As noted above,

aholehole colonized the pool by natural means. Interestingly, the presence of herbivorous milkfish and grass carp in Pond 1 have not deterred native crustacean species from colonizing and co-occurring with these fish. Our observations regarding the co-occurrence of other herbivorous fish species and native shrimp are similar; in the Waikoloa Anchialine Pond Preserve located at Waikoloa, South Kohala we have encountered several instances where kupipi or blackspot sargeant damselfish (Abudefuf sordidus) have naturally colonized anchialine pools and the native shrimp co-occur with these herbivorous fishes. One such kupipi has been documented in the same pool for more than four years. A second fish species that has co-occurred with native shrimp in the Waikoloa Preserve ponds is the introduced gold-spot herring (Herklotsichthys quadrimaculatus) which we suspect feeds on plankton. However when a known predatory species colonizes an anchialine pool, native crustaceans are usually rare or absent (Maciolek and Brock 1974, Brock 1977, Maciolek 1984, Brock 1985). The one exception to this is the occasional co-occurrence of native shrimp with the predatory o'opu akupa (Eleotris sandwicensis).

As noted above and in Appendix B, native anchialine species co-exist with the introduced sterile grass carp and milkfish; this mix of herbivorous species appears to have no discernible negative impact to the native species. The data suggest that the present management strategy probably presents little further direct impact to the surrounding anchialine resources if (1) no other fishes or fish species are released into the pools, (2) no infilling of the anchialine resources occurs on the site, (3) planted vegetation surrounding the pools is not increased over present levels which would increase the amount of shading and the rate of infilling by leaf litter, (4) that the waste treatment system continues to operate correctly and (5) no excessive or unnecessary use of chemicals occurs on the lands surrounding the ponds.

1.2 Management Plan - Objectives

The anchialine resources in pools located on TMK (3) 7-1-2:03 at Kiholo Bay are to be preserved and passively managed. The objectives of the preservation and management plan are to:

1. To maintain the physical environmental integrity (i.e., basin characteristics, water quality) of the anchialine resources situated in the project site;

2. To protect and preserve these coastal features to allow the perpetuation of the biological resources;

3. To control construction activities so that detrimental impacts to the pools or biota may be avoided during this period of time;

4. To provide criteria for any additional future landscaping and subsequent maintenance in the vicinity of the anchialine pools that avoids impacts to the pools or biota.

1.3 Pond Management Zones

Management zones refer to the two designations:

1. Anchialine Pools - The boundaries of the anchialine pools are identified by the maximum extent of the pond surface at high tide. This includes all waters that are exposed to the air under any overhangs at high tide.

   In general no further construction will be allowed in any recently developed ponds on the subject property. Other than permitted activities given below, other activities that are not permitted include the disposal of any trash, chemical, wastewater or stormwater into any of the pools as well as the introduction of any additional fish or other aquatic life into the system. No feeding of the anchialine pool organisms will be alllowed nor will any further hydrologic modification in the anchialine pools be made without the consent of the Chairperson of the Department of Land and Natural Resources, State of Hawaii. However, routine maintenance of the ponds (i.e., removal of trash, limited excess sediment removal, etc.) is permitted.

2. Anchialine Pool Buffer Zone - These zones are defined as being immediately adjacent to the anchialine pools where development is restricted. The width of the buffer zone is five feet as measured from the pond water edge at high tide.

   Permitted construction beyond the present development in the Pond Buffer Zone includes the construction of low rock walls to demarcate the pools and/or Pond Buffer Zone boundaries for the purpose of keeping storm water runoff, unwanted soil and debris from entering the pools. Walkways within the Buffer Zone and/or over the ponds are also permitted. Beyond the permitted planting that has already occurred, future

planting will be limited to native and/or xerophytic vegetation in the Pond Buffer Zone as long as growth does not create an overstory over the ponds or allow leaf litter to fall into the pools. Additional soil should not be placed in the Pond Buffer Zones.

In general any future construction activities must conform to the following:

a. Site grading should be designed such that all site drainage and storm water runoff from areas outside of the pond buffer zone will be prevented from flowing into the pond buffer zone or the anchialine pools.

b. Sewage and all wastewater facilities should be constructed as not to allow any of these materials from entering the anchialine pools either through surface runoff or via the groundwater.

c. All lighting should be designed and operated such that lights do not intentionally shine directly into the ponds at night and any future construction of buildings should be set back five feet from the Pond Buffer Zone boundaries to prevent excessive shading of the pools. However, normal lighting of the house and grounds will be permitted for security and safety reasons.

Allowable activities in the anchialine pools include:

a. Continued use of Pond 1 as a source of water for domestic use and the use of Pond 2 for the release of saline water from the potable water (reverse osmosis) system.

b. Continued use and maintenance of sterile grass carp and awa to control the algal problem in Ponds 1, 2 and 4.

1.4 Anchialine Pool Management

A. Responsibilities

The owner or his representative(s) shall be responsible for insuring the following:

1. That the Pond Buffer Zones are maintained and if necessary, undertake the construction of low perman-

ent rock walls to insure that soil and debris cannot enter the Pond Buffer Zones or the anchialine pools;

2. Insure that site drainage does not allow runoff to enter the anchialine pools or the Pond Buffer Zones;

3. Insure that all personnel residing or working at the site are informed of the sensitivity of the anchialine resource and that unauthorized entry into Pond Buffer Zones or pools is strictly prohibited unless for maintenance as given below;

4. Undertake the clearing by hand methods of vegetation that has either encroached into the Pond Buffer Zones and/or above the anchialine pools;

5. Using hand methods, undertake the removal of excess sediment and debris from pools on an as needed basis;

6. Insuring that the introduction of other aquatic species into the anchialine pools beyond the replacement and maintenance of fishes presently in the system does not occur and that feeding of the anchialine organisms is not allowed;

7. Informing the Director of the Department of Land and Natural Resources, State of Hawaii and/or his representative should any fishes or other alien species beyond those species and numbers presently in the system gain access to the anchialine pools and to cover the costs of their removal for the restoration of the system;

8. Implementing the recommendations given in Appendix B regarding the biological resources of the ponds on the subject parcel;

9. Insuring that chemicals including fertilizers are not introduced into the anchialine pools or Pond Buffer Zones and that surface runoff will not enter the Pond Buffer Zone;

10. Swimming or bathing is never allowed in the anchialine pools;

11. Insure that the sewage system continues to comply with Department of Health regulations and that the system functions properly to avoid contamination of the coastal groundwater and anchialine pools;

12. Allowing county, state and federal agency personnel access to anchialine pools for purposes of sampling;

13. Complying with all of the rules and regulations as stipulated in this Managment Plan.

14. The owner or his representative(s) may elect to employ a pond manager who will serve as an advisor on matters related to the management of the anchialine resources on the property but that the day-to-day maintenance will be carried out by on-site maintenance personnel.

15. Inform any subsequent owners of TMK (3) 7-1-2:3 of their responsibilities regarding this Anchialine Pool Management Plan.

These responsibilities should be written as covenants into the Conservation District Use Permit issued for the proposed work on this parcel (TMK 3/7-1-2:03)

1.5 Other Considerations

This resource management and protection plan has been developed utilizing information and methodologies generally accepted in the scientific community at the time of submission. The implementation of this plan cannot guarantee total resource protection and parties involved in the preparation of this plan shall not be held liable for any problem arising in the future with respect to the plan implementation, the resource or to any individual, corporation or other entity.

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APPENDIX A. Summary of the water quality parameters measured at 7 locations in two large pools (Pond 1, samples 1 and 2; Pond 2, samples 3, 4, and 5), one well (sample 6) and the original anchialine pool (sample 7) on the Kiholo Bay subject parcel on 23 December 1993 and 7 April 1994. Concentrations are uM unless otherwise noted.

Sample	Nitrate N	Ammonia N	Total N	Ortho P	Total P	Silica
#1 Pond 1 Mauka	51.75	1.41	56.55	1.43	1.47	754.20
#2 Pond 1 Makai	52.36	2.19	57.40	1.71	1.77	750.97
#3 Pond 2 South End	46.69	1.08	50.58	1.43	1.46	738.69
#4 Pond 2 Middle	52.84	0.89	57.49	1.58	1.59	742.70
#5 Pond 2 North End	58.05	0.06	63.14	1.85	1.89	753.54
#6 Well	44.56	1.14	48.96	4.75	4.80	753.45
#7 Pond 3 Original Pool	45.88	1.12	46.47	1.25	1.32	754.67

Sample	Turbidity NTU	Chl-a ug/l	Salinity °/oo	Temp. °C	pH
#1 Pond 1 Mauka	0.13	0.248	1.865	21.7	7.76
#2 Pond 1 Makai	0.09	0.347	1.847	22.1	7.86
#3 Pond 2 South End	0.15	0.877	1.905	21.9	7.85
#4 Pond 2 Middle	0.12	0.368	1.973	22.0	7.92
#5 Pond 2 North End	0.09	0.145	1.979	22.7	7.76
#6 Well	0.15	0.062	2.068	20.4	7.50
#7 Pond Original Pool	0.12	0.188	1.989	23.6	7.87

APPENDIX B. Notes on the intentional introduction of fishes into Ponds 1 and 2, (TMK 3/7-1-2:03) at Kiholo Bay, Hawaii. Some of the information below is courtesy of Mr. Steven Brown, caretaker on the subject parcel.

1. Background

The Conservation District Use Permit (CDUP) granted for the development of this parcel prohibits the intentional introduction of fishes to the constructed anchialine pools, specifically (from File No. HA-11/6/87-2092, Document No. 4817E, Page 4):

> "4. That the applicant affirm that no artificial 'seeding' of flora and fauna be undertaken. The ponds are to be left to naturally assemble a habitat inherent in a typical anchialine pond;"

Apparently the fish released into the two pools were done so to control the growth of algae. Soon after the construction of the two ponds, a green alga became established and created a near-continuous mat across the surface of the two pools. The herbivorous native shrimp Halocaridina rubra appeared in both ponds but did not control the algae; of the two pools, H. rubra was considerably more abundant in Pond 1. When it became apparent that the shrimp were not going to control the algae, sterilized grass carp and awa were released in the pools. As noted above, 30 carp and 8 awa were released into Pond 1 and another 70 carp and 292 awa were placed into Pond 2. Since their introduction, the algal problem has disappeared.

The species of algae involved was probably a member of the genus Cladophora. In the 1972 survey of the Kiholo anchialine resources (Maciolek and Brock 1974), Cladophora sp. was noted as a common element in most of the anchialine pools of the area but is usually not so in most anchialine systems. Cladophora sp. is probably successful in the Kiholo ponds because of the relatively low salinities present in these ponds.

The impact of exotic fishes on native anchialine biota has been documented by Brock (1985), Bailey-Brock and Brock (1993). In general there are two classes of fishes that are found in anchialine pools of the Kona coast; the first are all native species that are usually found in marine, brackish or fresh waters and the second group are non-native or exotic fishes (Brock 1977). Once in an anchialine pool, none of the native fishes are able to complete their lifecycle and require the ocean for successful reproduction. To the contrary, the exotic species

are able to reproduce in the anchialine habitat and possibly colonize other nearby pools. In many cases native fishes colonize anchialine habitats under their own impetus; some species as juveniles seek low salinity waters moving through subterranean interstices in the porous lava substrates that separate anchialine pools from the ocean. In other instances native fishes are carried into anchialine pools by high surf. Because of the lack of open freshwater environments (i.e., streams, etc.) on the Kona coast that are the usual habitat for most euryhaline exotic fishes, their spread along this coastline has been primarily through intentional introductions into brackish (anchialine pool) waters. People have spread topminnows to anchialine pools under the mistaken intention of controlling mosquitos or as a source of bait for fishing.

The most obvious impact resulting from the colonization of anchialine pond systems by native and exotic fishes is their predation on resident crustaceans, particularly the shrimps. Maciolek (1984) reviewed the impact that exotic fishes have in Hawaiian and other insular aquatic ecosystems. The adverse effects of these introductions center on predation or competition by the exotic species on native species. Insofar as the anchialine biota is concerned, the greatest impact of exotic fishes is that of predation on the small native red shrimps of the system. Brock (1985) hypothesized that exotic and/or native fishes introduced into an anchialine pool can initiate a change in ecological succession. The first and most obvious change that may occur is to reduce and soon eliminate the hypogeal shrimp from the exposed (lighted) parts of the exosystem. Following this, a slow succession of macroalgae may establish themselves and grow epiphytically on the carbonate-producing Schizothrix cyano-bacteria mat. With the herbivorous Halocaridina rubra present, these epiphytic macroalgae never come to dominate the benthos. Without them, an overgrowth situation develops leading to the local demise of the Schizothrix mat. These changes may take years to occur and thus would not be readily apparent to the scasual observer. With this change in pond flora comes a major change in the appearance of the pond system from one that has "anchialine" attributes (i.e., the cyano-bacteria carbonate producing mat, associated flora, and an aquatic fauna frequently dominated by hypogeal shrimp), to a system dominated by a mud substratum and exotic fishes. Preliminary studies (Bailey-Brock and Brock 1993) support this hypothesis.

Brock (1985) presented information on the spread of exotic fishes in anchialine waters of the Kona coast; Maciolek and Brock (1974) noted that in 1972 approximately 15 percent of the ponds examined were contaminated with exotic fishes. Fifteen years later OI Consultants (1985) found that about 38 percent of the ponds inventoried along much of the same coastline contained

exotic fishes and more recently, unpublished work carried out by University of Hawaii (Brock) and personnel from the U.S. Army Corps of Engineers in Honolulu suggest that more than 90 percent of the anchialine resource of the West Hawaii coast is contaminated with exotic fishes.

2. Biological Status of the Kiholo Ponds

As mentioned above, Pond 1 contains 30 grass carp and 8 milkfish or awa that were intentionally released. Natural colonizers of this pond include the brown goby or o'opu akupa (Eleotris sandwicensis), waterboatmen, dragonfly nymphs, the common snail (Melania sp.), the exotic tahitian prawn (Macrobrachium lar), the common anchialine unidentified red amphipod species and two hypogeal shrimp species, Halocaridina rubra as well as Metabetaeus lohena. The Schizothrix cyano-bacteria mat is well developed on the rocky substrate in this pond. Pond 2 was stocked with 292 awa and 70 grass carp; naturally occurring species in Pond 2 include the tahitian prawn, the melanid snail, the o'opu akupa and approximately 24 aholehole (Kuhlia sandvicensis). The substratum of Pond 2 is dominated by sand and mud; the cyano-bacteria mat is absent.

The presence of native red shrimp (Halocaridina rubra and Metabetaeus lohena) with the grass carp and awa in Pond 1 was unexpected; however these fishes are herbivorous and not predators on the shrimp thus they co-exist. The o'opu akupa is carnivorous (Kinzie 1990) and probably preys on the native shrimp but these species occur and co-exist naturally in other Kona coast ponds (Maciolek and Brock 1974, Brock 1977). The presence of the Schizothrix cyano-bacteria mat as well as the native shrimp suggest that this pool is functioning as a most anchialine pools do; it is free of most macroflora and the waters are clear.

Pond 2 lacks the usual complement of native anchialine species as well as the insects that are found in Pond 1. Pond 2 is dominated by the grass carp, awa and aholehole. These fish through their feeding activities appear to be controlling the development of the benthic and other components of the aquatic community in this pool. The lack of native anchialine shrimp in Pond 2 may be related to the presence of the carnivorous aholehole which are absent in Pond 1 where these shrimp are found.

Maintenance personnel for the subject parcel have noted that the only fishes released into Ponds 1 and 2 were the sterile grass carp and awa; there were no aholehole released into the ponds. In all probability, the aholehole colonized Pond 2 under completely natural circumstances. Brock (1977) suggested that a common recruitment mechanism is that of fishes being swept into

anchialine pools during periods of high or storm surf. When questioned, Mr. Brown (caretaker of the subject property) noted that high surf overtops the beach berm between Pond 2 and the sea about once a year. It is highly likely that the aholehole colonized Pond 2 via this mechanism.

Halocaridina rubra is apparently unable to control the growth of Cladophora in the Kiholo ponds. The early work by Maciolek and Brock (1974) found both herbivorous Halocaridina rubra and Cladophora co-occurring in some pools at Kiholo suggesting that the shrimp does not feed heavily on this macrophyte. Halocaridina rubra colonized the newly created pools on the subject property as did Cladophora; the latter quickly came to dominate these pools. The water chemistry results suggest that the brackish groundwater flowing through the Kiholo ponds does not have high inorganic nutrient concentrations that would "fuel" the growth of this alga. Indeed, the nutrient concentrations measured in this study are low relative to many anchialine pools situated in undisturbed settings but it should be remembered that despite the relatively low concentrations, these nutrients may already be in excess of biological requirements. The combination of grass carp and awa in Pond 1 has not deterred Halocaridina rubra from colonizing this pool and the benthic community development reflects the usual suite of anchialine species. The density of grass carp in Pond 1 is one carp per $5.6m^2$ of pond surface area and one awa per $21.3m^2$ or a total of one fish per $4.5m^2$ of surface area. This density and ratio of species (i.e., 1 awa to about 4 carp) appears to be sufficient to control the growth of Cladophora. In contrast, density of fish in Pond 2 is one fish per $0.9m^2$ of pond surface area or one carp per $4.5m^2$ and one awa per $1.1m^2$. The ratio of awa to carp in Pond 2 is one awa to 0.24 carp which is reversed from that of Pond 1.

The presence of aholehole in Pond 2 is the probable reason for the lack of many anchialine components in this pool. Past efforts to control the Cladophora algal problem has shown that the native shrimp are unable to do so; the addition of milkfish and grass carp in a ratio of 1 awa to 4 grass carp and at a density of one fish per $4.5m^2$ of water surface area results in the elimination of the algal problem yet allowing the usual anchialine components to colonize and survive.

Without heavy grazing pressure, the dominance of Cladophora in the ponds on the subject property has been experimentally demonstrated by excluding the grazing fishes from the southern third of Pond 2 by use of a fine-mesh fence net. This net was placed in Pond 2 on 19 December 1993; on the 23 December survey, we noted small (1-2mm) tufts of green algae present in fish-exclusion area. Cladophora was well-established and evident on

our 18 Janaury 1994 visit and even to a greater estent in the 7 April 1994 visit to the site demonstrating the ability of this alga to completely dominate the benthos of these ponds.

3. Recommendations Regarding Biological Resource Management

From the above information several recommendations can be made:

a. Continue to allow the use of sterile grass carp and awa in Ponds 1 and 2 to control the growth of unwanted algae in these ponds.

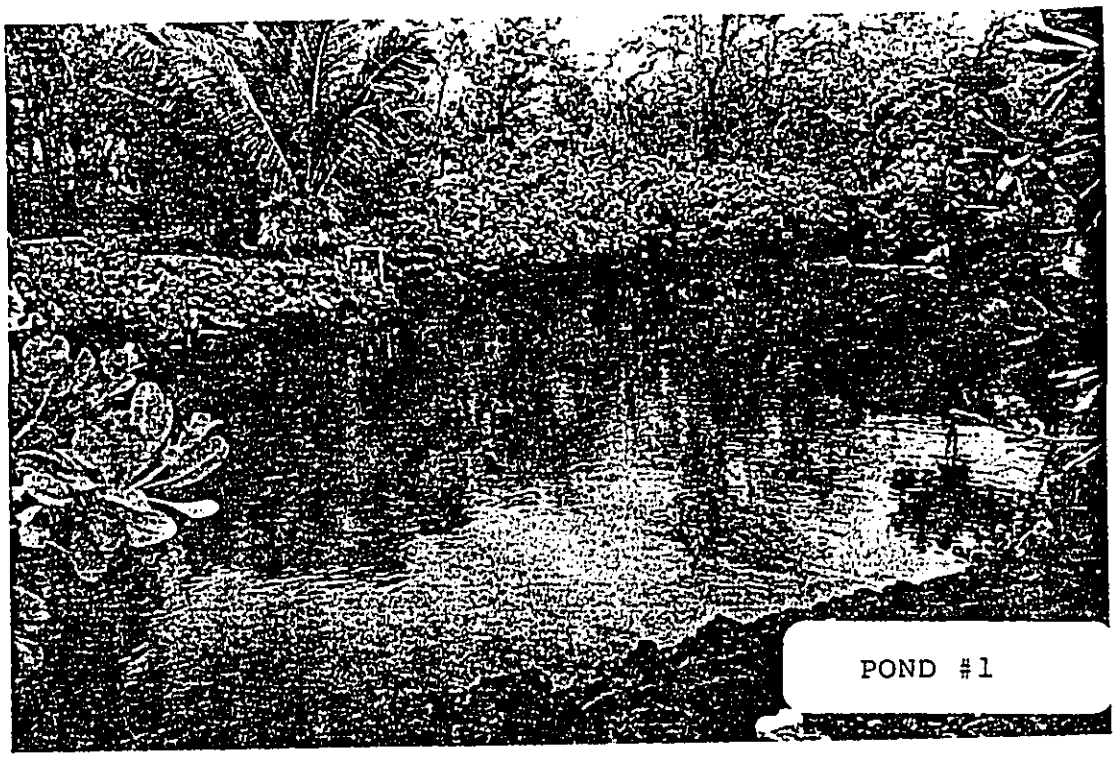
b. Select a pond manager to oversee and advise on the maintenance of all anchialine pools on the subject parcel which would include but not limited to the adjustment of the number of fishes in the ponds to control growth of unwanted algae.

c. Continue to carry out routine maintenance of the ponds by the regular grounds personnel in consultation with the pond manager as needed.

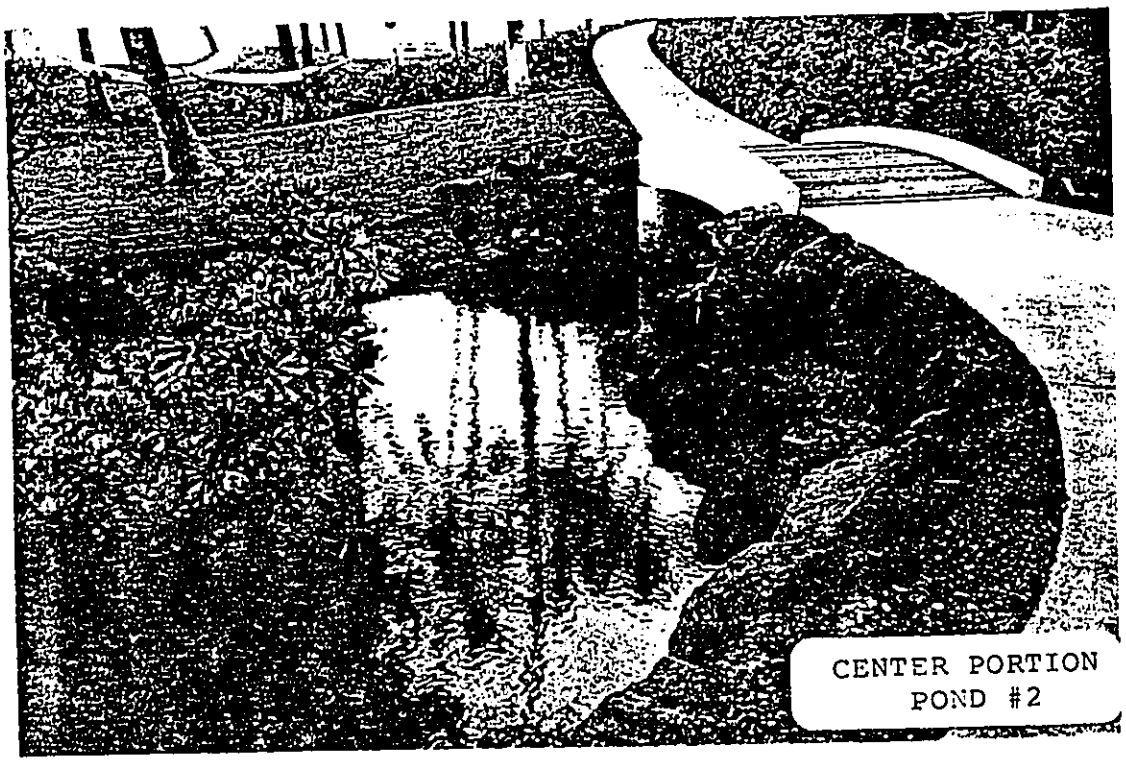
d. Attempt to remove all aholehole from Pond 2 as well as attempt to devise a means to reduce the opportunity for fish washing into the pond during periods of high surf.

e. Reduce the number of fish in Pond 2 from the current 362 individuals to approximately 56 individuals and establish a ratio of four grass carp for each awa (i.e., 14 awa and 42 grass carp).

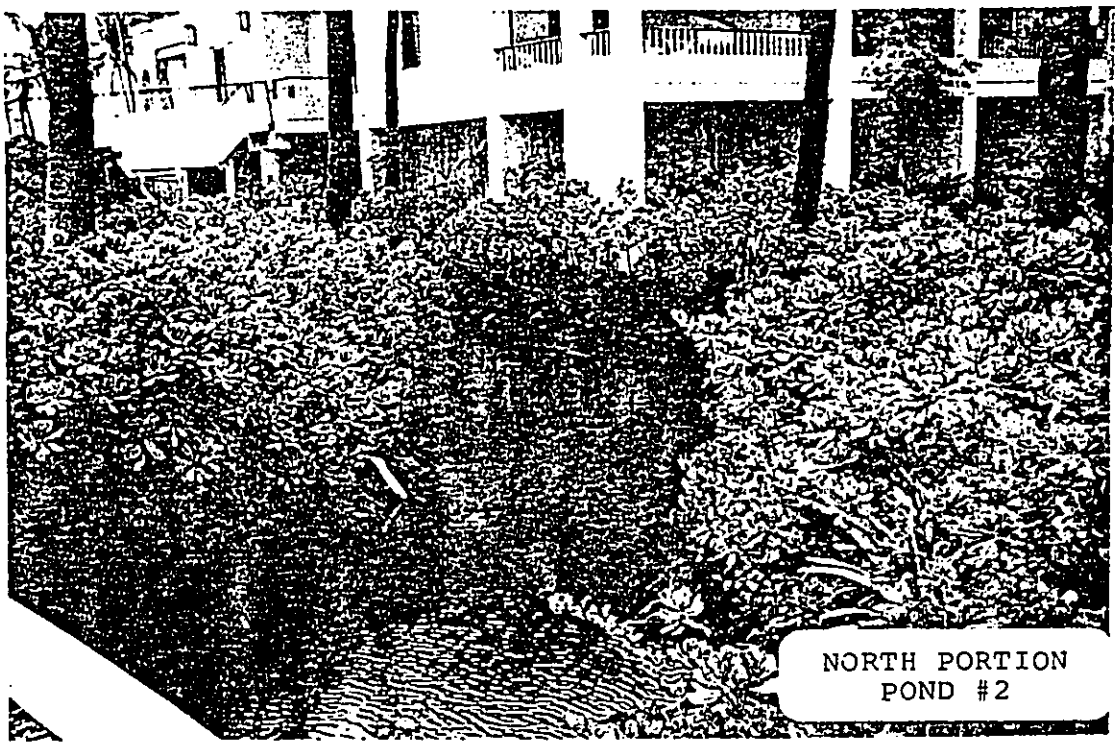
f. Since much of the substratum of Pond 1 is sandy mud and often the characteristic substratum of anchialine pools is the Schizothrix mat, placement of low, flat rock on some of the mud substratum should provide appropriate substratum for the establishment of the mat. If implemented, this recommendation should improve the overall appearance of Pond 2 as well as biologically improve the anchialine features of this pool.



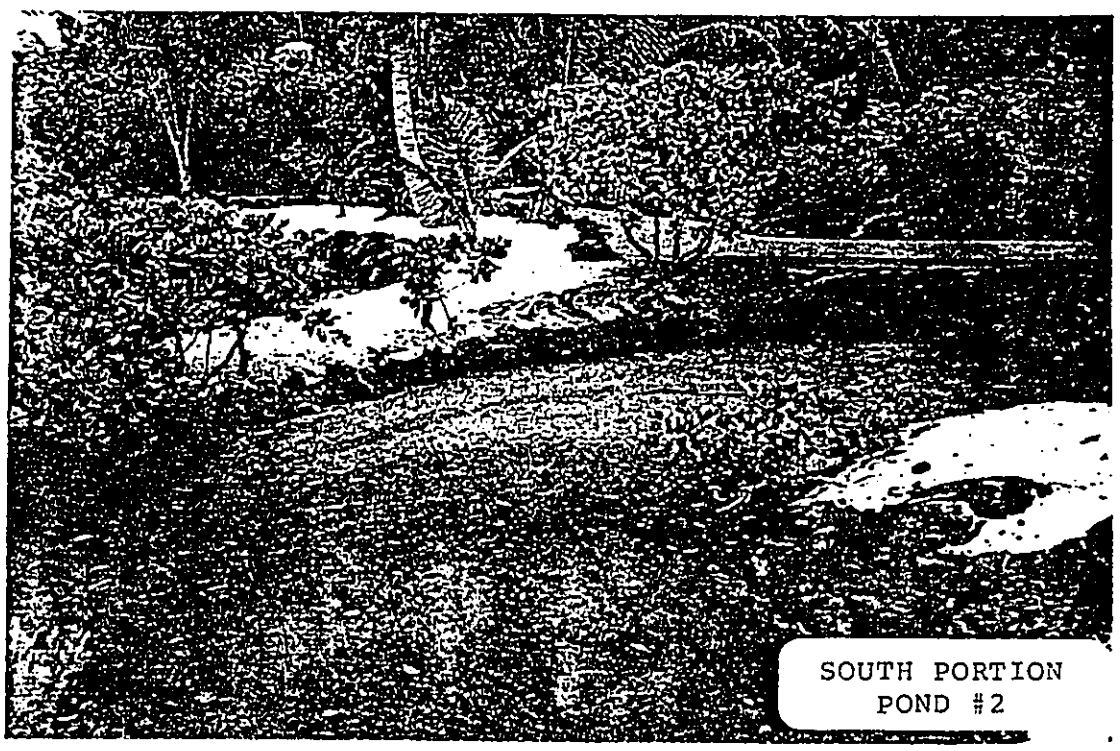
POND #1



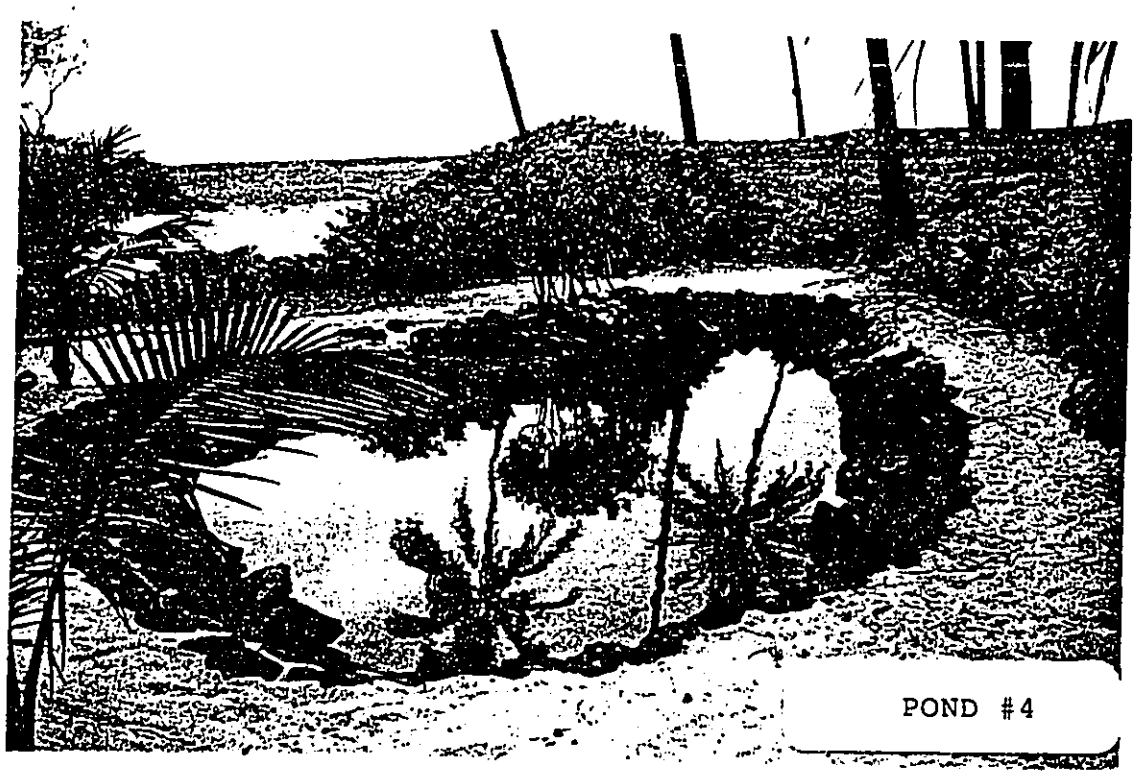
CENTER PORTION
POND #2



NORTH PORTION
POND #2



SOUTH PORTION
POND #2



POND #4

FQ-08
3/87

Permit No. 09-92-H-5771

Date Sept. 26, 1991

State of Hawaii
DEPARTMENT OF AGRICULTURE
Plant Quarantine Branch
701 Ilalo Street
Honolulu, Hawaii 96813-5524

IMPORT PERMIT

(Valid for one shipment(s) within one year(s) from date)

Permission is hereby granted to introduce the following, in accordance with Chapter 71, Rules of the Division of Plant Industry, Department of Agriculture, and the conditions listed below. *(Each lot must be inspected by a Plant Quarantine Inspector upon arrival before release.)*

Quantity	Commodity	Scientific Name
100	White Amur	Ctenopharyngodon idellus
Please see attached conditions.		

Conditions: It is the responsibility of the named importer personally contact the Federal Government and their [illegible] which are [illegible]

(NO SUBSTITUTIONS ALLOWED)

INSTRUCTION To Shipper: One copy of permit to accompany shipment to Hawaii.

Conditions or Object of Importation:

- ☒ To be kept in captivity at all times.
- ☐ For propagation
- ☐ Other

Condition: Items on this permit subject to cancellation [illegible]

Name and Address of Shipper: International Aqua Farms Inc., P.O. Box 157, Hauuala, HI 96717

Name and Address of Importer: Steven D. Brown / Doris Bakken, P.O. Box 383427, Waikoloa, HI 96743 Phone: 326-4612

Harry A. Rohrbacher
CHIEF PLANT INSPECTOR

Yukio Kitagawa
CHAIRPERSON, BOARD OF AGRICULTURE

FOR OFFICIAL USE ONLY

PORT _____ ARRIVAL DATE _____ FLIGHT/SHIP _____

WAYBILL NO. _____ INSPECTION DATE/TIME _____ INSPECTOR _____

REMARKS _____

CONDITIONS FOR CARP IMPORTATION FOR AQUACULTURE

1. The carp shall be examined by Dr. James Brock, Hawaii State Aquaculture Disease Specialist for disease and parasites.

2. The carp shall be kept in a closed system (tank or pond or lake) with a screened overflow to prevent their escape.

3. The placement of the carp in natural waterways is prohibited. They shall be confined to designated closed systems for aquacultural purposes only.

4. The carp and the confined aquacultural system shall be periodically inspected by the P.Q. Branch during reasonable working hours.

5. The Plant Quarantine Branch shall be notified in writing upon completion of fish cultivation.

6. The marketing or transfer of any live carp is prohibited, except authorized by the Plant Quarantine Branch.

7. The Permittee shall agree in advance to pay all expenses associated with the recapture or destruction of escaped animals including expenses incurred by the State as a result of the escape. The Permittee shall also agree in advance to defend and indemnify the State of Hawaii for any and all claims against the State that may arise from or be attributable to any of the animals that are introduced under this request.

PQPERMIT-02

01/91

Computerized Image Showing
— Proposed Battery Storage —
Building