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

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

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RUSSELL N. FUKUMOTO

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

Ref: LM-WMY

SEP 28 1989

DN 2254F

Hawaii Electric Light Co., Inc.
54 Halekauwila Street
Hilo, Hawaii 96720

Dear Gentlemen:

We have completed our review on your Final EIS pertaining to Pohoiki Geothermal Transmission Line.

The judgment in question is whether the Final EIS is an acceptable or non-acceptable document under Chapter 343, Hawaii Revised Statutes, as amended.

Acceptance means that the document fulfills the definition of an Environmental Impact Statement (EIS), adequately describes identifiable environmental impacts, and satisfactorily responds to comments received during the review of the statement.

The EIS means to us that an informational document has been prepared in compliance with the rules and regulations promulgated under Chapter 343-5 and which discloses the environmental effects of the proposed action, effects of the proposed action on the economic and social welfare of the community and State, effects of the economic activities arising out of the proposed action, measures proposed to minimize adverse effects and alternatives to the action and their environmental effects.

We are of the opinion that a major purpose in accepting or not accepting a statement, as suggested under Title 11, Chapter 200 of the Administrative Rules, is that the document adequately discloses environmental impacts and satisfactorily responds to comments.

Hawaii Electric
  Light Co., Inc.
Page Two
SEP 2 8 1989

Considering our focus on the requirements for information and disclosure as having been adequately met, and, we find the document acceptable under Chapter 343, Hawaii Revised Statutes, as amended and the Administrative Rules.

In our view, the document, in and of itself, should not be used as a vehicle to promote or detract from any required subsequent judgment on the proposed project itself. We have consistently maintained this posture in the past.

We should point out that the acceptability of this statement is based upon criteria set forth, and, as such we nevertheless have concerns relating to the substance within the document itself.

As such, these concerns relating to substance will be addressed in the analysis of the CDUA and the follow-up disposition of the grant of easement.

If you have any questions, please feel free to contact the Division of Land Management at 548-6460.

Very truly yours,

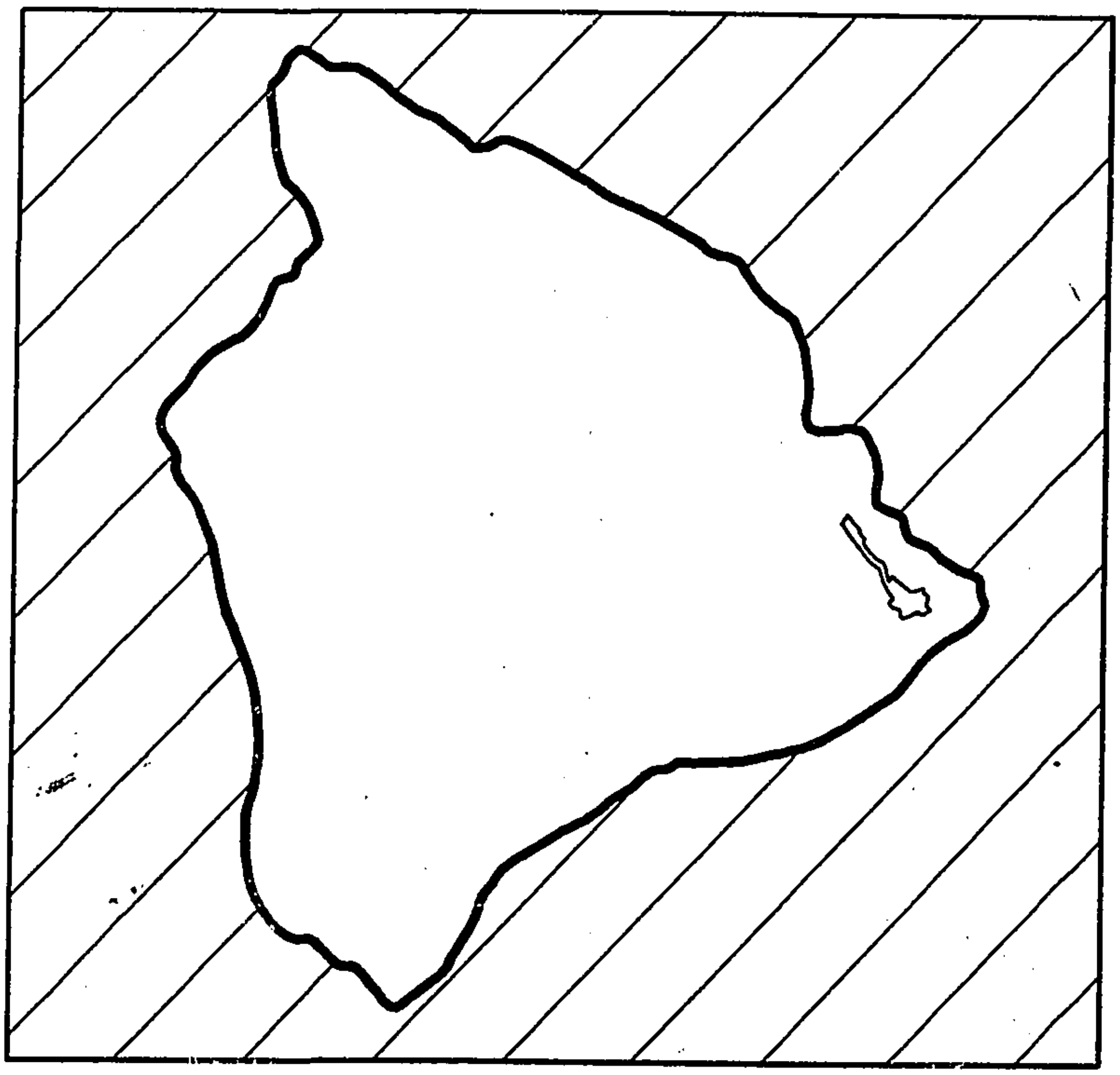
WWPaty

WILLIAM W. PATY

cc: Office of Environmental
  Quality Control
Herbert Arata
Glenn Taguchi
OCEA

# POHOIKI

GEOTHERMAL · TRANSMISSION · LINE



ENVIRONMENTAL · IMPACT · STATEMENT

# ENVIRONMENTAL IMPACT STATEMENT
# FOR
# POHOIKI GEOTHERMAL TRANSMISSION LINE

Submitted Pursuant to Chapter 343,
Hawaii Revised Statutes,
Environmental Impact Statement Regulations

Duk Hee Murabayashi, President

DHM inc.
Environmental Planning Consultant for
Hawaii Electric Light Company, Inc.

August 1989

# CONSULTANT TEAM

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Land Use and Environmental Planning

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Duk Hee Murabayashi
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Lynn Taguchi
Edie Yamaguchi

**BISHOP MUSEUM**

Archaeology
Botany
Entomology
Ornithology

**DAMES & MOORE**

Soils

POHOIKI GEOTHERMAL TRANSMISSION LINE

**PERSON SUBMITTING ENVIRONMENTAL IMPACT STATEMENT**

Mrs. Duk Hee Murabayashi
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**APPLICANT**

Hawaii Electric Light Company, Inc.
54 Halekauila Street
Hilo, Hawaii 96720
Phone: 969-0322

**ACCEPTING AUTHORITY**

Board of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

**PROJECT SITE**

| | |
|---|---|
| Project Location: | Puna District, Hawaii County |
| Tax Map Key: | 1-3-9:3, 4<br>1-4-1:2, 4, 17, 65, 66, 78, 79<br>1-4-3:8, 11<br>1-5-1:1, 3<br>1-5-8:6, 7<br>1-5-9:5-7, 9, 17, 23-26<br>1-5-10:3<br>1-5-117:14, 15<br>1-6-1:15, 16<br>1-6-3:3, 4, 22, 67, 68, 80 |
| State Land Use District: | Agricultural District<br>Conservation District: Resource Subzone |
| EIS Preparation Notice: | October 8, 1987, OEQC Bulletin |
| Draft EIS: | May 8, 1989, OEQC Bulletin |
| Comments and Concerns: | In response to comments expressed during the review period, revisions and additions to the draft Environmental Impact Statement are in bold type. |

# SUMMARY

Hawaii Electric Light Company, Inc. (HELCO) is proposing to construct, own, and operate two overhead 69 kV transmission lines that will originate at the site of the proposed geothermal power plant at Pohoiki and will terminate at the Puna Substation in Keaau, Hawaii. The objective of the project is to transmit 25 MW of power from the natural energy source at Pohoiki and to interconnect this power with HELCO's island-wide power grid at the Puna Substation. The two transmission lines will each require a 50-foot wide right-of-way and each transmission line will consist of three conductors and a shield wire. The conductors will be suspended from insulators supported on wooden poles between 57.5 and 76 feet tall from ground level. The length of each transmission line will be between 17 and 18 miles.

The majority of each line will be in the State Agricultural District. However, since a small segment of each line (less than one mile) will pass through the Conservation District Resource Subzone, approval of a Conservation District Use Application (CDUA) by the Board of Land and Natural Resources will be required for these segments. The Department of Land and Natural Resources has determined that an Environmental Impact Statement (EIS) is required for the project and this document has been prepared to fulfill that requirement.

Many of the potentially adverse environmental impacts of the proposed transmission lines have been avoided or minimized due to the method of route selection. Various alternatives to the proposed action were studied and route selection was based on an analysis of socio-economic and physical environmental considerations as well as cost-effectiveness and concerns of community organizations, public agencies, and government officials.

Additional mitigation measures, primarily to minimize land disturbance during construction and maintenance operations, are proposed to reduce the probability of adverse effects on the environment.

Construction of the project will create localized and short-term impacts on noise levels, air quality, vegetative cover, the rate of soil erosion, and traffic flow. Appropriate mitigation measures will be used to minimize the degree of these impacts. No long-term adverse effects on wildlife are expected. By and large, the proposed alignments avoid areas where the lines would be exposed to frequent viewing. In cases where it is likely to be prominently in view, such as from Highway 130, the use of joint and double circuit poles will minimize the visual impact that could otherwise occur from multiple pole lines within a narrow corridor.

Several alternatives to the proposed action were considered. The project-related alternatives fall into three categories: 1) construction of a single 69 kV overhead line, 2) construction of marine or underground lines, and 3) routing alternatives. The "no action" alternative was also considered.

The proposed project is consistent with the State and County land use and energy plans and policies to encourage development of renewable, indigenous energy resources.

TABLE OF CONTENTS

## EXHIBITS

## APPENDICES

# CHAPTER I

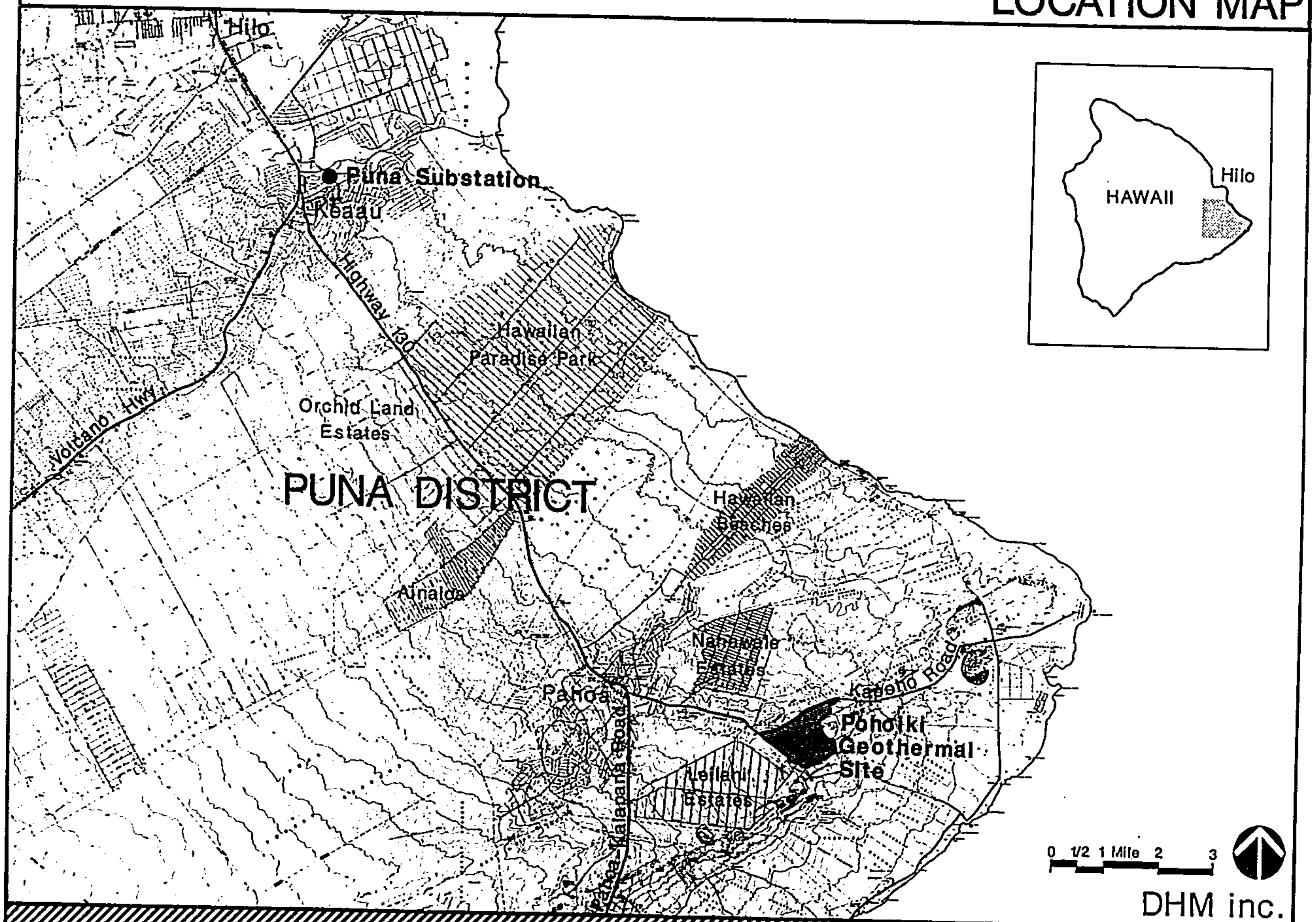
## CHAPTER I. DESCRIPTION OF PROPOSED ACTION

### A. BACKGROUND

Puna Geothermal Ventures (PGV) proposes to develop a 25 megawatt (MW) geothermal-electric power plant at the Pohoiki geothermal site (also referred to as "Pohoiki") in the Puna District of Hawaii. (Exhibit I-1) In compliance with the federal Public Utilities Regulatory Act (PURPA), Hawaii Electric Light Company (HELCO) will purchase the electric power generated by the geothermal power plant and will distribute it to customers on the Island of Hawaii. To do this, HELCO must construct transmission lines which connect the proposed generators at Pohoiki to the main power grid near HELCO's Puna Substation at Keaau. Two 69 kilovolt (kV) transmission lines capable of carrying 25 MW of power are required to provide and maintain reliable service.

The proposed transmission lines are needed exclusively to transmit the power produced by the 25 MW Pohoiki geothermal plant. The first new 69 kV line is needed by July 1990 when PGV intends to have at least 20 MW of power on line. The second 69 kV transmission line will be installed by December 1990 to provide back-up to the first 69 kV line.

## EXHIBIT I-1
## LOCATION MAP



The specific alignments selected for the two transmission lines were largely determined through a route selection process which is documented in the Routing Study.[1] The Routing Study describes the rationale for selecting the alignments between Pohoiki and the Puna Substation. References will be made to the Routing Study throughout this EIS in the discussion of environmental setting, potential impacts, mitigation measures and alternatives to the proposed action.

The route selection process was an objective evaluation of conditions in the study region to identify areas of constraint and opportunity for a transmission line through the area, and was conducted by DHM Planners inc., an environmental planning consultant. Two guidelines were given to the consultant by HELCO prior to commencing the study. They are as follows:

1. Due to the physical and technical difficulties of placing one or two additional alignments within the Highway 130 right-of-way, (Pahoa Highway),[2] identify and locate the proposed alignments outside of the Highway 130 right-of-way.

---

1. The report titled Pohoiki Geothermal Transmission Line Routing Study, by DHM inc., November 1987, hereinafter referred to as Routing Study, is bound at the end of this EIS.

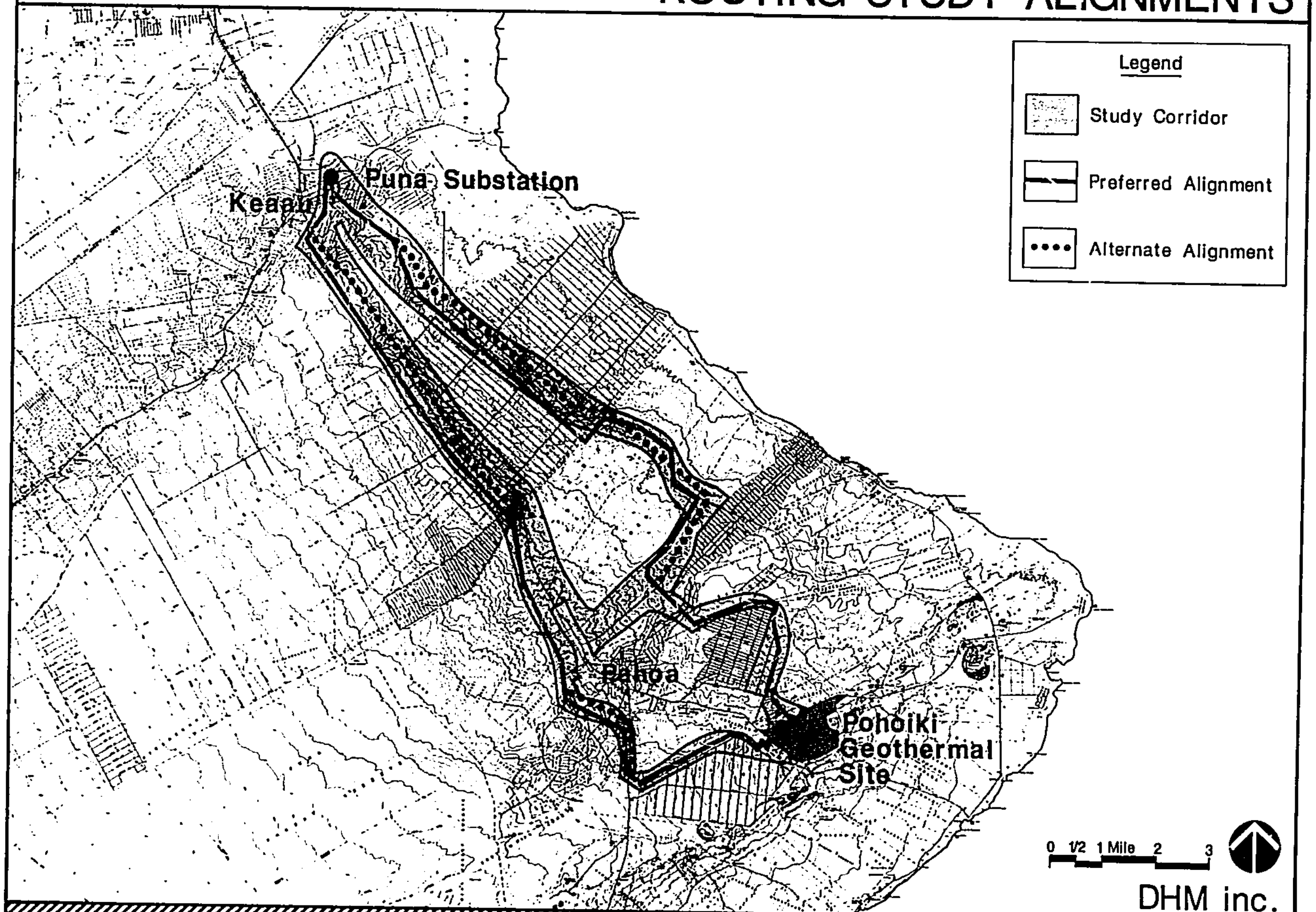
2. These difficulties are described on pp. 76 & 90 of the Routing Study.

2. The two alignments should be separated by one-half mile to reduce the risk of failure of both lines at one time due to a natural catastrophe such as an earthquake, lava flow, brush fire, or hurricane. Less than one-half mile separation was acceptable if the alignments were separated by a major highway corridor.

With these two conditions the route selection process proceeded in two phases. The first phase was an analysis which identified potential transmission corridors in the Puna region by means of overlay mapping of various geophysical, biological, socio-economic and cost constraint factors. The corridors varied in width, but in all cases were wide enough to permit the consideration of several alternate alignments. The second phase of routing selection involved more detailed mapping of the selected study corridors, based largely on field surveys and aerial photo interpretation. Several alignments were delineated and evaluated. During both phases, the public, affected landowners, and government agency representatives reviewed the constraint criteria and route selection. Detailed explanation of the routing study methodology is contained in Chapter II of the <u>Routing Study</u>. Preferred and alternate alignments were identified during the route selection process and they are shown and described in Chapter VI of the <u>Routing Study</u>, and are shown on Exhibit I-2 on the following page.

# EXHIBIT I-2

## ROUTING STUDY ALIGNMENTS

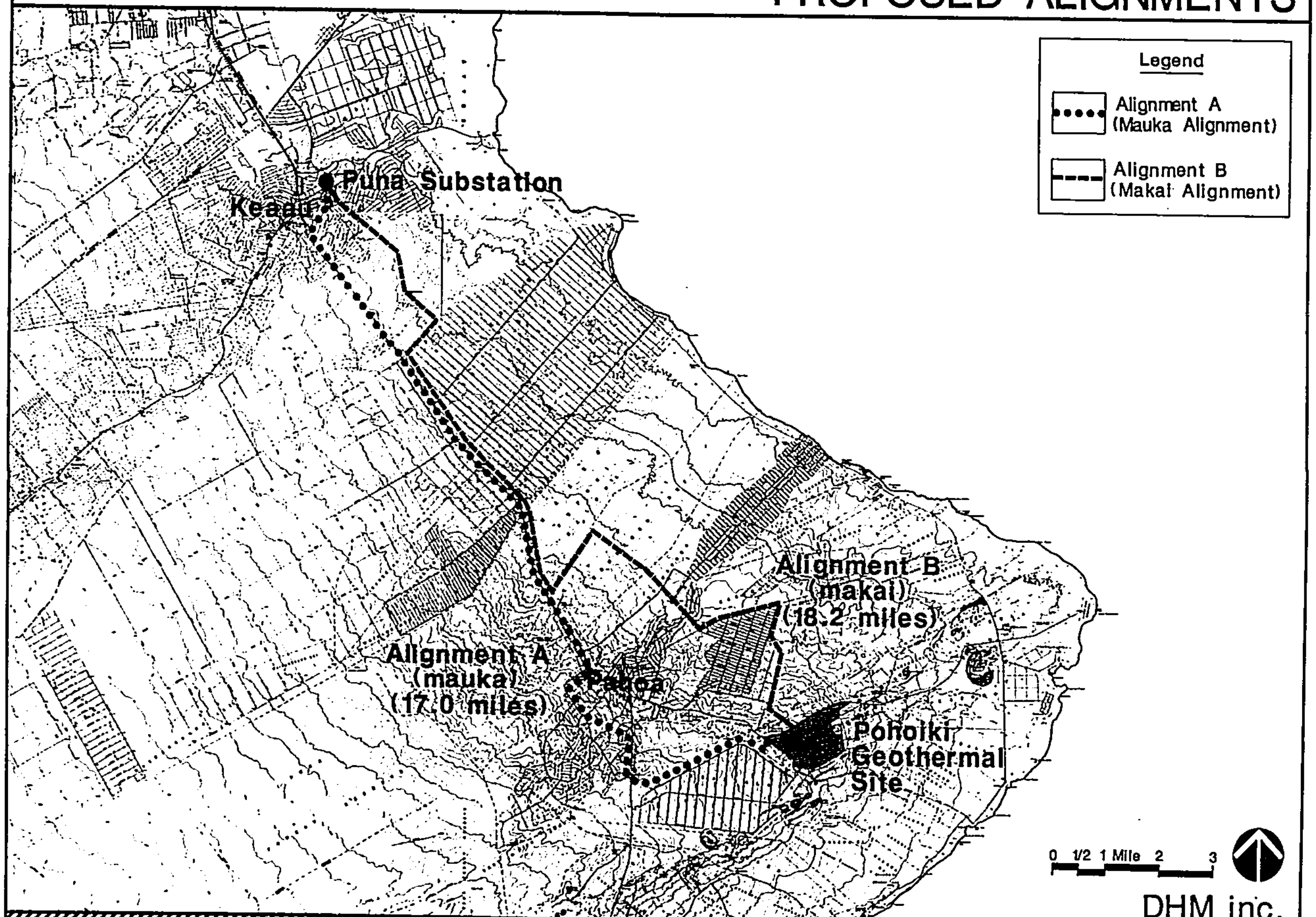


As a result of subsequent meetings with concerned community and subdivision associations, government officials, and Hawaiian Telephone Company, HELCO was able to lift its first of two guidelines and instructed DHM Planners, inc. to finalize the proposed routes, including portions along Highway 130. It is for these routes, shown in Exhibit I-3, that this EIS is written.

In the project area along the routes there are two geographic conditions which subject it to the requirements of Chapter 343, Hawaii Revised Statutes (HRS). A portion of each alignment passes through 1) the State Conservation District, and 2) State-owned land in the Agricultural District. (Refer to Exhibit I-4.) Therefore, the proposed action in these areas is subject to environmental assessment by the Department of Land and Natural Resources (DLNR), and the DLNR determined that an Environmental Impact Statement (EIS) is required. This document has been prepared to fulfill that requirement. Although only those routes within areas of State-owned or Conservation District land technically require an EIS, this EIS covers the entire length of both alignments to fully evaluate and expose the potential impacts and mitigation of the entire project.

# EXHIBIT I-3

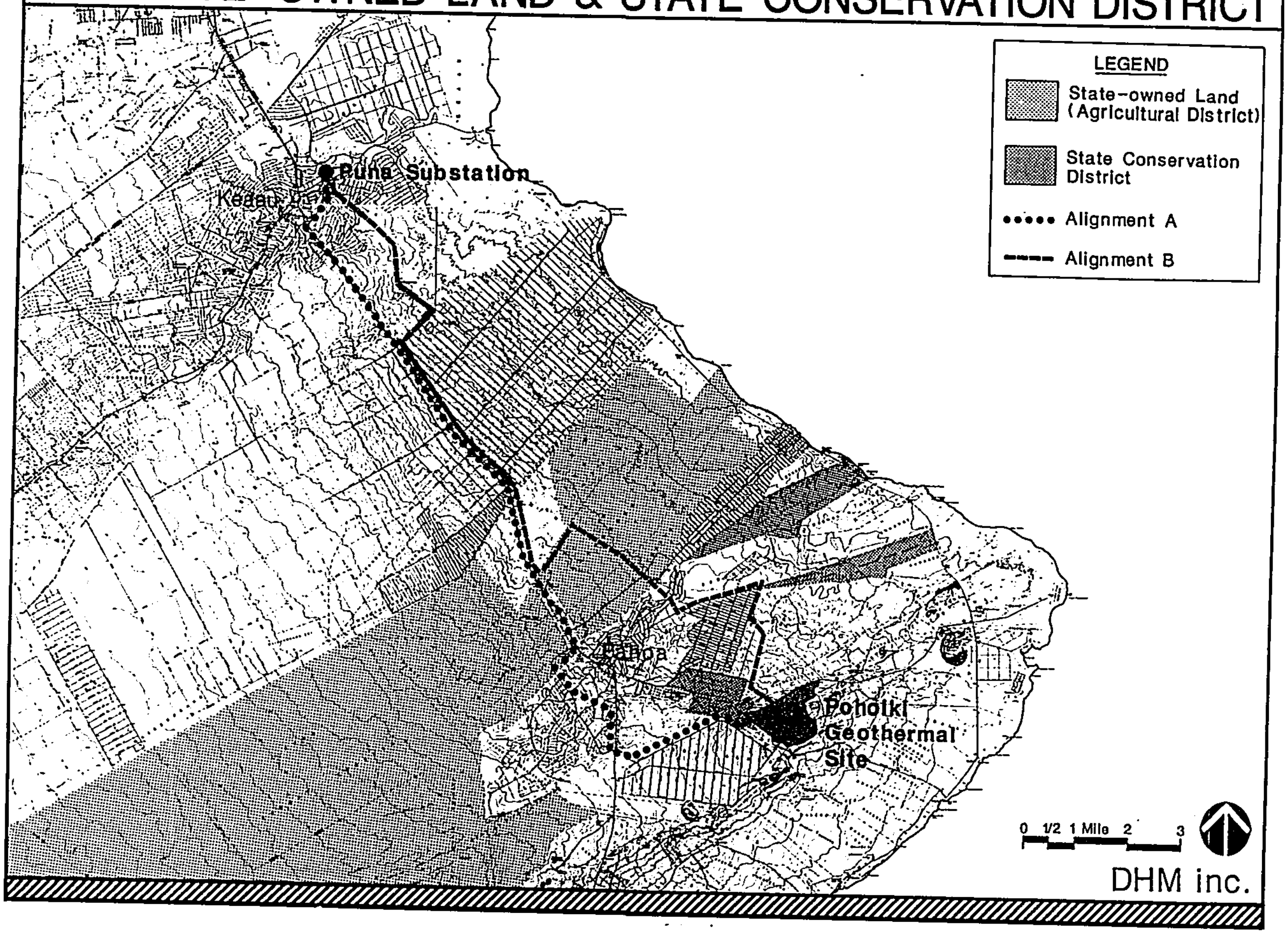
## PROPOSED ALIGNMENTS




DHM inc.

# EXHIBIT I-4

## STATE-OWNED LAND & STATE CONSERVATION DISTRICT



B. PROJECT LOCATION

As shown on Exhibits I-3 and I-4, the proposed project consists of two 69 kV transmission lines between the Pohoiki geothermal site and Puna Substation. Alignment A, the mauka alignment, will be constructed first. It will originate on the western edge of the geothermal site, cross Pohoiki Road, and enter Nanawale Forest Reserve (NFR) - Part 3 which is designated as State Conservation District. At the property line between the forest reserve and Leilani Estates Subdivision, the alignment will be located within the forest reserve to avoid crossing the numerous private one-acre residential parcels of the subdivision. The alignment within the Conservation District will be about 4,000 feet long. Once beyond the subdivision, Alignment A will be located on Puna Sugar Company land as it follows a dirt road along the northwest edge of Leilani Estates Subdivision toward Kalapana Road. Alignment A will cross Kalapana Road and continue across former sugarcane fields and along an existing road to Highway 130, just north of Pahoa town. From this point, the alignment will be located within the highway right-of-way, on the mauka side of the highway, for 9.7 miles. For the entire length along the highway, the new poles will be shared between HELCO and Hawaiian Telephone Company (HTCO). The existing telephone poles along the highway will be removed. About one-half mile south of Keaau, Alignment A will cross Highway 130 and follow a paved road northeast to connect to the main power grid near the Puna 69 kV Substation. The total length of Alignment A is 17.0 miles.

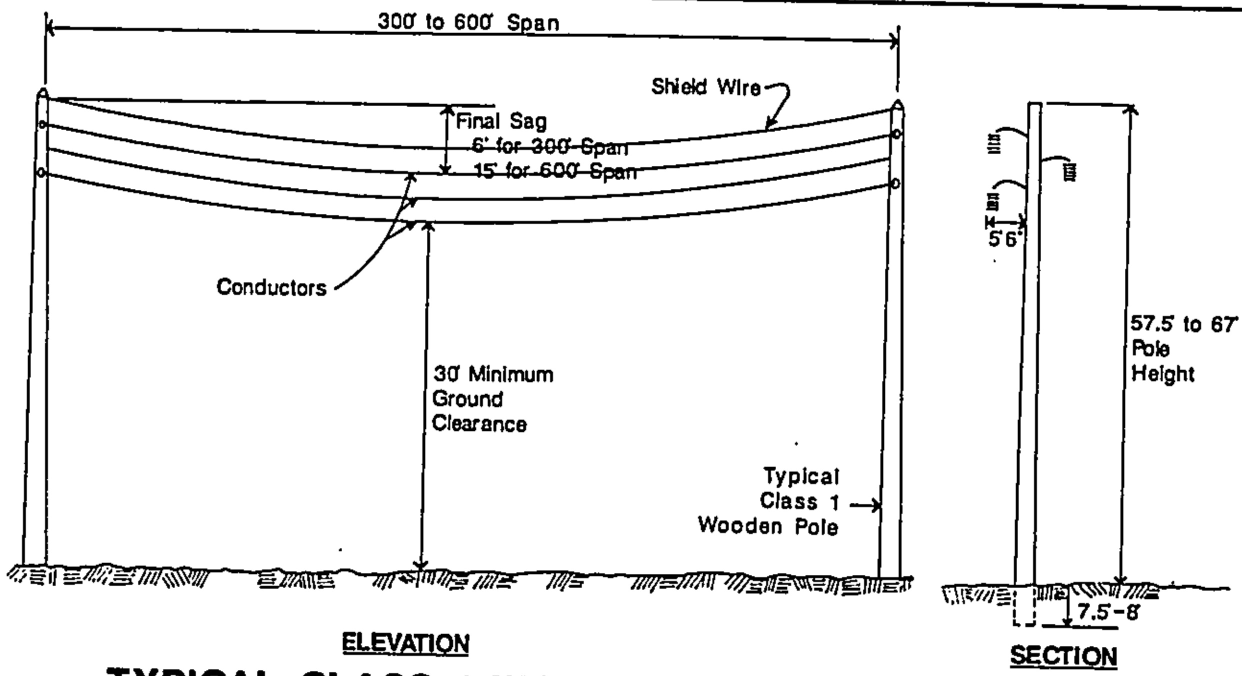
Alignment B, the makai alignment, is proposed to originate on the northern edge of the geothermal site, cross Kapoho Road, and head northwest across open vacant land to the edge of Nanawale Farm Ranch Lands. It then continues along the outside edge of the Ranch Lands and Nanawale Estates Subdivision to avoid the subdivided parcels. At the northeast corner of Nanawale Estates, the alignment will cross the triangular tip of Nanawale Forest Reserve, thereby crossing 250 feet of State-owned Conservation District land. Once beyond the forest reserve, the alignment is located on State Agricultural District land as it heads northeast, across Kahakai Boulevard, to the edge of Hawaiian Home Lands' Maku'u property. The alignment will remain on State land, adjacent to Maku'u, until it reaches Highway 130. Alignment B will then head northwest within the highway right-of-way for 5-1/2 miles, until it is north of Hawaiian Paradise Park Subdivision. Once it clears the subdivision, the alignment will be routed toward the former railroad right-of-way, now an existing jeep trail. It will continue to follow this jeep trail to 8-1/2 Mile Camp, at which point it takes the most direct route to the Puna Substation. The total length of Alignment B is 18.2 miles.

## C. PROJECT FEATURES

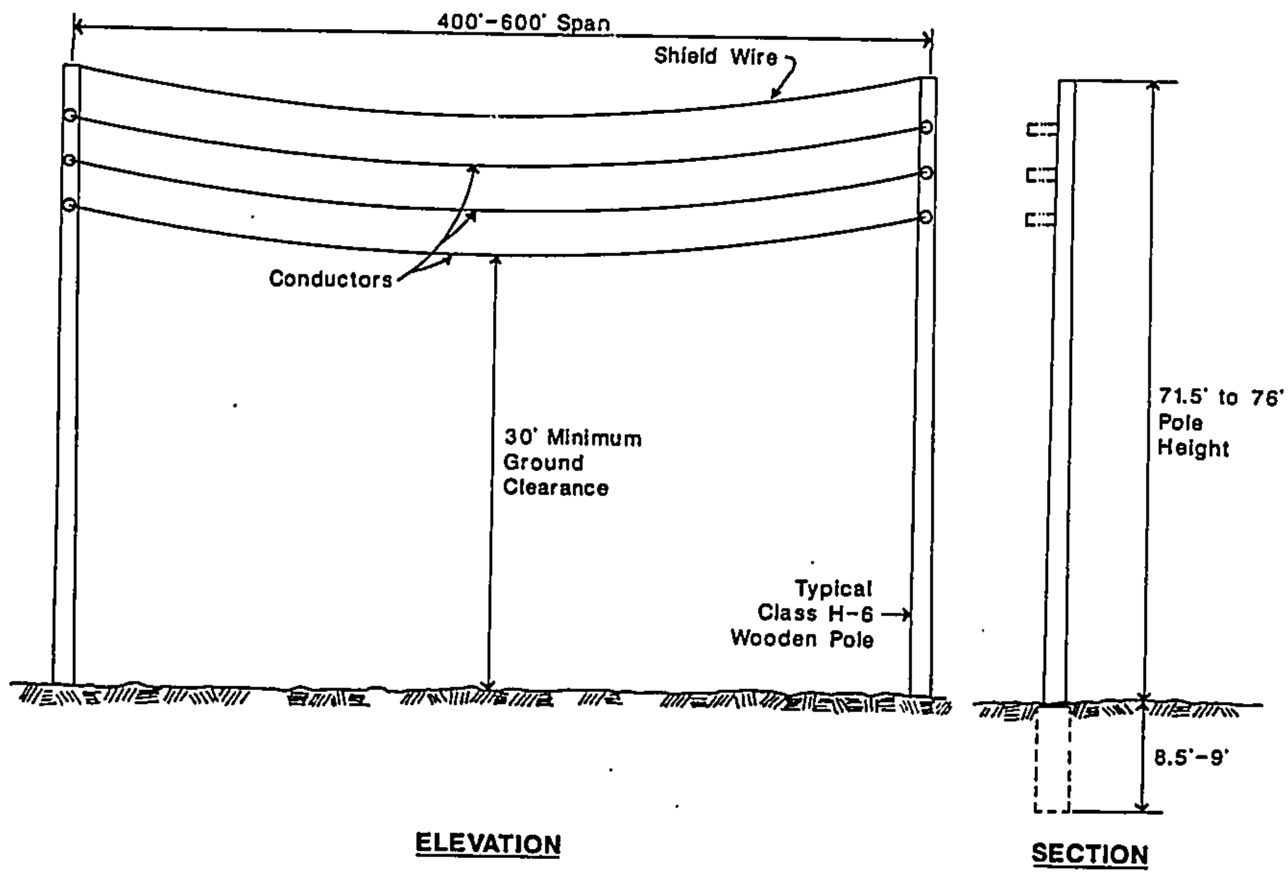
Each proposed 69 kV transmission line will consist of three aluminum conductors (0.856 inch diameter) which will be supported by horizontal post insulators or strings of suspension insulators attached to single wooden poles. (Exhibits I-5 and I-6) A shield wire (0.375 inch diameter) will be strung at the top of the poles for protection against lightning. The poles will be spaced approximately 300 to 600 feet apart, depending upon physical conditions in the vicinity of pole sites and various structural factors such as tension or weight on the conductors caused by changes in the direction of the alignment, high wind velocities and other climatic or atmospheric conditions. Alignment A will use approximately 224 poles (based on 400 feet span) over its 17.0-mile length and Alignment B will need approximately 240 poles over its 18.2-mile length.

Most of Alignment A and Alignment B will be constructed with class 1 wooden poles ranging between 57.5 and 67 feet above ground with 7.5 to 8 feet embedded in the ground. The poles will have a diameter of approximately 16 inches at the base, tapering to approximately 8.5 inches at the top. The wood will be fully treated against termite damage and rot. To provide stability against high winds and changes in direction of the alignment, guy wires and anchors may be installed on some poles.

# EXHIBIT I-5
## TYPICAL 69 KV LINES



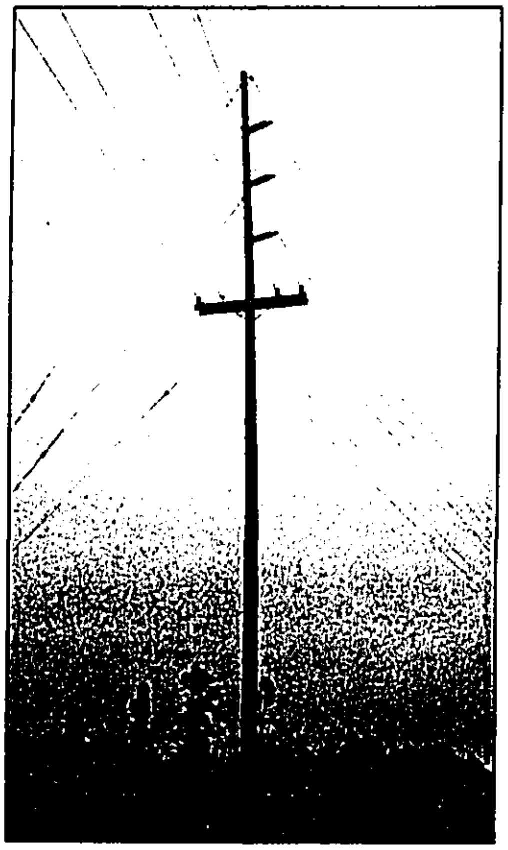
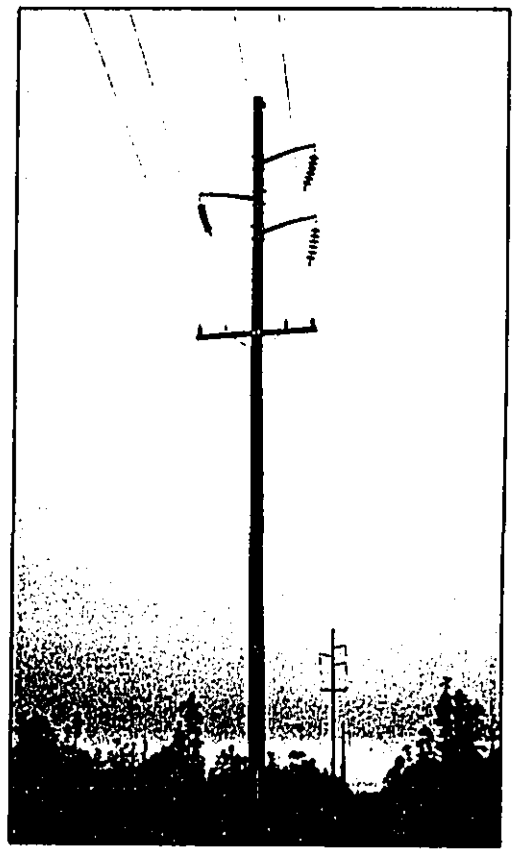

**TYPICAL CLASS 1 WOODEN POLE CONFIGURATION**




**TYPICAL CLASS H-6 WOODEN POLE CONFIGURATION**

DHM inc.

# EXHIBIT I-6
# PHOTOS OF TYPICAL POLES

Typical wooden poles (69 kV)

DHM inc.

Class H-6 wooden poles will be used for the limited segments of Alignments A and B which are within the highway right-of-way along Maku'u and Hawaiian Paradise Park Subdivision to provide added reliability in an area where the two alignment have minimal separation. (Exhibit I-7) Class H-6 poles are similar to class 1 except that they have a larger diameter and are therefore stronger. Alignment A class H-6 poles will be the same height as class 1 poles, 57.7 to 67 feet, and their diameters will range from 12.5 inches at the top to 21.5 inches near the base. Alignment B class H-6 poles will be 71.5 to 76 feet tall and 12.5 to 23.5 inches in diameter. (Exhibit I-5)

Where an alignment is not within an existing road right-of-way, HELCO will require a 50-foot wide easement for each transmission line. This will allow for conductor swing, multi-pole structures where necessary, and adjustments of pole sites in the field during construction should the pole hole diggers encounter adverse geological conditions, archaeological and historic sites, or areas of ecological sensitivity. The poles will generally be centered within the easement. Additional land segments may be required in some cases to accommodate guy wires and anchors falling outside the typical right-of-way.

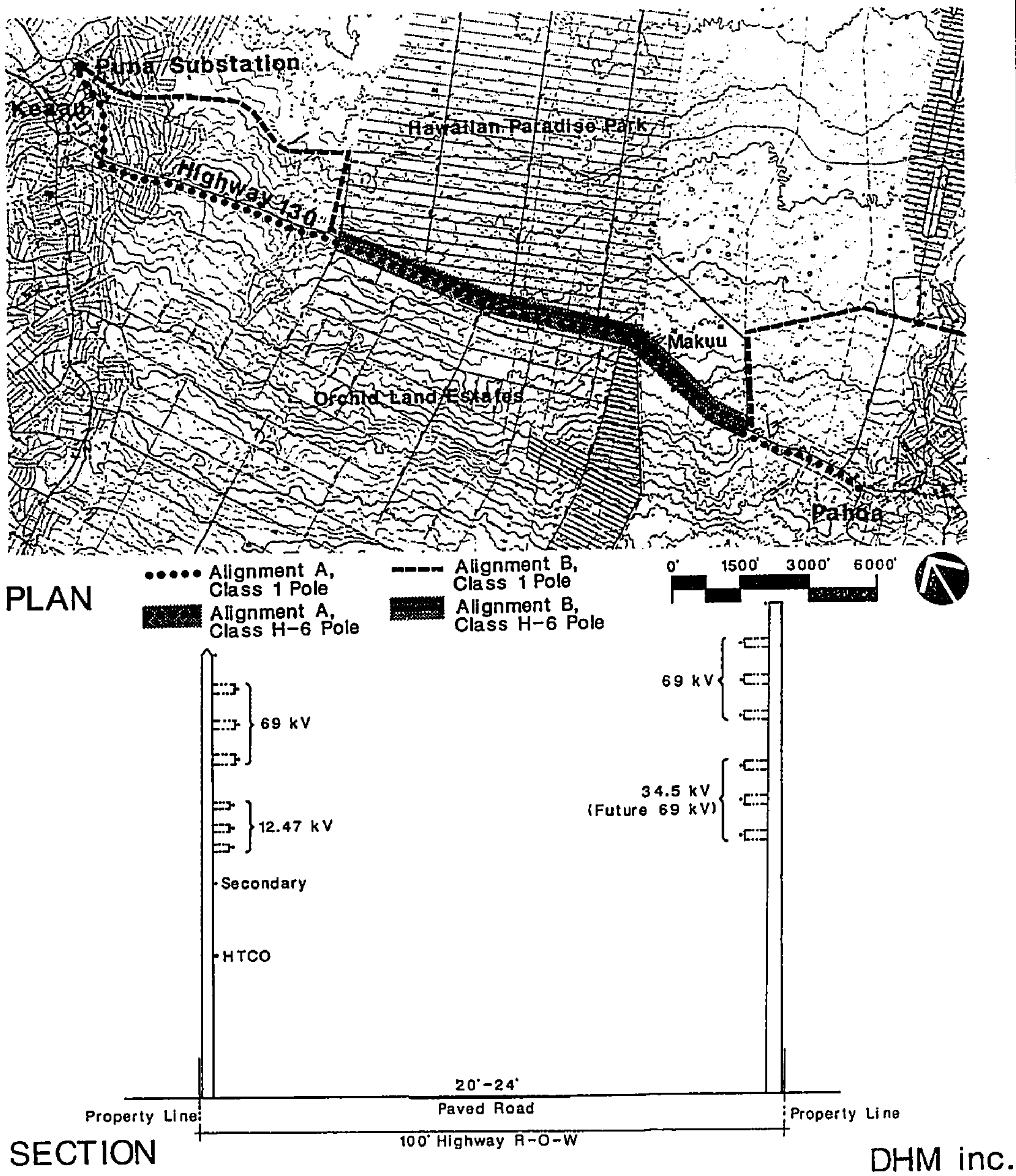
Where the two transmission lines are located within the right-of-way (R-O-W) of Highway 130, only necessary anchor and guy wire easements will be required. Although technically more difficult and expensive to design and construct, the alignment in the highway R-O-W allows the transmission lines to avoid crossing the subdivisions on either side of the highway. However, due to the limited space within the highway R-O-W, and the presence of existing subtransmission and distribution lines, special pole material and configurations are required.

As mentioned earlier, Alignment A along the highway will consist of class H-6 wooden poles used jointly between HELCO and HTCO. In addition to supporting the new 69 kV conductors (set of three), a shield wire, and the telephone line, the poles in this mauka highway segment will also support a 12.47 kV distribution line (set of three conductors) and secondary service lines. (Exhibit I-7) The 12.47 kV line and service lines are currently on existing poles with the 34.5 kV subtransmission line, located adjacent to the highway. Since these poles will be removed when Alignment B is constructed, the 12.47 kV line and service lines are planned to be relocated to Alignment A.

Where Alignment B is within the highway right-of-way, it will consist of taller class H-6 poles because the poles will support the proposed 69 kV transmission line and the existing 34.5 kV subtransmission line. The 34.5 kV line

# EXHIBIT I-7

# POLE LOCATION ALONG HIGHWAY 130



will be designed for possible conversion in the future to 69 kV, but will be initially energized at 34.5 kV. Upon completion of this alignment, the existing 34.5 kV line and poles along the highway will be removed.

Exhibit I-7 shows configuration of the poles along the highway, and shows the relationship between the two alignments and the highway right-of-way.

As the demand for electric energy grows in the Puna area, the existing 34.5 kV subtransmission lines, substations, and substation feeders will need to be upgraded to accommodate the growing demand.

## D. CONSTRUCTION

Construction of the proposed lines will entail the following steps:

- Preparation of staging areas where materials and equipment are stored and assembled.
- Hauling of poles and other materials to staging areas.
- Clearing and rough grading for construction/access road.
- Preparing pole sites.
- Hauling poles to their sites and framing the poles.
- Setting the poles.
- Stringing the conductors on the poles.

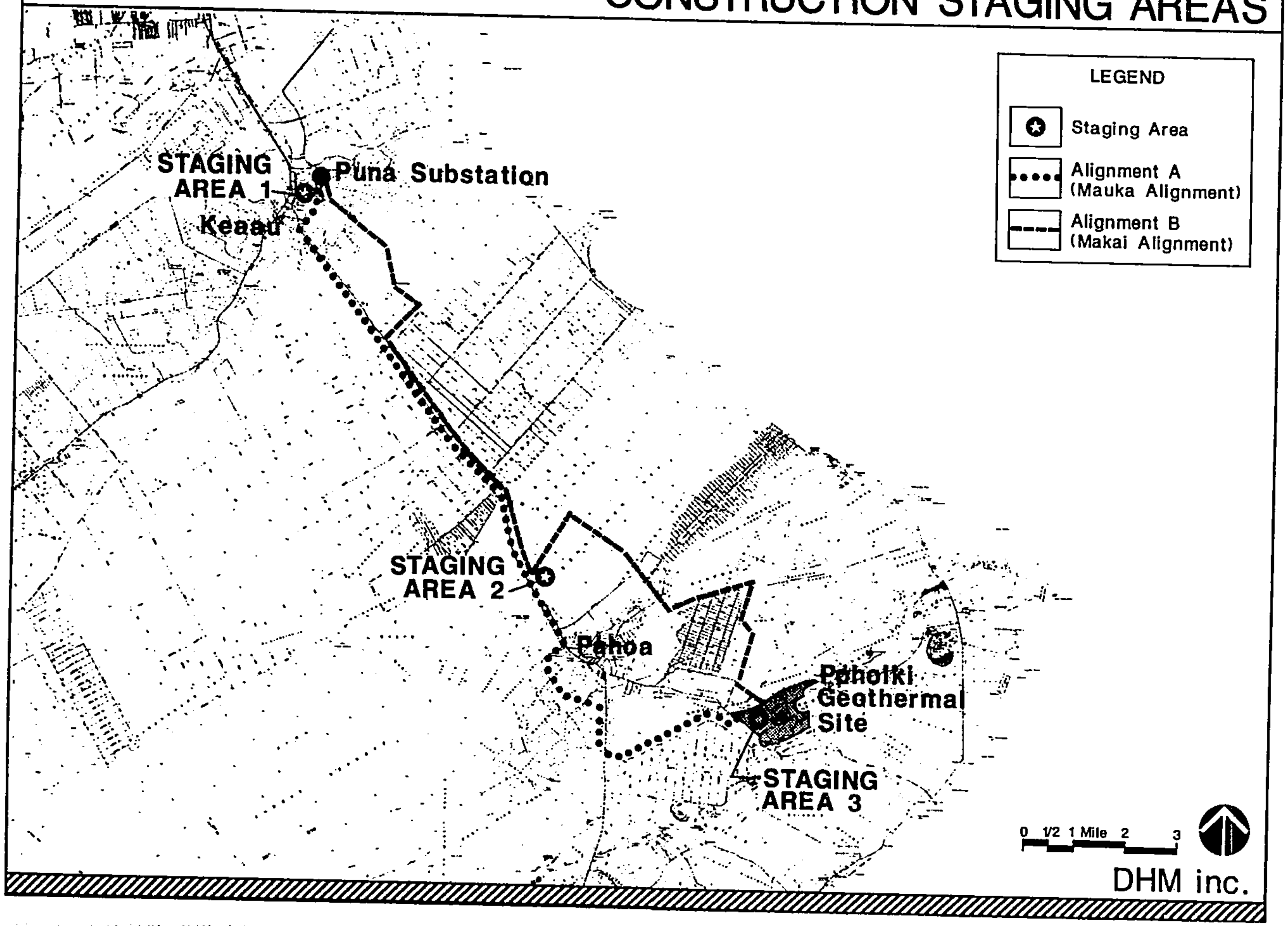
Three staging areas will be required during construction of the proposed lines for equipment and material storage throughout construction, as well as for helicopter support during conductor stringing operations. The staging areas are to be located near the beginning, middle, and end of the alignments as shown on Exhibit I-8. Each area will be approximately one acre in size.

The staging area sites have been selected based on their proximity to the alignments, their accessibility, and their relatively level ground surface. None of the sites has sensitive environmental features and all are within lands zoned for agricultural use. Site 1 is located within the Pohoiki Geothermal site property which is privately owned by Kapoho Land and Development. Site 2 is located along Highway 130, just north of the Pahoa landing strip on State-owned land; and Site 3 is located on former sugarcane land owned by Shipman, near the Puna Substation.

Site preparation of the staging areas would be limited to rough grading and the installation of a perimeter security fence. Transmission poles and other materials will be hauled to the staging areas by a pole trailer and equipment trucks.

The poles will be the largest and heaviest materials to be transported over ground. A trailer rig can carry about 10 poles per trip. Since a total of up to 240 poles will be

# EXHIBIT I-8
## CONSTRUCTION STAGING AREAS



required for each line, approximately 50 round-trips between a storage yard in Hilo and the staging areas will be made. The trailer rigs will travel during off-peak hours on Highway 130 and will utilize secondary roads as much as possible.

The staging areas will be used concurrently for a period of about 18 months. Transmission poles, guy wires, insulators and hardware such as nuts, bolts and washers will be stored there until they are moved to the specific pole sites. The conductors will most likely be kept in HELCO's base yard until the stringing operation commences. During stringing operations, the staging areas will be used for short time periods by helicopters to pick up materials or refuel. Fuel trucks will be brought to the staging areas as required. No fuel will be stored on-site. After construction, all equipment, supplies, and other man-made material will be removed from the area and the site will revegetate naturally.

Due to the relative accessibility of the area, and the number of existing roads and jeep trails through the area, construction of the two transmission lines will be undertaken primarily by ground crews and heavy ground equipment. Through undeveloped areas where there is no existing road or trail, a construction/access road will be created within the 50-foot right-of-way. This road must be 10 to 12 feet wide, roughly graded, passable by

4-wheel-drive vehicles, but need not be completely cleared of low vegetation. In an area heavily vegetated with trees and shrubs, an additional 10 to 15 feet along one side of the road must be cleared for framing and setting the poles. Existing trails or unpaved roads will be used to the greatest extent possible.

At each pole site, a hole approximately 2-1/2 feet in diameter and 7-1/2 or 8 feet deep will be dug. Hand tools and a back hoe will be used where possible. However, soil conditions at many of the sites, particularly those covered by recent lava flows, may preclude the use of manual digging. In such cases, the use of air hammers and explosives[3] may be necessary. After the pole has been set, the hole will be backfilled with excavated or imported material. Installation of anchors will be performed in a similar manner.

Most of the pole foundations will be embedded into basaltic rock which has a high lateral load bearing capacity. The primary concern in these areas will be to seek out and repair any lava tubes or other cavities immediately adjacent to the embedded foundations. When a pole site is directly above a lava tube or cavity, HELCO's general procedure is to evaluate the size and depth of the opening to determine its feasibility for a pole foundation. If the opening is small,

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3. Explosives will not be used in populated and developed areas.

and not identified by the biologist or archaeologist to be preserved or repaired, HELCO will build a foundation in it by filling the opening with rock, soil, and/or concrete. If a cave or cavity is too large, it will be re-sealed, and another pole site selected.

As the pole holes are prepared, transmission poles and necessary materials will be hauled to each pole site from the nearest staging area. The poles will be laid alongside the construction/access road near the respective pole site and crews of at least four persons will install transmission and grounding fixtures, conductor devices, and insulators on the poles while on the ground.

Poles will be lifted into place using a crane, and held in place while the hole is backfilled with the excavation material. A utility line-truck and pick-up or 4-wheel-drive would be at the site also, plus a minimum 4-man crew.

The construction process will include two methods for stringing the conductors. The location of the line determines the method of stringing. Use of helicopters saves time and cost, however they will be used only in open country, away from residential areas and highly travelled roads. In order to avoid the potential noise disturbance and property damage caused by helicopter rotor backwash, ground stringing methods will be used in populated areas. Trucks and equipment for ground stringing operations along a road will use one lane of the road for stretches averaging one-half mile at a time. Using the ground method, an average of one mile of conductors can be installed per day. Using one or two helicopters, an average of 4 to 5 miles of conductor can be installed per day. Conductor installation generally requires a 10 to 12-person crew.

E. SCHEDULE AND COST

The entire project, from initial planning to operation, is scheduled to proceed as follows:

1. Preliminary planning - This has been completed for both lines and is documented in the Routing Study and this EIS.

2. Design - This phase includes preparing construction documents and specifications for each line and ends when all necessary permits have been obtained.

3. Construction - This entails the actual building of the lines. Operation of each line marks the end of its construction phase.

The approximate schedule, by phase and line, for this project is shown in Exhibit I-9.

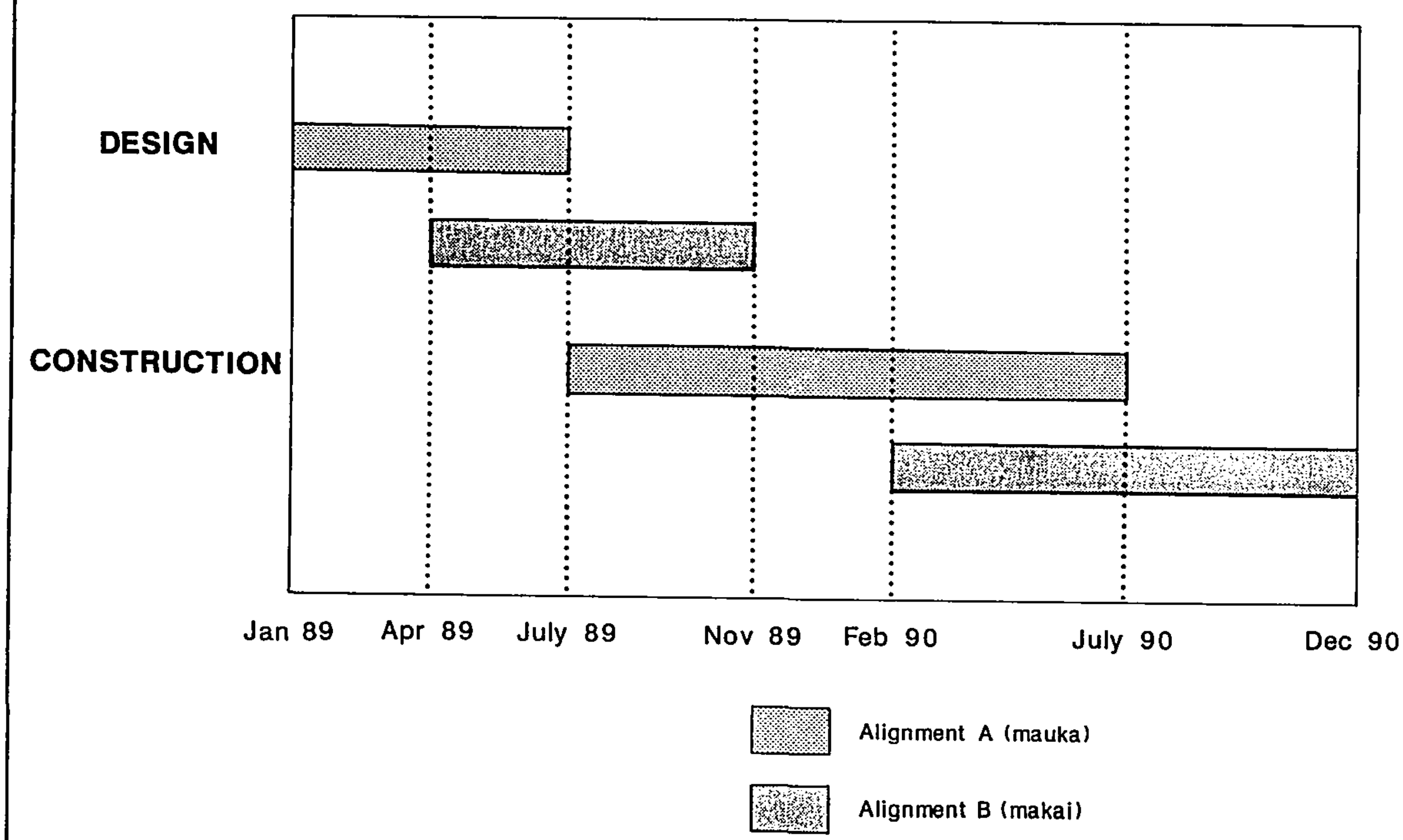
The design and construction of the transmission line(s) is expected to cost about $10 million (1989 dollars).

## F. MAINTENANCE

Once the transmission lines are built and in operation, the rights-of-way and construction/access roads will be used for maintenance purposes only. Periodic fly-overs and visual inspection will be done to identify problem trees that may be interfering with the conductors, and generally all vegetation beneath the lines that may grow over 30 feet will be removed. Other vegetation will be allowed to grow back within the right-of-way, especially at the edges.

With the exception of large trees, the access road will be cleared as necessary when it is being used. No herbicides will be used to control vegetation within the right-of-way.

## EXHIBIT I–9
## PROJECT TIMETABLE




DHM inc.

# CHAPTER II

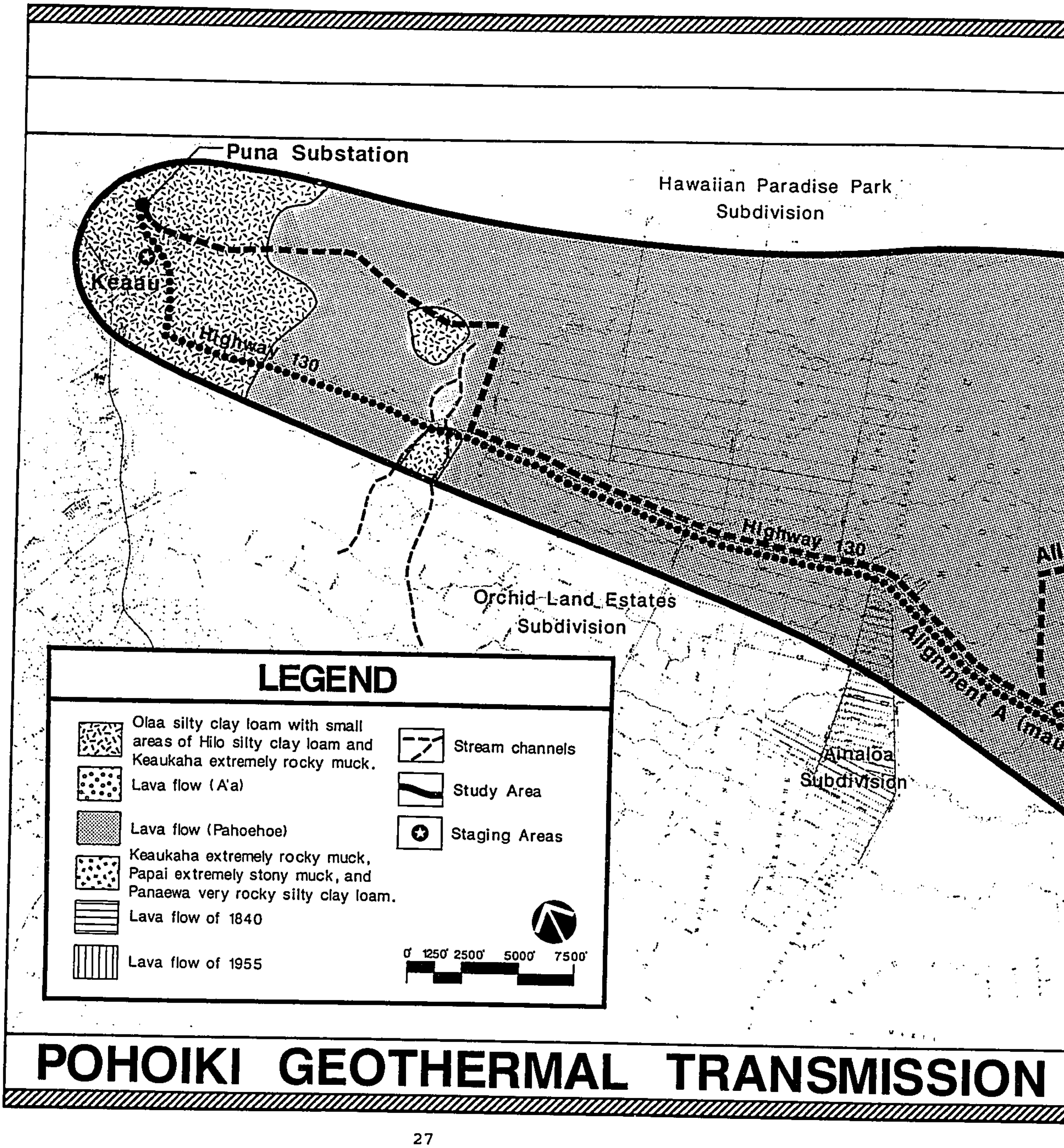
## CHAPTER II: EXISTING ENVIRONMENTAL SETTING

The physical and visual conditions in the routing study corridors influenced the selection of the proposed alignments for the two 69 kV transmission lines between Pohoiki and the Puna Substation. These conditions are described in Chapter VI of the Routing Study (pp. 74-93). The EIS study area, described in this chapter, encompasses both routing study corridors and the land between them.

### A. GEOLOGIC CHARACTERISTICS (Exhibit II-1)

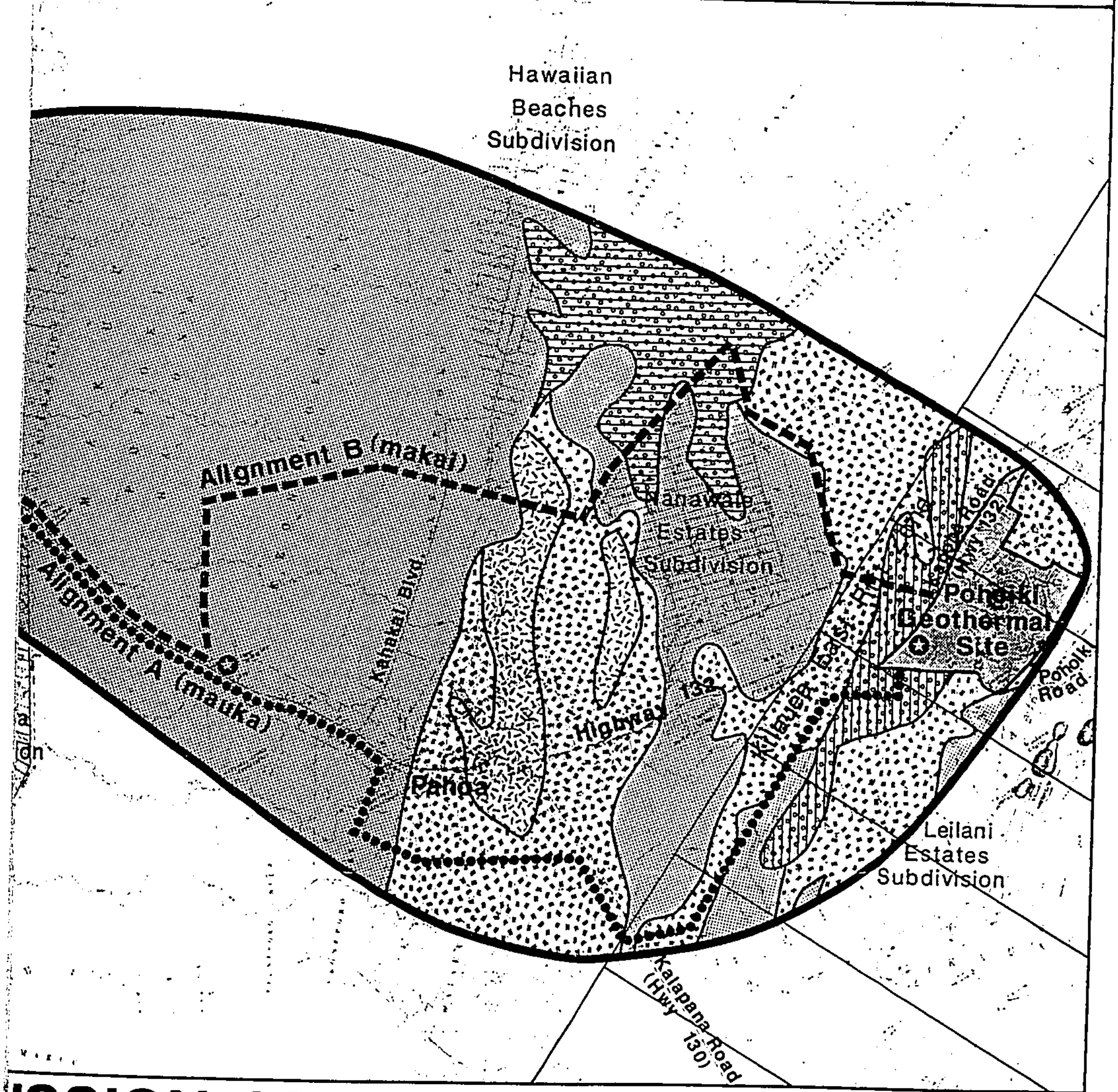
The proposed alignments are located on the lower east slopes of Kilauea and Mauna Loa volcanoes. The ground slopes downward towards the northeast across the corridors at an average gradient of two percent. However, on a smaller scale, the lava flows have created an irregular, undulating landscape.

Within the last 1500 years, many lava flows from the Kilauea summit have entered the corridor region, however the latest was 350 years ago. Most of the recent flows in the region have been emitted from Kilauea's east rift zone, including an 1840 and 1955 flow as indicated on Exhibit II-1. Earthquake epicenters are also concentrated along the east rift zone. As a result, there is a higher risk for potential lava flows and seismic hazards near the Kilauea east rift zone.


Puna Substation
Hawaiian Paradise Park
Subdivision
Keaau
Highway 130
Highway 130
Orchid Land Estates
Subdivision
Ainaloa
Subdivision
Alignment A (mau
LEGEND
Olaa silty clay loam with small areas of Hilo silty clay loam and Keaukaha extremely rocky muck.
Lava flow (A'a)
Lava flow (Pahoehoe)
Keaukaha extremely rocky muck, Papai extremely stony muck, and Panaewa very rocky silty clay loam.
Lava flow of 1840
Lava flow of 1955
Stream channels
Study Area
Staging Areas
0' 1250' 2500' 5000' 7500'
POHOIKI GEOTHERMAL TRANSMISSION

# EXHIBIT II-1

## SOILS/GEOLOGY

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The general geology of the area is conducive to the formation of lava tubes and cavities, and they are present along all of the alignments. Major lava tubes were mapped by Holcomb in 1980,[4] and others were identified by biological and archaeological consultants for the Routing Study in April 1987.

The soil and geologic conditions throughout the study area are very similar. In general, lava flows throughout the region exist at the surface or underlie shallow soil cover.

Most of the central portion of the region, that area north and northwest of Pahoa town, consists of pahoehoe lava flows and has little or no soil cover. The areas with soil cover are generally limited to the two ends of the corridors. Around Keaau and the Puna Substation, Olaa silty clay loam, up to 25 inches thick, is predominant, with limited areas of Hilo silty clay loam which is over 5 feet thick. These soils are formed from volcanic ash. Soils between Pahoa and the geothermal plant site consist primarily of organic and volcanic ash that is typically very rocky and less than 8 inches deep, and pahoehoe and a'a lava flows. Soils in the Puna region generally have rapid permeability, slow runoff, and slight soil erosion potential as rated by the Soil Conservation Service.

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4. Refer to Plate 4 in Appendix F of the Routing Study.

The absence of well-defined streams is typical for the Puna area where the rainfall percolates rapidly into the well-drained soils and highly permeable lava flows. Only two stream channels (both dry) pass through the study area, and these cross Alignment A just north of Orchid Land Estates. Between the highway and the former railroad alignment, the two stream channels merge and terminate just before Alignment B near Waipahoehoe.

## B. CLIMATE

The Puna region has a relatively high annual rainfall. The project area between Pahoa town and the Puna Substation have an average annual rainfall of 150 inches, while the area east of Pahoa, near the geothermal plant, receives 100 to 125 inches of rain per year. By comparison, Kailua-Kona and downtown Honolulu receive 20 to 30 inches of rain per year.

Temperatures in the area are quite uniform throughout the year, with the monthly means ranging from 71 to 76 degrees. The rainiest and coolest month in Puna is December, while the hottest and driest are June and July.

Winds in the Puna area are affected by Mauna Loa where the onshore flow provides an upslope wind by day and a counter downslope wind develops at night and in the early morning. The latter flow predominates. Average wind speeds range between 7 and 8 miles per hour, with slightly stronger winds in mid-afternoon and light winds in the evening hours.[5]

C. BIOLOGICAL CHARACTERISTICS

During the route selection, field surveys were conducted by scientists and professional experts to inventory the existing biological characteristics of the area in terms of vegetation, insects, and birds, and to identify areas of potential environmental problems or concerns. The surveys covered the entire corridor areas delineated in the Routing Study, except those portions through the agricultural subdivisions of Hawaiian Paradise Park, Orchid Land Estates, and Ainaloa. These subdivisions were not surveyed due to the present degree of disturbance to the environment resulting from the residential development. The proposed alignments do not cross these subdivisions.

1. Vegetation (Exhibit II-2)

The vegetation in the study region reflects the geologic and climatic conditions. Because of the volcanic activity in the Puna district, the natural maturation sequence of vegetation is constantly being truncated, resulting in youthful plant communities. This is particularly evident along the alignments near the power plant site. The dominant vegetation cover is the early successional association of ohia

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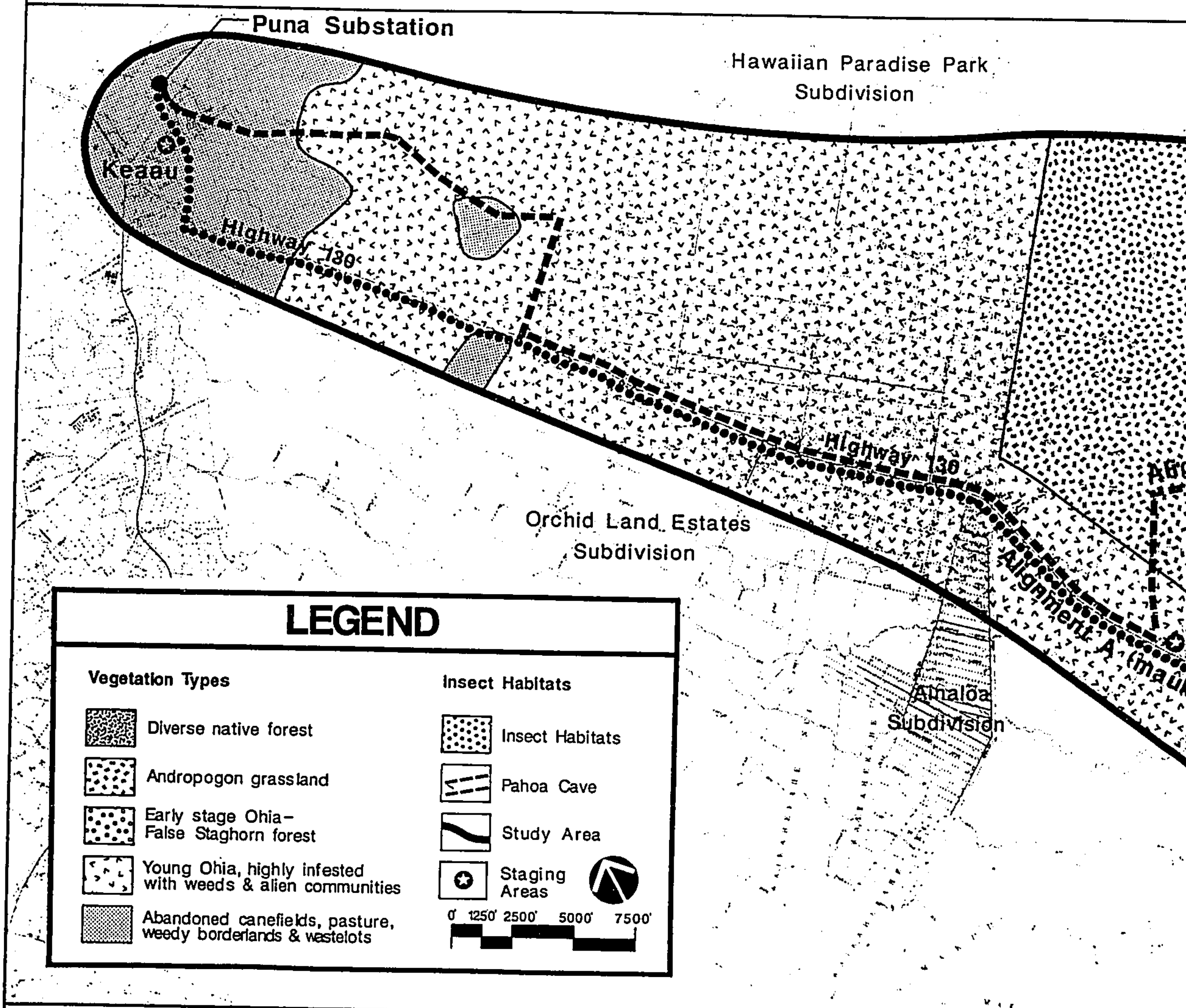
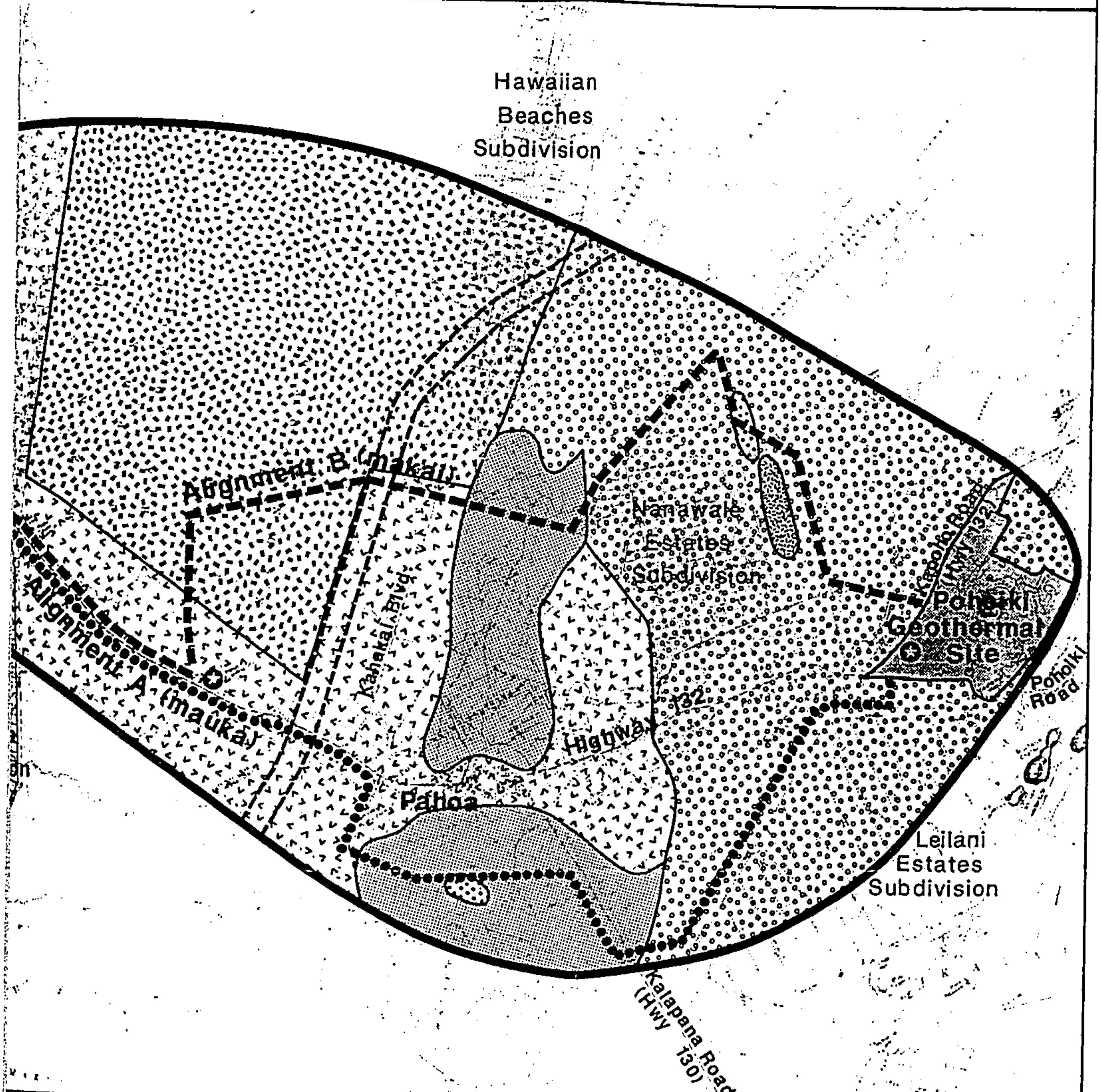
5. Bechtel National, Inc., Puna Geothermal Venture Project Application, December 1986, pp. 6-5 to 6-11.




POHOIKI GEOTHERMAL TRANSMISSION

# EXHIBIT II-2

## VEGETATION & INSECTS

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(Metrosideros polymorpha) and false staghorn fern (Dicranopteris linearis). While the species mix in the poorly developed to young forest is primarily of native character, diversity is very low and consists essentially of common plants found in many other regions of Hawaii. In areas with older lava flows, the ohia forest has greater maturity, height, interlocking overstory, and an increase in species count. A narrow strip of forest in the Nanawale Farm Ranch Lands was identified as the best example of native forest encountered within the project area, but "is still mundane on any absolute measure of vegetation quality."[6]

The area around Alignment A west of Pahoa consists primarily of abandoned canefields, pastureland, and weedy borderland. When native communities are present, they are the common early-stage ohia type. A small kipuka, or pocket of native vegetation surrounded by sugarcane, was identified as an important insect habitat in this area, although the plant species were common items.

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6. W.N. Takeuchi, et.al., Bernice P. Bishop Museum, "Botanical Survey," April 22, 1987, p. C-5. Full report is contained in the Routing Study as Appendix C.

Alignment B, between Kahakai Boulevard and Highway 130, crosses an area of extremely homogeneous flora; a virtually unbroken expanse of Andropogon virginicum grassland. The area, likely under burn influence, contains a large number of standing ohia snags ranging in condition from states of advanced decomposition to freshly dead boles.[7]

Where the alignments are routed across agricultural and residential land, human activity has fragmented the vegetation into a mosaic of contrasting types, all of minimal botanical value. The largest native forest in this area is the fraction on both sides of Highway 130. Short-statured ohia trees are the dominant cover in the area, however the understory is frequently infested with weeds. Alien communities of guava, mango and albizzia are also interspersed throughout the area. Due to the presence of numerous houselots and agricultural plots, there is no continuity to the plant formations.

Most of the deep-soil areas northeast of the subdivisions, near the substation, have a long history of intensive agricultural use, and are now in the process of converting to weedy wastelots. While there

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7. Ibid., p. C-10.

are some patches of native ohia forest, including those along stretches of Highway 130, the communities are heavily infiltrated by aliens.

More detailed descriptions of the vegetation within the routing study corridors, and representative photographs, are contained in the subconsultant's report, Appendix C of the Routing Study.

2. Insects (Exhibit II-2)

With the exception of four areas of important concentrations of native insect species, two of which are of critical importance, the project area is populated by non-native or common native insects. The critically important habitats are lava tube caves where surface vegetation provides the main energy source to the caves via root penetration. Cave-adapted animals which subsist in these environments are highly sensitive to surface alteration or destruction.

Pahoa Cave extends mauka-makai through the study area, roughly parallel to Kahakai Boulevard. Many cave-adapted creatures, unique to this cave, were collected and observed, including cixid bugs, crickets, crane flies, moths, millipedes, sow bugs, silverfish and centipedes.[8]

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8. G.M. Nishida and W.C. Gagne, "Terrestrial Arthropods," February 1987, p.3. Full report is contained in Appendix E of the Routing Study.

Kazumura Cave, another restricted habitat for many cave-adapted organisms, was not surveyed during this study but has been previously studied. It crosses Highway 130 and extends into Hawaiian Paradise Park subdivision. Due to the great number of lava tubes and caves in the Puna area, it is likely that additional important cave habitats exist beneath the alignments.

The other two significant insect habitats identified during the field survey are surface areas of native vegetation. The small kipuka southwest of Pahoa town, along the Pahoa dump road, produced a number of native insect species, including several that are probably new and undescribed.[9] In the northeast corner of Nanawale Farm Ranch Lands, paralleling Seaview Road, is a diverse community of native plants where a significantly high number of endemic and indigenous insect species, as compared to the number of alien species, were found, as well as a large number of species previously unknown from the Big Island.[10]

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9. Ibid., p. 4.

10. Ibid., pp. 5-6.

3. Birds

There is a relative abundance of common, exotic bird species throughout the project area. Based on the ornithological survey,[11] nutmeg mannikins and common mynas are most common in the agriculturalized area between the subdivisions and Puna Substation, whereas northern cardinals and house finches are more abundant in the wooded habitats of the remaining study area. Japanese white-eyes and the spotted dove and zebra dove are more evenly distributed throughout the area.

Nine less-common species were identified during the survey. Three of these were introduced exotic species (eurasian skylark, melodious laughing-thrash, and house sparrow), three were migrants (northern pintail, lesser scaup, and golden plover), and three were natives of special concern ('io or Hawaiian hawk, ae'o or Hawaiian black-necked stilt, and 'elepaio). The 'io and stilt are both endangered species. The single 'io was seen soaring high above Nanawale Farm Ranch Lands, and the two stilt were seen during one of four visits to some small ponds near the Puna Substation. The 'elepaio is not endangered but is not a common bird at these elevations on Hawaii. It was spotted near the railroad alignment just south of Keaau.

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11. Robert C. Fleischer, "Ornithological Survey," April 15, 1987. Full report is contained in Appendix D of the Routing Study.

The lack of a significant number of native forest birds or currently threatened or endangered species in the project area is largely due to the low elevation of the area and the lack of significant amount of wetland habitat.

D. <u>HISTORICAL AND ARCHAEOLOGICAL RESOURCES</u> (Exhibit II-3)

An intensive field survey and literature search were conducted to identify and evaluate archaeological resources in the study area.[12] The number of sites located (11 prehistoric-type and 3 historic-type)[13] is considered very low for the large study area that had not previously been examined through extensive fieldwork.[14] However, the findings do support a settlement pattern model for the area that predicts the occurrence of extensive prehistoric-type agricultural fields, and sites that reflect adaption to the physiograhic features in the area. The historic-type sites identified were associated with the sugar industry.

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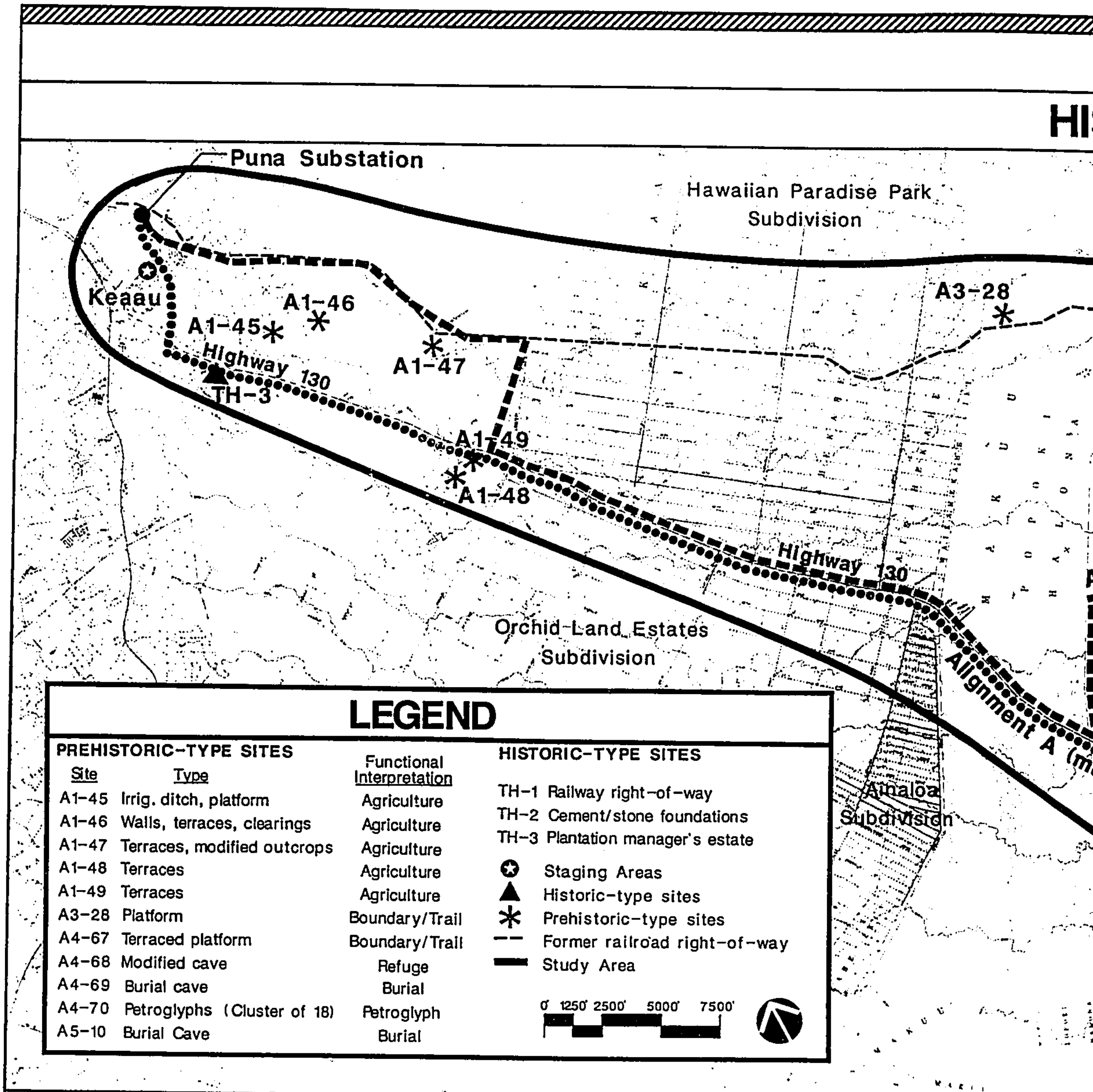
12. Eric K. Komori, "Archaeological Survey," Honolulu, April 30, 1987. Full report is contained in Appendix B of the <u>Routing Study</u>.

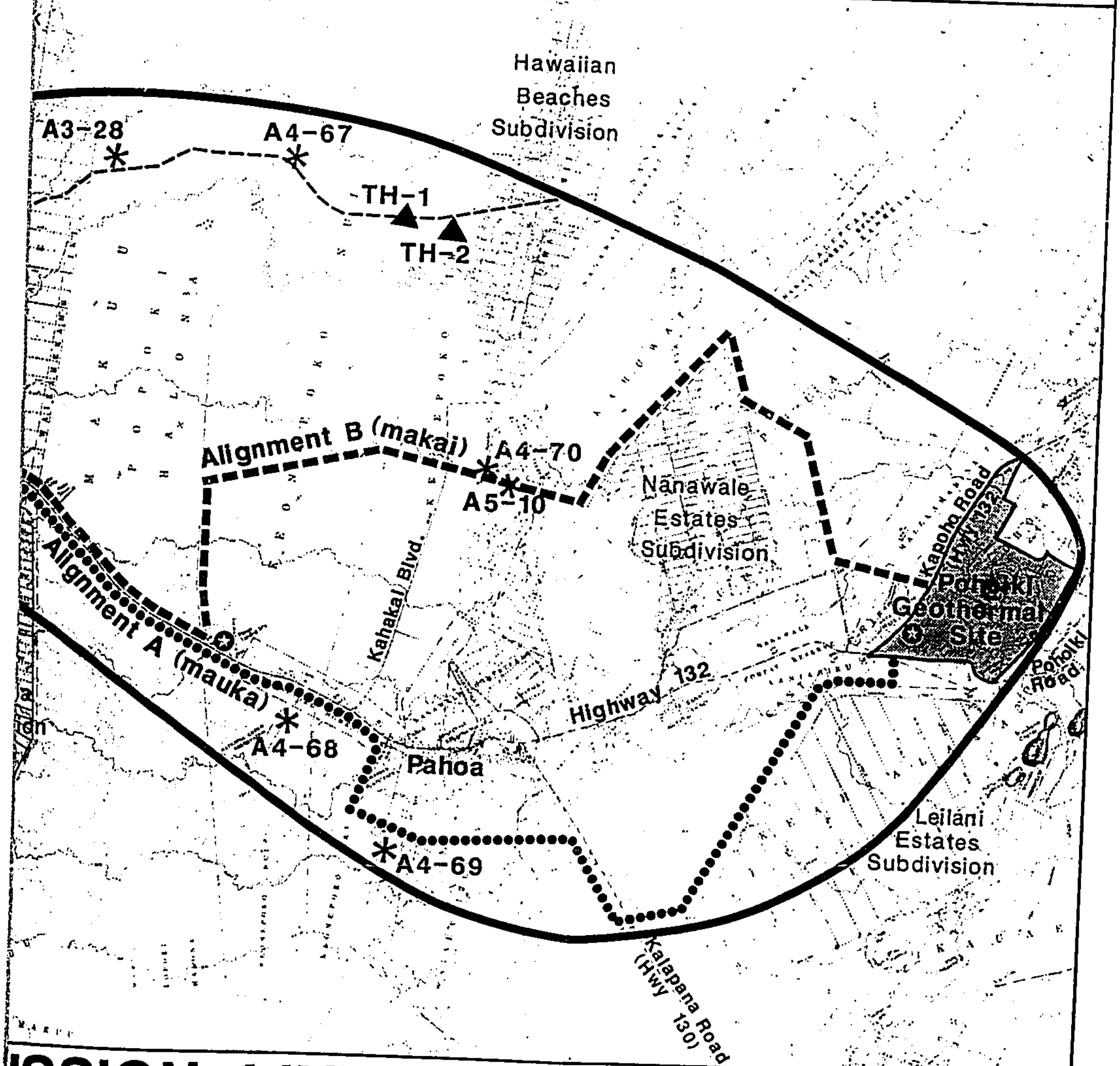
13. Prehistoric-type sites imply association with traditional Hawaiian cultures, and historic-type sites imply association with later cultures (typically after arrival by westerners in 1778).

14. E. Komori, p. 8.




# POHOIKI GEOTHERMAL TRANSMISSION

# EXHIBIT II-3
# HISTORIC & ARCHAEOLOGICAL SITES



Prehistoric Sites

Five sites (A1-45 through A1-49) are related to prehistoric-type agricultural activities and are located in the northwest portion of the study area where deeper soils occur. The sites are limited in extent due to extensive alteration of the terrain by modern agricultural use. However it is likely that the features are remnants of large, permanent agricultural complexes described by early historic visitors. The sites consist of such features as irrigation ditch, platform, walls, terraces, clearings, and modified outcrops.

Prehistoric sites A4-68, A4-69, A5-10 are lava tube caves that were used for refuge and burial. Skeletal material found in the burial caves were extensively disturbed, although they seem to be from the prehistoric period. The refuge cave is probably part of an extensive network of lava tubes located northwest of Pahoa town that may extend to coastal areas. It is highly likely that additional lava tube sites, possibly connected with the refuge cave, are present in areas with similar geologic morphology since two other refuge caves have been located in the general area.[15]

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15. Ibid., pp. 7 & 30.

Prehistoric sites A3-28 and A4-67 are platforms located along the former railway right-of-way and near ahupua'a boundaries. This leads to a tentative interpretation that they may be territorial boundaries or trail markers.

Prehistoric site A4-70 consists of petroglyphs similar to figures found at other sites in Hawaii.

Historic Sites

Pahoa town and the former right-of-way for the Hawaii Consolidated Railway are the only previously identified historic-type sites within the field survey corridors. The three historic-type sites identified in this survey are as follows:

Site TH-1 is the former right-of-way of the Hawaii Consolidated Railway that extends through the study area.

Site TH-2 consists of two cement foundation-like structures that are situated directly on the railroad right-of-way. This archaeological site has no association with prehistoric-type activities.

Site TH-3 is the Olaa Sugar Company plantation manager's estate located along Highway 130, approximately three-fourths mile south of Keaau.

Exhibit II-3 shows the location of the sites and their site numbers (as assigned following the Bishop Museum system), and summarizes the sites' type and function. Detailed descriptions of each site can be found in Appendix B of the Routing Study.

## E. AIR QUALITY

There are currently two State monitoring stations in the study area; one in Nanawale Estates and one in Leilani Estates. These stations were developed to measure only hydrogen sulfide ($H_2S$) for the purpose of developing State standards. They have been operating off and on since 1986.

More extensive baseline air quality monitoring was conducted in the Puna region in 1983-1985 by (then) Department of Planning and Economic Development (DPED), National Park Service, and a geothermal developer. The results obtained from five studies are summarized by DPED in Baseline Air Quality - Kilauea East Rift, Executive Summary, September 13, 1985.

The present air quality in the region is good most of the time since there are no large man-made stationary sources of pollution in the vicinity and the area is not highly urbanized. Air quality is primarily affected by the sulfur dioxide ($SO_2$) emissions from nearby volcanic activity. The studies indicate that the majority of the time, atmospheric concentrations of $SO_2$ in the project area are relatively low. However during periods of vigorous volcanic activity or periods of unusual meteorological conditions, such as winds from the south, episodes of high concentrations do occur.[16] In addition, vog and acid rain are increasing concerns on the entire island as well as in Puna.

Particulate matter has also been monitored along the Kilauea East rift and was found to be very low. The particulate concentrations of the area are much lower than mainland values and U.S. Environmental Protection Agency Standards.[17]

There are no available readings for carbon monoxide (CO) levels in the region, but they are expected to be low because of the rural character of the region and the few number of major roadways carrying significant amounts of traffic.

## F. NOISE LEVELS

Due to the rural character of the region and the relative absence of urban uses and highway traffic, noise levels throughout much of the project area are quite low. An environmental noise survey was conducted within and near the proposed Pohoiki geothermal plant site in 1986.[18]

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16. DPED, Baseline Air Quality-Kilauea East Rift, Executive Summary, September 13, 1985, p. 7.

17. Ibid, p. 3.

18. Bechtel, Section 8.

Hourly average (Leq) sound levels from two locations at the plant site ranged from 35 to 64 decibels (dB) during daytime, and 38 to 47 dB during nighttime. At a site located near Kahukai Street in Leilani Estates Subdivision, the daytime range was 39 to 51 dB and the nighttime range was 41 to 53 dB.[19] Prevalent noise during the daytime hours is from distant and local traffic, wind, birds, and insects. These readings are "acceptable" and "unconditionally acceptable" according to Federal standards,[20] and are probably characteristic for much of the region. As a general rule, noise levels of 55 Ldn (day/night sound level) or less occur in rural areas or urban areas shielded from high volume streets.

The existing traffic noise levels along Highway 130 are probably in the range of 65 to 70 dB, which is typical along highways and major roadways. These levels fall in the "significant exposure, normally unacceptable" category. Generally, traffic noise levels along the first row of homes fronting a major roadway represent the worst case (or highest) noise levels for homes of a subdivision. Traffic

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19. Moderate winds greater than 6 mph and moderate to heavy rains occurred during the one day of measurement at Leilani, and increased the nighttime sound level by up to 9 dB.

20. U.S. Department of Housing and Urban Development standards: "Minimal Exposure, Unconditionally Acceptable" - less than 55 Leq; "Moderate Exposure, Acceptable" - 55 to 65 Leq.

noise levels at interior lots typically have 5 to 10 Ldn lower noise levels resulting from shielding and distance effects.[21]

G. LAND USE/LAND OWNERSHIP (Exhibits II-4 & II-5.)

Major land uses in the project area include productive agriculture, residential/agricultural subdivisions, and vacant and abandoned agriculture lands. Land ownership and parcel size in the area is varied. There are many large properties owned by the State, Hawaiian Home Lands, and private landowners, as well as many small residential and agricultural properties owned by private individuals. Exhibit II-4 shows the various land uses within the project area and Exhibit II-5 shows the general land ownership pattern. Refer also to the larger-scale exhibits in Chapter VI of the Routing Study for land uses and land ownership.

1. Agriculture

Agriculture has had a significant impact on land use in Puna. Until the closing of Puna Sugar Company in 1985, sugarcane production was the primary agricultural land use in the region. Since then, papaya acreage has been steadily increasing. Agricultural land is also devoted to other types of produce and flower cultivation, and there are numerous plots of marijuana scattered throughout the region.

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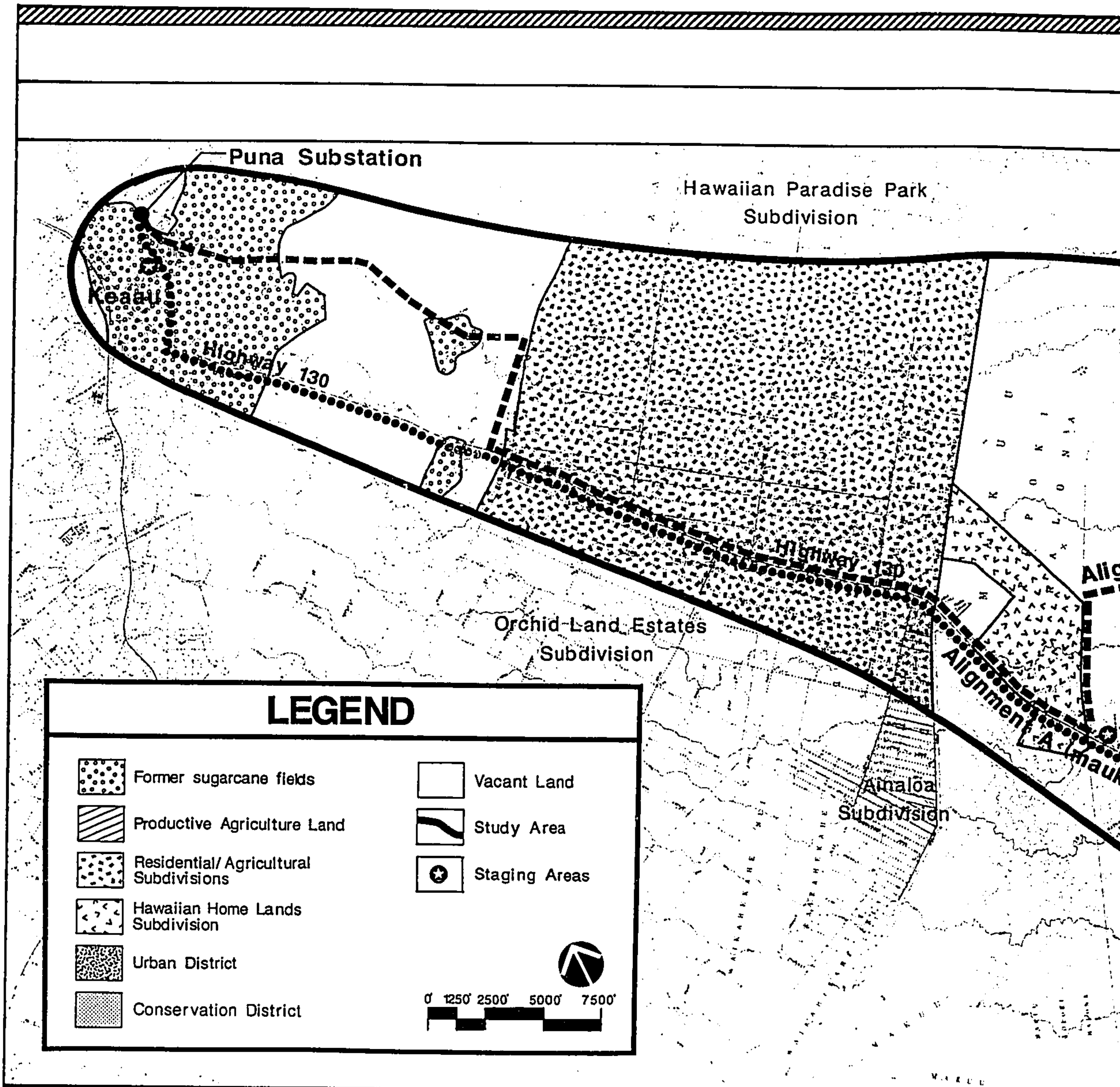
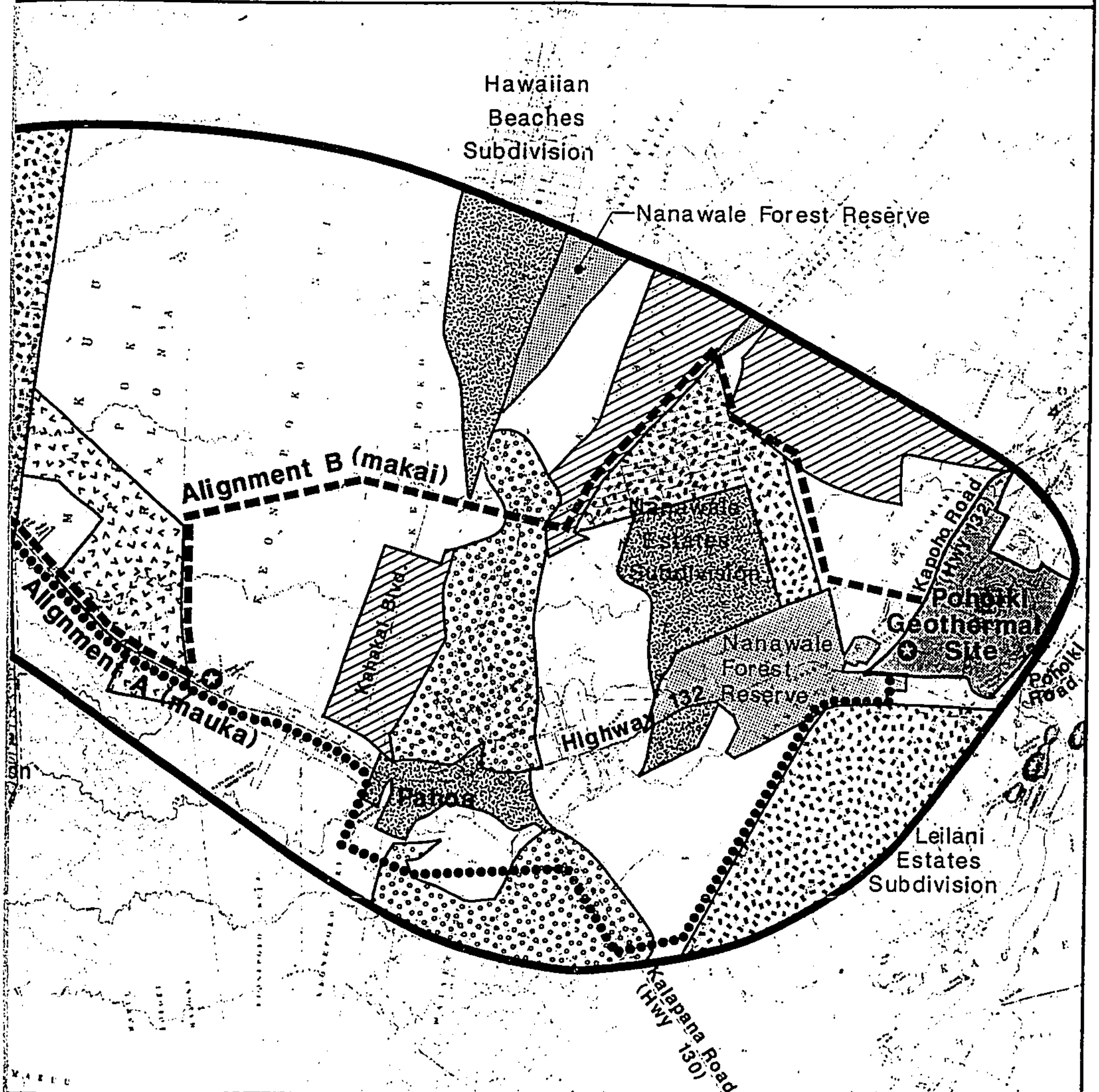
21. Y. Ebisu, Traffic Noise Study for the Proposed Nitto Kogyo Golf Course, 1986.

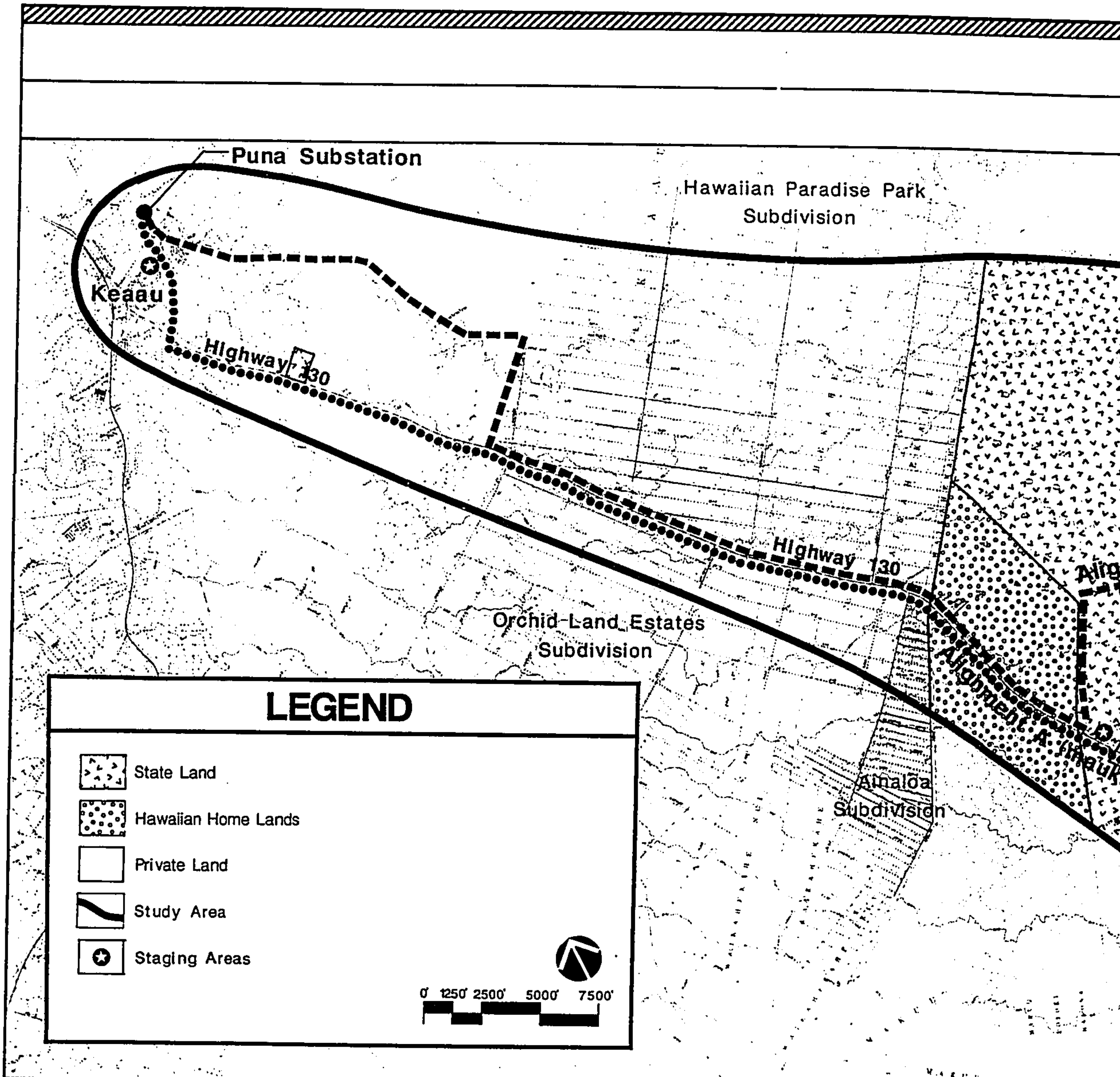



# POHOIKI GEOTHERMAL TRANSMISSION

# EXHIBIT II-4

## LAND USE

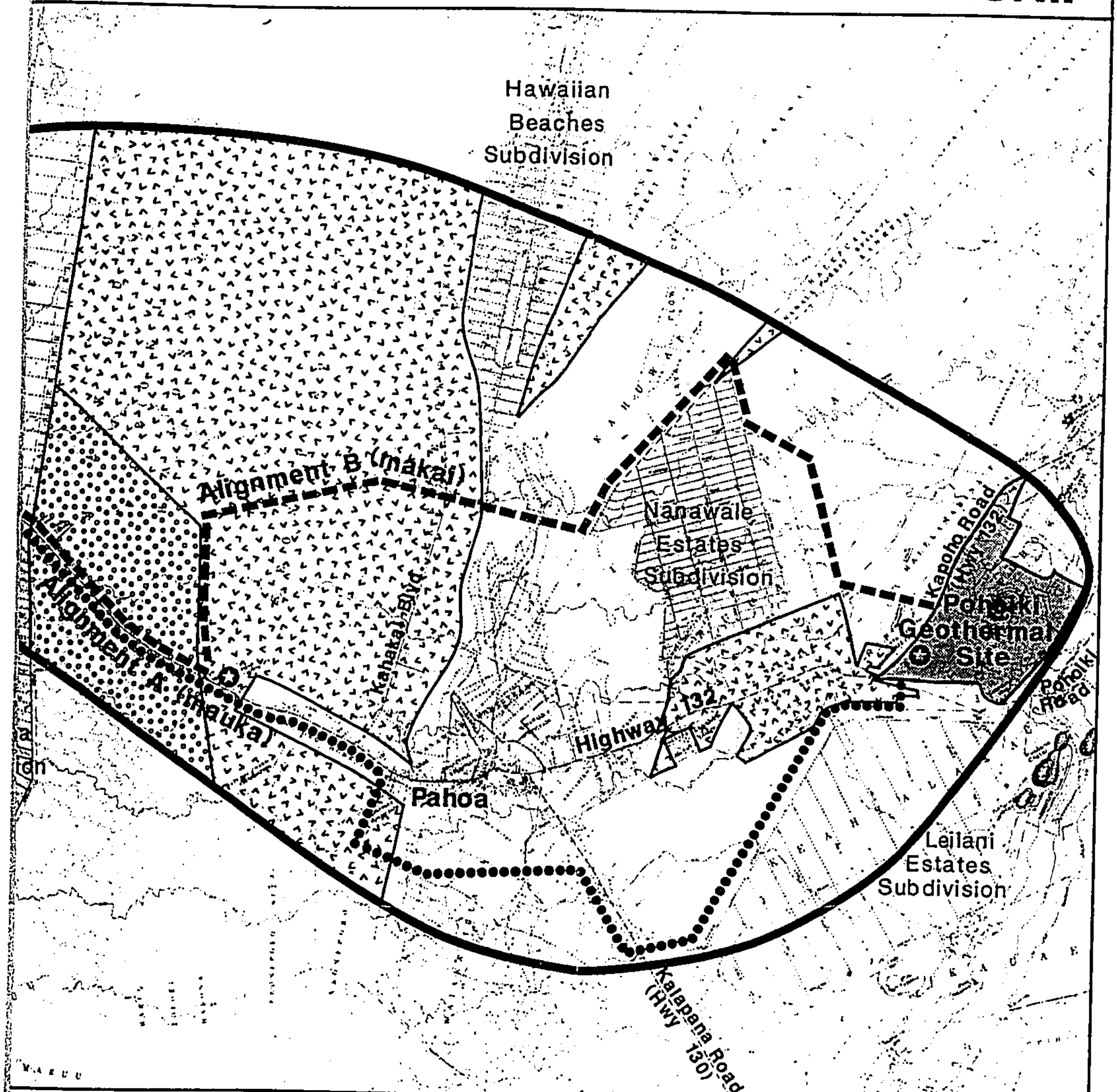





# POHOIKI GEOTHERMAL TRANSMISSION

## EXHIBIT II-5

## LAND OWNERSHIP

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The production of sugar is no longer an active land use in the region. The alignments cross several acres of former cane fields, which are now mostly reverting to scrub vegetation and weed lots. As shown on Exhibit II-4, Alignment A crosses abandoned cane fields owned by Puna Sugar Company along Kalapana Road and crosses abandoned fields on land owned by the Catholic Church, west of Pahoa. Alignment B crosses a former cane field south of Kahakai Boulevard on land owned by Bishop Estate and leased to Puna Sugar. In the project area near Puna Substation, both alignments cross former cane land owned by Shipman and leased to Puna Sugar Company.

Alignment B is located at the edge of productive papaya fields near Nanawale Estates Ranch Lands and Nanawale Estates Subdivision. Most of these lands are privately owned by large landowners such as Bishop Estate, and are leased to several small individual growers as well as Diamond Head Papaya Company. Along Kahakai Boulevard is the State-owned Pahoa Agricultural Park, 5- to 30-acre agricultural lease lots which are used primarily for flower production and foliage plants. Neither alignment will impact this agricultural park. The project area is likely to include other parcels in agricultural production of bananas, cocoa, cut flowers, and macadamia nuts particularly near the substation.

Despite the extensive agricultural zoning in the Puna district and the emphasis on agriculture in the County General Plan, only a small percent of the land has been classified by the Department of Agriculture's ALISH (Agricultural Lands of Importance to the State of Hawaii) system. In the vicinity of the proposed alignments, the Puna lands classified as "Prime Agricultural Lands"[22] are those which are described above as abandoned sugarcane lands. There are scattered patches of "Other Important Agriculture Lands"[23] in the Orchid Land Estates subdivision and between Hawaiian Beaches and Nanawale Estates Subdivisions.

2. Residential/Agricultural Subdivisions

Large portions of the Puna district, especially upper Puna, have been subdivided into fee-simple residential lots.

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22. Prime Agricultural Lands are defined as the best suited for the production of food, feed, forage and fiber crops. When treated and managed, including water management, according to modern farming methods, the land is capable of producing sustained high yields of crops economically.

23. Other Important Agriculture Lands are defined as having statewide or local importance for the production of food, feed, fiber and forage crops. However, these lands exhibit properties such as seasonal wetness, erodibility, limited rooting zone, slope, flooding or droughtiness.

Two subdivisions near Alignment B (Hawaiian Beaches, Shores and Parks, and the southern portion of Nanawale Estates) are zoned by the County for urban use and are designated by the State as Urban Districts. They have fee-simple lots of less than one-half acre. The proposed makai transmission line does not cross Hawaiian Beaches, but runs adjacent to it on vacant State land to the northeast. (Exhibit II-4) This line is also adjacent to Nanawale Estates on two sides.

The remainder of the subdivisions in the project area (Leilani Estates, Nanawale Farm Ranch Lands, Hawaiian Paradise Park, Orchid Land Estates, and Ainaloa) are zoned for agriculture by the County and are in the State Agricultural District. For the most part, however, they are not in agricultural use, but are generally in residential use. Yet, they generally do not conform to current subdivision standards for lot size and infrastructure developments (roads, sewer, water, utilities), because they were developed prior to enactment of the County subdivision and zoning codes.

Alignment A runs adjacent to the northeast edge of Leilani Estates, but is entirely outside the subdivision. Alignment B crosses Nanawale Farm Ranch Lands which has been subdivided but is not fully developed yet. The lots are large (2 to 5 acres), and will likely be used for some agriculture production.

The other three agricultural subdivisions (Hawaiian Paradise Park, Orchid Land Estates, and Ainaloa) form a wide block of land from the ocean to the slopes of Kilauea over which the transmission lines must cross to connect the Pohoiki plant with the Puna Substation. All of the subdivisions have fee simple lots of varying sizes: 1-acre lots in Hawaiian Paradise Park; 2-acre lots in Orchid Land; and 1/4-acre (12,000 s.f.) lots in Ainaloa. To avoid these large subdivisions, both alignments will be located within the highway right-of-way through this area.

In addition, a new agricultural subdivision of 2- and 5-acre lots is being developed on the Hawaiian Home Lands of Maku'u along Highway 130. The lots have been leased to native Hawaiian beneficiaries for residential and agricultural use. Once the infrastructure is completed around 1991, the lessees have one year within which to build on their lots.[24] Neither alignment will be located on Hawaiian Homes Land.

3. <u>Vacant Land</u>

Much of the project area consists of vacant, uncultivated land with predominantly natural vegetation. This is the case for much of the

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24. Hardy Spoehr, Department of Hawaiian Home Lands, personal communication, March 1988 and January 1989.

State-owned land as well as large areas of private land. Natural vegetation is also the predominant cover type within the residential/agricultural subdivisions except where small parts of these areas have been cleared for roads and a few residences.

4. Conservation District

Two physically separate portions of Nanawale Forest Reserve ("Part 3" and "Part 2") are crossed by Alignments A and B respectively. The forest reserve is designated State Conservation District and Resource subzone, and is State-owned land. The environmental character of the portions of the Reserve impacted by the alignments is very similar to the surrounding subdivisions and vacant lands, and is not environmentally sensitive.[25]

Nanawale Forest Reserve is open to the public for hunting wild pigs and goats. The public hunting period, regulated by DLNR, is weekends and holidays, year round. The only arms permitted on these lands are bows and arrows and knives.

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25. Appendices B, C, D and E of Routing Study and Appendix 1 of EIS.

5. Urban District

Lands encompassing the town of Keaau are designated State Urban District. These lands will be avoided by the alignments.

H. INFRASTRUCTURE

1. Roads

State Highway 130 (Pahoa Highway) is the primary route in Puna between Keaau and Pahoa and Kalapana. The highway is a two-lane paved, all-weather road, in good to excellent condition. It has a pavement width of 20 to 24 feet with 4 to 10-foot wide gravel shoulders within a 40-foot wide right-of-way. The State Department of Transportation is in the process of expanding the highway right-of-way up to 100 feet. The portion between Pahoa and Kalapana is planned to be realigned somewhat and widened to meet federal standards.

As the primary route in the Puna region, Highway 130 is travelled by commuting residents as well as tourists, having an adjusted average daily traffic count of 12,819 in 1988.[26] The general morning peak hour is 7:00 to 8:00 with 80% of the traffic heading north to Hilo. Although the afternoon peak hour varies

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26. Department of Transportation, Highways Division, Planning Branch, "Keaau-Pahoa Road, 1.6 Mile NW of Waipahoehoe Bridge, Final Report" for 1988.

according to location along the road, south of Keaau the peak hour is 4:45 to 5:45 p.m., with 73% southbound toward Pahoa. At the Kahakai intersection, the peak hour is between 2:00 and 3:00 with 53% to 60% northbound.[27]

Highway 130 would be the major route for transporting construction equipment and crews between Hilo and the final alignments.

Highway 130 currently runs through the center of Pahoa town. However, the State Department of Transportation has proposed construction of the Pahoa Bypass Road, which would carry through-traffic around the heart of the existing urban area. Right-of-way appraisal and acquisition is currently underway and advertising for bids is scheduled for early 1989. Actual construction is estimated to take one year. Based on this schedule, it is possible that the bypass could be usable during construction of the first 69 kV line, and most likely for the second line.

Two other major roadways in the region are Kapoho Road (State Highway 132) and Pohoiki Road (a County road), both of which are adjacent to the Pohoiki geothermal

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27. Department of Transportation, Highways Division, Planning Branch, 24 Hour Traffic Count Summaries for Keaau-Pahoa Road at Waipahoehoe Bridge, May 17-18, 1988; and Keaau-Pahoa Road at Kahakai Blvd., September 8-9, 1986.

site. These roads are two-lane, narrow roads with about 22-foot wide pavement and 5 to 6-foot dirt and grass shoulders in 50 to 80-foot wide rights-of-way.

In addition to the State and County roads in the region, there are numerous private roads, primarily within the subdivisions. The majority of these are cinder-surfaced within 40-foot rights-of-way, and are relatively well-maintained and easily accessible. The private unpaved roads in Orchid Land Estates, however, are poorly maintained, and access on these roads is much more difficult, time consuming, and influenced by the weather.

There is also a network of private "cane haul" roads throughout the area that could provide access for the proposed project as needed.

The former right-of-way of the Puna Consolidated Railway, now an overgrown jeep/walking trail, between Hawaiian Beaches and the Puna Substation could provide access opportunities in an otherwise secluded area with rough lava terrain.

2. Utilities

An existing 34.5 kV electric subtransmission line is located along Highway 130 and Kapoho Road, between the Puna Substation near Keaau and the Kapoho substation near the geothermal site. This is a radial line which provides power from Puna Substation to Hawaiian Paradise Park substation, Hawaiian Beaches substation, Kapoho substation, and soon to the new Ainaloa substation. The 34.5 kV line to Hawaiian Beaches substation is adjacent to Kahakai Boulevard. The subtransmission line between Pahoa and Kalapana, along Highway 130, is presently energized at 12.47 kV. It will eventually be 34.5 kV and feed the Kikala substation to service the Kalapana region. The two new 69 kV transmission lines will be connected to HELCO's main power grid at the Puna 69 kV Substation.

In addition to subtransmission lines, there is an existing network of electric distribution lines in the Puna area, typically along roadways. Within the routing study corridors, these lines are shown on the physical conditions exhibits in Chapter VI of the Routing Study. HELCO has franchise rights to use any public right-of-way for power lines, although State and County agency regulations must be adhered to. In areas where existing HELCO lines are not along roads, easements have been acquired.

Hawaiian Telephone Company's main trunk lines are located on the side of Highway 130 opposite HELCO's 34.5 kV line. Telephone lines are also located along most roadways in the corridors. Often times, in the subdivisions, poles are shared by HELCO and Hawaiian Telephone.

I. VISUAL CHARACTER (Exhibit II-6)

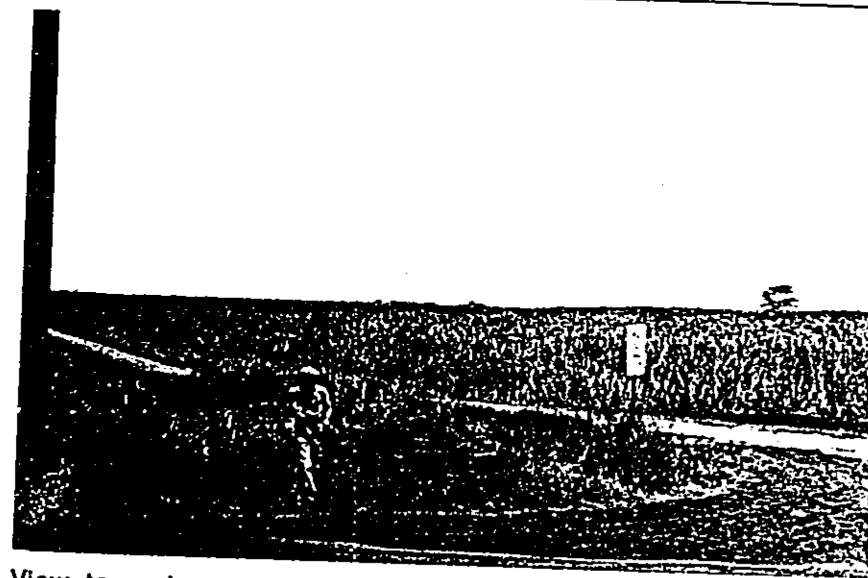
The Puna region has a clearly rural visual character exemplified by the natural and agricultural vegetation and low-density development. The gentle sloping topography allows wide-angle or panoramic views across areas with low scrub vegetation and recent lava flows and agricultural plantings. However, the rainy weather and amount of tree cover often limits extensive views, especially along the major highways. The most dramatic views in the region are those in which the ocean or the summits of Mauna Kea, Mauna Loa, or Kilauea can be seen.

The main highways through the region are continuous vantage points for frequent view exposure for large numbers of travellers, both residents and visitors. They are vantage points from which the new transmission line, if within visual range, potentially has the most significant impact on public views. For this reason, the detailed analysis phase of the routing study identified and mapped visual resources along major roads within and near the proposed corridors. (Refer to Exhibits VI-3,5,7, and 9 in the Routing Study.)

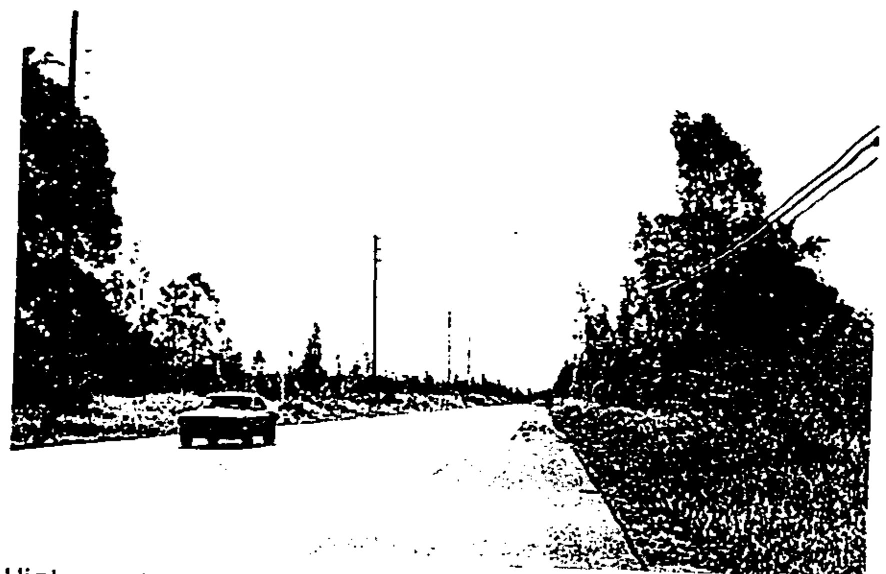
EXHIBIT II-6

# PHOTOS REPRESENTING VISUAL CHARACTER OF PUNA

Hawaiian Paradise Park subdivision (left) State land (right).



View toward ocean across former sugarcane fields from Highway 130 south of Keaau.



Highway 130, 34.5 kV transmission line (left), telephone line (right).

Typical view from road of dominant vegetation cover in region –young ohia forest.

DHM inc.

Physical features which screen views from major vantage points were indicated on the exhibits, as well as locations and descriptions of views.

The view from roads and lots within the subdivisions depends on the amount of development at specific locations, and, in undeveloped areas, the height of natural vegetation. Many residents in the subdivisions have built two-story homes with lanais and large windows at the second level to take advantage of expansive views to the ocean and mountains over the surrounding trees. At ground level, trees and undergrowth typically block long expansive views.

## J. SOCIAL-ECONOMIC CHARACTERISTICS

The proposed transmission lines are within the Puna District of Hawaii, which is comprised of two census tracts: Census Tract (CT) 210 (Keaau-Mountain View) and CT 211 (Pahoa-Kalapana). Exhibit II-7 shows the census tract boundaries within the Puna area. The population and socio-economic data for these census tracts is used in this section to give an overall picture of the existing characteristics of the Puna region.[28]

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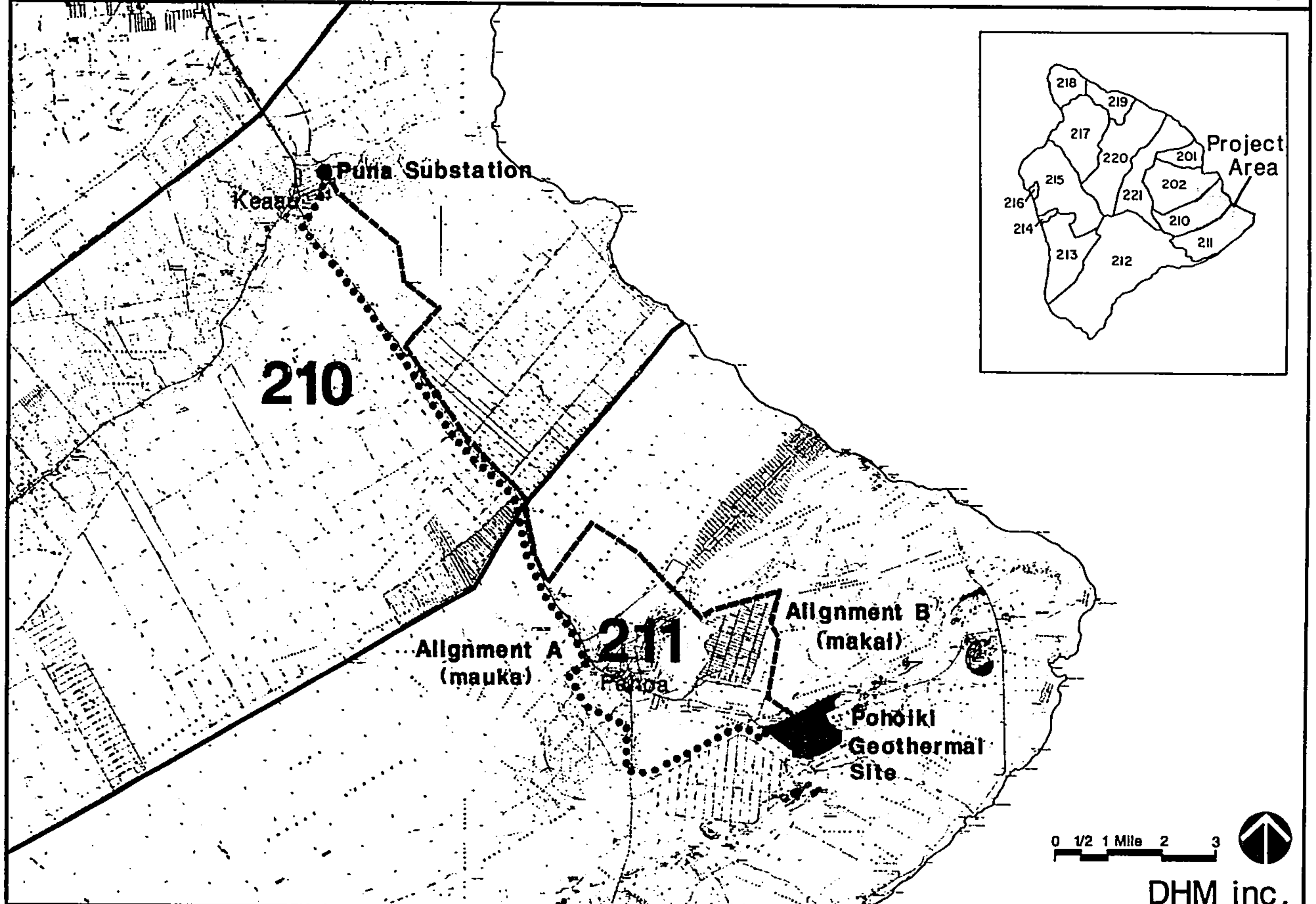
28. All data, unless otherwise noted, is based on the U.S. Bureau of the Census, 1980 Census of Population and Housing, Census Tracts, Hawaii, Issued June 1983.

# EXHIBIT II–7

## PUNA AREA CENSUS TRACTS




DHM inc.

Throughout the island of Hawaii and the Puna District, the population increased significantly between 1970 and 1980. Island-wide there was a 45 percent increase over the 1970 population, from about 63,500 to 92,000. In Puna, there was an increase of 128 percent, from 5150 to 11,750. In the period from 1980 to 1986, Puna had a growth rate of 57 percent, with an estimated 1986 population of 18,400.[29] Likewise, the number of residential HELCO customers has increased dramatically. The meter count between 1970 and 1980 increased 68% island-wide and 123% in the Puna District. From 1980 through 1986, the number of residential meters increased 35% island-wide and 61% in Puna.[30]

Puna's rapid population growth during the 1970's resulted in large part from in-migration, partially due to the abundant supply of relatively low-priced land for residential and/or agricultural purposes. Virtually all of Puna's growth from 1970 to 1980 was outside the three urbanized settlements of Keaau, Mountain View, and Pahoa. Ethnically, Puna changed from a largely Japanese to a largely Caucasian area. Also, more than half of Puna's net population growth from 1970 to 1980 was not Hawaii-born.[31]

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29. Dept. of Business and Economic Development, State of Hawaii Data Book, 1987.

30. HELCO, Customer and Consumer Services Division.

31. Bechtel National, Inc., Puna Geothermal Venture Project Application, December, 1986.

Despite a frequently expressed belief that Puna subdivisions are being filled by retirees, the district's population actually grew somewhat younger during the 1970's.

Compared with the island as a whole, the residents of the Puna region were much more likely to:

- o be born on the mainland or a foreign country
- o be caucasian
- o have a lower-than-average income
- o have an income below the official poverty level
- o be owner occupants of their home
- o have a lower-than-average house value
- o be a non-participant in the labor force
- o be unemployed
- o be self-employed

However, the Puna residents are comparable to island-wide residents in terms of:

- o median age
- o percent of population over 65 years old
- o education
- o number of persons per household

Exhibit II-8 shows specific 1980 Census statistics supporting the above generalizations for the two Puna census tracts and, for comparison, the island of Hawaii.

EXHIBIT II-8

1980 CENSUS STATISTICS FOR PUNA AND HAWAII COUNTY

| | CT 210 | | CT 211 | | Hawaii Co. | |
|---|---|---|---|---|---|---|
| TOTAL PERSONS | 7055 | | 4696 | | 92,053 | |
| **Place of Birth** | | | | | | |
| Hawaii | 4038 | 57% | 2877 | 61% | 64,938 | 70% |
| Mainland | 1874 | 27% | 1176 | 25% | 17,577 | 19% |
| Foreign | 1096 | 16% | 453 | 10% | 8,665 | 9% |
| **General Characteristics** | | | | | | |
| Median Age | 30 | | 27 | | 29 | |
| 65 years & over | 764 | 11% | 370 | 8% | 9,378 | 10% |
| Persons per household | 3.0 | | 3.2 | | 3.1 | |
| **Race and Origin** | | | | | | |
| White | 3154 | 45% | 1924 | 41% | 31,316 | 34% |
| Asian and Pacific Islander (incl. Hawaiians) | 3662 | 52% | 2619 | 56% | 57,063 | 62% |
| Other | 199 | 28% | 124 | 26% | 3,055 | 33% |
| Hawaiian | 750 | 11% | 1012 | 22% | 17,274 | 19% |
| **Years of School Completed** | | | | | | |
| Persons 25 years & over | 4338 | | 2547 | | 53,704 | |
| % College Grad | 633 | 15% | 245 | 10% | 8,142 | 15% |
| % High School Grad | | 68% | | 71% | | 69% |
| **Income** | | | | | | |
| Median (Household) | $15,364 | | $12,728 | | $16,975 | |
| Mean (Household) | $18,634 | | $16,124 | | $20,398 | |
| % Family Income Below Poverty Level | | 12% | | 17% | | 10% |
| **Housing** | | | | | | |
| Housing units | 2863 | | 1712 | | 34,215 | |
| Owner occupied | 1807 | 63% | 1035 | 60% | 17,731 | 52% |
| Median Value | $53,100 | | $47,900 | | $71,200 | |
| **Labor Force Statistics** | | | | | | |
| Labor Force | 2984 | | 1645 | | 41,214 | |
| % Persons 16 years & over in Labor Force | | 57% | | 52% | | 61% |
| % Civilian Labor Force Unemployed | | 13% | | 12% | | 7% |
| **Class of Worker (Percent of Labor Force)** | | | | | | |
| Private Wage & Salary Worker | | 57% | | 59% | | 66% |
| Gov't. Worker | | 17% | | 16% | | 18% |
| Self-employed | | 13% | | 13% | | 8% |

Source: U.S. Bureau of the Census, 1980 Census of Population and Housing, Census Tracts, Hawaii, Issued June 1983. Percentages and rounding were computed by DHM inc.

Significant growth is expected to continue in the Puna District, particularly in terms of the district's role within the County. Hawaii County Planning Department projections for the year 2005 consider Puna to have a larger percent of the island's total population than in the past - 23% as compared to about 13% in 1980. The projected population, based on a "medium" growth rate, is nearly 50,000 for Puna and 217,000 for the island of Hawaii.[32]

As has been the case in the past, additional population growth will generate housing development in Puna rather than vice-versa. Since there are no proposals for major residential home development in this area, the general prospect is for continued development of single homes on undeveloped subdivision lots.

The economic base in Puna was significantly affected by the closing of Puna Sugar Company in 1984. The closing took approximately 15,000 acres out of sugar production and resulted in the cumulative loss of approximately 485 jobs.[33] However, as a result of the release of acreage for other purposes, diversified agriculture has become more important, and is expected to continue to expand in Puna.

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32. Keith Kato, Hawaii County Planning Department, personal communication, May, 1988. Statistics from the General Plan Revision, August, 1987.

33. Bechtel National, Inc. p. 11-23.

Puna's residents view themselves primarily as rural and, more specifically, as people who have intentionally chosen such a lifestyle.[34] Exhibit II-9 lists the best features of life in Puna, as volunteered by the residents of Puna.

Certain frequently encountered community values may be particularly relevant to any proposed development in Puna. These include:

- Family. The concept of intact and extended families is of critical value.
- Slow pace. Puna's rural quality contributes to the slow pace of life.
- Land. Subdivision activities have allowed for 1- to 5-acre parcels for residents to grow their own food and to produce crops that can be marketed to supplement their income.
- Living off the land. Because Puna is largely undeveloped, people can enjoy a variety of activities within the district that are consistent with the Puna lifestyle image, i.e., hunting, fishing, and foraging for plants.
- The last frontier. Many of the district's newer residents view Puna as the frontier boundary of Hawaii. Its undeveloped character, from their point of view, is associated with the frontier values of rugged independence and self-sufficiency. Living in an active volcanic area adds to this feeling of frontier living.

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34. The following paragraphs consist of excerpts from Bechtel National Inc. Puna Geothermal Venture Project Application, pp. 11-26 to 11-28.

## EXHIBIT II-9

## BEST FEATURES OF LIFE IN PUNA

| ITEM | PERCENTAGE OF RESPONDENTS[(a)] |
|---|---|
| Population/development (generally lack of such features, e.g., country atmosphere, rural area, uncrowded, etc.) | 49 |
| Other physical/environment (climate, beauty, etc.) | 40 |
| Social/lifestyle factors | 33 |
| Personal associations/commitments | 19 |
| Economic attributes (cheap housing, land, prices) | 11 |
| Location/convenience factors (close to Hilo, work, ocean) | 11 |

(a) Percentages can total more than 100 percent because of multiple responses. Sample size = 778.

Source: SMS Research as recorded in Bechtel National Inc., p. 11-27.

These values help define what Puna residents might mean by the term "rural." Other, sometimes contradictory, lifestyle values are also operating in the community. For example:

- <u>Jobs</u>. People in Puna are seriously concerned about the district's economic future. A commonly reported problem in the 1982 survey was lack of opportunity.
- <u>Services</u>. Although the Puna lifestyle image is one of independence and a pioneering spirit, the residents are demanding better infrastructure and services.
- <u>Education</u>. People in the Puna area place a high value on education. Education is usually associated with upward mobility and economic success.
- <u>Underground economy</u>. Marijuana is the economic backbone of Puna's underground economy. Based on anecdotal information, it is surmised that marijuana provides a high cash income for those engaged in its production.

These present values can be expected to persist in the future with or without the proposed project.

# CHAPTER III

## CHAPTER III. IMPACT ANALYSIS

### A. POTENTIAL IMPACTS AND PROPOSED MITIGATION

Mitigation of potential adverse environmental, social, and economic impacts, short and long term, has been incorporated into the planning process for the proposed transmission lines from the initial stages, as documented in the attached Routing Study. As a result of the overall planning process and route selection process undertaken for the proposed transmission lines, the cumulative impacts of the dual-line project have been addressed, and the probability of significant adverse effects from the proposed project is minimized.

Nevertheless, there are some unavoidable potential impacts of the proposed actions which may occur during construction and/or operation and maintenance of the lines. Potential impacts and appropriate mitigation measures are discussed below.

#### 1. Soil Erosion

Due to extensive lava soils, minimal slope, high absorption of rainfall into the ground, and minimal surface runoff, the potential for long-term effects on soil erosion in the area is expected to be minimal. Further, soil erosion was one of the constraint factors considered in the selection of the alignments for the transmission line, so areas of high erosion hazard potential and steep slope have been avoided.

There is, however, some potential for soil erosion during the construction phase in areas which are cleared for the pole sites, pole anchors, and unpaved access roads. The following steps will be taken to minimize potential soil erosion problems:

- o Existing roads and jeep trails will be used as much as possible for access by necessary ground crews and equipment during construction and maintenance of the line.

- o In many cases, the access roads will not need to be totally cleared of vegetation unless it is heavily vegetated, so this will help reduce erosion of bare soils by wind and/or rain. In these areas, disturbance to soils and their vegetative cover will be confined to the pole sites. Fortunately, where new access roads may be needed, the ground is primarily lava flows where there is little if any soil cover and the erosion potential is very low.

2. Geologic Hazards

Geologic hazards in the project area include lava tubes and cavities and lava flows. Due to the possibility of unidentified subsurface lava tubes and cavities along the alignments, extensive field surveys will be conducted to determine optimum sites for poles in these sensitive areas. Remedial work may then be required to provide lateral support to transmission pole foundations where such tubes or cavities are encountered. These formations are also a concern for pole placement due to their high potential for archaeological sites and artifacts and unique ecosystems for insects. When a pole site is directly above a lava tube or cavity, an archaeologist and biologist will be called in to evaluate the significance of the formation and recommend appropriate mitigative action.

The potential for lava flows overrunning the alignments is generally equal throughout the area, with a slightly higher risk near the Kilauea east rift zone. To reduce the likelihood of a natural catastrophe damaging or destroying both lines at once, they were located at least one-half mile apart wherever possible.

Although seismic loads are probable throughout the alignments, the lateral loads due to seismic conditions would be expected to be less than that due to wind loads, and wind loads will probably be the criteria used for design.[35]

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35. Dames & Moore, "Final Report, Geologic Consultation," May 11, 1987, p. 10. Full report is Appendix F of Routing Study.

3. Biological Resources

Vegetation

A major criterion for route selection was the avoidance of unique or native ecosystems which might be adversely affected by the construction and operation of a transmission line. A detailed botanical survey of the routing study corridors indicated that the botanical resources in the area are common, of low diversity, and the impact of the project would be very minimal.[36] The project botanist confirmed that the plant formations in the Conservation District lands impacted by the project are also low-diversity and early-successional communities which occur throughout the Puna district.[37]

Much of the project area has already been highly altered by man and consists of introduced plant species and weeds. Even in cases where native Metrosideros (ohia) forest was encountered, the floristic quality was consistently poor, and the same species composition was repeatedly expressed. The botanical report confirmed that youthful communities of ohia forests like the ones common over the geologically active terrain in the Puna region are not likely to harbor plant rarities; and based on general ecological

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36. W.N. Takeuchi, et.al., Appendix C of Routing Study.

37. Wayne Takeuchi, Letter to DHM Planners dated April 20, 1988. See Appendix 1 of EIS.

principles, it is highly improbable that some outstanding botanical find could ever be retrieved from the kind of forests prevailing in the Puna district.[38]

Nevertheless, disruption to forest areas was minimized by locating the alignments along the edges of forests and avoiding densely vegetated areas. Because the degree of impact on vegetation is related to the amount of existing access along the alignments, existing roads and jeep trails will be used to the extent possible for access to the pole sites by construction and maintenance crews. No herbicides will be used to clear pole sites or to maintain clearance within the transmission line easements.

Other than the effects of direct physical disturbance to areas along the proposed alignment during construction and maintenance activity, the transmission lines' probable impact on nearby ecosystems is expected to be negligible. The possibility of fire due to arcing or spark discharge from conductors is extremely remote. Periodic tree trimming clears all vegetation within ten feet of energized conductors. In the grassland and scrub-vegetation areas, where the chance of fire hazard is greater, the height of vegetation is naturally low, well below the lowest point of the

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38. W.N. Takeuchi, et.al., Appendix C of Routing Study, p. C-16.

conductor sag. Any damage or disturbance to the line, such as the downing of a conductor, would cause the system to "trip out." The relay mechanism would sense a fault on the line and immediately (within one-fifth of a second) cause the breakers to open at Pohoiki Substation, stopping the flow of electricity.

## Wildlife

Vegetation in the project area primarily supports non-native and common native insects and birds. Further, the mitigation measures described under "Vegetation" will avoid the removal or degradation of important habitat, and therefore adverse effects on wildlife populations are expected to be minimal, and at most, temporary.

One 'io (Hawaiian hawk), an endangered species, was sited during the ornithological field survey. This species feeds primarily on rodents, insects and birds, and it is unlikely that the power line will hinder its activities, but may in fact provide appropriate hunting perches. **Electrocution of the 'io will be prevented by spacing the conductors about 48 inches apart vertically, whereas the wingspan of the 'io is only about 36 to 40 inches.**

While other native birds may occasionally be found in the alignment areas, it is not likely that they are dependent upon them. Bird populations may retreat from the area surrounding the pole sites during construction but will return after poles are set and conductors are placed.

Two stilt, endangered waterbirds, were seen on some small ponds which have been avoided by the alignments. No other wetland habitats were found in the project area.

Field surveys identified four areas of concentration of important native insect species, including two lava tube caves and two native vegetation habitats, all of which have been avoided by the proposed alignments. However, it is likely that additional subsurface caves, which may also be habitats to insects, exist along the alignments. Prior to construction, a consultant with knowledge of caves in the region and Hawaiian cave biotas will be hired by HELCO to provide input as to the best way to cross caves with the least possible disturbance. During the pole hole digging phase of construction, the consultant will be notified upon discovery or disturbance to subsurface caves. Upon inspecting the caves in terms of biologic significance, he will make recommendations for preservation and repair and assist HELCO in adjusting the pole site. If there is no need to preserve the cave (for animal habitat or archaeological reasons), HELCO will decide whether to pursue placing a pole foundation at that location.

During the maintenance of the lines, HELCO's policy of not using herbicides in the right-of-way will eliminate chances of killing the host plants above the caves, or of herbicides percolating down into the caves and directly affecting the animals.

4. Archaeological Resources

Due to the nature of the proposed project, ground construction impacts are limited to disturbance at the pole sites and along newly created or graded access roads. This allows sufficient flexibility in the placement of pole foundations to avoid sensitive areas. As a result, the proposed transmission line is not expected to have any adverse effect on sites which have been identified as having historic or archaeologic value.

The archaeological survey of the routing study corridors located eleven prehistoric-type sites and three historic-type sites, as described in Chapter II. The condition of the sites was evaluated to be fair to good, and they were assessed as having either good or excellent research potential.[39] Results of the survey also indicated that the sites located in the survey area are of limited areal extent, and are therefore easily avoided by adjusting the location of the poles.

There is a high probability, however, that isolated sites are present throughout the study area. The dense vegetation and rugged terrain of many parts of the study area make location of sites such as lava tube caves very difficult. To avoid destruction of unknown sites, proposed pole sites and any other surface areas that will be disturbed by construction activities will be surveyed by an archaeologist, who will locate and describe any historic remains within the areas affected by construction. Suitable means to protect or remove significant remains will be determined in consultation with the archaeologist and the Hawaii State Historic Preservation Office.

5. Air Quality

During construction of the transmission lines, air quality will be temporarily affected. The blasting and digging for poles and anchors, the movement of construction vehicles over unpaved trails, and the use

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39. Eric K. Komori, Appendix B of Routing Study.

of helicopters will create dust and particulate emissions. At no time, however, will State or Federal ambient air quality standards be exceeded.

Fugitive dust emissions from construction are a factor of rainfall and the soil silt content. Since much of the project corridor consists of lava flows with little or no soil cover, dust emissions will be minimal in these areas. Even in the areas with silty clay loam soils, fugitive dust is not likely to be a serious concern because of the high rainfall in the Puna region.

Since there is only a slight potential for fugitive dust, and the disturbed areas will be small and localized, adequate control measures should not be difficult to employ. To reduce air quality impacts during construction, helicopters and blasting will not be used near populated areas. Further, travelling speeds along unpaved trails within one mile of residences and roadways will be restricted to 20 mph. This will reduce dust generation by 65 to 80 percent. Should dry periods occur, dust control could also be accomplished through frequent watering of construction areas near roadways, residential and other active use areas where dust may be an annoyance or problem.

In areas away from main roads and agricultural subdivisions, these construction effects probably won't be noticed by anyone other than the workers on site.

Long term operation and maintenance of the lines will have no effect on air quality.

6. Noise Levels

There will be temporary and localized noise level impacts during construction of the project; however all pertinent State noise control regulations and ordinances will be complied with.

Noise generated by the construction equipment will contribute to the noise along the major roadways and and near the agricultural subdivisions. Although this noise generation will be of short duration, the levels will be substantially higher than ambient noise levels along much of the alignments. Noise emissions generated by various pieces of equipment such as trucks, backhoes, chainsaws, and jack hammers range from 70 to 95 dBA at 50 feet from the source. A hovering helicopter generates approximately 93 dBA at a distance of about 100 feet and blasting will probably generate levels of up to 95 dBA at the same distance. These outdoor noise levels will be loud enough to interfere with human speech (60 dBA or greater) within approximately a half-mile of the construction site.

To minimize noise level impacts on the residents in the region, helicopters will only be used for stringing operations and will not be used near the subdivisions and major roadways. All other construction noise will be controlled and mitigated as required to meet State standards.

After construction, there will be no long term or permanent noise impacts. The 69 kV lines are of low enough voltage that there will be no corona discharge.[40] It is possible that a barely-audible hissing sound could be produced from loose or worn hardware, or contaminants such as salt or dust on the lines. These problems can and will be corrected by HELCO crews.

7. Public Health and Safety

Electric and Magnetic Fields

In recent years there has been increasing interest in the long-term biological effects which are believed to be associated with the electromagnetic field generated by extra high voltage transmission lines (345 kV to 765 kV). On the U.S. Mainland and other parts of the world, 69 kV transmission lines, such as those

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40. Corona is the discharge of electrical energy from the transmission conductors into the atmosphere, where it is dissipated.

proposed, are not considered extremely high voltage lines. These power lines have been on the Big Island for 40 years and in service on the mainland for 75 years. There are about 500 miles of 69 kV transmission lines on the island.

Electric fields for transmission lines range from a fraction of 1 kilovolt per meter (kV/m) for 69 Kv lines up to 10-12 kV/m for 765 kV lines. Almost all household appliances and other devices that operate on electricity create electric fields when plugged into an electrical outlet. The field decreases rapidly with distance away from the device. Typical values measured one foot away from some appliances are shown in Exhibit III-1.

A magnetic field is created by an electric current flowing in any conductor (electric equipment, household appliance or otherwise). The magnetic field under transmission lines is low in comparison with measurements near many household appliances and other equipment. Typical values of magnetic field one foot away from some appliances are also shown in Exhibit III-1.

## EXHIBIT III-1

## ELECTRIC AND MAGNETIC FIELD VALUES FOR APPLIANCES[41]

ELECTRIC FIELD VALUES (at 1 foot distance away)

| Appliance | Electric Field, kV/m |
|---|---|
| Electric Blanket | .25 |
| Broiler | .13 |
| Stereo | .09 |
| Refrigerator | .06 |
| Iron | .06 |
| Coffee Pot | .03 |

MAGNETIC FIELD VALUES (at 1 foot distance away)

| Appliance | Magnetic Field, milliGauss |
|---|---|
| Refrigerator | .3-3 |
| Iron | 1-3 |
| Coffee Pot | .8-1 |
| Electric Range | 3-30 |
| Garbage Disposal | 10-20 |
| Can Opener | 35-250 |
| Blender, Processor | 6-200 |
| Fluorescent Fixture | 2-40 |
| Color TV | 9-20 |

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41. J. Michael Silva, "Pohoiki Geothermal 69 kV Transmission Line, Report on Electrical Measurements and Calculations," March 1987, p.3-4.

To address the concerns of Puna residents regarding potential health effects from the proposed project, HELCO hired an electric and magnetic field expert, J. Michael Silva, president of Enertech Consultants of Sunnyvale, California. Mr. Silva conducted an evaluation of the electric and magnetic fields for the proposed 69 kV lines in March 1987 which included computer calculations and field measurements near existing (and similar) 69 kV facilities. The report[42] documenting the results of Silva's evaluation is included in its entirety as Appendix 2 of this EIS.

Silva's field measurements of existing 69 kV lines indicated electric fields up to .265 kV/m at the centerline below the lowest point of sag, and .188 at 25 feet from the centerline. Magnetic fields were measured as 4.75-5.0 milliGauss (mG) at the centerline and 2.5-3.0 mG at 25 feet from the centerline. These field values are representative of typical situations.

Calculations were also made to account for conditions which may not have existed during routine field measurements such as high conductor temperatures and heavy electrical loads. Exhibit III-2 is a lateral profile of the electric field for a Pohoiki 69 kV line with a 30-foot minimum ground clearance. It

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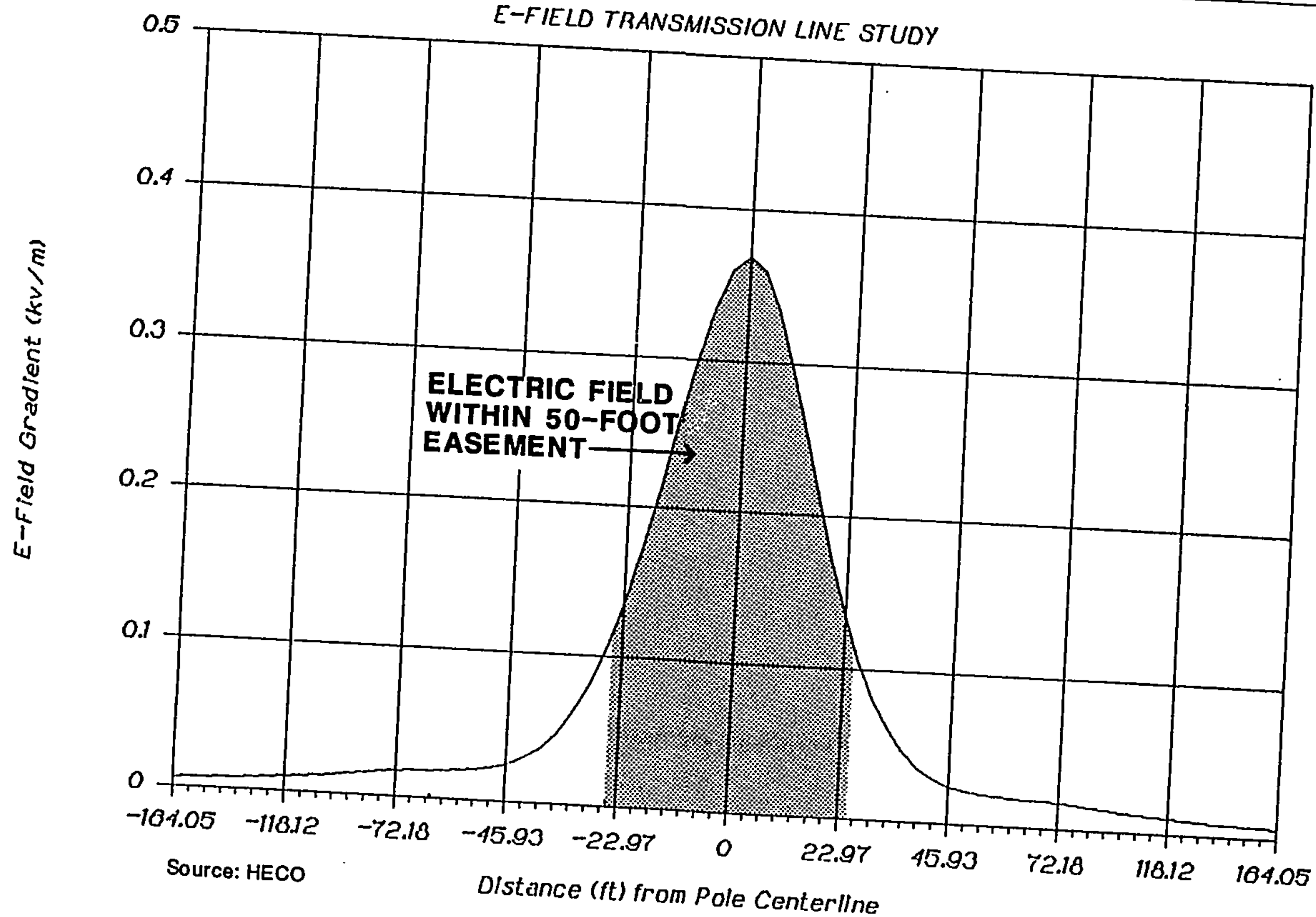
42. Ibid.

## EXHIBIT III-2

# ELECTRIC FIELD GRADIENT PROFILE FOR 69 KV LINE




DHM inc.

illustrates that the electric field gradients drop significantly as one moves a short distance from a transmission line. At the edge of a standard 50-foot right-of-way, the electric field exposure will be comparable to that which results from normal use of household appliances.

The maximum magnetic field in the same location will be about 2-5 mG. These values are low due to the higher than normal conductor ground clearance. They are generally comparable to some household appliances and some of the existing lower voltage distribution lines already in operation along the route.

Silva concluded that the proposed Pohoiki 69 kV line design is in compliance with Hawaii and federal standards. The ground clearance (30 feet minimum and 50 feet typical) is greater than the 20 to 22-foot clearance used on the Mainland. As a result, the electric and magnetic field values below the line are low. The proposed design will produce a well-engineered and safe facility.

Federal Aviation Administration (FAA) Property

The FAA leases 181 acres from Hawaiian Home Lands along Highway 130, just south of and adjacent to Hawaiian Paradise Park (TMK 1-5-10:17). The site contains a "non-directional beacon" and "CD facility" which are used for navigation and communication with aircraft. Initial discussions with FAA indicate that they do not foresee any problems or conflicts between their facilities and the proposed project.[43]

The Pahoa airstrip is located on the makai side of Highway 130 about one mile north Kahakai Boulevard, near both proposed transmission line alignments. Its present use is limited to helicopters for "Green Harvest" operations[44] and to crop-dusting planes for emergency landings. The FAA does not foresee any conflict with the proposed line as long as safety requirements are met.[45] The existing 34.5 kV subtransmission line along Highway 130 is equipped with standard aviation markers. The proposed lines will also comply with safety requirements of the FAA.

<u>Traffic</u>

Highway crossings and transmission lines within highway rights-of-way present certain safety considerations.

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43. Michael Musgrove, Pacific Airways Facilities Sector, FAA, personal communication, February 10, 1989.

44. "Green Harvest" operations are conducted by the County Police Department and involve aerial search for marijuana plots.

45. Norman Suzuki, FAA - Hilo, Personal communication, January 24, 1989.

Alignment A will cross Highway 130 once near Leilani Estates Subdivision and again south of Keaau, and will be within the right-of-way for 9.7 miles. It will also cross Pohoiki Road near the geothermal site. Alignment B will not cross Highway 130 but will be within the right-of-way for 5.5 miles. It will cross Kapoho Road near the geothermal site however.

Construction of the proposed lines will create short-term impacts on traffic conditions along Highway 130 between Pahoa and Keaau. The most frequent and regular type of vehicle trip will be the transporting of workers and materials to various locations along the alignment under construction. (The alignments will not be constructed concurrently.) The most concentrated use of the highway will be the hauling of poles from Hilo to the three staging areas. Approximately 50 trips will be required per alignment, however only a limited number of trucks (2-4) will be used, making continuous trips until all poles are delivered.

Construction-related traffic will be limited to weekday daylight hours. Slow moving, large transport vehicles carrying poles and other heavy materials may delay other drivers from time to time. However, increased traffic resulting from the project will not generally be noticeable on the major highway except during construction of the lines immediately along the highway.

The Traffic Impact Analysis[46] for the project indicates that construction of the alignments within the 100-foot highway right-of-way may intermittently disrupt traffic when one lane of the two-lane highway is temporarily closed or realigned. However, with appropriate mitigating measures **such as those described below,** traffic disruption can be minimized to an acceptable level.

Based on the capacity analysis for the Highway 130, no major traffic congestion problems are anticipated during construction of the proposed Pohoiki transmission lines, since proper construction procedures will be adhered to as specified by the State DOT Highways Division and the County of Hawaii Public Works Department. Also, if lane closures or channelization of two-way traffic flow through the work area is necessary, approved traffic control plans will be diligently implemented.

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46. Pacific Planning & Engineering, Inc., Traffic Impact Analysis for EIS, August 1988.

To lessen impact on traffic flow during the lane closures or constriction, the following mitigating measures will be utilized as necessary:

1. Informational signs advising motorists of possible delays due to lane closure will be posted at least two weeks in advance of the start of construction.

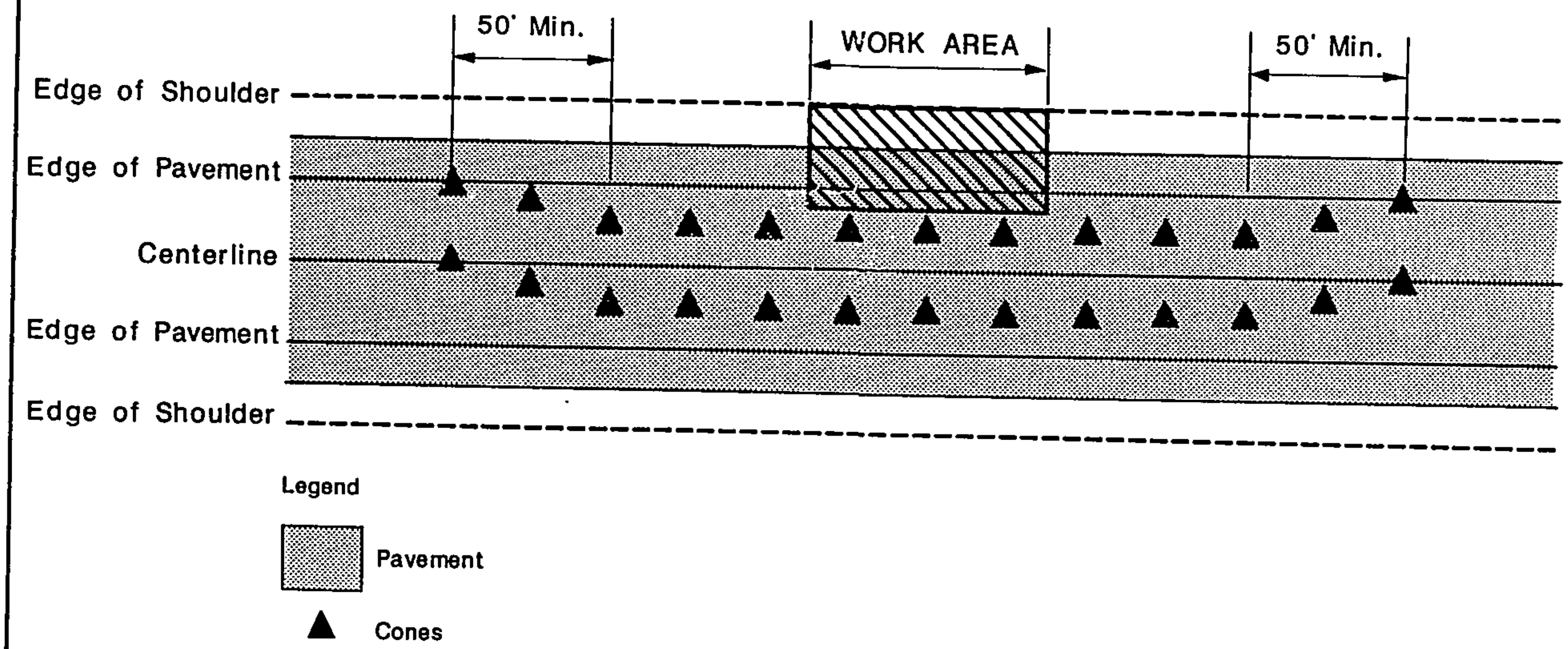
2. Lane closures will be avoided wherever possible by utilizing an approved channelization plan to maintain two-way traffic, as shown in Exhibit III-3. Where lane closure is necessary (highway segments without an adequate shoulder), an approved lane closure plan will be used, as shown in Exhibit III-4.

3. Avoid working during inclement weather or when visibility is significantly reduced.

4. Employ off-duty police officers at lane closures or near work areas.

During long-term operation of the lines, the probability of a significant interruption to traffic due to a fallen pole or conductor is small. As described in the vegetation section (fire hazard), a fallen line will trip out the system in one-fifth of a second.

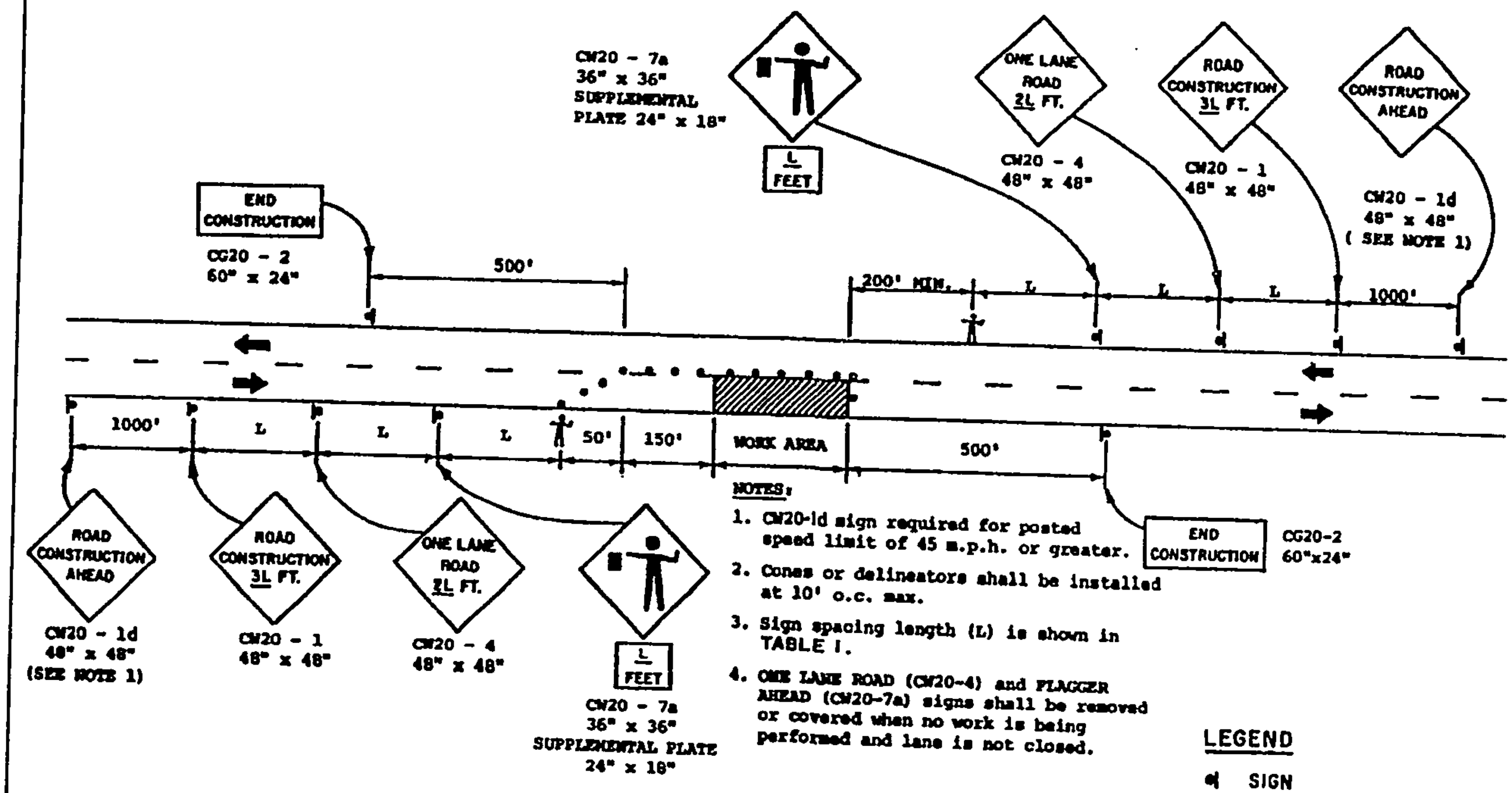
## EXHIBIT III-3
## HIGHWAY TRAFFIC CHANNELIZATION PLAN




DHM inc.

# EXHIBIT III-4

## HIGHWAY LANE CLOSURE PLAN




NOTES:

1. CW20-1d sign required for posted speed limit of 45 m.p.h. or greater.
2. Cones or delineators shall be installed at 10' o.c. max.
3. Sign spacing length (L) is shown in TABLE I.
4. ONE LANE ROAD (CW20-4) and FLAGGER AHEAD (CW20-7a) signs shall be removed or covered when no work is being performed and lane is not closed.

LEGEND

- SIGN
- CONE OR DELINEATOR
- DIRECTION OF TRAFFIC
- POLICE OFFICER/ FLAGMAN

Source: HELCO

Other

Other forms of effects on public health and safety could result from the project's impacts on air quality, noise levels, and fire hazard potential. As pointed out in previous sections, however, these factors are not expected to be significant.

Beneficial effects on public health and safety will result from the proposed project. It will allow for transmission of additional capacity and improve the reliability of electric power service on the Island of Hawaii. This will help prevent potentially dangerous conditions, such as traffic light failures, which can lead to traffic accidents, and darkened residential and commercial areas, which can lead to higher levels of criminal activity and personal injuries.

8. Surrounding Land Uses

The project will not significantly impact existing land uses in the immediate vicinity of the proposed alignments.

Since HELCO will acquire an easement rather than a fee-simple right-of-way for the proposed transmission lines, owners of property along the alignments will retain limited rights to the use of the property. The use will be restricted by safety requirements applying primarily to buildings and structures.[47] Uses such as parking lots and small sheds are permitted within the easement but no dwellings are allowed, nor are any structures which would encroach into the minimum clearance for transmission conductors. Compensation will be paid to landowners who grant the transmission line easements based on a fair market appraisal.

Since the alignments will be entirely within the State Agricultural or Conservation District, the use limitations obviously have less impact than they would on lands in the Urban District. Urban District lands have been purposely avoided to minimize conflicts with surrounding uses and property rights. Furthermore, potential conflicts with existing or potential uses have been avoided or minimized by following property lines as much as possible.

Owners of Agricultural District property within and alongside the proposed easement will be limited little more than they already are by existing land use controls. The potential for agriculture use, for example, will be largely unaffected. Easements for 69 kV transmission lines can and have been used in Hawaii for grazing and the cultivation of sugarcane, pineapple

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47. Public Utilities Commission, State of Hawaii, General Order No. 6: Rules for Overhead Electric Line Construction in the State of Hawaii.

and other crops without discernible adverse effect. Landowners may apply for special or conditional use permits for certain types of development projects outside the range of specified permitted uses in the Agricultural District, but it is not likely that the proposed transmission lines would preclude many such potential uses.

The productive agricultural lands, such as the papaya fields near Nanawale, will be temporarily impacted during construction of the transmission lines. The land within each transmission line easement would need to be cleared and used for construction vehicles and equipment. Once each line is complete, agricultural use could continue such that it doesn't conflict with safety requirements. Crop production and field operation on lands outside of each easement could continue throughout the construction phase without conflict.

Several agricultural subdivisions are located adjacent to the alignments. Transmission lines through residential areas are often perceived as a nuisance which can detract from the use and enjoyment of adjoining properties. For this reason, both alignments have been routed to avoid crossing residential lands.

Construction and operation of the Pohoiki 69 kV transmission lines will have no impact on hunting uses in the Conservation District lands. The alignments are located on the edges of the property. The easements may serve as a buffer between the hunting activity and the adjacent subdivisions.

9. Visual Quality

One of the criteria for selecting the proposed route for the transmission line was the avoidance of adverse visual impact.[48] Several means were used in route selection to minimize adverse visual impacts. Highway rights-of-way were not considered in the routing study for preferred alignments, as per HELCO's initial guideline; routes parallel to a highway were set back a sufficient distance to be screened by vegetation along the road; visual screens and distant backdrops were taken advantage of to avoid direct exposure or sharp contrast to views from the road; roads were crossed at right angles to minimize visibility; and road crossings were minimized.

Most of the proposed alignments still meet these criteria to minimize visual impacts. However, since a segment of each final proposed alignment is located within the right-of-way of Highway 130 between Pahoa

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48. See pp. 78-80 of the Routing Study.

and Keaau, the potential for continuous view exposure along this road will be the major visual impact of the project. Along this stretch of highway, the proposed lines will be visually prominent due to the lack of visual screens within the right-of-way. Fortunately, however, there will be many areas of solid or partial vegetation screens immediately behind the right-of-way. These will serve as a backdrop to the lines and will minimize the direct contrast of the poles against the sky and other surroundings. The backdrops will serve to visually "absorb" the poles.

The use of joint and double circuit poles along the highway will also minimize the visual impact that could otherwise occur from multi-lines within a single corridor. The existing telephone line (and poles) along the mauka side of the highway will be removed and combined with Alignment A on the mauka side. Once Alignment B, a double circuit line, is complete on the makai side of the highway, the existing 34.5 kV line (and poles) will be removed. Therefore, other than the use of taller poles, the visual impact of the lines along the highway will remain about the same.

There are vantage points other than the highway from which the proposed transmission lines will probably have occasional and limited view exposure, namely the subdivisions. As shown in the "Visual Resources" exhibits of the Routing Study (Exhibits VI-3,5,7,and 9), the existing solid and partial vegetation screens around the subdivisions will minimize the visual impact. Furthermore, the rustic appearance, texture and color of the wooden poles will blend well with the varied natural landscape.

10. Social and Economic Impacts

Overhead transmission lines through urban or residential areas are often perceived as nuisances which can detract from the use and enjoyment of adjoining properties. Some residents of Puna have expressed concerns about several such issues including the transmission lines' effect on property values, insurability, future transmission lines in area, health and safety, and radio and television reception. These issues are discussed below as well as project impacts on employment, the economy, and housing.

Property Values

HELCO consulted with the County of Hawaii regarding the impact of transmission lines on property values. It is difficult to ascertain whether there is a direct effect on property values due to the presence of transmission lines. However, data for residences along a street with a typical 69 kV line indicate that County assessments of property values, based on market sales, did not decrease.[49]

Insurability

According to several insurance companies contacted by HELCO, the factors which affect rates and insurability for homeowners insurance in respect to fire hazard are the distance from a fire hydrant and the accessibility of the house. The presence of electrical lines is not a factor in obtaining fire insurance for homes.

Future Power Lines

The proposed transmission lines are for the transport of 25 MW of power from PGV's geothermal development in Pohoiki only. This power is expected to be sufficient to support the project island load growth for the next 10 years. However, HELCO may require additional power depending upon the survival of the sugar industry and retirement of two existing generating units. The two proposed 69 kV alignments would not be capable of transmitting the additional power. If an additional 25 MW are required in the future, the proposed lines would have to be reconstructed or a third line installed in a separate easement. Any new line would require a new

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49. Joseph W. Andrews, Director of Finance, County of Hawaii, Letter to Clyde Nagata, HELCO, dated August 6, 1987. Letter is included as Appendix 3 of this EIS.

routing study to select the transmission line alignment. If a higher voltage line is necessary, wider easements, taller poles, and larger insulators, would be required in addition to PUC approval.

Future power to meet the island's energy needs may or may not come from geothermal development. Other than the contract with PGV for 25 MW, HELCO has no contracts with other geothermal developers. However, Puna residents are understandably concerned about the potential proliferation of geothermal-related transmission lines through the Puna District and the lack of an overall development plan by any governmental agency.

Health Hazards

Concerns about potential hazards of the project to people living near the transmission lines are addressed in section A.7 of this chapter.

Interference

Transmission lines and insulators can cause interference with AM radio and television reception under certain conditions, which may be an annoyance to residents in nearby areas. HELCO promptly investigates interference complaints to determine the nature, source, and cause of the interference. Generally, the primary cause of interference is loose, worn or damaged hardware which when replaced or tightened will remedy the problem. Occasionally dirty insulators require washing.

Employment and Economy

While most of the design and construction work for the proposed transmission lines will be done by personnel from HELCO and its parent company, HECO, certain tasks requiring specialized skills may be contracted to outside companies and individuals. At this time it is difficult to ascertain how many temporary jobs will be created or what proportion of these would be held by residents of the island of Hawaii. Outside contractors, who will be responsible for hiring their own personnel, have not yet been selected. A company based on the mainland will need to be hired for helicopter lifts and installation of poles, since there are no companies in Hawaii with the necessary equipment or specialized experience to perform this task. Otherwise, it is probable that all other outside contractor jobs will go to state residents. The creation of these temporary jobs will generate income and excise tax revenues accruing to the State government. Both the creation of direct jobs and the purchase of supplies and materials for construction will support jobs locally through the multiplier effect.

After construction, the project will have little direct or indirect effect on employment levels, since the maintenance requirements for a transmission line are not substantial. Nevertheless, by transporting an additional 25 MW to the island's electrical grid and providing reliable electrical energy service, the project will indirectly help maintain the viability of the island's various economic sectors.

Housing

The proposed project will not significantly or adversely impact the existing housing stock and population level in the area. Most workers will be HELCO employees and/or local residents. However, if skilled workers for specialized tasks are not available on the island, they will be brought in from outside Hawaii and will make their own arrangements for housing. Because they will be residing on Hawaii for a relatively short time, it is likely that they would rent quarters rather than build or buy housing. In addition, there will be no displacement or relocation caused by the project.

B. ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED

Construction of the project will create localized and temporary adverse impacts on air quality, noise level, and traffic flow. The movement of construction equipment, drilling, and blasting will increase the amount of air-borne dust and particulate emissions, and contribute to soil erosion around excavation sites. Noise will be increased above ambient levels along most of the proposed alignment. One lane of the highway may be temporarily closed during construction within the highway right-of-way. Traffic disruption will be minimized by channeling the traffic flow to maintain two lanes of moving traffic.

The disturbance to land areas during construction and occasional maintenance operations will have an adverse effect on some native plants and possibly on the rate of soil erosion, despite efforts to avoid the most sensitive areas through the route selection process and additional mitigation measures which were described in the previous section. Due to the precautions which have and will be taken, the adverse impacts are not expected to be significant over the long term.

Except along Highway 130, it is expected these impacts will be perceived by few people other than construction workers because of the remoteness of much of the proposed activities from urbanized areas.

The proposed transmission line may also have an adverse visual impact, depending upon one's subjective opinion regarding the quality of views and the appearance of the proposed transmission poles and conductors as seen within those views. The significance of this impact is also dependent upon the probable frequency of view exposure. Except along Highway 130, the lines will not be exposed to frequent viewing.

The potential for unavoidable adverse impacts must be weighed against the significant long-term benefits of the project. The new lines will transmit additional capacity and improve the reliability of electric power service on the island.

The potential adverse impacts to the environment must also be evaluated against the numerous State and County plans and policies intended to achieve energy self-sufficiency. The adverse impacts of the project are mitigable to levels which allow for balanced and acceptable tradeoffs between conservation-type plans and policies and energy-type plans and policies.

## C. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction of the proposed project will require an irreversible commitment of capital, labor, construction materials and fossil fuels. The facilities, once installed, will remain there for the life of the project and will require periodic maintenance. Some of the construction materials could be recycled if the facilities were dismantled, such as the copper and aluminum used for conductors, the steel used for guy wires and anchors and the wood poles used for supports. The vegetation which would be cleared to provide for pole sites, access roads and safety clearances for the energized lines will be irretrievably lost. However, much of this vegetation can be expected to regenerate over the long term. While it is conceivable that the transmission line could be removed or relocated, and the land restored to its natural condition or some other use, HELCO intends to acquire a perpetual easement wherever possible in anticipation that the affected land area will be committed to transmission line use for an indefinite period.

## D. UNRESOLVED ISSUES

The potential impacts of the proposed action are generally known and appropriate mitigation measures have been developed to address these impact. There are no significant unresolved issues.

# CHAPTER IV

## CHAPTER IV. RELATIONSHIP OF PROPOSED ACTION TO PLANS, POLICIES AND CONTROLS FOR THE AFFECTED AREA

A. FEDERAL

No Federal controls were found to be directly relevant to the proposed action.

B. STATE

1. State Planning Documents

The proposed project complies with the following objectives of the adopted Hawaii State Plan:

- o To protect rare and endangered plant and animal species and habitats native to Hawaii. (The selected routes for the transmission lines avoid important habitats and proposed mitigation measures will avoid or minimize impacts on these resources.)

- o To preserve and restore significant natural and historic resources. (The route selection process and proposed mitigation measures avoid potential adverse impacts on these resources.)

- o To provide dependable, efficient and economical energy systems capable of supporting the needs of the people. (The objective of the proposed project is to provide reliable electric power for the island of Hawaii.)

- To ensure that the development or expansion of power systems and sources adequately consider environmental, public health and safety concerns and resource limitations. (This objective was built into the project and route selection process from the outset.)

- To increase energy self-sufficiency and to promote the use of renewable energy sources. (The proposed project supports the development and use of geothermal energy.)

The proposed transmission line project also meets one of the Hawaii State Plan Priority Guidelines for energy use and development which is to encourage the development, demonstration, and commercialization of renewable energy sources.

Functional Plans have been prepared as part of the State planning process and were passed by the Legislature in 1984 and 1985. The following Functional Plans are pertinent to the proposed project.

- State Agricultural Plan: The proposed transmission lines would not interfere with or adversely affect any existing agricultural operations.

- State Conservation Lands Plan: The route selection process for the proposed transmission lines respects the policies to protect and preserve valuable natural resources and wildlife habitats.

- State Energy Plan: The proposed project is part of HELCO's overall strategy to encourage the development of renewable, indigenous energy sources.

2. <u>State Land Use Controls</u>

Most of the selected alignments are within the State Agricultural Land Use District. A small portion of each route crosses non-contiguous portions of the Nanawale Forest Reserve which is also State Conservation land. According to Chapter 205, Hawaii Revised Statutes (HRS), utility lines are allowed in the Agricultural District. Although transmission lines are not expressly allowed in the Conservation District, an approved Conservation District Use Application (CDUA) will allow such use if it can be shown that the public benefits outweigh any impact on the Conservation District.

The Conservation District, which is under the jurisdiction of the State Board of Land and Natural Resources, is divided into subzones, as authorized by

Chapter 183, HRS. The Board's Regulation No. 4 establishes four subzones and sets forth objectives and permitted uses for each, in varying degrees of restrictiveness. The Conservation land affected by the proposed alignments is in the Resource (R) subzone, which is one of the two most permissive subzones. The objective of the Resource subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas.

The Alignment A is on the boundary of the Nanawale Forest Reserve, adjacent to Leilani Estates Subdivision. (Refer to Exhibit II-4.) There is an existing 20-foot-wide perpetual non-exclusive easement to the County along this boundary for a future water line. Alignment B crosses 250 feet of the narrow triangular tip of the Nanawale Forest Reserve where it is adjacent to Nanawale Estates Subdivision. In neither location is the Conservation land distinctly different from the adjacent subdivisions or vacant lands in terms of environmental characteristics.[50] Due to the proximity to non-Conservation lands, and the localized nature of the project, the encroachment into the Conservation District is minimal and will not adversely affect the natural resource values which the District is intended to protect. On the contrary,

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50. Appendices B, C, D, and E of Routing Study and Appendix 1 of EIS.

alternative alignments through the subdivisions were found to have greater potential impact due to the number of small private landowners that would be affected. Residents of both subdivisions requested that the alignments be placed outside of their subdivisions.

3. <u>Environmental Impact Statements</u>

Under the provisions of Chapter 343, HRS, all proposed actions that involve the use of State lands are subject to an assessment by the State Department of Land and Natural Resources (DLNR) to determine whether or not an EIS is required. DLNR determined that an EIS is required for the proposed project and this document was prepared to fulfill that requirement. DLNR will be the accepting authority for this EIS.

4. <u>Department of Hawaiian Home Lands</u>

Although the project area includes portions of the Hawaiian Home Lands of Maku'u, neither proposed transmission line will cross these lands.

C. <u>COUNTY</u>

1. <u>General Plan</u>

The County of Hawaii General Plan was adopted in 1971, with revisions in 1979 and 1980. Additional proposed revisions are currently before the County Council for approval. The proposed project is consistent with the

County goal to strive towards energy self-sufficiency since the transmission lines also meet the County policy to encourage development of alternate energy resources. Other policies in the County General Plan which are met by the project include ensuring a proper balance between the development of alternate energy resources and the preservation of environmental fitness, and to assuring a sufficient supply of energy to support present and future demands.

The proposed transmission lines are not in conflict with planned land uses (as shown on the Land Use Pattern Allocation Guide Map of the General Plan), since the General Plan designates nearly all of the easement areas for "orchard." A small area near Keaau is designated "intensive agriculture," and the Puna Substation area is designated "industrial." Along Highway 130, near Kahakai Boulevard, the mauka alignment cross an area designated "alternate urban expansion."

2. <u>Other Land Use Controls</u>

The proposed easements are not in conflict with County zoning and is not within any special districts administered by the County.

D. PRIVATE

1. Easements

HELCO will seek to acquire a perpetual 50-foot wide easement for each transmission line from all private and public landowners along the proposed alignments. The easement will allow the landowner to retain limited use of the property. HELCO prefers to negotiate a settlement with property owners rather than exercise its power of eminent domain. The latter approach will be used only as a last resort.

Normally, the acquisition of an easement is a two-step process. The first step is a right-of-entry, which allows HELCO to conduct surveying necessary to stake the precise boundaries of the easement. Some of the proposed mitigation to avoid sensitive areas will be carried out at this stage. Once the boundaries are determined, formal documentation for the easement is drawn up.

E. LIST OF NECESSARY PERMITS AND APPROVALS

| TYPE OF APPROVAL | ISSUING AGENCY |
| --- | --- |
| Conservation District Use Permit | State of Hawaii Board of Land and Natural Resources |
| Construction Permit (for crossing State & County highways) | State of Hawaii Department of Transportation and County of Hawaii Department of Public Works |
| Right-of-Entry | Various landowners |

# CHAPTER V

## CHAPTER V. RELATIONSHIP BETWEEN SHORT TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Operation of the proposed transmission line project will result in a long-term gain and benefit for the region and island in terms of increased electrical generating capacity and reliability, and reduced dependence on oil-generated power.

Some short-term losses will occur during the project construction phase. These include disturbance to the vegetative cover and temporary impacts on air quality, noise levels, and traffic flow in the localized areas of the alignments.

The project's visibility, particularly from the major roadways, may subjectively be considered a long-term loss. No significant long-term losses of resources are anticipated.

Development of the project would not completely foreclose future options for land use beneath the lines as long as safety requirements are met. After initial disturbance by construction, the terrain and vegetation will pretty much revert to its natural state or can be maintained in its pre-project state by the landowner.

# CHAPTER VI

## CHAPTER VI. ALTERNATIVES TO THE PROPOSED ACTION

### A. NO ACTION ALTERNATIVE

The no action alternative would result if the geothermal-electric power plant at Pohoiki was not built. If no geothermal power plant was built to produce the proposed 25 MW of electricity, there would be no need for the two 69 kV transmission lines to transport this power to the Puna Substation. As a result, the no action alternative would eliminate all potential impacts, positive or adverse, identified in Chapter III.

The no action alternative is not a "no energy" alternative, but means a continued reliance on imported oil and petroleum products as the primary energy source on the island of Hawaii. This is counter to the State and County and HELCO energy goals of increased energy self-sufficiency. Because HELCO is legally required by the State of Hawaii Public Utilities Commission to provide reliable electric service to its customers, they would need to build a generating facility to replace the capacity of the geothermal plant if it was not built. This facility would be either a conventional power plant, or one or more gas (combustion) turbines, both of which use fuel oil to create electricity. As a result, the no project alternative has environmental impacts such as the air quality deterioration from the combustion of fuels associated with it. Furthermore, the cost of constructing and operating a new generating facility, including the transmission lines which would be necessary to transport the power, would be significant.

If a new conventional generating facility is built on the west side, the transmission lines of this project may not be needed. However, the existing transmission lines in the Puna region are nearly at maximum capacity, and increasing growth in the area will require new and/or upgraded transmission lines and substations in the future. The time frame for these improvements depends on how fast Puna grows.

## B. PROJECT ALTERNATIVES

A wide range of alternatives was considered during project and routing selection. They are discussed in various sections of the Routing Study. Others are a result of post-routing study discussions with Puna residents. The following are basic categories of alternatives which were studied.

### 1. Single 69 kV Line

Construction of a single 69 kV transmission line instead of two 69 kV lines was considered, however this alternative would not provide adequate system reliability and would increase the risk of power failures on an island-wide level.

HELCO's transmission planning is based on the ability to operate its electrical system within acceptable limits for a single contingency outage. For example, the loss of a single transmission line should still allow the electrical system to operate and provide service to its customers.

If only a single line were to connect the 25 MW geothermal plant to HELCO's system, its failure would cause the power plant to be disconnected from the system. This would cause a major disruption to HELCO's customers. Coupled with the unavailability of another large generating unit, this large loss of firm generation would result in rolling blackouts on the HELCO system. This reduction in reliability is unacceptable to HELCO and its customers because reliable electric power is important for the maintenance of public health, safety and economic well-being. Moreover, as mentioned earlier, HELCO is legally required to provide reliable electric service to its customers by the Public Utilities Commission.

2. Marine and Underground Cables

Marine and underground transmission cables were considered as generic alternatives to an overhead transmission line. The marine cable alternative would have an obvious influence on the selection of the route. An underground cable would also affect route selection, but in a less apparent way. The features, advantages and disadvantages of marine and underground cable systems are discussed in Chapter III of the Routing Study. The table in Exhibit VI-1 provides a summary comparison of the three systems in terms of the four basic categories used in route selection. The marine and underground cable alternatives are not cost-effective when compared to an overhead transmission line and they would probably not result in less environmental impact. Furthermore, the difficulties and delays involved in repairing these cable systems make them less reliable than an overhead line for the transmission of power.

3. Routing Alternatives

The study area for the route selection process was delineated to allow for routes up to 50 percent longer than the straight-line distance between the terminal points. (Refer to page 3 of the Routing Study.) Within this study area, virtually every possible overhead route between Pohoiki and the Puna Substation was considered. The methodology, described in Chapter II of the Routing Study, included a thorough analysis of constraints and opportunities for a transmission line route. Through a narrowing-down process, described in Chapters IV and V of the Routing Study, study corridors were identified. Chapter VI describes conditions in

## EXHIBIT VI-1
## COMPARATIVE CONSTRAINTS FOR OVERHEAD TRANSMISSION LINE, MARINE CABLE, UNDERGROUND CABLE

| FACTORS | OVERHEAD | MARINE | UNDERGROUND |
|---|---|---|---|
| GEOPHYSICAL | 1. Possible collapse of poles or lines due to earthquake or volcanic activity. | 1. Possible burial or rupture of cable due to earthquakes and slides.<br>2. Turbulence in ocean waters during construction and maintenance.<br>3. Possible oil leakage in ocean waters. | 1. Possible burial or rupture of cable due to earthquakes and lava flows.<br>2. Soil erosion and alteration of land form due to extensive |
| BIOLOGICAL | 1. Potential damage to vegetation and wildlift habitat due to fire hazard.<br>2. Potential bird collisions.<br>3. Lava cave habitats. | 1. Potential damage to marine habitat due to oil leakage.<br>2. Possible entanglement of deep-feeding marine organisms with cable. | 1. Potential damage to wildlife habitat and vegetation due to oil leakage.<br>2. Extensive removal of vegetation and wildlife habitat. |
| SOCIO-ECONOMIC | 1. Visibility of the poles and lines in areas exposed to public view.<br>2. Dense urban areas where high land values, fragmented ownership patterns, restrictive land regulation and potential interference with human activities are probable. | 1. Visibility and regulatory restrictions with respect to terminal stations near the shoreline.<br>2. Potential conflicts with commercial and sport fishing.<br>3. Regulatory controls on use of ocean. | 1. Visibility of right-of-way in forested areas or other uniform landscapes.<br>2. Potential disturbance of archaeological sites.<br>3. Limited use of land above the line. |
| COST | 1. Areas which are inaccessible by land.<br>2. Areas subject to high wind or salt spray and low rainfall.<br>3. High cost of special pole foundations in underground lava cavities. | 1. High cost of construction (3 times as much per mile as overhead line).<br>2. Difficulty of access for repair.<br>3. Uncertainties involving technology.<br>4. Energy loss through the cable.<br>5. Specializing equipment and crew required. | 1. High cost of construction (5 times as much per mile as overhead line).<br>2. Difficulty of access for repair.<br>3. Uncertainties involving technology.<br>4. Energy loss through the cable.<br>5. Specialized equipment and crew required. |

the study corridors and the criteria for selecting the potential alignments. Further evaluation and discussions with local community associations, elected officials, and Hawaiian Telephone, resulted in the final selected alignments, portions of which deviate from the routing study alignments.

# CHAPTER VII

## CHAPTER VII. AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

A. FEDERAL

Federal Aviation Administration

B. STATE

Department of Agriculture

Department of Business & Economic Development

Energy Division

Department of Hawaiian Home Lands

Department of Health

Department of Land and Natural Resources

Aquatic Resources
Forestry and Wildlife Division
Land Management Division
Office of Conservation and Environmental Affairs
State Parks and Historic Sites Division
Water and Land Development Division

Department of Transportation

Office of Environmental Quality Control

C. COUNTY

Department of Public Works
Department of Water Supply
Mayor's Office
Planning Department

D. OTHER

Ainaloa Community Association
Hawaii Audubon Society
Hawaiian Shores Subdivision
Leilani Community Association
Moku Loa Group, Sierra Club
Orchidland Community Association, Inc.
Ormat Energy Systems
Paradise Park Hui Hanalike
Puna Community Council
Thermal Power Company

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## REFERENCES


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# APPENDIX 1

Wayne Takeuchi/Botany
B I S H O P   M U S E U M
1525 BERNICE STREET • P.O. BOX 19000A • HONOLULU, HAWAI'I • 96817 0916 • (808) 847-3511

April 20, 1988



TO : Wendy McAllister
FROM : Wayne Takeuchi
RE : Vegetation Status of the Pohoiki Project Extention

As per our recent phone conversations, I have no salient amendments to the botanical assessment of the Pohoiki-Puna transmission corridor.

The revised alignments at 1) the northern end of Seaview Road and 2) along Kahukai Street, traverse terrain with vegetation similar to adjoining and previously described areas. Both extentions include native ohia forest, but the plant formations are low-diversity, early-successional communities which are common throughout the Puna district.

Since our field reconnaissance of February 1987 was conducted prior to the altered alignments, my judgment is based upon recollection of roadside observations--and not to an actual walk-through examination. From the information currently available to me, the recommendations and conclusions of our final report (22 April 1987) still stand as originally submitted. I see no reason for opposing the realignment on the basis of botanical concerns.

Respectfully submitted,

Wayne Takeuchi

UNIVERSITY OF UND NORTH DAKOTA

DEPARTMENT OF BIOLOGY
BOX 8238, UNIVERSITY STATION
GRAND FORKS, NORTH DAKOTA 58202
(701) 777-2621

28 March 1988

Ms. Wendie McAllaster
DHM Inc.
1188 Bishop Street
Suite 2405
Honolulu, HI 96813

Dear Ms. McAllaster,

In response to your letter of 8 March 1988 I have reviewed your maps and my notes and data concerning the areas proposed for the realignment of the Pohoiki Geothermal Transmission Line.

Both of these areas were essentially included in our initial survey because we surveyed a wide corridor around the proposed line (100-200 meters). The proposed realignment appears to correspond to our I, O and N subsections. Data for these subsections indicate that we observed only introduced birds within these areas (see Table 1 of my final report). It is doubtful that the numbers and types of birds would differ by much only 100-200 meters from the original line. In addition, my memory of these areas is that they did not contain likely habitat for any endangered or threatened avian species.

The realignment of the transmission line in these areas would not be objectionable to me. If you require additional information please do not hesitate to contact me.

Sincerely,

Robert C. Fleischer

Robert C. Fleischer, Ph.D.
Assistant Professor of Biology

BISHOP MUSEUM
1525 BERNICE STREET • P.O. BOX 19000A • HONOLULU, HAWAI'I • 96817 0916 • (808) 847-3511

Received
MAR 1 _ 1988
DHM inc.

March 8, 1988

Ms. Wendi McAllaster
DHM Planners Inc.
1188 Bishop Street
Suite 2405
Honolulu, HI 96813

Dear Ms. McAllaster,

I have examined the proposed revisions to two segments of the Pohoiki Geothermal Transmission Line alignments as shown on your map of the Pahoa area on the island of Hawai'i (dated February 29, 1988). Located in the Nanawale Forest Reserve, (TMK 1-4-3:8 and 1-4-1:4), the two segments are situated in areas that were included in the archaeological survey that I directed in February 1987. Therefore, the evaluations and recommendations presented in the survey report (Bishop Museum Ms. 043087) also pertain to the revised alignment sections.

No archaeological sites were found during the survey of the two areas (Transects 20 and 25) and the potential for sites was assessed as very low. However, additional archaeological survey should be conducted when specific alignments are selected.

Sincerely,

Eric Komori
Assistant in Anthropology

B I S H O P   M U S E U M
1525 BERNICE STREET • P.O. BOX 19000A • HONOLULU, HAWAI'I • 96817 0916 • (808) 847-3511

11 March 1988

Received
MAR 14 1988
DHM inc.

Wendy MacAllister
DHM, Inc.
1188 Bishop Street
Suite 2405
Honolulu, HI 96813

Dear Wendy:

This letter is in regard to your proposed realignment in the Pohoihi Geothermal Transmission Line Routing Study, date 29 Feb. 1988.

After studying the proposed realignment and after consulting our field notes, we do not feel that the proposed changes will seriously impact the areas affected. We do not feel that reassessment of the areas of concern is necessary at this time.

Sincerely,

Gordon M. Nishida
Acting Chairman
Department of Entomology

GMN:tmk

# APPENDIX 2

Hawaii Electric Light Company
Pohoiki Geothermal 69 kV Transmission Line

Report
on
Electrical Measurements
and
Calculations

Prepared
by
J. Michael Silva, PE
ENERTECH Consultants, Inc.
1010 W. Fremont Avenue
Sunnyvale, California 94087

March 1987

Summary

An evaluation of the electric and magnetic fields and corona noise for the proposed Hawaii Electric Light Company (HELCO) Pohoiki Geothermal 69 kV line has been conducted. This included computer calculations and field measurements near existing (and similar) 69 kV facilities and 12.47 kV and 34.5 kV facilities near the proposed line route. As a result of these measurements and calculations, the following conclusions were reached:

1. This voltage classification has been in service for over 75 years. There are currently over 324,000 miles of line in service in the United States rated at 69 kV and above. This provides a substantial base of operating experience for use in design, construction and operation of new 69 kV transmission lines.

2. The electrical performance of the proposed design was compared with other typical 69 kV line designs and generally accepted engineering standards. The design and electrical performance of the proposed HELCO 69 kV line is not unique, but very typical of other 69 kV lines. The line design methodology is based on sound engineering principles, and years of operating experience.

3. The proposed HELCO 69 kV line will be designed to normally not produce any commercial radio, television or amateur radio interference. If a situation should arise due to line hardware, HELCO has a policy of locating and correcting any interference problem due to the line.

5. The proposed Pohoiki 69 kV line design is in compliance with Hawaii General Order No. 6. In addition, the line design meets standards set by California General Order No. 95 (Rules for Overhead Electric Line Construction) and will exceed the National Electrical Safety Code (NESC). The long operating experience for lines designed with the NESC for many decades has shown that its requirements have provided an ample margin for public safety. The proposed design is consistent with the technology and state-of-the-art in transmission line engineering. The HELCO proposed design for the Pohoiki 69 kV line should produce a well-engineered and safe facility.

69 kV Transmission Lines

Transmission lines in the 69 kV range have been an important part of the electric energy system for over 75 years (transmission lines of this voltage were introduced in the first decade of this century). There are currently over 324,000 miles of transmission lines rated at 69 kV and above. The following Table 1 summarizes the miles of transmission line in service in the United States:

TABLE 1

U.S. TRANSMISSION LINE CIRCUIT MILES IN SERVICE

| Voltage Classification | Miles in Service* |
|---|---|
| 69 - 161 kV | 185,891 |
| 230 kV | 68,248 |
| 345 kV | 45,392 |
| 500 kV | 22,552 |
| 765 kV | 2,265 |
| | 324,348 |

* Source: North American Electric Reliability Council (1), and National Electrical Manufacturers Association (2).

## Pohoiki 69 kV Design

The proposed line will be designed in accordance with Hawaii General Order No. 6 and will also comply with the National Electrical Safety Code (NESC). The basic design for the proposed line is for a pair of single circuit, three phase, 60 Hertz, 69,000 volt, AC electric transmission lines. The phase conductors will consist of single 556,500 circular mil All Aluminum conductor. The transmission line will be constructed with one overhead shield wire. The three electrical phases will be supported by steel davit arms and 6 insulators in a delta configuration on wood pole structures. Minimum design ground clearance will be 30 ft (however, 50 ft would be a more typical value). The line would have a 50 ft wide right-of-way.

## Corona Performance

Corona is a partial discharge of electrical energy. Corona is not limited to powerlines, but also occurs in certain electrical devices such as air cleaners, copy machines, and electrical equipment. Natural corona due to the earth's electric field sometimes occurs on trees, ships, and airplanes. If corona is of sufficient magnitude, it can create some radio interference. Corona is an important design consideration for transmission lines operating at 345 kV or higher, but it is not a major factor for 230 kV lines and below due to lower voltage levels on the conductor. The calculated conductor surface gradient for the Pohoiki line of 6.7 kV/cm is only about half of values for higher voltage lines (about 12-16 kV/cm). This means that the proposed 69 kV line should not cause any radio or TV interference - the line noise should be less than ambient levels created by the earth and sun. (A calculated frequency spectrum for Corona noise is given in the Appendix).

It is possible that loose or poorly fitting hardware could cause a small gap discharge noise source. If this occurs, HELCO has a policy to locate and correct any interference situation due to transmission lines. In any event, the large majority of interference complaints are found to be attributable to sources other than transmission lines (eg. freezer, sewing machines, CB radio, ignition system, poor antenna, poor signal, fluorescent lights, aquarium thermostat, etc.)

## Electric and Magnetic Fields

Electric fields are due to the potential or voltage (electrical pressure) on an object. The measure of voltage is not limited to the surface of the object but exists in the space surrounding the object. The change in voltage over distance is known as the electric field. The units describing an electric field are volts per meter (v/m) or kilovolts per meter (kV/m). This means that a difference in electrical potential or voltage exists between two points one meter apart. The electric field becomes stronger near a charged object and decreases rapidly with distance away from an object.

Electric fields are a very common phenomenon. Body voltages have been measured by the Textile Research Institute as high as 15,000 volts due to walking across a carpet. The earth creates a static field in fair weather of about 0.150 kV/m. This means that a 6 ft tall person would have a static electric potential of about 275 volts between the top and bottom of the body. Natural static electric fields under clouds and in dust storms can reach 3-10 kV/m.

Electric fields for transmission lines range from a fraction of 1 kV/m for 69 kV lines up to 10-12 kV/m for 765 kV lines. Almost all household appliances and other devices that operate on electricity create electric fields when plugged into an electrical outlet. The electric field is due to the voltage on the appliance and the field decreases rapidly with distance away from the device. Typical values measured one foot away from some appliances are shown in Table 2:

TABLE 2

TYPICAL ELECTRIC FIELD VALUES FOR APPLIANCES (AT 12 INCHES)

| Appliance | Electric Field, kV/m |
|---|---|
| Electric Blanket | 0.25* |
| Broiler | 0.13 |
| Stereo | 0.09 |
| Refrigerator | 0.06 |
| Iron | 0.06 |
| Hand Mixer | 0.05 |
| Phonograph | 0.04 |
| Coffee Pot | 0.03 |

* 1-10 kV/m next to blanket wires

An electric current flowing in any conductor (electric equipment, household appliance, or otherwise) creates a magnetic field. The magnetic field intensity unit is the Gauss, which is a measure of the magnetic flux density – the intensity of magnetic field attraction over a unit of area. (Magnetic field is also given sometimes in the Tesla and Amp/meter). As a reference, the earth has a natural static magnetic field of about 0.5 Gauss (or 500 milliGauss, mG, since 1 mG = 0.001 Gauss).

The magnetic field under transmission lines is relatively low – at least in comparison with measurements near many household appliances and other equipment. The magentic field near an appliance decreases rapidly with distance away from the device.

Typical values of magnetic field near selected appliances are given in Table 3 as numerical examples to understand common household levels (units are in milliGauss, mG, or thousandths of a Gauss):

TABLE 3

Magnetic Field Due to Household Appliances

| Appliance | Magnetic Field - milliGauss (1mG = 0.001G) 12" Away | Maximum |
|---|---|---|
| Electric Range | 3-30 | 100-1,200 |
| Electric Oven | 2-5 | 10-50 |
| Garbage Disposal | 10-20 | 850-1,250 |
| Refrigerator | 0.3-3 | 4-15 |
| Clothes Washer | 2-30 | 10-400 |
| Clothes Dryer | 1-3 | 3-80 |
| Coffee Maker | 0.8-1 | 15-250 |
| Toaster | 0.5-8 | 70-150 |
| Crock Pot | 0.8-1 | 15-80 |
| Iron | 1-3 | 90-300 |
| Can Opener | 35-250 | 10,000-20,000 |
| Mixer | 6-100 | 500-7,000 |
| Blender, Popper, Processor | 6-20 | 250-1,050 |
| Vacuum Cleaner | 20-200 | 2,000-5,000 |
| Portable Heater | 1-40 | 100-1,100 |
| Fans/Blowers | 0.4-40 | 20-300 |
| Hair Dryer | 1-70 | 60-20,000 |
| Electric Shaver | 1-100 | 150-15,000 |
| Color TV | 9-20 | 150-500 |
| Fluorescent Fixture | 2-40 | 140-2,000 |
| Fluorescent Desk Lamp | 6-20 | 400-3,500 |
| Circular Saws | 10-250 | 2,000-10,000 |
| Electric Drill | 25-35 | 4,000-8,000 |

Electric and Magnetic Field Measurements

A series of electric and magnetic field measurements were made in the vicinity of the proposed routes for the Pohoiki 69 kV transmission line. These measurements were made with an Electric Field Measurements Company Model 113 Field Meter. This meter is designed for power frequency field measurements. The meter that was used has been calibrated at the National Bureau of Standards near Washington, DC. Measurements were made in accordance with Institute of Electrical and Electronics Engineers (IEEE) Recon-mended Practices for Measurement of Electric and Magnetic Fields from AC Power Lines: IEEE Standard No. 644-1979.

Measurements were made at nine (9) sites near existing 12.47 kV, 34.5 kV, and 69 kV transmission lines. The 12.47 kV and 34.5 kV lines are in the vicinity of the line route, while the 69 kV line was selected because it is similar to the proposed design for the Pohoiki line. The results of the measurement program are listed in the following data summary:

## ELECTRIC AND MAGNETIC FIELD MEASUREMENT RESULTS
(March 17, 1987: M. Silva, F. Karimoto, R. Hara)

**Site No. 1**

Location: Leilani Estates - Kahukai Blvd.
Time: 9:30 am
Line: 12.47 kV - vertical construction - 3 phase with common neutral and telephone underbuild. Midspan structures #42-43.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.009 | 0.0040 | 0.050 |
| 5 | 0.010 | 0.0045 | 0.056 |
| 10 | 0.013 | 0.0042 | 0.052 |
| 15 | 0.012 | 0.0037 | 0.046 |
| 20 | 0.009 | 0.0028 | 0.035 |
| 25 | 0.007 | 0.0025 | 0.031 |

**Site No. 2**

Location: HGPA Geothermal Plant - near entrance
Time: 9:50 am
Line: 34.5 kV - vertical construction - with 3 phase 12 kV underbuild with neutral and shieldwire on top. Midspan structures #26-27.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.010 | 0.0900 | 1.125 |
| 5 | 0.012 | 0.0800 | 1.000 |
| 10 | 0.013 | 0.0750 | 0.937 |
| 15 | 0.012 | 0.0700 | 0.875 |
| 20 | 0.012 | 0.0650 | 0.812 |
| 25 | 0.011 | 0.0600 | 0.750 |

**Site No. 3**

Location: Nanawale Estates - Lido Lane
Time: 10:05 am
Line: 34.5 kV - with 12 kV underbuild (flat plane). Midspan structures #277-278.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.037 | 0.3200 | 4.000 |
| 5 | 0.055 | 0.3000 | 3.750 |
| 10 | 0.067 | 0.2900 | 3.625 |
| 15 | 0.070 | 0.2700 | 3.375 |
| 20 | 0.062 | 0.2600 | 3.250 |
| 25 | 0.048 | 0.2300 | 2.875 |

**Site No. 4**

Location: Ainaloa Subdivision - Hwy #130
Time: 10:45 am
Line: 34.5 kV - vertical construction - with 12 kV underbuild. Midspan structures #147-148.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.020 | 0.0040 | 0.050 |
| 5 | 0.038 | 0.0035 | 0.043 |
| 10 | 0.055 | 0.0032 | 0.040 |
| 15 | 0.062 | 0.0030 | 0.037 |
| 20 | 0.060 | 0.0025 | 0.031 |
| 25 | 0.052 | 0.0020 | 0.025 |

**Site No. 5**

Location: Hawaiian Paradise - 28th St.
Time: 11:05 am
Line: 12 kV - single phase with neutral on bottom - Midspan structures #4-5.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.052 | 0.0005 | 0.006 |
| 5 | 0.054 | 0.0007 | 0.008 |
| 10 | 0.060 | 0.0006 | 0.007 |
| 15 | 0.058 | 0.0005 | 0.006 |
| 20 | 0.053 | 0.0004 | 0.005 |
| 25 | 0.044 | 0.0003 | 0.003 |

**Site No. 6**

Location: Hawaiian Paradise - 24th St. (near Mr. Ron Phillips' house)
Time: 11:20 am
Line: 12 kV - single phase

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.080 | 0.0005 | 0.006 |
| 5 | 0.085 | 0.0004 | 0.005 |
| 10 | 0.087 | 0.0003 | 0.003 |
| 15 | 0.083 | 0.0002 | 0.002 |
| 20 | 0.075 | 0.0002 | 0.002 |
| 25 | 0.066 | 0.0001 | 0.001 |

Site No. 7

Location: Hawaiian Paradise - Railroad Ave. (near 18th St. intersection)
Time: 11:40 am
Line: 12 kV (2 phase flat) with neutral and telephone cable.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.054 | 0.0004 | 0.005 |
| 5 | 0.055 | 0.0003 | 0.003 |
| 10 | 0.056 | 0.0002 | 0.002 |
| 15 | 0.050 | 0.0002 | 0.002 |
| 20 | 0.042 | 0.0001 | 0.001 |
| 25 | 0.030 | 0.0001 | 0.001 |

Site No. 8

Location: Kaumana Drive
Time: 12:20 pm
Line: 69 kV - Davit arms with 3 phase 2.4 kV underbuild. Midspan structures #72-73.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.033 | 0.3800 | 4.750 |
| 5 | 0.082 | 0.3700 | 4.625 |
| 10 | 0.162 | 0.3600 | 4.500 |
| 15 | 0.190 | 0.3200 | 4.000 |
| 20 | 0.185 | 0.2800 | 3.500 |
| 25 | 0.158 | 0.2400 | 3.000 |

Site No. 9

Location: Saddle Road
Time: 12:35 pm
Line: 69 kV - Davit arm without underbuild. Midspan structures #443-444.

| Distance from C.L. ft | Electric Field E, kV/m | Magnetic Field Resultant H, A/m | B, mG |
|---|---|---|---|
| 0 | 0.265 | 0.4000 | 5.000 |
| 5 | 0.280 | 0.3800 | 4.750 |
| 10 | 0.282 | 0.3500 | 4.375 |
| 15 | 0.262 | 0.2800 | 3.500 |
| 20 | 0.235 | 0.2500 | 3.125 |
| 25 | 0.188 | 0.2000 | 2.500 |

## Electric and Magnetic Field Calculations

The electric and magnetic field values that were measured near existing HELCO transmission and distribution facilities are representative of typical situations. However, often it is necessary to calculate electric and magnetic field values for conditions that may not exist during routine field measurements. For example, electric and magnetic fields for minimum ground clearance situations, high conductor temperatures, and heavy electrical loads. The electric and magnetic fields were calculated for typical 12.47 kV and 34.5 kV electrical facilities (with minimum clearance and heavy electrical loading) that are representative of lines in the vicinity of the proposed routes. Also, fields were calculated for the proposed Pohoiki 69 kV design for normal and emergency loadings. Sketches of the line details used in the calculations are provided in the Appendix (Figures 1A, 2A, 3A).

The results of these calculations are presented as lateral profiles of both the electric and magnetic fields. A lateral profile is a plot of the calculated maximum field as a function of distance away from the right-of-way (ROW) center.

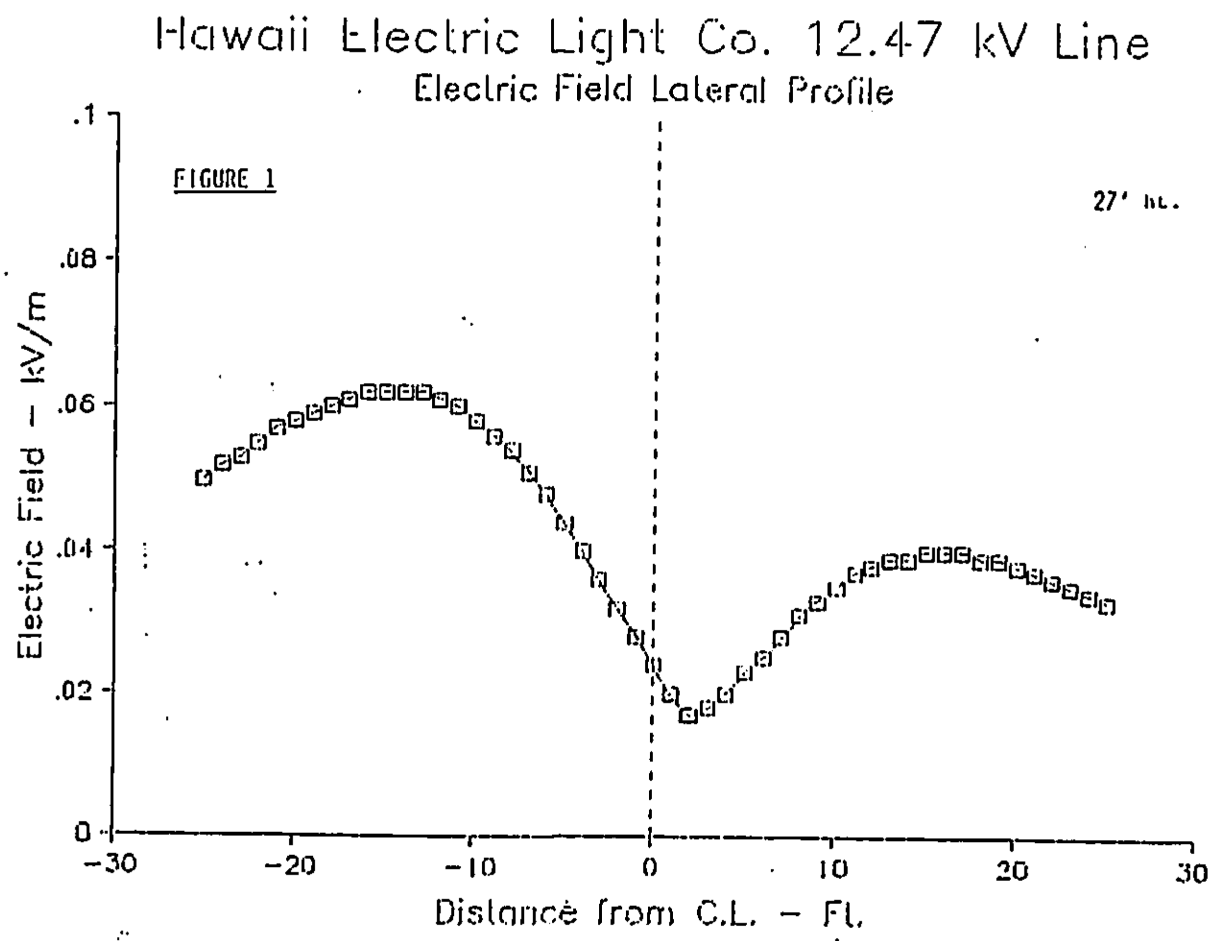
In Figure 1, the electric field is shown for a 12.47 kV distribution line with 27 ft minimum ground clearance. In Figure 2, the electric field lateral profile is presented for a 34.5 kV distribution line for 30 ft minimum ground clearance (and also for 40 ft - a more typical value).

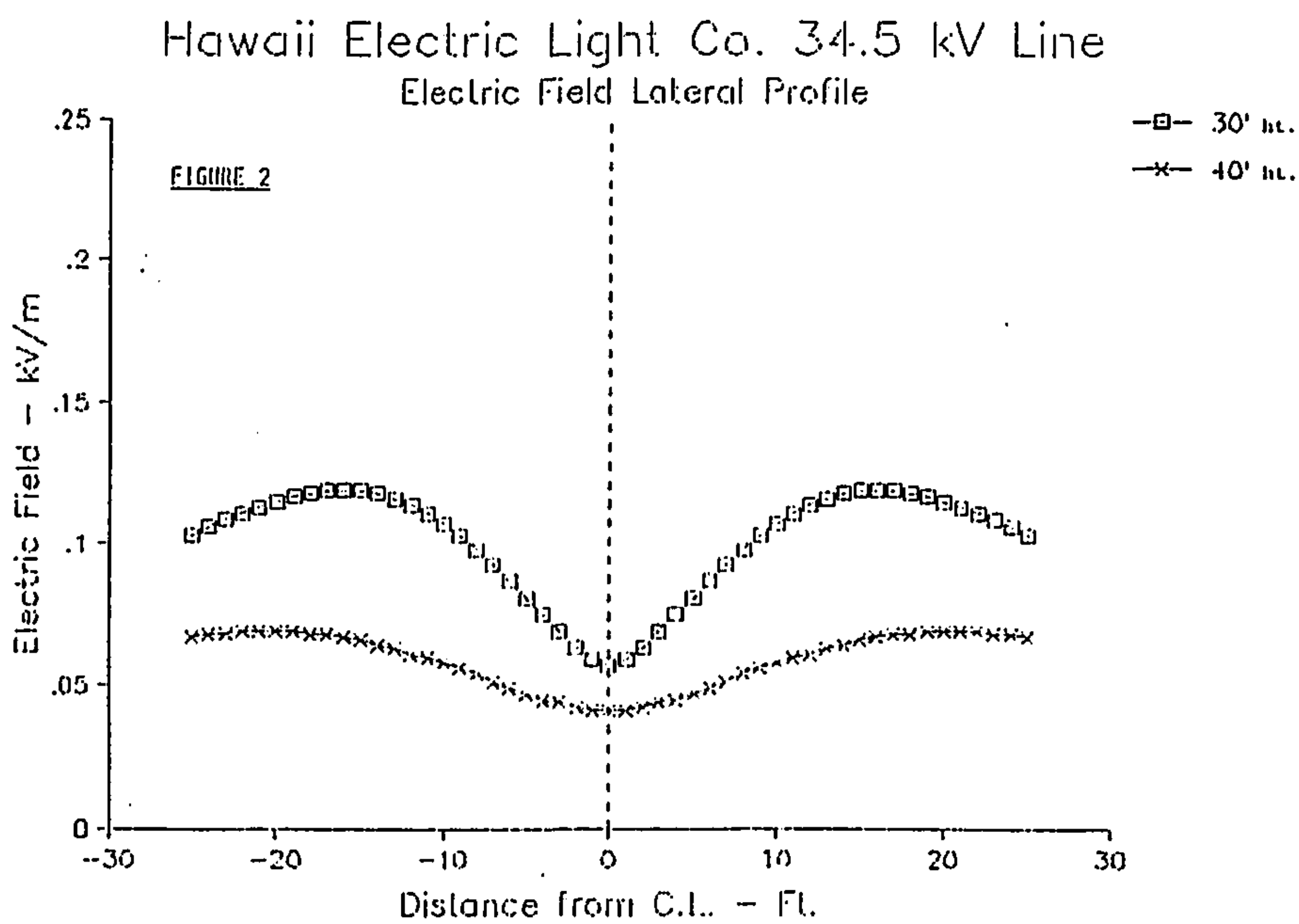
In Figure 3, the electric field is plotted for the proposed Pohoiki 69 kV line for 30 ft minimum (and 50 ft typical) ground clearance situations.

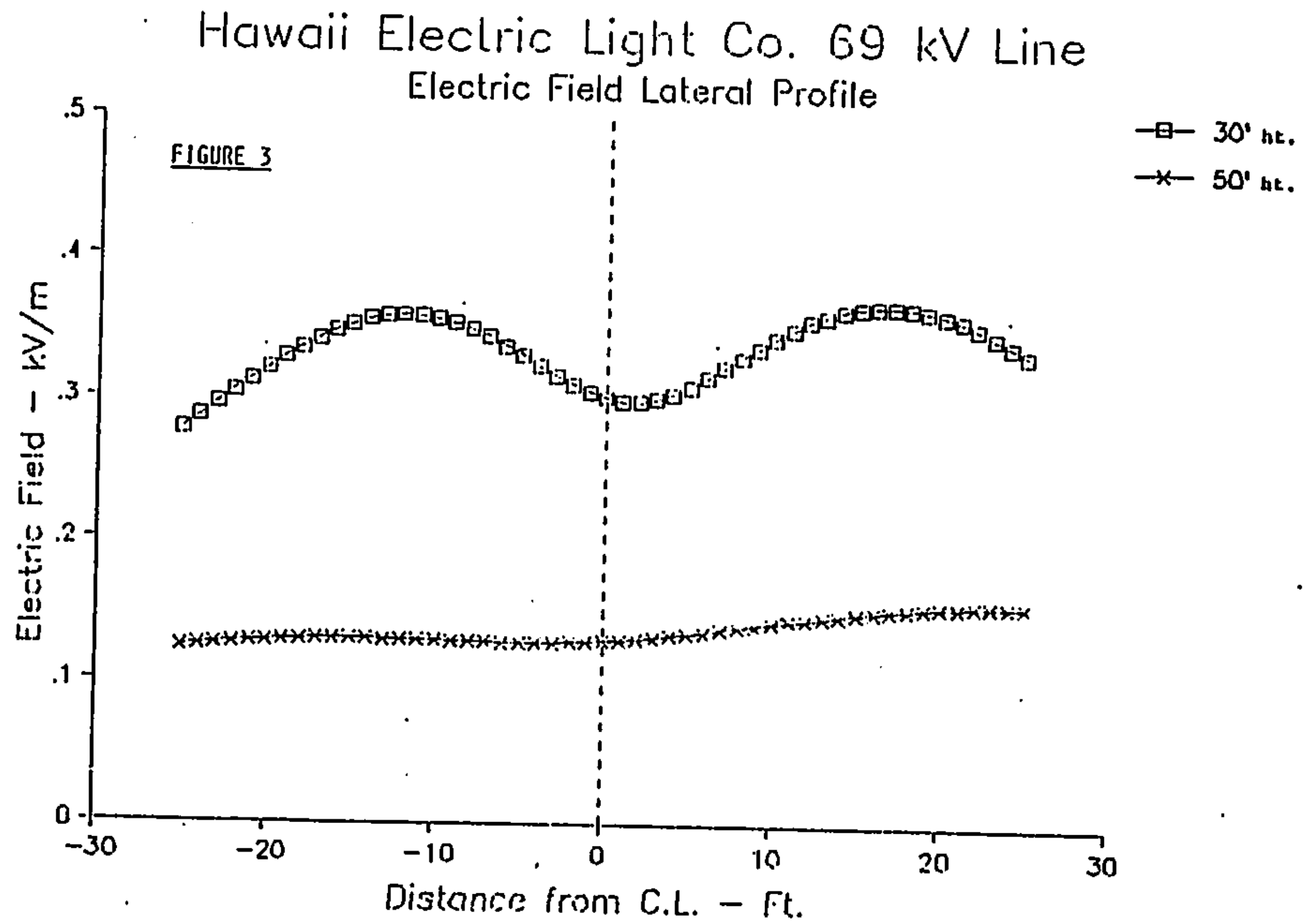
In Figure 4, the magnetic field lateral profile is given for a 12.47 kV line with a summer peak loading of 400 Amperes and 27 minimum ground clearance. Figure 5 provides the magnetic field lateral profiles for a 34.5 kV line with a summer peak load of 300 Amperes for 30 ft minimum ground clearance (and 40 ft typical clearance).

Magnetic field lateral profile values for the Pohoiki proposed 69 kV design are plotted in Figures 6 and 7. In Figure 6, the magnetic field is given for the output of one geothermal unit - 12.5 MW (about 105 Amperes). In Figure 7, the assumed electrical loading is doubled to 25 MW to simulate emergency conditions when a single 69 kV line might have to temporarily carry the output of two geothermal units.

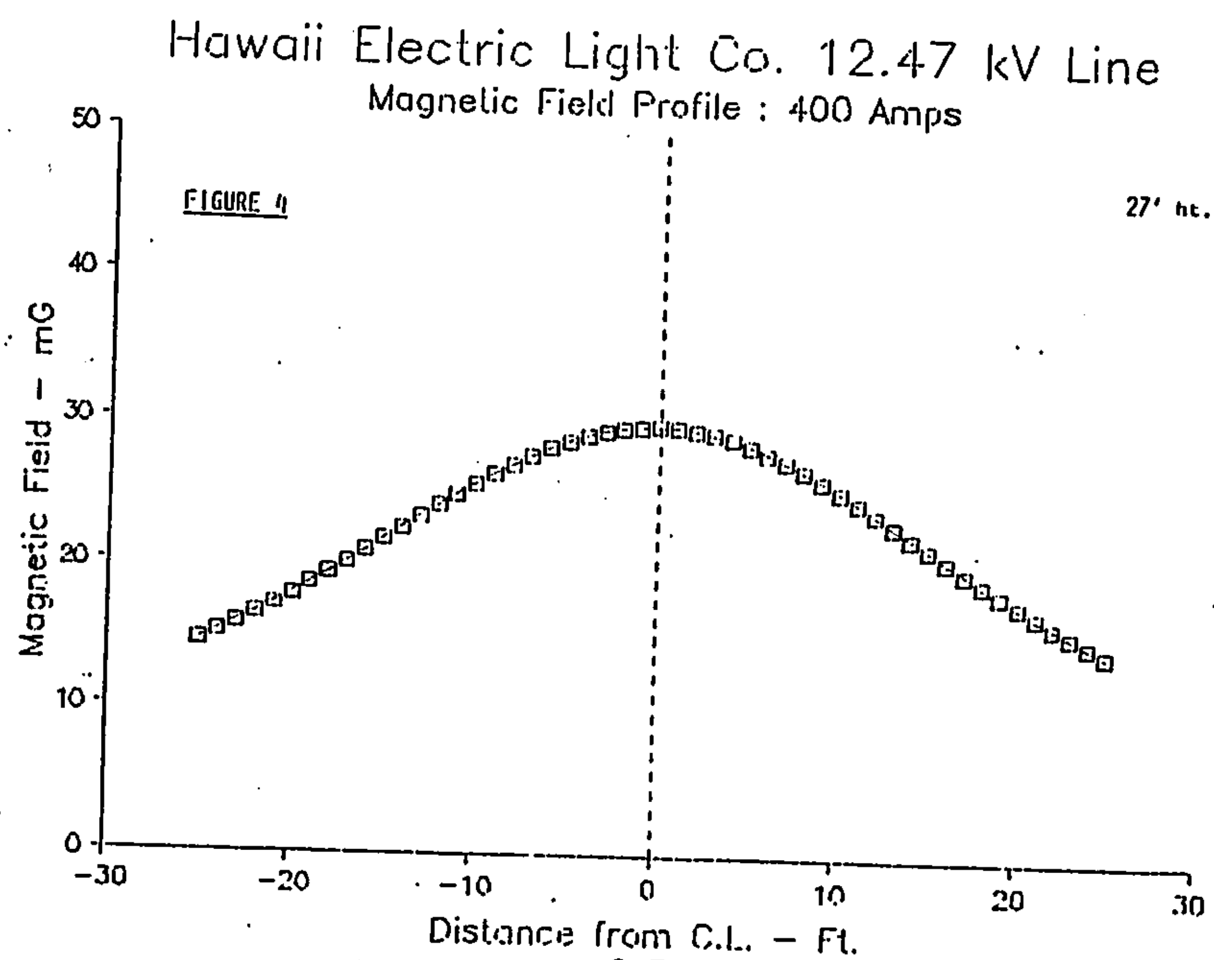
The calculation results are summarized in the following Table 4.


Hawaii Electric Light Co. 12.47 kV Line
Electric Field Lateral Profile
FIGURE 1
27' ht.
Electric Field - kV/m
.1
.08
.06
.04
.02
0
-30
-20
-10
0
10
20
30
Distance from C.L. - Ft.


Hawaii Electric Light Co. 34.5 kV Line
Electric Field Lateral Profile
FIGURE 2
30' ht.
40' ht.
Electric Field - kV/m
.25
.2
.15
.1
.05
0
-30
-20
-10
0
10
20
30
Distance from C.L. - Ft.

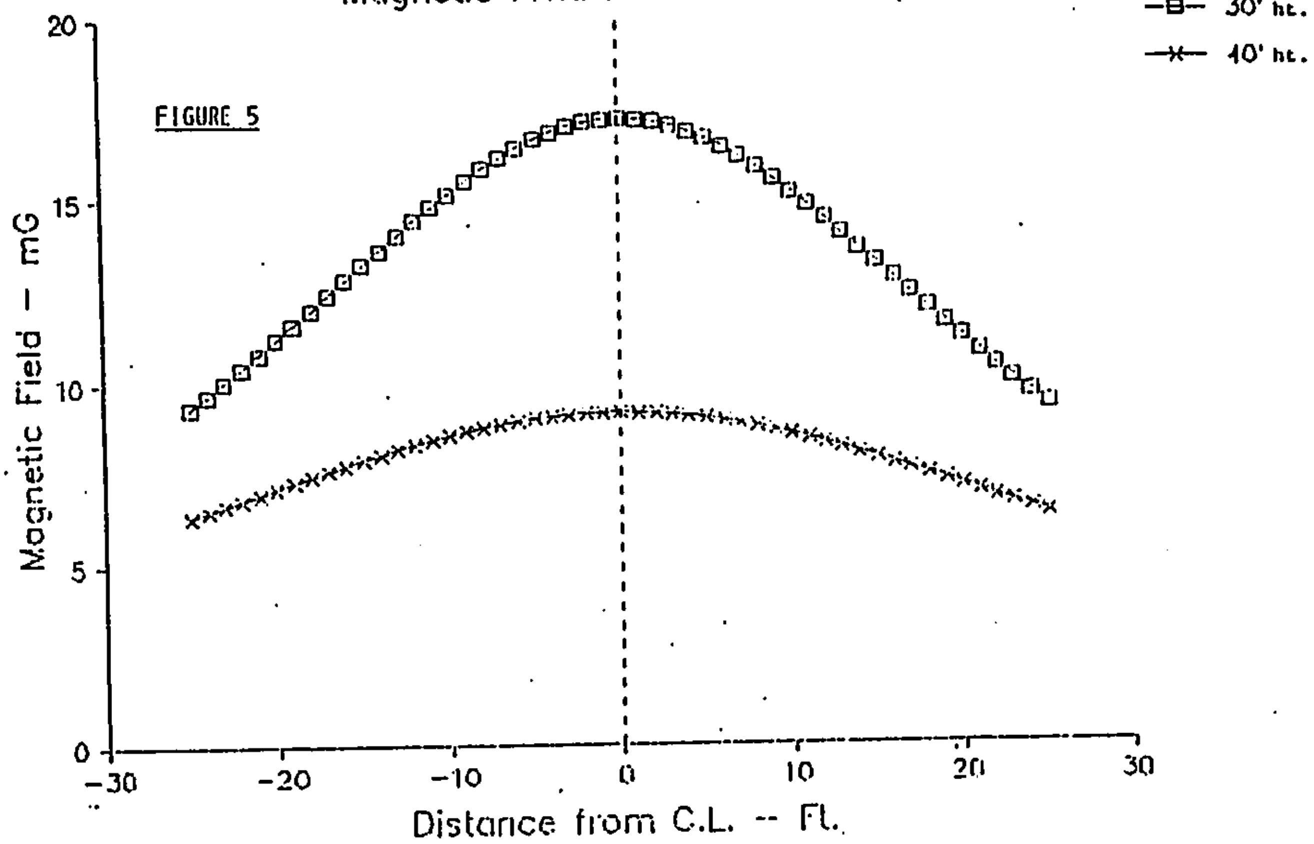


Hawaii Electric Light Co. 69 kV Line
Electric Field Lateral Profile
FIGURE 3
30' ht.
50' ht.
Electric Field – kV/m
Distance from C.L. – Ft.

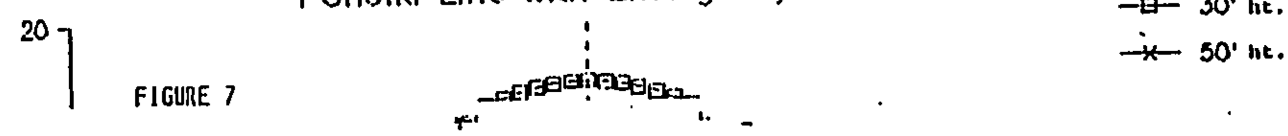



Hawaii Electric Light Co. 12.47 kV Line
Magnetic Field Profile : 400 Amps
FIGURE 4
27' ht.
Magnetic Field – mG
Distance from C.L. – Ft.

## Hawaii Electric Light Co. 34.5 kV Line
Magnetic Field Profile : 300 Amps




## Hawaii Electric Light Co. 69 kV Line
Pohoiki Line with Emergency 25 MW




## Hawaii Electric Light Co. 69 kV Line
Pohoiki Line with 12.5 MW

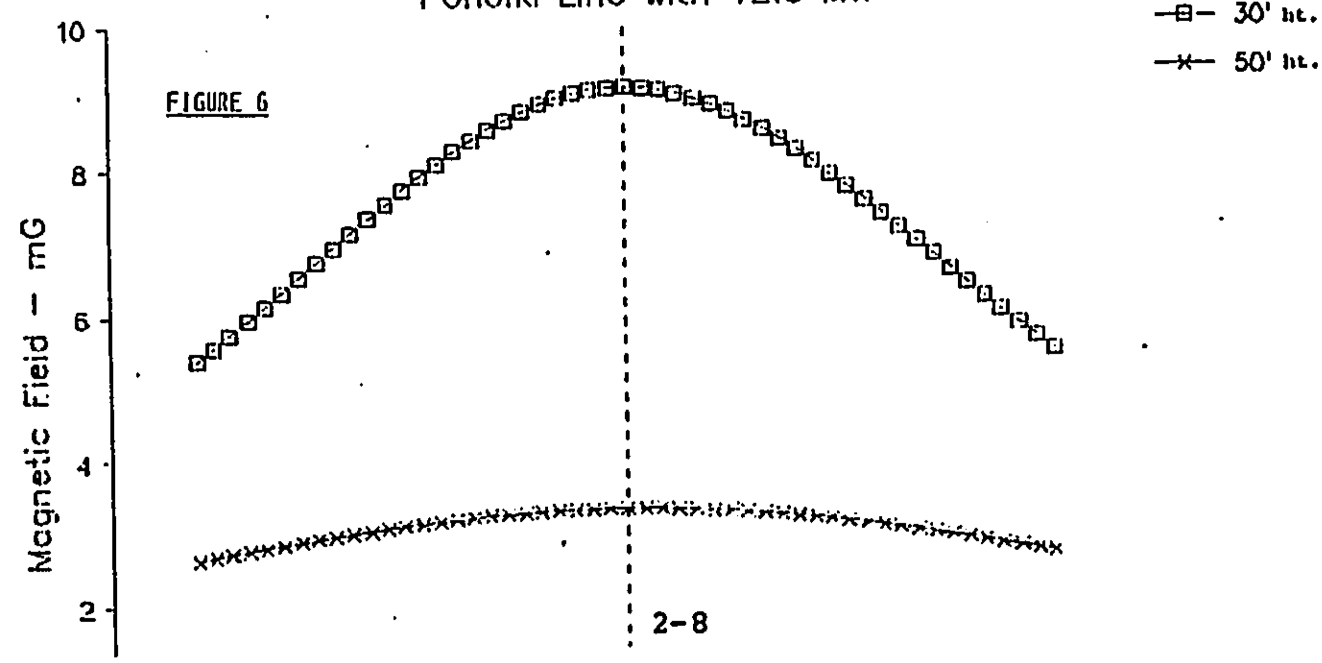


**TABLE 4**

SUMMARY OF ELECTRIC AND MAGNETIC FIELD CALCULATIONS

| | Case Number | Electric Field, kV/m Max | Electric Field, kV/m ROW Edge | Magnetic Field, mG Max | Magnetic Field, mG ROW Edge |
|---|---|---|---|---|---|
| 1) | 12.47 kV: 27 ft/400 A | 0.062 | 0.050 | 29.7 | 14.5 |
| 2) | 34.5 kV: 30 ft/300 A | 0.119 | 0.103 | 17.1 | 9.3 |
| 3) | 34.5 kV: 40 ft/300 A | 0.069 | 0.067 | 9.1 | 6.3 |
| 4) | 69 kV: 30 ft/12.5 MW | 0.359 | 0.334 | 9.1 | 5.4 |
| 5) | 69 kV: 50 ft/12.5 MW | 0.156 | 0.124 | 3.2 | 2.6 |
| 6) | 69 kV: 30 ft/25 MW | 0.359 | 0.334 | 18.2 | 10.9 |
| 7) | 69 kV: 50 ft/25 MW | 0.156 | 0.124 | 6.5 | 5.2 |

The results of electric and magnetic field calculations and measurements indicated that the fields associated with the proposed Pohoiki 69 kV line are generally similar to some of the HELCO existing distribution facilities.

The electric fields will be somewhat higher than distribution lines (but still less than all the other larger voltage lines) and fields will be somewhat lower for magnetic fields. The electric and magnetic fields associated with the proposed Pohoiki 69 kV line are also many times less than any existing standards for electric and magnetic fields.



## Conclusions

1. This voltage classification has been in service for over 75 years. There are currently over 324,000 miles of line in service in the United States rated at 69 kV and above. This provides a substantial base of operating experience for use in design, construction and operation of new 69 kV transmission lines.

2. The electrical performance of the proposed design was compared with other typical 69 kV line designs and generally accepted engineering standards. The design and electrical performance of the proposed HELCO 69 kV line is not unique, but very typical of other 69 kV lines. The line design methodology is based on sound engineering principles, and years of operating experience.

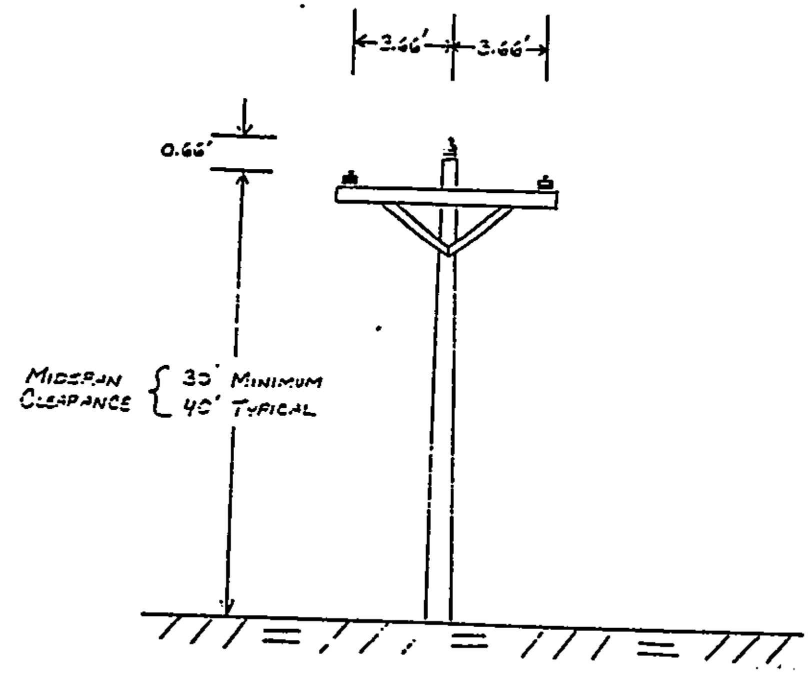
3. The proposed HELCO 69 kV line will be designed to normally not produce any commercial radio, television or amateur radio interference. If a situation should arise due to line hardware, HELCO has a policy of locating and correcting any interference problem due to the line.

4. The electric field of the proposed 69 kV line will be about 0.12-0.33 kV/m at the right-of-way edge. The maximum magnetic field in the same location will be about 0.002-0.005 Gauss (or 2-5 mG). These values are low due to the increased minimum design clearance. They are generally comparable to some household appliances and some of the existing lower voltage distribution lines already in operation along the proposed line routes.

5. The proposed Pohoiki 69 kV line design is in compliance with Hawaii General Order No. 6. In addition, the line design meets standards set by California General Order No. 95 (Rules for Overhead Electric Line Construction) and will exceed the National Electrical Safety Code (NESC). The long operating experience for lines designed with the NESC for many decades has shown that its requirements have provided an ample margin for public safety. The proposed design is consistent with the technology and state-of-the-art in transmission line engineering. The HELCO proposed design for the Pohoiki 69 kV line should produce a well-engineered and safe facility.

etc. ENERTECH Consultants
1010 W. Fremont, Suite E
Sunnyvale, CA 94087

SUBJECT: Hawaii Electric Light Co. 34.5 kV Line
BY: JMS DATE: [illegible] PROJ. NO. [illegible]
CHKD. BY: DATE: SHEET NO. OF



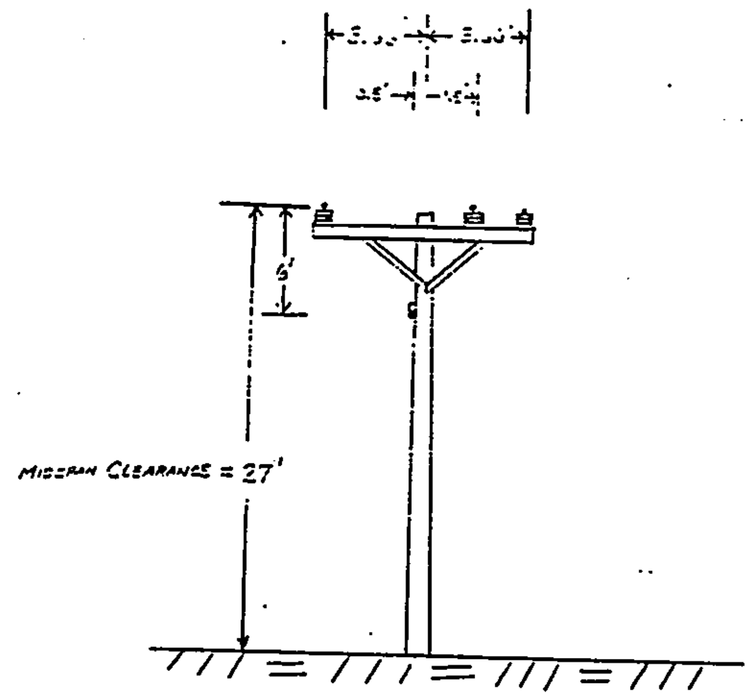

34.5 kV
300 Amp Load
336.4 kcm AAC
0.66" Diameter

FIGURE 1A

APPENDIX

SUBJECT HAWAII ELECTRIC LIGHT CO.
12.47 kV LINE
BY JMS DATE [illegible] PROJ. NO. [illegible]
CHKD. BY ______ DATE ______ SHEET NO. ______ OF ______

etc.
ENERTECH Consultants
1010 W. Fremont, Suite E
Sunnyvale, CA 94087

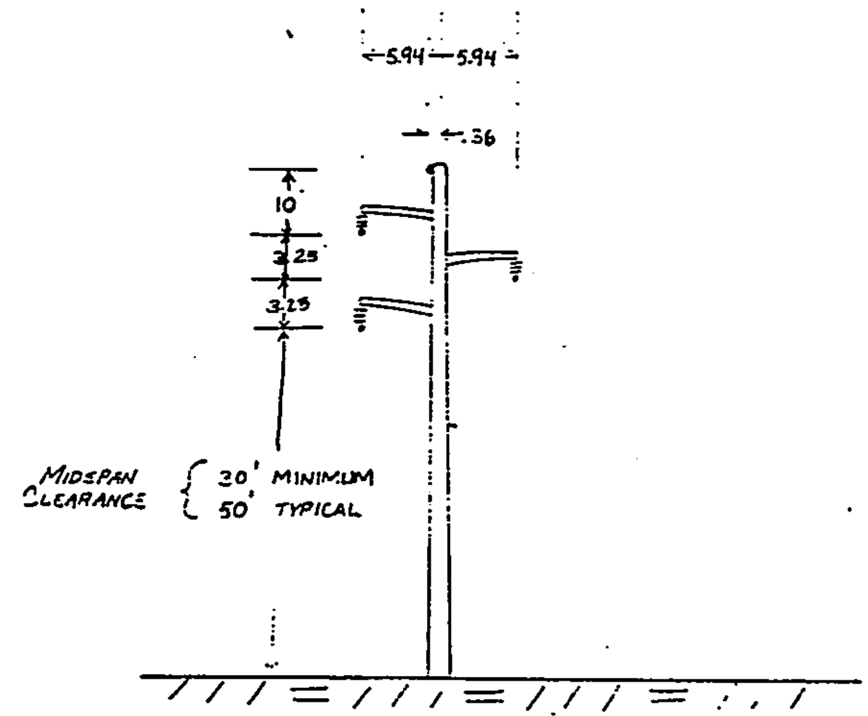



12.47 kV
400 AMP LOAD
336.4 KCM AAC
0.66" DIAMETER
NEUTRAL: 3/0 AAC
0.46" DIAMETER

FIGURE 2A

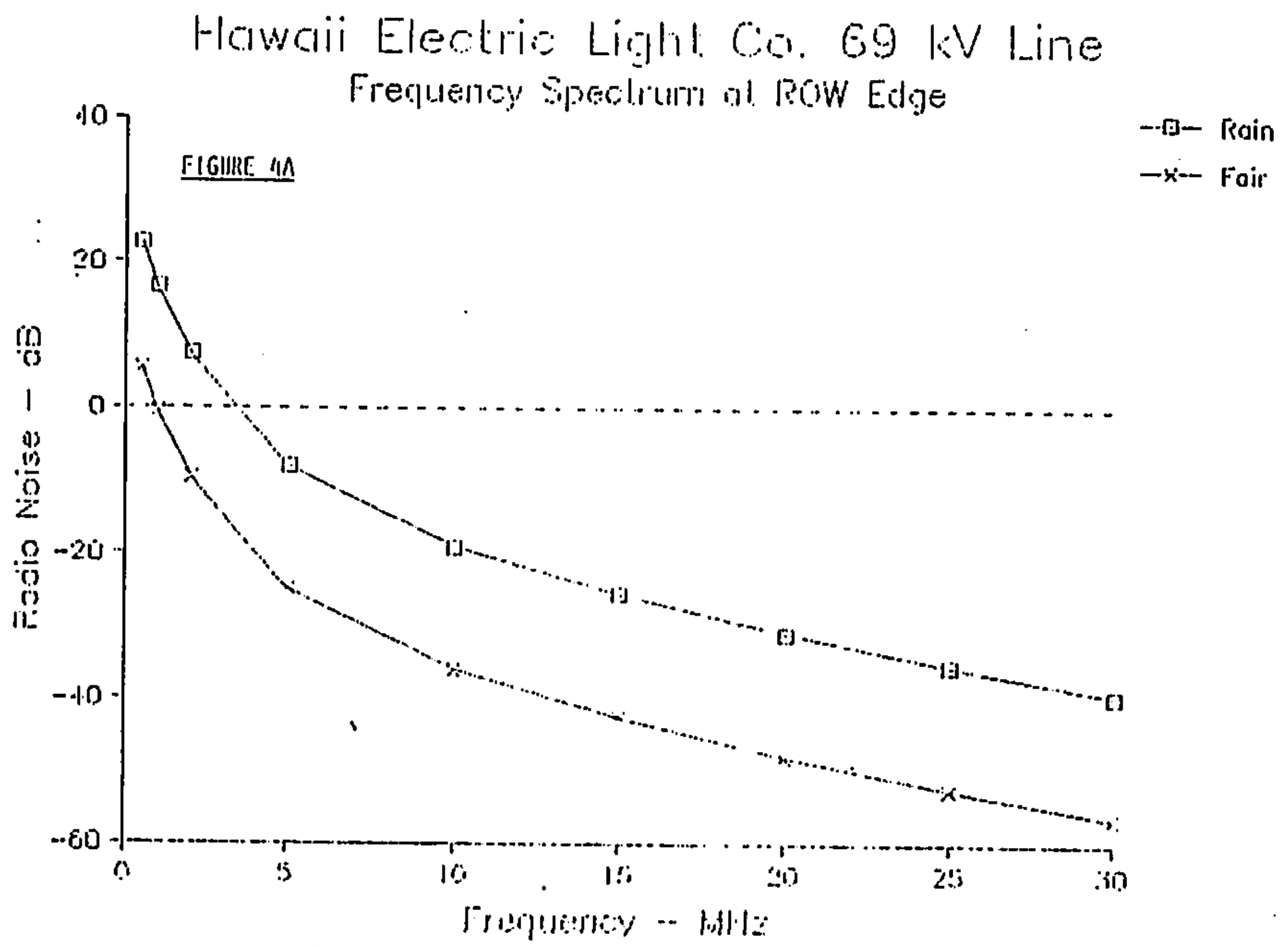
SUBJECT HAWAII ELECTRIC LIGHT CO.
POHOIKI 69 kV LINE
BY JMS DATE [illegible] PROJ. NO. [illegible]
CHKD. BY ______ DATE ______ SHEET NO. ______ OF ______

etc.
ENERTECH Consultants
1010 W. Fremont, Suite E
Sunnyvale, CA 94087




69 kV
LOAD: 12.5 MW NORMAL (105 AMPS)
25 MW EMERGENCY (210 AMPS)
556.5 KCM AAC
0.953" DIAMETER
SHIELD WIRE: 0.5" DIAMETER
CLASS 1 POLE

FIGURE 3A



Hawaii Electric Light Co. 69 kV Line
Frequency Spectrum at ROW Edge
FIGURE 4A
Rain
Fair
Radio Noise — dB
40
20
0
-20
-40
-60
0
5
10
15
20
25
30
Frequency -- MHz

# APPENDIX 3

DANTE K. CARPENTER
Mayor

JOSEPH W. ANDREWS
Director of Finance

COUNTY OF HAWAII
DEPARTMENT OF FINANCE
25 Aupuni Street
Hilo, Hawaii 96720

August 6, 1987

Mr. Clyde H. Nagata, Manager
Engineering Department
Hawaii Electric Light Company, Inc.
P. O. Box 1027
Hilo, Hawaii 96721-1027

Dear Mr. Nagata:

You have asked for our comments regarding our real property assessed values covering the fiscal years 1972 through 1976 pertaining to parcels abutting Kawailani Street.

As a general observation, I find that real property assessed values increased annually from 1972 through 1976. It should also be noted that between 1975 and 1976 there was a change in the percentage used to determine the assessed value. In 1975 assessments were based on 70% of market value whereas in 1976 this percentage was reduced to 60%. This change must be taken into account when comparing the assessed valuation of 1975 and 1976.

Very truly yours,

JOSEPH W. ANDREWS
DIRECTOR OF FINANCE

cc: Mayor Dante K. Carpenter

# APPENDIX 4

# APPENDIX 4

## COMMENTS AND RESPONSES DURING THE CONSULTATION PHASE

The EIS Preparation Notice was published in the OEQC Bulletin of October 8, 1987. All comment letters received by either the Department of Land and Natural Resources, OEQC, or the applicant during the consultation phase have been answered and both comment and response letters are included on the following pages.

Those writing to request a copy of the Environmental Assessment were immediately sent one. Substantive comments received have been addressed in the Draft EIS. Letters containing substantive comments were responded to in detail prior to filing the Draft EIS.

SEP 29 1987

Dr. Marvin T. Miura, Director
Office of Environmental
Quality Control
465 South King Street- Rm. 115
Honolulu, Hawaii 96813

Dear Dr. Miura:

Subject: Environmental Assessment Notice of Preparation of an Environmental Impact Statement for the Pohoiki Geothermal Transmission Line Project Puna, Hawaii

We have received the attached Environmental Assessment prepared by DHM Planners Inc. for the applicant, Hawaii Electric Light Company, and concur with the decision that an Environmental Impact Statement is required for the project.

Any comments or requests should be addressed to:

Wendie McAlaster
DHM Planners Inc.
1188 Bishop Street,
Suite 2405
Honolulu, Hawaii, 96813

Please find enclosed for your information four (4) copies of the EA/Prep Notice for the Pohoiki Geothermal Transmission Line.

For any questions to the foregoing, please contact our Land Management Division at 548-6460.

Very truly yours,

WILLIAM W. PATY
Chairperson of the Board

Enclosures
cc: Hawaii Board Member
Hawaii District Land Office
All Divisions, DLNR

MM:en



JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
465 SOUTH KING STREET, ROOM 104
HONOLULU, HAWAII 96813

MARVIN T. MIURA, Ph.D.
DIRECTOR

TELEPHONE NO.
548-6915

November 13, 1987

Ms. Wendie McAlaster
DHM Planners Inc.
1188 Bishop St., Suite 2405
Honolulu, Hawaii 96813

Dear Ms. McAlaster:

SUBJECT: Environmental Assessment/EIS Preparation Notice for the Pohoiki Geothermal Transmission Line

The Office of Environmental Quality Control has reviewed the subject environmental assessment/EIS preparation notice and offers the following comments for your consideration:

1. The corridors for the proposed transmission line will cross several privately-owned agricultural subdivisions. What is the total number of lots that will be developed at complete buildout of these subdivisions? What is the approximate number of lots that will be directly impacted by the location of the supporting poles?

2. In the documentation reviewed, it is stated that current research indicates that there will be no biological impacts on human health from these transmission lines. A discussion of what impacts have been studied should be included in the environmental impact statement.

Thank you for providing this office the opportunity to comment on the subject document. Should you have any further questions, please contact Faith Miyamoto at 548-6915.

Sincerely yours,

Marvin T. Miura, Ph.D.
Interim Director

Faith Miyamoto
Planner

**DHM inc.**
land use
and environmental
planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9655

November 18, 1987

Mr. Marvin T. Miura, Ph.D.
Interim Director
Office of Environmental Quality Control
State of Hawaii
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Mr. Miura:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Thank you for your November 13, 1987 response to the Environmental Assessment for the subject project.

At this time, the proposed alignments cross portions of the following privately-owned agricultural subdivisions: Hawaiian Paradise Park, Orchid Land Estates, Ainaloa, Leilani, and Nanawale Estates. The specific number of lots that will be impacted by the transmission lines has not yet been calculated. This will depend on whether the new lines are built within existing HELCO rights-of-way (over existing distribution lines), or whether new rights-of-way will need to be acquired. There are existing rights-of-way and distribution lines along most of the roads currently proposed as routes for the new transmission lines.

Hawaii Electric Light Company has consulted with J. Michael Silva of Enertech Consultants regarding the biological impacts of the proposed 69 kV lines. A discussion on current research and impacts that have been studied will be included in the EIS.

Sincerely,

Wendie McAllaster

Wendie McAllaster
Project Manager

RUSSELL S. KOKUBUN
Councilman

COUNTY COUNCIL
County of Hawaii
Hawaii County Building
25 Aupuni Street
Hilo, Hawaii 96720

November 24, 1987

Office of Environmental Quality Control
465 South King Street
Kekuanaoa Building, Room 104
Honolulu, Hawaii 96813

According to the October 8, 1987 issue of the OEQC Bulletin, DHM Planners, Inc. will be preparing an EIS for HELCO's proposed Pohoiki Geothermal Transmission Line in Puna, Hawaii.

As Chairman of the Subcommittee on Agriculture and Energy of the Hawaii County Council and a Councilman representing the Puna District, I am very much interested in learning more about the potential negative impact that HELCO's proposed transmission line will have on the environment. Therefore, I am requesting that I be consulted during the review process and that I be forwarded a copy of the Draft EIS when it is completed.

I realize that November 9, 1987 was the deadline for making such a request; however, circumstances prevented me from meeting the deadline. I sincerely hope that you will be able to accommodate my request.

Thank you for your cooperation.

Sincerely,

Russell S. Kokubun
COUNCILMAN

cc: ✓DMH Planners, Inc.
(Attn. - Ms. Wendie McAlaster)

DHM inc.
land use and environmental planning
1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9655

December 8, 1987

The Honorable Russell S. Kokubun
City Council
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Dear Councilman Kokubun:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Per your request to OEQC to be a consulted party in the EIS process for the transmission line project, we are enclosing a copy of the EIS Preparation Notice/Environmental Assessment.

Upon review of the document, if there is specific information which you would like covered in the forthcoming EIS, please inform us accordingly.

A copy of the draft EIS will be sent to you during the public review period. The complete text of the Routing Study report will be included in the EIS.

Sincerely,

Wendie McAllaster
Project Manager

Enclosure

**Ainaloa Community Association**
*A Non-Profit Hawaii Corporation*
RR 1 BOX 43
PAHOA, HAWAII 96778
TELEPHONE: (808) 966-8424

October 30, 1987

Office of Environmental Control
465 South King Street #104
Honolulu HI 96813

RE: 69K Transmission Line--Pohoiki Geothermal Line

Sirs:

It is the understanding of the undersigned that Hawaii Electric Light Co. must submit an Environmental Impact Statement with regards to the 69K Pohoiki Geothermal Transmission Line proposal.

As President of the Board of Directors of the Ainaloa Community Association, across whose members' property this proposed line will probably pass, I hereby request that I be a consulted party to the Environmental Impact Statement.

I can be reached by mail or telephone at the address and phone number listed above.

Thank you very much.

Sincerely yours,

Mary J. Owens
Mary J. Owens
President, Board of Directors

---

**DHM inc.** land use and environmental planning

1168 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9655

November 18, 1987

Ms. Mary J. Owens
President, Board of Directors
Ainaloa Community Association
RR 1, Box 43
Pahoa, Hawaii 96778

Dear Ms. Owens:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Per your request to OEQC to be a consulted party in the EIS process for the transmission line project, we are enclosing a copy of the EIS Preparation Notice/Environmental Assessment.

Upon review of the document, if there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

A copy of the draft EIS will be sent to you by EQC during the public review period. The complete text of the Routing Study report will be included in the EIS.

Sincerely,

Wendie McAllaster
Wendie McAllaster
Project Manager

Enclosure

Citizens for Responsible Energy Development with Aloha 'Āina

CREDAA
P.O. Box 574
Mt. View, Hawaii 96771

Ms. Wendy McAlaster
DHM Planners Inc.
1188 Bishop St., Suite 2405
Honolulu, Hawaii, 96813

October 30, 1987

Dear Ms. McAlaster,

CREDAA is a non-profit organization that is concerned about the impacts of geothermal development in our Big Island community. We would like to be included in the list of Concerned Parties for the
4 Environmental Impact Statement for the Pohoiki Geothermal
1 Transmission Line, Puna, Hawaii, listed in the OEQC Bulletin for
6 October 23, 1987.

We are also requesting a copy of the Draft EIS at this time. Thank you for your cooperation in this matter.

For CREDAA

Earl A. Dunn, Jr.

---

DHM inc.
land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph (808) 521-9855

November 4, 1987

Mr. Earl A. Dunn, Jr.
CREDAA
P.O. Box 574
Mt. View, Hawaii 96771

Dear Mr. Dunn:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

We appreciate your request to be a consulted party in the EIS process for the transmission line project.

Enclosed is a copy of the EIS Preparation Notice/Environmental Assessment for the subject project in Puna, Hawaii. Upon review of the document, if there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

Sincerely,

Wendie McAllaster
Project Manager

Enclosure

**Diamond Shamrock**
Thermal Power Company

Ralph A. Patterson, Jr.
Hawaii Project Manager

4 November 1987

Ms. Wendie McAlaster
DHM Planners Inc.
1188 Bishop Street #2405
Honolulu, Hawaii 96813

Dear Wendie:

In accordance with our conversation, please include Thermal Power Company as a consulted party in the matter of the EIS for the Pohoiki Geothermal Transmission line.

Thermal Power has no comments to offer at this time but will review the Draft EIS when it is available.

Thank you for your consideration.

Sincerely yours,

Ralph Patterson

RAP/cn/0330A

cc: DLNR, Div. of Land Mgt.
OEQC

Thermal Power Company, A Subsidiary of Diamond Shamrock
Central Pacific Plaza, 220 South King Street, Suite 1750, Honolulu, Hawaii 96813 Phone 808 524-8940

*For the Protection of Hawaii's Native Wildlife*

**HAWAII AUDUBON SOCIETY**

P.O. BOX 22832
HONOLULU, HAWAII 96822

P. O. Box 275
Volcano, HI 96785

November 6, 1987

Ms. Wendie McAlaster
DHM Planners, Inc.
1133 Bishop Street, Suite 2405
Honolulu, HI 96813

Re: Pohoiki Geothermal Transmission Line, Puna, Hawaii, to be constructed by the Hawaii Electric Light Company, Inc.

Dear Ms. McAlaster:

Thank you for sending the Society a copy of the preparation notice for an environmental impact statement (EIS) on the project named above. The Society asks to be a consulted party and receive a copy of the draft EIS when it is available.

We expect that detailed findings of the biological surveys conducted along the buffer zones and alignments of the transmission lines will be published in the draft EIS, along with biological surveys of the alternative routes between Pohoiki and Keaau. We look forward to objective analyses of the project's impacts on the native communities of plants, birds and insects in the area. The EIS should provide a full description of the forest of "scattered, immature Ohia trees" mentioned in the preparation notice. Also, the unique biological value of the newly-discovered lava tube ecosystems that are present in the project area should be discussed.

Thank you for the opportunity to make these comments.

Sincerely yours,

*Mae E. Mull*

Mae E. Mull
Island of Hawaii Representative

cc. DLNR
OEQC

---

**DHM inc.**

land use
and environmental
planning

October 19, 1987

Ms. Mae Mull
Hawaii Audubon Society
P.O. Box 275
Volcano, Hawaii 96785

Dear Ms. Mull:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Enclosed, per your request to Hawaiian Electric Company, is a copy of the EIS Preparation Notice/Environmental Assessment for the subject project in Puna, Hawaii.

We appreciate your interest in reviewing the document. If there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

Sincerely,

*Wendie McAllaster*

Wendie McAllaster
Project Manager

Enclosure

Ralph L. Yost
15-2713 N. Hee Street
Pahoa, HI 96778
October 28, 1987

Office Of Environmental Quality Control
Room 104
465 S. King Street
Honolulu, HI 96813

Aloha,

I am a resident of Hawaiian Beaches, in the District of Puna, and the Vice-President of the Hui Kahakai Community Association and the spokesperson for Hawaiian Shores Subdivision for this particular project.

The purpose of this letter is to announce our interest in the forthcoming Environmental Impact Study for HELCOS proposed High TensionTransmission Lines in the District of Puna.

It is our wish to be a Consulted Party in this study so that we can be assured of the oppertunity to know how the study was done and that we will be able to make rational comments and suggestions at the appropriate time.

With kind regards,
Ralph L. Yost
Ralph L. Yost



DHM inc. land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

November 18, 1987

Mr. Ralph L. Yost
Spokesperson for Hawaiian Shores Subdivision
15-2713 N. Hee Street
Pahoa, Hawaii 96778

Dear Mr. Yost:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Per your request to OEQC to be a consulted party in the EIS process for the transmission line project, we are enclosing a copy of the EIS Preparation Notice/Environmental Assessment.

Upon review of the document, if there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

A copy of the draft EIS will be sent to you by EQC during the public review period. The complete text of the Routing Study report will be included in the EIS.

Sincerely,

Wendie McAllaster
Wendie McAllaster
Project Manager

Enclosure

Leilani Community Association
P.O. BOX 361 - PAHOA, HAWAII 96778

November 4, 1987

Office of Environmental Control
465 South King St., Room 104
Honolulu, HI 96813

Sirs:

We would like to be a consulted party in the Pohoiki Geothermal transmission line E.I.S. and would appreciate being put on your mailing list.

Thank you.

Dave Hess
President



**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

November 18, 1987

Mr. Dave Hess, President
Leilani Community Association
P.O. Box 361
Pahoa, Hawaii 96778

Dear Mr. Hess:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Per your request to OEQC to be a consulted party in the EIS process for the transmission line project, we are enclosing a copy of the EIS Preparation Notice/Environmental Assessment.

Upon review of the document, if there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

A copy of the draft EIS will be sent to you by EQC during the public review period. The complete text of the Routing Study report will be included in the EIS.

Sincerely,

Wendie McAllaster
Project Manager

Enclosure

16 November 1987

DHM, Inc.
1188 Bishop Street
Suite 2405
Honolulu, HI 96813

Dear Sirs:

Please send me a rough draft of the EIS you are creating for HELCO, on the Big Island and their proposed transmission routes from Leilani Estates to Keaau.

Kahalo,
Richard MacQuiston
RR 1 Box 4653
Pahoa, Hawaii 96778

---

**DHM inc.** land use and environmental planning
1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9655

November 18, 1987

Mr. Richard MacQuiston
RR 1 Box 4853
Pahoa, Hawaii 96778

Dear Mr. MacQuiston:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

We appreciate you request to be a consulted party in the EIS process for the transmission line project.

Enclosed is a copy of the EIS Preparation Notice/Environmental Assessment for the subject project in Puna, Hawaii. It serves as a basis for an Environmental Impact Statement currently in preparation. Upon review of the document, if there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

A copy of the draft EIS will be sent to you by EQC during the public review period. The complete text of the Routing Study report will be included in the EIS.

Sincerely,

Wendie McAllaster
Project Manager

Enclosure

MOKU·LOA·GROUP
SIERRA CLUB • HAWAII CHAPTER

Ms. Wendie McAlaster
DHM Planners, Inc.
1188 Bishop St., Suite 2405
Honolulu, HI 96813

November 4, 1987

Dear Ms. McAlaster,

Sierra Club, Moku Loa Group requests to be a consulted party in the matter of the Pohoiki Geothermal Transmission Line in Puna, Hawaii.

Based on the informational hearings previously held in and around Pahoa, we are aware that attempts have been made by DHM Planners to identify and avoid routes impacting some of the most sensitive biological communities and archeological sites. We are also aware that the two chosen routes delineated by DHM still have not answered some major objections raised by affected communities along the corridor.

It is our position that this power-line is environmental degradation resulting from energy production or use and is a subsidy to the energy developers. We urge that a reasonable route be selected that addresses community concerns yet does not demand that the biological communities further subsidize geothermal industrial development.

We request that the draft EIS discuss in detail the following issues:

1) What the regulatory and other constraints are that inhibit the use of the Pahoa Highway (130 and 132) as the main power-line route. What accommodations would need to be made with what state agencies to allow this alternative route (since the State government so eagerly supports geothermal development).

2) What the requirements are for burying the power-line and what cost factors are involved. The DEIS should identify where and how many miles of power-lines must actually have to be buried (in the vicinity of communities) as one of the alternatives to the project.

3) What the business relationship of HELCO and Thermal Power is.

4) How HELCO will come to acquire title and control over the power-line when Thermal Power is the party paying for the feasibility studies and construction costs.

5) Whether HELCO has the power to condemn and acquire land (eminent domain for purposes of rights of way) if in fact they are acting as private subcontractors to Thermal Power.

6) What the constraints are of having this proposed power-line upgraded to a higher voltage using electricity from a) Thermal Power's potential expansion beyond 25 megawatts; and/or b) Campbell Estate's (True/Mid-Pacific geothermal developers) proposed 100 megawatt geothermal project in the former Wao Kele O Puna Natural Area Reserve, which is west of Leilani Estates.

7) What the procedure would be for any upgrading of the proposed 69 kv line to any higher voltage. What hearing processes, if any, would be initiated.

8) Whether this project is subject to "contested case" proceedings when it undergoes hearings before the Dept. of Land and Natural Resources and the Public Utilities Commission.

Sierra Club also requests that a copy of the draft EIS be provided our Club, as we have many members who wish to review it and provide input. Please mail the DEIS to P.O. Box 590 Mountain View, Hawaii 96771

Thank you for the opportunity to participate in this EIS process.

Yours truly,

Nelson Ho

Nelson Ho
for the Conservation Committee

P.O. BOX 1137 · HILO · HAWAII · 96721

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

November 18, 1987

Mr. Nelson Ho
Conservation Committee
Moku Loa Group, Sierra Club
P.O. Box 1137
Hilo, Hawaii 96721

Dear Mr. Ho:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

We appreciate your request to be a consulted party in the EIS process for the transmission line project. The issues you mentioned will be addressed in the EIS or the Routing Report which will be an appendix to the EIS. Questions that require very technical responses will be answered personally by us or by HELCO.

Enclosed is a copy of the EIS Preparation Notice/Environmental Assessment for the project. A copy of the draft EIS will be sent to you by EQC once it is completed.

Sincerely,

Wendie McAllaster

Wendie McAllaster
Project Manager

Enclosure

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

April 26, 1989

Mr. Nelson Ho
Conservation Committee
Moku Loa Group, Sierra Club
P.O. Box 1137
Hilo, Hawaii 96721

Dear Mr. Ho:

RE: Pohoiki Geothermal Transmission Line

As Moku Loa Group is a consulted party for the Pohoiki project, I am writing to inform you that the Environmental Impact Statement for the subject project will be filed with OEQC in May. Since completion of the Routing Study, HELCO has been meeting with community and subdivision organizations, government officials, and Hawaiian Telephone Company in attempt to delineate the alignments for the two proposed 69 kV transmission lines. As a result of these meetings, two alignments have been identified and the draft EIS prepared for these. A map showing the proposed alignments is enclosed for your information.

The issues you raised in your letter of November 4, 1987 have been considered in the preparation of the EIS. Specific responses to these issues are provided on the following pages in the sequence of your comments.

If you have additional comments on the draft EIS, please send them to us during the 45 day review period.

Sincerely,

DHM Planners inc.

Wendie McAllaster

Wendie McAllaster
Project Manager

WM:lt

Enclosures

1. The constraints for using Pahoa Highway as a 69 kV transmission line route are as follows:

   a. Highway 130 between Keaau and Pahoa is under the jurisdiction of the State Department of Transportation (DOT), and the portions of Highway 130 and 132 through Pahoa town is under the jurisdiction of the County of Hawaii. In order to construct any facilities within the State Highway portion, HELCO must submit its construction drawings to the DOT for approval. For those areas under the jurisdiction of the County of Hawaii, HELCO may construct its facilities within the public right-of-way in accordance with the franchise rights granted by the State of Hawaii and in compliance with the State's General Order No. 6 for overhead lines and General Order No. 10 for underground lines.

   b. Highway 130 through Pahoa Town is a highly traveled, narrow, two-lane road. In several places, the buildings along the highway closely abut the road pavement. Several of the existing utility poles fronting these have been installed through holes in the overhanging roofs of these buildings. Several construction restraints are present:

      1) The construction would necessitate closing one of the two lanes for the entire day for several weeks. Traffic would be severely disrupted. Business along the route would be inconvenienced.

      2) Replacing the existing poles with the taller ones necessary to support the additional 69 KV circuit would be extremely difficult especially where the poles protrude through the overhang.

      3) The taller poles would require additional easements for anchors.

   c. The Hawaiian Telephone Company's main trunk lines are located on one side of Highway 130. HELCO is working with the HTCO to construct a joint pole line (HELCO and HTCO occupying the same poles) rather than having each utility on its own pole line. This would minimize the total number of poles along the highway.

2. Underground power lines must meet requirements outlined in the <u>Rules for Construction of Underground Electric and Communications Systems</u>, General Order No. 10. Undergrounding the entire length of the route, approximately 17 miles, was investigated as an alternative for the proposed transmission lines. It was determined that undergrounding between the Pohoiki and Puna terminal points would affect the environment geophysically, biologically and socio-economically as will be described in the dEIS. The proposed transmission lines have been rerouted to avoid various subdivisions. There is no rule requiring underground power lines in the vicinity of communities. However, undergrounding the transmission lines between the two terminal points was estimated to cost $50 million, or nearly five times the estimated $10 million cost of the proposed overhead line.



3. Thermal Power was acquired by Ormat in August of 1988. HELCO's business relationship with a geothermal plant developer is one of manufacturer and buyer. A geothermal plant developer will manufacture electrical energy and will sell this energy to HELCO under a negotiated contract.

4. The interconnection of customer generation with HELCO's system must be achieved without adversely affecting HELCO and its customers. HELCO seeks a fair price for purchased power and seeks to recover all expenses, including interconnection costs. Interconnection costs are defined by PUC rules 6-74-1 and 6-74-26. The transmission lines linking the geothermal generating plant at Pohoiki with HELCO's transmission grid at the Puna Substation qualifies as an interconnection facility. Therefore, the Geothermal Plant Developer is required to pay for all costs incurred while HELCO will own, operate, and maintain the transmission lines.

5. HELCO is NOT a subcontractor for the geothermal plant developer. HELCO does have the power to condemn and acquire land if the rights-of-way acquired are held by HELCO. It does not have the power to acquire land for a private party.

6. The current agreement is for the purchase of only 25 MW of electric energy. If, in the future, this generating capacity is increased, due to any additional geothermal plants, the party responsible for the additional generation will also be responsible for interconnecting this power to HELCO's 69 kV grid by constructing additional 69 kV transmission lines or increasing the capacity of the existing 69 kV transmission lines. If the existing 69 kV transmission lines were to be upgraded to a higher voltage, approval by the PUC must be obtained before construction begins. Increasing the voltage would generally require wider easements, taller poles, and larger insulators.

7. HELCO does not anticipate the need to upgrade these lines in the current time frame. However, if and when these lines are upgraded to a higher voltage, public hearings with governmental agencies and community associations will be conducted in accordance with PUC Rules.

8. A public hearing for the project will be held by the Board of Land and Natural Resources for the segments of the alignments which cross conservation land and require a

Conservation District Use Permit. This public hearing is subject to "contested case" proceedings. State law also requires that the PUC hold a public hearing prior to approving the construction of new 69 kV overhead transmission systems in residential areas. This hearing is not subject to "contested case" proceedings.

Orchidland Community Association, Inc.
TRANSMISSION LINES COMMITTEE
S.R. Box 5684 - Kea'au, Hawaii 96749

November 6, 1987

Ms. Wendie McAlaster
DHM Planners Inc.
1138 Bishop Street, Suite 2405
Honolulu, Hawaii 96713

RE: Environmental Impact Statement for the Two Proposed Pohoiki - Kea'au Transmission Lines Routes

We wish to be considered a consulted party for this E.I.S. and submit the following questions:

1. On September 2 and 3, 1987 Helco announced their proposed transmission lines routes as recommended by their consultants DHM Planners Inc. As of November 6, 1987 we have been unable to review this study. Why is this?

2. What were the specific guidelines for this study?

3. Did the study include areas within privately owned residential-agricultural subdivisions? If these were excluded, why were they excluded?

4. Were there other specific areas or zones of exclusion for the routing?

5. Was any other transmission technology included besides overhead; i.e., underground, massive cable?

6. What are the existing technologies for placing high voltage transmission lines underground?

7. What is Helco's experience in placing transmission lines underground?

8. Helco proposes to construct, own and operate the transmission lines. How is this project financed?

9. What are the specific cost differences between overhead, underground and massive cable construction?

10. How do the overall costs compare when amortized over the life of the line, including initial construction, damage, maintenance, etc., for overhead, underground and massive cable construction?





11. How will the costs of construction and maintenance of the lines affect the current price per kilowatt hour being paid by the consumer?

12. The enclosure to Norman A. Oss' letter of August 20, 1987 ("Dear Neighbor") mentions lower costs for electrification of homes currently without service. Specifically, how will the transmission lines reduce these costs?

13. What are the existing corridors and routes available for high voltage transmission lines in the Puna District? How are the boundary lines for these corridors established?

14. If all available modern technology for existing corridors and routes were utilized, how much power could be transmitted from the geothermal generating facilities in Puna to the main power grid in Kea'au?

15. Are the proposed transmission lines in full compliance with the Hawaii County Ten Year General Plan? If not, in what specific areas do they differ and what are the long range effects?

16. Where is the specific interconnect point between Thermal Power and Helco?

17. Where specifically is the increased capacity for power provided by the proposed transmission lines to be used?

18. What plans presently exist to increase the capacity of the generating facility at Pohoiki within the next ten years?

19. When and where will additional transmission lines be placed to satisfy the need to transmit the increased power?

20. The proposed routes for the transmission lines impact many subdivisions. If these communities refuse to grant rights-of-way, how will Helco acquire access to these areas?

21. Was the same DHM Planners Inc. criteria applied equally to both proposed transmission lines routes through Orchidland Estates?

22. Will full and comprehensive archaeological site and historical site field studies be done for all proposed transmission lines routes, specifically those routes outside the corridors recommended by DHM Planners Inc.?

23. Would Helco cooperate with the Department of Transportation to incorporate underground transmission lines into the upcoming project to widen Highway 130?

24. In Orchidland Estates many homes are located close to the roadway which has a 40 foot easement. As Helco requires a 50 foot easement, what will be the impact of the transmission lines poles on these homes?

24 a. Current building codes allow houses to be built 30 ft. from the 40 ft. roadway. How will placing transmission poles and lines affect building codes, setback restrictions and zoning regulations?

b. As houses are already built very close to the roadway where the poles and lines would be placed, in what ways could they affect these homes in the event of:
   1) Hurricanes
   2) Strong wind gusts -Orchidland is quite open
   3) Electrical Storm
   4) Earthquake
   5) Traffic accident
   6) Vandalism

c. Is HELCO willing to compensate property owners if placing transmission poles and lines in front of their property causes a drop in property value?



25. The majority of the roads in Orchidland Estates are 40 feet wide and the transmission lines poles require between 40 and 50 feet. How will Helco compensate affected property owners?

26. Will Orchidland Estates be compensated for damage and wear to roads by Helco vehicles including vehicles and equipment utilized by Helco's subcontractors both during construction and later for maintenance and repair?

27. What compensation will be offered to property owners for the encroachment of pole support cables upon their property?

28. During the construction of the proposed transmission lines will there be significant grading, removal of trees, shrubs and groundcover?

   a. Where will removed material be dumped?

   b. Will private landscaping be replaced or will compensation be made to property owners?

   c. Will herbicides be employed by Helco in <u>any</u> phase of the construction, maintenance and repair of the proposed transmission lines? If so, specify which ones.

29. What impact will the clearance of trees, shrubs and grasslands have on the native flora and fauna occuring in the displaced, changed or destroyed environments?

30. Statements have been made by Ralph Patterson of Thermal Power (E.I.S. Public Workshop I, Hilo, Hawaii, July 31, 1987) to the effect should the geothermal generating plant have an emergency shutdown, a blackout would not occur because Helco would supply the additional power until the plant is producing again.

   a. Exactly why does Helco need two transmission lines from Pohoiki to Kea'au?

   b. Under what circumstances are these lines expected to fail?

   c. What criteria supports Helco's decision to construct two transmission lines routes across private subdivisions rather than a single line along Highway 130? Is it a general practice to construct two transmission lines when one will suffice?

   d. Has a single corridor for all geothermal transmission lines been considered for Puna as an alternative to two or three corridors? What were Helco's considerations?

   e. What would be the advantages of having only one underground transmission line for five - eight miles along Highway 130 capable of carrying 138 KV?

31. What is Helco's liability in this project? What bonding is required and in what amounts?

32. Is Helco willing to post a substantial bond for the removal of obsolete and abandoned equipment?

33. Referencing Paul A. Ingledew's lettor of July 3, 1987 (enclosed) how will Helco compensate property owners for their loss?

34. What will be the impact to the County of Hawaii's property tax base when the reduction in property values occurs?

35. According to the draft of the Hawaii County General Plan (April 1987, p. VI-2), the goals for the County of Hawaii with regard to natural beauty are:

"Protect, preserve and enhance the quality of areas endowed with natural beauty, including the quality of coastal scenic resources.

"Protect scenic vistas and view planes from becoming obstructed.

"Maximize opportunities for present and future generations to appreciate and enjoy natural and scenic beauty."

In Orchidland Estates, we have many areas where property owners have unobstructed views of the Puna Coastline, Mauna Kea and Mauna Loa. Existing 30 and 40 foot utility poles are partly hidden by ohi'a trees approximately the same height. How will Helco mitigate the visual intrusion of poles exceeding 60 feet in height?

36. An unobstructed view of the Puna coastline is seen from Highway 130 from the Plantation Managers House to Kokania Street, Kea'au-Kula Subdivision. How will Helco mitigate the obstruction of the coastal view by the two proposed transmission line routes, one that extends across Shipman property and the other that will come from behind the Plantation Managers House?

37. Will the proposed transmission lines cause an increase in the background interference noise for radios and televisions?

38. Is Helco presently in compliance with F.C.C. Rule 15?

39. What is Helco's response procedure and/or criteria when an R.F.I. or T.V.I. complaint is received?

40. Does Helco have a system for periodically monitoring interference generated or caused by their transmission lines?

41. What is Helco's procedure and/or criteria for monitoring the proposed transmission lines for R.F.I. or T.V.I.?

42. What technology does Helco presently use to eliminate R.F.I. and T.V.I.?



43. What type of specific diseases can be expected to occur among people living under or near high voltage transmission lines based on various studies of physiological effects of electromagnetic fields on humans?

44. What are electromagnetic effects on houses near a high voltage transmission line since the electromagnetic fields generated by transmission lines are a function of both the voltage and the current and energy could be coupled into normal household wiring and other metallic conductors such as copper plumbing?

45. Could this coupled energy be focused into specific areas of the house exposing humans to a hazardous level?

46. Please detail the effects of electromagnetic radiation on people with metallic parts within their bodies such as pins or plates.

47. Please detail the effects of electromagnetic radiation on persons with pacemakers. What studies have been conducted and what are the conclusions and recommendations?

48. Does the scientific community agree that overhead high voltage transmission lines do not pose a health hazard.

49. Have there been studies regarding the effect of E.M.F.'s on honeybees? What were the conclusions and recommendations?

50. Orchidland Estates residents raise racing pidgeons and exotic birds. What is the effect of E.M.F.'s on these and other avian life? Please cite reference materials pertaining to the impact on breeding of these birds.

51. What is the effect of E.M.F.'s on farm livestock such as pigs, milk cows and milk goats? Please cite reference material on milk production as well as breeding studies.

52. What effect does close proximity to electromagnetic fields have on human and animal behavior? Please cite references.

53. Are there any studies indicating a cause/effect relationship between electromagnetic radiation and physiological changes in humans and/or animals? What do they conclude and recommend? What are the specific qualifications of the researchers who conducted the study?

54. Are PCB's or other carcinogenic substances used in the construction of the transmission lines? Would burning or smoking of lines result in any carcinogenic byproducts?

55. What are the statistics regarding increased danger to life and property due to the presence of high voltage transmission lines?

56. What specific risks are there with the proposed transmission lines?

57. What is Helco's liability for damage incurred by downed poles?

58. Does the presence of the proposed lines increase the risk of lightning strikes? If so, what are the possible consequences?

59. Do the transmission lines poles increase the driving risks to vehicles using the road?

60. Could a vehicle colliding with a pole cause sparking and result in a brush fire?

61. Will access roads be required by Helco to reach some of the areas where poles are planned? Who will pay for maintaining these access roads? Will these access roads be available for use by emergency vehicles such as fire - rescue?

62. What are the results of geological studies concerning the possibilities of any destructive volcanic activity in the Pohoiki area where these proposed transmission lines originate?

63. What magnitude (Richter Scale) earthquake will the proposed transmission lines and equipment tolerate before they fail? What research supports that figure?

64. What magnitude (Richter Scale) earthquake will the poles tolerate before they fail and before the lines separate from the poles? What research supports those figures?

65. What is the response/repair priority for the proposed transmission lines if they are damaged in a district-wide disaster such as earthquake?

66. Twenty poles were knocked down by 70 m.p.h. wind gusts in 1985 because they were inadequately seated. What are Helco's procedures for installing the proposed transmission lines poles?

67. What installation methods will be used to deal with the incidence of intermittent streams which occur during heavy rains? Please identify the location of these intermittent streams.

68. What are the safety factors contained within the proposed transmission lines which do not allow a recurrance of the tragic accident which resulted in the electrocution death of a man near the entrance to Nanawale Estates in Puna?

69. What is the failure rate for this protective system?

70. What are the statistics on insulator breakage on transmission lines?

71. What damage would result to transmission lines, people and property due to insulator breakage?

72. How often will poles and equipment be replaced due to corrosion?



73. Orchidland Estates does not have fire-fighting equipment, water lines or hydrants. Will the presence of the proposed transmission lines increase the difficulty of obtaining residential fire insurance from available insurance companies? Would there be an increase in rates?

74. Have any judgements been handed down in the Courts against electric companies where transmission lines were judged to have contributed to human death, illness or disease?

75. What is the source of crackling, buzzing sounds heard from transmission lines? Can this noise be eliminated?

76. How long does it usually take for Helco maintenance or repair personnel to respond to a complaint call?

We appreciate the opportunity to respond to the preparation notice for this very important Environmental Impact Statement.

Sincerely,

TRANSMISSION LINES COMMITTEE

Daniel Laine

Daniel Laine
Chairman

/lg

Enclosures (2)

Hawaii Electric Light Company, Inc. • PO Box 1027 • Hilo, HI 96721-1027

August 20, 1987

Dear Neighbor:

About fourteen years ago, the National Science Foundation and the State of Hawaii envisioned a day when renewable energy might provide us with all the heat and light we needed and financed a University of Hawaii proposal to explore for geothermal energy at Pohoiki. Not only were the results successful, but today that small, exploratory well supplies enough electricity for about 800 Big Island homes.

The prospects that geothermal energy may provide more Big Island homes with electricity rose even higher this year when HELCO signed an agreement to purchase up to 25,000 kilowatts of geothermal-produced energy from Thermal Power Company, beginning in late 1989. This means that some 8,000 more Big Island homes will be getting their electricity from geothermal energy.

In a few months, we will begin construction of a new 69,000 volt transmission line between Thermal Power's proposed geothermal plant at Pohoiki to our substation in Keaau. Construction of this line will enable us to transport this geothermal-produced energy for use solely on the Big Island.

In order to plan the best route for the transmission line, we solicited public input and comments. At these meetings, some people understandably expressed a number of concerns, and a few did not like our plans at all. And, while we had the answers to most of the questions, we thoroughly investigated those we didn't.

Because some of those who are disenchanted with our plans have been making misleading statements, we'd like to set the record straight and share with you the results of our research.

I would also like to invite you to tune in when Clyde Nagata, our Manager of Engineering, and I discuss these important issues from 6:30 to 7:00 P.M., Thursday, August 27, on "Big Island Issues and Answers", KHBC, Channel 2.

You are also invited to a public informational meeting, which will be held at 7:00 P.M., September 3, 1987, at the Pahoa Neighborhood Center. The final transmission line alignments will be shown at this meeting.

Should you have any questions after reviewing either the materials or the show, please feel free to call Dennis Tanigawa at 935-1171.

Thank you for your interest and consideration.

Sincerely,

Norman A. Oss
President

An HEI Company

4-20

## QUESTIONS AND ANSWERS
## Pohoiki - Keaau 69,000 Volt Transmission Line

**Question:** Do transmission voltages increase the danger of injury and fire if a line falls to the ground?

**Answer:** Transmission lines are actually better designed for automatic protection than lower voltage distribution lines. By the time a transmission line falls to the ground, they are normally already de-energized by automatic protective devices which also signal an interruption to our system operations personnel.

During the February 1986 windstorm, for example, several of our 69,000 volt (69 kv) transmission lines fell and were automatically de-energized by protective devices. No injuries or fires resulted.

To our recollection, there have been no injuries or fatalities on the Big Island due to downed transmission lines. The tragic fatality earlier this year in Nanawale Estates involved a 12 kv line, a distribution voltage.

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**Question:** Will the electromagnetic field (EMF) created by a transmission line cause adverse health effects, particularly in children?

**Answer:** J. Michael Silva is a professional engineer and president of Enertech Consultants and has performed many studies on this subject. According to Silva, EMF from a 69 kv transmission line can be even less than that generated by some typical household appliances. His analysis, including field measurements and computer calculations indicate no significant effects from EMF on human health.

HELCo has always been concerned about this matter and continues to support research efforts of the Electric Power Research Institute (EPRI). To date, none of EPRI's studies over the past decade has found any correlation between EMF and human health.

Nonetheless, we recognize the need for additional research. EPRI has expanded its research program and has asked 15 experts from the scientific community and industry to serve on an oversight committee to review and to make recommendations on their research program.

**Question:** Will EMF cause interference with TV, radio, telephone, and emergency communications?

**Answer:** This usually doesn't occur, since interference can be minimized through proper design and the use of appropriate hardware, its primary cause. When it does, as was once the case on a part of our Hamakua 69 kv line, the introduction of special hardware immediately cleared up the problem.

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**Question:** Can future power lines from geothermal fields be master-planned to minimize adverse effects on the community?

**Answer:** Thermal Power Company appears to be the only active geothermal developer in Puna. Although it is possible that others may eventually produce geothermal power there, we have no knowledge of further developments. This makes master-planning of transmission lines extremely difficult, if not impossible.

In the meantime, our power needs are rapidly approaching the critical state. We need more generation and we need to proceed to plan and build the lines needed to tie Thermal's proposed plant to our system.

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**Question:** What about the visual intrusion the electrical power structures will have on views of the ocean, mountains, and landscape?

**Answer:** Contrary to what some people think, we will not be installing steel tower structures. What is being installed are 65- to 70-foot wooden poles, with 7 to 8 feet buried in the ground.

In addition, it is our experience that the issue of aesthetics is generally subjective. While one person may greatly dislike a utility pole in his view, another may be indifferent about it because he values other factors about his surroundings more.

**Question:** What effect would the presence of a transmission line have on property values?

**Answer:** There are a number of 69 kv lines already around the Big Island, including through some residential areas as Kawailani Street. Research by the County tax office established that there was no evidence of decrease in property values.

There is also the argument that values may increase in many sections of subdivisions currently lacking electricity, since distribution lines could be installed on the same 69 kv poles, making it more economically affordable for residents to obtain line extensions, especially in conjunction with our new Special Subdivision Project Provision Program (SSPP).

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**Question:** What effect, if any, would a 69 kv transmission line have on my home insurance premiums?

**Answer:** The insurance companies we contacted unanimously agreed that there would be no effect. In fact, they reported that premiums are sometimes lower in homes served by electric utility service rather than by their own generators. Some companies reported that they would not insure a house that didn't have electric service from a utility.

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**Question:** Could the transmission line be placed underground instead?

**Answer:** It could, but the cost would be approximately 6 times greater than an overhead line and would create an unfair and unnecessary financial burden on all our Big Island customers. In this case, it would cost $4 million for one overhead 69 kv line, compared to $22 million for one underground line.

There is pro and con to most situations and this is no exception. Because underground lines are buried and not visible, maintenance and restoration of power due to cable failure takes considerably more time. Depending on the severity, repairs may take several days. Also, since there are no poles on an underground line, they would have to be installed later, anyway, whenever line extensions are necessary to serve customers requesting electric service to areas currently without it.

Question: How wide will the easement for the line be?

Answer: Although the "corridors" we have been studying are quite wide, we normally require a maximum of only 50 feet for the actual alignment for a 69,000 volt line. However, if the line is located along a roadway (which is a likely case), we would be satisfied with an easement covering the width of the roadway. Then we would not have to ask for easements within individual lots except for anchors wherever the line changes direction.

DHM inc.
land use
and environmental
planning

1168 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9655

November 3, 1987

Mr. Daniel Laine
Orchid Land Community Association
Transmission Line Committee
SR 4607
Keaau, Hawaii 96749

Dear Mr. Laine:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

Enclosed, per your request to Hawaii Electric Light Company, is a copy of the EIS Preparation Notice/Environmental Assessment for the subject project in Puna, Hawaii.

We appreciate your interest in reviewing the document. If there is specific information which you would like covered in the forthcoming draft EIS, please inform us accordingly.

Sincerely,

Wendie McAllaster

Wendie McAllaster
Project Manager

Enclosure

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9555

November 18, 1987

Mr. Daniel Laine, Chairman
Transmission Lines Committee
Orchidland Community Association, Inc.
S.R. Box 5684
Kea'au, Hawaii 96749

Dear Mr. Laine,

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

We appreciate your request to be a consulted party in the EIS process for the transmission line project. The questions and concerns you mentioned in your letter of November 6 will be addressed in the EIS or the Routing Report which will be an appendix to the EIS. Questions that require very technical responses will be answered personally by us or by HELCO.

A copy of the draft EIS will be sent to you by EQC during the public review period.

Sincerely,

Wendie McAllaster
Project Manager

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

April 26, 1989

Mr. Daniel Laine
Chairman
Transmission Lines Committee
Orchidland Community Association, Inc.
S.R. Box 5684
Kea'au, Hawaii 96749

Dear Mr. Laine:

RE: Pohoiki Geothermal Transmission Line

As Orchidland Community Association, Inc. is a consulted party for the Pohoiki project, I am writing to inform you that the Environmental Impact Statement for the subject project will be filed with OEQC in May. Since completion of the Routing Study, HELCO has been meeting with community and subdivision organizations, government officials, and Hawaiian Telephone Company in attempt to delineate the alignments for the two proposed 69 kV transmission lines. As a result of these meetings, two alignments have been identified and the draft EIS prepared for these. A map showing the proposed alignments is enclosed for your information.

The issues you raised in your letter of November 6, 1987 have been considered in the preparation of the EIS. Specific responses to these issues are provided on the following pages in the sequence of your comments.

If you have additional comments on the draft EIS, please send them to us during the 45 day review period.

Sincerely,

DHM Planners inc.

Wendie McAllaster
Project Manager

WM:lt

Enclosures

1. The final Routing Study was completed and printed in December 1987. A copy was distributed to Orchidland Community Association by HELCO on January 26, 1988. The entire Routing Study will be bound at the end of the EIS.

2. The route selection process was an objective evaluation of conditions in the study region to identify areas of constraint and opportunity for a transmission line through the area. Two guidelines were given to the consultant by HELCO prior to commencing the study. They are as follows:

    a. Due to the physical and technical difficulties of placing one or two additional alignments within the Highway 130 right-of-way, (Pahoa Highway), identify and locate the proposed alignments outside of the Highway 130 right-of-way.

    b. The two alignments should be separated by one-half mile to reduce the risk of failure of both lines at one time due to a natural catastrophe such as an earthquake, lava flow, brush fire, or hurricane. Less than one-half mile separation was acceptable if the alignments were separated by a major highway corridor.

3. The study area for the Routing Study did include areas within privately owned residential-agricultural subdivisions.

4. HELCO did not explicitly exclude any area from the consultant's study. Therefore, a large extent of the Puna region was considered as the Routing Study study area. However, as part of the broadscale analysis methodology, "Exclusion Areas", or areas where regulatory controls are so restrictive that they essentially preclude a transmission line route, were identified. These included areas within the Protective Subzones of the State Conservation District.

5. The three basic configurations that transmission lines can be designed and constructed by (overhead lines, underground cables, and submarine cables) were seriously considered and thoroughly investigated for this project. The advantages and disadvantages of each are described in the Routing Study and the draft EIS.

6. The construction of an underground system would require excavation and backfill along the entire length of the cable route. Trenches 3 feet deep by 2 feet wide would be needed to hold the conductor cables. In addition, concrete manholes approximately 7 feet by 14 feet by 6.5 feet would be needed every 600 feet for cable installation and maintenance. Even with today's sophisticated equipment, a much longer duration of time is required to locate and repair an underground fault than an overhead fault.

7. HELCO has not performed any work on underground transmission lines.

8. Pursuant to Public Utilities Commission regulations, the geothermal plant developer must pay for all interconnection costs, including the costs of constructing transmission lines. The method of financing will be the developer's concern.

9. An underground system between Pohoiki and Puna Substation is estimated to cost $50 million while a cost of installing a submarine cable, including the terminal stations and the overhead portion of the marine route, is estimated to exceed $100 million. The two proposed overhead lines are estimated to cost $10 million.

10. If the overall cost is lower, amortized cost is also lower. Unfortunately, HELCO's experience has been limited to overhead transmission lines, therefore, no detailed comparison of amortized costs over the life of underground or submarine line can be given at this time. However, it can be said that maintenance costs of underground or submarine cables increase faster with the age of the system than those of overhead lines.

11. An increase in rates is not expected as a result of this project.

12. Since the proposed transmission lines will not be routed through any subdivisions, the lines will not affect line extensions under the SSPP program.

13. Existing public roadways and utility lines (including sewer, water, gas, telephone and electric) may represent potential routes for transmission lines because they are existing easements which could conceivably allow for additional poles or circuits on poles already in place. However, existing road and utility easements are not always available or optimal routes for new lines. For example, existing easement widths may not be adequate, and the visual impact of numerous lines in one corridor is a concern.

14. The amount of power that will be transmitted from the geothermal resource in Puna to the HELCO system will be limited by the amount of such power that the system can accept. At this time that limit is approximately 25 MW. Over the next twenty years, an additional 25 MW may be required based on expected system load growth. The proposed two alignments will be able to adequately transmit the present level of 25 MW. These lines may have to be reconstructed or a third line installed if an additional 25 MW is required within the next twenty years.

15. The relationship of the proposed project to the County General Plan will be discussed in Chapter IV of the draft EIS.

16. The interconnection point will be at a switching station located at the geothermal power plant.

17. Approximately 6 MW of the proposed generation will be used to supply the Puna area. The remaining 19 MW will flow into the existing transmission grid and will be utilized by the entire island.

18. HELCO is aware only of the potential of geothermal power within the Puna area, and is not able to develop definite plans until a firm contract is negotiated with any geothermal plant developer.

19. The only firm contract is for 25 MW of geothermal-generated power which should support the projected island load growth for the next 10 years. Only two 69 kV transmission lines are required to interconnect the 25 MW into HELCO's system grid. Any future contracts with geothermal plant developers will require a routing study to select the transmission line alignments as was done for this project.

20. The proposed routes for the transmission lines will not cross private residential subdivisions. Therefore no easements through subdivisions will be required.

21. Yes, the same criteria, as described in the <u>Routing Study</u>, were used to evaluate the entire project area.

22. An intensive field survey and literature search were conducted within the Puna area during the <u>Routing Study</u> identified sites have been avoided by the proposed alignments. The professional archaeologists' report is included as Appendix B of the <u>Routing Study</u>. In addition, project areas to be disturbed by construction of the proposed lines will be surveyed by an archaeologist and mitigative measures taken as necessary.

23. Any lines placed along Highway 130 will be with the concurrence of the Dept. of Transportation. If the geothermal developer pays for the underground system, HELCO will cooperate with the Dept. of Transportation in the acquisition of all necessary construction approvals and permits to place the transmission underground raceways along the highway. However, because cost was a major concern, it would not be economically feasible to underground the transmission lines.

24. a. The proposed transmission lines will not be located along subdivision roads. Therefore, there will be no impact on subdivision homes. Similarly, the proposed lines will not affect building codes, setback restrictions, or zoning regulations.

b. Each line in our system is designed specifically to conform to all applicable state and national safety codes for power lines. In addition, the proposed lines will be equipped with a protective relay device that will be able to detect abnormal or undesirable operating conditions. Upon detecting a faulty condition, the interrupting devices will de-energize the line in fractions of a second.

c. There have been no proven cases where placement of power lines in front of homes has decreased property value.

25. Neither of the proposed alignments will be located along roads in Orchidland Estates subdivision.

26. No roads in Orchidland Estates will be used for the project construction or maintenance.

27. HELCO will acquire easements as needed for pole guy wires. This will be negotiated by the property owners and HELCO. Should an agreement not be reached, the rate of compensation will be determined by an independent appraiser.

28. In areas where there is no existing road or jeep trail, narrow widths of land will need to be cleared of trees and large shrubs for construction access to the pole sites. Information on the vegetation in the project area and anticipated impacts and mitigative measures will be described in the draft EIS.

a. Disposal of cut foliage will be made according to the land owner's preference. Along roadways and within the Conservation District, cut foliage will be taken to a County-approved disposal site.

b. If "landscaped areas" (as opposed to natural vegetation) outside the easements are disturbed during construction, they will be replanted.

c. Insecticides and herbicides will not be used to construct or maintain the project.

29. The impacts of project construction on the native flora and fauna will be addressed in the draft Environmental Impact Statement.

30. a. HELCO is regulated by the Public Utilities Commission which requires that the utility's facilities are installed, operated, and maintained in accordance with

accepted good engineering practice in the electric industry. This assures, as far as reasonably possible, continuity of service, uniformity in the quality of service furnished, and the safety of persons and property.

For this project, two 69 kV transmission lines are needed to meet these requirements.

b. If only one 69 kV line were built for this project, HELCO's ability to maintain service to its customers would be severely jeopardized if the geothermal plant were to suddenly shut down. This unexpected loss of 25% of HELCO's generating capacity could cause an unstable condition which might cause complete or, at least, partial system blackout.

Transmission line outages or failures are primarily caused by salt or volcanic dust contamination, tree branches, wind, lightning, storms, and vehicular accidents. These unscheduled outages would cause severe disruptions in service to HELCO's customers if only one line is in service. Scheduled maintenance for the transmission line such as the repair of poles due to termite infestation, pole deterioration, and the repair of insulators or conductors would also seriously jeopardize the availability of the geothermal-generated power for extended periods of time.

c. The proposed lines will be within the Highway 130 right-of-way and will not cross private subdivisions. It is not a practice for HELCO or any utility to install any more lines than necessary to provide quality, reliable service to its customers.

d. No, one single corridor was not considered for both transmission lines as an alternative. To reduce the probability of losing both transmission lines due to a natural catastrophe, HELCO's position has been that the two transmission lines require a minimum separation of one-half mile. However, during the route selection process whereby input was received by the community associations and governmental agencies, the design criteria were relaxed at the expense of system reliability to allow the placement of a five-mile segment of both transmission lines within a single corridor along Highway 130.

e. The advantages would be reduced visual impact and reduced probability of vehicular impact. The disadvantages are reduced reliability with only one circuit, increased costs of undergrounding and need for transition stations at each end of the 138 kV circuit, increased potential of environmental pollution if oil leaks from cable, and increased outage time if cable fails. The disadvantages far outweigh the advantages.

31. HELCO's involvement in the Pohoiki Project is the subject of two contracts: 1) a Power Purchase Contract for Unscheduled Energy Made Available From a Qualifying Facility dated March 24, 1986 between HELCO and Thermal Power Company, Inc., whereby HELCO agrees to buy the power generated by the Facility and, 2) a letter agreement dated June 27, 1986 for construction of interconnection facilities including one or more power transmission line. HELCO's responsibilities under the letter agreement include route selection, preparing and processing of an environmental impact statement, preliminary engineering estimates, and obtaining governmental permits.

Bonding requirements do not apply to HELCO, as HELCO is not involved in drilling, maintaining or operating the wells, nor does it have a mining lease with the State. As discussed above, HELCO's involvement is limited to purchasing and transmitting the power generated by the wells.

32. HELCO will not post a substantial bond for the removal of its obsolete and abandoned equipment. The removal of HELCO's transmission equipment such as poles, conductors and insulators will be done at HELCO's expense.

33. The lines will be constructed within existing State or County road rights-of-way wherever possible. If a line crosses private property, HELCO must secure an easement, from the owner before installing the pole line. Compensation will be paid to landowners who grant the transmission line easements based on a fair market appraisal.

If the line is installed in large, unsubdivided properties owned by the State of Hawaii, HELCO will negotiate easement rights for a fifty foot wide perpetual easement. Compensation may be part of the negotiated easement terms.

34. The proposed lines are not expected to cause a reduction in property values. Real property taxes are based on the County's assessed value of a property, which may or may not be the same as market value.

35. The transmission poles are purchased with a dark creosote coating, blackish-brown in color, to preserve the wood as well as to provide a natural color which would blend in with the natural environment. Whenever possible, natural landforms and vegetation are used as visual screens, and distance and vegetation backdrops are used to visually absorb the pole line. There may be open areas where visibility of the pole line can't be totally avoided. In these cases, efforts will be made to minimize the visual impact by limiting pole heights and maximizing the distances between poles.

36. Same as item 35 above.

37. No, the proposed power lines will not increase the background level of RFI and TVI. A primary cause of RFI and TVI is loose or damaged hardware. This is readily remedied by tightening or replacement. Occasionally, under rainy conditions there have been cases of interference directly under the lines. These are usually corrected by washing the insulators.

Broken or loose hardware can cause radio noise under certain atmosphere conditions. It is HELCO's policy to correct these promptly upon notification.

38. Yes, HELCO's lines are in compliance with FCC Rule 15.

39. When any type of interference complaint is received, technical personnel promptly investigate the complaint to determine the nature, source, and cause of the interference problem. Corrective measures are then taken.

40. HELCO has over 500 miles of transmission lines and several thousand miles of distribution lines on the island. Both types of lines are potential sources of interference. Although these lines are inspected on a routine basis, interference problems are intermittent and not always evident during these inspections. The majority of interference problems are found and promptly corrected due to reports from our customers.

41. Same as item 40 above.

42. Computer models of conductor surface gradient can be used to predict conductor performance and line noise before a 69 kV line is built. Special clamps with smooth surfaces and special "fog type" insulators are often used. A properly designed line should not produce radio or TV interference. However, if complaints are received, HELCO has a policy of locating and correcting any interference problem due to the line.

43. A thorough research of all scientific literature to date concludes that there is no significant evidence of health hazards associated with high voltage transmission lines.

44. Energy coupled into normal household wiring and metallic conductors, such as currents in home water pipes, are primarily due to unbalanced loading of the wiring within the homes. Electromagnetic fields generated by transmission lines should not produce harmful currents in properly grounded pipes.

45. As noted above, currents in water pipes are primarily due to unbalanced loading of the house wiring and not from electromagnetic fields generated by transmission lines.

46. Electromagnetic field coupling to metallic objects depends on the surface area of the object and on the strength of the field. Items such as tooth fillings and orthodontic braces are too small for induced currents to cause an effect. This is especially true for the low fields due to 69 kV lines.

47. The project will have no impact on persons with pacemakers. Studies of pacemakers in electric fields show that 69 kV fields are <u>far</u> too low to cause any effect whatsoever.

Studies have been conducted by trained cardiologists and engineers at the Illinois Institute of Technology and the University of Rochester in New York. There are no effects at 69 kV lines and no state or government agency has seen the need to regulate such low fields.

48. Experts generally agree that no health hazards are associated with lines as low as 69 kV. However, because higher voltage lines continue to be built (up to 765 kV), the scientific community will continue their research on electric field effects.

49. Yes, there been studies regarding the effect of EMF's on honeybees. Electric fields above about 3-8 kV/m can cause small discharges in certain types of hives. It was recommended that bee hives be moved outside locations of this field strength. These fields were for lines with voltages of 765 kV. However, the field strengths for 69 kV are less than 0.4 kV/m and will not affect honeybees along the two alignments.

50. We know of no studies on the impact of electromagnetic fields on racing pidgeons. Many thousands of 69 kV lines on the mainland have not revealed any effect on pidgeons.

51. There were studies done by Purdue University in Indiana and in Ohio by the Power Siting Board that were unable to detect any effects of EMF on farm livestock for lines with voltages of 765 kV. There certainly should not be any problems at fields due to 69 kV lines.

52. We do not know of any obvious health hazards for 69 kV lines. The major literature reviews by the National Academy of Sciences, American Institute of Biological Sciences, State of Florida Scientific Advisory Panel, and World Health organizations reveal that it is unlikely that EMF causes harmful effects. The Pohoiki 69 kV line has very low field levels compared to those measured in the studies.

53. See questions 43, 46, 47, 48, 49, 50, 51, 52.

54. No PCB's or other carcinogenic substances will be used in construction of the project. Nor would burning or smoking of lines result in any carcinogenic byproducts.

55. There is no statistical data available on damages to property due to transmission lines. However, HELCO has had over 500 miles of transmission lines on the Big Island in the past 40 years and there have been very few reports of incidents of property damage. In fact, the statistical probability for risk may be greater for distribution lines since there are several thousand miles of these lines on the island.

56. People are unaware of the dangers that could originate from tampering with utility equipment. As such, the utility company construct its high voltage transmission lines in compliance with the State's General Order No. 6 which specifies minimum clearance and construction requirements.

57. HELCO's liabilities for public damages caused by downed lines shall be determined in a court of law.

58. No. The presence of the proposed lines does not increase the risk of lightning strike. However, the transmission lines are equipped with a 'shield wire' that spans from the top of each pole to protect the energized conductors from direct strokes of lightning.

59. Transmission poles will be placed adjacent to the roads and will present a hazard only if the vehicles leave the roadway.

60. When any type of vehicle collides with a pole, a number of things can happen. The amount of damage and the type of damage depends on the type of vehicle involved in the accident and on the speed at which it is traveling. While it doesn't happen often, it is conceivable that a car traveling at a very high rate of speed and colliding with a pole could cause the conductors to contact each other. This could cause sparks to occur. However, this rarely happens on the transmission system due to its extensive protection system. The few times this has happened have been primarily on the distribution lines. This is not a condition that is restricted to transmission lines, but also holds true for distribution lines.

61. Where the line is not installed next to an established road, access roads will be needed during the construction period. HELCO will be responsible for maintaining such access roads as required.

Yes, emergency vehicles will be able to use the access roads to reach the site of the emergency.

62. A geologic report was prepared by Dames and Moore in May 1987 for the project area and is included in the <u>Routing Study</u> as Appendix F.

Regarding volcanic hazards in the study area, the report states that a "future lava flow entering the corridor region will most probably come from Kilauea's east rift zone...." The most recent flows entering the corridor region were the flows of 1840 (near Nanawale Estates) and 1955 (near the geothermal plant site).

In terms of seismic hazards, several strike-slip faults are located in the corridor near the geothermal plant site, and earthquake epicenters in the region are concentrated along the east rift zone. However, Dames and Moore states that "although seismic loads are probable throughout the corridors, the lateral loads due to seismic conditions would be expected to be less than that due to wind loads, and wind loads will probable be the criteria used for design."

63. HELCO does not have any design standards which are based on the magnitude (Richter scale) of an earthquake. HELCO's pole lines have withstood earthquakes in the +7.0 range suffering only minimal damage.

64. Same as item 63 above.

65. Transmission lines that deliver firm power to the power grid will have the highest priority with respect to repair. The response time will be dependent on the accessibility to the damaged facilities and the availability of manpower, equipment and materials.

66. Construction procedures for the proposed lines will be described in the draft EIS.

67. Poles are not sited on <u>known</u> areas that flood or become watercourses during heavy rains. Two stream channels are identified in the routing report which run perpendicular to the transmission lines. The poles will be sited to span these channels.

68. The unfortunate incident you referred to involved distribution lines. The circuit protection system on transmission lines are much more intricate. There are several levels of system protection. A transmission system involves protective relays and breakers capable of de-energizing lines at remarkable speeds of about 1/6 of a second after a fault is detected. By the time a transmission line falls to the ground, it should already be de-energized by automatic protective devices which also signal an interruption to our system operations personnel.

69. Refer to item 68 above.

70. Insulators fail infrequently. The insulators HELCO buys are of excellent quality and have mechanical strengths commensurate with or exceeding design parameters. When insulators are broken, it is usually a result of gunshots, lightning strikes and wind storms.

71. Past experience has shown that slightly damaged insulators are capable of performing continuously in a satisfactory manner. Severely damaged insulators cause the system protective devices to take the circuit out of service.

72. The wood poles themselves are not affected by corrosion. The metal hardware such as bolts, guy wires, and anchor rods are the most susceptible to corrosion. However, these items are all protected by a galvanized coating and the average life expectancy for transmission line poles and hardware is 30 years.

73. Transmission lines, particularly through residential subdivisions, should not reduce the likelihood of residents being able to obtain fire insurance. The proposed transmission lines have been rerouted to avoid traversing through any subdivisions in the Puna District.

According to several insurance companies on the Big Island, the presence of transmission lines should not cause an increase in fire insurance fees.

74. According to our review of claims for the last five years, no judgments were entered in Hawaii against HECO, HELCO, or MECO where transmission lines were judged to have contributed to human death, illness, or disease.

75. Crackling and buzzing sounds can be caused by loose or worn hardware which can be replaced to eliminate the sounds. Dirty insulators are also another source of sounds. In this case, washing the insulators will eliminate the sounds.

76. When any type of interference complaint is received, technical personnel promptly investigate the complaint to determine the nature, source, and cause of the interference problem. Corrective measures are then taken.

**Paradise Park Hui Hanalike**
SR 11000
Keaau, Hawaii 96749

6 November 1987

TO: DHM Planners Inc.
1188 Bishop St. Suite 2405
Honolulu, Hawaii 96813

ATTN: Ms. Wendie McAlaster

SUBJECT: EIS, Pohoiki Geothermal Transmission Line, Puna, Hawaii

REFERENCE: OEQC Bulletin No. 19, dated October 8, 1987

In accordance with the above reference, the Community Action Committee of Hawaiian Paradise Park requests to be a consulted party in the preparation of the subject Environmental Impact Statement being prepared for the Hawaii Electric Light Co. (HELCO)/Dept. of Land and Natural Resources. Below is a list of questions and concerns that we would like to have addressed in the EIS.

HEALTH HAZARDS:

1. What type of specific diseases can be expected to occur among people living under or near high voltage transmission lines based on various studies conducted to date ?

2. Since the electromagnetic fields generated by transmissions lines are a function of both voltage and current, how much energy could be coupled into normal household wiring and other metallic conductors such as copper plumbing ?

3. Could this coupled energy be focussed into specific regions of the home, thereby, endangering humans with a hazardous level of exposure ?

4. Explain in detail the effects electromagnetic radiation may have on people who have metallic parts in their bodies due to past injuries.

5. What is the impact on persons with pacemakers ?

6. What studies have been conducted on the effect of electromagnetic radiation on pacemakers and what are their conclusions and recommendations ?

7. Does the scientific community agree that overhead high voltage transmission lines do not pose a health hazard ?

8. Are there any studies indicating a cause/effect relationship between electromagnetic radiation and physiological changes in humans and/or animals ?

9. What are the conclusions and recommendations ?

10. Please identify the specific qualifications of the researchers who conducted the studies.

HAZARDS OF DOWNED LINES:

1. What are the statistics regarding increased danger to life and property due to the presence of high voltage transmission lines ?

2. What specific risks are there with the proposed high voltage transmission lines ?

3. Does the presence of the proposed lines increase the risk of lightning strike ? If so, what are the possible consequences ?

4. Do the supporting poles increase the driving hazards to vehicles using the roadway ?

5. Could a vehicle colliding with a pole cause sparking and thus cause a fire ? Reference is made to an incident in the Kawaihai area involving a 69kv power line in April of this year.

6. Since all roads within residential sub-divisions are privately owned and maintained, will the construction and maintenance of the proposed transmission lines cause an economic impact to the community ?

7. Are access roads required to reach some of the areas where poles are planned ?

8. Will these access roads be usable by emergency vehicles - such as police and particularly fire equipment ?

9. What are the results of geological studies concerning possibilities of any destructive volcanic activity in the Pohoiki area where these proposed transmission lines originate ?

10. How similar are conditions where these lines are to be placed to where twenty poles were knocked down by 70 MPH gusts of wind above Hilo Coast Processing Co. in 1985 ?

11. Will there be safety factors present in the proposed transmission lines which will not allow the kind of tragic accident that took place earlier this year with death by electrocution of a man in Puna ? What is the failure rate ?

12. What are the statistics on insulator breakage on these types of proposed lines ?

13. What possible damaging effects would an insulator breakage present ?

14. As this island has its share of corrosive features, how often will poles and lines need to be replaced ?

15. Since the Puna District has only marginal fire protection, will transmissions lines, particularly through residential subdivisions, reduce the likelihood of residents being able to obtain fire insurance with any of the available insurance company's ?

16. Could this cause an increase in fire insurance fees ?

17. Have any Judgments been handed down in the courts against electric companies where transmission lines were judged to have contributed to human death, illness or disease ?

PROPERTY VALUES:

1. In reference to the Hawaii Board of Realtors attached letter, how does HELCO plan to compensate property owners ?

2. If a reduction in property values occur, what is the impact to the County of Hawaii's tax base ?

INTERFERENCE TO RADIO, TV, COMMUNICATIONS:

1. Will the proposed powerlines increase the background level of RFI and TVI ?

2. Are all current HELCO powerlines in the County of Hawaii in compliance with Federal Communications Commission Rule 15 ?

3. When a compliant of RFI or TVI is received by HELCO, what is the normal response ?

4. Does HELCO have a system for periodically monitoring interference generated or caused by their powerlines ?

5. What type of technology is currently being used to eliminate RFI and TVI ?

IMPACTS OF NATURAL BEAUTY:

1. The Hawaii County General Plan (draft, April 1987 p. VI-2) states that goals for the County of Hawaii with regard to natural beauty are:

- "Protect, preserve and enhance the quality of areas endowed with natural beauty, including the quality of coastal scenic resources.
- "Protect scenic vistas and view planes from becoming obstructed.
- "Maximize opportunities for present and future generations to appreciate and enjoy natural and scenic beauty."

Unobstructed views of Mauna Kea, Mauna Loa and the Puna coastline are seen from several vantage points and the majority of properties in Hawaiian Paradise Park. Some of the existing 30 ft and 40 ft utility poles are partly obscured by trees which do not exceed heights of approximately 40 ft.

a. How will HELCO mitigate the visual intrusion of transmission poles exceeding 50 ft in height ?

b. The former sugar processing plant with Mauna Kea in the background, is visible from many properties on the Kaloli side of Hawaiian Paradise Park. Will the transmission poles and lines also be visible the 3.75 mile distance between Hawaiian Paradise Park and the Keaau sub-station ?

c. An unobstructed view of the Puna coastline is seen from Highway 130 from the plantation manager's house to Kukania Street, Keaau - Kula sub-division. How will HELCO mitigate the obstruction of the coastal view by the two proposed transmission alignments, one that extends across Shipman property and the other that will come from behind the plantation manager's house ?

GENERAL:

1. The proposed route selection for the 69kv transmission lines was announced on 3 September 1987 by HELCO based on a study prepared by DHM, Inc. What were the specific guidelines for the study ?

2. Were there specific areas or zones of exclusion for the routing ?

3. Did the study consider the social-economic impact on private residential sub-divisions ? If not, why not ?

4. Was any other transmission technology seriously considered besides overhead, i.e. underground, submarine cable, massive cable ?

5. What is HELCO's experience in underground transmission line technology ?

6. What are the detailed cost differences between overhead, underground, submarine, and massive cable construction ?

7. How do the overall costs compare when amortized over the life of the line including initial construction, potential damage, maintenance, etc. between overhead, underground, submarine, and massive cable ?

8. Two alternative routes were presented to HELCO on 16 October 1987 by Hawaiian Paradise Park. Are these alternate routes, and the technologies suggested, being evaluated with the same detail as the currently proposed routes ?

9. HELCO proposes to construct, own, and operate the transmission lines. How is the project to be financed ? What is HELCO's contribution verus Thermal Power's ?

10. Will the construction and maintenance cost of the lines impact the current price per kilowatt hour being charged to the consumer ?

11. Where is the specific interconnect point between Puna Geothermal and HELCO ?

12. Are the proposed transmission lines in full compliance with

the Hawaii County 10 year General Plan ? If not, in what specific areas do they vary and what are the long range impacts ?

13. Where specifically is the increased capacity of power provided by these lines to be used ?

14. Is it a general practice to construct two transmission lines when one will suffice ?

15. Is HELCO aware of any plans to increase the geothermal generating capacity in Puna within the next 10 years ?

16. Does HELCO foresee the need for more than the two proposed lines within the next 10 years ? If so, when and where would the next lines be placed ?

17. Since the announced routes for the transmission lines cross several private residential sub-divisions, how does HELCO plan to acquire access if the affected communities do not want the lines and refuse to grant rights of way ?

18. Explain in detail how the transmission lines will reduce the costs of electrification to homes currently without service. What are the specific cost breakdowns and how does this tie in with the SSPP program ?

19. What are the existing corridors and routes available for transmission lines in the Puna District ? How are these corridors and boundary lines established ?

20. If one used all available modern technology for the existing corridors and routes, how much power could be transmitted from the geothermal resource in Puna to the main power grid in Keaau ?

21. Will full comprehensive archeological site and historical site field studies be done for all proposed transmission line routes, specifically those routes outside the corridors recommended by the DHM, Inc. study ?

22. Most of the roadways in the affected residential subdivisions are 40 ft wide or less. How does HELCO plan to construct the proposed lines which require a minimum easement of 50 ft ?

23. During construction of the lines, will there be significant removal of trees and ground cover ?

a. What is the method of disposal ?

b. Will insecticides or herbicides be used to keep foliage down ?

c. Will disturbed land scraping be replaced ?

24. What will be the rate of compensation to property owners should guy wires or cables attach to private property ?

26. In the event that a lava flow. earthquake, or other natural disaster renders the geothermal wells at Pohoiki useless, is HELCO prepared to remove the poles and restore the land to its original state ?

27. Since the proposed construction represents a significant impact to the community, what is HELCO's liability for damage and inconvenience to the community ?

RELIABILITY ISSUE:

1. We question the necessity of two transmission lines proposed by HELCO solely on the grounds of backup. On 31 July 1987 at the EIS Public Workshop held in Hilo, Hawaii, Ralph Patterson of Thermal Power stated that if the geothermal power plant had an emergency shut down, it would not lead to a blackout, because HELCO would be able to supply the additional power until the plant is back on line.

Under what circumstances is one or both of the proposed transmission lines expected to fail ?

Ron Phillips, Chairman
Community Action Committee
Paradise Hui Hanalike



**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

November 18, 1987

Mr. Ron Phillips, Chairman
Community Action Committee
Paradise Hui Hanalike
SR 11000
Keaau, Hawaii 96749

Dear Mr. Phillips:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

We appreciate your request to be a consulted party in the EIS process for the transmission line project. The questions and concerns you mentioned in your letter of November 6 will be addressed in the EIS or the Routing Report which will be an appendix to the EIS. Questions that require very technical responses will be answered personally by us or by HELCO.

Enclosed is a copy of the EIS Preparation Notice/Environmental Assessment for the project. A copy of the draft EIS will be sent to you by EQC during the public review period.

Sincerely,

Wendie McAllaster
Project Manager

Enclosure

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

April 26, 1989

Mr. Ron Phillips, Chairman
Community Action Committee
Paradise Park Hui Hanalike
SR 11000
Keaau, Hawaii 96749

Dear Mr. Phillips:

RE: Pohoiki Geothermal Transmission Line

As Hawaiian Paradise Park Hui Hana Like is a consulted party for the Pohoiki project, I am writing to inform you that the Environmental Impact Statement for the subject project will be filed with OEQC in May. Since completion of the Routing Study, HELCO has been meeting with community and subdivision organizations, government officials, and Hawaiian Telephone Company in attempt to delineate the alignments for the two proposed 69 kV transmission lines. As a result of these meetings, two alignments have been identified and the draft EIS prepared for these. A map showing the proposed alignments is enclosed for your information.

The issues you raised in your letter of November 6, 1987 have been considered in the preparation of the EIS. Specific responses to these issues are provided on the following pages in the sequence of your comments.

If you have additional comments on the draft EIS, please send them to us during the 45 day review period.

Sincerely,

DHM Planners inc.

Wendie McAllaster
Project Manager

WM:lt

Enclosures



HAWAIIAN PARADISE PARK HUI HANA LIKE

HEALTH HAZARDS:

1. A thorough research of all scientific literature to date concludes that there is no significant evidence of health hazards associated with high voltage transmission lines.

2. Energy coupled into normal household wiring and metallic conductors, such as currents in home water pipes, are primarily due to unbalanced loading of the wiring within the homes. Electromagnetic fields generated by transmission lines should not produce harmful currents in properly grounded pipes.

3. As noted above, currents in water pipes are primarily due to unbalanced loading of the house wiring and not from electromagnetic fields generated by transmission lines.

4. Electromagnetic field coupling to metallic objects depends on the surface area of the object and on the strength of the field. Items such as tooth fillings and orthodontic braces are too small for induced currents to cause an effect. This is especially true for the low fields due to 69 kV lines.

5. The project will have no impact on persons with pacemakers. Studies of pacemakers in electric fields show that 69 kV fields are <u>far</u> too low to cause any effect whatsoever.

6. Studies have been conducted by trained cardiologists and engineers at the Illinois Institute of Technology and the University of Rochester in New York. There are no effects at 69 kV lines and no state or government agency has seen the need to regulate such low fields.

7. Experts generally agree that no health hazards are associated with lines as low as 69 kV. However, because higher voltage lines continue to be built (up to 765 kV), the scientific community will continue their research on electric field effects.

8. There are no studies that have demonstrated a clear cause and effect relationship between electromagnetic radiation and physiological changes in humans and/or animals.

9. HELCO has always been concerned about this matter and continues to support research efforts of the Electric Power Research Institute (EPRI). To date, none of EPRI's studies over the past decade has found any conclusive evidence and correlation between electric and magnetic fields (EMF) and human health.

10. Biophysical and medical researchers and scientists, both at EPRI and at other organizations, have been examining the influence of EMF on plants, animals and humans for more than a decade.

**HAZARDS OF DOWNED LINES:**

1. There is no statistical data available on damages to property due to transmission lines. However, HELCO has had over 500 miles of transmission lines on the Big Island in the past 40 years and there have been very few reports of incidents of property damage. In fact, the statistical probability for risk may be greater for distribution lines since there are several thousand miles of these lines on the island.

2. People are unaware of the dangers that could originate from tampering with utility equipment. As such, the utility company construct its high voltage transmission lines in compliance with the State's General Order No. 6 which specifies minimum clearance and construction requirements.

3. No. The presence of the proposed lines does not increase the risk of lightning strike. However, the transmission lines are equipped with a 'shield wire' that spans from the top of each pole to protect the energized conductors from direct strokes of lightning.

4. Transmission poles will be placed adjacent to the roads and will present a hazard only if the vehicles leave the roadway.

5. When any type of vehicle collides with a pole, a number of things can happen. The amount of damage and the type of damage depends on the type of vehicle involved in the accident and on the speed at which it is traveling. While it doesn't happen often, it is conceivable that a car traveling at a very high rate of speed and colliding with a pole could cause the conductors to contact each other. This could cause sparks to occur. However, this rarely happens on the transmission system due to its extensive protection system. The few times this has happened have been primarily on the distribution lines. This is not a condition that is restricted to transmission lines, but also holds true for distribution lines.

6. The proposed alignments will not be located along private roads within residential subdivisions.

7. Where the line is not installed next to an established road, access roads will be needed during the construction period. HELCO will be responsible for maintaining such access roads as required.

8. Yes, emergency vehicles will be able to use the access roads to reach the site of the emergency.

9. A geologic report was prepared by Dames and Moore in May 1987 for the project area and is included in the Routing Study as Appendix F.

   Regarding volcanic hazards in the study area, the report states that a "future lava flow entering the corridor region will most probably come from Kilauea's east rift zone...." The most recent flows entering the corridor region were the flows of 1840 (near Nanawale Estates) and 1955 (near the geothermal plant site).

   In terms of seismic hazards, several strike-slip faults are located in the corridor near the geothermal plant site, and earthquake epicenters in the region are concentrated along the east rift zone. However, Dames and Moore states that "although seismic loads are probable throughout the corridors, the lateral loads due to seismic conditions would be expected to be less than that due to wind loads, and wind loads will probable be the criteria used for design."

10. The first dissimilarity is that the ground in the Kaumana-Pepeekeo area (to which you refer) is basically soil or Pepeekeo ash. The load bearing quality of this medium is very poor. The ground in the Puna area is basically volcanic rock except for areas that were previously cultivated for cane growing. Volcanic rock has superior load bearing capabilities. Another dissimilarity is that the wind in the Kaumana-Pepeekeo area bears perpendicular to the existing transmission lines. During high wind storms, the wind loading on the poles and conductors are at a maximum. The poor load bearing quality of the Pepeekeo ash combined with high wind loading resulted in damage to the pole lines above Hilo Coast Processing Company in 1985. Good ground and structural support of the proposed lines will minimize the probabilities of the line falling during storms.

11. The unfortunate incident you referred to involved distribution lines. The circuit protection system on transmission lines are much more intricate. There are several levels of system protection. A transmission system involves protective relays and breakers capable of de-energizing lines at remarkable speeds of about 1/6 of a second after a fault is detected. By the time a transmission line falls to the ground, it should already be de-energized by automatic protective devices which also signal an interruption to our system operations personnel.

12. Insulators fail infrequently. The insulators HELCO buys are of excellent quality and have mechanical strengths commensurate with or exceeding design parameters. When insulators are broken, it is usually a result of gunshots, lightning strikes and wind storms.

13. Past experience has shown that slightly damaged insulators are capable of performing continuously in a satisfactory manner. Severely damaged insulators cause the system protective devices to take the circuit out of service.

14. The wood poles themselves are not affected by corrosion. The metal hardware such as bolts, guy wires, and anchor rods are the most susceptible to corrosion. However, these items are all protected by a galvanized coating and the average life expectancy for transmission line poles and hardware is 30 years.

15. Transmission lines, particularly through residential subdivisions, should not reduce the likelihood of residents being able to obtain fire insurance. The proposed transmission lines, however, have been rerouted to avoid traversing through any subdivisions in the Puna District.

16. No, according to several insurance companies on the Big Island, the presence of transmission lines would not cause an increase in fire insurance fees.

17. According to HELCO's review of claims for the last five years, no judgments were entered in Hawaii against HECO, HELCO, or MECO where transmission lines were judged to have contributed to human death, illness, or disease.

PROPERTY VALUES:

1. The lines will be constructed within existing State or County road rights-of-way wherever possible. If a line crosses private property, HELCO must secure an easement, from the Owner before installing the pole line. Compensation will be paid to landowners who grant the transmission line easements based on a fair market appraisal.

   If the line is installed in large, unsubdivided properties owned by the State of Hawaii, HELCO will negotiate easement rights for a fifty-foot-wide perpetual easement. Compensation may be part of the negotiated easement terms.

2. The proposed lines are not expected to cause a reduction in property values. Real property taxes are based on the County's assessed value of a property, which may or may not be the same as market value.

INTERFERENCE TO RADIO, TV, COMMUNICATIONS:

1. No, the proposed power lines will not increase the background level of radio frequency interference (RFI) and TV interference (TVI). A primary cause of RFI and TVI is loose or damaged hardware. This is readily remedied by tightening or replacement. Occasionally, under rainy conditions there have been cases of interference directly under the lines. These are usually corrected by washing the insulators.

2. HELCO's lines are in compliance with FCC Rule 15.

3. When any type of interference complaint is received, technical personnel promptly investigate the complaint to determine the nature, source, and cause of the interference problem. Corrective measures are then taken.

4. HELCO has over 500 miles of transmission lines and several thousand miles of distribution lines on the island. Both types of lines are potential sources of interference. Although these lines are inspected on a routine basis, interference problems are intermittent and not always evident during these inspections. The majority of interference problems are found and promptly corrected due to reports from our customers.

5. Computer models of conductor surface gradient can be used to predict conductor performance and line noise before a 69 kV line is built. Special clamps with smooth surfaces and special "fog type" insulators are often used. A properly designed line should not produce radio or TV interference. However, if complaints are received, HELCO has a policy of locating and correcting any interference problem due to the line.

IMPACTS ON NATURAL BEAUTY:

1.a.b.c. The transmission poles are purchased with a dark creosote coating, blackish-brown in color, to preserve the wood as well as to provide a natural color which would blend in with the natural environment.

Whenever possible, natural landforms and vegetation are used as visual screens, and distance and vegetation backdrops are used to visually absorb the pole line. There may be open areas where visibility of the pole line can't be totally avoided. In these cases, efforts will be made to minimize the visual impact by limiting pole heights and maximizing the distances between poles.

GENERAL:

1. The route selection process was an objective evaluation of conditions in the study region to identify areas of constraint and opportunity for a transmission line through the area. Two guidelines were given to the consultant by HELCO prior to commencing the study. They are as follows:

a. Due to the physical and technical difficulties of placing one or two additional alignments within the Highway 130 right-of-way, (Pahoa Highway), identify and locate the proposed alignments outside of the Highway 130 right-of-way.

b. The two alignments should be separated by one-half mile to reduce the risk of failure of both lines at one time due to a natural catastrophe such as an earthquake, lava flow, brush fire, or hurricane. Less than one-half mile separation was acceptable if the alignments were separated by a major highway corridor.

2. HELCO did not explicitly exclude any area from the consultant's study. Therefore, a large extent of the Puna region was considered as the Routing Study study area. However, as part of the broadscale analysis methodology, "Exclusion Areas", or areas where regulatory controls are so restrictive that they essentially preclude a transmission line route, were identified. These included areas within the Protective Subzones of the State Conservation District.

3. Yes, the Routing Study did consider the social-economic impact of transmission lines on private residential subdivisions. In the Broadscale Analysis Phase, under the "Land Use" factor, areas zoned for residential and commercial uses and one-acre agricultural lots in the State Urban District were mapped as a high constraint for transmission lines. One, two, and three-acre agricultural lots were a medium constraint. In the "Land Ownership" factor, private land holdings of ten-acres or less were a high constraint. In the "Land Value" factor, Urban District lands and properties of ten-acres and less were a high constraint.

4. The three basic configurations that transmission lines can be designed and constructed by (overhead lines, underground cables, and submarine cables) were seriously considered and thoroughly investigated for this project. The advantages and disadvantages of each are described in the Routing Study and the draft EIS.

5. HELCO has not performed any work on underground transmission lines.

6. An underground system between Pohoiki and Puna Substation is estimated to cost $50 million while a cost of installing a submarine cable, including the terminal stations and the overhead portion of the marine route, is estimated to exceed $100 million. The two proposed overhead lines are estimated to cost $10 million.

7. If the overall cost is lower, amortized cost is also lower. Unfortunately, HELCO's experience has been limited to overhead transmission lines, therefore, no detailed comparison of amortized costs over the life of underground or submarine line can be given at this time. However, it can be said that maintenance costs of underground or submarine cables increase faster with the age of the system than those of overhead lines.

8. All suggested alternatives have been seriously considered using the criteria used to evaluate the Routing Study alternatives. The proposed alignments are based on input from the community, and government agencies as well as from findings of the Routing Study.

9. Pursuant to Public Utilities Commission regulations, the geothermal plant developer must pay for all interconnection costs, including the cost of constructing transmission lines. The method of financing will be the developer's concern.

10. An increase in rates is not expected as a result of this project.

11. The interconnection point will be at a switching station located at the geothermal power plant.

12. The relationship of the proposed project to the County General Plan will be discussed in Chapter IV of the draft EIS.

13. Approximately 6 MW of the proposed generation will be used to supply the Puna area. The remaining 19 MW will flow into the existing transmission grid and will be utilized by the entire island.

14. It is not a practice for HELCO or any utility to install any more lines than necessary to provide quality, reliable service to its customers.

HELCO is regulated by the Public Utilities Commission which requires that the utility's facilities are installed, operated, and maintained in accordance with accepted good engineering practice in the electric industry. This assures, as far as reasonably possible, continuity of service, uniformity in the quality of service furnished, and the safety of persons and property.

For this project, two 69 kV transmission lines are needed to meet these requirements.

15. HELCO is aware only of the potential of geothermal power within the Puna area, and is not able to develop definite plans until a firm contract is negotiated with any geothermal plant developer.

16. The only firm contract is for 25 MW of geothermal-generated power which should support the projected island load growth for the next 10 years. Only two 69 kV transmission lines are required to interconnect the 25 MW into HELCO's system

grid. Any future contracts with geothermal plant developers will require a routing study to select the transmission line alignments as was done for this project.

17. The proposed routes for the transmission lines will not cross private residential subdivisions. Therefore no easements through subdivisions will be required.

18. Since the proposed transmission lines will not be routed through any subdivisions, the lines will not affect line extensions under the SSPP program.

19. Existing public roadways and utility lines (including sewer, water, gas, telephone and electric) may represent potential routes for transmission lines because they are existing easements which could conceivably allow for additional poles or circuits on poles already in place. However, existing road and utility easements are not always available or optimal routes for new lines. For example, existing easement widths may not be adequate, and the visual impact of numerous lines in one corridor is a concern.

20. The amount of power that will be transmitted from the geothermal resource in Puna to the HELCO system will be limited by the amount of such power that the system can accept. At this time that limit is approximately 25 MW. Over the next twenty years, an additional 25 MW may be required based on expected system load growth. The proposed two alignments will be able to adequately transmit the present level of 25 MW. These lines may have to be reconstructed or a third line installed if an additional 25 MW is required within the next twenty years.

21. An intensive field survey and literature search were conducted within the Puna area during the Routing Study identified sites have been avoided by the proposed alignments. The professional archaeologists' report is included as Appendix B of the Routing Study. In addition, project areas to be disturbed by construction of the proposed lines will be surveyed by an archaeologist and mitigative measures taken as necessary.

22. Neither of the proposed alignments will be located along roads in residential subdivisions.

23. In areas where there is no existing road or jeep trail, narrow widths of land will need to be cleared of trees and large shrubs for construction access to the pole sites. Information on the vegetation in the project area and anticipated impacts and mitigative measures will be described in the draft EIS.

    a. Disposal of cut foliage will be made according to the land owner's preference. Along roadways and within the Conservation District, cut foliage will be taken to a County-approved disposal site.

    b. Insecticides and herbicides will not be used to construct or maintain the project.

    c. If "landscaped areas" (as opposed to natural vegetation) outside the easements are disturbed during construction, they will be replanted.

24. This will be negotiated by the property owners and HELCO. Should an agreement not be reached, the rate of compensation will be determined by an independent appraiser.

25. If, for any reason, the proposed geothermal generating plants at Pohoiki become inoperable and HELCO considers the interconnection facilities unnecessary, all interconnecting facilities will be removed in responsible manner and in compliance with all State, County and Federal rules, regulations, ordinances, laws, statutes and codes.

26. HELCO's liabilities with respect to construction damage are defined by existing laws. As a responsible corporate citizen in its service areas, HELCO fully intends to meet all legal responsibilities.

RELIABILITY ISSUE:

1. If only one 69 kV line were built for this project, HELCO's ability to maintain service to its customers would be severely jeopardized if the geothermal plant were to suddenly shut down. This unexpected loss of 25% of HELCO's generating capacity could cause an unstable condition which might cause complete or, at least, partial system blackout.

   Transmission line outages or failures are primarily caused by salt or volcanic dust contamination, tree branches, wind, lightning, storms, and vehicular accidents. These unscheduled outages would cause severe disruptions in service to HELCO's customers if only one line is in service. Scheduled maintenance for the transmission line such as the repair of poles due to termite infestation, pole deterioration, and the repair of insulators or conductors would also seriously jeopardize the availability of the geothermal-generated power for extended periods of time.

Patricia Singley
P.O. Box 6
Kurtistown, Hawaii, 98760

November 1, 1987

ENVIROMENTAL QUALITY CONTROL BOARD
465 South King Street
Room 104
Honolulu, Hawaii 96813

To Whom It May Concern,

I am writing in regards to the Poihiki Transmission Line Project, with specific reference to the HIGH VOLTAGE transmission lines, proposed location; property in Orchidland Estates Subdivision.

HS

My question is two part; First- How will these HIGH VOLTAGE transmission lines affect the radio and television reception in the homes of residents situated near the power lines? Secondly- Regarding the HIGH VOLTAGE transformers that will be installed along with the HIGH VOLTAGE transmission lines;

HECO

(a) How far apart will the transformers be placed? (distance in feet)
(b) What will occur when lightning strikes one of these transformers?
(c) What is the safety hazard for any person or animal that is with in 0-100 feet of the transformer at the time of lightning striking the transformer or pole?
(d) In the event of lightning striking the pole or transformer, what chemical, material or debris will be emitted into the air or dispursed on the ground, and at what rate of speed and what distance will the chemical, material or debris be scattered through the air or on the ground?

At this time, I request to be informed on the findings of this Board, and I would like to be a consulted party in this matter. I am requesting a copy of the ENVIRONMENTAL IMPACT STATEMENT DRAFT be sent to me as soon as it is available.

I Praise God I live in America, and I am thankful that we have a E.Q.C.B. to answer the questions of the public honestly and completely. I am looking forward to hearing from your Board in the near future.

Respectfully yours,
Patricia Singley
Patricia Singley



DHM inc.
land use and environmental planning
1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

November 18, 1987

Ms. Patricia Singley
P.O. Box 6
Kurtistown, Hawaii 98760

Dear Ms. Singley:

SUBJECT: EIS PREPARATION NOTICE
POHOIKI GEOTHERMAL TRANSMISSION LINE

We appreciate your request to be a consulted party in the EIS process for the transmission line project.

Enclosed is a copy of the EIS Preparation Notice/Environmental Assessment for the subject project in Puna, Hawaii. It serves as a basis for an Environmental Impact Statement currently in preparation. A copy of the draft EIS will be sent to you during the public review period. The complete text of the Routing Study report will be included in the EIS.

I have forwarded a copy of your November 1, 1987 letter to Anna Lau at Hawaii Electric Company. She will respond to your specific technical questions about the proposed transmission lines.

Sincerely,

Wendie McAllaster
Wendie McAllaster
Project Manager

Enclosure

DHM inc. land use and environmental planning
1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

April 26, 1989

Ms. Patricia Singley
P.O. Box 6
Kurtistown, Hawaii 98760

Dear Ms. Singley:

RE: Pohoiki Geothermal Transmission Line

I am writing to inform you that the Environmental Impact Statement for the subject project will be filed with OEQC in May. Since completion of the Routing Study, HELCO has been meeting with community and subdivision organizations, government officials, and Hawaiian Telephone Company in attempt to delineate the alignments for the two proposed 69 kV transmission lines. As a result of these meetings, two alignments have been identified and the draft EIS prepared for these. A map showing the proposed alignments is enclosed for your information.

The issues you raised in your letter of November 1, 1987 have been considered in the preparation of the EIS. Specific responses to these issues are provided on the following pages in the sequence of your comments.

If you have additional comments on the draft EIS, please send them to us during the 45 day review period.

Sincerely,

DHM Planners inc.

Wendie McAllaster

Wendie McAllaster
Project Manager

WM:lt

Enclosures



1. The proposed power lines will not increase the background level of radio frequency interference (RFI) and TV interference (TVI). A primary cause of RFI and TVI is loose or damaged hardware. This is readily remedied by tightening or replacement. Occasionally, under rainy conditions there have been cases of interference directly under the lines. These are usually corrected by washing the insulators.

2.a. No high voltage transformers will be installed on the transmission lines.

b. Since there will not be any transformers, this question is moot.

c. As for the pole, the shield wire will protect the pole from lightning strikes.

d. All the transmission poles will be protected by a shield wire at the top of the pole. As each shield wire is grounded at the pole, this provides a safe path to ground for any lightning strike.

# APPENDIX 5

## APPENDIX 5

### COMMENTS AND RESPONSES DURING PUBLIC REVIEW PERIOD

Written responses to the draft Environmental Impact Statement were received from the following persons and agencies. An asterisk (*) beside the reviewer's name indicates no substantive comments.

**Federal**

- * U.S. Department of the Army
- U.S. Fish and Wildlife Service
- * U.S. Department of the Navy

**State**

- * Department of Accounting & General Services
- * Department of Agriculture
- Department of Business and Economic Development
  - Energy Division
  - * Housing Finance and Development Corporation
- * Department of Defense
- * Department of Health
- Office of Environmental Quality Control
- * University of Hawaii, Environmental Center

**County of Hawaii**

- * Department of Parks and Recreation
- Department of Public Works
- * Department of Water Supply

**Others**

- Orchidland Community Association, Inc., Transmission Lines Committee
- Puna Community Council
- * W.H. Shipman, Ltd.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF:

Planning Branch

May 17, 1989

REC
'89 MAY 19 PM 2 05

Dr. Marvin Miura
Director
Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Thank you for the opportunity to review the Draft Environmental Impact Statement (DEIS) for the proposed Pohoiki Geothermal Transmission Line, Puna, Hawaii. The following comments are offered:

a. A Department of the Army permit is not required for the project.

b. According to the Flood Insurance Study for the County of Hawaii, the project site is located in Zone X, "Other Areas" determined to be outside of the 500-year flood plain as designated by the Federal Emergency Management Agency (FEMA) in September 1988.

Sincerely,

Kisuk Cheung
Chief, Engineering Division

Copies furnished:

Board of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Mr. Clyde Nagata
Hawaii Electric Light Company, Inc.
54 Halekauila Street
Hilo, Hawaii 96720

DHM inc.

land use
and environmental
planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U. S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

ENGINEERING DEPT.
HAWAIIAN ELECTRIC CO., INC.
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Room 6307

United States Department of the Interior
FISH AND WILDLIFE SERVICE
PACIFIC ISLANDS OFFICE
P.O. BOX 50167
HONOLULU, HAWAII 96850

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ENGINEERING DEPARTMENT

MAY 10 1989

Dr. Marvin T. Miura
Director, Office of Environmental
Quality Control
465 South King Street, #104
Honolulu, Hawaii 96813

Dear Dr. Miura:

This responds to your letter regarding a Draft Environmental Impact Statement (EIS) for Pohoiki Geothermal Transmission Line, Puna, Hawaii, dated May 1989.

We have reviewed the document and believe that in general, it adequately describes fish and wildlife resources within our jurisdiction. We note that the document states (page 72) that the proposed power poles may be beneficial to the endangered Hawaiian hawk (I'o) by providing hunting perches. We suggest that the final EIS clearly identify what measures will be taken to prevent the electrocution of I'o by the powerlines/poles.

We appreciate this opportunity to comment.

Sincerely yours,

Ernest Kosaka

Ernest Kosaka
Field Office Supervisor
Environmental Services

cc:
Board of Land & Natural Resources
✓Hawaii Electric Light Company, Inc.

DHM inc. land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 10, 1989

Mr. Ernest Kosaka
U. S. Department of the Interior
Fish and Wildlife Service
Pacific Islands Office
P.O. Box 50167
Honolulu, Hawaii 96850

Dear Mr. Kosaka:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

On behalf of the Hawaii Electric Light Company, thank you for the copy of your letter to Dr. Marvin Miura regarding the above.

In regards to your concerns about the possible electrocution of the I'o (Hawaiian Hawk), please consider the following:

1. The I'o is not a large bird like the golden eagle. It appears to stand approximately 17 inches and has a wing span of about 36" to 40". The phase conductors of the proposed 69 kV lines will be spaced a minimum of 48" apart, vertically. Electrocution of the I'o can be prevented by utilizing vertical construction standards.

2. Since the I'o is a hawk, it will probably select the highest wire as a vantage point. The highest wire is the shield wire that is not energized and is grounded.

3. HELCO has other 69 kV lines in areas inhabited by the I'o. Although HELCO has observed the I'o in the proximity of the transmission lines, they have not observed them perched on the lines or the pole tops. This is mainly due to the presence of trees that are taller than the poles. These tall trees appear to provide a better vantage point for the I'o.

As you suggest, the final EIS will expand on measures to be taken to prevent the electrocution of I'o by the powerlines.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

cc: OEQC
DLNR
HELCO

DEPARTMENT OF THE NAVY
COMMANDER
NAVAL BASE PEARL HARBOR
BOX 110
PEARL HARBOR, HAWAII 96860-5020

ENGINEERING DEPT.
CO., INC.
RECEIVED
MAY 16 1989

IN REPLY REFER TO:

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9 May 1989

ENGINEERING DEPARTMENT

Board of Land & Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, HI 96809

Gentlemen:

POHOIKI GEOTHERMAL TRANSMISSION LINE DEIS

The Draft Environmental Impact Statement (DEIS) for Pohoiki Geothermal Transmission Line has been reviewed, and we have no comments to offer. Since we have no further use for the DEIS, it is being returned to the Office of Environmental Quality Control.

Thank you for the opportunity to review the draft.

Sincerely,

W. K. Liu

W. K. LIU
Assistant Base Civil Engineer
By direction of
the Commander

Copy to:
✓Hawaii Electric Light Co, Inc.
OEQC (w/DEIS)

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. W. K. Liu
Assistant Base Civil Engineer
Department of the Navy
Commander
Naval Base Pearl Harbor
Box 110
Pearl Harbor, Hawaii 96860-5020

Dear Mr. Liu:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

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MAY 15 1989

Board of Land and Natural Resources
P. O. Box 621
Honolulu, Hawaii 96809

Dr. Marvin T. Miura
Director
Office of Environmental Quality Control
Honolulu, Hawaii 96813

Gentlemen:

Subject: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the opportunity to review the subject document. We have no comments to offer.

Should there be any questions, please have your staff contact Mr. Cedric Takamoto of the Planning Branch at 548-7192.

Very truly yours,

T. Tominaga

TEUANE TOMINAGA
State Public Works Engineer

CT:jnt
cc: Mr. Clyde Nagata

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. Teuane Tominaga
State Public Works Engineer
Department of Accounting
and General Services
Division of Public Works
P.O. Box 119
Honolulu, Hawaii 96810

Dear Mr. Tominaga:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

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June 20, 1989 ...ING DEPARTMENT

MEMORANDUM

To: Mr. William W. Paty, Chairperson
Board of Land and Natural Resources

Subject: Draft Environmental Impact Statement (DEIS) for
Pohoiki Geothermal Transmission Line
Hawaii Electric Light Company, Inc.
TMK: 1-3-09: 3, 4 et al
Puna, Hawaii
Area: easement of approximately
100 feet by 18 miles

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

It appears that both proposed alignments will involve only minimal intrusion into areas in agricultural production. We also note that agricultural production in the vicinity of similarly-rated transmission lines has not experienced discernible adverse effects.

We are of the opinion that the agricultural resources of the affected area will not be adversely affected by the proposed activity.

Thank you for the opportunity to comment.

Yukio Kitagawa

YUKIO KITAGAWA
Chairperson, Board of Agriculture

cc: OEQC
Hawaii Electric Light Company, Inc.
Attention: Mr. Clyde Nagata

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. Yukio Kitagawa
Chairperson, Board of Agriculture
State of Hawaii
1428 S. King Street
Honolulu, Hawaii 96814

Dear Mr. Kitagawa:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
HELCO
DLNR

DEPARTMENT OF BUSINESS
AND ECONOMIC DEVELOPMENT

JOHN WAIHEE
GOVERNOR
ROGER A. ULVELING
DIRECTOR
BARBARA KIM STANTON
DEPUTY DIRECTOR
LESLIE S. MATSUBARA
DEPUTY DIRECTOR

ENERGY DIVISION, 335 MERCHANT ST., RM. 110, HONOLULU, HAWAII 96813 FAX: (808) 531-5243

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ENGINEERING DEPARTMENT

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June 15, 1989

The Honorable William W. Paty, Chairman
Board of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

We appreciate the opportunity to comment on the Draft Environmental Impact Statement for the Pohoiki Geothermal Transmission Line.

We confirm the undesirability of the NO ACTION ALTERNATIVE discussed on pages 110 and 111. The no action alternative is not a "no energy" alternative because there is increased demand for additional electrical generation capacity on the Island of Hawaii. Without geothermal, this additional capacity would be met by additional oil-fired generators, further increasing the State's extreme dependence on this imported commodity for its electricity.

The Hawaii State Plan states that planning for the State's facility systems with regard to energy shall be directed towards the achievement of increased energy self-sufficiency. The Plan further states that it shall be the policy of the State to promote the use of renewable energy sources (Section 226-18, Hawaii Revised Statutes). Geothermal is a renewable energy source.

In the environmental trade-off between oil and geothermal as fuels for electricity, the U.S. Department of Energy favors geothermal. Geothermal contributes less total air emissions than does petroleum per kilowatt hour of generated electricity. Further, oil contributes to global warming about fifteen times more than geothermal per kilowatt hour of generated electricity. We believe that the proposed alternative is environmentally superior to the NO ACTION ALTERNATIVE.

Page 96 of the EIS makes it clear that the proposed transmission lines are only for the transport of 25 MW of power from PGV's geothermal development in Pohoiki and that the transmission of electricity from any other geothermal development in Puna will require independent routing studies. The EIS should address whether HELCO plans to purchase additional power from geothermal development from Puna in the next few years. The community has expressed concerns through the Puna Community Council, over a proliferation of geothermal transmission lines in Puna and the lack of an overall development plan. Therefore, we suggest that the EIS include a forecast of HELCO's expected additional purchases of power from geothermal development in Puna and an analysis of the technical, economic, environmental and social factors involved in providing sufficient additional capacity in the proposed alignment for the 25 MW transmission lines, versus utilizing entirely different transmission routes.

Thank you for the opportunity to provide these comments.

Sincerely,

Roger A. Ulveling

RAU/GOL:lta

cc: Dr. Marvin T. Miura, OEQC
Mr. Clyde Nagata, HELCO

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 10, 1989

Mr. Roger A. Ulveling
Department of Business
and Economic Development
Energy Division
335 Merchant Street, Room 110
Honolulu, Hawaii 96813

Dear Mr. Ulveling:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

On behalf of the Hawaii Electric Light Company, thank you for the copy of your letter to Mr. William Paty regarding the above.

Per your request, the final EIS will expand on HELCO's plans regarding future geothermal power and the island's forecasted electrical demand.

As described in the dEIS, the current agreement is for the purchase of only 25 MW of geothermal electric energy which should support the projected island load growth for the next 10 years. The proposed two alignments will be able to adequately transmit the present level of 25 MW into HELCO's system grid. However, over the next twenty years, an additional 25 MW may be required based on expected system load growth. If so, the lines of this project may have to be reconstructed or a third line installed.

If the generating capacity in Puna is increased due to any additional geothermal plants, the party responsible for the additional generation will also be responsible for interconnecting this power to HELCO's 69 kV grid by constructing additional 69 kV transmission lines or increasing the capacity of the existing 69 kV transmission lines. Increasing the voltage would generally require wider easements, taller poles, and larger insulators.

If the existing 69 kV transmission lines are to be upgraded to a higher voltage, approval by the PUC must be obtained before construction begins. A series of public hearings with governmental agencies and community associations will be conducted in accordance with PUC Rules. Any future contracts with geothermal plant developers would require a new routing study to select new transmission line alignments as was done for this project.

Mr. Roger Ulveling
July 10, 1989

Page 2

The community's concern is appreciated over a proliferation of transmission lines in Puna. Coordinated efforts among community, geothermal power plant developer, HELCO and appropriate government agencies are needed for an overall development. This concern and need will be included in the EIS.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

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'89 MAY 15 AM 7 47

ENGINEERING DEPARTMENT

89:PLNG/1748B JT

May 10, 1989

**MEMORANDUM**

TO: Dr. Marvin T. Miura, Director
Office of Environmental Quality Control

FROM: Joseph K. Conant

SUBJECT: Draft EIS for the Proposed Pohoiki Geothermal Transmission Line

Thank you for the opportunity to review the enclosed draft EIS. We have no comments to offer.

ORIGINAL SIGNED

JOSEPH K. CONANT
Executive Director

cc: Hawaii Electric Light Company

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. Joseph K. Conant
Executive Director
Department of Business
and Economic Development
Housing Finance and
Development Corporation
P. O. Box 29360
Honolulu, Hawaii 96820-1760

Dear Mr. Conant:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF DEFENSE
OFFICE OF THE ADJUTANT GENERAL
3949 DIAMOND HEAD ROAD, HONOLULU, HAWAII 96816-4495

ALEXIS T. LUM
MAJOR GENERAL
ADJUTANT GENERAL

MYLES M NAKATSU
COLONEL
DEPUTY ADJUTANT GENERAL

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ENGINEERING DEPARTMENT

May 11, 1989

Engineering Office

Board of Land and Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Gentlemen:

Pohoiki Geothermal Transmission Line
Puna, Hawaii

Thank you for providing us the opportunity to review the above subject project.

We have no comments to offer at this time regarding this project.

Sincerely,

Jerry M. Matsuda
Major, Hawaii Air National Guard
Contracting & Engineering Officer

cc:
Dr. Marvin T. Miura, OEQC
✓Mr. Clyde Nagata, Hawaii Electric Light Company, Inc.

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. Jerry M. Matsuda
Major, Hawaii Air National Guard
Contracting & Engineering Officer
State of Hawaii
Department of Defense
Office of the Adjutant General
3949 Diamond Head Road
Honolulu, Hawaii 96816-4495

Dear Mr. Matsuda:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

JOHN WAIHEE
GOVERNOR OF HAWAII

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

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

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In reply, please refer to:
EPHSD

May 24, 1989

MEMORANDUM

To: Honorable William W. Paty, Chairperson
Board of Land and Natural Resources

From: Deputy Director for Environmental Health Administration

Subject: Draft Environmental Impact Statement (EIS) for Pohoiki Geothermal Transmission Line, Puna, Hawaii, Tax Map Keys 1-3-9: 3,4; 1-4-1: 2,4,17,65, 66,78,79; 1-4-3: 8,11; 1-5-1: 1,3; 1-5-8: 6,7; 1-5-9: 5-7,9,17,23-26; 1-5-10: 3; 1-5-117: 14,15; 1-6-1:15,16; 1-6-3: 3,4,22,67,68,80

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.

BRUCE S. ANDERSON, Ph.D.

cc: OEQC
HELCO ✓

**DHM inc.**
land use
and environmental
planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Dr. Bruce S. Anderson
State of Hawaii
Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801

Dear Dr. Anderson:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

JOHN WAIHEE
GOVERNOR

MARVIN T. MIURA, Ph.D.
DIRECTOR

TELEPHONE NO.
548-6915

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
465 SOUTH KING STREET, ROOM 104
HONOLULU, HAWAII 96813

May 16, 1989

Ms. Duk Hee Murabayashi
DHM Planners Inc.
1180 Bishop Street, Suite 2405
Honolulu, Hawaii 96813

Dear Ms. Murabayashi:

Subject: Comments on the Draft EIS for the Pohoiki Geothermal Transmission Line

We wish to confirm with you that the Pohoiki geothermal project is the Puna Geothermal Venture Project for which Thermal Power Company filed an EIS in November 1987. If there has been any changes to the geothermal project, we would like to see a discussion of the changes in the EIS at this time.

Thank you for providing us this opportunity to review your EIS.

Sincerely,

MARVIN T. MIURA, PH.D.
Director, Office of Environmental Quality Control

ROY SAKAMOTO
Environmental Technical Specialist

cc: DLNR

DHM inc.
land use
and environmental
planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 7, 1989

Dr. Marvin T. Miura, Director
and Mr. Roy Sakamoto
State of Hawaii
Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura and Mr. Sakamoto:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for your letter of May 16, 1989 regarding the above.

The Pohoiki Geothermal Transmission Line project and EIS are separate from the Puna Geothermal Venture (PGV) project to which you referred in your letter. The PGV project involves the development of a 25 megawatt geothermal power plant at the Pohoiki geothermal site. The Hawaii Electric Light Company (HELCO) is not involved in that project. The subject Pohoiki Geothermal Transmission Line project, proposed by HELCO, involves the construction and operation of two 62 kV transmission lines that will transmit the geothermal power produced at the PGV plant from the plant site to HELCO's island-wide power grid at the Puna Substation.

If you have further questions regarding the relationship between these two projects, please feel free to contact me.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

# University of Hawaii at Manoa

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


June 22, 1989
RE:0535

Mr. William Paty
Board of Land and Natural Resources
P. O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

Draft Environmental Impact Statement
Pohoiki Geothermal Transmission Line
Puna, Hawaii

The above referenced document proposes the construction of two overhead 69 kV transmission lines that will originate at the site of the proposed geothermal power plant at Pohoiki and terminate at the Puna Substation in Keaau, Hawaii. The length of each transmission line will be between 17 and 18 miles.

This review was conducted with the assistance of Sheila Conant, General Science; Roger Fujioka, Water Resources Research Center/Public Health; Charles Lamoureux, Botany; Bruce Tabashnik, Entomology; Randall Rush and C. Anna Ulaszewski, Environmental Center.

Our reviewers concur that this document is comprehensive and adequately addresses their concerns. We suggest that in addition to consulting with a cave specialist and an archaeologist as construction progresses, an ornithologist should be consulted periodically to insure that the i'o nesting is not disturbed.

Thank you for the opportunity to comment on this Draft Environmental Impact Statement.

Yours truly,

John Harrison
Environmental Coordinator

cc: OEQC
Clyde Nagata
DHM, Inc.
L. Stephen Lau
Sheila Conant
Roger Fujioka
Charles Lamoureux
Bruce Tabashnik
Randy Rush
C. Anna Ulaszewski

of Water Resources Research Center

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 7, 1989

Mr. John Harrison
Environmental Coordinator
University of Hawaii at Manoa
Environmental Center
Crawford 317
2550 Campus Road
Honolulu, Hawaii 96822

Dear Mr. Harrison:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your letter to William Paty regarding the above. We appreciate your review of the subject document.

Care will be taken during project construction not to interfere with the I'o nesting or breeding. HELCO will consider your suggestion for periodic consultation with an ornithologist.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

Bernard K. Akana
Mayor
Larry Tanimoto
Director
George Yoshida
Deputy Director

# Department of Parks and Recreation

25 Aupuni Street, Rm. 210 • Hilo, Hawaii 96720 • (808) 961-8311

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June 2, 1989

Marvin Miura, Director
Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Board of Land and Natural Resources
State of Hawaii
P. O. Box 621
Honolulu, Hawaii 96809

Subject: Pohoiki Geothermal Transmission Line - Draft EIS

Dear Sir:

The draft EIS has been reviewed and none of the proposed alignments would adversely impact existing park sites.

Thank you for the opportunity to review the report.

Sincerely,

Larry Tanimoto
Director

Encl. EIS being returned (OEQC)

cc: Clyde Nagata
HELCO, Inc.
54 Halekauila Street
Hilo, Hawaii 96720

**DHM inc.** land use and environmental planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 6, 1989

Mr. Larry Tanimoto
Director
Department of Parks and Recreation
County of Hawaii
25 Aupuni Street, Room 210
Hilo, Hawaii 96720

Dear Mr. Tanimoto:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

Mayor
Hugh Y. Ono
Chief Engineer
Bruce C. McClure
Deputy Chief Engineer

# Department of Public Works

25 Aupuni Street, Rm. 202 • Hilo, Hawaii 96720 • (808) 961-8321 • Fax (808) 969-7138

May 24, 1989

BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII
P O BOX 621
HONOLULU HI 96809

SUBJECT: POHOIKI GEOTHERMAL TRANSMISSION LINE
Draft EIS
Puna, HI

Thank you for the opportunity to comment on this draft EIS.

It is preferable that the transmission lines avoid major arterials. The traffic on arterials are heavy and fast and utility poles are considered to be a hazard.

Also, arterials are the most likely to be improved in the future as the population grows.

* Does alignment 16A cross through the Kula Keaau Subdivision or around it? The maps used do not show the actual extent of this subdivision.

* If there are future geothermal ventures in the Puna area, would they be able to use these same lines?

ROBERT K. YANABU, Division Chief
Engineering Division

DHM:jjs

DHM inc.
land use
and environmental
planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 10, 1989

Mr. Robert K. Yanabu
Division Chief
Engineering Division
Department of Public Works
25 Aupuni Street, Room 202
Hilo, Hawaii 96720

Dear Mr. Yanabu:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

On behalf of the Hawaii Electric Light Company, we appreciate your review of the subject document and your letter dated May 24, 1989 to the Board of Land and Natural Resources. The following comments are in response to your letter:

1. HELCO has been, and will continue to be, in regular contact with the State Department of Transportation regarding the construction of the proposed lines within highway rights-of-way.

2. Alignment A, the makai alignment shown on page 16 of the dEIS, will not cross through the Kula Keaau Subdivision. The alignment is routed on an existing private road between Highway 130 and the Puna Substation.

3. Future contracts with geothermal plant developers in the Puna area will require a new routing study to select the transmission line alignments. The lines of the subject project would not be used by future developers.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII

25 AUPUNI STREET • HILO, HAWAII 96720

May 18, 1989

Dr. Marvin T. Miura
Director
Office of Environmental Quality Control
465 S. King Street, Room 104
Honolulu, HI 96813

DRAFT ENVIRONMENTAL IMPACT STATEMENT
POHOIKI GEOTHERMAL TRANSMISSION LINE
PUNA, HAWAII

'89 MAY 22 PM 2 21

The Department has existing water system facilities along Pohoiki Road, Pahoa-Kalapana Highway, Keaau-Pahoa Highway, Pahoa-Kapoho Highway, Kahakai Boulevard and within Keaau. Safeguards for protecting the existing water system facilities should be provided in the construction plans and specifications for the proposed transmission line.

H. William Sewake
Manager

QA/HWS

cc - Board of Land and Natural Resources
Hawaii Electric Light Company
Planning Department



*...Water brings progress...*

**DHM inc.**

land use
and environmental
planning

1188 Bishop Street
Suite 2405
Honolulu, HI 96813
Ph. (808) 521-9855

July 7, 1989

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

Dear Mr. Sewake:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

On behalf of the Hawaii Electric Light Company, thank you for the copy of your letter to Dr. Marvin Miura regarding the above.

HELCO will provide safeguards for protecting the County's existing water system facilities in accordance with all applicable County standards.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

Orchidland Community Association, Inc.

TRANSMISSION LINES COMMITTEE
S.R. Box 5684 - Kea'au, Hawai'i 96749

June 20, 1989

Mrs. Duk Hee Murabayashi
DHM Planners Inc.
1188 Bishop Street, Suite 2405
Honolulu, Hawai'i 96813

RE: Environmental Impact Statement for Pohoiki Geothermal Transmission Line

The Transmission Lines Committee supports HELCO's decision to relocate the alignments for the two 69 kV transmission lines within the right-of-way for Highway 130 instead of through residential subdivisions with the following conditions: 1) each line be buried or bermed along the highway or where it borders existing or proposed residential property; and 2) all statements made by the consultant for HELCO in the E.I.S. be included in subsequent contracts, applications, permits and other pertinent agreements with the condition that they be enforced.

Our specific concerns include:

Safety/Health: Studies on the potential adverse effects of electromagnetic fields are inconclusive; however, "enough evidence now exists to support the assumption that some forms of low-level electromagnetic radiation pose a health threat." A copy of Dr. Richard Littenberg's article "Electromagnetic Radiation - Friend or Foe?" which was published in The Center Report, Vol. 1, No. 2 January 1989, is enclosed. Also, in reviewing J. Michael Silva's field measurements of existing 69 kV lines, electric fields at the centerline below the lowest point of sag are .359 kV/m maximum, not .265 kV/m as stated on page 81. (See Appendix 2, Table 4, page 2-9.)

Visual Impact: The proposed high voltage transmission line alignments represent an unmitigated and lasting visual impact. In addition, the document is contradictory on the use of wood poles. Information regarding the construction and impact of wood poles is provided. Descriptions, diagrams and impacts of the steel poles proposed on page 69 has been omitted. It is obvious that the statement on page 94 that the visual impact will remain the same is not true.

Upgrading: Document response to questions concerning the future upgrading of the overhead transmission lines within the alignment corridors is vague and misleading with regard to the Hawaii Deep Water Cable Project. State of Hawai'i Department of Business and Economic Development reports state that existing corridors will receive priority consideration for the two planned 500 MW transmission line corridors necessary for the cable project. Present planning must encompass all aspects of geothermal development in the Puna District.

Cost: HELCO has repeatedly stated that the construction of underground or bermed lines is too costly; however, it is pointed out in this document that according to Public Utilities Commission regulations, the geothermal plant developer must pay the cost of constructing transmission lines and that should the developer pay for an underground system, HELCO will cooperate in its construction. It is necessary to the future wellbeing of the Puna District that all developers of geothermal energy for the production of electricity financially support burying or berming transmission lines.

Property Values: Affected property owners believe that a loss in property values will result if the two 69 kV transmission lines and larger lines to support logically anticipated system increases are not buried or bermed.

Thank you for the opportunity to express our concerns relating to the construction of overhead high voltage transmission lines along our subdivision. It is imperative that this project, one of the first phases for geothermal development in our community, set a precedent for all Big Island geothermal development. Therefore, we strongly urge that energy corridors be underground or bermed where they impact the human environment.

Sincerely,

TRANSMISSION LINES COMMITTEE

Lynne E. Goldstein
Secretary

/lg

Enclosure

# The Center Report

Dedicated to Determining the Relationship Between the Environment and Human Health — Volume 1, No. 2 January 1989

## ELECTROMAGNETIC RADIATION— FRIEND OR FOE?

by Richard Littenberg, MD

Nationally, there is a growing public concern about potential health hazards associated with the exposure to low level electromagnetic radiation. This is the form of radiation associated with power lines, electric motors, TV sets, computer consoles, microwave ovens, cellular phones, microwave transmissions, and broadcast antennas. Data suggesting a link between exposure to low level radiation from power lines and the occurrence of cancer has complicated new power line construction. Various cities are imposing limits on radio frequency and microwave radiation transmissions. Prospective home buyers in other areas are being warned about the proximity to power lines.

Here in Hawaii, a 1984 Environmental Protection Agency study identified Honolulu as the city with the highest level of radio frequency radiation in the nation due to the location of broadcast antennas in residential and commercial areas. Additionally, the proximity of the Omega station to the proposed H-3 highway caused concern regarding potential health risks to construction workers and motorists. This Omega station in Kaneohe is part of a worldwide system created to assist navigation by sending out strong electromagnetic signals. These signals are received by marine vessels and aircraft and help them establish their location. The new H-3 will pass directly beneath the antenna at the Kaneohe station.

Interest has focused on a portion of the electromagnetic spectrum which was previously considered of little biologic significance. While the potential harmful aspects have received the most attention, considerable beneficial effects on human health may also exist. Surprisingly, up until 1984, a large fraction of the world's literature on the subject emanated from the Communist bloc and was published only in the Slavic languages.[1] Most of this research was never translated so as to be available to Western scientists who, generally, professed little interest in this area.

Several studies alleging an association between exposure to low-level or non-ionizing radiation and childhood leukemia, problems with pregnancy, learning disabilities, and brain tumors have generated increasing scientific interest and public concern.[2,3,4,5] These studies associating low-level radiation to human disease have been epidemiological in nature and subject to attack. Additionally, many have not been reproducible in other localities. However, enough evidence now exists to support the assumption that some forms of low-level electromagnetic radiation pose a health threat.On the other hand, medically beneficial uses of low-level electromagnetism have already been well demonstrated. For example, when

Continued on page 2

While the potential harmful aspects have received the most attention, considerable beneficial effects on human health may also exist.

**Electromagnetic Radiation** Continued

broken bones fail to heal, a condition called "non-union," a device applied over the affected part is used to induce a pulsating electromagnetic field that can lead to healing,[6] eliminating the need for surgery. Similarly, skin wound healing may also be promoted by such devices.

It can be expected that a significant body of knowledge will emerge over the next several years. This new information may force painful and costly decisions on an increasingly technical society. It may also reveal new and exciting applications of electromagnetism in the diagnosis and treatment of human disease. An informed population, especially those in decision making positions, will be crucial. This *Center Report* will present some of the background concepts involving electromagnetic radiation, the electrical nature of biological systems, and the interaction between external electromagnetic radiation and the human body.

**An informed population, especially those in decision making positions, will be crucial.**

## Electromagnetic Radiation

While most non-scientists have a vague understanding of electromagnetic radiation, not enough of the specifics are generally understood to permit critical interpretation of information regarding its health effects.

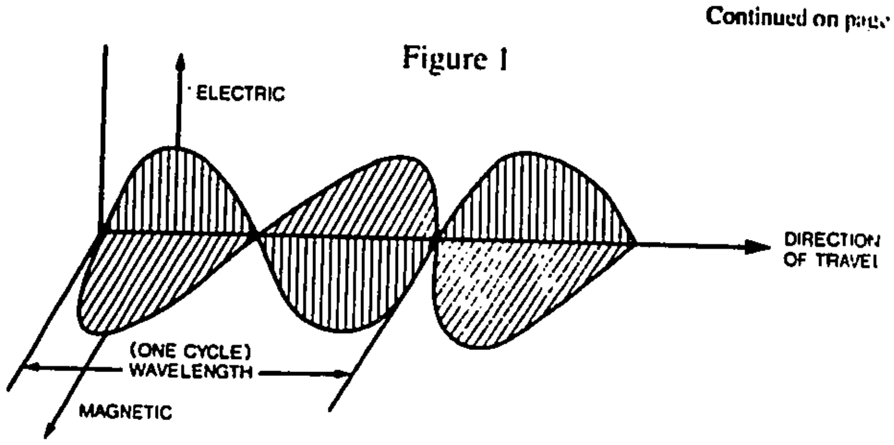
Simply stated, matter, the substance of the universe, is made up of atoms. These atoms are composed of negatively charged electrons which circulate around a nucleus, comprised of particles having both neutral and positive electric charges. An electric current occurs when electrons are passed from atom to atom in certain materials called conductors. The electrons circling the nucleus, as well as free electrons, such as those traveling in a conductor, can be given increased energy in a variety of ways. The same is true for the nucleus of the atom. When matter is energized, there is a fundamental tendency to give up this extra energy and to return to its unenergized state. One of the ways by which matter gets rid of this excess energy is through the emission of electromagnetic radiation.

Based upon experimental observations, scientists have created two different models of what electromagnetic radiation "looks like." Used together, these two models help explain the observed properties of this radiation.

The first model (Figure 1) pictures electromagnetic radiation as a wave made up of electric and magnetic components oscillating back and forth.

Continued on page 3

Figure 1

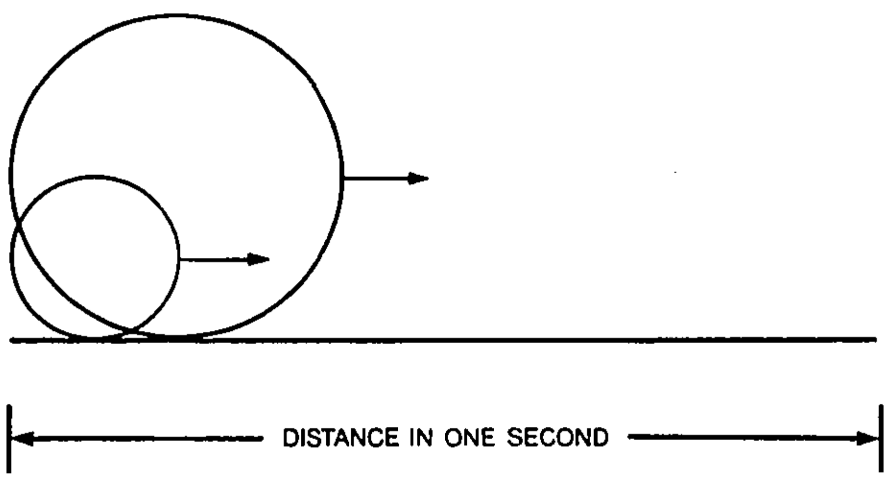


## Electromagnetic Radiation Continued

These components oscillate at right angles to each other while the wave travels in a direction perpendicular to the oscillation. The radiation travels at a specific speed in any given medium. For example, in a vacuum, electromagnetic radiation travels at the speed of light, 186,000 miles per second. In another medium, such as air, the speed will be somewhat less than that in a vacuum.

The wave model introduces two other characteristics needed to understand electromagnetic radiation—frequency and wave length. The frequency of the radiation is the number of complete cycles that the wave will undergo in a second. The wave length is the distance the wave will travel while undergoing one complete cycle. An analogy can be made using two hoops of different sizes (Figure 2). Both hoops have to travel the same distance in one second (186,000 miles in the case of a vacuum). In this analogy the wave length is the circumference of the hoop. The small hoop has a shorter wave length than the large hoop. To cover the same distance in one second, the small hoop has to turn faster, making more revolutions (higher frequency) than the large hoop. It is easily seen using this analogy that speed equals the wave length (circumference) times the frequency (number of revolutions). As one increase, the other decreases.

Figure 2




Other experiments performed many years ago show that the energy in the electromagnetic radiation is proportional to the frequency of the radiation. The faster the wave oscillates (the faster the hoop rotates), the more energy it contains. For example, cosmic rays created far out in the distant reaches of space have an extremely short wave length with very rapid frequencies and contain enormous energies. Conversely, extremely low frequency radiation, such as the 60 cycle per second (60 Hertz) power line frequencies in the United States, have a very low frequency and very little energy.

Electromagnetic radiation can exist in an infinite variety based upon its frequency (or wave length). This variety is called the electromagnetic spectrum and can range from the very low frequencies to the very high

Continued on page 4

## **Electromagnetic Radiation** Continued

frequencies. Different regions in the spectrum have been classified according to a set scheme (Table 1).

The other model of electromagnetic radiation is to picture the radiation in the form of small particles called photons. Each photon can be pictured as a little BB pellet. A burst of electromagnetic radiation originating at a single point in space could, therefore, be imagined as a cluster of little pellets shooting out simultaneously in all directions. Using the wave model, if the electromagnetic radiation was of a single frequency, then all the pellets would have a similar amount of energy. The further one got from the point of explosion, the more the pellets would be spread out and the fewer pellets could be detected. The number of pellets found at a given distance away could be increased by increasing the number of pellets liberated in the original explosion.

This model helps explain the difference between the energy of the electromagnetic radiation and the power of the radiation. The power of the radiation relates to the number of particles liberated. The energy of the radiation relates to the energy of a specific individual pellet or the frequency of the corresponding wave form.

The physics explained above helps in understanding the concerns involving the Omega station. The Omega station sends energized electrons into the antenna strung across Haiku Valley. These electrons lose energy in the form of *electromagnetic radiation*. The radiation of the Omega station is in the 10,000-13,000 cps (10-13 kilohertz) range. This portion of the electromagnetic spectrum corresponds to the very low frequency range. With such a low frequency, the amount of energy in the associated photons is very low (weak pellets). As the radiation emanates away from the antenna, the pellets spread out. In order for a ship or plane to detect enough pellets from the various Omega stations to help determine its position, a sufficiently high number of pellets must be emitted from the antenna. This is what dictates the very high power output needed from the Omega station antenna. In this case, the radiation itself is weak, but the power output must be large to accomplish its mission.

It is this high power requirement of the Omega station that creates its shock potential. As learned in elementary science, like charges repel each other while opposite charges attract. These electric charges can affect each other even at a distance. Conceptually, this action at a distance led to the concept of "field effect." It was considered that a charged particle influenced the space around it and any other charges entering the space would be affected. The large power output needed to communicate with ships or planes far away necessitates a high voltage (250,000 volts) to drive the required number of electrons through the antenna. The large number of electrons creates an electric field in the vicinity of the antenna. Conducting materials, such as iron or steel, have loosely bound electrons capable of moving from atom to atom. If such a conductor is placed in a strong Omega station electric field, the electrons will move from one side of the conductor to the other, creating a charge in the conductor itself. If the conducting material is attached to the ground by another conductor such as

**Table 1**
Wave lengths of electromagnetic spectrum

| | wavelength (cm) | frequency ($sec^{-1}$) | photon energy (eV) |
|---|---|---|---|
| cosmic ray photons | $3 \times 10^{-22}$ | $10^{32}$ | $4 \times 10^{17}$ |
| | $3 \times 10^{-20}$ | $10^{30}$ | $4 \times 10^{15}$ |
| | $3 \times 10^{-18}$ | $10^{28}$ | $4 \times 10^{13}$ |
| | $3 \times 10^{-16}$ | $10^{26}$ | $4 \times 10^{11}$ |
| | $3 \times 10^{-14}$ | $10^{24}$ | $4 \times 10^{9}$ |
| | $3 \times 10^{-12}$ | $10^{22}$ | $4 \times 10^{7}$ |
| gamma rays | $3 \times 10^{-10}$ | $10^{20}$ | $4 \times 10^{5}$ |
| X-rays | $3 \times 10^{-8}$ | $10^{18}$ | $4 \times 10^{3}$ |
| Ultraviolet-visible light | $3 \times 10^{-6}$ | $10^{16}$ | 40 |
| ionization energy | $1 \times 10^{-5}$ | $10^{15}$ | 12.4 |
| infared | $3 \times 10^{-4}$ | $10^{14}$ | 0.4 |
| microwaves | $3 \times 10^{-2}$ | $10^{12}$ | $4 \times 10^{-3}$ |
| radar | 3 | $10^{10}$ | $4 \times 10^{-5}$ |
| UHF, VHF, FM | 300 | $10^{8}$ | $4 \times 10^{-7}$ |
| shortwave am radio | $3 \times 10^{4}$ | $10^{6}$ | $4 \times 10^{-9}$ |
| longwave | $3 \times 10^{6}$ | $10^{4}$ | $4 \times 10^{-11}$ |
| radio | $3 \times 10^{8}$ | $10^{2}$ | $4 \times 10^{-13}$ |

Continued on page 5

a wire, the conductor is called "grounded." The electrons will flow from the conductor into the ground and dissipate the charge. If an ungrounded conductor is touched by an individual not wearing protective clothing, the individual acts as a ground, with the current passing through him, creating a shock.

## Biological Systems

The scientific understanding of most phenomena has usually evolved in a fashion analogous to peeling the layers of an onion. The outermost layer is gross description followed by function, chemistry, physics, and finally mathematics.

The human body can be used an an example. The first descriptive understanding undoubtedly began before the dawn of recorded history by observations made during the butchering of animals and drawing analogy with the human counterpart. Subsequently, over many thousands of years, gross anatomic dissection allowed precise descriptions of the individual structures within the body and their relationship to each other. In relatively recent human history, direct observation was extended to the cellular level with the use of the microscope.

Functional understanding, or physiology, followed direct observation and description by many thousands of years. Virtually all of the understanding of human physiology has been developed over the past several centuries, escalating ever more rapidly during the last century.

The next layer of understanding, where we currently find ourselves as we approach the year 2000, is at the biochemical level. Biochemistry is a common thread extending through the disciplines of molecular biology and genetics. Illustrative examples describing our current stage of development include the constant expansion of knowledge concerning the biochemical nature of disease, such as atherosclerosis and cancer. Therefore, in our current stage of development, we picture the body from an anatomic and biochemical basis. What will the next layer of the onion disclose?

All chemical reactions follow the laws of physics. Chemistry focuses on the interactions between atoms and molecules which occur through electromagnetic forces. Therefore, the image of the body in this next stage of scientific evolution will add the new dimension of electromagnetic fields to the existing picture of anatomy and biochemistry.

It is obvious that the scientific "eras" overlap to some extent. Since the first time an electrical impulse was used to stimulate the body, the "electrical nature" of the body was suggested. In fact, the electrical nature of the body is used currently in clinical medicine on a routine basis. The electrocardiogram and the electroencephalogram are both crude techniques by which the gross electrical fields generated by the heart and brain respectively are studied. Even these gross measurements of organ electrical activity provide important and useful clinical information. Thus, the electrical fields generated by the heart, as measured by the electrocardiogram, are routinely used as one of the key standards for establishing the

Continued on page 6

**It is this high power requirement of the Omega station that creates its shock potential.**

presence of irregularities in cardiac rhythm, as well as heart attacks. The electroencephalogram remains the major tool for diagnosing seizure disorders.

One of the newest techniques, magnetic resonance imaging (MRI), is based upon the electromagnetic nature of the body. The patient is literally placed in a large magnetic field and has radio frequency energy pumped in to generate an internal signal from the body. MRI uses some of the most sophisticated advances in electronics, magnetism, and mathematical image reconstruction theory to interact with the body's own electromagnetic fields on an atomic/molecular level to create pictures of the inside of the body. Despite the sophistication of the science employed, MRI still uses gross electromagnetic signals similar to the electrocardiogram or electro-encephalogram. In other words, our most sophisticated techniques are barely scratching the surface of the complex electromagnetic phenomena occurring within the body.

One can visualize that the basis of life is the maintenance of the separation of charges and the creation of electrical fields. The living unit of our bodies, the cell, is surrounded by a membrane which separates the inside of the cell from the fluid outside. Throughout its life, the cell continuously pumps electrically charged atoms and molecules across the cell membrane to create separation of charge and, therefore, an electric field. The function of our brain, nerves and muscles are all based upon transient charges in these fields. The rest of our bodies can be thought of as being cast in a support and supply role. The digestive system breaks down food into the fuel needed to supply energy to maintain the separation of charge. The pulmonary system supplies the oxygen to burn the fuel. The circulatory system transports the fuel and oxygen to the cells. Hormones and other active molecules work, at least in part, by affecting the cell membrane and somehow modifying the electrical field and, thereby, cell function.

New research indicates that electric phenomena play a significant role in a far more sophisticated and complex way than previously imagined. W.R. Adey, at Loma Linda University, has been a main proponent in advancing this picture of molecular and cellular function.[7] He pictures the cells as whispering to each other with electrical signals. Since all molecules in the body have electrical charges on them, when they are exposed to either internal or external electromagnetic radiation, they tend to oscillate and vibrate. Depending upon the frequency of the signals, these oscillations can occur in many "modes." The molecules can be pictured as a rope attached a one end and being shaken at the other end. Depending upon the speed, or frequency, with which the rope is shaken, different modes, or patterns can be established in the rope. All of the large molecules in the body, including DNA, could participate in this "dance." Since many molecules including hormones and antibodies must interact with specific receptor molecules, much like a lock and key, the possibility exists that the function of these molecules can be altered, depending upon their modes of oscillation. Perhaps the action of these molecules could be enhanced or diminished by the application of specific electromagnetic fields.

> **In other words, our most sophisticated techniques are barely scratching the surface of the complex electromagnetic phenomena occurring within the body.**

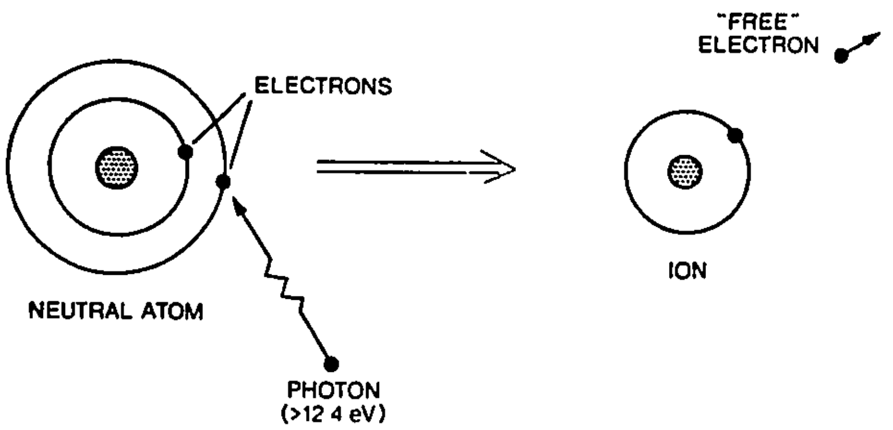
Continued on page 7

**Electromagnetic Radiation** Continued

## Radiation-Body Interactions

External electromagnetic radiation can interact with the body in a number of ways based upon the photon energy. A division can be made in the electromagnetic spectrum at 12.4 eV ($2.99 \times 10^{15}$ cps) which is the energy with which the weakest bound electron is attached to an atom. A photon with energy exceeding 12.4 eV can be pictured as a BB pellet with enough energy to dislodge this electron from the atom if it strikes it (Figure 3). During this process, termed "ionization," the remaining part of the atom or molecule develops a net electric charge and is called "an ion." Ionization can directly disrupt or fracture important molecules, such as DNA. Ionizing radiation more commonly leads to the formation of highly charged small molecules, called "free radicals," which are chemically very reactive and can disrupt other molecules. Examples of ionizing radiation include x-rays and gamma rays. The adverse health effects of this form of electromagnetic radiation are essentially unquestioned. Exposure to massive amounts of ionizing radiation can lead to death from brain damage within hours. Somewhat lower doses of ionizing radiation can lead to severe radiation sickness over a matter of days to weeks as observed with the nuclear accident at Chernobyl. Much lower exposures can lead to long range effects, such as cancer formation many years later. These phenomena were clearly seen as an aftermath to radiation exposure at Hiroshima and Nagasaki.

Figure 3




Non-ionizing radiation involves that portion of the spectrum where photon energies are inadequate to produce ionization. The effects of non-ionizing radiation can be divided into thermal and non-thermal effects. This non-ionizing radiation is not strong enough to strip electrons away from molecules, but it is strong enough to agitate molecules by transferring energy into increased vibration and rotation. Innumerable studies have been done and were summarized by the Environmental Protection Agency in 1984.[8] These thermal effects are fairly well understood. Animals exposed to non-ionizing radiation of sufficient intensity begin to generate heat. Blood flow changes in the body bring more heat to the surface for dissipation. Depending on the species, sweating and panting can also occur in order to increase the loss of heat. When the heat dissipating mechanisms of the

Continued on page 8

## **Electromagnetic Radiation** Continued

body are overcome, the body temperature begins to rise and death can ensue. Additionally, thermal effects have caused specific abnormalities such as sterility, changes in brain function, and probable effects on the immune system.

For these thermal effects to occur, sufficient energy must be transferred, or "coupled," from the radiation into the body. For efficient coupling to occur, the wave length of the radiation must be similar in size, or smaller than, the body irradiated. It is in the near microwave and microwave region (300 million to 3 billion cps: 0.3–3 gigahertz) in which most of the coupling and thermal effects can occur. Therefore, in the case of thermal effects, the photons need to be energetic enough and in the proper frequency range to couple sufficient energy into the biological system to increase its temperature.

Working with these thermal effects and the energy coupling based upon frequency, standards have been set that dictate the allowable exposure that both workers and the general public are permitted to safely receive. These standards specify the field strength (the concentration of photons) for given frequencies (photon energies).

It has been the non-thermal effects associated with non-ionizing low-level electromagnetic radiation that has been the focus of the national debate. As recently as 1982, the American National Standards Institute (A.N.S.I.) maintained that insufficient documentation existed for non-thermal effects of electromagnetic radiation to even create standards for allowable exposure. Research data generated since 1982 has clearly established the existence of non-thermal effects. However, the significance on human health remains unclear.

**Research data generated since 1982 has clearly established the existence of non-thermal effects. However, the significance on human health remains unclear.**

The association with human disease, such as cancer, birth defects, and neuropsychological problems, is based on epidemiologic studies whose validity is open to challenge. More basic research has shown developmental abnormalities in chicken embryos exposed to low-level radiation.[9] Effects on the brain have also been observed.[10] The beneficial effects involving bone and skin healing have already been noted.

All of these effects appear to be very frequency dependent. This would be consistent with Adey's hypothesis of the "dancing molecules" with either enhancement of, or interference with, important molecular interactions. Certain frequencies of electromagnetic radiation, when applied to broken bones, may increase the actions of various hormones and other chemicals to promote bone healing. Conversely, other frequencies, by blocking molecular action, may interfere with immune system cancer surveillance or even cause cancer promoting changes in the DNA of the cells.

Several factors combine to make relevant research in this area very difficult. Since electromagnetic interactions are involved in virtually every function of the body, the possible effect or effects are many and varied. Research must be designed to focus on one, or at most a few, specific effects at a time. Some of these effects, such as cancer induction, may not show up for years or decades after exposure, with additional and different

Continued on page 9

exposures clouding the picture as well. Further, the frequency range over which non-thermal effects could be sought after is very large. Only very limited, or specific, segments of the electromagnetic spectrum may induce significant non-thermal effects. A confounding feature is that biological-systems respond to a specific wave form and not necessarily the inherent frequency of the radiation. For example, a 10,000 cps (10 kilohertz) electromagnetic radiation turned on and off 16 times per second, may be perceived by the biological system as a 16 cycle per second (16 hertz) signal. Therefore, not only does the frequency of the radiation need to be considered, but for pulsed systems, the pulse rate (how often it is turned off and on) as well. The situation may be analogous to searching for a needle in a haystack; compounded by having multiple haystacks.

Incidentally, it is the same pulse rate problem that may cause interference with cardiac pacemakers. The electronics in these devices are programmed to sense electrical impulses in a certain frequency range to maintain a normal heart rate. If the device mistakes pulsed external electromagnetic radiation for an abnormal heart rate, it may inappropriately be turned on and off, thus creating a health hazard.

In summary, this issue of the Center's report has provided background information on the nature and characteristics of electromagnetic radiation. An attempt has been made to add the dimension of electromagnetism to the image of the human body along with anatomy and biochemistry. Clearly, electromagnetic radiation and fields can have various and substantive effects on the body.

High field strengths, such as those that exist in the neighborhood of an Omega station antenna, cause significant charge induction in conducting materials and create the likelihood of shock especially if the conducting substance is not properly grounded. This potential risk, in association with the construction of the H-3 highway, has been well discussed in the local press.

Electromagnetic radiation in the ionizing range has proven adverse effects on biological systems. Its danger is well recognized and generally guarded against.

The thermal effects of non-ionizing radiation are also well known. It is this effect that is used to set standards for exposure for both workers and the general public. Thermal effects are dependent on the ability to couple energy from the electromagnetic radiation into the biological system. This is clearly frequency-dependent and would not be expected with radiation in the Omega station's frequencies.

The non-thermal effects have only been recently recognized. Their existence is no longer in doubt, but the biological significance and associated risks are still unclear. The difficulties associated with meaningful research in this area have been noted.

Significant new research is to be expected in the next several years concerning the general area of the electromagnetic radiation and its effects on biological systems. Both positive and negative health effects may be found

Continued on page 10

**...not only does the frequency of the radiation need to be considered, but for pulsed systems, the pulse rate (how often it is turned off and on) as well.**

## **Electromagnetic Radiation** Continued

depending perhaps on the frequency, signal strength, and duration of exposure. Certain exposures in the environment may need to be lowered or limited while others may be found to be beneficial, having preventive or therapeutic applications. It is hoped that the information presented here will provide some readers with a broader foundation to help assess and evaluate this new information. ❧

**References**

1) Biological Effects of Radiofrequency Radiation. September 1984, EPA-600/8-83-026F; 2) Wertheimer N. et al. American Journal of Epidemiology 1979, Vol. 109, No. 3:273-284. 3) Nordstrom S. et al. Bioelectromagnetics 1983, 4:91-101; 4) Thomas J. et al. Bioelectromagnetics 1986, 7:349-357; 5) Coleman M. et al. International Journal of Epidemiology 1988, Vol. 17, No. 1:1-13; 6) Brighton C T. et al. Journal of Orthopaedic Res 1983, 1, 42; 7) Adey W R. Electromagnetic Fields and Neurobehavioral Function Alan R Liss, Inc. 1988, 81-106. 8) Biological Effects of Radiofrequency Radiation. September 1984, EPA 600/8-83-026F; 9) Delgado J M R. et al. Journal of Anatomy 1982, Vol. 134, No. 3: 533-551; 10) Sheppard A R. et al. Radio Science Nov.-Dec 1979, Vol. 14, No. 6s:141-145.

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July 10, 1989

Ms. Lynne E. Goldstein
Orchidland Community Association, Inc.
Transmission Lines Committee
S.R. Box 5684
Kea'au, Hawai'i 96749

Dear Ms. Goldstein:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for your letter dated June 20, 1989 regarding the above. The following responses reflect the sequence of your comments.

Safety/Health

The .265 kV/m electric field referred to on page 81 of the draft EIS is the maximum field measurement taken by Silva beneath an existing 69 kV transmission line along Saddle Road. (Refer to field measurement data for Site No. 9 in Silva's report, p. 2-5.) Table 4 in Silva's report is a summary of mathematical calculations which were performed to take into account conditions that may not exist during routine field measurements, as explained on page 81 of the draft EIS. The calculations are plotted and shown in Exhibit III-2, page 82. The peak of this graph corresponds to Silva's calculation of .359 kV/m.

Visual Impact

The project will not utilize steel poles, as mistakenly indicated on page 69. Wooden poles as described and shown on pages 11 through 17 will be used. The final EIS will be revised to reflect this.

Upgrading

The proposed Pohoiki Geothermal Transmission Line project is completely separate and unrelated to the State's Deep Water Cable Study. The proposed lines and right-of-way widths are not intended to, or capable of transmitting power produced by the Deep Water Cable project.

Cost

Pursuant to Public Utilities Commission regulations, the geothermal plant developer must pay for all interconnection costs. However, the developer is not obligated to pay for the higher interconnection cost alternative. The present geothermal developer does not want to pay for an underground transmission line because of the substantial increase in cost from an overhead transmission line.

Property Values

As stated in the EIS, County records do not support the concern that transmission lines will result in decreased property values. However, the Hawaii Island Board of Realtors has recommended to HELCO (in their letter dated July 3, 1987, printed on page 4-40 of the dEIS) that the lines be located along Highway 130, above or below ground to avoid a loss in property values. HELCO has followed this recommendation by locating both alignments along the highway rather than through the adjacent subdivisions.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

**PUNA COMMUNITY COUNCIL**
P.O. Box 1294
Pahoa, Hawaii 96778-1294

12 June 1989

Duk Hee Murabayashi, President
DHM Planners, Inc.
1188 Bishop St.
Suite 2405
Honolulu, Hawaii 96813

RE: Pohoiki Geothermal Transmission Line EIS

The Puna Community Council's Transmission Corridor Subcommittee has reviewed in detail the above referenced draft EIS dated May 1989. We wish to provide comments on the following issues:

1. On page 3 , it is stated that the Pohoiki Geothermal Transmission Line Routing Study dated November 1987 performed by your company will be used throughout this EIS presumably to support potential impacts, discussions of environmental setting, and mitigating measures and alternatives.

As you know, the study has never been accepted by the community and others, therefore, its use in support of this EIS is questionable.

2. On page 9, alignment "A" proposes to cross state conservation land and then proceed along the Pahoa boundary of Leilani Estates subdivision toward Kalapana Road.

The impacts and mitigating measures associated with this proposal have not been addressed.

3. Does the proposed design include safety nets where the transmission line crosses Highway 130 and other traveled roads ?

4. The EIS addresses the proposed alignment "B". This proposed line is not acceptable to the community and was part of an agreement with HELCO and several representatives of the state and county. It should not be included in this EIS.

5. The document "Traffic Impact Analysis for EIS" referenced in the footnote on page 86, is not included in this document for review. As an example, the statement on page 86 , "however, with appropriate mitigating measures, traffic disruption can be minimized to an acceptable level" has no meaning.

6. Chapter III A, page 67, the first paragraph "By planning for and selecting routes ..." is not clear as to its intent. Again reference is made to the routing study.

7. On page 71, the last paragraph contains a sentence that says "The possibility of fire due to arcing or spark discharge from conductors in extremely remote." Where is the evidence to support this statement ? As a minimum, HELCO should submit their "problem

log" for the past several years.

8. On page 78, under Public Health and Safety, none of the statements are supported by qualified medical experts.

9. On page 93, the paragraph in the middle of the page addresses the visual impact as seen from the highway. It does not, however, address the visual impact to the property owners along the right of way.

10. The discussion of social and economic impacts on page 95, makes no mention of the letter dated 3 July 1987 from the Hawaii Island Board of Realtors as to property values. Should not this also be taken into consideration ?

In addition to the above comments, the subcommittee reviewed the written comments provided by Hawaiian Paradise Park and Orchidland subdivisions. It is the general consensus that most of the answers provided by your company failed to adequately address the issues.. In accordance with the rules for the preparation of an EIS, no opportunity was provided the community as consulted parties to discuss the issues in open meeting so that your company could more properly address the many concerns associated with this project.

It is, therefore, formally requested that a meeting be held with the community during the 45 day period and prior to the final preparation of the draft EIS. It is hoped that this meeting will address all of the concerns identified for this project and that most can be resolved to the satisfaction of all parties.

Sincerely,

Ronald C. Phillips
President

cc: Governor John Waihee
Senator Andrew Levin
Representative Jerry Chang
Representative Mark Andrews
County Council Chair Russell Kokubun
Mayor Bernard Akana
Cynthia Thielen, Esq.
Office Env. Quality Control

**DHM inc.** land use and environmental planning

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July 10, 1989

Mr. Ronald C. Phillips
Puna Community Council
P.O. Box 1294
Pahoa, Hawaii 96778-1294

Dear Mr. Phillips:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for your letter dated June 12, 1989 regarding the above. The following responses reflect the sequence of your comments.

1. The Pohoiki Geothermal Transmission Line Routing Study was the result of an objective evaluation of conditions in the project study region to identify areas of constraint and opportunity for a transmission line. In addition to the findings of the Routing Study and public meetings held during the Routing Study process, the dEIS is based upon further research of documented material and subsequent meetings with government officials, subdivision associations, and community organizations, including the Puna Community Council.

2. Chapter III, Impact Analysis, discusses potential impacts which may occur at any or all locations along the proposed alignments as well as appropriate mitigative measures. The area to which you refer is covered in this chapter.

3. Safety nets will not be installed where the transmission line crosses Highway 130 and other traveled roads because they are not outlined in the General Order No. 6, Rules for Overhead Electric Line Construction in the State of Hawaii. Any lines placed along Highway 130 will be done so with the concurrence of the Department of Transportation and according to all appropriate rules and standards.

4. Alignment B in the draft EIS is a modification of the Routing Study's makai alignment (Alignment B). This is shown on Exhibits 1-2 and 1-3 of the draft EIS. The alignment was modified by re-routing the alignment to Highway 130 instead of traversing Hawaiian Paradise Park Subdivision. This modification was the result of discussions with the Puna Community Council, the subdivisions, public officials, government agencies, and Hawaiian Telephone Company.

5. Thank you for bringing this to our attention. The "appropriate mitigative measures" referred to on page 86 are those listed on page 87 of the Draft EIS. The mitigative measures will be used to meet State and County standards for acceptable traffic flow.

6. This sentence will be revised to read as follows in the Final EIS: "As a result of the overall planning process and route selection process undertaken for the proposed transmission lines, the cumulative impacts of the dual-line project have been addressed, and the probability of significant adverse effects from the proposed project is minimized."

7. HELCO does not have a written log of fires related to their transmission lines. However, according to HELCO's General Superintendent, only one fire incident involving the 69 kV system occurred two years ago.

8. The information provided on pages 78-83 is primarily from the research of J. Michael Silva, a specialist in electric and magnetic fields. His complete evaluation of the projected fields for the proposed lines is included in the EIS as Appendix 2.

9. As is the case within the highway right-of-way, the visual impact to property owners adjacent to the right-of-way will remain about the same as the visual impact of the existing lines. This is due to the proposed use of joint and double circuit poles as described on page 94 of the draft EIS. Furthermore, existing vegetation at the edge of the right-of-way and along the property lines of the adjacent landowners will help to screen the alignments from view.

10. The Hawaii Island Board of Realtors letter, to which you refer, is included in the draft EIS in Appendix 4, pages 4-40 and 4-41. Its contents were not only taken into consideration during the EIS, but were followed. The author

"strongly urges" that "the only fair and practical route for this transmission line is to run it along the edge of the Pahoa Highway, either above or below ground." Accordingly, the proposed alignments have been located at the edge of the highway right-of-way on above-ground poles, instead of traversing the adjacent subdivisions.

Additional Comments

Chapter 343, Hawaii Revised Statutes, provides the general public with two opportunities to comment on a project subjected to the EIS process:

1) a 30-day comment period following publication of the EIS Preparation Notice, and

2) a 45-day comment period following the submittal of a draft EIS.

Letters received during the 30-day comment period and our responses were published in the draft EIS as Appendix 4. Letters received during the 45-day comment period and our response will be published in the Final EIS as Appendix 5.

Although the EIS process does not include public meetings or hearings, numerous public meetings were held during the routing study phase for the Pohoiki project. Subsequent meetings were held with individual subdivision associations and community groups as well.

HELCO would be happy to meet with you again, Mr. Phillips, as you have requested. They will be contacting you soon regarding a meeting time and place.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
DLNR
HELCO

# W.H. SHIPMAN, LTD.

KEAAU
HAWAII ISLAND

June 9, 1989

Ms. Duk Hee Murabayashi, President
DHM Planners, Inc.
1188 Bishop Street, Suite 2405
Honolulu, Hawaii 96813

Dear Ms. Murabayashi:

Re: Pohoiki Draft E.I.S.

We have reviewed the draft E.I.S. and have no comments to make other than we favor geothermal power and wish HELCO well in this venture.

Sincerely,

Roy S. Blackshear

Roy S. Blackshear, President
W. H. Shipman, Limited

RSB:bnm



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July 6, 1989

Mr. Roy S. Blackshear, President
W. H. Shipman, Limited
P.O. Box 950
Keaau, Hawaii 96749

Dear Mr. Blackshear:

RE: Pohoiki Geothermal Transmission Line
Draft Environmental Impact Statement

Thank you for the copy of your correspondence in reference to the above. On behalf of the Hawaii Electric Light Company, Inc., we appreciate your review of the document and prompt response.

Sincerely,

DHM inc.

Duk Hee Murabayashi (Mrs.)
President

WM:lt

cc: OEQC
HELCO
DLNR

# POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY

Prepared for:

HAWAII ELECTRIC LIGHT COMPANY, INC.

Prepared by:

DHM inc.

November 1987

# CONSULTANT TEAM

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Botany
Entomology
Ornithology

**DAMES & MOORE**

Soils

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# SUMMARY

Two 69 kv transmission lines will be required by 1991 to carry 25 megawatts of power from the proposed geothermal-electric power plant in Pohoiki to the Puna Substation near Keaau. This report describes the process of identifying the transmission line routes based on an analysis of environmental, social, economic and technical factors.

The methodology used for selection of the route is a sequence of steps organized into two phases. The first phase narrows down the number of routing possibilities by identifying optimum corridors for further study. Numerous data factors were evaluated in light of opportunities and constraints for the location of a transmission line, and then displayed in map form. These factors included exclusion areas such as protective subzone lands; geophysical factors such as slopes, soils and geologic hazards; biological considerations including special vegetation zones and wildlife habitats; socio-economic conditions such as land use, land regulation and land ownership patterns, recreation and archaeologic resources, and transportation and utility networks; and cost considerations based on land value, accessibility and maintenance requirements. An overlay mapping technique aided identification of less constraint areas for a transmission line, within which, potential corridors were delineated.

Phase 2 of the routing study leads to the selection of two specific route alignments based upon a more detailed analysis of conditions *within* the corridors. First-hand field observations by technical specialists such as archaeologists, botanists, entomologists, geologists, landscape architects and environmental planners, as well as secondary source material were used to identify and map data directly influencing the location of the transmission lines. The data factors for Phase 2 include land use, land ownership, land regulation, visual resources, vegetation zones, wildlife habitats and archaeological and historic sites.

The route identification process was accompanied by public involvement including meetings with State and County government agencies and community workshops in the study area.

Two alignments were identified between the proposed Pohoiki geothermal plant site and Puna Substation. One alignment heads mauka, skirting Leilani Estates and crossing Kalapana Road. It then proceeds northerly, passing mauka of Pahoa and Highway 130 until just before Keaau where it crosses Highway 130 to reach the Puna Substation. The other route heads north from Pohoiki, passing makai of Nanawale Estates crossing Hawaiian Paradise Park and tying in with the former railroad alignment which it generally continues to follow to the substation.

TABLE OF CONTENTS

## EXHIBITS

# GLOSSARY

## GLOSSARY

| TERM | DEFINITION |
|---|---|
| A'a (lava flow) | A rough-surfaced lava flow consisting of layers of glass-like fragments of lava. Pahoehoe lava flows often change to a'a as they advance downhill. |
| Alignment | The route of a proposed transmission line. |
| Archaeological site | Locations of prehistoric or historic use or habitation by humans. |
| Areas of least constraint | During the alignment identification process, the objective is to locate potential routes where the least environmental impacts are thought to occur. See Chapter V for the application of this concept. |
| Broadscale analysis | The process of mapping and analyzing available information to identify potential corridors warranting further study. See Chapter IV for the factors and criteria involved. |
| Composite map | This map is a composite of several environmental data factors. The purpose of the composite map is to present an overall view of the constraints and opportunities for the transmission line route. See Chapter V for a description of the final composite maps. |
| Conductor | The wire or cable suitable for carrying electric current. |
| Constraint | A condition which discourages, but not necessarily precludes, a transmission line route. |
| Corridor | A broad, linear area which provides ample space for delineating and studying several alternative alignments for a proposed transmission line. |
| Detailed analysis | During phase 2 of the routing study, following the broadscale analysis, a detailed analysis of the areas of least constraint is conducted. This activity requires the collection of detailed field data based on site surveys by environmental specialists. See Chapter VI for a description of this phase. |
| Distribution Line | A set of conductors which deliver electrical energy from the transmission system to the consumer. |
| Easement | An interest in land that entitles its holder to a specific land use, such as a transmission line. |

| TERM | DEFINITION |
| --- | --- |
| Endemic species | Plants and animals whose natural range is restricted to the Hawaiian Islands and are found nowhere else. |
| Firm power | Power which can be supplied on a 24-hour, 365 day-per-year basis. |
| Geothermal energy | The internal energy of the earth, available as heat from heated rocks or water. |
| Generation capacity | The nominal power output of a production facility, often measured in watts or megawatts. |
| Indigenous species | Species of plants and animals which are native to the Hawaiian Islands, but also with natural occurrences elsewhere. |
| Kilovolt (kV) | One thousand volts; a volt is a unit of electrical potential difference and electromotive force. |
| Load | The amount of electric power delivered or required at any specific point or points on a system. Load originates primarily at the power consuming equipment of the consumers. |
| Main power grid | Hawaii Electric Light Company's main transmission line system connecting generators to loads which provides power throughout the Island of Hawaii. |
| Makai | Hawaiian word for oceanward. |
| Mauka | Hawaiian word for mountainward. |
| Megawatt (MW) | One million watts; a watt is the absolute unit of electrical power equal to the rate of work represented by a current of one ampere under a pressure of one volt. |
| Native species | Plants and animals which are present in an environment and were not introduced to that type of environment by humans. |
| Opportunity | A favorable juncture of conditions for a transmission line route. |
| Pahoehoe (lava flow) | A smooth-surfaced lava flow, often with wrinkles formed by the movement of liquid lava beneath a cooler but still-plastic crust. The liquid lava sometimes leaves subsurface hollow tubes with diameters of up to 50 feet. |
| Peak load | The highest portion of demand, usually that occurring less than 10% of that time. |

| TERM | DEFINITION |
| --- | --- |
| Potential alignment | A potential alignment denotes a possible transmission line route. See Chapter V for discussion. |
| Potential corridors | Potential corridors are derived from the least constraint areas identified in the broad scale analysis. See Chapter IV and V for the identification of the corridors and a discussion of the analytical process. |
| Preferred alignment | A preferred alignment appears to have the least environmental impact, and to be the most desirable based on the study criteria. See Chapter V for discussion. |
| Pu'u | Hawaiian term for a hill, peak, or mound. |
| Rare and endangered species | Rare species or subspecies are animals or plants which are in such limited numbers throughout their range that they may become endangered if their environment worsens. Endangered species are threatened with extinction. Both terms have a legal definition and are used here in that sense. |
| Registered historic site | The legal recognition of an historic property. The National and Hawaii Registers of Historic Places are planning tools used to assess, but not necessarily prevent, the potential impact of a publicly funded, licensed or permitted activity on the cultural resources or heritage of the State. |
| Right-of-Way (ROW) | A legal right of passage over another person's land; the land used by a public utility. |
| Rift zone | A system of fractures and faults in the earth's crust. |
| Seismic | Pertaining to an earthquake or earth vibration, including those that are artificially induced. |
| Study corridors | Corridors selected for study in the detailed analysis phase. See Chapter VI. |
| Substation | A subsidiary station in which electric energy is transformed. It is often combined with a switching station. |
| Switching station | A subsidiary station in which electrical energy is switched from one circuit to another. It is often combined with a station. |
| Transmission line | A set of conductors which transport electrical energy between generators and loads. |

# CHAPTER I

## CHAPTER I: SYSTEM REQUIREMENTS AND STUDY AREA

### A. PROPOSED GEOTHERMAL DEVELOPMENT AND REQUIRED TRANSMISSION SYSTEM

Puna Geothermal Venture, a joint venture between Thermal Power Company and AMFAC Energy, Inc. proposes to develop a 25 MW (megawatt) geothermal-electric power plant at the Pohoiki Geothermal site (also referred to as "Pohoiki") in the Puna District, Island of Hawaii. (Exhibit I-1.) The plant would consist of two 12.5 MW generators. The first generator is scheduled to be completed in 1989 and the second in 1993. Thermal Power Company is preparing an environmental impact statement for the geothermal power plant.

Hawaii Electric Light Company (HELCO) is required to purchase[1] the electric power generated by the geothermal power plant and will distribute it to customers on the Island of Hawaii. To do this, HELCO must construct transmission lines to connect the proposed geothermal-electric generators at Pohoiki to the main power grid near HELCO's Puna substation[2] at Keaau, a straight-line distance of approximately 14 miles. It was determined that the most feasible point for connection of the HELCO grid is near the Puna Substation since this is the closest point on HELCO's 69 kV grid that could accept the 25 MW generation. The new transmission lines will be a part of the main power grid which is the total network of transmission lines connecting generating sources on the Island of Hawaii to the system loads at the various substations. HELCO proposes to construct two separate transmission lines capable of carrying 25 MW at 69 kV *(kilovolts).*

If only a single line were to connect the 25 MW plant to the system, its failure would cause the power plant to be disconnected from the HELCO system. This occurrence would cause a major disruption to HELCO's customers. By installing two lines, HELCO would be able to provide continuous service to its customers and fulfill its obligation to provide and maintain reliable service.[3]

In addition, HELCO engineers have specified that the two 69 kV transmission lines should typically be separated by one-half mile to reduce the probability of losing both transmission lines at one time because of potential hazards such as hurricanes, earthquakes, lava flows and particularly brush fires in Puna District. Less separation may be acceptable where a suitable firebreak exists. For example, Highway 130 is of sufficient paved and cleared width to function as a fire break so that the two transmission lines could be placed on opposite sides of the highway, closer than one-half mile apart.

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1. The federal Public Utilities Regulatory Power Act (PURPA) requires a public utility to purchase electric power from independent producers or developers. Under PURPA, HELCO must buy power if offered for sale by a private producer.

2. HELCO's Puna Substation is located at the site of the former Puna Sugar Mill.

3. Reliable electric service is required by the State of Hawaii Public Utilities Commission standards for electric utility services. Under these standards, HELCO must prevent low voltages from occurring in transmission lines, a condition which may occur when a power source is lost to the main grid. It is desirable to prevent low voltage conditions because they can cause damage and abnormal operation of customer equipment.

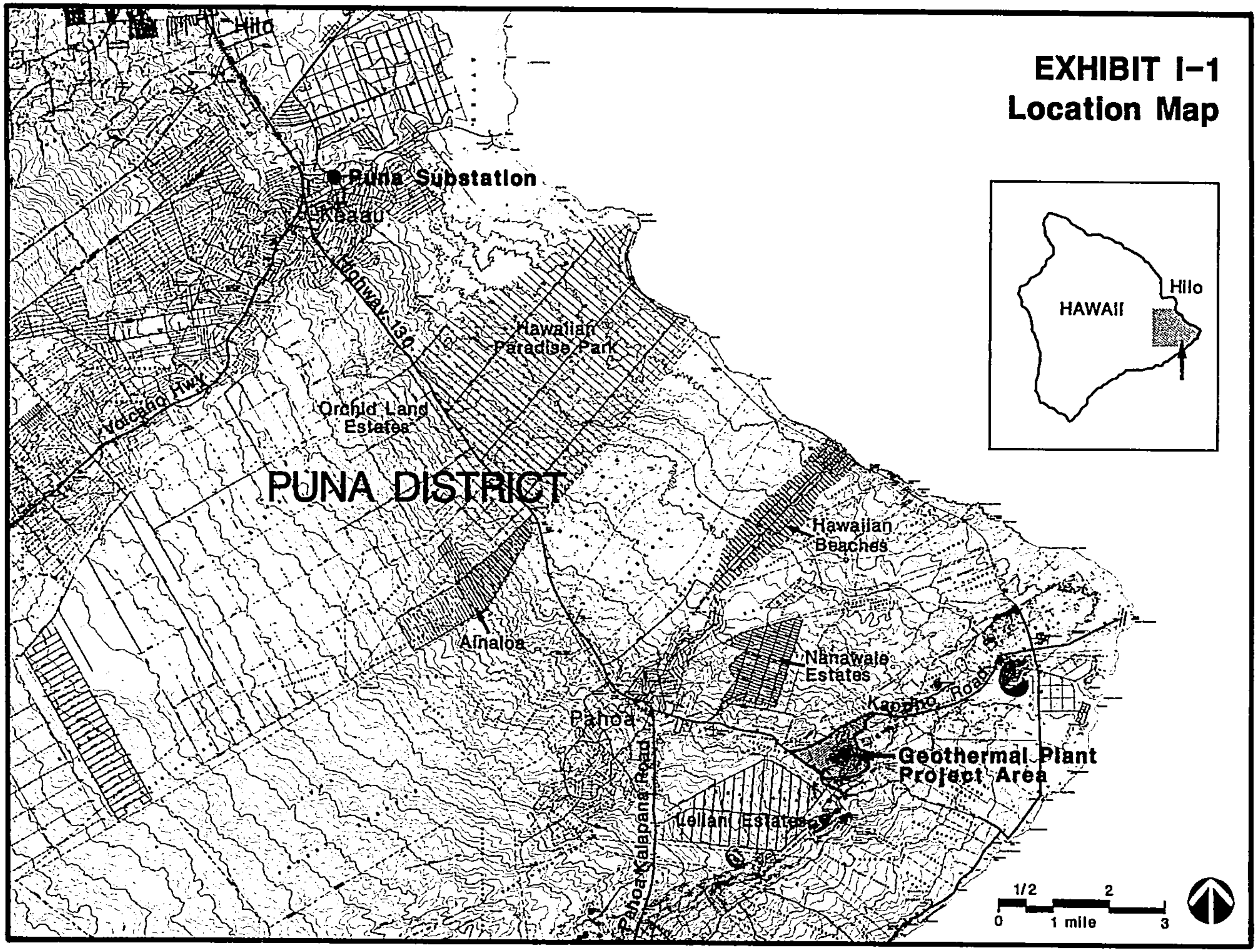



**EXHIBIT I-1**
**Location Map**

**DHM Inc.**

## B. TRANSMISSION LINE FEATURES

Each proposed 69 kV transmission line will consist of three aluminum conductors (0.856 inches in diameter) which will be supported by horizontal post insulators or strings of suspension insulators attached to single wooden poles. The poles will be spaced approximately 300 to 600 feet apart and will carry a steel shield wire (0.375 inch in diameter) at the pole top for protection against lightning. (See Exhibit I-2.) The actual distance between poles will depend upon physical conditions in the vicinity of pole sites and various structural factors, such as tension or weight on the conductors caused by changes in the direction of the alignment or high wind velocities.

The wooden poles will range between 57.5 and 67 feet above ground with 7.5 to 8 feet embedded in the ground. The poles will have diameters of about 1.5 feet at their base, tapering to about 0.75 feet at the top. The wood will be fully treated against termite damage and rot. To provide stability against high winds and changes in direction of the alignment, guy wires and anchors may be installed on some poles.

HELCO requires a typical right-of-way (ROW) between 40 and 50 feet wide for each 69 kV transmission line. This will allow for conductor swing, use of multi-pole structures where necessary and adjustments of pole sites in the field during construction should the pole hole diggers encounter adverse geological conditions (such as lava tubes), archaeological and historic sites, or areas of ecological sensitivity. Additional land segments may be required in some cases to accommodate guy wires and anchors falling outside the typical right-of-way.

## C. DEFINITION OF STUDY AREA

Although the required transmission lines will originate at the switching station near the geothermal plant, the origin of the lines for this study is considered to be the edge of the power plant project area (as shown on Exhibits I-1 and I-3). The reason for this is to avoid duplication between this routing report and Thermal Power Company's EIS which will cover the entire power plant area. The terminal point for the proposed lines is the existing 69 kV line that leaves Puna Substation heading west to Kaumana.

Theoretically, the shortest, most direct route between the proposed geothermal resource at Pohoiki and the Puna Substation is a straight line. However, there are numerous intervening factors which may make the idealized straight-line route for a transmission line impractical or undesirable.

The definition of a study region for the routing analysis balances these competing considerations. On one hand, the study region should be large enough to insure that no feasible alternatives are arbitrarily excluded at the outset. On the other hand, route length is obviously a limiting factor. Longer routes require more time, energy, manpower and materials to construct the transmission line. A longer easement is required. Furthermore, the energy loss would be greater over a longer distance.

To define the study region, a broad oval-shaped area was plotted which permits a variety of routing alternatives, including those which are up to 50 percent longer than the straight-line distance between the two terminal points of the proposed transmission lines. (See Exhibit I-3.) To determine this area, the ends of a string

50% longer than the straight-line distance was fixed at each terminal point. The string was then pulled taut at various points along its length, on either side of the straight-lined route to define an elliptical area around the straight-line.

Note that the ellipse includes areas behind the two terminal points, represented in Exhibit I-3 as the lighter-toned shaded areas. Portions of this lighter shaded area are included in the study region, because it is conceivable that a feasible alternative might double-back somewhat behind the terminal point to avoid major constraining factors or take advantage of certain routing opportunities. The study region window also includes areas which extend well beyond the ellipse.

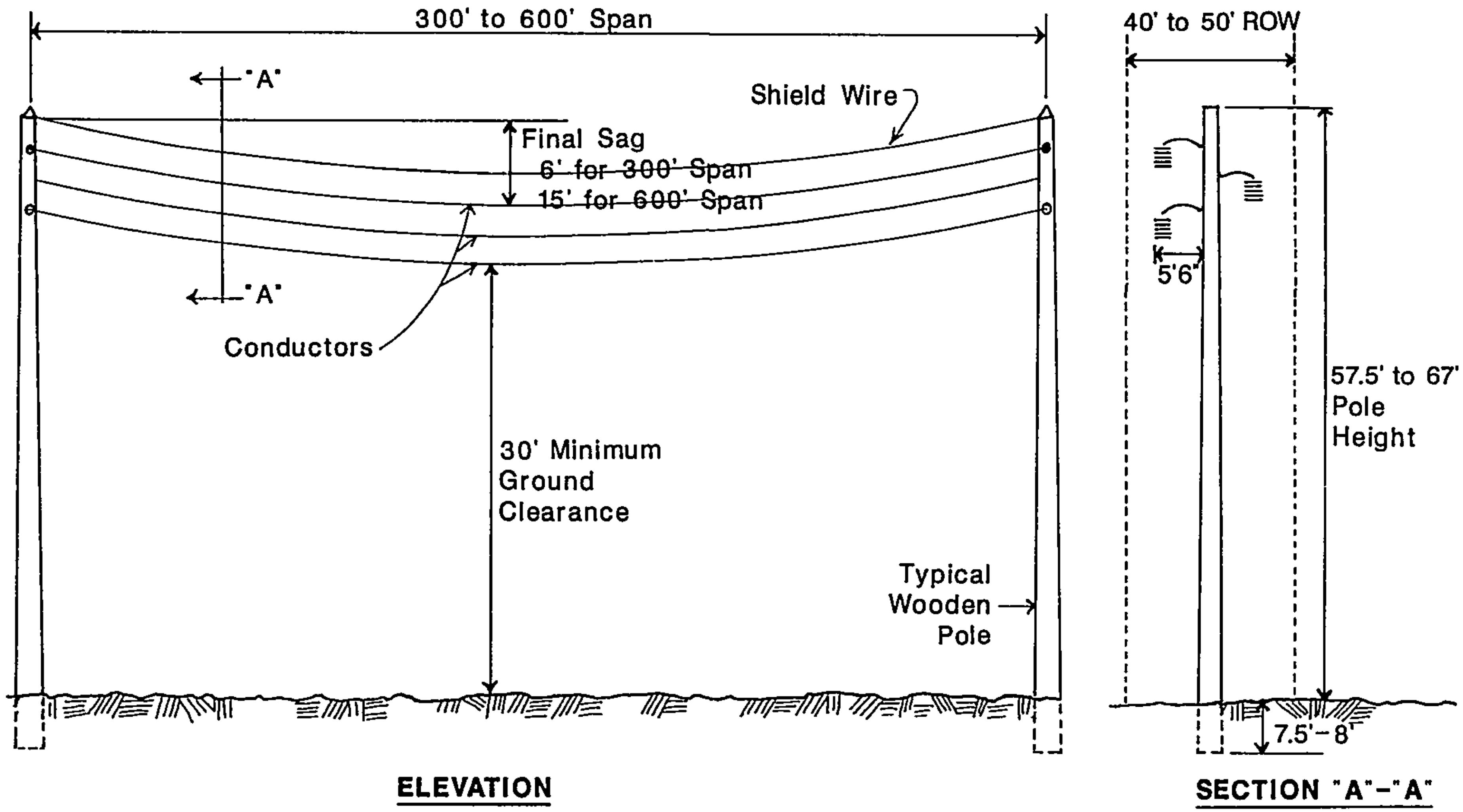



**EXHIBIT I-2 Typical 69kV Line Spacing and Line Sag**

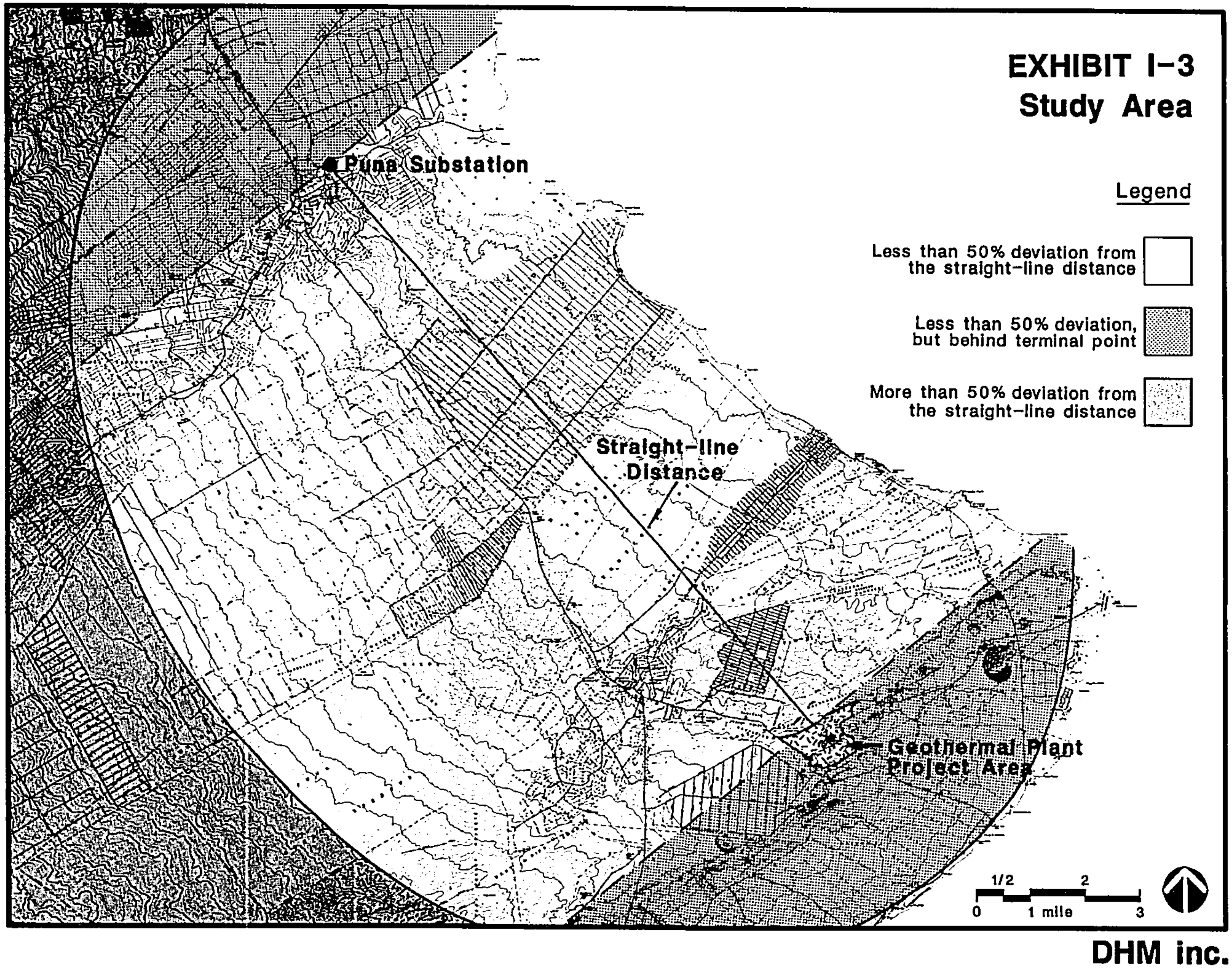


EXHIBIT I-3
Study Area
Legend
Less than 50% deviation from the straight-line distance
Less than 50% deviation, but behind terminal point
More than 50% deviation from the straight-line distance
Puna Substation
Straight-line Distance
Geothermal Plant Project Area
1/2
2
0
1 mile
3
DHM inc.

# CHAPTER II

# CHAPTER II: TRANSMISSION LINE ROUTING METHODOLOGY

## A. OVERVIEW

There is a wide range of geographic alternatives for routing a transmission line between Pohoiki and the Puna Substation, a straight-line distance of approximately 14 miles. HELCO's objective is to select the route which has the least environmental and capital cost, and minimal impact on land use along the route.

The methodology used for the selection of the route is a sequence of steps organized in two phases. Phase 1 narrows down the large number of possibilities by identifying an optimum corridor for further study based upon a broadscale analysis of opportunities and constraints for a transmission line route. The width of the study corridor may vary, depending upon the type and number of constraining factors in any particular vicinity, but will be ample enough to permit several alternative alignments. Phase 2 leads to the selection of a specific route alignment, based upon a detailed analysis of conditions within the study corridor and the development of measures to mitigate the potential adverse effects of the line.

During each phase a comprehensive set of data factors is used to structure the analysis. For Phase 1, Broadscale Analysis, the factors are grouped under five general categories: Exclusion Areas, Geophysical Factors, Biological Factors, Socio-Economic Factors and Cost Factors. The data categories span a wide range of considerations that relate to construction of overhead transmission lines.

Exhibit II-1 outlines the data categories and data factors used in Phase 1. They are defined briefly as follows:

**EXHIBIT II-1**
**PHASE 1**
**BROADSCALE ANALYSIS**
**DATA CATEGORIES AND FACTORS**

| CATEGORY | | FACTOR | |
|---|---|---|---|
| A. | Exclusion Areas | 1. | Protective Subzones |
| B. | Geophysical Factors | 1. | Slope and Soils |
| | | 2. | Geologic Hazards |
| C. | Biological Factors | 1. | Vegetation |
| | | 2. | Wildlife |
| D. | Socio-Economic Factors | 1. | Recreation |
| | | 2. | Land Use |
| | | 3. | Transportation and Utilities |
| | | 4. | Land Ownership |
| | | 5. | History and Archaeology |
| | | 6. | Land Regulation |
| E. | Cost Factors | 1. | Land Value |
| | | 2. | Maintenance |
| | | 3. | Access |

<u>Exclusion areas</u> are those where regulatory controls are so restrictive that they essentially preclude a transmission line route.

<u>Geophysical factors</u> relate to the physical properties and processes of the earth. The specific factors which affect the location of transmission lines are:

- Topographic features, particularly slopes and soils.

- Geologic characteristics, including seismic, volcanic and other types of foundation hazard.

<u>Biological factors</u> include both plant life and animal life. The specific factors are:

- Vegetation zones and their susceptibility to construction activity.

- Wildlife habitats, particularly for species which are susceptible to potential hazards from transmission lines.

<u>Socio-economic factors</u> relate to the human use of land and the effect which a transmission line might have upon the use or value of land. Specific factors are:

- Recreational resources, such as parks, boat launching ramps, hiking and hunting areas.

- Urban and non-urban land uses of various categories.

- The transportation and utilities network.

- Land ownership patterns.

- Historic and archaeological resources.

- Regulatory controls over land use, other than Exclusion Areas, such as special management area, or subzones in State Conservation Land Use District.

<u>Cost factors</u> are those which the utility company, and eventually the utility customers, pay for the acquisition of an easement and the construction and maintenance of a transmission line. These factors are:

- Land value based on assessed valuations.

- Physical conditions which affect the maintenance and operation of the line.

- The relationship between site accessibility and construction and maintenance costs.

The data factors are further defined by criteria which have for the most part been developed in previous scientific and planning studies sponsored by government agencies. The criteria deal with conditions on a general level. They are evaluated in terms of constraints or opportunities for the location of a transmission line and then displayed in map form shown in Chapter IV.

Phase 2, Detailed Analysis, involves a similar analytical framework. However, the analysis is much more detailed, relying on first-hand field observations as well as secondary sources, and covers the corridor areas identified in the Broadscale Analysis which appeared to pose less constraint or provide greater opportunity for transmission lines. Along with a more detailed scale of study, comes a revised description of data categories and factors (Exhibit II-2). These are derived from factors which directly influence the location of a transmission line such as land use, land ownership, land regulation, and visual resources, and from the field survey reports which provided detailed information on insects, birds, vegetation, archaeological sites, geology and soils.

**EXHIBIT II-2**

**PHASE 2**
**DETAILED ANALYSIS**
**DATA CATEGORIES AND FACTORS**

| CATEGORY | FACTOR |
|---|---|
| A. Physical Conditions | 1. Land Use<br>Existing electric distribution and transmission lines<br>Existing telephone lines<br>Productive agriculture lands<br>Archaeological and Historic sites<br>Pahoa Bypass Highway<br>Urban District |
| | 2. Biological<br>Vegetation<br>Insects<br>Birds |
| | 3. Land Ownership<br>Privately owned<br>Publicly owned<br>Hawaiian Home Lands |
| B. Visual Resources | 1. Visual Screens |
| | 2. Views |

B. STEP-BY-STEP PROCEDURE

The following is a description of the sequence of steps leading to route selection. The procedure is illustrated in Exhibit II-3. Detailed descriptions of the data sources and methods used can be found in the texts of Chapters IV through VI.

PHASE 1: BROADSCALE ANALYSIS

Step 1: Review System Requirements and Define Study Area

The system requirements and terminal points for the geothermal transmission line were established by HELCO and are described in Chapter I. Definition of the study area is also discussed in Chapter I.

Step 2: Describe and Analyze Transmission Line Alternatives

There are three transmission line alternatives for the project: overhead lines, underground cables and submarine cables. The design features of the latter two and their limitations and advantages relative to an overhead line are discussed in Chapter III.

Step 3: Define Data Categories and Factors

This step provides a structure for analyzing and evaluating physical, social and economic conditions which create constraints or opportunities for routing an overhead transmission line. The data categories and factors are defined in the preceding pages and a more detailed discussion of them is made in Chapter IV.

Step 4: Develop Evaluation Criteria for Broadscale Analysis

Criteria for evaluating the relative constraints and opportunities for the transmission line route within each data category are described in Chapter IV. These evaluations rely almost entirely on secondary source material, particularly data and planning maps prepared by government agencies.

Step 5: Identify Areas of Less Constraint and Potential Corridors

Broadscale evaluation criteria are displayed through an overlay mapping process which highlights the areas of less constraint or opportunity for a transmission line route. Potential corridors are identified by linking the areas of less constraint to provide a continuous connection between the Pohoiki geothermal site and the vicinity of the Puna Substation. The areas of less constraint are more extensive in some areas than in others, so the corridor width varies accordingly.

Step 6: Evaluate and Select Study Corridors

The potential corridors are rated quantitatively by measuring the type and extent of constraint area crossed by a "test route" through each of the corridor segments. This rating, combined with a narrative description, leads to the selection of the study corridor. Steps 5 and 6 are included in Chapter V.

## PHASE 2: DETAILED ANALYSIS

### Step 7: Map Conditions in Study Corridors

Conditions in the study corridors which will influence the routing of the transmission line are defined and mapped. The types of conditions correspond to the data factors for the broadscale analysis but more detailed criteria and information sources are used for this phase. Secondary sources are used, when available. These are supplemented with visual analyses, aerial photo interpretation, field surveys, and consultation with technical specialists, resource managers and land agents. In addition, the technical and engineering requirements of HELCO are considered at this time. These considerations include maintaining a minimum vertical separation distance on the same pole from a lower voltage line; a minimum horizontal separation distance of one transmission line pole length (approximately 80 feet) from existing telephone lines; a minimum separation distance of three fourths the pole height of a transmission line (approximately 60 feet) from an existing power line unless the power line would be placed on the same poles beneath the transmission line.

### Step 8: Identify Potential Alignments

Based on an analysis of constraints in the mapped data, preliminary potential alignments are delineated. Along some sections of the corridor, particularly where there are trade-offs between the types of constraints which are encountered, more than one potential alignment may be shown. The potential alignments are used as a basis for consulting with various government regulatory agency representatives and landowners who would be affected by the proposed easement.

### Step 9: Determine Preferred Alignment

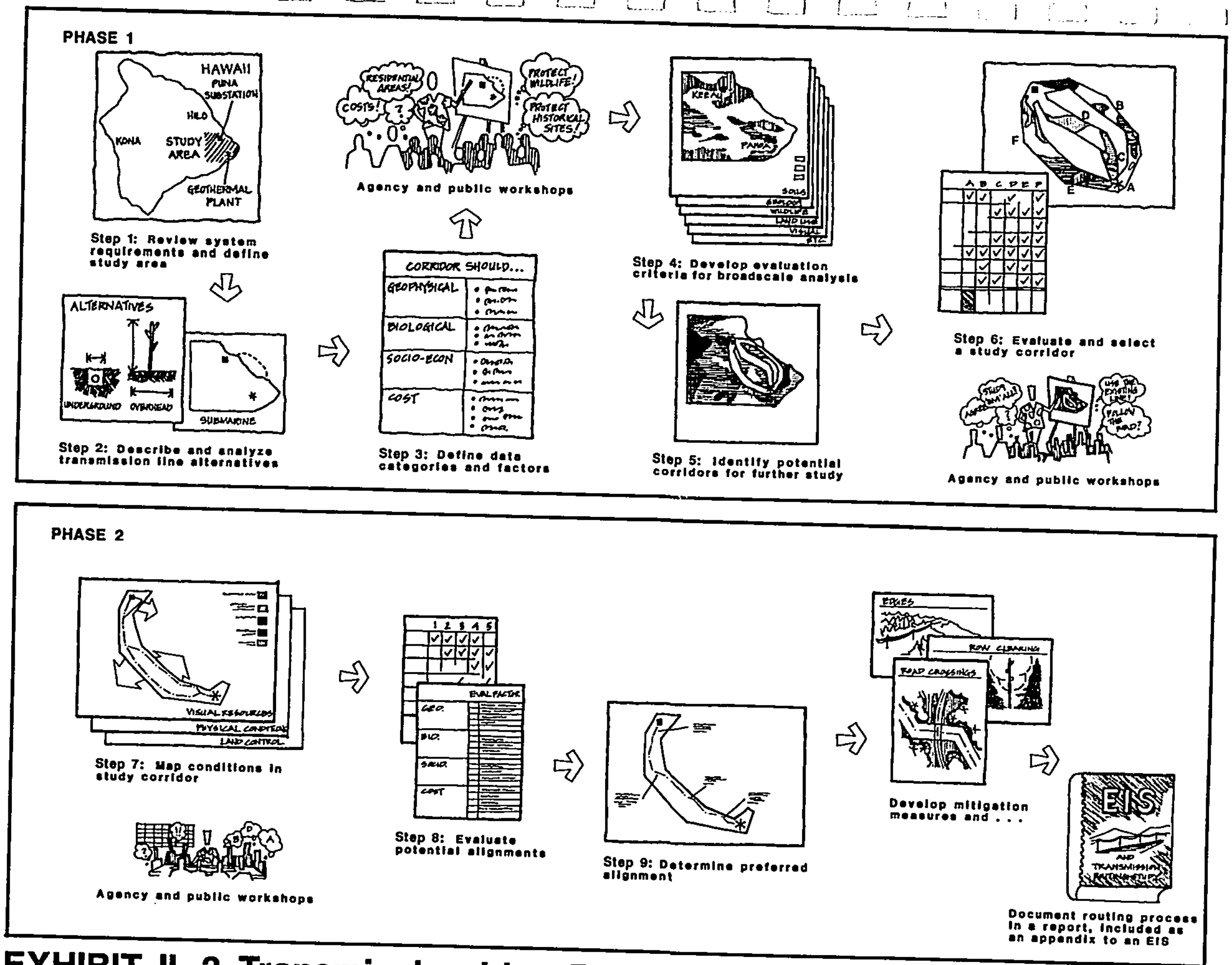
Adjustments to the potential alignments are made as the result of consultations in Step 8. A rationale for the selection of the preferred alignment is then elaborated based on the various selection criteria.

## C. PUBLIC REVIEW

Workshops were held throughout the route selection process with government agencies and residents of the Big Island, particularly the Puna District, to inform them of the progress of this study and actively solicit their opinions and concerns. Three sets of public meetings were held. Each set of meetings consisted of a workshop for government agencies in Honolulu and in Hilo, and a public meeting in the evening at Pahoa. Government agencies were invited through written notices based on the OEQC mailing list. The public was invited through notices in newspapers, and letters sent to the community associations in Puna. These meetings were held in November and December of 1986 and in September of 1987.

In addition, a special meeting was held in April, 1987 at the request of the Hawaiian Paradise Park Community Association for their membership. The meeting addressed residents' concerns about the impacts of the proposed transmission lines if routed through their community. Representatives from HELCO also met with representatives of this group on two earlier occasions.

Summaries of the workshops, and copies of the notices and mailing lists are included in Appendix A.




# EXHIBIT II-3 Transmission Line Routing Study Process

DHM inc.

# CHAPTER III

## CHAPTER III: TRANSMISSION LINE ALTERNATIVES

### A. TYPES OF ALTERNATIVES

Electrical transmission lines can be designed and constructed in three basic configurations: overhead lines, underground cables, and submarine cables. A transmission line project may utilize any one of the three forms, or combinations of any two, or all three forms. The determining factors would be environmental considerations, economics and system reliability. Experience has shown that the most economical method of transmitting bulk electrical power over a long distance is via overhead transmission lines. Underground transmission cables are utilized primarily in densely populated areas and over short distances. Nationwide, there are 323,000 miles of transmission lines and only 3,000 miles of these are underground.[4] Submarine transmission cables are utilized primarily where there is no land connecting the two terminal points, such as between Oahu and the island of Hawaii, or if the submarine route is more viable than the overland route. For the transmission of geothermal power from Pohoiki to the Puna Substation, overhead lines are proposed and have been described in Chapter I. Underground cables and submarine cables are presented as alternatives in this chapter.

There are two basic electrical modes to transmit bulk power: alternating current (ac) and direct current (dc). Electric power is usually generated, transmitted, and distributed entirely using alternating current. However, when transmitting bulk power over long distances on an ac system, the energy losses become considerable and use of a dc system, which has significantly lower energy losses, becomes more attractive. As the ac and dc systems are incompatible and cannot be directly connected together, interfaces must be installed at some point (often at the generating plant) to convert the ac to dc, and at another point (often at the load or at a substation) to invert the dc to ac. These interfaces are expensive. The cost may be justified when the value of electric power transmitted over this type of system does not exceed the value of power generated locally and transmitted via ac circuits. This situation varies with the length of transmission lines and other factors. For example, the proposed Hawaii Deep Water Cable program justifies the use of dc for submarine cable routes when crossing channels between the major Hawaiian Islands because of the great distances involved.[5]

This is not the case for this transmission line routing study because the distance between Pohoiki and Puna via a submarine route is relatively short, about 23 miles, of which only 11 miles would be underwater. Therefore only an ac submarine cable was considered.

The following sections will discuss generic issues related to the underground and submarine cable alternatives as compared to an overhead transmission line, and will consider factors which would influence the routing of an underground or submarine cable.

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4. HELCO, Speech to the Hawaiian Paradise Park Community Association, April 7, 1987.

5. The Hawaii Deep Water Cable (HDWC) Program, which is studying the technical feasibility of electrically linking the islands of Hawaii and Oahu (and possibly Maui and Molokai, as well), is considering a submarine, high voltage, direct current (HVdc) cable system. See various reports on the HDWC Program prepared for the Department of Planning and Economic Development, State of Hawaii.

## B. UNDERGROUND CABLE

### Components

The basic components of an underground transmission system include cables, its encasement, and manholes.

1. Cables and Encasement

   At the present time, the most commonly used underground system for 69 kV circuits in the United States consists of insulated cables installed in buried conduits. The cables have either copper or aluminum conductors and are insulated with a synthetic dielectric material. These are installed in conduits encased in concrete for mechanical protection.

2. Manholes

   Most underground systems require manholes at intervals along the cable routes. These manholes are used for installing, joining, splicing and maintaining the cable system. The maximum spacing between manholes is limited by the amount of tension which can be used to pull the cable into the pipe. In some cases, the maximum length of cable that can be transported to the job site may also have a bearing on the manhole spacing.

There are certain inherent technical disadvantages associated with underground systems. A primary consideration in the design, manufacturing, installation and operation of these systems is the insulation and cooling of conductors. Overhead conductors are cooled and insulated naturally by the air which surrounds them. Underground cables must be insulated artificially to prevent electric charge from escaping into the surrounding environment. The artificial insulating material, however tends to trap heat, thereby reducing power capacity. The resulting heat build-up impairs the electrical insulating properties of the insulating material itself.

### Impacts

The potential impacts relating to the construction, operation and maintenance of an underground cable between the Pohoiki and Puna terminal points have been placed in four categories and are discussed below.

1. Geophysical Impacts

   In general, the construction of an underground transmission system would have more extensive impacts on topography and soils than an overhead system because greater alteration to surface and subsurface conditions is involved. The construction of the underground system requires excavation and backfill along the entire length of the cable, whereas the overhead line requires only the installation of poles spaced several hundred feet apart and the area between poles remains relatively undisturbed.

   Changes in physical characteristics of the soils affected by an underground line include compaction of surface soils from movement of equipment and personnel, changes in grain size and chemical make-up from accelerated soil weathering caused by earthwork and excavation and soil warming from cable operations, and visible changes in soil color and texture at the ground surface, especially in off-road barren areas.

A related impact is the rate of soil erosion, which would be increased due to greater rainfall runoff over the compacted soils. Also, after vegetation clearing during construction, a different type of vegetation, often less effective at retaining soil, may take root within the easement boundaries. Surface water runoff could be altered in a number of ways as well, including

changes in runoff rates due to changes in soil characteristics and vegetative cover, and changes in surface runoff patterns due to surface grading and excavation.

Alterations to land forms from construction of the underground line may occur by grading within the easement, particularly on hillsides in steep terrain, grading for access roads, and excavating and filling trenches.

2. Biological Impacts

The construction of underground transmission lines tends to affect a variety of vegetation types over the entire length of the corridor. The degree of disturbance may vary. For example, in open grasslands, vegetation would recover rapidly. In mature forests, recovery would be much slower and the likelihood of exotic species reforestation would be high. In the case of overhead lines where routes through tall trees have been avoided, the impacts may not be significant because such an installation, which is greater in height than the surrounding vegetation, does not require cutbacks during construction.

During operation, maintenance of the underground line would tend to take place at manholes. The majority of the surface above an underground line, after the initial recovering by vegetation, would tend to remain undisturbed by maintenance activities. These effects may not be significantly different from those of an overhead line constructed through low forest or ground cover where maintenance pruning would not be required because the line would be above the vegetation.

Wildlife is affected by underground transmission lines primarily because of the changes caused to vegetative habitats. For example, removing vegetation affects wildlife by changing the cover and food supply. These impacts would be felt particularly among Hawaii's native birds. Direct impacts could occur to microorganisms or insect communities which are found at or near the surface.

3. Socio-Economic Impacts

In many respects, the generic socio-economic impacts of an underground cable and an overhead transmission line are similar. Considerations such as land use and land regulation, transportation and utility easements, land ownership and recreation areas are dependent upon the route rather than the type of system which is selected.

In areas where the transmission corridor is exposed to public view, the underground cable would be perceived as having less adverse impact on visual quality than an overhead line would. However, the extent of the overhead line's impact varies according to the closeness of view range, the character of the visual background, the configuration of the overhead line and its supporting structures and the subjective preferences of the viewer.

Overhead transmission line routes through densely developed urban settings have a great deal of potential view exposure. This consideration, in combination with other socio-economic factors, such as high land values, fragmented ownership patterns, restrictive land regulation and potential interference with a wide variety of human activities, sometimes makes undergrounding the transmission cable beneath public streets, along with other utility lines, an attractive option.

However, if an underground line is not placed within an existing right-of-way, the limited use of the land above the line is a disadvantage. For instance, a wall cannot be built over an underground line; crops, trees, bushes cannot be planted over an underground line. Also, construction and maintenance is more time consuming, thus more inconvenient to the public.

The potential impacts of an underground system on historic and archaeological sites are relatively greater than those of an overhead line due to the greater degree of disturbance to surface and subsurface areas. More extensive surveys of an underground route would be necessary to determine the location of archaeological remains.

4. Cost Impacts

Costs specific to the underground system, including the cable material, conduits, installation (trenching, backfill, manholes, joint bays) and operation (energy losses), are very high compared to the capital costs of an overhead line. An underground system between Pohoiki and Puna Substation is estimated to cost $18.6 million or nearly 5 times the estimated $3.8 million cost of the proposed overhead line[6].

Normal operation and maintenance costs are higher for an underground line. Annually, HELCO estimates that an underground line for this project would cost more than the maintenance and repair costs of an overhead line. Also, when something does go wrong with the underground cable, it is more expensive and time-consuming to repair than an overhead line because of the difficulty in locating the cause of cable failure and getting access for repair crews and equipment. The cost of service restorations are three times greater than an overhead line.[7]

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6. HELCO, Speech to the Hawaiian Paradise Park Community Association, April 7, 1987.

7. Ibid.

## C. SUBMARINE CABLE

### Components

The components of a submarine cable system[8] are as follows:

1. Cable

Submarine cables consist basically of a central conductor surrounded by insulating material, enclosed in hard armoring. There are four types of submarine cables depending upon the type of insulation: self contained oil-filled, pipe, solid paper and solid dielectric. The self contained oil-filled cable has a history of good performance in the transmission of both 138 kV and 69 kV power, and would most likely be the type of cable used for this kind of project. The pressurized oil, or dielectric fluid, is very light, similar to mineral oil.

2. Terminal Stations

In addition to the cable itself, a submarine cable system requires terminal stations where the cable is brought above ground and connected to overhead equipment or lines. These would be located close to the shoreline. For public safety, system security, and reliability, the cable is usually buried in a trench for approximately 100 feet from the terminal station.

There are 26 submarine high-voltage electric transmission cables in operation throughout the world. The first submarine cable was installed in 1942. Submarine cables share with underground systems the technical disadvantages of insulation and cooling. In addition, there are other difficulties posed by the marine environment. These include extremely high pressures on the exterior surface of the cable when submerged at depths, the corrosive nature of seawater, and problems with currents and rough ocean bottoms which constitute an abrasive climate to the exterior skin of the cable.

The potential marine route for this project runs parallel to the shoreline between Cape Kumukahi and Kaloli Point. (See Exhibit III-1.) The distance of the route from the shoreline would depend largely upon benthic characteristics. Since the ocean bottom drops sharply from this coastline and the laying of submarine cable in deep waters presents added complications, it is likely that the route would be within a few hundred feet of the shore.

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8. Discussion of cable components and history of usage is based on H. H. Hwang and Bryan Young, A Study of the Feasibility of Linking the Islands of Maui, Molokai, and Lanai with Submarine Electrical Power Cables (Honolulu: University of Hawaii, Hawaii Natural Energy Institute, January 1979); and G. Krasnick and G. A. Chapman, for Hawaiian Electric Company, Inc., and the State of Hawaii Department of Planning and Economic Development, Hawaii Deep Water Cable Program, Phase II-A, Task I: Environmental Analyses) (Honolulu: Parsons Hawaii) March 1984.

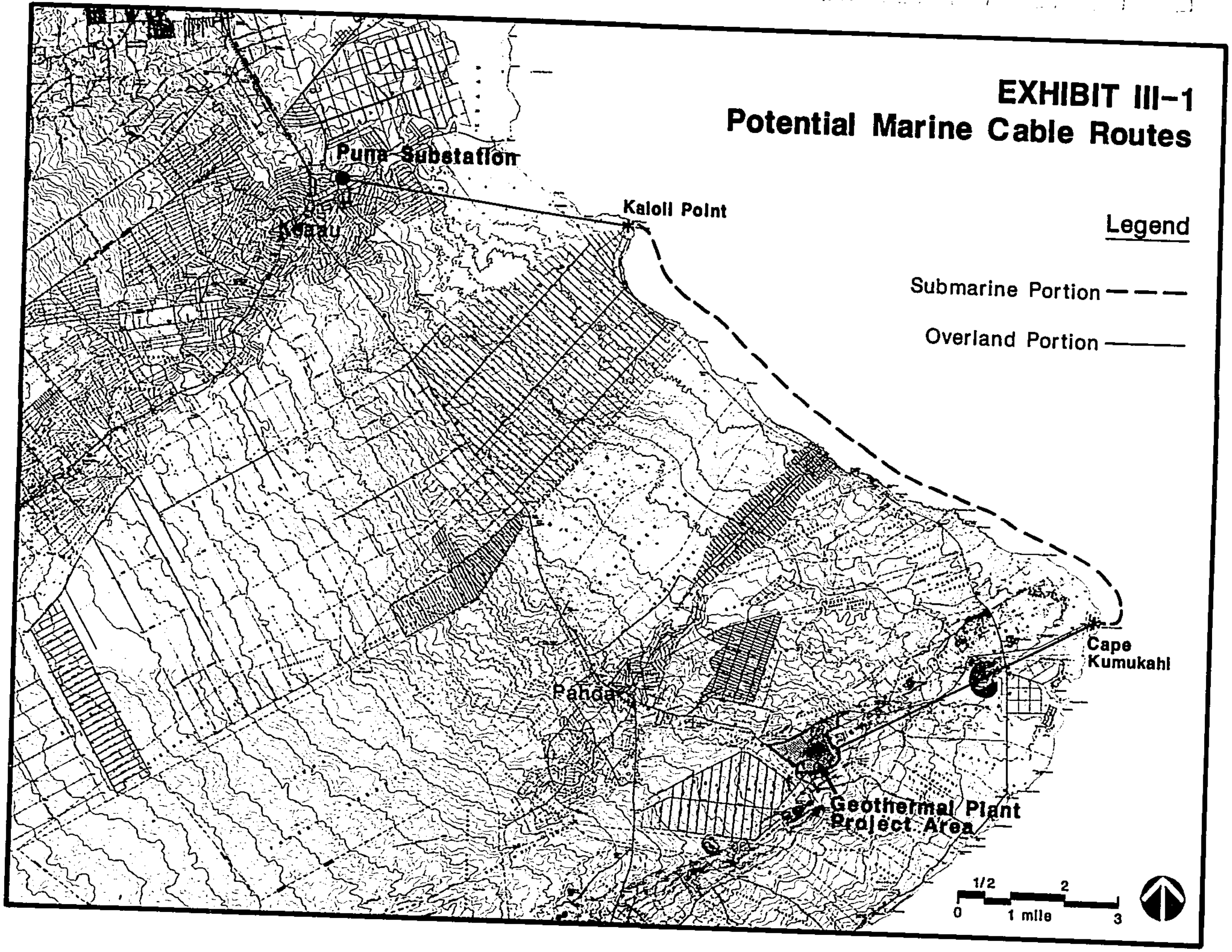
EXHIBIT III-1
Potential Marine Cable Routes
Legend
Submarine Portion
Overland Portion
Puna Substation
Keaau
Kaloli Point
Pahoa
Cape Kumukahi
Geothermal Plant Project Area
0
1/2
1 mile
2
3

DHM inc.

The main impacts related to submarine cables are described below:

1. Geophysical Impacts

This stretch of coast is a series of low bluffs meeting the ocean with abrupt descents of 10 to 40 feet[9]. Much of the shoreline and sea bed consists of irregular, rocky surfaces due to prehistoric and historic lava flows[10]

The typical ocean current flows northwest and generally parallels the coast from Cape Kumukahi to Kaloli Point. Because of the exposure to North Pacific storm swells, surge action is also possible. This action could potentially cause chafing of the cable along the ocean bottom. Since the surface of the ocean flow is rough in this vicinity, additional armoring of the cable may be necessary to prevent wear. The shoreline terminals for the cable would have to be suitably protected against potential inundation and damage from a tsunami triggered elsewhere in the Pacific ring.

Damage from earthquake and volcanic activity is another potential hazard in this area. The study region, including off-shore areas, has one of the highest incidences of historic seismic and volcanic activity in Hawaii. Seismic events could produce underwater landslides which could bury or undermine the cable. The shoreside terminal or portions of the cable could also be damaged or buried by a lava flow. Several lava flows have extended seaward along this coast in historic times.

2. Biological Impacts

According to Chapman and Krasnick, the cable route would not cross any particularly viable coral communities. Therefore, the marine biological impacts would be localized, temporal and generally not significant[11].

Energy loss through the cable will be dissipated as heat and conducted to surrounding marine waters. This discharged heat poses a potential impact to benthic organisms in the immediate area of the cable. The temperature elevation would be confined primarily to the substrate because of the diluting effect and current flow of the surrounding waters.

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9. U. S. Department of Commerce, National Ocean and Atmospheric Admin., United States Coast Pilot, Pacific Coast: California, Oregon, Washington and Hawaii, Sixteenth Edition (Washington D.C.: U.S. Government Printing Office) June 1980.

10. Discussion of geophysical conditions is drawn largely from Ralph Moberly Jr., et. al., Hawaii's Shoreline, Appendix I: Coastal Geology of Hawaii, (Honolulu: University of Hawaii, Hawaii Institute of Geophysics) November 1963..

11. Discussion of biological factors is based primarily on G. Krasnick and G. A. Chapman, op. cit. The substantial shield and armoring (see description in Chapter I) of the cable will prevent potential electromagnetic field effects on marine animals).

Trenching of the nearshore areas will probably require blasting because of the hard substrate, resulting in a temporary shock wave impact to biota in the vicinity. However, endangered marine species such as the humpback whale and green sea turtle are not known to frequent the area of the route[12]. In any event, it is possible to conduct blasting at a safe range and avoid potential harm to these species.

A break of the cable could result in the discharge of insulating dielectric oil into marine waters. It may be necessary, depending upon the repair strategy, to continue to pump oil through the cable to prevent the inflow of sea water. By the time the cable break is located and repaired, a considerable volume of oil could have been discharged into the ocean. However, the dielectric oil is of very low viscosity, solubility and toxicity. The oil would rise to the ocean surface and evaporate rapidly. There are no heavy hydrocarbons or polychlorinated biphenols (PCB) in the oil to cause ecological damage. Biodegradation would occur within thirty days[13].

3. Socio-Economic Impacts

Depending on the depth of the cable and its placement along the ocean bottom, commercial and sport fishing activities may constrain a submarine cable alternative. Eighty-one percent of reported damage to existing submarine cables during a six year period (1975 to 1981) was attributed to external damage[14]. Of this percentage, 45 percent of the damage was caused by fishing and trawling gear, and 22 percent was caused by anchors. Trawling is not a factor along this route, however, because of the rough ocean bottom. The potential for damage from other fishing activities also appears to be remote, based on experience with other undersea cables in the Hawaiian islands[15].

4. Cost Impacts

A major cost consideration is related to route length. A submarine corridor would be an indirect and lengthy route between the geothermal well site and the Puna substation. Installation proceeds much more quickly than with an overhead line because the cable is laid directly on the ocean bottom by a cable-laying barge. However, this savings in labor costs is more than off-set by the expense of the cable material and use of a cable-laying barge. The cost of installing a submarine cable for about 11 miles, including the

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12. S. F. Payne and E. O. Hartwig. "The Ecology of Hawaiian Marine Animals Emphasizing the Impact of Ocean Thermal Energy Converstion (OTEC) on Endangered Species" Lawrence Berkeley Laboratory, Marine Sciences Group MSG-82-017, LBL-13192. 1982.

13. G. Krasnick and G. A. Chapman, op. cit.

14. Sumitomo Electric Technical Review, Number 21, January 1982, "Studies on Submarine Cables with High Resistance to External Damage", Mitsuru Takada, Kusuo Sanjo and Minoru Kameda.

15. Letter from Mr. Henry M. Sakuda, Division of Aquatic Resources, State of Hawaii Department of Land and Natural Resources, to Mr. George Krasnick, Parsons Hawaii, dated November 1, 1983.

terminal stations, is approximately $80.5 million.[16] In addition, there still remains the cost of the overland portion of the marine route which is approximately 12 miles or three-fourths of the proposed overland route. The total cost of the submarine route would exceed $83.5 million. The cost of regular maintenance of a submarine cable is minimal. Emergency repair to the cable, however, represents a significant cost. Adverse weather and sea conditions can seriously impede access to the cable. In 1977, for example, a crew from the Long Island Lighting Company had to abandon its repair barges due to a storm.

5. Other Considerations

Installation of a submarine cable would come under the review of both Federal and State agencies. The U. S. Army Corps of Engineers would base its review of an application to do work in navigable waters on an evaluation of the probable impact of a submarine cable on the public interest, which the Corps defines with a wide range of physical, environmental and socio-economic criteria.

The State government's review of a submarine cable proposal would be coordinated by the Department of Land and Natural Resources (DLNR), which administers the State Conservation District. The entire submarine route is in the Resource (R) subzone of this District, so the cable would require a permit from DLNR's Board. The R subzone is less restrictive than two of the three other Conservation District subzones[17]. Nevertheless it would be necessary to demonstrate that the cable would not adversely affect the "sustained use of the natural resources" of the subzone. Given the uncertainties about the long-term impacts of these cables, this would not be easy to show conclusively.

The submarine route would still require a significant length overland between the geothermal well site to the seashore and from the shore to the Puna Substation. The constraints for these land portions are analyzed in Chapter IV.

D. SUMMARY AND CONCLUSIONS

Environmentally, the impacts of the submarine cable or underground line are, in many respects, as great or greater than those of an overhead line. Although all three alternatives have their own unique set of impacts, none is significantly more adverse than the others.

An overhead line is unique because of its exposure to the public and its potential for contact with plants and animals. In Puna, it may be possible (because of the nature of the relatively flat topography, the significant roadside vegetation and the general lack of extensive view planes) to screen the proposed transmission lines from frequent public view. Careful routing and various design, construction and operations measures, can avoid or minimize adverse impacts on physical and visual resources.

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16. HECO, Letter of May 18, 1987 to DHM inc.

17. The Protective (P) and Limited (L) subzones are more restrictive than the R subzone as to use. The fourth subzone, the least restrictive, is the General (G) subzone.

The cost per mile and the total cost for construction of a submarine cable or an underground transmission line would be substantially higher than for an overhead line. The submarine route, including the overland portions, would be over 23 miles long or about 6-9 miles longer than a reasonably direct overland route. The high cost of these two alternatives makes them relatively infeasible when compared to an overland line.

Chapter IV, which follows, describes criteria for routing an overhead transmission line in a way which responds to sensitive environmental factors.

# CHAPTER IV

# CHAPTER IV: BROADSCALE ANALYSIS

## A. INTRODUCTION

As described earlier, an initial step in the overhead line route selection process is the identification and definition of criteria for broadscale analysis. These criteria consist of data factors that have a bearing on the location of a transmission line. The evaluation of criteria relies essentially upon information which is already available in mapped form without having to do field surveys. This forms a sufficient data base for the broadscale analytical objectives of Phase 1.

The data factors for the routing evaluation are organized under five broad data categories - "Exclusion Area", "Geophysical", "Biological", "Socio-economic" and "Cost". A narrative for each data category describes the issues considered in the routing of an overhead transmission line in the study region. Data factors are described and quantified to provide a basis for comparison.

Under each data factor, with the exception of "Exclusion Areas", the conditions are evaluated in terms of degrees of constraint for the location of transmission lines. These constraints ranged in three degrees from "high" to "low" for each factor, with a description of the criteria used to rate the conditions. A constraint map accompanies the analysis of each data factor. The lower the constraints in a given area, the greater the opportunity for placing a transmission line corridor there.

Each data factor is evaluated separately and equally with no weighting given to any factor. No single factor is a determinant of the route. The routing opportunities are identified through a composite view of the data factors provided by an overlay mapping process.

## B. EXCLUSION AREAS

Regulatory restrictions on land use are generally considered potential constraints in the evaluation of physical and socio-economic data factors. In their most restrictive form, regulatory measures may preclude rather than constrain the location of transmission lines. Consequently, such areas are excluded at the outset from the analysis of potential routes. The exclusion areas are as follows:

1. Protective Subzone - The Board of Land and Natural Resources has established boundaries and regulations for four major subzones of the State Conservation District. The most restrictive of these subzones is the Protective Subzone, which includes "restricted watersheds, fish, plant and wildlife sanctuaries, significant historic, archaeological, geological and volcanological features and sites, and other designated unique areas[18].

## C. GEOPHYSICAL FACTORS

The geophysical factors considered in the study region are slope and soils, and geologic hazards, particularly seismic and volcanic activity. These factors influence the stability of the transmission poles which support the line, and therefore the reliability of power.

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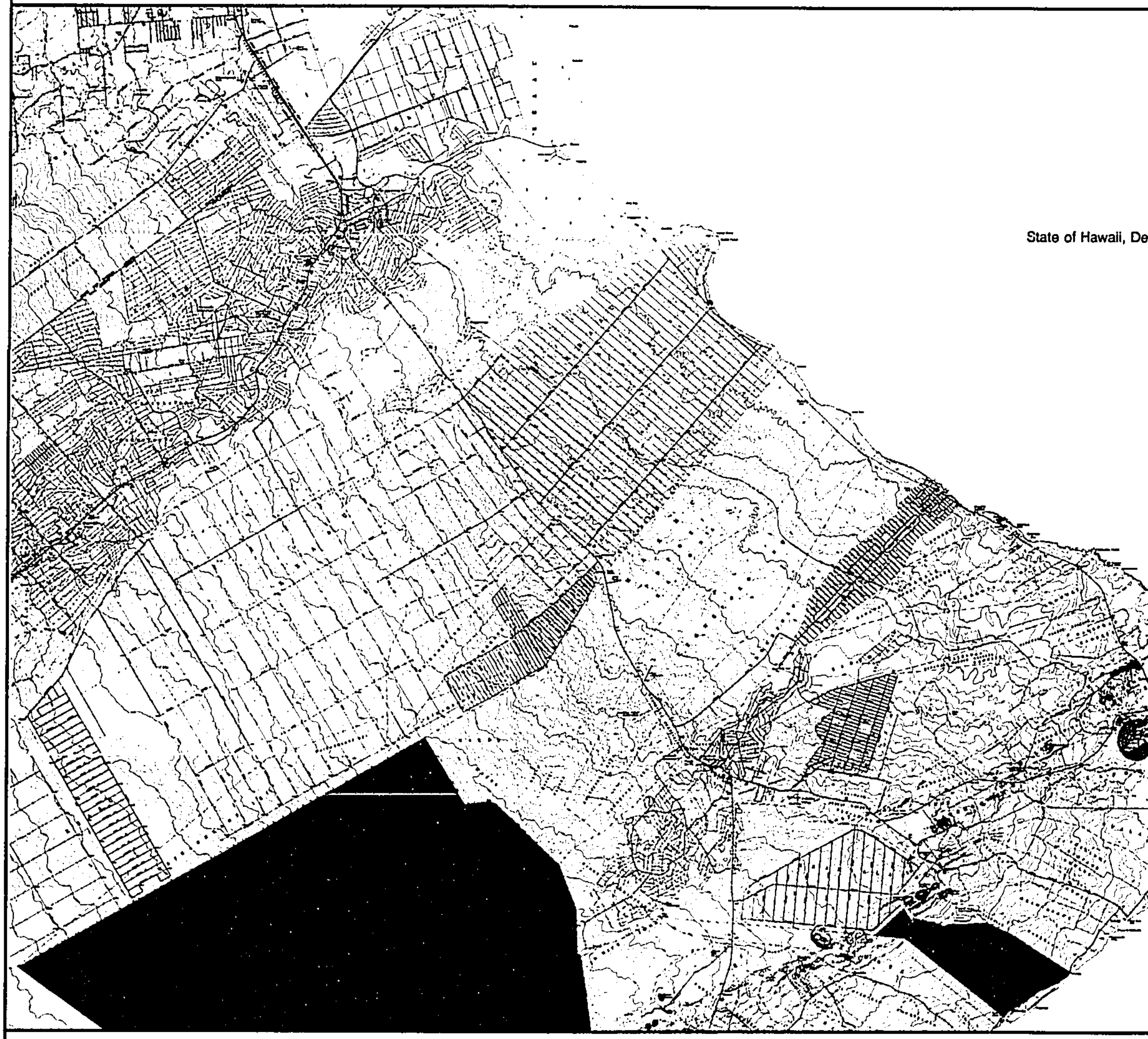
18. State of Hawaii, Board of Land and Natural Resources, Regulation No. 4, pursuant to Chapter 183-41, Hawaii Revised Statutes, Honolulu, Hawaii, May, 1978.



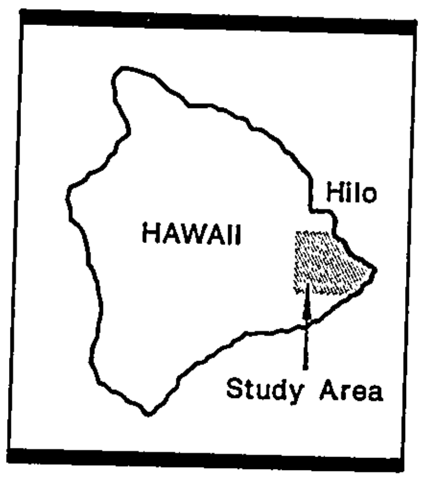

POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTI

# EXHIBIT IV-1
# EXCLUSION AREAS

Exclusion Areas

Source

State of Hawaii, Department of Land and Natural Resources, Conservation District Subzones.




0 1/2 1 mile 2 3

ON LINE ROUTING STUDY • DHM inc.

Hydrologic characteristics are not a significant factor in the study region because there are no major streams or inland water bodies. While average annual rainfall ranges from 75 to 200 inches, almost all of the study region has a wet climate with the seasonal variations causing distinctive dry periods.

1. Slope and Soils

Slope and soil characteristics, particularly erosion hazard potentials, are two related factors which should be considered when locating a transmission corridor.

Slope affects the length of transmission lines, location of the line, positions of utility poles and substation, length of access roads, construction methods required for access roads, the amount of earth movement for road and utility pole construction, and vegetation removal. Gentler slopes are more suitable then steeper slopes for pole construction and access road location because road and line distances are shorter and necessary earth movement and vegetation removal are minimal. A common threshold used to distinguish "steep" from "gentle" slopes for land use suitability analysis is 20 percent[19]. This is a standard which is appropriate for identifying "high" constraint areas for transmission corridors. Slopes between 10 to 20 percent are a "medium" constraint.

Soils conditions combine with slopes to define topographic constraints. The clearing of vegetation and placement of structures is less desirable in an area whose soils are subject to considerable wind and water erosion than in areas where this hazard is not as significant. While the utility poles would not occupy a large area, the stability of these structures may be lessened by erosion. In addition, the presence of man-made structures, including access roads, tends to aggravate natural erosion hazards. Thus, soils with severe erosion hazard potential should be avoided, if possible. The U. S. Soil Conservation Service has rated the erosion hazard potential as "severe", "moderate" or "slight" for each of the soil classifications which they have identified and described for the study region[20]. These ratings correspond to "high", "medium" and "low" constraints respectively.

Many areas of the project region are covered by relatively recent lava flows that have not yet deteriorated sufficiently to produce true soil layer. Hawaii's volcanoes produced two types of lava: pahoehoe and a'a[21]. Pahoehoe flows pose a relatively greater constraint because the smooth, hard face of these flows is often underlain by cavities known as "lava tubes". On the other hand, a'a, which is basically the same composition as pahoehoe,

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19. EDAW inc., State of Hawaii Use Districts and Regulations Review, Honolulu, Hawaii, 1969. Plate 10, page 44, Potential Hazard Areas.

20. U. S. Department of Agriculture, Soil Conservation Service, Soil Survey of the Island of Hawaii, State of Hawaii, (Washington, D. C.: U. S. Government Printing Office) 1973.

21. Ibid.

flows to form a "...massive, relatively dense interior...[22]. Pahoehoe flows are therefore considered a "medium" constraint because it can be difficult to locate a suitable suite for transmission pole placement in this material.

## SLOPE AND SOILS

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Soil erosion hazard potential rated "severe"; slope greater than 20 percent. |
| Medium | Soil erosion hazard potential rated "moderate"; pahoehoe lava flows; slope between 10 and 20 percent. |
| Low | Soil erosion hazard potential rated "slight". |

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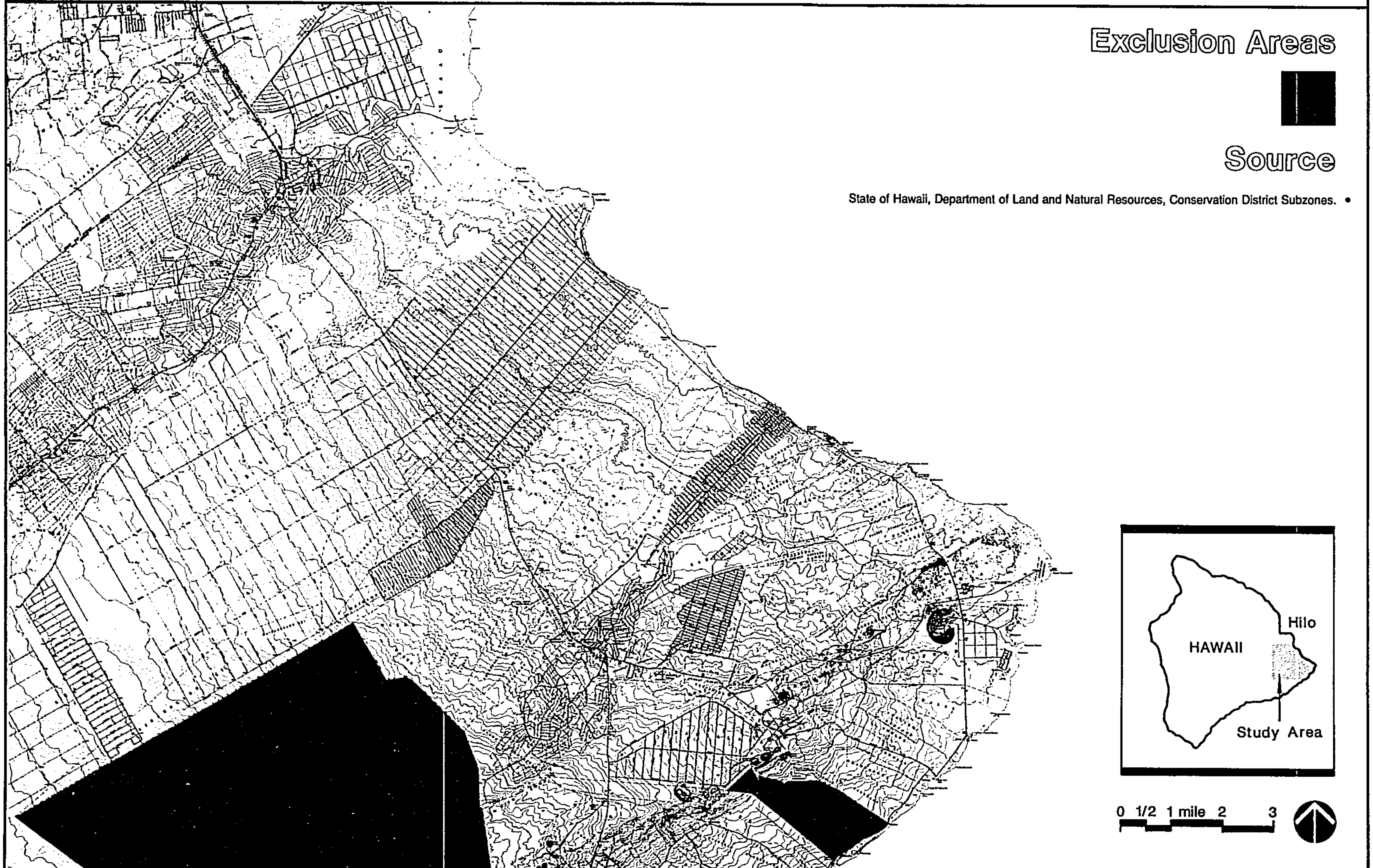
22. Macdonald, Gordon A. and Agatin T. Abbott, Volcanoes in the Sea: The Geology of Hawaii, University of Hawaii Press, Honolulu, p. 26, 1970.

# CORRECTION

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

# EXHIBIT IV–1

## EXCLUSION AREAS




POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.

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19. EDAW inc., State of Hawaii Use Districts and Regulations Review, Honolulu, Hawaii, 1969. Plate 10, page 44, Potential Hazard Areas.

20. U. S. Department of Agriculture, Soil Conservation Service, Soil Survey of the Island of Hawaii, State of Hawaii, (Washington, D. C.: U. S. Government Printing Office) 1973.

21. Ibid.

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## SLOPE AND SOILS

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Soil erosion hazard potential rated "severe"; slope greater than 20 percent. |
| Medium | Soil erosion hazard potential rated "moderate"; pahoehoe lava flows; slope between 10 and 20 percent. |
| Low | Soil erosion hazard potential rated "slight". |

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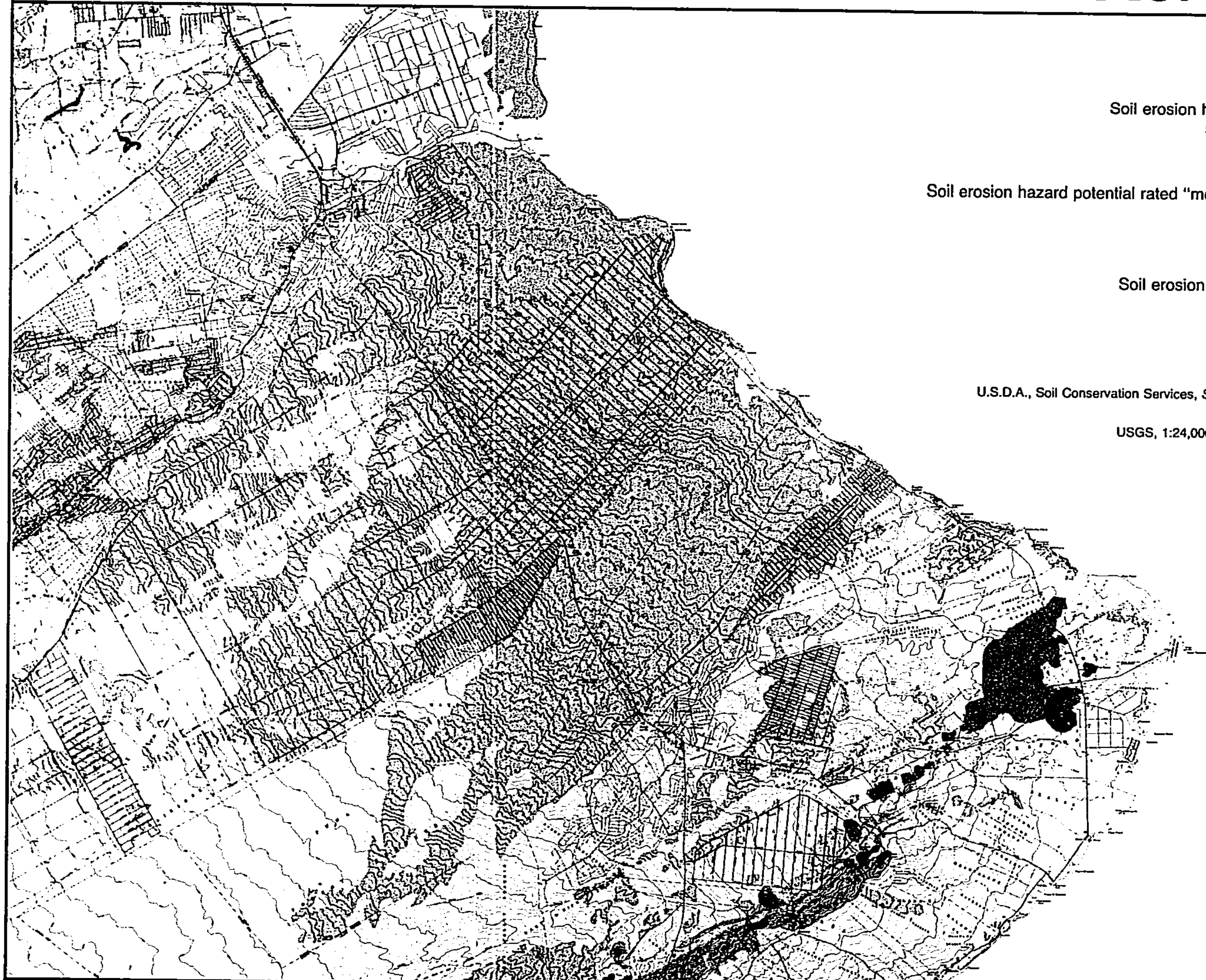
22. Macdonald, Gordon A. and Agatin T. Abbott, Volcanoes in the Sea: The Geology of Hawaii, University of Hawaii Press, Honolulu, p. 26, 1970.

# EXHIBIT IV–2

## SLOPE AND SOILS



### Constraints

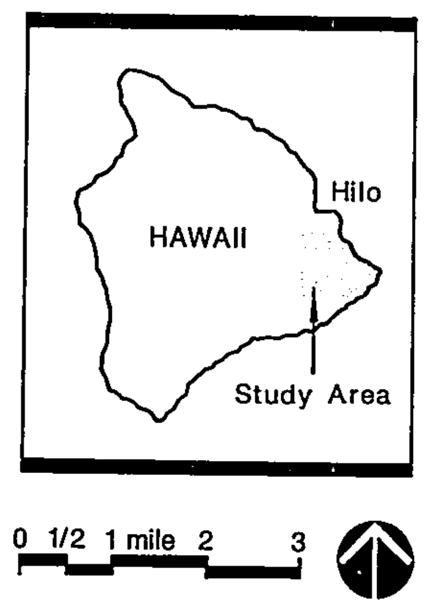
H — Soil erosion hazard potential rated "severe"; slopes greater than 20 percent.

M — Soil erosion hazard potential rated "moderate"; Pahoehoe lava flows; slope between 10% and 20%.

L — Soil erosion hazard potential rated "slight."

### Source

- U.S.D.A., Soil Conservation Services, *Soil Survey of the Island of Hawaii, State of Hawaii,* Washington, D.C., 1973.
- USGS, 1:24,000 scale Topographic Quadrangle Maps, 1980-1983.
- DHM inc.



2. Geologic Hazards

The Island of Hawaii is geologically the most active in the Hawaiian archipelago. Many volcanic eruptions and earthquakes on this island have been recorded in historic times. Several faults and rift zones are present, as well as potential lava flows, tubes and vents from volcanic activity. These hazards pose a physical constraint for the location of transmission lines. While the entire project region is a potential hazard area in this respect, there are various degrees of risk according to location. Historical records of lava flows and seismic events provide some indication of the relative risk in various geographic areas of the island[23]. The southern portion of the project area, in particular, is subject to the influence of the Kilauea volcano and rift zone. Part of the west central section of the project region, in the vicinity of Mountain View, is within the recently mapped Mauna Loa Rift Zone[24].

The risk of seismic and volcanic hazard has been rated as "high", "medium" and "low", based on data regarding lava flows and rift zones. The characteristics of these constraint areas are as follows:

GEOLOGIC HAZARDS

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Rift zones; areas covered by lava flows since 1778. |
| Medium | Other areas which have been covered by lava flows within the past 5000 years. |
| Low | All remaining areas. |

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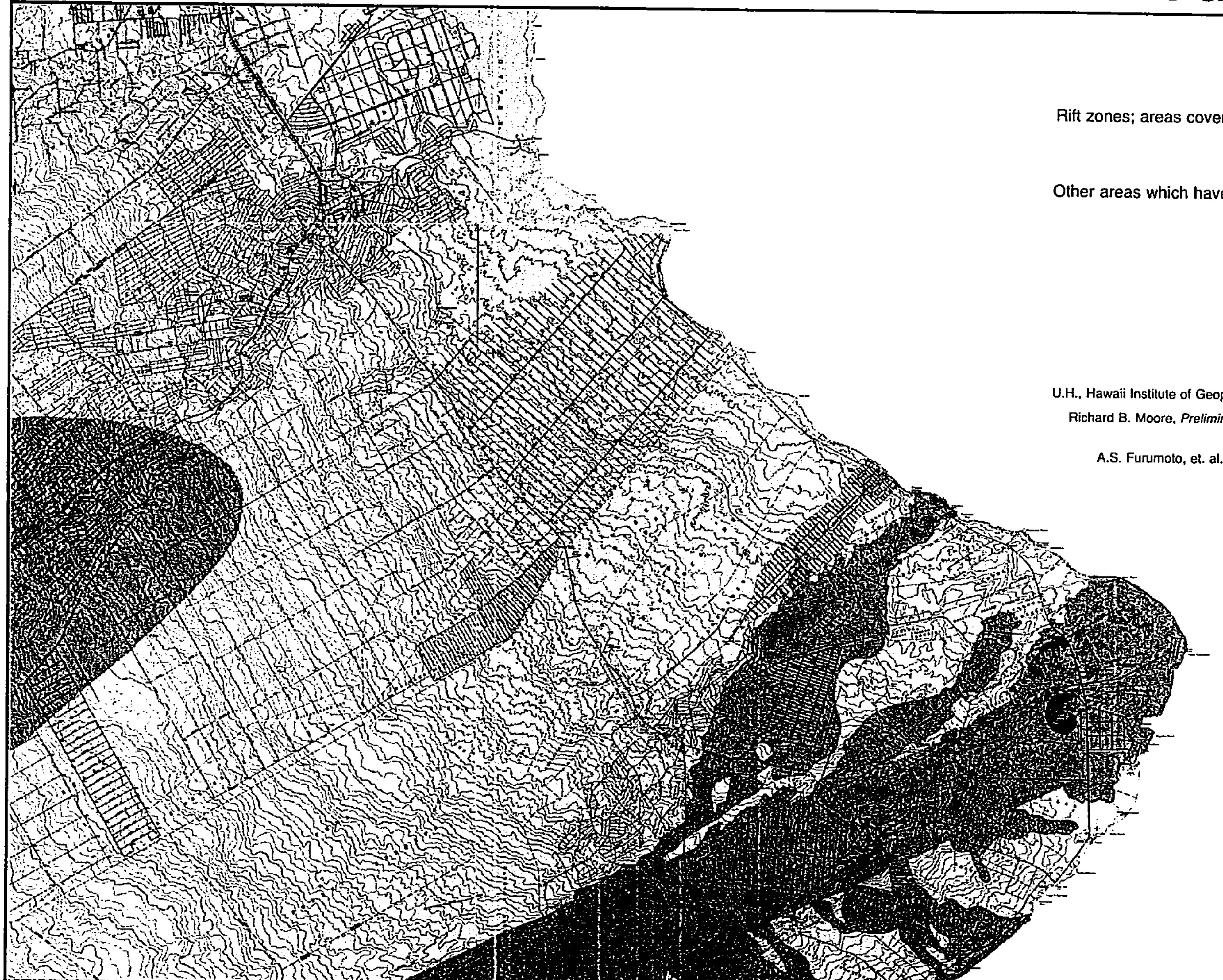
23. U. S. Department of the Interior/Geological Survey, Natural Hazards on the Island of Hawaii, Washington, D. C.: U. S. Government Printing Office, 1977. Figures 2 and 4, pp. 7 and 11; and Donald R. Mullineaux and Donald W. Peterson, Volcanic Hazards on the Island of Hawaii, U. S. Geological Survey Open File Report 74-239, 1974. Written historic records of volcanic and other events commenced shortly after the arrival of Captain James Cook in 1778.

24. University of Hawaii, Hawaii Institute of Geophysics, Geothermal Resources in Hawaii, 1983.

# EXHIBIT IV–3

## GEOLOGIC HAZARDS



### Constraints

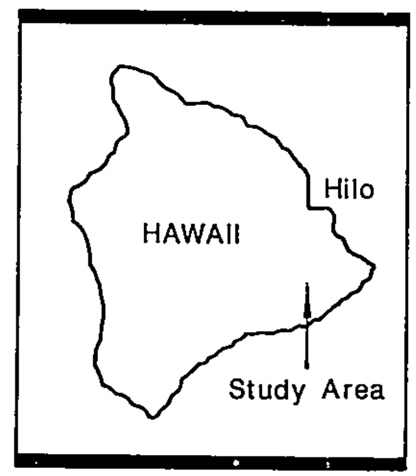
H — Rift zones; areas covered by lava flows since 1778.

M — Other areas which have been covered by lava flows within the past 5000 years.

L — All remaining areas.

### Source

- U.H., Hawaii Institute of Geophysics, *Geothermal Resources in Hawaii*, 1983.
- Richard B. Moore, *Preliminary Geologic Map of Kapoho and Pahoa South Quads*, 1981.
- A.S. Furumoto, et. al., *Preliminary Studies for Geothermal Exploration in Hawaii*, 1973-1975.

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**POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.**

## D. BIOLOGICAL FACTORS

The potential biological effects of 69 kV ac transmission lines include disturbance to vegetation and disruption of habitat for wildlife due to the construction and maintenance of the lines. These effects can be minimized by careful choice of a transmission line route and through construction and maintenance policies.

Based on available scientific data, potential health effects on humans or other species associated with electromagnetic fields are not a major consideration in the routing of these lines because of their relatively low voltages[25]. However, human exposure to transmission lines is a consideration in the following section, Socio-Economic Factors.

### 1. Vegetation

The construction and maintenance of a transmission line inevitably entails some disturbance to ground areas, including the removal of foliage. The degree of disturbance to plant communities can be reduced in various ways. For example, if no continuous access road is constructed along the transmission line alignment, the potential for cumulative disturbance to adjoining plant communities is reduced. This is particularly important in the case of native ecosystems, which are vulnerable to invasions by competing exotic species of plants and the disruptive activities of feral mammals and humans. Impacts on forest areas may be reduced by "feathering back" the taller trees within the transmission line easement rather than uprooting them to provide adequate clearance for the transmission conductors. Avoiding the use of herbicides or other chemical substances within the transmission line easement would also mitigate potential impacts on surrounding planting communities.

The kind and rigor of mitigating measures necessary to avoid adverse ecological effects depends upon the characteristics of the plant community and its degree of sensitivity to disturbance. In the study region, the plant communities most sensitive to disturbance from the construction and maintenance of a transmission line are the relatively mature forests, as indicated by the typical height and coverage of the tree canopies. All forests with a "closed" canopy (i.e., those having greater than 80 percent tree cover) are considered a high constraint. With the exception of reforestation projects, these are the areas which support the greatest diversity and abundance of plant species and where a greater number of indigenous species are found.

Also, more open-canopy forests (40 to 80 percent cover) with a typical canopy height greater than 30 feet are a high constraint because a transmission line through such areas may require extensive clearance of vegetation.

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25. B. Scott-Walton, K. M. Clark, R. B. Holt, D. C. Jones, S. D. Kaplain, J. S. Crebs, P. Poulson, R. A. Shepherd, J. R. Young, Potential Environmental Effects of 765 kV Lines, prepared by SRI for the U. S. Department of Energy, Report No. DOE/EV-0056, November, 1979; J. E. Bridges, "Environmental Considerations Concerning the Biological Effects of Power Frequency (50 or 60 Hz) Electric Fields," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-97, #1, Jan./Feb., 1978; New York Public Service Commission, Opinion No. 78-13, Case 26529 and 26559: Common Record Hearings on Health and Safety of Extra-High Voltage Transmissio Lines, June 19, 1978.

Vegetation may be cleared initially in order to construct the transmission line and vegetation is maintained in a cut back manner to clear transmission lines. For this project, the minimum clearance between the lowest point of the transmission line and the ground has been specified to be 30 feet.

The following describes the relative constraints pertaining to vegetation for transmission line routing at the regional scale.

VEGETATION

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | All closed-canopy (greater than 80% cover) forests; open-canopy (40-80% cover) forests with tall stature trees (greater than 30 feet)[26]. |
| Medium | All forest areas with an open-canopy and medium statute trees (6 to 30 feet tall). |
| Low | All remaining areas, including agricultural and urban uses and barren lava flows. |

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26. Approximates classifications used in James D. Jacobi, Mapping the Natural Vegetation of the Hawaiian Islands, March 7, 1983. Only a portion of the study-region has been mapped according to this classification system. For the remaining areas, maps were produced by DHM inc. based on aerial photo interpretation and field work by Lee Hannah and Linda Cuddihy, using simplified version of the Jacobi system to classify vegetation zones according to tree species and forest type.

# EXHIBIT IV–4
## VEGETATION

### Constraints

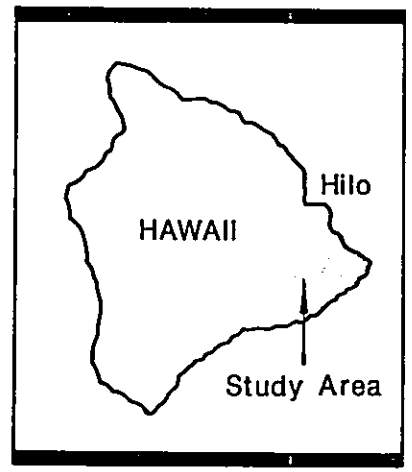
H — All closed-canopy forests; open-canopy forest with typical tree height above 30′.

M — Open-canopy forests with typical tree height between 6′ to 30′.

L — All remaining areas, including agricultural and urban uses and barren lava flows.

### Source

- James D. Jacobi, *Mapping the Natural Vegetation of the Hawaiian Islands*, March 7, 1983.
- U.S. Fish and Wildlife Service, *Jacobi System Vegetation Maps—Advance Prints*, 1979-1984.
- U.H. Environmental Center, Lee Hannah, and Linda Cuddihy, Vegetation Maps based on Jacobi System for Kapoho and Pahoa South Quads, 1984.
- DHM inc.

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POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.

2. Wildlife

In the study area, the focus of wildlife concerns relative to a transmission line route is on birds or flying mammals and their habitats. This is because of the presence of native rain forests, particularly in the Nanawale Forest Reserve, but also, perhaps, in the extensive Ohia forests in the Puna area. Indigenous land mammals are of relative insignificance. The Hawaiian Bat (Lasiurus cinereus semotus), listed as an endangered species, is the only endemic terrestrial mammal that may be found in the region. Since it depends upon flight, its relationship to transmission line concerns is more similar to that of birds than of other land mammals. Common mammals such as the mongoose and the feral pig, goat and sheep destroy some of the best bird habitats and often prey on birds or compete with them for forage[27]. Endemic insects and land snails are to be found in the same habitats as the native bird species, since both are dependent on the same ecosystem.

The definition of constraint areas for bird habitats is closely related to vegetation zones. The most readily defined habitat for rare and endangered bird species is the closed-canopy native rain forest. The rain forest offers a greater diversity and volume of habitat for forage and can therefore support a greater number of bird species and a greater density of birds. It is here that endangered species of the Hawaiian Honeycreeper sub-family (Drepanidinae) can be found; such as the Akiapola au (Hemignathus munroi) the Hawaii Akepa (Loxops coccineus coccineus), the Hawaii Creeper (Loxops maculatus mana) and the Ou (Psittirostra psittacea). There are several other endemic birds, which, while not designated as rare and endangered species, are dependent on native forests; these include the Amakihi (Hemignathus virens virens), the Elepaio (Chasiempis sandwichensis sandwichensis), the Omao (Phaeornis obscurus obscurus), and the Apapane (Himatione sanguinea sanguinea)[28].

The Io, or Hawaiian Hawk (Buteo solitarius), is an endangered species that can also be found in the study region. It has a wide range and is not strictly dependent on the native forest[29]. However, since it tends to areas dominated by native vegetation and avoids rockland communities, it is included here as requiring habitats similar to those of other species totally dependent on native forests.

A transmission line route through a closed-canopy native forest would require the removal of vegetation, thereby reducing habitat. Disturbance to the forest and an opening in the canopy would also promote the introduction of competing plant species and access by feral mammals and humans, which

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27. J. K. Baker and C. A. Russell, "Mongoose Predation on a Nesting Nene", Elepaio (40:51-52) 1979. d. Mueller-Dombois and G. Spatz, "The Influence of Feral Goats of the Lowland Vegetation in Volcanoes National Park", Phytocoelogia (3:1-29) 1975. G. Spatz and D. Mueller-Dombois, "Succession Patterns after Pig Digging in Grassland Communities on Mauna Loa, Hawaii, Phytocoelogia (3:346-373) 1975.

28. J. M. Scott and J. D. Jacobi, Hawaii Forest Bird Survey (Honolulu: U. S. Fish and Wildlife Service) 1981.

29. Hawaii Audubon Society, Hawaii's Birds, Second Edition (Honolulu: Hawaii Audubon Society) 1978.

would have a long-term adverse effect on the quality of the habitat. Moreover, the presence of transmission lines in these forests creates a potential collision hazard.

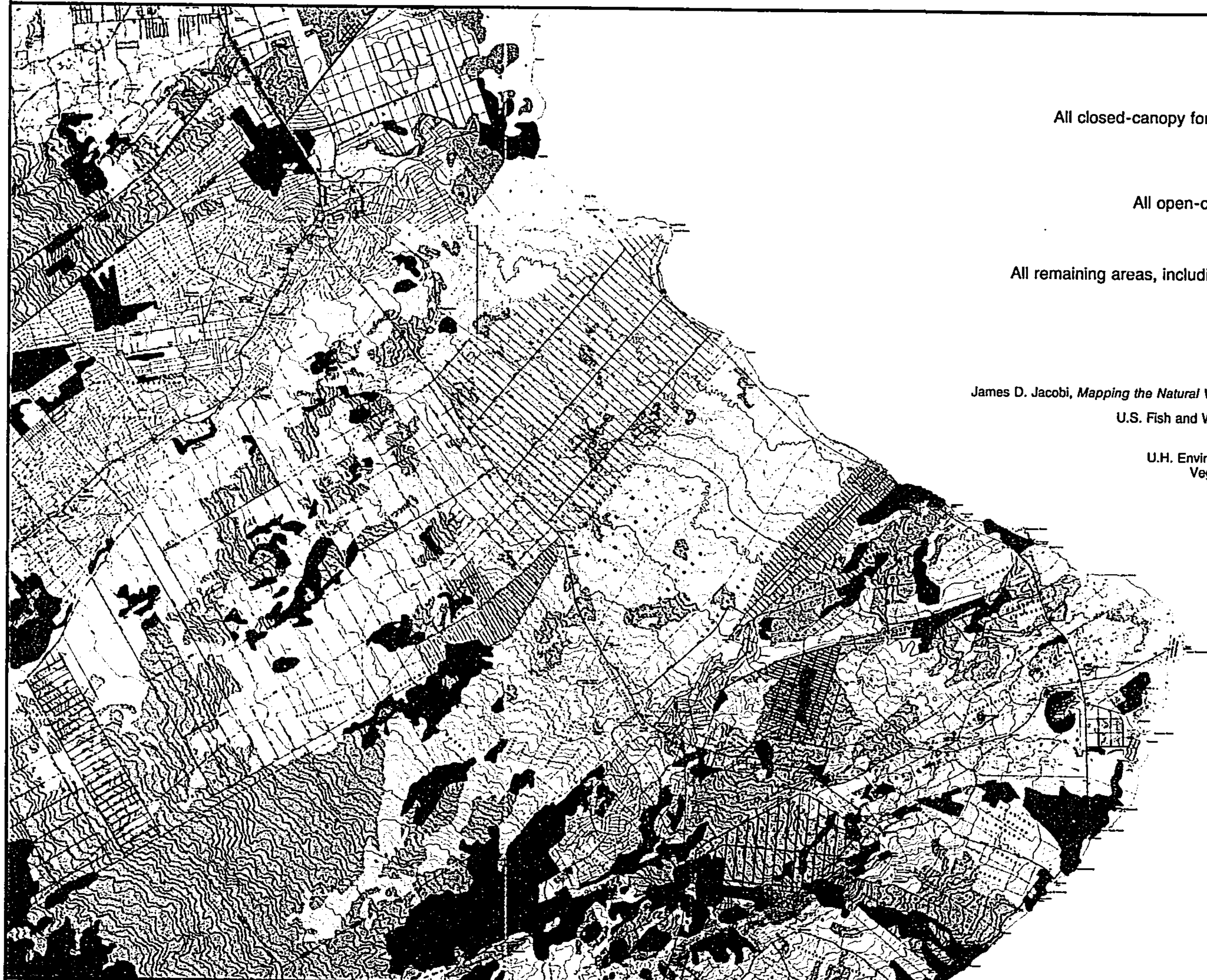
The relative wildlife constraints can, therefore, be defined as follows:

## WILDLIFE

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | All closed-canopy forests (greater than 80% cover). |
| Medium | All open-canopy forests (40-80% cover). |
| Low | All remaining areas, including agricultural and urban uses and barren lava flows. |

# EXHIBIT IV–5

## WILDLIFE

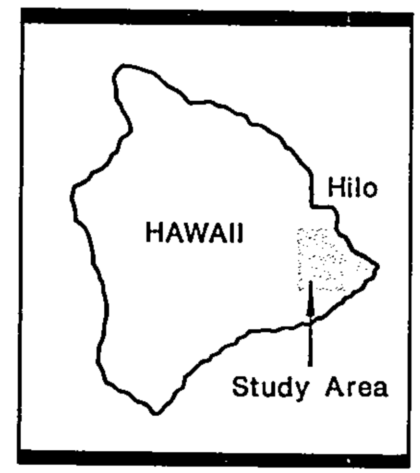


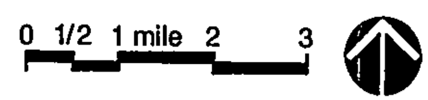
### Constraints

- **H**: All closed-canopy forests (greater than 80% cover).
- **M**: All open-canopy forests (40-80% cover).
- **L**: All remaining areas, including agricultural and urban uses and barren lava flows.

### Source

- James D. Jacobi, *Mapping the Natural Vegetation of the Hawaiian Islands*, March 7, 1983.
- U.S. Fish and Wildlife Service, *Jacobi System Vegetation Maps—Advance Prints*, 1979-1984.
- U.H. Environmental Center, Lee Hannah, and Linda Cuddihy, Vegetation Maps based on Jacobi System for Kapoho and Pahoa South Quads, 1984.
- DHM inc.




**POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.**

## E. SOCIO-ECONOMIC FACTORS

Socio-economic considerations in the routing of the proposed transmission lines relate to human uses of land in the study region. As previously noted, scientific evidence indicates that the electromagnetic fields of 69 kV ac transmission lines do not cause adverse biological effects on human beings. Nevertheless, the public seems to have negative perceptions of transmission lines based on aesthetic values and uncertainty regarding potential health risks.

There are also certain nuisance factors associated with transmission lines. For example, a transmission line easement which bisects a property may be seen as detracting from the property's future use potential. A more direct nuisance effect is the potential interference with AM radio and television reception under certain conditions due to sparking and corona discharge from transmission lines. This problem can be eliminated by proper design, installation and maintenance of the transmission line.

It is characteristic of the following socio-economic factors that the constraints are based at least as much on human perceptions of transmission lines and their effects as they are on any inherent physical qualities. There are, however, some opportunities for routing the lines in the network of existing linear corridors for transportation and utilities in the study region. These corridors identify areas where an additional transmission line may be perceived as less of an encumbrance.

Although the visual aspect of a transmission line is often a key feature in human perceptions, visual constraints are discussed later, in Chapter VI, Detailed Alignment, because of the site-specific nature of their effects.

### 1. Recreation

While transmission lines often co-exist with recreational areas, they are sometimes perceived as an encumbrance. This may tend to constrain the recreational value of an area underneath and to either side of the transmission line, but the degree of constraint varies according to the type of recreation area. Beach parks and playgrounds designed for active recreation use, such as organized games and sporting events, are usually smaller in size and exposed to more frequent and intensive use than are wilderness parks. Therefore, a transmission line easement would tend to consume a greater percentage of these recreation areas and be perceived as a greater encumbrance. In a large wilderness park, however, the easement would take a smaller percentage of the total recreation area and the opportunities for camouflaging or locating the line itself to avoid or minimize exposure to park users are greater.

Existing and proposed public recreation areas - County, State and Federal - have been identified in a technical supplement to the State Comprehensive Outdoor Recreation Plan (SCORP)[30]. This document also rates the intensity of use for these recreation areas as high, moderate, medium, low and no value[31]."

High" constraint areas (which include high and moderate from the SCORP categorization) involve active recreational use and often a high frequency of use, frequently in an urban area. These areas include a beach park, boat launching ramp or areas where there are special natural or cultural resources.

"Medium" constraint areas (or medium and low from the SCORP categorization) include "back country" or naturally pristine lands where the use is dispersed or "controlled" and where nature and solitude may be enjoyed.

All other areas have "low" constraints.

RECREATION

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | High and moderate[32] recreation use such as active beach parks, boat harbors and urban parks. |
| Medium | Medium and low[33] recreation use such as "back country" and controlled use in pristine areas. |
| Low | All remaining areas or areas of "no value" as identified in SCORP. |

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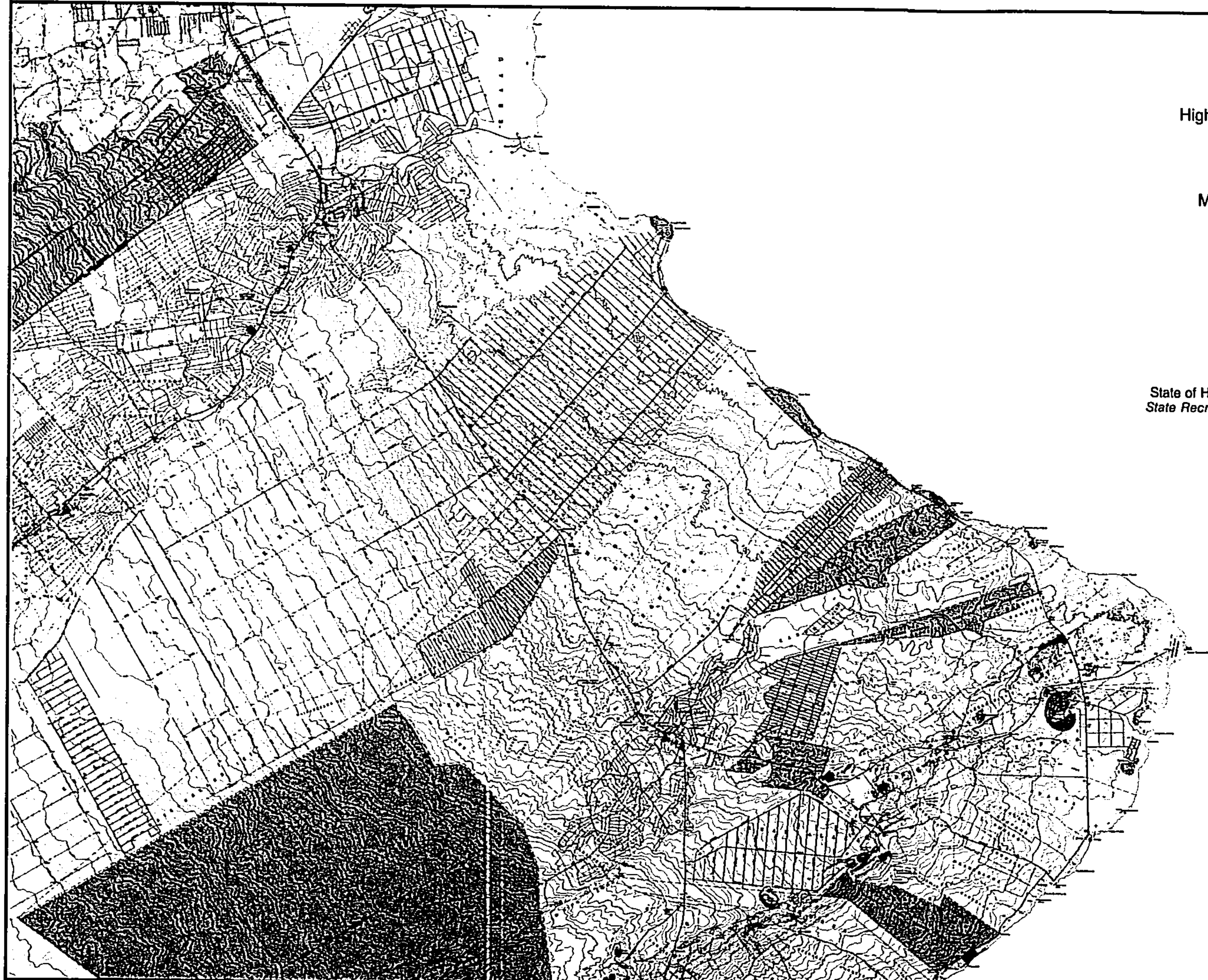
30. See State of Hawaii, Department of Land and Natural Resources, State Recreation Plan Technical Reference Document, Honolulu, September, 1980, pp. 215-226.

31. The definitions and descriptions of recreational use provided in this report are taken from SCORP. SCORP's "High" and "Moderate" are equivalent to a "High" constraint; "Medium" and "Low" equal a "Medium" constraint; "No Value" equals a "Low" constraint.

32. SCORP classifications

33. SCORP classifications

# EXHIBIT IV–6
## RECREATION



### Constraints

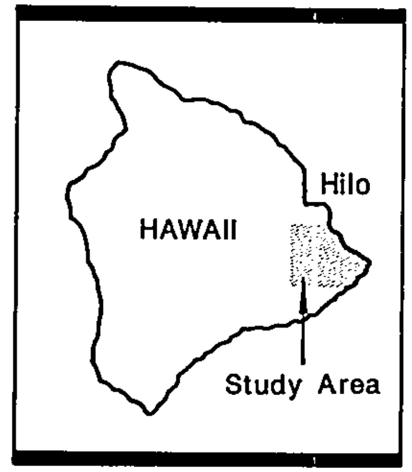
H — High and moderate recreation use.

M — Medium and low recreation use.

L — All remaining areas.

### Source

State of Hawaii, Department of Land and Natural Resources, *State Recreation Plan Technical Reference Document*, 1980.

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**POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.**

2. Land Use

Land uses described in this report are based on the General Plan[34] of the County of Hawaii, zoning[35] applied by the County of Hawaii, Land Use Districts[36] administered through the State Land Use Commission and the Department of Land and Natural Resources, and certain agricultural areas delineated on the State's Agricultural Land Use Map[37].

Because the most intense use by the population occurs in urban or developing areas, all lands zoned by the County for urban use or designated by the State as Urban Districts are classified as a "high" constraint for the location of a transmission line. In some areas, one of the County's agricultural zoning classifications [A - Agriculture (1a), which permits one-acre lots] is also designated for urban use on the County General Plan or is in the State Urban District. Such areas are considered a "high" constraint.

Industrial areas are considered a "medium" constraint because the perceived hazards and nuisances of industrial activities are often as great or greater than those of a transmission line. Agricultural subdivisions with a minimum lot sizes of one to three acres [A - Agricultural (1a), A - Agricultural (3a)] as zoned by the County also are considered to have a "medium" constraint, primarily because these areas tend to be residential in character.

In the study area there are a variety of other agricultural uses, zoning and General Plan allocations. Minimum lot sizes vary from one to 20 acres. Puna has the largest area of papaya orchards in the County of Hawaii and also extensive macadamia nut orchards. There are numerous small cut-flower nurseries and a variety of truck farming operations. There are also some grazing and ranching operations on a small scale. These active and productive uses are considered a "medium" constraint. The agricultural uses described above do not include all lands in the State Agricultural District because not all agricultural lands are productive.

Former Puna Sugar Plantation lands are included as "medium" constraints because the land is continuing in active agricultural production. Much of the former sugar land is being placed in macadamia nuts or other orchard crops which may include cocoa.

All other areas have a "low" constraint.

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34. County of Hawaii, The General Plan, (Adopted by Ordinance No. 439 on December 15, 1971, revised 1986).

35. Department of Planning, County of Hawaii, Zoning Maps, 1986.

36. Land Use Commission, State of Hawaii, Land Use District Boundaries, Honolulu, Hawaii, 1987.

37. Department of Agriculture, State of Hawaii, Agricultural Land Use Maps, 1982.

## LAND USE

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Areas zoned for residential and commercial uses; one-acre agricultural lots that are in the State Urban Land Use District or are designated for urban use on the County General Plan[38]. |
| Medium | Areas zoned for industrial use and one, two and three-acre agricultural lots that are not in the State Urban Land Use District or are not designated for urban use on the County General Plan[39]; areas in agricultural production[40]; former Puna Sugar Plantation lands. |
| Low | All remaining areas. |

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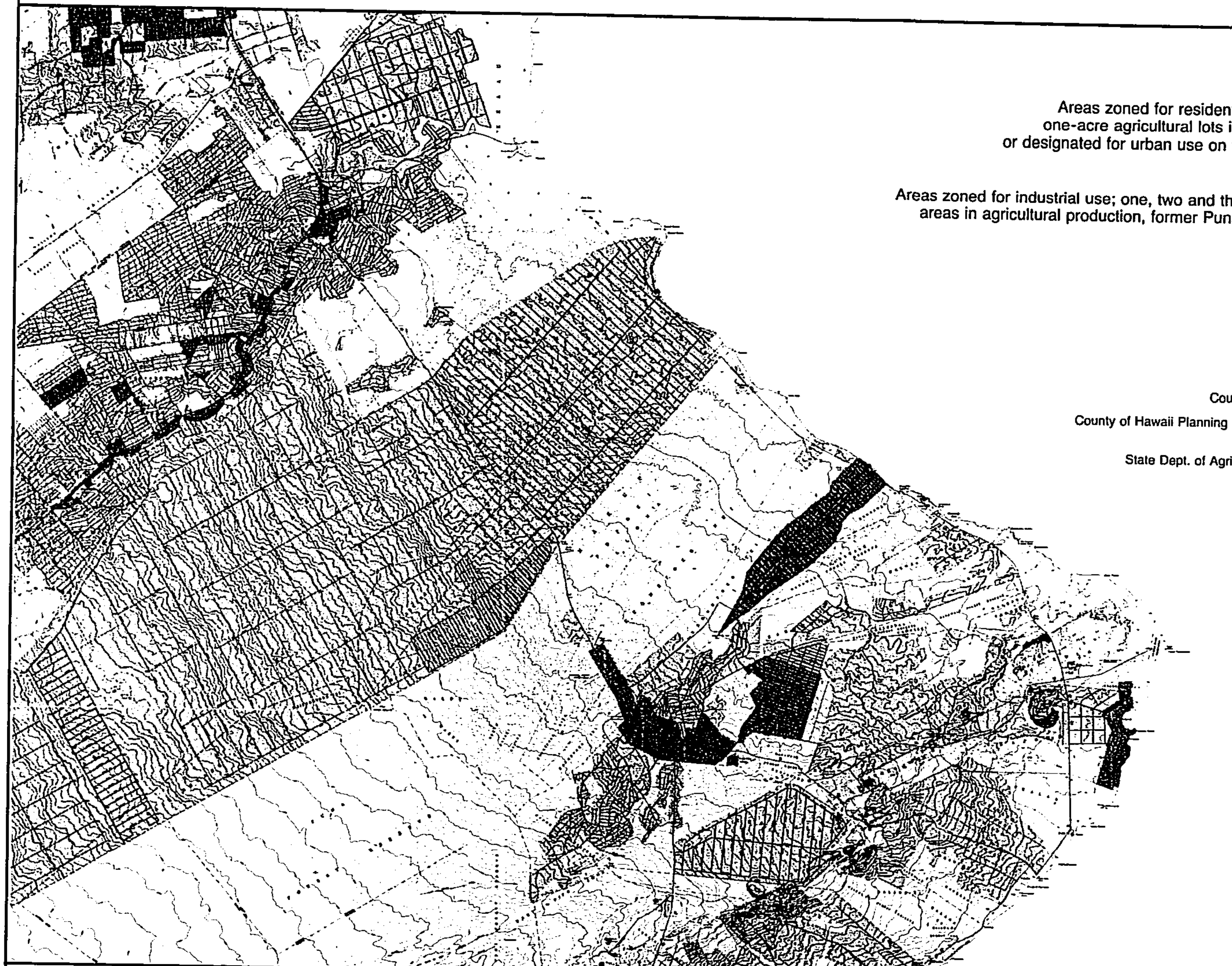
38. County of Hawaii zoning classifications: RS - Single Family Residential (10, 15, 20); RM - Multi-Family Residential (2); RA - Residential Agriculture (.5a); A - Agriculture (1a) if designated on County of Hawaii General Plan for urban use or included in a State Urban Land Use District; CV - Village Commercial (10); CN - Neighborhood Commercial (10).

39. County of Hawaii zoning classification: ML - Limited Industrial (20); A - Agriculture (1a, 3a) if not in State Urban Land Use District or designated urban on General Plan.

40. Areas delineated on Agricultural Land Use Map prepared by the State of Hawaii Department of Agriculture, current as of 1982.

# EXHIBIT IV–7

## LAND USE



### Constraints

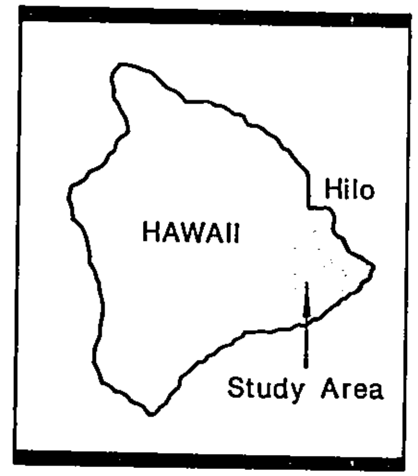
H — Areas zoned for residential and commercial uses; one-acre agricultural lots in the State Urban District or designated for urban use on the County General Plan.

M — Areas zoned for industrial use; one, two and three-acre agricultural lots; areas in agricultural production, former Puna Sugar Plantation lands.

L — All remaining areas.

### Source

- County of Hawaii Planning Dept., Zoning Maps.
- County of Hawaii Planning Dept., *The General Plan, County of Hawaii,* 1971 (revised 1986).
- State Dept. of Agriculture, *Agricultural Land Use Maps*, 1982.
- State Land Use Commission, Land Use District Boundaries, 1987.

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3. Transportation and Utilities

The study area's network of roadways, power lines and a former railroad alignment were reviewed to assess the opportunities they may offer for locating transmission lines because utilities and roads often occupy the same corridors. In some cases there are existing easements or rights-of-way which may allow for installation of new transmission lines.

The major advantage of conforming to existing roadway or utility alignment patterns is that new lines can be readily incorporated into the existing features of these areas. In the study area, transmission or power lines tend to be located near or within existing highway or road rights-of-way. In the case of the former railroad, only a short length of the former route has a single owner. The remainder of the route is held by adjacent property owners except through Hawaiian Paradise Park where the former railroad easement is owned by each of the lot owners of the entire subdivision[41]. Therefore the former railroad route represents no advantage (in terms of an available right-of-way) over any other route.

For this factor, areas are evaluated in terms of "high" and "low" constraints only. Areas without any linear easements, or without existing roads or power lines, are considered a "high" constraint. Specifically, this means that "high" constraint areas are more than 1/4 mile from existing paved or well-maintained unpaved roads which are passable under most weather conditions. Areas with "low" constraints are those lands less than 1/4 mile from existing paved or well maintained unpaved roads.

HELCO requires that the two proposed 69 kV lines be separated by one-half (0.5) mile[42] in order to reduce the risk of failure of both lines at one time due to a natural catastrophe such as an earthquake, lava flow, brush fire, or hurricane. This requirement might be reduced if each of the proposed 69 kV lines could be placed on either side of a major road. This is because a major road could be considered as a firebreak which could prevent a dual line outage caused by fire.

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41. Letter to editor, Puna/Kau Independent News, 11:11:6, November 1986. According to Ms. Kiki Shappell "...the Railroad roadways in increment I are indeed owned by the lot owners in common, with each lot owner holding title to 1/5750 of all the roadways. No one owns any particular piece of road. Every part is owned jointly by all of the lot owners in increment I."

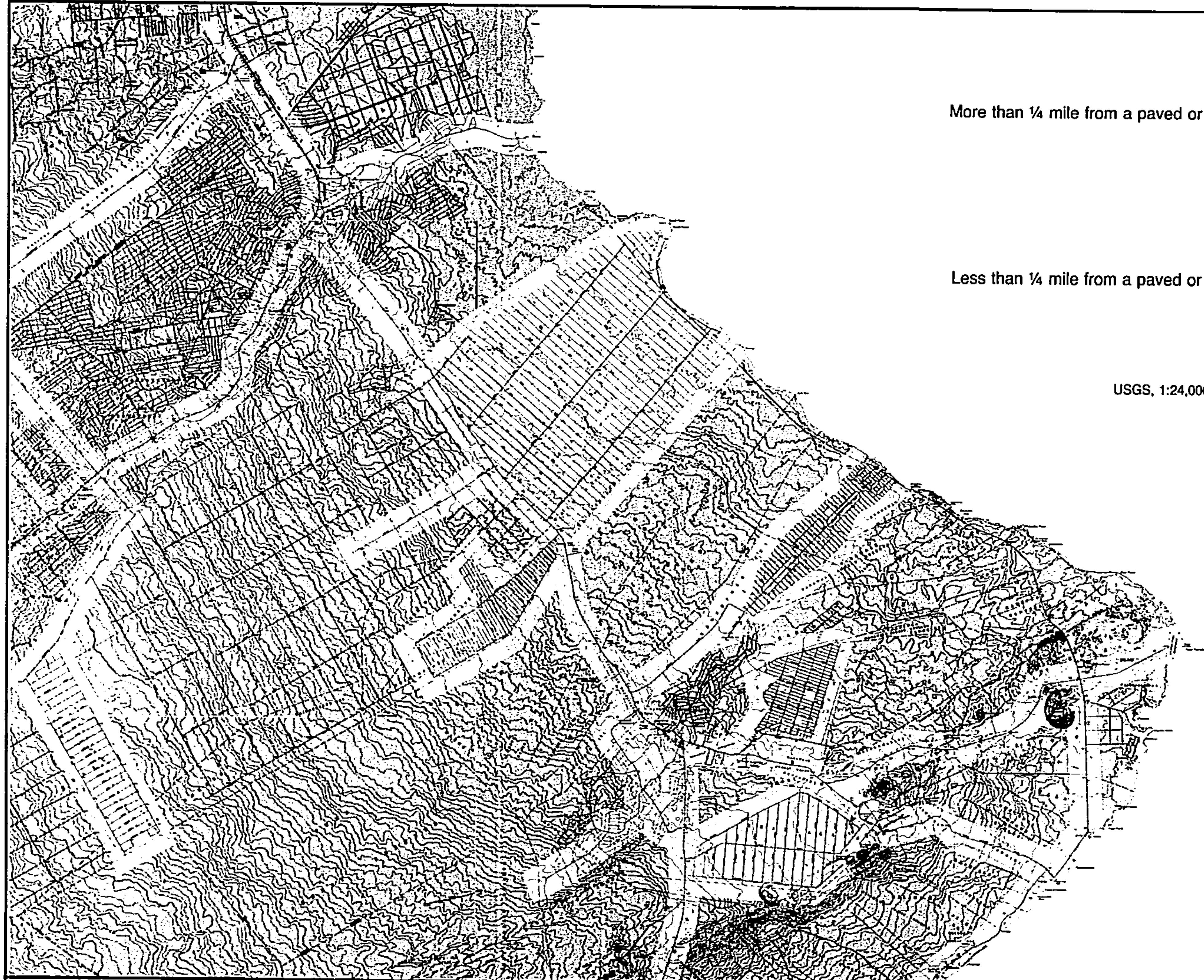
42. The minimum separation distance is considered to be 0.5 miles unless a major road is between the two proposed 69 kV lines. If so, then the separation distance could be less, but not less than the PUC requirement of 3/4 the pole height.

## TRANSPORTATION AND UTILITIES

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | More than 1/4 mile from a paved or well-maintained unpaved road which is passable under most weather conditions. |
| Medium | Not Applicable. |
| Low | Less than 1/4 mile from a paved or well-maintained unpaved road which is passable under most weather conditions. |

# EXHIBIT IV–8

# TRANSPORTATION AND UTILITIES



## Constraints

More than ¼ mile from a paved or well-maintained unpaved road. **H**

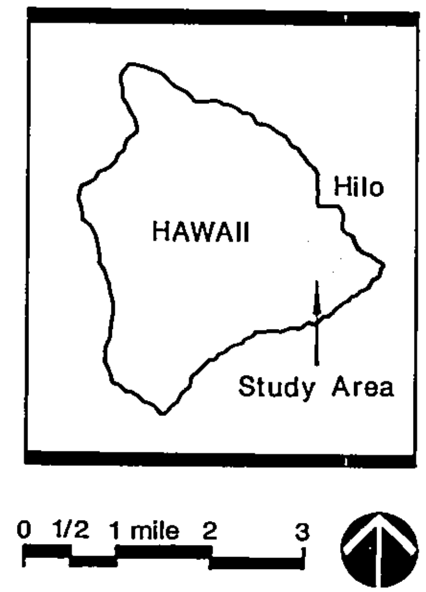
Not Applicable. **M**

Less than ¼ mile from a paved or well-maintained unpaved road. **L**

## Source

USGS, 1:24,000 scale Topographic Quadrangle Maps, 1980-1983. •

DHM inc. •




**POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.**

4. Land Ownership

For safety and access, typical rights-of-way up to 50 feet wide[43] are required for 69 kV transmission lines. The acquisition of a right-of-way would have a more significant impact on the potential use of small parcels than it would on large ones. Landowners are primarily concerned that transmission line right-of-way acquisitions do not create small, irregularly shaped remnant parcels that reduce the value of their property. On smaller properties, this often means locating the easement adjacent to the property boundary, which can result in a very indirect route that zig zags through areas with numerous such parcels.

"High" constraints exist where there are private land holdings of 10 acres or less. When there are a high number of landowners within a proposed right-of-way easement the public costs become greater and are eventually reflected in higher utility rates. When the utility company must negotiate with many property owners to acquire a right-of-way easement, the documentation and procedural requirements are more extensive and more costly. Thus, there is a greater constraint where there is a substantial degree of parcelization. Much of the Puna region has been subdivided into residential and agricultural lots of 10 acres or less in size.

Hawaiian Homes Lands under the jurisdiction of the Hawaiian Homes Commission (HHC) are considered a "medium" constraint. These lands pose a unique situation because of Federal and State statutory restrictions which limit the period for the granting of easements across these lands to a maximum of 21 years. Utility companies normally seek a perpetual easement. Moreover, the HHC is obligated to use these lands to the benefit of native Hawaiians. Recent litigation by Hawaiians against the Commission has clouded the land use plans for any agency wishing to use Hawaiian Home Lands. The use rights for these lands can be difficult to acquire.

The Department of Hawaiian Home Lands recognizes the potential for rural residential use in the areas straddling the Pahoa-Keaau Highway and recreational use of the parcel along the shoreline[44]. The Commission has recently created a subdivision of 2- and 5-acre lots[45] in the Lands of Makuu on both sides of the highway which further parcelizes their holdings. The lots are leased to native Hawaiian beneficiaries.

Portions of the study region are comprised of extensive private estates and public lands. Amfac, Bishop Estate, Shipman Estate, Kapoho Land and Development Company, Tokyu Land Development, and the State of Hawaii are major landowners in the region. These private land holdings of more than 10 acres are considered to have a "medium" constraint for a transmission corridor.

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43. The precise right-of-way (ROW) may vary depending on pole spacing. Pole spacing of 600 feet requires a 50-foot ROW; lesser pole spacig requires a lessor ROW width.

44. State of Hawaii, Department of Hawaiian Home Lands, General Plan, Honolulu, 1975.

45. Telephone communication, Department of Planning, County of Hawaii, 1986.

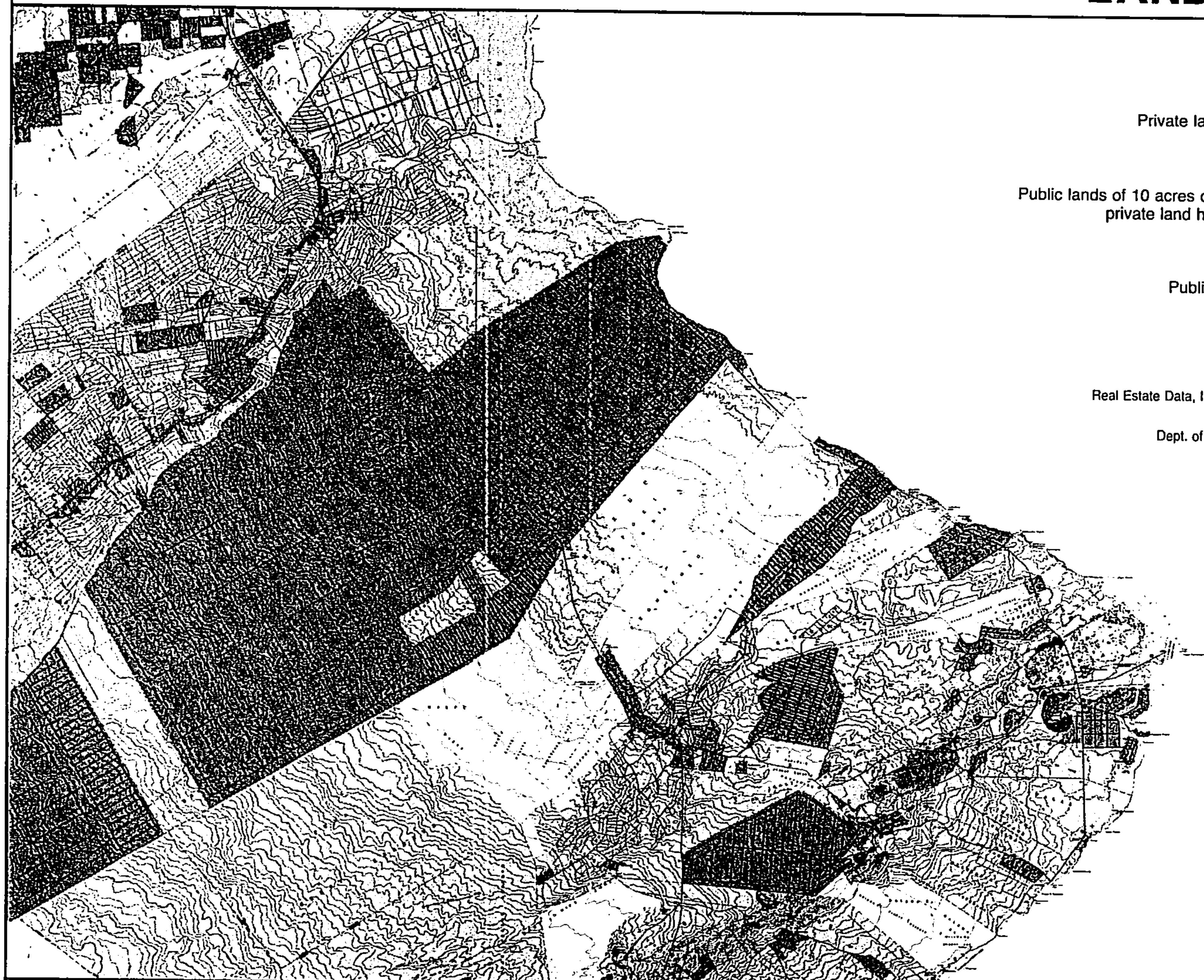
In the study area, large parcels of state land represent an opportunity for a transmission route because these lands are generally not intensively used and there is no expectation of future profitable use, as in the case of private landowners. For this reason, State lands of more than 10 acres are classified as a "low" constraint.

## LAND OWNERSHIP

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Private landholdings of 10 acres or less. |
| Medium | Public lands of 10 acres or less; Hawaiian Home Lands; private land holdings of more than 10 acres. |
| Low | Public lands of more than 10 acres. |

# EXHIBIT IV–9

## LAND OWNERSHIP



### Constraints

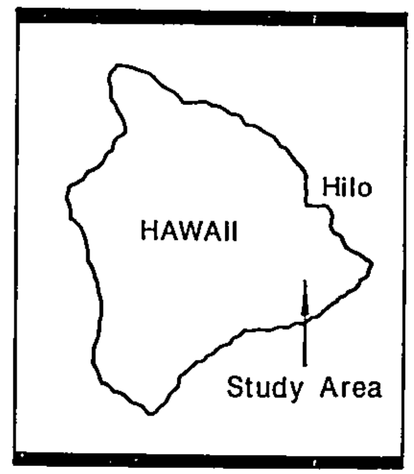
H — Private landholdings of 10 acres or less.

M — Public lands of 10 acres or less; Hawaiian Home Lands; private land holdings of more than 10 acres.

L — Public lands of more than 10 acres.

### Source

- Real Estate Data, Inc., *Real Estate Atlas of Hawaii, County of Hawaii, Map Volume Zone 1*, 1986.
- Dept. of Hawaiian Home Lands. Map of Maku'u Farm Lots.

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## 5. History and Archaeology

The construction of a transmission line may detract from the research, cultural or sacred value of a historic property or archaeological site which lies in or very near its path.

In Hawaii, a distinction is generally made between cultural properties which pre-date (pre-historic) the arrival of Captain James Cook in Hawaii in 1778 and those which are more recent (historic) in origin. The study region's three major areas of historic interest are the towns of Mountain View, Keaau and Pahoa. Their location and historic characteristics are well-defined[46]. The pre-historic sites which have been identified in the study region consist of the archaeological remains of Hawaiian settlements, heiau, petroglyphs, burial grounds and ancient trails[47].

All of the sites from both periods which have been located, described and assigned a site number by the State Historic Preservation Office are considered "high" constraint areas. Some sites, however, are so small in size that their areal coverage must be exaggerated somewhat in order to be distinguishable on a regional scale map. Such sites can be delineated more precisely in a more detailed analysis if they should appear in a potential transmission line corridor.

In addition to the known historic sites, there is a possibility of undiscovered archaeological remains in the region. The probability of a large number of such sites in this region is limited by several factors. Large areas of the region have been covered by lava flows in the past 500 years, which has both discouraged human settlement of the area and destroyed much of what evidence there might have been of human use[48]. In addition to natural disturbances, urbanization and agriculture in the post-Cook period may have destroyed archaeological remains in some areas.

Nevertheless, there are some relatively undisturbed areas which can be rated a "medium" constraint, in recognition of the relatively greater possibility of undiscovered archaeological remains there.

The remainder of the study area is considered a "low" constraint in terms of historic and archaeological resources. It should be noted that the designation of areas by degree of constraint does not eliminate the necessity of conducting a more detailed analysis at later stages of route selection and project planning. A field study of potential corridors and of areas that may be disturbed in transmission line construction will mitigate against the

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46. The entire towns have been described as historic areas and have been assigned site numbers by the State Historic Preservation Office, although none is on the official State or Federal registers of historic places.

47. State Historic Preservation Office, file of site descriptions.

48. Comments on lava flow coverage attributed to Richard B. Moore, former Survey Geologist with the U. S. Geological Survey at Hawaiian Volcano Observatory.

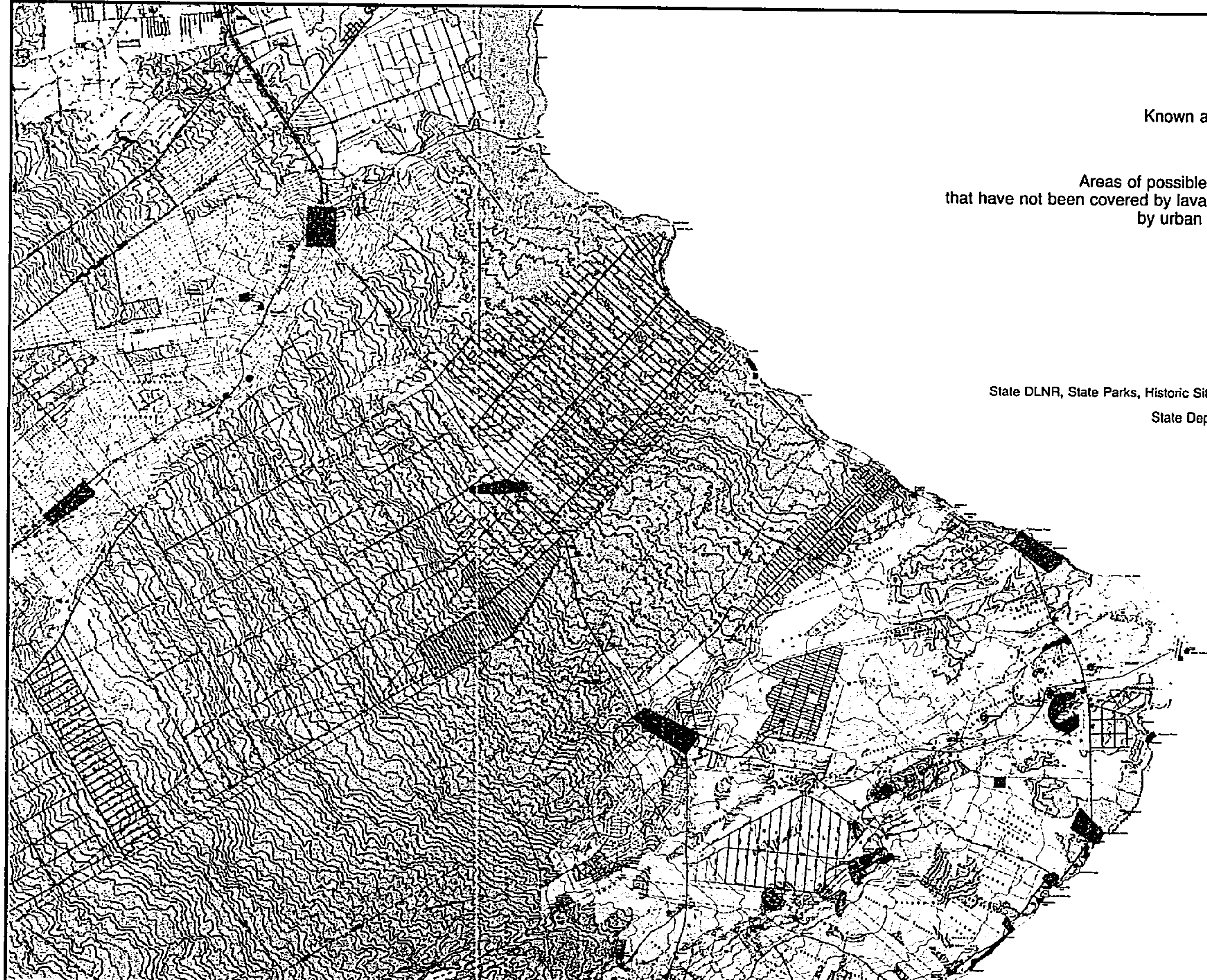
destruction of a previously undiscovered archaeological site. During initial planning, the constraint analysis at the regional scale is intended to avoid areas where sites are known to exist or where the possibility of their existence is relatively greater.

## HISTORY AND ARCHAEOLOGY

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Known archaeological and historic sites. |
| Medium | Areas of possible human use in pre-Cook period that have not been covered by lava flows or substantially disturbed by urban or agricultural uses since 1778. |
| Low | All remaining areas. |

# EXHIBIT IV–10

## HISTORY AND ARCHAEOLOGY



### Constraints

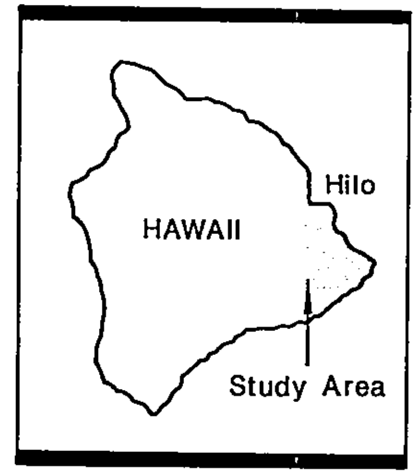
H — Known archaeological and historic sites.

M — Areas of possible human use in pre-Cook period that have not been covered by lava flows or substantially disturbed by urban or agricultural uses since 1778.

L — All remaining areas.

### Source

- State DLNR, State Parks, Historic Sites Section, Historic and Archaeological Sites Maps.
- State Dept. of Agriculture, Agricultural Land Use Maps, 1982.
- Richard B. Moore, *Preliminary Geologic Map of Kapoho and Pahoa South Quads*, 1981.
- DHM inc.

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6. Land Regulation

There are some areas where the construction of a transmission line would be discouraged by regulatory controls designed to protect special resource values. The controls are not so restrictive that they eliminate these areas from further consideration, such as the Exclusion Areas which were described earlier. Nevertheless, a permit application for a proposed transmission line through these areas would be evaluated in terms of the line's possible conflicts with special resource values.

There is a ring of land area encircling the island which has been designated the Special Management Area (SMA) as part of the State's Coastal Zone Management Program[49]. The County reviews permit applications for development within the SMA in terms of a number of policies and guidelines. One of these policies is to "protect the shoreline of the County where needed from encroachment of man-made improvements and structures[50]. The SMA is considered a "high" constraint area.

The State Conservation District contains several subzones and special districts representing a range in degree of restrictiveness[51]. The most restrictive area is the Protective Subzone, which has previously been described as Exclusion Areas. Next in the hierarchy of restrictiveness are the Limited and Resource subzones. While regulations governing these subzones would not preclude a transmission line, their stated objectives and narrow range of permitted uses for these areas suggest a "high" regulatory constraint. The General Subzone of the Conservation District is more permissive, and can be considered a "medium" constraint. A transmission line route through any portion of the Conservation District would require the review and approval of the State of Hawaii Board of Land and Natural Resources.

LAND REGULATION

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Limited and Resource Subzones of the State Conservation District. Special Management Area of the coastal zone. |
| Medium | General Subzone of the State Conservation District. |
| Low | All remaining areas. |

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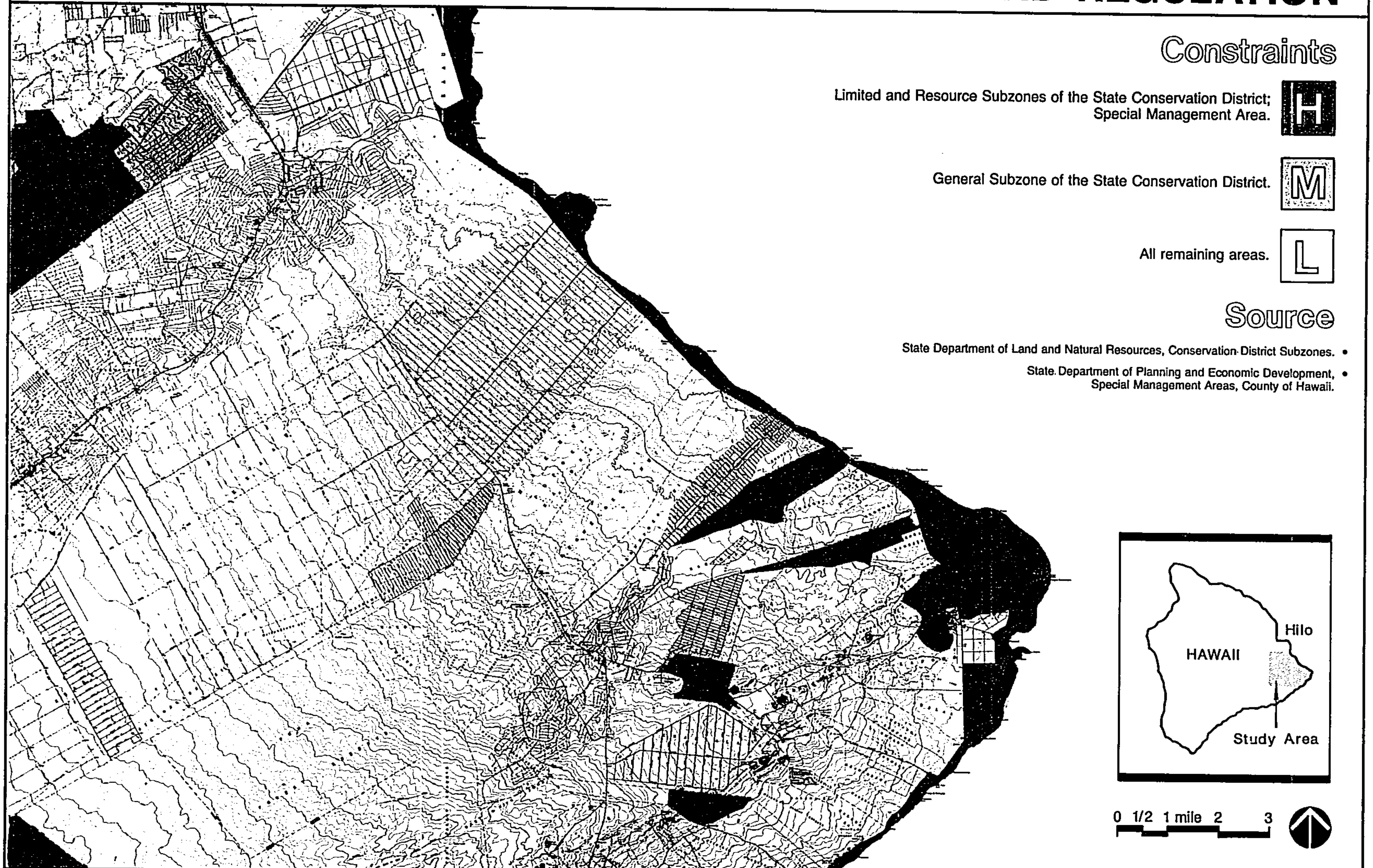
49. State of Hawaii, Department of Land and Natural Resources, Regulation No. 4 pursuant to Chapter 183-41, Hawaii Revised Statutes, Honolulu, Hawaii, May, 1978.

50. County of Hawaii Planning Department, "Rules Relating to Administrative Procedures: Planning Commission," Hilo, Hawaii, October, 1975.

51. County of Hawaii Planning Department, "Rule Relating to Administrative Procedures: Planning Commission," Hilo, Hawaii, October, 1975.

# EXHIBIT IV–11

## LAND REGULATION

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F. COST FACTORS

The cost of constructing and maintaining the proposed transmission lines is a concern not only to the utility company but to all Island of Hawaii residents and businesses who are supplied with electric power by the utility, since these costs are eventually borne by customers through the utility's rate base.

Route length is an obvious determinant of cost. This has been taken into account by restricting the study region to the southeast portion of the island, which still permits a very large number of routing alternatives, some of which could be quite indirect. No additional route length criteria are considered in the broadscale analysis, but the length of the route can be a factor in the identification of specific routing alternatives and the selection of a preferred route.

Transmission line costs at the regional scale of analysis are influenced primarily by relative land values, various physical conditions which impinge on access to the transmission lines, and certain land uses and physical elements that effect the amount of maintenance required by the line.

1. Land Value

Land value has a direct impact on the cost of acquiring an easement for a transmission line. Utility companies usually pay private property owners a consideration based on an appraised value for transmission line easements. In recent years, the State government also has tended to demand compensation for the use of public lands, although not necessarily at a rate comparable to private lands.

Land values are usually negotiated. While the utility company has power of eminent domain, this is used only as a last resort because the proceedings for this form of acquisition add to costs in terms of legal fees and project delays.

The present and potential use of a property is the most significant influence on its value. Potential use can be determined by the property's location, physical characteristics and zoning designation. The land use classifications used for real property assessment purposes in Hawaii take potential use into account; e.g.; there is a separate classification for "unimproved residential" land[52]. Assessed valuation provides the most comprehensive available indicator of land value according to present and potential use. It is possible, on the basis of public records, to determine the average valuation per acre for different categories of existing and potential use[53].

Assessed valuations for these categories fall into three distinct groups, corresponding closely to the State Land Use District categories. The Urban District is the high-value category. The Rural and Agriculture District are medium-value and the Conservation District is a low-value category.

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52. Hawaii uses the code system established by the "Pittsburgh Law" of differential tax rates for real property assessment and taxation. Cf., Chapter 246, Hawaii Revised Statutes.

53. City and County of Honolulu Department of Finance, Real Property Assessment Division, "Real Property Tax Valuations, Tax Rates and Exemptions, 1983-1984 Tax Year, State of hawaii," Honolulu, 1984. The City's Department of Finance compiles property tax data for all of Hawaii's counties.

Market value alone, however, does not determine the cost of a transmission line easement. HELCO has found, for example, that large landowners are often willing to provide easements at a minimal cost. Sometimes, the transmission line is a benefit to these landowners and can result in an increase in value of certain portions of their properties which they wish to develop. On the other hand, small property owners are less likely to reap these benefits and are more likely to expect compensation from the utility company.

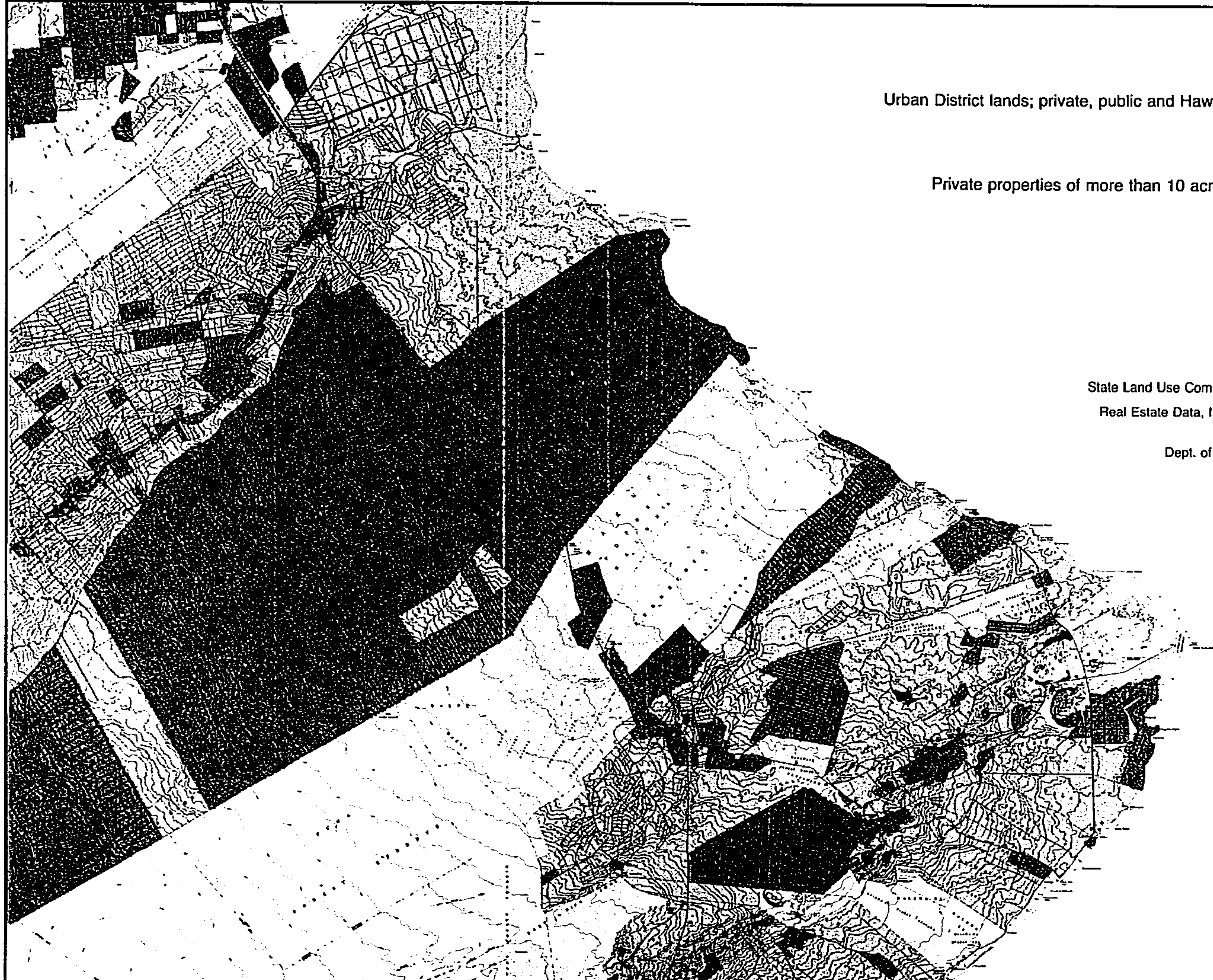
The utility company can usually obtain easements across public land at lower cost than on comparable private land, particularly if the property is located in the State Conservation or Agricultural District. Urban District land is usually more expensive, since an appraiser bases the cost on a percentage of market value. The percentage represents the diminished utility which is a reflection of a property's inability to fulfill its highest and best use.

## LAND VALUE

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Urban District lands; private, public, and Hawaiian Home Lands properties of 10 acres and less. |
| Medium | Private properties of more than 10 acres in the Agricultural and Rural Districts. |
| Low | All remaining areas. |

# EXHIBIT IV–12

## LAND VALUE



### Constraints

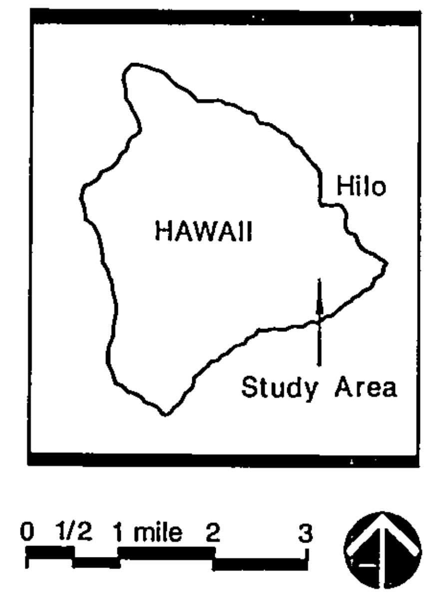
H — Urban District lands; private, public and Hawaiian Home Land properties of 10 acres and less.

M — Private properties of more than 10 acres in the Agriculture and Rural Districts.

L — All remaining areas.

### Source

- State Land Use Commission, State Land Use District Boundaries, 1987.
- Real Estate Data, Inc., *Real Estate Atlas of Hawaii, County of Hawaii, Map Volume Zone 1*, 1986.
- Dept. of Hawaiian Home Lands, Map of Maku'u Farm Lots.

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## 2. Maintenance

A major consideration in maintenance costs is the need for clearance between the transmission conductors and nearby objects such as trees. HELCO's engineering standards require that all areas within 10 feet of the transmission lines be kept free of vegetation. The specified minimum ground clearance (at the point of maximum line sag) of the proposed power line is 30 feet. This means that vegetation would be maintained at a maximum height of 20 feet (30 foot high power line - 10 foot clearance = 20 foot high vegetation) within the transmission line easement. Because of this standard, forest areas with canopy heights in excess of 30 feet pose a constraint because of the high cost of severe pruning. Both closed- and open- canopy forests with trees greater than 30 feet in height are considered as "high" constraints.

Salt spray, which occurs up to 1/2 mile[54] from the shoreline inland, poses a "high" constraint. Salt spray can cause flashovers at insulators and is generally corrosive to electrical systems and to hardware. Therefore, transmission lines within this area incur high maintenance costs.

Considerations stemming from human activities can also affect the maintenance of a transmission line especially where vandalism by hunters may occur. Hunter vandalism is associated with the discharge of firearms and the use of the transmission line insulators and conductors for target practice. This generally occurs in or near areas where game hunting is common. Game hunting areas are considered a "high" constraint.

Open-canopy forests with medium stature trees (6 to 30 feet tall) are a "medium" constraint because of potential pruning costs to keep vegetation clear of transmission lines.

It should be noted that in general, Puna has a somewhat higher incidence of fires, especially during dry periods, than have less developed areas on the Island of Hawaii[55]. However, mapped data is unavailable. For the purposes of this study, it is assumed that the fire hazard is relatively equal throughout the district.

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54. Based on information provided by HELCO.

55. Based on communications with staff, Department of Land and Natural Resources, Division of Forestry, September, 1986.

MAINTENANCE

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | All closed-canopy forests (i.e., more than 80% cover); open-canopy (40 to 80% cover) forests with trees greater than 30 feet[56]; designated salt spray areas; game hunting areas. |
| Medium | Open-canopy forests with trees 6 to 30 feet tall. |
| Low | All remaining areas. |

56. Jacobi, James D., Mapping the Natural Vegetation of the Hawaiian Islands, March 7, 1985.

# EXHIBIT IV–13

## MAINTENANCE

### Constraints

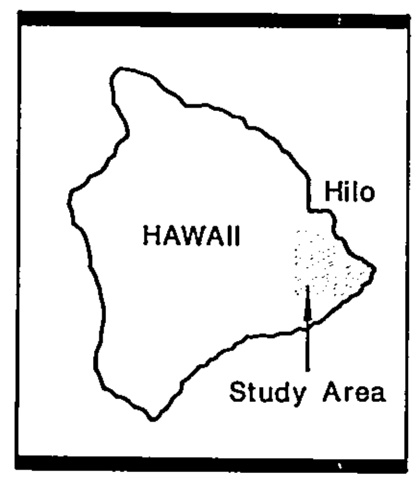
**H** — All closed-canopy forests; open-canopy forests with trees 30′ or greater; designated salt spray areas; hunting areas.

**M** — Open-canopy forests with trees 6′-30′ tall.

**L** — All remaining areas.

### Source

- U.S. Fish and Wildlife Service, *Jacobi System Vegetation Maps*, 1979-1984.
- State DLNR, *State Recreation Plan Technical Reference Document*, 1980.
- HECO, Inc., *Insulation Areas, Engineering Data*.
- DHM inc.




0 1/2 1 mile 2 3

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3. Access

The cost of constructing and maintaining a transmission line is affected by the degree of its accessibility. Areas which are distant from existing roads or characterized by rugged terrain or other physical barriers or difficulties, such as steep slopes, subsurface lava tubes and dense vegetative cover are the most costly sites for the construction and maintenance of transmission lines. To some extent, proximity to roads and geophysical characteristics are interdependent criteria, since roads tend to be aligned in areas with less difficult physical conditions. This is generally the case in the study area, therefore "access" constraints are mapped based on distances from existing areas.

Areas which are more than 1/2 mile to either side of a paved road or improved and well maintained road which may be unsurfaced are considered "high" constraints. Also areas more than 1/4 mile from unpaved, poorly maintained roads such as jeep trails or agricultural lot access roads are considered "high" constraints.

Areas between 1/4 and 1/2 mile from paved or improved and well maintained roads and areas within 1/4 mile of unpaved, poorly maintained roads are considered "medium" constraints.

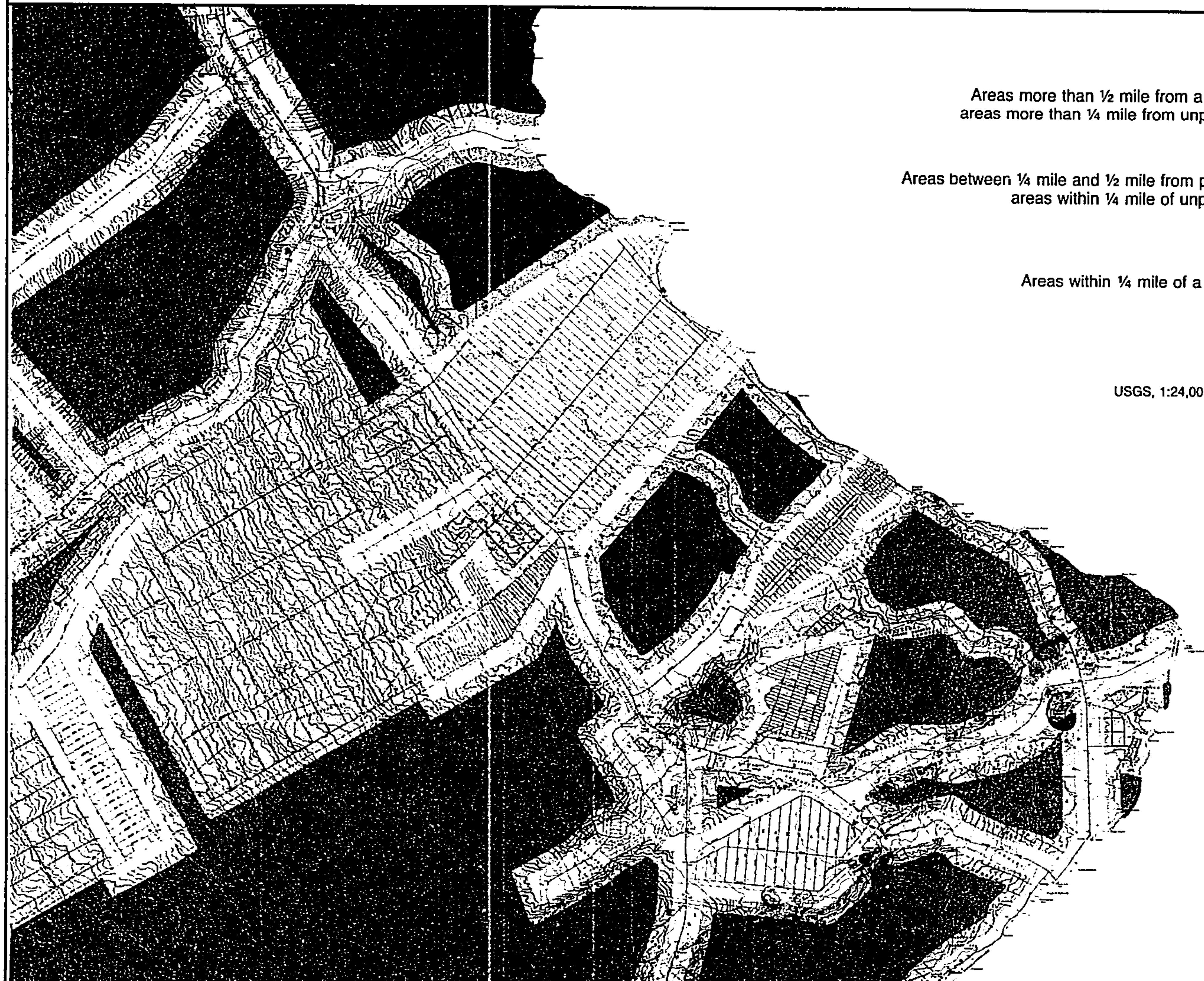
Areas within 1/4 mile of a paved or improved well maintained road which may be unpaved are considered to have "low" or the least amount of constraints for access to construct and maintain transmission lines.

ACCESS

| DEGREE OF CONSTRAINT | CRITERIA |
|---|---|
| High | Areas more than 1/2 mile from a paved or improved, well maintained road; areas more than 1/4 mile from unpaved, poorly maintained roads such as jeep trails. |
| Medium | Areas between 1/4 mile and 1/2 mile from a paved or improved, well maintained road; areas within 1/4 mile of unpaved, poorly maintained roads such as jeep trails. |
| Low | Areas within 1/4 mile of a paved or improved, well maintained road. |

# EXHIBIT IV-14

## ACCESS



### Constraints

H — Areas more than ½ mile from a paved or well maintained road; areas more than ¼ mile from unpaved, poorly maintained roads, such as jeep trails.

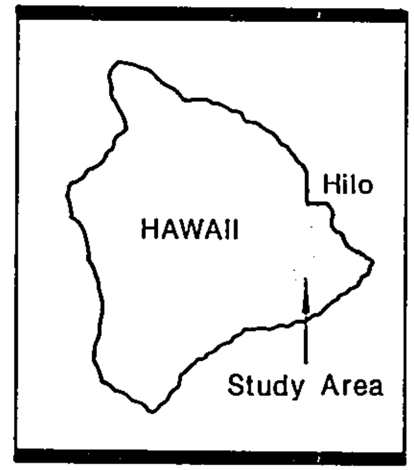
M — Areas between ¼ mile and ½ mile from paved or well maintained roads; areas within ¼ mile of unpaved, poorly maintained roads, such as jeep trails.

L — Areas within ¼ mile of a paved or well maintained road.

### Source

USGS, 1:24,000 scale Topographic Quadrangle Maps, 1980-1983. •

DHM inc. •




0 1/2 1 mile 2 3

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# CHAPTER V

## CHAPTER V: IDENTIFICATION OF CORRIDORS AND POTENTIAL ROUTES

### A. COMPOSITE MAPS

In order to present an overall view of the constraints and opportunities for the transmission line route, a composite overlay map was prepared for each data category (geophysical, biological, socio-economic, and cost factors). The composite maps represent the combined constraints of all the data factors in each data category and identify the areas of less constraint for each category.

Composite maps for the data categories of geophysical, biological, socio-economic and cost factors are shown in Exhibits V-1, V-2, V-3 and V-4. In Exhibit V-5, the four composite maps and the Exclusion Areas map are laid over one another. One can see color tones ranging from black (Exclusion Areas), through dark grey (high constraint) to light grey (low constraint). The "relatively" lighter areas are mapped as areas of less constraint, and are viewed as opportunities for transmission line corridors. The areas of less constraint are mapped in Exhibit V-6.

Potential corridors are identified by linking the areas of less constraint to provide a continuous connection between the geothermal power plant site and the Puna Substation area at Keaau. This was done using the areas of less constraint as the main guide and linking them where they did not join. Linkages were normally made across the shorter route and if possible along an existing road or jeep trail. Urban and Conservation District lands were avoided. Where necessary, the corridors were widened to allow for alternative alignments if the widening did not affect environmentally sensitive areas such as Urban or Conservation Districts. Through large areas of less constraint, such as agricultural subdivisions and the mauka lands, the most direct route was chosen between the identified corridor on either side. The potential corridors are shown on Exhibit V-7. The width of the corridors is one-quarter to three-quarters of a mile to permit a choice of alignments.

### B. POTENTIAL CORRIDORS

The corridors identified for further evaluation have been divided into five segments (as shown on Exhibit V-7) for review purposes. The segments may be combined to form three primary corridors from the Pohoiki geothermal plant to the Puna substation:

| | |
|---|---|
| Corridor AB | Nanawale/Railroad Corridor |
| Corridor ACE | Nanawale/Highway Corridor |
| Corridor DE | Leilani/Highway Corridor |

Below is a brief description of the five segments:

Segment A - This segment, referred to as the Nanawale segment, is common to both the Nanawale/Railroad corridor and the Nanawale/Highway corridor. It originates at the geothermal plant site and proceeds north across Nanawale Farm Ranch Lands, then west along the edge of Nanawale Estates Subdivision. It terminates at the State-owned lands of Keonepoko Ki ahupuaa, near the mauka corner of Hawaiian Beaches Subdivision.

Segment B - This segment originates along Kahakai Road near Hawaiian Beaches Subdivision and proceeds along the northern boundary of the subdivision to the former railroad alignment, which it then follows north to the Puna Substation. Proceeding towards the substation, the first 4 1/2 miles of this segment cross vacant State-owned lands of tall grasses and scattered Ohia trees. The segment then passes through Hawaiian Paradise Park, a one-acre agriculture lot subdivision, for close to 4 miles. This portion of the subdivision is sparsely populated with between 25 and 50 developed parcels. The final 3 1/2 miles of the segment continue to follow the railroad route through scrub Ohia trees and the Puna Sugar lands to the substation.
Segment C - This segment is a "connector" between the Nanawale segment and the Highway segment. It primarily follows Kahakai Road between Hawaiian Beaches and Pahoa town, and encompasses State-owned land, including the Pahoa Agricultural Park. It does not include the lands of Keonepoko Homesteads along the highway. Segment C terminates near the Pahoa landing strip.

Segment D - This segment is referred to as the Leilani segment because it originates at the Pohoiki geothermal plant site and heads west, along the northern edge of Leilani Estates Subdivision. It completely avoids the State conservation lands of Nanawale Forest Reserve on the right. The segment heads north for a short distance spanning Kalapana Road, then veers off to the northwest across former sugar lands and vacant State-owned lands on the west side (mauka) of Pahoa. This segment terminates across Pahoa Highway (Highway 130) from the Pahoa landing strip and segment C.

Segment E - The highway segment is common to both the Nanawale/Highway corridor and the Leilani/Highway corridor. It extends along Pahoa Highway from the Pahoa landing strip to just south of Keaau, at which point it continues northeast to the Puna Substation. Near its origin, segment E passes through the Maku'u parcel of Hawaiian Home Lands, portions of which have been subdivided and leased to native Hawaiian beneficiaries. It then crosses the eastern tip of Ainaloa Subdivision and 3-1/2 miles of Orchid Land Estates three-acre agriculture lot subdivision on the mauka side of the highway. On the makai side, this corridor segment passes through 3-3/4 miles of Hawaiian Paradise Park one-acre agriculture lot subdivision. North of the subdivisions, the corridor segment includes vacant scrub Ohia lands and former sugarcane fields, terminating at the substation near the Puna Sugar Mill.

## C. CORRIDOR EVALUATION

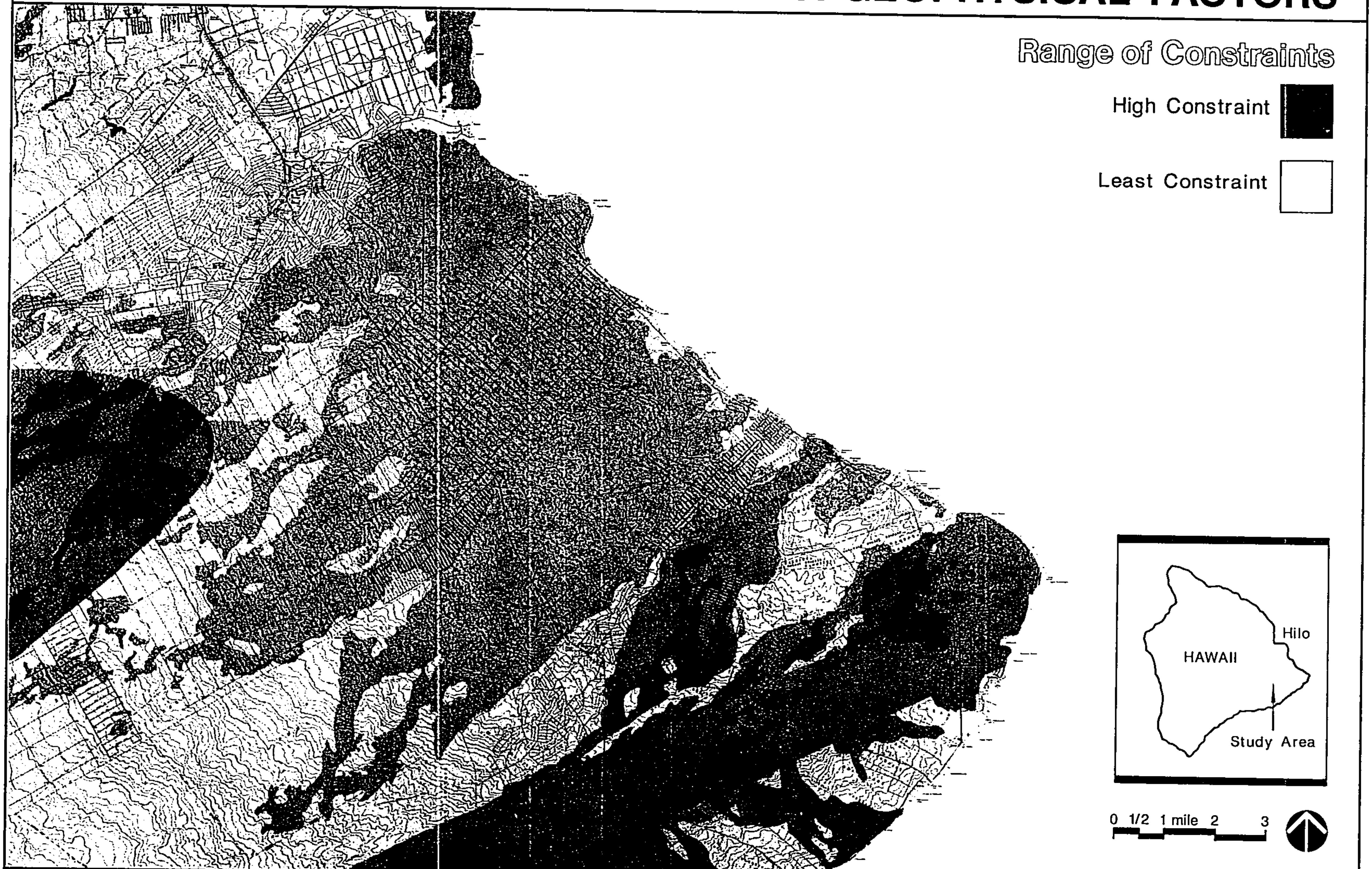
To generate a rating for each corridor to serve as a basis for comparing the corridor alternatives, "test routes" were identified by going through the lightest areas of the composite maps. The test results provide a point of reference to evaluate each segment against all the previously mapped data factors. These test routes were overlaid on each broadscale data factor constraint map. Each time the test route passed through either a high or medium constraint area, the linear distance through the constraint area was measured in inches. The unit of measurement is a relative figure, depending upon the scale of the map or, the actual conditions in the field. Therefore the measurement of constraint becomes the "score" for that data factor in the particular segment where it was encountered. Exhibit V-8 shows a map of the test routes and V-9 shows the scores for each data factor and each segment of the test routes. The table shows a total score for each route.

In calculating the total score, each high constraint score was multiplied by three to reflect its relative importance while each medium score was recorded as it was measured. The test route with the least constraints (the lowest total score) was "D" - the one just mountainward of the State Highway. The next lowest score was "AC" - the one just seaward of the State Highway. Potential route "AB" - the former railroad alignment - had the highest score but is still considered an acceptable alternative because its score is not significantly greater than the other two potential routes.

Note that the three total scores are quite close in value which reflects the overall similarity of the study area in general. Because of this, it was decided to study all the corridors in the detailed analysis phase. The results of this study are described in Chapter VI.

## EXHIBIT V–1

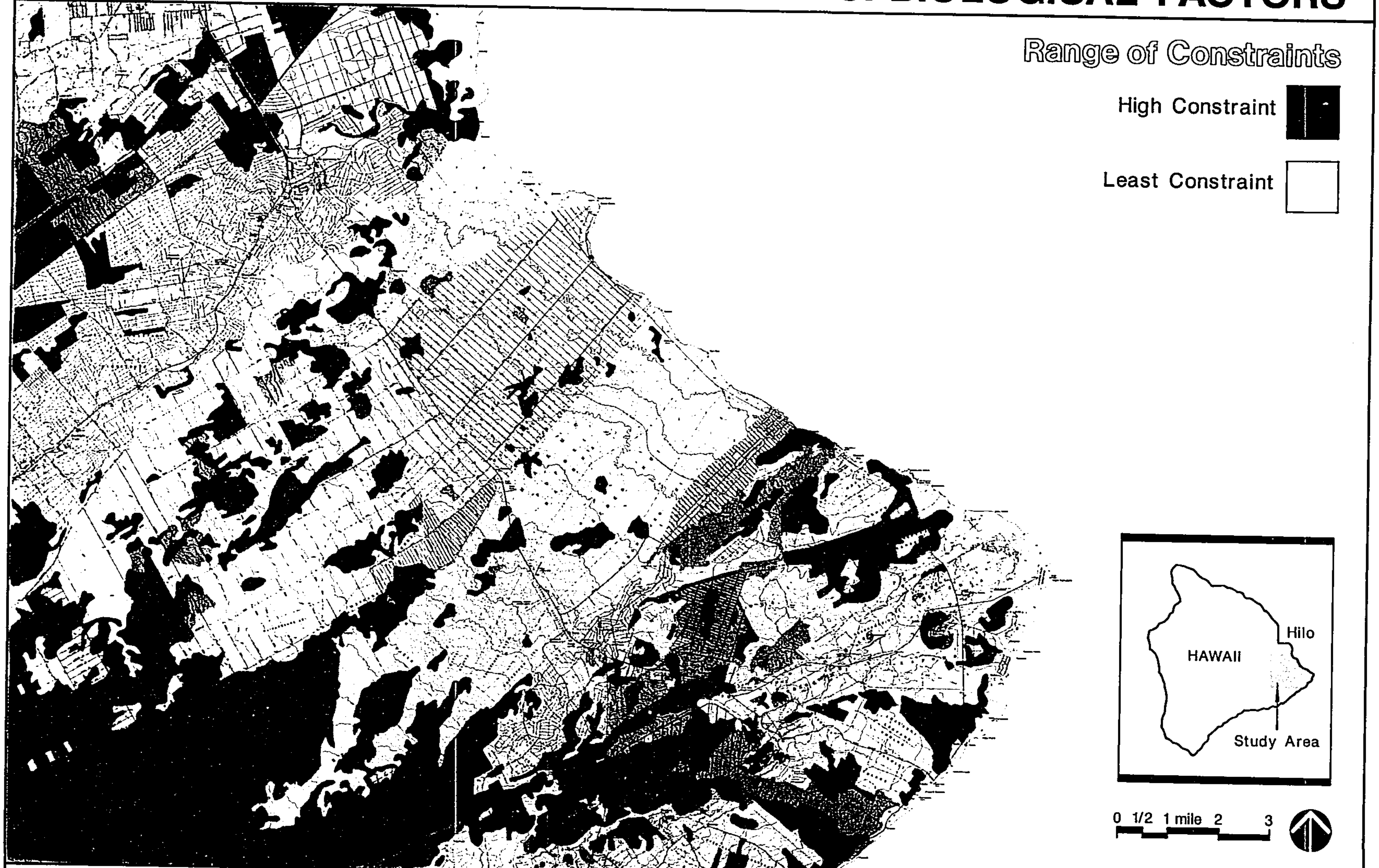
# COMPOSITE CONSTRAINTS: GEOPHYSICAL FACTORS




POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY · DHM inc.

# EXHIBIT V–2

## COMPOSITE CONSTRAINTS: BIOLOGICAL FACTORS




POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.

# EXHIBIT V-3

## COMPOSITE CONSTRAINTS: SOCIO-ECONOMIC FACTORS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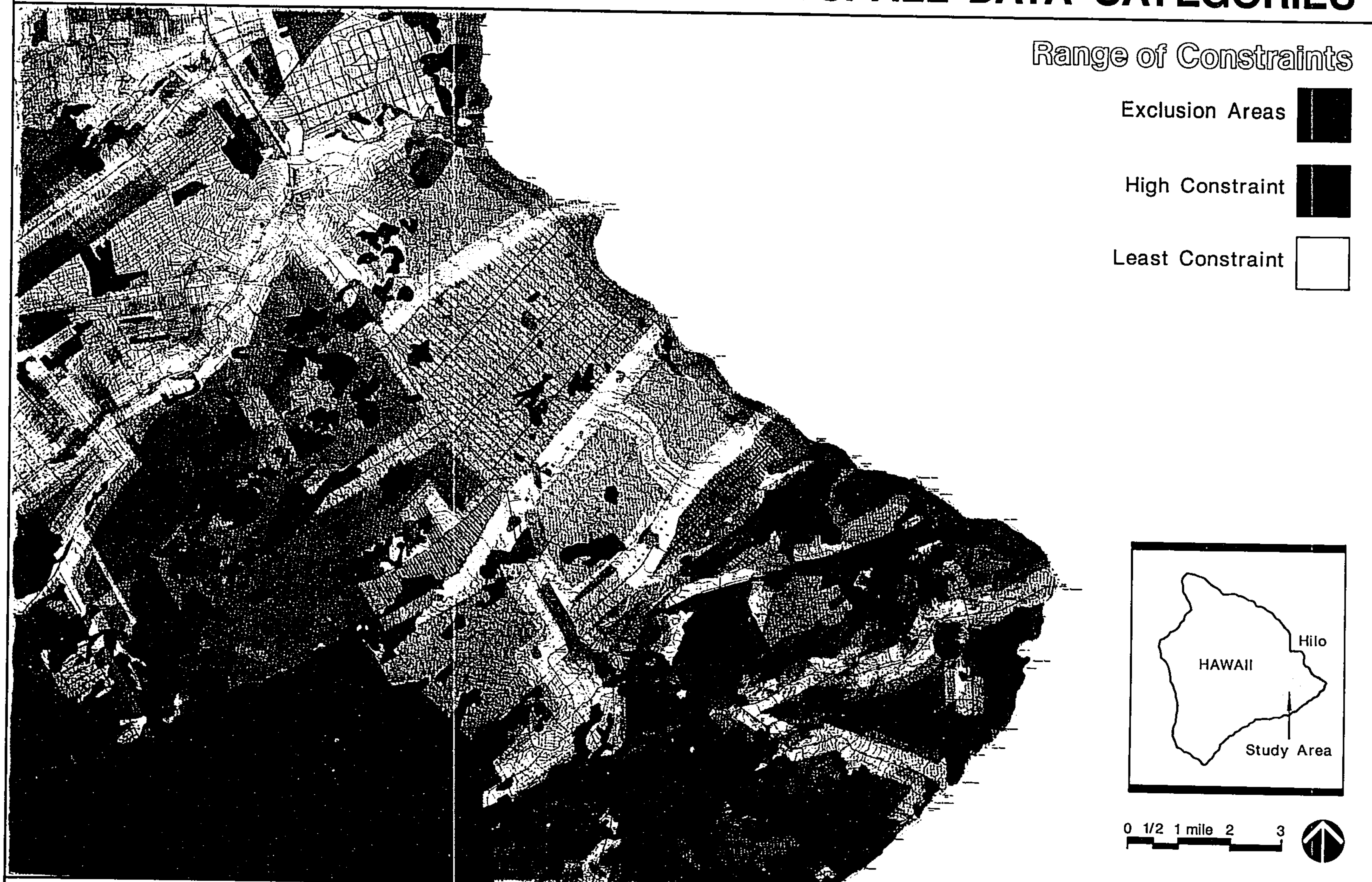
## EXHIBIT V-4

# COMPOSITE CONSTRAINTS: COST FACTORS

# EXHIBIT V–5

## COMPOSITE CONSTRAINTS: ALL DATA CATEGORIES




POHOIKI GEOTHERMAL TRANSMISSION LINE ROUTING STUDY • DHM inc.

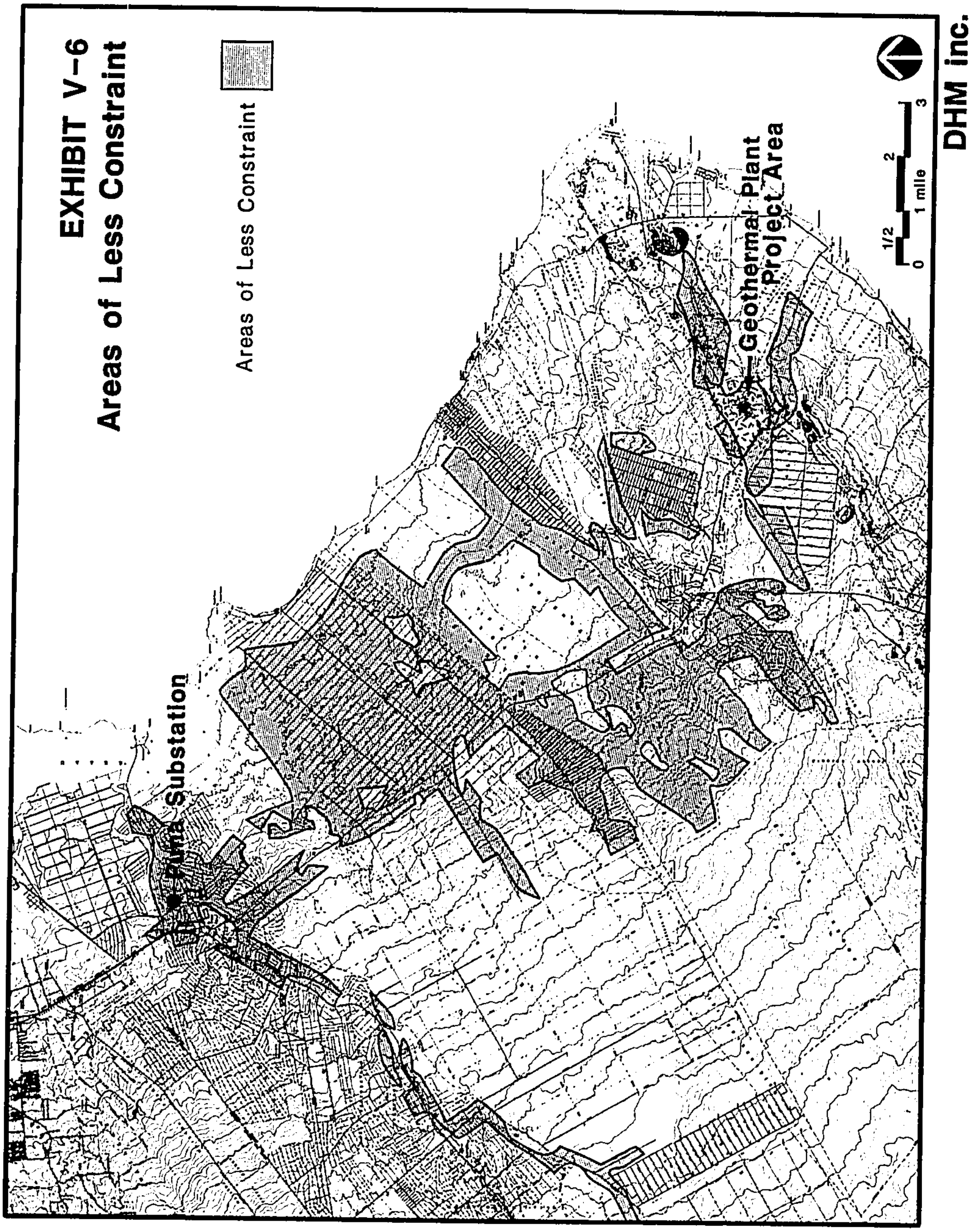


EXHIBIT V-6
Areas of Less Constraint
Areas of Less Constraint
Puna Substation
Geothermal Plant Project Area
0 1/2 1 mile 2 3
DHM inc.

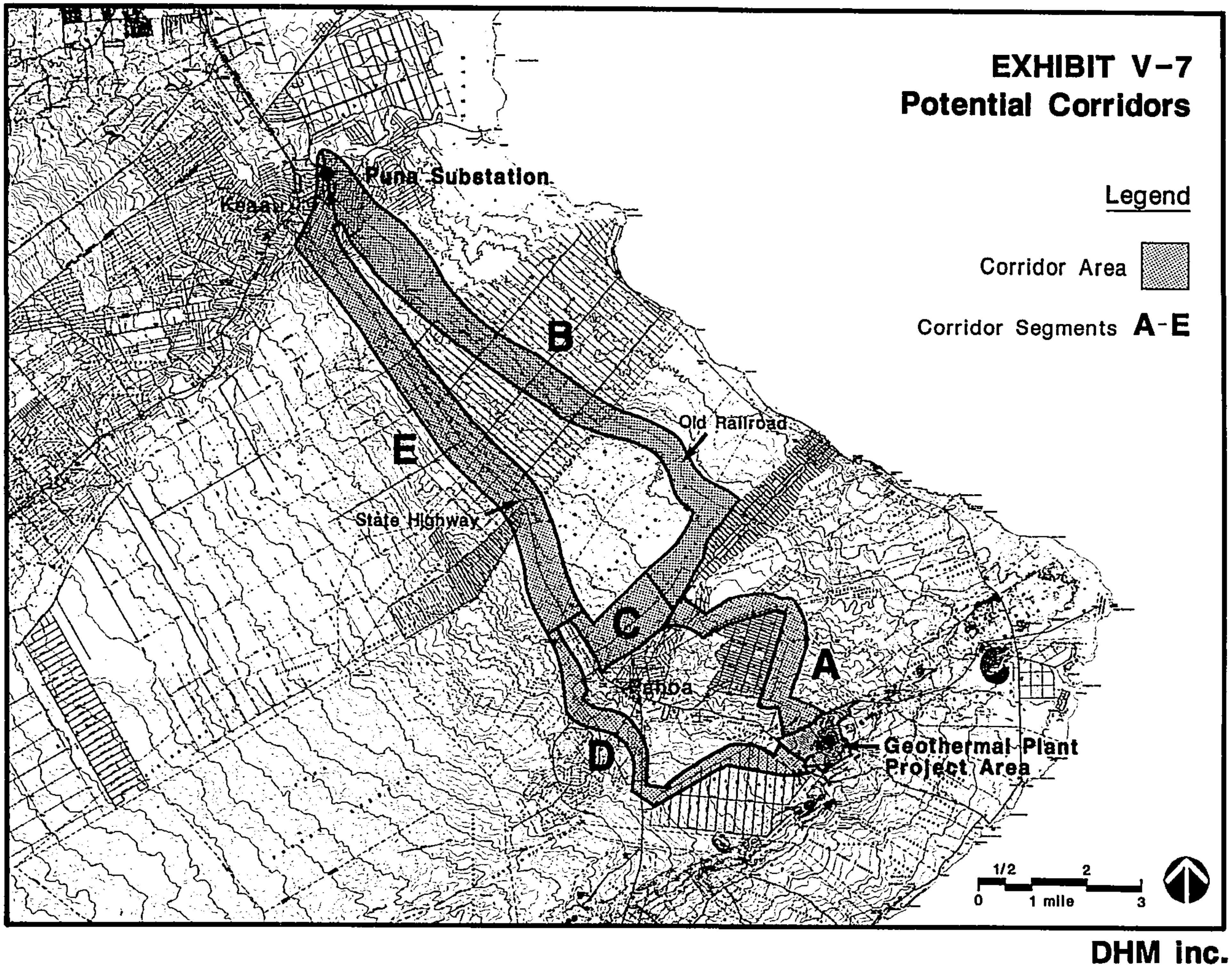


EXHIBIT V-7
Potential Corridors
Legend
Corridor Area
Corridor Segments A-E
Puna Substation
B
E
Old Railroad
State Highway
C
A
D
Pahoa
Geothermal Plant
Project Area
0
1/2
1 mile
2
3
DHM inc.

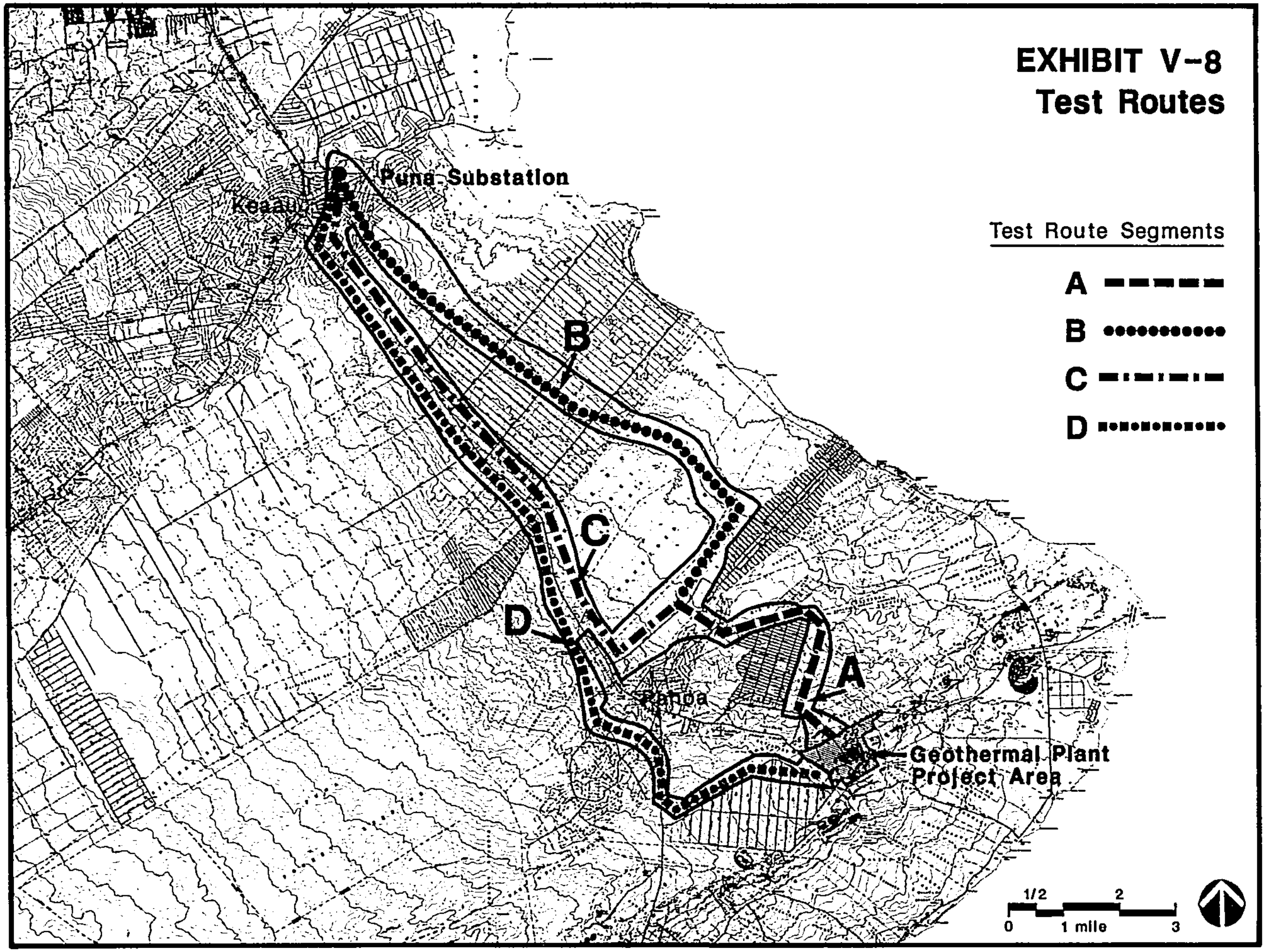


EXHIBIT V-8
Test Routes
Test Route Segments
A
B
C
D
Puna Substation
Geothermal Plant
Project Area
1/2
2
0
1 mile
3

DHM Inc.

EXHIBIT V-9

CONSTRAINT SCORES FOR TEST ROUTE SEGMENTS, BY DATA FACTOR

Numbers represent the length of constraint area crossed by a test route.

| DATA FACTOR | TEST ROUTE SEGMENT A | B | C | D |
|---|---|---|---|---|
| GEOPHYSICAL | | | | |
| 1. Slope and Soils | | | | |
| High | | | | |
| Medium | 3.30 | 16.83 | 18.28 | 18.96 |
| 2. Geologic Hazards | | | | |
| High | 7.12 | | | 5.73 |
| Medium | 1.41 | 20.91 | 20.91 | 23.54 |
| BIOLOGICAL | | | | |
| 1. Vegetation | | | | |
| High | 0.56 | 1.17 | 1.94 | 4.60 |
| Medium | 2.94 | | 0.36 | 0.20 |
| 2. Wildlife | | | | |
| High | | 0.57 | | 0.30 |
| Medium | 3.57 | 0.60 | 1.86 | 4.74 |
| SOCIO-ECONOMIC | | | | |
| 1. Recreation | | | | |
| High | | | | |
| Medium | 0.12 | | | 0.35 |
| 2. Land Use | | | | |
| High | | | | |
| Medium | 6.64 | 10.08 | 12.00 | 16.68 |
| 3. Transportation and Utilities | | | | |
| High | 1.44 | 8.56 | 3.40 | 0.88 |
| 4. Land Ownership | | | | |
| High | 2.32 | 6.50 | 6.78 | 11.28 |
| Medium | 6.94 | 6.07 | 11.69 | 14.36 |
| 5. History and Archaeology | | | | |
| High | | | | 0.46 |
| Medium | 0.82 | 17.34 | 10.58 | 13.66 |

| DATA FACTOR | TEST ROUTE SEGMENT A | B | C | D |
|---|---|---|---|---|
| 6. Land Regulation | | | | |
| High | 0.11 | | | 0.48 |
| COST | | | | |
| 1. Land Value | | | | |
| High | 2.36 | 6.52 | 10.69 | 12.32 |
| Medium | 7.02 | 6.10 | 6.81 | 12.03 |
| 2. Access | | | | |
| High | | 1.84 | | |
| Medium | 1.60 | 7.60 | 2.44 | 4.60 |
| 3. Maintenance | | | | |
| High | 0.66 | 1.17 | 1.94 | 5.00 |
| Medium | 2.67 | | 0.37 | 0.48 |
| HIGH (3x) + MEDIUM | 80.74 | 164.52 | 159.50 | 232.75 |

RATINGS FOR THREE TEST ROUTES

H (3x) + M

1. A+B = 245.26
2. A+C = 240.29
3. D = 232.75

# CHAPTER VI

## CHAPTER VI: DETAILED ANALYSIS

### A. MAP FORMAT AND DATA

The detailed analysis of conditions in the study corridors requires a larger map scale. The Phase 2 mapping scale is 1:24,000 (1 inch = 2,000 feet), whereas the Phase 1 (Broadscale) analysis scale is 1:36,000 (1 inch = 3,000 feet). Both phases use USGS quadrangle sheets for their base. The study corridors are divided into four sections for suitable page-sized display in this report, beginning at the geothermal plant project area in Section 1 and terminating near the Puna substation in Section 4. The segments are shown in Exhibit VI-1.

Air photos[57] were used to provide additional information on land use, man-made and natural features such as vegetation, roads, developed lands. Data from these were verified by field surveys. Consequently, much of the data shown on the large scale maps is new information collected during field surveys (see Appendices B-F) expressly for this project. Field surveys were performed by scientists and professional experts to identify the following detailed information: archaeology and history, ornithology, entomology, botany, geology and soils, and visual resources.[58] Other relevant data was also mapped, including existing telephone lines, existing electric transmission and distribution lines, a new Hawaiian Home Lands subdivision on both sides of Highway 130, lands in agriculture production, and land ownership.

Above data are shown in two data maps for each section: (1) Physical Conditions and (2) Visual Resources. The following paragraphs describe the data factors placed on each map, and their relative constraints and opportunities for transmission line alignment.

### B. PHYSICAL CONDITIONS

#### 1. Land Use

Land use factors mapped in the study corridors include urban lands, productive agriculture lands, residential agriculture lands, existing utility line and road rights-of-way, the planned Pahoa By-pass Highway, and archaeological and historic sites.

Productive agricultural lands are typically used for field crop cultivation which includes nurseries, orchards, or other diverse crops. While these lands are not a highly restrictive constraint to a transmission line route, they are more constraining than vacant or pasture lands due to the level of human activity and land value. These lands are identified on the detailed analysis maps based on field checks of productive agricultural lands mapped by the State Department of Agriculture (as described in Phase 1).

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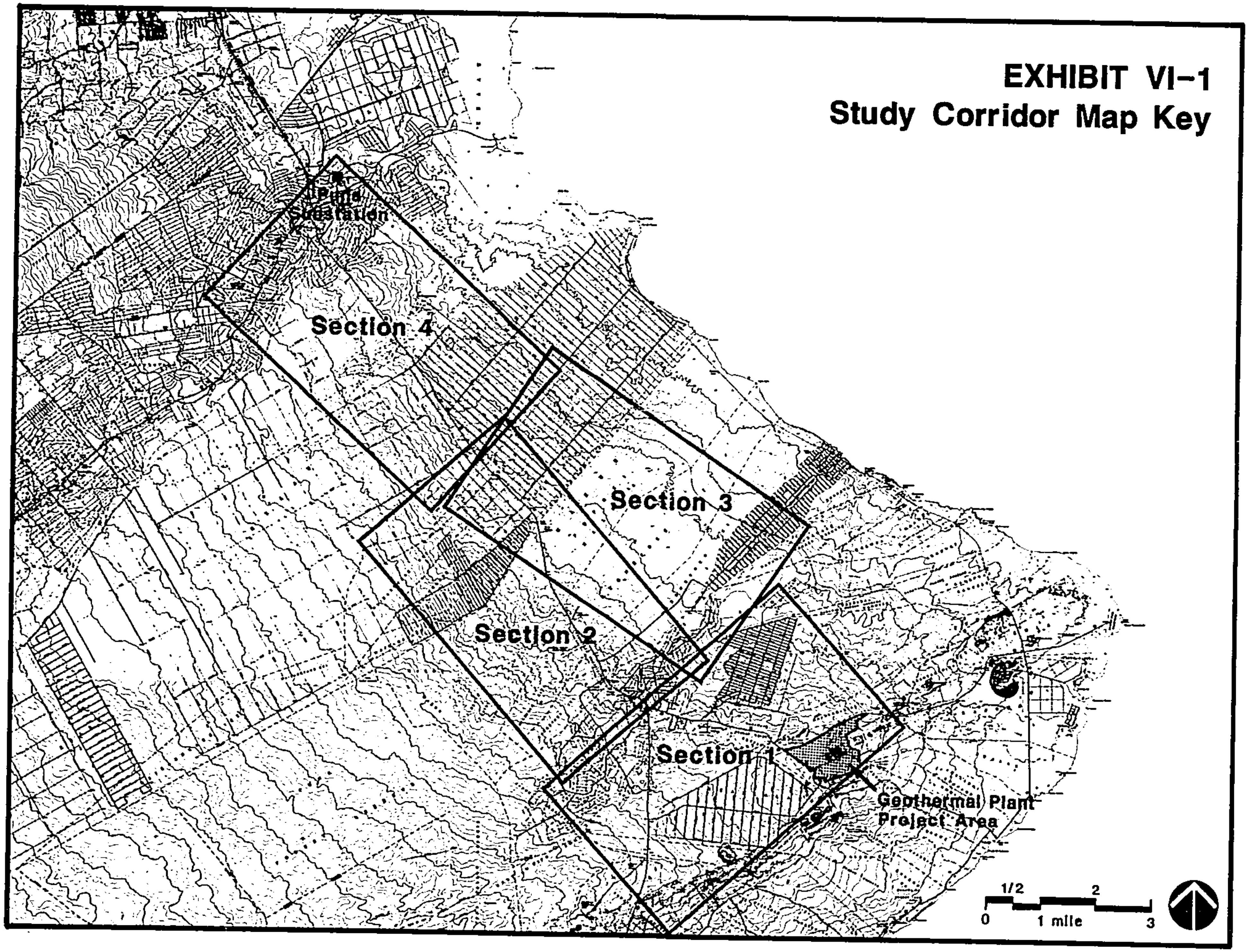
57. Air photos are dated 1977. Field checks were used to update the air photo information and to verify changes in land uses.

58. Field surveys were conducted of the entire study corridors with the exception of the agricultural subdivisions of Orchid Land Estates, Ainaloa, and Hawaiian Paradise Park as these areas have been physically disturbed.

## EXHIBIT VI-1
## Study Corridor Map Key




DHM inc.

There are four agriculture-zoned subdivisions in the corridors (Hawaiian Paradise Park, Orchid Land Estates, Ainaloa Estates and Hawaiian Home Lands) which, for the most part, are not in agricultural use, but are more residential in character. The agricultural subdivisions form a wide block of land from the ocean to the slopes of Kilauea over which a transmission line must cross if it is to connect the Pohoiki geothermal power plant with the Puna substation. These subdivisions and two small areas of urban land in Keaau which extend into the corridor, are a general constraint due to the degree of human activity there.

The existing system of roads within the corridors are opportunities for alignments because of direct access available for transmission line construction and maintenance. This includes Highway 130 between Keaau and Pahoa and the agricultural subdivision roads. Former sugarcane roads, jeep trails, and the former railroad alignment (now a jeep trail except through Hawaiian Paradise Park where it is a road), offer similar opportunities for a transmission line alignment because of the access they could provide through otherwise difficult access areas.

The opportunities associated with existing utility lines are contingent upon many factors including road rights-of-way, utility (HELCO) rights-of-way, and technical aspects. For example the existing 34.5 kV transmission line and telephone line along Highway 130 are located within the highway right-of-way. However, the right-of-way width is not sufficient to allow an additional transmission line adjacent to the existing line, and installation of the 69 kV line on the same 34.5 kV poles would cause considerable outages to the present customers throughout Puna during construction. Therefore, the existing 34.5 kV line is considered a constraint for alignment selection. Hawaiian Paradise Park, Orchid Land Estates, and Ainaloa appear to provide opportunity for construction of the 69 kV line within an existing HELCO right-of-way by installing higher poles with the new transmission lines on top and the existing distribution lines underneath. Outages to the distribution line would occur during construction, however the customers affected would be limited to those within about a half-mile area.

Pahoa By-pass Highway, a change in Highway 130 which is scheduled for construction in 1988, will by-pass Pahoa to the east. Its route is through agricultural land with few or no residences, however, it presented no real opportunities for a powerline alignment.

Some archaeological and historic sites[59] are located in the corridors and are a constraint in that although the conductors of the line may be allowed to cross overhead, specific pole sites must not disturb them.

2. Biological

Based on air photos, areas of dense trees were identified because these may affect powerline construction and maintenance by requiring extensive cutbacks. The botanical survey (Appendix C) identified an area of diverse plant growth which is shown on the detailed analysis maps. Although there is a moderate coverage of Ohia trees throughout Puna, much of the growth is

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59. Appendix B, Archaeological Survey.

stunted, sparse and immature. Because of the relative youth of Ohia in the study area, the plant communities have only a few of the potential number of species which would develop in a mature forest. Overall, "the floristic quality was consistently poor and the same species composition was repeatedly expressed"[60] in the study areas.

The ornithological survey identified the presence of three native birds and several common non-native species (see Appendix D). The native birds found were the 'Elepaio, the 'Io (Hawaiian Hawk), and the Hawaiian Stilt. The Hawaiian Stilt were sighted on small ponds in the vicinity of the Puna Substation. The 'Elepaio and the 'Io were seen in the makai corridor above Nanawale Farm Ranch Lands, however specific locations for them are not mapped because these birds apparently use broad areas in Puna District and are not dependent on any specific locations, although they favor forests at the higher elevations. The survey report notes that the environments in the study corridors are not particularly hospitable towards native species and that although they "...may occasionally use these areas, it is not likely that they are dependent upon them".[61]

The entomological survey (see Appendix E) found several native species of insects. Their habitats are all below ground in caves or lava tubes. From highest to lowest significance, the areas are: "...1) Pahoa Cave, both upper and lower caves, 2) The kipuka area south of Pahoa..., 3) The Seaview Road site".[62] Generally, the presence of insects is determined by the surrounding vegetation. An important insect habitat in the caves are Ohia roots which enter the cave roof from the ground surface. The report notes that in order to preserve the insects, the surrounding vegetation must be protected, especially from herbicides which may be used to control vegetation as part of power line maintenance practices. Also there is a potential for the infiltration of herbicides into the caves which could present a serious threat to the fragile ecosystems there.

3. Geophysical

The major finding of the field survey (see Appendix F) is that there is a high probability of encountering lava tubes and caves which ultimately will affect pole foundations and the precise alignment. The caves are ubiquitous to the area and are often obscured by vegetation. With the exception of the larger underground formations described above in the biological section, the caves or lava tubes will generally need to be identified during construction and avoided.

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60. Appendix C, Botanical Survey.

61. Appendix D, Ornithology Survey Report, p. 9.

62. Appendix E, Entomology Survey, p. 6.

### 4. Land Ownership

Land ownership was mapped from tax key maps which identify each parcel of land, its owner, size and geographic location. Major land owners include the public[63], Hawaiian Home Lands, and private entities.
State lands consist mostly of large parcels (greater than 10 acres) although there are some small leased parcels.

Hawaiian Home Lands are on both sides of Highway 130, just south of Hawaiian Paradise Park and Ainaloa Estates. More than half of these lands have been divided into agricultural lots of 5-acres (on the makai side of Highway 130) and 2-acres (on the mauka side of Highway 130).

Privately owned lands consist of large vacant or agriculture parcels as well as small residential parcels in urban areas or agricultural subdivisions.

## C. VISUAL RESOURCES

A primary aesthetic consideration in the siting of a transmission line is the extent to which the poles and conductors are screened from view at important vantage points by vegetation, natural landforms and buildings or structures. In the case of the study corridor, the area within visual range of the major roadways gets the most frequent view exposure since these roadways act as a continuous vantage point for motorists and passengers. These viewers include local residents, island-wide residents, and visitors to the island.

### 1. Visual Screens

The physical features which screen views from major vantage points are indicated on the detailed analysis maps. Four types of screens are noted: 1) solid vegetation, which consists of a thick growth of trees near the road, 2) partial vegetation, which is thinner or lower vegetative growth that allows occasional or penetrated views, 3) urban, which is usually created by the buildings and vegetation of an urban environment, and can be either partial or solid in effect, and 4) berms, which may be either man-made road cuts or natural earth formations that limit all or part of the view from the road.

Partial vegetation screens and urban screens may allow occasional or penetrated views to a transmission line. The effectiveness of a berm as a screen depends upon berm height, distance from the road, vegetation cover, and the slope of the ground beyond it. The major constraint for all types of screens is if they are not tall enough to screen the entire pole, all or portions of the poles may be silhouetted against the sky, resulting in a highly visible contrast of form and color.

Urban screens and residential areas can be a constraint if the line is highly visible from the urban or residential area itself.

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63. Nearly all public land in the corridors belongs to the State of Hawaii, only a small parcel along Highway 130 near Keaau belongs to the County of Hawaii. There is no federally owned land.

On the other hand, solid vegetation screens offer the best opportunity for masking the view of a transmission line. Solid screens virtually block one's view at the edge of the road, creating an enclosure and directing the line of sight away from the screen. A transmission line beyond the screen or well within it would not be visible from the road. Partial vegetation screens are effective if the line is set back far enough to appear no taller than the screen itself, and so views of the line are sufficiently diffused by the vegetation.

The urban screens of Pahoa and Keaau are wide enough that the corridors beyond are not visible from the main roads. The agriculture subdivisions and lands in agriculture production serve as partial screens in some locations along the major roads.

The majority of the berms mapped are the result of man-made road cuts and are immediately adjacent to the road. They can serve as solid screens if the line is located far enough back so that it appears no taller than the berm itself. Berms are also effective screens if they are covered with trees or if the ground beyond slopes away. These conditions can vary considerably over short distances however.

2. Views

Views of the corridor from major roads are indicated on the detailed analysis maps along with a verbal description for each in terms of openness and viewgrounds (ie. *foreground, middleground, background*).[64]

All views are constraints to the extent that they allow a transmission line to be fully visible from a major vantage point. Rights-of-way of major roads are a visual constraint because lines adjacent to major roads are highly visible, often silhouetted, and visually exposed to large numbers of people. Existing utility lines (electric and/or telephone) in road rights-of-way are an additional constraint because of the cluttered effect which may be created by adding another line. Transmission lines would be very visible and difficult to conceal when crossing major roads, so the number of road crossings should be minimized. If the line must cross a major road, it should do so at a right angle, if possible, in order to shorten the visible length of the line.

Although much of the existing urban and residential land in the corridor is heavily vegetated, thereby providing screening opportunities for a transmission line, there is also potential for significant views of the line. Open views are predominant along existing roadways and in areas with little vegetation or cleared of vegetation. Site-specific screening and view constraints are not mapped for these areas; all urban and residential lands are considered equally as a constraint in terms of visual resources.

Generally, views of the corridor from major roadways are infrequent and short in duration, especially considering the speed of passing motorists and passengers. Thus, the visual impact of views to the transmission line can be minimized by careful alignment within the viewplane. In the case of open views where a vista of the foreground, middleground and background is

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64. DHM Planners, inc. for Parsons Hawaii et. al., Visual Impact Analysis of Proposed 300 kVdc Line, Hawaii Deep Water Cable Program, January 1987.

present, it is preferable to locate the transmission line either directly in front of a total backdrop to avoid having poles and conductors silhouetted against the sky, or at a distance far enough away that the line is visually absorbed by the landscape. Where only a foreground is visible, the line can be placed immediately behind the screen which blocks the middleground and background. Alternately, it can be placed immediately in front of the screen, using it as a backdrop to minimize visual impact.

When there is more than one utility line along a major roadway, placement of the separate lines on a single pole minimizes the visual impact and cluttered appearance of several lines.

D. <u>DESCRIPTION OF ALIGNMENTS</u>

On the basis of these constraint analyses, a preferred alignment was delineated. The path of this alignment, in relation to the various data factors for all four (4) map sections, is shown in Exhibits VI-2 through VI-9. Also shown are alternative alignment segments. A narrative accompanying each map section describes the conditions encountered by the preferred alignment travelling northwest, and explains the reasons why it was selected over alternative alignments.

SECTION 1 (Exhibits VI-2 and VI-3)

<u>Alignment "A"</u>: This alignment originates on the western edge of the geothermal plant project area at Pohoiki Road. The alignment crosses Pohoiki Road and follows the western property lines of Pohoiki Bay Estates, a partially subdivided subdivision. At the southwest corner of Pohoiki Bay Estates, the alignment heads west along the outside edge of Nanawale Forest Reserve, at no time entering the respective Conservation District. At Reference Marker 1A, as shown on the map, the alignment turns southwest to follow a dirt road located on the northwest edge of Leilani Estates Subdivision, parallel to Kahukai Street. This dirt road is also marked by the dense vegetation along it, consisting of early stage <u>Ohia</u> forest and thick undergrowth of <u>Uluhe</u> fern. The alignment is located on Puna Sugar Company land to avoid crossing the numerous one-acre lots of Leilani Estates. Before Reference Marker 3A, the alignment unavoidably passes through the dense trees (which continue beyond the corridor) and crosses Kalapana Road at a right angle to minimize visual impacts. This is the first point at which the line is openly visible from a road since it originally crossed Pohoiki Road near the geothermal site. Once across Kalapana Road, the alignment parallels the road with a sufficient setback to be screened by the vegetation along the road and, where visible, allow the solid vegetation screen in the middleground serve as a backdrop to the line. At approximately Reference Marker 4A, the alignment heads northwest across former sugarcane fields to the end of Section 1.

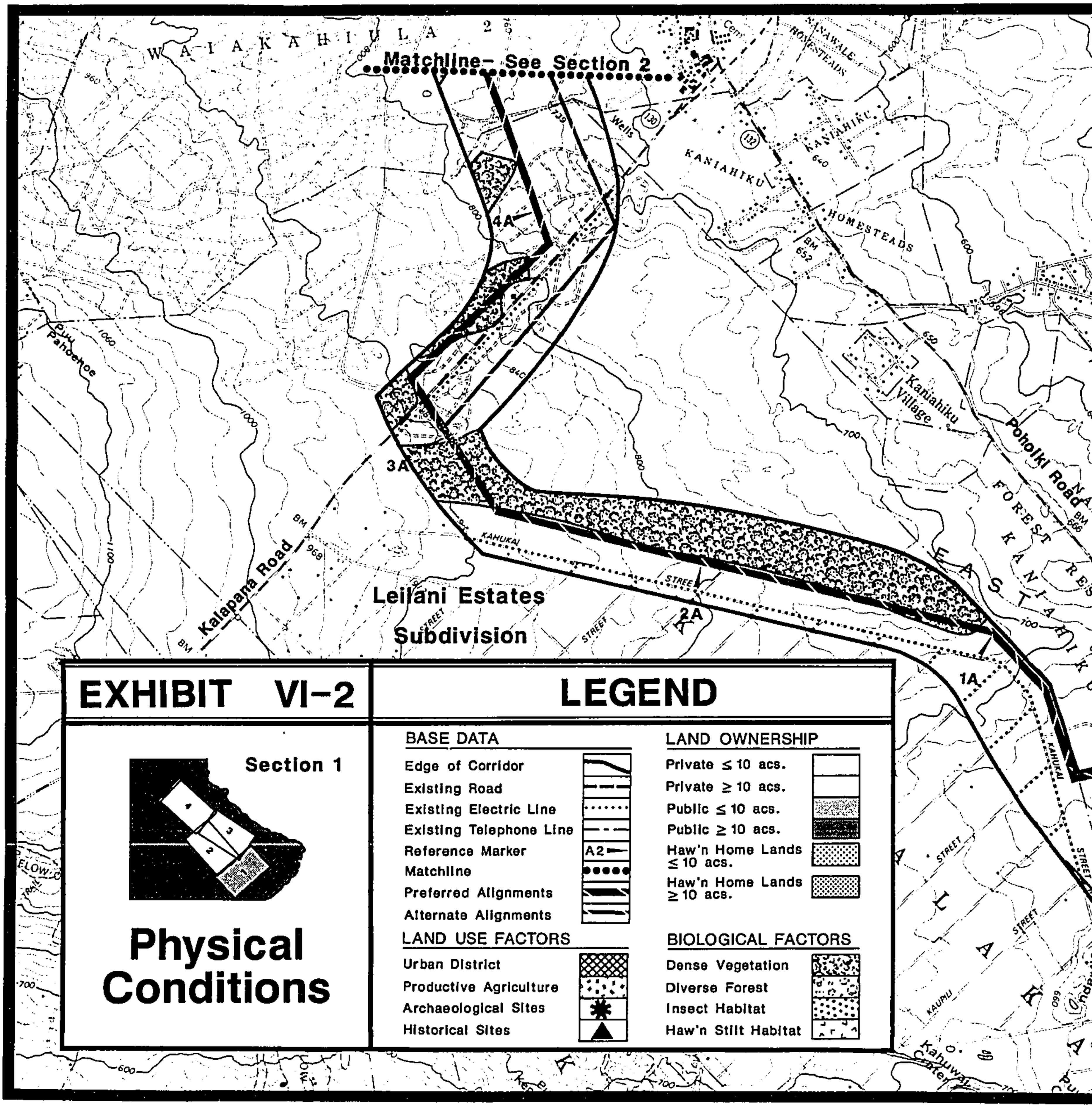
An alternative alignment segment begins at Reference Marker 3A and parallels Kalapana Road on the east side. This alternative crosses the former sugarcane fields of Puna Sugar Company to the edge of the corridor where it turns to cross Kalapana Road. Although the alternative is set back 500 feet from the road, it is still within the open foreground view, thus visually less preferable.

<u>Alignment "B"</u>: Preferred alignment "B" originates on the northern edge of the geothermal plant project area at Kapoho Road. Thermal Power intends to route the transmission line along the existing dirt road from the proposed power plant site near Puu Honuaula to Kapoho Road. From this point, the preferred alignment crosses Kapoho Road and heads northwest across open herbaceous weedland to the

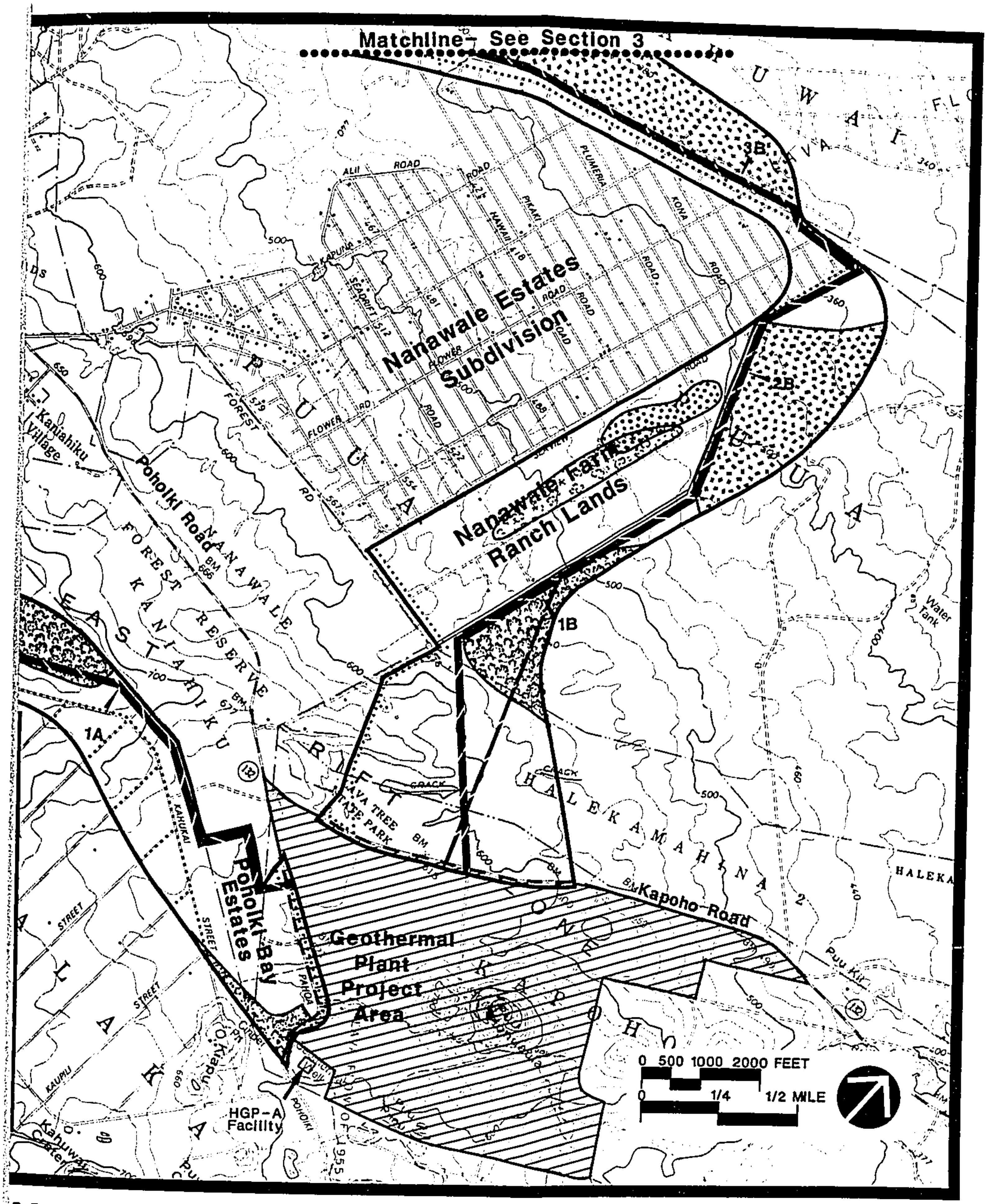
edge of Nanawale Farm Ranch Lands, avoiding an area of dense tree growth to minimize environmental disturbance and additional construction and maintenance costs. Likewise, by following an existing dirt road along the east side of the Ranch Lands, considerable disturbance to the forest area is avoided. Views to the alignment are screened by a berm and dense vegetation along Kapoho Road. The preferred alignment continues outside the west and north boundaries of the Nanawale Farm Ranch Lands to avoid the numerous subdivided parcels and areas of diverse forest and unique insect habitat identified during biological field surveys. Near Reference Marker 2B, the alignment is on the edge of productive orchard lands as identified by the State Department of Agriculture.

Between Reference Marker 2B and edge of Section 1, the alignment runs adjacent to the northern edge of Nanawale Estates Subdivision. Only at the northeast corner of the subdivision (about halfway between Reference Marker 2B and 3B) is the preferred alignment located inside the subdivision property line, along an existing road. This is necessary to avoid routing the line through the Conservation District lands of Nanawale Forest Reserve. Once past the Forest Reserve, the alignment is located in State land which is leased to a large papaya growing company and is identified as productive agricultural land. By keeping the alignment close to the property line, it will have minimal impact to agricultural use of the land and will not be visible from the subdivision due to the dense vegetation screen along the road.

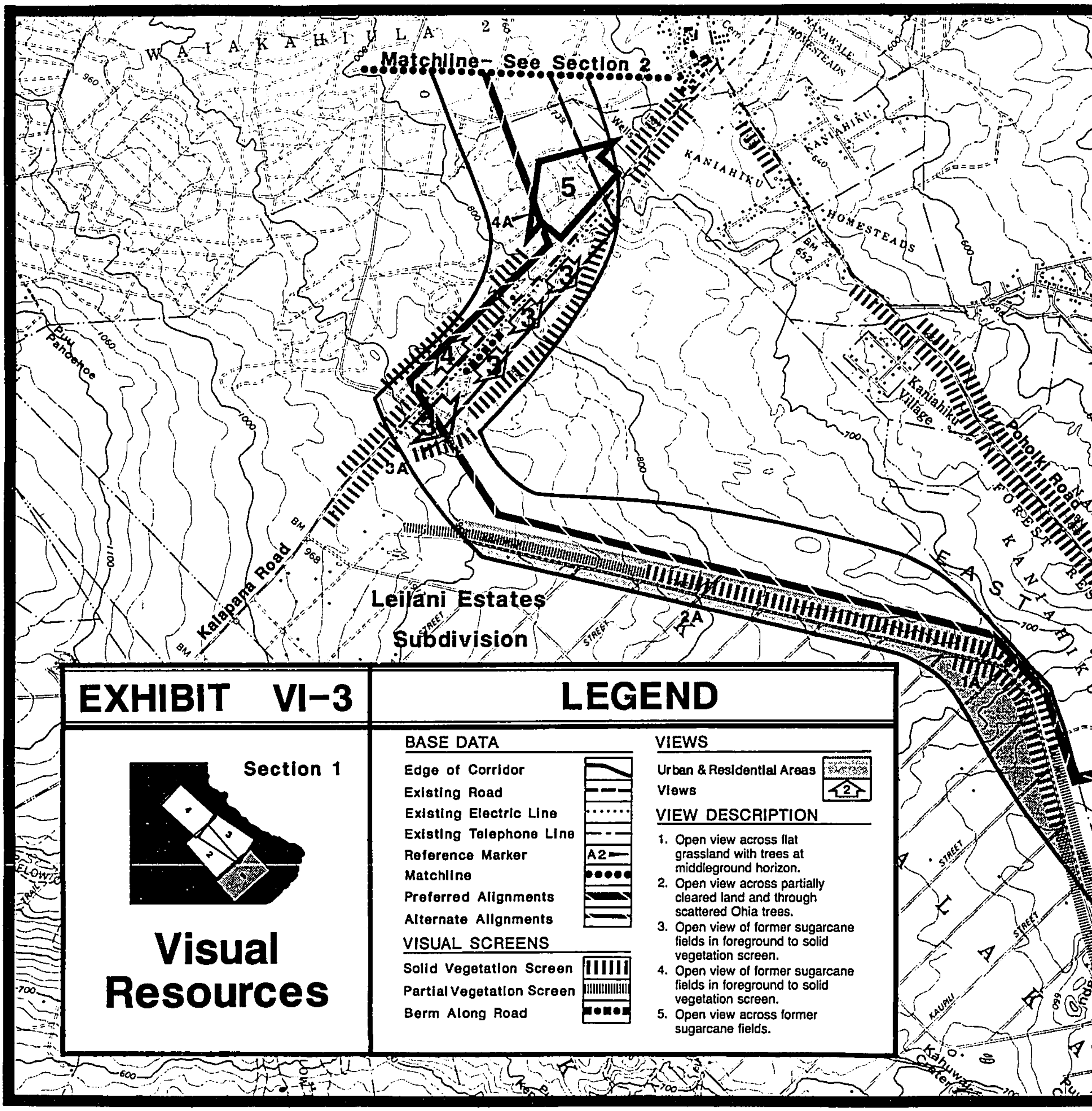
An alternative alignment segment also originates at Kapoho Road, a few hundred feet west of the preferred alignment, in order to cross the road and follow a property line between two large (50 acre) flag lots. This alignment avoids bisecting individual privately owned parcels, however it crosses through nearly a half mile of dense vegetation. Since all the parcels affected by the preferred alignment have the same owners and leasee, it was selected over this alternative. However, the final alignment is dependent on negotiations with the landowners involved.



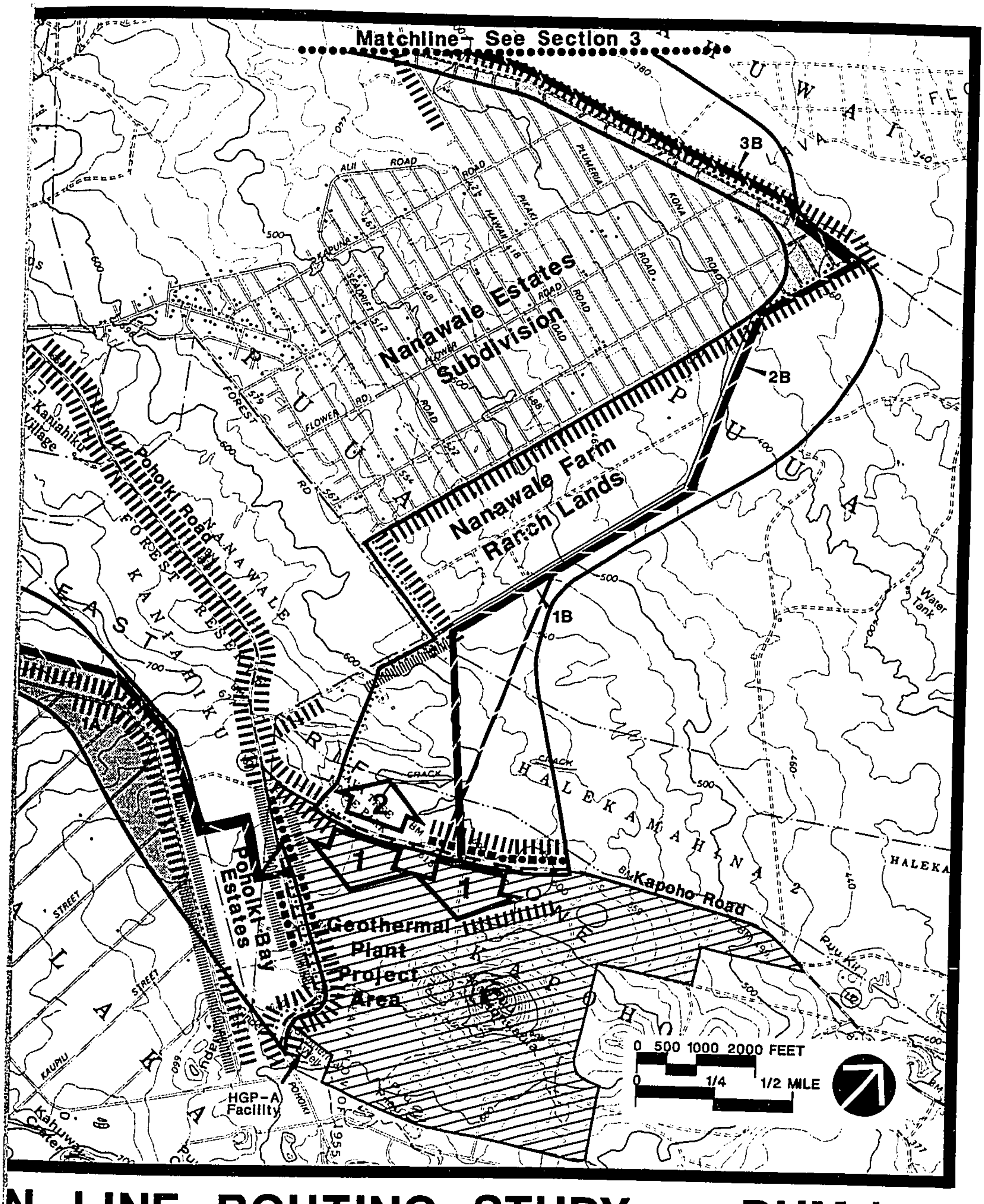

# POHOIKI GEOTHERMAL TRANSMISSION LINE




N LINE ROUTING STUDY ◦ DHM inc.




# POHOIKI GEOTHERMAL TRANSMISSION LINE




N LINE ROUTING STUDY ○ DHM inc.

SECTION 2 (Exhibits VI-4 and VI-5)

Alignment "A": The preferred alignment "A" continues across the former sugarcane fields, skirting a small kipuka of native forest which is a significant insect habitat. Near Reference Marker 5A, the alignment heads north along the existing Pahoa By-pass Road. The alignment is kept on the makai side of the road because of the Pahoa solid waste station and a burial cave archaeological site on the mauka side.

The alternative alignment to the north meets the preferred alignment near the solid waste station.

From the waste station until nearly Reference Marker 7A, the preferred alignment crosses State-owned land which is basically vacant lava land, overgrown with weeds and scattered scrub Ohia trees. Unavoidably, the alignment crosses the upper portion of Pahoa Cave which was identified during the field surveys as a sensitive insect habitat. The cave is believed to extend far upland, therefore, even a transmission line route outside the study corridor may not avoid crossing it. Significant care must be taken during design and construction of the line to avoid damaging the cave or exposing it to increased access.

Through the Hawaiian Home Lands of Maku'u (between Reference Marker 7A and Ainaloa), the alignment is located near the mauka edge of the study corridor to by-pass the newly subdivided 2-acre lots which are leased to native Hawaiian beneficiaries.

The alignment route through Ainaloa Subdivision was based on the location of the *preferred alignment in Orchid Land Estates. In Orchid Land, the alignment follows* 35th Avenue because it has the greatest length of existing distribution lines, thus existing utility rights-of-way. Also, 35th Avenue is a continuous road through the subdivision and has fewer existing homes along it than does 34th Avenue. In Ainaloa Subdivision however, the extension of 35th Avenue is a densely populated road with an existing distribution line.

There is native Ohia forest of short, pole-like habit on both sides of the highway through this section. Guava, mango and other alien trees are interspersed among the Ohia and the understory consists of weeds. The presence of the numerous houselots and agriculture lots disrupt the integrity of the forest, and as a result there is no continuity to plant formations.[65] This is the case throughout the subdivision areas in all corridor sections.

The alternative alignment through Ainaloa Subdivision follows a deadend, sparsely populated road with no existing utility ROW, to meet with 34th Avenue in Orchid Land Estates. This alternative is so located because in Section 4 it joins Highway 130.

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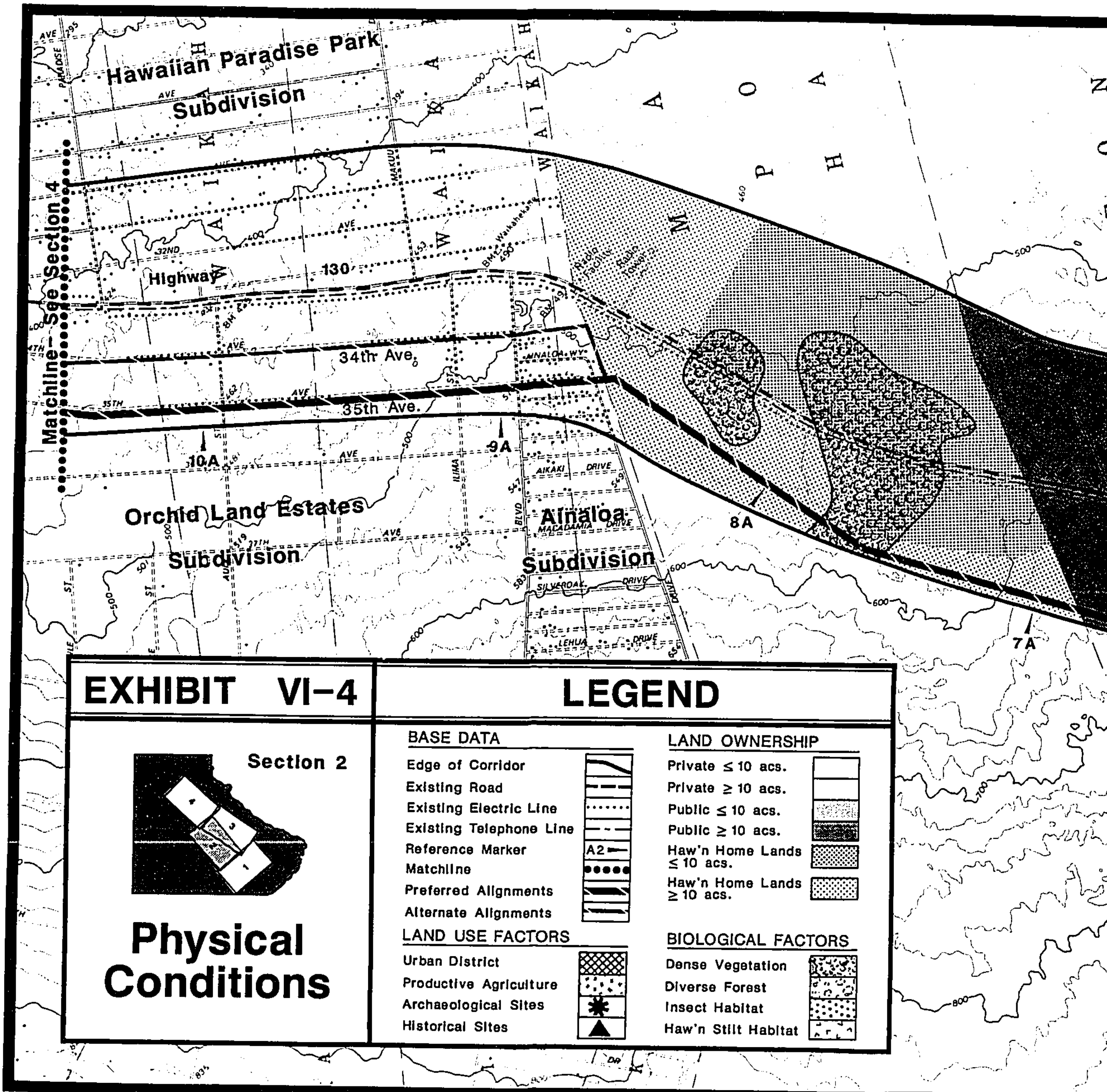
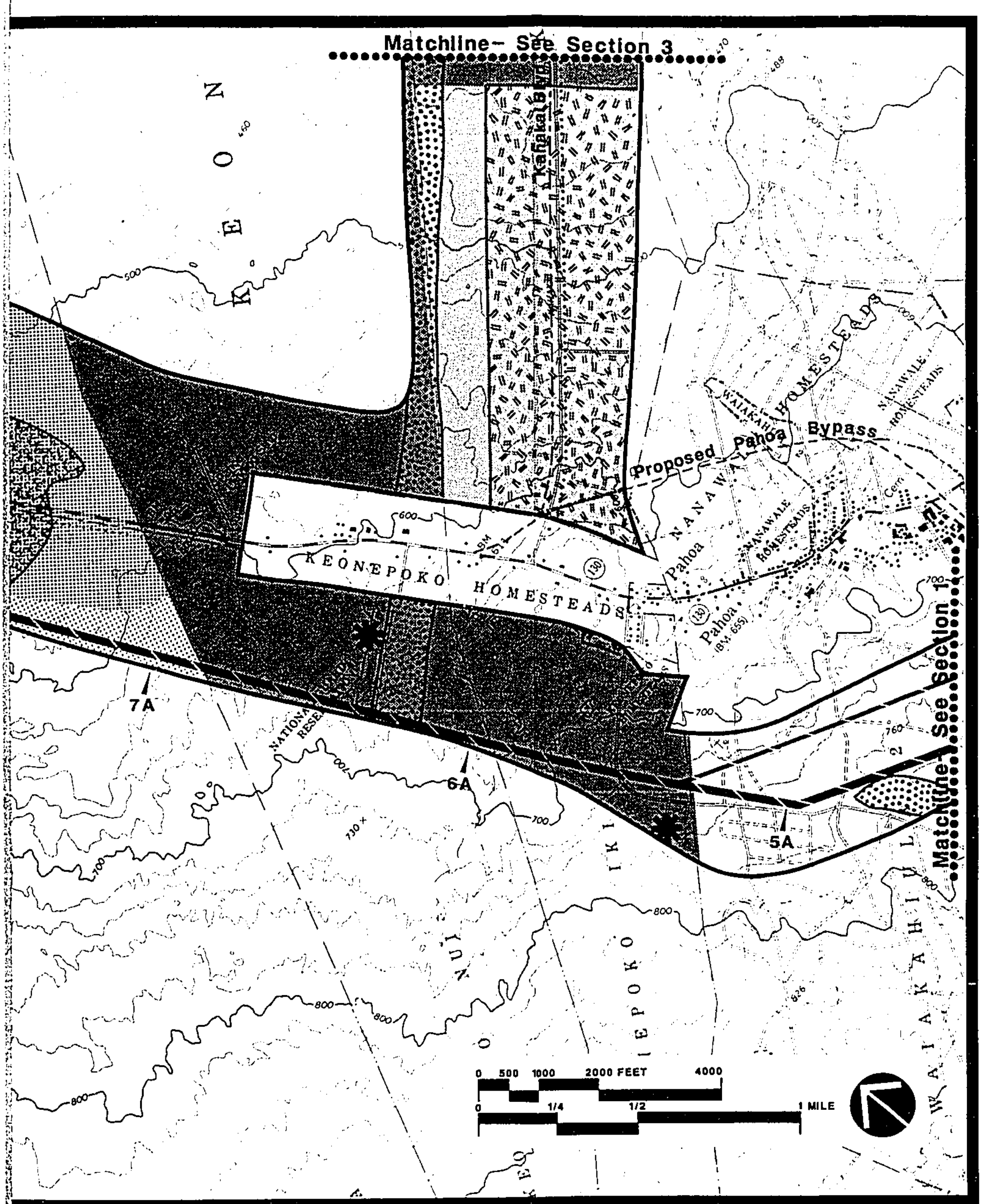
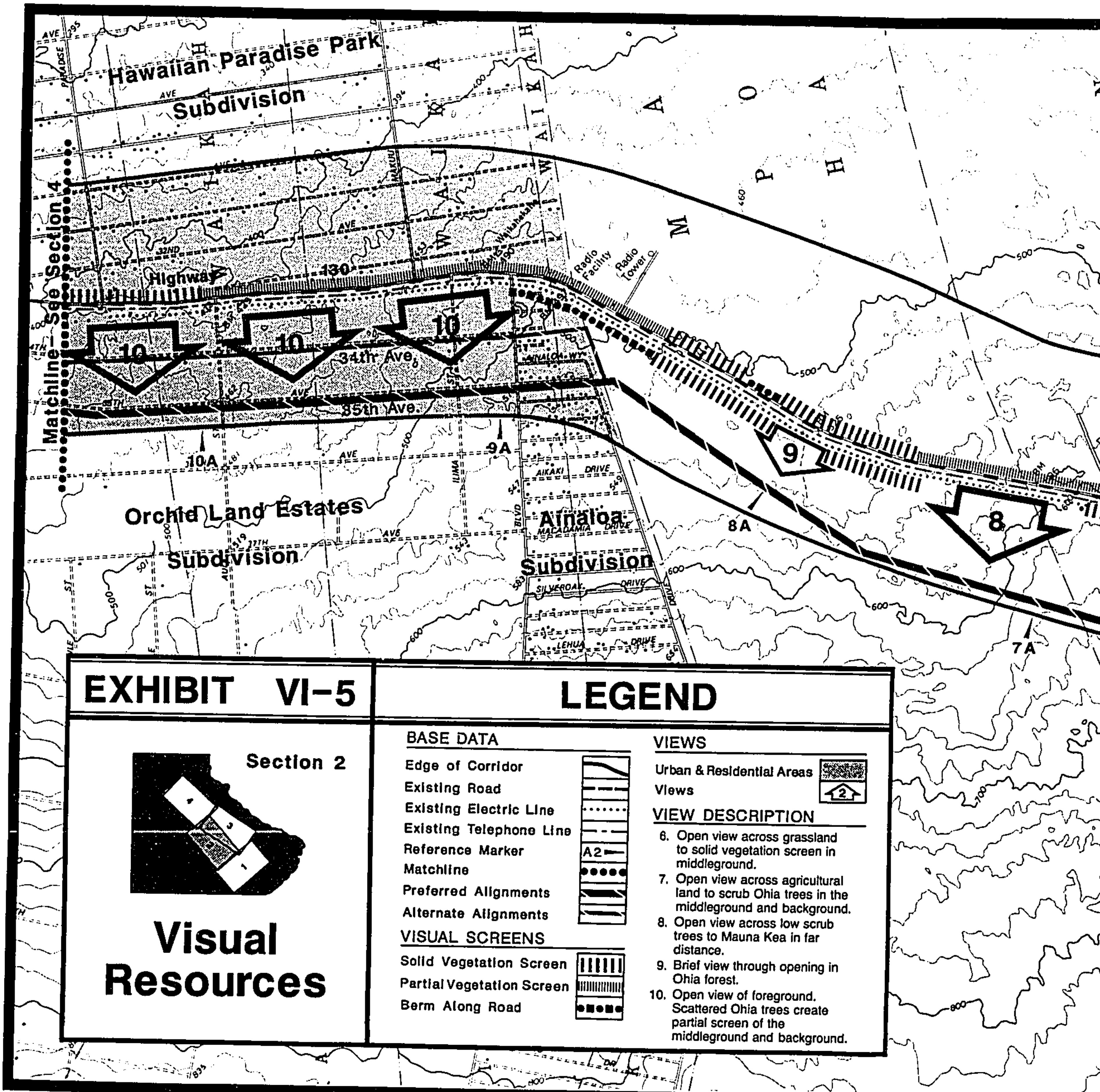
65. Appendix C, Botanical Survey.



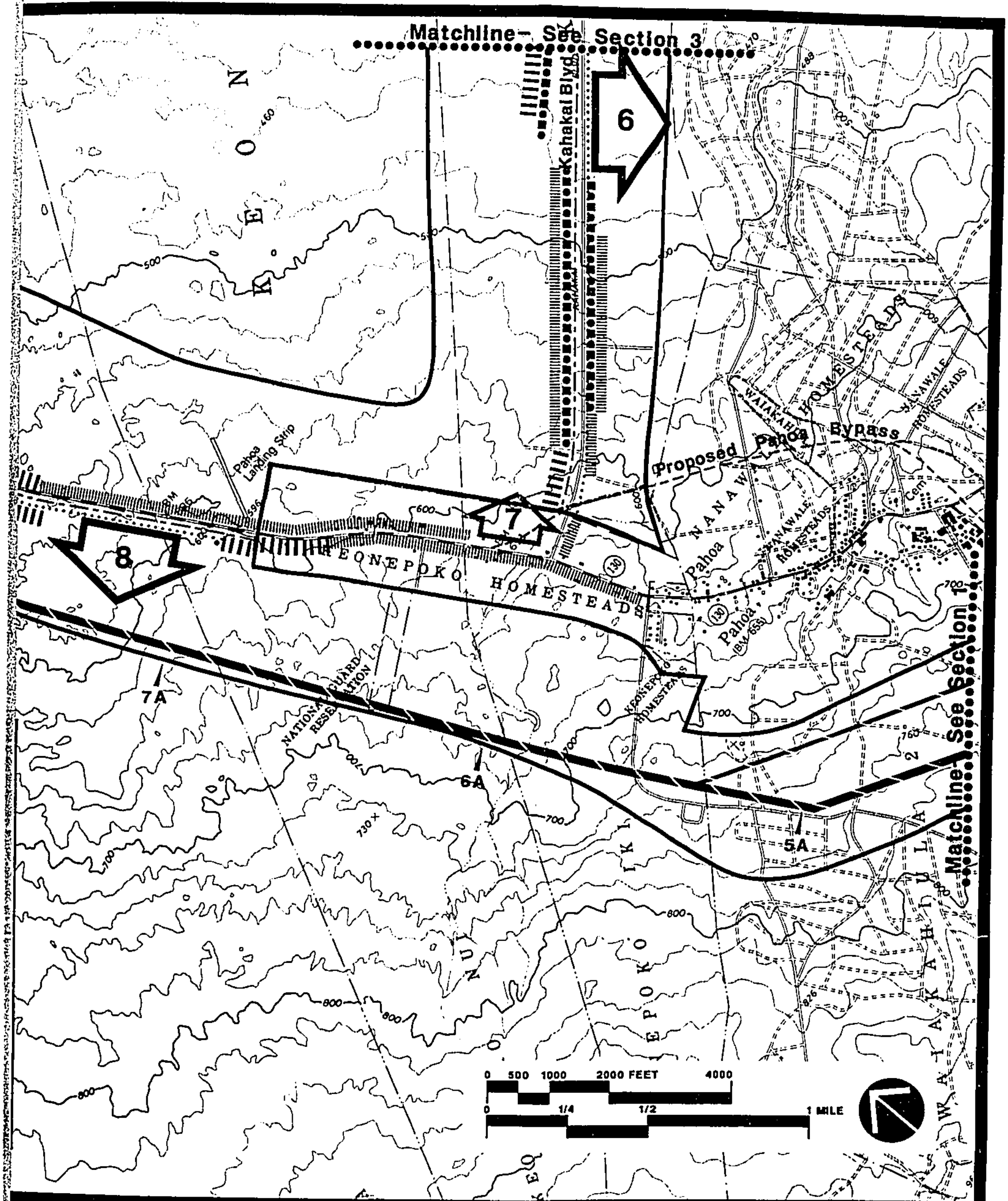

# POHOIKI GEOTHERMAL TRANSMISSION LINE R




N LINE ROUTING STUDY ○ DHM inc.




POHOIKI GEOTHERMAL TRANSMISSION LINE P




N LINE ROUTING STUDY ○ DHM inc.

SECTION 3 (Exhibits VI-6 and VI-7)

Alignment B: From the matchline with Section 1, the preferred alignment turns away from the boundary of Nanawale Estates heading northwest across private-owned agricultural parcels and former sugar lands. At the western tip of Hawaiian Beaches Subdivision, near Reference Marker 5B, the alignment passes close to an existing water tank, and between two archaeological sites identified in the field survey. There is sufficient distance between the line and the sites to avoid any disturbance to them. The site closest to the subdivision is a cluster of petroglyphs and the site south of the alignment is a burial cave.

The alignment continues northwest across the State-owned grassland terrain in Keonepoko Iki land division. From Kahakai Boulevard, which the alignment crosses, there is an open view to the north, but a partial screen looking south. The lower portion of Pahoa Cave, an important insect habitat, is unavoidably crossed by the alignment, but is crossed at a right angle to minimize the distance. The final alignment may be adjusted once the cave is accurately surveyed. Beyond the cave, the alignment hugs the Keonepoko boundary to the former railroad right-of-way, keeping the maximum distance between the line and Hawaiian Beaches Subdivision.

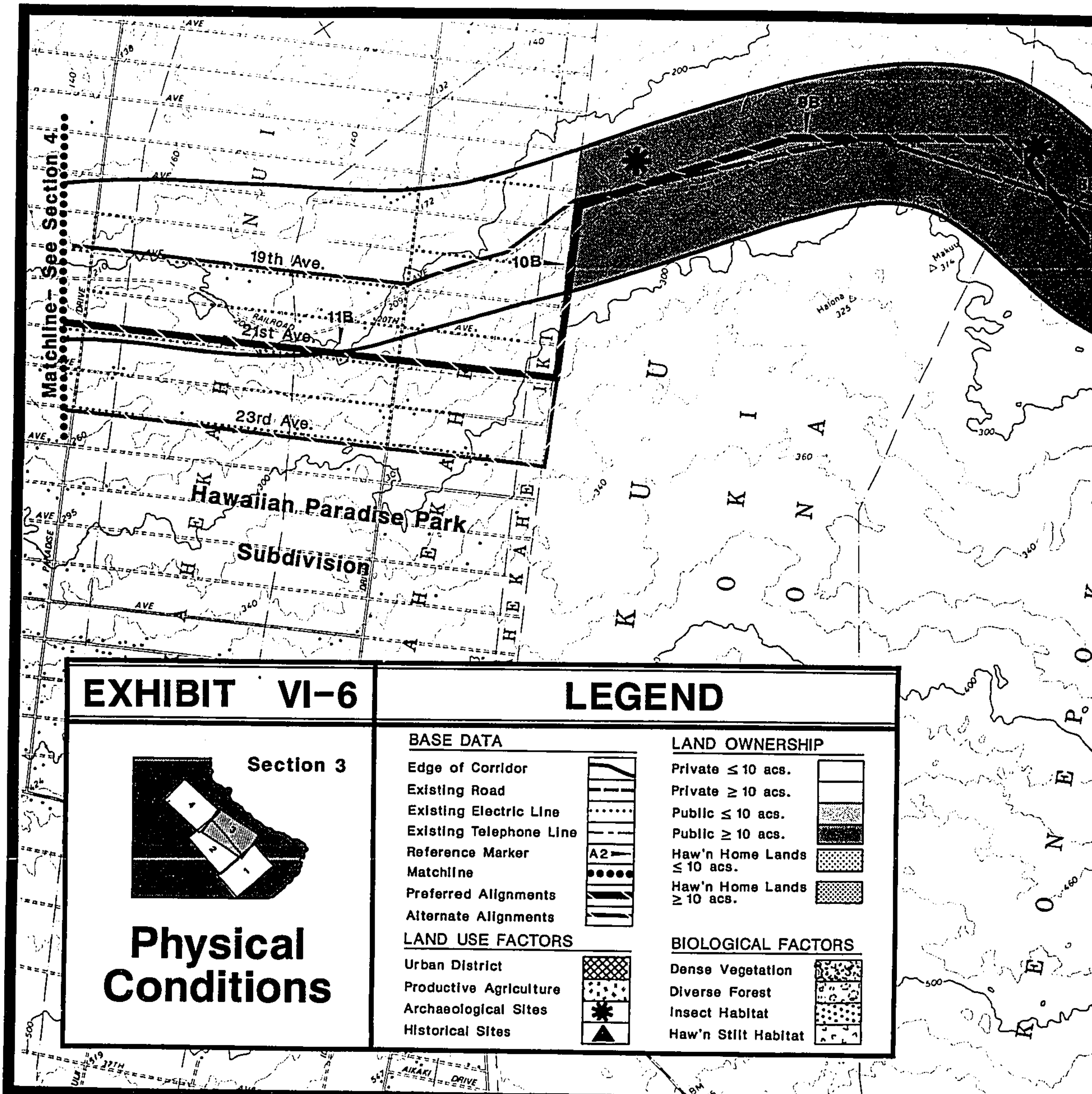
Along the former railroad right-of-way, the preferred alignment follows the existing jeep trail closely to take advantage of the accessibility provided and to minimize unnecessary disruption to the surrounding environment. It also avoids interfering with two archaeological sites near the old railroad route.

Throughout this area (State-owned land) the landscape is very homogeneous, consisting of andropogon grassland with scattered Ohia snags, apparently previously burned.

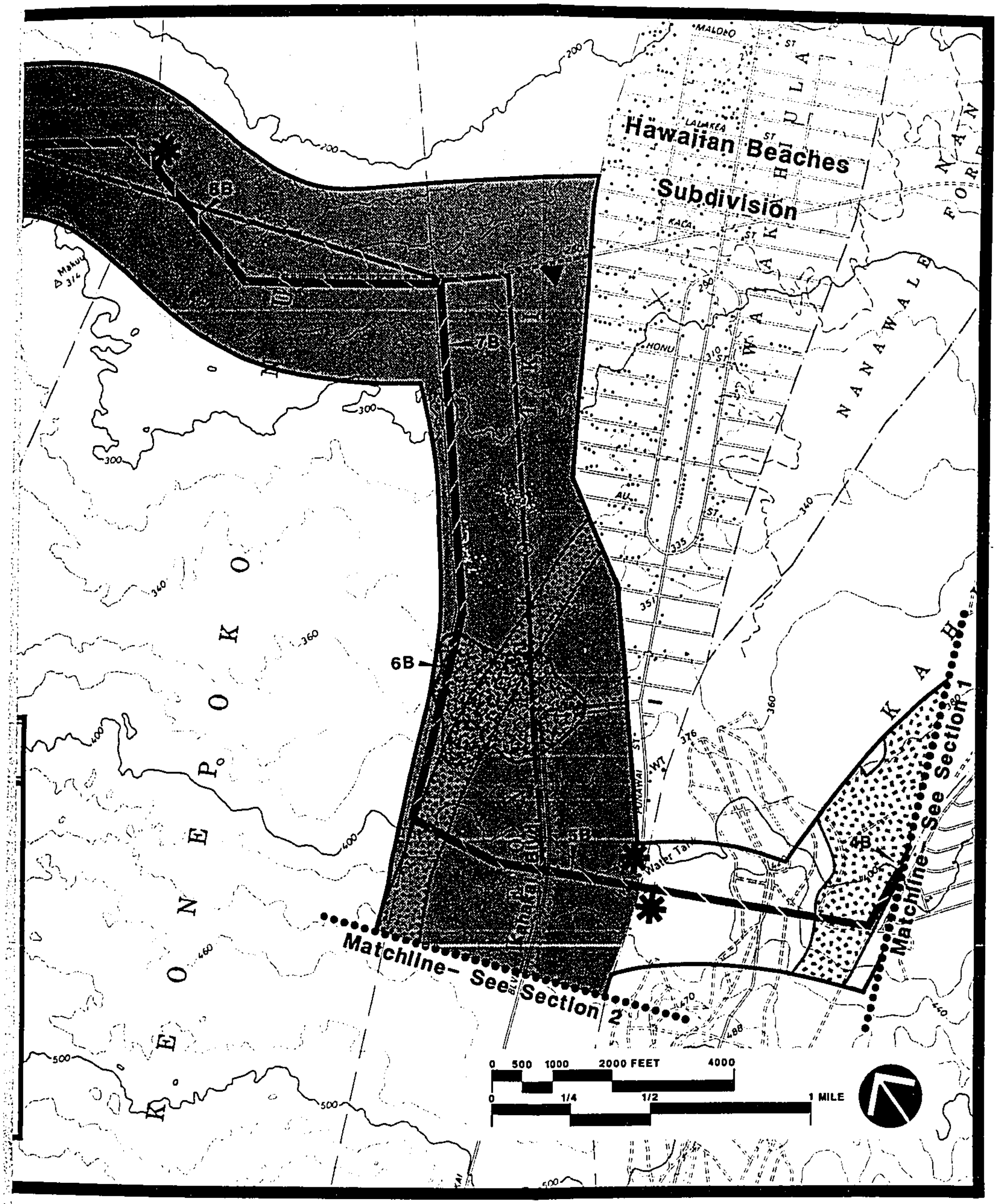
Where the railroad meets Hawaiian Paradise Park Subdivision (Reference Marker 10B), the preferred alignment turns and follows the subdivision boundary to 21st Avenue, where it turns and continues on 21st Avenue through the subdivision to the matchline with Section 4. 21st Avenue is the preferable route because it has an existing distribution line and 40-foot wide HELCO easement along much of it.

An alternative alignment segment heads north toward the railroad ROW along the north side of Kahakai Boulevard (near Reference Marker 5B). While this increases the ease of access, it also makes the line more visible from the boulevard and possibly from Hawaiian Beaches Subdivision. When this alternative meets the railroad ROW however, it follows a straight-line route, minimizing line length and the number of changes in direction, but diverging up to 700' from the jeep trail.

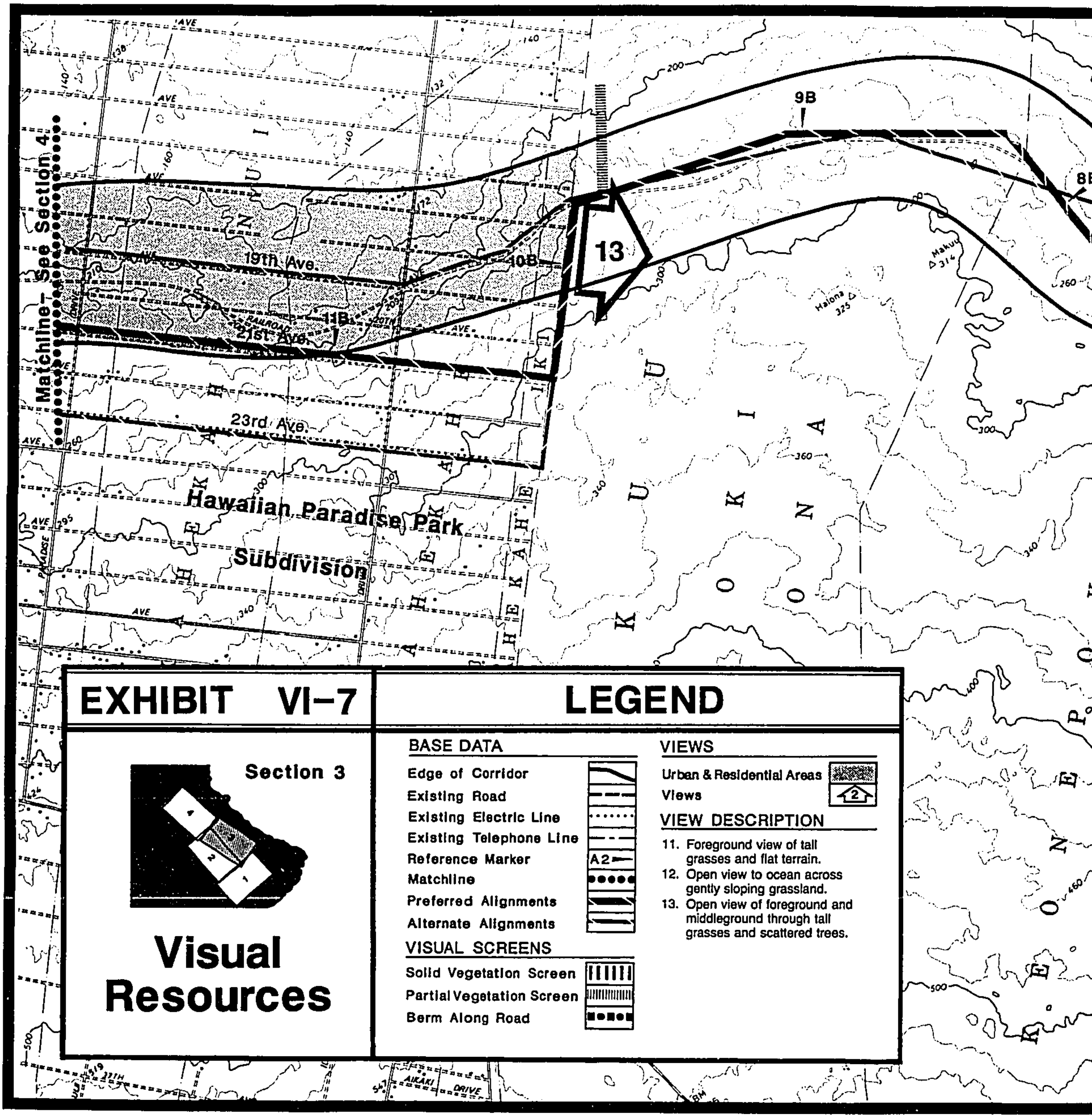
There are two alternatives through Hawaiian Paradise Park. The makai alternative follows Railroad Avenue to 19th Avenue, along which there are large sections with existing distribution lines. The mauka alternative is along 23rd Avenue which also has distribution lines, but is entirely outside the corridor. The corridor boundaries through the subdivision define the most direct route between the areas of less constraint on either side. (Refer to Chapter IV and V).



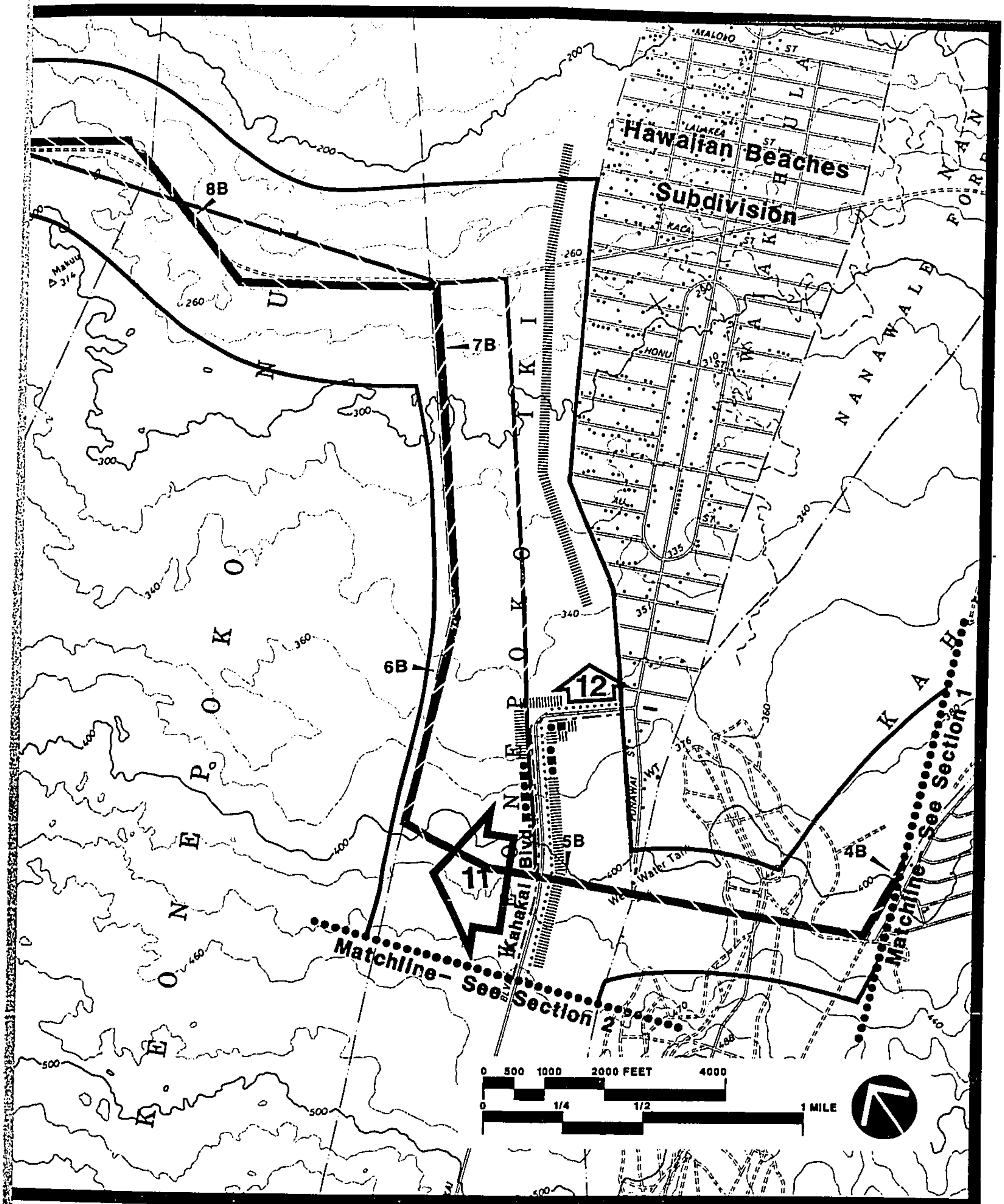

POHOIKI GEOTHERMAL TRANSMISSION LINE



Hawaiian Beaches
Subdivision
6B
7B
6B
Water Tank
Matchline- See Section 2
Matchline- See Section 1
0 500 1000 2000 FEET 4000
0 1/4 1/2 1 MILE




# POHOIKI GEOTHERMAL TRANSMISSION LINE




N LINE ROUTING STUDY ○ DHM inc.

SECTION 4 (Exhibits VI-8 and VI-9)

Alignment "A": From the match line with Section 3, the preferred alignment continues on 35th Avenue through Orchid Land Estates to the edge of the subdivision. There is an existing distribution line and utility easement along most of 35th Avenue in this section, and very few of the 3-acre lots have existing houses. The road itself is an unmaintained dirt road.

North of the subdivision, the preferred alignment crosses a small area of former sugarcane fields (Reference Marker 13A). Although there is an open view of the fields from Highway 130, the alignment is set back far enough that it will not be visually prominent. As the preferred alignment continues northward across vacant lava land and scrub vegetation, the distance effect and the existing berm and partial vegetation screen along the highway eliminate any adverse visual impacts. The alignment remains set back from the highway as it crosses through more abandoned cane fields near Reference Marker 15A, in order to pass behind (mauka of) the plantation manager's estate, which is identified as an historic site.

The preferred alignment crosses Highway 130 south of Keaau at the intersection with a paved sugarcane road. The alignment then follows this road northeast and then north to meet the existing 69 kV line which leaves Puna Substation heading for Kaumana. The alignment avoids all urban and residential lands of Keaau and the community of "8-1/2 Mile Camp". The proximity of the alignment to the existing paved road provides convenient access for construction and maintenance and eliminates the need to construct a special access road.

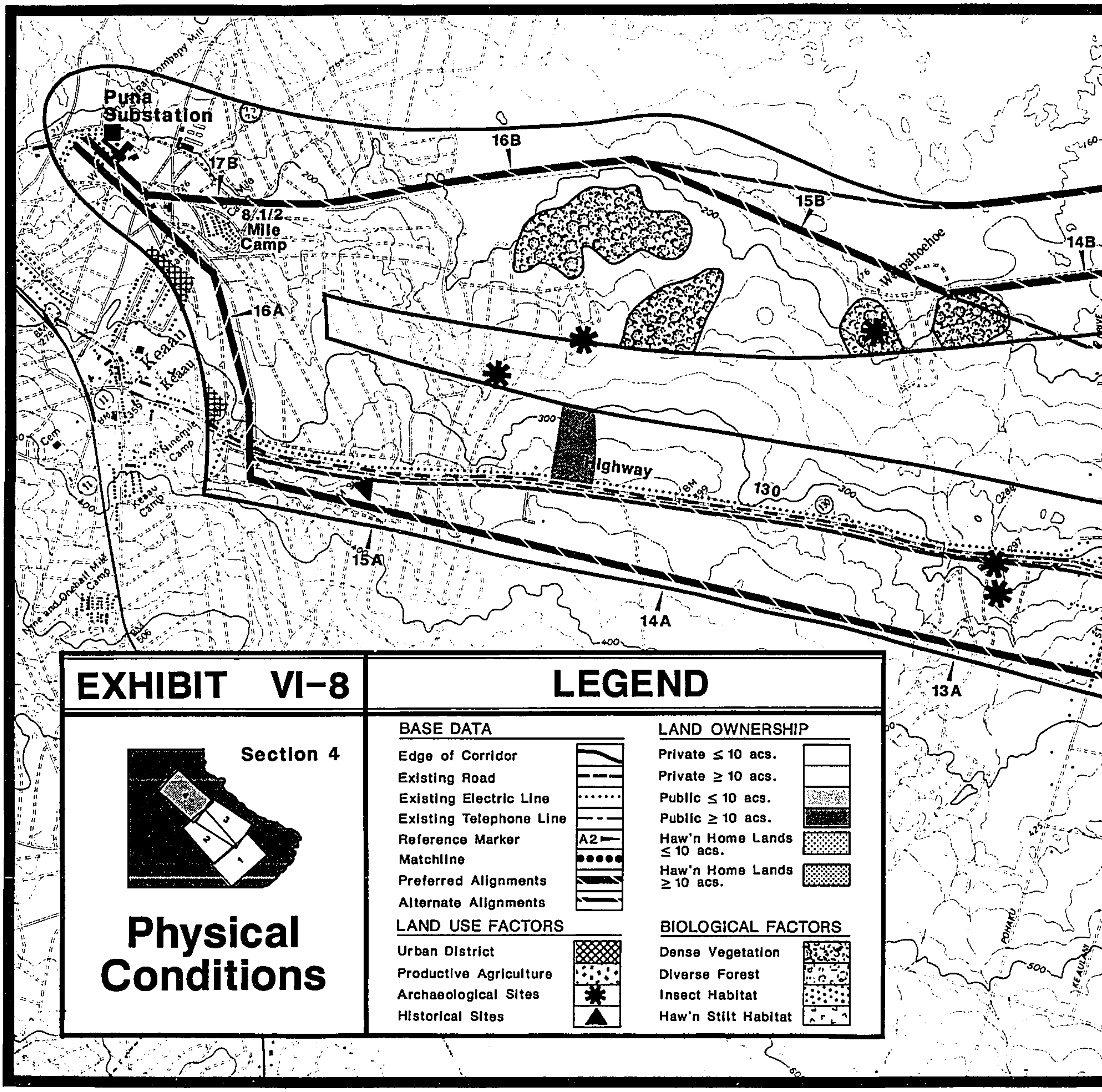
Although the alternative alignment segment shown in Section 4 avoids traversing the subdivisions, it has 3 major disadvantages: visual impacts, and environmental and technical problems. The alternative is located within the right-of-way of Highway 130, mauka of the road, for nearly 5 miles. The adverse visual impact created by this alignment would be significant, especially considering the existing 34.5 kV transmission line on the makai side of the road. If the alignment could be set back to take advantage of the existing vegetation screens along the highway, the visual impacts could be reduced considerably. Environmentally, this alternative crosses one archaeological site of agricultural terraces near Reference Marker 13A and passes between the highway and the historic plantation manager's house near Reference Marker 15A. Careful placement of the poles may avoid disturbing the archaeological and historic sites. From the technical aspect, there is currently a telephone line in the highway right-of-way mauka of the road. Because of limited right-of-way width, arrangements would have to be made between HELCO and Hawaiian Telephone to share poles.

Alignment B: Preferred alignment "B" continues through Hawaiian Paradise Park along 21st Avenue, within existing utility ROW where it exists, until 21st Avenue ties into Railroad Avenue. The alignment then follows Railroad Avenue out of the subdivision, where the railroad ROW is again a jeep trail. Crossing rough lava terrain, scrub vegetation, and former sugarcane lands, the alignment stays close to the railroad trail until Reference Marker 17B. At this point it takes the most direct route to meet the existing 69 kV line west of Puna Substation.

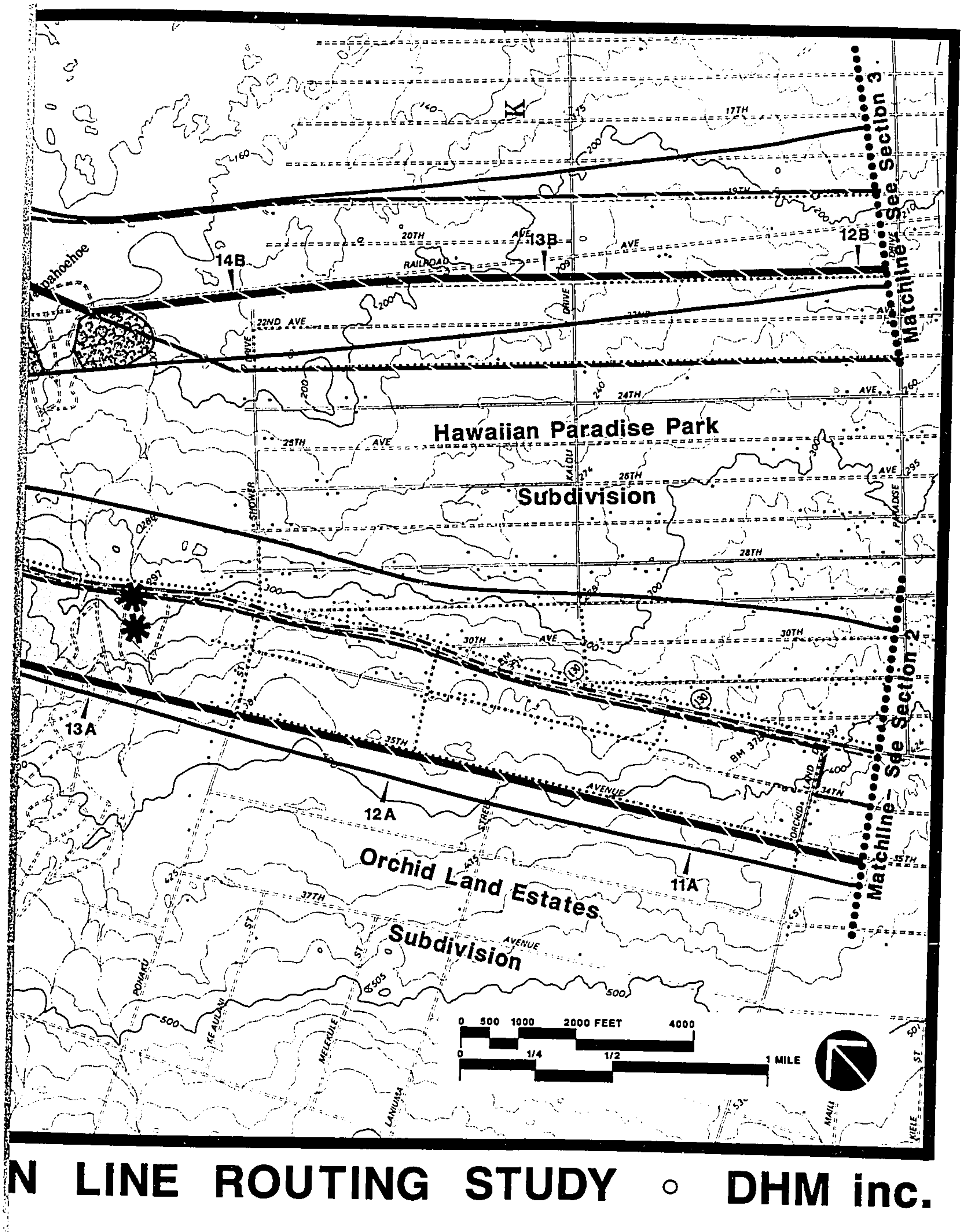
The makai alternative follows 19th Avenue to the end of the subdivision and continues northwest across the vacant lava/scrub land to meet the railroad trail. This alternative would require a mile-long access road beneath it because of its distance from the railroad and the rough terrain it crosses.

The mauka alternative through the subdivision follows 23rd Avenue outside the corridor, and meets the preferred alignment near Waipahoehoe, between Reference Markers 14B and 15B.

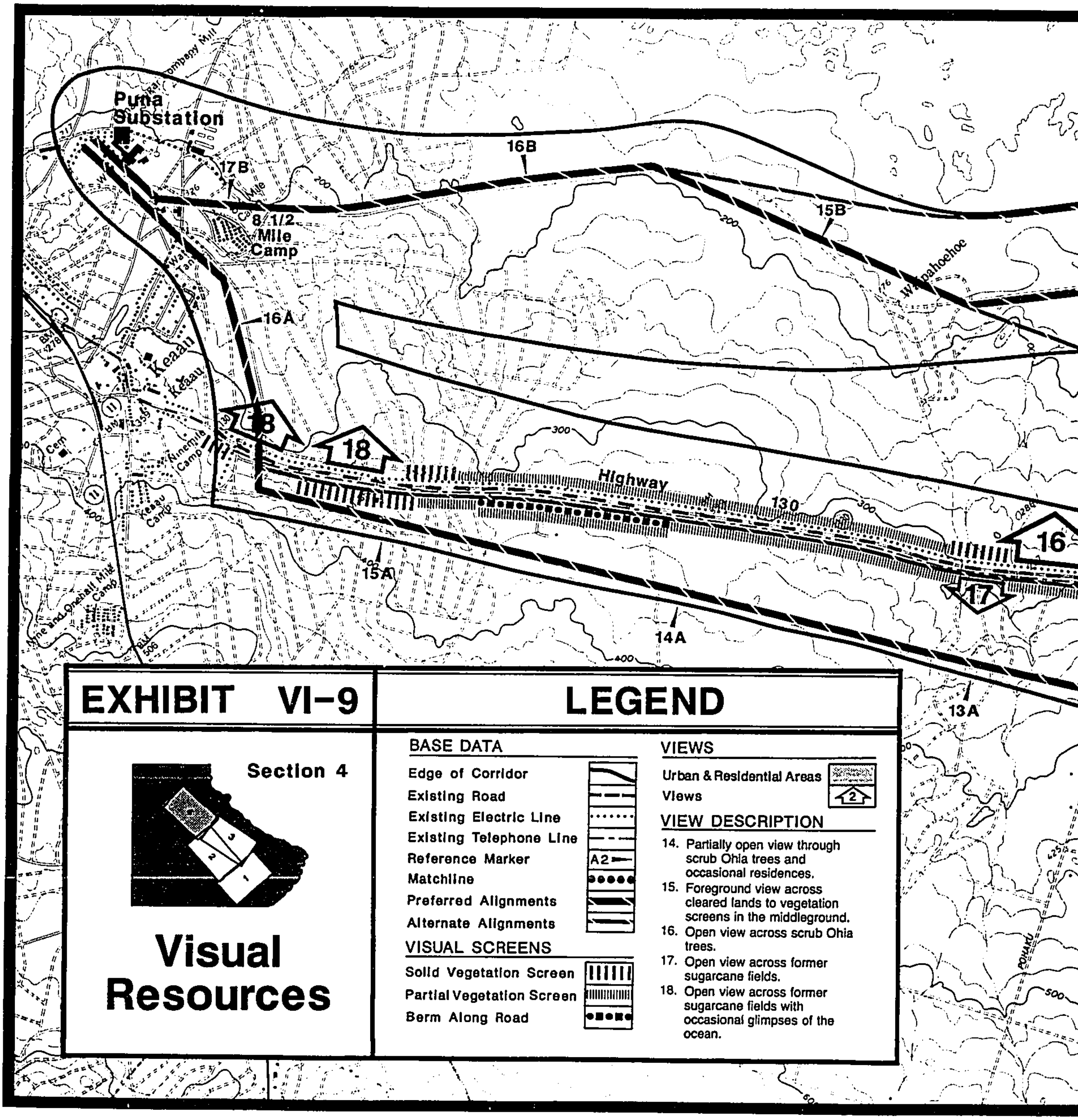
The overall alignments of preferred and alternative "A" and "B" are shown in Exhibit VI-10.



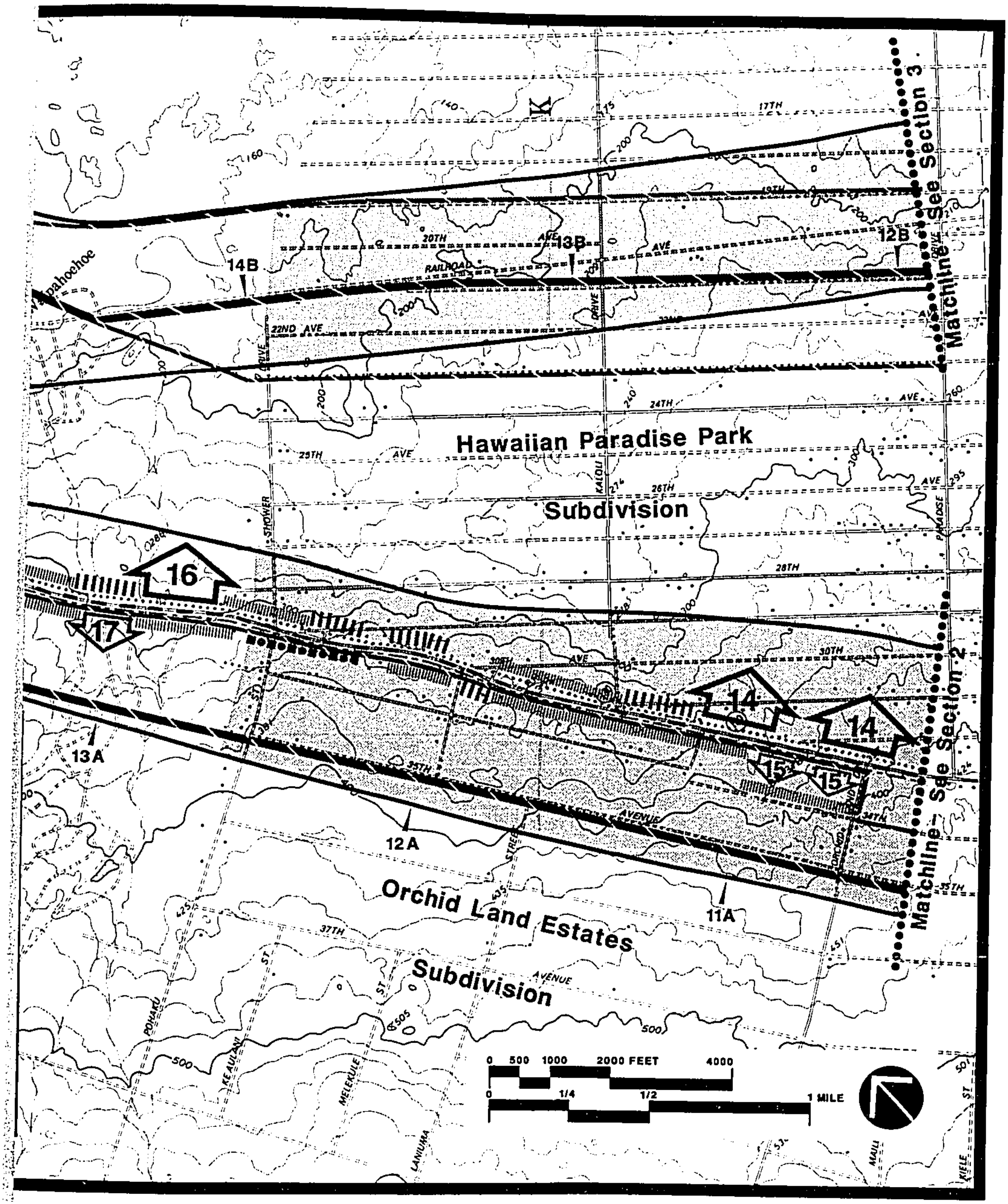

**POHOIKI GEOTHERMAL TRANSMISSION LINE F**




N LINE ROUTING STUDY ○ DHM inc.




# POHOIKI GEOTHERMAL TRANSMISSION LINE

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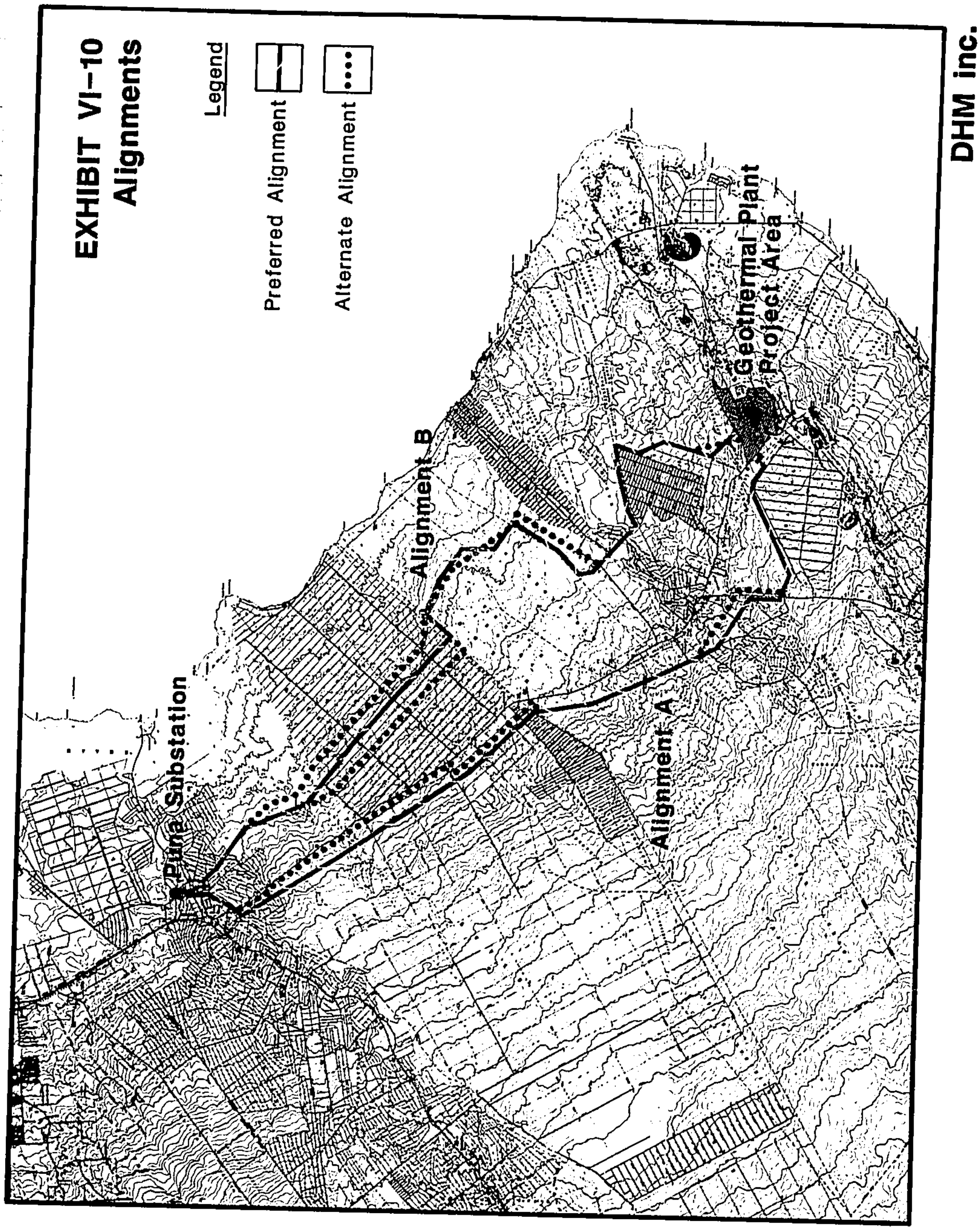
EXHIBIT VI-10
Alignments
Legend
Preferred Alignment
Alternate Alignment
Puna Substation
Alignment B
Alignment A
Geothermal Plant
Project Area
DHM inc.

# APPENDIX A

## APPENDIX A

## SUMMARY OF FIRST COMMUNITY WORKSHOP

Pahoa Community Center
Pahoa, Hawaii
Wed., November 12, 1986
7:00 p.m.

Twenty five residents attended the workshop in Hilo, as shown on the attached list. The workshop began with a presentation by HELCO on its system planning requirements and the need for the proposed transmission line. HELCO also explained why they are involved with the proposed geothermal plant, and indicated that Thermal Power Company will be holding separate workshops related to the general plant itself in the near future. This was followed by a presentation by DHM inc. on transmission line routing methodology and samples of broadscale data factor maps from a previous transmission line routing study.

After these presentations, workshop attendees were asked to comment on or suggest revisions to the criteria or methodology for the routing study. They were also invited to raise questions and concerns related to the description and rationale for the project.

Specific issues raised during the question and answer period were:

1. <u>Project Need and Description</u>

    a. Will the new poles be shared with other utilities such as telephone?

    b. What "class" of pole will be used?

    c. When making right-of-way acquisitions, will you be contacting individual landowners?

    d. What kinds of projections does HELCO make for future energy demands?

    e. How long will the proposed 2 transmission lines be adequate to meet the projected demands?

    f. What is the capacity of the geothermal resource?

2. <u>Routing/Environmental Considerations</u>

    a. Will the old railroad right-of-way be a possible route?

    b. Does the proposed line have to go through Pahoa Town?

    c. Where is State Conservation land?

    d. Is it more difficult to go through Hawaiian Homes Land?

Most of these questions received immediate responses. Participants were told that additional information and the potential study corridors will be presented at the second round workshops to be held December 11th.

Twelve of the questionnaires distributed at the workshop were completed and returned. Attached is a summary sheet showing the various rankings that each routing factor received. If factors were "x"'d instead of given numerical rankings, the "x"'s have been translated to number "1" rankings. It is interesting to note that, based on this small sample, the highest priorities for routing considerations include residential areas, preservation lands, impacts on wildlife and native forest areas, using small private priorities, and areas with archaeological sites.

## FIRST COMMUNITY WORKSHOP ATTENDEES

| PERSON | AFFILIATION |
| --- | --- |
| Daniel Elia | |
| Raymond K. Elia | |
| William S. Gardner | |
| David T. Hess Sr. | |
| Patricia Hess | |
| Lorna Worswick | |
| Virginia Spencer | |
| Gordon Souder | |
| S. P. Gibbons | |
| Carl Davidson | |
| Betty Davidson | |
| Frank J. Mulec | |
| Peter K. Hauanio | |
| Wim (Pappy) Warren | |
| Mae E. Mull | |
| Robert E. Cooper | Hawaii Audubon Society |
| Wallace T. Oki | W. H. Shipman Ltd. |
| Gregory J. Plescia | |
| Sydney Keliipuleole | Kamehameha Schools/Bishop Estate |
| Lee Kenty | |
| M. Kenty Chamberlin | |
| Marguerite Kenty | |
| W. H. Kenty | |
| R. W. Pulcare | |
| Russell Kokubun | County Council Representative |
| Fred Karimoto | HECO |
| Anna Lau | HECO |
| Eugene Yoshimi | HECO |
| Scott Shirai | HECO |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Duk Hee Murabayashi | DHM inc. |
| Wendie McAllaster | DHM inc. |
| Eugene Dashiell | DHM inc. |

## QUESTIONNAIRE
## COMPOSITE SCORES AND RANKS

Instructions:

We would appreciate your taking the time to fill in this questionnaire. We want to know what you think are the most important things to consider in selecting a transmission line route.

Please read the list of factors which can be considered in routing a transmission line. Then rank them by putting a "1" in the blank space to the left of the factor which you consider most important, a "2" next to the second most important factor, and so on. You may give two or more factors the same ranking if you feel they are equal in importance and you may omit ranking any factor which you think is not important.

If something you are concerned about is missing from this list, please add it at the bottom of the list and show how you would rank that concern.

A TRANSMISSION LINE ROUTE SHOULD AVOID:

| RANK | FACTOR |
|---|---|
| 4, 8, 1, 1, 2 | SOIL EROSION AND USE OF STEEP SLOPES. |
| 4, 2, 5, 1, 2, 1 | DAMAGE TO THE LINE AND INTERRUPTION OF SERVICE DUE TO LAVA FLOWS AND OTHER NATURAL DISASTERS. |
| 1, 1, 6, 1, 1, 1 | IMPACTS ON WILDLIFE AREAS, ESPECIALLY NATIVE BIRD HABITATS. |
| 1, 1, 4, 1, 1, 1 | IMPACTS ON NATIVE FOREST AREAS. |
| 2, 3, 1, 2, 2 | RECREATION AREAS, INCLUDING HUNTING AREAS. |
| 3, 1, 3, 1, 1, 1, 1, 3, 2. 2 | RESIDENTIAL AREAS. |
| 3, 5, 1, 1, 3 | PRIME AGRICULTURAL LAND. |
| 2, 1, 1, 2, 1, 1, 1, 1 | PRESERVATION LANDS. |
| 4, 7, 2, 1, 4, 2 | USING LAND OUTSIDE OF EXISTING ROAD OR UTILITY EASEMENTS. |
| 4, 1, 1, 1, 5, 1 | USING SMALL PRIVATE PROPERTIES. |
| 3, 2, 1, 2 | VISIBILITY OF THE LINES FROM HEAVILY TRAVELLED ROADS. |
| 3, 2, 4, 3, 1, 1, 1 | AREAS WHERE ARCHAEOLOGICAL SITES ARE KNOWN TO EXIST. |
| 1, 5, 1, 10, 1, 2 | HIGHER COSTS FOR CONSTRUCTING THE LINE. |
| 2, 5, 10, 1 | HIGHER COSTS FOR MAINTAINING THE LINE. |
| 8 | LARGE AREA BUSINESS HOLDINGS OF PRIME AG.* |
| 3 | SMALL FARMS WITH PRIME AG.* |

WHICH COMMUNITY DO YOU LIVE IN?

| | | | |
|---|---|---|---|
| 1 | KEEAU | 1 | HAWAIIAN PARADISE PARK |
| ___ | ORCHID LAND ESTATES | ___ | HAWAIIAN ACRES |
| ___ | AINALOA ESTATES | 3 | HAWAII BEACHES ESTATES |
| 4 | PAHOA | ___ | NANAWALE ESTATES |
| 1 | VOLCANO | 1 | KOAE |
| 1 | OTHER | | |

SUMMARY OF FIRST PUBLIC AGENCY WORKSHOPS

Auditorium
Hawaiian Electric Co. Inc.
Honolulu, Hawaii
Wed., Nov. 12, 1986
10:00 a.m.

Auditorium
Hawaii Electric Light Co., Inc.
Hilo, Hawaii
Thurs., Nov. 13, 1986
9:30 a.m.

HONOLULU SESSION

Five representatives from State agencies were present at the workshop, as shown on the attached list. The workshop began with a presentation by HELCO on its system planning requirements and the need for the proposed transmission line. HELCO also explained why they are involved with the proposed geothermal plant, and indicated that Thermal Power Company will be holding separate workshops related to the geothermal plan itself in the near future. This was followed by a presentation by DHM inc. on transmission line routing methodology and samples of the broad-scale data factor maps from a previous transmission line routing study.

After these presentations, workshop attendees were invited to raise questions regarding any of the material presented.

Issues raised during the question and answer period were:

1. Puna Natural Area Reserve is no longer designated as a natural area reserve.

2. Has the option to place part or all of the transmission line underground already been foreclosed?

Immediate responses were made to these comments. Participants were told that the potential study corridors will be presented at a second workshop, scheduled for December 10, 1986. The workshop adjourned at 11:00.

HILO SESSION

Four agency representatives attended the workshop in Hilo. The presentation was identical to that in the Honolulu session the day before. No comments or questions were raised by participants.

# CORRECTION

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

## SUMMARY OF FIRST PUBLIC AGENCY WORKSHOPS

Auditorium
Hawaiian Electric Co. Inc.
Honolulu, Hawaii
Wed., Nov. 12, 1986
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### HILO SESSION

Four agency representatives attended the workshop in Hilo. The presentation was identical to that in the Honolulu session the day before. No comments or questions were raised by participants.

## FIRST PUBLIC AGENCY WORKSHOP ATTENDEES

| PERSON | AFFILIATION |
| --- | --- |
| **Honolulu Session** | |
| George Krasnick | Parsons Hawaii |
| Anne Lo-Shimazu | Department of Land & Natural Resources - OLEA |
| Nobuo Honda | Department of Land & Natural Resources - Division of Forestry & Wildlife |
| John D. Nakagawa | Department of Planning and Economic Development - CZM Program |
| Gerald Lesperance | Department of Planning and Economic Development - Energy Division |
| Faith Miyamoto | Office of Environmental Quality Control |
| Maurice Richard | Thermal Power Company |
| Fred Karimoto | HECO |
| Anna Akamu | HECO |
| Eugene Yoshimi | HECO |
| Keith Kobuke | HECO |
| Jake Fernandez | HECO |
| Andy Chang | HECO |
| Scott Shirai | HECO |
| Chuck Freedman | HECO |
| Ken Morikami | HECO |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Duk Hee Murabayashi | DHM inc. |
| Wendie McAllaster | DHM inc. |
| **Hilo Session** | |
| Rodney T. Oshiro | Division of Forestry & Wildlife |
| Ilima Piianaia | County Planning Department |
| Brian Nishimura | County Planning Department |
| Cheryl Ramos Blyth | Legislative Auditor - County Council |
| Fred Karimoto | HECO |
| Anna Akamu | HECO |
| Eugene Yoshimi | HECO |
| Scott Shirai | HECO |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Mark Gushiken | HELCO - Land |
| Alex Gentry | HELCO - Land |
| Duk Hee Murabayashi | DHM inc. |
| Wendie McAllaster | DHM inc. |
| Eugene Dashiell | DHM inc. |

## SUMMARY OF SECOND COMMUNITY WORKSHOP

Pahoa Community Center
Pahoa, Hawaii
Wed., December 10, 1986
7:00 p.m.

Thirteen residents and landowners attended the workshop. (See the attached list.) The content of the workshop was the same as for the agencies. DHM described the corridor evaluations by briefly discussing each factor and showing a map of the composite factors, the corridors and the typical alignment being used for the surveys.

The following questions and concerns were raised:

1. Can you put the transmission lines along the highway?

   Response: Three lines along the highway would be difficult to construct.

2. Ownership of the former railroad alignment in Hawaiian Paradise Park is in dispute. The community association may not own it. It appears to be owned by each of the landowners in Hawaiian Paradise Park. Thus each person may own 1/5750 of the former alignment through HPP.

3. Why is the voltage so low? Why not 138 kv?

   Response: The voltage is 69 kv ac because that is adequate for the purpose and because the remaining HELCO grid is 69 kv ac also.

4. Why are two lines needed?

   Response: Two lines are required to provide a reliable system. Because this line would provide about 25 percent of Hawaii's power, an outage of the entire 25 MW could adversely affect the entire system. If there are two lines, it is more likely that an outage would affect only one line and power would be restored much more rapidly.

## SECOND COMMUNITY WORKSHOP ATTENDEES

**PERSON**

Jenny Allen
Betty Vincent
Tsune Matsumoto
Sally Wang
Michael McMillan
Tadashi Higaki
Ted Shepherd
Will Sutherland
Frank Hicks
David Ford
Robert Cooper

Fred Karimoto
Anna Akamu
Eugene Yoshimi
Scott Shirai
Clyde Nagata
Dennis Tanigawa

Duk Hee Murabayashi
Eugene Dashiell

**AFFILIATION**

Amfac Property

Paradise Anui Kanalike HPP

Hawaiian Acres C. C.

Paradise Park

W. H. Shipman Ltd.

HECO
HECO
HECO
HECO
HELCO
HELCO

DHM inc.
DHM inc.

## SUMMARY OF SECOND PUBLIC AGENCY WORKSHOP

Auditorium
Hawaiian Electric Company, Inc.
Honolulu, Hawaii
Wed., December 10, 1986
10:00 a.m.

HONOLULU SESSION

Six representatives from State and County agencies attended the workshop (see the attached list). Dennis Tanigawa, of HELCO, chaired the meeting. He noted that this was the second in a series of three meetings, that the third would be held in May with the proposed transmission alignment as the subject. DHM inc. presented the corridor identification analysis and described the methodology and the findings. DHM showed maps of the corridor and the possible routes which are being more fully investigated during field work beginning this month. DHM described the extent of the alignment investigations which are now beginning.

Attendees asked the following questions:

1. Bruce Anderson of DOH expressed concern that the report and the EIS include a discussion of the available information which describes scientific findings regarding the effect on human health of similar transmission lines. He offered to provide a list of reference and copies of some of the current articles.

   Response: DHM noted that the report and EIS will include discussion of these materials, but that our present understanding is that transmission line voltages of 69 kv ac are relatively low and that most scientific studies are concerned with lines of much higher voltage, perhaps 200 to 400 kv. Anderson agreed. DHM will follow-up with Anderson's offer.

2. Nobuo Honda of the Division of Forestry expressed concerns over the height of vegetation when considering maintenance or corridors. He felt that the analysis should reflect the actual species of the tree rather than just present heights because even though they may be short now some species may grow to be taller.

   Response: DHM noted that we are using the Jacobi maps which recognize this concern and identify species.

HILO SESSION

Nine persons from State and County agencies attended the workshop. The presentation was identical to that in Honolulu.

The following questions were asked:

1. How many transmission lines will eventually be built in the Puna region? What are the future plans regarding transmission lines?

   Response: HELCO is planning for 69 kv for the 25 MW geothermal power plant development. Although a feasibility study for a 300 kVdc transmission is a part of the Hawaii Deep Water Cable Program, HELCO is not planning for the project.

   Hurricane Iwa caused transmission line planners to be concerned about creating an energy corridor in which all transmission lines are located. They are concerned about the system reliability. As a result, HELCO set up a policy of 0.5 mile separation between the proposed 69 kv and other transmission lines.

2. How many alignments will be selected and will you rank them?

   Response: DHM will suggest two alignments to HELCO. There will be no ranking.

3. Can the 2 lines handle 50 MW if Thermal Power wants to build more generating units?

   Response: No.

4. Will your EIS cover other than State lands?

   Response: Yes. It will cover the full length of the selected alignments.

5. Are you seeking a Conservation District Use Application (CDUA) permit or a boundary amendment?

   Response: No CDUA permit will be required if we can avoid crossing the Conservation land. No boundary change is needed. We will be preparing an EIS because of a potential easement request from the State due to the transmission lines crossing the State-owned land areas.

6. When will additional lines be required?

   Response: When more than 25 MW is required.

7. How many lines can you get in a corridor?

   Response: It depends on how wide a corridor is. It will also depend on the right-of-way width of 50 feet for a 69 kv line and a minimum separation of pole height length. In addition, a minimum of 0.5 mile separation between two transmission lines is required by HELCO at this time.

## SECOND PUBLIC AGENCY WORKSHOP ATTENDEES

| PERSON | AFFILIATION |
|---|---|
| **Honolulu Session** | |
| Colleen Spiering | Department of Health |
| Bruce Anderson | Department of Health |
| Dean Nakano | Department of Land & Natural Resources |
| Rick Nabarrete | Hawaiian Homes |
| Nobuo Honda | Department of Land & Natural Resources, Division of Forestry |
| Gerald O. Lesperance | Department of Planning and Economic Development, Energy Division |
| D. H. Mason | Thermal Power Company |
| Maurice Richard | Thermal Power Company |
| Fred Karimoto | HECO |
| Anna Akamu | HECO |
| Eugene Yoshimi | HECO |
| Scott Shirai | HECO |
| Ken Morikami | HECO |
| J. Oda | HECO |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Duk Hee Murabayashi | DHM inc. |
| Eugene Dashiell | DHM inc. |
| **Hilo Session** | |
| Bruce McClure | County of Hawaii Department of Public Works |
| David Murakami | County of Hawaii Department of Public Works |
| Rodney Nakano | County of Hawaii/Planning |
| Andrea Gill Beck | Hawaii Energy Extension Service |
| Ronald Bachman | State Department of Land and Natural Resources, Wildlife |
| Rodney T. Oshiro | Division of Forestry/Wildlife |
| Charles K. Wakida | Division of Forestry/Wildlife |
| Russell Kokubun | County Councilman |
| Cheryl Ramos Blyth | Legislator Auditor-County Council |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Fred Karimoto | HECO |
| Anna Akamu | HECO |
| Eugene Yoshimi | HECO |
| Scott Shirai | HECO |
| Duk Hee Murabayashi | DHM inc. |
| Eugene Dashiell | DHM inc. |

SUMMARY OF THIRD COMMUNITY WORKSHOP

Pahoa Community Center
Pahoa, Hawaii
Thurs., September 3, 1987
7:00 p.m.

Approximately one hundred residents attended the workshop, as shown on the attached list. The Public Utilities Commission attended the workshop and served as a moderator.

The meeting was organized into three sections. First, HELCO and their planning consultant, DHM inc., presented the two selected alignments for the proposed 69 kV transmission lines. DHM inc. described the types of factors which were mapped and evaluated in the process of identifying the alignments. They also described the proposed route of each alignment across the Puna area.

The second portion of the meeting was an opportunity for the residents to ask specific questions about the DHM inc.'s presentation, the proposed alignments, and their selection. Questions were raised concerning such issues as:

- late notice about the project to affected property owners
- the density of Ainaloa subdivision
- why the transmission lines were a separate issue from the geothermal power plant
- will the subdivision(s) affected by the lines get electricity from them
- impacts on property values
- consideration of undergrounding the lines
- consideration of human beings and their homes
- easement width and compensation to property owners
- consideration of using large landowners' property
- constraints given to the consultant by HELCO

The questions were responded to by HELCO or DHM inc.

During the final portion of the meeting, the residents were encouraged to voice their general concerns and opinions about the proposed project to the Public Utility Commission and HELCO. Several residents spoke, and their concerns are summarized below. Speakers were encouraged to submit their comments in written form to HELCO with a copy to the Commission.

- Ainaloa is a densely populated subdivision with small lots and private roads.
- How much will the line cost and what would it cost to go underground?
- Why can't the line(s) go along the highway?
- What kind of improvements will be made to 35th Ave. if the line goes there?
- Put the line in the mauka part of Ainaloa where it is less populated and the residents need power.
- What would be the affect of the line on property value.
- Alignment selection needs to consider fire hazards and salt corrosion.
- The former railroad is more of a hiking path than a jeep trail.
- Safety.
- There is no fire access to the railroad area and Hawaiian Paradise Park.

The attendees were informed that HELCO will continue to work with the subdivision associations in attempts to come to mutually agreeable locations for the alignments within the respective subdivisions.

## WORKSHOP ATTENDEES

**NAME**

Catherine Ford
Fern Gilchrist
Daisy U. Smith
Jessie E. Daskam
Robin M. Daskam
Peg J. Daskam (sp.?)
Kile Golden
Peggy Golden
Don Tinker
Tesse Tinker
Marilyn Lusareta
William G. Lusareta
Rocky J. Nunes
Debra L. Nunes
Ruth Sleightholm
June Shamwell
Vicky Jacobs
Edward Jacobs
Gordon Souder
Mary J. Owens
Kini L. Pea
Jim E'more (sp)
William Reich
Nelson Ho
James H. Green
Bill Milks
David A. Kikau Sr. (sp.?)
Jeam Mayberry
Douglas Mayberry
Doug Bell
Chuck Sperry
Frank Dewater
Marvin Watts
Lewis Goldenberg
Michael Gurr
Shirley Gil
Shirley Chaekowski (sp.?)
W. Mastenbrook
Norma Mastenbrook
Sally Wang
Rex Ivan Delden
H. L. Kenty
Marge Chamberlin
Gerald & Deborah Hay
Peggy Rosendahl
Lynne Goldestein
Patrick W. Goldstein
Kathleen Furtado

**NAME**

Diana & Londo Londi
Sue Clark
Dick Miner
Ron Phillips
Mike Greenlaw
Paul Alan
Russell Kokubun
Donna Licata
Richard Hahn
H. H. Huret
Ralph V. Kelly
Michael McMillan
Eric Bushu (sp.?)
Bud Ahrender (sp.?)
Thomasine Deitch (sp.?)
Violet Santiago
Morgen M.E. Bahurinsky
John A. Wassell
John, Jackie, Cartor (sp.?)
Patrick McHugh
B. Aloha McHugh
Kay Wiley
Del Pranke
Deborah Pranke
Milton Papineau
Rubye Papineau
Esther Kayl
Jeanne Fuller
Charles Boehnke
Virginia Boehnke
Peter Yost
Carolyn Yost
Ralph Yost
Carl Neely
Norma Neely
Barbara Hogan
Tom Henderson
Eve Henderson
Barbara Novak
L. J. Novak
W. W. Boysel
Ralph W. Frink
Lola R. Frink
Alice D. Boysel
Moira Kokkolio-Bright(sp.?)
James K. Bright
James Smith
W. B. Mason

**NAME**

Fred C. Gills
R. W. Pulcare
S. Meneles
B. M. DenCause (sp.?)
J. Armstrong
Sherrie Moore

Fred Karimoto
Anna Lau
Eugene Yoshimi
Scott Shirai
Clyde Nagata
Dennis Tanigawa

Duk Hee Murabayashi
Wendie McAllaster

(sp.?) Spelling may be incorrect due to handwriting on attendance list.

## SUMMARY OF THIRD PUBLIC AGENCY WORKSHOPS

Auditorium
Hawaiian Electric Co. Inc.
Honolulu, Hawaii
Thurs., Sept. 3, 1987
10:00 a.m.

Auditorium
Hawaii Electric Light Co., Inc.
Hilo, Hawaii
Fri., Sept. 4, 1987
10:00 a.m.

HONOLULU SESSION

The fourteen individuals that attended the workshop included six representatives from State agencies as shown on the attached list.

DHM inc., HELCO's planning consultant, presented the two selected alignments for the proposed 69 kV transmission lines. They described the types of factors which were mapped and evaluated in the process of identifying the alignments, and also described the proposed route of each alignment across the Puna area.

HILO SESSION

Four agency representatives attended the workshop in Hilo. The presentation was identical to that in the Honolulu session the day before.

## THIRD PUBLIC AGENCY WORKSHOP ATTENDEES

| PERSON | AFFILIATION |
|---|---|
| **Honolulu Session** | |
| J. Kirkham M.D. | Department of Health |
| Ronald L. Walker | Dept. of Land & Natural Resources, Division of Forestry and Wildlife |
| Mike Shimabukuro | Dept. of Land & Natural Resources, Division of Land Management |
| Y. Miyashiro | |
| Dean Nakano | Dept. of Land & Natural Resources, Division of Water & Land Development |
| J. Hendrickson | Ainaloa Subdivision |
| June Peter | |
| Clarence Edwards Sr. | |
| Lawrence Dawson | Bodissage Hawaii, Inc. |
| Allan Kawada | True Geo Energy Co. |
| Doug Bell | Thermal Power Company |
| Dan Mason | Thermal Power Company |
| Ralph Patterson | Thermal Power Company |
| Fred Karimoto | HECO |
| Anna Lau | HECO |
| E. Yoshimi | HECO |
| Ken Morikawa | HECO |
| Andy Chang | HECO |
| Kevin Doyle | HECO |
| Ann Yamamoto | HECO |
| Scott Shirai | HECO |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Duk Hee Murabayashi | DHM inc. |
| Wendie McAllaster | DHM inc. |
| **Hilo Session** | |
| Jim Lui-Kwan | County Planning Department |
| Virginia Goldstein | County Planning Department |
| B. McClure | County Dept. of Public Works |
| Ron Ibarra | Mayor's Office |
| John and Mary Davis | |
| Doug Bell | Thermal Power Company |
| Fred Karimoto | HECO |
| Anna Lau | HECO |
| Eugene Yoshimi | HECO |
| Scott Shirai | HECO |
| Clyde Nagata | HELCO |
| Dennis Tanigawa | HELCO |
| Duk Hee Murabayashi | DHM inc. |
| Wendie McAllaster | DHM inc. |

PARTIES PERSONALLY NOTIFIED OF PUBLIC AGENCY AND COMMUNITY WORKSHOPS

COUNTY OFFICIALS

Mayor Dante Carpenter
Councilman Robert Herkes
Councilwoman Merle K. Lai
Councilman Stephen K. Yamashiro
Councilman Takashi Domingo
Councilman James Dahlberg
Councilman Spencer Kalani Schutte
Councilman Russell Kokubun
Councilwoman Lorraine Jitchaku-Inouye
Councilman Frank De Luz III

COUNTY AGENCIES

Department of Public Works
Office of the Mayor
Planning Department

STATE REPRESENTATIVES

The Honorable Harvey Tajiri
The Honorable Dwight Takamine
The Honorable Virginia Isbell
The Honorable Wayne Metcalf
The Honorable Andrew Levin

STATE SENATE

The Honorable Malama Solomon
The Honorable Richard Matsuura

STATE AGENCIES

Department of Agriculture
Department of Business and Economic Division
Department of Hawaiian Home Lands
Office of Hawaiian Affairs
Department of Health
Department of Land and Natural Resources
  Aquatic Resources Division
  Conservation and Resources Enforcement
  Forestry and Wildlife Division
  State Parks, Outdoor Recreation and Historic Site Division
  Water & Land Development Division
Office of Environmental Quality Control
Department of Transportation
University of Hawaii
  Environmental Center
  U.H.H. Division of Natural Science
  U.H. Cooperative Extension Service

FEDERAL AGENCIES

Department of Agriculture
  Soil Conservation Service
Department of Interior
  Fish & Wildlife Service
  Geological Survey
  National Park Service

COMMUNITY ORGANIZATIONS

Ainaloa Community Association
Aloha Association
AMFAC Sugar Company
Big Island Committee on Municipal Power
Big Island Papaya Growers Association
Conservation Council for Hawaii
Fern Acres Community Association
Golden State Hawaiian Corporation
Hawaii Anthurium Growers Cooperative
Hawaii Audubon Society
Hawaii Energy Extension Service
Hawaii Island Chamber of Commerce
Hawaii Redevelopment Agency
Hawaiian Beaches Community Association
Hawaiian Beaches Hui Kahakai
Hui Hana Like
Hui Hanalike Community Association
Hui O Puna Jaycees
Hui O Puna Jayceettes
Hui O Puna Nui
ILWU
Kalapana Community Association
Kalapana Gardens Community Association
Kalapana Star of the Sea
Kamehameha Lodge
Kamehameha Schools/Bernice Pauahi Bishop Estate
Keaau School PTA
Leilani Community Association
Lions Club
Nanawale Community Association
Opihikau Church
Orchidland Community Association
Pahoa Filipino Club
Pahoa Nikkei Jin Kai
Pahoa School PTSA
Paradise Park Hui Hanalike
Puna Community Forum
Puna Geothermal Committee
Puna Hui 'Ohana
Puna Lions Club
"Puna Reflections"
Puna Soil and Water Conservation District
"Puna Speaks"
W. H. Shipman, Ltd.
Tokyu Land
"Volcano Views"
Waawaa Community Association

HEI

October 17, 1986

Puna Geothermal Committee
Post Office Box 370
Volcano, Hawaii 96785

Gentlemen:

Subject: Proposed Pohoiki-Puna Transmission Line

Hawaii Electric Light Company has conducted a thorough study of how we might best transmit the potential electric power produced at the Pohoiki geothermal plant. After studying all the possible alternatives, we have concluded that it will be necessary to construct new transmission lines between substations at Pohoiki and Puna.

The route of this transmission corridor is an obvious concern of the people of the Puna district, and we intend to involve community residents in the planning process. For this reason, we would like to extend a special invitation to you to attend the first of several public workshops that will be held on the transmission line project in the next several months.

The workshops will be conducted by DHM Planners, Inc., a consultant, and will explain the approach we are using in the routing study and respond to comments from the public. It will also include a brief description of the proposed geothermal development. I must emphasize that routes have not yet been selected and that the final placement of the transmission line corridor will depend a great deal on the comments and preferences expressed by the public at the workshops.

The first session in November will be held at the Pahoa Neighborhood Center on ~~Thursday~~ Wednesday, November 12, 1986, at 7:00 p.m.

Your participation will be greatly appreciated, and our agenda is enclosed for your reference. If you would like more information about the workshop, please call Mr. John Corbelli at 935-1171, ext. 122, or Dennis Tanigawa at 935-1171, ext. 351.

Sincerely,

Norman A. Oss
Norman A. Oss
President

NO:md
Enclosure

A Hawaiian Electric Industries Company



**Dear Big Island Customer,**

Helco welcomes your help in planning the best possible route for new electric transmission lines between Pohoiki and our Puna substation. The two lines are needed to transmit electric power to our Big Island customers from the new geothermal plant that will be built at Pohoiki by Thermal Power.

Like you, Helco is concerned about keeping the cost of the project as low as possible, protecting the environment, and minimizing the project's visual impact.

At 7pm on November 12, in the Pahoa Neighborhood Center, we will hold the first of several public workshops to help us identify the best corridor for these lines.

Because selection of a route will depend a great deal upon comments, preferences, and suggestions received at these workshops, your input would be greatly appreciated.

Please call Helco's Dennis Tanigawa at 935-1171 if you want more information. Mahalo.

The people of
Hawaii Electric Light Company

# Helco plans to string up Puna line

By Leigh Critchlow
Tribune-Herald

Hawaii Electric Light Co. announced today it plans to construct a new transmission line between Thermal Power Company's proposed geothermal plant at Pohoiki and Helco's Puna substation next to the old Puna Sugar Co. plant.

A study of all possible alternatives by Helco has determined that the new 69,000-volt transmission line is required to serve Big Island customers, explained Helco president Norman Oss.

Helco earlier this year signed a contract with Thermal Power to purchase up to 25,000 kilowatts of geothermal-produced power by 1993, enough electricity for about 8,300 Big Isle homes.

The power will be provided in two increments of 12,500 kilowatts — the first by 1989 and the second by 1993.

Oss said Helco will be seeking public involvement in determining the route for the new transmission line.

"The placement of any transmission line is a concern to people in the affected areas. There are geophysical, biological, economical, and social concerns, to name a few, Oss said.

"For these reasons, we wish to invite the public, not just to attend but also to give us their input, at a series of informational workshops scheduled over the next several months.

"We want the community to help us determine a final route for this important project," Oss said.

Helco will pick the route judged to be the "least environmentally objectionable," said Alva Nakamura, manager of Helco's engineering department, at a press conference this morning in Hilo.

Oss said the route for the transmission line will use existing roadways wherever possible. The project could benefit residents of some rural areas who are far from electricity, he said.

The first public meeting will be held at 7 p.m. Nov. 12 in the Pahoa Community Center.

The session will be conducted by DHM Planners, Inc., whose representatives will explain the approach being used in the routing analysis and answer questions from participants.

There also will be a brief description offered of the proposed geothermal development.

Community involvement in planning the transmission line's route is important in order that every environmental concern is addressed and resolved during the route selection process, which subsequently will be described in an environmental impact statement Oss said.

—T-H photo by Larry Kadooka

PLANS FOR PUNA — Helco officials this morning announced plans for a new 69,000-volt transmission line in Puna. From left are Alva Nakamura, manager of the engineering department; Helco president Norman Oss, engineer Clyde Nagata; and engineer Dennis Tanigawa, the project manager.

Tribune-Herald 11-6-86

## LEGAL NOTICE
### PROPOSED POHOIKI-PUNA TRANSMISSION LINE

The first in a series of public workshops will be held on November 12, 1986 to advise the public about a proposed 69,000 volt transmission line to carry electric power from Thermal Power's proposed geothermal development at Pohoiki, Puna, to HELCO's Puna substation at Keaau.

A study is being conducted to identify alternate corridors within which new lines may be constructed. The study will consider various factors which would affect placement of the line, including geophysical, biological, economical, and social. The findings will be described later in an Environmental Impact Statement.

HELCO invites members of the public to present their concerns and suggestions to assist in identifying possible corridors from which the final alignment may be selected. Additional meetings will be held periodically to update the public on progress and to receive further comments.

The first informational meeting is scheduled as follows:

Date: Wednesday, November 12, 1986
Time: 7:00 P.M.
Place: Pahoa Neighborhood Center

Hawaii Electric Light Co., Inc.
(914 — Hawaii Tribune-Herald: Nov. 5, 9, 1986)

HEI

November 26, 1986

Big Island Committee on Municipal Power
c/o Alex Smyklo
Post Office Box 1412
Pahoa, Hawaii 96778

Gentlemen:

Subject: Proposed Pohoiki-Puna Transmission Line

Last month, we held the first round of public workshops concerning the proposed 69 KV transmission line project which will connect Thermal Power's proposed geothermal power generating plant at Pohoiki to HELCO's 69 KV grid at the Puna Substation.

At those workshops, we apprised you of the transmission line project and the method by which the transmission line corridors will be selected.

The second round of public workshops will be held this month. At the workshops, you will be apprised of the areas which have been identified as potential corridors and how these corridors were selected. The preferred corridors will also be identified. The workshops will be conducted by DHM Planners, Inc.

We extend a special invitation to you to attend the workshop which will be held on Wednesday evening, December 10, 1986, at 7:00 P.M., at the Pahoa Neighborhood Center.

If you have any questions about the workshop, please call HELCO at 935-1171 and ask for Mr. John Corbelli or Mr. Dennis Tanigawa.

Sincerely,

Norman A. Oss
Norman A. Oss
President

NAO:md

A Hawaiian Electric Industries Company

A-21

RESIDENT'S LETTER - 3,954 MAILED

Hawaii Electric Light Company, Inc. • PO Box 1027 • Hilo HI 96721-102

August 20, 1987

Dear Neighbor:

About fourteen years ago, the National Science Foundation and the State of Hawaii envisioned a day when renewable energy might provide us with all the heat and light we needed and financed a University of Hawaii proposal to explore for geothermal energy at Pohoiki. Not only were the results successful, but today that small, exploratory well supplies enough electricity for about 800 Big Island homes.

The prospects that geothermal energy may provide more Big Island homes with electricity rose even higher this year when HELCO signed an agreement to purchase up to 25,000 kilowatts of geothermal-produced energy from Thermal Power Company, beginning in late 1989. This means that some 8,000 more Big Island homes will be getting their electricity from geothermal energy.

In a few months, we will begin construction of a new 69,000 volt transmission line between Thermal Power's proposed geothermal plant at Pohoiki to our substation in Keaau. Construction of this line will enable us to transport this geothermal-produced energy for use solely on the Big Island.

In order to plan the best route for the transmission line, we solicited public input and comments. At these meetings, some people understandably expressed a number of concerns, and a few did not like our plans at all. And, while we had the answers to most of the questions, we thoroughly investigated those we didn't.

Because some of those who are disenchanted with our plans have been making misleading statements, we'd like to set the record straight and share with you the results of our research.

I would also like to invite you to tune in when Clyde Nagata, our Manager of Engineering, and I discuss these important issues from 6:30 to 7:00 P.M., Thursday, August 27, on "Big Island Issues and Answers", KHBC, Channel 2.

You are also invited to a public informational meeting, which will be held at 7:00 P.M., September 3, 1987, at the Pahoa Neighborhood Center. The final transmission line alignments will be shown at this meeting.

Should you have any questions after reviewing either the materials or the show, please feel free to call Dennis Tanigawa at 935-1171.

Thank you for your interest and consideration.

Sincerely,

Norman A. Oss
Norman A. Oss
President

An HEI Company

(ATTACHMENT SENT WITH ALL LETTERS)

QUESTIONS AND ANSWERS
Pohoiki - Keaau 69,000 Volt Transmission Line

Question: Do transmission voltages increase the danger of injury and fire if a line falls to the ground?

Answer: Transmission lines are actually better designed for automatic protection than lower voltage distribution lines. By the time a transmission line falls to the ground, they are normally already de-energized by automatic protective devices which also signal an interruption to our system operations personnel.

During the February 1986 windstorm, for example, several of our 69,000 volt (69 kv) transmission lines fell and were automatically de-energized by protective devices. No injuries or fires resulted.

To our recollection, there have been no injuries or fatalities on the Big Island due to downed transmission lines. The tragic fatality earlier this year in Nanawale Estates involved a 12 kv line, a distribution voltage.

---

Question: Will the electromagnetic field (EMF) created by a transmission line cause adverse health effects, particularly in children?

Answer: J. Michael Silva is a professional engineer and president of Enertech Consultants and has performed many studies on this subject. According to Silva, EMF from a 69 kv transmission line can be even less than that generated by some typical household appliances. His analysis, including field measurements and computer calculations indicate no significant effects from EMF on human health.

HELCo has always been concerned about this matter and continues to support research efforts of the Electric Power Research Institute (EPRI). To date, none of EPRI's studies over the past decade has found any correlation between EMF and human health.

Nonetheless, we recognize the need for additional research. EPRI has expanded its research program and has asked 15 experts from the scientific community and industry to serve on an oversight committee to review and to make recommendations on their research program.



Question: Will EMF cause interference with TV, radio, telephone, and emergency communications?

Answer: This usually doesn't occur, since interference can be minimized through proper design and the use of appropriate hardware, its primary cause. When it does, as was once the case on a part of our Hamakua 69 kv line, the introduction of special hardware immediately cleared up the problem.

---

Question: Can future power lines from geothermal fields be master-planned to minimize adverse effects on the community?

Answer: Thermal Power Company appears to be the only active geothermal developer in Puna. Although it is possible that others may eventually produce geothermal power there, we have no knowledge of further developments. This makes master-planning of transmission lines extremely difficult, if not impossible.

In the meantime, our power needs are rapidly approaching the critical state. We need more generation and we need to proceed to plan and build the lines needed to tie Thermal's proposed plant to our system.

---

Question: What about the visual intrusion the electrical power structures will have on views of the ocean, mountains, and landscape?

Answer: Contrary to what some people think, we will not be installing steel tower structures. What is being installed are 65- to 70-foot wooden poles, with 7 to 8 feet buried in the ground.

In addition, it is our experience that the issue of aesthetics is generally subjective. While one person may greatly dislike a utility pole in his view, another may be indifferent about it because he values other factors about his surroundings more.

**Question:** What effect would the presence of a transmission line have on property values?

**Answer:** There are a number of 69 kv lines already around the Big Island, including through some residential areas as Kawailani Street. Research by the County tax office established that there was no evidence of decrease in property values.

There is also the argument that values may increase in many sections of subdivisions currently lacking electricity, since distribution lines could be installed on the same 69 kv poles, making it more economically affordable for residents to obtain line extensions, especially in conjunction with our new Special Subdivision Project Provision Program (SSPP).

---

**Question:** What effect, if any, would a 69 kv transmission line have on my home insurance premiums?

**Answer:** The insurance companies we contacted unanimously agreed that there would be no effect. In fact, they reported that premiums are sometimes lower in homes served by electric utility service rather than by their own generators. Some companies reported that they would not insure a house that didn't have electric service from a utility.

---

**Question:** Could the transmission line be placed underground instead?

**Answer:** It could, but the cost would be approximately 6 times greater than an overhead line and would create an unfair and unnecessary financial burden on all our Big Island customers. In this case, it would cost $4 million for one overhead 69 kv line, compared to $22 million for one underground line.

There is pro and con to most situations and this is no exception. Because underground lines are buried and not visible, maintenance and restoration of power due to cable failure takes considerably more time. Depending on the severity, repairs may take several days. Also, since there are no poles on an underground line, they would have to be installed later, anyway, whenever line extensions are necessary to serve customers requesting electric service to areas currently without it.



**Question:** How wide will the easement for the line be?

**Answer:** Although the "corridors" we have been studying are quite wide, we normally require a maximum of only 50 feet for the actual alignment for a 69,000 volt line. However, if the line is located along a roadway (which is a likely case), we would be satisfied with an easement covering the width of the roadway. Then we would not have to ask for easements within individual lots except for anchors wherever the line changes direction.

# APPENDIX B

**B I S H O P   M U S E U M**
1525 BERNICE STREET • P.O. BOX 19000-A • HONOLULU, HAWAI'I • 96817-0916 • (808) 847-3511

CULTURAL AND BIOLOGICAL RESOURCES SURVEY
OF THE POHOIKI TO PUNA-SUBSTATION
69KV TRANSMISSION CORRIDOR
KAPOHO TO KEA'AU, PUNA, HAWAI'I ISLAND

Final Report:
Archaeological Survey
Department of Anthropology
Bernice Pauahi Bishop Museum

ORIGINAL

B-1

# CULTURAL AND BIOLOGICAL RESOURCES SURVEY OF THE POHOIKI TO PUNA-SUBSTATION 69KV TRANSMISSION CORRIDOR KAPOHO TO KEA'AU, PUNA, HAWAI'I ISLAND

Final Report:

Archaeological Survey

April 30, 1987

Eric K. Komori

Appendix:

Literature Review of
Previous Archaeological Work,
Previous Historic Land Use, and
Legends and Traditions

Ingrid R. Peterson

Prepared for:

DHM Inc.
1188 Bishop Street
Suite 2405
Honolulu, Hawai'i 96813

Department of Anthropology
Bernice P. Bishop Museum
Honolulu, Hawai'i

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## ABSTRACT

Thirty six archaeological transects of inland portions of Puna district on the the island of Hawai'i were conducted to locate archaeological sites and assess the potential for additional resources in the area. The purpose of the study is to provide data for an environmental impact statement on a transmission line.

The number of sites located is very low (11 prehistoric-type and 3 historic-type sites), however, the findings support a settlement pattern model for the area that predicts the occurrence of extensive prehistoric-type agricultural fields, and sites that reflect adaptation to the physiographic features in the area. Historic-type sites were associated with the sugar industry.

Previous geologic research provides estimates of the age of the substrates in the study area that allow tentative generalized interpretations of the archaeological sites. The hypothesis that expansion of Hawaiian settlements away from initial foci after A.D. 1100 is supported by estimated dates of no older that A.D. 1450 for the sites. The estimated age and type of a small number of petroglyphs located supports the findings of previous research that indicates a change in stylistic preference.

Preservation of all sites located is recommended and further archaeological survey once a particular alignment is chosen is specified.






## INTRODUCTION

This report presents the results of an archaeological study of alternate routes for the proposed Pohoiki-Kea'au Transmission Line Corridor located in the district of Puna on the island of Hawai'i. The study was conducted under contract to DHM, Inc. by the Department of Anthropology, Bernice. P Bishop Museum. The archaeological fieldwork was conducted between February 9-20, 1987 by the author, William Fortini, Elaine Rogers-Jourdane, and Jeffery Yasauchi. All records and data are deposited in the Department of Anthropology, Bernice Pauahi Bishop Museum. I would like to express my appreciation to Mr. Timothy Lui-Kwan (Hawai'i County Planning Department), Mr. Bruce Butts (Hawai'i County Civil Defense), Mr. Sonny Kinney (Alu Like, Inc.), and Mr. Clarke Wallace (Aafac Inc.) for providing valuable assistance and information during the course of the fieldwork.

The primary objective of this study is to provide data for an environmental impact statement on the transmission line corridors. The tasks undertaken were:

1. Identification and evaluation of archaeological resources found in the area through field survey and literature search.

2. Assessment of potential for the existence of additional archaeological resources in the area.

3. Evaluation of possible effects of the proposed transmission line on archaeological resources in the area.

A literature search on the legends and traditions, previous archaeological research, and historical data concerning the general Puna area was also conducted and is included as an appendix.

## GEOGRAPHIC SETTING

The study area consists of three discontinuous corridors that begin near the Puna Sugar Mill (east of the town of Kea'au), continues to the Pahoa town area, and end near the existing geothermal plant at Pu'u Honuaula, in Pohoiki (fig. 1). The corridors generally follow existing roads, range from 450 to

850 meters (1500-3000 feet) in width and are approximately 42 kilometers (26 miles) in total length. For the purposes of this report the corridors have been divided into nine segments "A" through "I" (fig. 1).

The corridors are entirely located in the traditional Hawaiian district of Puna and cross twelve ahupua'a (traditional Hawaiian land divisions). The ahupua'a crossed are: (roughly north to south)

| | | | | | |
|---|---|---|---|---|---|
| 1 | Kea'au | 5 | Keonepoko Nui | 9 | Halekamahina 2 |
| 2 | Waiku'u | 6 | Keonepoko Iki | 10 | Kapoho |
| 3 | Popoki | 7 | Kahuwai | 11 | Kanaahiku |
| 4 | Halona | 8 | Puua | 12 | Keahialaka |

During the "Mahele" in the mid-1800's, when the traditional Hawaiian land tenure system was overthrown, only fourteen land awards were recorded in the Puna area. Of these three were for less than 20 acres, the other awards (primarily to chiefs) range from 1,110 to 64,275 acres in area (Indices 1929).

Modern activities in the area include: geothermal and biomass electrical energy plants, papaya plantations, cut-flower farms, sugar cane plantations (now abandoned) and large scale land developments.

ENVIRONMENTAL SETTING

The study area is located on the windward slopes of Kilauea Volcano one of the best known and intensively studied (geologically) volcanoes in world (Holcomb 1981:2). Kilauea volcano is highly active and recent eruptions such as those in 1955, 1840 and circa 1790, have affected portions of the southeastern limits of the study area (Ibid:plate 3). The elevation of the corridor ranges from 61 to 274 meters (200 to 900 feet) above sea level and rainfall is from about 318 to 445 centimeters (125 to 175 inches) per year (Stearns and MacDonald 1946:212).





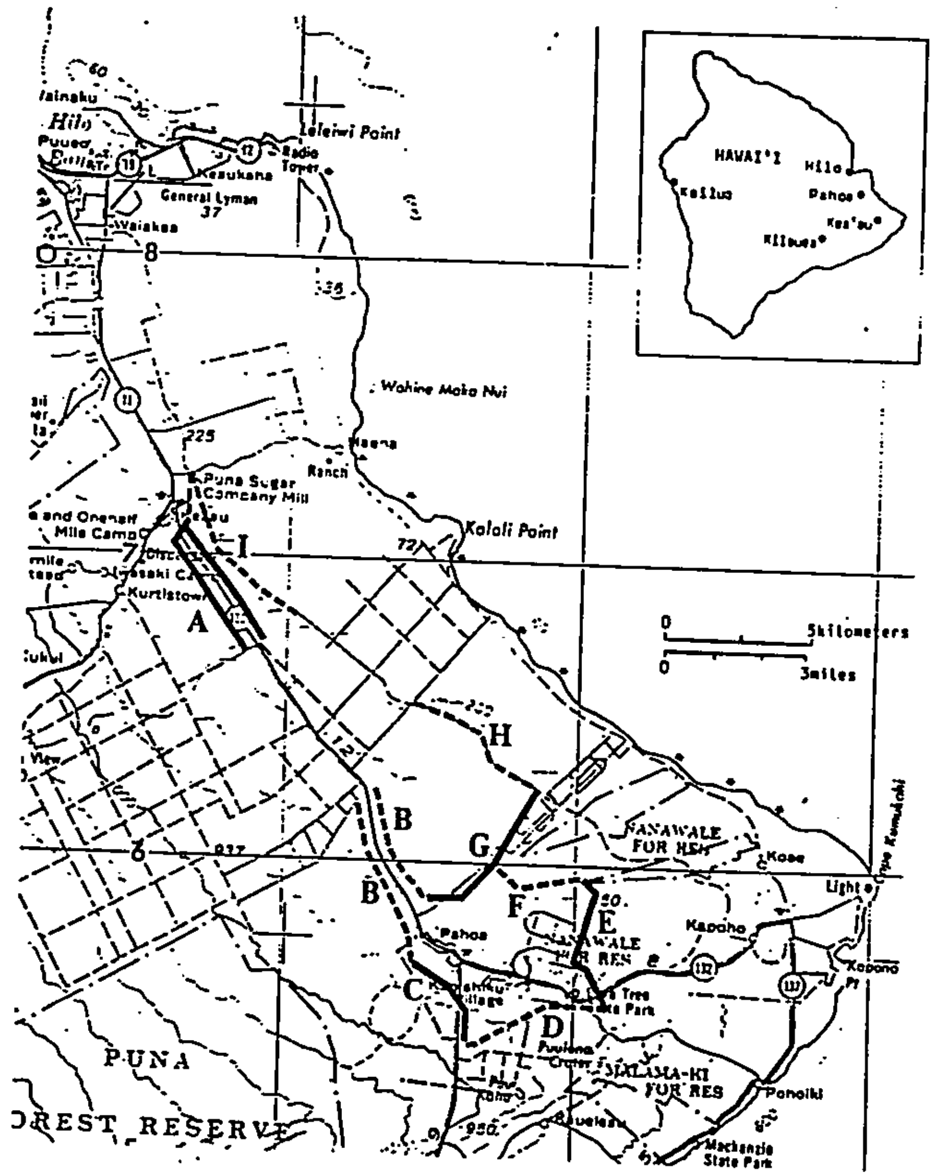


FIGURE 1. Map of Project Area with Corridor Segments and Locations.

Geology

The deeper soils in the area are represented by limited areas of ash deposits and weathered 'a'a. Virtually all of these areas have been used for sugar cane fields or pasture land and are extensively disturbed. These deposits are surrounded by a large number of extensive, more recent lava flows that have little or no soil development (Soil Conservation Service 1972; Holcomb 1981).

The high frequency of diverse, recent lava flows in the study area has resulted in a topography that is highly variable and closely linked to flow morphology. A recent study that details the chronology of the surficial lava flows of Kilauea volcano shows that much of the study area is covered with recent pahoehoe lavas less than one thousand years old, with pockets of 'a'a lava that are generally older (Holcomb 1981:plate 3). Utilizing data such as radiocarbon dates, paleomagnetic data, stratigraphic relationships, or historic accounts, Holcomb arranged the lava flows into nine age groups. The age intervals for the groups range from 100 to 500 years, with the most recent lavas being from the twentieth century and the earliest lavas being older than 1500 years B.P. (Ibid).

Two basic types of lava flows, surface-fed and tube-fed are distinguished for Kilauea Volcano. The surface morphology, however, is influenced by many factors such as its physical properties, the environment into which it is introduced, rate of flow, and duration. The large number of factors result in a variety of surface textures that range from relatively smooth flat surfaces, to broken plate-like structures, to extremely rough 'a'a lava (Ibid:77-98).

Flora

Forested areas that are undisturbed by modern agricultural or urban activities are dominated by 'ohi'a (Metrosideros collina) with an understory that includes an assortment of ferns and shrubs. More exposed areas range from less dense 'ohi'a forests with a ground cover of thick matted uluhe ferns (Dicranopteris sp.) to open grassy areas commonly called "'ohi'a dieback". Variations in vegetation in these unaltered areas appear to be closely related to substrate type and age.





Although poorly represented, plants found in the study area that are commonly associated with prehistoric-type Hawaiian activity include kukui (Aleurites moluccana), hala (Pandanus odoratissimus), 'ulu (Artocarpis communis) and ki (Cordyline terminalis) Small numbers of recent introductions such as guava (Psidium guajava), siris (albizia lebbeck), koa haole (Leucaena glauca), and mango (mangifera indica) are frequently found, clustered in relatively unaltered areas. (For a complete listing, the reader is referred to concurrent research by Takeuchi and Imada for DHM, Inc.)

Fauna

Indications of the presence of feral pigs (Sus scrofa) was noted throughout the study area, however, only one deceased juvenile was seen. Cows and horses are also present, however, no feral examples of large mammals other than pigs were observed. Doves and myna birds are common in the area and egrets were occasionally seen. (For further information on the ornithology of the area the reader is referred to concurrent research by Fleischer for DHM, Inc.; entomological resources in the area are covered in Nishida et al. for DHM, Inc.)

## TERMINOLOGY

The present research is primarily intended to provide an assessment of archaeological resources in the study area based previous documentation and sampling of surface remains. Therefore, in order to avoid ambiguity since the cultural and chronological associations ascribed to each site is based on limited data, terms used for site interpretation must be well defined. Of principal concern are the dichotomies of prehistoric - historic (Hawaiian vs. non-Hawaiian), and archaeological - historic (mainly concerned with methodology).

Prehistoric - Historic

The discovery of the Hawaiian Islands by westerners in A.D. 1778 (technically ending the "pre-historic" period) was not accompanied by an immediate end to pre-contact Hawaiian culture. It must be recognized, therefore, that well into the "historic" period sites were being formed within a traditional Hawaiian context. The terms historic and prehistoric are not used here as they imply a sharp chronologic break. Instead the site interpretations use the terms: prehistoric-type to imply association with traditional Hawaiian culture, historic-type to imply association with later cultures, and prehistoric/historic-type when an interpretation cannot be made. In cases where more than one type of interpretation can be made multiple terms are used.

In the absence of excavated data, the site attributes of prehistoric-type and historic-type are based on three characteristics that are observable through examination of surface features:

1. Artifact and midden types.

2. Construction techniques and structural configuration.

3. Spatial associations.

Of these, the interpretation of artifacts and midden is usually the most reliable means of site evaluation.

The methodology for analysis of construction techniques, structural configurations and spatial associations, based on surface characteristics is not systematized for Hawaiian sites. However, although site interpretations based solely on these characteristics are less explicit, they comprise a useful basis for subsequent investigations.

Archaeological Site - Historic Site

Another potential source of confusion are the terms: archaeological site, and historic site. For the purposes of this study archaeological and historic sites are differentiated based on the potential for reliable documentation (i.e. oral history or or coeval documentation). This criteria will determine the primary research methodology, archaeological for an archaeological site or historical for a historical site.

Sites that are primarily associated with prehistoric-types of activities are unlikely to have coeval documentation and are therefore called archaeological site. Sites that are associated with historic-types of activities are called historic site if the site has coeval documentation, or archaeological site if such documentation is lacking.





## PREVIOUS ARCHAEOLOGICAL WORK

This section is principally concerned with the study area proper, a more generalized report covering previous archaeological research in the Puna area is included as an appendix.

Archaeological research regarding the inland areas of Puna has been extremely limited. Most study areas have been limited in size and frequently concerned with only one site. A notable exception, although no fieldwork was conducted, is a comprehensive analysis of archaeological and historical literature concerning the Puna area (McEldowney 1979), that is utilized in the development of the research design for the present study (see below).

Although the present study area is quite extensive only one project involving archaeological fieldwork had been previously conducted in the area (Bordner 1977). This project resulted in the location of one, possibly prehistoric-type site (State of Hawai'i Site 50-10-46-6417a) (Ibid). This site is an ahu (stone mound) located approximately 91 meters (300 feet) east of Highway 130, approximately 5.5 kilometers (3.4 miles) northwest of Pahoa town. This site was not relocated during the present survey and may have been destroyed by subsequent construction activities.

Pahoa town, (State of Hawai'i Site 50-10-55-7380) and the former right-of-way for the Hawai'i Consolidated Railway, are the only previously identified historic-type sites within the corridors.

Prehistoric-type sites located in the general vicinity of the proposed corridors consist of four lava tube sites: Shipman's Cave (50-Ha-A1-11), Kapo Kohe Lele Cave, Pahoa Cave, and a "modified lava tube" (see appendix). With the exception of the "modified lava tube," these all contain human skeletal remains. Pahoa Cave and Shipman's Cave are thought to be refuge caves as well (see appendix). These caves (lava tube segments) are part of an extensive system of lava tubes that occur in many sections of the study area and may be connected to lava tube sites located during the present fieldwork.

Historic-type sites located near the corridor are for the most part related to sugar plantation activities in the area. The closest example is

Kea'au District (State of Hawai'i site 50-10-44-7389) which encompasses most of Kea'au town.

## RESEARCH DESIGN

The study objectives outlined in the introduction are primarily related to the development an environmental impact statement concerning the proposed activity and not necessarily related to general archaeological research goals. Since the study area covers a large area that has not been previously examined through extensive fieldwork, it is necessary to relate the present research activities to the context of the general Puna area.

### Settlement Pattern Model

The research design for the present study focuses on prehistoric-type activity in the study area and utilizes a settlement pattern model based on analysis of archaeological data from previous studies and literature from the early historic period (McEldowney 1979). The analysis was primarily concerned with the east Puna region between the town of Hilo and Cape Kumukahi to an altitude of 2900 meters (9,500 feet), and included the present study area. McEldowney identified five zones of prehistoric-type Hawaiian settlement and land use roughly corresponding to elevation:

I. Coastal settlement (0-50 ft.)
II. Upland agriculture (50-1,500 ft.)
III. Lower forest (1,500-2,500 ft.)
IV. Rainforest (2,500-5,500 ft.)
V. Sub-alpine (5,500-9,500+ ft.)

Substantial prehistoric-type settlements were found to have occurred on the coast, with extensive agricultural fields located in areas of Zone II. The higher elevation areas of Zones III, IV, and V were have been utilized for exploitation of a large variety of forest resources such as trees, fibers, birds, etc. and trails (McEldowney 1978:15-33).

McEldowney noted that differing land use patterns, although closely related to elevation (i.e. proximity to coastal areas and primary settlements) are also related to variability in physiography (geologic morphology, and





vegetation) within each zone (Ibid:3, 4, 14). Two extremes in geologic variability are represented by thick, older, volcanic ash deposits from Mauna Loa volcano (relatively well developed soils), and the recent lavas of Kilauea volcano (little or no soil development).

McEldowney illustrated specific adaptations to the environment of the region utilizing data from early historic descriptions and previous archaeological research:

> [on the ash deposits]...the land use patterns were unform [uniform], consisting of more concentrated settlements on gulch or valley floors near the coast and of widely spaced plantations and huts scattered across an "unwooded," gentle slope up to 2,000 ft elevation (Ellis, 1963:349; Macrae, 1922:48-49; Menzies, 1920:51). [on recent lavas]...adaptation patterns centered around maximizing use of a frequently changing landscape with a rough, uneven, and highly variable surface having little soil development. Practices typical of the area, such as the modification of lava tubes and outcrops for shelter, the use of mounds and mulching for planting, ...typify this adaptation [McEldowney, 1979:14, 15].

In terms of overall site frequency in Zone II McEldowney suggests that few prehistoric-type sites are to be expected in areas of recent lavas, and that undisturbed volcanic ash deposits and older lava flows have a higher potential (Ibid:19).

### Research Goals

General research problems addressed by the present study are related to the prehistoric-type settlement pattern model presented by McEldowney. Although the study area is limited by "artificial constraints" (i.e. the study area boundaries are not congruent with archaeological research considerations), the study must be conducted within the context of regional considerations.

The following research problems or questions are addressed by fieldwork in the present study area:

1 Previous archaeological work has not resulted in the location of agricultural features in areas of Zone II as predicted by the settlement model. Is this the result of inadequate sampling or are weaknesses in the model the source of the discrepancy?

2 What kinds of prehistoric-type activities other than agriculture are indicated by archaeological sites in the areas of Zone II studied, and what is their distribution.

3 The effects of volcanic activity especially during the prehistoric period.

Although historic-type sites are not evaluated here in the context of research goals, identification and evaluation of these resources is included as one of the objectives of the study.

Sampling Design

Due to the dense vegetation, rough topography, and large size of the study area a surface survey of 100 percent of the area was considered unfeasible. Thus, the adoption of a sampling strategy was necessary. Although no large scale ground surveys had been previously conducted within directly comparable areas, research in nearby areas suggest the occurrence of archaeological sites in association with certain physiographic features. Therefore a stratified sampling strategy was chosen (McEldowney 1979).

Compared to a more random design, a stratified sampling strategy increases the probability of obtaining a representative sample if relevant distributional factors are known. The parameters adopted for the stratified sampling are untested, therefore, a set interval strategy is incorporated into the overall stratified design.





For the present study this means that within each physiographic area identified for sampling, more than one transect was performed and that the transects were, in general, evenly spaced.

Methodology

The sample areas identified, utilizing aerial photos, geologic and topographic maps, and helicopter reconnaissance, consist of various lava flows, ash deposits and associated vegetation. These large physiographic areas are well defined although internally, numerous small scale variations in the terrain and vegetation occur.

Approximate locations for transects were set at central and/or peripheral portions of each physiographic area. Selection of the precise location of each transect, however, was often influenced by degree of accessibility and localized variations in terrain. It should be noted that the considerable physiographic variability of the study area resulted in a set interval pattern of transect placement for the whole area (fig. 1). Transects were generally oriented perpendicular or parallel to the survey corridors, however, other orientations were selected as necessary (e.g. at the border of two physiographic areas transect were oriented to include both). Table 1 summarizes information on each transect.

Surveys were conducted using systematic sweeps oriented to compass bearings. Personnel were usually spaced 25 meters apart and transect widths were generally 100 meters, except in areas of extremely rough terrain or unusually dense vegetation. When features were found an intensive search of the vicinity was conducted for other features. Verbal descriptions were written for each sites and all site locations plotted on 1:24,000 scale maps (U.S.G.S). Time constraints did not allow for the mapping of all the sites located, however, sketch maps were drawn and photographs taken whenever feasible. Artifacts and samples were not collected during the survey.

**TABLE 1**
**TRANSECT SUMMARY**

| Transect | Substrate Type | *Substrate Age | Site |
|---|---|---|---|
| 1 | Ash | >1500 | ----- |
| 2 | Ash | >1500 | A1-45 |
| 3 | TF pahoehoe | 350-500 | ----- |
| 4 | TF pahoehoe | 350-500 | ----- |
| 5 | 'A'a soil | >1500 | A1-48, 49 |
| 6 | Ash | >1500 | ----- |
| 7 | Ash | >1500 | A1-46 |
| | TF pahoehoe | 350-500 | ----- |
| 8 | 'A'a soil | >1500 | A1-47 |
| | TF pahoehoe | 350-500 | ----- |
| 9 | TF pahoehoe | 350-500 | ----- |
| 10 | TF pahoehoe | 350-500 | **50-10-46-6417 |
| 11 | TF pahoehoe | 750-1000 | ----- |
| 12 | TF pahoehoe | 350-500 | ----- |
| 13 | TF pahoehoe | 350-500 | ----- |
| 14 | TF pahoehoe | 350-500 | A4-68 |
| 15 | TF pahoehoe | 350-500 | A4-69 |
| | TF pahoehoe | 750-1000 | ----- |
| 16 | TF pahoehoe | 750-1000 | ----- |
| | 'A'a soil | 750-1000 | ----- |
| 17 | TF pahoehoe | 750-1000 | ----- |
| | 'A'a soil | 750-1000 | ----- |
| 18 | S pahoehoe | 19th century | ----- |
| | Rampart | 19th century | ----- |
| 19 | S pahoehoe | 17th century | ----- |
| 20 | S pahoehoe | 16th century | ----- |
| 21 | S pahoehoe | 17th century | ----- |
| 22 | 'A'a soil | 16th century | ----- |
| 23 | S pahoehoe | 19th century | ----- |
| 24 | 'A'a soil | 750-1000 | ----- |
| 25 | S pahoehoe | 19th century | ----- |
| 26 | S pahoehoe | 19th century | ----- |
| 27 | 'A'a soil | 16th century | ----- |
| 28 | TF pahoehoe | 350-500 | A4-70, A5-18 |
| | 'A'a soil | >1500 | ----- |
| 29 | TF pahoehoe | 350-500 | ----- |
| 30 | TF pahoehoe | 350-500 | ----- |
| 31 | TF pahoehoe | 350-500 | ----- |
| | TF pahoehoe | 750-1000 | ----- |
| 32 | TF pahoehoe | 350-500 | TH-2 |
| 33 | TF pahoehoe | 350-500 | ----- |
| 34 | TF pahoehoe | 350-500 | A4-67 |
| 35 | TF pahoehoe | 350-500 | ----- |
| 36 | TF pahoehoe | 350-500 | A3-20 |

TF pahoehoe = tube fed pahoehoe
S pahoehoe = surface pahoehoe
*Age ranges are given in years B.P.
**State site 50-10-46-6417 was not relocated.





## SURVEY RESULTS

Eleven archaeological and three historic sites were located during the survey (fig. 2a, 2b attached at end of report).

Historic-type sites have been assigned temporary numbers prefaced by "TH-". All sites that contain probable prehistoric components have been assigned site numbers following the established Bishop Museum system:

50 = State of Hawai'i
Ha = Island of Hawai'i
A = Puna
1 = ahupua'a of Kea'au
3 = ahupua'a of Maku'u, Popoki, Halona
4 = ahupua'a of Keonepoko Nui, Keonepoko Iki
5 = ahupua'a of Waikahiula

The terminal number is a discrete site number assigned in order of recordation within each ahupua'a.

### Archaeological Sites

Tentative determinations of site functions based on comparisons with structures analyzed in previous studies have been summarized, with environmental data, in Table 2. The age of the geologic substrates are based on data from Holcomb's study of the chronology of surficial lava flows in the area (Holcomb 1981).

With one exeception (TH-2), all the archaeological sites below have associations with prehistoric-type activities. Site 50-Ha-A4-69, a burial cave, contains human skeletal material associated with early historic artifacts as well as skeletal remains without similar associations and is interpreted as both prehistoric-type and historic-type (see above Terminology).

### Site 50-Ha-A1-45

This site consists of a stone platform and a ditch that are located in a steep gulch that is situated in the midst of extensive sugar cane field. The platform constructed of stacked, angular stone measures 3 by 4 meters and

**TABLE 2**
**PREHISTORIC-TYPE ARCHAEOLOGICAL SITE**
**FUNCTIONAL INTERPRETATIONS AND SUBSTRATE DATA**

| Site | Type | Functional Interpretation | Substrate Type | *Substrate Age | Corridor Section |
|---|---|---|---|---|---|
| A1-45 | Irrig. ditch, platform | Agriculture | Ash soil | >1500 | A |
| A1-46 | Walls, terraces, clearings | Agriculture | Ash soil<br>Pahoehoe | >1500<br>350-500 | I |
| A1-47 | Terraces, mod. outcrops | Agriculture | 'A'a soil<br>Pahoehoe | >1500<br>350-500 | I |
| A1-48 | Terraces | Agriculture | 'A'a soil | >1500 | A |
| A1-49 | Terraces | Agriculture | 'A'a soil | >1500 | A |
| A3-28 | Platform | Boundary/Trail | Pahoehoe | 350-500 | H |
| A4-67 | Terraced platform | Boundary/Trail | Pahoehoe | 350-500 | H |
| A4-68 | Modified cave | Refuge | Pahoehoe | 350-500 | B |
| A4-69 | Burial cave | Burial | Pahoehoe | 350-500 | C |
| A4-70 | Petroglyphs | Petroglyph | Pahoehoe | 350-500 | G |
| A5-10 | Burial cave | Burial | Pahoehoe<br>'A'a | 350-500<br>>1500 | G |

* Substrate age in years B.P.





stands 100 centimeters high. The ditch is approximately 23 meters long, 2 to 3 meters wide and 30 centimeters deep. Recent debris, including bottles, metal fragments and pieces of plastic were found. Soils in the area are deep and the vegetation includes guava, 'ulu and banyan (Ficus sp.).

Site 50-Ha-A1-46

Located at the boundary between former sugar cane fields and an 'ohi'a forest, this complex of stacked stone structures occupies an area of approximately 150 x 40 meters. The principal feature in the area is a stacked stone wall that appears to extend over the entire length of the area. A large number of terraces, clearings, and small wall segments appear to form a continous series of structures that occupy the entire area. No artifacts or midden were found, although remnants of a modern fence was present. The dense vegetation includes guava, 'ulu, banyan and siris. The substrate appears to be a mixture of the deep soils of the sugar cane fields and the rocky surface of the 'ohi'a forest.

Site 50-Ha-A1-47

Occupying an area that measures approximately 100 x 30 meters, this complex of structures is bounded on the west by one of the sugar cane fields at Waipahoehoe and on the east by forest (fig. 3). Numerous modified outcrops, clearings and small terraces (less than five meters long) were found in the area. A long, narrow depression, 15 meters long, 1 meter wide and 20 centimeters deep is located near the eastern boundary of the area. This structure is oriented 240 degrees east of magnetic north, bounded by 1-2 courses of angular stone and its shallow interior consists of a deposit of sediments. No artifacts or midden were observed.

The vegetation includes guava, 'ulu banyan and siris. As at site A1-46 the substrate in this area appears to be a mixture of the deep soils of the sugar cane fields and the rocky surface of the 'ohi'a forest.

In 1846 Chester Lyman traveled to Waipahoehoe and described a "little village" in the area (Lyman 1846:108).

Site 50-Ha-A1-48

This structure consists of a five meter long terrace situated at the top of the steep southeast bank of an intermittent stream. The terrace is located

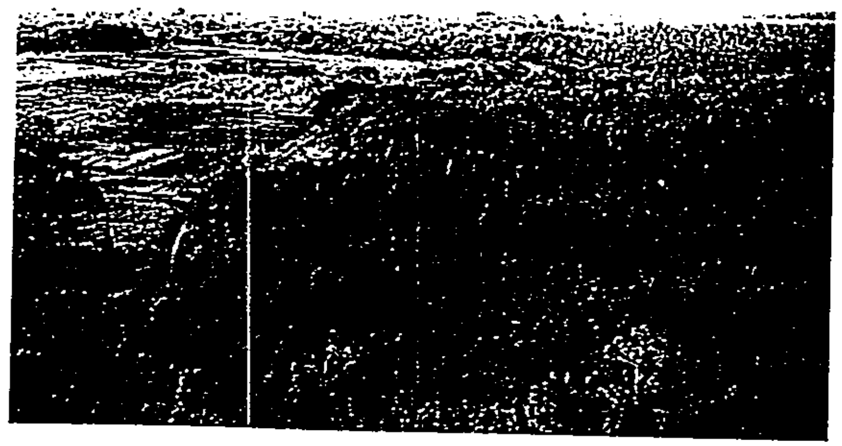

FIGURE 3. Aerial View of Topography near Site A1-47. (agricultural complex)



in a dense, narrow stand of hau (Hibiscus tiliaceus) that follows the stream and between two sugar cane fields. The terrace is constructed of stacked angular stones, two to three stones high (60 centimeters) and oriented approximately 10 degrees east of magnetic north. No artifacts or midden were observed. Disturbed remnants of additional terracing were found nearby and the soil in the area is deep.

Site 50-Ha-A1-49

Situated about 150 meters northeast of A1-48, along the same bank of the stream, this structure is a segment of terracing 25 meters long. Constructed of 4-5 courses (75-100 centimeters high) of stacked angular stone, the structure is oriented approximately 355 degrees east of magnetic north. The site has been disturbed by bulldozing of the deep soils of the adjacent sugar cane field and is covered with guava. No artifacts or midden were observed.

Site 50-Ha-A3-28

This structure is a low terrace or platform situated at the base of a pressure ridge system in an open pahoehoe flow. The structure is ill-defined, however, it appears to be constructed of 1-2 courses of stacked angular stone and measures 2.4 by 1.8 meters. No midden or artifacts were observed. A modern hunter's blind constructed of lumber was found nearby. The site is situated in the "'ohi'a dieback" an open grass areas with sparse 'ohi'a, but ki, hala and guava were found clustered along the pressure ridge.

Site 50-Ha-A4-67

Located immediately adjacent to the railroad bed, this structure is a stepped stone platform constructed of stacked stone facings with an interior fill of smaller stone (fig. 4, 5). No artifacts or midden were found on the structure. This site is located in the "'ohi'a dieback" area, very close to the boundary between the ahupua'a of Halona and Keonepoko Nui. The substrate is relatively bare pahoehoe.

Site 50-Ha-A4-68

This site consists of a collapsed lava tube sink roughly 30 meters in diameter and 5 meters deep that has been extensively modified. Entry into an extensive network of lava tubes that is accessible from the sink has been restricted by the construction of stacked stone walls and platforms that block the tube openings (fig. 6). An interesting feature at the west end of the

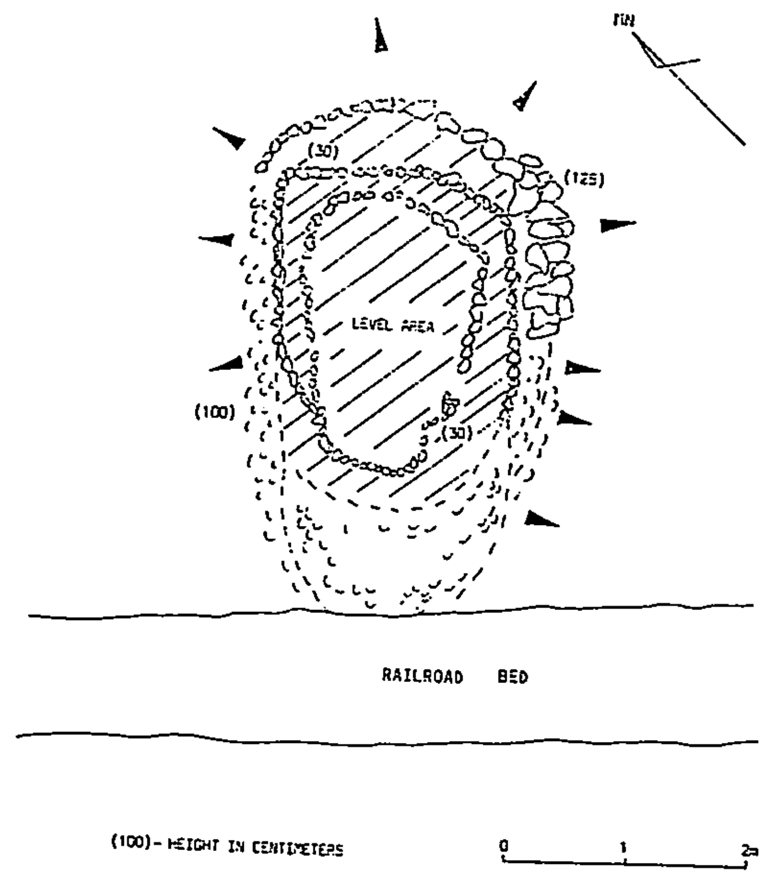


FIGURE 4. Sketch Map of Site A4-67 (terraced platform).



FIGURE 5. Site A4-67 (terraced platform), in "ohi'a dieback" Area. View to North.

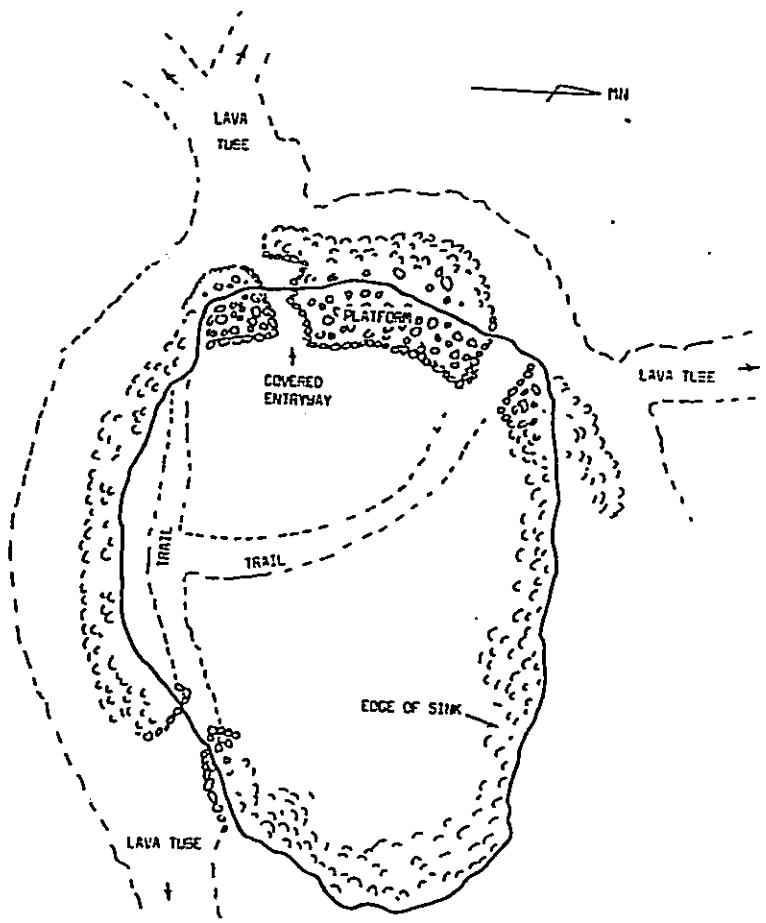


FIGURE 6. Rough Sketch of Site A4-68 (refuge cave). Not to Scale.



sink is a passageway that allows access to the lava tubes. This entry is a small constructed opening 60 centimeters high and 75 centimeters wide, faced on both sides and ceiling, that continues for a distance of about four meters.

Prehistoric-type midden material consists of marine shell and burnt kukui nuts. There is a deep deposit of sediments on the bottom of the sink area and the excavation potential is good. The lava tubes were followed for approximately 400 meters and no interior structures were located, however, the system continues for an unknown distance and is probably related to the system associated with the "Pahoa Cave" (Yent 1983).

The sink is located in an area of pahoehoe lava with little soil development. Vegetation in the area is dominated by 'ohi'a and dense uluhe. Solitary kukui and banyan trees were found growing in the sink (fig. 7).

This lava tube had been previously designated as a Civil Defense shelter and there is evidence of recent modifications to the site. Stones have been removed from walls and platforms, a path constructed into the sink, and pipes and lumber are scattered on the surface. Civil Defense shelter maps show another lava tube cave located east and across the highway from A4-68, however, it could not be relocated

Site 50-Ha-A4-69

This site is a collapsed lava tube sink that has no structural modifications and very little soil development. The sink is about 10 meters in diameter and 5 meters deep, with openings into lava tubes that extend to the north and south. The badly disturbed skeletal remains of approximately five individuals were found scattered for approximately 100 meters along both tubes. The tubes were not completely explored due to time constraints and additional skeletal remains may exist.

No prehistoric-type artifacts or midden were found in the tubes. Artifacts from with the early historic period (e.g. square shank nails, bottles with hand formed lips, bone buttons), however, appear to be associated with certain concentrations of bone and it is likely that both prehistoric-type and historic-type internments are represented (fig. 8). Modern artifacts such as pieces of corrugated iron and a bottle with "Territory of Hawaii"

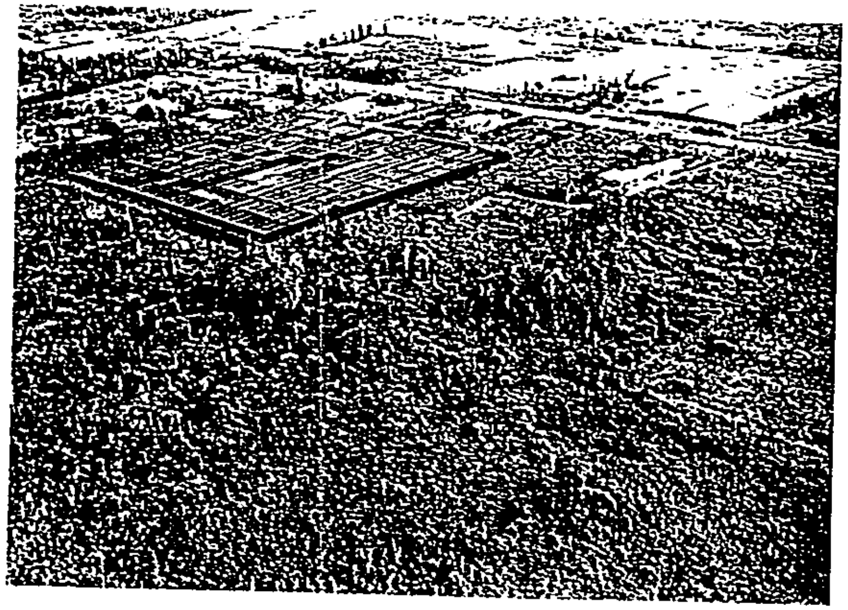

FIGURE 7. Aerial View of Topography near Site A4-68 (refuge cave).



FIGURE 8. Interior of Site A4-69 (burial cave).
View to West.

embossed on it were also found, inferring relatively recent activity at the site.

The site is located in an area covered with dense uluhe and sparse 'ohi'a.

Site 50-Ha-A4-70

This site is a cluster of 18 petroglyphs located on a smooth pahoehoe lava flow in an area covered with dense uluhe and sparse 'ohi'a. Nine figures are anthropomorphic, the others being triangular, circular or irregular in shape (fig. 9, 10, 11).

Hidden under a dense mat of organic material the petroglyphs were discovered by the landowner while clearing a large area with hand-tools. Therefore, even though no additional petroglyphs were found in nearby areas, other figures may exist. The landowner said that children had found "bones" in a nearby lava blister, however, no such materials could be located.

Site 50-Ha-A5-10

Located approximately 150 meters south of A4-70, this site is a collapsed lava tube sink that is 20 meters wide, 7.5 meters long and 6 meters deep. A large number of human skeletal remains were found near the sink opening, including two crania, a pelvis, long bones, vertebrae, ribs, etc.. The remains had been disturbed and were scattered in crevices and along lava tubes that branched from the sink. No artifacts of any kind nor any midden was found and there is little or no soil development. The site is located in an area covered with dense uluhe and sparse 'ohi'a (fig. 12).

TH-2

Located near the southwest end of corridor segment "I" this site consists of two structures, a 6 by 5 meter cement foundation and a 1 by 1.5 meter stone and cement structure 1.8 meters high, that are situated directly on the railroad right-of-way. A large amount of historic-type debris including porcelain bowl fragments, 20th century glass bottles, etc. are present in the vicinity of the structures. Ten mango and four coconut (Cocos nucifera) trees are located at the site, which is otherwise situate in an area of "'ohi'a dieback".





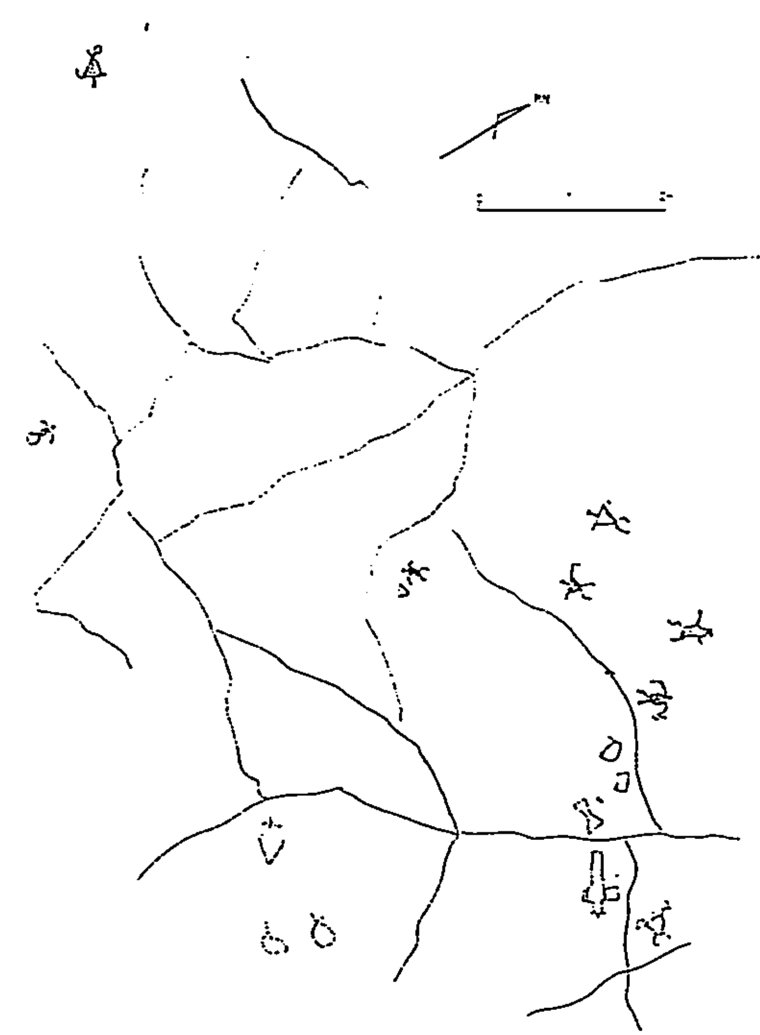

FIGURE 9. Sketch Map of Site A4-70 (petroglyphs).

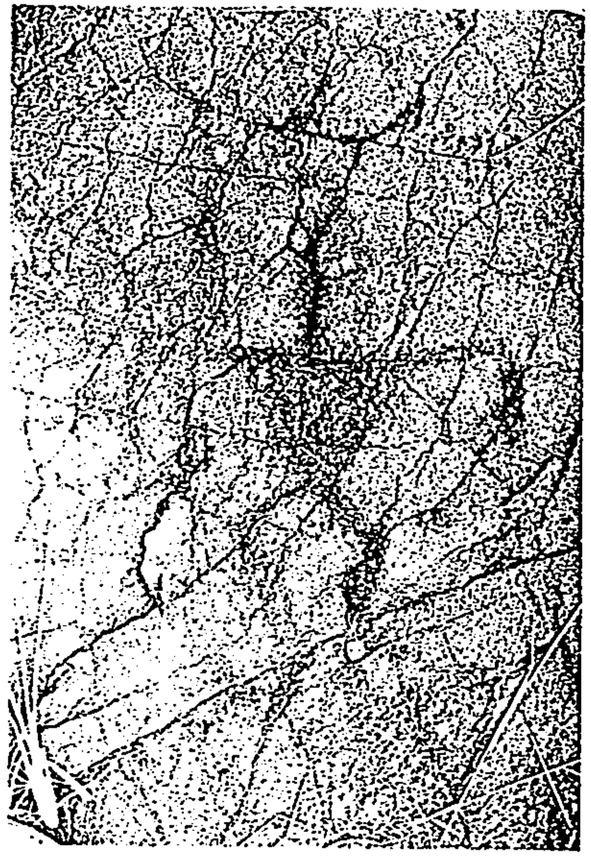

FIGURE 10. Petroglyph Site A4-70, Triangular Human Figure.

FIGURE 11. Petroglyph Site A4-70, Triangular Human Figure.

FIGURE 12. Vegetation at Site A45-10 (burial cave). View to South.



## Historic Sites

TH-1

This site is the right-of-way of the Hawaii Consolidated Railway, that extends from Hilo bay to the Kapoho area in south Puna. The tracks were removed in the early 1920's and many portions, especially in the Hilo area and the subdivided areas in Puna have been utilized for modern roads, however, the railroad bed itself is relatively intact. (see appendix for further information on this site)

TH-3

The Olaa Sugar Company, plantation manager's estate is located approximately 1.2 kilometers (3/4 mile) south of Kea'au town along Highway 130. This site is directly associated with Kea'au District (State of Hawai'i site 50-10-44-7389), which includes much of the plantation town of Kea'au, and appears to be in relatively good condition.

## DISCUSSION

The limited scope of the present study makes interpretations very tentative, however, the settlement pattern model presented in the research design is generally supported by the results of the survey. The predicted occurrence of extensive agricultural fields and adaptation patterns closely related to physiographic features is supported by the current data.

It should be noted that the present study area covers only the central portions of Zone II (discussed in the Research Design). The underlying question of where the "inland" areas begin, with regard to prehistoric-type site distribution is not addressed by the present study.

### Agricultural Sites

Five sites are related to prehistoric-type agricultural activities and are located near the northwest boundary of the study area, where deeper soils occur. These soil deposits were used for modern agriculture and the terrain has been extensively altered. Therefore, although the sites are limited in extent it is likely that the features are remnants of large, permanent agricultural complexes described by early historic visitors.

Two of these sites are agricultural complexes that are situated in areas where the deep soils derived from volcanic ash, or weathered 'a'a are mixed with more recent lava flows. Although the ash is older than 1500 years, the relatively unweathered lava was formed 350-500 years B.P., therefore, a tentative limit of 500 years is suggested for the age of these features. The other agricultural sites are all located in nearby areas and are probably closely related to the two complexes.

It should be noted that although a large number of agricultural features were destroyed when the areas with deep soils were plowed for sugar cane fields, another source of disturbance for features in the area may have been recent lava flows. Many of the flows in the area are less than 1000 years old (well within the period of human occupation for Hawai'i), and may cover earlier sites in the area. The substrates on which the other types of sites are located were formed between 350-500 years B.P. indicating that they too were utilized within the last 500 years.





### Refuge Caves

The refuge cave located during the present study is probably part an extensive network of lava tubes located northwest of Pahoa town that probably extend to coastal areas. It is highly likely that additional lava tube sites, possibly connected with this refuge cave, are present in areas with similar geologic morphology since two other refuge caves have been located in the general area. Although traditional histories ascribe a secondary political role for Puna, the lands were considered valuable and the conflict implied by the presence of refuge caves may be related to control of local resources.

### Burial Cave

The skeletal material located at the two burial caves, were extensively disturbed and only minimal interpretations regarding possible age of the burials is made. The remains found in one of burial caves appear to be from both the historic and prehistoric period and may indicate continual use of the cave over a period of time spanning the transition from prehistoric-type to historic-type activities. The other cave may be related to prehistoric-type activities only. Traditional Hawaiian burials are frequently associated with habitation areas, however, no known prehistoric-type habitation sites are situated near these sites. One explanation is that some burial sites, usually for high ranking persons were secreted in remote areas. The other possibility is that many sites have been destroyed by modern activities and features that remain are difficult to locate.

### Platforms

Two of the sites are platforms located in open areas of smooth pahoehoe. Since both of the structures are located near boundaries between two ahupua'a a tentative interpretation is that they may be territorial boundaries or trail markers.

### Petroglyphs

The petroglyphs found at site A4-70 are similar to figures found at other sites in Hawai'i. The importance of the carvings is that an age limit of no older than 500 years (the estimated age of the lava flow on which they have been inscribed) can be placed on them. To this author's knowledge, only one other site, the Hilina Pali Petroglyph Cave (Bishop Museum site 50-Hv-363) has produced direct chronological associations for Hawaiian petroglyphs.

The research at the Hilina Pali site indicates that there was a stylistic change in human figure petroglyphs at about A.D. 1600. Human figures carved when the cave was first occupied (circa A.D.1600) are dominated by linear figures (80%), with few open-bodied (10%) and triangular figures (10%). Based on inferential data a hypothesis that there was a subsequent change in preference for triangular forms as opposed to linear figures, was proposed, however, further research was considered to be necessary (Clegnorn 1980).

At site A4-70 all of the nine human figures are either triangular or open bodied, no linear figures were found. Although the sample is small the complete absence of linear figures in a cluster of petroglyphs produced after circa A.D. 1500 lends support to Cleghorn's hypothesis.

Summary

The period of time suggested for occupation of the sites located during the present study is from circa A.D. 1450 to the present. In terms of the prehistoric Hawaiian occupation of the islands this spans the latter part of the Expansion Period (A.D. 1100-1650) and the entire Proto-Historic Period (A.D. 1650-1795) as proposed by Kirch for the evolution of Hawaiian culture (Kirch 1985). During these periods the population increased rapidly, settlements expanded from valley foci, and social systems underwent significant changes, resulting in the advanced culture encountered by Europeans in the late eighteenth century (Ibid).

The hypothesis that settlements expanded from primary contexts into other (presumably less desirable areas) after A.D. 1100 is supported by the results of the present study. The establishment of agricultural complexes, far from the primary areas used for settlement on the coast (circa 5 km.) sometime after A.D. 1450 is consistent with Kirch's model for the development of Hawaiian culture.





RECOMMENDATIONS

This section contains general recommendations regarding selection of the transmission line corridor and specific recommendations regarding the treatment of archaeological and historic sites located during the survey. The recommendations for corridor selection are based on the potential for existence of additional archaeological sites in each corridor section ("A" through "I") and recommendations for specific sites are based on site evaluations and possible impacts the construction of the transmission line may have on the features located.

General Recommendations

The results of the survey indicate that the archaeological sites located in the survey area are of limited areal extent. There is a high probability, however, that isolated sites are present throughout the study area. Therefore, when a specific alignment for the corridor is selected additional archaeological research should be conducted in areas to be disturbed. The dense vegetation and rugged terrain of many parts of the study area make location of archaeological sites such as lava tube caves very difficult. If the the area to be studied is well-defined, concentrated efforts to locate sites can be made.

Archaeological Site Evaluations and Recommendations

Evaluations of condition, research potential and interpretive value of each archaeological site are listed in Table 3. The terms used are hierarchical and consist of: excellent, good, fair, or poor.

The condition of the site is evaluated through a qualitative assessment of the site's structural integerity. Research potential is related to the possibility that the site may contain data important to the prehistory or history of the area, region, or Hawaiian archaeology in general. Interpretive value is based on the potential of a site for public use or display. Site qualities taken into consideration include: uniqueness in the region , site condition, accessibility, and public interest.

The archaeological sites identified during the present study are assessed as having either good or excellent research potential. Since the present study indicates that very few prehistoric-type sites remain in the area, the

**TABLE 3**
**ARCHAEOLOGICAL SITE EVALUTATIONS**

| Site | Description | Condition | Research Significance | Interpretive Potential |
|---|---|---|---|---|
| A1-45 | Irrig. ditch, platform | Fair | Good | Poor |
| A1-46 | Walls, terraces, clearings | Good | Excellent | Good |
| A1-47 | Terraces, mod. outcrops | Fair | Good | Poor |
| A1-48 | Terrace | Fair | Good | Poor* |
| A1-49 | Terrace | Poor | Good | Poor |
| A3-28 | Platform | Fair | Good | Poor |
| A4-67 | Terraced Platform | Good | Good | Fair |
| A4-68 | Refuge cave | Fair | Good | Poor |
| A4-69 | Burial cave | Fair | Good | Poor |
| A4-70 | Petroglyphs | Fair | Good | Fair |
| A5-10 | Burial cave | Fair | Good | Poor |
| TH-2 | Cement/stone foundation | Poor | Good | Fair |

* Access to these sites should be limited, therefor interpretive value assessed as poor.



importance of known features to future research is very high since their research potential is enhanced. The historic-type site TH-3 is probably a railroad depot, however, in the absence of specific historical data this interpretation is tentative and further research is necessary.

In most cases the placement of foundations for transmission line poles allow enough flexibility to avoid all sites.

It is recommended, therefore, that all of the located sites be preserved.

**Historic Site Recommendations**

Most of the previously identified historic sites in the Puna area were evaluated during the Statewide Inventory of Historic Places conducted in the early 1970's. The majority of the sites are associated with sugar plantations and, based on such factors as architectural uniqueness, historical background and representative style, have been assigned reserve status (the four terms available were high value, valuable, reserve, and marginal).

Although detailed information on the plantation manager's estate, site TH-3, is presently unavailable, it may be eligible for nomination for registration as a historic place. The estate area is well defined and of limited area, and should be avoided by the proposed construction activities.

The formulation of specific recommendations regarding the railroad right-of-way is problematic due to its extreme length. Although preservation of portions of the railway foundation that remain is desirable, the specific parts to bo preserved is difficult to determine. However, two sections that should be preserved are the portions near sites TH-2 and A3-28, both located immediately adjacent to the railway bed.

The proposed construction activities are unlikely to affect significant portions of the railway bed, however, specific construction activites should be reviewed with regard to possible extensive alterations.

Corridor Evaluations

In order to facilitate description the corridors have been divided into nine sections, "A" through "I" (fig. 1).

Segments "A" and "I"

Portions of the northwest and southeast limits of these segments are situated in areas utilized for sugar cane fields and modern house lots. However, restricted areas such as small gulches and the margins of the sugar cane fields may contain additional archaeological sites such as the five agricultural sites (A1-45 through 49) located. No sites were located in the central parts of this segment, however, it is likely that lava tube systems are present in the pahoehoe substrate of these areas and cave sites may exist.

Segment "B"

An extensive lava tube system is known to be located in the pahoehoe substrate in this area. It is highly likely that additional sites such as the burial (A4-69) and refuge caves (A4-68) located are present in the area. These sites are very difficult to locate but are usually of limited extent.

Segment "C"

This segment crosses terrain that has been extensively disturbed by intensive modern agricultural activities. No sites were located in these areas and the potential for sites is very low.

Segment "D"

The substrate in this area is extremely rocky and irregular, and less than 400 years old with very little soil development. The eastern part of the segment has been extensively disturbed by modern agricultural activities. No sites were located in this area and the potential for sites is very low.

Segment "E"

Portions of this segment are covered by lava flows that occurred in the 19th century, other areas with older substrates have been extensively distubed by modern agricultural activities. No sites were located in this area and the potential for sites is very low.





Segment "F"

The east part of this segment has been extesively disturbed by modern agricultural activities. No sites were located in these areas by the present survey and the potential for sites is very low. The northwest end, however, at the intersection with segment "F" is situated on an undisturbed pahoehoe flow where petroglyphs (A4-70) and a burial cave (A5-10) was located. Although these sites are of very limited extent, there is a possibility that additional, similar sites may be present.

Segment "G"

It is likely that an extensive lava tube system exists in the pahoehoe substrate of this area. Therefore, although the only site located along this segment is site TH-2 (possible railway depot), there is a possibility that cave sites may be present.

Segment "H"

The substrate in this area is similar to that in segment "G" and there is a possibility that cave sites are present. Two isolated platforms (A3-28, A4-67) were located along this segment by the present survey and additional, similar sites may exist.

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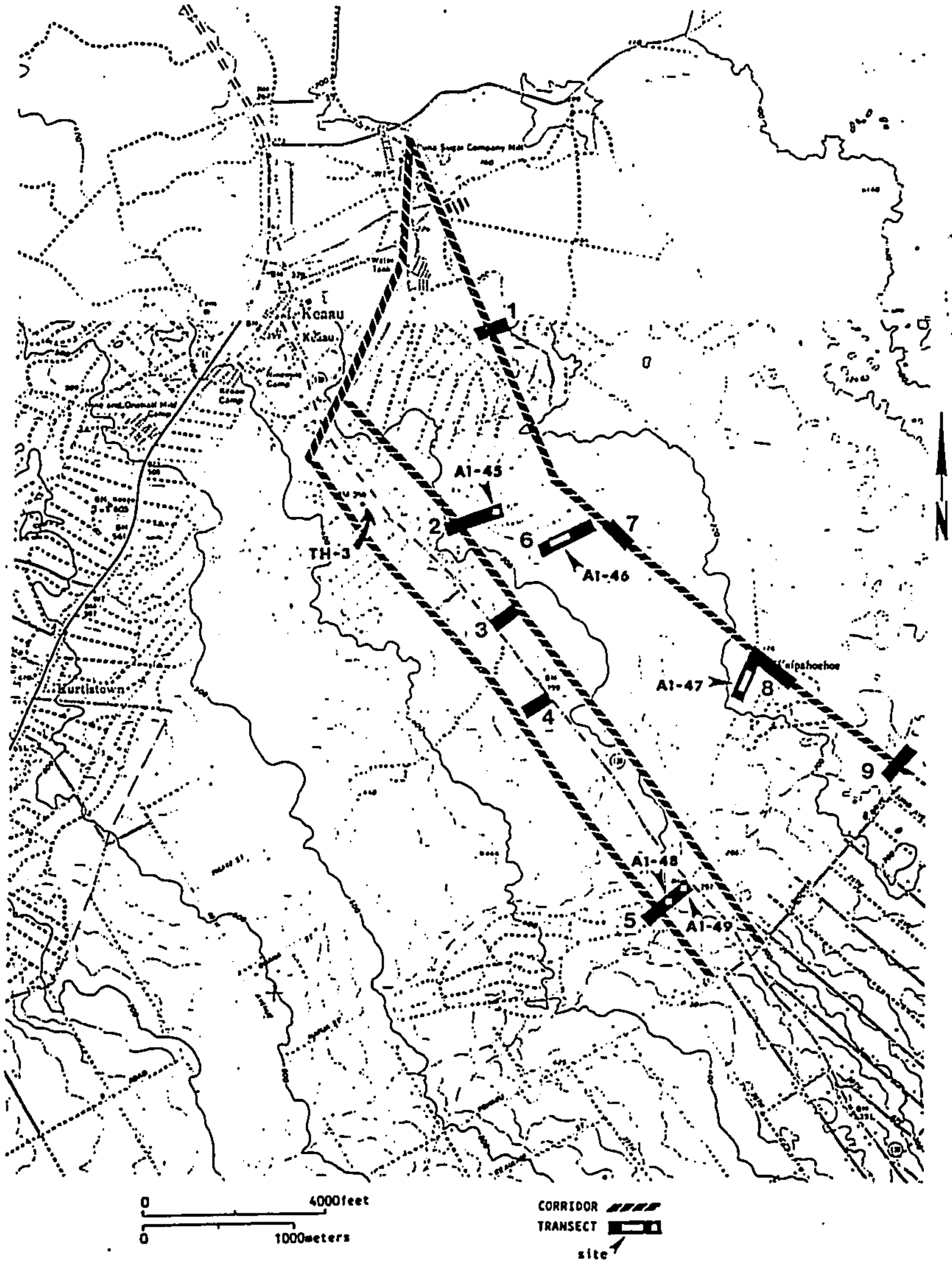


FIGURE 2a. Site Location Map with Transect Locations.

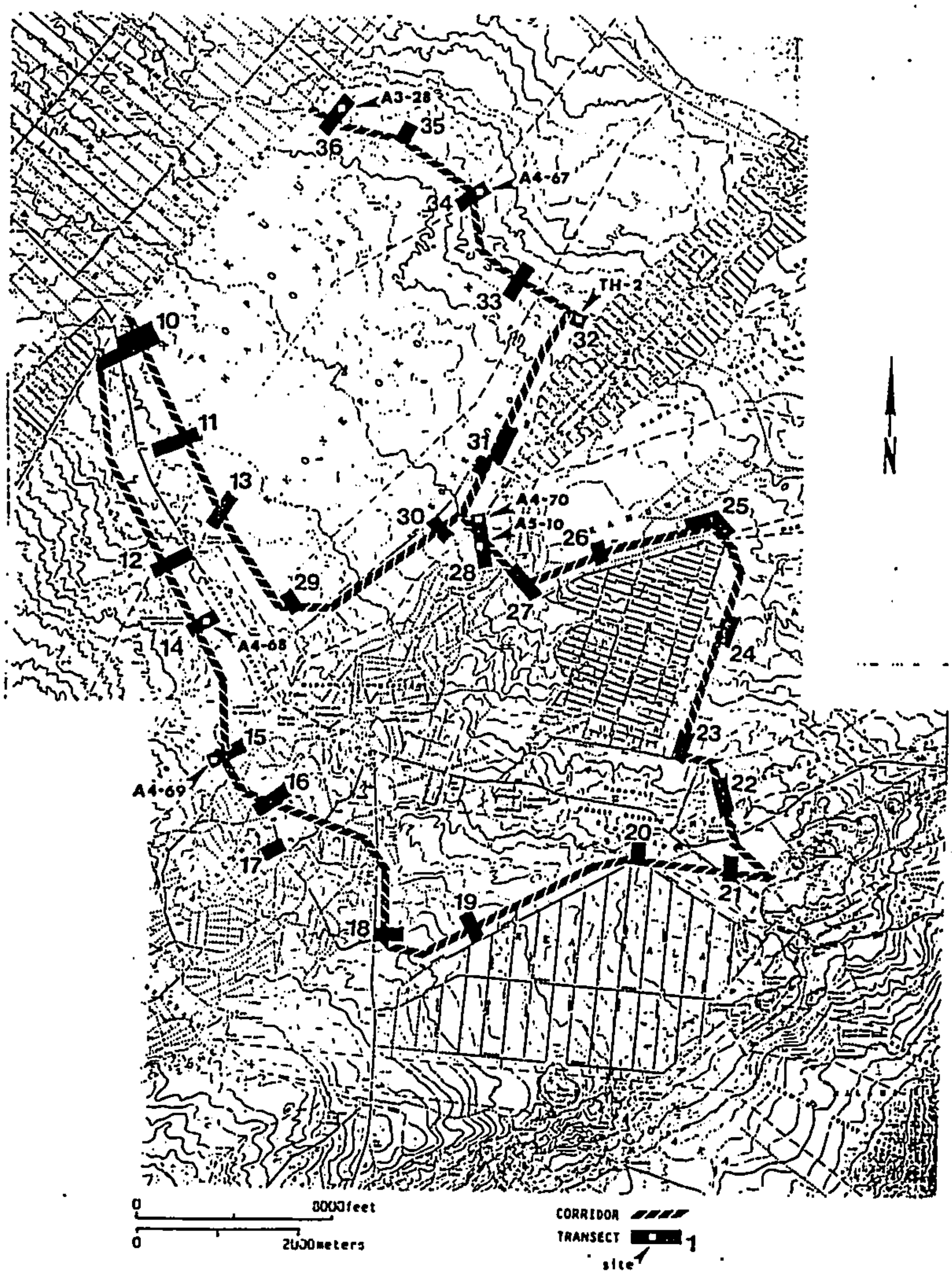


FIGURE 2b. Site Location Map with Transect Locations.

Appendix

LITERATURE REVIEW

of

PREVIOUS ARCHAEOLOGICAL WORK,
PREVIOUS HISTORIC LAND USE AND
LEGENDS AND TRADITIONS

by

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TABLE OF CONTENTS

## PREVIOUS ARCHAEOLOGICAL WORK

Archaeological research in the study area was first conducted in the early 1900s. Early research focused on heiau. More comprehensive surveys of archaeological sites began in the 1930s. However, the bulk of the research has been conducted in coastal areas. Studies of inland areas have been conducted in only very limited areas, investigating either specific archaeological sites or specific small areas slated for development.

The previous archaeological work for the Puna district pertinent to the study area is summarized below. See Table 1 (at end of report) for an inventory of archaeological and historical sites in the study area.

| DATE | RESEARCHER | DESCRIPTION |
|---|---|---|
| 1906 | J. F. G.Stokes | A surface survey of the prominent religious structures of Hawai'i. |
| 1907 | T. G. Thrum | Description of Kukii Heiau, in Kapoho and its construction. |
| 1930-1932 | A. E. Hudson | Conducted archaeological reconnaissance survey on the east coast of Hawaii. Hudson's record provides good general information on the Puna area and was the most comprehensive survey of Puna at that time. |
| 1945 | K. P. Emory | Explored Shipman's Cave in Keaau, Puna. |
| 1959 | K. P. Emory et al. | Staff of the Bishop Museum conducted research on the natural and cultural history of the Kalapana extension of Hawaii Volcanoes National Park. The report provides good information on the land and traditional history of the Puna district. |
| 1963 | L. J . Soehren | Conducted archaeological reconnaissance survey of Kahuwai Village, Puna. |
| 1966-1968 | V. Hansen | Conducted archaeological reconnaissance surveys in the Puna area, and recorded, mapped, and located numerous sites for the district. |
| 1970 | V. Loo and W. Bonk | Anthropological Research International compiled an inventory of historical sites in the northern portion of the island of Hawai'i, with a good review of the Puna district, in conjunction with Dept. of Planning, County of Hawai'i. |
| 1971 | N. Crozier and D. Barrere | Staff of the Bishop Museum conducted archaeological reconnaissance survey and historical research of Pu'ala'a, Puna, in conjunction with Bishop Estate. |
| 1972 | R. Bevaqua and T. Dye | Staff of the Bishop Museum conducted archaeological reconnaissance survey of the proposed Kapoho to Kalapana highway, in conjunction with Sam O. Hirota Inc. and Dept. of Public Works, County of Hawaii. |
| 1973 | N. Ewart and M. Luscomb | Staff of the Bishop Museum conducted archaeological reconnaissance survey of the proposed Kapoho to Keaukaha highway, in conjunction with Sam O. Hirota Inc. and Dept. of Public Works, County of Hawaii. |

| | | |
|---|---|---|
| 1977 | R. M. Bordner | Archaeological Research Center, Inc. conducted archaeological reconnaissance survey of a proposed radar beacon system in Maku'u, Puna, in conjunction with Federal Aviation Administration. |
| 1979 | Fed. Hwy. Adm. | Federal Highway Administration and the Land Transportation Division of State of Hawaii Dept. of Transportation discovered two sites in preparing an Environmental Impact Statement for proposed Pahoa By-Pass for Keaau-Pahoa Road in Kaniahiku, Puna. |
| 1979 | H. McEldowney | Staff of the Bishop Museum conducted archaeological survey, historical research, and compiled site inventory of southern Hilo and northern Puna Districts, in conjunction with U.S. Army Corps of Engineers. |
| 1980 | W. Bonk | Conducted archaeological reconnaissance surveys of small <u>mauka</u> areas in Keahialaka and Pohoiki, Puna, in conjunction with Geothermal Exploration and Development Corp. |
| 1980-1981 | E. J. Ladd | Conducted archaeological reconnaissance survey of Cape Kumukahi, in conjunction with U.S. Coast Guard. |
| 1982 | M. Yent and J. Ota | Staff of Division of State Parks and Historic Sites, Dept. of Land and Natural Resources, State of Hawaii conducted archaeological reconnaissance survey of a <u>makai</u> part of the Nanawale Forest Reserve in Halepua'a, Puna, in conjunction with Division of Forestry. |





| | | |
|---|---|---|
| 1983 | M. Yent | Staff of Division of State Parks and Historic Sites, Dept. of Land and Natural Resources, State of Hawaii conducted archaeological reconnaissance survey of a lava tube in Halona, Puna, in conjunction with Division of Forestry. |
| 1983 | D. Cox | Conducted archaeological reconnaissance survey of the proposed Cape Kumukahi Small Craft Navigation Improvements Project, in conjunction with U.S. Army Corps of Engineers. |
| 1984 | E. Rogers-Jourdane and B. Nakamura | Staff of the Bishop Museum conducted archaeological reconnaissance survey and historical research in Kapoho, Puna, in conjunction with Geothermal Development by the Thermal Power Company. |

The vast majority of recorded sites have been found within 1 mile of the coastline. The only prehistoric sites in the study area that are definitely farther inland are three lava tube sites, one <u>ahu</u>, and six sites along the east rift zone. The "Pahoa Cave" lava tube site, located in Halona and listed in the inventory, is actually slightly inland of the study area. The three lava tube sites are: "Shipman's Cave," located in Kea'au (site 50-Ha-A1-11); the unnumbered site in the Kaniahiku area of Halepuaa-Kenekiki-Puua (Federal Highway Administration 1979); and the unnumbered site in Pohoiki (Bonk 1980b). The <u>ahu</u> is located in Maku'u (State of Hawai'i site 50-10-46-6417a).

Two of the east rift zone sites are in Kula: Kukii Heiau (site 50-Ha-A8-1) and a grave (Hudson site 107). Three sites are in Kapoho: the Kapoho petroglyphs (50-Ha-A9-1), the <u>holua</u> slide site Ka Holua O Kahawali (50-Ha-A9-2), and the unnumbered site of male and female sacred stones (Hudson site 108). In Pu'ala'a is the site of a destroyed <u>holua</u> slide and partially destroyed agricultural patches (50-Ha-A10-6).

In addition, some of Ewart and Luscomb's unmapped Kea'au sites that are in our study area and north of Kaloli Point may be up to 2 miles inland (Ewart and Luscomb 1974:3), and some of Yent and Ota's prehistoric sites in Halepua'a may be up to 1.75 miles inland (Yent and Ota 1982:11).

For an area including the study area, McEldowney asserts that the combined results of archaeological studies alone "...do not provide an adequate basis for predicting site distribution...Coverage of even the most extensively examined coastal area remains incomplete" (McEldowney 1979:8). However, based on early historic accounts, McEldowney describes land use zones at the time of Western contact and possibly earlier, and she makes some comments on site distribution. Her Coastal Settlement Zone, extending 1 mile inland, and her adjacent Upland Agricultural Zone include the study area (Ibid.:14,48,64).

She finds the highest number of people of the early historic period, and therefore the highest site probabilities, are in the Coastal Settlement Zone.

> Early descriptions, as well as the distribution of known sites, suggest that structures representing both permanent and/or temporary use occur along the entire coast....The occurance of...the better developed organic soils important to crops, of potable fresh and brackish water, of local coastline formations amenable to sea exploitation, and of ponds or streams for acquaculture and/or marshland taro cultivation...appear to be major factors associated with population concentrations (Ibid.:15).

Structures occur singularly, clustered in small, widely-spaced groups, or concentrated in the six villages mentioned in early historic literature (Kea'au or Haena, Maku'u, Wai'akahiula, Honolulu, Kahuwai, and Kula or Koa'e) (Ibid.:15-16).



Agricultural areas were nearby and/or slightly inland in the Upland Agricultural Zone. McEldowney states, "Within this zone, the possibilities of remnant agricultural complexes could be high on both ash and older aa or pahoehoe substrates that have not been disrupted by historic agricultural practices (Ibid.:19). She also notes that land use in this zone may have focused also on the lava tubes underlying the pahoehoe flows.

Cordy makes some predictions on potential site patterns based on historical and archaeological records for two areas of Puna in the study area. In Maku'u-Popoki-Halona, he suggests a high concentration of sites in the coastal area up to 1.75 miles inland, where permanent settlement was likely to be near the shore, with agricultural areas nearby and slightly inland. Farther inland he predicts a sparse distribution of sites, with burials or transit campsite remains in lava tube caves or transit campsite remains in surface walled shelters (Cordy 1986a).

In discussing Kapoho Ahupua'a, Cordy notes that in the surrounding areas a general pattern appears to exist of most permanent housing and associated heiau nearest the coast (0-1 miles inland) and agricultural areas nearby the houses and just inland from them. Farther inland he predicts sporadic land use and few sites, which might be shelters in caves or surface enclosure walls or burials in caves or in platforms on cinder cone slopes (Cordy 1986b).

PREVIOUS HISTORIC LAND USE

Railroad

A railroad operated in Puna from 1899 to 1946. The development of the sugar, lumber, and rock industries in and around the study area is tied in with the building of this railroad and the development of the companies that ran it. Hilo Railroad Company operated the railroad from the time of its incorporation in 1899 until its reorganization in 1916. From 1916 until 1946 Hawaii Consolidated Railway, Ltd. ran the railroad (Kelly et al. 142).

The major promoters of Hilo Railroad Company were Honolulu businessmen Benjamin F. Dillingham and Lorrin A. Thurston. They were also the major promoters of Olaa Sugar Company, incorporated in 1899, and Puna Sugar Company, incorporated in 1900 (ibid.144, 131). Hilo Railroad company arranged a 40-year contract to transport all Olaa Sugar Company freight (Ibid. 144). The first product of Olaa Sugar Company was 'ohi'a wood, obtained in clearing forests in the 'Ola'a area.

In 1900, Hilo Railroad Company built about 8.3 miles of railroad line from a terminal and harbor facilities at Waiakea, Hilo to the Olaa Sugar Company mill near Kea'au, Puna (ibid.). Raw sugar was transported from Olaa mill to Hilo Harbor on this line. By the end of 1901, the line was extended farther south to Kapoho with a 5-mile branch to Pahoa, for a total of 25.1 miles. Another 10 miles were also completed from Olaa Mill to Kea'au and up to Mountain View. Together these lines made up the "Hilo Division" (Ibid. 147). Sugar was cultivated in areas near the terminals at Kapoho, Pahoa, and Mountain View (Ibid. 132, 147 162; 164, see also Hawaii Survey 1906).

By 1910, the railroad also served Pahoa Lumber Mill in Pahoa. The mid-1910 annual report for Hilo Railroad Company describes the expediency of changing the rails on the Pahoa branch to 60 pounds and practically reconstructing the line due to heavy traffic from the lumber company freight and sugar cane (Kelly et al. 162). In 1909, Pahoa Lumber Mill "had about 10 miles of railroad track"





(Ibid. 114). The arrangement between the lumber company and the railroad company concerning the railroad in the Pahoa area was not determined.

The railroad also carried rock for the Hilo breakwater from quarries in Kapoho from 1908 to 1925 (Ibid. 193).

In mid-1910, the annual report of Hilo Railroad Company described an extension reaching 7 miles southwest of Kapoho to Kaueleau and a lumber mill there. (Kauoleau is outside the study area.) The company secured the right to operate over the portion of the railroad grade and tracks owned by Puna Sugar Company. The extension also reached the rubber plantation of Pacific Development Company (Ibid. 162, 164). (Whether the rubber plantation was located within the study area was not determined.) A 1906 map shows sugar cultivation just west of where the extension terminated (Hawaii Territory Survey 1906). Perhaps the extension was also used to carry this sugar.

Hawaii Consolidated Railway was controlled by the owners of the sugar plantations it served in Hilo and adjoining districts (Ibid. 142, 165). In 1946, after a tidal wave caused a great deal of damage to Hawaii Consolidated Railway, the company liquidated (Ibid. 175).

A map of southern Puna shows railroad tracks, including a branch to Pahoa, an extension from Kapoho to Kaueleau, and an additional branch, apparently not described above, in Kapoho that terminated near Pu'u Honuaula (Hawaii Territory Survey 1952). This branch probably served Puna Sugar Company fields in Kapoho and the Kapoho quarries. Only a very short part of its appears on a 1902 map (Hawaii Territory Survey 1902).

In northern Puna, a 1917 Olaa Sugar Company field map shows two branches off the main railroad line. One branch extends east from Olaa through sugar in Kipuka 4. The other branches off the main line south of the mill at Waipahoehoe, passing through sugar at Kipuka 2 and terminating at Kipuka 1 ("Field map, Olaa Sugar Co., July 1917" in Conde and Best 1973:95, see also Hawaiian Territorial Survey 1930).

Sugar

"The incorporation of the Olaa Sugar Plantation in 1899 marked the beginning of sugar cultivation in the Puna District" (Kelly et al. 1981:144). In the 'Ola'a area, the company took over land formerly cultivated with coffee and cleared land covered in 'ohi'a forest. In 1900 the plantation covered about 19,500 acres, forming one of the largest sugar plantations in the Territory (Kelly et al. 1981:144). By 1902, the plantation stretched 14 miles mauka from the mill (Kelly et al. 1981:147, see also Hawaii Survey 1906), extending far outside the study area. By 1905, Olaa Sugar had 7,676.4 acres under sugar cultivation (Kelly ot al. 131). In a 1917 Olaa Sugar Company field map, sugar cultivation in the study area can be seen in the are around Olaa Mill, in a smaller area to the east along a road branch (Kipuka 4), and in two smaller areas south of the mill on the Waipahoehoe railraod branch (Kipuka 1 and2) ("Field Map, Olaa Sugar Co., July 1917" in Conde and Best 1973:95, see also Land Court Map 1936).

Puna Sugar Company was established in 1900 by the same people who developed Olaa Sugar Company (Kelly et al. 1981:131). It had no mill, but sent its cane to Olaa Mill (Kelly et al. 1981:154). "By 1905, Puna Plantation was taken over by Olaa Sugar Plantation" (Kelly et al. 1981:131). However, it was not until 1936 that Olaa Sugar Company officially bought out Puna Sugar Company (Kelly et al. 1981:131).

Puna Sugar Company cultivated sugar in Kapoho (Kelly et al. 1981:164, Conde and Best 1973:99) and near Pahoa (Kelly et al. 1981:162, 164). A 1906 map shows these areas and another sugar plantation area which is west of Kaueleau (and outside the study area) (Hawaii Survey 1906). In 1907, Hawaiian Mahogany Lumber Company of Pahoa, later known as Pahoa Lumber Company, cleared 'ohi'a forests on Puna Sugar Company land. This land was then to be planted in cane (Conde and Best 1973:101). By mid-1910, the Hilo Railroad Company annual report spoke of a great increase in the amount of cane passing over the Pahoa branch line (Kelly et al. 1981:162).





In 1955, a volcanic flow at Kapoho eliminated 1,400 acres of cane area belonging to Olaa Sugar Company, Ltd. (Kelly et al. 1981:132). By 1956, the company had 9,400 acres planted in sugar cane (Kelly et al. 1981:131). Its name was officially changed to Puna Sugar Company, Ltd. in 1960 (Conde and Best 1973:94). In 1979, the company harvested 6,944 acres of cane and had a total of 16,145 caneland acres (Kelly et al. 1981:119).

Coffee

In the 1890s, coffee plantations were established in 'Ola'a district (between the present Puna and South Hilo districts) (Cordy 1978:4). It may be that all of these plantations were far from mauka of the later Olaa Mill (see Olaa Title Map 1900) and therefore out of the study area. In 1900, Olaa Sugar Company took over land from former 'Ola'a coffee homesteaders (Kelly et al. 1981:131, 144). "Unfortunately the coffee boom in Hawaii ended soon after it began and by 1902, Hawaiian coffee growers could no longer compete with foreign growers" (Cordy 1978:4).

"In the more remote district of Puna, the coffee industry was undeveloped except for a coffee plantation and mill established at Pohoiki by Robert Rycroft in or before 1894 (Cordy 1978:4). Rycroft had planted 35 acres (Cordy 1978:4). His mill was near the coast at Pohoiki and therefore out of the study area, but his coffee fields were about 3 miles mauka (Cordy 1978:4, see Loebenstein 1895, Hawaii Territory Survey 1952). "It is not known when Robert Rycroft abandoned his coffee plantation at Pohoiki, but other records show he had established a soda works manufacturing plant in the Sheridan Tract of Kakaako, Honolulu in 1900" (Cordy 1978:4). By 1927, coffee was no longer being cultivated in Puna district (Cordy 1978:4).

Lumber

In 1907, Hawaiian Mahogany Lumber Company of Pahoa cleared 'ohi'a forests on Puna Sugar Company land (Conde an Best 1973:101). By 1909, it had a contract to provide Santa Fe Railway Company with ties (Kelly et al. 1981:164). In 1909, Hawaiian Mahogany Lumber Company was taken over by Pahoa Lumber Company, also known as Pahoa Lumber Mill. The ties were to be shipped directly to California from Hilo port (Kelly et al. 1981:114).

From April to December 1909, the mill turned out 91,407 standard ties, about 622,662 ft of small ties, and 101,202 ft of lumber. The mill operated its own plant for building railway cars and repairing machinery. It had about 10 miles of railroad track, four locomotives, forty-five cars, and nine logging donkeys. In addition to railroad ties, which were in high demand in the Islands as well as on the Mainland, the company expected increased business in shingles and lumber for cars, wagons, carriages, etc. (Ibid.).

In 1910, Pahoa Lumber Mill secured the "right to lumber the forest on a tract of unleased government forest land in Puna, adjoining the Kaohe Homesteads at Pahoa, and having an approximate area of 12,000 acres" (Conde and Best 1973:103).

Later the company was known as Hawaii Hardwood Company, which folded in 1918 (Conde and Best 1973:101).



Rock

"Construction of the Hilo breakwater began in 1909 with the building of a rock fill.... In the first several years of breakwater construction, the railroad hauled all of the rock: most was from the Kapoho quarry in Puna" (Kelly et al. 1981:157). There was also an Olaa quarry.•

From 1908 to 1910, 148,200 tons of rock for the Hilo breakwater were quarried from the Kapoho, Waiakea, and Olaa quarries. From 1910 to 1912, 95,577 tons of rock for the project were quarried from the Kapoho and Waiakea quarries. From 1924 to 1925, 88,657 tons of rock for the breakwater were quarried from the Kapoho quarries (Kelly et al. 1981:193).



Ranching

In Puna the "native agricultural system began to decline around 1840 as the population declined. At this time, there was a shift to ranching, coffee, and sugarcane" (Yent and Ota 1972:12). Evidence of ranching was found in Nanawale Forest Reserve near the coast in the ahupua'a of Halepua'a (Yent and Ota 1972:15-16). Enclosures that were through to be former cattle pens were found in the ahupua' of Kea'au and in the ahupua'a of Maku'u-Popoki-Halona (Ewart and Luscomb 1974:16-19, 26). There was a Shipman Ranch in Kea'au (Emory 1945). An 1895 map shows "Lyman's Ranch Paddock" in Kapoho between Kapoho Crater and Pu'u Kuki'i (Loebenstein 1895). A 1923 Hawaii Consolidated Railway map shows cattle ranching in an undefined large area makai of the railroad and between Olaa Mill and branch of the railroad leading to Pahoa (Kelly et al. 1981:164).

## LEGENDS AND ORAL TRADITIONS

### Traditonal History of Politics and Religion

In recounting the traditional political history of Puna, Barrere states:

> ...that Puna, as a political unit, played an insignificant part in shaping the course of the history of Hawaii island. Unlike the other districts of Hawaii, no great family arose upon whose support one or another of the chiefs seeking power had to depend for his success. Puna lands were desirable, and were eagerly sought; but their control did not rest upon the conquering of Puna itself, but rather upon control of the adjacent districts, Ka'u and Hilo. An attempt to follow in detail the course of Puna's history is meaningless, since her history is bound up with the fortunes of the ruling families on either side of her (Barrere 1959:15).

Barrere does, however, describe events that were significant to Puna itself.

Around 1475 A.D., Puna was one of six districts of Hawai'i Island whose chiefs acknowledged Liloa as their supreme chief. The unity of the districts was temporarily destroyed with the death of Liloa. At this time Hua'a was the chief of Puna. 'Umi, a son of Liloa, but not the acknowledged heir to his position of supreme chief, reunited the kingdom. The Hawaiian historian S. M. Kamakau describes the death of Hua'a on the battlefield of Kuolo in Kea'au during the conquest of Puna by 'Umi (Barrere 1959:15-16). Other political events relating specifically to Puna from the time of 'Umi up until the time of Kamehameha's conquest of Hawai'i Island are also described by Barrere (1959; see Appendix A).

The Kings' Pillars (050-Ha-A8-2), the stone cairns at the tip of Cape Kumukahi, "are said to have been built by the various monarchs of the Hawaiian kingdom upon assuming the throne" (Hudson 1932:325). Others say the rock piles





are funeral cairns or that they are built to signify that one's illness is being left behind (Mary Kawena Pukui in Emory et al. 1959:60).

Puna had importance as a center in the development of Hawaiian religion. It was in Puna that the priest Paao first established his line of priesthood. The line continued until after Kamehameha I's death in 1819 (Beckwith 1979:371-375). The first heiau constructed by Paao was in a part of Puna outside the study area (Thrum 1907a:48). According to tradition, Kukii Heiau (050-Ha-A8-1) on the summit of Kukii Hill in Kapoho was built by 'Umi, ruler of Hawai'i Island, who was devoutly religious. Kukii Heiau was one of the heiau erected by 'Umi on his tour around the island after he came to power. Each of these heiau was said to have been distinguished by its dressed- or hewn-stone construction (Fornander 1969:101-102). It was said there was once an important heiau in Pohoiki called Oolo, but it was entirely destroyed by 1907 (Thrum 1907b).

### Legends

Many of the legends of Puna refer to an early time when the area was famous for its long stretch of sand, its fertile plains, and its hala trees. Numerous legends describe Pele's anger causing lava to cover either large areas of the region or more limited sections of it. It has been pointed out that traditions imply that Puna "was once Hawaii's richest agricultural region and that it is only in relatively recent time that volcanic eruption has destroyed much of its best land" (Handy and Handy 1972:542).

Puna, or some say the eastern side of the district (Green 1928:10-11 in "The Story of Kalaikini), was known as ka paia 'ala i ka hala, which means "the forest bower or wall scented by hala" (Pukui and Elbert 1971:270). Hala grew abundantly in Puna and people tucked hala blossoms in the walls of their houses and in their sleeping mats. Puna was also famous for the fine mats people made of the short white husks of hala blossoms and for the soft breeze that in the old days was scented by hala and lehua blossoms 62).

In the legend of Puna'aikoa'e ((Mary Kawena Pukui in Emory et al. 1959:37), Pele covers most of the land of Puna, including most of its long beach, with lava. In the legend of Keliikuku (Westervelt 1916:31-32), Pele covers houses, fertile plains, and forests, including hala, with burning lava. Several other Puna chiefs anger Pele, causing lava to cover parts of their land.

Listed below are some of the legends referring to Puna generally or more specifically to Puna lands within the study area. Given the size of the area and the close connection between Pele and the volcanically active land of Puna, there are surely additional references to this area of Puna which are not mentioned here.

<u>Legend of Iwa</u> (Elbert 1979:18-30)

In the legend of Iwa a man named Kea'au, who lives in that region, owns two <u>leho</u> shells (cowries) called Kalokuna. He treasures the shells for their exceptional power as bait for squid fishing. One has only to expose them and squids come up and enter the canoe. 'Umi, chief of Hawai'i Island, who is then living in Kona, hears of Kea'au's shells and sends his messengers to demand that they be turned over to him. Kea'au complies, but then yearns for his shells. He brings the infamous boy thief Iwa from O'ahu to recover the shells from 'Umi for him. This Iwa does, but soon after he steals them back from Kea'au for 'Umi. Iwa then performs other feats of thievery for 'Umi, and Kea'au is left without his shells and living in Leleiwi, "the point of land adjoining Kumukahi, between Puna and Hilo" (Elbert 1979:22).

<u>The Story of Kalaikini</u> (Green 1928:10-15)

In this story of Kalaikini, the traveling <u>kupua</u> or sorcerer from Tahiti, he is defeated in battle with another sorcerer, Pohakuolekia, at Kapoho Crater. Pohakuolekia is now a magic slab-like rock on the rim of the crater. His wife, the scorceress Pohaku o Hanalei, is a magic rock on the opposite side of the crater. (These rocks appear to be Hudson's site #108.) In the legend, they were standing in these positions when Kalaikini comes upon them. Kalaikini creates a column of dust in almost digging up Pohakuolekia from his firmly planted stance. At his wife's tears and cries of love, Pohakuolekia twists and squirms until he is so deeply rooted in the earth's foundations that Kalaikini abandons his efforts to dislodge his foe.





Legend of Halemano (Elbert 1979:258-290)

In this complicated romance, handsome Halemano of O'ahu falls deeply in love, through dreams, with Kamalalawalu, the beauty of Puna. She is the daughter of the chiefs of Kapoho, and has been brought up with her favorite brother Kumukahi as her only companion and eight hundred dogs to guard and serve her. Hua'a, the chief of Puna, and Kulukulua, the chief of Hilo, court her without success (Elbert 1979:258).

With the help of his older sister, the sorceress Laenihi, Halemano travels to Puna and lures Kamalalawalu to his canoe. Halemano and Laenihi arrive off of Maku'u and Popoki (Elbert 1979:256), where they use specially prepared playthings to entice Kumukahi, who in turn summons his sister. Both are abducted to O'ahu by Halemano and Laenihi. Halemano and Kamalalawalu marry there, and she sends Kumukahi back to Hawai'i to live with their parents (Elbert 1979:260).

Later in the story when Halemano and Kamalalawalu are living in Waiakea, Hilo, she is taken to Hua'a, chief of Puna. She tells her brother to take good care of Halemano. Kumukahi and Halemano live together for eighty days (Elbert 1979:266).

Later still, in trying to win back Kamalalawalu, Halemano chants to her of their days in Puna, mentioning Cape Kumukahi and <u>ke ahi a Laka</u> ("the fires of Laka") (Elbert 1979:276).

At the end of the legend Kamalalawalu is living on O'ahu as the wife of a chief. Hua'a, the chief of Puna, and the chief of Hilo sail to O'ahu with an army, defeat the O'ahu chiefs, and bring Kamalalawalu back to Hawai'i (Elbert 1979:290).

<u>Kumukahi from Kahiki</u> (Mary Kawena Pukui in Emory et al. 1959:61-62)

Kumukahi and his brother Palamoa came from Kahiki to Hawai'i long ago in the time the gods still walked on earth. Some say he was a relative of Pele (Beckwith 1979:119). Others say he came with his older brother, the great chief Moikeha (Fornander 1918 4:114). With their sister Kahikinaakala ("the sunrise"), they took the form of mortals and settled in Puna at the most easterly point of land in the Hawaiian Islands (Cape Kumukahi).

Kumukahi had four wives: Kanono, Pa'upo'ulu, Ha'eha'e, and Hanaka'ulua. (Some say Ha'eha'e was Kumukahi's younger brother [Fornander 1918 4:114].) The wives manipulated the seasons by pushing the sun back and forth. They were later seen as four large stones spaced evenly apart at Cape Kumukahi, and were used to calculate the solstices of the sun. Cape Kumukahi is known therefore as the "Ladder of the Sun" and the "Source of the Sun." The literal translation of "Kumukahi" is "first beginning" (Pukui et al. 1976:124).

Sun worshipers brought their sick to be healed at Cape Kumukahi. Along with the lake at Kapoho Crater, it was one of the stops on "the journey of health" frequently made by those who had recovered from illness (Westervelt 1916:28-29).

At some point Pele destroyed Kumukahi and his family as mortal beings. However, they were powerful 'aumakua. Kumukahi could take the form of a man or a kolea bird (the migrant plover). Palamoa could take the form of a rooster.

Legend of Kumukahi, a Chief of Puna (Westervelt 1916:27-28)

There are several legends about chiefs of Puna who angered Pele. Kumukahi is also the name of one of these chiefs. He was a handsome man who loved the ancient games. He pleased Pele, but when she came to him as an old woman demanding to join the games, he ridiculed her. She chased him to the sea, covering him with lava, forming the cape called Kumukahi.

Legend of Kahawali (Thrum 1912:39-42)

In this legend, Kahawali, chief of Puna, and Ahua (Westervelt 1916:41), one of his favorite companions, are racing with their holua (sleds) down the side of a hill in Kapoho (Ka Holua o Kahawali, 50-Ha-A9-2). At the bottom of the race course, Kahawali sticks his broad spear into the ground, and then climbs the hill called Kahaleokamahina (Westervelt 1916:40) (or Halekamahina).



Back at the top of the slide, Pele, in the form of a woman, challenges Kahawali to a race and loses. She then asks him for his sled. Not realizing her identity, Kahawali abruptly refuses and sleds off down the hill. Enraged, Pele stamps her foot, causing an earthquake and an opening in the hill. She transforms into her supernatural state and chases Kahawali with streams of lava.

At the bottom of the hill, Kahawali looks back and sees Pele. He grabs his spear and with Ahua flees for his life. The spectators and entertainers at the race are overwhelmed by Pele's lava as she pursues Kahawali. In his flight, he pauses at Pu'ukoa, where he throws off his ki leaf cloak. He then bids farewell to his favorite pig Alo'ipua'a (Westervelt 1916:43), to his mother at Kuki'i, to his wife Kanakawahine, to his children Poupoulu and Kaohe, and finally, after crossing a deep chasm, to his sister Koai in Kula. Kumukahi and Ahua escape in a canoe, despite the large rocks Pele throws at them from the shore.

Legend of Papalauahi (Westervelt 1916:29-30)

The chief of Puna, Papalauahi, was also challenged to a holua race by Pele, appearing this time in the form of a beautiful woman. He won and Pele stamped on the ground, letting loose floods of lava. Papalauahi and many of the neighboring chiefs attending the games were destroyed as they fled, and the spectators on the plains below were turned into pillars of lava.

Legend of Keliikuku (Westervelt 1916:31-32)

This legend tells of a chief of Puna, Keliikuku, who is very proud of his homeland. While on O'ahu he boasts to a prophet of Pele, Kaneakalau, "My country is charming. Abundance is found there. Rich, sandy plains are there, where everything grows wonderfully" (Westervelt 1916:31). The prophet ridicules him, saying tht Pele has desolated Puna. "The trees have descended from the mountains to the sea. The ohi'a and puhala are on the shore. The houses of your people are burned. Your land is unproductive. You have no more people" (Westervelt 1916:31-32). Keliikuiu heads home. He comes around the eastern side of Hawai'i, lands his canoe, and climbs the highest point for a view of Puna. He sees his fertile plains covered with black lava still pouring out clouds of smoke. The remnants of forests are still burning. Pele has heard

Keliikuku boasting and has demonstrated that the land around her pit of fire is not secure against her will. Keliikuku hangs himself.

Legend of Kapapala (Westervelt 1916:33-34)

Kapapala was a Puna chief who went up to the crater to see Pele. They enjoyed each other's company until Kapapala dared to surf her lake of fire. Pele caused him to fall off his board into the flames.

Legend of Kealohalani and Honolulu (Mrs. Anne Hall in Emory et al. 1959:42-43)

In this legend a Puna chief named Kealohalani angers Pele by courting one of her sisters. Pele chases him and, as he dives into the ocean, his helmet falls off onto a sand hill. Pele changes man and helmet into stone. Kealohalani can be seen below the sand hill as the red stone formation of a may lying in the water.

The sand hill became known as Honolulu, because the chief Honolulu, one of Kealohalani's retainers, composed the chant of this story. Later he settled on O'ahu.

The helmet stone, also called the Honolulu stone or the bell stone for its shape, was moved first to Kalapana and then to Olaa.

Legend of Puna'aikoa'e (Mary Kawena Pukui in Emory et al. 1959:37)

Before Pele and her family came to Hawai'i, Ka'u and Puna were beautiful lands with only earth from one end to the other and no lava beds. A very long stretch of sand, called Keonelau'enaakane, stretched from Waiakea in Hilo to Panau in Puna.

In the legend of Puna'aikoa'e, Pele and Wakakeakaiwai, the mo'o (lizard) goddess, have a great battle over their husband Puna'aikoa'e. He was a supernatural man with a koa'e (tropic bird). He lived at Pu'ula, Puna, near a place called Koa'e (Pukui and Elbert:397). The fighting between Pele and Waka extended from Punalu'u in Ka'u to Waiakea in Hilo, covering most of Puna in





lava. Only traces of the long beach remain. Pele destroyed Waka and Puna'aikoa'e in her fires. (See also Thrum 1923:185-196.)

Legend of Pele and Hi'iaka (Emerson 1915)

In this long, complex legend there are many mentions of Puna (e.g., Emerson 1915:200, 209, 211). References to specific place names in Puna include mentions of Pu'ulena (Emerson 1915:193, 203, 213), Keahialaka (Emerson:189, 211), Kea'au (Emerson 1915:223) and Ha'eha'e (Emerson 1915:189).

TABLE 1

INVENTORY OF
ARCHAEOLOGICAL AND HISTORICAL SITES
IN THE STUDY AREA

B.P.B.M.=Bernice P. Bishop Museum, Dept of Anthropology
S.H.P.O.=Hawaii State Preservation Office
Site numbers are B.P.B.M. site numbers unless otherwise noted.
Page numbers are given only when references to sites are not easily located by site numbers.

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| AHUPUA'A A1: KULA, OLAA | | | |
| 50-Ha-A1-11* Shipman's Cave | sections of burial-refuge lava tube | >1 | Emory 1945<br>McEldowney 1979 |
| 50-Ha-A1-12 | enclosure, kerbed trail | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>Apple 1965:31-39<br>McEldowney 1979 |
| 50-Ha-A1-13 | burial lava tube | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-17 | historic habitation-agricultural complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-18 | possibly historic habitation-agricultural complex | >9 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-21 | complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-22 | enclosure, probably historic cattle pen | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-24 | mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-25 | historic L-shape structure | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |





| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A1-26 | enclosure, probably historic cattle pen | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-27 | complex, probably historic cattle enclosures | >6 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-28 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-29 | small complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-30 | complex | >7 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-31 | facing | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-34 | possibly historic cattle enclosure | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-35 | complex | 6 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-40 | facings, wall | >2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-41 | mounds, platform | >2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-42 | enclosure | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-43 | small complex | >2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-44 | short wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A1-64 Ha'ena Pond | pond | 1 | McEldowney 1979<br>Kikuchi 1973:31, 25 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A1-65 Ha'ena Complex | partly historic complex | ? | McEldowney 1979 |
| State 10-44-7389 Kea'au District | historic commercial, domestic, religious, and plantation-related structure | >1 | S.H.P.O. Site Folder<br>McEldowney 1979 |
| AHUPUA'A A2: WAIKAHEKAHE NUI, WAIKAHEKAHE IKI | | | |
| 50-Ha-A2-1 | complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A2-2 | probably habitation-agricultural complex | >9 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A2-3 | complex, including possible heiau | >8 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| AHUPUA'A A3: MAKUU, POPOKI, HALONA | | | |
| 50-Ha-A3-1 | possibly agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-2 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-3 | possibly agricultural complex | >4 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-4 | complex, at least partly historic cattle pen | >1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-5 | probably agricultural walls and mounds, historic walls | >4 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-6 | historic petroglyphs | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-7 | mostly historically modified complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |





TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A3-10 | probably habitation-agricultural complex | >9 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-14 | historic wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-15 | depressions in lava, possibly for food preparation | 2 | McEldowney 1979<br>Hudson 1932, #60 |
| 50-Ha-A3-16 | trail | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-17 | at least partly historic burial platforms | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-18 | partly historic habitation-agricultural complex | >9 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-19 | possible habitation-agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-20 | ahupua'a boundary wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-24 | probably prehistoric petroglyph field | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979<br>Hudson 1932:308<br>S.H.P.O. Folder #4222 |
| 50-Ha-A3-25 | at least partly historic petroglyph field | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979<br>Hudson 1932:308 |
| 50-Ha-A3-26 | probably burial mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-27 | stone-lined depression, possibly animal enclosure | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A3-28 | platform | 1 | McEldowney 1979<br>Hudson 1932, #62 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| Hudson #81 | platforms, walls, enclosures | >5 | Hudson 1932 |
| State 10-45-4222 Maku'u Petroglyphs | historic petroglyphs | 1 | S.H.P.O. Folder<br>Ewart and Luscomb 1974:29<br>McEldowney 1979 |
| State 10-45-7476 | historic domestic structure | 1 | S.H.O.P. Folder<br>McEldowney 1979 |
| State 10-46-6417a | ahu | 1 | Bordner 1977 |
| Pahoa Cave | burial-refuge lava tube | 1 | Yent 1983 |
| AHUPUA'A A4: KEONEPOKO NUI, KEONEPOKO IKI | | | |
| 50-Ha-A4-1 | mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-2 | at least partly historic small complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-3 | complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-4 | platform | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-5 | historic small complex | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-6 | retaining wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-7 | possibly agricultural complex | 6 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-10 | complex, platforms and probably agricultural walls | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-11 | possibly agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |



TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A4-12 | probably windbreak wall, mound | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-13 | trail | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979<br>Hudson 1932, #83 |
| 50-Ha-A4-14 | C-shape structure | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-15 | probably ahupua'a boundary ahu | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-16 | probably historic wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-19 | historic small complex | 12 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-21 | faced depression | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-22 | disturbed burial mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-23 | possibly burial mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-24 | possibly agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-25 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-26 | platform | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-27 | stone outline | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A4-28 | faced depression | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-29 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-30 | small complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-31 | complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-32 | probably agricultural complex | >2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-33 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-34 | possibly burial mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-35 | faced depression | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-36 | faced rise | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-37 | complex | >2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-38 | probably agricultural complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-39 | probably agricultural complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-40 | possibly agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |



TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A4-41 | small complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-42 | complex of walls | >1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-43 | possibly habitation complex | >6 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-44 | complex | >1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-45 | complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-46 | probably burial mound | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-47 | small complex | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-48 | possibly agricultural complex | >6 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-49 | complex | 4 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-50 | possibly shelter wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-51 | complex | 6 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-52 | complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-53 | faced pit, ravine | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A4-54 | enclosure | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-55 | faced slope | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-56 | wall, possibly burial mounds | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-57 | cemetery | 5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-58 | faced depression | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-59 | possibly agricultural complex | 4 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-60 | complex | >5 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-61 | retaining wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-62 | possibly agricultural small complex | >1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-63 | complex | >1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-64 | possibly burial mounds | 2 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A4-66 | small complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney |
| 50-Ha-A4-67 | complex | >1 | McEldowney 1979<br>Hudson 1932, #84 |



TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| AHUPUA'A A5: WAIAKAHIULA, HONOLULU | | | |
| 50-Ha-A5-1 | canoe shed | 1 | Photos H-660/14 & 15 (B.P.B.M. Anthro. Dept.)<br>B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-2 | possibly destroyed trail | 1 | Photo H-680/17 (B.P.B.M. Anthro. Dept.)<br>B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-3 | possibly destroyed bait cup | 1 | Photo H-680/16. (B.P.B.M. Anthro. Dept.)<br>B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-4 | possibly agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-5 | possibly burial or houre site platform | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-6 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-7 | wall | 1 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-8 | possibly habitation-agricultural complex | >3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-9 | small complex | 3 | B.P.B.M. Site Card<br>Ewart and Luscomb 1974<br>McEldowney 1979 |
| 50-Ha-A5-10** | wall | 1 | McEldowney 1979<br>Hudson 1932, #85<br>Loo and Bonk 1970, #71 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| State 10-45-4221<br>Honolulu Landing | probable habitation complex, probable well | >7 | S.H.P.O. Folder<br>Hudson 1932, #85<br>Hansen 1967 |
| State 10-55-7388<br>Pahoa District | historic commercial, domestic, religious, community, and school structures | >29 | S.H.P.O. Folder |
| AHUPUA'A A6: NANAWALE, WAAWAA, KAHUWAI | | | |
| 50-Ha-A6-1 | habitation complex | >7 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #93<br>Barrere 1962<br>Orr 1963a<br>Orr 1963b<br>McEldowney 1979 |
| 50-Ha-A6-2 | paved trail | 1 | B.P.B.M. Site Card<br>Hudson 1932, #86<br>McEldowney 1979 |
| 50-Ha-A6-3<br>Nanawale Village | habitation walls, partly destroyed | >1 | B.P.B.M. Site Card<br>Hudson 1932, #86<br>Wilkes 1845:189<br>McEldowney 1979 |
| 50-Ha-A6-4 | canoe shed | 1 | B.P.B.M. Site Card<br>Hudson 1932, #87<br>McEldowney 1979 |
| 50-Ha-A6-5 | platform | 1 | B.P.B.M. Site Card<br>Hudson 1932, #89<br>McEldowney 1979 |
| 50-Ha-A6-6 | possibly burial platforms, burials | 7 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #90<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-7 | sloped pavement, possibly a meeting place | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #91<br>Orr 1963a<br>Orr 1963b<br>McEldowney 1979 |



TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A6-8 | canoe sheds | 2 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #92<br>Orr 1963a<br>Orr 1963b<br>Ahue 1963<br>Barrere 1962:164-165<br>McEldowney 1979 |
| 50-Ha-A6-9 | enclosure, possible heiau | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #94<br>Orr 1963a<br>Orr 1963b<br>Ahue 1963<br>McEldowney 1979 |
| 50-Ha-A6-10 | possibly habitation-agricultural complex, destroyed | >3 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #95<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-11 | habitation-agricultural complexes | >5 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #96<br>Orr 1963a<br>Orr 1963b<br>McEldowney 1979 |
| 50-Ha-A6-12 | platforms | 3 | B.P.B.M. Site Card<br>Barrera 1974<br>Hudson 1932, #97<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-13 | platforms | 6 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #98<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |

**TABLE 1 (contd.)**

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A6-14 | probably burial platform | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>McEldowney 1979 |
| 50-Ha-A6-15 | possibly burial platform | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>McEldowney 1979 |
| 50-Ha-A6-16 | burial | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-17 | possibly burial platform | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-18 | possibly house platform | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-19 | grave | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-20 | trail | 1 | B.P.B.M. Site Card<br>Bishop Estate Map 2432<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |



**TABLE 1 (contd.)**

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| 50-Ha-A6-21 | cyst burials | 2 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Hudson 1932, #95<br>Orr 1963a<br>Orr 1963b<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-22 | burials | >1 | B.P.B.M. Site Card<br>Barrera 1974<br>S.H.P.O. Folder #4278<br>Soehren 1963<br>McEldowney 1979 |
| 50-Ha-A6-23 | possibly house platform | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>Orr 1963a<br>McEldowney 1979 |
| 50-Ha-A6-24 | grave | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>Orr 1963a<br>McEldowney 1979 |
| 50-Ha-A6-25 | grave | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>Orr 1963a<br>McEldowney 1979 |
| 50-Ha-A6-26 | house platform | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>Orr 1963a<br>McEldowney 1979 |
| 50-Ha-A6-27 | walled house site with paving | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>Orr 1963a<br>McEldowney 1979 |
| 50-Ha-A6-28 | walled house site | 1 | B.P.B.M. Site Card<br>Barrera 1974<br>Orr 1963a<br>McEldowney 1979 |
| 50-Ha-A6-29 | alignment | 1 | B.P.B.M. Site Card<br>Hudson 1932, #88<br>McEldowney 1979 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| State 10-46-4270 Kahuwai Village Complex*** | partly historic habitation-agricultural complex | >56 | S.H.P.O. Folder<br>B.P.B.M. Site Cards A6-1, -6 through -11, -13 through -22<br>Hudson 1932, #90-98<br>Loo and Bonk 1970, #70 |
| AHUPUA'A A7: HALEPUAA, KANEKIKI, PUUA | | | |
| 50-Ha-A7-1 | probably shelter platform, possibly destroyed | 1 | McEldowney 1979<br>Hudson 1932, #99 |
| 50-Ha-A7-2 | petroglyphs, destroyed | 3 | McEldowney 1979<br>Hudson 1932, #100 |
| State 10-45- | historic church | 1 | S.H.P.O. Site Folder |
| none | traditional agricultural complex, plus probably historic enclosures and walls | >9 | Yent and Ota, 1982 |
| none | historic slaughterhouse | 1 | Federal Highway Administration 1979 |
| none | modified lava tube | 1 | Federal Highway Administration 1979 |
| AHUPUA'A A8: KULA, HALEKAMAHINA (see note below) | | | |
| 50-Ha-A8-1 State 10-46-2500 Kukii Heiau | <u>heiau</u> | 1 | B.P.B.M. Site Card<br>S.H.P.O. Folder<br>Hudson 1932, #106<br>Thrum 1907a:40<br>Thrum 1907b:55<br>Stokes n.d.:588<br>Bevacqua and Dye 1972<br>Loo and Bonk 1970, #69<br>Rogers-Jourdane 1984:I-4 |
| 50-Ha-A8-2 State 10-46-4250 Kings' Pillars/ Kii Pohako Alii | cairns, 1 destroyed | 3 | B.P.B.M. Site Card<br>S.H.P.O. Folder<br>Hudson 1932, #103<br>Cox 1983a, #1<br>Rogers-Jourdane 1984:I-4 |
| 50-Ha-A8-4 | platform, destroyed | 1 | McEldowney 1979<br>Hudson 1932, #101 |
| 50-Ha-A8-5 | platform, destroyed | 1 | McEldowney 1979<br>Hudson 1932, #102 |





TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| Loo & Bonk #68 Kuaukahi Gravesites? | historic platforms | 2 | Loo and Bonk 1970<br>S.H.P.O. Folder #4251<br>Cox 1983a, #6 |
| State 10-46-4251 Kuaukahi Gravesites | possibly burial platforms | 2 | S.H.P.O. Folder<br>Loo and Bonk 1970, #68<br>Cox 1983b, State #10002<br>Cox 1983a, #6 or #7+#8<br>Rogers-Jourdane 1984:I-4 |
| State 10-46-10002 | clusters of platform-like features | 2 | Cox 1983b<br>Cox 1983a, #7 and #8<br>S.H.P.O. Folder #4251 |
| Cox #6 | platform, possible <u>ko'a</u> platform | 2 | Cox 1983a<br>Loo and Bonk 1970, #68<br>S.H.P.O. Folder #4251 |
| Cox #2 | historic petroglyphs | 2 | Cox 1983a |
| Cox #3 | old trail | 1 | Cox 1983a |
| Cox #4 | lava blister shelter caves | 2 | Cox 1983a |
| Cox #5 | pond, probably modified | 1 | Cox 1983a |
| Cox Cluster A | terraced platforms | 2 | Cox 1983b |
| Cox Cluster B | complex | 6 | Cox 1983b |
| Cox Cluster C | hollow with vertical slab | 2? | Cox 1983b |
| Cox Cluster D | platforms | 4 | Cox 1983b |
| Cox Cluster E | platforms | 3 | Cox 1983b |
| Cox Cluster F | platforms, paved area | 9 | Cox 1983b |
| Cox Cluster G | platforms, 2 with burial | 5 | Cox 1983b |
| Cox Cluster H | platform | 1 | Cox 1983b |
| Cox Cluster I | platform, pavements | >2 | Cox 1983b |
| Ladd Area A | historic platform | 1 | Ladd 1981 |
| Ladd Area B | historic petroglyphs | 2 | Ladd 1981 |
| Ladd Area C | <u>ahu</u> | 2 | Ladd 1981 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| Ladd Area D | probably shelter lava bubble | 1 | Ladd 1981 |
| Hudson #102 | platform, cairns, platform graves | >4 | Hudson 1932 |
| Hudson #104 | shelter, adjoining platform | 2 | Hudson 1932 |
| Hudson #105 | canoe house | 1 | Hudson 1932 |
| Hudson #107 | cyst-type grave | 1 | Hudson 1932 |
| Hudson #112 | trail, small enclosures, agricultural workings | >4 | Hudson 1932 |
| Hudson #113 | enclosure | 1 | Hudson 1932 |
| Hudson #114 | enclosure | 1 | Hudson 1932 |
| Hudson #115 | paved area, possibly house site | 1 | Hudson 1932 |
| Hudson #116 | canoe house, trails, walks, shallow pits, small pens | >6 | Hudson 1932 |
| Hudson #117 | probably house site platform, trail, terraces | >3 | Hudson 1932 |
| Hudson #118 | paved area, probably house site | 1 | Hudson 1932 |
| Hudson #119 | paved area, faced hole | 2 | Hudson 1932 |
| Hudson #120 | platform | 1 | Hudson 1932 |
| Hudson #121 | enclosures | 2 | Hudson 1932 |
| Hudson #122 | canoe house | 1 | Hudson 1932 |
| Hudson #123 | terraced platform | 1 | Hudson 1932 |
| Hudson #124 | probably historic windbreak wall | 1 | Hudson 1932 |
| Hudson #125 | enclosure on terrace | 2 | Hudson 1932 |
| Hudson #126 | platform | 1 | Hudson 1932 |
| Hudson #127 | wall windbreak | 1 | Hudson 1932 |



TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| Hudson #128 | enclosure | 1 | Hudson 1932 |
| Hudson #129 | paved area | 1 | Hudson 1932 |
| Hudson #130 | probably canoe house | 1 | Hudson 1932 |
| Hudson #131 | terraced platform | 1 | Hudson 1932 |
| Hudson #132 | house platform | 1 | Hudson 1932 |
| Hudson #133 | trail | 1 | Hudson 1932 |
| Hudson #134 | probably historic circular shelter | 1 | Hudson 1932 |
| Hudson #135 | wall windbreaks | 2 | Hudson 1932 |
| Hudson #136 | possible platform, probably for house | 1 | Hudson 1932 |
| AHUPUA'A A9: KAPOHO | | | |
| 50-Ha-A9-1 State 10-46-2501 Kapoho Petroglyphs | clusters of petroglyphs | >1 | B.P.B.M. Site Card S.H.P.O. Folder Bevaqua and Dye 1972 Rogers-Jourdane 1984:I-4 |
| 50-Ha-A9-2 State 10-46-5245 Ka Holua o Kahawali | <u>holua slide</u> | 1 | B.P.B.M. Site Card S.H.P.O. Folder Hudson 1932:332 Rogers-Jourdane 1984:I-4 |
| State 10-46-4254 Kapoho Point Platform | platform | 1 | S.H.P.O. Folder Rogers-Jourdane 1984:I-4 Hudson 1932, #137 |
| State 10-46-7492 Lyman Marker | historic rock marker | 1 | S.H.P.O. Folder |
| Hudson #108 | male and female sacred stones | 2 | Hudson 1932 |
| AHUPUA'A A10: PU'ALA'A, AHALANUI, LAEPAOO, OHELOA | | | |
| 50-Ha-A10-6 State 10-46-4295 Pualaa Complex 2 | destroyed <u>holua</u> slide, agricultural patches, some remaining | >4 | B.P.B.M. Site Card S.H.P.O. Folder Hudson 1932:82 Hudson 1932, #109,110,111 Crozier and Barrere 1971 Loebenstein 1895 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| AHUPUA'A A11: POHOIKI, KEAHIALAKA | | | |
| 50-Ha-A11-2**** Oolo Heiau | destroyed heiau | 1 | B.P.B.M. Site Card<br>Thrum 1907a:39<br>Nakamura 1984:II-2 |
| none | possibly burial-refuge lava tube | 1 | Bonk 1980b |
| THROUGH MANY AHUPUA'A: | | | |
| Hawaii Consolidated Railway | destroyed railroad | >1 | Kelly et al. 1981: 142-177<br>Hawaii Survey 1952<br>USGS Pahoa North Quad<br>USGS Kapoho Quad<br>McEldowney 1979 |
| Hilo to Puna Trail | partially destroyed trail | >1 | Hudson 1932:246-249<br>Loebenstein 1895<br>USGS Kea'au Quad<br>USGS Pahoa North Quad<br>USGS Kapoho Quad<br>McEldowney 1979 |

* B.P.B.M. Site Card A1-11 describes a diffferent lava tube site which is out of the study area, but also refers to Emory's manuscript on Shipman's Cave. McEldowney lists Shipman's Cave as site A1-11 in her inventory.

** This well may be the one mentioned at State 10-45-4221.

*** This site includes many previously listed sites.

**** This site was probably not in our study area. Its former location is known only as being in Pohoiki.

(note) Some sites may be listed more than once. There is much uncertainty as to whether different archaeologists are describing the same sites in the areas of Cape Kumukahi and the Kumukahi Gravesites. Some Hudson sites (#102, 104, 105, 112-136) may be destroyed by lava.





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# CORRECTION

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

TABLE 1 (contd.)



| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| Ladd Area D | probably shelter lava bubble | 1 | Ladd 1981 |
| Hudson #102 | platform, cairns, platform graves | >4 | Hudson 1932 |
| Hudson #104 | shelter, adjoining platform | 2 | Hudson 1932 |
| Hudson #105 | canoe house | 1 | Hudson 1932 |
| Hudson #107 | cyst-type grave | 1 | Hudson 1932 |
| Hudson #112 | trail, small enclosures, agricultural workings | >4 | Hudson 1932 |
| Hudson #113 | enclosure | 1 | Hudson 1932 |
| Hudson #114 | enclosure | 1 | Hudson 1932 |
| Hudson #115 | paved area, possibly house site | 1 | Hudson 1932 |
| Hudson #116 | canoe house, trails, walks, shallow pits, small pens | >6 | Hudson 1932 |
| Hudson #117 | probably house site platform, trail, terraces | >3 | Hudson 1932 |
| Hudson #118 | paved area, probably house site | 1 | Hudson 1932 |
| Hudson #119 | paved area, faced hole | 2 | Hudson 1932 |
| Hudson #120 | platform | 1 | Hudson 1932 |
| Hudson #121 | enclosures | 2 | Hudson 1932 |
| Hudson #122 | canoe house | 1 | Hudson 1932 |
| Hudson #123 | terraced platform | 1 | Hudson 1932 |
| Hudson #124 | probably historic windbreak wall | 1 | Hudson 1932 |
| Hudson #125 | enclosure on terrace | 2 | Hudson 1932 |
| Hudson #126 | platform | 1 | Hudson 1932 |
| Hudson #127 | wall windbreak | 1 | Hudson 1932 |

TABLE 1 (contd.)



| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| Hudson #128 | enclosure | 1 | Hudson 1932 |
| Hudson #129 | paved area | 1 | Hudson 1932 |
| Hudson #130 | probably canoe house | 1 | Hudson 1932 |
| Hudson #131 | terraced platform | 1 | Hudson 1932 |
| Hudson #132 | house platform | 1 | Hudson 1932 |
| Hudson #133 | trail | 1 | Hudson 1932 |
| Hudson #134 | probably historic circular shelter | 1 | Hudson 1932 |
| Hudson #135 | wall windbreaks | 2 | Hudson 1932 |
| Hudson #136 | possible platform, probably for house | 1 | Hudson 1932 |
| AHUPUA'A A9: KAPOHO | | | |
| 50-Ha-A9-1<br>State 10-46-2501<br>Kapoho Petroglyphs | clusters of petroglyphs | >1 | B.P.B.M. Site Card<br>S.H.P.O. Folder<br>Bevaqua and Dye 1972<br>Rogers-Jourdane 1984:I-4 |
| 50-Ha-A9-2<br>State 10-46-5245<br>Ka Holua o Kahawali | holua slide | 1 | B.P.B.M. Site Card<br>S.H.P.O. Folder<br>Hudson 1932:332<br>Rogers-Jourdane 1984:I-4 |
| State 10-46-4254<br>Kapoho Point Platform | platform | 1 | S.H.P.O. Folder<br>Rogers-Jourdane 1984:I-4<br>Hudson 1932, #137 |
| State 10-46-7492<br>Lyman Marker | historic rock marker | 1 | S.H.P.O. Folder |
| Hudson #108 | male and female sacred stones | 2 | Hudson 1932 |
| AHUPUA'A A10: PU'ALA'A, AHALANUI, LAEPAOO, ONELOA | | | |
| 50-Ha-A10-6<br>State 10-46-4295<br>Pualaa Complex 2 | destroyed holua slide, agricultural patches, some remaining | >4 | B.P.B.M. Site Card<br>S.H.P.O. Folder<br>Hudson 1932:82<br>Hudson 1932, #109,110,111<br>Crozier and Barrere 1971<br>Loebenstein 1895 |

TABLE 1 (contd.)

| Site Number/Name | Site Type | Features | References |
|---|---|---|---|
| AHUPUA'A A11: POHOIKI, KEAHIALAKA | | | |
| 50-Ha-A11-2**** Oolo Heiau | destroyed heiau | 1 | B.P.B.M. Site Card<br>Thrum 1907a:39<br>Nakamura 1984:II-2 |
| none | possibly burial-refuge lava tube | 1 | Bonk 1980b |
| THROUGH MANY AHUPUA'A: | | | |
| Hawaii Consolidated Railway | destroyed railroad | >1 | Kelly et al. 1981: 142-177<br>Hawaii Survey 1952<br>USGS Pahoa North Quad<br>USGS Kapoho Quad<br>McEldowney 1979 |
| Hilo to Puna Trail | partially destroyed trail | >1 | Hudson 1932:246-249<br>Loebenstein 1895<br>USGS Kea'au Quad<br>USGS Pahoa North Quad<br>USGS Kapoho Quad<br>McEldowney 1979 |

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# APPENDIX C

# CULTURAL AND BIOLOGICAL RESOURCES SURVEY OF THE POHOIKI-TO-PUNA SUBSTATION 69 KV TRANSMISSION CORRIDOR KEA'AU TO KAPOHO, PUNA, HAWAI'I ISLAND

Final Report:

Botanical Survey

22 April 1987

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## INTRODUCTION

To simplify botanical description of the project terrain, the following narrative is keyed to the individual parcels into which our field survey was divided. Sectors have been delimited from the total territory on the basis of logical considerations relating to spatial continuity and approximate homogeneity of forest/community condition. Geographic north is indicated for each of the various diagrams. Except for zone 6 (where the map reference is self-evident), the interrelation of the various subunits is depicted in figure 1.

Representative species lists are provided for most of the survey sections. The following symbols are employed in the enumeration:

E = endemic; a plant whose natural range is restricted to the Hawaiian Islands.

I = indigenous; a plant native to the Hawaiian Islands, but also with natural occurrences elsewhere.

A = alien; introduced by man, accidentally or by design.

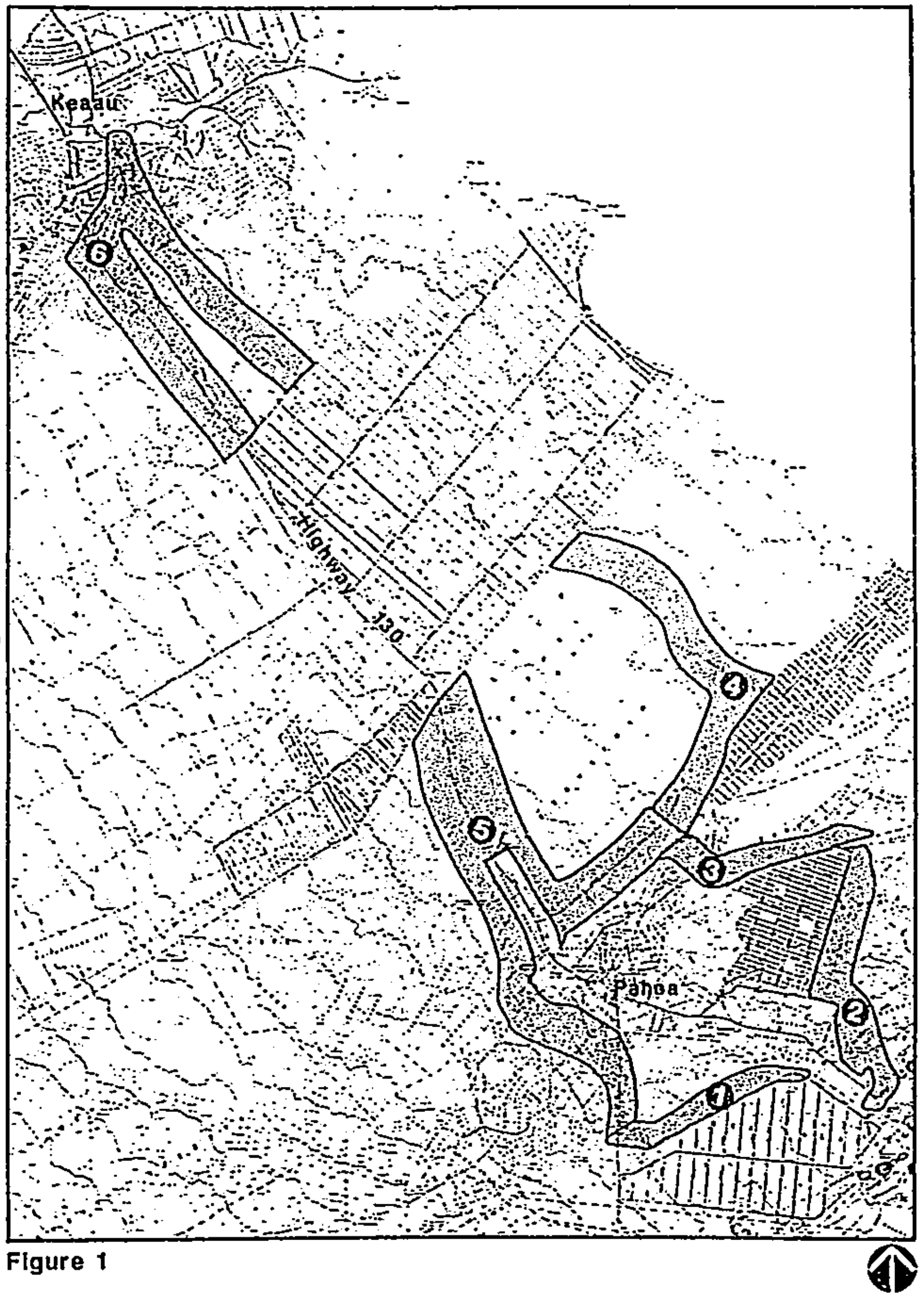



Figure 1



## DESCRIPTION OF ZONES

### ZONE 1: Kahukai Street Corridor at Keahialaka

The proposed track along Kahukai Street extends through an early stage forest consisting primarily of Metrosideros polymorpha and Dicranopteris linearis. A fissured substrate of undecomposed a'a underlies most of the area. Due to the hazards presented by unsettled clinker, reconnaissance was necessarily limited to a few discretionary off-road penetrations. But in any event, the structure of this forest type proved capable of characterization without intensive coverage.

The Kahukai corridor has a monotypic Metrosideros canopy topping at a height of 7-8 m. Trees are widely spaced, so direct insolation passes unimpeded into understory strata. Such light-intense environments are very favorable to Dicranopteris linearis (i.e. uluhe fern), and the thicket-forming heliophyte now envelops most of the sector in a 2 m high tangle. The uluhe congests the ground interval so effectively that few plants can penetrate the stratum. Diversity is thus severely suppressed. Among native species, Sadleria cyatheoides and Pipturus albidus are the most consistent emergents from the Dicranopteris matrix. Where disruption of the native groundcover has occurred through natural or manmade agency, weedy volunteer crops of varied composition are frequently released. Many aliens were registered from roadsides and houselot margins, but only Melastoma candidum appears to pose an environmental threat.

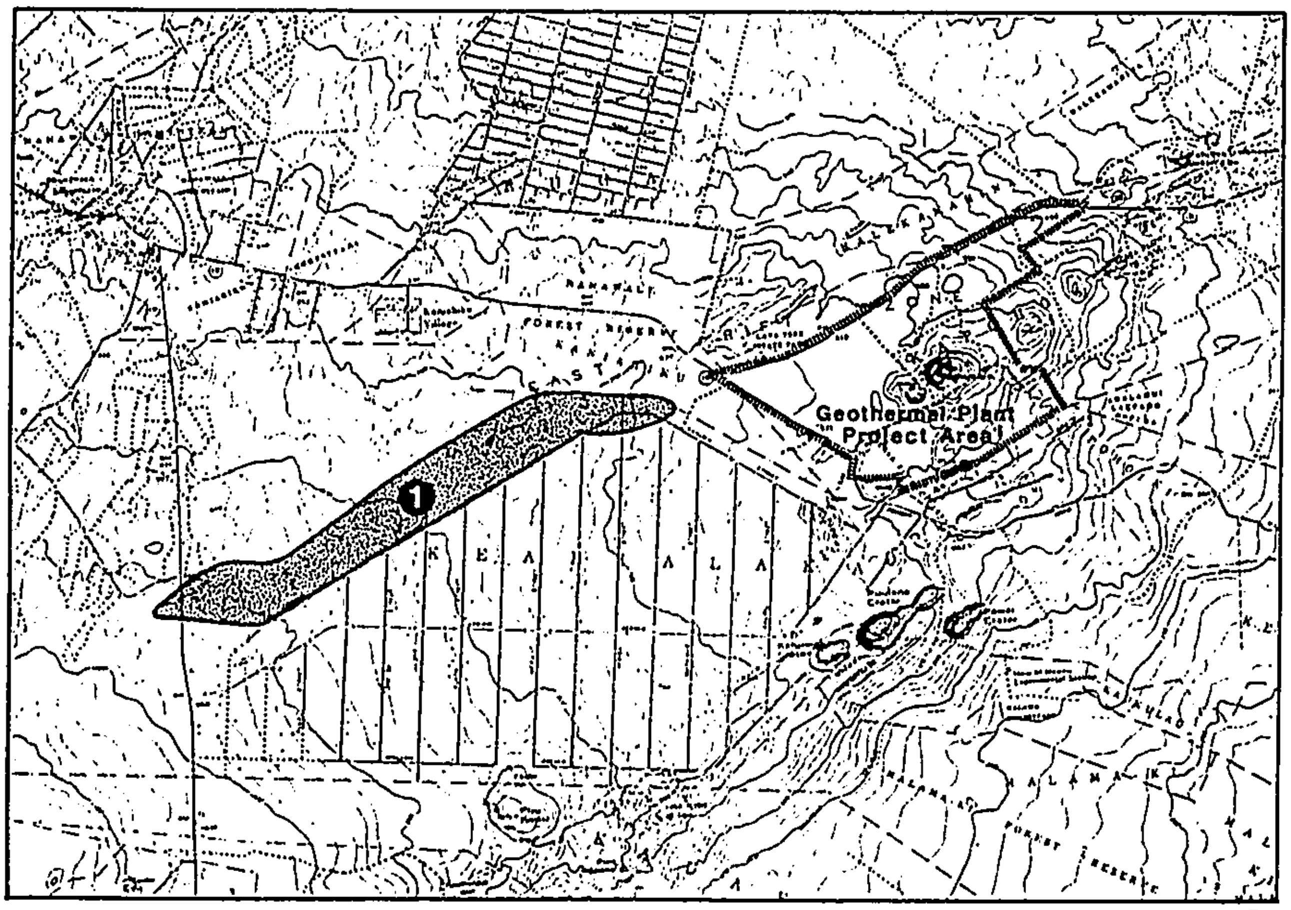
Towards the NE end of the tract, the Metrosideros-Dicranopteris formation passes rather sharply into a forest of greater maturity. The abruptness of transition indicates that the floristic demarcation is probably a historical flow boundary. With passage across this structural line, certain features of successional process are displayed. In the forest of contrasting condition, the Metrosideros canopy assumes higher stature, and lateral elaboration of individual crowns has produced an interlocking overstory. The resulting reduction of subcanopy light is associated with the replacement of uluhe fern by a shade-adapted assemblage dominated by Cibotium chamissoi and Ophioglossum pendulum.

Within the mature acreage there is also a noticeable increase in species count, with Diospyros sandwicensis, Myrsine lessertiana, and Psychotria hawaiiensis var. hawaiiensis achieving significant frequencies in a normally depauperate canopy. The appearance of additional taxa results in a more equitable occupation of the different height increments, so that a solid front of plant growth confronts the observer. There is no disjunction between vegetation layers as is obvious in the Metrosideros-Dicranopteris association.

In addition to the species mentioned in the text, the following plants were recorded from zone 1:

Albizzia sp. (A), Melochia umbellata (A), Psidium cattleianum (A), Psidium guajava (A), Aleurites moluccana (A), Persea americana (A), Bambusa sp. (A), Musa acuminata (A), Cecropia obtusifolia (A), Pluchea symphytifolia (A), Buddleia asiatica (A), Ardisia crispa (A), Alyxia oliviformis (E), Freycinetia arborea (I), Cordyline terminalis (A), Rubus rosifolius (A), Impatiens sultani (A), Commelina diffusa (A), Psilotum nudum (I), Pleopeltis thunbergiana (E), Begonia hirtella (A), Stachytarpheta dichotoma (A), Cyperus sp. (A), Cyperus halpan (A), Castilleja arvensis (A), Youngia japonica (A), Ageratum conyzoides (A), Ageratum houstonianum (A), Mitracarpus hirtus (A), Spermococe assurgens (A), Polygala paniculata (A), Lindernia crustacea (A), Sacciolepis indica (A), Digitaria violascens (A), Paspalum dilatatum (A), Paspalum scrobiculatum (A), Cannabis sativa subsp. indica (A), Coprosma menziesii (E), Machaerina angustifolia (I), Machaerina mariscoides (I), Coix lachryma-jobi (A), Arundina bambusifolia (A), Spathoglottis plicata (A), Nephrolepis sp., Cocculus trilobus (I), Chamaesyce hirta (A), Andropogon virginicus (A), Pityrogramma calomelanos (A), Lycopodium cernuum (I), Chamaesyce prostrata (A), Sphenomeris chinensis (I), Paederia scandens (A), Phymatosorus scolopendria (A), Melaleuca quinquenervia (A), Elaphoglossum crassifolium (E), Christella parasitica (A), Adenophorus sp. (E), and Peperomia sp. (E).

Zone 1. Metrosideros forest with dense understory of Dicranopteris linearis. A common community type throughout the Hawaiian Islands.




Zone 1

ZONE 2: Corridor Between Puua and the Geothermal Plant

This sector is recognized primarily for purposes of report convenience rather than vegetation homogeneity. A number of distinct community entities are actually included within zone 2, but the various elements tend to be of such small area that their individual description would be cumbersome. Comment is thus limited to statements of general pattern, with attention directed to specific parcels only when warranted by some salient site feature.

Zone 2 spans the full range of developmental states from near-barren lava to mature forest.

An example of vegetation in the first stages of successional recovery from volcanism is found immediately around the geothermal facility. There the plant life is exceedingly sparse, with much of the landscape consisting of nothing more than lichen-encrusted rocks. A scattering of Metosideros saplings provides the only significant cover. Nephrolepis multiflorum (A), Arundina bambusifolia (A), Andropogon virginicum (A), Styphelia tameiameiae (I), Pluchea symphytifolia (A), Waltheria indica (I), Phymatosorus scolopendria (A), Buddleia asiatica (A), Albizzia sp. (A), Mitracarpus hirtus (A), Hyparrhenia rufa (A), and Spathoglottis plicata (A), compose the remainder of an extremely abbreviated flora.

Moving north towards highway 132, the terrain becomes an open weedland with herbaceous pests such as Melinis minutiflora (A), Mimosa pudica (A), Arundina bambusifolia (A), Phymatosorus scolopendria (A), Buchnera sp. (A), Sporobolus indicus (A), Dissotis rotundifolia (A), Desmodium triflorum (A), Brachiaria mutica (A), Hyptis pectinata (A), and Paederia scandens (A). Canopy is absent, but small shrubs of Melochia, Pipturus, and Cecropia spike intermittently through the ground tangle.



Near Lava Tree State Park, a developing forest of juvenile Metrosideros forms the dominant cover. The understory is occupied by discontinuous patches of Dicranopteris linearis (E), Melastoma candidum (A), Machaerina angustifolia (I), Desmodium cajanifolium (A), and a host of the same weeds to be found in virtually all of the zones surveyed. The early stage forest covers essentially the entire remaining territory parallel to Seaview Road. Hibiscus tiliaceus (I), Pandanus tectorius (I), and Cecropia obtusifolia (A) can achieve dominance through localized areas, but the Metrosideros-Dicranopteris combination is clearly the major association.

In a preliminary report, specific mention was made of the narrow strip of forest running down the center of the Seaview Road parcel. The strip is very distinct on a wide range of community descriptors and is undoubtedly the best example of native forest encountered within the project area. This assessment represents only a relative judgment however. Compared to survey sections elsewhere, the parcel is richer by comparison, but is still mundane on any absolute measure of vegetation quality. Occurrences of Tetraplasandra hawaiensis, an indeterminable Cyrtandra, and an elevated species count, are collectively deserving of note--though not so significant as to merit special dispensation for the site. Species recorded from this strip include: Psychotria hawaiiensis var. hawaiiensis (E), Tetraplasandra hawaiensis (E), Myrsine lessertiana (E), Dicranopteris linearis (I), Pipturus albidus (E), Antidesma platyphyllum (E), Diospyros sandwicensis (E), Freycinetia arborea (I), Metrosideros polymorpha (E), Asplenium nidus (I), Vittaria elongata (E), Cibotium chamissoi (E), Thelypteris hudsonianum (E), Vandenboschia sp. (E), Ophioglossum pendulum subsp. falcatum (E), Adenophorus tamariscinus (E), Alyxia oliviformis (E), Cyrtandra sp. (E), Melastoma candidum (A), Oplismenus hirtellus (A), Cecropia obtusifolius (A), Spathoglottis plicata (A), Psidium cattleianum (A), Blechnum occidentale (A), Mimosa pudica (A), Rubus rosifolius (A), Ageratum houstonianum (A), Psilotum nudum (I), Trema orientalis (A), Persea americana (A), Musa xparadisiaca (A), Pluchea symphytifolia (A), Paederia scandens (A), Impatiens wallerana (A), Nephrolepis sp., Cordyline terminalis (A), Arundina bambusifolia (A), Christella sp., Plectranthus scutellarioides (A), Desmodium sp. (A), Setaria palmifolia (A), Dissotis rotundifolia (A), Cocculus trilobus (I), Phymatosorus scolopendria (A), Lycopodium phyllanthum (E), Wikstroemia sandwicensis (E), Pandanus tectorius (I), Hibiscus tiliaceus (I), and Peperomia sp. (E)



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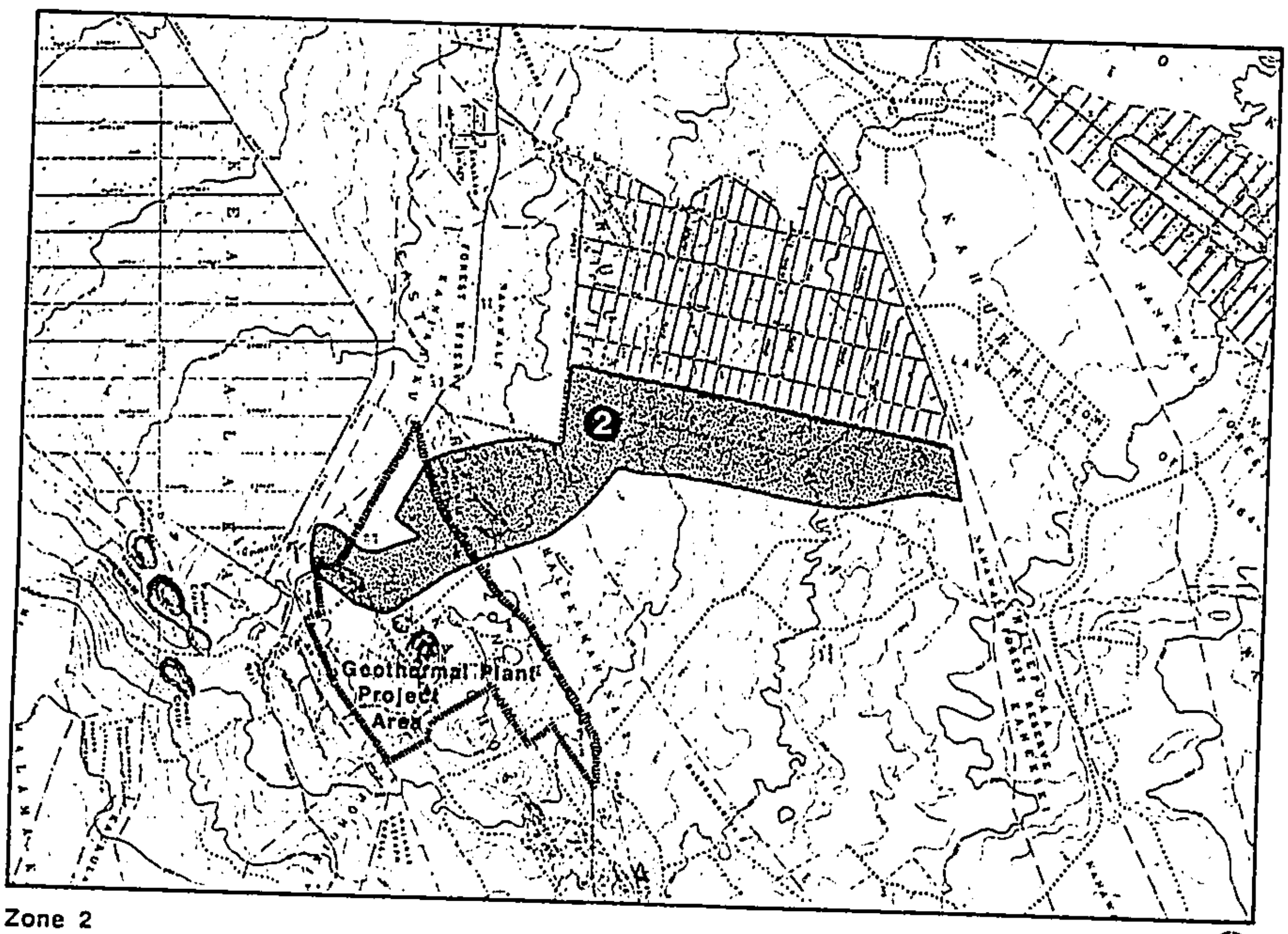
Zone 2. Top: 1955 lava flow near the geothermal facility. Bottom: Herbaceous weedland adjacent to route 132.




Zone 2

ZONE 3: Kahuwai Corridor

The Kahuwai corridor is the narrow trace along the northern boundary of the Puua subdivision. The early successional association of <u>Metrosideros</u> - <u>Dicranopteris</u> is again the dominant vegetation cover. Although the species mix is primarily of native character, diversity is very low and consists essentially of common plants found in many other regions of Hawaii.

Overall, the community in zone 3 is poorly developed. Most of the <u>Metrosideros</u> are mere scrub-sized individuals scattered over relatively fresh clinker. The living biomass is composed almost entirely by just <u>Metrosideros</u> and <u>Dicranopteris</u>.

Moving toward the western end of the strip, the land supports an increasingly weedier and taller forest with <u>Eucalyptus</u> and <u>Cecropia</u> as stature dominants. As with other survey sections exhibiting similar cover, there is nothing of real botanical value in this area. The species compilation for the zone was much smaller than comparable sites in units 1 and 2, and with no new additions of consequence.



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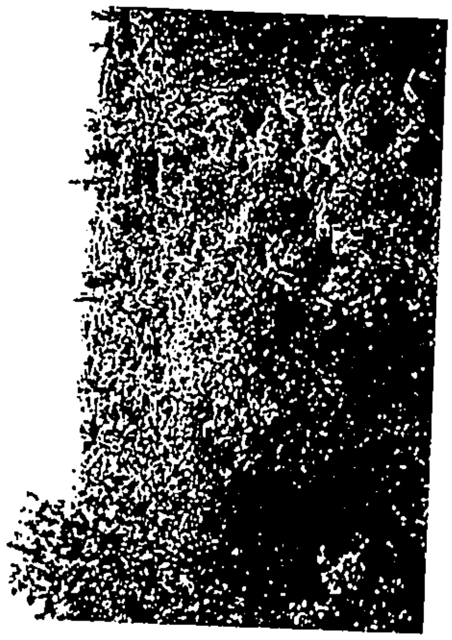
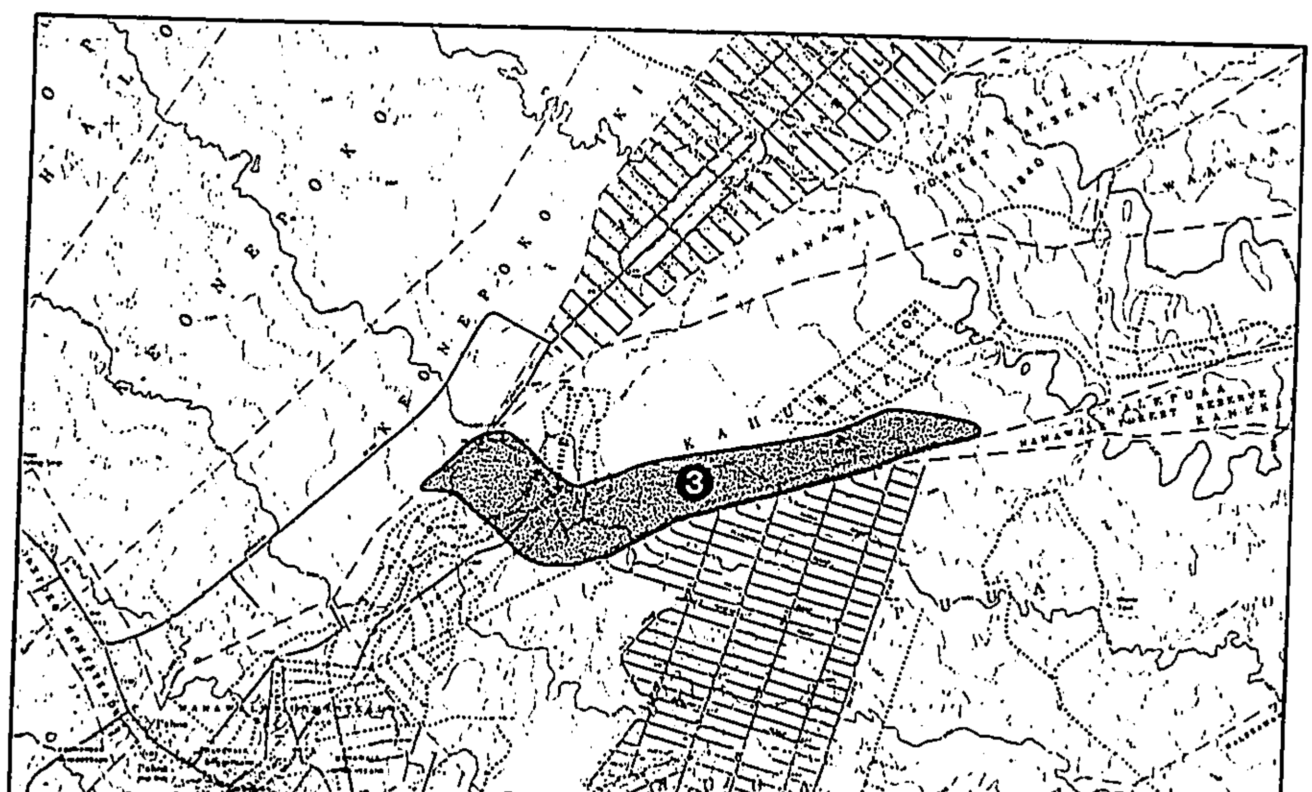


Zone 3. Showing the principal vegetation of Metrosideros and Dicranopteris.



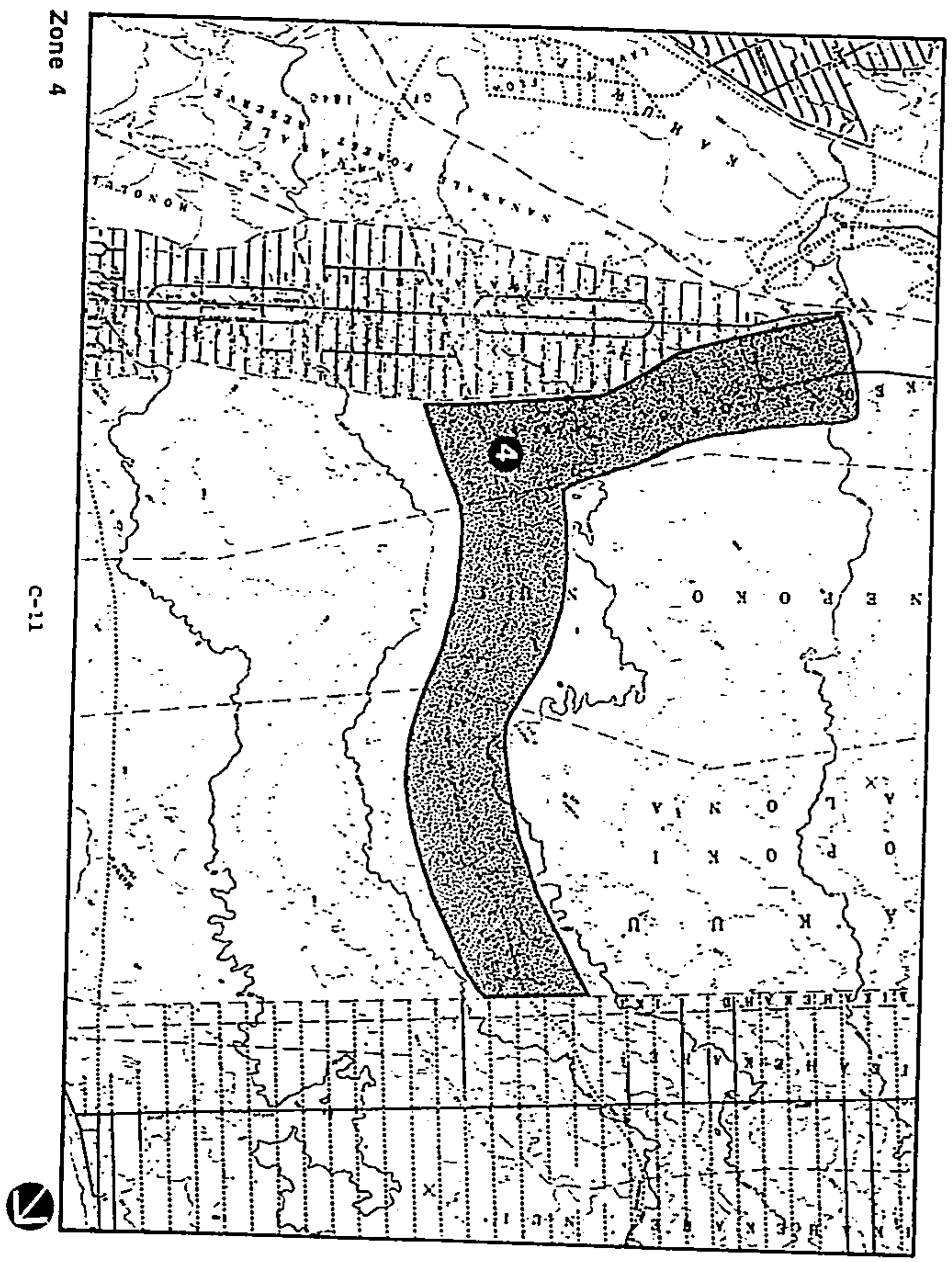
Zone 3

ZONE 4: Railroad Avenue near Keonepoko

The Keonepoko parcel is the survey unit formed by portions of Railroad Avenue and the lane extending from Kahukai Boulevard. This sector is extremely homogeneous floristically, as it consists of a virtually unbroken expanse of Andropogon virginicum grassland. Judging from the large number of standing snags, an open canopy of Metrosideros must have once extended the full length of the zone. A wide range of snag condition was noted, with dead trees ranging from states of advanced decomposition to freshly dead boles without bark exfoliation or twig drop. The canopy dieback process in this tract was apparently very prolonged and only recently completed. Live Metrosideros was recorded mainly at the northwestern end of the Railroad Avenue segment and then only with individuals of low vigor.

The entire area, or at least sections of it, are likely under burn influence. Grazing is probably not responsible for grassland maintenance since the property is unfenced and cattle was not seen. At least one dieback section had signs of fire scarring on standing wood and ash residue on the ground.

Besides Metrosideros polymorpha (E) and Andropogon virginicum (A), the following are the notable species in zone 4: Osteomeles anthyllidifolia (E), Pluchea symphytifolia (A), Arundina bambusifolia (A), Passiflora foetida (A), Waltheria indica (I), Chamaecrista nictitans subsp. patellaria var. glabrata (A), Wikstroemia sandwicensis (E), Cassytha filiformis (I), Indigofera suffruticosa (A), Spathoglottis plicata (A), Mimosa pudica (A), Psidium guajava (A), Psidium cattleianum (A), Mangifera indica (A), Cocos nucifera (A), Melinis minutiflora (A), Nephrolepis multiflora (A), Centella asiatica (A), Stachytarpheta urticifolia (A), Crotalaria spectabilis (A), Crinum sp. (A), Thunbergia fragrans (A), Crassocephalum crepidioides (A), Desmodium incanum (A), Pennisetum setaceum (A), Hyptis pectinata (A), Themeda gigantea (A), Albizzia sp. (A), Emilia fosbergii (A), Erechtites valerianifolia (A), Cyperus sp., Machaerina mariscoides (I), Trema orientalis (A), Scleria testacea (E), Castilleja arvensis (A), and Pityrogramma calomelanos (A).



Zone 4

Zone 4. Andropogon grassland with dead snags from a former Metrosideros forest. Foliated trees in bottom frame are Eucalyptus.

ZONE 5: Highway Parcels near Pahoa

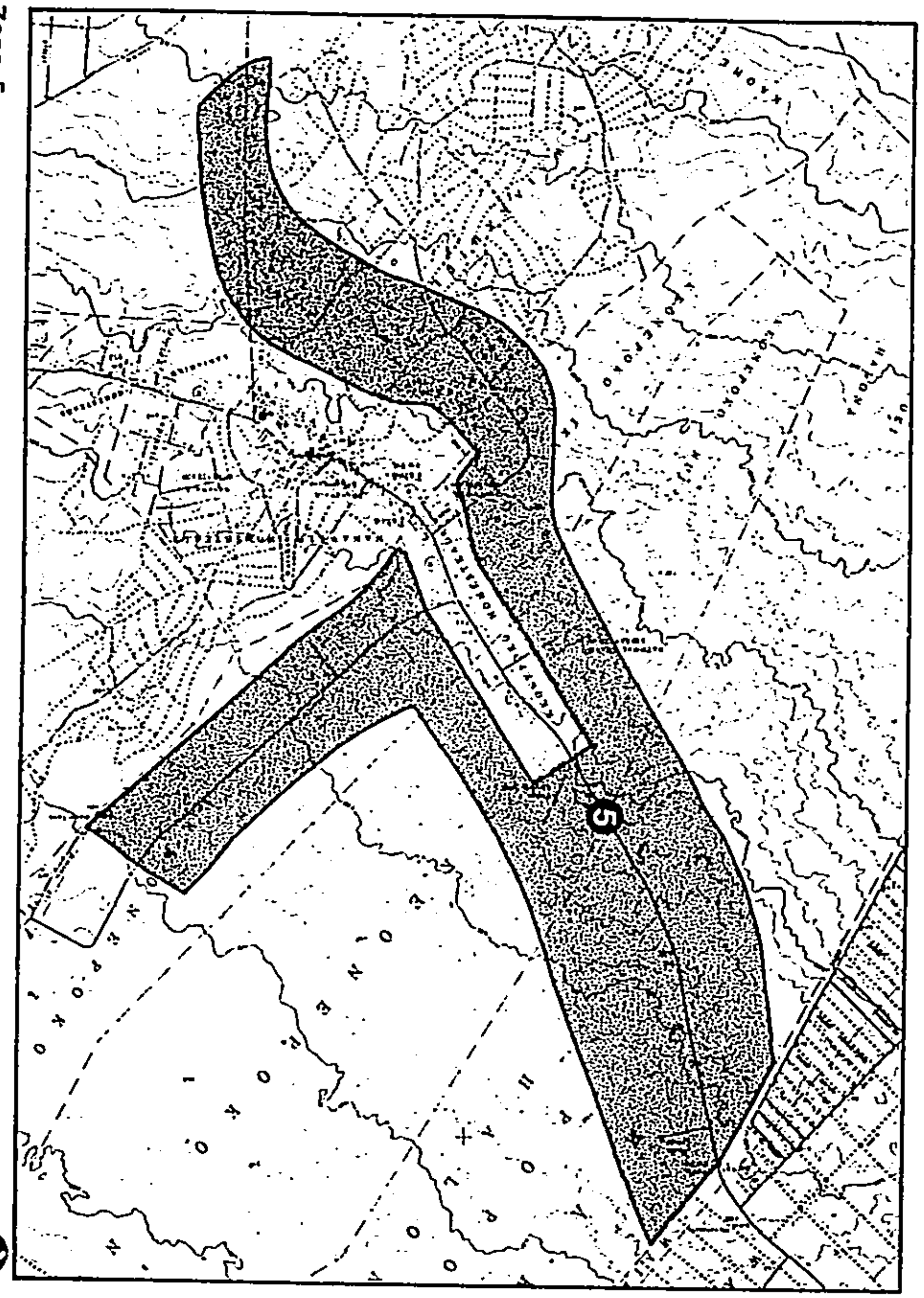
The survey units near Pahoa occur primarily on agricultural or residential land bracketing major roads. Human activity has fragmented the vegetation into a mosaic of contrasting types difficult to bring under common description, other than with the fact that they are universally of minimal botanical value.

In general, the largest area of native forest is the fraction on both sides of highway 130 (toward Keaau). Short-statured Metrosideros of pole-like habit is the dominant cover in the area. However the understory component is frequently infested with weeds such as Melastoma candidum (A), Andropogon viriginicum (A), Polygonum capitatum (A), Castilleja arvensis (A), Eragrostis unioloides (A), and Arundina bambusifolia (A). Alien communities of (primarily) Psidium cattleianum, Psidium guajava, Mangifera indica, Pluchea symphytifolia, Albizzia sp., and Cecropia obtusifolia are also interspersed throughout the section. Due to the presence of numerous houselots and agricultural plots, there is no continuity to the plant formations.

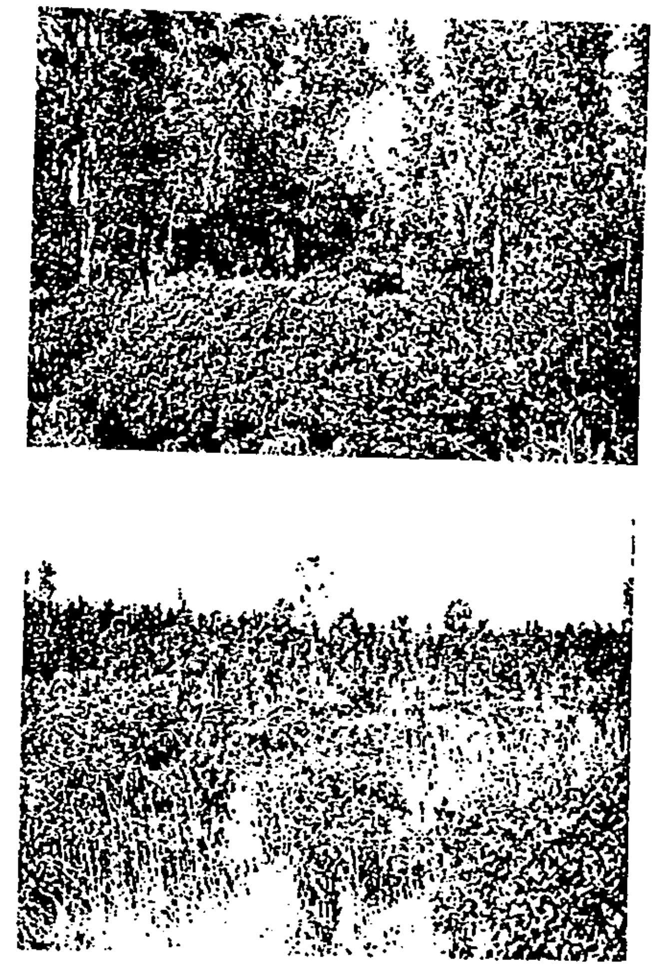
This same pattern is repeated in the properties along Kahukai Boulevard. Substantial patches of the Metrosideros-Dicranopteris association are distributed through the strip but the residential and commercial farm lots completely disrupt the integrity of forest. Melochia umbellata, Pluchea symphytifolia, Buddleia asiatica, and Psidium guajava are common pests.

The lane forming an arc to the west of Pahoa is similarly of low botanical quality. Much of the area consists of abandoned canefields, pastureland, or weedy borderland. When native communities are present, they are nearly always of the ubiquitous pioneer type composition. Exceptions such as the kipuka by Pahoa Dump may contain a richer-than-usual species suite but the taxa recorded are still common items to be found almost anywhere.

Relictual stands of Metrosideros-Psychotria forest were encountered along the portion of route 130 which runs south from Pahoa. Certain sites have higher species counts than the survey norm but again the plants involved are common throughout Hawaii.




Zone 5



Zone 5. Two views of the Metrosideros forest near Keonopoko Homesteads. Foreground: the alien shrub Melastoma candidum as an aggressive invader.

ZONE 6: Puna Substation

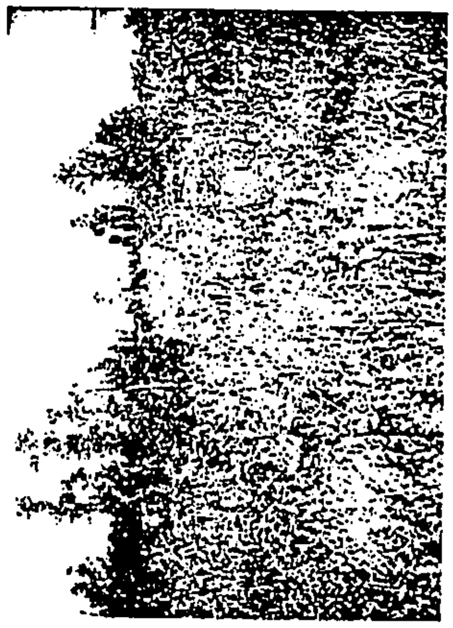
The survey section near the Puna substation extends to the SE in a double-lane configuration, with one arm passing through Waipahoehoe and the second superimposed upon the Keaau-Pahoa highway. Most of this area has had a long history of intensive agricultural use. Native plant cover is absent from a wide territory, especially in the region adjoining the substation.

Due to the failure of the sugar industry around Keaau, former plantation acreages are now in the process of converting to weedy wastelots. Although Saccharum officinarum (i.e. sugar cane) remains the dominant species in abandoned tracts, Cecropia obtusifolia and Melochia umbellata are invading. From present indications, the untended fields should eventually develop into an alien forest dominated by Psidium cattleianum--if the land is allowed to continue on a free running sequence.

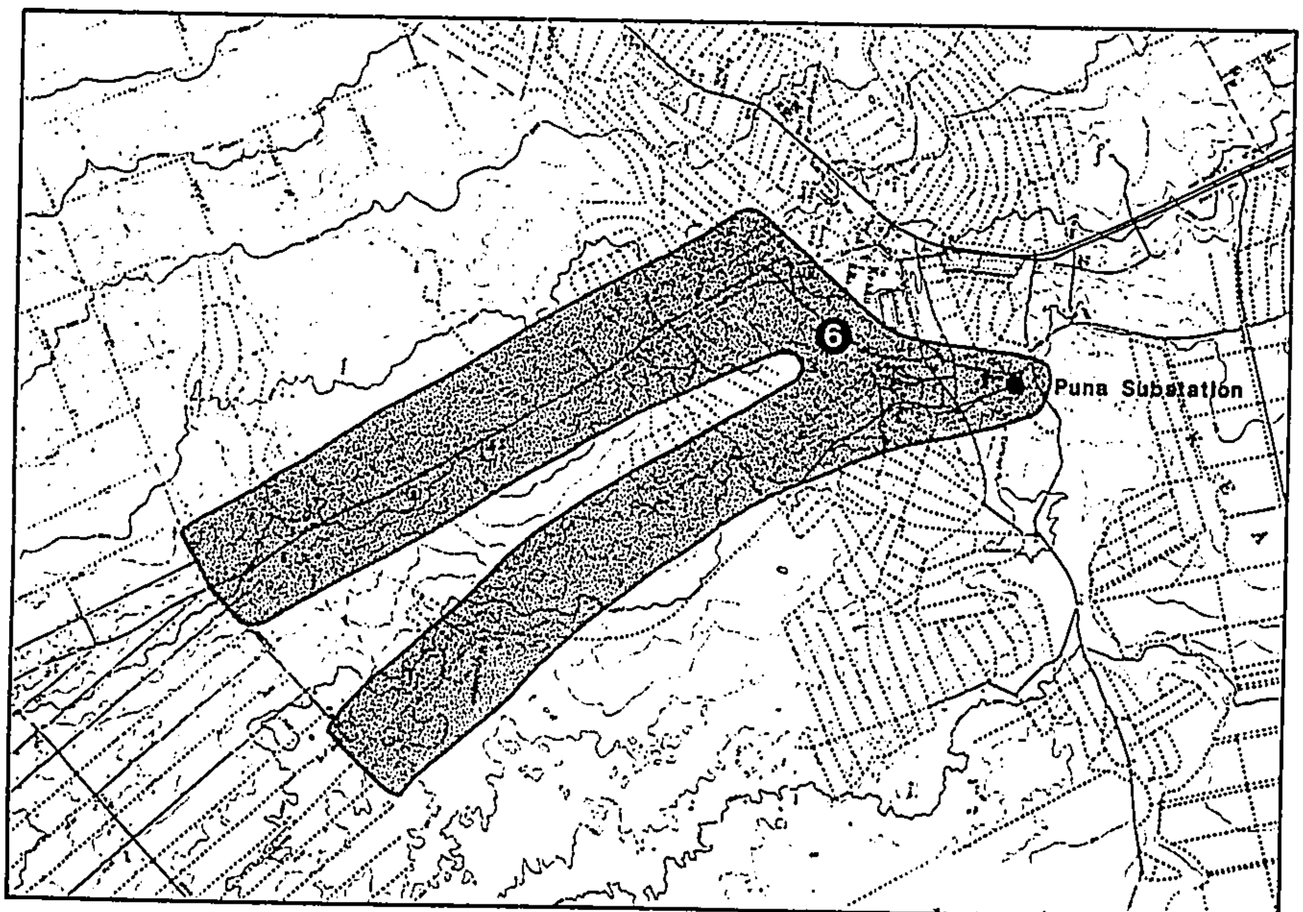
A large number of sites in zone 6 are presently invested in small scale cultivation of alternative crops. Many agricultural plant pests and incidental ephemerals are associated with the farm plots. No attempt was made to compile a botanical inventory of the occurrences since they represent disturbance formations irrelevant to the proposed project.

Near Waipahoehoe, a second growth forest of Trema orientalis and Cecropia obtusifolia is distributed in discontinuous fashion among agricultural clearings. Further to the southeast this vegetation gives way to an Andropogon virginicum-Arundina bambusifolia rangeland. Pluchea symphytifolia, Psidium guajava, Desmodium cajanifolium, Clusia rosea, Mangifera indica, Cordyline terminalis, and Melinis minutiflora are conspicuous weeds in the rangeland community.

As a general pattern, deep-soil habitats in zone 6 are associated with the kind of weedy plant assemblages to be expected from past or present agricultural use. Patches of native forest are present only over terrain which has been renewed by relatively recent volcanic activity. In the latter situation, an open Metrosideros-Dicranopteris community develops as a successional pioneer on the unweathered lava. Examples of the pioneer forest are present along stretches of route 130 but the communities are heavily infiltrated by aliens such as Andropogon, Arundina, and the serious pest Psidium cattleianum.



Zone 6. Top: Secondary forest near Waipahoehoe, abundantly vegetated by all manner of plant pests. Canopy of Trema orientalis and Cecropia obtusifolia. Bottom: Andropogon-Arundina rangeland to SE of Waipahoehoe.




Zone 6

SUMMATION

Our examination of the routes under consideration indicates that the botanical impact of the intended project would be very minimal. Many of the areas submitted for review are managed landscapes which have already been highly altered by man. Even in cases where native forest was encountered, the floristic quality was consistently poor, and the same species composition was repeatedly expressed.

An ecological comment of general application can be made of this study terrain:

As a vegetation matures, it normally progresses through a continuous series of changes known collectively as succession. In Puna environments, the program of change is initiated when an existing plant cover is erased by lava flows, the terrain subsequently recovering its vegetation through stages of incremental repopulation. Though of wide spatial extention, the ohia stands in the survey tract are consistently at an early stage in the successional process. Volcanism in the district is so active that the maturation sequence is constantly being truncated, and both the landscape and the plant communities are kept youthful by continual resetting to the starting point in the development cycle. Due to their incipient status, the plant communities contain only a small fraction of the species diversity which can be potentially exhibited by forests of their type. The biological value is diminished accordingly.

Rare and endangered taxa of <u>Metrosideros</u> forests are primarily associated with the mature, dense-shade environments produced by old stands. Youthful communities like the ones common over geologically active terrain are not likely to harbor plant rarities. It is physically impossible to inspect the contents of every patch of native forest with occurrence inside the project boundary. But just on general ecological principles, it is highly improbable that some outstanding botanical find could ever be retrieved from the kind of forests prevailing in the Puna district.

We recommend that botanical concerns be omitted from the evaluation process for final route selection. There is no compelling basis for altering or abandoning any of the intended tracks on the basis of vegetation considerations.

# APPENDIX D

# CULTURAL AND BIOLOGICAL RESOURCES SURVEY OF THE POHOIKI TO PUNA-SUBSTATION 69KV TRANSMISSION CORRIDOR KEA'AU TO KAPOHO, PUNA, HAWAI'I ISLAND

Final Report:

Ornithological Survey

15 April 1987

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## Introduction

A survey of birds was conducted under contract to DHM, Inc., during the period 18-23 December 1986 in the proposed 69KV transmission corridor between Pohoiki and Puna-Substation in the Puna District, Hawai'i Island. The study area consists of corridors of land roughly 26 miles in length surrounding the proposed transmission alignments (see Fig. 1). The primary goal of the study was to document the presence of avian species that might be affected by the construction and continued presence of the power line. In particular, I attempted to document species that are currently threatened, endangered or are in some other way of concern (e.g. non-endangered native forest birds). The elevation of the study area (< 300 m), and the lack of a significant amount of wetland habitat made it unlikely that such species would be found, and this was largely confirmed. I report below my methods of surveying the study area, the results tabulated for various sections of the study area, and a discussion of the potential impact the power line might have on avian species in general, and on threatened or endangered ones in particular.

## Study Site and Habitats

The study area was located between the Puna Substation and the geothermal plant located at Pohoiki (see Fig. 1).

Several potential routes were specified, and coverage of the study area included all of these. The corridors were divided into 23 subsections and six major sectors (see Fig. 1 and Tables 1 and 2). The sectors were combined from the subsections as follows: Puna West: A, G, E, F; Puna East: B, C, D, E, F; Old RR: H, R; Southeast: Q, T, I, O, J, N; 130 East: L, M1, M2, PL; 130 West: L, PR, K1, K2, S, N. As can be seen, some subsections are found in more than one sector. This is primarily because of overlap of separate "corridors" at the ends of the transmission line (i.e., Puna Substation and Pohoiki plant; see Figure 1). Bird species numbers were summarized for each subsection and then for each sector. The six sectors can be variously combined to provide summary data for each of the three most likely transmission line corridors.

Habitats were varied in the study area, and included sugarcane fields (mostly in the Puna east and west sectors; Fig. 1); 'ohia forest (mostly in the "southeast" and "Old RR" sectors); mixed 'ohia and introduced tree forests and savannas, and residential areas (mostly in the "130 West" sector). Many of the 'ohia trees were in bloom during the survey period, so nectar resources were available for native honeycreepers, if they were present in the area. The underlying substrate was fairly rough and rocky, and in some areas a thick understory of grass and thorny shrubs limited



our access. (See the report from the B. P. Bishop Museum's botanical survey for a more detailed description of the vegetation types available for birds.)

## Methods

All fieldwork was conducted during the period 18-23 December 1986. Surveys were generally conducted from about sunrise (about 6:30 a.m.) to about 3:00 or 4:00 p.m. Our methodology involved making counts at least every 0.2 miles along each transect. Counts were conducted at stations from which most or all of the corridor area was visible for at least 0.1 miles. This was also a distance within which songs of most avian species could be heard. Therefore, coverage of the corridor was fairly close to 100%. The numbers of each species of bird seen or heard during a five-minute period was recorded into field notebooks at each station. Habitat types at each station were also noted. The number of birds for each sector was summed from the stations within each sector. I and my field assistant attempted to be as realistic as possible in estimating the number of birds seen or heard. We spent the first day of the study (18 December) visiting the entire study area, both to determine the best plan for conducting the survey and to familiarize or refamiliarize ourselves with the types of birds present in the study area and their songs.

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## Results and Discussion

Raw summaries of the survey results are presented in Table 1. A total of 1254 individuals of 16 species of birds were counted during the survey. Five species were found in no more than one of the 23 subsections, and an additional four species were found in fewer than half of the 23 subsections (Table 1). Table 2 and all subsequent analyses summarize the results by sector for each of the seven species found in more than 50% of the subsections (Common Myna, Acridotheres tristis; Northern Cardinal, Cardinalis cardinalis; Japanese White-eye, Zosterops japonicus; Nutmeg Mannikin, Lonchura punctulata; House Finch, Carpodacus mexicanus; and the two dove species [Spotted Dove, Streptopelia chinensis; and Zebra Dove Geopelia striata] combined into a single "doves" category). There is also a separate category with all of the other species combined. All seven of the species found in more than 50% of the subsections ("common species") are exotics.

The relative abundance of the common species in each major sector is plotted in Figure 2. As can be seen, Nutmeg Mannikins and Common Mynas were most common in the agriculturalized Puna East and Puna West sectors, whereas Northern Cardinals and House Finches were more abundant in the wooded habitats of all sectors other than Puna East and Puna West. Japanese White-eyes and the doves were more



evenly distributed among all of the sectors. Similar trends can also be identified in Figure 3. The "others" that are so common in the Puna sectors are primarily ducks (see below).

Of the remaining nine "other" species, three are introduced exotic species (Eurasian Skylark, Alauda arvensis; Melodious Laughing-Thrush, Garrulax canorus; and House Sparrow, Passer domesticus), three are migrants (Northern Pintail, Anas acuta; Lesser Scaup, Aythya affinis; and Golden Plover, Pluvialis dominica) and three are natives of special concern (the ʻIo or Hawaiian Hawk, Buteo solitarius; the Hawaiian Black-necked Stilt or Aeʻo, Himantopus mexicanus knudseni; and the ʻElepaio, Chasiempsis sandwichensis). The ʻIo and the Stilt are both endangered species (Pyle 1983); the ʻElepaio is not endangered but is not a common bird at these elevations on Hawaii (Pratt 1980).

The two duck species and the stilts occurred only in some small ponds at the edge of the corridor in subsection F (Fig. 1). These ponds were checked a total of four times during the survey to determine how often they were being used by the waterfowl and stilts. The stilts were seen on only one occasion, the ducks on three of the four visits. The ponds and their inhabitants are not likely to be affected greatly by construction of the power line because they are on the very edge of the corridor (> 200 m from the probable position of the power line). However, if this route is chosen, care should be taken to disturb these habitats as little as possible.

The single 'Io was seen soaring high above the abandoned railway track in subsection J. This endangered species feeds primarily on rodents, insects and birds (Berger 1981, Griffin 1984). They hunt mostly from stationary perches but also while soaring (Griffin 1984). Thus, it is unlikely that the power line would hinder their activities, in fact, the poles or lines might provide appropriate hunting perches for the hawk (assuming precautions are taken to eliminate the risk of electrocution). In addition, the destruction of forested or second growth habitat associated with establishment of the power line would increase open areas, which the hawk is known to use to find food (Griffin 1984). All care should be taken during construction and/or maintenance of the line not to interfere with breeding attempts by the hawk. 'Io breed between March and September (Griffin 1984).

The 'Elepaio was the only other endemic form found during the survey, and is the only native passerine that could normally be expected at this low elevation on Hawaii (Scott et al. 1986). Although 'Elepaio are not listed as an endangered species by the U.S. Fish & Wildlife Service,





their numbers have appeared to decrease in recent years (Scott et al. 1986). The birds were sighted in subsection D (Figure 1, Table 1). Other native passerines were carefully listened and searched for (e.g. Apapane, _Himatione sanguinea_ and Common Amakihi, _Hemignathus virens_), but none were noted. It is possible that during other times of the year (perhaps when more 'ohia are in bloom) these species do come down to lower elevations. A literature search through _The 'Elepaio_ and other sources failed to find any evidence that these honeycreepers do or have in recent times occupied this specific area.

## Conclusions and Recommendations

The 'Elepaio, the 'Io, and the Hawaiian Stilt were all found along the same corridor (sectors Puna East, Old RR and Southeast combined). I therefore suggest that developing one of the two alternate routes (i.e., the two along the highway) would be best to minimize impact to these native birds. Only non-native (and mostly pest) species were found along the alternate corridors during the surveys (Table 1, Figure 1). I believe that our coverage of the sites was adequate to document whether native species of birds occur along these corridors. Such native birds may occasionally use these areas, but it is not likely that they are dependent upon them. I also do not feel that populations of the introduced, pest species would be extraordinarily affected by the construction and maintenance of the power line.



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Table 2. Total of species grouped by sector.

| Species: | Puna West | Puna East | Old RR | South -East | 130 East | 130 West |
|---|---|---|---|---|---|---|
| Common Myna | 70 | 73 | 11 | 39 | 26 | 39 |
| Northern Cardinal | 15 | 12 | 17 | 13 | 41 | 44 |
| Japanese White-eye | 68 | 61 | 36 | 73 | 77 | 98 |
| Nutmeg Mannikin | 117 | 149 | 6 | 0 | 18 | 18 |
| House Finch | 8 | 9 | 48 | 66 | 64 | 81 |
| "Doves" | 8 | 15 | 17 | 15 | 23 | 15 |
| Others | 46 | 49 | 1 | 5 | 10 | 5 |
| Total | 332 | 368 | 136 | 211 | 259 | 300 |
| % | (26.5) | (29.3) | (10.9) | (16.8) | (20.7) | (23.9) |
| Total # Species | 14 | 14 | 8 | 9 | 9 | 8 |

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Table 1. Total number birds by area and species

| SPECIES | A | B | C | D | E | F | G | H | I | J | K1 | K2 | L | M1 | M2 | N | O | PL | PR | Q | R | S | T | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pintail | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| Lesser Scaup | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Hawaiian Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Golden Plover | 0 | 1 | 8 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 17 |
| Hawaiian Stilt | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Spotted Dove | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 6 | 0 | 3 | 4 | 0 | 2 | 1 | 5 | 2 | 3 | 2 | 6 | 1 | 7 | 2 | 0 | 48 |
| Zebra Dove | 4 | 5 | 4 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 11 | 1 | 2 | 0 | 2 | 2 | 3 | 0 | 1 | 41 |
| Eurasian Skylark | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Common Myna | 13 | 4 | 24 | 0 | 37 | 8 | 12 | 3 | 5 | 4 | 2 | 2 | 10 | 5 | 5 | 19 | 10 | 6 | 10 | 1 | 8 | 0 | 0 | 188 |
| Melodius Laughing-thr | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 |
| House Sparrow | 4 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 6 | 3 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 22 |
| Northern Cardinal | 9 | 8 | 1 | 1 | 2 | 0 | 4 | 8 | 7 | 0 | 4 | 1 | 20 | 4 | 6 | 0 | 2 | 11 | 17 | 2 | 9 | 8 | 2 | 126 |
| Japanese White-eye | 35 | 17 | 8 | 22 | 10 | 4 | 19 | 25 | 5 | 22 | 22 | 13 | 24 | 20 | 15 | 21 | 7 | 18 | 25 | 9 | 11 | 0 | 9 | 361 |
| Nutmeg Mannikin | 6 | 24 | 5 | 11 | 89 | 20 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 2 | 0 | 0 | 0 | 0 | 183 |
| House Finch | 6 | 4 | 0 | 5 | 0 | 0 | 2 | 37 | 0 | 12 | 7 | 2 | 5 | 17 | 26 | 40 | 5 | 16 | 12 | 3 | 11 | 11 | 6 | 227 |
| Elepaio | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| TOTAL | 79 | 65 | 52 | 41 | 146 | 64 | 43 | 86 | 17 | 43 | 39 | 18 | 65 | 47 | 76 | 86 | 29 | 71 | 80 | 18 | 50 | 21 | 18 | 1254 |
| PERCENT OF TOTAL | 6.3 | 5.2 | 4.1 | 3.3 | 11.6 | 5.1 | 3.4 | 6.9 | 1.4 | 3.4 | 3.1 | 1.4 | 5.2 | 3.7 | 6.1 | 6.9 | 2.3 | 5.7 | 6.4 | 1.4 | 4.0 | 1.7 | 1.4 | |

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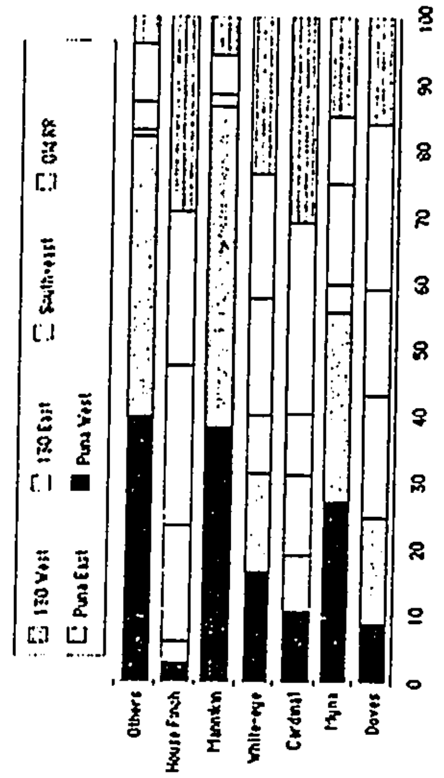


FIG. 2. Species groups by area.

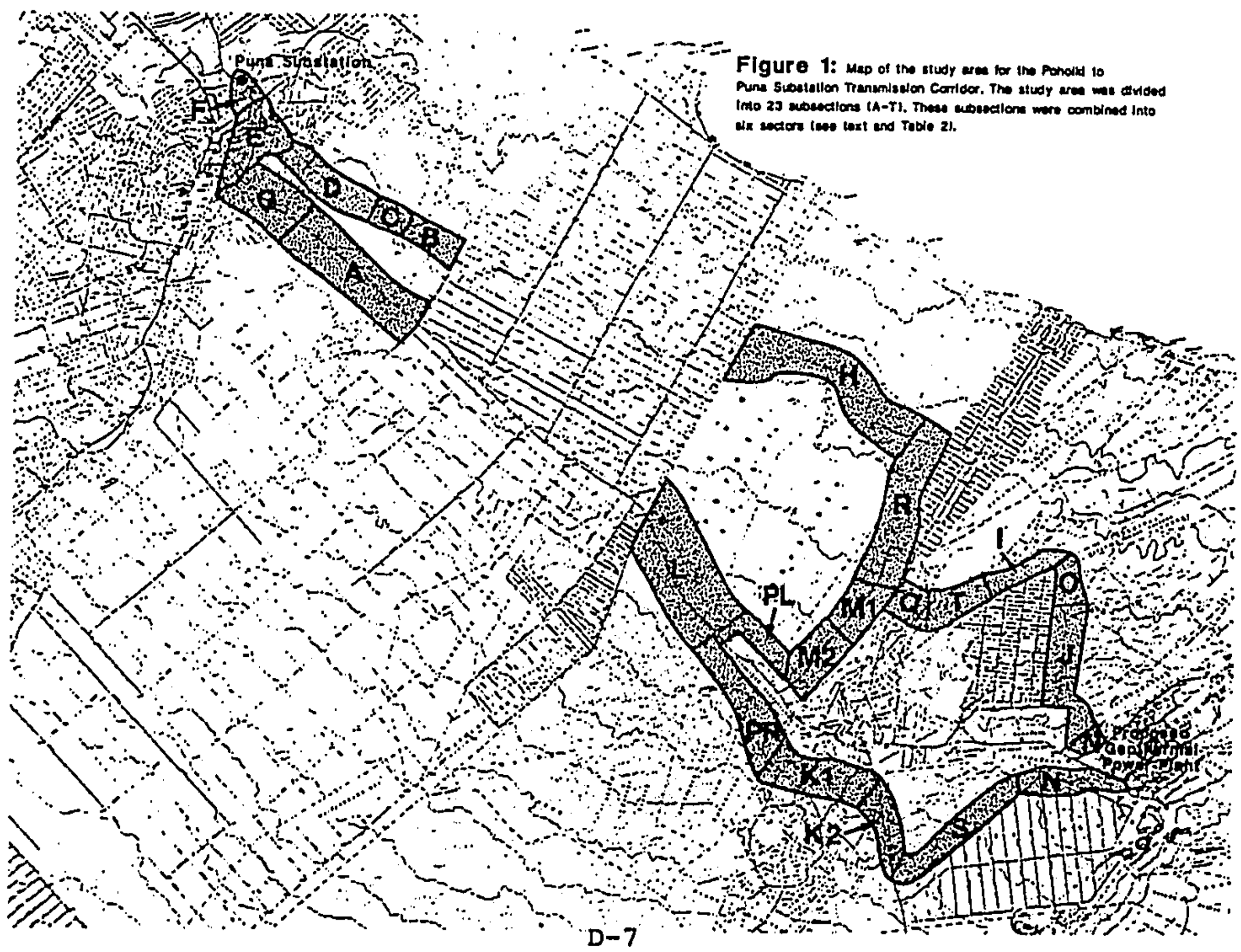


**Figure 1:** Map of the study area for the Pohoiki to Puna Substation Transmission Corridor. The study area was divided into 23 subsections (A-T). These subsections were combined into six sectors (see text and Table 2).

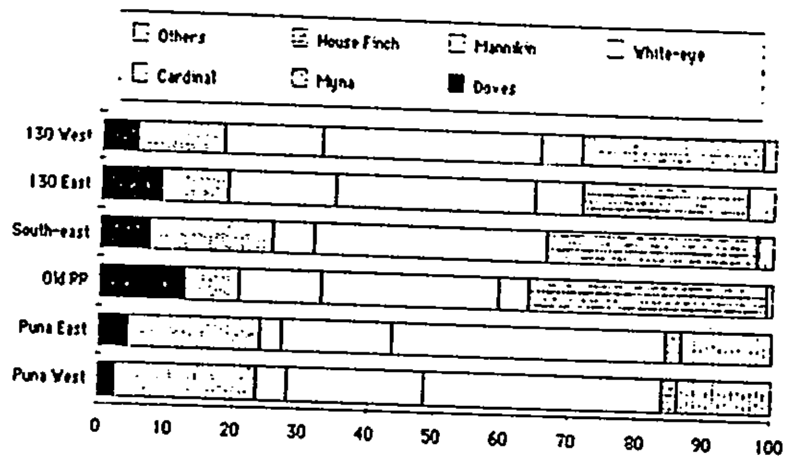


Fig. 3. Areas by species group.

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# APPENDIX E

Final Report of the Pohoiki to Puna Powerline EIS:
Terrestrial arthropods

by G.H. Nishida and W.C. Gagné

The Department of Entomology of Bishop Museum conducted entomological field surveys of the Pohoiki to Puna proposed powerline alignments, on 5-11 February, based on maps provided by DHM, Inc. Eighteen promising locations were sampled during this period. Sampling methods included sweeping, beating, and hand collecting during both day and night. During the evenings, a mercury vapor lamp was used to attract insects. Lists of the insects and other arthropods collected from the areas outlined by DHM and identified are found in Appendix 1.

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Three areas of important concentrations of native species were found during the survey, one of critical importance. These areas are outlined in Appendix 2. A critical fourth area, though not included in the survey, will be crossed by the powerline using either of the alternate routes.

The following narrative will begin from the Puna Substation and work south and east toward the geothermal plant following the two nearly parallel alternative routes marked on the DHM maps. One route followed the old railroad track bed. The other paralleled the Keeau to Pahoa Road. Divergences to these basic routes occurred at and beyond Pahoa.



The survey areas just to the south and southeast of the Puna Substation contained introduced species or common species of native insects. The railroad bed route was surrounded by mostly sugar cane and weeds and populated by non-native insect species. The road route was mostly late flow lava vegetated with o'hia trees and uluhe fern and populated by non-native or common native insect species.

The survey map provided by DHM shows a coverage gap between Shower Drive to slightly beyond Makuu Drive. Accordingly, this area was not formally surveyed. However, the area was driven through and visually surveyed. Superficially, there appears to be not much entomologically that would be affected by a powerline across this subdivision. However, we are concerned, as this "non-survey" area crosses above Kazumura Cave, the restricted habitat for a number of remarkable cave-adapted organisms (Gagné and Howarth 1975, Gurney and Rentz 1978, Bellinger and Christiansen 1974, Gertsch 1973). Kazumura Cave has been previously studied and much Hawaiian lava tube research has taken place there (Howarth 1973).

South of Makuu Road, the Keeau to Pahoa Road route diverges just before Pahoa town. One fork skirts Pahoa to the south. The other fork makes a sharp bend at Kahakai Boulevard and joins with the abandoned railroad route, which has made a similar bend (but in the opposite direction). At this location, the railroad route crosses an area of scattered o'hia that appears to have been previously burned. Nothing of entomological significance was found along the surface of this route. The route following the road was, again, populated by non-native or relatively common native species.

Perpendicular to the outlined survey areas and paralleling Kahakai Boulevard is the most significant habitat located within the survey parameters (see Appendix 2). This is the general location of Pahoa Cave. Collected and observed in this cave were unique cave-adapted creatures. Many have adapted so well to the environment as to have become eyeless, using other means to communicate with each other. These unique cave animals, found only in this cave, included cixiid bugs, crickets, crane flies, moths, millipedes, sow bugs, silverfish and centipedes. A major scientific study of the cixiid bugs from Pahoa Cave is currently underway, with important discoveries on the behavior of these bugs (Hoch and Howarth, pers. communication). Pahoa Cave crosses underneath both alternative routes including both forks of the alternate route on either sides of the Keeau to Pahoa Road. Concern about this extremely important biological resource is not focused only on possible physical damage to the cave during construction or possible exposure of the cave to increased access and thus pressure on the fragile habitat of these animals, but also extends to general maintenance of powerlines. A common practice of powerline maintenance is to use herbicides to control the vegetation beneath the lines. This practice of spraying would be extremely dangerous to the cave animals, as the herbicide would kill the host plants - the major energy sources





for the cave animals. The herbicide is also likely to percolate down into the caves, directly affecting the animals.

Continuing first with the southernmost fork of the roadway alternative, the proposed route skirts Pahoa to the south and west. The fauna around the solid waste disposal site is very similar to the previously mentioned roadway faunas, with nothing unique. Traveling south and east, the area is mostly sugar cane and weeds without any entomological significance. However, a small kipuka of native forest does appear at the edge of this fork, on the map appearing beside and below the last "A" in Waiakahiula (see Appendix 2 for location). This area produced a significant number of native species, including several that are probably new and undescribed. This kipuka is relatively small and located in the midst of sugar cane. It could be easily skirted by the proposed powerline if the alignment was placed directly in the middle of the alternative route or moved somewhat closer to Pahoa.

Further along, this alternative goes south along State Route 130 for a short section, then proceeds east paralleling Kahukai Street in the Keahialaka Subdivision before it takes a turn towards the geothermal facility. Some native insects were collected along Kahakai Street, but most species were of general distribution.

Returning to the railway route, after the two forks combine along Kahakai Boulevard, we find that the route parallels the northern edge of Puna Subdivision, makes a sharp right-angle turn, and parallels Seaview Road along an unnamed dirt road. The route then skirts Nanawale Forest Reserve and Lava Tree Molds State Park before heading towards the geothermal plant. Another area of significance was discovered along the east side of the dirt road paralleling Seaview Road (see Appendix 2). This site is approximately outlined by the dirt road to the east, Seaview Road to the west, Plumeria Road extended to the north, and Hawaii Road extended to the south. The dominant native tree, lama (Diospyros hawaiiensis), made up the canopy of a comparatively diverse community of native plants.

In many of the other sites, Anoplolepis longiceps, the long-legged ant, was found in abundance. This introduced alien species apparently heavily impacts resident insect populations, thus areas foraged by this ant yield significantly fewer native species than might be expected. This ant was also found in abundance in the Seaview Road site, and indeed, day collecting was not as productive as might have been expected. However, collecting at night using a mercury vapor lamp attracted many natives including 14 species of native moths (Hyposmocoma) alone, despite the occupation by the long-legged ant. This area is one of the lowest elevation patches of remaining lowland native forest with surviving native species.

Based on Appendix 1, the species totals are as follows:

| | |
|---|---|
| Endemic species | 44 |
| Indigenous species | 3 |
| Exotic or Alien species | 70 |
| Species new to Big Island | 12 |



The total for the endemic and indigenous species as compared to the alien species is significant especially in light of the occupation by the long-legged ant. The other surprising total was the large number of species previously unknown from the Big Island.

In summary, the areas of entomological significance, in probable order of significance are: 1) Pahoa Cave, both upper and lower caves, possibly extending to the ocean. 2) The kipuka area south of Pahoa near the last "A" in Waiakahiula. 3) The Seaview Road site. The latter two sites provided a living laboratory insight as to the impact of long-legged ants on native arthropods in that one kipuka had ants and the other didn't. The native arthropod composition of these two sites were dramatically different. This provided the first comparison of the impact of this recently introduced ant on the island of Hawaii. In addition, the area crossed by Kazumura Cave not included in this survey is extremely significant.

In general, the alignments could probably be adjusted to skirt or skip the significant sites. Pahoa Cave and Kazumura Cave are extremely important living biological laboratories and great care should be extended when passing over these caves. Our recommendation is that someone with knowledge of the caves be added as a consultant when the final alignment is decided, to provide input as to the best possible way to cross the caves with the least possible perturbation. We would suggest Dr. Fred Stone of the Department of Geology at the University of Hawaii at Hilo, and one knowledgeable about Hawaiian cave biotas, as a possible consultant.



Acknowledgements:

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## Appendix 1.

### INSECTS COLLECTED ON POWERLINE SURVEY
February 1987

E = endemic
I = indigenous
* = species previously not recorded from Hawai'i island

| | | |
|---|---|---|
| | **ORDER DICTYOPTERA** | |
| | Family Ectobiidae | |
| | *Lupparia notulata* (Stal) | Stops 2, 3, 5, 8 |
| | Family Blattellidae | |
| | *Blattella lituricollis* Walker | Stop 8 |
| | Family Blattidae | |
| | *Melanozosteria soror* (Brunner) | Stops 4, 8 |
| | *Periplaneta australasiae* (Fabricius) | Stop 8 |
| | Family Panchloridae | |
| | *Pycnoscelis surinamensis* (L.) | Stop 8 |
| | Family Mantidae | |
| | *Orthodera burmeisteri* Wood-Mason | below sugar mill |
| | **ORDER ORTHOPTERA** | |
| | Family Tettigoniidae | |
| | *Phaneroptera furcifera* (Stal) | Stops 4, 8 |
| | *Conocephalus saltator* (Saussure) | Stops 4, 5 |
| | Family Gryllidae | |
| * | *Myrmecophila quadrispina* Perkins | Stop 5 |
| | *Acheta oceanicum* (Le Guillou) | Stop 8 |
| E | *Paratrigonidium* sp. | Stop 9 |
| E | *Caconemobius* sp. | Pahoa Cave |

## ORDER DERMAPTERA

### Family Chelisochidae

Chelisoches morio (Fabricius) — Stops 2, 5, 9
Sparattina nigrorufa (Burr) — Stop 5

## ORDER HETEROPTERA

### Family Anthocoridae

Orius sp. — Stop 5

### Family Miridae

E Hyalopeplus pellucidus (Stal.) — Stop 3
E Orthotylus n. sp. near kanakanus Kirkaldy — Stop 7
E Orthotylus n. sp. near perkinsi — Stop 9

### Family Reduviidae

Oncocephalus pacificus (Kirkaldy) — Stops 5, 8

## ORDER HOMOPTERA

### Family Cicadellidae

E Balclutha hospes (Kirkaldy) — Stops 5, 8, 10, 11
E Nesophrosyne (Nesoreias) oceanides Kirkaldy — Stop 9
E Nesophrosyne (N.) silvicola Kirkaldy — Stop 9

### Family Cixiidae

E Iolania perkinsi Kirkaldy — Stops 3, 5

### Family Delphacidae

E Nesothoe sp. near maculata (Muir) — Stop 1
Sogatella kolophon (Kirkaldy) — Stops 5, 8, 10

### Family Flatidae

Melormenis antillarum Kirkaldy — Stop 5
Siphanta acuta (Walker) — Stops 1, 3, 4, 8, 9

### Family Membracidae

Vanduzea segmentata (Fowler) — Stops 3, 4, 5, 11

### Family Psyllidae

E Kuwayama minuta Crawford — Stop 8
E Kuwayama nigricapitata Crawford — Stop 8
E Trioza sp. cf. hawaiiensis Crawford — Stop 8
E Trioza sp. cf. lanaiensis Crawford — Stop 8
E Trioza ohiacola Crawford — Stop 8
E Trioza sp. nr. pullata Crawford — Stops 4, 5, 8

## ORDER HYMENOPTERA

### Family Formicidae

Anoplolepis longipes (Jerdon) — Stops 2, 4, 5, 10
Monomorium sp. prob. destructor (Jerdon) — Stop 8

## ORDER LEPIDOPTERA

### Family Carposinidae

E Carposina sp. — Stop 5

### Family Gelechiidae

Anatrachyntis incertulella (Walker) — Stop 5
Autosticha pelodes (Meyrick) — Stop 5
E Hyposmocoma (Euperissus) sp. cf. hirsuta (Walsingham) — Stop 5
E Hyposmocoma sp. 1 — Stop 5
E Hyposmocoma sp. 2 — Stop 5
E Hyposmocoma sp. 3 — Stop 5
E Hyposmocoma sp. 4 — Stop 5
E Hyposmocoma sp. 5 — Stop 5
E Hyposmocoma sp. 6 — Stop 5
E Hyposmocoma sp. 7 — Stop 5
E Hyposmocoma sp. 8 — Stop 5
E Hyposmocoma sp. 9 — Stop 5
E Hyposmocoma sp. 10 — Stop 5
E Hyposmocoma sp. 11 — Stop 5
E Hyposmocoma sp. 12 — Stop 5
E Hyposmocoma sp. 13 — Stop 5
Stoeberhinus testaceus — Stop 5
?Stoeberhinus sp. — Stop 5

### Family Gracillaridae

E Philodoria (P.) sp. — Stop 5

### Family Lycaenidae

Strymon bazochii Godart — Stop 4

| | | |
|---|---|---|
| | **Family Noctuidae** | |
| | Autographa chalcites (Esper) | Stop 5 |
| | Bocana manifestalis Walker | Stop 5 |
| | Eublemma anachoresis (Wallengren) | Stop 5 |
| | Hypocala deflorata (Fabricius) | Stop 5 |
| | Leucocosmia nonagrica (Walker) | Stop 5 |
| | Ophiusa indiscriminata (Hampson) | Stop 5 |
| E | Schrankia n. sp. 1 | Stop 5 |
| E | Schrankia prob. n. sp. | Stop 6 |
| | Simplicia lantokiensis (Prout) | Stop 5 |
| | Spodoptera exempta (Walker) | Stop 5 |
| | **Family Nymphalidae** | |
| E | Vanessa tamehameha (Escholtz) | Stop 5, 9 |
| | **Family Pyralidae** | |
| | Bocchoris fatualis Munroe | Stop 5 |
| E | Eudonia sp. #1 | Stop 5 |
| E | Eudonia sp. #2 | Stop 5 |
| E | Eudonia sp. #3 | Stop 5 |
| E | Hedylepta localis (Butler) | Stop 5 |
| | Paraponyx fluctuosalis (Zeller) | Stop 5 |
| E | Udea sp. | Stop 5 |
| | **Family Sphingidae** | |
| | Macroglossum pyrrhostictum (Butler) | Stop 5 |
| | **Family Tineidae** | |
| | Decadarchis simulans (Butler) | Stop 5 |
| | **Family Yponomeutidae** | |
| | Plutella sp. prob. xylostella (Linn.) | Stop 5 |
| | **ORDER NEUROPTERA** | |
| | **Family Chrysopidae** | |
| | Chrysopa sp. | Stop 9 |
| | **ORDER ODONATA** | |
| | **Family Libellulidae** | |
| I | Pantala flavescens (Fabricius) | Stop 5 |

| | | |
|---|---|---|
| | **ORDER TRICHOPTERA** | |
| | **Family Hydropsychidae** | |
| | Cheumatopsyche analis (Banks) | Stop 5 |
| | **ORDER COLEOPTERA** | |
| | **Family Anthribidae** | |
| | Araecerus sp. | Stop 8 |
| | **Family Carabidae** | |
| *? | Perigona nigriceps Dejean | Stop 8 |
| | **Family Cerylonidae** | |
| * | unidentified | Stop 5 |
| | **Family Coccinellidae** | |
| | Scymnus bilucernarius Mulsant | Stop 1 |
| | **Family Colydiidae** | |
| *? | Penthelispa rufipennis Montrouzier | Stop 5 |
| | **Family Cucujidae** | |
| I*? | Moanus crenatus Sharp | Stop 3 |
| I*? | Psammoecus pallidipennis (Blackburn) | Stop 8 |
| | **Family Elateridae** | |
| E*? | Anchastus swezeyi VanZwaluwenburg | Stops 2, 4 |
| | Conoderus exsul (Sharp) | Stop 8 |
| | **Family Lathridiidae** | |
| *? | Corticaria sp. | Stop 8 |
| | **Family Nitidulidae** | |
| | Haptoncus ocularis (Fairmaire) | Stop 8 |
| | **Family Staphylinidae** | |
| *? | Carpelimus sp. | Stop 8 |

ORDER DIPTERA

Family Stratiomyidae

Hermetia illucens (L.)

Family Syrphidae

Ornidia obesa (Fabricius)
Mesograpta marginata (Say)
Ischiodon grandicornis (Macquart)
Syritta orientalis (Macquart)

Family Dolichopodidae

E Chrysosoma fraternum Van Duzee
E Chrysotus pallidipalpis Van Duzee

Family Drosophilidae

Genus #1
Genus #2

Family Lauxaniidae

Homoneura spp.

Family Chloropidae

Rhodesiella scutellata (de Meijere)
Desmometopa sp.
* Monochatoscinella sp.

Family Sciaridae

unidentified

Family Chironomidae

unidentified

Family Tipulidae

Limonia (Libnotes) perkinsi Grimshaw

Family Sphaeroceridae

Limosininae, ?Genus 1
Leptocera abdominiseta Duda
Pterogramma brevivenosa (Tenorio)

Family Psycodidae

Psychoda alternata Say
Telmatoscopus albipunctatus (Williston)

Family Tephritidae

Dacus (Bactrocera) dorsalis Hendel
Acinia picturata (Snow)
Procecidochares alani Steyskal

Family Muscidae

Musca domestica (L.)

Family Culicidae

Aedes prob. albopictus (Skuse)

Family Sarcophagidae

Boettcherisca peregrina (Robineau-Desvoidy)

Family Cecidomyiidae

unidentified

Family Periscelididae

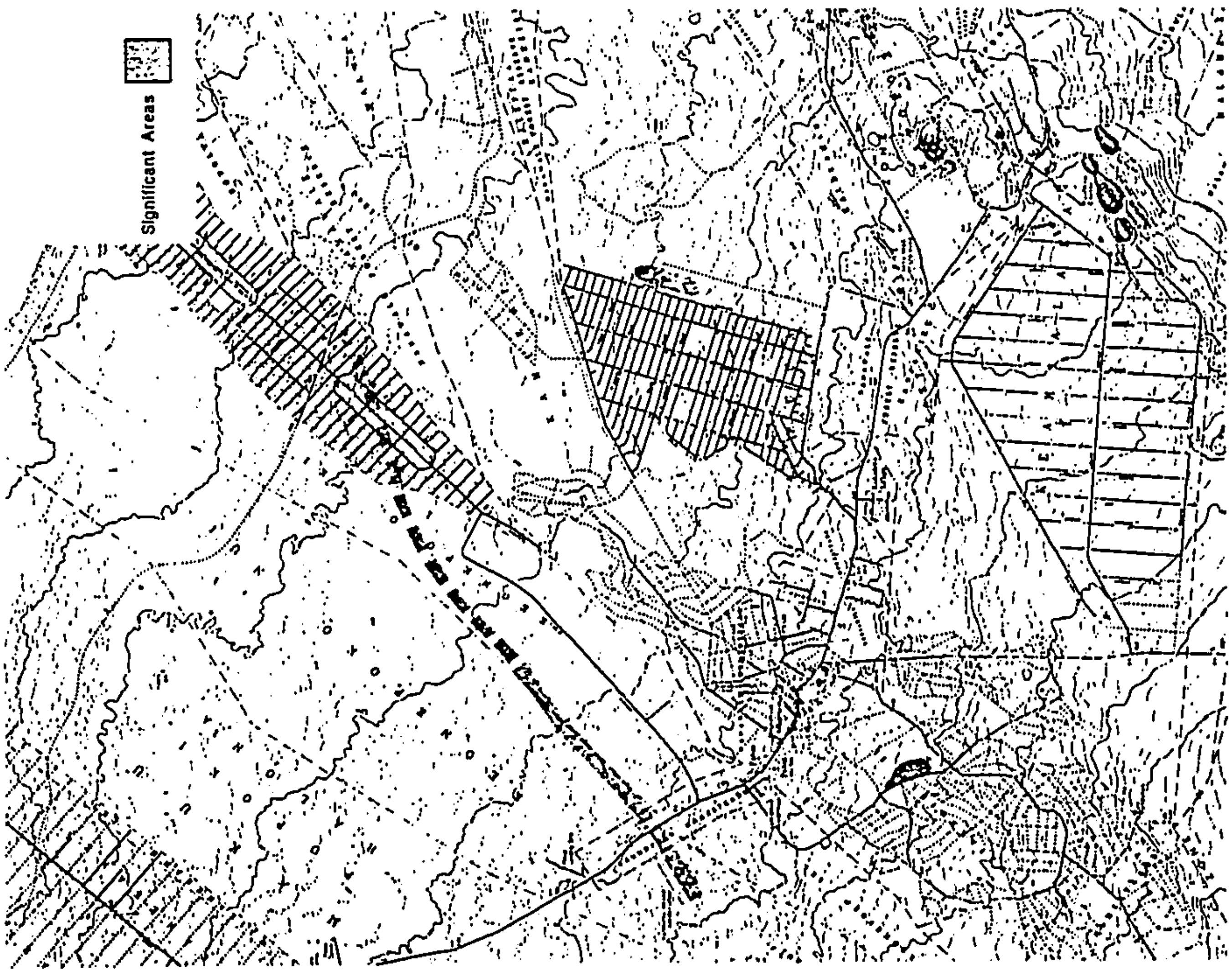
* Stenomicra (Podocera) distinctipennis Collin

Family Scatopsidae

* genus near Rhegmoclemina

Family Sphaeroceridae

unidentified




Appendix 2.

# APPENDIX F

FINAL REPORT

GEOLOGIC CONSULTATION

PROPOSED PUNA-POHOIKI TRANSMISSION LINE

PUNA, HAWAII, HAWAII

FOR THE HAWAII ELECTRIC LIGHT COMPANY

May 11, 1987


## SUMMARY

Geologic conditions would not appear to be a significant factor in the choice among proposed transmission line alignments. Very similar geology is found along the proposed corridors and generally the same soil and geologic conditions would be encountered along each alignment.

Significant geologic hazards appears to be lava tubes and cavities, and lava flows. Lava tubes and cavities are present along all of the candidate alignment corridors, and any immediately adjacent to transmission line foundations would need to be located and repaired.

The potential for lava flows overrunning the transmission line appears to be equal for all corridors. Many lava flows from the Kilauea summit have crossed the alignment corridors within the last 1500 years, the last at least 350 years ago. The last lava flow from Mauna Loa to enter any of the corridors occurred over 1500 years ago. Kilauea's east rift zone has emitted most of the recent flows in the region, including an 1840 flow which crossed a section of a proposed corridor, and a 1955 flow which occurred near the Geothermal Plant terminus of the alignments.






## INTRODUCTION

This report summarizes our findings and recommendations regarding the potential corridors for the Puna-Pohoiki transmission lines, Puna, Hawaii, Hawaii. The general location of the corridors are indicated on the Map of Area, Plate 1. The specific corridors are shown on the Plot Plan, Plate 2. The corridor segments have been labeled as shown on the Plot Plan (A, B, C, D, & E) to facilitate discussion of these segments.

Dames & Moore was retained to provide geological consulting services for the corridors and alignments selection and to provide geologic input for the subsequent Environmental Impact Statement (EIS). Our scope of work was defined in our revised proposal dated October 22, 1986.

## OUR UNDERSTANDING OF THE PROPOSED PROJECT

DHM Inc. has been charged by HECO/HELCO to select two 69 kv alignments for transmitting 25 MW of electricity, to be generated by Thermal Power in the Pohoiki area, to the Puna substation.

For these two transmission lines, two quarter-mile wide corridors would be selected based upon environmental conditions, land use, and socioeconomic constraints. Geological conditions within these corridors would be one of the environmental conditions evaluated for corridor suitability.

The results of the selection team efforts would be published in a transmission line corridor selection report, and used in subsequent environmental studies.

## SCOPE OF WORK

The purpose of our geologic consultation is to provide geologic information for use in optimizing transmission corridor and right of way selection from the standpoint of geologic hazards, suitability and ease of construction. To accomplish this purpose the following tasks were performed.

1. Review of Project Description and Relevant Literature - We reviewed the description of the proposed project provided by DHM to familiarize ourselves with geological routing and design requirements and to identify key issues relevant to our subsequent services. We also reviewed regional geological information in our files.

2. Field Investigation of Selected Corridors - We conducted our field investigation of the selected corridors in two parts. The first part was a helicopter fly-over of the two corridors with the project team. The fly-over was recorded with a video camera to assist in later review of relevant features and to assist with subsequent field work.

   Following the fly-over, an on-the-ground field study of the two selected corridors was conducted. The field investigation included sampling of near surface soils for classification and limited test pit excavation to determine the depth of surface soils at selected locations.

Analysis and Report Preparation - We evaluated data collected in the field and obtained during the literature review. The analysis considered topography, geology, and natural hazards as well as the effect of surface





hydrology on erosion and construction techniques. Anticipated foundation conditions were also factored into our analysis. Our findings and recommendations are presented in this draft report. Following DHM review of our draft report, a final report will be prepared, incorporating your comments.

## SURFACE CONDITIONS

### TOPOGRAPHY AND MORPHOLOGY

The proposed alignment corridors are located on the lower east slopes of Kilauea and Mauna Loa volcanoes. The ground slopes downward towards the northeast across the corridors at an average gradient of 2 percent. The ground elevation across the corridors rises from +200 feet to +400 feet near the site of the Puna substation and from +340 feet to +920 feet near the site of the geothermal plant. The ground elevation rises from +200 feet to +610 feet over a distance of about 13.5 miles between the sites of the Puna substation and geothermal plant.

Access through the corridor region is provided through a network of mapped public and private, paved and non-paved roads through agricultural, residential, and forest reserve lands.

The topography within the corridors is controlled by the morphology of landforms created by basaltic lava flows. In general, lava flows throughout the region either exist at the surface or underlie shallow soil cover. Lava flows in this region originate from Hawaiian-type eruptions, which are characterized by very fluid lavas with flows usually less than 15 feet thick and capable of spreading great distances from their vents creating very gentle slopes. Some of the flows have advanced as sheets forming nearly flat surfaces sometimes extending hundreds of yards. Most of the flows, however, have advanced as uneven, separate flow units characteristic of flows that have traveled far from their vents. In general, as these flows continue to spread and cool, they undergo divergence often resulting in a distribution of thickened lobes piled upon one another or upon older flows creating an irregular, rugged landscape. Continued cooling and thickening eventually transforms the flow from pahoehoe to a'a. Landforms such as spatter cones, collapsed lava tubes, and fissures contribute to the irregular landscape. Other common landforms include tumuli, pressure ridges, and pressure plateaus, which are cracked, dome-shaped hillocks occasionally greater than 20 feet in height. The lava flows in this region have created a topography that, on a large scale measured over several square miles, consists of a very gentle slope rarely greater than 10 percent in average gradient and, on a smaller scale, consists of an irregular, undulating landscape with variations in topographic relief up to about 20 feet.

SOILS

Soil data gathered during this investigation are summarized on Plate 3, Soil Map. Test Pit logs are presented in the Appendix, as are laboratory test data. Test pit locations are mapped on Plate 2.

Most of the central portion of the corridor region has little or no soil cover above the lava flows with vegetation consisting of scattered ohia trees, moss, grass, and ferns. In areas of soil cover, the soil is typically less than 1.5 feet thick. Soil cover has removed the smaller irregularities from the lava flow landscape. Larger lava flow landforms exist either as hillocks and nobs covered by soil or as rock outcrops.

Areas with soil greater than 1.5 feet thick over the lava are generally limited to the two ends of the corrider alignments (See Soil Map, Plate 3). At the Puna end, Olaa silty clay loam, up to 25 inches thick, is predominant,





with limited areas of Hilo silty clay loam which is over 5 feet thick. There are limited areas of Olaa silty clay loam at the Pohoiki end of the alignments.

Thirteen test pits were excavated in soil areas along the alignments, to assist in checking mapped soil classification information. All encountered basalt rock within 1.5 feet of the ground surface, except for test pits 9 and 11, which were located within Hilo silty clay loam areas.

Organic soils overlying older lava bedrock and silty clay loams formed from volcanic ash are the two basic soil types found in the corridor region.

The organic soils are typically very rocky, less than 6 inches thick and support a natural vegetation consisting of ohia, dense growths of uluhe fern, guava, and grass. These lands are mainly used for woodland, pasture, and homesites.

The silty clay loams are often very stony and usually less than 1.5 feet thick. One type of loam occurring near Keaau, called the Hilo Series Silty Clay by the USDA Soil Conservation Service (SCS) can extend to depths greater than 5 feet. Lands consisting of loams support a natural vegetation of Hilo grass, California grass, guava, ohia, and tree fern. Loam areas are used for sugarcane, truck crops, and pasture.

Both the organic soils and silty clay loams have rapid permeability, slow runoff, and support vegetation with roots that, unless the soil is very deep, pass through to the bedrock. The chance of erosion in these soils is rated by the SCS as slight.

Laboratory testing (see Appendix) indicates that the soils are generally gravelly silty clays or organic soils. The organic soils are only suitable for possible use as topsoil. The gravelly silty clays are suitable for use in near surface backfill for transmission tower or pole foundations. Along most of the alignments, very little soil is available for construction purposes.

SURFACE DRAINAGE

Only two stream channels pass through the corridor region. Both streams are dry and both are part of the Waipahoehoe Stream. The channels enter the corridor region along an area of silty clay two miles south of Keaau and culminate, before leaving the corridor region, on the surface of a pahoehoe flow at about +180 feet. The absence of well-defined streams is a characteristic of areas of Hawaiian volcanic growth where the rate of successive flows is often high enough to cover previously eroded surfaces and where the rocks are so permeable that runoff is very slight.

## GEOLOGY

GENERAL GEOLOGIC CONDITIONS

The geology of the corridor region to within 1.5 miles of Keaau is defined by lavas of the Ka'u Volcanic Series of Mauna Loa and the corridor region south of this area is defined by lavas of the Puna Volcanic Series of Kilauea. In general, the type and thickness of the overlying soil cover and vegetation can be used to determine the relative ages of the lava flows in the region. The oldest lavas are covered by volcanic ash which is typically about 1.5 feet thick. Most of the ash areas have been cultivated for sugarcane. Younger lavas have organic clayey silt less than 1 foot in thickness and are covered by dense vegetation. The most recent lavas have no soil cover. The relatively high average rainfall of 150 inches per year in this region has made it possible for the growth of ohia, ferns, and grass on lavas that flowed as recently as the year 1840.



VOLCANIC HAZARDS

The three regions of volcanic activity that could send lava flows into the corridor region are Mauna Loa, the Kilauea summit area, and the east rift zone of Kilauea. Many lava flows from the Kilauea summit have crossed the alignment corridors within the last 1500 years (Holcomb, 1980). However, it has been at least 350 years since lavas from the Kilauea summit area entered the corridor region. The last lava flow from Mauna Loa to enter any of the corridors occurred over 1500 years ago.

A future lava flow entering the corridor region will most probably come from Kilauea's east rift zone, where most of the recent flows in the region have been emitted. The most recent flow entering the corridor region was the flow of 1840 which erupted along a two-mile long fissure within the corridor area running parallel to the rift zone and crosses portions of corridor segment A. In 1955, a lava flow occurred near the Geothermal Plant terminus of the alignments. The location of the 1840 and 1955 lava flows are indicated on the Soils Map, Plate 3.

SEISMIC HAZARD

Seismic activity in the region is primarily associated with the shifting of rocks near areas of volcanic activity as the movement of magma inflates and deflates the volcanic structures. Several strike-slip faults created by the movement of magma and running parallel to the east rift zone are located within the corridor region near the site of the geothermal plant. Earthquake epicenters in the region are concentrated along the east rift zone.

SLUMPS AND LANDSLIDES

The general absence of significant soil cover over almost the entire area indicates that slumps and landslides are not significant hazards. No slump or landslide areas were observed during our field reconnaissance.

LAVA TUBES

The general geology is conducive to the formation of lava tubes. Major lava tubes in the area were mapped by Holcomb (1980) based on vegetation which tends to cluster over tubes. The Geologic Map (Plate 4) indicates the major lava tube locations mapped by Holcomb. Other smaller tubes or cavities may be encountered during construction of the transmission lines and remedial work may be required to provide lateral support to transmission pole or tower foundations where such tubes or cavities are encountered.

SOIL EROSION

Due to the lack of soil cover, the soil characteristics, and the relatively gentle slopes, the SCS has rated the entire corridor area as having slight erosion potential.

DESIGN AND CONSTRUCTION CONSIDERATIONS

Construction along the selected alignment will consist of a series of transmission poles or towers with moment (laterally loaded) foundations. Most of the foundations will be embedded into basaltic rock, which has a high lateral load bearing capacity. The primary concern in these areas will be to seek out and repair any lava tubes or other cavities immediately adjacent to the embedded foundations. It may be necessary to conduct probing operations using air-track drill or jackhammer type probes to check for such cavities



immediately adjacent to foundations. There would be little or no suitable soil for backfill in these areas, and backfill soil to be placed over the concrete foundations may need to be imported.

In the few areas with significant soil cover (Hilo silty clay loam), the foundations would need to be designed for the lower lateral load bearing capacity of these soils.

Existing wooden utility poles within the proposed corridors appear to be performing well with some tilting evident in two areas. Some poles within the Hilo silty clay loam near Keaau are tilting, probably due to the lower lateral load bearing capacity of these soils. Several poles in the vicinity of Kahakai Blvd (where segment A splits into B and C) were tilted. This tilting corresponds to the tilting of trees in the near vicinity, indicating that wind loads in this vicinity are high.

Although seismic loads are probable throughout the alignment corridors, the lateral loads due to seismic conditions would be expected to be less than that due to wind loads, and wind loads will probably be the criteria used for design.

The high elevation and geologic conditions indicate that a groundwater table would not be encountered within foundation excavations.

## DISCUSSION AND RECOMMENDATIONS

### ALIGNMENT CHOICE

Geologic conditions would not appear to be a significant factor in the alignment choice. Very similar geology is found along the proposed corridors and generally the same soil and geologic conditions would be encountered along each alignment.

The only significant geologic hazards appears to be lava tubes and lava flows. Lava tubes are present along all of the candidate alignment corridors.

The potential for lava flows across the transmission alignment is present for all of the corridors. The most probable source of such lava flows would the East Rift Zone, which contains the initial sections of both segments A and D. A longer section of segment D is located within the East Rift Zone (approximately 15,000 feet) than for segment A (approximately 5,000 feet). However, segment A was intercepted by a lava flow from the East Rift Zone as recently as 1840. It does not appear that either corridor is significantly less likely to be overrun by a lava flow.

### MITIGATION MEASURES

Mitigation measyres for lava tubes is discussed in the section on construction considerations.

Mitigation measures for lava flows does not appear to be economically feasible for this type of project.

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The following Plates and Appendix are attached and complete this report.

| | |
|---|---|
| Plate 1 | Map of Area |
| Plate 2 | Plot Plan |
| Plate 3 | Generalized Soils Map |
| Plate 4 | Geologic Map |
| Appendix | Field and Laboratory Data |

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Respectfully submitted,

DAMES & MOORE
A Professional Limited Partnership

Masanobu R. Fujioka, P.E.
Consultant

MRF/1ml(3522B/169B)1269-078-11
(Three copies submitted)

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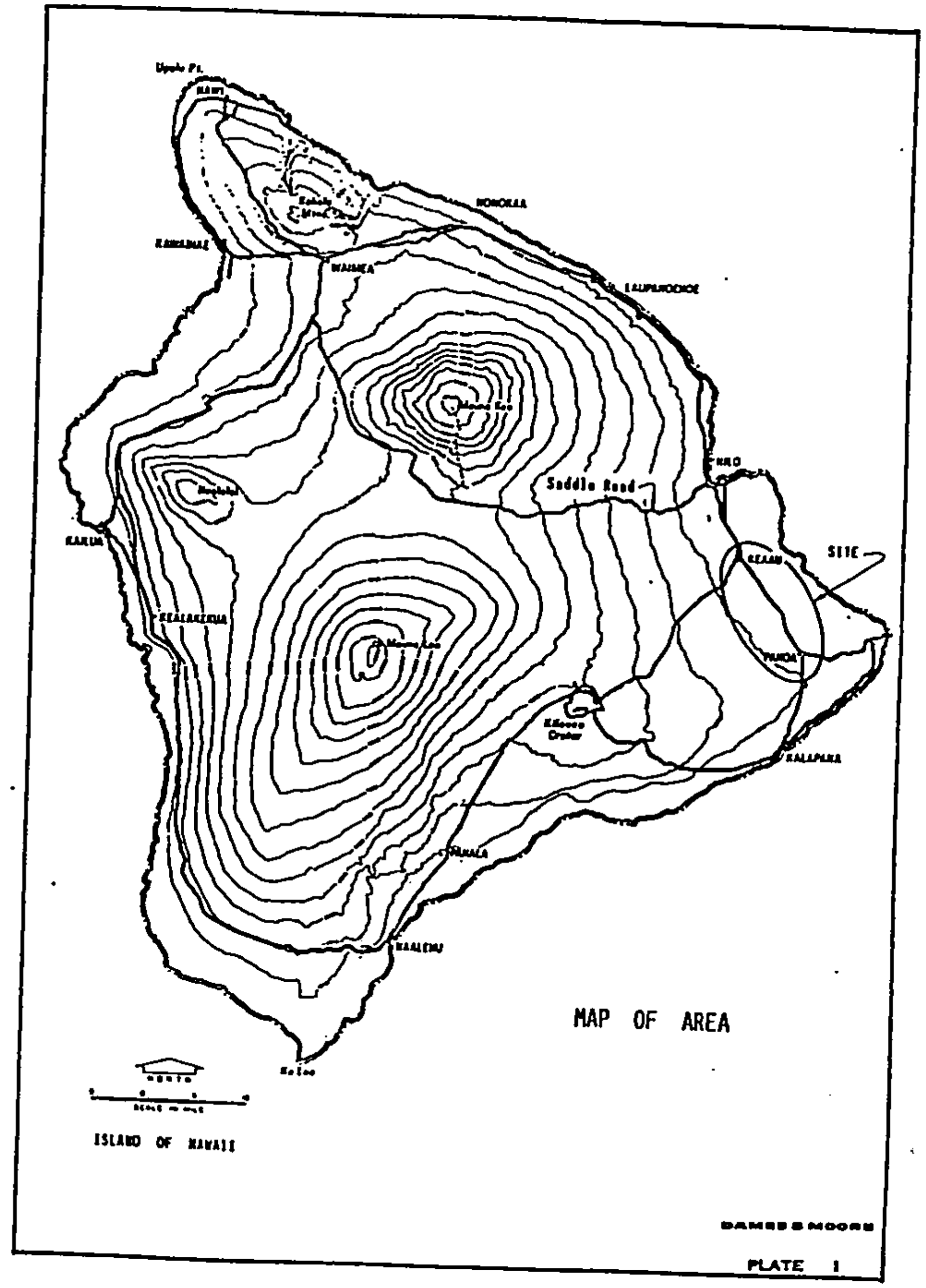
3. Stearns, H. T., G. A. MacDonald, Geology and Groundwater Resources of the Island of Hawaii, Hawaii Division of Hydrography, Bulletin 9, 1946.

4. U. S. Department of Agriculture, Soil Conservation Service, Soil Survey of Island of Hawaii, State of Hawaii, Washington, D.C.: U.S. Government Printing Office, December 1973.

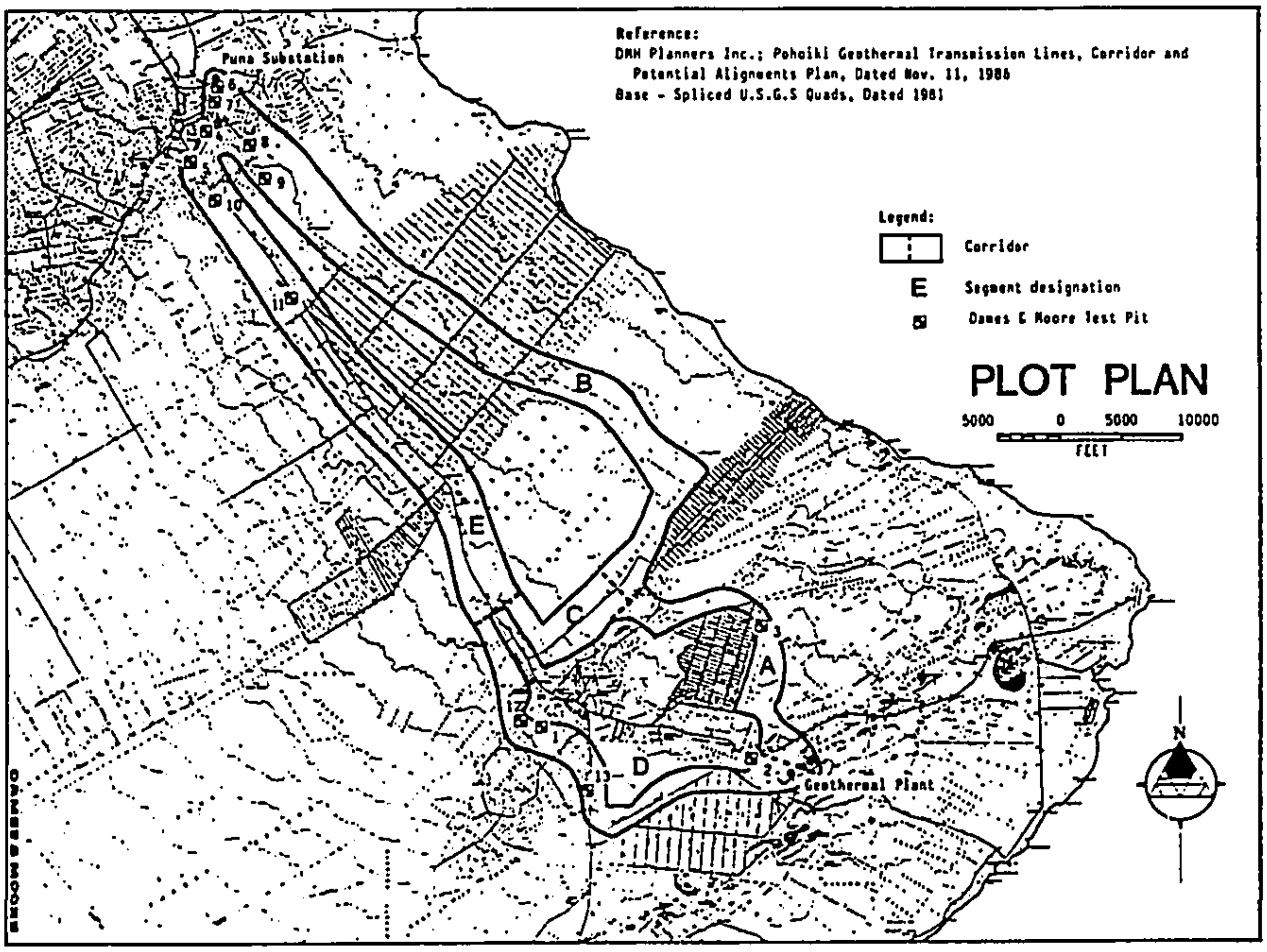



PLATE 2

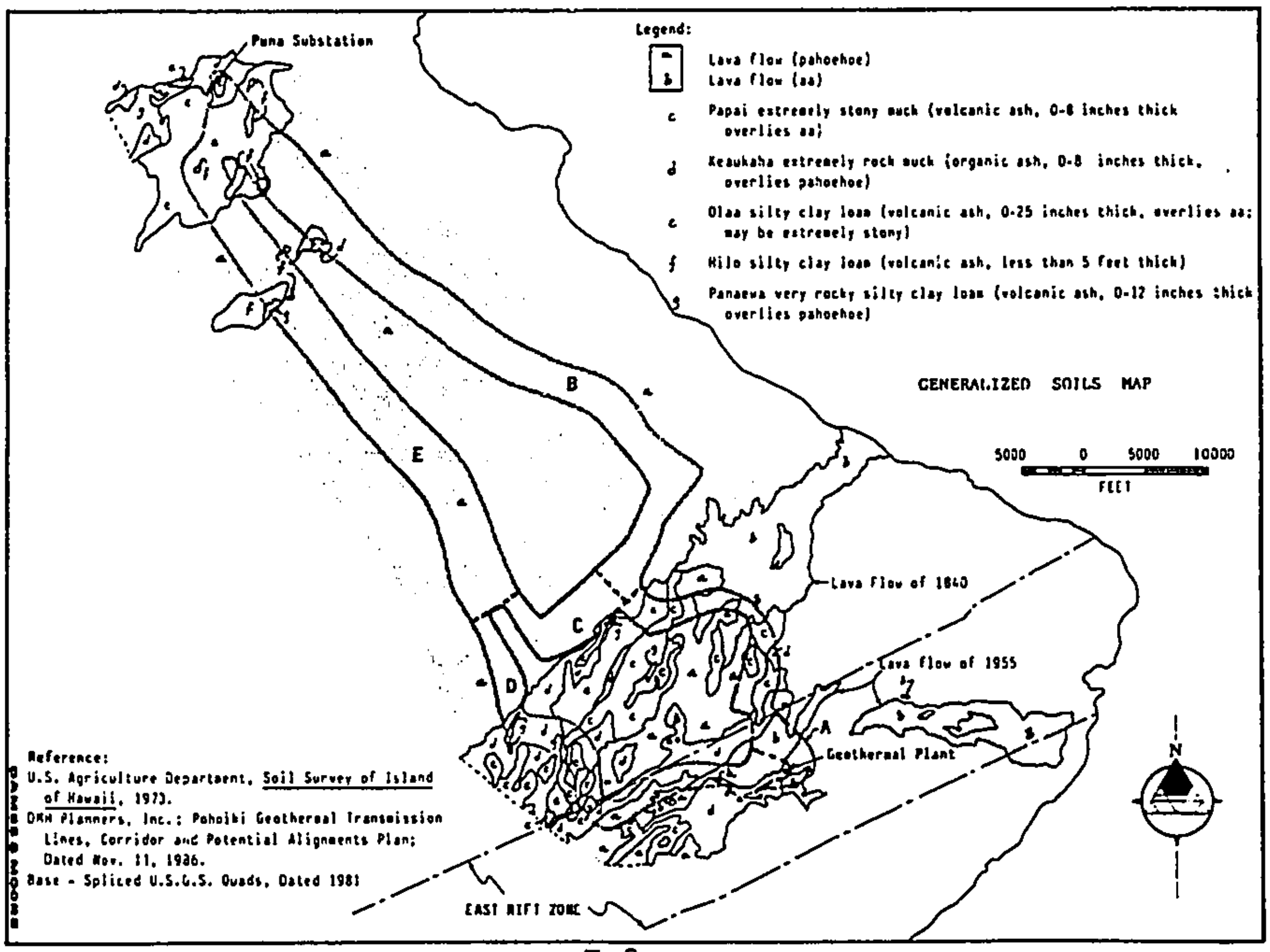



PLATE 3

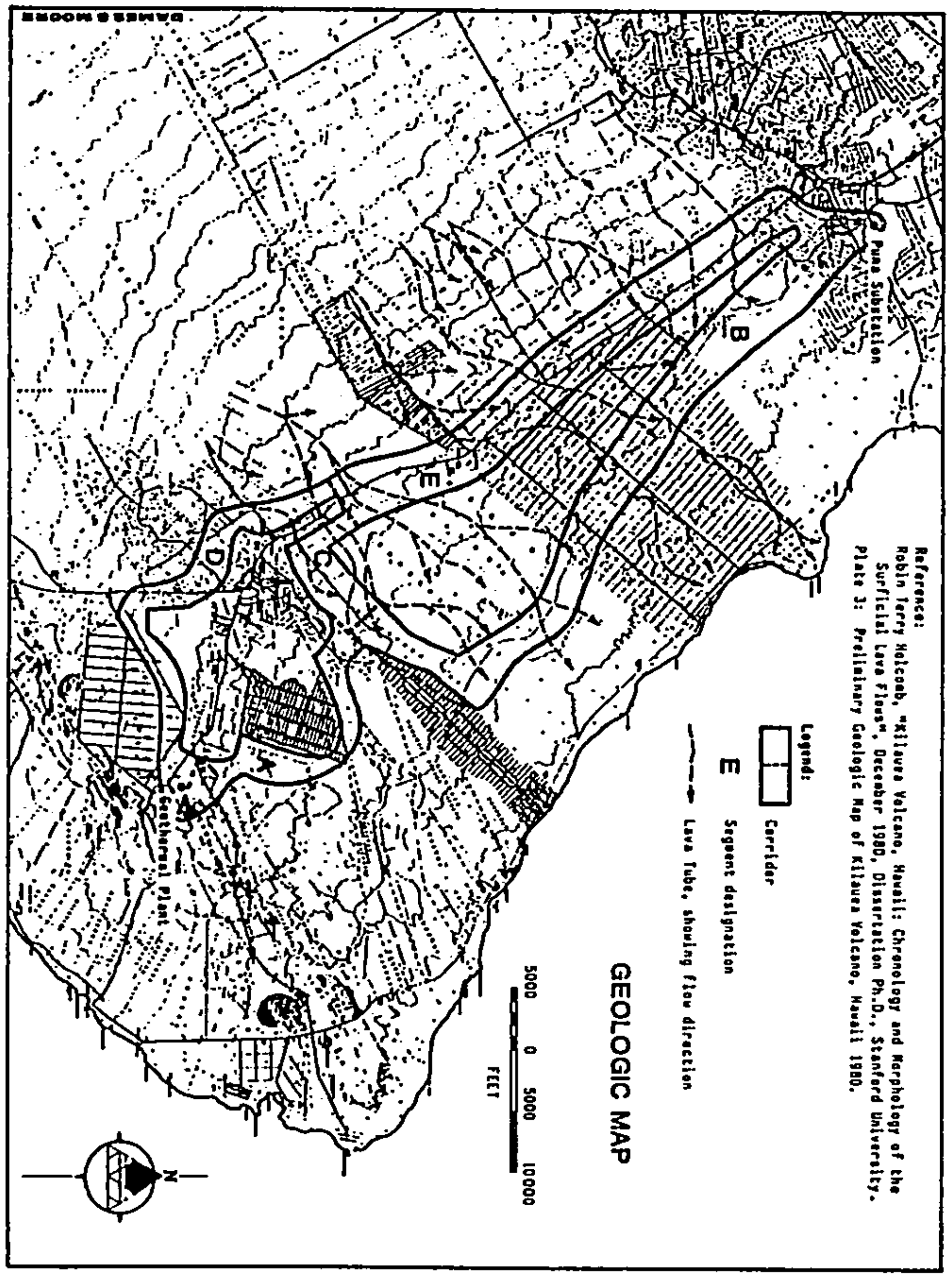



PLATE 4

APPENDIX

FIELD INVESTIGATION AND LABORATORY TESTING

FIELD INVESTIGATION

The field investigation was conducted in two parts. The first part consisted of a helicopter fly-over of the selected corridors with the project team. This fly-over was performed on September 26, 1987. During the fly-over, we used a video camera to record the aerial view of the selected corridors. Later review of the video tape assisted us in identifying significant topographic features and access constraints, such as dense vegetation and rugged terrain.

The second part of the field investigation consisted of a field reconnaissance of the corridors during which we examined in more detail the general site conditions identified during our preliminary studies and helicopter fly-over. We examined topographic features, geologic features, and conditions, soil and rock types, and natural hazards during the week of January 26, 1987.

Access through the corridors was provided by a network of paved and non-paved roads. The large size of the corridor region and the often rugged and densely vegetated terrain restricted most of the field reconnaissance to areas accessible by roads.

Thirteen shallow test pits, 0.3 to 1.5 feet in depth, were excavated with hand auger equipment at selected locations. Disturbed soil samples were retained for further examination and laboratory testing. Soil types were classified in accordance with the Unified Soil Classification System shown on Plate A-1.

In general, test probing with the hand auger advanced until rock was encountered. Logs of the test pits are summarized on Table A-1.

## LABORATORY TESTING

Selected samples of the near surface soils obtained in the field investigation were subjected to laboratory testing to aid in evaluating their engineering properties. The testing consisted of moisture determinations, grain size analyses, Atterberg limits tests, and an expansion test.

Moisture Determinations - Moisture content determinations were performed on each soil sample. The test results are presented in the Summary of Test Pits, Table A-1.

Atterberg Limits Tests - Four Atterberg limits tests were performed on selected soil samples to aid in the classification of these materials. The tests were performed in accordance with ASTM Test Method D 4318-84. The test results are presented on Plate A-2 and in the Summary of Test Pits, Table A-1.

Grain Size Analysis - Three grain-size analyses were performed on representative soil samples to aid in the classification of these materials. The tests were performed in accordance with ASTM Test Method D 422-84. The test results are presented as gradation curves on Plate A-3.

Percent Expansion Test - One expansion test was performed on a selected sample of organic silty clay obtained from Test Pit 6 to determine its shrink-swell characteristics. The expansion test was performed by placing a one-inch thick remolded sample of soil into a consolidometer and applying a surcharge load of 100 pounds per square foot to the sample. The sample was then immersed in water and the linear volumetric expansion recorded. The results of this test are listed below.

| Test Pit Number | Depth (ft) | Initial | | Final | | Percent Expansion |
|---|---|---|---|---|---|---|
| | | Moisture (%) | Dry Density (%) | Moisture (%) | Dry Density (%) | |
| 6 | 0-1.0 | 31.5 | 86.5 | 33.5 | 86.4 | 0.5 |

- o0o -

The following Table and Plates are attached and complete this Appendix:

Table A-1 - Summary of Test Pits

Plate A-1 - Unified Soil Classification System
Plate A-2 - Atterberg Limits
Plate A-3 - Gradation Curves (Grain Size Analyses)

## TABLE A-1

### SUMMARY OF TEST PITS

| Test Pit No. | Depth (ft) | Unified Soil Class. | Soil Description | Moisture Content | Atterberg Limits (%) PL | LL | PI | Test Reported Elsewhere |
|---|---|---|---|---|---|---|---|---|
| 1 | 0-0.3 | OH | Dark brown sandy clayey silt with some gravel, roots, and some organics, moist | 30 | 87 | 139 | 52 | |
| | 0.3 | | Gray basalt | | | | | |
| 2 | 0-0.3 | GP-GM | Dark brown silty sandy gravel with roots and decomposed vegetation, moist | 13 | | | | G |
| | 0.3 | | Gray basalt | | | | | |
| 3 | 0-0.5 | GP | Dark brown to black silty sandy gravel with trace of organics, moist | 5 | | | | G |
| | 0.5 | | Gray basalt | | | | | |
| 4 | 0-1.0 | ML | Dark brown sandy clayey silt with some basaltic gravel, lots of roots, and organics, moist | 17 | | | | |
| | 1.0 | | Gray basalt | | | | | |
| 5 | 0-1.5 | ML | Dark brown clayey silt with some sand and gravel and some roots, moist | 130 | | | | |
| | 1.5 | | Gray Basalt | | | | | |
| 6 | 0-1.0 | OH | Dark brown to black organic clayey silt with some sand, gravel, roots, and some decomposed vegetation, moist | 63 | 67 | 85 | 18 | Exp. |
| | 1.0 | | Gray basalt | | | | | |
| 7 | 0-0.5 | GP-GM | Dark brown silty sandy gravel with some roots, moist | 11 | | | | G |
| | 0.5 | | Gray basalt | | | | | |
| 8 | 0-1.5 | ML | Dark brown clayey silt with some sand and gravel, and some roots, moist | 24 | | | | |
| | 1.5 | | Gray basalt | | | | | |

Continuation ...

(3522A/169B)



## TABLE A-1
Page 2

### SUMMARY OF TEST PITS

| Test Pit No. | Depth (ft) | Unified Soil Class. | Soil Description | Moisture Content | Atterberg Limits (%) PL | LL | PI | Test Reported Elsewhere |
|---|---|---|---|---|---|---|---|---|
| 9 | 0-1.5 | ML | Brown clayey silt with some sand and gravel and some roots, moist | 76 | | | | |
| 10 | 0-0.5 | OH? | Dark brown sandy clayey silt with some gravel and lots of decomposed vegetation, moist | 33 | | | | |
| | 0.5 | | Gray basalt | | | | | |
| 11 | 0-1.5 | OH | Reddish brown clayey silt with some roots, moist | 239 | 191 | 256 | 65 | |
| 12 | 0-1.0 | MH | Dark brown sandy clayey silt with some gravel and some roots, moist | 47 | 112 | 171 | 59 | |
| | 1.0 | | Gray basalt | | | | | |
| 13 | 0-1.0 | ML | Dark brown sandy clayey silt with basaltic gravel and some roots, moist | 55 | | | | |
| | 1.0 | | Gray basalt | | | | | |

Note: G - Designates grain size analysis performed, Refer to Plate A-3.

(3522B/169B)

## SOIL CLASSIFICATION CHART

| Major Divisions | | | Graphic Symbol | Letter Symbol | Typical Descriptions |
|---|---|---|---|---|---|
| Coarse grained soils | Gravel and gravelly soils | Clean gravels (little or no fines) | | GW | [illegible] |
| | | | | GP | [illegible] |
| | More than 50% of coarse fraction retained on No. 4 sieve | Gravels with fines (appreciable amount of fines) | | GM | [illegible] |
| | | | | GC | [illegible] |
| More than 50% of material is larger than No. 200 sieve size | Sand and sandy soils | Clean sand (little or no fines) | | SW | [illegible] |
| | | | | SP | [illegible] |
| | More than 50% of coarse fraction passing No. 4 sieve | Sands with fines (appreciable amount of fines) | | SM | [illegible] |
| | | | | SC | [illegible] |
| Fine grained soils | Silts and clays | Liquid limit less than 50 | | ML | [illegible] |
| | | | | CL | [illegible] |
| | | | | OL | [illegible] |
| More than 50% of material is smaller than No. 200 sieve size | Silts and clays | Liquid limit greater than 50 | | MH | [illegible] |
| | | | | CH | [illegible] |
| | | | | OH | [illegible] |
| Highly organic soils | | | | PT | [illegible] |

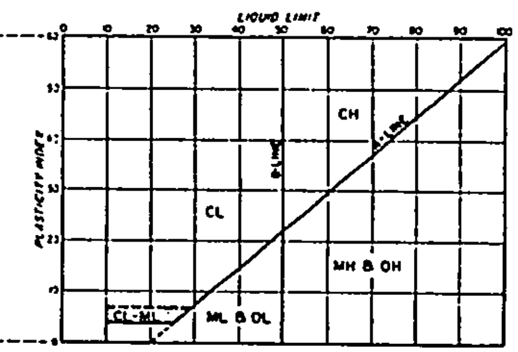
NOTES

[illegible]

## GRADATION CHART

| Material Size | Particle Size: Lower Limit (Millimeters) | Lower Limit (Sieve Size) | Upper Limit (Millimeters) | Upper Limit (Sieve Size) |
|---|---|---|---|---|
| Sand | | | | |
| Fine | [illegible] | [illegible] | [illegible] | [illegible] |
| Medium | [illegible] | [illegible] | [illegible] | [illegible] |
| Coarse | [illegible] | [illegible] | [illegible] | [illegible] |
| Gravel | | | | |
| Fine | [illegible] | [illegible] | [illegible] | [illegible] |
| Coarse | [illegible] | [illegible] | [illegible] | [illegible] |
| Cobbles | [illegible] | [illegible] | [illegible] | [illegible] |
| Boulders | [illegible] | [illegible] | [illegible] | [illegible] |

## PLASTICITY CHART



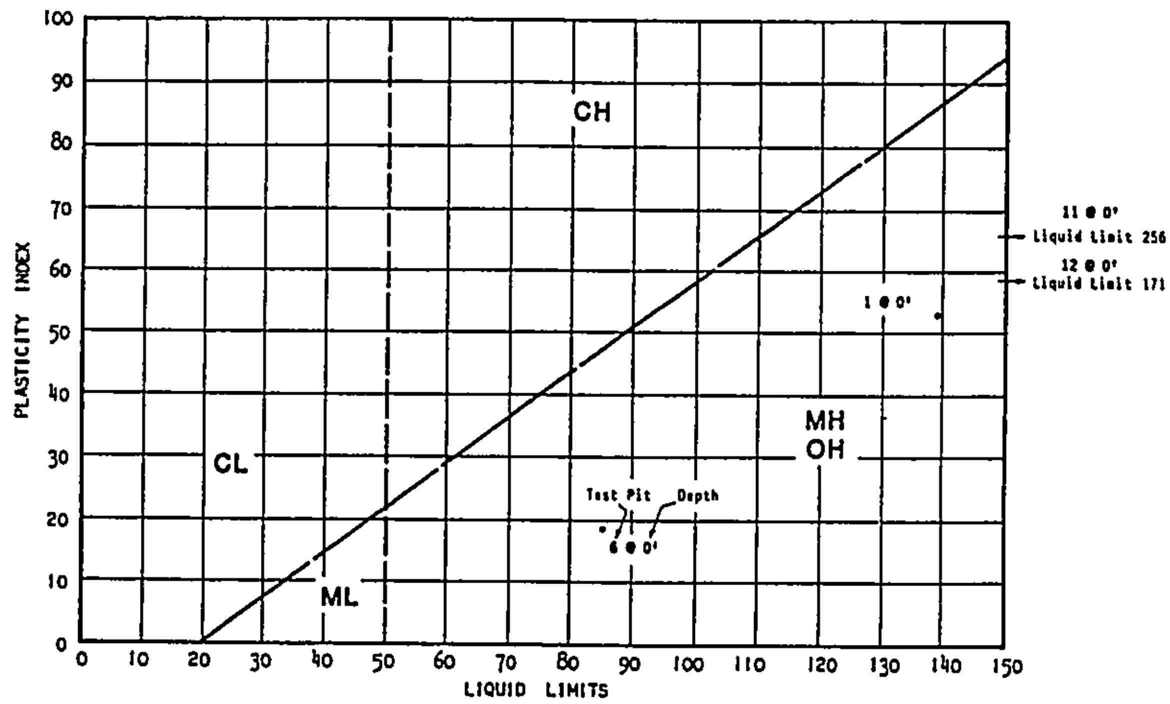

## SAMPLES

[illegible]

# UNIFIED SOIL CLASSIFICATION SYSTEM

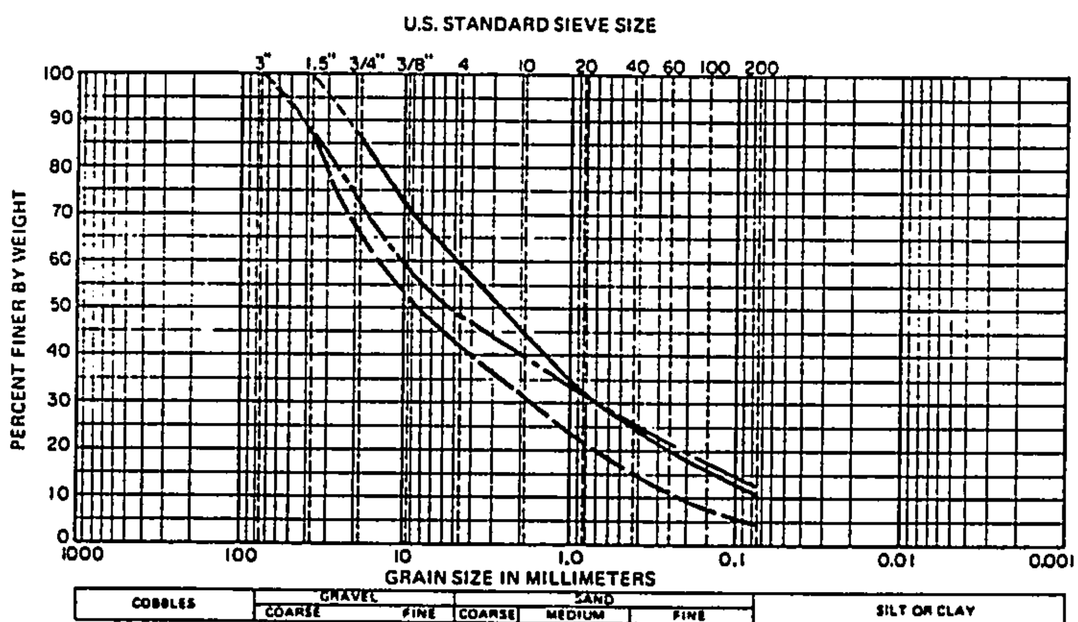
Dames & Moore

PLATE A-1




## ATTERBERG LIMITS

Dames & Moore
PLATE A-2




| TEST PIT | DEPTH | CLASSIFICATION | | NAT. W C | LL | PL | PI | |
|---|---|---|---|---|---|---|---|---|
| 2 | Surface | GP-GM | Dark brown sandy clayey silt with some gravel, roots and organics, moist | | | | | |
| 3 | Surface | GP | Dark brown to black silty sandy gravel with trace organics, moist | | | | | |
| 7 | Surface | GP-GR | Dark brown silty sandy gravel with some roots, moist | | | | | |

## GRADATION CURVE

Dames & Moore
PLATE A-3

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