Kahauale'a

GEOTHERMAL PROJECT

PUNA, HAWAII

Environmental Impact Statement for the Kahauale'a Geothermal Project

April 1982

A True/Mid-Pacific Geothermal Venture in Coordination with the Trustees of the Estate of James Campbell

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ENVIRONMENTAL IMPACT STATEMENT
FOR THE
KAHAUALE'A GEOTHERMAL PROJECT

District of Puna, Island of Hawaii
State of Hawaii

TAX MAP KEY: No. 1-1-01, Parcel 1 and
No. 1-2-08, Parcel 1

This Environmental Document is Submitted
Pursuant to Chapter 343, HRS

BY

THE TRUE/MID-PACIFIC GEOTHERMAL VENTURE

In Coordination With

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APRIL 1982

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TRUE/MID-PACIFIC GEOTHERMAL VENTURE

MAY 5th 1982
DATE

KAHAUALE'A GEOTHERMAL PROJECT

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INTRODUCTION

GEOTHERMAL ENERGY

Ever since man walked on earth, volcanoes have awed and frightened him. Volcanic eruptions have, at times, devastated the land. Whole islands have disappeared. And, yet, volcanoes over eons have built-up the land through countless eruptions and the ensuing lava flows. This process has continued since the birth of the planet earth.

Volcanoes are a manifestation of the hot and partially molten interior of the earth. This hot liquid material comes to the surface of the earth's crust during an eruption. The crust of the earth is made up of six principal tectonic plates. Volcanic and earthquake activity are most common along the plate boundaries. One of these tectonic plates is the Pacific plate and one boundary of this plate called the Pacific "rim of fire" as evidenced by volcanic activity from New Zealand, the Philippines, Japan and across to Alaska.

The heat trapped in the earth, the ultimate geothermal resource, appears at the earth's surface as hot springs, geysers, steam vents, and volcanic activity. This volcanic activity is either along the plate boundaries or at places within the plates called hot spots. Hawaii has been favored by one of these hot spots where molten rock, or magma, rises to the earth's surface through crustal fractures.

Geothermal resources have been classified by the USGS into five categories:

1. Conduction-dominated regimes.
2. Igneous-related geothermal systems.
3. High temperature (greater than 150°C) and intermediate temperature (90° to 150°C) hydrothermal convection systems.

4. Low temperature (less than 90°C) geothermal waters.
5. Geo-pressured-geothermal energy (both thermal energy and energy from dissolved methane).

Hawaii's geothermal resources are in categories (2) and (3) above but also include potential resources in category (4).

The commercial exploitation of geothermal energy requires that three conditions be met: (1) an abnormally high local geothermal gradient; (2) permeable host rocks to act as heat reservoirs; and (3) hot water or steam which serves as a medium for storage and transfer of heat.

The geothermal reservoirs are of two basic types that determine the hydrothermal convection systems: (1) dry steam and (2) hot water. In the dry steam (vapor-dominated) reservoir, the steam emanating from the geothermal well is simply routed to a separator to remove particulate matter before entering the turbo-generator. The spent steam is processed through condensers and cooling towers and transformed into a liquid state for disposal. Disposal alternatives include reinjection through an enclosed well bore surface runoff or evaporated into the atmosphere. The dry steam type of geothermal resource is rare and the best example can be found at The Geysers in Sonoma County, California.

The hot water (liquid-dominated) reservoir offers certain advantages as well as disadvantages. The hot water, which is at temperatures often exceeding 150°C, must be "flashed" to separate the steam from the fluid. This is done by lowering the pressure. The steam and hot fluid is routed to a separator before the steam is directed to the turbo-generator to produce electricity. The hot water fraction still possesses enthalpy and can be utilized for direct heat applications before being combined with the condensate and returned underground through reinjection wells. This hot water type of underground reservoir is the variety discovered at Pohoiki in the Puna District of the Island of Hawaii. It is also the most abundant type of the known geothermal resource elsewhere in the world and the major

geothermal resources discovered in New Zealand, Italy, Iceland, Japan and the Philippines are of this type.

GEOTHERMAL ENERGY DEVELOPMENT WORLDWIDE

The first successful generation of electricity from geothermal resources was achieved at Larderello, Italy, in 1904. In the United States, the first commercial success in electricity production from geothermal energy occurred at The Geysers, 80 miles north of San Francisco. The first generating unit had a 12.5 MWe capacity. Additional units have been added subsequently and today production is about 900 MWe and will soon reach 1,000 MWe. The experience gained by the development at The Geysers has greatly enhanced the technology of harnassing geothermal energy for power generation.

Geothermal energy technology is now well known throughout the world. Geothermal electric power generation facilities are also operated successfully in New Zealand, Mexico, Japan, the Philippines, Iceland, El Salvador, Turkey, the USSR and China. Countries planning geothermal power plants include Portugal (the Azores), Chile, Costa Rica, Guatamala, Hondurus, Indonesia, Kenya, Nicaragua and Panama. (In all, there are 65 countries engaged in the exploration and/or development of geothermal resources.) In the U. S., besides the Geysers and Hawaii, geothermal power plant development is occurring in East Mesa and Brawley, California, Raft River, Idaho, and Valles Caldera, New Mexico. Proposed geothermal power plant development is occurring in Roosevelt Hot Springs, Utah, and Desert Peak, Nevada. A hybrid coal-geothermal plant is proposed for the City of Burbank, California.

GEOTHERMAL ENERGY IN HAWAII

Hawaii is at the southern terminus of a volcanic chain that stretches from the Aleutians to Midway Island down the northwestern Hawaiian Islands (often called the Leeward Islands) to Hawaii. Volcanic activity in the northern islands ceased long ago and many of the northwestern Hawaiian Islands have eroded away and only rock pinnacles, shoals and coral reefs

serve as reminders of early volcanic activity. There were even older islands further northwestward but these have long, long ago sunk below the seas. The current Hawaiian Islands will suffer the same fate millions of years from now.

Volcanic activity continues only on the Island of Hawaii today although neighboring Maui Island recorded its last eruption about 1790 in the Makena-La Perouse District. The Island of Hawaii exhibits volcanic eruptions of undiminished intensity. Eruptions of the past years, indicative of the growth process, are listed elsewhere in this report.

Only recently, scientists from the National Oceanic and Atmospheric Administration (NOAA) described volcanic activity south of Hawaii off the coast of Kalapana. In the past years, numerous seismic tremors on the ocean floor have emanated from this area. Underwater cameras have detected evidence of recent volcanic activity on the ocean floor. Prediction is that at some future date, an island will emerge from the sea. Loihi, as the scientists have named this volcano of a yet unborn island, will then be the newest of the chain of islands that start at Midway and Kure Islands, 1,600 miles northwest of Kilauea Volcano.

The most famous geographical feature of the Island of Hawaii is Kilauea Volcano. Thousands of visitors annually stop to gaze at the wonder of nature's hidden power. The numerous craters, lava flows, cinder cones, and devastated forest present ample evidence of the tremendous forces lying below. The frequent eruptions of Kilauea and Mauna Loa still give vivid visual proof of this frightening power. Watching an eruption can best be described as being a witness at the dawn of earth. An now, that power is being tapped and controlled to serve mankind.

In the early 1960's, the Hawaii County Water Department and the State Department of Land and Natural Resources undertook an exploratory water well drilling program in Puna. The results were varied. The location of water wells and the temperature and chloride measurements are shown in

Figure 6-1. Here was additional proof of geothermal anomalies along with the steam vents (fumaroles) at Kilauea in the national park, and the obliterated warm springs at Kapoho. In 1961, Magma Power Company drilled 4 exploratory wells in the Puna area in an attempt to find geothermal energy. The wells were shallow, less than 1,000 feet, and drilling was abandoned as no geothermal reservoirs were encountered. In 1972, George Keller, a professor of geophysics at the Colorado School of Mines received a National Science Foundation (NSF) grant for geothermal research in the Hawaii Volcanoes National Park. Since the National Park Service is prohibited from selling any of its resources, the geothermal drilling was solely for research purposes; no commercial sale of any geothermal resource would be possible. Keller's work showed high temperatures in the 3,500-foot deep hole, but no steam. It did suggest that hot water or steam might have been located in a deeper hole. Buoyed by the results of previous tests and the existence of anomalies indicating Hawaii Island's untapped geothermal resource, the University of Hawaii started its geothermal research program in 1972 with the encouragement of the State and County governments. Howard Harrenstein, Director of the UH Center for Engineering Research initiated a research proposal to the National Science Foundation (NSF). However, before the project was funded, Harrenstein resigned to accept another position elsewhere. John Shupe, Dean of the UH College of Engineering, became the project's principal investigator for the NSF grant. As project director, Shupe became head of a team possessing varied talents and experience. His co-principal investigators included Augustine Furumoto, Geophysics Professor; Paul Yuen, Engineering Professor; and Robert Kamins, Economics Professor. The project was called the "Hawaii Geothermal Project" (HGP) and its executive committee was composed of Shupe, George Wollard, Director of the UH Hawaiian Institute of Geophysics; and John Craven, Dean of the UH Marine Programs and Marine Affairs Coordinator for the State.

The scope of the project had to be prepared, then redefined to conform to requirements enabling it to qualify for Federal funds. This initial effort was for the feasibility studies: geophysical surveys, engineering research and environmental-socio-economic study. Funds from the NSF matched by State/County grants totalled $452,000. The NSF was replaced by the Energy Research and Development Administration (ERDA) which became the lead agency in the national energy program. The drilling of the Pohoiki well was funded by ERDA - $1,064,000, State - $508,000 and HECO (Hawaiian Electric Company) - $45,000, for a total of $1,609,000. Drilling started on December 10, 1975 and the target depth of 6,400 feet (1,951 meters) was reached April 27, 1976. Additional funds were received to make slight modifications and to complete drilling completion tests which supplied temperature readings and gave indications of permeability from pump-down tests. On July 2, 1976, the well was flashed concluding the drilling completion tests.

The formal well tests to determine the well's potential (electrical generating capacity) and productivity (life of the geothermal well) occurred between July 1976 to June 1978 and were funded by ERDA and the State. The results are shown in the following tables:

HGP-A DISCHARGE RESULTS

	November	December	January	March
Well Head Pressure (psig)	47	53	59	59
Well Head Temperature (°C)	146	150	151	153
Mass Flow Rate (klb/hr)	88	103	114	120
Steam Flow Rate (klb/hr)	60	64	72	75
Steam Quality* (percent)	68	62	63	62
Electric Power Potential (MWe)	3.4	3.8	4.3	4.5

*Steam Fraction

LONG-RANGE POWER PROJECTIONS FOR HGP-A

Time in Years	Total Mass Flow Rate in klb/hr	Steam Flow in klb/hr	Well Head Pressure in psig	Enthalpy in Btu/lb	Power in MWe
1	81	59	153	900	3.2
15	78	58	142	904	3.0
30	77	57	140	906	3.0

SOURCE: Hawaii Geothermal Project, HGP-A Reservoir Engineering, September 1978, p. 42.

The final evaluation was that the Pohoiki well would be able to generate 3 MWe over the life of the power plant. The results disclosed that the downhole temperature of 676°F (358°C) made it one of the hottest geothermal wells in the world.

The testing disclosed some of the problems that can occur with geothermal energy development and provided the basis for development of solutions to mitigate or avoid these problems. Noise and hydrogen sulfide odor caused constant and valid complaints from nearby residents. Being experimental and short on funds, the geothermal well initially lacked noise mufflers and H_2S scrubbers to control or eliminate these adverse impacts. No doubt those who ran the project would have preferred to have taken proper measures early and not antagonize the local populace.

In June 1975, Agatin Abbot, who had been the drilling coordinator, left the project due to ill health. Soon after, on July 31, 1975, he died. It was his decision to drill at the Pohoiki site and for his key role and contributions to the geothermal program, the Pohoiki well would be called the "Hawaii Geothermal Project - Abbot" well ("HGP-A" well) in his honor.

Further problems confronted the geothermal program. Funding for the development of the HGP-A well had to be shifted from research oriented to application and utilization in line with ERDA's national energy objectives. To cope with this, Shupe prevailed upon Hideto Kono, Director of the State

Planning and Economic Development and State Energy Coordinator, to organize a geothermal consortium for continuing the State's pioneering effort in developing its geothermal resources. Kono became the Executive Director of a consortium which included the State, County of Hawaii, HECO and the University of Hawaii through the HGP group. Funds to build an experimental geothermal power generating station were sought in a proposal submitted to the U. S. Department of Energy (DOE), successor to ERDA. In June 1978, negotiations were completed for this facility to cost in excess of $6,000,000. A construction contract was subsequently awarded and on July 19, 1981, Governor George Ariyoshi turned on a switch that started Hawaii's first commercial geothermal plant in operation, making Hawaii the second State in the nation to achieve this distinction.

The foregoing introduction is presented to acquaint the reviewer of this EIS document with geothermal energy in general and to provide an insight of the problems involved. The brief description given of Hawaii's nearly 10-year struggle to tap our vast geothermal resource to benefit our State proves the vision of our University's scientists and those government officials who supported this endeavor. The proposed Kahauale'a project is a result of their dedicated efforts to help Hawaii develop alternative energy resources and, perhaps, reach the goal of electrical energy self-sufficiency.

SECTION 1
SUMMARY

INTRODUCTION

Geothermal energy technology has advanced significantly since the first successful conversion of this natural resource into electricity in Italy in 1904. The interest in using geothermal energy was given major and urgent impetus as a result of the oil crisis of 1973. It has been reported that there are 65 countries now engaged in the exploration for and/or development of geothermal resources as an alternative to fossil fuels.

The State of Hawaii is the second State in America, following California, to convert geothermal energy into electricity for public consumption through the HGP-A well in Puna. As a test and feasibility demonstration effort, it has provided invaluable information and incentive to private developers to justify proceeding with geothermal exploration and development to determine the extent of such resources in the Kilauea East Rift Zone and whether such resources can be economically produced at levels to compete with and displace an equivalent amount of imported oil.

Because of the continuing vulnerability of the State and its people to a disruption of oil supplies and to arbitrary price increases, the development of natural alternate energy resources in Hawaii is essential. It appears that among the potential alternate energy resources, geothermal energy can provide, in this century, a significant portion of the electrical energy requirements for the State.

The reduction in the amount of dollars sent out of our economy to purchase imported oil will cause a stimulation of our own economy and result in a growth of local jobs. If the development objective of the Kahauale'a Geothermal Project is achieved, i.e., the production of 250 MWe, the importation of foreign crude oil could be reduced by more than 3,000,000 barrels per year.

The success of the Kahauale'a Geothermal project could assure that electrical energy self-sufficiency for the Big Island will be reached by the year 1990. The electrical energy prices may then be stabilized and decoupled from pricing based on the depleting nonrenewable fossil sources.

It is believed that geothermal energy can successfully compete with oil and other alternate energy resources and that competition in the market place in Hawaii among all energy sources will prove to be a significant, long term benefit to the State and people of Hawaii.

PROJECT DESCRIPTION

The Kahauale'a Geothermal Project will be located on the Island of Hawaii in the District of Puna. The developer, True/Mid-Pacific Geothermal Venture, in coordination with the landowner, the Trustees of the Estate of James Campbell, has prepared a plan to tap the geothermal resources underlying the lands of Kahauale'a. The operator for the resource development phase is True Geothermal Energy Company of Casper, Wyoming.

Upon discovery of an economically producible resource, the project is planned to alternate exploration and development (production) drilling in parallel with development of a market for the energy available from this resource. Based on geophysical data and measurements, the estimated electric energy potential of the project area is 250 MWe. The resource potential will be developed over a span of 14 to 20 years.

The Kahauale'a Geothermal Project will be developed on two contiguous parcels of private lands, the larger of which was acquired from King Kalakaua. These parcels lie generally between the Hawaii Volcanoes National Park and the Puna Forest Reserve. The current State land use designation places the larger parcel, Kahauale'a, in the Conservation District which is under the jurisdiction of the State Department of Land and Natural Resources. The project lands encompass an area of 25,416 acres of which 21,943 acres lie within the Conservation District boundary, and 3,518 acres within an agricultural zone. A Conditional Use Permit will be required for geothermal development in the Conservation District. A Special Use Permit

will be required from the County at the time development activity on the agricultural lands is to be initiated. This Environmental Impact Statement has been prepared in support of a Conservation District Use Application for a Conditional Use Permit.

The initial objective of this project is to prove the existence of a geothermal resource, its characteristics, and whether or not it can be economically produced and marketed. The initial 25 MWe electrical power will be offered to Hawaii Electric Light Company (HELCO) in response to their Request for Proposal should the initial exploratory effort prove successful. Additional geothermal energy will be developed to meet market needs or the export of power to Oahu through an undersea cable now being studied.

To develop the initial 25 MWe power, at least 8 wells will have to be drilled. The power plant will be constructed in two units, each 12.5 MWe in size. Subsequent power plant units are expected to have a capacity of 55 MWe with no more than two such units at any one site. Assuming each production well will produce 3.5 MWe, up to 70 wells would be required over the 14- to 20-year development period to generate the estimated potential of 250 MWe. The geothermal well field will include 35 drilling sites of 5 acres each. Up to six wells per drilling site are planned using directional drilling, if feasible, and up to six wells will be drilled and tested per year. Each geothermal well will extend 4,000 to 8,000 feet below sea level. Five power plants ranging in size from 25 MWe to 110 MWe and requiring between 7 to 15 acres each are included in the ultimate development plan. The project will require the construction of an access road from Volcano Highway to the first drilling site (approximately 9 miles) and secondary connecting roads between drilling sites and power plants. A "gathering system" of pipelines will be constructed aboveground to transmit the geothermal fluids to a power plant for conversion into electricity. The power lines will be installed by HELCO and will require 69 KV lines to handle the initial 25 MWe and 138 KV lines to accommodate the power generated above 25 MWe.

A drilling rig capable of drilling to a depth of 13,000 will be shipped to Hawaii within 4 months after all permits required to commence drilling operations within Kahauale'a are obtained.

The latest technology for hydrogen sulfide abatement will be incorporated in the design and construction of power plants. The iron catalyst system will most likely be installed in the 25 MWe power plant and the widely used Stretford process in the larger plants. Using these systems, over 90 percent of the hydrogen sulfide can be removed from the noncondensable gases released from the geothermal fluids.

ENVIRONMENTAL SETTING

The Kahauale'a Geothermal Project is located on lands relatively undisturbed. The project area can be described as an 'ohi'a forest with dense 80 percent canopy in the eastern section to 40 percent canopy in the south and western sections to open areas devastated by lava flows in the rift zone. Baseline assessment surveys have been conducted within the project area to obtain a general knowledge of the physical environment of the property and specific knowledge in the areas where most of the project activity is planned, and to provide benchmark reference data on vegetation, air, and soil samples. A road survey was conducted from Volcano Highway through private property access (granted by the Shipman Estate) to the first drilling site.

Environmental surveys have revealed the presence of rare/endangered and new plant species in the northeastern section: the Cyrtandra, Cyanea, Clermontia and Adenophorus periens. The project site plan was adjusted to avoid this sensitive area. However, the Adenophorus periens fern was found in a subsequent survey and additional surveys were commissioned to determine its presence along the access road and planned power plant sites. This fern, once thought to be rare and listed as a candidate for the Rare and Endangered Species List was sighted in abundance along portions of the access road and at three of the power plant sites along the road and is now estimated to occupy a large portion of the Kahauale'a 'ohi'a forest.

The Hawaiian Hawk ('Io) and Hawaiian Honeycreeper ('O'u) have been sighted in Kahauale'a. The hawk is a wide ranging raptor that frequents woody forest areas. Its population count has risen in recent years and its rare/endangered status may no longer be true. The honeycreeper has been sighted previously in Kahauale'a but it is not known if this bird nests in this area.

A single sighting of the Hawaiian Bat, the only known mammal in Hawaii and also on the Rare/Endangered Species List, was made in a shallow, cave in an exposed lava area during the baseline assessment survey. It, too, is a wide ranging creature.

Documentary literature searches for evidence of sites which may have archaeological interest within the project area were conducted. While there is no record of archaeological sites with the State Historic Preservation Office, the literature search did reveal indications of early Hawaiian activity in the mauka regions of Kahauale'a.

The Kilauea East Rift Zone between Thurston Lava Tube and Napau Crater abuts the boundary of Kahauale'a before crossing the property and continuing into the Puna Forest Reserve. The proximity of project lands to the rift zone enhances the prospect for successful recovery of energy-producing geothermal resources.

IMPACTS

The potential sources of environmental impacts that may be caused by this project are derived from land clearing and construction activities, drilling and well testing, and power plant and production well operations. The overall summary assessment is that:

- the amount of land surface required for the project is so limited that there should be no significant impact to plants and wildlife;

- with the exception of brief periods during venting of a well on discovery of a resource and for maintenance of the well, noises associated with the project can be abated to levels that conform to noise guidelines published by the Hawaii County Planning Department;

- the emission from project operations of most concern is the H_2S nuisance level emission. H_2S emissions can be effectively abated through currently available and proven abatement systems, except for brief periods when a well is vented after discovery of a resource and during maintenance operations;

- except for the brief period of initial venting of the well, the discharge of fluid onto the surface from well testing will be directed to a sump for analysis and settling of solids and then disposed of by percolation, reinjection and/or removal to an approved waste disposal site. During normal operations, it is planned that all fluids will be reinjected to depths sufficiently below the basal water lens to protect any freshwater supplies that may exist in the rift zone;

- visual impacts of permanent facilities in the project area are expected to be minimal due to the remote location of the site, the shielding that will be afforded by heavy forest cover of 'ohi'a trees, and the distance to the nearest points where most tourists to the Hawaii Volcanoes National park could view the project area. It is expected that such view corridors will be limited. However, it is possible that satisfactory mitigation measures may be possible to reduce any adverse visual impacts from the more sensitive view corridors within the Park; and

- while the existence of archaeological sites have not been recorded, literature research indicates evidence of early Hawaiian activity in the mauka area of Kahauale'a. The

evolutionary nature of the project and the limited amount of surface area to be disturbed minimizes the potential for inadvertently disturbing sites that may have archaeological significance. The landowner and developer are committed to take the necessary actions to protect such sites in locating and clearing of sites for project facilities.

ALTERNATIVES

The alternatives were considered in relation to other uses of the land; development of other alternate energy sources, in lieu of geothermal energy; development in other areas with geothermal potential; and the alternative of "no action" or "delayed action." It is concluded that:

- other long-term productive uses of the land are not promising at this time,

- that geothermal resources offer the most promise for supplying a significant portion of Hawaii's energy needs in this century,

- that the areas with greatest potential are in the Kilauea East Rift zone, but that segments of the rift zone are precluded from development, therefore, limiting the potential resource area that can be developed to about 30 percent of the rift zone,

- that "no action" or "delayed action" in developing this alternate energy resource leaves Hawaii dependent on imported oil as the major source of its energy for electrical power.

The economic impacts from this project will have beneficial effects on the County's labor market. The project will require local construction labor for the most part. Since the project will take 15 to 20 years to complete, it will add a measure of stability to the local labor market. The estimated infusion of private capital for labor and materials to develop the full resource potential of the property will stimulate the economy of the County.

SECTION 2

DESCRIPTION OF THE PROPOSED ACTION

2.1 PROJECT OVERVIEW

This Environmental Impact Statement (EIS) for the Kahauale'a Geothermal Project has been prepared to support a Conservation District Use Application (CDUA) and a request for a Geothermal Mining Lease to mine and market geothermal resources on conservation land (Kahauale'a) owned in fee by the Estate of James Campbell and located in the Puna District, Island of Hawaii. It has been prepared for the True/Mid-Pacific Geothermal Venture, developer and prospective sublessee of the mining lease for the foregoing property in coordination with the Trustees of the Estate of James Campbell.

The EIS describes the exploration and development operations that are expected to occur in fully developing the geothermal resource potential of the Kahauale'a parcel and the potential environmental impacts which could occur from the project activities.

The initial objectives of this project are to prove the existence of a geothermal resource, its characteristics, and whether it can be economically produced and marketed. Subsequent exploration and development, in parallel with additional market development, will help determine the extent of the producible resource underlying the Kahauale'a parcel, the rate of development and whether the planned scope of the project can be realized. It has been calculated that the Kahauale'a parcel can potentially produce up to 250 megawatts of electrical power (MWe) from geothermal resources.

The development concept is designed to alternate exploration and development (production) drilling as provided for within the terms of Title 13, Subtitle 7, Chapter 183, HRS, pertaining to State mining leases. Upon proving through exploration and confirmation drilling the existence of resources sufficient to supply an existing or contracted for demand,

development drilling (i.e., drilling of "step-out" wells) will be conducted until that demand is satisfied.

The exploration, development and marketing activities described in the EIS will be executed over a period of 14 to 20 years depending on the extent and quality of the resource and the development of suitable markets to utilize the resource. The principal activities during the initial stages of the development effort consist of:

- exploration and development drilling to compete for the current projected electrical power market of Hawaii Electric Light Company (HELCO).

- additional exploration drilling to extend the areas of proven geothermal resources.

This will be followed by additional development drilling to meet additional existing or potential market demands.

It is estimated that 20 successful exploration wells will have to be drilled to prove that up to 250 MWe of power can be produced from the Kahauale'a parcel. Therefore, during the initial development activity, a portion of this overall exploration objective will be accomplished consistent with the prospects for proceeding with the undersea cable project or such other markets as may be identified.

There are 35 planned drilling sites in selected areas of the exploration and development zones projected to have high and moderate resource potential. Selection of additional drilling sites within the leased area will be based on the results of all previous drilling on the property. It is contemplated that drilling operations will be conducted on an on-going basis. The drilling rate is projected at six wells per year with an average success rate of four wells per year.

After an initial discovery, one or more confirmation wells will be drilled to verify the presence of a reservoir capable of economical production, to gain additional information on its dimensions and characteristics and to facilitate well testing between the wells drawing from a common reservoir. Wells will be vented initially upon discovery of a resource, after periods of shut-in of the wells and infrequently during the life of the well. After a period of initial venting, wells will be flow tested under appropriate emission and noise abatement control procedures.

A "gathering and injection system" consisting primarily of pipelines to transmit the hot geothermal fluids from the production wells to an electric power plant and to return cooled fluid to a reinjection well, will be constructed, where practical, adjacent to the roads connecting well sites with power plants.

It is planned that processed geothermal fluids which cannot be disposed of on the surface after treatment will be reinjected into a completely enclosed and sealed well bore to a depth that will assure it will not disturb any potable basal water lens. One injection well is planned for every three production wells.

The scope of the project encompasses the construction of power plants to convert the geothermal energy into electricity. There are five power plant sites tentatively located for the project within one to two miles of prospective drilling sites, except where volcanic hazards dictate further separation between the well and power plant. Design of the power plants will be based on an analysis of the chemical composition, temperature, and flow rate of the resource of several wells. This data, together with reservoir engineering data, will determine whether commercial production is technically and economically feasible. The EIS describes conceptual designs for both a 12.5/25 MWe and a 55/110 MWe plant and their operation to enable evaluation of the smallest and largest operating systems proposed for the project and to assist in the estimation of the environmental impacts. The 25 MWe plant represents the present demand by HELCO for a

base load power on the Big Island. The 55 MWe plant is currently the industry standard for geothermal plants. Actual plant size will be a function of resource characteristics.

Right-of-way acquisition, design, construction and maintenance of transmission lines to transport the electrical power from the switching station within Kahauale'a to the connection with HELCO's main distribution lines is the responsibility of HELCO. Transmission lines (69 KV) for the first 25 MWe of power are expected to parallel the proposed access roads and existing off-site roads. Routes for transmission lines for the larger power requirements (138 KV) for use on the Big Island or for export via undersea cable cannot be determined until the extent and location of geothermal power resources and users are known.

Drilling operations will be conducted by the operator, True Geothermal Energy Company. It is anticipated that most construction operations will be contracted through local companies.

Traffic into the Kahauale'a parcel will be controlled by a gate at the entrance together with such safety and security patrol activity as may be required for the drilling and construction operations within the property. The landowner and developer will cooperatively institute a security management plan to provide for orderly control of project activities and monitoring activities necessitated by opening a road into this parcel.

After the initial exploration objectives of the project are realized, project activity will consist primarily of development drilling to satisfy expanding market requirements. Additional exploration drilling would be conducted to prove the existence of such additional reserves as may be required to supply a portion of the electrical power demand for an undersea transmission cable and to further demonstrate the resource potential of the property.

Environmental baseline data has been obtained and evaluated on the basis of the plan to fully develop the estimated geothermal potential of the property. Similarly, this EIS is based on the full development scenario of 250 MWe as reflected in the development plan.

2.2 PURPOSE AND NEED

The purpose of the proposed project is to develop the geothermal resources within Kahauale'a to generate 250 MWe as a major contribution toward achieving the energy objectives of the State and County Plans. The need is to replace expensive and uncertain fossil fuel supplies with electrical energy developed from a local alternate energy source, the east rift zone of the Big Island.

The State of Hawaii is almost totally dependent on imports of crude oil and petroleum products and is vulnerable to supply disruptions and price fluctuations in the global energy market. As a consequence of the high cost of imported fuel, electricity rates in Hawaii are among the highest in the nation. A disruption of oil supplies from major oil producers could cause catastrophic impact within the State from either drastically increased costs or greatly curtailed availability of electrical energy or both.

Because of the Hawaiian Island's recent volcanic origin and geography, the State has no indigenous fossil fuel reserves and is isolated from systems such as coal and natural gas. Fortunately, Hawaii is rich in renewable energy resources which are becoming available under new and improved technologies. Those resources include geothermal, solar, wind, biomass, hydropower, and ocean thermal gradients. The development of a local energy source will serve to stabilize energy costs and avoid the serious consequences of remaining tied to imported oil. While coal is an alternative to oil as the primary energy source for Hawaii, it would also be imported and there would be potentially significant environmental impacts to consider. Nuclear generated power does not appear at this time to be a feasible alternative to fossil fuel energy in Hawaii.

Because of the abundance of renewable natural resources in Hawaii, the State efforts are now directed toward decreasing the dependence upon imported fuel and focusing on the development of indigenous energy sources such as geothermal energy which has the potential now to satisfy the major

part of Hawaii's electrical energy needs. It is unlikely that any other renewable, indigenous energy resource will be available in this magnitude before the end of this century.

In 1978, the State Legislature enacted the Hawaii State Plan, Chapter 226, of the Hawaii Revised Statutes. The purpose of the plan is to improve the State-wide planning process, which is to articulate goals, objectives, and policies intended to guide future development in Hawaii. The State Plan includes two energy objectives. The first is to provide a dependable, efficient, and economical State-wide energy system capable of supporting the current and future needs of the people of Hawaii. The second is to provide increased energy self-sufficiency by decreasing Hawaii's dependence on imported fuel.

The amended General Plan of the County of Hawaii places emphasis upon energy self-sufficiency because of the excessive dependence on imported oil and the escalating cost of electricity. The County's objectives include energy self-sufficiency and the establishment of the Big Island as a demonstration community for the development and use of natural energy resources.

The State Department of Planning and Economic Development is the lead agency for energy planning and development in the State. On the Big Island, the County Department of Research and Development has a similar responsibility. These State and County agencies have in recent years promoted the development of significant alternate energy projects on the Big Island, including ocean thermal energy conversion (OTEC), biomass, wind and geothermal projects. The geothermal projects hold particular promise of near-future significance.

The 3 MWe HGP-A geothermal plant in the lower east rift zone in Puna has been operated as a demonstration plant under the supervision of the University of Hawaii. Additional exploratory geothermal drilling operations are now underway in the Puna District. A study has been initiated to define the infrastructure requirements for large scale (500

MWe) geothermal production. Research and development is also in progress to develop an underwater electrical cable capability to link the Island of Oahu, the State's main user of electrical power, with the Big Island geothermal power source by means of a deepwater cable.

Large scale development of the geothermal resources on the Big Island is believed essential to the attainment of the State and County objectives of energy self-sufficiency.

2.3 DESCRIPTION OF THE PROPOSED PROJECT

2.3.1 Site Location

The project location within the Puna District of the Big Island is indicated on Figure 2-1. The property on which a Conservation District Use Application (CDUA) and a geothermal mining lease are requested for exploration, development and marketing of geothermal resources is shown on Figure 2-2. The Kahauale'a ahupua'a is adjacent to the Hawaii Volcanoes National Park and extends downslope from the Kilauea Iki volcano crater to the ocean shoreline by Queen's Bath, near Kalapana. The Trustees of the Estate of James Campbell will submit a Geothermal Mining Lease Application to include most of the Campbell Estate lands as indicated on Figure 2-2. Figures 2-1 and 2-2 show the location and project area maps. The property is shown on Tax Maps as TMK No. 1-1-01, Parcel 1, containing 21,943 acres more or less (Conservation District Subzone Code L), and 992 acres more or less (Agricultural District) for a total of 22,935 acres more or less, and adjoining parcel TMK No. 1-2-08, Parcel 1, (Agricultural District) containing 2,526 acres for a total project area of 25,461 acres more or less. Both parcels are referred to hereinafter as Kahauale'a. The lower portion of the Campbell property near the ocean shoreline and coastal highway will not be explored.

2.3.1.1 Site Selection

The selection of Kahauale'a as the site for development of geothermal resources is based primarily on the estimate of a major resource potential underlying a large portion of the parcel and the fact that a potential development program sufficiently large enough to justify the costs and risks can be planned and carried out under one lease and in coordination with a single landowner. That is, planning and development can proceed on an integrated coordinated basis rather than by time consuming, sequential effort that would occur with two or more property owners and two or more leases. Moreover, within a large parcel under a single owner, the pipelines, transmission lines and road access rights-of-way will be granted simultaneously within the terms of a single lease. These factors are expected to result in more economical and efficient development of the resources. Except for the Puna Forest Reserve and private lands now leased

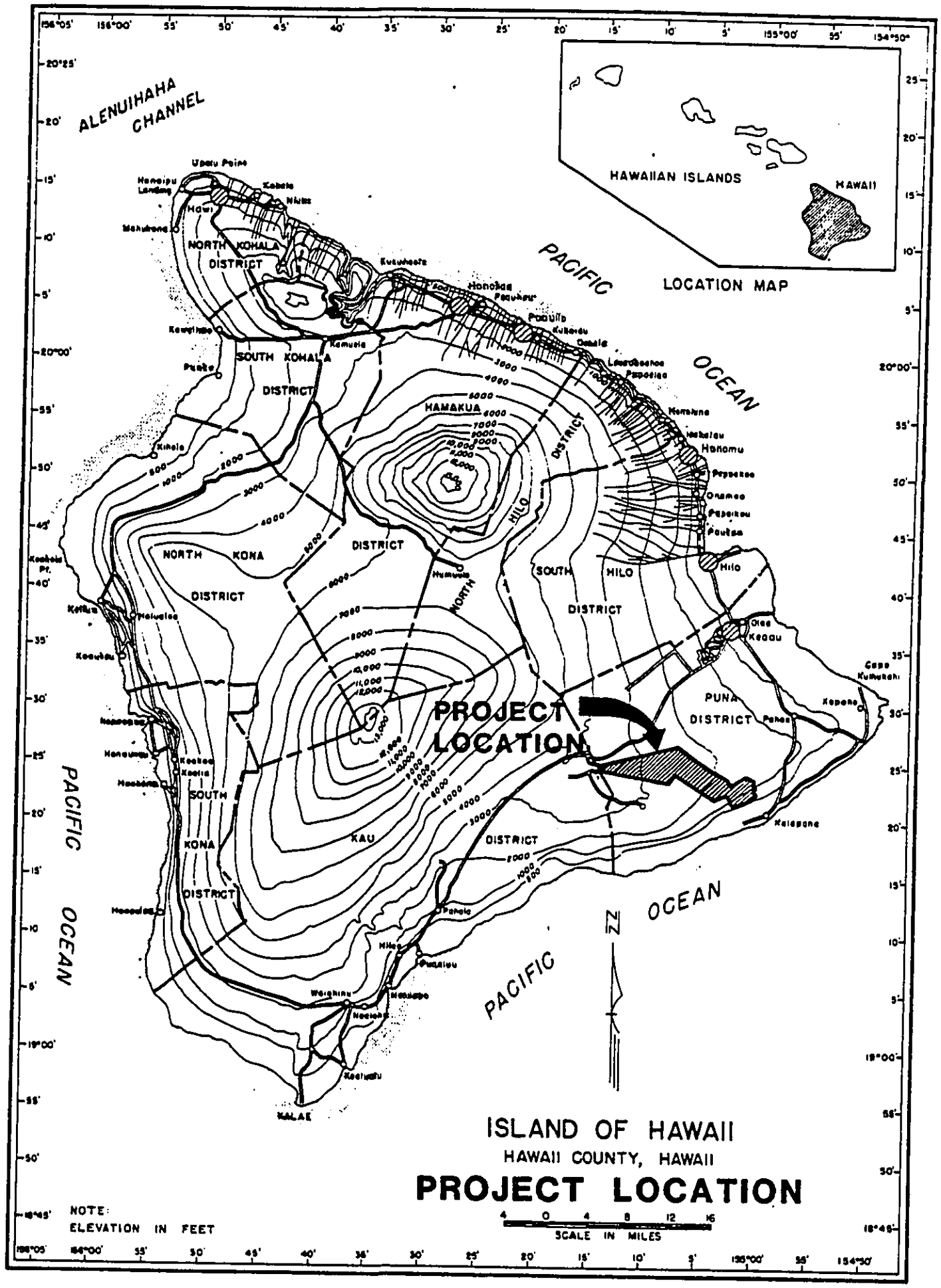

ALENUIHAHA CHANNEL
PACIFIC OCEAN
HAWAIIAN ISLANDS
HAWAII
LOCATION MAP
NORTH KOHALA DISTRICT
SOUTH KOHALA DISTRICT
HAMAKUA DISTRICT
HILO DISTRICT
NORTH KONA DISTRICT
SOUTH KONA DISTRICT
KAU DISTRICT
PUNA DISTRICT
PROJECT LOCATION
ISLAND OF HAWAII
HAWAII COUNTY, HAWAII
PROJECT LOCATION
NOTE:
ELEVATION IN FEET
SCALE IN MILES

FIGURE 2-1

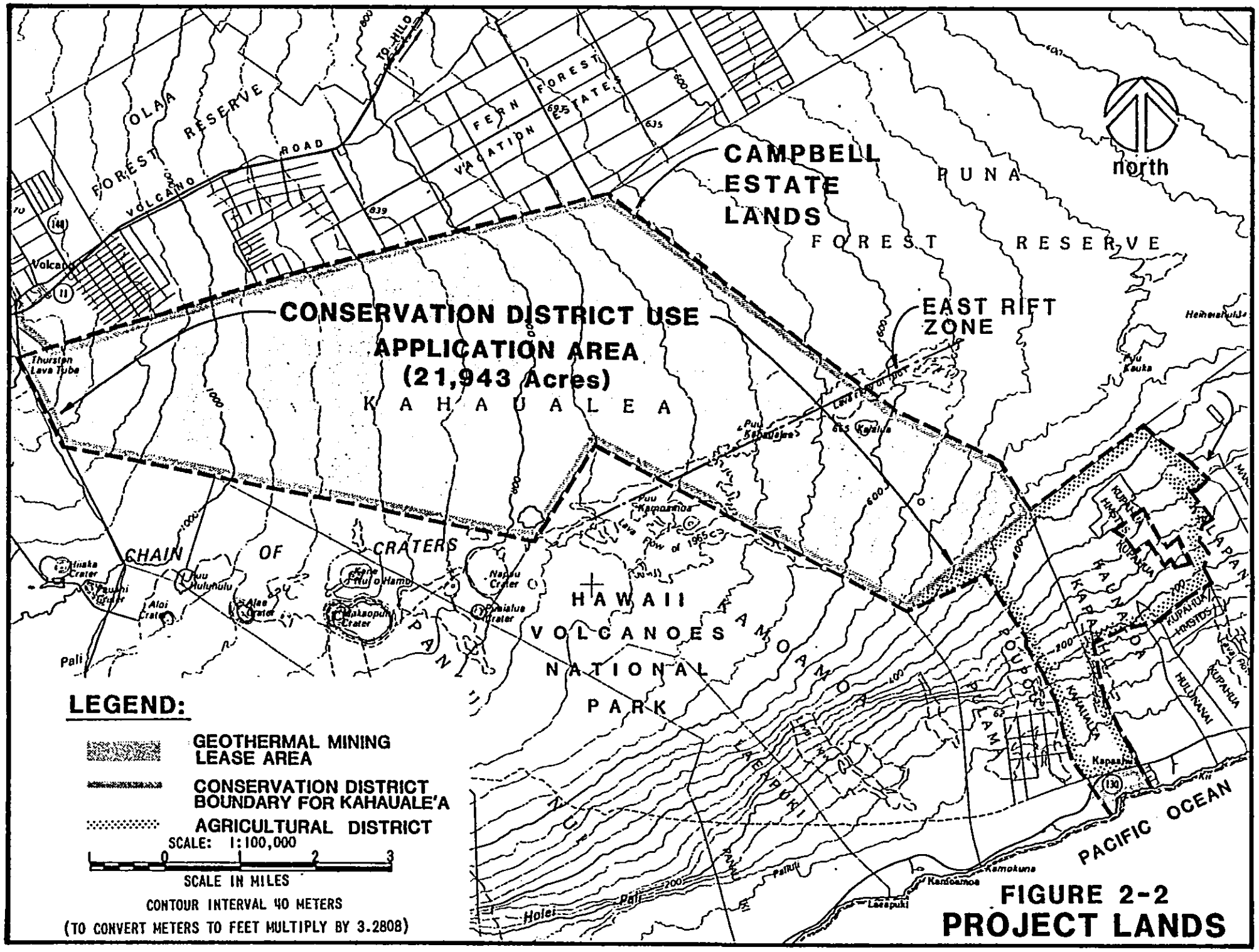


FIGURE 2-2
PROJECT LANDS

or held for geothermal development, there is no other parcel within the East Rift Zone of sufficient size and potential to justify the initial development costs. The initial costs to prove the existence of a producible resource could amount to $4.0 to $6.0 million.

Lease of the entire parcel enables essential flexibility in being able to rapidly relocate the drill rig to other potential resource areas with minimum down time of the rig if initial discoveries prove to be uneconomical to produce or if volcanic activity forces abandonment of an area. In addition, the large parcel will enable a more efficient well spacing program under a single developer to ensure a rate of production that will conserve this natural resource. In undertaking the initial risks of exploration and development, the developer who proves a resource is better able to plan the subsequent resource development if he has the flexibility to develop other potential areas within the parcel. On the other hand, discovery of a resource on a smaller parcel without access to adjacent parcels with geothermal potential would minimize the risks of a second developer who controlled the adjacent parcel and/or result in greatly inflated acquisition costs for the adjacent parcel. However, the concerns for potential impacts on the portion of the Volcanoes National Park adjacent to Kahauale'a are recognized. All reasonable measures will be taken to mitigate impacts on the Volcanoes National Park which might occur from any of the project's planned activities. Sections 5 and 6 address the potential impacts of the project and measures to mitigate these impacts.

Another essential consideration in the selection of Kahauale'a is the relative remoteness of the prospect area from residential populations. The development of the proposed facilities can proceed with minimal visual, noise and air pollution intrusion upon an existing population. The generally flat and gently sloping terrain is densely vegetated with a screening 'ohi'a forest except in those rift zone areas where lava flows have destroyed the vegetation. It is believed that the Kahauale'a site

presents a unique opportunity to develop a much needed alternate energy source with minimal impact upon the existing Big Island community.

2.3.2 Project Development Plan

2.3.2.1 General

The existence of geothermal resources can only be determined by the drilling of exploration wells to the depths of existing reservoirs, which in Hawaii are expected to occur between 4,000 feet and 8,000 feet below sea level. The concept of development is designed to allow for concurrent exploration and development effort as provided for in "Rules on Leasing and Drilling of Geothermal Resources," Chapter 183, HRS. A successful exploration effort would be followed immediately with development (production) drilling, followed by construction of facilities (power plants) to convert geothermal energy into electrical power, to meet the then current level of demand or market for such energy. It is planned that all wells will be designed and drilled as development (production) wells (i.e., conventional hole completion) even though the purpose of the drilling may be for exploration to discover a resource. Full implementation of the plan will require between 14 to 20 years (beginning in 1982), depending primarily on the extent of the resources underlying the property and the rate at which a market to use the discovered resources is developed. Figure 2-3 shows the site development plan for the project.

The geophysical assessment of the property, together with historical data of volcanic eruptions from Kilauea and along the east rift zone, and the data obtained from the 3 MWe HGP-A geothermal power plant support the projection that sufficient geothermal resources are available within the boundary of the property to produce up to 250 MWe.

The most likely prospect areas within the property have been identified, based on proximity to the East Rift Zone and to the Kilauea Iki Crater. Within the several prospect areas, planned drilling sites and power plant sites have been tentatively located. It was determined that 35

multiple-well drilling sites would be required to fully develop the geothermal resource potential of the property. The location of these sites and the sequence of drilling are intended to balance the prospects of discovery in potential resource areas with acceptable risks from volcanic hazards. Selection of additional drilling sites, as may be required to achieve the development objectives of the project, will be based on the results of all previous drilling on the property.

Five prospective electrical power plant sites are located within one to two miles of the drilling sites, except in several cases where the volcanic hazards potential dictates further separation between wells and power plants. The final location of a power plant, and its generating capacity, will be determined primarily by the location and characteristics of producible wells, volcanic hazards and environmental considerations.

Initial project activity through 1987 will be directed towards discovery and development of resources to compete for a contract with Hawaiian Electric Light Company (HELCO) for supplying base load power up to 25 MWe. If successful, a power plant with the required capacity will be constructed. Additional exploration drilling as may be feasible will be conducted during this period to extend the known area of proven reserves. Additional development drilling would be undertaken to meet new or potential market demands. The impetus towards proceeding with plans to interconnect the islands with an undersea transmission cable depends largely on demonstrating the existence of sufficient, reliable resources in the Kilauea rift zone to supply the cable. It would require 20 successful exploration wells to prove the potential of the Kahauale'a parcel to produce 250 MWe. Figure 2-4 indicates the preliminary schedule for the project exploration and development activity.

Up to 30 exploration and development wells could be drilled by 1987 if warranted by drilling results and market demand. It would be possible to

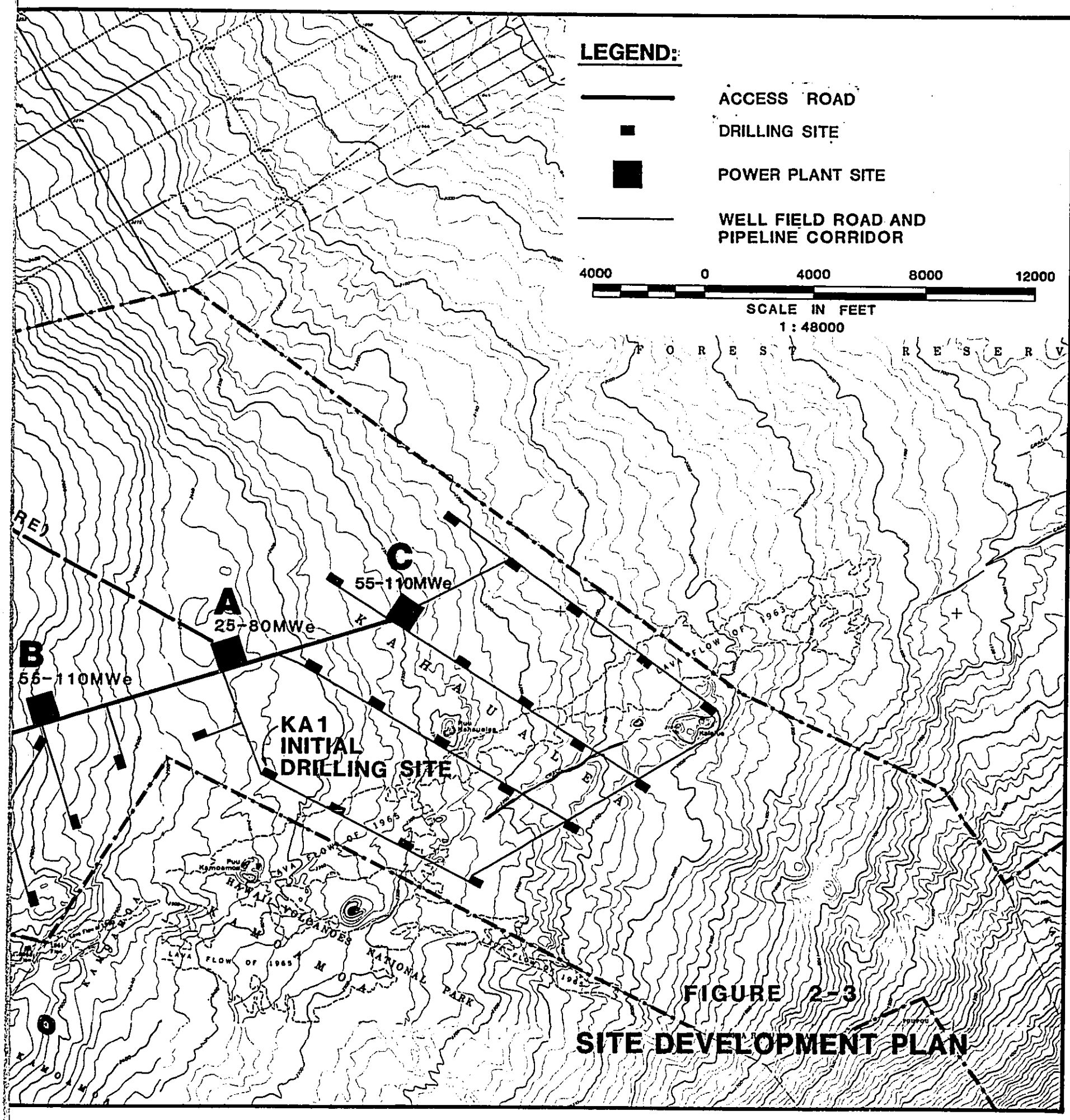
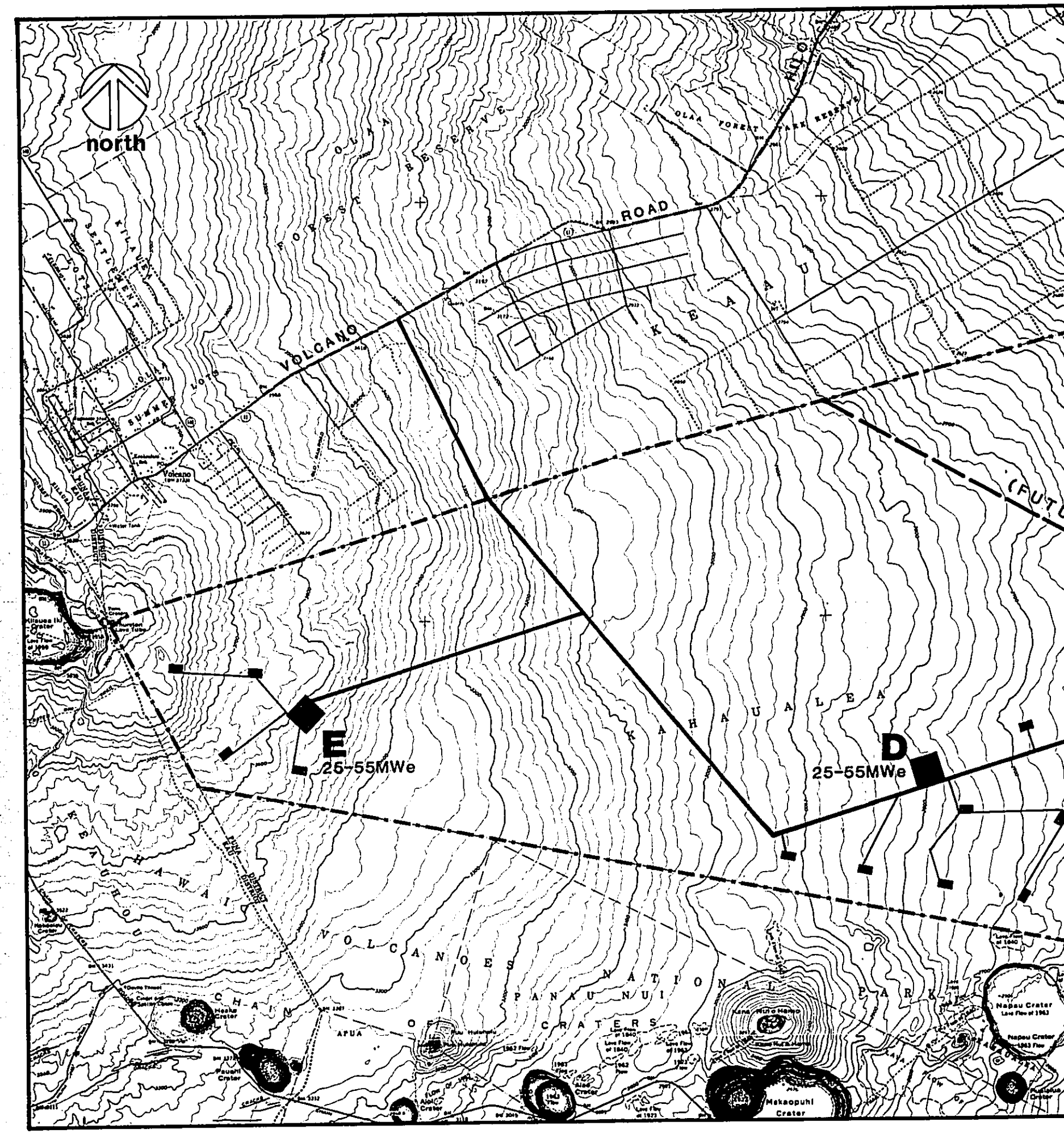


FIGURE 2-3

SITE DEVELOPMENT PLAN


north
VOLCANO ROAD
OLAA FOREST RESERVE
KEAAU
KAHAUALEA
E
25-55MWe
D
25-55MWe
HAWAII
VOLCANOES NATIONAL PARK
CHAIN OF CRATERS
Volcano
Mekaopuhi Crater
Napau Crater

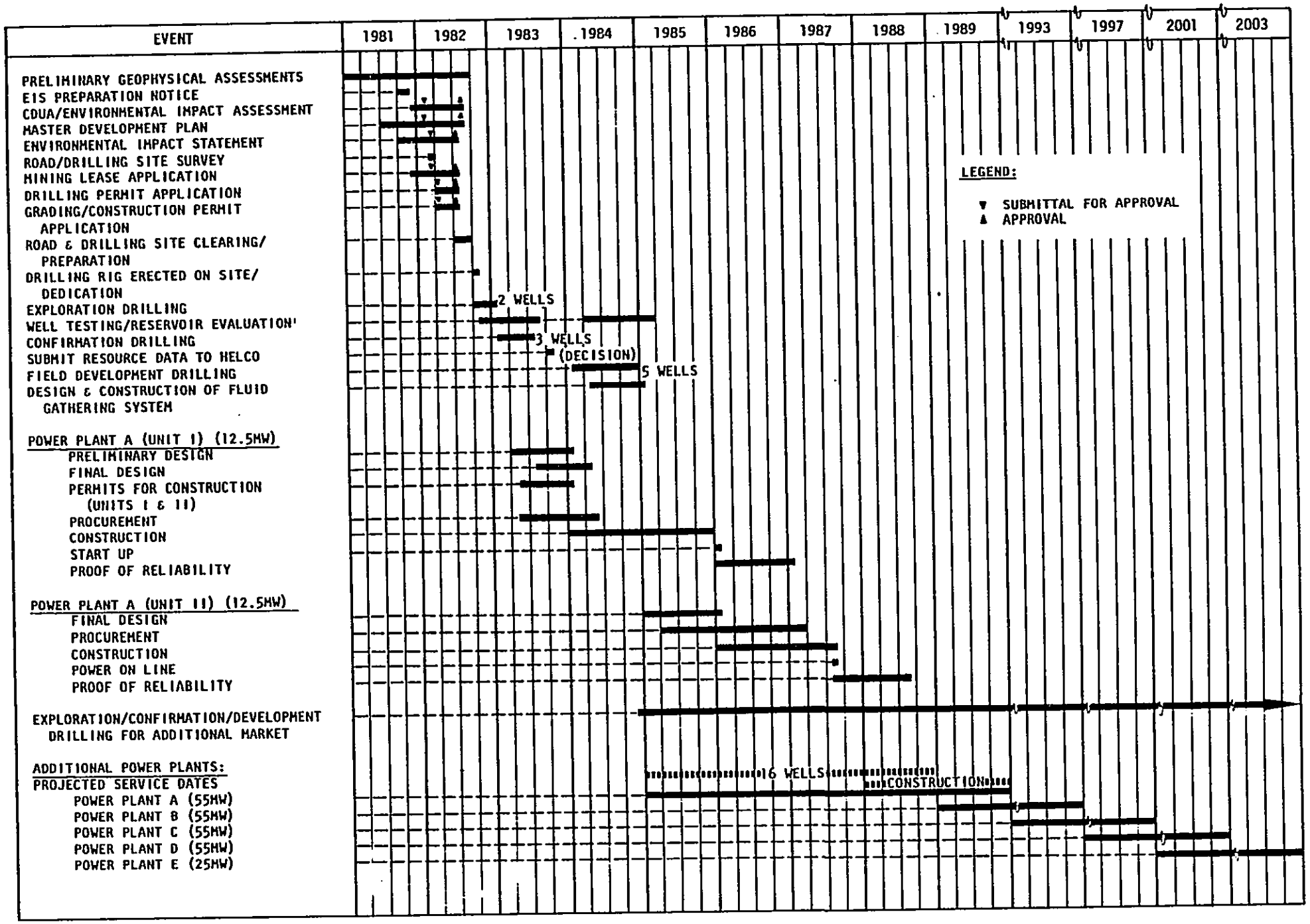


FIGURE 2-4

PROJECT DEVELOPMENT SCHEDULE

continue at this rate so that by year 1994, there would be a sufficient number of production wells to produce approximately 150 MWe of power, and 250 MWe by year 2002.

After year 2002, project activity would consist primarily of drilling replacement wells, well field maintenance operations to maintain production capability and additional exploration drilling.

2.3.2.2 Drilling Plan

It can be projected that the probability of discovering a geothermal resource in the project area is high; however, the probability of discovering a producible resource at any particular drilling site is less than 50 percent. After a discovery is made within a drilling site, it is expected that one of three wells will be unsuccessful, that is, have inadequate production to be economically viable. Hence, the number of planned drilling sites is more than will be developed. Using geological data gained from previous drilling to influence the choice of subsequent drilling sites, the number of unsuccessful wells drilled can be minimized, reducing the total number of wells drilled to fully develop the resource potential of the property.

In order to enhance the chances of discovering a producible resource on the first well, the first drilling site (KA1, as indicated on Figure 2-3) will be in an area of high geothermal potential, recognizing the possibility of hazard due to lava flow. In attempting to define the boundaries of the producing reservoirs, subsequent exploration drilling, assuming success on the first well, will move towards areas of gradually reduced potential and volcanic hazard. Geophysical evaluations indicate the resource potential diminishes rapidly as the distance from the rift zone increases. However, the potential is considered to increase again in the Northwest area of the property due to its proximity to Kilauea Iki Crater. The lava flow hazard is greatest in the active area of the rift zone and south of this zone and reduces towards the north and west.

After an initial discovery is made, the characteristics of the resource and reservoir must be evaluated through analysis of the fluid and flow testing of the well while simultaneously initiating the drilling of one or more confirmation wells to ascertain the dimensions of the reservoir and to obtain additional data on the production characteristics of the resource/ reservoir. Data thus derived will be used to justify undertaking of development (production) drilling to supply a market.

After reservoir confirmation and evaluation is completed and a decision is made to develop and market the resource, development drilling will be initiated in one of the exploration or confirmation drilling sites from which a discovery was made or confirmed. If directional drilling is not feasible from any successful exploration or confirmation drilling site, it will be necessary to drill from single well sites initially spaced to optimize production and utilization of the resource. In such cases, it is anticipated that up to 6 step-out wells would be drilled within a radius of 2,000 feet from the intended multiple well drilling site.

Concurrently with commencement of development drilling, refinement of the development plan for the area of discovery can begin. For example, planned development drilling patterns may be adjusted, if required, to move in the direction of the indicated reservoir trend; production and marketing plans can be adjusted; preliminary design for the type of power plant most suited for a particular reservoir can begin; earlier assumptions can be validated or invalidated; and adjustments, as required, can be made in the development plan.

It is estimated that resources underlying the Kahauale'a property will be discovered at depths beginning at 4,000 feet below sea level; that the optimum production zones of a reservoir will range at depths between 6,000 and 8,000 feet below sea level; that the reinjection depth can be set at approximately 2,000 feet below the basal water level depending on the local geology. As much as possible, the water quality will be monitored during drilling operations. Abandoned wells will be plugged in accordance with

Chapter 183, Subchapter 19, HRS, and State mining lease requirements, but normally at three locations: at the surface; near sea level; and at least one point substantially below sea level to preclude upper movement of the warm, brackish water.

2.3.2.3 Scope of Planned Development Activity

In spite of a number of uncertainties about locating and producing geothermal resources, the developer recognizes the need to be as definitive as possible in preparing the development plan so that all review and approval agencies and the public will know what is being requested for approval and how it will be implemented if approved. Therefore, the scope of the plan has been limited in the following areas to better define the major parameters on which regulatory agency review and permitting decisions can be made:

- The development plan is designed primarily to convert discovered geothermal resources into electrical energy with steam turbine generator power plants for sale of electric power.

- The potential amount of electrical production that can be generated from this property is estimated at 250 MWe. Power plant capacity will be limited at any one location to 110 MWe. If an increase in production in excess of 250 MWe can be achieved and the market to use this additional power develops, a supplement to the EIS would be submitted for approval.

- The total land areas to be disturbed by the exploration and development activities, the construction of gathering systems and electrical generating facilities, and the transmission lines is not expected to exceed approximately 1.7 percent (422 acres of the 25,461 acres) of the property (see Table 5-1 on total acreage required for project. If directional drilling is not feasible, an additional 220 acres (approximate) could be required for individual production wells.

2.3.2.4 Technical and Economic Considerations

The principal technical and economic considerations which affect the implementation of this plan are as follows and were considered within the context of the environmental concerns:

- Selection of potential drilling sites which offer the best potential for locating a producible resource while simultaneously minimizing the potential for volcanic and seismic hazards.

- Selection of sites for power plants in safe areas and in close proximity to the producing wells to allow economic transport of the geothermal fluids to the using facility.

- Provision for the proper spacing of production wells to attain optimum use and conservation of the discovered geothermal resources.

- Evaluation of any discovered resources and reservoir(s) to determine whether long-term quantity production is technically and economically feasible and making the decision to proceed with development.

- Optimization of the rate of exploration and development efforts in parallel with development of a market to use the resource.

2.3.2.5 Project Cost Considerations

While little industry experience data on geothermal exploration and development costs has been developed in Hawaii, experience data from other development areas can be used as a guide to develop initial cost estimates for the early phases of the project. Because of the widely varying conditions in each development area, especially as to the nature and quality of the discovered resource and the underlying geologic structure, a range of costs for the various operations and components of the project has

been used. The initial cost estimates are projected for a 25 MWe resource production capacity and power plant. If the project is successful, and additional resources are discovered to meet a market demand, adjustments in these estimates will be made as incremental development occurs. New technology and environmental considerations that may be reflected in subsequent development could cause significant differences in project costs.

The following cost estimates (1981 dollars) are projected for an initial 25 MWe projection and generating capacity:

- Shipping Costs for Drilling Equipment .... $0.3 to $0.5 million

- Total Average Cost
  Per 10,000-foot Well ..... $1.7 to $2.5 million
  (Includes all costs for labor, a prorated share of road construction, site preparation, well head equipment, drilling pipe, casing, cement, drilling supplies, equipment, maintenance and well logging.)

- Fluid Gathering System ..... $5.3 to $7.3 million
  (Includes pumps, filters, pipelines and supports, separators, insulation, valves, flash tanks and settling tanks.)

- Power Plant Per MWe ..... $1.0 to $1.5 million
  (Includes generator, steam turbine, condenser, pump systems, emission abatement systems and cooling towers.)

- Field Operations and Maintenance
  Per Year ..... $0.8 million
  (Includes maintenance of well bore, well head equipment and gathering system, reworking and abandoning of wells, road maintenance, etc.
  Does not include costs of drilling replacement wells.)

Excluding capital costs of drilling rig and equipment and post development operating costs, it is estimated that the cost for exploration and

development of the geothermal wells and the construction of the power plant to deliver 25 MWe will range between $44.0 and $65.0 million. All of these costs will be assumed by private capital.

The costs to HELCO to construct and maintain the required power transmission lines are not included above. For the 69 KV transmission system, they are estimated at approximately $1.7 million for the central switching station and $300,000 per mile for the dual lines within the access road corridor.

2.3.2.6 Contingencies

Following is a list of events which should they occur will result in adjustments in the development plan.

- Development schedules may be delayed due to lack of market, unexpected technical and mechanical difficulties in drilling, and natural causes; or the development drilling may be accelerated in the event markets develop earlier than forecasted.

- The drilling sequence and pattern, road locations and power plant sites and size may have to be altered due to information obtained from previous drilling, geophysical data, reservoir analysis and environmental considerations.

- Unexpected difficulties in directional drilling from a planned multiple (development) drilling site could require that some or all development wells be drilled vertically from separate surface sites.

- Well testing/resource evaluation may have to be extended due to difficulties encountered during the regular test period.

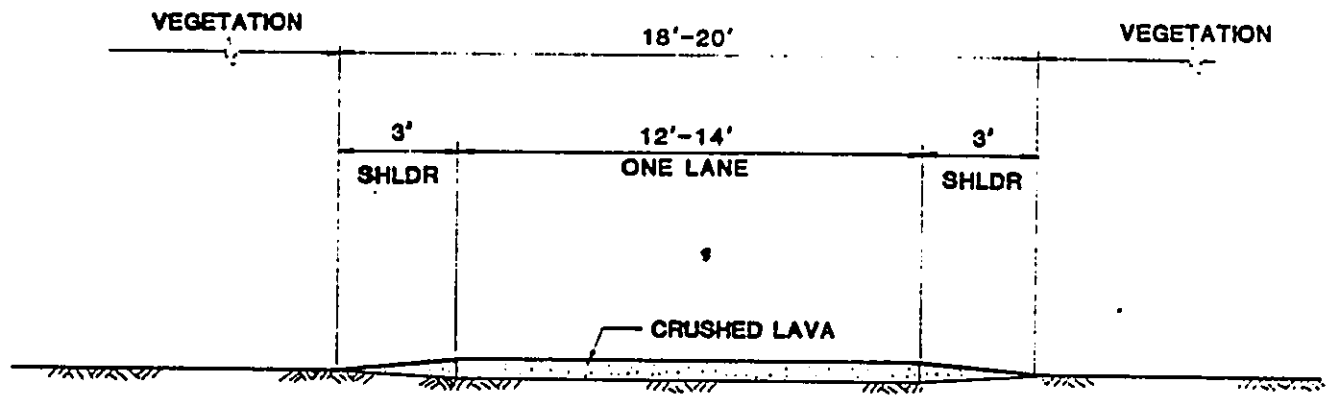
- Notwithstanding the relative isolation of this property and the installed noise attenuation devices, noise levels from drilling, construction, and well testing could temporarily exceed standards at the nearest residence due to climatic conditions.

2.3.3 Road Description

2.3.3.1 Road Design

At present there are no roads within Kahauale'a. The Site Development Plan (Figure 2-3) indicates an ultimate roadnet to support the planned 250 MWe production level. As indicated thereon, there will be access roads leading from the existing Volcano Road (State Highway No. 11) into Kahauale'a and connecting the separated power plant sites. An existing 1.4-mile easement through the undeveloped W. H. Shipman, Ltd., property will permit direct road access from the Volcano Road to Kahauale'a. Discussions have been initiated with the Directors of Fern Forest Vacation Estates Community Association for a future easement (Figure 2-3) through Fern Forest to provide an alternate road (principally for egress) from the eastern portion of the project area.

The constraints in road design in Kahauale'a are severe. They include minimal road length and width to mitigate the environmental impacts, avoid the volcanic hazards (geophysical faults and cracks) that characterize the rift zone, avoid of the areas believed to include unique botanical communities and to minimize the high cost of construction. In addition, the access road corridor must be essentially straight to accommodate the power transmission lines. An evolutionary approach for the access road is required for construction wherein the initial minimal one-lane, unpaved road can evolve into a two-lane paved road with provisions for power transmission line corridors. Figure 2-5 indicates the planned road designs for the initial and ultimate access and well field roads. The access roads are the main roads from the Volcano Highway into the project area, interconnecting the power plants. The well field roads are the secondary roads leading from the power plants to the drilling sites.



INITIAL ACCESS & WELL FIELD ROAD
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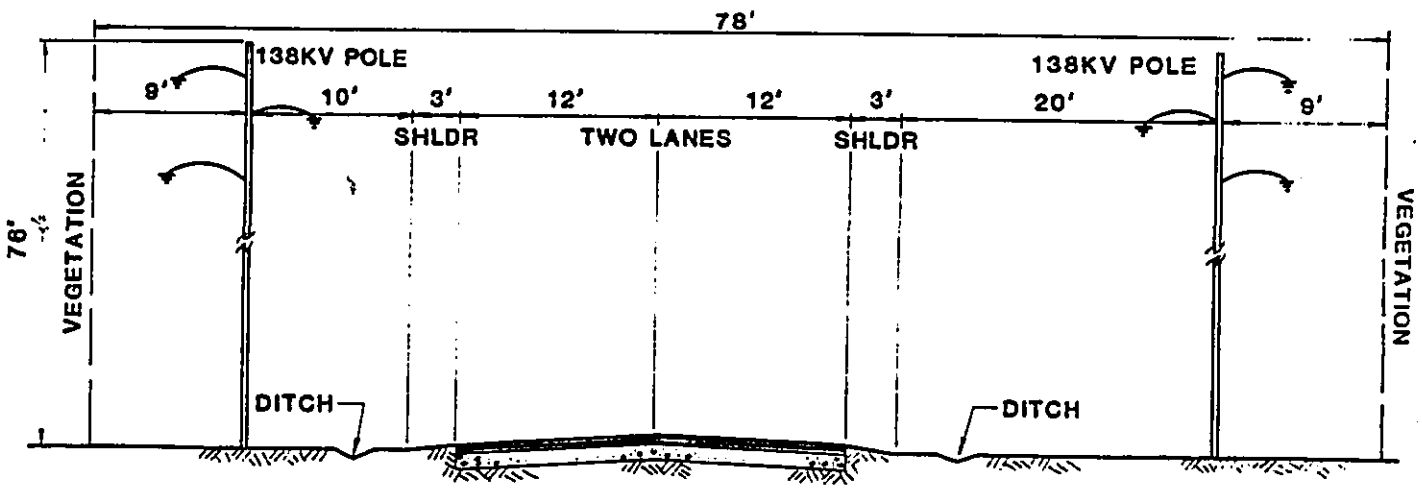

ULTIMATE ACCESS ROAD
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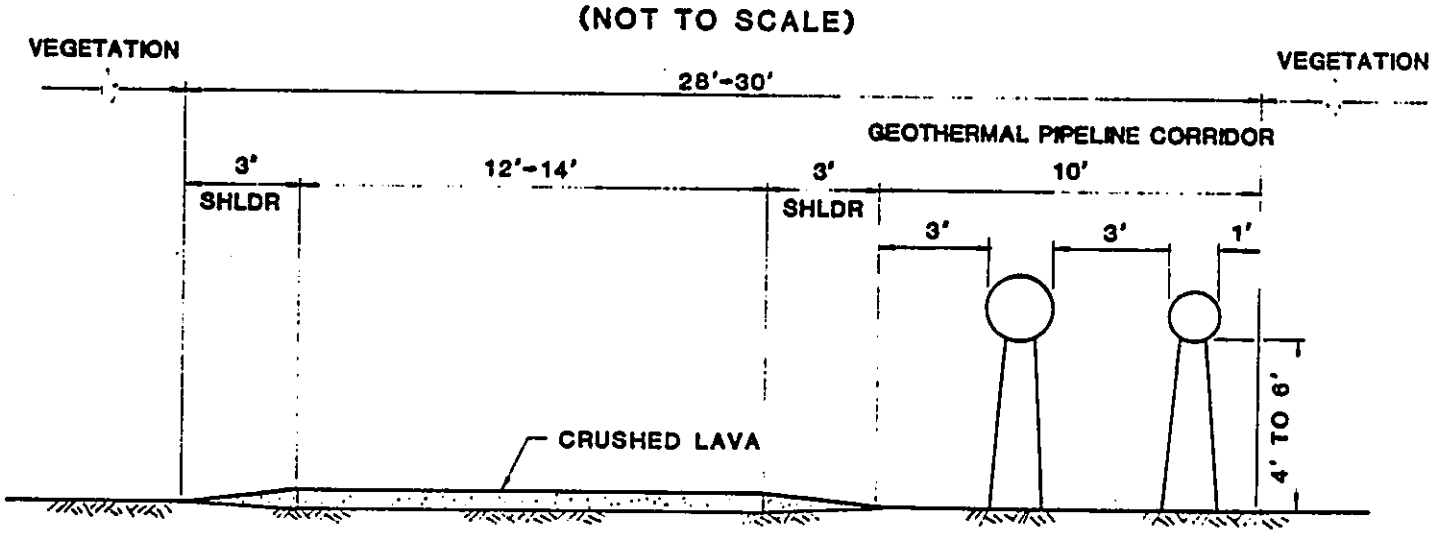


ULTIMATE WELL FIELD ROAD
(NOT TO SCALE)

FIGURE 2-5
ROAD DESIGN

Development of both the access roads and the well field roads will follow the same pattern of alignment selection. Alignment selection has initially been limited to the access and secondary roads required to move the drilling equipment to the first drilling site. Other alignments will be selected as the development progresses. Alignment selection will initially be planned using the above constraints and available information. The planned alignments will be laid out in the field using conventional land survey methods. The alignment will then be field evaluated by means of a ground survey by a multi-discipline team of experienced road engineers, ecologists, archaeologists and geologists. Alignment adjustments will then be made as indicated by the ground survey team assessment before final road construction is initiated. The initial access road from the Volcano Road to power plant site "A" and the initial well field road to the first drilling site (KA1) have been so planned and validated by ground survey. This pattern of alignment selection will be used on all subsequent access and well field road alignments.

The initial access and well field roads will be designed for low speed movement of trucks and trailers to the drilling sites. The design of the roads will be submitted for County approval. An estimated 40 to 50 trailer loads will be used to move the disassembled drilling rig and equipment by truck tractors to the drilling site. The basic design requires clearance of the vegetation to a width of 18 to 20 feet, which will include shoulders and some width for turnouts and passing. The roadway width of 12 to 14 feet will be developed by scarifying and grading the on-site pahoehoe lava, with limited addition of aa lava fill material where required to develop a suitable and minimal roadway. Since the alignment is well drained, drainage ditches will not be required except in those limited bog areas that may be encountered. The gentle, flat slope (3 percent grade) of the Kahauale'a area will permit road construction with a minimum of excavation and embankment. The on-site pahoehoe lava provides an excellent subgrade for road construction.

The ultimate access road will be a two-lane roadway (24-foot width) with three-foot shoulders and corridor provisions on each side for 138 KV power lines (initially 69 KV). The Site Development Plan (Figure 2-3) indicates an overall access road mileage within Kahauale'a of approximately 9.8 miles (not including the possible future access road through the Fern Forest Vacation Estates). The ultimate well field road will include a 10-foot geothermal pipeline corridor with pipelines to carry the hot geothermal fluids from the well sites to the power plants and the spent fluids from the plants to the injection well sites. These steel pipelines will be designed to blend in with the natural background colors and will be elevated on saddles 4 to 6 feet aboveground. The Site Development Plan indicates that approximately 19.2 miles of well field roads will be required to connect all 35 drilling sites to the power plants.

2.3.3.2 Road Construction

The construction of the initial access and well field roads will follow existing practices on the Big Island for construction of access roads through forested areas. A large bulldozer will proceed down the alignment, dozing away the vegetation to the desired clearance width. The larger trees that are unavoidable will be cut and removed to the side of the cleared area for later harvesting if desired. A second bulldozer with scarifier teeth and dozer blade will pulverize the pahoehoe lava. Steel rollers will be used for crushing the lava as required. A motor grader will shape it to the desired grade and cross section for truck traffic. Aa lava fill material will be trucked in and used to build up the road bed as required. The 14-foot roadway width will be maintained except where construction obstacles (e.g., large trees) indicate a reduced 12-foot width. It is estimated that the initial access road construction will cost in excess of $50,000.00 per mile of length.

2.3.3.3 Road Operation and Maintenance

All road operation and maintenance activities will be conducted by the developer. Kahauale'a will have controlled access, in that only project and government agency personnel will be permitted access to this privately owned land. A project access control station will be established where the

access road connects to the Volcano Road. In general, public access will not be permitted due to safety consideration and the need for control of personnel and vehicles in an area of mining operation and heavy construction equipment activity and volcanic hazards.

Use of the initial road network will be limited to those activities in support of the drilling operations. The low speed, low volume of traffic initially planned will require a minimum of road maintenance with a motor grader. Construction and maintenance of the power transmission lines and corridors on the sides of the access roads will be conducted by HELCO.

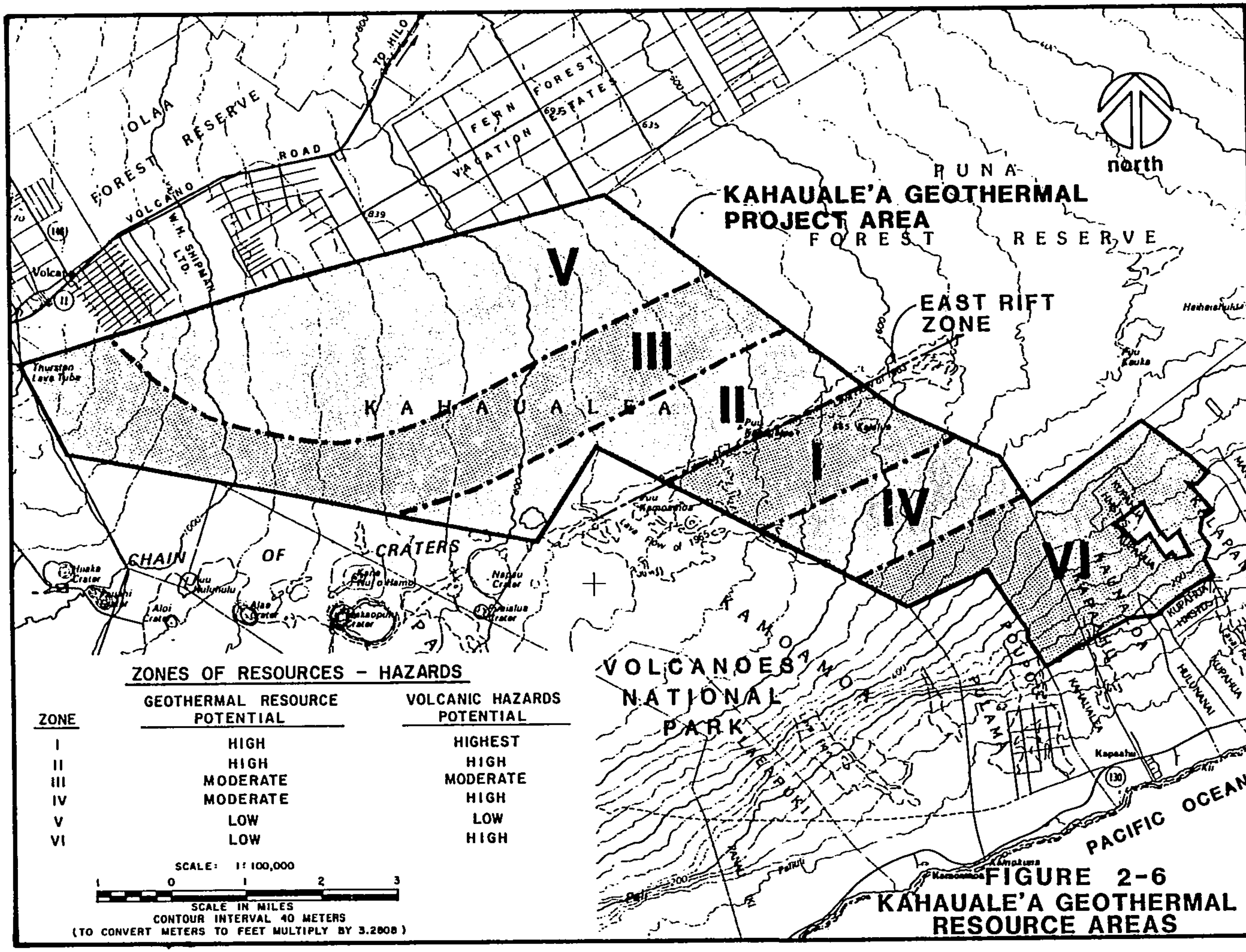
2.3.4 Well Field Descriptions

2.3.4.1 Drilling and Well Testing

A. Design

The project's Site Development Plan (Figure 2-3) indicates a grouping of well sites for each power plant. The well field includes the drilling sites that feed geothermal fluids into the power plant and the associated well field roads and pipeline corridors. The Site Development Plan indicates the planned distribution of drilling sites and well fields based upon the presumed uniform distribution of the underground geothermal reservoir. The Kahauale'a project area has been conceptually divided into six zones of varying geothermal resource potential and volcanic hazards potential (Figure 2-6). The drilling, operation and maintenance of geothermal wells are closely regulated by the State regulations, "Rules on Leasing and Drilling of Geothermal Resources," Chapter 183, HRS.

The objective of well field planning is to develop the well field in the areas of highest geothermal resource potential and least volcanic hazards potential. The planned well fields in Kahauale'a have therefore been limited initially to Zones I, II and III (see Figure 2-6). A planning constraint is the assumption that no geothermal power plant of greater than 110 MWe capacity should be



ZONES OF RESOURCES - HAZARDS

ZONE	GEOTHERMAL RESOURCE POTENTIAL	VOLCANIC HAZARDS POTENTIAL
I	HIGH	HIGHEST
II	HIGH	HIGH
III	MODERATE	MODERATE
IV	MODERATE	HIGH
V	LOW	LOW
VI	LOW	HIGH

SCALE: 1:100,000

SCALE IN MILES
CONTOUR INTERVAL 40 METERS
(TO CONVERT METERS TO FEET MULTIPLY BY 3.2808)

FIGURE 2-6
KAHAUALE'A GEOTHERMAL RESOURCE AREAS

constructed in any one location, to avoid any possible overload effect on the environment. Another planning constraint is the engineering criteria of keeping a power plant's well field within a two-mile radius of the power plant to limit costs and to prevent unacceptable heat losses in the movement of the hot fluids to the plant.

The individual drilling sites indicated on the Site Development Plan are planned to ensure complete coverage of a geothermal resource presumed to be uniformly distributed underground in Zones I, II and III. Extensive instrumentation of the rift zone in Kahauale'a is being conducted to obtain a better definition of the likely distribution of the geothermal fluids within the project area in order to more precisely locate the drilling locations. This remote sensing will be combined with the early drilling results to determine the subsequent locations of the drilling sites. The ultimate pattern of the developed well fields in Kahauale'a will evolve with time as the productive geothermal resource zones are identified and developed. Final location of drilling sites will follow the same pattern as that used in locating road alignments. All planned sites will be validated by ground surveys. Environmental consultants, including archaeological, will be used as required in selecting new sites.

Four of the five planned power plants are located on a line above and parallel to the rift zone to ensure survivability during volcanic events. As indicated in the planning of the initial well field, Well Field "A" (Figure 2-7), the well fields of necessity must extend down to and through the rift zone to tap the most probable geothermal resource location. The well field roads generally traverse the rift zone at a right angle to minimize the obstacles in crossing the faults and cracks of the rift zone and to provide the most direct routes away from the

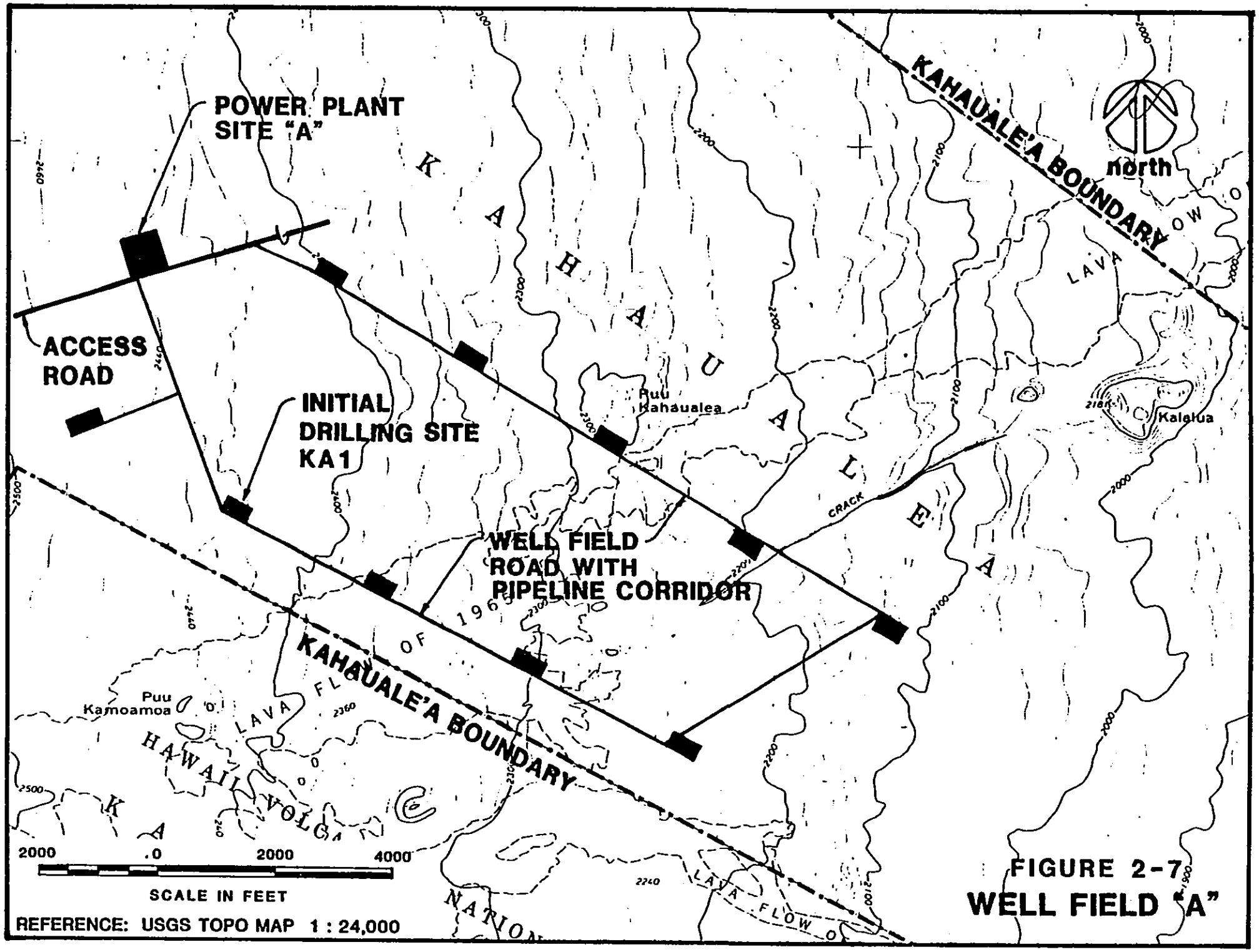
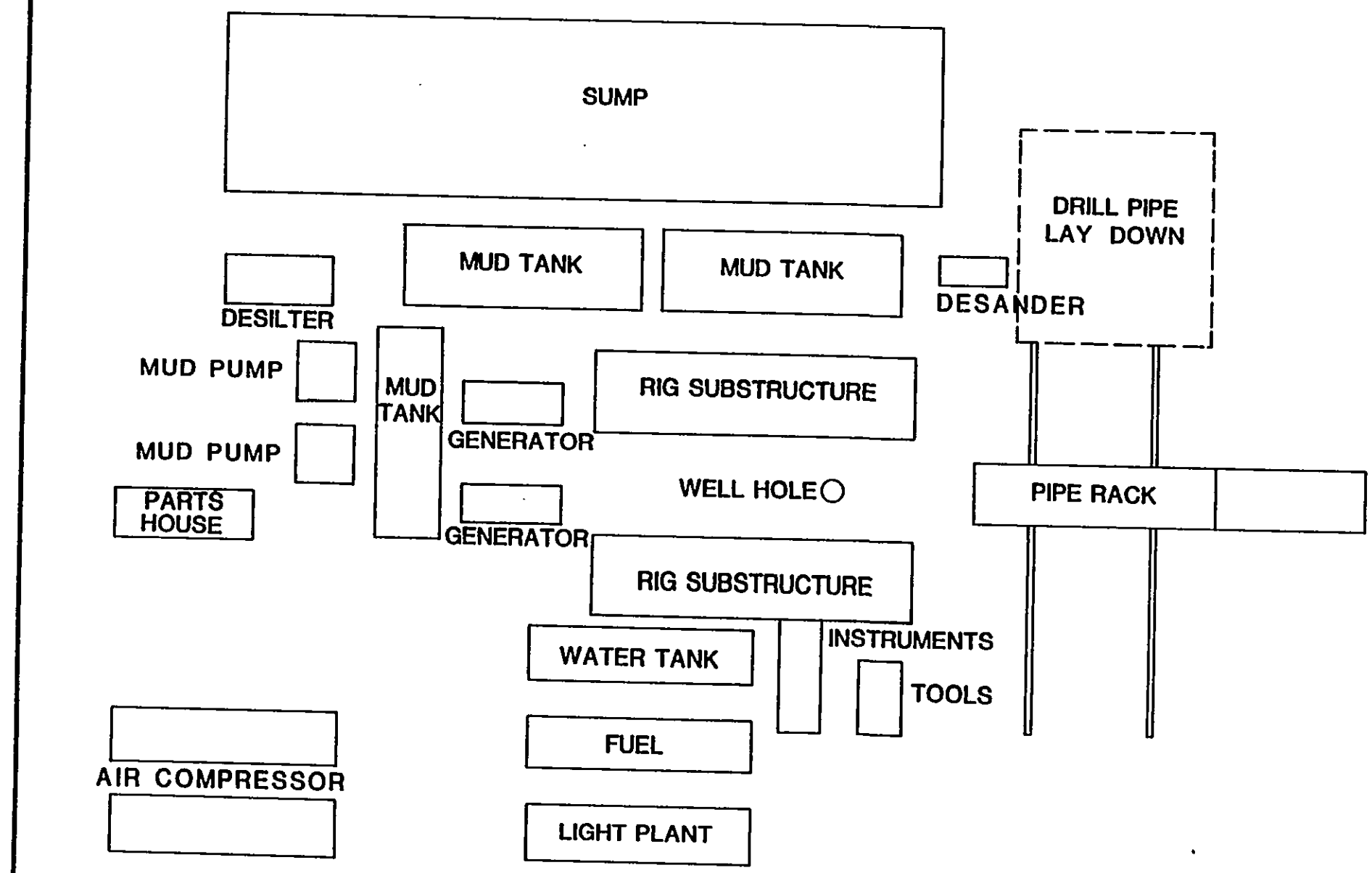


FIGURE 2-7
WELL FIELD "A"

rift zone in case of volcanic activity. An exception is the well field for power plant "E" which is essentially unrelated to the rift zone and derives its geothermal potential from proximity to the Kilauea Iki crater. A design constraint by the developers is the voluntary setting of a reasonable offset distance of 1,000 feet from all property boundaries for all surface construction activity, e.g., drilling sites and well field roads. Actual underground drilling may be conducted to within 100 feet of all property boundaries through use of directional drilling from the drilling sites.

Each multiple well drilling site will require approximately 5 acres. However, the cleared area for each site may be limited initially to approximately 2 acres for drilling of the first well. If the exploration results in a discovery of a producible resource, that site will become a development site where multiple production wells can be drilled directionally from the same site, using small (30 to 50-foot) offsets from the previous well holes on the drilling site. In such cases, the drilling site would be expanded in size to approximately 5 acres.

The planned configuration for a single well site (Figure 2-8) is a cleared rectangular area, approximately 500 feet in length by 300 feet wide to include a disposal sump with a depth of 10-12 feet and a capacity of 750,000 gallons (100,000 ft^3). A 60-foot wide perimeter is included within the drill site for safety and control. Over a period of 14-20 years, it is possible that a total of 17 exploration/development drilling sites covering approximately 5 acres each in size (total of approximately 85 acres) would be occupied, assuming the resource is spread uniformly in the areas of greatest potential, and directional drilling is possible at each site.



(NOT TO SCALE)

FIGURE 2-8
DRILLING SITE LAYOUT

Drilling operations are planned to commence within approximately 4 months after the developer obtains the last required permit or license from the applicable Federal, State or County regulatory agency. Following a discovery, confirmation drilling and well testing will be conducted to determine the nature and extent of the reservoir, and if warranted by the results, development (production) drilling will be initiated to meet a market requirement. If no immediate market exists, additional exploration wells may be drilled in the project area to further define the extent of the reservoir(s) underlying this property and to enhance development of a market for these resources.

For each geothermal reservoir, there is an optimum well location plan and well density that provides the maximum production rate under the prevailing operational and economic conditions. Pending resource discovery and completion of reservoir engineering analysis, the number and location of planned drilling sites (Figure 2-3) were determined on the basis of geophysical and surface geologic data, and the normal drilling pattern for initial spacing of one well (bottom hole) per 40 acres in those areas assumed to have high and moderate potential for geothermal resources. The pattern was adjusted to minimize volcanic hazards and adverse environmental impacts and to accommodate property boundary constraints.

Drilling sites are designated by a code which will interrelate all drilling conducted within a development area to a specific power plant that is to be located in that area to receive production from the wells. The designation code consists of two letters and a number to identify the site, followed by a second number to identify the well within a specific site. For example: "KA1," where "K" represents the Kahauale'a Geothermal Project; "A" identifies the power plant; "1" signifies the first drilling

site in the project area for power plant "A" site. Adding a second number, e.g., "KA1-1" indicates the first well drilled within the first drilling site.

All reports on wells will use the designation code followed by a letter in parenthesis to indicate the type of well. Wells are classified according to the purpose of the drilling or activity pertaining to a well as follows:

Exploration -	(E)
Confirmation -	(C)
Development -	(D)
Injection -	(I)
Reworked Well -	(R)
Abandoned Well -	(A)

The bottom hole location of all directionally drilled wells will be described as a direction and distance from the surface drilling site. Prior to initiating drilling, a "target" location for the bottom hole will be reported. Upon completion of the well, the actual bottom hole location and depth will be reported.

Drilling sites will be occupied in a sequence that will best accomplish the objectives of the project. Previous drilling results will have the most significant influence on selection of subsequent drilling sites and bottom hole targets. Site specific environmental considerations may also influence drilling sequence and alternate site locations.

The initial drilling permit application will be filed with DLNR for drilling of 12 exploration or development wells at selected drilling sites in the conservation district portion of Kahauale'a. It is expected that at least two of these wells will be converted to injection wells.

The first exploration well in the project area will be drilled vertically. Subsequent exploration wells will be drilled vertically, or directionally, depending on the results of previous drilling. Confirmation and development wells will be drilled directionally wherever feasible.

In the initial stages of implementation, development drilling will progress at a rate that reflects existing or firm future demands for electrical power. Because of the current requirement for additional power on the Big Island and the minimal base load HELCO can initially accept from a geothermal power source, the first phase of development drilling will be limited to that required to produce sufficient resources to supply a 25 MWe power plant. Depending on the quality and quantity of the resource, approximately 8 development (production) wells would be required to supply a plant of this capacity. The drilling required to provide this quantity of resource (up to 12 wells) could be completed within approximately 24 months. Changes in market projections or demand would require reevaluation of development drilling plans.

B. Construction

Figure 2-9 indicates the basic elements of a rotary drilling rig of the type to be used at Kahauale'a. The proposed drilling rig to be used is capable of drilling to depths of 13,000 feet using 4-1/2-inch drill pipe with 3-1/2-inch drill pipe below 11,000 feet. The proposed drilling rig consists of the following or comparable components and auxiliary equipment.

National 50-A Drawworks with 40" double hydromatic brake with two Waukesha F2896 DSIU Engines rated 500 HP each.

Twin disc fluid couplings.

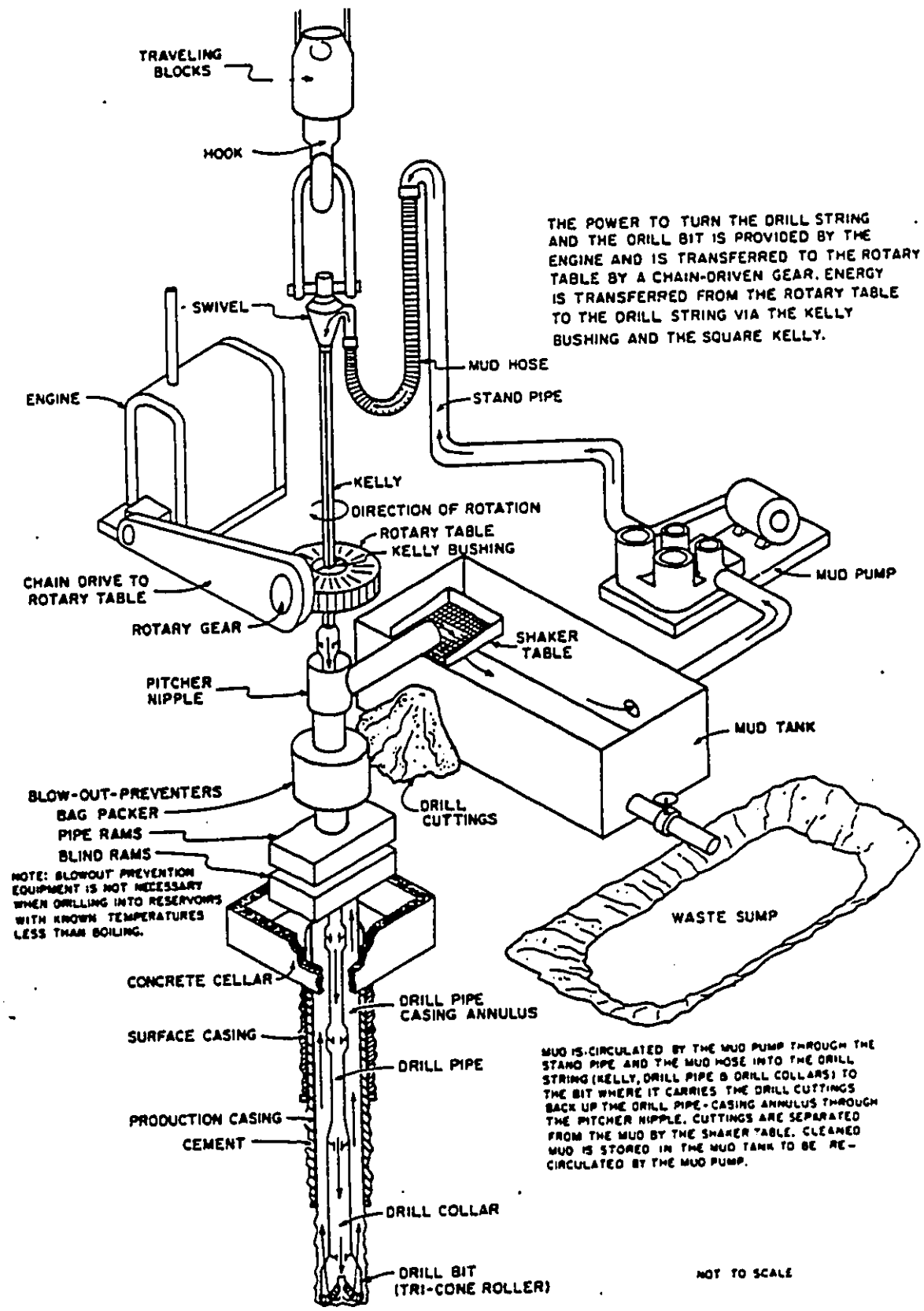


FIGURE 2-9

BASIC ELEMENTS OF A ROTARY DRILLING RIG

Lee C. Moore Jackknife Derrick (131' x 18') capable of stringing up six to eight lines. Sixteen-foot clearance under rotary beams. Capacity is rated at 750,000#.

National K-700 Mud Pump (7" x 16") driven from compound. (Capacity: 600 GPM)

National C-250 Pump (7-1/4" x 15") driven from compound. (Capacity: 400 GPM)

Ideco Rotary Table (27-1/2") driven by the drawworks.

Shaffer Type B Double Gate Blowout Preventer (12"-900) 5000# working pressure, with 900 series flanges, hydraulically operated.

GK Hydril Preventer (12"-900).

Rotating Head (12"-900).

200 KW Three Phase 110-220 AC Generator.

125 KW Three Phase 100-200 AC Generator.

Hutchinson Vapor Proof Lighting System.

Three Steel Mud Tanks 5' x 8' x 28'.

Link Belt NRM 145 4' x 5' Shale Shaker.

Three (3) Cone Desander.

A mud system capable of circulating 500 barrels of fluid with one shale shaker and 400 barrels of mud in storage.

Bear Automatic Driller.

TOTCO 3 Pen Recorder.

11,000' 4-1/2" OD 16.60# Grade E drill pipe with 6" OD API extra hole tool joints.

18 6-3/8", 6-1/2", 7" OD x 2-13/16" ID x 30' long drill collars with 4-1/2" extra hole tool joints.

450 Bbl. Water Tank.

Trailer House.

Transportation of the drilling rig, auxiliary equipment and supplies into the project area will require three axle trailers with tandem tractors to haul loads up to 40,000 lbs. Local truckers and cranes will be used. Transfer of all equipment and supplies to the project area is expected to take three days.

Drilling operations will be conducted by a 15-man crew on a 3-shift basis of 5 men each; drilling supervisors and geologists will direct the operations.

The drilling program is usually divided into phases according to the type of drill pipe or casing installed at various depths. All geothermal wells (Figure 2-10) will be cased with standard drill pipe to protect the environment, groundwater resources, geothermal resources, life, health and property. Casing is normally classified according to depths installed or function as follows:

1. Conductor Pipe. The first string of pipe installed, normally 20-inch diameter to 150 feet (100 lbs./ft.) set in 26-inch hole.

2. Surface Casing. 13-3/8-inch diameter API grade to 2,500 feet (50 lbs./ft.) set in 17-1/2-inch hole.

3. Intermediate Casing. 9-5/8-inch diameter to 3,600 feet (36 lbs./ft.) set in 12-1/4-inch hole. Set with hanger in 13-3/8-inch casing.

4. Production Liner. 7-inch diameter from the top of producing interval to total depth installed in 8-3/4-inch hole. Also will be set with hanger in 9-5/8-inch casing.

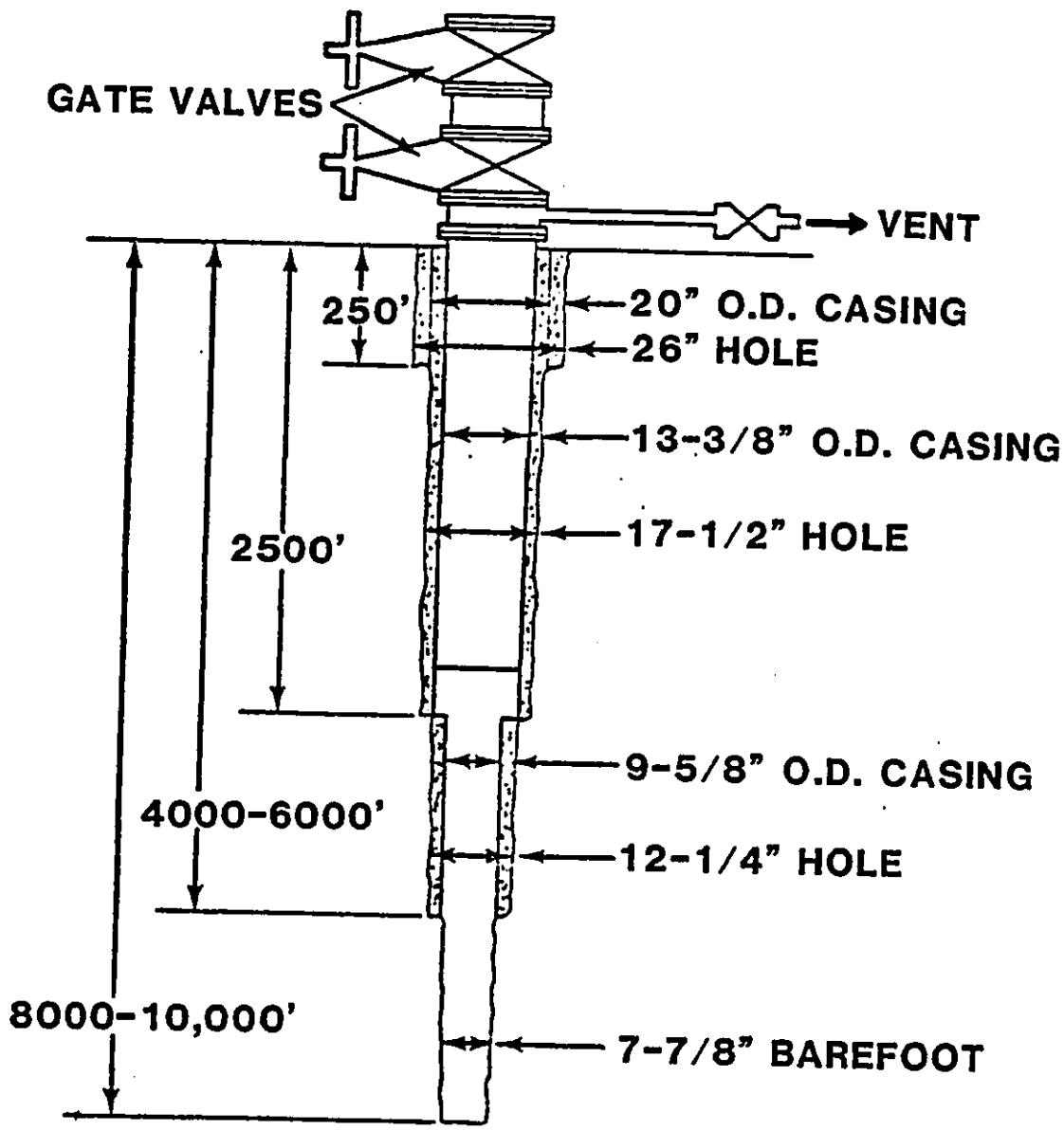


FIGURE 2-10
TYPICAL WELL PROFILE

Each well will have a casing head installed on the surface casing; to this a master gate valve will be installed which will be left on the well. In addition, a hydraulically operated master gate valve with annular preventer will be installed; when air drilling is being conducted, a rotating head will be installed for positive control.

Depending on the subsurface geology, it is planned to drill with air from the surface to total depth using two low stage compressors with 1,200 CFM and one high stage compressor for pressure up to 400 psi providing the formations drilled are compatible. Air drilling is successful in hard rock where there is no influx of formation waters. When air drilling is not possible, mud drilling will be conducted using the lowest weight per gallon ratio possible and the least viscosity possible to remove the cuttings from the formations drilled. For drilling in the softest formations, approximately 2,000 barrels of water per day would be required. For hard formations, approximately 100 barrels per day would be required. A rain catchment system will be considered as a supplemental source to meet project water requirements.

All casings will be joined and cemented to assure the integrity of the well bore from surface to the producing interval. The objectives in cementing the casing are to completely in-fill the cased and open hole annuli to resist landsliding and groundwater movement and to anchor the casing sections to each other and to the ground. The cement sheath will protect the casing against possible corrosion by thermal brines and gases, prevent uncontrolled flow of thermal water and steam outside the casing, and minimize creep due to thermal expansion. The casings will be cemented using Type G cement from the bottom of casing to the surface in accordance with industry standards. The 9-5/8-inch casing will be landed with hanger, cemented from hanger point to

top of producing interval. The 7-inch liner will be landed with hanger, from base of 9-5/8-inch casing to total depth. This liner will not be used if experience shows it unnecessary.

The following standard safety devices will be used to protect against a blowout from the well:

1 Double Gate preventer with CSO rams plus 4-1/2-inch drill pipe rams, 12-inch 900 series.
1 Annular Preventer 12-inch 900 series.
1 Rotating Head when air drilling.

A blowout prevention system is individually designed for each cemented casing string. Figure 2-11 shows a typical blowout preventer system designed for high pressure wells.

Safety is stressed in all aspects of this type of operation. All employees are and will be instructed in closing and opening blowout preventers (BOP's) which will be hydraulically operated. The operator has an on-the-job training program using video tapes and projectors pertaining to safety, BOP's and maintenance, etc. (True Drilling Company has been awarded the International Association of Drilling Contractors Safety Commendation Award for each of the past seven years.)

Hydrogen sulfide (H_2S) is known to be associated with hot springs and fumarole activities throughout the world. In geothermal development, it is a constituent of the fluid in varying degrees as a noncondensable gas. Abatement systems will be designed to control H_2S emissions during extended well testing and for power plant operations. The operator will have H_2S detectors mounted at various locations throughout the active area of operations for emission monitoring and control.

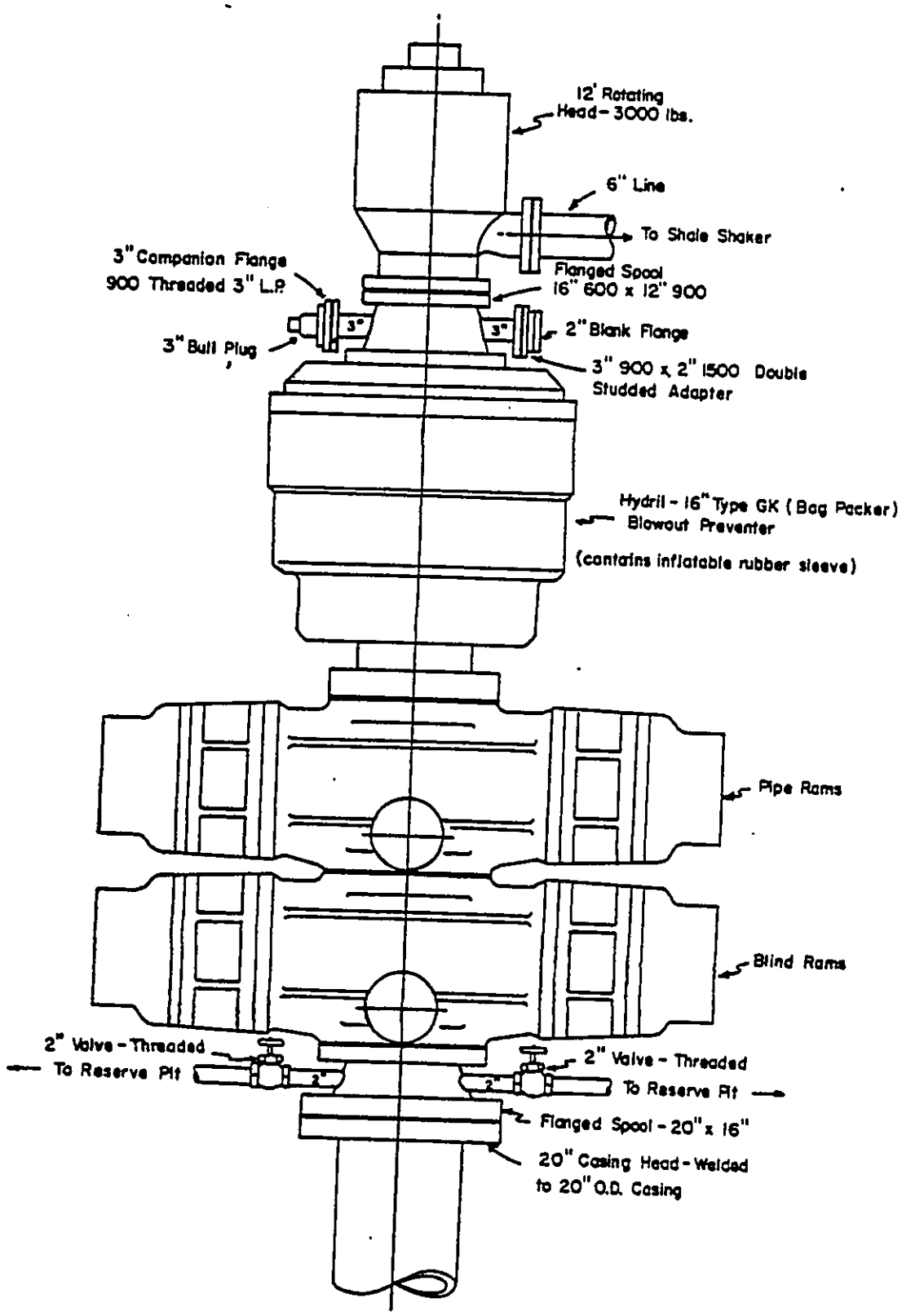


FIGURE 2-11

BLOWOUT PREVENTER SYSTEM

While drilling, all data will be recorded in duplicate. All information will be logged by a well site geologist. Summary reports will be made available upon completion of each well, as well as standard well completion reports.

The rig to be used has three steel mud tanks with 750 bbl capacity each; also an earthen reserve or storage pit will be dug and lined to handle excess fluid.

Upon determining that a well must be abandoned, the operator will analyze data from the logs to determine what formations are required to be covered by cement. The plugging will be performed through open ended drill pipe using Type G cement in accordance with industry standards. After the downhole plugging is performed, a cement plug will be placed in the top of the surface casing.

The operator carries liability insurance as required by Title 13, Chapter 183, HRS, for the drilling and completion of wells in the area.

C. Well Testing and Reservoir Evaluation

The viability of the project after discovery of a resource will be determined on whether characteristics of the geothermal reservoir and fluid are suitable for generating electrical power and the price received for that power. In essence, the following criteria determine the potential of a reservoir to support a power generation operation at full capacity for 25-30 years:

1. Depth and subsurface structure.
2. Temperature of the fluid.
3. Downhole enthalpy.
4. Flow rate of each well.
5. Chemistry of the geothermal fluid.

6. Reservoir and production zone dimensions (reserves).
7. Reinjection potential.

Testing of the wells will follow a procedure similar to the most recent test of the HGP-A well in Puna in which both noise and environmental pollution abatement was accomplished by use of a "sparging pit" and the injection of caustic soda to remove unwanted hydrogen sulfide gas. Tests will also be conducted on the integrity of the well to bottom hole through casing, logging of the cementing tests, and pressure testing.

After each well is completed, an initial test by accepted industry methodology will be conducted to get an approximation of its electric power production potential. If it is judged to be a commercial producer, portable flow testing equipment will be installed to acquire a full suit of data on the physical and chemical characteristics of the reservoir fluids. This will include a flash steam separator, skid-mounted flow metering and temperature measurement equipment for steam and brine, noncondensable gas sampling equipment, and injection and mixing equipment for H_2S abatement with caustic soda.

A warm-up pond or reserve pit will be constructed at each producing well site to receive the geothermal fluid flow during the production tests. For example, at the HGP-A well, the well flow rate amounted to approximately 85,000 pounds per hour. The project's environmental specialists will evaluate the reservoir fluids from each well and will consult with the appropriate regulatory agency to determine whether the fluid can be percolated into the ground or pond liners will be required. Due to the highly porous nature of the topsoil and near surface formations, fluids should percolate readily into the ground. The

chemistry of the well fluids are expected to be relatively benign, if similar to the HGP-A well, and should have no adverse impact on the basal water table at sea level.

During the production test, engineers will monitor the production rates, steam water ratio, hydrogen sulfide content, salinity, fluid chemistry, and noncondensable gas content. All of these items are necessary to design an appropriate power plant and to devise an appropriate abatement system for protecting the air quality, surface and subsurface environments. This information will provide a data base that is necessary in order to satisfy HELCO, or other user, that the resource and its production capability are totally reliable as an alternative energy source and that the potential for producing up to 250 MWe from the Campbell property can be realized.

When a minimum of three successful wells has delineated a potential reservoir of sufficient size, interference tests will be run to establish intercommunication within the reservoir and provide the necessary engineering data to assess the volume of the geothermal fluid reserves, the available heat, and the estimated productive life of the reservoir. A competent geothermal reservoir engineer will be engaged to independently assess the geothermal energy potential.

D. Operation and Maintenance

The well field production system for this plan as fully implemented would consist of 5 separate field (development) production areas comprised of production wells, well head equipment, pipelines and disposal systems managed through an integrated operations and maintenance system. For all practical purposes, the well field production systems for each area would be essentially the same except where applications of new

technology are made. This section describes the type of well field production system envisaged for the initial development activity within Kahauale'a.

The initial production is realistically planned to meet the current and near term market requirements projected by HELCO and to expand production capability as rapidly as HELCO can accept additional power. For this reason, the production plan during the first two years is to develop sufficient resources to supply a 25 MWe power plant in two increments of 12.5 MWe power plants; the first in 1986 and the second in 1987.

Resource production from three active wells and one reserve (spare) well are projected to be required to support installation of a 12.5 MWe power plant. The disposal of residual brine after production steam removal would require one injection well.

The second 12.5 MWe generator to be installed would be included in the initial complex with minimal additional equipment. However, five more wells as described above would be required.

The geologic and geohydrologic characteristics of the Island of Hawaii are unique in comparison to other producing geothermal resources in the world. Therefore, it is not possible at this stage of experience with the lower Kilauea east rift system to predict the long-term response of the wells to sustained high volume production. However, it is considered prudent to budget development on the assumption that the reservoir behavior will be similar to that of other hydrothermal resources where individual well production is known to decline with time.

There is little published data available on production histories of the various reservoirs; however, based on a study of the Cerro

Prieto field in Mexico by J. de J. Sanchez R. and A. de la Pena L., a requirement is assumed of two replacement production wells and one replacement disposal well for each 12.5 MWe plant over a 30-year period.

2.3.4.2 Geothermal Fluid Gathering System

The design of the gathering system that will carry the geothermal fluids to supply the power plants will be based on the following resource characteristics:

- Enthalpy (downhole)
- Wellhead Pressure
- Wellhead Temperature
- Flow Rate
- Well Spacing
- Projected Well Flow Decline with Time
- Reservoir Chemistry

Based on what is known of the resource discovered at the HGP-A well, it is expected that the gathering system selected to collect the hot geothermal brine will consists of a pipeline network designed for two-phase flashing flow from the well sites to a flash steam separator at the power plant. Considerations of topography, flow characteristics, and economy in the pipeline network will be utilized to optimize the final design of the network.

The two-phase flashing flow design simplifies the gathering process by not requiring wellhead or satellite separators, and eliminates the need for two pipelines.

Substantial cost advantages result in utilizing and optimizing this single pipeline gathering system. Two-phase flow experiments conducted by Mitsubishi Heavy Industries and Kyushu Electric Company as part of the design of the 50 MWe Hatchobaru geothermal power station in Japan have

demonstrated the feasibility of two-phase gathering systems over a wide range of transient flow conditions.

The gathering system piping will be of carbon steel, 4 to 6 feet above ground, mounted on saddles, with anchors and expansion loops as required by dynamic forces and thermal movements. The gathering system piping will be insulated to minimize heat loss. Typical sizes are expected to be 16 inches to 22 inches in diameter. Additional lateral restraints may be required to protect against possible lava flow hazards.

The primary component involved in the flashing process is the separator (or flash tank). Mixed brine and steam flow enters the separator at the inlet from the gathering main, and that portion of the flow flashed to steam is directed to the single stage turbine. All unflashed brine flows to the silica drop-out pond and then to the suction header of the injection pumps.

The separator has provisions for pressure control and is equipped with safety relief valves which open in the event of a turbine trip or other occurrence causing the main steam stop valves to close.

2.3.4.3 Geothermal Fluid Disposal System

Hydrothermal fluids with chemistry similar to that expected to be found at the Campbell Estate property are known to begin precipitating silica as they cool below 150°C. Because the residence time in the flashing equipment will be less than three minutes, only a nominal amount of silica scaling is expected at this stage. However, to eliminate plugging in the injection piping and wells the spent fluids would be cooled in ponds to drop out silica prior to transfer to the injection pumps. The cooled fluids would then be mixed with the spent caustic stream from the H_2S abatement system and the neutralizing cooling tower blowdown and pressured through polishing filters. This silica system will be sized to provide an hour's residence time and cooling to about 70°C.

Injection pumps at the power plant will return effluent from the silica dropout system and transfer clear effluent into the ground at a suitable injection site near the geothermal reservoir.

The injection pumps will receive effluent primarily from the flash separator, the cooling tower basin blowdown pumps and the bypass stream H_2S abatement system. The pumps will be rated to deliver effluent through the solids polishing filters and then to the wellheads at a wellhead pressure which is adequate to inject the design flow into appropriate geological formations.

Injection wells may be required to dispose of the residual fluids of geothermal power generation to avoid environmental degradation to the area, and to minimize temperature loss within the production field.

It is estimated that 65 to 75 percent of the original reservoir fluid will be available for injection. It can be assumed that a disposal well will consume more fluid than a production well can produce because of the added effect of the hydrostatic column of water. Thus, only one disposal well may be required for every three operating production wells.

Several criteria for disposal wells can be stated in approximate order of importance:

- On the basis of flow and interference tests there should be communication between injected fluid and production wells.

- Disposal zones should be at least as deep as production zones, to allow for reheating and upwelling of the injected fluid. This will enhance the maintenance of reservoir mass and pressure, with minimum loss of temperature. Disposal depth must be set at a distance below freshwater aquifers, if they exist, to avoid possible degradation of the quality of these waters.

- Disposal wells, wherever possible, should be downslope of the power plant, to allow for gravity flow disposal, at significant savings in energy.

- Unsuccessful wells could be used wherever possible as injection sites rather than drilling additional disposal holes. This will reduce the drilling costs significantly as well as the environmental impacts of drilling.

- Disposal wells should be located at or as close as possible to the power plant to reduce pipeline costs and the amount of disturbance to the land.

From these criteria it can be seen that disposal sites should not be selected until well testing is completed. If long-term tests show that there is no direct communication between holes in some quadrant of the field, unsuccessful wells in that quadrant can be converted to disposal wells if permeability is adequate. This would be the most economical solution to disposal.

Otherwise, sites would be selected at or just beyond the field margins, utilizing downhill flow at short distances from the power plant. Disposal wells would be drilled at these sites. This highlights the importance of drilling field boundary-definition wells along with production wells. Nonproduction boundary-definition wells may be easily converted into disposal wells. Productive boundary-definition wells will serve to extend the field and increase the estimated reserves of geothermal energy.

Similar to the gathering network, the injection system piping will be of carbon steel and mounted aboveground. All piping will be nominally insulated, as required, to preclude temperature losses which leads to scale build-up in the injection system piping, and for protection of personnel.

In the event of unexpected drops in power demand, load shedding would require some venting of production steam, which would have separate abatement equipment for H_2S control. The H_2S abatement of the bypass steam may be accomplished by neutralizing with caustic soda in a scrubber or such other techniques as may be developed. The H_2S would then be injected in the chemically-bound condition as sodium sulfide (Na_2S) together with the effluent from the main scrubber.

Due to the remoteness of the proposed plant site and the densely forested nature of the terrain, the normal noise attenuation provision for geothermal power plants is expected to suffice to guard against any adverse environmental impact from any bypass flow of a portion of the resource production.

2.3.5 Power Plant Descriptions

2.3.5.1 General

This section provides general information on the design characteristics, construction and operation of geothermal power plant systems. Power plants to convert geothermal energy into electrical power will vary in capacity from 12.5/25 to 55/110 megawatts of electricity (MWe). (1 MWe = 1,000 kilowatts of electricity.) The first 25 MWe plant would be constructed in two increments of 12.5 MWe each because of the comparatively small base load power requirements of HELCO.

Assuming adequate resources and reserves will be discovered, power plant requirements beyond the first 25 MWe of capacity will depend on achieving an export capability via an undersea transmission cable from the Big Island to Oahu, or significant increases in electrical power requirements on the Big Island. For either of these eventualities, the next power plant to be constructed is projected as a 55 MWe (gross) capacity plant. Approximately 3.6 MWe would be used internally for normal plant operations, leaving a net generating capacity of 50-51 MWe. The requirement for a 110 MWe plant would be satisfied by incorporating a second 55 MWe within the site for the

first 55 MWe plant, or using a new site for constructing two 55 MWe plants. It appears now that 55 MWe units will be the most efficient and economical size for each turbine generator system.

To permit assessment of the impact of power plant construction and operations in the project area, drawings of the smallest and largest operating units planned are included in this section. These drawings depict plants that have been designed and are in operation at other locations. The designs of the power plants to be constructed in the project area are expected to be quite similar to the designs described herein. The detailed designs will be based on the nature and characteristics of the resource discovered and the most appropriate abatement system available will be submitted for review and approval as completed.

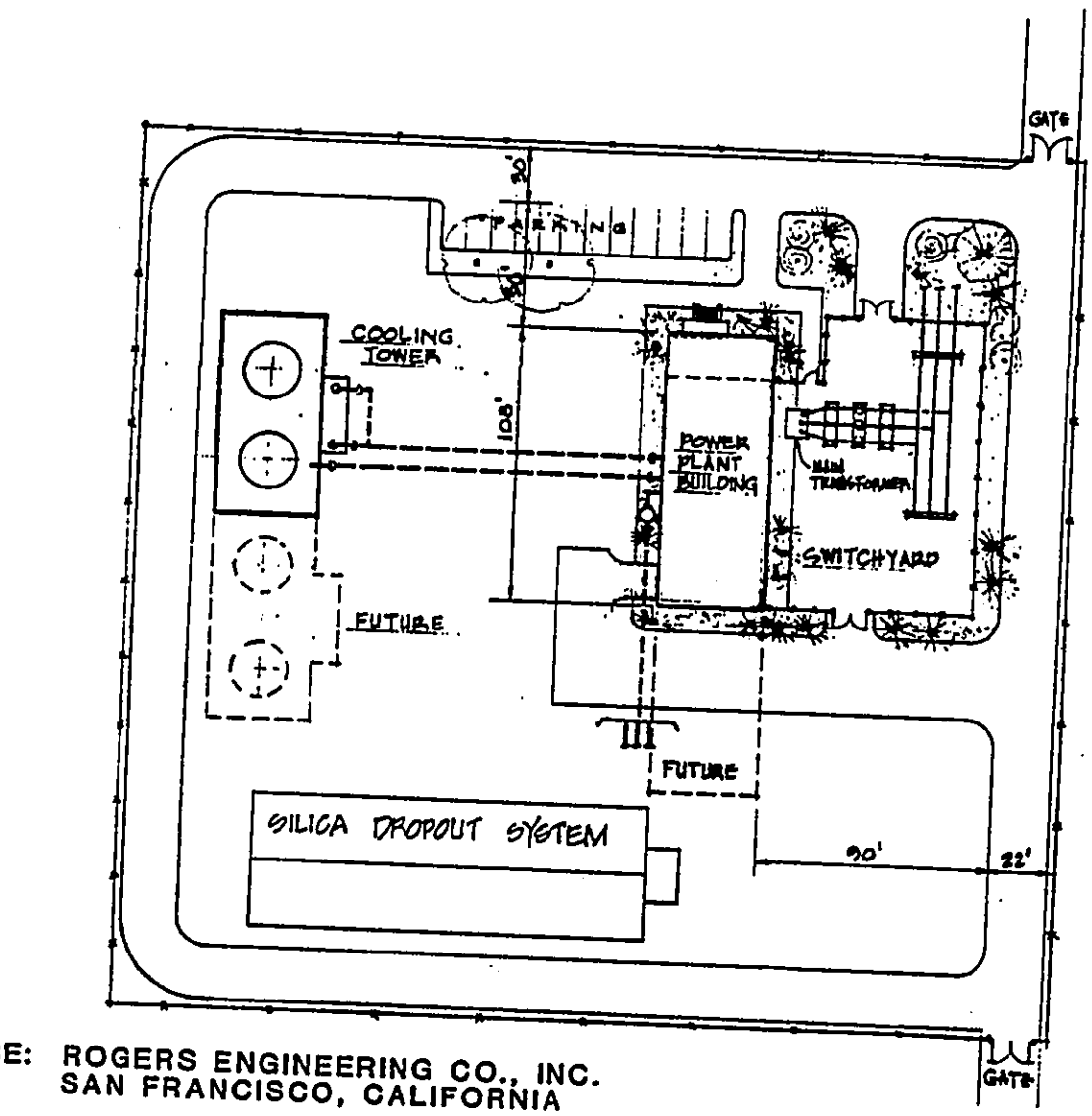
2.3.5.2 Design of 12.5/25 MWe Power Plants

A. Building and Site Characteristics

1. General Description

Figure 2-12 is a perspective drawing for the initial 12.5 MWe power plant. The site plan (Figure 2-13) indicates the general layout of the building, cooling tower, fence and parking area, together with space provisions for future expansion with an identical 12.5 MWe for a total plant capacity of 25 MWe. The overall site acreage requirement is approximately 7 acres, including a 60-foot cleared area around the site for security and control purposes.

The power plant building for a system capable of producing 12.5 MWe will comprise a 2-story structure, 90' x 40', fully enclosed, approximately 50 feet high in combination with a 3-story control/administrative support module, 40' x 18'. The control/administrative module will be located on the north side of the main building. The turbine generator building and equipment arrangements and elevations are shown



SOURCE: ROGERS ENGINEERING CO., INC.
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FIGURE 2-13

SITE PLAN
INITIAL 12.5MWe POWER PLANT
(WITH EXPANSION TO 25MWe)

100 0 100 200
SCALE IN FEET

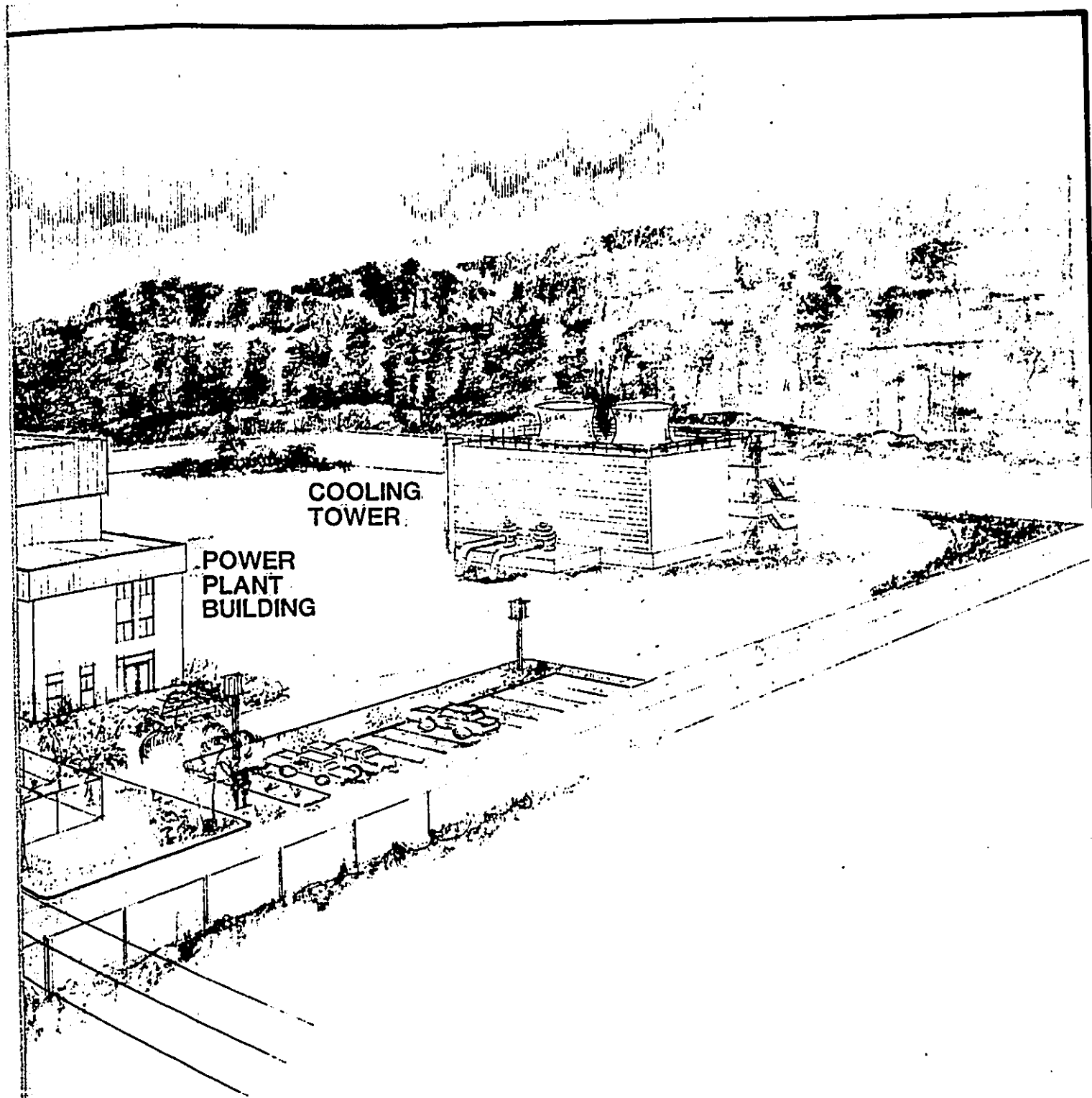
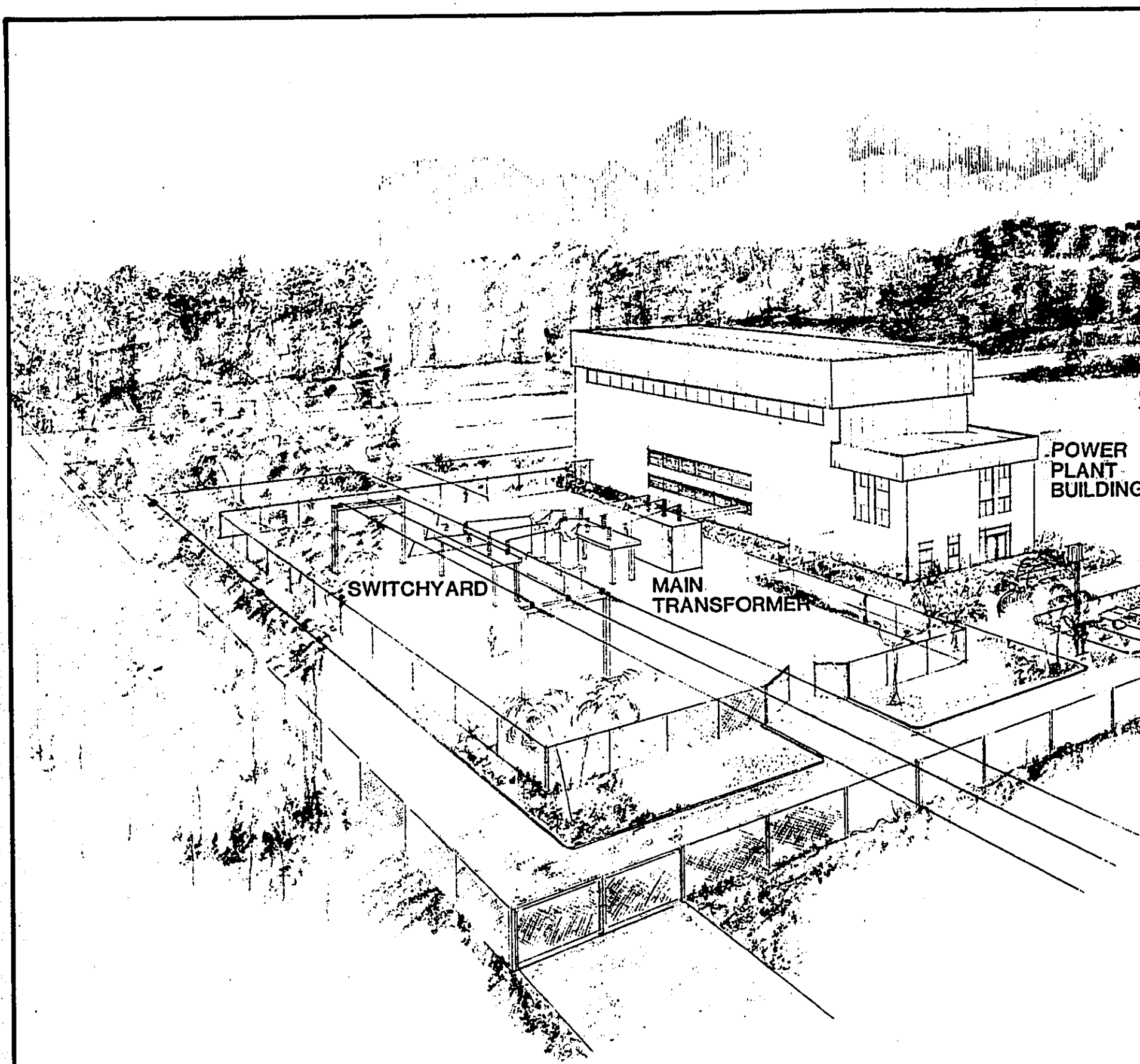


FIGURE 2-12

PERSPECTIVE
INITIAL 12.5MWe POWER PLANT



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in Figures 2-14 and 2-15. The ground floor slabs will be constructed on engineered fill with an elevation of 3 feet above normal grade. The main operating floor, 22 feet above the ground floor, will comprise steel framing with a concrete-filled steel deck designed for 250 psi. Certain areas will have steel grating. The general structural arrangement of the main building will be rigid steel frame designed on ±24-foot bays, with girts and purlins, respectively, to accommodate galbestos, or similar, wall and roofing panels. A 20-ton bridge crane will be incorporated to traverse the entire length of the building, with main hook height ±20 feet above the operating floor.

2. Ground Floor Area

The ground floor of the plant building proper will accommodate the following areas and major equipment:

a. Loading and Unloading
b. Machine Shop
c. Main Condenser
d. 13.8 KV Volt Switchgear
e. 480V Motor Control Center
f. Air Compressors
g. 69 KV Switchgear Control Panel

The loading area located at the west end will access via a 14' x 16' rolling steel door at the northwest corner of the building.

3. Operating Level

The operating level will accommodate the following areas and equipment:

a. Turbine Generator
b. Laydown Area
c. Clean Parts Storage

A concrete pedestal on rigid mat foundation will support the turbine generator and main condenser units. The pedestal will be of ample rigidity such that no resonance in the natural frequency of the pedestal foundation and the turbine-generator unit will occur.

To suit the functional requirements of the bridge crane in connection with turbine-generator maintenance and access to the laydown area, the ground floor loading area will be open for the full height of the building and open to the operating floor.

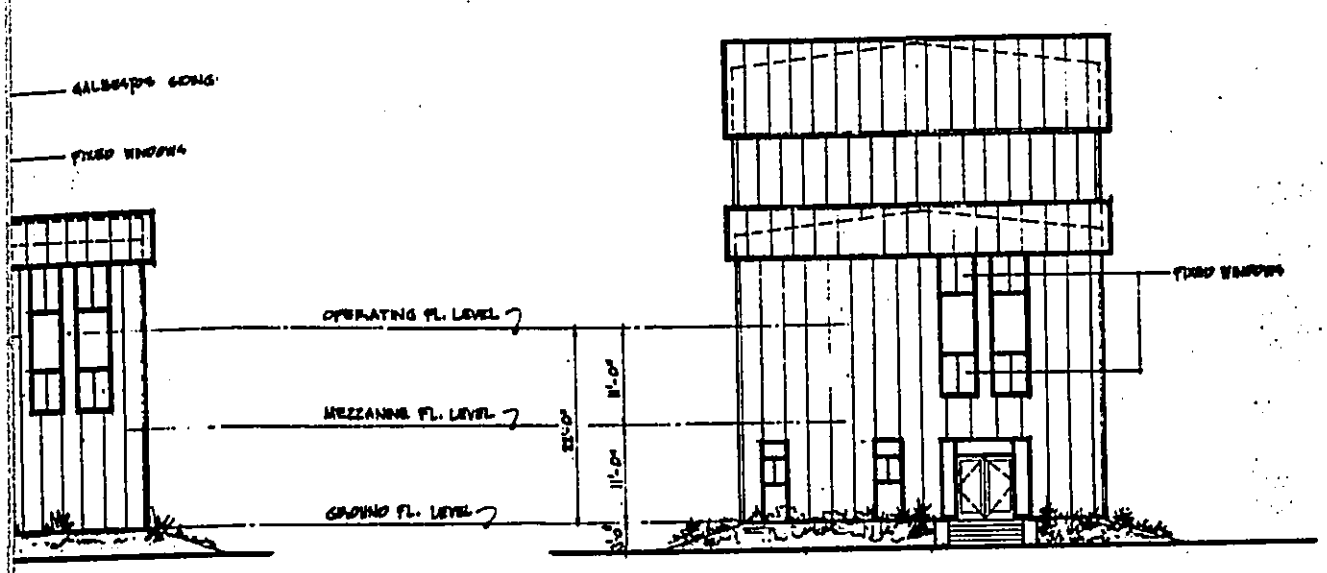
Fixed windows will extend the full length of the main building on the upper east and west walls. The plant generated heat will be dissipated using a system of operable wall louvers in conjunction with open steel grating at the operating level, and roof mounted motor-operated discharge fans.

4. Control/Administrative Modules

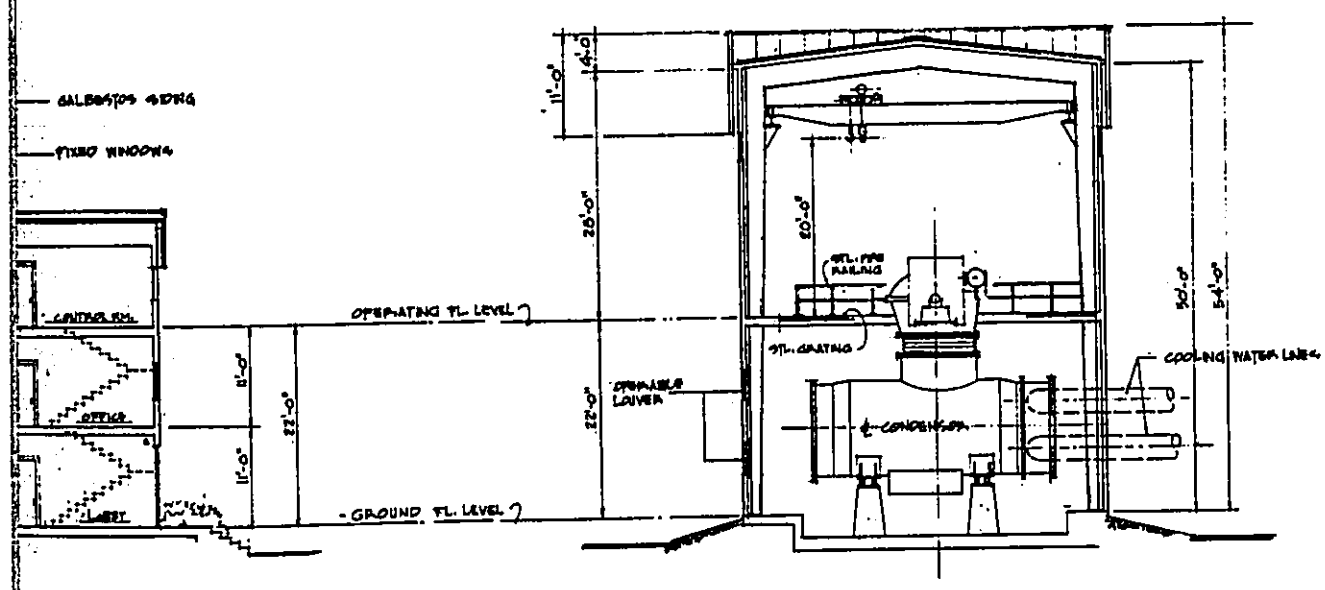
The ground floor of the control/administrative module will accommodate the following areas:

a. Main Entrance/Reception Lobby
b. Men's and Women's Rest Rooms
c. Janitor Supply Room

The second level (mezzanine) of the control/administrative module will accommodate the following areas:



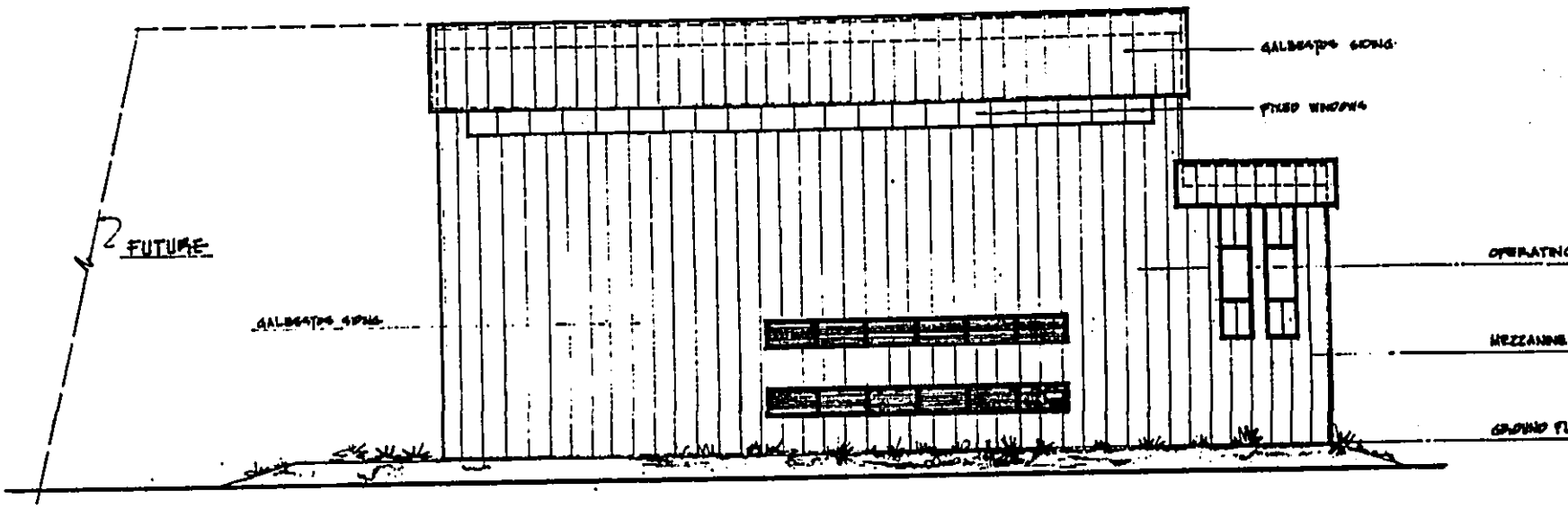
FRONT ELEVATION



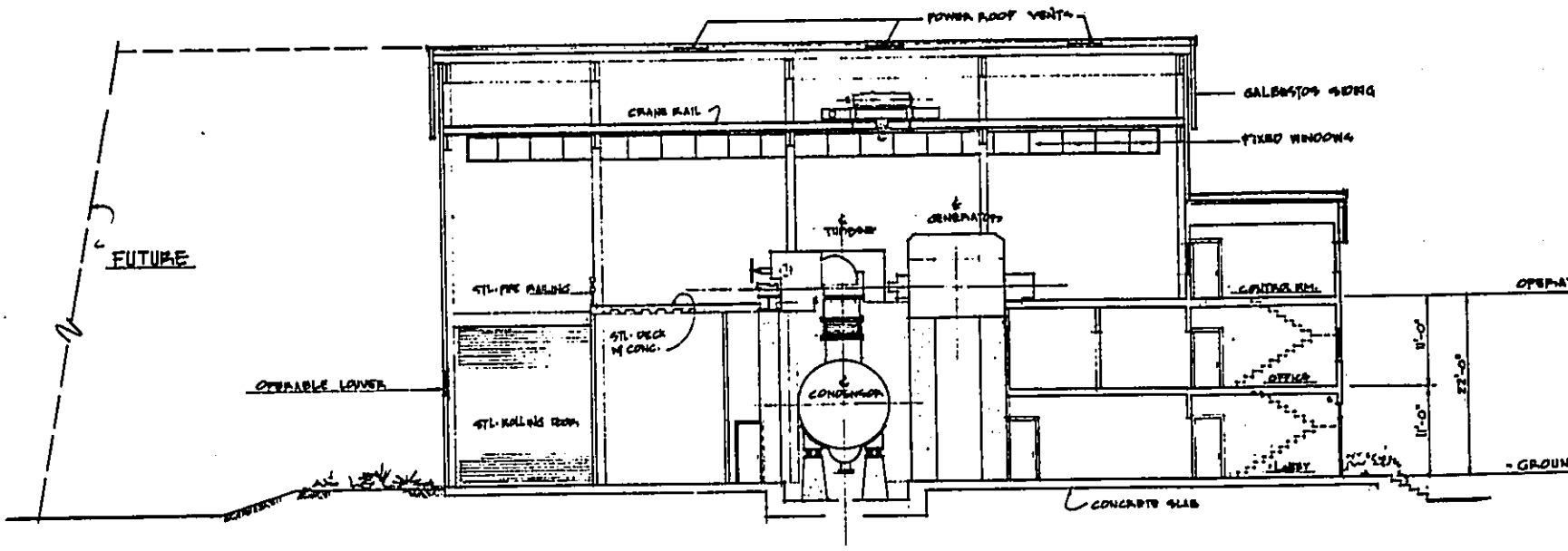
SECTION B-B

FIGURE 2-14

ELEVATIONS AND SECTIONS
INITIAL 12.5MWe POWER PLANT



SIDE ELEVATION



SECTION A-A

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10 0 10 20 30 40 50

SCALE IN FEET

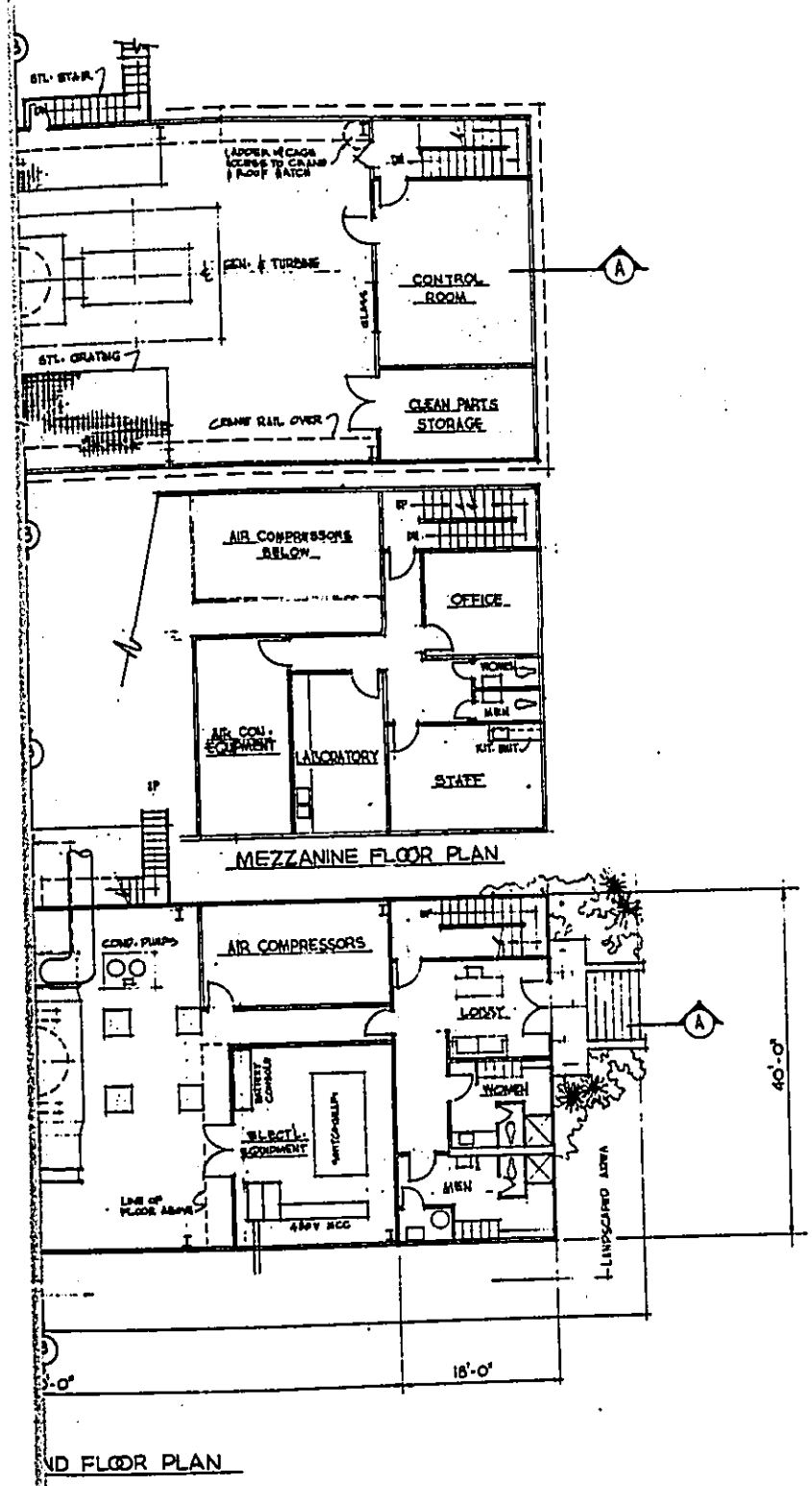
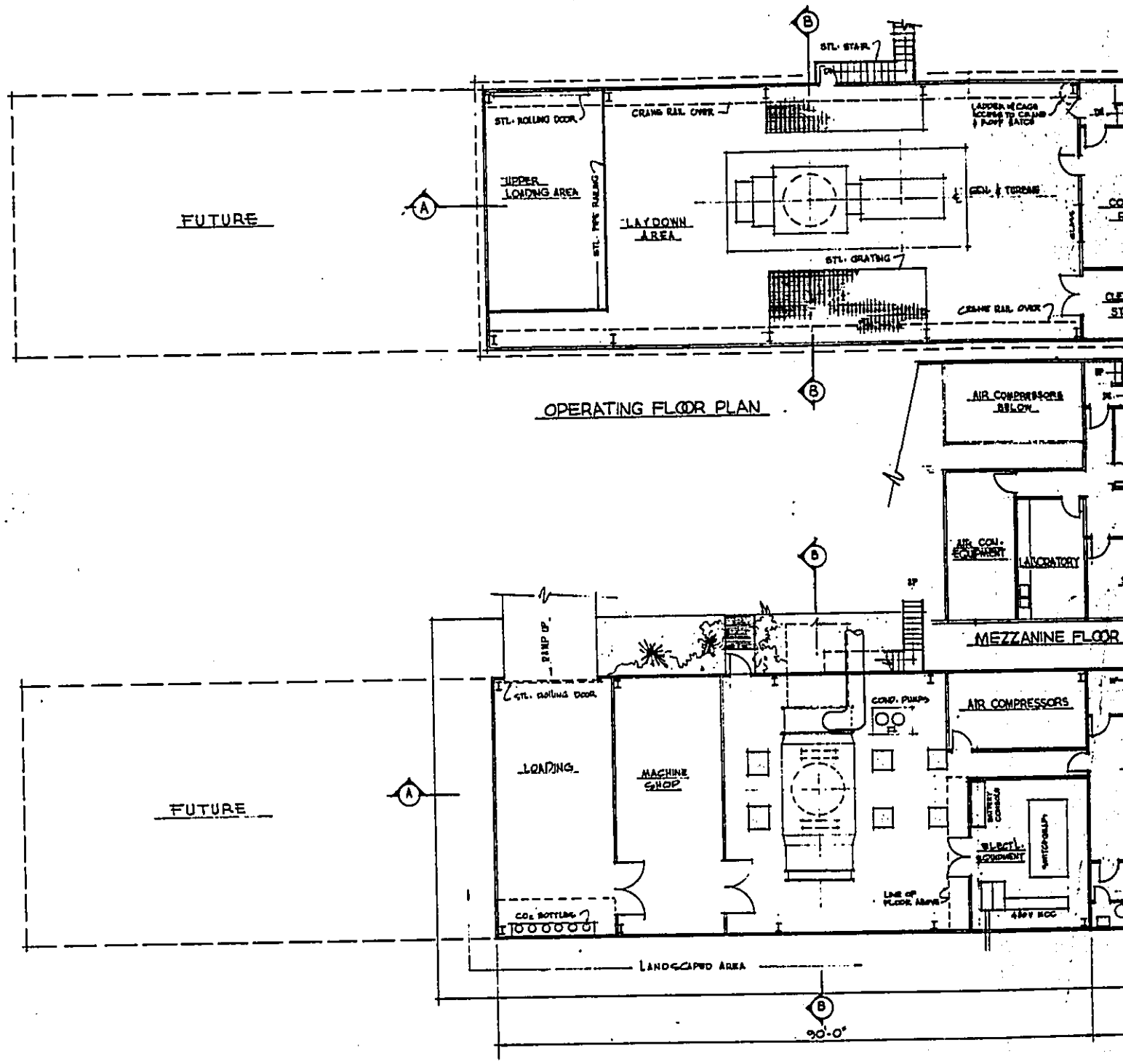


FIGURE 2-15

FLOOR PLANS
INITIAL 12.5MWe POWER PLANT



SOURCE: ROGERS ENGINEERING CO., INC.
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10 0 10 20 30 40 50 60 70 80 90 100

SCALE IN FEET

a. Administrative Office
b. Staff Room
c. Rest Room
*d. Laboratory
*e. Air Condition Equipment

*These areas encroach upon the Main Building, effecting a mezzanine between ground floor and operating floor.

The upper floor of the control/administrative module accommodates the Control and Clean Parts Storage. A staircase adjoining the lobby will effect access between the floors of the control/administrative areas and the floors of the main plant building. A second stairway located on the west side of the operating floor will permit exit from upper floor areas.

5. Environmental Control

Instrumentation equipment enclosures, switchgear room and associated electrical equipment, and enclosed personnel areas will be air conditioned and slightly pressurized to maintain a positive air flow of clean filtered air from the equipment and personnel areas to the exterior.

B. Gathering and Injection System

Figure 2-16 indicates the gathering and injection system for the initial 12.5 MWe power plant. It indicates the flow of the geothermal fluids into and from the power plant. The hot mixed brine and steam flow enters the high pressure flash drum and the portion flashed to steam is directed to the single stage turbine. The unflashed brine is directed to the flash steam mufflers, the silica dropout pond and to the suction header of the injection booster pumps. Section 2.3.4, Well Field Description, includes a more complete description of the well field components of the gathering and injection system.

C. Turbine Generator Systems

The 12.5 MWe steam turbine is a single pressure, single flow, impulse type condensing unit with a single cylinder, direct coupled to a totally enclosed air cooled generator.

Plant Gross Production (One 12.5 MWe Turbine Generator)

Machine Minimum Capacity	4,000 KW Gross Generation
Machine Normal Capacity	12,500 KW Gross Generation
Machine Maximum Capacity	12,500 KW Gross Generation

Auxiliary Load

Power Plant	800 KW
Gathering	0 KW
Injection	400 KW
	1,200 KW

Plant Net Production

Plant Minimum Capacity	2,800 KW Net Generation
Plant Normal Capacity	11,300 KW Net Generation
Plant Maximum Capacity	11,300 KW Net Generation

Initially, one unit will be installed with provision for purchase and installation of the second similarly sized unit, following satisfactory experience (24 months) with the wells after first unit startup.

The turbine generator system includes a single pressure admission condensing unit. The equipment includes all the necessary automatic tripping devices required to protect the unit when a malfunction occurs.

The turbine blading will be stiff and short with stress levels considerably lower than those supplied for comparable fossil fuel steam turbines and will utilize those features which will result in long-term reliable service with geothermal steam. Corrosion

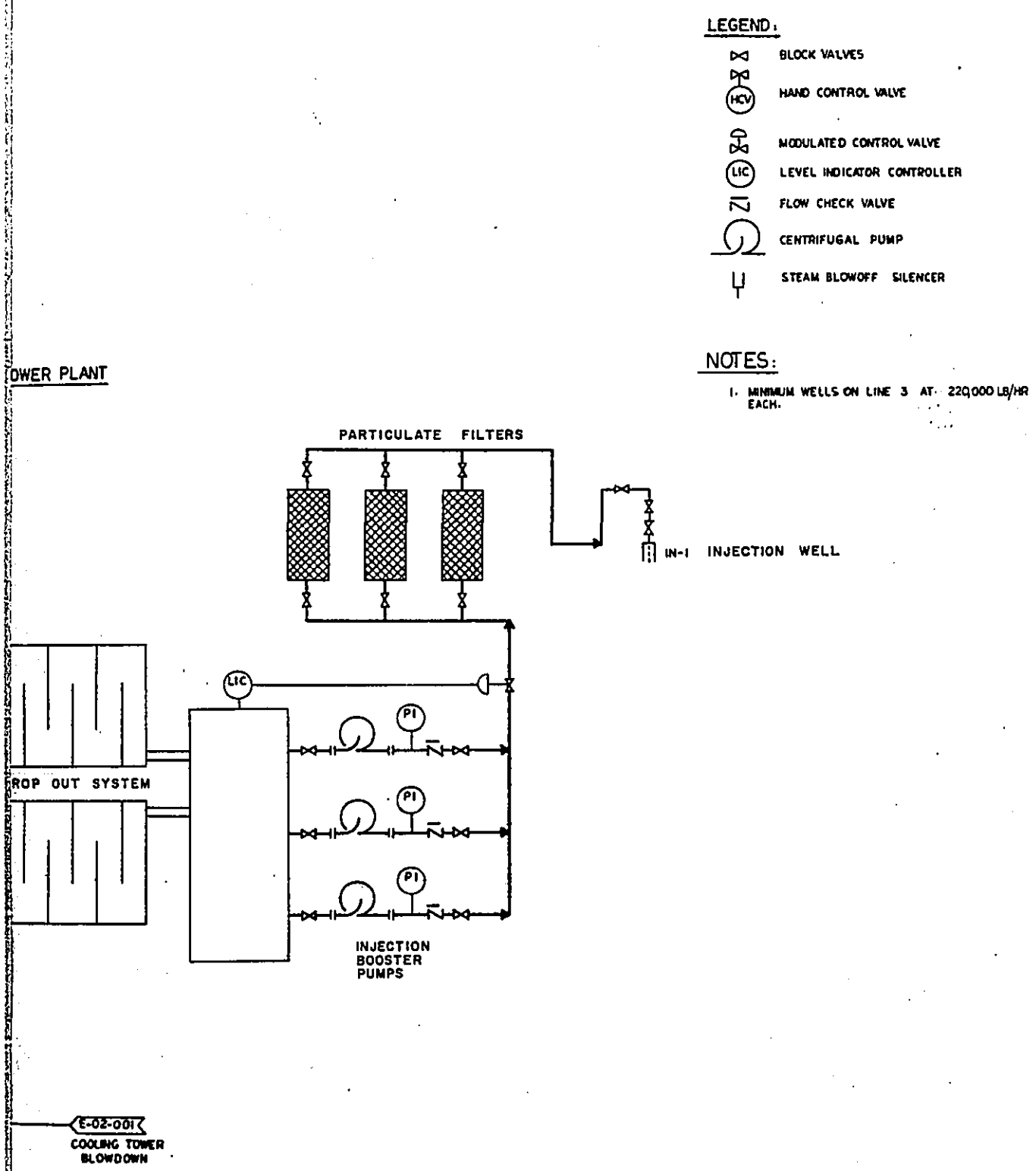
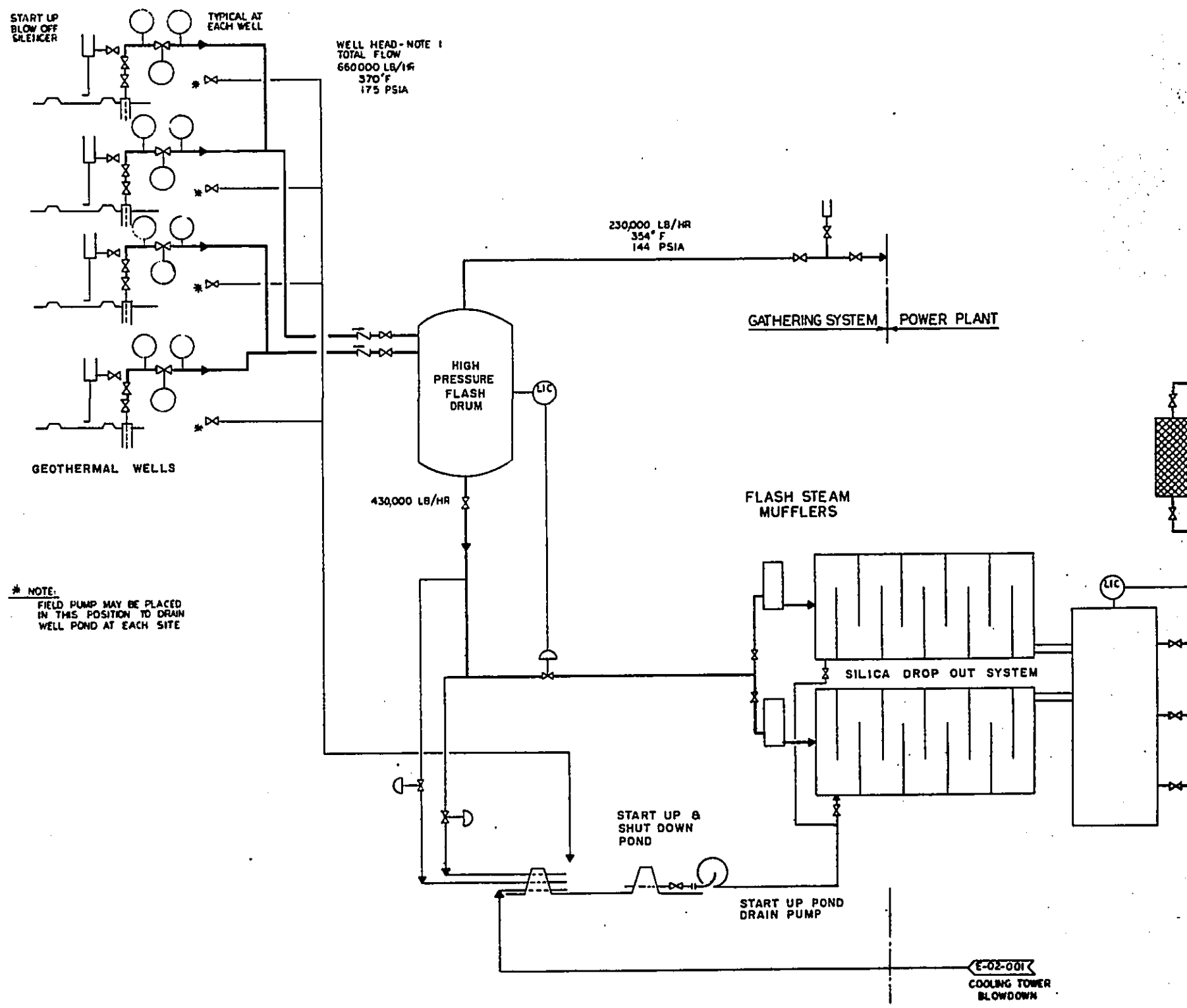


FIGURE 2-16

GATHERING AND INJECTION SYSTEM INITIAL 12.5MWe POWER PLANT



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resistant materials will be specified for turbine internals in contact with geothermal steam.

The generator supplied with the turbine will be designed in accordance with the latest standards of American National Standards Institute C50.10-75, and C50.13-75 and applicable National Electrical Manufacturers Association and Institute of Electrical and Electronic Engineers, Inc., standards.

The condenser will be designed and constructed, where applicable, to conform with the latest American Society of Mechanical Engineers Code and will be of the surface type. The condenser will be constructed of 316 SS clad carbon steel. Internal parts such as tubes and tube plates will be austenitic stainless steel. Water boxes will be carbon steel with epoxy coating. The liquid level in the condenser is controlled by automatic liquid level controller. All the condensate from the geothermal steam is to be returned to the cooling tower. Makeup water for the cooling water system will be provided from the steam condensate.

D. Auxiliary Systems and Internal Power Requirements

All necessary auxiliary systems will be supplied in addition to the major systems of the power plant, and will be designed specifically for the special conditions imposed by the utilization of geothermal steam and the site environment. The auxiliary systems include, but are not limited to the following:

Auxiliary Cooling Water System
Turbine Generator Lubricating Oil System
Instrument Air System
Fire Protection System
Noncondensable Gas Removal System

The turbine generator lubricating oil system is a part of the turbine generator supplied equipment.

E. Controls and Instrumentation

A main control panel in the control room will contain electrical and pneumatic controls for the various electrical and auxiliary process systems. In general, pneumatic systems will be used for level, pressure, flow and valve controls. Pneumatic transmitters in the field will provide inputs to the panel-mounted indicators, controllers and recorders. Resistance temperature detectors will provide electrical temperature signals from the field to solid state electronic temperature indicators and controls. Electric control will be used for the turbine generator, switchgear and motors. An annunciator will alert the operator to off normal conditions and indicate causes for turbine trip.

F. Electrical System

Electric power generated at 13.8 KV will be transmitted to the transmission line through a main step-up transformer. The transformer will be connected to the line through a group operated disconnect switch which will be equipped with a high speed grounding switch. The grounding switch will be operated only in the event of transformer malfunction. Transmission line faults will be cleared by a 13.8 KV circuit breaker. The transformer will be a standard open busing unit, oil filled and equipped with fans. Space will be provided in the switchyard for a future bus and circuit breakers if found to be necessary.

The 13.8 KV station bus will be connected by an air circuit breaker to the generator and the low voltage side of the main step-up transformer. This bus will also supply power to the auxiliary transformer and to the steam gathering and injection pump sytem through fused load break switches. The 13.8 KV bus will consist of an assembly of metal-clad drawout circuit breakers and fixed position fused switches. The metal-clad

switchgear will have a 500 MVA interrupting capacity. A grounding transformer and resistor will be provided since the main step-up transformer will have a 13.8 KV delta winding.

The auxiliary transformer will step down the voltage from the 13.8 KV bus to 480V in order to supply the 480V switchgear and a motor control center. The auxiliary transformer will be of the unit substation type with fans and a 55/65°C rise. Capacity has been derated due to high ambient temperatures. The various pumps, cooling tower fans, small motors and a transformer for house lighting and other low voltage power requirements are supplied by the 480V motor control center. The 480V motor control center bus will split into a normal and critical load bus. The latter bus has limited capacity and feeds the lighting transformer, air conditioning units, plant sump pumps, turbine auxiliary oil pump, instrument air compressors and other small critical motor loads. This bus will feed through a transfer switch either from the 480V motor control center normal bus or from a separate reserve transformer.

The 480V switchgear consists of a metal-clad assembly of low voltage large air circuit breakers which will be used as starters for motors smaller than 200 HP. Switchgear will be bus connected to the auxiliary transformer.

G. Energy Conversion (Process Systems)

The following paragraphs provide elementary descriptions of the steam cycle, circulating water systems, steam condensate system and exhaust of noncondensable gases. Taps will be located on these piping sytems in order to withdraw samples of steam, condensate, noncondensable gases and cooling water. A technical laboratory organization will be retained to take these samples and perform chemical analysis as required.

Steam from the gathering systems is supplied to the plant steam line at the boundary. A steam line pressure relief system will be installed for emergency shutdown of the turbine generator. Steam is piped to the turbine, and in smaller quantities, to the turbine gland seals, first noncondensable gas ejector and second stage noncondensable gas ejector. Turbine steam is exhausted at 4 in. Hg Abs. downward to the shell side of a surface condenser. Cooling water flow through the horizontal condenser tubes is in a multi-pass arrangement.

Surface type condensation equipment was selected for the concept design to permit extraction of the noncondensable gases for environmental cleanup by chemical or incinerator process.

Two full capacity transfer pumps (one spare) are provided to pump the condensate from the main condenser hot well to the cooling tower basin.

Noncondensable gas is removed from main condenser by a first stage steam jet ejector discharging to an inter-condenser where noncondensable gases are drawn off by a second stage steam jet ejector discharging to the atmosphere through a silencer. Condensate from the inter-condenser flows by vacuum pressure differential to the main condenser. Figure 2-17 indicates the Flow and Control Diagram for a 12.5 MWe plant.

Two 60 percent capacity main circulating water pumps are provided to pump cooling water from the cooling tower forebay through the main condenser, inter-condenser, generator heat exchanger, lube oil cooler, air compressor cooling system, and back to the sprays in the cooling tower. These main circulating water pumps operate when the turbine generator is operating. An auxiliary cooling water pump is provided to supply cooling water to essential heat exchangers when the turbine generator is shutdown. Cooling tower blowdown is required and is based on concentrations of treated

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY
SEE FRAME(S) IMMEDIATELY FOLLOWING

resistant materials will be specified for turbine internals in contact with geothermal steam.

The generator supplied with the turbine will be designed in accordance with the latest standards of American National Standards Institute C50.10-75, and C50.13-75 and applicable National Electrical Manufacturers Association and Institute of Electrical and Electronic Engineers, Inc., standards.

The condenser will be designed and constructed, where applicable, to conform with the latest American Society of Mechanical Engineers Code and will be of the surface type. The condenser will be constructed of 316 SS clad carbon steel. Internal parts such as tubes and tube plates will be austenitic stainless steel. Water boxes will be carbon steel with epoxy coating. The liquid level in the condenser is controlled by automatic liquid level controller. All the condensate from the geothermal steam is to be returned to the cooling tower. Makeup water for the cooling water system will be provided from the steam condensate.

D. Auxiliary Systems and Internal Power Requirements

All necessary auxiliary systems will be supplied in addition to the major systems of the power plant, and will be designed specifically for the special conditions imposed by the utilization of geothermal steam and the site environment. The auxiliary systems include, but are not limited to the following:

Auxiliary Cooling Water System
Turbine Generator Lubricating Oil System
Instrument Air System
Fire Protection System
Noncondensable Gas Removal System

The turbine generator lubricating oil system is a part of the turbine generator supplied equipment.

E. Controls and Instrumentation

A main control panel in the control room will contain electrical and pneumatic controls for the various electrical and auxiliary process systems. In general, pneumatic systems will be used for level, pressure, flow and valve controls. Pneumatic transmitters in the field will provide inputs to the panel-mounted indicators, controllers and recorders. Resistance temperature detectors will provide electrical temperature signals from the field to solid state electronic temperature indicators and controls. Electric control will be used for the turbine generator, switchgear and motors. An annunciator will alert the operator to off normal conditions and indicate causes for turbine trip.

F. Electrical System

Electric power generated at 13.8 KV will be transmitted to the transmission line through a main step-up transformer. The transformer will be connected to the line through a group operated disconnect switch which will be equipped with a high speed grounding switch. The grounding switch will be operated only in the event of transformer malfunction. Transmission line faults will be cleared by a 13.8 KV circuit breaker. The transformer will be a standard open busing unit, oil filled and equipped with fans. Space will be provided in the switchyard for a future bus and circuit breakers if found to be necessary.

The 13.8 KV station bus will be connected by an air circuit breaker to the generator and the low voltage side of the main step-up transformer. This bus will also supply power to the auxiliary transformer and to the steam gathering and injection pump sytem through fused load break switches. The 13.8 KV bus will consist of an assembly of metal-clad drawout circuit breakers and fixed position fused switches. The metal-clad

switchgear will have a 500 MVA interrupting capacity. A grounding transformer and resistor will be provided since the main step-up transformer will have a 13.8 KV delta winding.

The auxiliary transformer will step down the voltage from the 13.8 KV bus to 480V in order to supply the 480V switchgear and a motor control center. The auxiliary transformer will be of the unit substation type with fans and a 55/65°C rise. Capacity has been derated due to high ambient temperatures. The various pumps, cooling tower fans, small motors and a transformer for house lighting and other low voltage power requirements are supplied by the 480V motor control center. The 480V motor control center bus will split into a normal and critical load bus. The latter bus has limited capacity and feeds the lighting transformer, air conditioning units, plant sump pumps, turbine auxiliary oil pump, instrument air compressors and other small critical motor loads. This bus will feed through a transfer switch either from the 480V motor control center normal bus or from a separate reserve transformer.

The 480V switchgear consists of a metal-clad assembly of low voltage large air circuit breakers which will be used as starters for motors smaller than 200 HP. Switchgear will be bus connected to the auxiliary transformer.

G. Energy Conversion (Process Systems)

The following paragraphs provide elementary descriptions of the steam cycle, circulating water systems, steam condensate system and exhaust of noncondensable gases. Taps will be located on these piping sytems in order to withdraw samples of steam, condensate, noncondensable gases and cooling water. A technical laboratory organization will be retained to take these samples and perform chemical analysis as required.

Steam from the gathering systems is supplied to the plant steam line at the boundary. A steam line pressure relief system will be installed for emergency shutdown of the turbine generator. Steam is piped to the turbine, and in smaller quantities, to the turbine gland seals, first noncondensable gas ejector and second stage noncondensable gas ejector. Turbine steam is exhausted at 4 in. Hg Abs. downward to the shell side of a surface condenser. Cooling water flow through the horizontal condenser tubes is in a multi-pass arrangement.

Surface type condensation equipment was selected for the concept design to permit extraction of the noncondensable gases for environmental cleanup by chemical or incinerator process.

Two full capacity transfer pumps (one spare) are provided to pump the condensate from the main condenser hot well to the cooling tower basin.

Noncondensable gas is removed from main condenser by a first stage steam jet ejector discharging to an inter-condenser where noncondensable gases are drawn off by a second stage steam jet ejector discharging to the atmosphere through a silencer. Condensate from the inter-condenser flows by vacuum pressure differential to the main condenser. Figure 2-17 indicates the Flow and Control Diagram for a 12.5 MWe plant.

Two 60 percent capacity main circulating water pumps are provided to pump cooling water from the cooling tower forebay through the main condenser, inter-condenser, generator heat exchanger, lube oil cooler, air compressor cooling system, and back to the sprays in the cooling tower. These main circulating water pumps operate when the turbine generator is operating. An auxiliary cooling water pump is provided to supply cooling water to essential heat exchangers when the turbine generator is shutdown. Cooling tower blowdown is required and is based on concentrations of treated

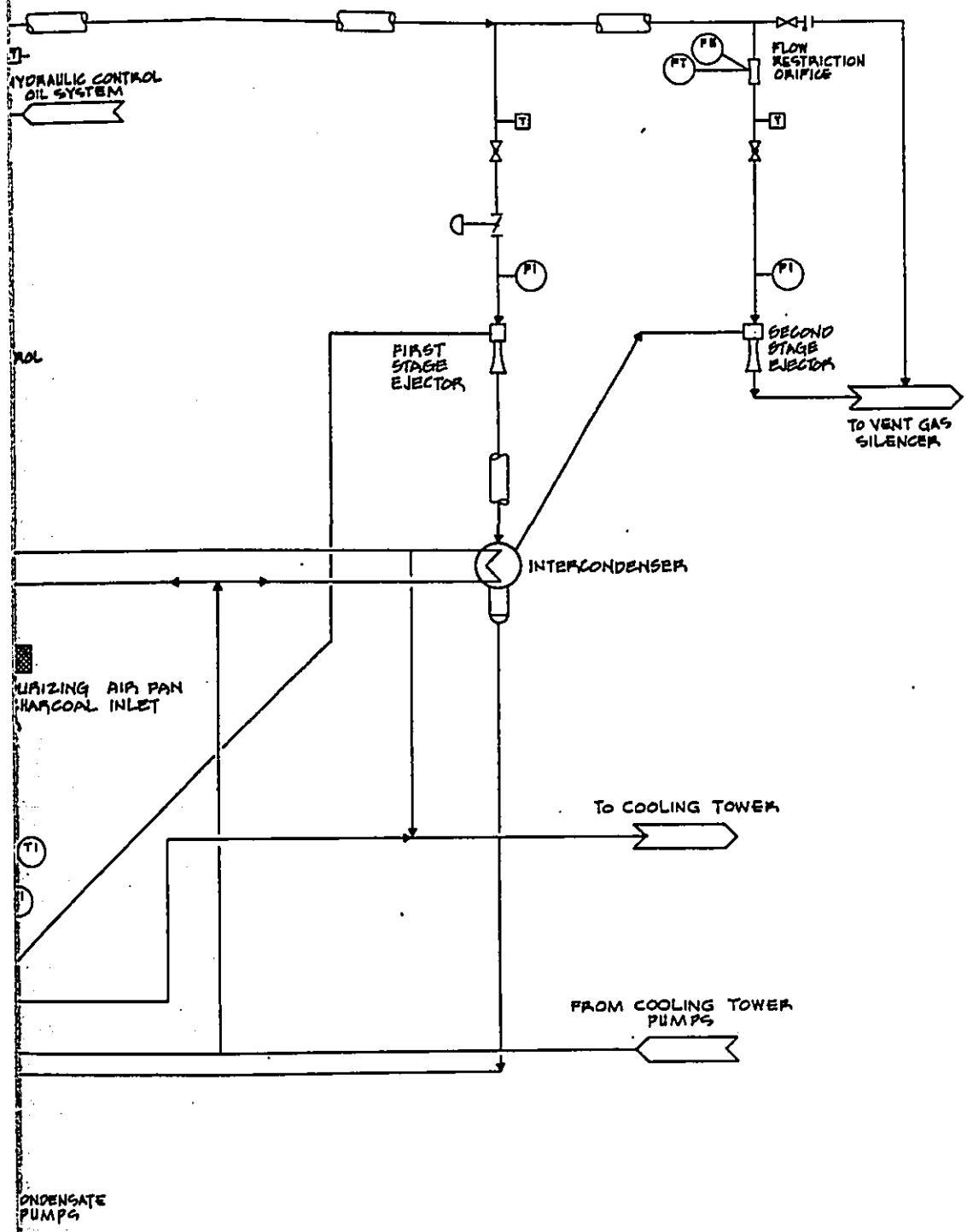
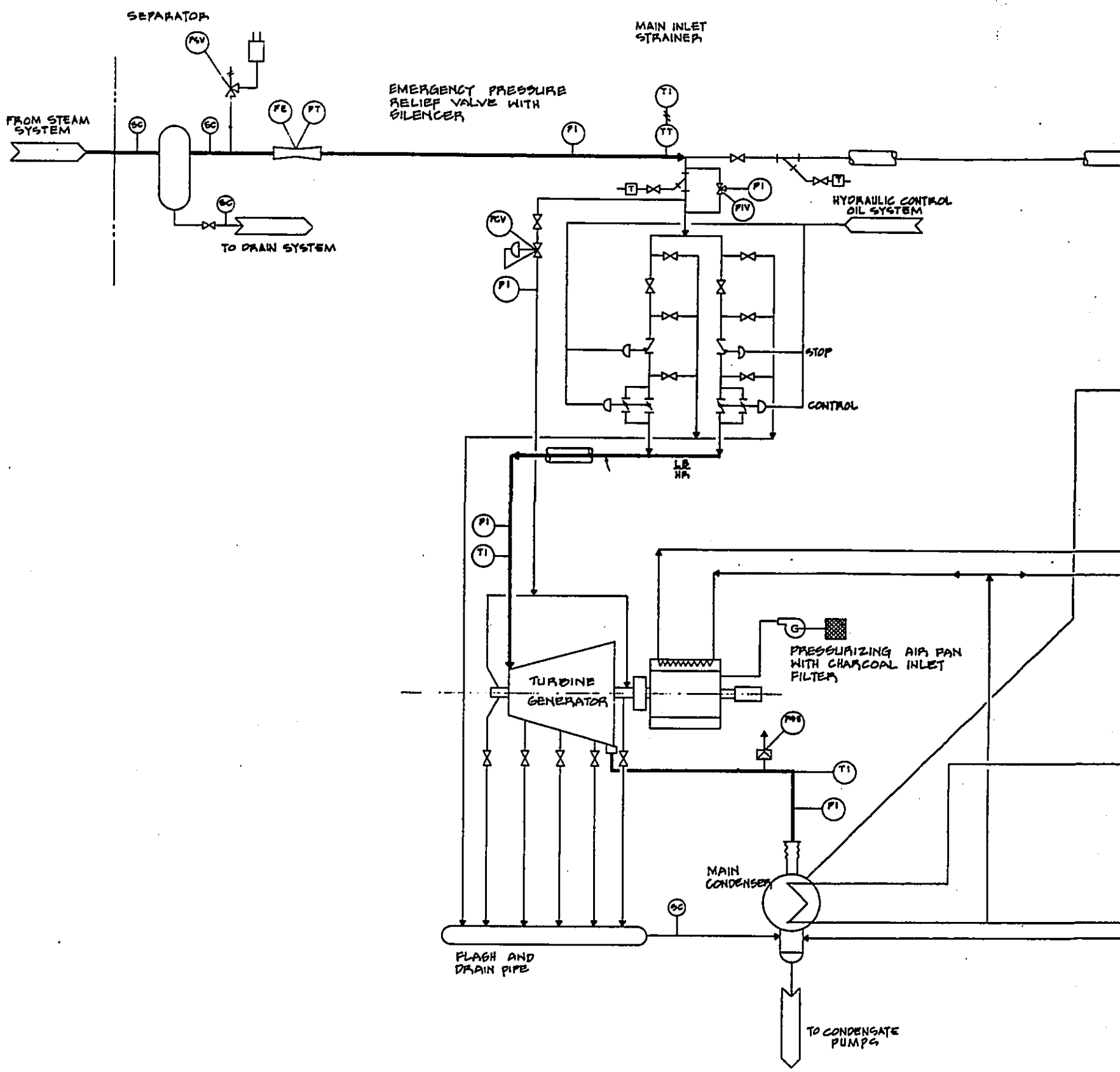


FIGURE 2-17

FLOW AND CONTROL DIAGRAM INITIAL 12.5MWe POWER PLANT



SOURCE: ROGERS ENGINEERING CO., INC.
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makeup water. The blowdown is pumped into the brine disposal system. Alternatively, it may be possible to discharge into a drain or percolation pond for initial plant startup.

Based on the assumption that this resource will be similar to that of HGP-A, the noncondensable gases may consist of 0.2 percent by weight of the total steam flow. This value was used in establishing the Flow Diagram and will be reevaluated once initial production from this area is achieved and actual chemistry is known. Abatement systems for this project will be designed for the concentrations of noncondensable gases and the chemistry of the fluids found at Kahauale'a.

2.3.5.3 Design of 55/110 MWe Power Plant

A. Building and Site Characteristics

1. General Description

It is likely that the characteristics of the geothermal fluids will be quite similar throughout the potential reservoir underlying the Kahauale'a region. Accordingly, much of the foregoing discussions with respect to the type of facilities for the 25 MWe power plant are directly applicable to the larger 55/110 MWe dual units. The purpose of this section is to describe those elements of the larger plants that will be significantly different from the 25 MWe unit.

The 55 MWe geothermal plant is shown in perspective in Figure 2-18, with provisions for expansion to 110 MWe. The major components are similar in function to those found in the 25 MWe plant described above but are considerably larger in size. In addition, the larger scale of operation will require a sizeable hydrogen sulfide abatement facility. A silica drop-out system, if required, would be similarly

enlarged. The overall site acreage requirement is approximately 15 acres, including a 60-foot cleared area around the site for security and control purposes. Figure 2-19 indicates the planned site layout and a typical section cut through the facility for the 55 MWe plant, including its expansion to 110 MWe.

B. Building and Site Characteristics

The 110 MWe power plant building (2 units of 55 MWe each) will have the same basic arrangement as the 25 MWe building (2 units of 12.5 MWe each), but it will be scaled up in size substantially. The overall dimensions of the 110 MWe building will be approximately 350' x 80' and 65 feet high, compared to 198' x 40' and 50 feet high for the 25 MWe building.

The development will be in two stages, with one complete 55 MWe unit first, followed by a second 55 MWe generating unit as an extension of the first building. A transverse section of the building is shown in Figure 2-20.

The six bays at the right comprise the "Power Building" and contain all the major mechanical and electrical equipment. The right end wall of this section will be built so it can be removed when the second 55 MWe unit is added. The lower portion of the structure, on the left, is the "Support Building" - a three level structure which contains administrative offices, the main control room, and most of the storage and maintenance facilities. The addition of the second 55 MWe unit will involve only the addition of a second "Power Building," or a duplication of the full height section on the right.

The turbine generator pedestals for the 55 MWe units will extend approximately 25 feet below ground level to allow space for the

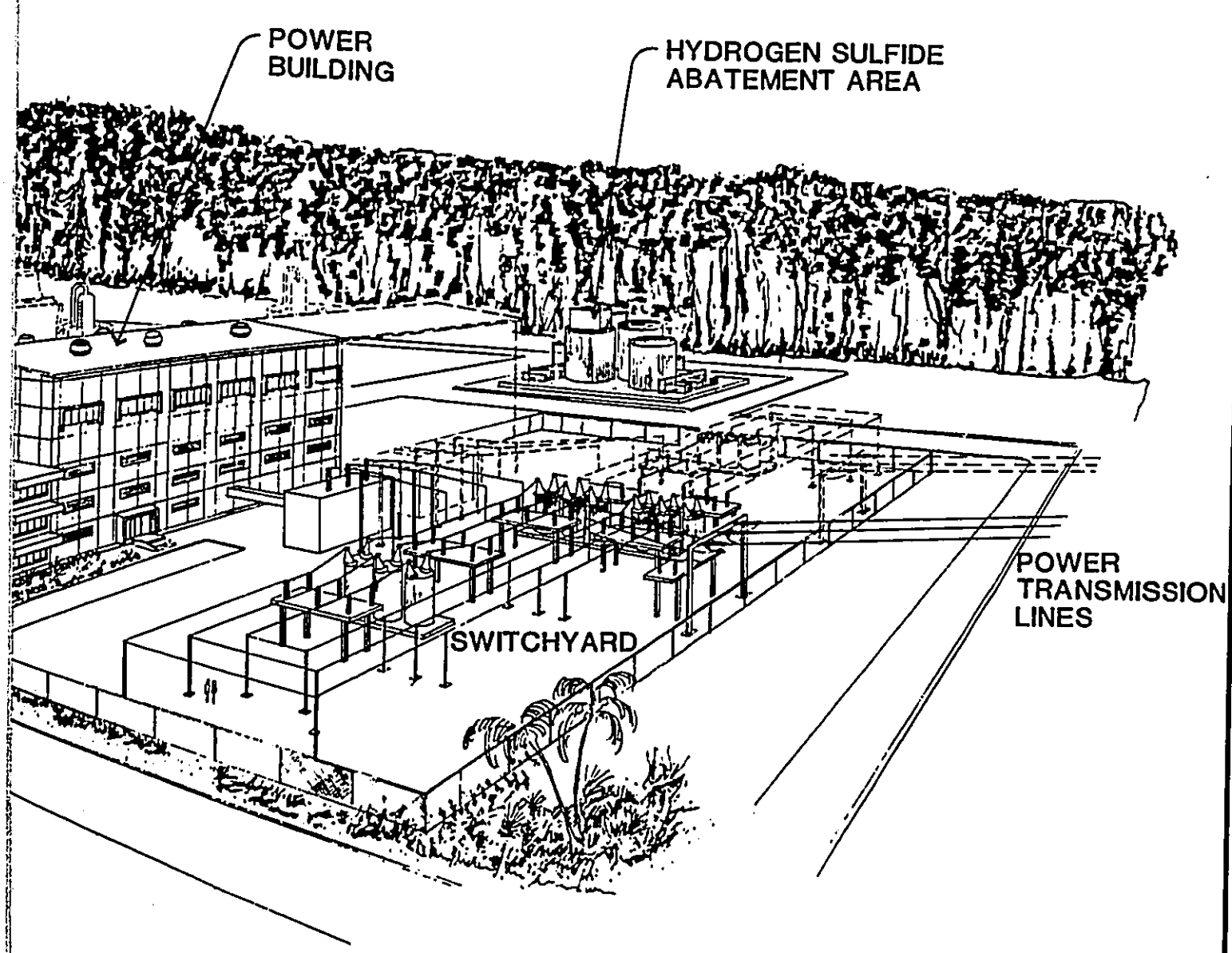
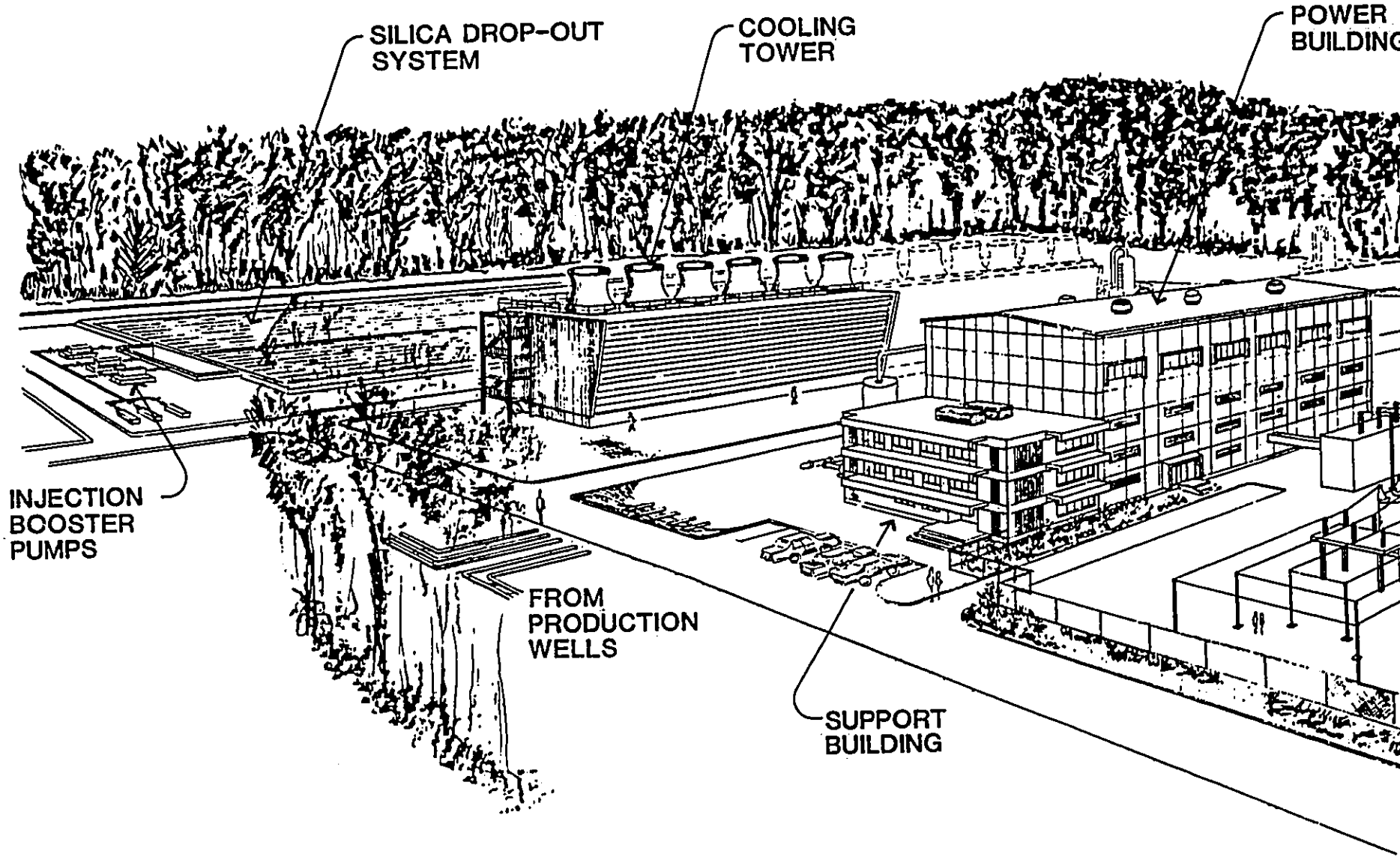


FIGURE 2-18

PERSPECTIVE
55MWe POWER PLANT
(WITH EXPANSION TO 110MWe)



SOURCE: ROGERS ENGINEERING CO., INC.
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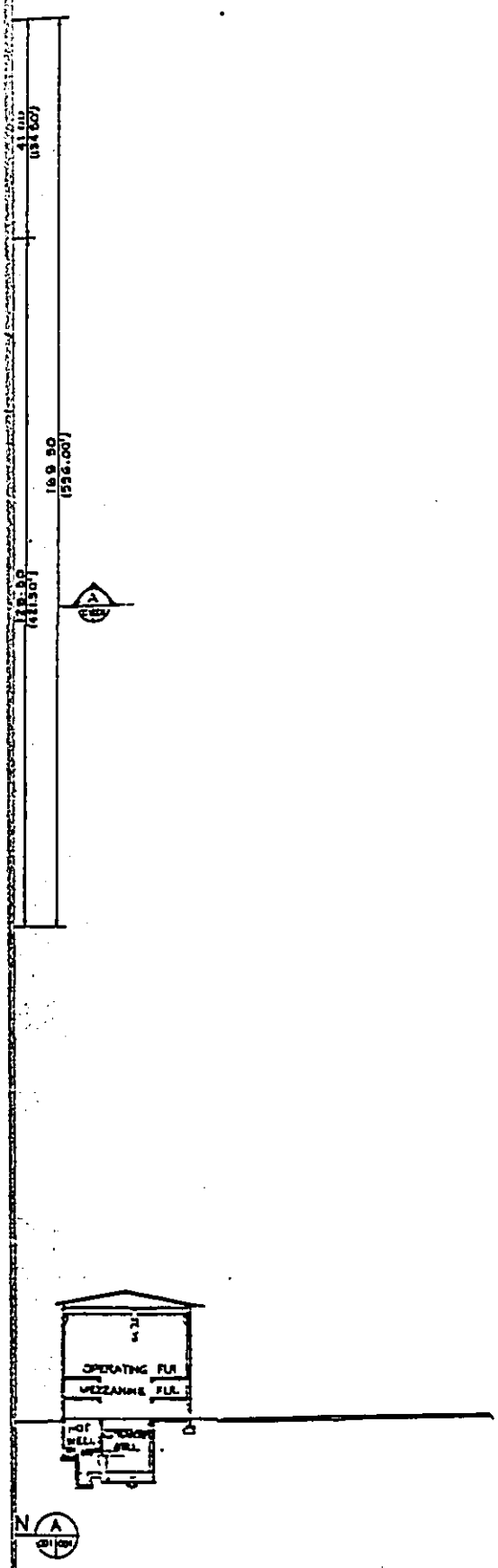
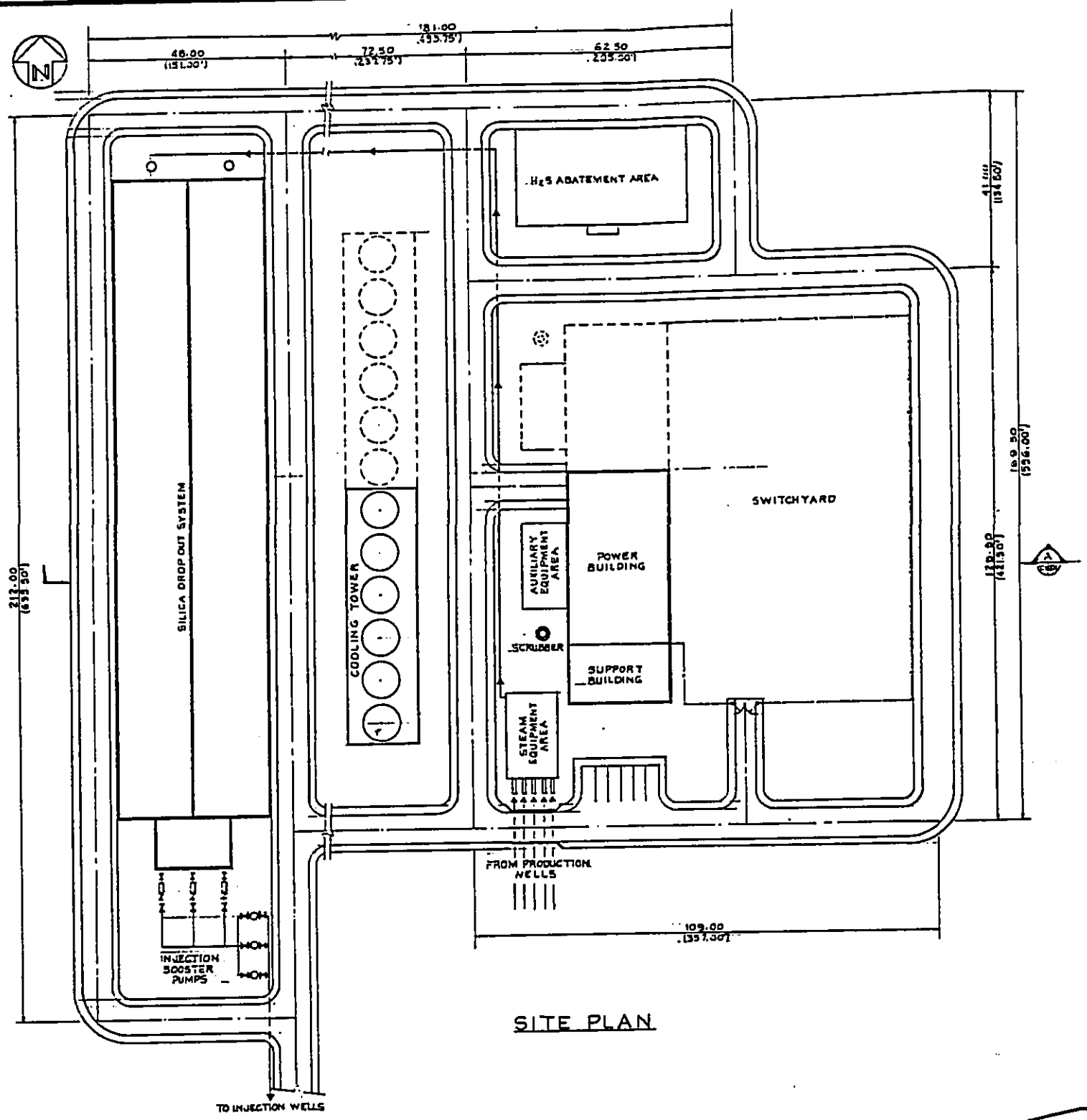


NOTES:

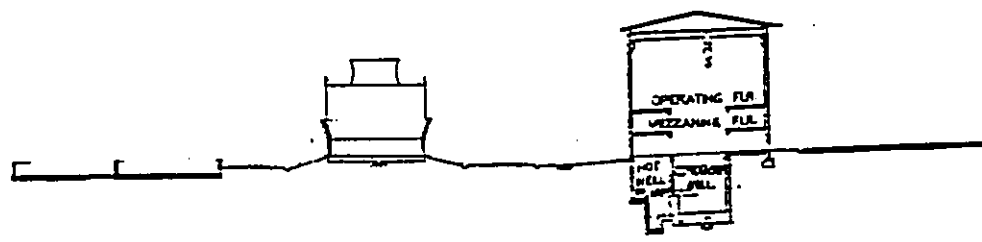
1. BUILDING CAN BE EXPANDED TO THE NORTH IF AN ADDITIONAL 55 MW UNIT IS REQUIRED
2. COOLING TOWER CAN BE EXPANDED TO THE NORTH IF AN ADDITIONAL 55 MW UNIT IS REQUIRED.

FIGURE 2-19

SITE PLAN AND SECTION
55MWe POWER PLANT
(WITH EXPANSION TO 110MWe)



SITE PLAN



SECTION A

SOURCE: ROGERS ENGINEERING CO., INC.
SAN FRANCISCO, CALIFORNIA

100 0 100 200 300 400 500

SCALE IN FEET

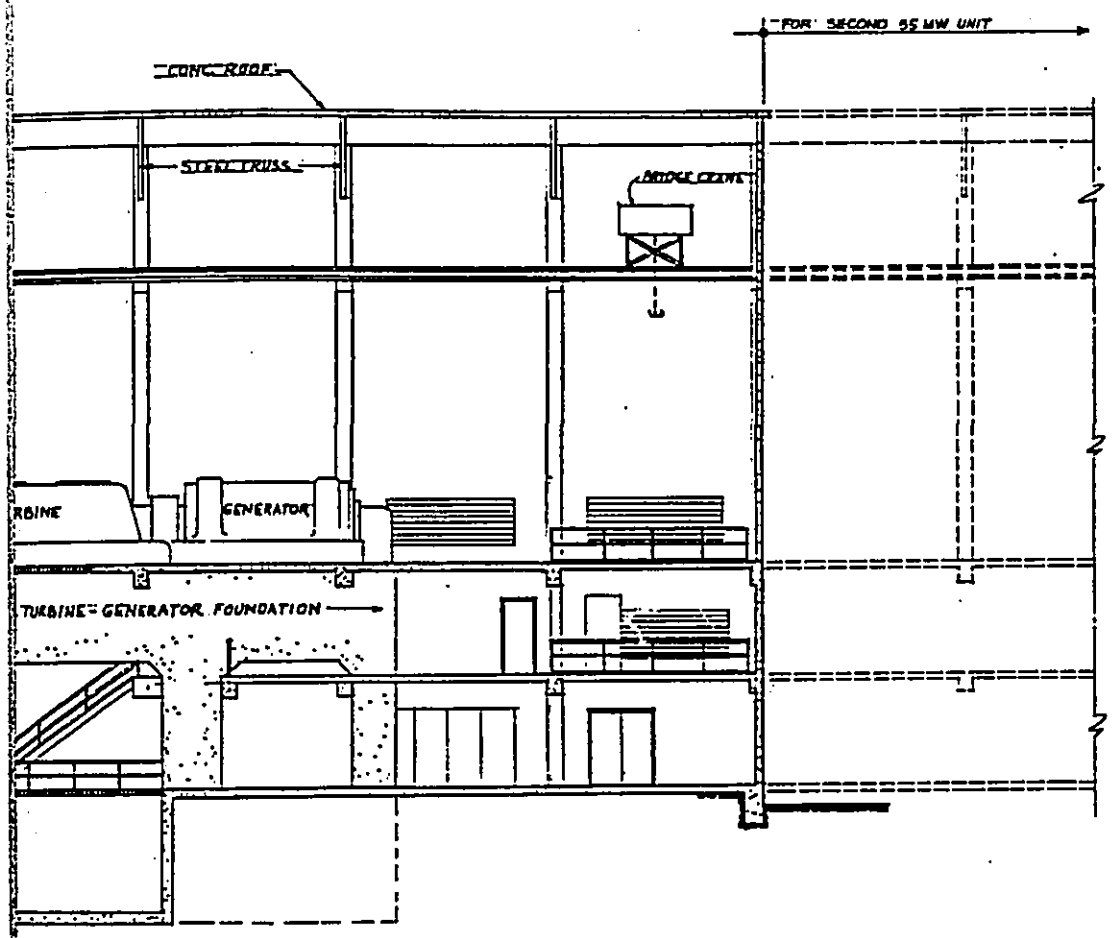
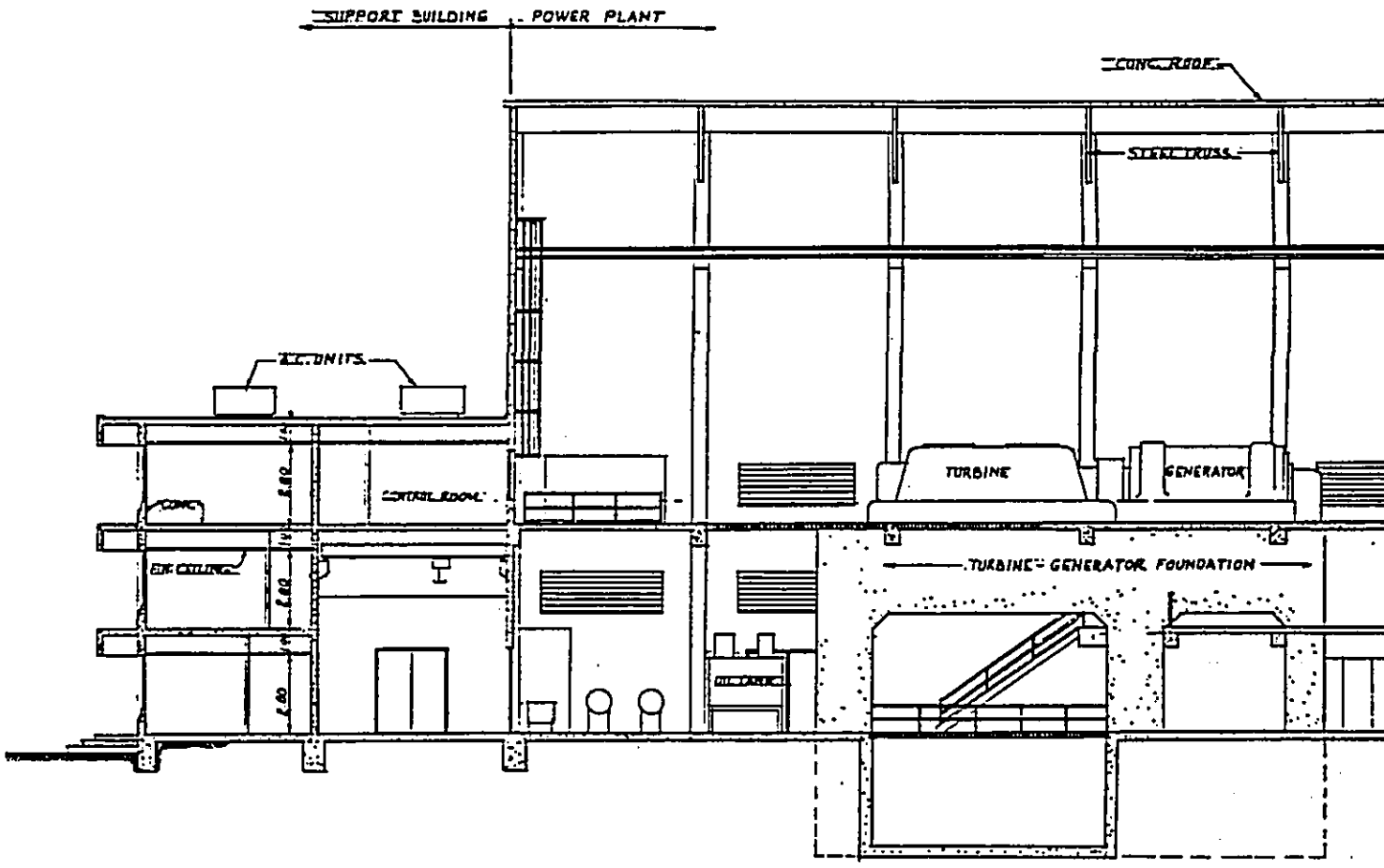


FIGURE 2-20

TRANSVERSE SECTION
55MWe POWER PLANT
(WITH EXPANSION TO 110MWe)



TRANSVERSE SECTION 'A-A'

SOURCE: ROGERS ENGINEERING CO., INC.
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10 0 10 20 30 40 50 60 70 80 90 100

SCALE IN FEET

main condenser. The "hot wells" for the main condensate pumps will extend further to about 33 feet below ground.

The only significant difference in the siting and arrangement of the 110 MWe plant as compared to the 25 MWe plant is in the size. The 55 MWe plant site will occupy approximately 15 acres, compared to about 7 acres for the 25 MWe plant.

C. Gathering and Injection System

Figure 2-21 indicates the gathering and injection system for a 55 MWe power plant. It indicates the flow of the hot geothermal fluids from the well field into the power plant. The hot mixed brine and steam flow first enters a high pressure flash drum, followed by entry into a low pressure flash drum. The portions flashed to steam are directed to the double pressure, double flow steam turbine. The unflashed brine is directed to the silica drop-out system and the injection well pumps.

D. Turbine-Generator System

The power plant is to be designed for two 55 MWe gross geothermal steam electric power generating units. It is anticipated that Unit No. 1 would be installed first to meet the projected schedule for increased on-line power. The second unit would then follow after obtaining experience on the first unit. The actual final design of these plants will be based upon production well flow test data.

The steam turbine will be a double pressure, double flow, impulse/reaction type condensing unit with single cylinder, direct-coupled to a totally enclosed hydrogen-cooled generator.

Plant Gross Production (One 55 MWe Turbine Generator)	
Machine Minimum Capacity	14,000 KW Gross Generation
Machine Normal Capacity	55,000 KW Gross Generation
Machine Maximum Capacity	55,000 KW Gross Generation

Auxiliary Load	
Power Plant	2,400 KW
Gathering	0 KW
Injection	1,200 KW
	3,600 KW

Plant Net Production	
Plant Minimum Capacity	10,400 KW Net Generation
Plant Normal Capacity	51,400 KW Net Generation
Plant Maximum Capacity	51,400 KW Net Generation

Initially one unit will be installed with provision for purchase and installation of the second similarly sized unit, following satisfactory experience (24 months) with the wells after first unit startup.

The turbine generator will be a double pressure admission condensing unit. The equipment includes all the necessary automatic tripping devices required to protect the unit when a malfunction occurs.

E. Electrical Systems

Most, but not all, electrical components for the 55 MWe units will be larger in size than those for the 25 MWe plant, generally in proportion to their size. The auxiliary power system will not only be larger in capacity but also will have more components. This equipment will be all indoors except for the auxiliary power transformer.

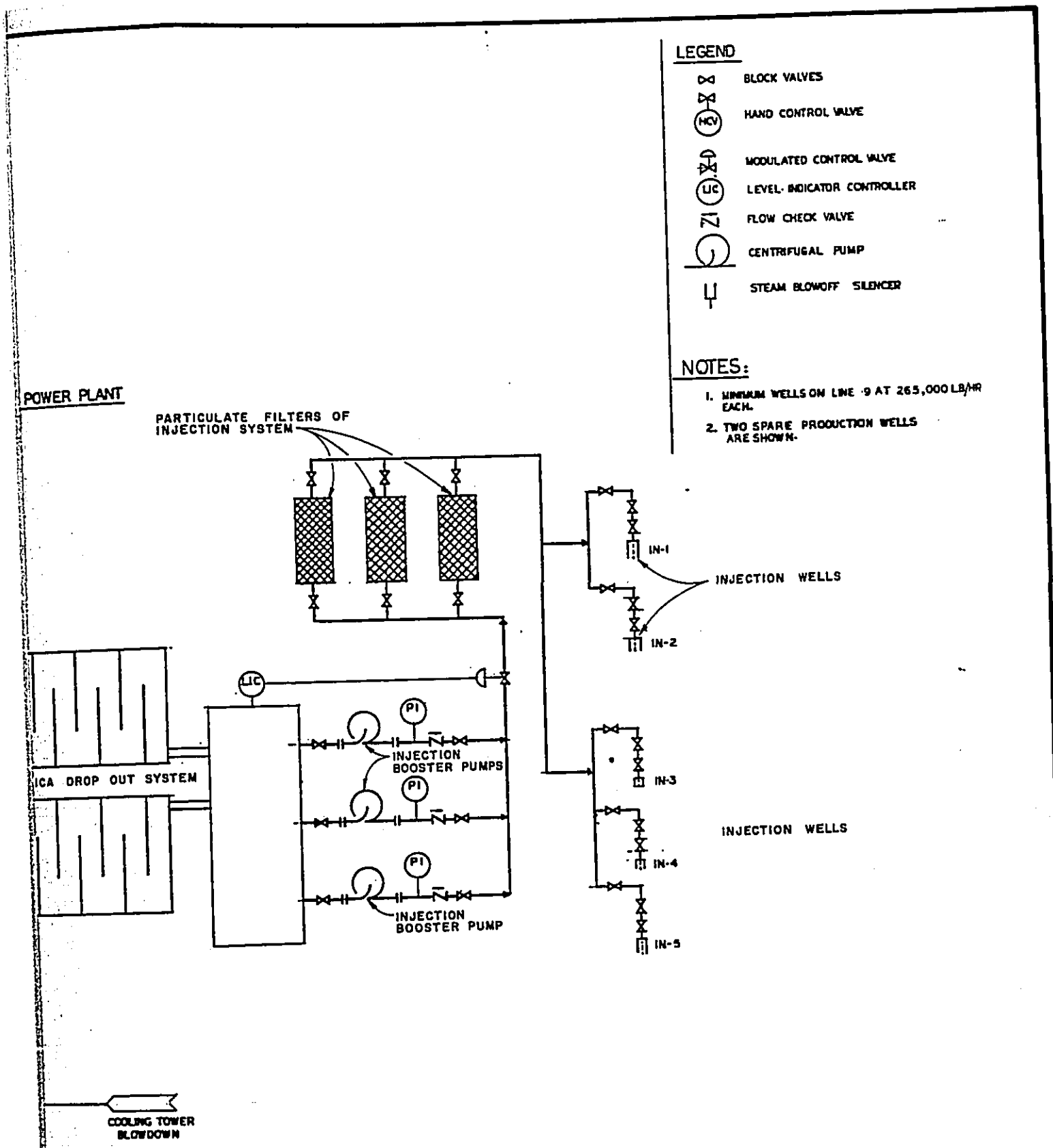
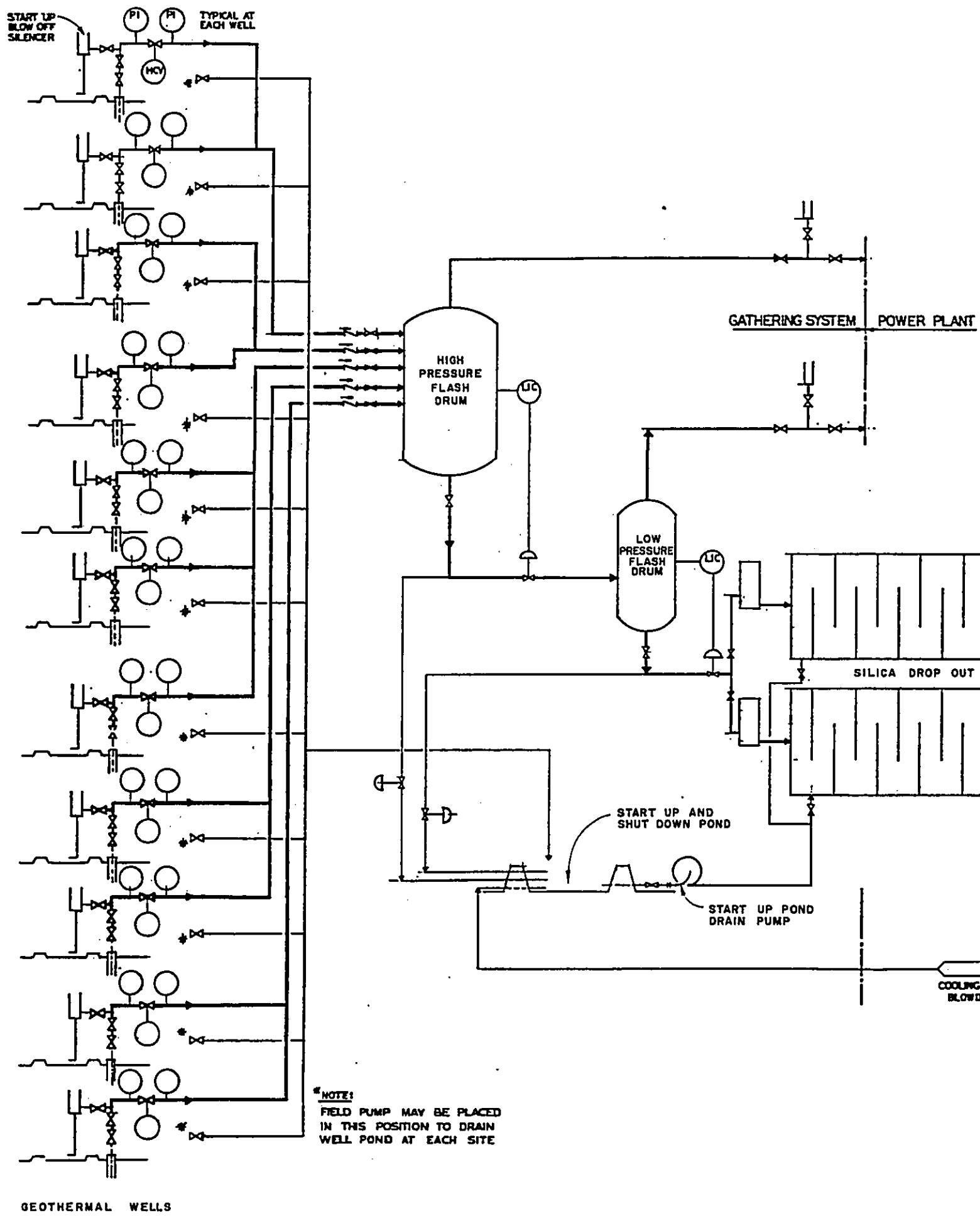


FIGURE 2-21

GATHERING AND INJECTION SYSTEM
55MWe POWER PLANT



SOURCE: ROGERS ENGINEERING CO., INC.
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The size of some electrical components, such as communications, protection, control, monitoring, and alarm systems, are not a function of the size of the units and will have the same impact for both sizes of generating units.

The physical size of the high voltage switchyard and its apparatus is mostly a function of voltage. The 55 MWe generating units will have a higher transmission voltage, 138 KV, instead of the 69 KV level planned for the 25 MWe plant. Higher voltage requires greater spacing for the air insulated conductors used for transmission of power. To obtain proper clearances, taller structures and a larger area are needed for the switchyard at the higher voltage. A slightly higher visual impact will result.

A second generating unit will double the amount of generating equipment and will approximately double the size of the power room. The higher voltage switchyard will have one more 138 KV circuit breaker and related buses added for the second unit, approximately a 1/4 increase in amount of equipment.

F. Energy Conversion (Process) System

Steam from the gathering systems is supplied to the plant steam lines at the plant boundary (See Figure 2-22). A steam line pressure relief system will be installed for emergency shutdown of the turbine generator. Steam is piped to the turbine, and in smaller quantities, to the turbine gland seals, first stage noncondensable gas ejector and second stage noncondensable gas ejector. Turbine steam is exhausted at 4 in. Hg Abs. downward to the shell side of a surface condenser. Cooling water flow through the horizontal condenser tubes is in a multi-pass arrangement.

Discharge from the first stage (main condenser) steam jet ejector enters an inter-condenser where noncondensable gases are drawn off by a second steam jet ejector discharging to the after-condenser. The after-condenser gas and uncondensed steam is discharged to a gas abatement unit which converts the H_2S in the noncondensable gas to sulfur. This bulk sulfur by-product should find a market in the agriculture and sugar industries of Hawaii. The other nominal end-products of the process will be combined with the spent brine in the silica dropout pond before reinjection.

2.3.5.4 Power Plant Construction

The construction methods and equipment used for construction of the geothermal power plants are essentially the same for the 12.5/25 MWe and 55/110 MWe plants since the construction differs significantly only in size. The plant construction sequence and schedule will be determined by the actual results of the exploratory and production drilling and the development of the market for power. At this time, the following sequence and schedule of geothermal plant construction is planned:

Plant Site	Potential Production Capacity	Cumulative Total	Year In Power Production
(Begin Drilling Operations ..... 1982)			
A	25 MWe	25 MWe	1985
A	55 MWe	80 MWe	1989
B	55 MWe	135 MWe	1993
C	55 MWe	190 MWe	1997
D	55 MWe	245 MWe	2001
E	25 MWe	270 MWe*	2003

*If the geothermal resources support this scenario, a Supplemental EIS will be required when production capacity reaches 250 MWe.

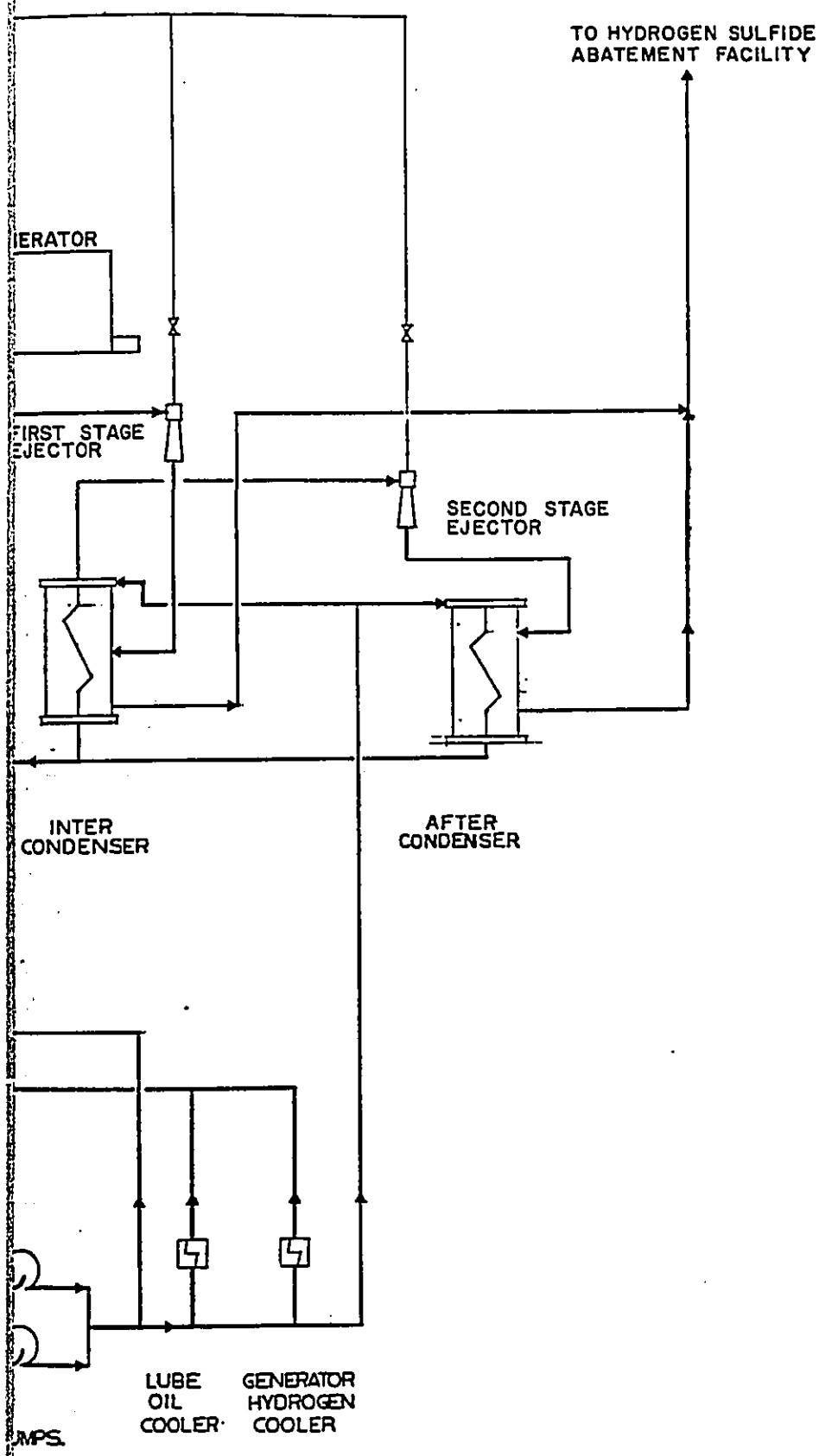
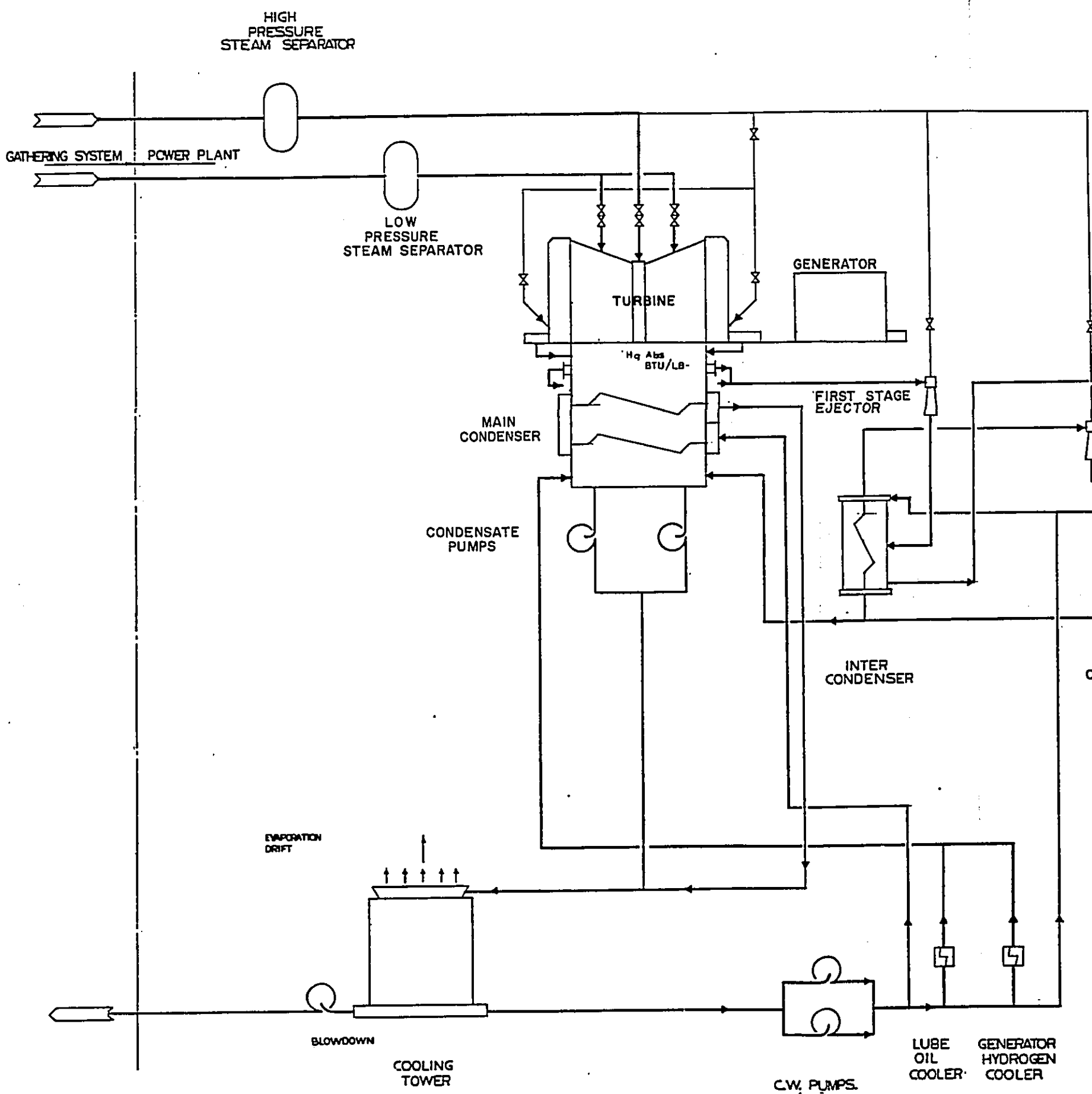


FIGURE 2-22

FLOW DIAGRAM
55MWe POWER PLANT



SOURCE: ROGERS ENGINEERING CO., INC.
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Plant E is the closest to existing residences. It is anticipated that this site will be developed last and will receive the benefit of experience from the earlier development activities.

Construction at any given plant site would be preceded by extensive design planning and ground surveys. The proposed site will be staked out on the ground for a survey by engineers, ecologists and geophysicists. Site location adjustments would then be made as required. Of particular concern would be the presence of geophysical faults and cracks that could make a planned site dangerous. In general, plant sites would be located on higher ground, if practicable, to minimize volcanic hazards.

The site preparation would begin with vegetation clearing and grubbing. Care would be taken to preserve larger trees if possible and include them in the site landscaping where practicable. Site grading requirements will be minimized to the extent possible by adjusting site structures to the existing elevations. The pahoehoe lava provides an excellent structural foundation, given the absence of lava tubes. The foundation investigations will place particular emphasis upon the definition and avoidance of lava tubes, if any are identified on the sites. The gentle slope of approximately 3 percent will permit structure construction without excessive excavation and embankment.

It is planned that all construction work will be accomplished by local contractors and the local labor force to the extent practicable. The larger 110 MWe plants will be constructed incrementally with 55 MWe units. It is estimated that a second 55 MWe unit would be on line within 3 years after completing the first unit.

2.3.5.5 Power Plant Operation and Maintenance

Geothermal power plants are designed for long-term, base load operations with minimal operation and maintenance costs. Maintenance will require a total of 5 weeks per year of which 4 weeks will be required for the annual scheduled turbine and plant overhaul.

According to the current experience of other geothermal power plants in the United States, acceptable emission control systems are available and being used to meet existing air quality standards.

The method of abating hydrogen sulfide (H_2S) for the 55 MWe units will be different from that used in the HGP-A plant and the 25 MWe plant as proposed. In the smaller plants, a higher operating cost for an effective abatement process is accepted in preference to the relatively large capital cost of installing the alternate process suitable for larger plants. In the 55 MWe plants the economics are in favor of installing process equipment, such as the iron catalyst system or the Stretford process.

In the iron catalyst system for H_2S abatement, approximately 70 percent of the noncondensables in the steam dissolve in the cooling water and steam condensate mixture in the condenser hotwell; the balance is removed from the condenser by the noncondensables ejector system and is ducted to the cooling tower air stream. In plants not equipped for H_2S abatement, the gases dissolved (including H_2S) in the cooling water/condensate are air stripped from solution in the cooling tower and released to the atmosphere.

To prevent the emission of H_2S, the cooling water is doused with ferric ions via injection of ferric sulfate. The ferric ions react with the dissolved H_2S to yield elemental sulfur, water, and ferrous ions. As the cooling water is aerated in the cooling tower, the ferrous ions react with oxygen to reform ferric ions; continuous regeneration of ferric ions is thus provided to sustain the H_2S reactions, which repeat continuously to yield sulfur. The sulfur thus formed is removed from the system via clarifiers (after flocculation) as a sludge and dumped at an approved site. The H_2S ducted to the cooling tower as part of the condenser vent gases is similarly treated after the H_2S is scrubbed from the air stream by the falling water, which is high in ferric-ion content. Overall H_2S abatement efficiencies of up to 92 percent have been reported.

The basic elements of a typical iron catalyst system include the catalyst injection system, the clarifier, transfer pumps, the flocculator/clarifier, and the sludge handling system. Note that this method of abating H_2S emissions is used only with power plants employing direct contact condensers or processes in general in which H_2S is dissolved in the cooling water and released by air stripping in cooling towers. The system has the advantage of being inherently simple and utilizes conventional in-water treatment systems. It has some disadvantages, including increased corrosiveness of the cooling water/condensate, potential plugging of the cooling water/condensate piping, and the need for removal and handling of the sulfur sludge produced by the process.

In a power plant configuration incorporating the Stretford process the direct contact condenser is replaced by a surface condenser thus precluding release of H_2S via the cooling water.

The Stretford process is a proprietary process widely used to desulfurize process gas streams. As typically applied to geothermal steam power plants, the noncondensable gas purged from the condenser is washed with an aqueous solution of sodium carbonate, sodium ammonium polyvanadate, and anthraquinone disulfonic acid. The H_2S in the purge gas is absorbed in the solution and reacts with the sodium carbonate to yield sodium bisulfide, which is subsequently oxidized in the process to elemental sulfur. Following oxidation, the solution is recirculated to the absorber column, an a sulfur-bearing froth is separated, filtered or centrifuged, washed, and melted to produce commercially pure sulfur. Oxidation of the sodium bisulfide is effected by the vanadate, which is reduced from a 5-valent to a 4-valent state. The vanadate is, however, later regenerated to a 5-valent state through a mechanism involving oxygen transfer through the anthraquinone disulfuric acid.

The Stretford process is essentially an independent facility co-located with the power plant and has no direct influence on the power cycle. It

thus does not have the added corrosion problem associated with the iron catalyst system. It has, in addition, the advantage of producing a commercially saleable product in lieu of a sludge requiring disposal. It does, however, have the disadvantage of being more complex and costly than the iron catalyst system.

Rogers Engineering Co., Inc., Pacific Gas and Electric Company and other geothermal engineering firms have an on-going program of active study of alternative methods of H_2S abatement. It is probable that some improvement in the state-of-the-art of hydrogen sulfide abatement may be available by the time the 55 MWe generating units are built at Kahauale'a.

A lower percentage of the hydrogen sulfide in the fluid that circulates through the cooling tower will be removed by prior treatment, resulting in a low rate release of hydrogen sulfide to the atmosphere.

Other effluents of operation consist of the Stretford process fluids, cooling tower blowdown and excess geothermal fluid, which are sent to the injection station, and geothermal fluid in the form of water vapor and drift droplets released to the atmosphere from cooling tower exit air.

The vapor and drift released to the atmosphere from the cooling tower will contain small concentrations of dissolved solids and noncondensable gases which are present in the geothermal steam. Although the gases will be present in the same amount, the drift will contain liquid with a dissolved solids concentration similar to the cooling water blowdown. The drift loss will be small and should percolate into the lava. See Section 5.3.3

2.3.6 Power Transmission Line Descriptions

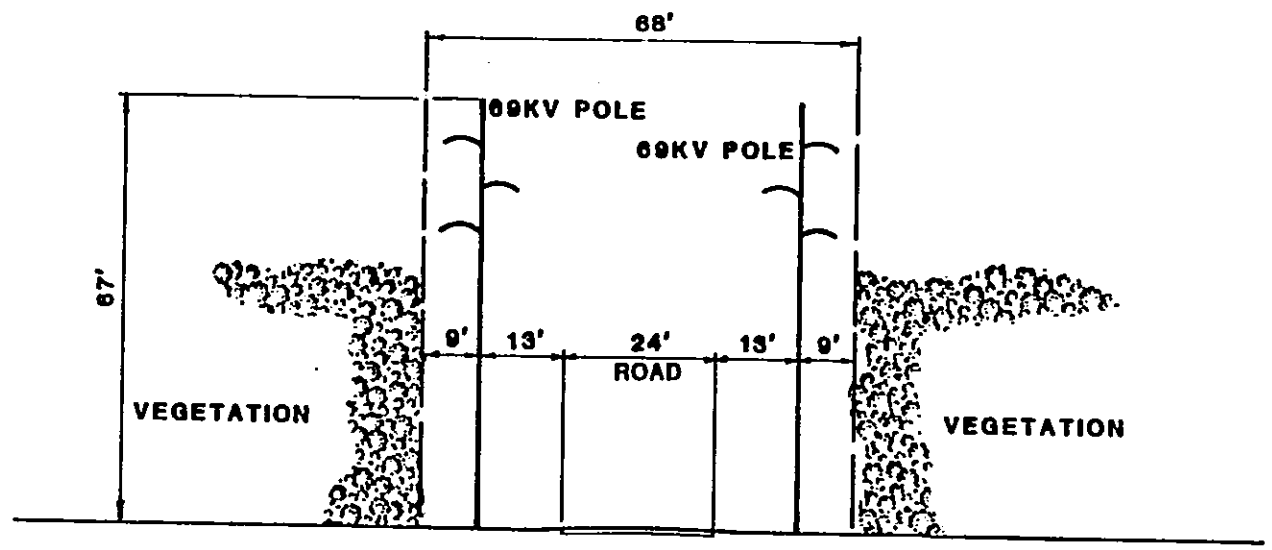
2.3.6.1 Design

The design, construction, operation and maintenace of all power transmission lines from the geothermal power plants will be conducted by HELCO in accordance with its standards for such work on the Big Island.

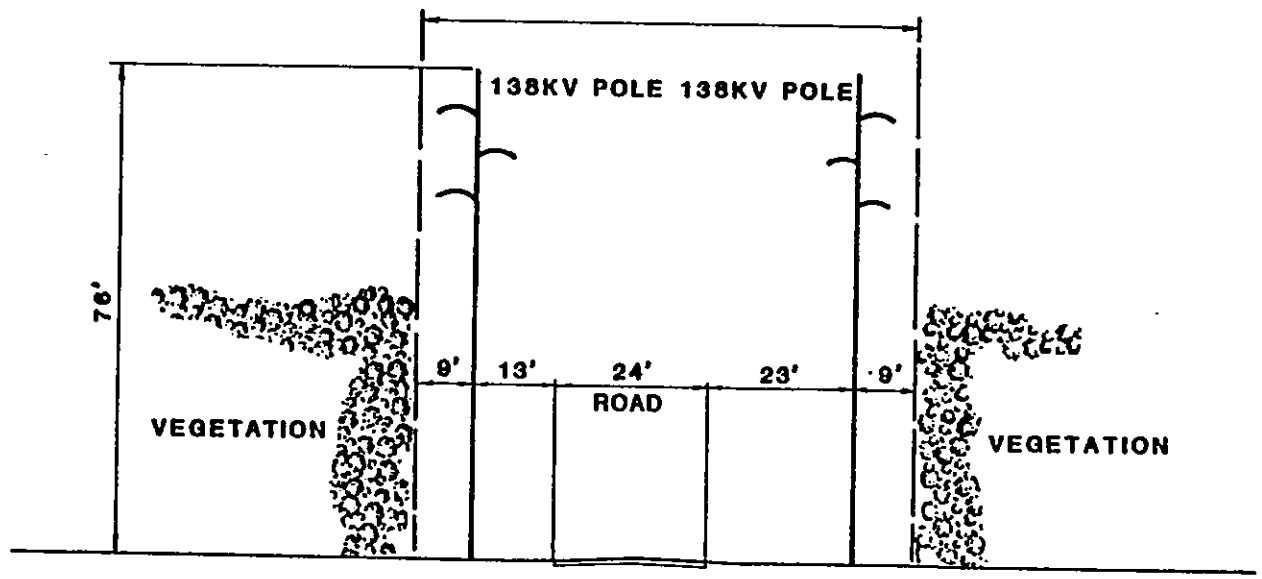
Electric power at the plants will be generated at 13.8 KV and transmitted to the power transmission lines through main step-up transformers converting the voltage to 69 KV or 138 KV at the plant site. HELCO standards require dual, redundant power lines on the Big Island to ensure continued transmission of base load power from the geothermal power plants. For example, should one of the power transmission lines be out of service due to maintenance, structure or conductor failure, or volcanic activity, the remaining power transmission line would still be able to carry the full load. If wood poles are utilized, a physical separation between the two power transmission lines as shown in Figure 2-23 would be highly desirable.

The initial 12.5/25 MWe power plant at plant site "A" will transmit power at 69 KV to an existing HELCO power transmission system. Detail "A" of Figure 2-23 indicates the two required 69 KV power transmission lines, one on each side of the fully developed two-lane road. An overall corridor clearance of 68 feet will provide vegetation clearance to a distance of 9 feet outside of the line of poles. A typical wooden power pole will reach a height aboveground of 67 feet, with an additional 8 feet extending into the ground. Span length will average 600 feet between poles.

The existing HELCO power transmission system in and adjacent to the Puna District is indicated in Figure 2-24. At the present time, there is a 34.5 KV power line extending along the Volcano Road. New 69 KV power transmission lines from Kahauale'a would extend from the project area, through the W. H. Shipman, Ltd., property to connect to HELCO's electrical grid system (see Figure 2-24). Planning, design and construction of the power lines will proceed with the decision to construct the initial 12.5 MWe power plant. The initial planning and ground surveys for the access roads will include the right-of-way width to accommodate the power lines along the sides of the corridor. The wooden poles for the 69 KV lines will provide a minimum clearance of 27 feet between the ground surface and the conductors. Each of the 69 KV lines will have three aluminum conductors, one per phase. Each phase (conductor) will be suspended from the pole structure by a single 7-bell insulator string, with vertical spacing between phases of 6.5 feet. The conductors will be



69KV POWER TRANSMISSION LINE CORRIDOR
(DETAIL "A")



138KV POWER TRANSMISSION LINE CORRIDOR
(DETAIL "B")

SOURCE: HECO
SCALE: 1" : 30'

FIGURE 2-23
POWER TRANSMISSION LINE CORRIDORS

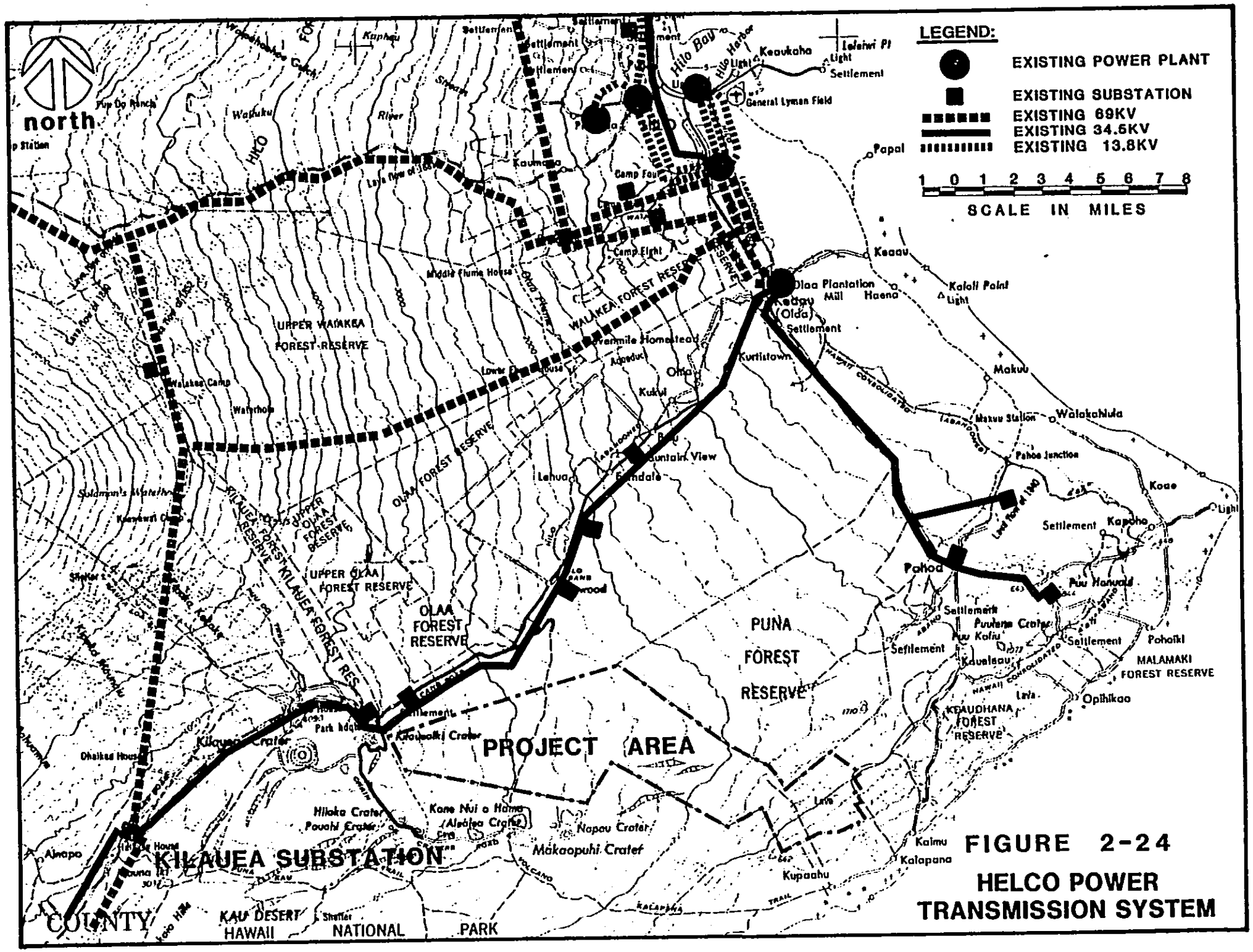


FIGURE 2-24

HELCO POWER TRANSMISSION SYSTEM

protected from lightning strikes by an overhead shield wire mounted on the tops of the wooden poles and connected by ground wires to ground rods driven into the earth at the bottom of the poles. A lot size of about 150 feet by 135 feet will be required for a switching station near the main step-up transformer at the 12.5/25 MWe power plant site (site "A").

If additional power (in excess of 25 MWe) can be accepted locally by HELCO, 138 KV lines will be required. It is likely that the same corridor would be used to accommodate the 138 KV transmission lines. The 138 KV lines will require higher wooden power poles (typical height of 76 feet aboveground) as indicated on Detail "B" of Figure 2-23. Special steel pole structures may be used at angles, deadends, and for long spans or where special visual or safety considerations exist. The average span length between the poles will be 600 feet. The 138 KV power line will include double bundle capabilities.

The change-over from 69 KV to 138 KV power transmission lines can be accommodated along essentially the same corridor. One of the dual 138 KV lines can be constructed along the same pole line as one of the de-energized 69 KV lines. The second 138 KV dual line will be constructed 78 feet away from the first line to avoid line interference if one line is damaged and falls toward the other. This increased corridor width can be obtained by clearing the vegetation on only one side of the corridor to an additional 10 feet, thereby limiting the vegetation disturbance to one side along the corridor.

If electrical power is to be transported off island, higher voltage transmission lines may be required. At present there is no HELCO power line on the Big Island that has a higher voltage than 69 KV and none have been designed to date. Therefore, it cannot be determined at this time where the ultimate off-site power line corridor alignment will be located. Presently, HELCO is not in the position to provide plans for a transmission system that could export electricity from Hawaii to Oahu should the deep water submarine cable become a reality. HELCO must take into consideration

the power that may be generated by the other geothermal developers who are also actively pursuing the development of this energy resource. In addition, the location of the termination station of the submarine cable on the Big Island has not yet been determined. The location of this station is very important when designing the export-power transmission system. Also, the location(s) of the Alternating Current/ Direct Current (AC/DC) converter station(s) will have to be determined. These locations can only be determined after the geothermal generating unit sites are known and the shoreline termination station of the underwater cable is located.

2.3.6.2 Construction

Construction of the transmission lines will proceed after development of the ultimate two-lane road and will probably coincide with power plant construction. Construction activities will consist of clearing and site preparation for the right-of-way and pole sites; erection of transmission pole and line stringing; and clean-up and reclamation. Essentially the same construction procedures will be followed for both the 69 KV and 138 KV lines.

A. Site Preparation and Vegetation Clearing

The power line corridor will be along the access road and therefore additional vegetation clearing will be limited to the minimum required (Figure 2-23). Outside of the right-of-way, trees that might contact the lines during wind-induced swing will also be removed or topped.

For each transmission pole, a site will be cleared and leveled for structure assembly and erection. Leveling will be accomplished with a bulldozer. In addition to the assembly sites, conductor stringing sites will be leveled and cleared at approximately 3.1-mile intervals along the right-of-way. These stringing sites will be used to pull conductors into place and for tensioning the conductors.

B. Line Construction

A wagon drill mounted on a truck or tracked tractor will be used to dig holes for the poles. The poles will be transported to each site and erected by crane. After erection and placement of the poles, the holes will be backfilled. Various pieces of heavy construction equipment are used in the transport, assembly and erection of the poles. Blasting may be required to excavate the pole holes in areas of hard rock.

The transmission line conductors will be attached to the structures by a "tension-stringing" method whereby a bulldozer or helicopter will be used to pull the sock line (a lightweight leader cable) down the center of the right-of-way. The sock line is then used to pull the conductors into place under tension, using a vehicle operating along the access road and power line centerline.

C. Cleanup and Reclamation

Vegetation cleared during line construction will be left on site except for any large trees which may be harvested. Disturbed areas will be restored where necessary. All areas disturbed during line construction will be permitted to revegetate with appropriate natural species. Revegetation techniques may be required to assist the natural revegetation and will vary according to each vegetation type along the transmission right-of-way.

2.3.6.3 Operation and Maintenance

HELCO's transmission line responsibilities will include operation and maintenance of the lines. The transmission line corridors will be inspected at least twice a year for possible problems with the power poles and electrical systems. Vegetation will be periodically trimmed, as required, to maintain the desired right-of-way and clearance to the poles and conductors.

SECTION 3
DESCRIPTION OF THE ENVIRONMENTAL SETTING

To assess the environmental impact of the Kahauale'a Geothermal Project, a description of the existing conditions within the Geothermal Project area and along the proposed access road and transmission line was prepared. The following is a discussion of general site description, physical environment, biological environment and human environment in the project area and vicinity.

Baseline environmental studies of the Kahauale'a Geothermal Project area began in June 1981. Ecotrophics, a consulting firm specializing in the performance of environmental surveys and analyses of ecosystems, was engaged by the developer to conduct field environmental surveys, including fauna, flora, and chemical toxicant emission on air and plants. Initial baseline surveys were conducted to obtain knowledge of the entire project area in a general sense with special emphasis on site specific knowledge in or along areas of currently planned project activities.

The environmental baseline study involved 74 man/woman days of effort in the field and over 20 man/woman days devoted to laboratory analysis/library research. The survey covered over 500 acres of the project area.

The baseline assessments provide not only a detailed description of the existing environment but also provide: (1) a reference data set against which to determine the extent and direction of future change, whether initiated by human activities or natural process; and (2) a reference standard toward which corrective measures can be directed if need be.

Through sampling techniques and traverse of the power plant sites, initial drilling site area, and access road to the first drilling site, a fairly accurate description of the forest was obtained.

3.1 GENERAL SITE DESCRIPTION

The project location within the Puna District on the Island of Hawaii is indicated on Figure 2-1. The Land of Kahauale'a extends from the Thurston Lava Tube area to the sea and includes historic "Queen's Bath." The land was originally purchased in 1893 from the Estate of King Kalakaua. A portion of Kahauale'a was acquired by the Territory of Hawaii through land exchange for addition to the Hawaii Volcanoes National Parks in 1927. The Campbell Estate received from the Territory a 2,526-acre site adjoining Kahauale'a. The total acreage for the project is 25,461 acres. The extent of the project area is indicated on Figure 2-2.

The current State land use designation for the Kahauale'a region is shown in Figure 3-5. The County of Hawaii land uses for this region is shown in Figure 3-6.

The native forest in the project area is composed of many different tree and shrub species. From the 4,000-foot elevation near Thurston Lava Tube down to the 900-foot elevation above the Royal Garden Estate, the forest is dominantly ohia which shows extensive dieback in the initial project development area. Generally, the ohia trees provide a fairly open canopy (about 50 percent cover); therefore, the understory consists of other trees, shrubs and various ferns and mosses.

A vegetation type map, compiled through interpretation of aerial photographs and ground check by the Division of Forestry and the U. S. Forest Service, provides information on the kind and extent of the forest land with its timber resources on the land of Kahauale'a. This is shown in Appendix B.

3.2 PHYSICAL ENVIRONMENT

The field examination for the baseline study began at the end of Captain's Drive in the Fern Forest subdivision. A 3.5-mile long trail to the lava devastated area of the first drilling site was cut through dense native forest of 70-100 percent canopy containing rare and/or new species of Adenophorus, Cyrtandra, Cyaneae and Clermontia. See Section 3.3.2, "Rare and Endangered Species." It is noteworthy, however, that except for the Adenophorus periens, these valuable plants were found only in the dense upper portion of the trail.

This area is largely free of exotic and weed species most associated with disturbance. In contrast, nearly one-half of the inner mile adjacent to the lava field is acutely disturbed with many fume- and heat-killed tall trees still standing. Above this fume- and heat-killed zone, the canopy (reduced to 40-70 percent cover) gives evidence of feral pig damage and the introduction of weed species into open areas. The band of disturbed to acutely disturbed forest forms a belt around the 1965 lava field varying from 0.5 to 1.5 miles in width. The canopy along the access trail from Captain's Drive into Kahauale'a varies from dense to closed, and harbors new and/or rare plant species along its upper extent. It is a relatively young forest with many saplings and older trees generally less than 5 inches DBH (diameter at breast height).

To the southeast, toward Royal Gardens subdivision, the land is predominantly lava field, open forest (less than 40 percent canopy), and forest severely damaged by past eruptions.

Moving southward and westward from the end of the Glenwood side dense forest trail and in the lower half to three-quarter mile strip along the park boundary lies the interface with the eruption of 1965.

For five miles to the west along this southern tier, the near barren lava and the interface of severely damaged and disturbed forest persist. One exception, about 2 miles northeast of Napau Crater there is a tract of larger trees (greater than 8 inches DBH) in an area of about 1 mile

diameter. This is not a prime example of native forest because it is somewhat more open and drier, and shows evidence both of pig and volcanic disturbances.

West of a line from Napau Crater to Olaa Forest Park Reserve and extending from the Hawaii Volcanoes National Park boundary to Volcano Highway, there are approximately 18 square miles consisting mainly of open, disturbed land with perhaps 15-20 percent of dense forest. Most of the area has less than 40 percent canopy. Starting at the Shipman property, a new survey was begun, taking the whole forest picture into account. Between the initial and, later, more intensive surveys, a helicopter supported mission into the lava fields was carried out. The foot reconnaissance from the lava field combined with the aerial view over the area contributed to a comprehensive picture of the prospect area.

Following recommendations that the access route to the geothermal field be sought toward Volcano. The site selected begins at Volcano Highway with an easement through the middle of the Shipman Estate, about 1.5 miles east of Jade Avenue, then extends after a 1.5-mile trail into the prospect area. The lower section of Shipman land contains 70 percent cover, but the floor contains strawberry guava, and composite weeds such as Pluchea and Erechtites, all indicative of disturbance. Pig trails were also evident and damage was extensive in certain areas.

The proposed access route extends through open forest -- 10-69 percent canopy, well endowed with exotic plants and pig trails, and without evidence of rare or endangered birds. As it turns eastward, the route crosses lava fields and the interface of forest and lava fields. The NW-SE segment harbors no rare, threatened or endangered species.

As the road turns sharply to the ENE, however, the botanical situation changes. In the vicinity of the proposed 1-mile route between power station sites B and D, an area of significant potential impact was found. About 3 miles SE of Route 11 near Volcano Village and at an elevation of 2,200-2,900 feet, a 15-year old lava field cuts through a mature native

forest. The lava field and forest were accessible only by means of a second helicopter entry. The largely unweathered aa represents an early successional stage in the formation of mixed native-exotic woody community with occasional small isolated stands of mature native vegetation.
The bordering, however, is a closed native forest (60 percent cover) with 'ohi'a trees of 15 meters and more in height as dominants with other native species as well as olapa and hapuu. This area, with its closed subcanopy is rich in epiphytes up to 3 meters in height. These include Peperomia, 'ie'ie and Psilotum together with Grammitis, Mecodium and other endemic ferns.

The presence of the previously very rarely seen Adenophorus periens was most surprising here. This fern has been proposed for listing as an endangered species. It appears to grow in a restricted area within the Kahauale'a forest. Its growth conditions include high humidity, northern exposures, shade and a mat of epiphytes.

Taken altogether, this is a climax native forest with a rich variety of endemic and native species, and relatively little pig damage or invasion by exotics.

Westward toward the 3,400-3,900 foot elevation near Power Station Site E, there is a relatively open and disturbed forest with dieback areas. Pig activity, sometimes severe, is evident toward the Thurston Lava Tube area. Native species regeneration is poor and no rare, threatened or endangered species are present.

By February 1982 air quality baseline data had been taken for 7 months and extended from Royal Gardens Subdivision in the SE to Captain's Drive (Fern Forest) in the NE, to Route 11 at Shipman access to the NW, to Thurston Lava Tube, and south of Route 11 to the lava fields and the Hawaii Volcanoes National Park boundary. (Some locations such as Royal Gardens, Thurston Lava Tube, Volcano Highway, etc., have been sampled for over 10 years.)

Data on record show this entire area to be high in air mercury naturally by EPA, not NIOSH (National Institute of Occupational Safety and Health) standards. Both hydrogen sulfide and sulfur dioxide levels are below standard detection limits. This atmospheric situation is typical of sites near the Kilauea East Rift, but located upwind or windward of sulfur-rich fume areas. It is in marked contrast to the air quality at HVNP to the south, downwind of the East Rift where both sulfur gases and mercury reach undesirable levels.

Based on an overview of the prospect area via ground and air, the native forest to the northeast can be spared any significant impacts, including emissions, as these forests are upwind of the proposed site, and development can proceed without serious or significant ecological damage in other parts of the parcel.

3.2.1 Geology and Soils

3.2.1.1 Geology

The Island of Hawaii lies at the southeast end of a chain of islands extending nearly 2,000 miles across the north central Pacific. The state consists of eight major islands and 124 minor islets and atolls.

The County of Hawaii encompasses the Island of Hawaii and is the State's largest county in size with a total land area of 4,038 square miles. Its principal city is Hilo which is the county seat and fourth largest city in the State.

The Island of Hawaii was formed by five volcanoes, and the resulting mountains with their peak elevations are: Mauna Kea, 13,796 feet; Mauna Loa, 13,677 feet; Hualalai, 8,271 feet; Kohala, 5,480 feet; and the Kilauea Caldera, 4,090 feet. Two of these volcanoes, Kilauea and Mauna Loa are still active. The latest eruptions by the volcanoes were the Pauahi Crater eruption on November 16, 1979 and the Kilauea eruption at Puu Kiai during September and October of 1977.

The earliest exposed lava flow and thin intercalated ash beds of Kilauea Volcano comprise the Hilina Volcano series. These are capped by the Pahala ash which in turn is overlain by the lava and thin ash beds of the Puna Volcanic series. The lava of both series are very largely olivine basalt. The volcanoes of the Island of Hawaii are believed to have started their activity in the tertiary period.

The Land of Kahauale'a begins at a point adjacent to Kilauea Volcano. Kilauea's two main rift zones (east and west) are defined by large pit craters, cracks, and cinder cones. Lava flows, devastated areas, and steam cracks show old and new activity. The Kilauea East Rift Zone crosses the Kahauale'a parcel. Lava from eruptions of Kilauea in 1963 and 1965 passed into the east rift zone and vented at two points in the Kahauale'a parcel.

3.2.1.2 Soils

Soil Classification - The soils in the project area belong to the Keei, Kiloa, Papai, and the Puhimanu series. The U. S. Department of Agriculture, Soil Conservation Service classified most of the land as Keei extremely rocky muck, 6 to 20 percent slopes (rKGD). Small sections are classified as Kiloa extremely stony muck, 6 to 20 percent slope (rKXD); Papai extremely stony muck, 3 to 25 percent slopes (rPAE); and Puhimanu silt loam, 2 to 6 percent slopes (rPHB). Following are the brief descriptions of the soil types:

A. Keei Extremely Rocky Muck, 6 to 20 Percent Slopes (rKGD)

This soil type is a very dark brown muck about 10 inches thick. The soil is strongly acid and underlain by pahoehoe lava bedrock. The soil above the lava is rapidly permeable. The lava is very slowly permeable, but water moves rapidly through the cracks. Runoff is medium and erosion hazard is slight. Keei soil is used mostly for woodland and watershed. Small acreage are cleared and used for pasture purposes.

B. Kiloa Extremely Stony Muck, 6 to 20 Percent Slope (rKXD)
The surface layer of this soil type is very dark brown extremely stony muck about 10 inches thick. The soil is strongly acid and underlain by fragmented aa lava. Permeability is rapid, runoff is slow, and the erosion hazard is slight. Kiloa soil is mostly used for woodland and pasture.

C. Papai Extremely Stony Muck, 3 to 25 Percent Slopes (rPAE)
This soil type is very dark brown extremely stony muck about 8 inches thick. The soil is strongly acid and underlain by fragmental aa lava. Permeability is rapid, runoff is slow and the erosion hazard is slight. Papai soil is mostly used for woodland and small areas for pasture, orchards and truck crops.

D. Puhimanu Silt Loam, 2 to 6 Percent Slopes (rPHB)
The surface layer of this soil type is very dark brown and very dark grayish-brown silt loam and loamy fine sand, about 5 inches thick. The next layer is about 8 inches thick and consists of very dark grayish-brown and dark-gray sandy loam, and underlain by pahoehoe lava. This soil dehydrates irreversibly into sand size aggregates. Permeability is rapid, runoff is slow, and the erosion hazard is moderate. Puhimanu soil is mostly used for woodland. Small acreage are used for pasture and truck crops.

Soil Chemistry - Examination of soil samples was to verify existing conditions and to establish baseline readings to monitor possible future change.

Soil reaction (pH) provides baseline information at two levels: intrinsically, departures from the range of about 5.9 to 6.3 are suboptimal for most plants. There are, of course, specific case of acid and alkali tolerant adaptations. Common *Rumex*, for example, thrives at pH 3.5 whereas Great Plains grasses including species of *Sporobolus* thrive at pH 8. The local flora are well adapted to the mildly acidic conditions encountered on the forest trail and its environs. (See Table 3-1 - "Soil Chemistry - pH

TABLE 3-1

SOIL CHEMISTRY - pH MEASUREMENTS
(July 3 - August 18, 1981)

Location	Range	Mean
Trail Edge (End of Captain's Drive)	5.0 - 6.0	5.6±0.3
Outer Trail (from edge)	5.5 - 6.0	5.6±0.3
Inner Trail (to field)	5.3 - 6.0	5.7±-.2
Fringe, Thurston Lava Tube Area	5.5 - 6.1	5.8±0.3
Fringe, Royal Garden Area	5.0 - 5.6	5.3±0.4
Comparative, Sulfur Bank		
Barren Land	1.6 - 3.8	2.1±0.9
Vegetated Land	3.9 - 5.6	4.2±0.7

All samples are based on 3 - 5 samples ± standard deviations.

Measurements.") That the plants of the area, in general, can adapt to far more severe conditions is suggested by the presence in pH 4.2 soil at the Sulfur Bank of grasses such as Andropogen and Paspalum, together with Lycopodium, ohelo (Vaccinium), 'ohi'a (Metrosideros) and other species. Second and no less important is the indicator value of soil pH in the monitoring of future change, if for example, excessive release or generation of acid mist (sulfuric acid aerosols) should occur. Previous HGP-A experience does not lead us to expect such acid buildup and deposition, although natural acid rains are known to occur in the Park and its environs.

Comparatively, the forest trail topsoils and those nearby are well endowed with basic nutrients as nitrate, phosphate and potassium ("NPK"). The value of these data is as reference values against future change. If introduced technological disturbances upset the local ecosystem significantly, this would be reflected in visible changes in the composition of the forest. The exact nature of such changes, for example, interferences in nitrogen recycling as a result of effects of acid mist on legumes would be reflected in decreased soil nitrogen and concurrent reduction in soil pH. Guidelines for abatement and/or restoration measures can thus be provided (see Table 3-2 - "Soil Chemistry - Fertility Data").

Changes in the canopy, in drainage, groundwater, will all affect soil chemistry; some before plant responses are obvious; some only at a later stage.

Some baseline parameters have utility by providing a frame of reference within which virtually any change may be detected and the direction and magnitude of such changes assessed. This may well apply to any baseline data set, but in addition, some are highly situation specific. Fertility data are general; pH data can find uses as both general and specific indices; the latter in assessment of acid precipitation. Soil mercury and arsenic are primarily specific indicators of environmental intoxication.

TABLE 3-2

SOIL CHEMISTRY - FERTILITY DATA
(July 3 - August 18, 1981)

Location	N(as NO_3^-)	P(as PO_4^{-3})	K
Trail Edge (End of Captain's Drive)	47	111	127
Outer Trail (from edge)	59	117	201
Inner Trail (to field)	51	104	121
Fringe, Thurston Lava Tube Area	61	108	177
Comparative Clay Loam Potting Soil	60.5	137	300

Figures based on duplicate samples.

Arsenic is present in some Hawaiian soils along the Kilauea East Rift to the extent of 0.5 to 2 ppm, but is 10- to 100-fold greater in volcanic extrusives and thermal fluids in Italy, New Zealand and Mexico. It has not been found in the current survey (see Table 3-3 - "Soil Chemistry - Mercury and Arsenic"), but is known in the Opihikao area to the southeast.
Levels of soil mercury in the prospect area, 40 to 60 ppb, correspond to mean crustal abundance values (U.S. Geological Survey), but are low by "Big Island" standards. Comparatively, the barren soils at the Sulfur Bank run 7- to 9-fold higher, whereas those covered with vegetation contain only twice the amount of the mercury found in forest soil. The difference between barren and plant-covered soils reflects actual removal of the element by plant uptake and revolatilization.

Soils and plants of the Puna area analyzed in 1975 were 3- to 7-fold higher in mercury content than those collected at the same sites in 1980. During the period 1970-75 over 10^8 cubic meters of extrusives were released whereas only 10^7 cubic meters of solids were released from 1975-80. Thus, local environmental mercury levels are readily influenced by volcanic activity many kilometers distant.

Plant data collected in the present survey also shows the proximity factor (see Table 3-4 - "Leaf Tissue Analysis for Mercury").

Forest fringe and trail samples of 'ohi'a leaves and uluhe fronds yielded the expected levels of mercury, about 100 ppb, based on sampling over the past two years at more than 20 sites from Volcano to Kapoho. The selection of 'ohi'a (Metrosideros) and uluhe (Dicranopteris) for sampling was based on their pre-eminent status as the principal endemic tree and endemic ground cover, respectively, of the native rain forest.

Samples of the same species growing at Sulfur Banks contained 2.5- to 3-fold more mercury than forest specimens.

TABLE 3-3

SOIL CHEMISTRY - MERCURY AND ARSENIC
(July 3 - August 18, 1981)

Location	Arsenic ppm	Mercury ppb
Trail Edge (End of Captain's Drive)	<0.05	40±2
Outer Trail (From Edge)	<0.05	42±2
Fringe, Thurston Lava Tube Area	<0.05	40±4
Fringe, Royal Garden Area	<0.05	58
Comparative, Sulfur Bank		
Barren Land	0.07	355±37
Vegetated Land	<0.05	84±5

All values based on 3 - 6 samples ± standard deviations.

TABLE 3-4

LEAF TISSUE ANALYSIS FOR MERCURY
(July 3 - August 18, 1981)

Location	Species	Hg Content (ppb)
Trail Edge	Ohia*	93±4
	Uluhe*	123±21
Outer Trail (From Edge)	Ohia	92±5
	Uluhe	110±11
Inner Trail (To Field)	Ohia	102±6
	Uluhe	111±13
Fringe, Thurston Lava Tube Area	Ohia	88±5
	Uluhe	93±5
Comparative, Sulfur Bank	Ohia	318±16
	Uluhe	250±15

Figures based on triplicate samples ± standard deviations.

*'Ohi'a is Metrosideros polymorpha; uluhe is Dicranopteris linearis.

3.2.2 Meteorology and Air Quality

3.2.2.1 Climate

There has been no continuous weather recording in the Kahauale'a geothermal project area. The information presented is based on short period data and reports outside the area plus general meteorological theory and principles. The brief description of these reports and data are at the end of this presentation. Since weather variables, such as wind, air temperature, and temperature inversion, are important factors in analyzing sound propagation and emission dissipation or chemical matter distribution, weather monitoring and weather data collection in the project area will be coordinated with the National Oceanic and Atmospheric Administration (NOAA).

The following are the three main controllers of the climate at the project area: location, very large scale horizontal and vertical weather systems, and diurnal solar heating and radiational cooling of the land. The blending and interaction of the different weather factors make up the climate of the area. The following is a presentation of the weather by individual elements:

A. Winds

The broad zone of winds blowing from the northeast through east direction, commonly called the trade winds, prevail about 65 percent of the time over exposed Hawaiian waters. By months, the mean percent frequency of trade winds are: January - 42 percent February - 55 percent, March - 61 percent, April - 74 percent, May - 86 percent, June - 91 percent, July - 95 percent, August - 94 percent, September - 83 percent, October - 71 percent, November - 64 percent, December - 57 percent. These persistent winds, extending through the atmosphere from the surface to about 10,000 feet over thousands of square miles, when well established, play a major role in the weather of the project area. The trade winds carry inland clouds formed over the ocean, produce clouds over the windward mountain slopes, and interact with the local winds.

The trade winds affecting the project area blow inland from the northeast between Hilo and Kapoho Point. The wind flow decelerates approaching land and deflects southward around massive Mauna Loa.

During the daytime, under solar heating of the land, the sea breeze flows inland from the ocean and moves up the windward mountain slopes. During the nighttime, with radiational cooling of the land, the thinner layer of the downslope winds, the land/mountain breeze, moves down the windward mountain slopes. Under light wind conditions, the sea and land/mountain breezes dominate the local wind circulation.

Under light to moderate trade wind conditions, during the daytime, about 9 a.m. to 6 p.m., the sea breeze interacts with the prevailing deeper depth trade winds to cause northeast upslope winds over the project area. The mean wind speed of this resultant flow is estimated to be about 10 to 15 mph above the forest, and appreciably lower from the northeast direction under the trees. During the nighttime, about 7 p.m. to 8 a.m., the shallower drainage wind caused by the land/mountain breezes interacts with the trade winds to result in the downslope wind towards the south over the project area. The drainage wind speed is significantly less than the daytime upslope wind speed. The depth of the nighttime drainage downslope wind can be a few hundred feet to about a thousand feet (Figures 3-1 and 3-2 show the schematic daytime and nighttime wind direction pattern under moderate trade wind conditions over the project area).

Under strong trade wind conditions, the direction of the resultant upslope flow is about the same as during moderate trade wind conditions but the mean wind speeds above and below the trees are increased: estimated 15 to 25 mph above, and 5 to 15 mph below the trees. Northeast upslope wind flow probably prevails throughout the day and night over the project area.

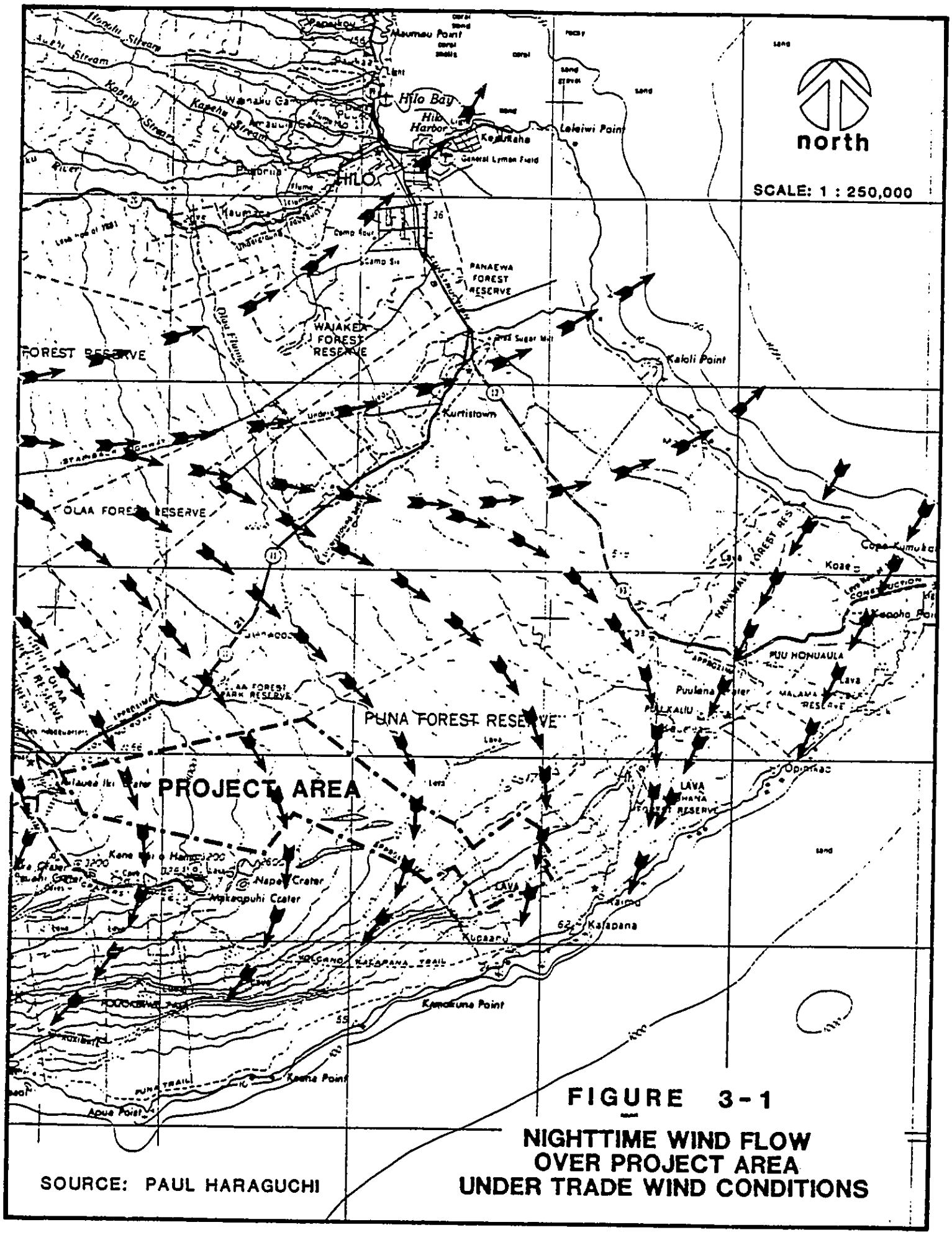


FIGURE 3-1

NIGHTTIME WIND FLOW OVER PROJECT AREA UNDER TRADE WIND CONDITIONS

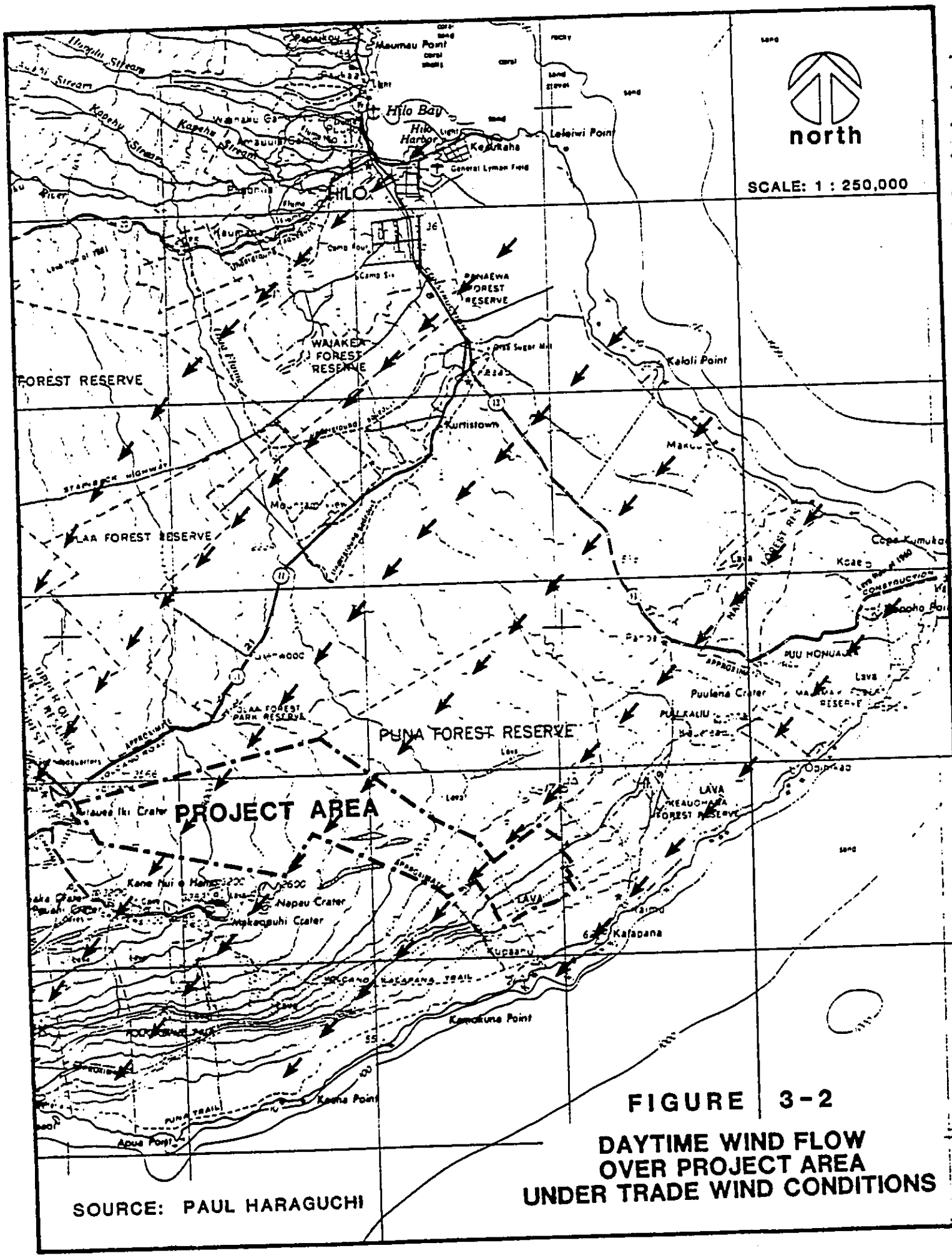


FIGURE 3-2

DAYTIME WIND FLOW OVER PROJECT AREA UNDER TRADE WIND CONDITIONS

The other large scale wind flows that affect the project area are the winds from the southeast through southwest directions, and to a much lesser degree, the winds from the north. The south winds, associated with heavy rains at times over the southeastern slopes of Mauna Loa, occur about 20 to 25 percent of the time. Light winds, when there is no large scale wind flow over the State, are included in the south wind frequency because the weak wind flow during these conditions is generally from the south. North winds are not too common, probably occurring less than 5 percent of the time.

As it did with the trade winds, the sea breeze will merge and interact with the southerlies during the daytime and the resultant wind will push up the windward slopes towards the west or northwest. During the nighttime, the drainage wind will probably undercut the light to moderate southerlies for a downslope flow towards the southeast over the project area. Under strong southerlies, the daytime and nighttime winds over the project area can be upslope from the direction of the south wind. Wind speeds will probably be in similar ranges as under the respective different strength trade wind conditions.

With northerlies, the north wind will interact with the sea breeze during the daytime, and with the drainage wind during the nighttime for a resultant wind direction towards the south quadrant.

With light wind conditions, the sea breeze dominates the daytime with light upslope flow towards the west. During the nighttime, the drainage wind would probably flow downslope towards the southeast. The mean sea breeze wind speed, stronger than the near drainage wind speed, could range from 5 to 15 mph above the forest.

B. Temperature Inversions

A temperature inversion is a layer in the atmosphere in which the temperature increases with altitude. The trade wind temperature inversion probably occurs about 70 percent of the time over the project area at about 6,000 to 8,000 feet mean height above sea level. It occurs more often during the summer months than during the winter months. Its strength varies from no temperature decrease through the layer to several degrees (°F) through the layer. The trade wind temperature inversion is likely to persist in space and time.

The cooler drainage air and the radiational cooling of the ground during the night will probably produce a ground level temperature inversion. The strength of this inversion is probably only a few degrees (°F) increase in temperature through a shallow layer of a few hundred feet. This temperature inversion will break down by the heating of the land by the sun during the day.

C. Rainfall

Monthly rainfall for the project area was estimated from the study of rainfall statistics for three nearby rainfall stations: Hawaii Volcanoes National Park Headquarters (HVNPH) to the west, Pahoa to the east, and Mountain View to the north.

This is a rainy area. Figure 3-3 shows the median annual rainfall for the project area. The northern sections can expect over 150 inches of rain a year, the central and eastern parts about 125 to 150 inches a year, and the western end about 100 to 125 inches a year.

The wetter northern section can expect about 15 inches per month during the rainiest months of March, November and December and about 9 to 12 inches per month during the remaining months of the year. July is the lowest rainfall month. The central and eastern portions of the area can expect about 13 inches of rain

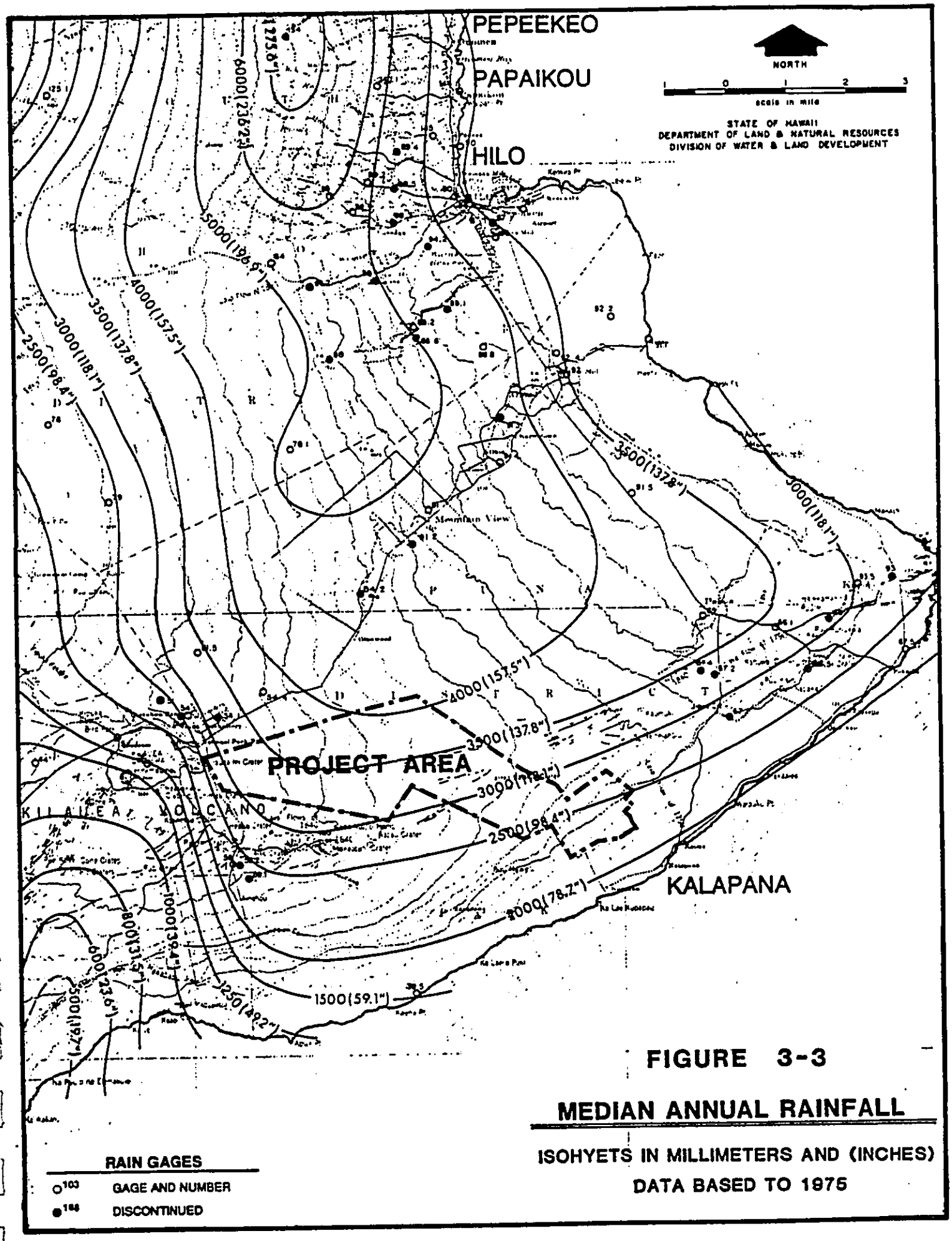


FIGURE 3-3

MEDIAN ANNUAL RAINFALL

ISOHYETS IN MILLIMETERS AND (INCHES)
DATA BASED TO 1975

RAIN GAGES

○ 103 GAGE AND NUMBER
● 188 DISCONTINUED

per month during the rainiest months of March, November and December and about 6 to 9 inches per month during the other months of the year. The drier western portion of the area can expect about 10 inches per month during the rainiest months of March, November and December and about 5 to 8 inches per month during the other months of the year.

There is great variation in monthly rainfall. Rainfall statistics for HVNPH, located to the west of the project area, show the great fluctuations; in 47 years of record, the highest monthly rainfall was over 40 inches and the lowest rainfall in a month was less than an inch. In a 25-year record, the greatest one-day rainfall amount was 11.75 inches.

For an estimate of the diurnal rainfall over the project area, the summarized records of two recording rain gage stations, HVNPH to the west and upslope of the project area and Lava Tree Park to the east and downslope of the project area, were used. The department of Meteorology, University of Hawaii, furnished the rainfall statistics of the frequency of rain equal to or greater than 0.01 inch of rain during an hour.

At Lava Tree Park in Pahoa, the minimum frequency of 11 percent in the mean annual rainfall frequency curve occurred between 1 p.m. and 3 p.m. The maximum frequency of 26 percent occurred between 1 a.m. and 2 a.m. and between 3 a.m. and 4 a.m. April and November were the months with the greatest rainfall frequency and February and September had the least frequent rainfall. At HVNPH, the minimum frequency of 11 percent in the mean annual rainfall frequency curve occurred between 9 a.m. and 11 a.m. The maximum frequency of 26 percent occurred between 5 p.m. and 7 p.m. The months of greatest rainfall frequency are April and December, and the months of lowest rainfall frequency are August, September and October.

The interaction of the trade winds with the sea breeze and the land/mountain breeze is the cause of the patterns of the diurnal frequency curves at the two rain gage stations. From the data above for the project area, one can expect the minimum frequency of 11 percent in the mean annual rainfall frequency curve between 9 a.m. and 1 p.m., and the maximum frequency of 26 percent between 5 p.m. and 4 a.m. over the project area. April, November and December would probably have the greatest rainfall frequency and September would have the lowest rainfall frequency at the project area.

D. Temperature

Air temperature changes by approximately 3°F per 1,000 feet change in elevation. Hawaii Volcanoes National Park Headquarters (HVNPH), located outside the upper end of the project property, is used as the reference temperature station to estimate the monthly temperatures of the project area. For an approximation of the project area's temperatures, add 3°F from that of the HVNPH temperatures for every 1,000-foot lower elevation. The following are temperature statistics for HVNPH: February is the coolest month with a mean maximum temperature of 65°F and a mean minimum temperature of 50°F. August is the warmest month with a mean minimum temperature of 50°F. August is the warmest month with a mean maximum temperature of 71°F and a mean minimum temperature of 55°F. The mean annual maximum temperature is 68°F and the mean annual minimum temperature is 53°F. Although the next two statistics are good only for the HVNPH, reference to the project area can be made. In a 25-year period, the highest daily maximum temperature was 85°F and the lowest daily minimum temperature was 37°F. From these extreme temperature records, it can be expected that the project area's daily maximum temperature could be a few degrees (°F) above 85°F and its daily minimum temperature would not be less than 37°F.

E. Solar Radiation

Global radiation at a location usually relates to its cloudiness and rainfall. Global radiation received on a flat horizontal surface, in langleys per day, measured at Hawaii Volcanoes National Park Headquarters, Mountain View and Pahoa, plus rainfall values at these stations were used to derive the approximate solar radiation at the project area. The data at HVNPH is used as the reference to estimate the project area's solar radiation. For the approximate global radiation value for the northern portion of the project area, reduce the volcano's value by 15 percent; for the eastern and central portion of the area, reduce the volcano's value by 10 percent; and for the western portion of the area, reduce the volcano's value by 5 percent. The mean annual global radiation at the volcano is 407 langleys per day. The mean monthly global radiation for the sunniest month, August, is 556 langleys per day, and the mean monthly global radiation for the cloudiest month, January, is 273 langleys per day. Reducing the above values by the respective percentages will provide the global radiation for the different portions of the project area.

The following reports and weather data were used in this report.

A. Wind measurements at Hawaii Volcanoes National Park Headquarters (HVNPH) and Cape Kumukahi during June 10-23, 1980 for the Hawaii Mesoscale Energy & Climate Project by the Department of Meteorology, University of Hawaii:

Trade winds, strongest during the first half of the period, prevailed over the State. At the volcano, for the 12 complete days of record, June 11-22, 1980, the frequency of winds from the four direction quadrants were 67 percent from the northeast quadrant, 2 percent from the southeast quadrant, 16 percent from the southwest quadrant, and 14 percent from the northwest quadrant. (One percent was lost in rounding off percentages.) The average

wind speed for all hourly measurements was 6 mph. The wind speed was significantly stronger during the daytime (8 a.m. to 7 p.m.) than during the nighttime on most days. During eight of the twelve days, northeast winds prevailed during the daytime. Wind speeds were stronger during the daytime when the wind direction was from the northeast than when the winds were from other directions, south, or southwest. On the 11th, when strong trade winds prevailed over the State, winds from the northeast occurred throughout the 24 hours. During the nighttime hours, 8 p.m. to 7 a.m., the most common winds were from the north through northwest when the trade winds (northeast direction) were not blowing throughout the day. All the fluctuations and variations in wind direction and speed are not explained by a simple land and sea breeze circulation interacting with the prevailing trade winds. Other local effects plus other meteorological factors must be considered.

At Cape Kumukahi, the eleven complete days of record, June 12-23, 1980 showed winds from the northeast quadrant prevailed 90 percent of the time. Ten percent of the winds were from the northwest quadrant. The northeast trade winds occurred continuously during the daytime. The average wind speed of all the hourly speeds was 10 mph. The wind speed was stronger during the daytime but the difference between daytime and nighttime wind speeds was not as markedly apparent on most days as at the volcano.

B. Daily 8 a.m. wind observations at the Hawaii Volcanoes National Park Headquarters during January 1982:

State-wide, the winds were light during most of the month. There were a few days of moderate southerly winds and a few days of moderate to gusty trade winds. The summary for the once-a-morning readings at volcano follows: The wind directions were about evenly divided between winds from the north through northeast and

winds from the southeast through southwest, and the wind speeds averaged 7.7 mph. The following were the general relationships in comparing the 8 a.m. wind observations with the State-wide winds. When volcano's wind directions varied and the wind speeds were low, the State-wide winds were light; when the volcano wind was from the northeast at 15 mph, the State-wide winds were gusty trade winds; when the volcano wind was from the southeast at 20 mph, the State-wide winds were moderate southerlies; when the volcano winds were from the north through northeast most of the time, the State-wide winds were trade winds.

C. A Rainfall Climatology of Hilo, Hawaii, by Charles Fullerton, Water Resources Research Center, Tech. Report No. 61, December 1972:

The prevailing wind at Hilo Airport is not the northeasterly trade wind, but the southwesterly wind that drifts downslope off Mauna Loa during the night and early morning hours. Annual rainfall is highly variable. The annual diurnal rainfall curve for Hilo Airport exhibits a minimum in the afternoon between 2 p.m. and 3 p.m.

D. Project Ahuapua'a Solar Meteorological Field Measurements on the Island of Hawaii -- Summer 1978, 2. Eastern Flank of Mauna Loa by Paul Ekern and Alfred Garrett, Department of Meteorology, University of Hawaii, 79-04, August 1979:

During June 1-11, 1978, solar radiation and other meteorological data were gathered at eight stations in a nearly linear transect along the Stainback Highway on the eastern slope of Hawaii from Hilo Airport to Mauna Loa Observatory. In general, normal early summer trade wind weather prevailed. The summary of the average hourly wind speed and direction for the 1,840-foot station follows: northeasterlies between 9 a.m. and 6 p.m., north wind at 7 p.m., westerlies between 8 p.m. and 8 a.m.; wind speed

slightly over 5 mph between noon and 4 p.m. with a peak at 2 p.m. of about 6 mph, 2 to 4 mph over the remainder of the time. The summary of the average hourly wind speed and direction for the 3,840-foot station follows: northeasterlies between 9 a.m. and 6 p.m.; northerly between 7 p.m. and 10 p.m.; westerly between 11 p.m. and 7 a.m.; northerly at 8 a.m. Wind speeds were 5 to 6 mph between 10 a.m. and 5 p.m., 3 to 4 mph over the remainder of the time. Wind direction had generally the same upslope by day and downslope by night pattern. Notable differences were found at stations above the 5,000-foot level. Daytime wind direction was more uniform than during the nighttime because of more effective mixing in the convectively unstable air which allowed trade wind flow to dominate over slope orientation. In general, daytime upslope, nighttime downslope wind pattern held on all 11 days of the field program. However, individual stations did occasionally deviate from this diurnal oscillation.

E. The Trade Wind Inversion at the Slopes of Mauna Loa, Hawaii, by Bernard Mendonca and Wayne Iwaoka, J. of Applied Met., Apr 1969:

The average height of the trade wind inversion is about 6,000 feet and the inversion occurs about 80 percent of the time.

F. Local Wind Circulation on the Slopes of Mauna Loa by Bernard Mendonca, J. of Applied Met., August 1969:

At Mauna Loa Observatory, the warm turbulent and generally moist upslope wind can extend to a depth of 2,000 feet while the nocturnal cool, drier, downslope wind extends to only 180 feet depth.

G. Project Ahuapua'a -- Solar Meteorological Field Measurements on the Island of Hawaii. Summer 1978 -- 5. Southern Flank of Mauna Loa, Department of Met., in prep., Paul Ekern and R. Becker:

Linear transect was made from near sea level to 2,200-foot elevation above Na'alehu during June 12-21, 1978. Four vans monitored solar and meteorological data. Stronger than normal trade wind conditions prevailed during the period. During the day, east-northeasterly winds or sea breeze-upslope winds prevailed with only occasional interruptions. At night, winds shifted to a more northerly direction. Nighttime winds were weaker than daytime winds and the wind direction was more variable. Although slightly upslope, nocturnal winds were a general rule.

3.2.2.2 Air Quality

A. General

Since June 1981, baseline assessments have been carried out and air sampling has been one of the measurements taken. The area bordering Kahauale'a surveyed extends from the Royal Gardens Subdivision above the coastal Kalapana Road in the southeast, to Captain's Drive roadway in the Fern Forest Estate Subdivision in the northeast, to the Volcano Road (Route 11) at the access roadway across the shipman property in the northwest, to Thurston Lava Tube in the northwest and south of the Volcano Road across Kahauale'a to the lava fields and the HVNP boundary.

The data on record shows this entire area to be high in air mercury naturally by EPA Standards (but not by NIOSH Standards). Both hydrogen sulfide and sulfur dioxide levels are below standard detection limits, hydrogen sulfide was less than 0.03 ppm and sulfur dioxide less than 0.05 ppm. This atmospheric condition is typical of sites near the Kilauea East Rift Zone, but located upwind or windward of sulfur-rich fume area.

B. Sampling (January 1982)

At a point about 2,000 feet southeast of the Thurston Lava Tube visitors' area, the mercury level was 0.5 ±0.03 ug/m^3. At another site 2,000 feet due east of the first site, the mercury

level was 0.76 ±0.08 ug/m³. The values resemble the mean concentrations found at the lava fields of the project site, 0.67 ±0.79 ug/m³. In the dense forested area and trails above the lava fields, the mercury levels were lower, ranging from 0.12 to 0.25 ug/m³.

Three samples near power station D showed mercury levels of 0.69 ±0.08 ug/m³, 0.93 ±0.27 ug/m³, and 0.50 ±0.05 ug/m³. Presence of a fume area and the southerly wind may account for these measured values.

Hydrogen sulfide and sulfur dioxide were below detection limits.

C. Sampling (July-August 1981)

The Tables 3-5 (Fixed Gas Aerometry) and 3-6 (Mercury Aerometry) show the results of the air sampling.

Hydrogen sulfide and sulfur dioxide were below detection limits.

The absence of hydrogen sulfide and sulfur dioxide is somewhat misleading. In contrast to mercury which remains detectable in the forest because it retains its identify as a chemical element and as such is absorbed by vegetation and reemitted into the atmosphere, sulfur compounds undergo chemical change and lose their identity when they impact on plant and animal life. The sulfur compounds are consumed, transformed and assimilated by the life forms in the ecosystem.

The emissions of sulfur, mercury and other volcanic gases are a continuous process at Kilauea, the rift zone, and the adjacent forest and its inhabitants have long been exposed to lower levels of these toxic emissions and intermittently to higher levels. It follows that significant levels of geothermal gases are part of the norm for native Hawaiian plants and animals.

TABLE 3-5

FIXED GAS AEROMETRY
(July 3 - August 18, 1981)

LOCATION	GAS AEROMETRY (PPM)				
	H_2S	SO_2	NO_x	CO	CO_2
Trail Edge (Edge of Captain's Drive)	<0.03	<0.05	<0.25	<0.5	380±42
Mid-Trail (Two miles into Forest)	<0.03	<0.05	<0.25	<0.5	-
Fringe, Thurston Lava Tube Area	<0.03	<0.05	<0.25	<0.5	356±40
Fringe, Royal Garden Area	<0.03	<0.05	<0.25	<0.5	-
*Comparative, Sulfur Bank at fumeroles	18±2	68±6	<0.25	2.8±1	1500±250
in open air	0.17±0.02	0.58±0.15	<0.25	<0.5	340±38

Figure means of 3 - 5 samples ± standard deviations.

*Included to show the magnitude of continuous natural emissions from a source and the dilution effect of air to which any visitor is exposed.

TABLE 3-6

MERCURY AEROMETRY
(July 3 - August 18, 1981)

Location	Mercury in ug/m³ Air	Mercury in ug/m³ Soil Gas
Trail Edge (Edge of Captain's Drive)	0.13±0.10	<0.25
Mid-Trail (Two miles into Forest)	0.22±0.07	-
Fringe, Thurston Lava Tube Area	0.44±0.04	<0.25
Fringe, Royal Garden Area	0.72±0.11	-
*Comparative, Sulfur Bank at fumeroles	31.50±6.50	-
in open air	4.90±4.40	-

Figures are means of 24 samples ± standard deviations where appropriate.

*Included to show the magnitude of continuous natural emissions from a source and the dilution effect of air to which any visitor is exposed.

3.2.3 Hydrology and Water Quality

3.2.3.1 Surface Water - Water Quality

There are no known surface streams in this project area. Drinking water in this area is normally imported or obtained by roof catchment rather than water wells because of the great depth for drilling and pumping.

3.2.3.2 Groundwater - Water Quality

The hydrology of the Puna District is not well established. The general hypothesis, as in other portions of the Hawaiian Islands, is that the area is underlain by a lens of basal water floating on salt water, with a relatively narrow band of dike-confined water (not floating on salt water) running across the southern part of the District, and with a coastal zone of brackish basal water west of Kalapana. Underlying the rift zone area, the groundwater would be brackish and warm or hot. Figure 6-1 shows the chloride levels in wells in the South Puna region.

The groundwater resources of the Puna District occur in both confined and unconfined aquifers. The general theory is that the freshwater lens floats on salt water. This is based on the Ghyben-Herzberg concept which states that the lower density fresh water rests on the higher density salt water. The rule is that for each foot of fresh water above sea level, the fresh water extends 40 feet below. An allowance must be made for a mixing or transition zone.

Results of the potable supply from the Keauohana wells below the rift zone near Iilewa Crater suggest that a barrier, possibly dikes, prevents normal interaction with seawater. On the upper side of the rift zone, the Pahoa wells produce excellent quality water. A short distance below Pahoa and in the rift zone, the brackish nature of the groundwater is evident.

Tests of waters from shallow wells show that the mean residence time does not exceed a few years. Tritium concentrations and oxygen isotope ratios compare with those of local rainwater. These data suggest local recharge and short residence time.

The chemical of downhole samples from the HGP-A well indicate that the geothermal reservoir water differs from shallow well water in several respects. While the water is brackish, it differs from the shallow aquifer waters in the following respects: (1) high acidity of pH value of about 3 as compared to pH of 7 or greater for shallow wells; (2) high silica content 440 vs. 80 mg/liter; and (3) very low tritium content. The low tritium content is significant because it indicates a relatively long residence time, possibly exceeding 50 years. This suggests little hydraulic interaction between the geothermal reservoir and the shallow aquifers.

It has been suggested that impermeable vertical dikes may form a barrier between the geothermal water and the ocean water on the south side of the rift zone. The measured chemical parameters of the well under no flow conditions do not vary appreciably as a function of depth. For example, the HGP-A well water is brackish despite its origin at great depth where typical seawater would normally be present.

The chlorine concentration steadily increased from 2,500 mg/liter to 3,200 mg/liter during the 42-day flow test. This would indicate saltwater encroachment as the geothermal reservoir water is withdrawn over a period of time.

Water from an intermediate depth aquifer evidently mixes with geothermal reservoir water during continuous discharge. A probable cause for this condition is the manner in which the HGP-A well was completed. The intermediate depth interval was completed with slotted liner rather than with cemented casing. While this completion method may reduce the generating capacity of the well, it should have little or no effect on shallow aquifers having potential potable resources.

3.2.4 Geologic Hazard

Any area with young geologic features has concomitant geologic hazards and Kilauea Volcano is no exception. The primary hazard along the rift zone consists of earthquakes, lava flows and eruptions. Seismic activity is

fairly common in Hawaii. Earthquakes from active volcanoes are constantly recorded. Up to 1,400 microquakes per week have been recorded. Few are strong enough to cause major damage. Table 3-7 lists earthquakes of magnitude 5 or greater (Richter Scale) which have occurred in the State. Renewed volcanism is a definite possibility. Most recent volcanic activity has occurred in the East Rift in November 1979. No volcanism is expected to be induced by the project activities.

3.2.5 Geothermal Resources

As assessment of the geothermal resource potential of the Island of Hawaii was made using available geological and geophysical data of which the primary sources were the geological maps and published reports by eminent geologists such as Dr. Harold T. Stearns and the late Professor Gordon A. MacDonald. With these data and the published data from the geothermal research group at the Hawaii Institute of Geophysics of the University of Hawaii, the developer used this combined information with aerial photographs to determine the geothermal potential areas.

Kilauea Volcano has two rift zones running generally east and west through which magma (molten rock) moves in the subsurface whenever volcanic eruptions take place in the lower elevations of the rift zone.

The east rift system of Kilauea Volcano passes through (or is adjacent to) significant portions of the Kahauale'a property in the vicinity of Puu Kahauale'a. Geologic assessments indicate that sufficient heat has been retained in the subsurface to make possible a viable geothermal resource. The currently active east rift system (last eruption in this area was in 1977) has a trend of approximately north 65 degree east in this area. The region of historical activity has a width of about 1 mile and a length of about 3 miles beneath this portion of the property. To the west of Puu Kahauale'a the most active portion of the rift system lies within the Volcanoes National Park, but a portion of this active zone also lies within the Kahauale'a property north of Napau Crater. The area of this portion of the active rift zone within the Kahauale'a property is about 1-1/2 square miles.

TABLE 3-7

EARTHQUAKES OF MAGNITUDE 5 OR GREATER: 1957 TO 1980

Date	Location	Magnitude (Richter Scale)
1957: Aug 18	E. of Hana, Maui	5.6
1961: Sep 25	Hawaii	5.75-6
1962: Jun 27	Hawaii	6.1
Jun 28	Hawaii	5.75
1963: Oct 23	Hawaii	5.4
1964: Oct 11	W. of S. Kona	5.3
Dec 10	Hawaii	5
1969: May 9	Hawaii	5
1971: Aug 1	S.E. of Hawaii	4.5-5
1972: Dec 23	W. of Kona	5
1973: Apr 26	Hawaii	6.2
Oct 9	Hawaii	4.8-5
1974: Nov 30	Hawaii	5.5-6
1975: Jan 1, 2:41 AM	Near Pahala, Hawaii	5.1
Jan 1, 3:20 AM	Mauna Loa, Hawaii	5.1
Jan 2	Near Pahala, Hawaii	5.6
Jan 5	Mauna Loa, Hawaii	5.1
Nov 29, 3:35 AM	Puna, Hawaii	5.7
Nov 29, 4:47 AM	Puna, Hawaii	7.2
1977: Jan 22	100 Miles S. of Kauai	5.0
1979: Sep 21	Puna, Hawaii	5.5

SOURCE: Augustine S. Furumoto, N. Norby Nielsen, and William R. Phillips, "A Study of Past Earthquakes, Isoseismic Zones of Intensity and Recommended Zones for Structural Design for Hawaii" (University of Hawaii, Center for Engineering Research, June 15, 1972), pp. 16-19; Hawaii Institute of Geophysics, Records; U. S. Geological Survey; National Earthquake Information Service.

County of Hawaii Data Book, 1980.

To the north of the currently active rift is a zone about 1-1/2 miles wide that appears to be a rift system that is about 300 to 500 years old (total area of about 10 square miles) and appears to have geothermal potential with extremely low volcanic hazard.

3.3 BIOLOGICAL ENVIRONMENT

3.3.1 Terrestrial Ecology

For decades, most of the native forests have ceased to exist under pristine conditions. Most of the native forests have been altered by man, introduced feral animals and cattle, forest fires, lava flows and aggressive exotic plant species.

This description of terrestrial ecology considers the general project area shown in Figure 2-2. The vegetational communities found in the land of Kahauale'a are generally similar to those found in the Hawaii Volcanoes National Park on the west and southwest boundary, and the Puna Forest Reserve on the east boundary. Vegetational zones are primarily controlled by elevation and slope exposure, which in turn affect moisture and temperature. Elevations on the project area range from about 4,000 feet near Thurston Lava Tube in the Hawaii Volcanoes National Park down to about 1,400 feet above Royal Garden Estate to the south.

3.3.1.1 Flora

Land of Kahauale'a includes an array of plant communities. The major vegetation communities are the closed Metrosideros collina (J. R. & G. Forst) Gray., ('ohi'a-lehua) forest, open Metrosideros collina - Cibotium sp. ('ohi'a-lehua-hapu'u) forest, and open scrub. Other minor vegetation communities are sporadically found throughout the major communities and include Dicranopteris linearis (uluhe) patches.

The majority of the tract is dominated by Metrosideros collina ('ohi'a-lehua), and in places showing co-dominance with Cheirodendron trigynum ('olapa), and Antedesma platyphyllum Mann., and with many smaller trees, such as Pipturus sp. (mamaki), Broussaissia arguta Gaud. (kanawao, Pelea clusiaefolia Gray. ('alani), Ilex anomala Hook & Arn. (kawa'u), Dodonaea eriocarpa Sm. (a'ali'i), and Coprosma sp. (pilo), making up a second layer of trees. Shrubs of many genera such as Gouldia terminalis (H. & A.) hbd. (manono), Cibotium sp. (hapu'u), Cyanea, Cyrtandra, Wikstroemia ('akia), Vaccinium calycinum Sm. ('ohelo), Myrsine, Psychotria,

Clermontia, and Scaevola (naupaka, form a lower layer, with ferns, Peperomia, and other herbs and mosses as ground cover. Ferns of a number of genera, as well as a few epiphytes, climbers, such as Freycinetia arborea Gaud. ('ie'ie), Smilax, Alyxia (maile), and lichens are found on the trunks and branches of the trees. Openings tend to be filled with Dicranopteris linearis (uluhe), and recent disturbed areas are occupied with exotic such as Pluchea, Eupatorium, Galinsoga, Andropogon and other weeds and grasses.

The Metrosideros collina population in the project land shows evidence of "dieback." In adjacent areas, Metrosideros collina have died on thousands of acres, the specific cause or causes of the tree death is not known, however, several hypotheses on the dieback have been advanced, and are currently the subject of major federally funded projects. Notwithstanding, regeneration has been observed.

The species list from the area of potential geothermal drilling sites, access roads and power plant sites is arranged phylogentically in (St. John, 1973) Table 3-8. The new species and "rare or endangered species" are marked by an asterisk (*) and exotic or introduced species are noted by "x." These species are discussed in Section 3.3.2. All other species recorded are either endemic (E) or indigenous (I).

3.3.1.2 Fauna

A. Birds

The fauna of the Kahauale'a area generally consist of species that typically occur in the Hawaii Volcanoes National Park, Puna Forest Reserve forests and adjacent areas.

No endangered birds were sighted during a brief field survey by Ecotrophics in September 1981 and again in February 1982. This does not preclude the existence of rare or endangered forest birds on the land of Kahauale'a.

TABLE 3-8

List of Plants From the Project Area:
Roadways, Drilling Sites, and Power Plant Sites, and Transmission Line Corridors
Kahauale'a, Puna, Hawaii

	STATUS	SITE E	B-DF	B-D LF
PTERIDOPHYTES (Ferns)				
PSILOTACEAE				
Psilotum complanatum Sw.	I	O	C	-
Psilotum nudum (L.) Beauv.	I	O	C	R
Psilotum complanatum X nudum (hydrid)	I	-	R	-
LYCOPODIACEAE				
Lycopodium cernuum L.	I	C	O	-
Lycopodium phyllanthum H. & A.	I	R	O	R
SELAGINELLACEAE				
Selaginella arbuscula (Kaulf.) Spring	E	-	O	-
ASPLENIACEAE				
Asplenium contiguum Kaulf.	I	-	R	-
ANTHYRIACEAE				
Athyrium japonicum (Thunb.) Copel.	X	-	O	-
BLECHNACEAE				
Blechnum occidentale L.	X	-	R	-
Sadleria cyatheoides Kaulf.	E	O	R	O
Sadleria pallida H. & A.	E	C	O	-
DICKSONIACEAE (Hapu'u)				
Cibotium chamissoi Kaulf.	E	E	R	-
Cibotium glaucum (J. Sm.) H. & A.	E	A	A	C
Cibotium hawaiense Nakai and Ogura	E	O	R	-

ELAPHOGLOSSACEAE				
Elaphoglossum alatum Gaud. var. parvisquameum (Skottsb.) Anders. & Cros.	E	-	R	-
Elaphoglossum crassifolium (Gaud.) Anders. & Cros.	E	O	O	R
Elaphoglossum hirtum (Sw.) C. Chr. var. micans (Mett.) C. Chr.	E	E	O	-
GLEICHENIACEAE				
Dicranopteris emarginata (Brack.) Robins.)	E	A	O	-
GRAMMITACEAE				
Adenophorus hymenophylloides (Kaulf. H. & G.	E	R	O	-
*Adenophorus periens L. E. Bishop	E	-	O	-
Adenophorus pinnatifidus Gaud.	E	E	R	-
Adenophorus tamariscinus (Kaulf.) H. & G.	E	R	C	-
Adenophorus tripinnatifidus Gaud.	E	-	O	-
Grammitis hookeri Kaulf.	I	-	O	-
Grammitis tennella Kaulf.	E	C	A	-
Xiphopteris saffordii (Maxon) Copel.	X	-	-	R
HEMIONITIDACEAE				
Pityrogramma calomelanos (L.) Link	X	-	-	R
HYMENOPHYLLACEAE				
Mecodium recurvum (Gaud.) Copel.	E	O	O	-
Sphaerocionium lanceolatum (H. & A.) Copel.	E	-	O	-
Sphaerocionium obtusum (H. & A.) Copel.	E	C	O	-
LINDSAEACEAE				
Sphenomeris chinensis(L.) Maxon.	I	O	O	-

NEPHROLEPIDACEAE				
Nephrolepis cordifolia (L.) Presl	I	R	O	-
Nephrolepis exaltata (L.) Schott	I	-	R	-
Nephrolepis multiflora (Roxb.) Jarrett ex (formerly called N. hirsutula) Maxon.	X	-	R	A
OPHIOGLOSSACEAE				
Ophioglossum pendulum L. ssp. falcatum (Presl) Clausen	I	-	R	-
POLYPODIACEAE				
Pleopeltis thunbergiana Kaulf.	I	-	R	R
Polypodium pellucidum Kaulf. var. pellucidum	E	-	R	-
Polypodium pellucidum var. vulcanicum Skottsb.	E	-	-	O
THELYPTERIDACEAE				
Macrothelypteris torresiana (Gaud.) Ching	X	-	-	R
Pneumatopteris sandwicensis (Brack.) Holtt.	E	-	O	-
MONOCOTYLEDONS				
CYPERACEAE				
Cyperus haspan L.	X	-	R	-
Cyperus polystachyus Rottb.	I	-	R	-
Machaerina angustifolia (Gaud.) Koyama	I	O	O	R
Machaerina mariscoides (Gaud.) Ker subsp. meyenii (Kunth) Koyama	I	-	R	-
Uncinia uncinata (L.f.) Kuek.	I	O	-	-

GRAMINEAE				
Andropogon glomeratus (Walt. BSP	X	R	-	-
Andropogon virginicus L.	X	O	R	O-C
Holcus lanatus L.	S	R	-	-
Isachne distichophylla Munro ex Hbd.	E	C	C	-
Microlaena stipoides (Labill.) R. Br.	X	O	-	-
Paspalum conjugatum Berg.	X	O	O	-
Paspalum urvillei Steud.	X	C	-	-
Sacciolepis indica (L.) Chase	X	O	R	-
Setaria geniculata (Poir.) Beauv.	X	R	-	-
Setaria palmaefolia (Koen.) Stapf	X	R	-	-
Sporobolus africanus (Poir.) Robyns and Tournay	X	R	-	-
JUNCACEAE				
Juncus effusus L.	X	-	R	-
LILIACEAE				
Astelia menziesiana Sm.	E	R	R	-
ORCHIDACEAE				
Arundina bambusaefolia (Lxb.) Lindl.	X	-	R	O
Phaius tankervilliae (Banks ex L'Her.) Bl.	X	O	R	-
Spathoglottis plicata Bl.	X	-	R	-
PANDANACEAE				
Freycinetia arborea Gaud.	E	-	O	-
DICOTYLEDONS				
APOCYNACEAE				
Alyxia olivaeformis Gaud.	E	-	R	-
AQUIFOLIACEAE				
Ilex anomala H. & A.	E	C	R	-

ARALIACEAE				
Cheirodendron trigynum (Gaud.) Heller	E	R	C	R
ASTERACEAE				
Conyza bonariensis (L.) Cronq.	X	R	R	-
Dubautia scabra (DC.) Keck	E	R	-	O
Erechtites valerianaefolia (Wolf) DC	X	R	R	-
Eupatorium riparium Regel	X	R	R	O
Gnaphalium japonicum Thunb.	X	R	-	-
Pluchea odorata (L.) Cass.	X	-	R	R
Vernonia cinerea (L.) Less.	X	R	R	-
Youngia japonica (L.) DC.	X	-	-	R
EPACRIDACEAE				
Styphelia tameiameiae F. Muell.	I	R	-	-
ERICACEAE				
Vaccinium calycinum Sm	E	C	C	-
GESNERIACEAE				
Cyrtandra platyphylla Gray	E	R	R	-
GOODENIACEAE				
Scaevola chamissoniana Gaud. var. bracteosa Hbd.	E	-	R	-
GUTTIFERAE				
Hypericum degeneri Fosb.	X	R	R	-
LOBELIACEAE				
Clermontia parviflora Gaud. ex Gray	E	R	O	-

RUBIACEAE				
Coprosma ochracea Oliver var. rockiana Oliver	E	O	O	-
Gouldia terminalis (H. & A.) Hbd.	E	-	R	-
Hedyotis centranthoides (H. & A.) Steud.	E	O	R	R
Psychotria hawaiiensis (Gray) Fosb.	E	-	O	-
RUTACEAE				
Pelea clusiaefolia Gray Var. cuneata St. J. & Hume	E	-	R	-
Pelea sp.	E	-	R	-
SAXIFRAGACEAE				
Broussaisia arguta Gaud.	X	O	C	-
SCROPHULARIACEAE				
Castilleja arvensis Schlecht. & Cham.	X	-	R	-
THYMELAEACEAE				
Wikstroemia sandwicensis Meisn.	E	O	O	-
URTICACEAE				
Pipturus hawaiiensis Lévl.	E	-	R	O

LOGANIACEAE				
Buddleja asiatica Lour	X	-	O	O
Labordia hedyosmifolia Baill.	E	R	R	-
LYTHRACEAE				
Cuphea carthagenensis (Jacq.) Macbride	X	-	R	-
MYRICACEAE				
Myrica faya Ait	X	-	O	-
MYRSINACEAE				
Myrsine lessertiana A. DC.	E	R	R	-
MYRTACEAE				
Metrosideros collina (J.R. & G. Forst.) Gray ssp. polymorpha (Gaud.) Rock	E	A	A	A
Psidium cattleianum Sabine	X	-	R	-
POLYGONACEAE				
Rumex skottsbergii Deg. & Deg.	E	-	-	R
RANCUNCULACEAE				
Anemone hupehensis (Lem. & Lem. f.) Lem. & Lem. f.	X	O	-	-
ROSACEAE				
Fragaria vesca L.	X	O	-	-
Rubus penetrans Bailey	X	R	-	-
Rubus rosaefolius Sm.	X	O	O	-

Table I provides the following information:

I. Abundance ratings are given for three habitats:

SITE E = forest at site E near Thruston Lava Tube

B-D F = forest along line between sites B and D

B-D LF = open lava flow (probably from mid-1960's) just of drill sites B and D.

II. Five Abundance classes are recognized:

A = abundant = plants widely distributed, numerous, forming a dominant structural element of the vegetation

B = common = plants widely distributed but less numerous, not forming dominant structural element of vegetation

O = occassional = found here and there, often in scattered colonies.

R = rare = fewer than 5 plants found during survey.

- = absent = not found in this habitat

* = rare and endangered or new specie.

III. The biogeographic status of each species is indicated:

E = endemic = native to Hawaiian Islands only, not occurring naturally elsewhere.

I = indigenous = native to Hawaiian Islands and also to one or more other geographic areas.

X = exotic or introduced = not native to Hawaiian Islands; brought here by man, intentionally or unintentionally.

Names in this list are in accordance with H. St. John's 1973 "List and summary of the flowering plants in the Hawaiian Islands" (for flowering plants only), and with an unpublished checklist of Hawaiian Pteridophytes prepared by C. H. Lamoureux.

Non-endangered native birds commonly found in the area are the 'Apapane (Himantione sanguinea sanguinea), 'Oma'o (Phaeornis obscurus obscurus), 'Elepaio (Chasiempis sandwichensis sandwichensis), 'Amakihi (Loxops virens virens), and 'I'iwi (Vestiaria coccinea). Exotic birds such as the Japanese White Eye, Cardinal, Red-Billed Leiothrix and others also frequent this area.

Table 3-9 lists the birds in the south central portion of the study site; Table 3-10 lists the birds in Thurston Lava Tube study site; and Table 3-11 is data extracted from previous studies for the area north of Napau Crater in the power plant A region.

B. Mammal

Except for a single sighting of a Hawaiian Bat, there are no other mammals of special concern in the project area. Feral pigs and wild cattle are present in the area and are denuding the understory of the native forest. The Hawaiian Bat sighted was in a shallow cave on open lava.

3.3.2 Rare and Endangered Species

3.3.2.1 The 'O'u - Hawaiian Honeycreeper

While the 'O'u bird was not sighted during the baseline surveys of the project area, 'O'u sightings have been recorded in recent years. One sighting was made within Kahauale'a and others have been made in the general area. It was reported that the 'O'u was sighted during a U. S. Fish and Wildlife Service survey in 1978 at transect 38, Station 19. (Personal Communication to Dr. Sheila Conant.) Other sightings include the following:

TABLE 3-9

List of Birds in South-central Portion of Study Site

Scientific name	Hawaiian and Vernacular names	Total number observed	Percent Frequency	Percent Relative Abundance
Family Accipitridae (Hawks)				
Buteo solitarius	'Io (Hawaiian Hawk)	2	not observed during census	
Family Turdidae (Thrushes)				
Phaeornis obscurus obscurus	'Ōm'o (Hawaiian thrush)	4	20%	4%
Family Zosteropidae (White-eyes) *Zosterops japonicus*	Japanese white-eye	7	40%	6%
Family Drepanididae (Hawaiian honeycreepers) *Himatione sanguinea sanguinea*	'Apapane	98	100%	87%
Vestiaria coccinea	'I'iwi	3	20%	<3%
Family Fringillidae (finches)				
Cardinalis cardinalis	Cardinal	1	10%	<1%

Japanese White-eye and the Cardinal are exotics introduced to Hawaii; the others are endemics.

The Hawaiian Hawk is an endangered species.

TABLE 3-10

List of Birds at Thurston Lava Tube Study Site

Scientific Name	Hawaiian and Vernacular Names	Total Number Observed	Percent Frequency	Percent Relative Abundance
Family Turdidae (Thrushes)				
Phaeornis obscurus obscurus	Hawaiian Thrush 'Ōma'o	16	80%	12%
Family Zosteropidae (White-eyes) *Zosterops japonicus*	Japanese White-eye	4	40%	3%
Family Drepanididae (Hawaiian Honeycreepers)				
Loxops virens virens	'Amakihi	22	100%	17%
Himatione sanguinea sanguinea	'Apapane	89	100%	67%
Vestiaria coccinea	'I'wi	1	10%	<1%

The Japanese White-eye is an exotic species; the other are endemics.

TABLE 3-10 - Continued

List of Birds at Thurston Lava Tube Study Site

Scientific Name	Hawaiian and Vernacular Names	Total Number Observed	Percent Frequency	Percent Relative Abundance
Family Turdidae (Thrushes)				
Phaeornis obscurus obscurus	Hawaiian Thrush 'Ōma'o	16	80%	12%
Family Zosteropidae (White-eyes) Zosterops japonicus	Japanese White-eye	4	40%	3%
Family Drepanididae (Hawaiian Honeycreepers)				
Loxops virens virens	'Amakihi	22	100%	17%
Himatione sanguinea sanguinea	'Apapane	89	100%	67%
Vestiaria coccinea	'I'wi	1	10%	<1%

The Japanese White-eye is an exotic species, the other are endemics.

TABLE 3-11

List of Birds in South-central Portion of Study Site on July 1976

Scientific name	Hawaiian and Vernacular Names	Total Number Observed	Percent Relative Abundance
Family Accipitridae (Hawks)			
Buteo solitarius	'Io (Hawaiian Hawk)	Individuals observed several times during survey	
Family Timaliidae (Babblers)	Melodious Laughing-thrush		
Garrulax canorus	Chinese Thrush, Hwa-mei	2	<1%
Family Muscicapidae (Old world Flycatchers) *Chasiempis sandwichensis sandwichensis*	'Elepaio	19	8%
Family Turdidae (Thrushes)			
Phaeornis obscurus	'Ōma'o (Hawaiian Thrush)	81	33%
Family Zosteropidae (White-eyes)			
Zosterops japonicus	Japanese White-eye	84	34%
Family Drepanididae (hawaiian Honeycreepers) *Himatione sanguinea sanguinea*	'Apapane	55	23%
Vestiaria cocinea	'I'iwi	3	1%
Family Fringillidae (Finches)			
Cardinalis cardinalis	Cardinal	3	1%

The Melodious Laughing-thrush, the Cardinal, and the Japanese White-eye are exotics introduced to Hawaii; the others are endemics. The Hawaiian Hawk is an endangered species.

1964	Kauai	Richardson/Bowles	3
1971	Olaa Forest	Banko	1
1971	HVNP	Smith/Smith	1
1974	Olaa Forest	Smith/Jacobi	2
1977	HVNP	van Riper	1
1977	Olaa,Hilo Waiakea Forests	USFWS	61
1978	HVNP	Reeser	1

The original food for the 'O'u was the inflorescence and fruit of the 'ie'ie vine. It also feeds on berries of the lobelias, the 'ohi'a flower nectar, and exotic fruits like the guava.

The 'O'u is parrot-billed with a yellow head and bright green body in varying shades on different parts. It was one of the birds trapped by the Hawaiians for feather work.

3.3.2.2 The 'Io - Hawaiian Hawk

While not seen during the baseline surveys, the 'Io was sighted over Kahauale'a by the USFWS survey team during 1976-1979. This raptor is wide ranging and numerous sightings have been made in the woody sections of the adjacent Hawaii Volcanoes National Park. The 'Io is known to frequent the lower Puna region which includes the papaya farms in the Nanawale area. The 'Io feeds on mice, rats, insects and small non-native birds.

Curtise R. Griffin, working under a grant from the U. S. Fish and Wildlife Service, recently stated in a news article (Honolulu Advertiser, September 29, 1981) that the Hawaiian Hawk (*Bueto solitarius*) early population estimate suggested that there were just a few hundred Hawaiian Hawks left in existence. His study indicates the actual count could be about 2,000 and the population appears to be stable. The critical habitat for the Hawaiian Hawk has not been determined and studies are currently underway. Distribution is from sea level to 8,000-foot elevation on Mauna Loa and Mauna Kea. His study indicates that the Hawaiian Hawk nests over most of the Big Island from near sea level to 5,800-foot elevation. The

hopeful signs of a healthy hawk population presented by the study could result in declassification of the Hawaiian Hawk's endangered status by the U. S. Fish and Wildlife Service.

The critical habitat for the 'O'u and the Hawaiian Hawk has not been determined. A major objective of native forest birds researched in Hawaii is the determination of their biology, ecology, and population dynamics. Generally, this lack of information on the status and distribution of our forest birds has severely hampered efforts to help revive and protect the threatened and endangered faunas.

It is hoped that environmental surveys and studies that emanate from this project will enhance the endangered species program by providing useful information to wildlife biologists.

3.3.2.3 The Hawaiian Bat

During the baseline study in 1981, a Hawaiian Bat was seen in a shallow cave on open lava. A member of the hoary bat species, it is primarily found on the Island of Hawaii. Its range has been reported to be from sea level to the 13,200-foot elevation. It feeds on flying insects. Information on the Hawaiian Bat is limited. The bat is the only mammal for Hawaii on the endangered species list.

3.3.2.4 The Adenophorus Periens Bishop

The *Adenophorus periens* Bishop is a member of a fern genus endemic to Hawaii. Therefore, it is unique in the world. In addition, this species, which during the nineteenth century was commonly found on all of the Hawaiian Islands, has been sighted quite infrequently in the recent past. Since 1976, sightings of *Adenophorus periens* have been limited to the ahupua'a of Kahauale'a. *Adenophorus periens* has therefore been proposed for listing as an endangered species pursuant to the Endangered Species Act of 1973 (Federal Register Vol. 41, #117, June 16, 1976, p. 24560) and is currently under review pursuant to the revisions of this Act, as a category 1 species (one for which the U. S. Fish and Wildlife Service has sufficient information to support the biological appropriateness of its being listed

as an endangered species, but where all necessary information about critical habitat have not been made) (Federal Register, Vol. 45, #242, Dec. 15, 1980, p. 82485).

The Adenophorus periens fern was first observed during the Ecotrophics baseline survey in July 1981. Subsequent investigations disclosed additional sightings of the fern. The sightings of the endangered fern, Adenophorus periens Bishop began about 1/8 of a mile from the start of the trail at the end of Captain's Drive and extended in about 3/4 mile from the trail head. Overall distribution was rather clumped. The ferns were observed only on 'ohi'a trees in the areas of densely closed canopy. A heavy moss and bryophyte cover appears to be a requirement for the fern in this area. Distribution of the fern is probably partly a function of the dense canopy creating the required microclimate.

A 25 x 25 meter quadrat was established about 1/2 mile in from the trail head in an area where Adenophorus periens appeared as abundant as anywhere along the trail. The area was dominated by 10 to 15 meter high 'ohi'a trees forming a closed canopy with hapu'u forming a second story of about 50 percent cover. 'Ohi'a tree density in the 625 m^2 quadrat was 22 trees (352 trees/hectare). The epiphytic fern was observed on only three 'ohi'a trees in the quadrat (48 trees/hectare), each tree supporting an average of about 10 fern clumps.

In January and April 1982, additional botanical surveys were conducted along the access route. The Adenophorus periens population numbered 126 during the January 1982 survey and during the more intensive survey of April 1982, 274 plants of Adenophorus periens epiphytic on 91 'o'hia trees was observed. These were found to be concentrated within definite recognizable areas. With just 3 or 4 exceptions, Adenophorus periens was never found in wide open dieback or pig disturbed spots. The majority of the populations occur along the proposed roadway which runs parallel to the lava flow, between planned power plant sites D, B & A. Before station 23, 33 individuals of Adenophorus periens were observed. Station 23 marks the point where the proposed roadway turns left paralleling the flow. From

here to station 39 (the furthest point reached by the botanists), 235 individuals were counted. For an estimation of population density, each worker would clearly observe 20 feet off one side of the trail. With each observing only one side to maximize sampling efficiency, we may say a 40-foot wide swath along 39,000 feet of trail was comprehensively surveyed, or 35.8 acres. Thus, within the area of stations 1 through 23 there is an average of 1.6 plants/acre. Within the area of stations 23 through 39 there is an average of approximately 16 plants/acre. See Figure 3-4 for access route stations along the access road.

Since the first evidence of Adenophorus periens was observed after station 14, this can be said to mark the northern limit of the populations within the Kahauale'a rain forest. From Station 15 on, Adenophorus periens was found quite consistently but in varying amounts. Observation of large scale aerial photographs of the region reveal a uniform semi-open to closed canopy throughout the proposed power plant installation area. Overall, the forest from approximately one mile north of the lava flow extending eastward in a band to the 2,500-foot contour line appears to be suitable habitat for Adenophorus periens. Thus, from the ground survey performed and the aerial photos analyzed it appears that the greatest potential concentration of Adenophorus periens sighted along the access route coincides with the area for which the east-west access road and future power plants are planned.

3.3.3 Aquatic Ecology

There is no stream flow within the Kahauale'a project area and as such does not support any identified unique or important aquatic species.

3.3.4 Natural Area Reserve System

The State Board of Land and Natural Resources at the recommendation of the Natural Area Reserve Commission has taken action to set aside 16,710 acres of the 25,700 acres of State-owned Puna Forest Reserve as the Wao Kele 'O Puna Natural Area Reserve. The entire southwest boundary of this proposed reserve is adjacent to the property of James Campbell Estate as shown on

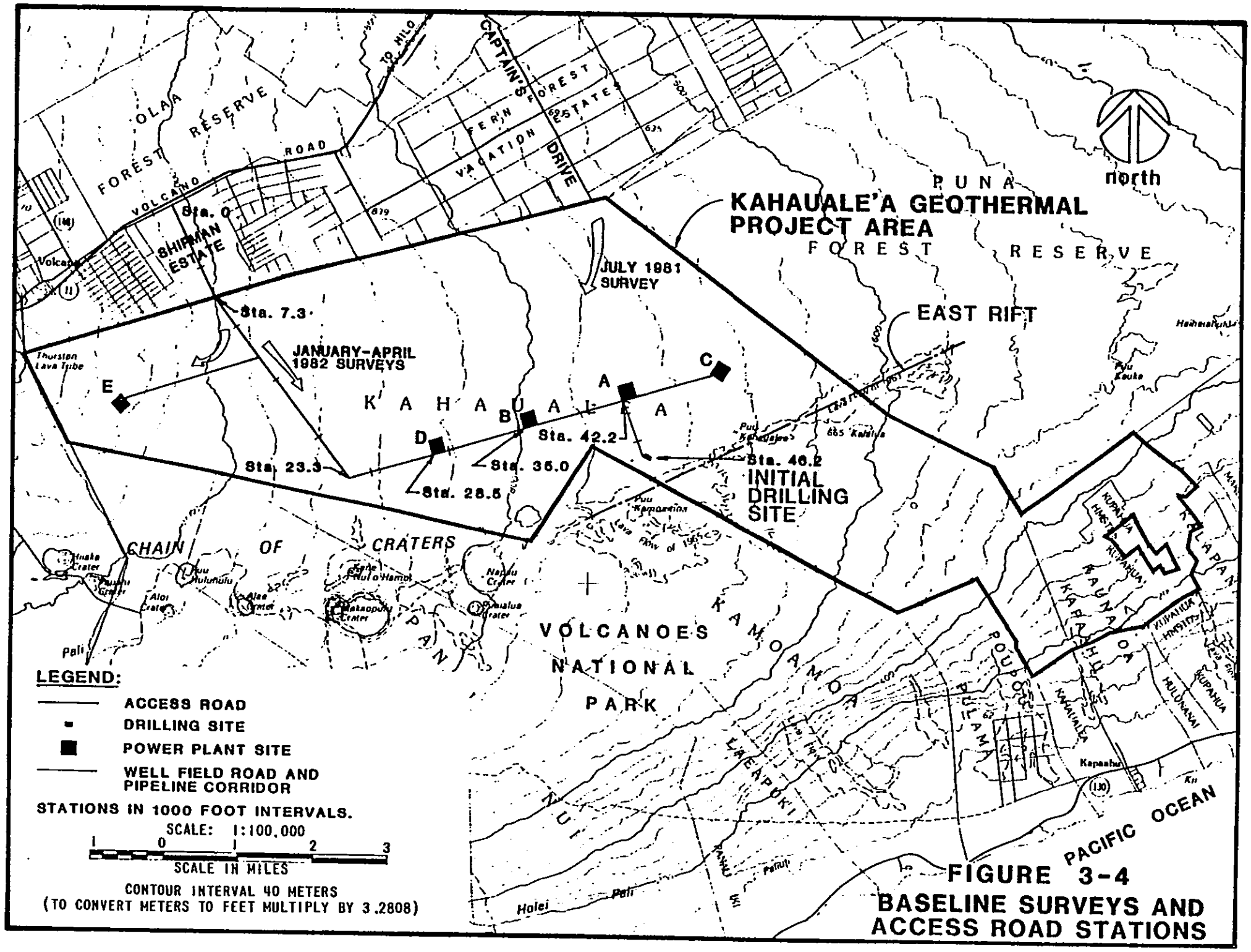


FIGURE 3-4
BASELINE SURVEYS AND ACCESS ROAD STATIONS

Figure 2-2. It is another example of an 'ohi'a rain forest that is relatively inaccessible.

It is very probable that the candidate "rare and endangered" fauna and flora species found on the northeast boundary of the James Campbell Estate may also be found in the proposed Wao Kele 'O Puna Natural Area Reserve.

The physical and biological characteristics of the Puna Forest Reserve are generally similar with the land of Kahauale'a.

Other natural area reserves on the Island of Hawaii already adopted by the Board of Land and Natural Resources for inclusion in the Natural Area Reserve System (NARS) are as follows:

Name	Acres	Dominant Features
Puu O Umi N.A.R.	10,182	Mixed mesophytic forest, 'ohi'a rain forest, a montane bog.
Laupahoehoe N.A.R.	9,030	'Ohi'a rain forest.
Mauna Kea Ice Age N.A.R.	3,894	Geological: Ice Age and Lake Waiau.
Puu Makaala N.A.R.	12,106	'Ohi'a and koa rain forests.
Manuka N.A.R.	26,181	Dryland schlerophyll and mixed mesophytic forests, 'ohi'a and koa rain forests.

3.4 HUMAN ENVIRONMENT

3.4.1 Introduction

Social characteristics can be viewed from the quantitative and qualitative aspects. Quantitative data such as population, unemployment and welfare dependency are readily accessible. Practically all of the information on the Island of Hawaii was drawn from the County of Hawaii, Data Book, 1980. Qualitative data such as community attitudes toward development of geothermal energy is being acquired beginning with the HGP-A project, the efforts of developers, the media and others.

Inasmuch as the Kahauale'a project is programmed for a 14 to 20-year period, there will be continuing opportunities for the citizens to assess the project impacts.

3.4.2 Island of Hawaii (The Big Island)

In 1980, 92,206 persons lived on the Big Island. As such, they constituted roughly 10 percent of the residents of the State. Of the 6,425 square miles in the State, the Big Island accounts for 4,037 or 63 percent of the square miles in the State; that is, 10 percent of the people are living on 63 percent of the State's space. The population density is 23 residents per square mile, the lowest in the State outside of Niihau. Oahu, in contrast, has 1,345 residents per square mile.

Between 1930 and 1960, the population of the Big Island decreased from 73,325 to 61,332. The principal reasons for this decrease were the mechanization of the sugar industry and the increasing income and employment opportunities on Oahu and elsewhere. In 1970, this population increased for the first time since 1930 to 63,468, a small 3.4 percent increase. However, the 1970-80 decade saw an increase from 63,468 to 92,206, a 45 percent increase. This increase was attributed to the

INDUSTRY CATEGORY	PERCENT
Services	25
Retail Trade	19
Local, State, Fed. Govt.	18
Manufacturing	11
Agriculture, Forestry	11
Trans., Comm., Utilities	7
Wholesale Trade	5
Finance, Ins., Real Estate	4
TOTAL	100
N =	25,778

Services including workers in tourism, retail trade and government employment accounted for nearly two-thirds of the workers. Job count estimates by industry for the period 1973 through 1979 showed the following increases: Finance, insurance, real estate, 41 percent; services, 38 percent; local, State, Federal Government, 33 percent; retail trade, 28 percent; and transportation, communication, utilities, 22 percent. Manufacturing of durable and non-durable goods had a small increase of 4 percent. Agriculture showed a decline of 500 jobs in sugar which was compensated by a similar increase in other agriculture.

Total personal income on the Big Island amounted to $540.9 million in 1978. The 1978 per capita personal income was $6,687. This, however, was the lowest for the four counties: Oahu, $8,806; Maui, $7,676; Kauai, $7,044.

In April 1980, the family income poverty level was set at $8,570 for a four-person non-farm family and $7,300 for a four-person farm family. In the 1970 census, 1,430 families or 9.7 percent of the total of 14,692

continued growth of tourism, stability of the sugar industry, and the development of diversified agriculture.

The Districts of greatest growth were: North Kona, 188 percent; Puna, 129 percent; South Kohala, 99 percent; South Kona, 43 percent; and South Hilo, 25 percent.

The percent distribution of the population of the Big Island by ethnic stock by the 1970 census and the 1976 Health Surveillance Study (H.S.S.) shows the following:

Ethnic Stock	Percent	
	1970 Census	1976 H.S.S.
Japanese	37	32
Caucasion	29	31
Filipino	17	17
Hawaiian	12	15
Chinese	3	2
Other	2	3
TOTAL	100	100
N =	63,468	2,683

In 1979, the total civilian labor force for the Big Island was 35,200 of which 2,900 or 8.1 percent were unemployed. At that time, the State's unemployment rate was 6.3 percent. For the years 1974 through 1979, the Big Island's unemployment rate was always higher than the State's rate by about 2 percentage points.

The percent distribution of the labor force by industry category in 1975 was as follows:

families and 1,771 or 39.0 percent of the unrelated individuals were below the poverty level.

In 1975, income of families in Hawaii County by OEO districts indicated that 22.8 percent of the families had incomes under $7,000 per year.

Public welfare costs for money payments totalled $15.2 million in FY 80. If estimated costs of medical payments of $11 million and food stamps bonus cost of $9 million are added to basic money payments, the estimated welfare costs for the Bis Island amount to over $25 million.

The monthly average count of persons served by these money payments in 1980 was 10,115. To this must be added persons covered by food stamps only which totaled 6,244 in 1980 and medical payment only which averaged 2,447 persons per month in 1979. The unduplicated count of individuals receiving public welfare help during an average month in 1980 is therefore estimated to be 18,806. This means that about one out of every five residents on the Big Island received some type of welfare help in 1980.

It is projected that the Big Island's population will increase by 31,100 to 123,000 by year 2000. Although projections for districts are not available, it is expected that South Hilo, Puna, South Kohala, and North Kona will experience the greatest population growth in the next 10-15 years.

Concurrently, projections are made for 16,600 jobs from 1980 to 2000 with decrease in sugar production and manufacturing and increase in food processing, hotels, government, trade, and services.

The Health Surveillance Study of 1977 of residents of the Big Island by their residence one year earlier showed the following percent distribution:

Place of Residence One Year Earlier	Percent
Same House	83
Different House, Same Island	10
Different Island	2
Different State/Country	3
Not Reported	2
TOTAL	100
N =	2,313

The above indicates that about 5 percent of the residents moved to the Big Island from outside in 1977.

In 1970, the major ethnic groups had the following median ages by sex:

Major Ethnic Group	Median Age	
	Male	Female
Japanese	36.4	38.8
Caucasian	26.8	25.8
Filipino	36.7	18.9
Hawaiian	20.1	23.2
Chinese	28.5	26.0
ALL GROUPS	29.6	28.1
STATE		

The severe out-migration which occurred between 1950 and 1960 occurred mainly in the 20-24 year category as high school students left the island for jobs elsewhere. This had a definite effect on the County's median age which increased from 24.7 years in 1950 to 27.4 years in 1960, and 28.7 years in 1970 but there was an increase in 1970 over 1960 of 52.4 percent in the 20-24 year age group. The marriage of elderly Filipino men

to teenagers from the Philippines is reflected in the low median age for Filipino women. The low median age for Hawaiians is notable for a group which is slowly growing in size.

Median school years completed by persons 25 years and older was 11.4 years for Hawaii County in 1970. Beyond high school, plans by 1978 high school graduates of Hawaii County, by percentages, were as follows:

ACTIVITY	PERCENT
Will Attend School	63
Employed Full Time	12
Military Service	12
Not Employed, Not in School	5
Other	8
TOTAL	100
N =	1,099

Almost two-thirds of high school graduates expressed a desire to continue their education at colleges, technical or business schools.

In 1959, 89 percent of registered voters voted in the primary election; in 1980, this dropped to 68 percent. In 1959, 94 percent of registered voters voted in the general election; in 1980, this dropped to 83 percent.

The number of housing units in the County increased from 18,118 in 1960 to 18,972 in 1970 to an estimated 34,222 housing units in 1980, an increase of 80 percent. Of the total housing units on the island, it is estimated that 15.3 percent of the total are vacant. This reflects the number of second homes of residents and non-residents.

3.4.3 Kahauale'a

Kahauale'a is situated in the Puna District; 11,775 persons were living in Puna on April 1980; this constituted roughly 13 percent of the Big Island's population. In district size in population, Puna ranks third after South Hilo and North Kona. Puna's population density of 23 per square mile is the same for the County as a whole.

From a high of 8,284 in 1930, residents of Puna reached a low point of 5,030 in 1960. This decrease is largely attributable to mechanization in the sugar industry. In 1970, the population increased to 5,154, a 2.4 percent increase. The 1970-80 decade saw a 129 percent increase from 5,154 to 11,775. This large increase is partly attributable to diversified agriculture and the emerging role of Puna as a "bedroom" community for Hilo. Continued growth in population can be anticipated if significant geothermal energy is developed in Puna.

Within the Puna District, roughly 20 percent (2,246) of the residents were living in the three towns of Keaau, Mountain View, and Pahoa. The balance of 80 percent (9,529) were scattered throughout the District. There are several small and thinly populated communities in the Glenwood-Volcano areas north of Kahauale'a. There are no residents in Kahauale'a. The distance to the nearest home for the initial drill site is approximately 2-1/2 miles. The distance to the nearest home from the drill site at power plant E is about one mile.

In 1970, the percentages, by ethnic stock for Puna residents, was as follows as compared with similar data from the 1976 Health Surveillance Study (H.S.S.) for the island as a whole.

ETHNIC STOCK	PERCENT 1970-PUNA	1976-H.S.S.
Japanese	41	32
Caucasian	24	31
Filipino	22	17
Hawaiian	9	15
Chinese	2	2
Other	2	3
TOTAL	100	100
N =	5,154	2,683

Because the population for Puna has more than doubled since 1970, the breakdown by ethnic stock might be closer to the percentages presented by the Health Surveillance Study.

The 1975 labor force distribution, by percent, by industry category, provides the following information for the Puna area as compared to the County as a whole:

INDUSTRY CATEGORY	PERCENT PUNA	COUNTY
Agriculture, Forestry	48	11
Manufacturing	24	11
Local, State, Fed. Govt.	15	18
Retail Trade	6	19
Wholesale Trade	4	5
Services	2	25
Finance, Ins., Real Es.	1	4
Trans, Comm., Utilities	--	7
TOTAL	100	100
N =	1,440	25,778

In 1975, nearly half (687) of the labor force in Puna were in agriculture; nearly a quarter (352) were in manufacturing, possibly accounted for by jobs in sugar mills and food processing. Jobs associated with tourism under services were minimal.

Mechanization of the plantation greatly reduced employment in the local sugar industry from almost 2,000 in 1940 to some 500 in 1960. Since that time, sugar employment in Puna has remained stable at about 500. Current trends in the sugar subsidy program do not seem to augur well for the industry. According to Kamins, roughly 1,180 full and part-time jobs were identified in the production of papayas, macadamia nuts, guavas, anthuriums, and orchids. These jobs are characterized by seasonality, large turnover, and family operations.

Kamins observed that a disproportionately large part of the population growth in Puna occurred in the age bracket where people are most likely to be in the labor market from ages 22 through 44. He also observed that Unemployment rates in the (Puna) District during the past few years (in 1978) have averaged about 10 percent, among the highest in the State. It is highly probable that the unemployment rate for the young adults, ages 18 through 22, would be at least 20 percent if we assume general unemployment of 10 percent. In view of the general recession at present, one would estimate unemployment in Puna to be at least 10 percent.

If unemployment of 10 percent is higher in Puna when compared to the County rate of 8.1 percent, then it follows that rates would be higher in such programs as unemployment compensation, food stamps, medicaid, and public assistance. Based on data for the County, it is estimated that about 2,500 individuals are receiving some form of welfare help.

According to Kamins:

> "the quality of housing available in Puna is relatively adequate...the ratio of population-to-housing units in Puna was second lowest among the nine districts. Between 1973 and 1976, some 300 additional units were constructed in Puna bringing the mid-1976 inventory of housing units in the district to

approximately 2,900...In 1976, over a third of the units were less than 6 years old; about half less than 16 years old. Only about 5 percent were judged to be in poor condition structurally; less than 3 percent lacked complete plumbing and kitchen facilities...however, the social support system needed to serve an increasing population may present different demands even if the supply of housing itself is adequate."

The infrastructure described by Kamins in 1977 is summarized as follows:

"1. Water Supply. Only around the more built-up areas in Keaau and Pahoa, and in the beach area around Kaimu does the Hawaii County system provide a public supply. (For other areas, rain catchment appears to be the major source of water.)

"2. Sewage Disposal. There is no public sewage disposal or treatment facility in Puna. Residences and other habitations must provide their own cesspools, septic tanks, or other methods of disposal.

"3. Roads and Highways. There are approximately 168 miles of County roads in Puna, most of the mileage being along Highway 11, which connects Keaau...with the Hawaii Volcanoes National Park; along Highway 130 which comes down from Keaau to Pahoa and then continues to the black sand beaches in the southern coast of Puna; and along Highway 132, which goes from Pahoa, through the papaya growing area near Kapho and then to Cape Kumukahi...The quality of the Puna Roads varies considerably. Highways 11 and 130 are generally broad and well paved.

"4. Public Transportation. Along with other readily accessible areas of the Big Island, Puna is served by a public bus system, based in Hilo, which provides twice daily service. There are no local taxis, shuttles, or U-drive companies; these are concentrated in Hilo and its airport.

"5. Police and Fire Stations at Keaau and Pahoa. Within the Puna District, there are fire stations and police stations at Keaau. Emergencies have to be serviced from Hilo.

"6. Public Health Facilities. There are no hospitals or clinics in Puna District. The nearest hospitals are in Hilo, less than an hour's drive from most communities in the district.

"7. Schools and Libraries. There are three public, no private, schools in Puna: elementary and intermediate schools at Keaau and Mountain View, and a kindergarten through high

school at Pahoa, which is relatively central in the district. The single public library in Puna is also at Pahoa.

"8. Recreational Areas and Facilities. The one category of public facilities with which Puna is well endowed is natural recreational areas. The Hawaiian Volcanoes National Park is readily available by car. So are the beach parks: Harry K. Brown, Isaac Hale, McKenzie, Kaimu Beach, the area around Queen's Bath.

"In population centers, there are five ball parks or general public parks, playgrounds at the Keaau and Pahoa Schools, and two gymnasiums open to the public. The one movie house in Puna is at Pahoa."

The Puna District has community associations in Pahoa, Kalapana, Volcano, Mountain View, Glenwood, Leilani and Fern Forest. Other community associations may exist. The Puna Hui 'Ohana is a community organization which represents four native Hawaiian groups in the area (Puna Hawaiian Organization, Hawaiian Parents Society, Hui O'pio and Puna Young Adult Hawaiian Club).

According to Canan, the organizations that have expressed formal opinions about the geothermal energy within this district are Puna Hui 'Ohana and the Leilani Community Association. In general, the attitudes expressed are in favor of developing the (geothermal) resource but not at the expense of our community environment. The Young Adult Hawaiians were concerned about jobs from which they can make a living and feed their families. Throughout their testimonies, both organizations expressed the critical need for local involvement in geothermal decisions.

3.4.4 Economic

The economic activity on the Island of Hawaii in 1981 was the lowest in a decade of relatively steady growth. The major industries that were affected by low earning levels were tourism, sugar, and construction.

Tourism was affected by the recession on the mainland but held up reasonably well by the east bound tourists from the Far East. The Island of Hawaii had the lowest occupancy rate of all islands and in 1982 the same trend continued.

The sugar industry has suffered from the low prices due to subsidized foreign sugar imports to the United States. All plantations incurred financial losses in 1981. Amfac announced in early 1982 that it was phasing out Puna Sugar Company in 1984 and that 500 employees would be laid off during 1982 and 1983. C. Brewer also announced in February 1982 that it was taking 8,000 acres of sugarcane land out of production for macadamia nut plantings. This activity will again reduce employment in the sugar industry although adding a few workers to the macadamia industry.

The multiplier effect for the sugar industry has been historically the highest in the State at 2.9 as compared to 1.7 for truck farming. This high multiplier effect results from the fact that the industry is highly cost- and labor-intensive, and also because sugar is an export commodity which induces new monies into the State. Local business activity is affected severely when a plantation ceases operation as in the case of Kohala Sugar and now Puna Sugar Company.

The construction industry has seen its lowest activity in 1981 in many years and in 1982 the effect of the recession, tight money supply and high interest rates have resulted in minimal construction activity. Contractors have laid off all surplus employees, have reduced manpower and are working at reduced payroll. Construction activity is limited to repair and maintenance, contracts for new hotels and condominiums where financing had been arranged before interest rates increased dramatically in late 1980 and early 1981, and government projects. Construction in sugar is minimal at this time.

The Island of Hawaii suffers the highest unemployment rate in the State. The February 1982 survey shows the Oahu unemployment is 5.2

percent as compared to 7.8 percent on the Big Island. The unemployment in January 1982 for the Big Island was 7.3 percent and the forecast is higher unemployment in 1982.

Comparison of jobs in the State from January 1982 versus December 1981 shows the number of jobs decreasing in construction, manufacturing, transportation, communications and utilities, trade, services and miscellaneous, and government. Trade jobs were down 3,000, government jobs down 3,200, and service jobs down 1,500. The government sector laid off all parttime and hourly employees,

The only private industries that have been doing well during this period have been the macadamia and floral industries. Both industries are feeling the effects of competition from foreign production and anticipate 1982 to be a no growth year. The papaya industry suffered a great loss when the U. S. Department of Agriculture determined that the chemical levels of methyl bromide used in papaya processing exceeded acceptable limits of toxicity. The papaya industry is slowly recovering as the market reopens its doors in response to positive steps taken by the papaya industry.

In 1979, the Department of Energy together with the State and County of Hawaii embarked on the installation of a 3 MWe geothermal power plant. In 1980 and 1981, the 3 MWe geothermal power plant was constructed at a cost of approximately 12.0 million dollars. Local construction workers were used in the majority of this installation.

During 1980 and 1981, Geothermal Exploration Drilling Company (Gedco) drilled two wells in the Pahoiki area and is presently drilling for Thermal Power Company. This drilling effort has required approximately 25 people.

3.4.5 Historical/Archaeological Sites

A review of historical records indicates that Kahauale'a was populated along the coast and inland a few miles. Ruins at Queen's Bath and the surrounding area attest to this. The early white folks who travelled this area described coastal fishing activities and inland farming. Kahauale'a was probably farmed at certain sites, but was most used for harvesting of its forest products which included koa logs for canoes, pulu (the woolly substance found at the base of the hapu'u ferns), 'ohi'a logs and other products. This area was part of the forest bird trapping region. The Kilauea and Ola'a region including Kahauale'a was famous for the bird feathers gathered by trappers.

Numerous lava flows have overrun what may have been part of the ahupa'a agricultural field system. As was the custom, the coastal fishing villages had inland agricultural fields. For the most part, the fields were 3 miles or so inland. Information is scanty on the area above the rift zone.

Some trails are shown on early maps. Parts of these trails have been erased by lava flows. Even in ancient times, the hazardous conditions of the rift zone were noted and tales of persons disappearing in cracks that abound in the rift zone were related. Appendix A contains an executive summary of an archaeological literature survey commissioned by the Estate of James Campbell on Kahauale'a.

The State Historic Preservation Officer has no record of archaeological sites within the project area. However, this does not mean that archaeological sites do not exist in the area, only that no sites have been located to date. The project obligates the landowner and developer to exercise the utmost caution in conducting any activity which could disturb or damage any sites or areas having archaeological significance.

3.4.6 Visual Perspective

The project area of geothermal exploration and development is situated generally along the central portion of the land of Kahauale'a coinciding with the Kilauea East Rift Zone. Kahauale'a is a rather smooth sloping land running down from near the 4,000-foot elevation to the sea at Queen's Bath. The area above the geothermal prospect area is much more heavily wooded than the lower portion. 'Ohi'a, hapuu and other native plants intermingle with exotics to form a rugged wooded area. The lower portion is characterized with smaller scattered 'ohi'a trees with grassy open spaces. The overall view is one of a land lightly touched by man. The east rift zone site is a harsh land and difficult to cross due to numerous cracks and recent lava flows. Large areas have been inundated by lava. Large tracts of trees bordering the lava flows have been killed by volcanic heat.

Bordering the Kahauale'a property on the southwest is the Hawaii Volcanoes National Park (HVNP). All along the Chain of Craters Road the vista is one of grandeur and of sweeping wide open space. The view of Kahauale'a from this area of the National Park will be one of looking up towards the Kahauale'a forest, two or more miles distant.

The Puna Forest Reserve bordering Kahauale'a on the east is a relatively untouched native forest quite similar to portions of the adjacent Kahauale'a land. This fairly good example of our native forest will be added to the State's Natural Area Reserve System as representative of an 'ohi'a rain forest. Access to the Puna Forest Reserve is very difficult.

The north side of the Kahauale'a property is bordered by agricultural subdivisions. The area is mostly 'ohi'a, hapuu and grasses. The 'ohi'a blight is quite evident. The subdivisions are sparsely occupied, few hundreds of the thousands of lots are occupied, most of the lots are owned by absentee landowners or held for land speculation. The lots are relatively inexpensive today due to lack of paved roads and

water mains. It will be very difficult to see any of the project facilities from this area due to the 'ohi'a forest.

3.4.7 Noise

Ambient noise (or background noise) refers to the noise levels which presently exist in the environs of the project site at locations where people reside, play, or work. Typical ambient noise sources are the wind in foliage, motor vehicular traffic, aircraft, lawn mowers, TV and radios, home generators, etc. Ambient noise varies with location as well as with the time of day and with the seasons.

Ambient noise also varies in frequency (or spectral) content, e.g., the low frequencies from a diesel engine exhaust to the high frequencies from crickets. Research has shown that the use of an "A" weighted noise level approximates the frequency characteristics in the human hearing mechanism. Thus, sound levels measured in decibels "A" weight (or dBA) are adequate for most community noise surveys and evaluations. Also, human response varies widely between individuals--what may seem loud to one person may not to another. Table 3-12 provides a comparison between noise levels and typical subjective interpretations for common sounds.

The residual ambient noise level in very rural areas distant from the surf is usually controlled by wind in the foliage, birds, and insects during periods of time between motor vehicular and aircraft events occurring within several miles. This residual noise level can be expressed as the L_n percentile level of L_{90}, or the dBA noise level which is exceeded 90 percent of the time. In very remote areas, there are often long periods of low ambient noise levels between such transportation noise events; e.g., L_{90} levels of 25 dBA have been measured on the Big Island in the Pohakuloa area, near the observatory base camp on Mauna Kea, and along the Kilauea Crater in Hawaii Volcanoes National Park.

During the daytime in most remote rural areas, distant transportation noise events and distant construction projects often control the ambient L_{90} in a

range of 30 to 35 dBA, but the listener is usually not conscious of the noise sources due to the fact his own movements and activities readily mask such low level noise. However, at night when persons are trying to sleep, the sounds of an individual vehicle movement within several miles of a residence in a remote rural area may be very detectable. During such times, the outdoor L_{90} typically ranges from 25 to 35 dBA while interior noise levels in naturally ventilated Hawaiian housing would be 5 to 10 dBA less when there are no inside noise sources, e.g., when the refrigerator is not running.

From the above discussion and Table 3-12, it can be seen that in the very remote rural areas, ambient noise levels would be subjectively judged to be "Very Quiet." During the day, in less remote areas where there is more continuous motor vehicular activity as well as usually some type of construction project within a mile or so, typical ambient noise levels (experienced by persons shielded from direct traffic noise) would range from 35 to 45 dBA. Such noise levels ranging between "Very Quiet" to "Quiet" in Table 3-12 should exist in the town of Volcano and the Fern Forest Subdivision area closest to the highway. At night, noise levels should approach "Very Quiet" conditions in such areas. The County Planning Department states that the nighttime ambient L_{10} in the rural Puna District ranges between 30 dBA and 35 dBA.

It is to be noted that large subdivisions which now have relatively few homes, but are gradually developing, will have ambient levels which are continuously increasing as a function of the density of population. The building of new homes involving site preparation with bulldozers, construction noises, the transportation of supplies, etc., readily cause daytime ambient levels to increase significantly. After the new homes are occupied, each unit usually generates numerous trips with vehicles, and use of lawnmowers, power tools, TV, radios, home generators, etc., which all tend to "fill-in" the quiet periods that

may have existed before. Thus, the ambient noise in such communities tends to raise from the "Very Quiet" toward the "Quiet" condition as the community grows.

The impact that noise has on a person depends on many things. For example, the "intrusiveness" of lower level noises can be used best to predict annoyance as well as task or sleep interference. Intrusiveness refers to the degree that the noise can be detected above the surrounding ambient sounds. For higher levels of noise, the degree that it interferes with one's ability to listen to others talk (or listen to the TV and radio) is often the major cause of noise impact. At even higher levels of noise (e.g., above 80 dBA), one's hearing may be damaged if he is continuously exposed to such levels for long periods of time. See Table 3-12 for dB values of common sounds.

The noise level measurable from a source depends on the strength of the source and the sound propagation loss, or attenuation, that occurs in the sound transmission path between the source and the listener. In the Puna area on Hawaii, it has been found that the sound transmission path can be very variable and a major factor in controlling the propagation of geothermal activity noises. The following excerpt from the Geothermal Noise Level Guidelines of the Hawaii County Planning Department describes these propagation considerations because it is assumed that the same conditions will exist in the environs of this project:

> "As sound waves move through the atmosphere, the energy of the waves are weakened (attenuated) as the distance from the source increases. The factors affecting the amount or level of attenuation include the distance traveled, the frequency of the sound waves, the relative humidity, temperature and wind velocity.
>
> "In general, there are three distinct conditions or combinations of factors which affect the rate of attenuation of sound...
>
> "Condition 1 - Cylindrical spreading based on 3 dB loss per doubling of distance which is the worst case theoretically. This condition exists when compound sound velocity gradients

TABLE 3-12

COMPARISON OF SOME COMMON SOUNDS AND HOW THEY RANK WITH RESPECT TO SUBJECTIVE RESPONSE TO A TYPICAL SUBURBAN DWELLER

----------Sound Levels and Human Response----------

Common Sounds	Noise Level (dB)	Effect
Carrier deck jet operation Air raid siren	140	Painfully loud
	130	
Jet takeoff (200 feet) Thunderclap Discotheque Auto horn (3 feet)	120	Maximum vocal effort
Pile drivers	110	
Garbage truck	100	
Heavy truck (50 feet) City traffic	90	Hearing damage (8 hour/day)
Alarm clock (2 feet) Hair dryer	80	
Noisy restaurant Freeway traffic Man's voice (3 feet)	70	Telephone use difficult
Air conditioning unit (20 feet)	60	
Light auto traffic (100 feet)	50	Quiet
Living room Bedroom Quiet office	40	
Library Soft whisper (15 feet)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Hearing begins

Note: To the ear, each 10 dB increase seems approximately twice as loud.

in the atmosphere cause the ducting of sound. Excess (additional) attenuation is due only to the molecular and anomalous phenomena.

"Condition 2 - Spherical spreading based on 6 dB loss per doubling of distance plus excess attenuation for propagation through air only. This condition exists when sound velocity gradients exist to "bend" sound rays over trees and other obstacles.

"Condition 3 - Spherical spreading based on 6 dB loss per doubling of distance plus excess attenuation for propagation through air (Condition 2), plus ground attenuation due to the absorption and scattering caused by trees and other foliage.

"The positive sound velocity gradients or ground inversions mentioned in Conditions 2 and 3 result when sound waves are refracted or bent as they travel through the atmosphere. These inversions are normally attributed to wind or thermal gradients (changes in wind velocity or temperature over a unit distance) or combinations of both. When these ground inversions occur, they usually take place about one hour before sunset and continue to about one hour after sunrise. The conditions which contribute to the ground inversions usually exist in the atmosphere from ground level to about 200 feet in altitude above the terrain.

"When there are no ground inversions and ground-to-ground sound transmission is in a straight line, large excess attenuation often exists due to shielding by topographic features and buildings as well as due to absorption and scatter of sound by foliage (Condition 3). If a positive sound velocity gradient exists, then the sound rays may travel on a large arc passing above some of the obstructions, causing much less excess attenuation to be present (Condition 2). If the gradient is strong enough, it is possible that the only sound attenuation experienced by the listener is similar to a free space condition....(Condition 1)."

The following additional findings are reported in the guidelines:

"(1) The propagation loss may vary by 15 to 20 dB during a 24-hour period for a given distance between source and listener...., indicating the generation and disappearance of sound velocity gradients which bend sound rays over trees and other foliage (Conditions 1 and 2).

"(2) Usually propagation loss was not less than Condition 2, but there are strong indications implying that energy in the lower frequencies....do experience a compound sound velocity gradient at times (Condition 1).

"(3) For estimating noise levels in residential areas, a reasonable average value for sound propagation loss is to use Condition 2 as a worst case understanding that when there are compound sound velocity gradients, noise levels in the low frequencies may be 5 to 10 dB greater."

The following "Guidelines" were established by the County:

"1. That the acceptable geothermal noise guidelines should be at a level which reasonably assures that the Environmental Protection Agency and U. S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met....

"2. That the sound level measurements should take place at the affected residential receptors.

"3. That, in conjunction and appreciation of the other guidelines, the acceptable noise levels for geothermal development are as follows:

"a. That a general noise level of 55 dBA during daytime and 45 dBA at night not be exceeded except as allowed under b. For the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m.;

"b. That the allowable levels for impact noise be 10 dBA above the generally allowed noise level. However, in any event, the generally allowed noise level should not be exceeded more than 10 percent of the time within any 20-minute period;

"c. That the noise level guidelines be applied at the existing residential receptors which may be impacted by the geothermal operation; and

"d. That sound level measurements be conducted using standard procedures with sound level meters using the "A" weighting and "slow" meter response unless otherwise stated."

The distance from the closest boundary of the Fern Forest Subdivision to the initial geothermal prospect site is about 2.6 miles. The distance from the initial site to the town of Volcano is about 8.3 miles. During the daytime when the trade winds are blowing, sound from the geothermal operations should <u>not</u> be refracted to these residential areas due to wind gradients. The sound propagation condition should be Condition 3 where there is spherical spreading with air absorption plus excess attenuation

due to shielding and absorption of the ground and foliage. During nights when the resultant winds are controlled by the interaction of the trade winds and land/mountain breezes, the residential areas should be upwind of the geothermal operations. (See Section 3.2.2.1, Climate, on the weather in the area.) Under these conditions, there would be even greater attenuation of sounds than the Condition 3 propagation situation because the sound rays will bend upwards, tending to place the residential areas in an acoustic shadow. On nights when conditions allow a ground level inversion to form, then sound propagation Conditions 1 and 2 may exist between the geothermal site and the residential areas. More detailed meteorological data are required to predict the frequency of ground level inversions.

The distance from the initial geothermal prospect site to the nearest point of the Chain of Craters Road in the Hawaii National Park is about 1.5 miles. The park should be downwind of the geothermal operations during trade wind conditions during both the day and night, thus sound propagation Conditions 1 and 2 may occur. The extent that sound refraction will occur and cause higher noise levels in the park depends on the statistical behavior of the wind gradient in the first few hundred of feet from the ground. There are no known prediction techniques to estimate the noise levels other than the worst case conditions as shown in Table 3-12.

The above considerations involve only the impact of noise on humans. Studies have shown that animal behavior also is affected by excessive noise, which has been shown to cause changes in the size, weight, reproductive activity, and behavior of farm animals. In some wildlife species, changes in mating behavior, predator-prey relationships, and territorial behavior have been observed.

To date, levels of noise have not been identified to protect wild animals as has been done for humans, however, if further information is obtained which shows that specific animal species protected by current law are being endangered due to noise levels from the project, then efforts will be made to reduce noise levels to mitigate the impacts on such animals.

3.4.8 Land Use

The geothermal project area, occupying land owned by Campbell Estate, is classified conservation and agriculture by the State Land Use Commission. The property is forested with native trees and shrubs, interrupted by patches of scrub vegetations and barren lava flow. The property is presently undeveloped and unproductive. It has been reported that hunters and others use the upper conservation area illegally for pig hunting and growing of marijuana.

In the past, the area was leased for pasture purposes for cattle. Some hapuu harvesting was carried out under a State CDUA permit but was discontinued before any large scale operations were initiated. Other proposals were made to harvest the 'ohi'a trees but were never negotiated.

The Department of Land and Natural Resources has designated the conservation area as Limited, L-subzone. The lower portion of the project area is designated for extensive agriculture by the County of Hawaii. Figures 3-5 and 3-6 show the current County and State land use designation.

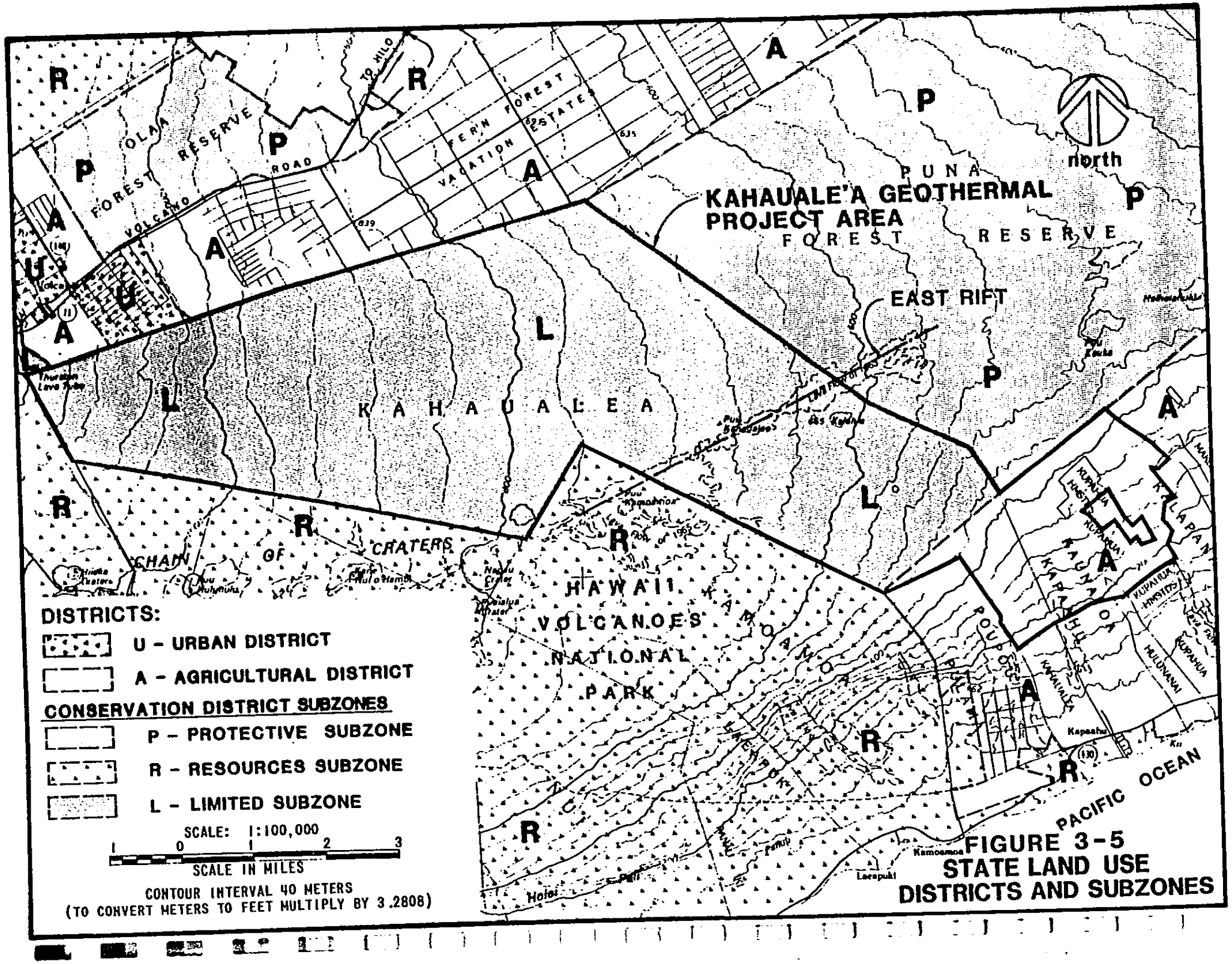


FIGURE 3-5
STATE LAND USE
DISTRICTS AND SUBZONES

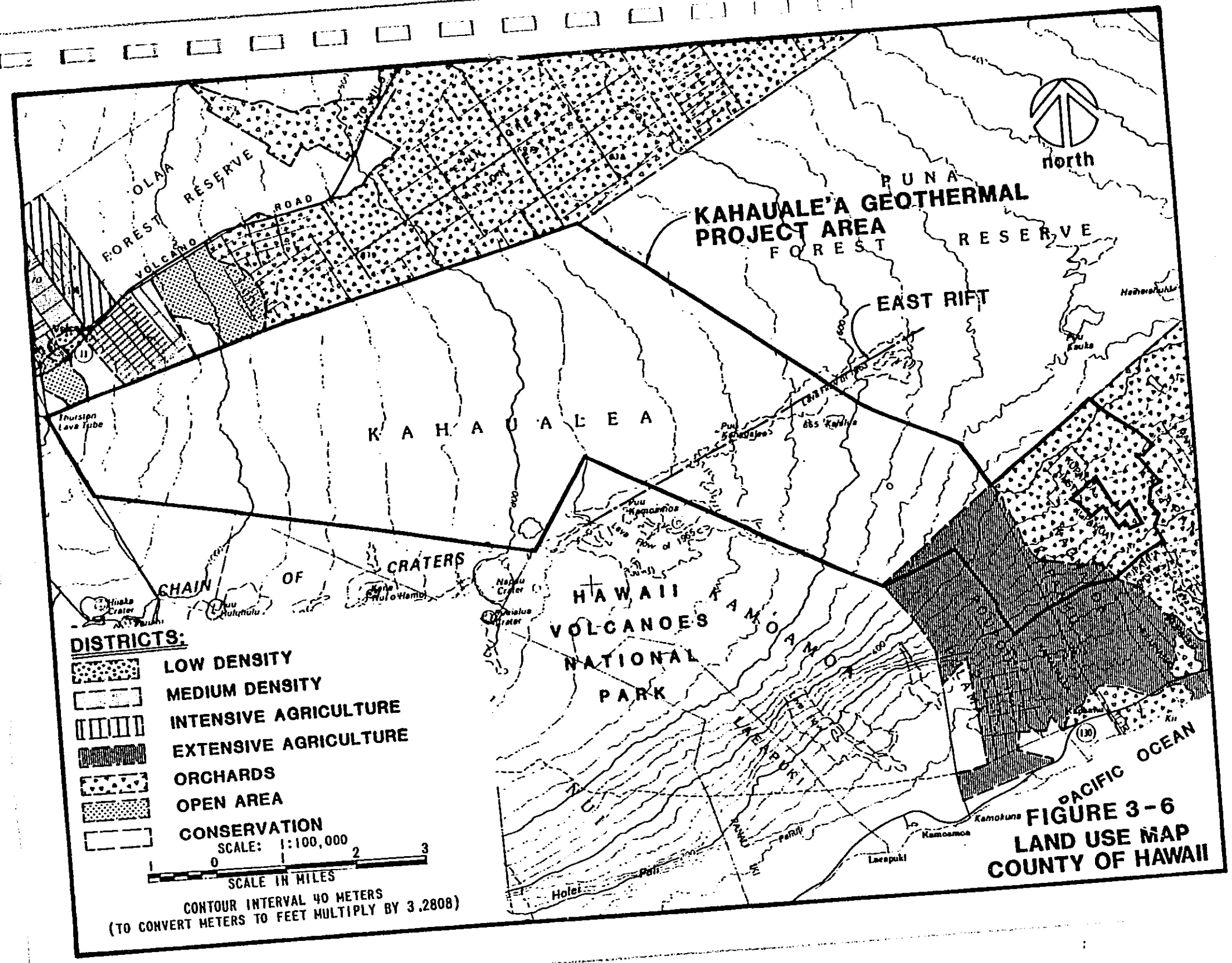


FIGURE 3-6
LAND USE MAP
COUNTY OF HAWAII

SECTION 4

THE RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS FOR THE AFFECTED AREA

4.1 INTRODUCTION

Hawaii has an abundance of renewable energy resources which are becoming available and competitive under new and improved technologies and financial incentives. These energy resources include wind, geothermal, solar, hydropower, biomass and ocean thermal.

Several State, County of Hawaii, and Federal plans, policies and controls have important relationships to the project. These fall within three general categories: (1) land use plans, (2) policy plans, and (3) other programs and controls.

4.2 LAND USE PLANS

Land use plans are much more specific than policy plans, primarily because they contain maps relating to the particular area of concern. These land use plans and controls affect the development of the project. These are the (1) State Land Use District Regulations, (2) State Administrative Rules for Conservation District, (3) the County General Plan, (4) the County Detailed Land Use Maps, and (5) the County Zoning Regulations.

4.2.1 State Land Use District

Under the provisions of Chapter 205-2, Hawaii Revised Statutes (commonly known as the "green belt law"), all lands in the State of Hawaii are classified into one of four major land use districts by the State Land use Commission: (a) urban, (b) rural, (c) agricultural, and (d) conservation.

The counties regulate the internal zoning of the urban, rural and agricultural districts.

The State Department of Land and Natural Resources administers uses in the Conservation District. Figure 3-4 shows the State land use designation for the project lands and adjacent areas.

4.2.2 State Regulations for Conservation District

The State Department of Land and Natural Resources regulates uses in the Conservation District under Title 13, Subtitle 1, Administration, Chapter 2. The current Department of Land and Natural Resources designation for this parcel in the Conservation District is subzoned as Limited (L) Use. The objective of the Limited (L) subzone is to limit uses where natural conditions suggest constraint on human activities. This designation is reserved for lands susceptible to floods and erosion, and land's necessary for the protection of the health and welfare of the public by reason of the land's susceptibility to inundation by tsunami and flooding or to volcanic activity and landslides which incorporate a general slope of 40 percent or more.

Permitted uses in the Limited (L) Use subzone are:

- All permitted uses stated in the (P) subzone;
- Emergency warning systems or emergency telephone systems;
- Flood, erosion, or siltation control project; and
- Growing and harvesting of forested products.

Permitted uses in the (P) subzone are:

- Research, recreational and educational use which require no physical facilities;

- Establishment and operation of marine, plant and wildlife, sanctuaries and refuges, wilderness and scenic areas, including habitat improvement;

- Restoration or operation of significant historic and archaeological sites listed on the National or State Register;

- Maintenance and protection of desired vegetation, including removal of dead, deteriorated and noxious plants;

- Programs for control of animal, plant and marine population, to include fishing and hunting;

- Monitoring, observing and measuring natural resources;

- Occasional use; and

- Any other government facilities not enumerated herein where the public benefit outweighs any impact on the Conservation District.

These permitted uses provide the Board of Land and Natural Resources with discretionary authority to determine if a specific use within the Conservation District is compatible with the goals of the Conservation District.

The Board of Land and Natural Resources plays an integral role in the development of geothermal resources. Its responsibility through the Department of Land and Natural Resources includes permitting geothermal explorations and issuing of geothermal mining leases, in addition to permitting and regulating the drilling and maintenance of geothermal wells in the State.

At present, geothermal use is not a permitted use in any district. The Conservation District Use Applicant (Trustees of the Estate of James Campbell) is requesting that "conditional use" permission be granted for geothermal exploration and development. Notwithstanding, the applicant believes that the geothermal use within the (L) subzone should be permitted since the project area was so designated (L) subzone because of volcanic activity. The Kilauea Volcano has created natural resource (geothermal energy) that can be utilized for the benefit of the people of Hawaii. Conservation encompasses the wise use of our natural resources. Since forests of this type exists elsewhere on the Island of Hawaii, partial use of this vast tract of land presents a viable solution. The Board must determine whether or not geothermal development of the area, as requested, is prudent and represents the best use of one of the State's natural resources.

The Board of Land and Natural Resources will carefully review and weigh the environmental impacts on air and water quality, flora and fauna, visual values, and our social structure against the benefits to be derived. These include increased productivity of the land and the resultant economic activity which will add to the State and County tax revenues, increased energy self-sufficiency and additional employment for local residents.

The growing awareness of alternate energy resources has resulted in legislation permitting wind turbine generators of electric power in districts classified as agricultural districts.

Since geothermal energy is a natural resource and conservation districts are established to manage and assure the prudent use of such resources, it is expected that development of geothermal energy resources would be compatible with conservation district objectives.

4.2.3 The General Plan of the County of Hawaii

In 1971, the County of Hawaii adopted a General Plan designed to guide the long-range comprehensive development of the Island of Hawaii. The plan sets forth the objectives, standards and courses of action for achieving the ultimate goals of a coordinated growth of the island. Since its inception, various amendments were made and in February 1980, special emphasis was placed on energy self-sufficiency because of the heavy dependence on imported fuel and the escalating cost of electricity.

The amended plan contains several goals and policies which relates to the development and research of alternate energy resources. Among those relating directly to energy development are as follows:

- Goal: To strive towards energy self-sufficiency for Hawaii County.

- Goal: To establish the Big Island as a demonstration community for the development and use of natural energy resources.

- Policy: The County shall encourage the development of alternative energy resources.

- Policy: The County shall encourage the expansion of energy research industry.

- Policy: The County shall strive to educate the public on new energy technologies and foster attitudes and activities conducive to energy conservation.

- Policy: The County shall ensure a proper balance between the development of alternative energy resources and the preservation of environmental fitness.

- Policy: The County shall strive to assure a sufficient supply of energy to support present and future demands.

- Policy: The County shall provide incentives which will encourage the use of new energy sources and promote energy conservation.

- Policy: The County shall seek funding from both government and private sources for research and development alternative energy resources.

- Policy: The County shall coordinate energy research and development efforts of both the government and private sectors.

4.2.4 County Development Plan

The County Development Plan provides more detail to the General Plan of the County of Hawaii by establishing a relatively detailed plan of an area or region. The Development Plan, in conjunction with the Zone Guide Map, will further refine the broad Land Use Pattern Allocation Guide (LUPAG) Map of the General Plan, after considering more detailed social, environmental and economic data of an area. This system is unique in the State of Hawaii and emphasizes the policy orientation of the General Plan and gives decision makers some measure of flexibility. There are broad land use patterns provided in the LUPAG Maps to provide general direction in an orderly and rational fashion.

Since the project lands are within the Conservation District and the uses administered by the Department of Land and Natural Resources, County zoning is not applicable to the Kahauale'a property. However, use of the conservation lands of Kahauale'a may impact upon the County and its infrastructure and, hence, the County will review probable uses within the land of Kahauale'a and make such recommendations as it deems appropriate to the Department of Land and Natural Resources.

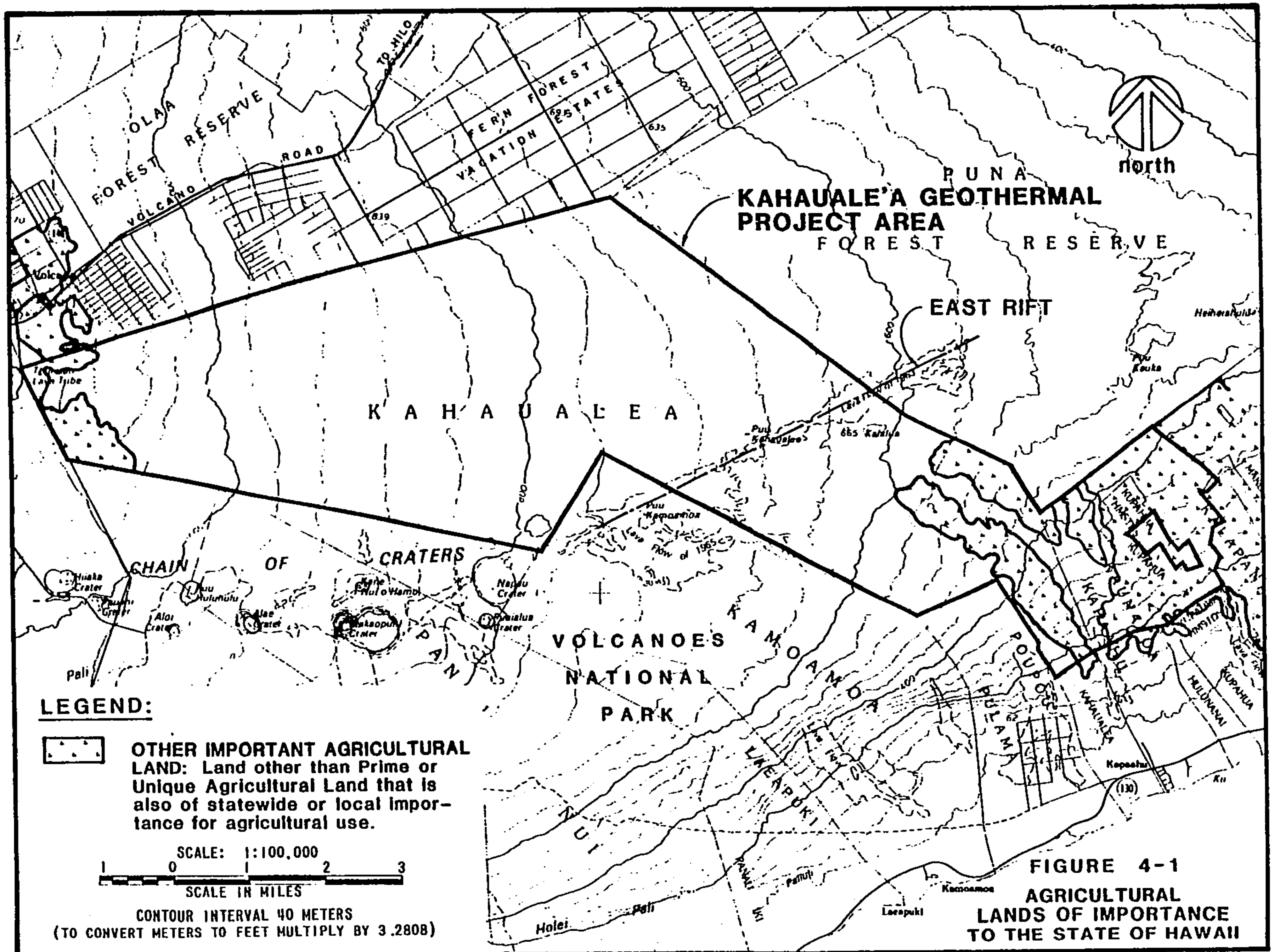
4.2.5 ALISH Designation

The State Department of Agriculture has instituted a land classification system called: Agricultural Lands of Importance to the State of Hawaii (ALISH). This classification is used by the Department of Agriculture in assessing uses of agricultural lands. This system does not have any statutory standing at this time.

The system is based on three categories of agricultural lands. These categories in order of importance area:

- Prime Agricultural Land
- Unique Agricultural Land
- Other Important Agricultural Land

Two sites on the lands of Kahauale'a fall within the least important category of the ALISH system: Other important Agricultural Land. One site is below the rift zone and lies below the initially planned geothermal prospect area. The second site is at the northwestern end of Kahauale'a and is within the Conservation District. This area adjoins the Thurston Lava Tube site. Two drilling sites at Power Station E are located within the ALISH boundary. See Figure 4-1.



LEGEND:

OTHER IMPORTANT AGRICULTURAL LAND: Land other than Prime or Unique Agricultural Land that is also of statewide or local importance for agricultural use.

SCALE: 1:100,000

SCALE IN MILES (1 – 0 – 1 – 2 – 3)

CONTOUR INTERVAL 40 METERS
(TO CONVERT METERS TO FEET MULTIPLY BY 3.2808)

FIGURE 4-1
AGRICULTURAL LANDS OF IMPORTANCE TO THE STATE OF HAWAII

4.3 OTHER POLICIES AND PLANS

There are Federal as well as State efforts to combat the escalating price of petroleum due to OPEC actions. Legislation spurring the development of new energy sources have been enacted providing incentives. These legislative acts have brought about land use changes in Hawaii. Tree farms in State forest reserves have been started for biomass burning in existing power generating facilities; and wind turbine generator use in agricultural lands have become a permitted use. To meet the challenge of developing alternative energy requires new and innovative uses of our land resources.

Both the State of Hawaii and the County of Hawaii have adopted policy plans to guide the physical, social and economic development of the Island of Hawaii. These contain general objectives and policies that seek to encourage and guide the development of nonfossil fuel renewable energy resources, including geothermal, and therefore are not specific in their recommendations regarding a particular site. Although the discussion of these plans and policies must necessarily be general, they do provide the overall policy framework within which a geothermal project can be developed. The Federal government has also adopted certain laws in response to the national energy crisis. These provide the general framework, on a national basis, for developing nonfossil fuel renewable energy resources.

4.3.1 Hawaii State Plan

In 1978, recognizing Hawaii's extremely vulnerable energy situation as well as its opportunities, the State Legislature enacted the Hawaii State Plan, Chapter 226, of the Hawaii Revised Statutes. The purpose of the plan is to improve the State-wide planning process, which is to articulate goals, objectives, and policies intended to guide future development for the State of Hawaii. The State Plan defines two energy objectives. The first is to provide a dependable, efficient, and economical State-wide energy system capable of supporting the current and future needs of the people of Hawaii. The second is to provide increased energy self-sufficiency by decreasing Hawaii's dependence on imported fuel.

Although the State Plan goals, objectives, and policies are broadly stated, the geothermal project appears to be consistent with many of the State Plan objectives and specific policies. These are discussed with regard to the geothermal project, which relates to the general objective of increased energy self-sufficiency:

- Policy: Accelerate research development and use of new energy sources.

- Policy: Provide adequate, reasonably priced, and dependable power and communication services to accommodate demand.

- Policy: Ensure a sufficient supply of energy to enable power systems to support the demands of growth.

- Policy: Promote the use of new energy sources.

4.3.2 State Energy Plan

The State Energy Plan is one of the proposed 12 State Functional Plans that are intended to further define and particularize the State Plan comprehensive goals, objectives, policies and priority directions. The State Energy Plan document dated October 1981 is intended to create an economic environment which will attract capital for research, development, and maintenance of new means of energy production to ensure energy self-sufficiency for the State.

4.3.3 The Public Utilities Regulatory Policy Act (PURPA) of 1978

The objectives of the Act are:

- conservation of energy;
- efficient use of facilities and resources; and
- equitable rates to electric consumers.

To achieve these goals, the Act sets forth 11 standards for rate design and utility practices which must be considered by State Public Utilities Commissions and non-regulated utilities.

The rate designs include: cost of service, declining block rates, time of day rates, seasonal rates, interruptible rates, and load management techniques. Other standards include master metering, automatic adjustment clauses, and termination procedures. The impact of this provision per se is likely minimal in Hawaii since the State Public Utilities Commission is currently considering most of these ideas already in rate hearings. The provisions of the Act, however, might be to encourage conservation and therefore to reduce the demand or peak load for electric energy. To make the legislation more effective, the Federal government is given the right to participate and intervene in rate-making proceedings or other appropriate regulatory deliberations. It is also authorized to require interconnections of grids and wheeling of power, subject to the proviso that such action does not place undue burden on a utility, impair the reliability of a system, or require an enlargement of generation facility. To achieve interconnections, the Federal Energy Regulatory Commission can exempt utilities from State laws or regulations which prohibit or prevent voluntary pooling. This provision can be significant in Hawaii as there have already been instances where sugar companies wanted to use the public utility grid to wheel power from one of their bagasse generators to other points of use and this, in the past, has been denied by electric utilities. It should be noted that Section 202, Interconnection and Section 203, Wheeling, requires the Commission to consider other factors in making such determinations.

The Act also requires the Federal Energy Regulatory Commission to prepare rules whereby utilities will be obligated to both buy and sell power to qualified co-generation facilities and qualifying small power production facilities. This would have impacts in Hawaii not only on power generation at the scale of individual multi-KW windmills (or photovoltaic arrays) but also on larger scales, e.g., bagasse generation plants or private

geothermal generation ventures, both of which are significant factors in Hawaii. In effect, this legislation gives a Federal imprimatur to the legal initiative begun in Hawaii by the State Legislature--the legislation to insure that utilities would buy power generated by bagasse and geothermal (and other renewable energy options).

Section 201 of PURPA defines a "small power production facility" as a facility which:

- Produces electric energy solely by the use, as a primary energy source, of biomass, waste, renewable resources, or any combination thereof; and

- Has a power production capacity which, together with any other facilities, located at the same site (as determined by the Commission), is not greater than 80 megawatts.

A co-generation facility is defined as a facility which produces electric energy and steam or forms of useful energy (such as heat) which are used for industrial, commercial, heating, or cooling purposes.

Thus, co-generation facilities simultaneously produce two forms of useful energy, namely, electric power and heat. Co-generation facilities can use significantly less fuel to produce electricity and steam (or other forms of energy) than would be needed to produce the two separately. By using fuels more efficiently, co-generation facilities can make a significant contribution to the Nation's effort to conserve its energy resources.

Small power production facilities as defined in the Act use biomass, waste, or renewable resources, including wind, solar energy and water, to produce electric power. Reliance on these sources of energy can reduce the need to consume fossil fuels to generate electric power.

4.3.4 The Concept of "Avoided Cost" (PURPA)

In the proposed rule, "avoided cost" is defined as the costs to an electric utility of energy or capacity or both which, but for the purchase from a qualifying facility, the electric utility would generate or construct itself or purchase from another source. This definition is derived from the concept of "the incremental cost to the electric utility of alternative electric energy" set forth in Section 210(d) of PURPA. It includes both the fixed and the running costs on an electric utility system which can be avoided by obtaining energy or capacity from qualifying facilities.

The cost which an electric utility can avoid by making such purchases generally can be classified as "energy" costs or "capacity" costs. Energy costs are the variable costs associated with the production of electric energy (kilowatt-hours). They represent the cost of fuel, and some operating and maintenance expenses. Capacity costs are the costs associated with providing the capability to deliver energy; they consist primarily of the capital costs of facilities.

If, by purchasing electric energy from a qualifying facility, a utility can reduce its energy costs or can avoid purchasing energy from another utility, the rate for a purchase from a qualifying facility is to be based on those energy costs which the utility can thereby avoid. If a qualifying facility offers energy of sufficient reliability and with sufficient legally enforceable guarantees of deliverability to permit the purchasing electric utility to avoid the need to construct generating unit, to build a smaller, less expensive plant, or to reduce firm power purchases from another utility, then the rates for such a purchase will be based on the avoided capacity and energy costs.

One way of determining the avoided cost is to calculate the total (capacity and energy) costs that would be incurred by a utility to meet a specified demand in comparison to the cost that the utility would incur if it purchased energy or capacity or both from a qualifying facility to meet part of its demand, and supplied its remaining needs from its own

facilities. The difference between these two figures would represent the utility's net avoided cost. In this case, the avoided costs are the excess of the total capacity and energy cost of the system developed in accordance with the utility's optimal capacity expansion plan, excluding the qualifying facility, over the total capacity and energy cost of the system (before payment to the qualifying facility) developed in accordance with the utility's optimal capacity expansion plan including the qualifying facility.

4.3.5 Public Utilities Commission

The operations of public utilities fall under the jurisdiction of the State Public Utilities Commission (PUC). In 1978, a new State law was enacted relating to the purchase by a public utility of geothermal energy. The Legislature stated in its findings and purpose that commercial development of the State's geothermal energy resources requires an assurance that the product can be sold at a just and reasonable rate and that the interest of the producer, public utility and the consumer be considered. The new law states:

> "The rate payable by a public utility to the producer of geothermal steam or electricity generated from geothermal steam shall be established by agreement between the public utility and the supplier, subject to approval by the Public Utilities Commission; provided that, if the public utility and the supplier fail to reach an agreement for such rate, or if the agreed upon rate is disapproved by the commission, the Public Utilities Commission shall establish a just and reasonable rate for the geothermal steam or electricity generated from geothermal steam supplied to the public utility by the producer.
>
> "The producer of geothermal steam or electricity generated from geothermal steam shall be excluded from coverage of the term "public utility" as defined in Section 269-1."

4.3.6 Developer's Pricing Philosphy Relative to State Energy Plan and PURPA

This section addresses the economic aspects of developing geothermal energy to replace an equivalent amount of oil-generated energy for sale to a public utility or directly to an industrial user. The economic factors and

philosophy which will influence the pricing of geothermal energy sold to a public utility are included as a matter of interest to the public. In this context, the cost of geothermal energy must be considered not only in relation to the cost of oil-generated energy, but in light of the alternative of continuing to depend on oil (or to convert to coal) as the primary source of energy if it is determined that the geothermal resources in Hawaii cannot be economically produced. The most important potential economic benefit to be derived from developing a local energy resource that can compete with oil is the prospect for stabilizing energy costs while minimizing or avoiding the serious economic impact which would result from disruption of oil imports or greatly increased prices.

From the developers' viewpoint, the expectation of being able to discover, produce and sell geothermal energy at acceptable costs is the principal assumption on which a project of this magnitude is conceived and initiated. The estimated range of costs for exploration and development of geothermal resources and the conversion facilities (power plants) to generate 25 MWe of power are outlined in Section 2. However, there are many factors, conditions and variables which will affect the actual costs and therefore the sales prices of the energy delivered to a public utility. The most significant factors include the following:

- The large capital requirement to initiate and sustain project development and the long lead time before cash flow could be expected.

- The high degree of risks in discovering an economically producible resource and in estimating the capability of a reservoir to sustain operations over the economic life of production and generating facilities.

- The characteristics (chemical composition, temperature, flow rate, etc.) and extent of the resource discovered.

- State-of-the-art technology available and applied to the numerous tasks, facilities, and equipment involved in the project.

- The risks of market uncertainty, a condition presently unique to Hawaii among existing geothermal development areas of the world.

- The amount of royalties and overriding royalties and taxes paid on the gross production of geothermal resources.

- Hazards associated with development in an area of an active volcano.

- The competitive costs of all other current energy sources (especially oil), and future alternate energy sources such as OTEC energy, and the reduced demand for energy through conservation measures.

For the project to be initiated, the sales price expectation must be such as to project adequate compensation for the risks and costs incident to the above factors, recognizing that recent money markets for investment funds in excess of $100,000 have paid up to 20 percent interest with little if any risk. On the other hand, the last factor, competition, will force the adjustment of the sales price expectation to a level ultimately determined by the market place for the production and sale of energy. If that level is inadequate to compensate for the other project economic and risk factors, the project simply cannot survive; the ultimate risk in initiating the project. Continuing assessment and analysis of projected future competitive market forces in light of the risks and economic factors being experienced is crucial to the developer throughout the project life as commitments to further development are made.

For the near future, it is likely that oil at OPEC prices will remain the base line for determining energy costs. The rapid and arbitrary increases in OPEC oil prices amounting to 1200 percent since 1974 caused serious, adverse economic and strategic impacts on the nation and the world. The

response in the U. S. has been towards conservation, and greatly increasing exploration for domestic oil and, more importantly, to developing alternate energy sources with the aid of various government incentives. Moreover, recent decisions of OPEC oil countries to counter the effects of increasing oil inventories indicate that these actions by the U. S. and other major oil consuming countries have had a temporary stabilizing effect on oil prices. However, it is not implausible that oil prices could be arbitrarily reduced for a sufficient period of time to levels that would seriously jeopardize current alternate energy projects and discourage investment in existing or new alternate energy projects, an element of risk that must be considered by potential investors in alternate energy developments. For the long term, the price of oil is expected to continue to escalate gradually. Should political events disrupt production of any of the major producers, oil prices can be expected to increase to significantly higher levels.

On balance, it is believed that geothermal energy in Hawaii can successfully compete with oil (allowing for some leveling or reductions in prices) as well as alternate energy sources now being developed. In competing with these energy sources, the price for geothermal energy would be expected to be less than that of oil (or the other alternate energy sources). Excluding the possibilities of major unforeseen difficulties in the exploration and development phase, discovery of marginal quality resources, or serious economic impacts due to OPEC oil pricing policies, it is the current intent of the developers that the provisions of the Public Utilities Regulatory Policy Act (PURPA) will not be invoked to obtain a contract sales price equivalent to the avoided cost of oil for production of geothermal energy in increments up to 80 MWe. Therefore, it is the developer's objective to sell geothermal energy to a utility company at a base-year sales price, to be negotiated, which would be less than the company's generation station bus bar full costs of electrical energy in the year of contract negotiation on the assumption that over 80 percent of the plant capacity would be used.

An important consideration in any energy sales contract is the rate at which the base year sales price may increase. As to price increases for geothermal energy, it is the developer's position that increases in base year contract prices should be more the result of increased development or operating costs being experienced in Hawaii and not on the arbitrary machinations of OPEC oil members. It should be noted that the Public Utility Commission (PUC) in Hawaii is required to review and approve any purchase power contract between the utility company and a producer.

As more alternate energy is developed and produced in Hawaii, together with continuing conservation, the competitive forces of the market should result in a lower rate of price increases or lower base prices or both.

Pending the development of sufficient acceptable alternate energy resources, the people of Hawaii remain vulnerable to:

- Disruptions or cessation of oil supplies from foreign sources due to political events in or among the major producing countries.

- Further arbitrary oil price increases as dictated by OPEC policies including curtailment of production to increase demand.

- Continuing outflow of dollars to out-of-state and out-of-country suppliers.

Because of the foregoing threats to Hawaiian economy and the welfare of its people, and the long lead time to research, discover and/or develop alternate energy sources that can compete with oil, it is essential that geothermal development (and other alternate energy sources) proceed with efficiency and with a sense of urgency.

The most important potential economic benefit to be derived from the development of a local energy resource that competes with oil is the prospect of stabilizing electric power costs in the State.

SECTION 5
IMPACTS OF THE PROPOSED PROJECT

The purpose of this section is to identify all potential project sources or events which could cause environmental impacts and to assess the level of such impacts should they occur. The measures to mitigate impacts that occur are discussed in Section 6.

The proposed project will have impacts on the environment as a result of (1) land clearing and construction activities, (2) drilling operations and well testing, and (3) power plant and production well operations. There is also the possibility of environmental impacts being created by any natural volcanic and seismic activity that might disrupt project operations and facilities. Potential and expected environmental impacts will be assessed in relation to flora and fauna, water quality, air quality, ambient noise levels, visual perspective of the project area, future land use and archaeological sites.

Generally, the environmental impacts that must be considered are those that are expected and those that have the potential to occur. The expected impacts are those for which impact predictions can be made and mitigation measures designed and implemented, unless the impact is so transient as to render it insignificant. (Such impacts include emissions, noise, land clearing, visual effects, fugitive dust, etc.)

The potential impacts are those which are possible and for which suitable precautionary mitigation measures must be taken or considered even though the probability is low that such impacts would occur. (Such events include natural volcanic and seismic activity which could affect project operations, the rupture of a pipeline, or a system, or equipment failure.)

The project as a whole will have beneficial sociological and economic impacts of a magnitude that depends upon the extent to which the scope and objectives of the project are ultimately achieved and the time span over which the planned development activities occur (see Section 5.5).

The major potential source of impacts of geothermal exploration, development and energy conversion operations would be the geothermal fluid itself (in the water phase and the steam/gas phase) and how it is controlled in the production and energy conversion process. Therefore, special measures are taken and planned to prevent or mitigate any impacts from geothermal fluid. Other potential sources of environmental impact of geothermal development are expected to be comparatively minor, or transient in nature, or to constitute a reasonable balance between acceptable impacts and overall benefits of the project.

5.1 IMPACTS OF CLEARING AND CONSTRUCTION ACTIVITIES; ROADS, DRILLING SITES, POWER PLANT SITES AND STRUCTURES, TRANSMISSION CORRIDORS, AND POWER PLANT CONSTRUCTION

5.1.1 Impacts on Land Use

The proposed use of the land could involve approximately 1.7 percent (422 acres) of the total of 25,461 acres of the project lands of which 21,943 are within a conservation district and 3,518 acres are within an agricultural district. The use of this small portion of the surface area of the Kahauale'a parcel required to develop a potentially significant renewable underground energy resource and the installation of energy conversion facilities would have minimal impact on the land with respect to its current designated use. (See Table 5-1 for a tabulation on all surface area requirements.)

It can be assumed that the Subzone-L Conservation District designation was based chiefly on the apparent volcanic hazards posed by the extension of the Kilauea Rift Zone through the property. Under present departmental regulations governing uses within this area, the growing and harvesting of forest products is a permitted use. In the past, a permit was obtained for hapuu harvesting in a 3,840-acre section but the harvesting was not accomplished. The acreage authorized for harvesting of hapuu under the permit was nine times greater than the 422 acres expected to be used in fully implementing the master plan for this project.

The 1975 Master Plan for the HVNP contemplates the acquisition of Campbell Estate lands at Kahauale'a for expansion of the National Park. Over 59 years ago, the Territory exchanged 2,526 acres of land from Campbell Estate by an exchange. This land was given to the Federal Government by the Territory for park purposes. At that time, it was the practice of the State government and private landowners to dedicate lands at no cost to the

TABLE 5-1
ESTIMATED ACREAGE REQUIRED FOR PROJECT

	Year	Road Length (Ft)	Road Width w/o Trans Line (Ft)	Road Width w/ Trans Line (Ft)	Road Width w/ Pipe (Ft)	No. of Drilling Sites	Area Per Drilling Site (Ac.)	Area Acres	Total (Acres)
Kahauale'a Access Road to Initial Drill Site (KA1)*	1982	39,310	20	--	--	--	--	18	18
Ultimate Access Rd to Power Plant Site "A"*		35,210**	--	58	--	--	--	47	
Well Field "A" Road		(27,600)	--	--	**	--	--	20	
Power Plant Site "A"	1989	--	--	--	--	--	--	15	
Well Field "A" Drilling Sites		--	--	--	--	10	5	50	132
Addition to Ultimate Access Road to Power Plant Site "B"		0	--	--	--	--	--	0	
Well Field "B" Road		17,500	--	--	30	--	--	12	
Power Plant Site "B"	1993	--	--	--	--	--	--	15	
Well Field "B" Drilling Site		--	--	--	--	7	5	35	62
Addition to Ultimate Access Road to Power Plant Site "C"		6,100	--	78	--	--	--	11	
Well Field "C" Road		33,900	--	--	30	--	--	23	
Power Plant Site "C"	1997	--	--	--	--	--	--	15	
Well Field "C" Drilling Sites		--	--	--	--	10	5	50	99
Addition to Ultimate Access Road to Power Plant Site "D"		0	--	--	--	--	--	0	
Well Field "D" Road		10,000	--	--	30	--	--	7	
Power Plant Site "D"	2001	--	--	--	--	--	--	15	
Well Field "D" Drilling Sites		--	--	--	--	4	5	20	42
Addition to Ultimate Access Road to Power Plant Site "E"		10,200	--	78	--	--	--	18	
Well Field "E" Road		8,000	--	--	30	--	--	6	
Power Plant Site "E"	2003	--	--	--	--	--	--	15	
Well Field "E" Drilling Sites		--	--	--	--	4	5	20	59

*Does not include 1.4-mile easement through Shipman property to Volcano Road.

** Balance to KA1 New Road

[4,100'(10') + 27,600'(30')] 1/43,560 = 19.95 Ac.
SAY 20 Acres

	412 Acres
Misc. Use	10 Acres
TOTAL	422 Acres

National Park system. In recent times, the Federal land acquisition funds for park expansion has normally been the subject of congressional deliberation and action.

Because of the importance for the State of Hawaii to plan for its future energy requirements and to begin timely efforts toward achieving energy self-sufficiency, it is wise for the Campbell Estate to proceed with development of its alternate energy program at Kahauale'a, in view of the potential resources available.

The Kahauale'a Geothermal Project will be developed with a sensitivity to the aesthetic and other environmental concerns of the neighboring national park. It is intended that geothermal operations will be carried out with the implementation of reasonable mitigation measures to control visual, noise and odor impacts. These measures are discussed elsewhere in this report.

5.1.2 Impact on Surface and Groundwater Quality

There is no permanent surface water (streams or open reservoirs) in the project area except for very localized bogs created by impermeable underlying lava. Clearing and construction activities are not expected to have any impact on surface or groundwater quality within or adjacent to the project area.

5.1.3 Impacts on Air Quality

The normal pollutants that would be emitted during clearing and construction activities may have impact on air quality in the immediate vicinity of the activity depending on the intensity and duration of that activity and the current weather conditions. Pollutants from clearing operations include dust and waterborne silt, vegetation debris and exhaust. Debris of forest vegetation may be disposed of by controlled permit burning

in accordance with established forestry practices. Such burning would create, temporarily, air pollution. Pollutants from construction are derived from debris, runoff erosion, construction materials, and machinery operations. The principal pollutants would be soil dust, other airborne particulates, and waterborne suspended solids. However, most of these pollutants are classified as fugitive emissions (without control or direction) and are considered to be transient and nuisance-creating rather than hazardous contaminants.

5.1.4 Impacts of Noise

Noise impacts during the clearing and construction operations are derived from vehicles, machinery and equipment, and assembly operations with some directionally controlled blasting. While project activity is expected to be continuous, noises associated with these activities are considered generally to be short term and intermittent over short periods.

Traffic noise generated by the Kahauale'a project will be based on the equipment and transportation requirements of personnel and crews supporting the project. (See Section 5.5.3 for discussion of traffic impacts.) Since much of the project activity will be done sequentially, it is estimated that an average of 140 persons would require transportation in or out of the project area on days when construction activities are at a peak and depending on the size of the power plant under construction. Some of this transportation requirement will be met with carpools and/or buses, which should limit the average maximum traffic per day during a peak phase of construction to approximately 96 trips. There are no residences along the access road from Volcano Road into the project area; therefore, the noise impact of this traffic is expected to be minimal.

Clearing operations for the access road will begin at Volcano Road and continue to the first planned drilling site, KA1, a distance of

approximately 10 miles. It is estimated that completion of the access road will require up to three months. The heavy equipment noise associated with this activity will be increasingly separated from residences in the Volcano/Fern Forest communities. After completion of the access road, preparation of the first drilling site will be initiated and completed in approximately one week. Clearing of secondary roads, other drilling sites and power plant sites will occur generally in sequence but construction may occur simultaneously with other activities.

Noises from site preparation and power plant construction will be similar to but more intense than noises derived from road clearing operations. The cumulative noise level of these activities will be at a peak if and when drilling operations and power plant construction are simultaneous. Power plant construction noises will occur in cycles with varying intensity over two to three-year periods. Drilling site preparation and secondary road clearing noises will be intermittent over brief periods (one to three weeks). However, the location of this activity and the nature of the noise in relation to the nearest residences indicate there is little potential for significant noise impacts. (See Table 5-2 for examples of noise levels for construction activities.)

5.1.5 Impacts on Biota

The surface area required for the full development of the estimated resource potential for Kahauale'a includes roads (access and secondary), multiple and single drilling sites, power plant sites, and transmission lines for electricity and for geothermal fluid transport between well sites and power plants. Although transmission lines are the responsibility of HECO, it is expected they will be constructed along road corridors to minimize the amount of required clearing.

TABLE 5-2

NOISE LEVELS OF GEOTHERMAL OPERATIONS AT THE GEYSERS AND ESTIMATED DISTANCES WHERE 45 dBA WILL OCCUR WITH 3 DIFFERENT SOUND PROPAGATION CONDITIONS

Operation	Duration	dBA at 100'	Cond. 1	Cond. 2	Cond. 3
WELL DRILLING					
Mud Drilling	60 days/well	69-74	4.7 to >10 mi.	1585' to 2818'	794' to 1230'
Air Drilling, Including	30 days/well				
blow line		108	>10 mi.	6.5 mi.	4.34 mi.
blow line w/air sampler		83	6.4 mi.	3390'	2630'
blow line w/air sampler & water injection		73	1.4 mi.	1350'	1175'
Well Cleaning; Open Well	3-6 days	112	>10 mi.	10 mi.	6.1 mi.
Well Testing; Open Wells	14 days	112	>10 mi.	10 mi.	6.1 mi.
Rock Muffler		77	2.5 mi.	2000'	1585'
Well Bleeding Before Connection to Generator	Variable				
open hole		60	1000'	400'	363'
rock-filled ditch		39	--	--	166'
blowouts	Variable (infrequent)	112	>10 mi.	10 mi.	6.1 mi.
CONSTRUCTION					
Operation of Construc. Machinery (Trucks, Bulldozers, etc.)	1-2 yrs.	64-84	1.5 to >10 mi.	892' to 1.7 mi.	513' to 2884'

TABLE 5-2(Continued)

Operation	Duration	dBA at 100'	Cond. 1	Cond. 2	Cond. 3
PLANT OPERATION	20-30 Years				
Steam Line Vent (Muffled)	Intermittent	90	>10 mi.	1.2 mi.	4900'
Jet Gas Ejector	Continuous				
unattenuated (old design)		97	>10 mi.	2.4 mi.	1.7 mi.
with acoustical insulation		64	1892'	600'	513'
Steam Line Separator	Continuous	68	3390'	850'	724'
Steam Line Breaks	Brief, Infrequent	94	>10 mi.	1.8 mi.	1.3 mi.
Cooling Tower	Continuous	60-70	.6 to 6 mi.	400' to 1025'	363' to 871'
Turbine-Generator Bldg.	Continuous				

NOTES:

1. Different propagation loss expressions are used for steam jet noise versus machinery noise. The typical steam jet noise spectrum is assumed to have a broad peak in noise level at 1,000 Hz and drops off at 3 dB/octave at frequencies above the peak and at 10 dB/octave below the peak (Ref. 6). Thus, the large amount of acoustic energy in the mid and high frequency ranges tend to attenuate more rapidly with distance than does low frequency energy associated with mechanical equipment. Therefore, the sound propagation loss assumptions for the conditions in Table 5-2 are X log d or Y dBA/double distance (see Section 3.4.5):

Source	Condition 1 X	Condition 1 Y	Condition 2 X	Condition 2 Y	Condition 3 X	Condition 3 Y
Steam Jets	15.0	4.5	24.8	7.5	26.6	8
Machinery	10	3	20	6	26.6	8

2. At distances greater than about 4 miles, high frequency energy is generally dissipated and only low frequency sounds should generally be audible as a "rumble."

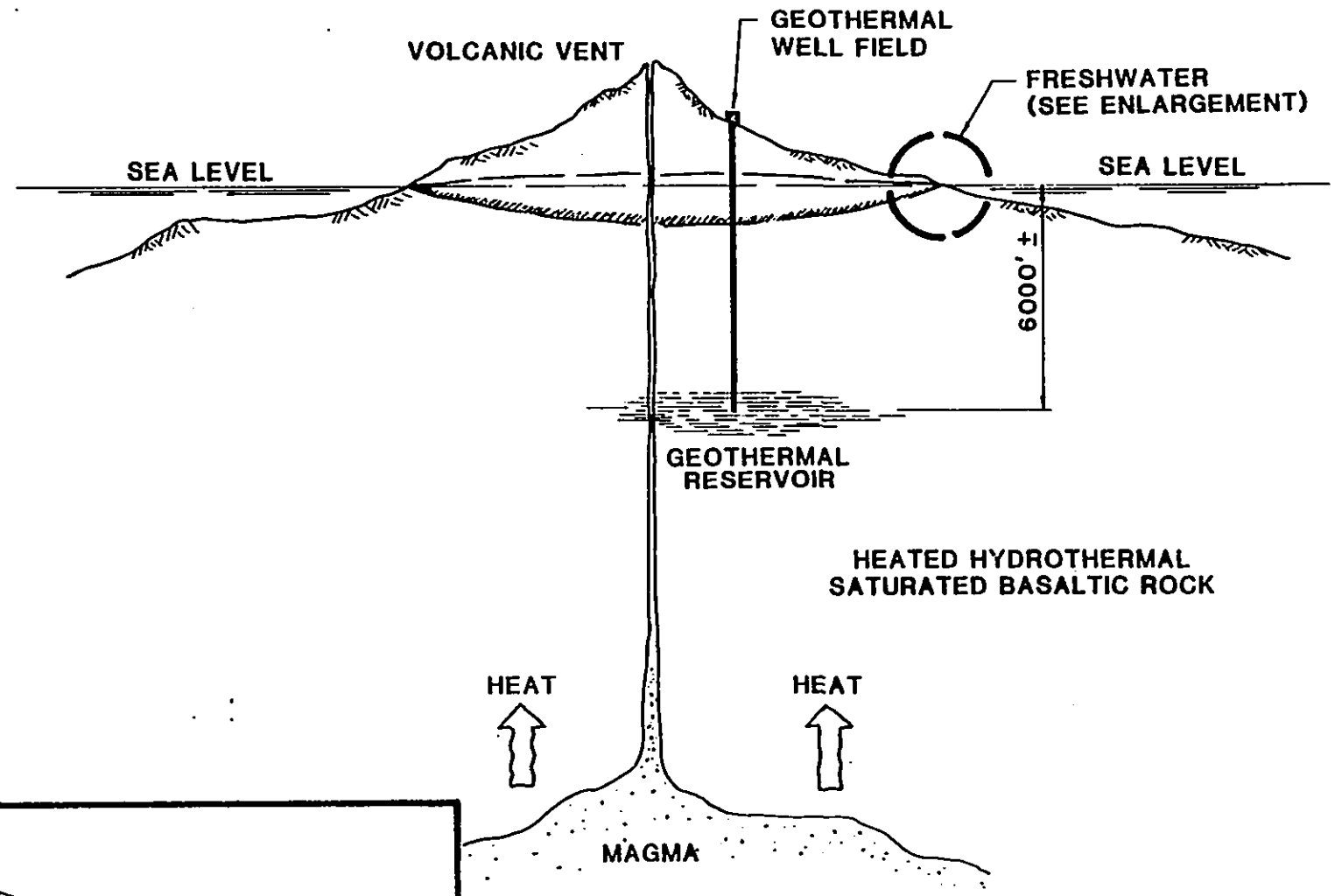
3. Actual noise levels perceived for Condition 3 depends on site specific geometries; e.g., the amount of foliage and topographic features between the source and the listener.

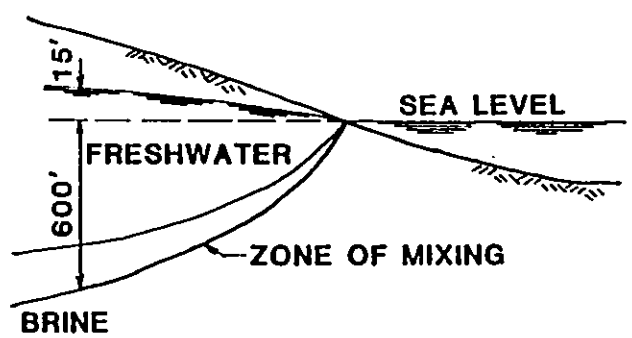
The estimated total amount of vegetation/trees required to be cleared adjusting for open areas containing lava and limited growth is 323 acres or 1.3 percent of the total project area. The estimated surface area required to be cleared for each successive geothermal development phase is summarized in Figure 5-1.

Due to the gradual slope of the surface area, there will be minimal requirement for cut-and-fill operations in road and site preparations. Some additional surface material may be required on segments of the roads. The initial width of the access road will be 14 to 20 feet. Subsequent improvements will extend the width to 30 feet. Clearing for the access road (approximately 7.5 miles), as proposed, will require removal of a long narrow strip of vegetation and trees, but most of the area along this road is more open than the northeastern section of Kahauale'a which has areas with up to 80 percent canopy, an area through which the initial access road was planned. The clearing of portions of the access road will necessitate removal of species of a rare plant, the Adenophorus periens, which grows on 'ohi'a trees along sections of the road as well as in other areas of the project area. (See Section 5.1.5.1 for further discussion of the impact of project operations on this plant.)

Clearing for the secondary roads will occur incrementally over 14 to 20 years. A major portion of the secondary roads will be in areas either devastated by lava flows or in less dense areas some of which include "dieback" populations of the 'ohi'a trees.

Clearing for drilling sites (up to five acres each for multiple well drilling sites and two acres each for any single drilling site) will be accomplished incrementally, averaging between five and eight acres per year at the projected rate of drilling. Limited excavation will be required for portions of a drilling site including a wellhead cellar and wellhead sump with a capacity of 750,000 gallons. (See Figure 2-8 for the layout of equipment and facilities at the drilling sites.)





ENLARGEMENT
GHYBEN-HERZBERG PRINCIPLE

FIGURE 5-1

A GEOTHERMAL WELL SHOWING ITS GEOLOGICAL RELATIONSHIP TO THE BASAL GROUNDWATER AQUIFER

The power plant facilities will be located within forested areas and at safe distances beyond the edge of the active rift zone and past lava flows. There are five sites tentatively located as shown on Figure 2-3. The Adenophorus periens fern is present on 'ohi'a trees in the vicinity of power plant sites D and B. Each site will vary in size between 7 and 15 acres depending on the generating capacity of the plant. Some excavation will be required at these sites, the largest of which will involve excavation for a silica drop-out pond and power plant foundation. (See Figures 2-13 and 2-19 for power plant site layout.) Approximately seven acres will be cleared for the first power plant site beginning in the second year of the project and up to 15 acres each for the 4 additional power plants sites every third year thereafter over a period of approximately 18 years.

Geothermal fluid transmission pipelines will be constructed adjacent to the secondary roads connecting the well sites with the power plants and along a segment of the access road. The right-of-way will require clearing approximately 10 feet additional surface area along one side of the road. Since the pipelines will be mounted on saddles, 4 to 6 feet aboveground, complete clearing will be required only at saddle emplacement points (about 36 square feet). Vegetation would be trimmed under and adjacent to the pipeline. Trees in the direct path of the pipeline right-of-way would be removed. Installation of the pipeline would be incremental over a period spanning 14 to 20 years in parallel with well field development and power plant construction.

Electrical power transmission lines can be expected to be constructed within an energy corridor along the access road from power plants to a connection point at Volcano Highway. The right-of-way will require clearing or trimming of trees and vegetation along a 25-foot corridor on either side of the access road for a 69 KV transmission line and 40 feet for a 138 KV transmission line.

Construction activities involving road grading, drilling site preparation, and transmission line (fluid and electrical) construction are similar to other heavy construction operations. The potential impacts on biota would be derived primarily from tree and vegetation clearing or trimming and from materials emitted during this activity such as road dust, waterborne silt, vehicle and equipment exhausts, debris, and possible runoff erosion. Most pollutants in this category are transient and generally considered more as a nuisance rather than as hazardous contaminants.

In constructing the transmission lines, a site along the access road will be cleared and leveled for each transmission pole. Assembly and erection activities will occur at selected locations approximately three miles apart along the transmission corridor. It is expected that three of these areas will be cleared and used temporarily as conductor stringing sites. These sites will be approximately 100 by 200 feet. The power lines will be laid out and pulled into place by a bulldozer. Vegetation will be removed or disturbed by construction equipment within the power line right-of-way and any trees adjacent to the right-of-way that pose a hazard will be trimmed or topped. There will be continuous trimming of high trees and some clearing around the transmission line poles on a routine maintenance basis.

The clearing of forest vegetation will disrupt existing plant communities and, in turn, reduce some or a portion of the habitat of fauna. However, the relatively small amount of clearing in relation to the large parcel would not constitute a significant adverse impact due to habitat loss. Clearing and construction activities will unavoidably alter or eliminate some animal habitat. However, in many cases, animals can exist in a modified niche or shift to adjacent forest areas.

Since there are no existing streams in this area or open reservoirs, project activity will not create an impact on aquatic biota.

5.1.5.1 Impact on Rare and Endangered Species

A. Flora

The rare plant Adenophorus periens Bishop has been sighted on three separate botanical surveys conducted in the Kahauale'a parcel as well as on an earlier U. S. Fish and Wildlife bird survey completed in 1976. During these baseline surveys, populations of this plant have been found in widely separated areas extending from the northeast corner of the property as well as the northwest section of the property and along a major portion of the access road. Sightings along the access road indicate that population densities may vary from three plants per acre to more than 50 plants per acre. In correlating the location of the sightings with aerial photographs of the area, there is indication that areas with similar forest cover or density which is characteristic of the site locations for the Adenophorus periens are present throughout much of the project area and could amount to approximately 6,400 acres. Examination by stereophoto pairs parallel to and north of the access road indicates, to a high degree of confidence, that approximately 1,600 acres in this area contain forest essentially identical to that along the access road where the Adenophorus periens were sighted. Examination of large scale aerial photographs of the areas further to the north indicates similar rain forest areas covering approximately 4,800 acres for a total of 6,400 acres. These areas also have approximately the same elevation ranges, and the same rainfall as the areas where the fern was sighted. Based on this analysis, in relation to the survey findings and observations, and using a conservative estimate of an average density of about 10 plants per acre, it is possible that there could be approximately 64,000 plants throughout the area north of the rift zone.

Allowing for approximately 55 acres of clearing required for the access road beginning at station 14, the first sighting of the

rare plant along the access road, and continuing to power plant site A, and 45 acres required for three power plants along that road, approximately 1,000 such plants (about 1.5 percent) of the estimated population would be affected. The impact of removing this portion of the estimated population is not considered critical to ultimate survival of the remaining populations. In contrast, by natural events such as the 1963 and 1965 lava flows, it is estimated that approximately 600 acres of dense forest containing the average of 10 plants per acre were destroyed for a total loss of approximately 6,000 Adenophorus periens. (See Section 6.1.5.1 for discussion of mitigating measures with respect to the impact on this species.)

B. Fauna

There are reported sightings of the 'O'u (Pittirostra psittacea) in areas near and adjacent to Kahauale'a in the Hawaii Volcanoes National Park and the Kilauea and Olaa Forest Reserves, and one sighting within Kahauale'a during the U. S. Fish and Wildlife Service survey of endangered forest birds (see Section 3.3.2). Since little is known about the 'O'u bird as to its basic biology, present distribution, total population, or habitats and food requirements, breeding habitats and the whole life cycle, it is not possible to estimate the impact of the limited clearing operations associated with this project. Until more information is known it is concluded at this time that the minimal removal of vegetation and trees within the project area should not significantly threaten the O'u.

5.1.6 Impacts on Archaeological Sites

The project site is located on land that was formed by lava flows less than 500 years old; some areas probably as recent as 300 years. This would lead us to believe that any evidence of human activity prior to this time would not be present.

An initial literature search on Kahauale'a indicated no evidence of archaeological sites of such significance within the mauka areas of the project area. A second documentary literature search was commissioned by the Estate of James Campbell as a result of additional information which revealed that there is evidence of early Hawaiian activities in the mauka regions of Kahauale'a. A portion of the areas reported to have been used by the Hawaiians may be in the vicinity of a portion of the geothermal development area. Since all project activity is to be accomplished incrementally over an extended period of time, and because of the limited surface area to be disturbed by clearing and limited excavation, the potential for inadvertently disturbing sites having archaeological value will be reduced (see Section 6.1.6).

5.1.7 Visual Impact

In general, clearing of forested areas and construction of facilities in areas similar to Kahauale'a, including private residences, create a visual impact of some degree. Many natural resources are predominantly prevalent in such areas, and activity designed to use or develop those resources creates a visual impact. The recovery of a natural resource such as geothermal energy requires that its energy be used or converted where it is located which involves not only the drilling or mining operation, but the construction of permanent facilities. Because of the relative isolation of the project area, the rural nature of the surrounding area and the heavy forestation of the project lands, there can only be limited visual impact of the road network, pipelines and the well head equipment at drilling sites. Most of these facilities will be shielded by trees and vegetation from views outside of the project area. Segments of the electrical transmission lines could be visible from some view corridors outside of the project area. It is suggested that transmission lines mounted on single poles (67 to 76 feet in height) are an accepted, necessary feature even in rural areas and the sighting of such is a common occurrence and not considered to be a significant visual impact.

The drilling rig may also be visible from certain areas outside of the project area and at night due to lights mounted on and around the drilling rig. Except when the rig is in the western portion of the project area near the Park boundary, the distance from the rig to any areas outside of the property is such that a visual impact is unlikely or greatly diminished.

The power plants will be located in forested areas away from lava-cleared areas where 'ohi'a trees are 30 to 50 feet in height. Much of the power plant facility and associated elements will not be visible except from the access road adjacent to a power plant. However, the upper portion of the power plant buildings, which are 50 to 65 feet in height, and the cooling towers could be visible from the south and west in certain view corridors. The effect would be diminished due to distance. Due to forestation and the drop in elevation away from the western edge of the project area, it is not expected that any facility in that area would be visible from inside the Park at Thurston Lava Tube. (See Section 6.1.7 on mitigation measures.)

5.2 IMPACTS OF DRILLING OPERATIONS AND WELL TESTING

The drilling operations involve the use of a rotary drilling rig, diesel engines, compressors, drilling fluid mediums (mud, foam, air, etc.), well casing, drilling pipe, cementing, and collection and analysis of cuttings returned to the surface. Operations are continuous including during nighttime, except for periodic checks, replacement of parts, maintenance and shifting of the drilling rig. (See Figure 2-9 for display of drilling rig and components.)

The potential impacts of drilling operations and well testing could be derived from: (1) noise of equipment/machinery, and during venting of the well and extended well testing, (2) exhaust emissions from machinery operations and accidental spills of fuel supplies, (3) emissions (steam/gas phase) during venting and well testing, (4) discharge of fluid (water phase) during venting and well testing, (5) loss of drilling mud (when used) into shallow rock strata, (6) any migration of deep saline waters into shallow surface water supplies which may occur if well casing and cementing are not properly installed and (7) a well "blowout," even though only remotely possible during drilling, which could cause venting of geothermal fluid to the surface and atmosphere until the flow could be controlled. The occurrence of a "blowout" would be accidental, and is not likely to happen with modern drilling practices. (Only a few such events have been known to occur during all past geothermal drilling in the world.)

Equipment operation during drilling can cause exhaust emissions and high noise levels especially when drilling with air due to noise of the air compressor and the exhaust of pressurized air from the well bore (see Table 5-2 for indications of noise levels associated with this activity). Diesel engines generate the power for drilling operations, air compressors and mud pumps.

Well testing begins normally with the spontaneous discharge up the well bore of the geothermal fluid after drilling is completed. The initial flow

of about 4 hours duration, or venting, is essential to acquire preliminary data on the well and chemical composition of the fluid and to clear fragments of rock and other detritus from the reservoir. The current practice for venting the initial well flow occurs without benefit of noise or H_2S abatement systems. After the well is shut-in, pending additional testing or power plant construction, free flow or venting for a brief period is again required for the well start-up. Subsequent flow testing of the well (up to three months) occurs with abatement systems (both for noise and emissions) in operation. The potential impact of well testing derives from discharge of the geothermal fluid and noise.

5.2.1 Impacts on Land Use

Drilling operations in a prospect area will normally involve only one drilling rig in operation on a small area of land cleared for this purpose. The parcel accommodates all equipment and routine operations necessary in the drilling phase. There would be minimal, if any, conflict with other uses of the surrounding land under conservation or agricultural policies. Similarly, normal well testing including the brief venting of the well after discovery and subsequently on start-up would not impact or prevent other land uses in adjacent areas under conservation and agriculture districts. The land dedicated to a drilling site is likely to be used for the life of the reservoir which, depending on its quality, may extend for a period in excess of 30 years.

5.2.2 Impacts on Surface and Groundwater

Under normal, uneventful drilling operations, surface and groundwater are not likely to be impacted. In the event of accidental release of drilling mud (lost circulation) into the subsurface, the impact is expected to be minimal due to the relative immobility and benign nature of the constituents, normally a mixture of clays with materials added such as barite, and sodium hydroxide to provide correct density, chemistry and lubricating characteristics. In any deep geothermal well there is the possibility that deep saline waters could migrate up the well bore into near surface waters if proper casing and cementing practices have not been followed. Also, in the unusual event of a well "blowout," geothermal fluid

could be vented to the surface. However, the installation of "blowout" preventers on all well heads has achieved the desired safety objective in this type of operation and only a few reported "blowouts" have occurred during all of the geothermal drilling conducted around the world. Regulations governing drilling of deep geothermal wells are stringent and are intended to prevent such occurrences. The potential for contaminating surface or groundwaters from these causes is therefore considered minimal.

The potential impact of exhausts from vehicle traffic and machinery and equipment during drilling operations is considered minimal.

The potential impact of geothermal fluid being discharged to the atmosphere and on the surface during initial venting of the well, and during subsequent start-ups, would be determined mostly on the basis of chemical composition of the fluid being discharged. Using the HGP-A well fluid as a model, the fluid would not be toxic to groundwater at the relatively small rate of discharge (200 to 250 gpm) on the surface during venting of the well. This limited amount of discharge would be absorbed in a very localized area. Since the project area is one of high rainfall, there would be effective dilution of any fluid absorbed by the surface. For example, one inch of rainfall on a 5-acre drilling site will dilute the discharge from four hours of flow (60,000 gallons) by 132,050 gallons. In order to establish a reference base for water quality, groundwater in the vicinity of the well will be tested during drilling. The steam and gas portion of the geothermal fluid discharged during venting of the well would be about 30 percent or more of the total discharge. The potential impact on surface water, including water catchment systems, or on groundwaters, of this type of limited discharge (water and steam/gas phase) is minimal.

During extended well testing, the discharged fluid (water phase) will be more extensive. However, the amount of discharge is small in relation to the rainfall recharge in the area. The average rainfall per acre based on 100 inches per year amounts to 7,439 gallons per acre per day. At this rate, the rainfall on 250 acres, the approximate spacing between drilling sites, is 1,859,750 gallons per day. All such surface discharge during

extended testing will be directed into a sump in each drilling site for subsequent percolation after settling out of solids. The steam/gas phase of the discharge during extended well testing will be abated to meet prescribed limits for H_2S emissions. Neither well venting nor well testing will introduce elements into the atmosphere of such quantities as to alter safe water quality standards of catchment water for human use. Analysis of water catchment systems near HGP-A after an extended 8-month period of flow testing indicated all water was within the safe water quality standards for human use.

5.2.3 Impacts on Air Quality

Potential impacts on air quality from drilling and well testing operations would be derived from machinery exhausts, dust created by air drilling, and the steam/gas emissions from geothermal fluid discharged during venting of the well and during extended well testing.

During drilling operations with a single rig, diesel-driven mud pumps or air compressors and a power generator are operating simultaneously. The exhaust from these systems will be apparent in the immediate vicinity of the rig but will cause no significant environmental impact on the air quality.

Dust will be created during air drilling operations by high pressure air forcing out rock chips from the subsurface into sump. Depending on dampness, rainfall, wind, etc., this dust will normally be a nuisance problem in the immediate vicinity of the drill rig.

The impact on air quality of steam and gas discharged with geothermal fluid during venting and testing will again depend on the chemical characteristics of the fluid which will vary between reservoirs and to some degree within a reservoir. In general, geothermal fluids with low salinity or low total dissolved solids (TDS) such as in the HGP-A well are associated with relatively low concentrations of toxic chemical constituents. While higher temperature fluids generally contain higher

concentrations of toxic elements, the higher temperature fluids from volcanic rock such as those in Hawaii and Iceland are exceptions. Pending discovery and analysis of a resource in the project area, the chemical constituents of the fluid produced at the HGP-A well, as shown in Table 5-3, will be used as the baseline to evaluate potential environmental impacts of this project.

Noncondensable gases usually comprise from less than 1 percent to more than 5 percent of the geothermal steam phase. The noncondensable gases are generally made up of carbon dioxide, hydrogen sulfide, nitrogen and hydrogen, with traces of several other gases being present as well. Carbon dioxide is usually the major constituent of the noncondensable gas phase, but during steam discharge to the atmosphere, ambient concentrations are below toxic levels for flora and fauna. Hydrogen sulfide is the second most abundant noncondensable gas present in geothermal steam; however, in terms of potential environmental impacts, it is of greatest concern. Table 5-4 shows the effects of H_2S on man at various levels. The extremely low threshold recognition level of H_2S is approximately 0.0005 parts per million (ppm). At concentrations above this level, H_2S produces a characteristic "rotten egg" odor and can pose a nuisance impact in the near vicinity of a well in a downwind position. (See Section 6 for a discussion on calculated downwind concentrations.) However, the health hazard threshold level for hydrogen sulfide exposure is 10 ppm. Current Occupational Safety and Health Administration regulations list an acceptable maximum ambient concentration of 20 ppm without respiratory protection. At substantially higher concentrations, hydrogen sulfide cannot be detected by smell and is extremely toxic.

Hydrogen sulfide (H_2S), as discharged in the steam/gas phase of geothermal fluid during initial unabated venting of the well, will affect air quality in the direction of the winds at the time discharge is occurring. The geothermal steam from the HGP-A well contains concentrations of H_2S at 750 ppm in the separator, but less than 20 ppm in the steam plume downwind of the separator stacks, a distance of 200 to 300 feet, which shows the rapid

TABLE 5-3

CHEMICAL ANALYSES OF GEOTHERMAL AND OTHER RELATED FLUIDS

No.	Element/ Compound	HGP-A Brine	Seawater	15% Seawater	Iceland (approx. ave.)	Wairakei Well 24	Salton Sea (approx. ave.)	Geysers
1	Na	1694	10,500	1440	5798	1250	50,400	12
2	K	239	380	59.7	922	210	17,500	5
3	Ca	55.3	400	67.5	983	12	28,000	47
4	Mg	0.21	1300	194	4.5	0.04	54	281
5	Li	0.46	0.2	0.03	0.3	13.2	215	
6	Ba	2.1	0.02	0.003				
7	Sr	1.13	8	1.2				
8	B	≤0.5	4.5	0.7	7.6	29	390	3.1
9	Cl	2920	19,500	2925	12,070	2210	155,000	0.5
10	SO_4	81	2650	407	4.5	28	5	5710
11	SiO_2	875	4	0.9	447	670	400	225
12	Cu	≤0.01	0.67	0.1		1.3	5500	
13	Cd	0.10	0.13	0.02			2000	
14	Zn	≤8.0	2	0.3		1.5	520,000	
15	Pb	16	0.05	0.008			91,000	
16	As	0.085	0.4	0.06		4.5	12	
17	Sb	≤2	0.33	0.5		70	400	
18	Hg	0.4	0.03	0.0045			6	
19	CO_2	900	130	19.5	436	17	7100	1242
20	H_2S	825	Tr	Tr	1.5	1	16	33
21	N_2	195	15	2.25				
22	H_2	10.2	Tr					9.5
23	He	Tr	Tr					
24	Ar	Tr	Tr					
25	Rn	7.7	Tr				41	120

Element Nos. 1-11 given in milligrams per liter.
Element Nos. 12-18 given in micrograms per liter.
Element Nos. 19-24 given in milligrams per liter.
Element No. 25 given in picocuries per liter.

Source: Donald M. Thomas, Ph.D, Environmental Considerations Associated With Geothermal Development in Hawaii, January 1981.

TABLE 5-4

EFFECTS OF HYDROGEN SULFIDE

Concentrations, Parts Per Million	Effects
0.0007 to 0.030	Odor threshold
0.33	Distinct odor can cause nausea
2.7 to 5.3	Odor offensive and moderately intense
20 to 33	Odor strong but not intolerable
100	Can cause loss of smell in a few minutes
210	Smell not as pungent, olfactory paralysis
667	Can cause death quickly due to respiratory paralysis
750	Virtually no odor sensation, death can occur rapidly upon very short exposure

(Source: U. S. Public Health Service; Preliminary Air Pollution Survey of Hydrogen Sulfide - A Literature Review; Consumer Protection and Environmental Health Service; APTD-37, 1969).

dilution effect of air on H_2S concentrations. This concentration was not found to be toxic to flora and fauna in the vicinity of HGP-A even during a six-week (1,000 hours) unabated test. Since unabated testing is not currently planned for this project in excess of eight hours, no significant impact on flora and fauna is expected from well venting. There could be cumulative impact downwind if the unabated emissions were concentrated in one direction for periods longer than have occurred with the HGP-A testing.

After H_2S abatement equipment is installed, well testing can be carried out over a two-week to two-month period with assurance that the emissions from discharge will be abated to meet air quality standards for H_2S. Caustic soda will be used to remove the H_2S during testing by reacting it to a benign component, sodium sulfide (NA_2S). The H_2S characteristic "rotten egg" smell may continue to be detectable to some degree in the vicinity of the well even though air quality standards are being maintained downwind. This nuisance factor is not likely to be detected in any residential areas adjacent to the project area due to the distance and the prevailing winds in the area. Estimations of the sulfur produced by fumaroles within the HVNP on noneruptive days place the quantity at 12 to 20 tons per day.

Radioactive elements in low concentrations are generally found in geothermal fluids. Radon, a product of radium decay, and a natural component of all rocks and air is the most recognized of the radioactive components found in geothermal fluids. Radon concentration in the HGP-A fluid was reported to range from 23.9 to 52.8 micro Curies per hour, while natural radon emissions from soils and rock in Hawaii are 919 micro Curies (Km^2) per hours. Short-term 4- to 8-hour discharges of geothermal fluid during venting and extended testing of the well would produce an insignificant amount of radon relative to that radon being emitted from natural sources in the project area.

5.2.4 Impacts of Noise

Drilling operations and well testing will create various levels of noise both intermittently and continuously.

Noise from drilling operations is derived from power generators and compressors for air drilling, the release of compressed air from the well bore as cuttings are forced to the surface, or pumps for mud drilling. Drilling noises will be more or less continuous except for brief periods and when the drilling rig is being moved to another site. Because of the relative isolation of Kahauale'a, these noises will not have significant impact on nearby residences. The noise limit levels contained in the guidelines published by the County of Hawaii will be maintained.

Noise from venting of the well, flashing the fluid to steam, and testing of wells is considerably louder than drilling noises unless noise abatement procedures are used. The initial venting of a well will normally not be muffled. The short term duration of these events (4 to 8 hours) is not expected to cause significant impact. During extended well testing the noise from pressurized steam will be abated to a level that meets the County guidelines. The unabated noise level from venting a well is expected to be approximately 125 dB(A) at about 15 meters (see Table 5-2). Noise abatement systems tested at HGP-A reduced the noise level during extended well testing to 41 dB(A) at 20 meters.

5.2.5 Impacts on Biota

Drilling operations involving the disposition of drilling mud and cuttings could have a detrimental effect on plant life if the constituents contained in the drilling fluid are toxic. It cannot yet be determined the extent to which drilling noises would have an impact on fauna. Venting of a well for short periods could temporarily disrupt fauna in the area. However, long term well testing will be muffled to meet noise and emission standards and, thus no significant noise impact on local fauna is expected.

5.2.6 Impacts on Archaeological Sites

There are no archaeological sites known at this time that would be affected by drilling operations and well testing.

5.2.7 Visual Impacts

The sighting of a drilling rig (day or night operations) from outside the project area is not considered to create a visual impact of significance any more than water well or oil rigs do in isolated, forested areas. The specific site of the rig is temporary, up to two or three months normally. The public recognizes the purpose of a drilling rig and its temporary nature and it is doubtful that a negative image would always be created by observing this equipment in a rural area.

Initial venting of the well, steam flashing, and well testing will create steam plumes in the project area. Depending upon temperature, humidity, and wind conditions, these plumes may be unnoticeable as they drift downward along the ground or they may be quickly dissipated by the winds. It is also possible that climatic conditions would allow the condensate to reach altitudes of 150 to 200 feet above the well head and remain over that area for intermittent periods of time. The entire East Rift Zone emits fog and steam under certain weather conditions. The addition of steam plumes for short periods due to venting of the well should not constitute a significant impact. During extended well testing, the operation of abatement systems would tend to reduce the steam plume over the well head.

5.3 IMPACTS OF OPERATIONS: POWER PLANTS AND PRODUCTION WELLS

During normal operations, the potential for environmental impacts could be derived from the following activities:

- Producing geothermal resources at required levels.
- Transmitting geothermal fluid to a facility for conversion into energy levels specified in purchase contracts.
- Disposing of solid waste, spent brine, and by-products from the conversion process.
- Transmitting the power produced in the conversion process to a distribution system.
- Reworking of wells to maintain required flow rates.
- Abandoning and plugging of wells.
- Drilling replacement wells including reinjection wells.
- Maintaining well head equipment, pipelines, transmission lines, power plant facilities and equipment including surface waste disposal facilities and roads.
- Daily adjustments in power generation loads resulting possibly in directing the steam phase through the by-pass system.

The operation of the geothermal power plants requires systems and measures or procedures to control H_2S emissions and to dispose of spent geothermal brine. Technologies have been developed to control power plant emissions of H_2S to meet applicable health standards. Final design of power plant for this project will specifically identify the emission abatement systems to be incorporated to meet the applicable standards on emissions.

5.3.1 Impacts on Land Use

The production wells, transmission systems, and power plant facilities will occupy less than 2.0 percent of the total project area within a conservation district under a conditional use permit and also within an agricultural area as authorized by County and State land use permits. The relatively small area of the surface disturbed by the project and the fact that individual components of the project will be separated, leaving areas between components essentially undisturbed, indicates minimum potential for significant adverse impacts on the land use of this area. The portions of the property not used in connection with the project can continue to be managed under the provisions and in accordance with the objectives of conservation district and agricultural land use policies.

5.3.2 Impacts on Surface and Groundwater Quality

The potential impacts of geothermal operations on water, including water catchment systems, could derive from continued drilling operations (replacement wells, reinjection wells, and reworked wells), well testing of new or reworked wells, emissions from normal power plant operations, and system failures. The potential for failures of plant and well field operating systems is an inherent part of engineering design and the basis for incorporation of suitable design features to minimize the potential for such failures, together with backup or emergency control systems. Even though remote, total system failures which could result in temporary discharge of fluid (water and steam/gas phase) to the surface and subsurface include the reinjection system, overflow of well head pumps, overflow of cooling tower collectors and rupture of a fluid transmission pipeline. In such occurrences, the potential impact would be determined by the amount of fluid that would be released, the location of the failure within the overall system, and the content or chemical constituents of the fluid at the point of failure. For a pipeline rupture, a single well flow could discharge up to 300 gpm of untreated brine until the well head could be secured and/or diverted to another line. Allowing 15 minutes to detect and take corrective action, there would be a total of 4,500 gallons spilled from a single well. The failure of a trunk line would be multiplied, as

appropriate, by the number of wells feeding into a trunk steam gathering line.

There is a slight chance that a well bore could be ruptured in the subsurface by faulting or lava movement. If the rupture is below the water table, it is not likely that any evidence of the blowout would be noticed at the surface. If the rupture were near the surface, it is possible that temporary uncontrolled discharge of geothermal fluid would occur. In such cases the impact lies in the possibility of geothermal fluids mixing with basal groundwater which is expected to be brackish in the rift zone. In this case the discharge would continue until remedial measures using directional drilling are taken to intercept the well bore at the rupture point so that it may be secured or brought under control. The impact could be equivalent in time to the unabated flow during testing of the HGP-A well for a period of three months from which no long term adverse impacts have been identified.

However, due to the nature of the faults in the project area in which the vents or faults are vertical at the surface, it is unlikely that there would be a rupture of the well bore near the surface.

Not all total system failures at the power plant would result in discharge of fluid to the land surface or atmosphere. For example, a generator failure would result in steam being diverted through the by-pass system which means that backup abatement systems would be in operation and pumps to the reinjection wells would be supplied by backup power sources for the power plant. A total system failure of the primary and backup abatement processes could result in untreated geothermal fluid (steam/gas) being discharged to the atmosphere until such time as the problem could be corrected. If the failure cannot be corrected within 4 to 8 hours, the well flows would be shut down.

The potential impacts of drilling operations and well testing on surface and groundwater have been discussed in Section 5.2. Reworking of a well

could involve additional drilling with mud and/or modifications in the well bore and subsequently in venting of the well as part of the start-up operation. The potential impact of fluid discharge and accidental mud release in the well bore were discussed in Section 5.2. The same stringent regulations on drilling of exploratory or production wells applies to drilling of reinjection wells. The potential source for impacts which could derive from reinjection wells could result from the mixing of spent brine and freshwater supplies if they are present within the rift zone. Drilling of reinjection wells to depths sufficiently below the basal water lens, expected to be brackish, together with proper cementing and casing, will minimize any potential for mixing of spent brine with freshwater supplies.

Abated emissions (within prescribed standards) from power plants during normal operations are considered to have little potential for impacting surface water, including water catchment systems, or groundwater. A discussion of effective emission abatement systems is contained in Section 2.

5.3.3 Impacts on Air Quality

The potential impacts of continued well field and power plant operations would be derived from emissions due to continued drilling operations, well testing, normal power plant operations including hydrogen sulfide abatement, incinerator operations, cooling tower drift, waste steam emission, handling of by-products such as silica and sulfur, and any total system failures which would permit steam/gas emissions to be discharged unabated.

Under normal operations, well field drilling of all types would continue at a rate of six wells per year; testing of development wells would be of less duration than the testing of exploration or confirmation wells. It is estimated that venting of wells in the project area (for new wells and startup of previously drilled wells) will occur 4 to 6 times a year except when a power plant is to be brought on line at 2 to 3-year intervals, at which time a brief venting of each well would be required.

As a result of analyses of H_2S emission levels at the Geysers geothermal fields in California, it has been proposed that H_2S emissions should be limited to 0.45 - 0.90 lbs/MWe/hr of power generation in order to maintain the prescribed emission levels. This is the range that has been experienced in Hawaii with the HGP-A experiment. The HGP-A well produces 16 lbs/MWe/hr prior to abatement, and after abatement at 95 percent efficiency, H_2S would be reduced to 0.8 lbs/MWe/hr which is within the recommended range cited above.

Assuming fluids at Kahauale'a are similar to those at HGP-A and that the H_2S concentration in the steam phase is about 1,000 ppm, the emission limit for a 25 MWe plant would be 11-22 lbs/hr and for a 110 MWe plant, the range would be between 49-97 lbs/hr. If the H_2S abatement level of 95 percent is achieved in the power plant, the H_2S emission would be 15.6 lbs/hr for a 25 MWe plant and 69 lbs/hr for a 110 MWe plant. Thus, the H_2S emissions for both size plants would be within the emission levels proposed for the Geysers.

The nuisance impact of H_2S emissions at the above level of abatement for the largest power plant considered for the project (110 MWe) on individuals downwind of the facility can be assessed by estimating the atmospheric dispersion of H_2S at a point one mile downwind of the plant. (One mile is the approximate downwind distance to the Park boundary from any of the power plants proposed for the project.) A means for accomplishing this analysis has been provided by D. B. Turner in public Health Service Publication 999AP26 entitled, "Workbook of Atmospheric Dispersion Estimates." Assuming the hydrogen sulfide discharge plume has a Gaussian distribution (a conservative estimate), the ground level concentration, X, at any point downstream of a point source can be calculated from the following formula:

$$X(x,y,z,H) = \frac{Q}{2\pi S_y S_z U} \exp\left[-1/2\ (Y/S_y)^2\right] \exp\left[-1/2\ (H/S_z)^2\right]$$

Where Q is the mass of discharge of hydrogen sulfide per second, H is the height of the emission source, and S_y and S_z are the standard deviation of the experimentally determined plume concentration distribution in the horizontal, Y, and the vertical, Z, directions; x being the distance (downwind) between the source and observation point. The parameters S_y and S_z can be taken from charts for wind regimes typical of Hawaii (15 mph) and at one mile are S_y = 525 feet and S_z = 312 feet. Solving the above equation for the 25 MWe and 110 MWe cases, assuming an emission of 0.88 lbs/MWH, yields maximum concentrations at one mile of 0.0031 ppm and 0.0138 ppm, respectively. This level of emission is in the lowest range detectability level for H_2S as shown in Table 5-1. At the Chain of Craters Road, a distance of more than 5 miles from power plant site A, the H_2S concentration becomes an undetectable (by smell) level of 0.0002 ppm and 0.0008 ppm, respectively.

Based on a planned limitation of 110 megawatts of capacity from any one power plant site, and adequate dispersal of the plants with due consideration for prevailing winds and upset conditions, it is expected that no environmental hazards due to air quality will result as long as the emission limits set by the county are achieved. Since no SO_2 is produced in the power plant operations, no possibility exists for "acid rain" being produced from this source. The nuisance factor from H_2S emissions is similarly not expected to be of significance due to emission abatement control systems, the prevailing winds and location of plants with respect to residences. Since Federal ambient air quality criteria do not include H_2S, it may be of interest to compare EPA sulfur emission limits for abated coal and oil-fired plants which are, respectively, 7,400 pounds per day and 4,400 pounds per day for a 25-megawatt power plant. In both cases the limit is based on the use of high sulfur content coal and oil.

Radon emissions from full development of this project would be comparable to that being emitted from the natural environment of 1.5 square miles of surface area, or the equivalent of 10 percent of the natural emissions

level from the planned project area which is 3,330 micro Curies per hour. The concentration of radon in direct steam effluent is 1/20 of the OSHA recommended limit for workers. The concentration in a steam plume 100 meters downwind from the plant is estimated to be approximately 1/1000 of the OSHA Standard which is 3×10^{-8} micro Curies/cc for an 8-hour day.

There would be minimal impacts due to other constituents in the discharge fluid due to their expected low concentration, or their lack of toxicity in comparison with the natural background emissions. The concentrations of trace transition elements in geothermal fluid from the HGP-A well are similar to those in sea water and are generally below the EPA recommended limits except for mercury which is emitted in the steam phase of geothermal discharges. Natural sources around the Kilauea Volcano produce far more mercury than would be emitted during the short period, limiting test discharges of geothermal fluids to the surface.

With respect to cooling tower operations and the question of cooling tower drift, the constituent of primary concern is H_2S. All other elements in cooling tower water are in concentrations at levels less than that of local groundwater (or on rain water). Experience at HGP-A has shown that with the exception of sodium sulfate (Na_2SO_4), the cooling tower removes more particulates from the ambient air than it emits.

Condensate from the condenser has about 6 ppm of H_2S as it leaves the condenser. The condensate is treated with caustic soda (NaOH) before it is released to the cooling tower. This converts all of the H_2S to sodium sulfite (Na_2S) which subsequently converts to sodium sulfate (Na_2SO_4) in addition to water vapor. The H_2S should be less than 0.001 ppm which is at or below the limit of human detectability. Moreover, since no SO_2 is produced in the cooling tower (or during power plant operations), no possibility exists for "acid rain" being produced from this source.

5.3.4 Impacts of Noise

Potential noise impacts during normal operations will occur from drilling of new wells, including injection wells, reworking of wells, venting (atmospheric flashing) of new wells and during startup operations for shut-in wells, during normal well testing, from power plant operations (generator-turbine noise) and cooling tower noise created by blowdown fans. The impact of noise is generally considered to be contaminating while the noise is occurring and only in the immediate vicinity of the noise source. Thus, the potential impacts or consequences of noise would occur near the source and are directly related to the length of exposure. The extent of the noise impacts from these operations would be based on the intensity of the noise and the exposure time. While noise effects on humans, such as hearing loss, interfering with communication, and sleep disturbance are generally well documented, there is less information concerning the effects on animal life. The Occupational Safety and Health Administration (OSHA) requirements for work places specify that no worker be subjected to 115 dB(A) for more than 15 minutes unprotected or to 90 dB(A) for more than eight hours.

Noise limitations related to geothermal operations on federal lands prescribe a maximum level of noise at 65 dB(A) at a boundary or a distance of one-half mile from the source, whichever is greater. Table 5-2 is derived from the Hawaii County guidelines on noise levels and is modified to show the distances that noises from various geothermal operations may propagate to a noise level of 45 dB(A). The 45 dB(A) level represents the allowable general nighttime noise level in the County. The three sound propagation conditions listed in the table relate to those defined in the Hawaii County guidelines. Because of the low noise level limit imposed by the County, it is doubtful that the noise from geothermal operations will have significant impact on animal life within the project area. There will, unquestionably, be changes in the ambient noise level in the immediate vicinity of the noise source during power plant operation.

However, the normal operating noise from power plants is not considered a significant noise source. During the venting of wells the noise level standards may be exceeded for short periods of time.

5.3.5 Impacts on Biota

The potential environmental impacts that could derive from normal operations include noise impacts on animal life (see Section 5.3.4 above), clearing of land for new drilling sites and injection wells (see Section 5.1) from land disposal of solid waste, and surface discharge of geothermal fluid in the water and steam/gas phase.

Any toxic or hazardous solid waste materials derived from operations will be managed and disposed of in accordance with existing regulations. The probable solid waste material to be dealt with in this project would include drilling muds, well cuttings, and any sludge material resulting from treatment of gases and liquids. The handling of these solid wastes in accordance with regulations will assure that there will be no impact on biota in and around the project area from such waste materials.

5.3.6 Impacts on Archaeological Sites

The potential impacts on archaeological sites which were not discovered would occur during the clearing and construction activities (see Section 5.1.6). It is not likely that normal operations as defined above would impact any known archaeological sites since they would be protected or dealt with in an appropriate manner.

5.3.7 Visual Impacts

The source of potential visual impacts from continued operations would be the appearance of the drilling rig during the drilling of new wells or replacement wells and injection wells, the presence of permanent facilities, i.e., power plants, the continued presence of transmission power lines, geothermal fluid transmission lines and the periodic steam plumes from the power plant cooling towers and the less frequent venting of replacement wells and start-up venting for previously drilled wells.

5.4 VOLCANIC, SEISMIC AND GEOLOGIC RELATED CONDITIONS

5.4.1 Volcanic Seismic and Geologic Related Conditions

5.4.1.1 General

Geothermal resources in the Puna district owe their existence to the recent volcanic activity of the region. Without this constant "resupply" of heat to the system, it is unlikely that the resources would be as extensive as they are thought to be, based upon the results of the HGP-A project. This volcanic activity that is responsible for the resource also creates a certain degree of hazard in the form of earthquakes and the risk of volcanic eruption. Any geologically young area has similar risks, e.g., the San Andreas Fault system in California that affects the cities of San Francisco, and Los Angeles, as well as the geothermal developments in the Imperial Valley, Iceland, the Cascades, in Central America, and in the Philippines. The latter three areas have successfully operating geothermal plants in the shadows of the active volcanoes, areas considerably more hazardous than any in Hawaii. The issue is not to avoid geologically young areas, which have the highest resource potential, but to use adequate safeguards in the detailed evaluation to reduce the risk to an acceptable level.

Any area with young geologic features has concomitant geologic hazards, and Kilauea volcano is no exception. The primary hazard along the rift zone consists of earthquakes, lava flows, eruptions, and sudden ground movement (subsidence) associated with faulting. Although these hazards are present, the economic risk is probably small as is discussed below. Subsidence due to the removal of geothermal fluids is not a concern in Hawaii due to the massive nature of the rock in the reservoir. Production is expected from fractures and intrinsic porosity of the lava and not from sands as is the case on the Mainland where subsidence problems have been encountered.

5.4.2 Earthquakes

The largest earthquake in the recent past on the Big Island was the Kalapana earthquake of 1975 (M=7.2). Smaller earthquakes occurred in 1954 (M=6.5), in 1951 (M=6.5 and M=6.9), in 1929 (M=6.5), and in 1868 (large but magnitude unknown). Despite the size of these earthquakes, little structural damage occurred and accelerations rarely exceeded 0.4g. These

accelerations have a peak amplitude response, primarily in the vertical direction. In a risk analysis for the University HGP-A well site (Rogers Engineering, 1978), it was recommended that the design criteria for primary components (components whose failure involves severe economic loss or possible loss of life or severe injury) be adequate to withstand a ground acceleration of 0.41g with a response spectrum peaking at approximately 4 Hz. These characteristics were recommended on the basis of a 30-year design life and an assumption that it was acceptable for the ground acceleration to exceed 0.41g with a probability of 10 percent in the 30-year period. These criteria are applicable to the Kahauale'a project and present no real problem relative to power plant design.

5.4.3 Volcanic Eruptions

Volcanic hazards within the rift zone can be divided into two categories: (1) those due to events taking place in the immediate vicinity of an eruption and (2) those are associated with the downslope movement of lava issuing from a vent. The planned power plants will be constructed in such areas near the edge of and outside of the currently active rift zone and if the exploration program is successful, a substantial portion of the well field production will be from areas outside the currently active rift zone as well. Within the rift zone itself, past eruptions have been frequent in some areas and virtually absent in others. Thus, even within the rift zone there are areas where the hazard, due to eruptive activity, can be minimized perhaps to the point of being insignificant. These areas, while having a low hazard relative to eruptive activity, have a high hazard relative to lava flow for the lava flows tend to pond and flow within the rift zone area. There is still a significant hazard due to flowing lava outside of the rift zone, especially in the project area south of the rift zone. The use of artificial barriers or construction on high ground tend to minimize this hazard. According to the Rogers Engineering (1978) report, 3 to 8 percent of all the land area within the rift zone is likely to be buried by lava flows in any given 20-year period, while only 0.5 to 3 percent of all the areas outside the rift zone would be covered during the

same period. Thus, location of the major facilities outside the rift zone, particularly if the location is in an area of high ground, should provide an adequately low risk for a major investment.

5.4.4 Ground Subsidence

Subsidence would not be caused by the withdrawal or reinjection of geothermal fluids. The pahoehoe and aa basalts are permeable and permit free basal water flow. It is improbable that withdrawals would lead to collapse of the basaltic underground formation. From samples taken at various depths in other areas of Puna, the rocks found at great depths are dense pillow basalts. The formation has fracture porosity ranging from 3 to 18 percent. This will allow geothermal fluids to pass through without significant loss of strength. The dense basalt rocks are self-supporting. Compressive strength of the rocks are not dependent on the fluids existing in this underground region. In addition, the high rainfall would continuously recharge the reservoir. Based on the foregoing, there is minimal potential that subsidence from geothermal operations would occur.

Ground subsidence has historically been limited to the rift zone itself or to areas to the south of the rift zone in the vicinity of the Hilina Pali fault zone. Subsidence accompanied by small earthquakes has occurred within the rift zone in 1924 and again in 1955 in association with eruptive activity and occurred south of the rift zone in 1975 at the time of the 1975 earthquake. There is no historic record of subsidence taking place north of the rift zone. Thus, the risk of subsidence should be minimal and insignificant to a power plant site if the site is located well north of the rift zone.

Where subsidence has occurred on the mainland, it can be attributed to clay or sand ground formations whose mass volume has been reduced by withdrawals of water, oil, gas or geothermal fluids.

5.4.5 Volcanic Hazards in the Active Rift Zone

The above analysis has primarily dealt with the hazards outside of the active portion of the rift zone. The producing wells and the associated gathering pipeline system may be subjected to all the hazards (earthquakes, subsidence, lava flows) of the rift zone if, by necessity, resources cannot be located outside the active portion of the rift zone. Earthquakes will probably not result in damage to the wells or pipeline with the possible exception that a production well may be severed should a subsurface fracture intersect the well bore.

5.4.6 Hazard History in Geologic Time

Recent geologic mappings of Kilauea Volcano by Robin Holcomb of USGS permit a reevaluation of the volcanic hazard maps made by Mullineaux and Peterson, 1978. The Mullineaux and Peterson assessment shows the volcanic hazard to be more or less symmetrical about the rift zone. For the upper area of the rift zone, the surface of the north of the rift zone is 350 to 1,000 years old, as is the surface to the south. Younger units cover substantial portions of the area in the rift zone and to the south of the rift zone but have almost no coverage of this older unit to the north of the rift zone. Thus, the data for the past 350 years indicates that there is negligible hazard north of the rift zone in this area. This is in contrast to the case near the HGP-A well site where virtually all the surface is younger than 500 years and more than 50 percent of the surface is younger than 250 years. This is true even at distances up to 4 miles from the axis of the rift zone. All of the power plant sites for this project have been tentatively sited in this region where no lava flows have occurred during the past 350 years.

5.5 SOCIO-ECONOMIC IMPACTS

5.5.1 Impact on Community

Due to the remoteness of the project site, impact on the adjacent volcano communities will be minimal. The presence of traffic through the Shipman property access road will represent new activity in the area. The traffic/transportation impact is discussed in Section 5.5.3. Initially, the project will primarily involve the drilling crew and the personnel of contractors and subcontractors for road clearing and site preparation for the first 1-1/2 years. This level of activity will be hardly noticeable. The major activity during this period will be the construction of the access roadway over a 3-month period. It is expected that road construction personnel, drilling crew, and others connected with the project will be entering the property regularly after start of the project.

Workers will patronize stores along the highway at Volcano, Glenwood, Mountain View, Kurtistown and Keaau. Discussions on the project with local residents will serve to keep the residents aware of the activity occurring.

The drilling crew consisting of approximately 20 personnel, will be quartered in Hilo, probably due to the availability of rental units and services required to support the project. Equipment repair services will be required for those unable to be handled on the job site.

The economic activity to be generated by this long-range project will occur over a span of 14 to 20 years and cause no disruption to existing communities by the sudden influx of a large construction crew. A continuing public relations program will disseminate progress reports of the project to assure community awareness of the project as it proceeds from road construction, well drilling and power plant construction. Since each power station will be the result of a sequential operation involving other operations, the presence of construction workers on road construction, well drilling and power station erection will tend to stabilize and become a routine occurrence for this area.

The native Hawaiians hold the Fire Goddess Pele in deep reverence. Respect is paid to Pele during ceremonial rites at Kilauea. Some are apprehensive that Pele's underground domain is being intruded upon. There remains strong cultural influence with regards to ancient Hawaiian religious beliefs. Some express a feeling that if Pele's power is used for beneficial purposes, harm will not come to the project.

5.5.2 Economic/Labor Impacts

The economic activity which could be generated by this project would build up gradually during the initial years of exploratory and development drilling. In locating and confirming the geothermal resource, the major and steady employment will be the drilling crew of about twenty persons, together with subcontractor employment for road construction, site preparation and transport of materials.

If the resource is located on Kahauale'a, is deemed to be economically producible, and a purchase power agreement is negotiated with HELCO for 25 MWe of capacity, additional economic activity will occur. Construction of the gathering system and generating plant with the necessary emission abatement and waste disposal equipment would begin in 1984 and continue in 1985. This construction activity, supported almost entirely by the Big Island's construction trade establishment, would see a growth in employment for on-site projects. The preliminary estimates anticipate 100 jobs in the first year (1984) of construction and over 200 in the second year (1985).

The exploration and development drilling would continue in parallel with market development. Operating with a single drilling rig, about six wells a year can be completed at a cost of $12 million involving about 20 jobs. A portion of these jobs will see a rapid transition, following training and qualification, from mainland crew members to local residents. This drilling activity would continue into the next century as the full projected resource potential of 250 MWe is developed to satisfy a market demand. The discovery and development of sufficient resources to produce

this level of production would require drilling a range of 60-106 wells over 14 to 20 years of which 40-70 would be production wells, depending on the quality of the resource.

The power generating plants, after the first 25 MWe facility for the local utility, are forecasted to be brought on line incrementally in 1989, 1993, 1997, 2001 and finally in 2003. This anticipates a gradually growing demand for the electrical power to be supplied by this project. The construction of the larger sized plants (55 MWe) will require employment levels on site, still drawn from the established construction trades in the State, to increase to nearly 300 workers at one time. This is in addition to the drillers and operating and maintenance personnel.

The investment capital that would be required over the 14 to 20-year time period to fully develop the resource potential of this property is estimated as follows:

Category	$ Per Year	$ Per Plant (in thousands)	$ Total
Roads			$ 3,188
Drilling	$12,000		230,000
Power Plants			
25 MWe		$37,800	37,800
55 MWe		81,900	327,600
			$598,588

The economic impact of investment activity of this magnitude reduced for expenditures made on the mainland U. S. for equipment, materials, goods and services, and then factored with the multiplier will be considerable and account for continued economic vigor on the Big Island over the next two or more decades.

When we speak of "economic effect" to a community, we normally think of the influence an industry has on the community from the earnings that the employees and service industries receive from that industry. There is also

a cascading effect on other indirect service industries in the community. This is called the "multiplier effect."

In the study conducted by the State Department of Planning and Economic Development (DPED) it was found that this multiplier effect ranges between 1.7 and 2.9, depending on whether the industry generates income of new dollars from out of State or whether it is an industry which circulates money from within the State.

Therefore, an industry such as the tourist industry or the sugar industry has a higher multiplier effect than a laundry, or other service industry which circulates money within and does not usually import new revenues.

The geothermal industry is thought to have a multiplier effect in the range of 2.3 to 2.5, since the development of the geothermal power attracts capital from out of State and would replace dollars normally spent in fossil fuel purchases. The fossil fuel purchases require monies to leave the State and this money does not circulate within the State to help our economy.

For our analysis we will use a multiplier effect of 2.5 to describe the extent to which this Kahauale'a project would impact on our community when developed over a period of 20 years.

Since most of the construction materials will be in terms of large units purchased out of store, the spending in the local economy was calculated to be approximately 50 percent of the total spending. The turbine generator pollution abatement system, cooling tower equipment, condensers, separators, transformers and switch gear would be imported to the Big Island. Concrete and labor will be the primary local input into this project.

After the units are constructed, the operation will not require a large staff since the power will be dispatched by the electric utility. It is

assumed that the utility will increase their staff to operate these power plants, but the maintenance of the fluid gathering systems and the well heads will be maintained by the owners. Well reboring or new production wells must be drilled to insure reliable production.

Concurrently with new generating capacity being installed at Kahauale'a, additional economic benefits will come with the displacement of the oil brought in and the retention in our economy of those energy-exported dollars. The amount of that dollar recirculation with 250 MWe capacity on line would be $240,000,000 in 2001. That capacity will make a small but significant impact on our community's social objective of becoming energy self-sufficient in electrical energy generation by the turn of the century.

Any adverse economic impact for the 25 MWe scenario would be minimal. The present recession in the local economy plus the already adequate infrastructure available within the County in terms of roads, electricity, schools, police and fire protection, housing and other services can easily accommodate this 25 MWe plan.

Any adverse economic impact for the 250 MWe scenario would be the result of an increased requirement for more police and fire protection, more school rooms, and more housing. Since the primary objective of the project is to develop electrical power for sale to the public utility with much of the labor force being drawn from the Big Island, the impact on infrastructure should be minimal. Such impacts as there may be, would accrue gradually which would allow County and State departments to prepare for and adjust to such requirements. Taxes would increase due to the development activities and would provide additional revenue to be applied to required growth in the infrastructure. There are thousands of vacant lots in the Puna district that can accommodate requirements for more new housing.

The most compelling reason for developing the 250 MWe scenario, besides lessening the State's near total dependence on imported oil for its energy,

is to reduce the outflow of dollars in fuel oil purchases from the State of Hawaii. The 250 MWe electrical production will be a sizeable contribution to the reduction of the 1.5 billion dollar annual outflow of the State's income.

5.5.3 Transportation/Traffic Impacts

According to the HVNP statistics for 1981, 2,368,907 persons entered the Park. Since the Volcano Road is part of the major transportation highway that circles the island, non-park visitors account for 1/3 of the total visitor count. In other words, nearly 800,000 were those passing through the Park and 1,500,000 were visitors to the Park. These include off-island visitors as well as local residents who enjoy the varied attractions offered by the Park.

Traffic generated by the Kahauale'a Geothermal project will be based on an estimated: (1) 20 men (24 hours on job site) drilling crew who will be working in shifts; (2) road construction crew estimated at 15 to 25 men at any one time; (3) power plant construction crew estimated at a maximum of 80 to 120 at any one time; (4) transmission line construction crew of 30 to 40; and (5) miscellaneous visitors such as scientists, local organization officers, government officials and the developer's team. A security gate will be used for control.

Assuming an average of 140 persons at the project site on days when construction activities are at a peak, and assuming construction workers will be bussed or operate on a car pool basis, the daily maximum traffic during these periods will probably total 96 trips: (1) 9 trips by drill crew; (2) 15 trips by road construction crews; (3) 40 trips by power plant personnel including subcontractors; (4) 20 trips by transmission line construction crew; and (5) 12 trips by others.

The Volcano Highway is designed for high speed traffic and can accommodate 1,700 vehicles per day in each direction. Present traffic count on this highway is about 800 vehicles per day each way at the Volcano entrance.

Therefore, the anticipated traffic volume will not cause any significant adverse impact. Movement of heavy slow moving equipment will be during off-peak hours and coordinated with the Police Department.

5.6 NATURAL AND GEOTHERMAL EMISSIONS

It would be appropriate to review the overall presence of geothermally-related chemical toxicants in air, water and soil to ascertain if the toxic chemicals pose a threat to the environment.

Continuous testing at the Pohoiki HGP-A well area has been carried out. The geothermal activities have shown no evidence of change in the fixed gases (SO_2 and H_2S). The levels have been consistently lower than threshold levels and well under hazardous levels in spite of the proximity, 25 miles, of natural vents in the HVNP which discharge large quantities of these gases continuously. These toxic gases, for example, only occasionally reach the HGP-A well site. Not only the convective and wind dispersal patterns reduce the levels of these sulfurous gases, photo-chemical and biochemical reactions oxidize the gases to sulfates, and the metabolizing action of soil microorganisms and vegetation may contribute to ecological "detoxification" of these sulfur gases.

Mercury readings have also been taken at HGP-A. The upsurge of mercury levels in the air during flashing was thought to have been a "burst" releasing mercury accumulated at depth. Later, it was found to be emitted from the heiheiahulu spatter cone about 8 miles distant. Additional measurements have led to the conclusion that mercuric gases are natural area contamination and not from the HGP-A well. Tests conducted since the HGP-A project began have yielded no evidence of a buildup of mercury or any other potentially toxic element at or around the well site.

The conclusion of researchers is that "there is no reason to assume that the HGP-A itself has any negative emission features beyond nuisance values of H_2S and noise, but is (itself) influenced by its proximity to natural geotoxicant sources." The findings and conclusions would be applicable to

the Kahauale'a Geothermal Project as well. This, of course, takes into consideration the efficient abatement systems to be incorporated into the power plant facilities.

Table 5-3 shows the chemical analyses of the HGP-A geothermal fluids as compared to those of other locales.

SECTION 6

MITIGATION OF ENVIRONMENTAL IMPACTS AND MONITORING MEASURES

Since the proposed project will have impacts on the environment as a result of project activity related to (1) land clearing and construction, (2) drilling operations and well testing, and (3) power plant and production well operations and will be subject to impacts of seismic and volcanic activities, this section addresses the mitigating measures to be considered and taken to minimize the impacts described in Section 5. In the sections that follow, each of the mitigating measures is discussed in the same order as the impacts in Section 5.

6.1 MITIGATION OF IMPACTS DUE TO CLEARING AND CONSTRUCTION

6.1.1 Land Use

The nature of this project is such that the total land use dedicated to achieve its purposes is minimal, approximately 400 acres or 1.7 percent, of the total surface area. Since the objective of the project is to discover and retrieve underground natural resources, only so much of the land surface specifically required to achieve this objective will be used. Drilling sites have been planned to enable up to six wells to be drilled within a single cleared area, thereby reducing the amount of surface disturbance for this purpose. In addition, a portion of the secondary roads interconnecting the drilling sites with power plant sites and a number of drilling sites are located in areas that have been disturbed by historic lava flows. The specific space requirements are spread in such a way that the use of the land as presently permitted can continue with minimal interference by project operations.

Any cleared areas or any drilling sites which are not required on a continuing basis in support of the project will be restored and revegetated as may be required.

With the opening of an access road into this property, it is also possible that the land use can be improved through a coordinated game management

program with State Forestry and Wildlife officials. (The control of the extensive pig population within the project area is needed to prevent continued and extensive degradation of the flora.) In addition, those interested in botanical and ornithological research and study may, with the approval of the landowners, have easier access for this purpose.

6.1.2 Surface and Groundwater

Surface clearing and construction activities are not expected to have any impact on water quality within the vicinity of the project area. Nevertheless, care will be taken to prevent erosion or runoff from the cleared areas. Due care will be exercised in the handling of fuels to minimize the possibility of spills. Private sewage systems in the permanent facilities on the property will be installed to comply with State and County rules and regulations for disposal of the small amount of wastewater generated on the site. See Figure 6-1 for temperature readings and chloride levels of existing wells.

6.1.3 Air Quality

Dust from clearing and construction activities in the project area and combustion emissions from construction vehicles and equipment are inevitable. However, the level of emissions from these sources would not be significant and is not anticipated to result in any adverse environmental impacts. The potential problem of dust emission will be attenuated, somewhat, since the soil type in the project area is predominately stony muck, and the Keei, Kiloa, Papai, and Puhimanu soil series should not be subject to significant runoff and soil erosion. The relatively high rainfall in the project area will further minimize dust problems arising during construction and from vehicular and equipment operations. Regular maintenance of vehicles and equipment will be made to prevent undue exhaust discharges. Fugitive dust emissions will be reduced by watering of disturbed roadways and sites as is necessary for further control.

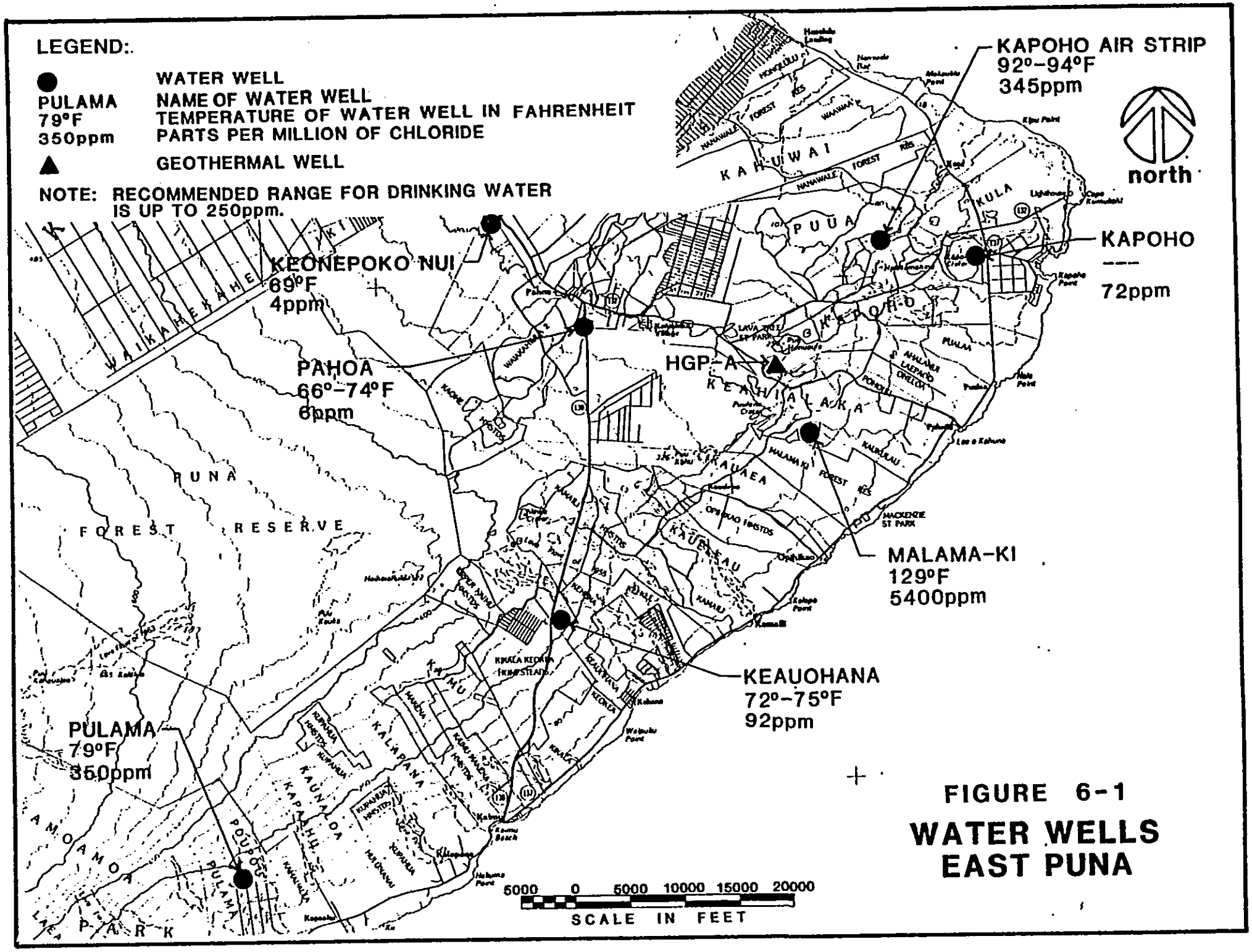


FIGURE 6-1
WATER WELLS
EAST PUNA

6.1.4 Noise

The noises associated with road clearing and construction activities within the project area are not considered to constitute a significant noise impact within the surrounding community. Based on current projections as to the potential resource areas within the property, approximately 70 percent of the project activity will be more than two miles from any residence. Approximately 10 percent of the project activity will be about one mile from any residence. Mufflers on engines and equipment operating in the area will be monitored to assure effective operation. Any required blasting will be conducted during daylight hours. There will be a minimum of traffic into or out of the project area at night. It is expected that most construction activity will be during daylight hours. See Tables 6-1, Predicted Project-Related Noise at 50 Feet and Table 6-2, Noise Attenuation by Distance Alone (No Effects of Wind, Relative Humidity, Topography, etc.)

6.1.5 Biota

Mitigation of the effects of clearing and construction activities on vegetation will be accomplished by carefully limiting vegetation removal to only that which is essential to achieve the objective of the project and when there is no feasible alternative. Biological surveys, by qualified personnel, will be conducted prior to construction at any site for which baseline data has not been obtained.

Revegetation measures will be taken where required with native species. 'Ohi'a logs will be salvaged, if feasible to do so. The forest vegetation cleared for roads and sites will be disposed of in accordance with existing practices in coordination with State Forestry personnel as appropriate. Grading at power plant sites will be limited to that which is essential to the construction of the plant. Surface material will be disposed of to achieve a landscape that blends into the adjacent forest. Reasonable care will be taken to avoid, wherever possible, sensitive flora. No exotic plants will be intentionally introduced into the area, and access control

TABLE 6-1

PREDICTED PROJECT-RELATED NOISE AT 50 FEET

Activity	Noise Level (dBA)[1] at 50 Feet
Road Building Equipment	80 - 90
Drilling Rig (Air)	102
Steam Exiting a Blooie with Muffler	60
Steam Well Venting - Standby	60 (at source)
Truck Traffic Bringing Equipment & Supplies	100

[1]Decibel A Scale: A decibel is the universally adopted unit for measuring sound intensity. One decibel change in sound is approximately the smallest difference in sound intensity that the human ear can detect.

Source: Enviros, 1974.

TABLE 6-2

NOISE ATTENUATION BY DISTANCE ALONE (NO EFFECTS OF WIND, RELATIVE HUMIDITY, TOPOGRAPHY, ETC.)

50 Ft. Base Level dB	1000 Ft. -26 dB	½ Mile -34.5 dB	1 Mile -40.5 dB	1½ Miles -44 dB	1-3/4 Miles -45.3 dB	2 Miles -46.5 dB	3 Miles -50 dB
60	34	25.5	19.5	16	14.7	13.5	10
70	44	35.5	29.5	26	24.7	23.5	20
80	54	45.5	39.5	36	34.7	33.5	30
85	59	50.5	44.5	41	39.7	38.5	35
90	64	55.5	49.5	46	44.7	43.5	40
95	69	60.5	54.5	51	49.7	48.5	45
100	74	65.5	59.5	56	54.7	53.5	50
105	79	70.5	64.5	61	59.7	58.5	55
110	84	75.5	69.5	66	64.7	63.5	60
115	89	80.5	74.5	71	69.7	68.5	65
125	99	90.5	84.5	81	79.7	78.5	75

$$\text{Sound Levels}_2 = \text{Sound Level}_1 - 20 \log \frac{(\text{distance}_2)}{(\text{distance}_1)}$$

+10 dB is normally perceived as being twice as loud. Adding two sounds of the same dB level produces a composite sound +3 dB above individual sound levels.

55 dB interferes with outdoor speech, etc.

70 dB is standard to protect against hearing damage from long-term exposure to noise.

SOURCE: U. S. Fish and Wildlife Service: Geothermal Handbook, June 1976.

should help curb the introduction of exotics. Controlled permit burning of cleared vegetation will minimize fire hazards. The access road through the parcel will enable rapid access for control of forest fires.

A hunting program to reduce the feral pig population within Kahauale'a will be instituted by the landowner in cooperation with the State Forestry and Wildlife officials. This action would be of significant benefit to the flora now being destroyed or disturbed by these animals.

Aquatic biota is not known to exist in this area and applicable mitigation measures have therefore not been determined.

6.1.5.1 Rare and Endangered Species

A. Flora

The rare and endangered and new flora species identified during the baseline surveys of Kahauale'a are described in Section 3.3.2. The *Adenophorus periens* heretofore thought to be extremely rare, appears to exist in considerable abundance in a large portion of Kahauale'a.

Within the presently projected development areas it appears that of the new, rare, or endangered species identified, only the *Adenophorus periens* will be impacted along portions of the access road, including the planned power plant sites A, B, and D adjacent to the access road. Plans for development activity in the dense forest area where the *Cyrtandra*, *Cyanea* and *Clermontia* were found have been abandoned at this time to assure that this area with its unusual flora will not be disturbed pending additional study in the general area.

Construction of the access road through this portion of the property and three of the power plants at the planned sites A, B and D will require removal of 'ohi'a trees on which the fern is growing. Based on the density estimates and evidence of probable

distribution of the Adenophorus periens through a large portion of the parcel, as presented in Section 5.1.5, about 1.5 percent of the fern's estimated population would be directly impacted. It is possible that this level of disturbance can be reduced by some adjustments in road alignment to the north to avoid the area of heaviest fern density.

The alternative of moving the access road to the south to the recent lava flows in the rift zone was considered but determined not to be feasible because of unacceptable risks regarding the possibility of future lava flows along the same paths previously followed. A lava flow over the road would cut off access to and from the project activity, and could endanger the safety of personnel. Moving the east-west portion of the access road to the north beyond the populations of the Adenophorus periens is not likely to reduce the impact because several north-south roads in lieu of one east-west road would have to be constructed through the same general high density areas of the population fern to gain access to the power plant sites and to connect the plant sites with production wells.

There is some flexibility in locating power plant sites within the constraints imposed by location of the wells. If the resource is located as predicted, it is possible to adjust power plant locations laterally along the access road for distances up to 1,000 feet from the presently planned locations. Also, it is possible that only one plant site (15 acres) with a capacity of 110 megawatts would be required in the areas of the denser growths of the Adenophorus periens. Moreover, judicious clearing, landscaping, and layout of power plant sites can further minimize the number of ferns directly impacted by the plant sizing.

Specialists on this fern will be consulted during the road clearing operations and final selection of power plant sites to ascertain that all feasible measures are being taken to minimize the impacts of the clearing for access road and power plant sites on the populations of this plant adjacent to these cleared areas. Continuing botanical research and monitoring of the estimated considerable populations of this fern within Kahauale'a can be carried out on approval of the landowner.

B. Fauna

Animals are dependent upon vegetation for food and cover, therefore plant damage or removal resulting from road and site clearing will affect wildlife indirectly. In addition, noises from construction and clearing operations may disturb some of the wildlife. Mobile populations can shift to adjacent areas or adjust to the disturbed conditions. While it is not likely that any species will be severely affected, the number of individuals may be reduced in the project area, particularly near the roads and power plant sites. Care will be taken to avoid disturbing any nesting of rare and endangered birds discovered in the project area.

6.1.6 Archaeological Sites

Two separate archaeological literature searches were conducted for evidence of earlier human activity in Kahauale'a. One study reports that there are indications of activity by early Hawaiians in portions of the Kahauale'a property in the past. As a result of that information, the developers will be particularly alert for evidence of sites of archaeological value and interest during clearing and construction activities. Should there be any evidence uncovered during these operations that suggest findings of archaeological interest, a qualified archaeologist will be brought into the site for evaluation of this finding and for recommendations on how to protect or preserve such evidence as determined to be of significance.

6.1.7 Visual

Whenever feasible, and if not counter productive to noise and emission abatement considerations, power plants and cooling towers will be designed to reduce structure heights and to orient structure profiles in a direction with the least visual impact from sensitive view corridors. The developer will be sensitive to visual impacts created by clearing and construction for which feasible mitigating measures can be taken. The view corridors from the Volcanoes National Park area will be given special consideration when locating or orienting any facilities and equipment in the western edge of the project area within one mile of the Thurston Lava Tube or within a view corridor from Chain of Craters Road. In some view corridors, landscaping may be effective as a supplement to natural vegetation to shield some facilities from view outside of the project area.

6.2 MITIGATION IMPACTS OF DRILLING OPERATIONS AND WELL TESTING

6.2.1 Land Use

All standard practices will be used by the developer to confine the effects of drilling operations and well testing to the specific areas of land dedicated or cleared for these purposes. Geothermal fluid or drilling discharges will be controlled through the use of sump ponds to avoid flow of fluids outside of specifically defined containment areas. Drilling sites that are determined to be non-productive and are subsequently abandoned, will be revegetated as may be required.

6.2.2 Surface and Groundwater

The depth of geothermal wells will extend well below the top of the zone in which the basal freshwater lens may exist. The well will be cased to prevent leakage of the basal water into the well bore as drilling progresses. This casing will also serve to prevent geothermal fluids, subsequently recovered from greater depths, from migrating into the higher basal water lens should one exist.

During well drilling, strict adherence to accepted practices will minimize the possibility of failures that would result in significant quantities of drilling mud escaping into the subsurface, or result in the contamination of freshwater, if present, with geothermal fluids. Sumps will be used for drilling mud and discharged fluid during extended well testing to allow an analysis of the discharged fluid and the solids that have settled out. Proper disposition will be made of the remaining materials by percolation, reinjection or removal to an approved disposal site.

The groundwater immediately below the lower East Rift Zone has been found to be brackish and at temperatures of 90°F or higher. This water is generally unsuitable for domestic or agricultural use. Therefore, should the constituents of the geothermal fluids be found, by testing, to be benign or similar to brackish water existing in the vicinity of the well, disposal could be made of the effluent at that location by settling out of the solids and subsequent percolation of fluids.

6.2.3 Air Quality

Machinery exhausts during drilling operations are not expected to constitute a significant impact on air quality. The considerable amount of dust, which could be created when drilling with air, will be attenuated by directing the cuttings into a wet sump or underground rock chamber similar to the sparging pit at HGP-A. This would minimize both noise and dust emissions.

The steam/gas emission from geothermal discharge during the preliminary 4 to 8-hour venting of the well is expected to have minimal impact due to the limited time in which the emission would occur and the lack of toxicity in the quantity of emissions released. During more extended well testing, the steam/gas phase of the fluid will be directed through appropriate abatement processes.

Well drilling operations are specifically designed to prevent failures in the well bore, including "blowouts." The area around the well casing will be firmly cemented to prevent geothermal fluids from escaping from the sides of the casing. The cement packing also serves to contain the fluids in the event the well casing should rupture. The cement packing will extend a considerable distance below the ground surface to reinforce well casing and to protect the casing against possible corrosion and to assure that the casing sections are firmly anchored to each other and to the surrounding rock. Blowout prevention equipment (BOPE) will be installed to minimize the potential of a blowout. The heavy-duty double gate preventer with annular preventer and rotating head will meet standards of the industry for the pressures anticipated. In addition, water from the sump is available to cool the well if it is required to stop the steam flow.

6.2.4 Noise

Operating equipment and engines used in the drilling operations will be muffled as may be required to meet noise level guidelines published by the County of Hawaii.

The noise level from the initial 4 to 8-hour venting of the well cannot, with current technology, be safely or practicably abated; however, the short term duration of well venting is not expected to result in a significant noise impact. Time periods for conducting such tests will be during daylight hours. Such testing will generally be limited to 4 to 6 times per year within the project area under currently projected well drilling schedules. Since most of these tests are expected to be conducted at distances in excess of two miles to the nearest residence and because of the heavy forestation in the area, it is expected that the noise will be attenuated to acceptable levels during the relatively short period of their duration.

All extended well testing will be accomplished with or through noise abatement systems such as rock pits and other noise attenuating devices which will be available to meet County of Hawaii guidelines.

6.2.5 Biota

There are expected to be no impacts on biota (other than from clearing the drilling site) as a direct result of drilling operations except possibly for noises which could disturb animal life that may inhabit areas near the noise source. Well testing during which geothermal fluid is discharged to the surface will be controlled to minimize direct fluid contact with vegetation in the vicinity of the well site. H_2S will be abated to acceptable standards during extended well testing programs to preclude adverse impacts on flora or fauna. Due to the limited periods of time when the fluid is discharged unabated, no significant impact on biota is expected.

6.2.6 Archaeological Sites

Neither well drilling operations nor well testing is considered to have any significant impact on archaeological sites that may be located in the project area. Consultation with archaeologists on discovery of such sites located within or adjacent to proposed drilling sites will occur before

drilling operations commence to determine the most feasible measures to preserve or protect such sites.

6.2.7 Visual

The visual impacts which could result from drilling operations (the rig) and well testing (steam plumes) are considered transitory and minimal. However, as may be consistent with sound safety practices during nighttime drilling, lights on the rig will be directed and shielded to the maximum extent feasible.

6.3 MITIGATING IMPACTS OF OPERATION OF POWER PLANTS AND PRODUCTION WELLS

6.3.1 Land Use

The developers will institute the necessary management controls to assure that all required design specifications of project systems and subsystems are achieved in the project development with the objective of preventing or mitigating impacts of the project on land uses within the surrounding or adjacent parcels. Moreover, careful planning will be accomplished to assure that the minimum amount of surface land is disturbed or utilized for the purposes of the project.

Power plant sites will be located, whenever feasible, to draw from the largest possible well production area thereby further minimizing the amount of land required for permanent facilities. Similarly, pipeline corridors and electrical transmission line corridors will parallel areas cleared for roads, whenever possible, to avoid additional clearing. Wells will be drilled to an optimum depth with the objective of increasing production from single wells thereby reducing the total number of wells that would be required to develop the estimated production potential from the property. In addition, multiple wells (up to six) will be drilled from a single cleared site, if feasible, to minimize the amount of surface disturbance.

Depending on the quality and distribution of the resource, it is possible that power plants in some areas within the property (outside of the active rift zone) can be co-located at the well head thereby minimizing the need for additional roads and pipelines to transmit the fluid to a separate power plant site. Such composite areas of project activity would result in increasing the land areas which would not be disturbed by the project.

6.3.2 Surface and Groundwater

Continued operation of power plants and production wells could have impacts derived from drilling of replacement and injection wells, from well testing, from emissions during normal power plant operations and from a system failure.

Measures to mitigate potential impacts on surface and groundwater due to drilling operations and well testing are discussed in Section 6.2.2 above. Measures to mitigate potential impacts on surface and groundwater from continued emissions during normal power plant operations will be incorporated primarily in the design of the power plants and the abatement systems to be incorporated in such plants after analysis of the geothermal fluid. See Section 6.3.3 below for discussion on mitigating power plant emissions.

Strict compliance with regulations and standard practices on drilling operations should prevent a failure in the well bore. The unabated venting of wells upon initial discovery of a resource and subsequent venting during start-up operations after shut-in or for periodic maintenance purposes will be kept to a minimum.

Pressure and flow rate sensing devices will be incorporated between well heads and power plants to enable immediate detection of a rupture in a fluid pipeline so that immediate corrective action can be taken to shut in or divert the well or wells supplying that pipeline.

Backup pumps will be incorporated in fluid disposal systems that control flows between condensers and cooling towers and reinjection of spent brine into the injection well. Such backup systems would minimize the chance of overflow or spill due to a primary pump system failure.

6.3.3 Air Quality

The principal measures proposed or projected to mitigate the potential impacts on air quality by project activities include the following: (1) proper and complete analysis of the chemical composition of the geothermal fluid from each well or wells to be fed to a single power plant to assure that an adequate abatement system and reinjection system can be and is designed; (2) incorporating in the design suitable backup or fail-safe systems at the critical points in the energy conversion and well field production processes which, in the event of failure, have the potential to

impact the environment; (3) installation of a steam bypass system to assure continued abatement of the H_2S in the steam/gas phase in the event of generator shutdown and when electrical power demands are reduced; (4) providing redundancy in the fluid transmission pipelines whenever feasible to allow redirection of individual well production to the power plant through alternate pipelines or to another power plant; and (5) providing for adequate environmental monitoring within the project area to enable continuing, long-term evaluation of the effectiveness of the abatement systems.

All emission control facilities will be designed to conform with Class 1, clean air quality standards. The preferred current technology for removing H_2S is the Stretford Process. This system removes 85 to 90 percent of the H_2S in the steam and converts it to elemental sulfur that can be sold as a by-product. Another method of H_2S control is the Iron Catalyst-Peroxide-Caustic system (ICPC) which has abatement efficiencies in the 90 to 92 percent range. However, this method consumes costly chemicals in large amounts and creates solid waste that must be disposed of at approved sites. See Section 2 for a description of the chemistry involved in the Stretford and ICPC process. See Section 5.3.3 for data on H_2S concentrations downwind of power plants.

All discharges from abatement systems must also meet minimum ambient concentrations within the areas immediately surrounding the development area to assure that conditions at the plant site are made safe for regular employees. This also assures that the effects of emissions on areas or persons outside of the project site would be negative.

The prevailing winds and high rainfall in the area will serve to further minimize the potential impacts of project emissions on air quality. (See Section 3 for data on ambient air quality samples.)

6.3.4 Noise

Mitigation of noises associated with drilling operations is discussed in Section 6.2.4. Power plant noises can be mitigated somewhat by the proper orienting of the power plant and cooling towers in a direction that recognizes prevailing winds and the nearest residential areas. During routine operations requiring discharge of fluid for brief well tests or reduction in power load requirements, a noise abatement system will be employed.

6.3.5 Biota

Since the potential impacts associated with continued power plant and well field operations would be derived from noise and any contaminating discharges, the principal mitigating measures include back-up systems and design features that can be incorporated into the production and energy conversion systems. Management and employees will be alert to any potential for environmental impacts on biota that may result from the continued production and power plant operation. Environmental monitoring within the project area, together with such regional environmental monitoring as may be established by State and County agencies, should assure that any cumulative effects of geothermal development activities on biota can be detected at the first indication of such effects. Continued access control over the property will tend to reduce the opportunities for introduction of exotic species into the area.

6.3.5.1 Rare and Endangered Species

Locations of known rare and endangered flora will be recorded to assure that continuing project activities are planned with the due consideration for minimizing impacts on such species.

6.3.6 Archaeological Sites

Throughout the life of the project, inspections of sites to be cleared will be made to minimize the potential for any important archaeological

information within the property to be inadvertently destroyed or disturbed. In the event evidence is discovered which suggests earlier human activity in the area, qualified archaeologists will be consulted to enable proper evaluation as to the significance of those findings and a determination of measures which should be taken for their preservation, or data retrieval, if appropriate. It is doubtful that there would be any long term cumulative effects of the continued operation of power plants and well fields on an archaeological site in the immediate vicinity of these operations.

6.3.7 Visual

The principal mitigating measures related to long term operation of power plants and well fields are, first, that the developer recognizes potential visual impacts of the project that may occur from certain view corridors and, second, that such steps as may be feasible are taken to minimize those impacts. For example, lighting of power plants and the drilling rig will be directed and shielded as may be feasible consistent with safe and efficient operations; siting of permanent facilities will be made whenever feasible in consideration of any sensitive view corridors; and the design and orientation of permanent facilities will consider structure profiles and heights as a means of minimizing any visual impacts.

6.4 VOLCANIC, SEISMIC AND GEOLOGICALLY RELATED CONDITIONS

6.4.1 Earthquakes

Abatement procedures for seismic hazards are well known from experience in other parts of the world where seismic hazards exist. These experiences suggest that a design criteria of 0.5g vertical acceleration with peak amplitude at about 4 Hz and having a maximum particle motion perpendicular to the rift zone would be appropriate. Moreover, the axis of the generator should probably be approximately parallel to the rift system.

6.4.2 Volcanic Eruption

Abatement procedures against volcanic hazard thus consist of (1) locating all major facilities north of the active rift zone, preferably on high ground; (2) constructing barriers on the uphill side of the facility; (3) placing major facilities on raised platforms; or (4) placing critical components in buried cellars that lava cannot enter. The preferable procedure for the power plant is procedure (1) while the wellheads can best be protected by procedures (3) and/or (4). Close and continuing coordination with the Hawaii Volcano Observatory will be maintained to assure that the operator is aware of any impending conditions for which early warning would enhance the safety of personnel and equipment in the project area.

6.4.3 Ground Subsidence

As indicated in Section 5.4.4, subsidence from geothermal operations appears unlikely. The potential impact of subsidence due to natural faulting can be mitigated by constructing the power plant outside of the active rift zone. Added safety requires that the power plant design provide for leveling correction of the turbine and that adequate end thrust bearings be installed.

6.4.4 Volcanic Hazards in the Active Rift Zone

A production well may be severed by an earthquake but it is an unlikely possibility that can be best mitigated through having reserve production

wells separated from each other by some distance. The pipeline itself should not be damaged by earthquakes nor should it be disrupted by heat from lava flows so long as steam continues to flow within the pipeline, for it is then essentially self cooling. Lava flows, on the other hand, could disrupt the pipeline if they become very viscous or blocky, while little disruption is likely to occur if the pipeline is on the surface and is overrun by a very fluid flow. Hazard to the pipelines in areas of potential lava flows can be minimized by shallow burial or by surface installation with downslope support structures. Should a pipeline be broken or ruptured, the resource can be closed off at the wellhead. Since the pipeline must be designed with numerous expansion joints in order to accommodate thermal expansion and contraction, ground subsidence or extension should have little effect on its operation. Periodic inspection of the pipeline will be accomplished. See Figure 6-2 for location of the Kilauea East Rift Zone as related to other rift zones on the island.

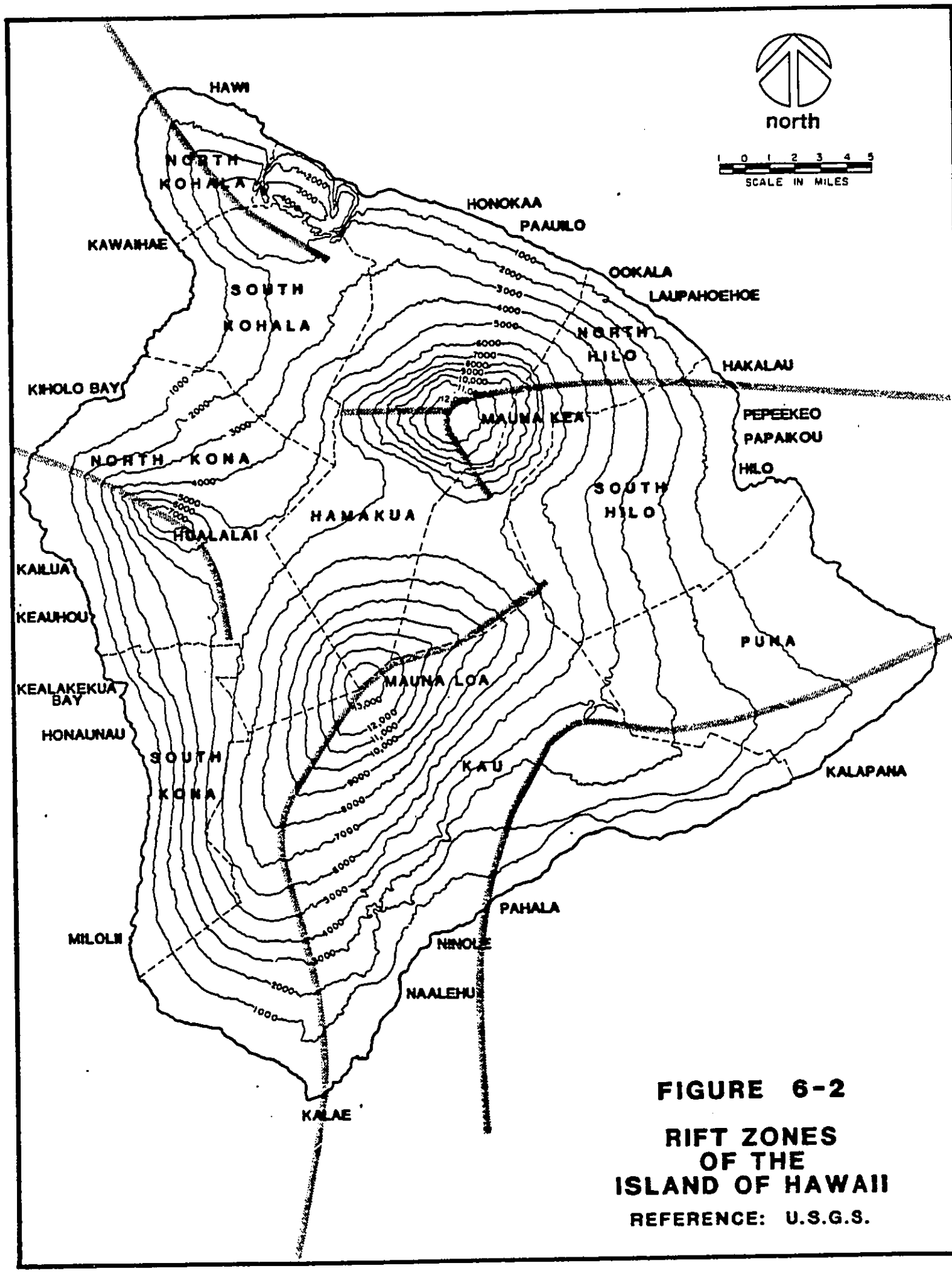


FIGURE 6-2

RIFT ZONES OF THE ISLAND OF HAWAII

REFERENCE: U.S.G.S.

6.5 MONITORING

As required by Title 13, Subtitle 7, Chapter 183, Rules on Leasing and Drilling of Geothermal Resources, the operator will be responsible to monitor localized environmental impacts, associated with specific activities under the operator's control. The operator is also required to provide environmental baseline data prior to commencement of production operations, i.e., generation of electrical power. Sampling of baseline data was initiated in June 1981 and has continued at appropriate intervals.

Monitoring of the environment is included in the section of mitigation measures since monitoring will provide, in part, evidence of the effectiveness of many of the mitigating measures that are being taken with respect to this project.

Substantial quantities of pollutants are emitted continually from natural volcanic activities along the East Rift Zone of Kilauea. However, there is no generalized evidence of adverse impacts from these emissions. The process of developing and converting geothermal resources into energy results in limited emissions of noncondensable gases within standards set by various regulatory agencies.

As a result of currently indicated activities by private developers, it seems probable that segments of the East Rift Zone of Kilauea will be developed as a major source of geothermal energy. Individual operators will be responsible to monitor localized environmental impacts associated with specific activities in their areas of development. In order to monitor the entire area and assure coordination between State and County regulatory agencies with private developers, the State Department of Planning and Economic Development (DPED) has initiated action to undertake a regional baseline environmental survey in the vicinity of the East Rift Zone of Kilauea. Following the DPED baseline survey, a continuing monitoring program would be established.

The data derived from the DPED baseline survey, when combined with data from a continuing monitoring program will enable detection of any changes in any of the baseline data. When combined with localized data from individual developers, the broader data base should improve the effectiveness of environmental monitoring and help to identify the causes for any changes, especially as to whether the changes may be the result of volcanic activity or due to the activity of the private developers, individually, or collectively, or due to some other cause.

The regional baseline survey conducted by the State would include air quality monitoring, rainfall catchment monitoring and botanical surveys: (1) Air monitoring during the survey period would be designed to measure the ambient quality by determining the presence and type of suspended particulates and gaseous pollutants in the air due to natural emissions and current conditions. Pollutants of primary interest include sulfur dioxide, hydrogen sulfide, mercury vapor, carbon monoxide and radon; (2) Rainfall catchment samples would be analyzed for pH, arsenic, selenium, mercury, thalium, boron, lead, fluoride, sulfide and sulfate; and (3) transects in areas of botanical interest would record the existence and condition of various plants supplemented by photo documentation surveys.

The geothermal developers are required to prepare and submit to the Chairman, Board of Land and Natural Resources, an environmental monitoring plan prior to commencing production operations. In implementing such a plan, the developer will cooperate with designated State and County agencies to assure that an effective environmental monitoring system is established in the Puna district.

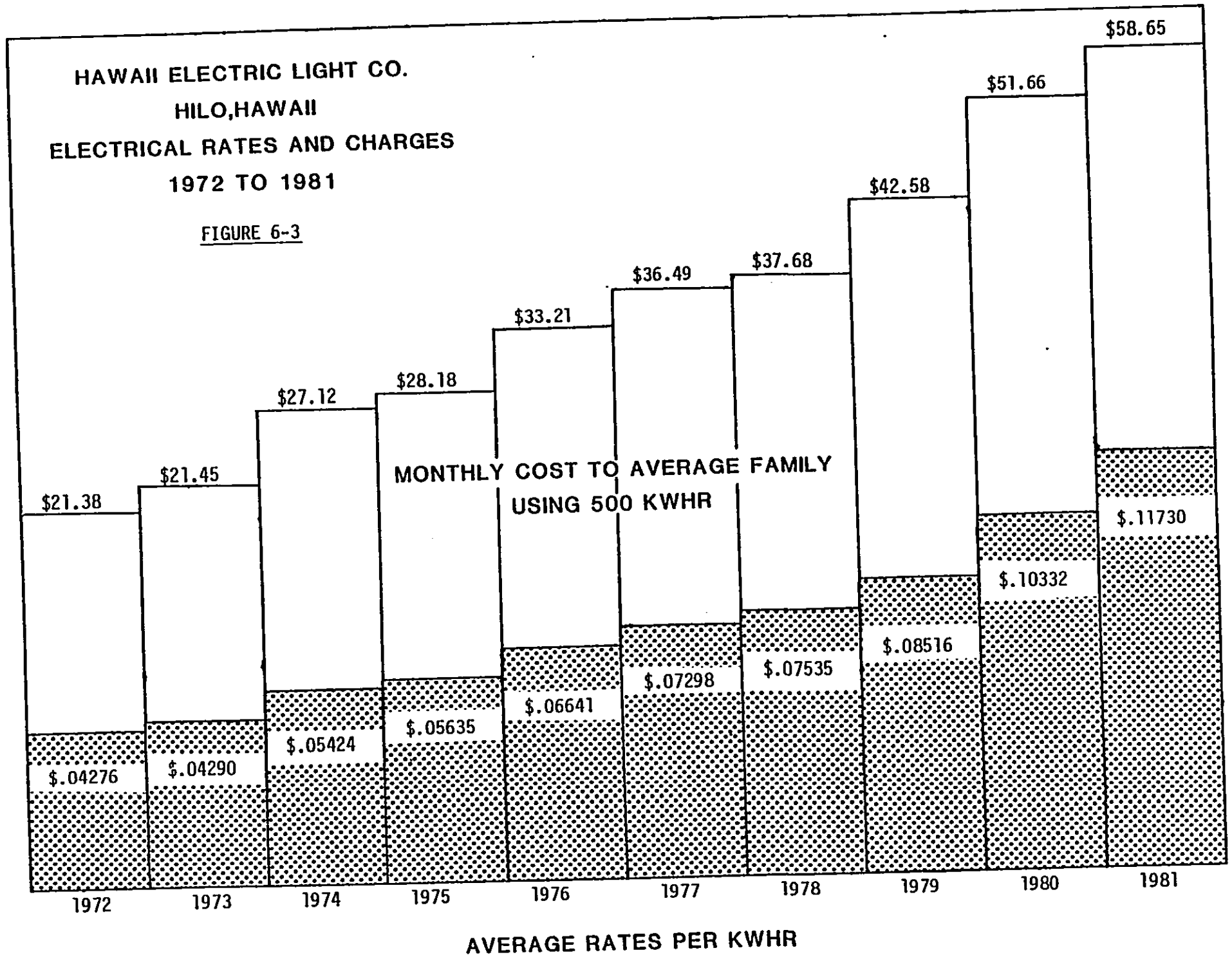
6.6 SOCIO-ECONOMIC MITIGATION MEASURES

There are no known adverse economic impacts. The project will be executed gradually over a span of years beginning with exploratory drilling. Then, if successful, development of the geothermal production wells and power plant construction will follow ending with the operational phase of the completed facilities. This sequence will be repeated for each power plant and related geothermal production well development. The gradual build-up and stabilizing nature of the construction activities will cause no adverse economic impact. The influx of private funds will assure fairly steady employment opportunities to employees of local contracting firms.

Except for a small supervisory staff, it is the long-range objective of the developer to hire local residents (contracting firms) as much as possible. This will cause little or no adverse social impact. The gradual need for County infrastructure services (police, fire, etc.) will most likely be by normal increase and not directly attributable to the Kahauale'a Geothermal Project. The population growth of Puna was foreseen years ago and is taking place as a result of improved roads, water system expansion, etc., which has created a "bedroom" community for Hilo.

The use of geothermal energy to reduce out-of-State fuel oil purchases will add to the financial strength of the County. The stabilizing of electric power costs will be of direct benefit to residents. Figure 6-3 shows the effects of increased oil costs on the electricity bills of the average family on the Big Island.

The developer will continue to maintain a public relations program. Newsletters or public announcements will be used to keep residents informed on the progress of the project. A local office (in Hilo or Puna) will be in operation to receive calls from persons requesting information. In this manner, any concern on any aspect of the project can be immediately handled.



SOURCE: STATE PUBLIC UTILITIES COMMISSION

Traffic on the Volcano Road will not cause any significant impact as the project will generate a small increase of traffic in relation to the rated carrying capacity. Slow moving vehicles will be scheduled at non-peak hours.

SECTION 7

ALTERNATIVES TO PROPOSED ACTION

7.1 INTRODUCTION

7.1.1 Selection of Site

Kilauea volcano has two rift zones running generally east and southwest through which magma (molten rock) moves in the subsurface whenever volcanic eruptions take place in the lower elevation of the rift zone.

The east rift system of Kilauea volcano passes through (or is adjacent to) significant portion of the Kahauale'a property in the vicinity of Puu Kahauale'a. The developer in their assessments of the area believes that sufficient heat has been retained in the subsurface to develop a viable geothermal resource. The currently active east rift last erupted close to this area in 1977. To the west of Puu Kahauale'a the most active portion of the rift system lies within the Hawaii Volcanoes National Park, but a portion of this active zone also lies within the Kahauale'a property north of Napau Crater. To the north of the currently active rift is a zone about 1-1/2 miles wide that appears to be a rift system that is about 300 to 500 years old (total area of about 10 square miles) and appears to have geothermal potential with extremely low volcanic hazard. Several craters and areas of irregular topography lie to the south of the active rift zone and suggest that this area may also be underlain by geothermal resources.

Further, the discovery at the Pohoiki HGP-A Geothermal Well at the lower end of the Kilauea East Rift Zone and results of the earlier experiments at the upper end within the Park area by Professor Keller further indicates the potential for geothermal resources trapped beneath Campbell Estate lands between the Hawaii Volcanoes National Park and the State Puna Forest Reserve.

Figure 7-1 shows Kilauea Volcano and the rift zones emanating from the volcano site. It is readily apparent that large sections are closed off to geothermal development as such sections are within the HVNP and the

proposed Wao Kele'O Puna Natural Area Reserve. Except for the lands now based in the lower end of the East Rift Zone, the available lands for further geothermal resource explorations are limited.

Other alternative geothermal resource sites may exist elsewhere than in the Kilauea East Rift Zone. Figure 6-2 shows the rift zones for the Island of Hawaii. Two exploratory geothermal wells attempted in the Hualalai region of Kona were not successful. Geothermal anamolies exist at the southwest end of Kohala mountains; a water well disclosed basal water temperature exceeding 90°F. However, there is no evidence at this time to prove that productive geothermal resources can be recovered other than from the Kilauea East Rift Zone.

7.1.2 Other Uses of Project Site

Various alternative land uses have been considered in the past for the project area, including truck crop, grazing, timber and hapu'u harvesting. These alternatives were either not economically feasible, or were not conducive to good land management practices. Since the Kahauale'a property is classified conservation and designated a limited subzone, its potential uses are restricted under existing regulations. The difficult access into this area, the availability of other lands with easier access to forest products, the rugged character and remoteness of the Kahauale'a tract have discouraged any long term productive land use activity to the present.

7.1.2.1 Timber

The timber resources have attracted potential purchasers. Records indicate interest by two local Big Island firms. A study by L. W. Byran for Campbell Estate outlined the timber harvesting procedures to be followed. A proposal with Wood Slicing Corporation in 1970 for the annual harvesting of 1,000,000 board feet did not materialize. The timber potential of Kahauale'a is a recognized fact.

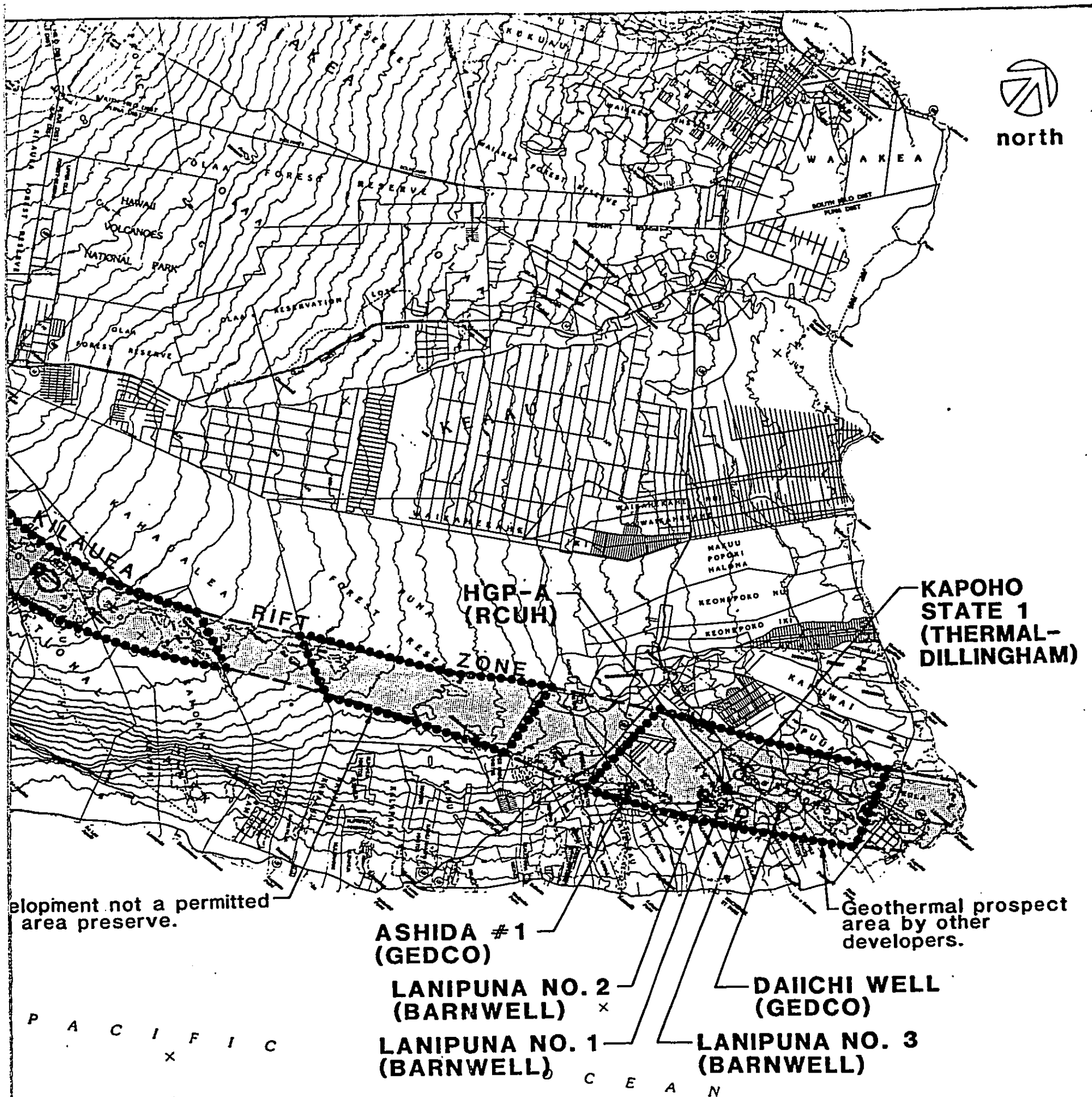
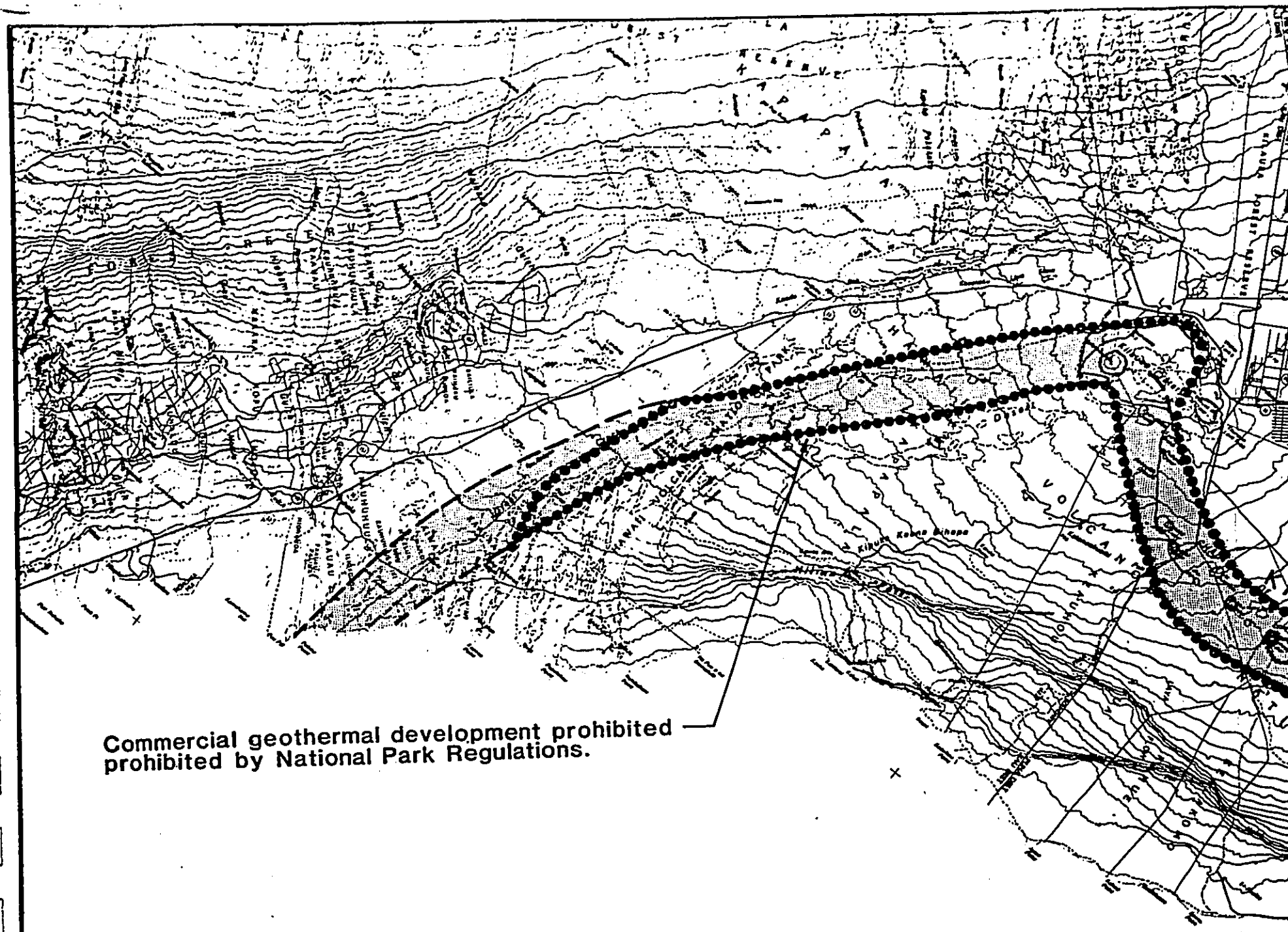


FIGURE 7-1

RIFT ZONES OF KILAUEA



Commercial geothermal development prohibited
prohibited by National Park Regulations.

LEGEND:

RIFT ZONE

Geothermal develop
use in a natural are

10,000 0 10,000 20,000 30,000 40,000

SCALE IN FEET

7.1.2.2 Hapu'u

The extensive hapu'u growth on Kahauale'a resulted in a contract with Fernwood Industries. A CDUA Permit for harvesting of 3,840 acres of hapu'u was approved in 1970. However, little if any harvesting was carried out under this contract which was subsequently terminated.

7.1.2.3 Grazing

Most of the Kahauale'a lands were leased out for pasture purposes prior to 1957. When the lease expired, the Campbell Estate offered the land at public auction in 1960 for agricultural purposes including pasturage. There were no bidders.

7.2 DISCUSSION OF ALTERNATIVES

7.2.1 Coal

The abundance of coal in the western United States has led to the possibility of coal as a fuel for Hawaii. Small scale uses of coal is a fact in Hawaii. Two local cement companies on Oahu utilize coals.

It has been suggested that coal be used as a backup for bagasse at sugar plantations to fire their generators. This would be contrary to the plantations' present effort to increase the use of biomass (wood chips) to supplement bagasse burning. Further, coal would involve installing new infrastructure to accommodate its use. Mill emissions of pollutants would increase unless improvements to existing abatement systems are installed due to the coal having higher pollutant emissions as compared to fuel oil or biomass.

HECO has studied this concept but obstacles -- a deep draft harbor, ash disposal site, higher levels of pollutants in emissions, storage facilities, shipping costs -- have to be overcome first.

7.2.2 Biomass

HELCO's oil-based generating facilities provide nearly 65 percent of the County of Hawaii's electricity. About 35 percent is generated by bagasse and oil-burning by sugar plantations: Puna Sugar Co., Hilo Coast Processing and Honokaa Sugar Co.

Efforts to explore and enhance the feasibility of biomass fuel sources (e.g., tree farms, ethanol and bagasse) are underway or under consideration by others. C. Brewer, Ltd., has a tree farm experiment in progress under a Federal grant in South Hilo. Wood chip burning would require about a ton of wood to equal a barrel of oil. To further increase the efficiency of bagasse as a fuel, drying and pelletizing of the bagasse have been carried out by the Honokaa Sugar Company.

Another project, funded by the Department of Energy, would use the hydropyrolysis process (developed by the Institute of Gas Technology - Chicago) to produce liquid or gaseous fuel from cellulosic biomass materials. Three species of eucalyptus merit consideration. To produce the equivalent of 1,000 barrels of oil per day, 49,500 acres of land would be required. To replace the 4,000 barrels of oil per day consumed on the Big Island, 196,000 acres of land would be required.

7.2.3 Hydroelectric

HELCO's hydroelectric power generating units provide less than 2 percent of the electricity consumed in the County of Hawaii. There are two hydroelectric power stations owned by HELCO at Waiau (1.1 MWe) and Puueo (5.3 MWe, a combination of hydro and diesel power). These two stations depend on the Hilo Watershed (Wailuku River Water Basin) for their hydropower resources. The extreme variable watershed flows (small flows are a natural occurrence) preclude dependability on this source for power. HELCO is considering enlarging its Waiau Station; however, the additional power would be small.

In the past, the former Kohala Sugar Company tapped the water sources of the Kohala Mountains for hydropower development. Since the demise of the plantation, no power generating facility has been maintained. The lack of perennial streams on the Island of Hawaii has been a deterrent to hydropower development.

7.2.4 Wind Energy

Kahua Ranch in Kohala was awarded a contract in 1980 for the installation of a 45-kilowatt wind turbine generator funded as a demonstration project by the U. S. Department of Energy. Other smaller wind turbine generators are being installed for ranches in the Waimea, South Kohala area.

Two potential wind resource regions have been identified on the Big Island. These sites are the North and South Kohala lands surrounding Kohala Mountains, and the South Point area in Kau.

Due to the intermittent power generating nature of wind turbine generator, it cannot be considered for electrical base load purposes. Generally, 10 percent, more or less, is what a utility will accept from wind generated facilities for incorporation in their power capacity calculations.

7.2.5 Solar Thermal and Photovoltaics

Solar thermal power systems generally refer to the generation of electricity from solar energy using the heat in a collector to drive a heat engine, such as a steam turbine. Such systems are generally considered feasible only in areas with high insolation (i.e., incoming solar radiation) for most of the year and with low precipitation and dust. Hilo Coast Processing Company has received grants from Department of Energy for a feasibility study on a focusing solar collecting system to produce medium temperature steam for use in the sugar processing industry.

7.2.6 Ocean Thermal Energy Conversion

In ocean thermal conversion (OTEC) solar energy, stored in the warm ocean waters, is converted to a usable resource electricity. Energy is extracted from the ocean by using the temperature differential between warm surface waters and the cold waters of great ocean depths. OTEC research and development has been conducted in several phases at the Hawaii Natural Energy Laboratory at Ke-ahole Point, County of Hawaii.

The physical location of Ke-ahole, a land base with the deep polar-fed cold sea currents a relatively short distance offshore, has attracted initial small scale OTEC experiments. Commercial scale components still need to be developed and the economical feasibility must be demonstrated. Recent OTEC developments include two design contracts by the Federal Department of Energy for two OTEC conceptual designs: a land based concept and an offshore tower concept. Both concepts involve the HECO Kahe Point power plant and are based on a 40 MWe pilot plant.

Notwithstanding the OTEC potential, this alternative energy program from a renewable resource will be capital intensive. The by-products of OTEC, production of hydrogen gas, aquaculture spillover benefits, or desalinization, may justify such large plant investment costs. At present, estimates peg OTEC development costs at $8,000/kw capacity for prototype plants or 3 to 4 times the present costs of geothermal power plants.

7.2.7 Nuclear Fuel

The use of nuclear power for generating electricity would likely encounter heavy opposition here in Hawaii. The State Constitution prohibits the use of nuclear energy power generating facilities without the express approval of the State Legislature by a two-thirds majority vote.

The economical size of a nuclear power generating facility starts around 500 MWe. The large size makes it impractical for use other than for Oahu. Further, the size of the plant, over 50 percent of the projected 1990 base load of Oahu would be above the desired level for any single plant.

A growing concern with the proliferation of nuclear plants is the unresolved issue of nuclear waste disposal. Except for the radiation hazard associated with nuclear power, there would be no pollutant emissions from such facility as compared to oil, coal and geothermal power generating facilities.

The State Energy Plan does not foresee nuclear energy use for the State for the next twenty years, if at all. In addition, it is felt that nuclear energy as a fuel would be contrary to the present energy policy: "The billion dollars now pouring out of the State for imported petroleum can be better spent in developing indigenous resources and creating local employment and income from new energy industries. Nuclear equipment, technology, expertise, and fuel would all have to be imported, thus, this technology conflicts with the opportunities to achieve energy self-sufficiency and diversify the economy."

7.3 ALTERNATIVE GEOTHERMAL SITES

Figure 6-2 shows the rift zones for the Island of Hawaii. Two wells were drilled in the Hualalai Mountain region at elevation 2,500± feet. These wells were not successful in locating a geothermal reservoir. While geothermal anamolies exist at various locations on the Island of Hawaii, successful geothermal exploration wells have only been drilled in the Kilauea East Rift Zone. Early work by Professor Keller at Kilauea Volcano was followed by the HGP-A well. The HGP-A has been turned into a production well furnishing geothermal steam to power a 3 MWe facility. The Kilauea East Rift Zone has known geothermal resources. The other areas still need exploration to determine the existence of a geothermal resource.

Along the Kilauea East Rift Zone, the land for geothermal development is restricted. Figure 7-1 shows that large portions of the East Rift Zone are not available for geothermal development. The HVNP is prohibited from developing commercial geothermal power. The Puna Forest Reserve has been proposed as a Natural Area Reserve and geothermal development is precluded within the boundaries of a Natural Area Reserve. In addition, portions of the lower areas of the East Rift Zone are committed to other geothermal developers. These factors, together with the considerable number of small landowners in the lower areas, indicate that only about 30 percent of the East Rift Zone could be effectively developed.

As Figure 7-1 shows, the Campbell Estate parcel of Kahauale'a is the only sizeable area with geothermal potential uncommitted to geothermal development at present. The developer, True/Mid-Pacific Geothermal Venture, in coordination with the Campbell Estate, has logically selected Kahauale'a for geothermal development. The remoteness of the prospect area from residences, the single ownership, and the present unproductive state of the Kahauale'a surface lands make it the only viable geothermal development site available to the developer.

7.4 NO ACTION/DELAYED ACTION

The "no action" alternative, leaving the land in its present undeveloped state, is not a sound land management practice nor economically feasible to the landowner. Although this alternative would retain the land in its natural state, there are disadvantages, aside from the economic disadvantage to the landowner, which also militate against a "no action" alternative.

- The "no action" alternative would lose the opportunity to develop one of the more promising geothermal sites in the State of Hawaii. The proximity to potential geothermal resources, the large size of Kahauale'a, and its location, remote from habitation, present a very unique opportunity to develop a large geothermal production capability with minimal environmental and social impact.

- The "no action" alternative would further reduce the area of geothermal resource potential which could be developed to supply an undersea cable. If sufficient resources are not proven to justify proceeding with the cable program, it is possible that the State would remain dependent on foreign oil with the attendant uncertainty of supply associated with imported fuel and escalating electricity costs.

- The "no action" alternative would not necessarily preclude the possibility of geothermal development by other applicants in the future. Others have expressed interest in exploring and developing geothermal resources in the land of Kahauale'a. The site is within an area designated as having one of the best properties for geothermal resources in the State and, therefore, will remain a potential site for development and use by other developers.

SECTION 8

THE RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE OF LONG TERM PRODUCTIVITY

The project site is presently undeveloped and unproductive. The soil consist mainly of stony muck and such area is mostly used for watershed, woodland and pasture and has very limited truck crop value. The landowner derives no income from this property at present. The State and County governments presently receive very little in tax revenues from the use of this forest land. Value may be attributed to the aesthetic and scenic quality of forested land. Another value that is measureable is the worth of the forest products. Full scale commercial harvesting of the forest products could degrade the existing natural qualities of the property.

A possible short-term use of the property would appear to be timber and hapu'u harvesting allowing the land to revegetate itself without any thought of selective planting. This would be poor land management. Replanting could be initiated; however, the understory and character of the forest would change. From a natural forest, it would be converted into a tree/hapu'u farm. Another alternative would be land clearing to convert the area into pasture lands with minimal economic benefit and removal of large sections of the forest as it exists today.

Neither of these possible short-term alternative uses would degrade the long term value on potential productivity of the property, nor would the use of limited portions of the surface to recover underground resources.

Inevitably, the value of land changes with progress and population changes. The highest and best use of many private and public lands to date is not the same as it was 50 years ago. Nor will it remain static over the next 50 years. Further, Hawaii's geographic isolation and total lack of fossil fuel makes it more imperative that alternative energy programs be developed. Situations such as dock strikes, oil embargoes, drastic increases in the cost of oil, and other unanticipated developments can

generate economically disruptive effects. This points out the importance of strengthening the alternate energy program to provide Hawaii with a more secure and stable base for its energy sources.

It should be emphasized that only 1.7 percent of the total project area (422 acres out of 25,461 acres) is the estimated surface area required for geothermal power production at the projected level of 250 MWe. Other potential uses for the remaining forest, including tree harvesting and/or maintenance of a natural, relatively undisturbed forest, would continue to be an option of the landowner.

Due to the geologic structure of the project area, the existence of a rift zone, permeability of the subsurface, and recharge assured by high rainfall, a well managed geothermal production program should enable long-term productivity of the subsurface environment without affecting long-term productivity of the surface environment. As with any natural mineral resource, there will be depletion over time. In the case of geothermal resources, productivity of individual reservoirs over time would decrease.

In the context of short-term uses of the property and environment, the actions proposed by this project will also not affect the long-term productivity of the surface of the property while benefiting the State and County governments in several ways; the increased productivity and economic activity will add to the tax revenues; provide increased energy self-sufficiency by decreasing Hawaii's dependence on imported fuel; and provide employment and services needed by the residents.

The proposed action will take a small portion of the land surface area out of a "non-productivity" state to allow the subsurface to be developed into a productive resource that will benefit the present and future economy of the County of Hawaii and the State. Long-term economic and social benefits can be gained from the prudent use of the geothermal resources underlying Kahauale'a.

SECTION 9
IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The proposed project will involve commitments of land, labor, materials and private capital. The limited portion of the land surface area required to develop this underground natural resource is expected to be under a long term commitment for this purpose. The developers will commit their capital for the initial access roads, exploratory drilling and facilities development costs and will continue to expend their capital to further the development of the geothermal resources as the market for the resource expands. This will serve the purpose of reducing dependence upon imported fossil fuels, and stabilizing the now escalating cost of electrical energy.

The geothermal fluid withdrawn from the geothermal reservoir may possibly be an irreversible and irretrievable resource use, based on current knowledge of the geology and geothermal theories. However, due to active underground lateral movement of the magma from Kilauea and Mauna Loa, there is a distinct possibility of heat renewal of the geothermal reservoirs which have been depleted or cooled over time. At present there is no estimate of how long heating of the recharge fluid would take, but it is assumed that reheating to average reservoir temperature would occur. The amount of heat withdrawn in the area is inconsequential with respect to the total heat source from which it is produced.

Most ecosystems in Hawaii have been affected to some degree by human economic and social activities as well as by the deliberate and accidental introduction of exotic plants, birds and animals. These activities have been both beneficial and adverse to the forest and their inhabitants.

The undertaking of geothermal resource development brings into consideration the public concern for a balance between activity which would bring economic benefits and the degree of environmental preservation which can be maintained with that activity. The development of geothermal

resources within the scope of this project would stimulate healthy economic activity in terms of employment and related service industries which, in turn, would favorably affect the County's tax revenue. The use of the land of Kahauale'a for geothermal resource development is planned with careful consideration for the environment. The degree of commitment indicated by this project of land surface for the retrieval of natural, underground resources is very limited and will leave approximately 98 percent of the surface of this parcel relatively undisturbed.

SECTION 10

OTHER INTERESTS AND CONSIDERATION OF GOVERNMENTAL POLICIES ARE THOUGHT TO OFFSET THE ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

As indicated in Section 5, Impacts of the Proposed Project, and other Sections, most of the adverse short term and long term impacts are multifaceted and will be difficult to distinguish one from the other; because the project will be executed as a continuum of efforts over a 14 to 20-year period to explore, develop and market the geothermal resource. Early successful geothermal resource confirmation could result in the initial construction and operation of a 25 MWe power plant to convert discovered geothermal resources to electrical power.

Much has been said of the demise of the Hawaii's forest birds; however, there has been little scientific effort in the past directed towards understanding the basic cause of their diminished population. Although these birds are an integral part of the forest ecosystems, their role in the ecosystems, their requirement, the interdependency of individual species and habitat elements are not fully known. While reduction of forest lands through land clearing practices and wild animal browsing can have adverse impact on native forest birds, avian disease transmitted by mosquitoes and competition from non-native species are contributing causes for decline of our native forest birds. Scientific studies that are being carried out by the U. S. Fish and Wildlife Service, U. S. Forest Service and the State Division of Forestry and Wildlife should be continued.

The Department of Land and Natural Resources by statutes and regulations has been given the authority to regulate drilling and production of geothermal resources. The Department is responsible to ensure that the development operations do not needlessly degrade the land, water or other natural resource values of the State.

Common features of these regulations are: required permits for each well drilled, converted, capped or abandoned; required drilling reports and well logs; and restrictions on the methods of handling drilling materials and well effluents. In addition, State air and water pollution control regulations apply to geothermal development.

As described elsewhere in this report, the Planning Department of the County of Hawaii has prepared noise level guidelines for monitoring geothermal activities. Compliance with the noise level guidelines should result in limiting noise nuisance derived from project activities.

The Center for Science Policy and Technology Assessment of the State Department of Planning and Economic Development is directing a Geothermal Commercialization Project to evaluate the near term public and private sector requirements for geothermal development. The project serves as a focal point for exchange of information among the local community, industry, and the various State agencies responsible for the geothermal activities in the State of Hawaii.

SECTION 11
SUMMARY OF UNRESOLVED ISSUES

Pursuant to Chapter 181, Hawaii Revised Statutes, geothermal resources have been defined as a mineral resource. Under this provision of the law, enacted in 1974, the State of Hawaii placed under its ownership all geothermal resources, except for a few exceptions, based on the premise that since the Great Mahele of 1848 the government of Hawaii had reserved mineral rights. This is complicated by the fact that many grants since 1900 did not explicitly reserve mineral rights to the government. In 1963, the mineral clause was again inserted in all government land grants.

Another issue is whether or not the geothermal resource can be considered a mineral resource. Hawaii, according to law research, is the only State to define geothermal resources as a mineral. Other various interpretations exist throughout the country.

Because of the unsettled and complex nature of these legal issues, it is apparent that a formal legal process may be necessary for a fair and adequate resolution of the issues, and it is therefore inappropriate for a statement of the landowner's legal position to be included in an environmental impact statement. For the purposes of this section, it is sufficient to state that these issues exist and may be a continuing source of controversy.

The existence and the potential of the geothermal resource to be economically produced are still to be verified. Only after a number of exploratory wells have been drilled can the geothermal resource be measured and power facilities designed accordingly. The present effort at Kahauale'a is based on (1) geologic and geophysical field surveys, and (2) the results of drilling at Kilauea Volcano and the Kapoho region.

The growing of marijuana on the land of Kahauale'a is a concern of local authorities and the landowner.

SECTION 12
LIST OF NECESSARY APPROVALS

The exploration, development and marketing of geothermal energy will require various government approvals. A list of approvals are as follows:

12.1 STATE OF HAWAII

A. Department of Land and Natural Resources; Conservation District Use Approval. Approval of construction drawings.

B. Department of Land and Natural Resources; Geothermal Mining Lease and Drilling Permits.

C. Department of Health; responsible for checking on air and water quality standards and sewage disposal on the site; Public Health Regulations must be met. Noise control. Approval of Construction Drawings.

D. Department of Transportation; all access and utility connection to the main highway will require approval of the Division of Highway. Highway permit to move heavy equipment.

E. Public Utilities Commission; purchase of electrical power by HELCO.

F. Department of Regulatory Agencies; Drilling and Contractor's Licenses.

12.2 COUNTY OF HAWAII

A. Department of Public Works; approval of all construction drawings, construction of structure comprising the power plant, erosion control, and drainage plans.

B. Department of Public Works; approval of building, plumbing and electrical permits.

C. Department of Public Works; grading permit for site development.

D. Department of Planning; review the building plans for conformance to codes within its jurisdiction as part of the permit application review procedure.

E. Department of Planning; Shoreline Management verification.

F. Department of Water Supply; water purchase application and permit.

G. Police Department; traffic permit for moving heavy equipment.

SECTION 13
ORGANIZATIONS AND PERSONS CONSULTED

As required by the State Environmental Impact Statement Regulations, the following agencies, organizations and individuals were sent copies of the EIS Preparation Notice. They were included as a result of either requesting to be consulted parties or their known interest in the project. Letters from those who chose to submit comments based on information in the EIS Preparation Notice are reproduced in Appendix C and the responses to those comments. Additional comments on the EIS and responses will be included in the revised EIS.

13.1 COUNTY OF HAWAII

Mayor
Department of Planning
Department of Public Works
Department of Water Supply
Department of Research and Development
Civil Defense Agency
County Council
Fire Department
Police Department

13.2 STATE OF HAWAII

Governor
Department of Agriculture
Department of Land and Natural Resources
Department of Planning and Economic Development
Department of Education
Department of Health
Department of Transportation
Environmental Quality Commission
University of Hawaii - Hawaii Natural Energy Institute
University of Hawaii - Hawaii Institute of Geophysics
University of Hawaii - Environmental Center
University of Hawaii - Water Resources Research Center
University of Hawaii - College of Engineering
University of Hawaii - College of Arts and Sciences
University of Hawaii - School of Public Health
University of Hawaii at Hilo
University of Hawaii - College of Tropical Agriculture and Human Resources
(2) State Legislators From Big Island
President of the State Senate
Speaker of the House of Representative
Office of Hawaiian Affairs
State Public Utilities Commission

13.3 FEDERAL GOVERNMENT

Senator Daniel K. Inouye
Senator Spark M. Matsunaga
Representative Daniel Akaka
Representative Cecil Heftel
Department of the Army - U. S. Army Corps of Engineers
Department of the Interior - Hawaii Volcanoes National Park
Department of the Interior - Water Resources Division
Department of the Interior - U. S. Geological Survey - Volcano Observatory
Department of the Interior - U. S. Geological Survey - Menlo Park
Department of the Interior - U. S. Fish and Wildlife Service
Department of the Interior - National Park Service, (Hawaii Regional Office)
Department of Energy - Hawaii Office
Pacific Institute of Forestry Research

13.4 PRIVATE ORGANIZATIONS

Pahoa Community Association
Kalapana Community Association
Puna Hui 'Ohana
Chamber of Commerce - Big Island
Volcano Community Association
Mountain View Community Association
Glenwood Community Association
Leilani Estates Community Association
Fern Forest Community Association
Audubon Society
Sierra Club
Life of the Land
Nature Conservancy
W. H. Shipman, Ltd.
Hawaii Botanical Society
Conservation Council
Japanese Chamber of Commerce and Industry
Aloha Aina Life Education Center
Alu Like
Hawaiian Electric Company
Hawaii Electric Light Company
Hawaii Contractor's Association
Dr. Otto Degener
American Lung Association
Aina Loa Community Association
Hawaiian Beaches Community Association
Nanawale Community Association
Pacific Tropical Botanical Gardens
Paradise Park
Puna Community Association
Volcano Golf and Country Club Estate Association
Hawaii County League of Women Voters

Brock and Associates
David Ford Real Estate, Inc.
Republic Geothermal, Inc.

13.5 INDIVIDUALS

Each of the following persons asked to be a consulted party. All parties will be kept informed by newsletters which will summarize details of the geothermal project.

D. G. Hasenyager
Hawaii Forest Bird Recovery Team
Bonnie Goodell
Wendell Y. Y. Ing
Thomas L. & Judy L. Stenger
Wayne Westlake
Jerry W. Pedroni
Henry A. Ross
Nelson Ho
Diane Ley
D. Priestley
Kelley Thompson
Peter Leonard
C. McLaughlin
John H. Threlfall
Charlotte A. Lewis
L. R. McBride
Mr. & Mrs. Albert E. Aviles, Jr.
Frederick R. Warshauer
Virginia Spencer
Terence Spencer
Rose Yigas
Pat Murphy
Anne Dina Kagelee
C. W. Whittle
J. P. Lockwood
Paul K. Higashino
Koi Lee & Anthony Lee
Bill Christie

Ronald Baptista
Frank Salmaraghi
William P. Mull
Wanda Aus
Russell S. & Anne E. Kokubon
Grant Gerrish
Larry & Kathryn Klein
Larry Kitahara
Rolf Fuhrmann
J. H. Monane
Cindy N. Furukawa
Michael & Ann Markham
Fred Beecher
Yukie Yoshinaga
Carol Martinelli
Elizabeth M. Kodis
Robert K. Zimmerman, Jr.
Rolt K. Zil
Paul C. Phillips
Victor R. Becker
Jeffrey Mermel
Veneeta Z. Ascon
Howard Z. Streicher
Geary Mizuno
Collin A. Lewis
Greg Owen
Jane Worthington
Sid & Jane Gale
John R. Rozett
Thompson M. Warren
Bedford D. Edwards
G. K. Reese
Dennis Fitzpatrick

H. L. Carson
Darrell Cadle
Valerie Campbell
Richard Deolorm
Bennie G. Di Bona
Richard Dempsky
Norman Inaba
Takeshi Yoshihara
Robert Parker
Kathleen Ing
Al Nakagi

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6. Collie, M. J., Geothermal Energy - Recent Developments, Noyes Data Corp., 1978.

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APPENDICES

APPENDIX A

APPENDIX A

Archaeological Literature Research
Tommy Holmes
April 1982

The following is a brief summary of the findings of a documentary literature search on the ahupuaa of Kahauale'a in the Puna District of the island of Hawaii. Attention is given to the entirety of the ahupuaa, though the emphasis is on the mauka portions from about 1,500' to 3,800' elevation, or roughtly three miles inland to the northern terminus of the ahupuaa, just below Kilauea Iki. The present document consists of excerpts from a longer report entitled "A Preliminary Report on the Early History and Archaeology of Kahauale'a, Puna, Hawaii" prepared by Tommy Holmes for the Estate of James Campbell.

TRAILS

In Puna, where canoe landing and launching sites were very few and extremely dangerous, trails held special significance. Given terrain that was alternately rugged lava and thick jungle, Puna residents had no choice but to develop a good trail system over which a great part of trade, communications and transportation occurred.

Several old trails were known to have either passed through Kahauale'a ahupuaa or started at some point outside the area or at the coast and penetrated into Kahauale'a for a certain distance. At least four of these trails traversed Kahauale'a in a rough east-west direction. The trail most makai followed the contour of the coastline just a few feet from the ocean.

A second ancient trail called on maps today the Kalapana or Volcano-Kalapana Trail crossed Kahauale'a a little more than half a mile inland. This was apparently the preferred route in traveling from Puna to the Volcano area (although there were other routes, e.g. Ellis' path).

Coming up on this same trail from Puna, one could continue on to the Volcano or branch off to the right just below Makaopuhi crater to re-enter and recross Kahauale'a at about the 2,700-ft. level. About ten miles inland, this ancient trail, called the Glenwood-Makaopuhi Trail on today's maps, took one through to Keeau and Ola'a and eventually back to Hilo.

The fourth ancient trail, used by Capt. Wilkes' party in 1840, apparently began just to the east of Makaopuhi and traversed Kahauale'a at about the 2,200-ft elevation, passed just north of Kalalua crater and continued down the rift zone.

Hudson also mentions an "old trail across the lava flow south of Makaoiki [a heiau in Kahauale'a about a mile inland].

Makai-mauka trails are shown on U.S. Geological Survey maps compiled in 1912 and 1922. A single trail begins at the coast on the border of Kahauale'a and Kapaahu ahupuaa and runs inland for about three miles in a roughly northerly direction before it branches. The major branch, called the Kapaahu trail, continues into Kahauale'a till about the 1,500-ft. elevation where on the map it terminates. The branch trail fairly closely parallels the Kapaahu trail before it too seems to end at about the same elevation. Most likely one or both trails might have at one time gone considerably further inland serving bird-catchers, canoe-makers, upland farmers, forest product gatherers, travelers, etc. Chester Lyman reported in 1846, taking a trail that appears to have started at the coastal village of Kahauale'a and continued almost due north into the interior of Kahauale'a and back to Hilo.

Indeed there were probably a number of coast-inland trails that accessed the archaeological sites, reported as far as three miles or more inland on neighboring ahupuaa of Kahauale'a. That some would have gone inland up the Kahauale'a corridor is very likely.

The manufacture and export of pulu, the soft, wooly substance found at the base of hapuu ferns, was, according to Thrum, an important industry from 1851 to 1884. Most pulu came from an extensive tract of fern and ohia forest in the Kilauea vicinity. Brigham noted that, "In the early sixties [1860's] the business of picking and packing pulu had become so important that trails cut by the many natives thus employed opened the crater country far more than ever before."

SITES

As mentioned previously, most known sites in Kahauale'a are found quite close to the shore. The most seaward is a canoe ladder site, one of several along the cliff-bound coast of Puna.

Considering the numerous ahupuaa that make up the Puna District, the reported presence of three heiaus in Kahauale'a alone, where many other Puna ahupuaa, often more populous, had none is of some interest.

Located within a couple of hundred yards from the sea adjoining Waikupanaha pond is what Hudson calls Waiaka heiau.

A second heiau, called Punaluu, unquestionably in Kahauale'a, was quite large and complex.

The other reported heiau in Kahauale'a, called by Thrum and Hudson, Makaoiki, was located "about a mile inland from Kupaahu village...in the middle of an aa flow. The adjacent graves are pits sunk in the surface of the flow. Hudson also notes a "former burial cave, a short distance south of site 179 [Makaoiki]. The cave is known as "Kalua Makini".

In the land of Pulama (on old maps the ahupuaa bordering Kahauale'a to the west) Hudson reports a heiau, Makaiwa, three miles from the sea. Thrum calls it an "ipuolono" or agricultural-type heiau. Early Hawaiian scholar S. M. Kamakau says such "ipuolono heiaus... temples, or more properly household shrines, were to foster food.

Mention of this heiau, though it is not in Kahauale'a, is made here for two reasons.

First: The location of Makaiwa heiau three miles inland, coupled with the location of several other heiau in the southwest Puna area that Hudson places nearly as far inland, strongly suggest that there was significant activity in Kahauale'a and nearby ahupuaa well inland of what was expected when the present study was initiated.

Second: At three miles from shore, Makaiwa heiau and attendant sites are almost to the furthest inland reaches of Pulama which is bounded by a dog-leg of Kahauale'a to the north. In fact, Makaiwa heiau and the other sites are located just a few hundred yards outside Kahauale'a. Hudson notes that in support of the classification of Makaiwa as an "ipuolono" heiau are "the many old agricultural workings found nearby [that] indicate that the purpose of the heiau was to protect and fructify the crops". He goes on to say "In the neighborhood of Makaiwa heiau are a number of platforms, house sites, terraces, pens, and walls.

To extrapolate that there might be sites or site complexes a few hundred yards away in Kahauale'a, at the same distance or more inland, is not unreasonable.

UPLAND SITES

It is, in fact, at the elevation of Makaiwa heiau and accompanying sites that Jim Jacobi [personal communication 1982] reported during a bird survey done in the late 1970's, seeing a number of sites. His recall is that these sites were about 1½ to 2 miles below Kalalua Crater situating them

in Kahauale'a at about 1200'-1500' elevation, 3½ to 4 miles inland, and by crude calculation relatively near the Makaiwa heiau complex.

Moving up in elevation Mr. Jacobi also recalled seeing a scattering of apparent sites immediately mauka of Kalalua Crater. He also reported part of the ancient trail that Wilkes' party used as still being in evidence in this Kalalua vicinity. Lastly, he recalls seeing certain cultigens, particularly the ti plant, growing in the Kalalua area, further suggesting one time agricultural activity.

Handy recorded information regarding the extent of inland agricultural activity in western Puna in 1935, when there were still individuals living who were familiar with Puna's early history. According to his informants, there is very strong evidence for agricultural activities well inland in Kahauale'a. "Land northeast of Kapa'ahu [that, according to Handy's informants]...used to be covered with plantations" is adjacent and virtually identical in terms of terrain and vegetative cover to the lower mauka portions of Kahauale'a. The description of Kaho'onoho at least 2.5 miles into Kahauale'a's forested interior, and Wala'ohia, also considerably inland, as "the two great forest planting areas in Kahauale'a" rather pointedly suggests upland agricultural activity in Kahauale'a. Similarly, the Kupahua homesteading area, upper Kalapana and upper Kaimu are all three to four miles inland, quite close to Kahauale'a, and similar in nature of terrain and vegetation. Supporting Handy's observations on agricultural activity in western Puna are other references, some already noted and more below.

Two other references, if calculations and assumptions are correct, would place agricultural activities well into Kahauale'a's interior. An "extensive upland taro patch" referred to in 1841 by Capt. Charles Wilkes, head of the U.S. Exploring Expedition, was apparently in Kahauale'a, probably at about 2,000' to 2,200' elevation.

Chester Lyman, who traveled through Puna in 1846 with Rev. Coan, also reports a plantation about five miles inland in Kahauale'a.

At 10 miles he makes note of "a small grass shanty" that could have been a temporary abode for travelers, farmers, or forest product gatherers.

At Panau, a small village near Kahauale'a at about 2,500' elevation and just below Napau crater, there was also agricultural activity. Rev. William Ellis, traveling in 1823 through what appears to be the Panau area, says "The natives ran to a spot in the neighborhood, that had formerly been a plantation, and brought a number of pieces of sugar-cane..."

That there was a permanent village this far inland (about 5 miles) and within minutes of walking time from Kahauale'a, would lead one to suspect that permanent and temporary inhabitants of Panau made regular trips into Kahauale'a for various forest products.

Wilkes, in 1841, says of Panau that "Here many canoes are built and transported to the sea, the trees in the vicinity being large and well adapted to this purpose. What this and other canoe related references suggest is that logging koa trees for canoe hulls and procuring wood for other canoe parts might well have been another inland forest activity within Kahauale'a.

The pre- and early post-contact native forest regime of mauka Kahauale'a, with its extensive ohia canopy provided a near ideal habitat for many of the birds sought after by bird-catchers, kia manu. Feathers from certain birds were made into the highly-prized feather work artifacts of the ali'i - capes, cloaks, helmets, kahili, etc.

Early Hawaiian scholar, N. B. Emerson writing in 1895 about bird-catching considered Kilauea, Puna, and upper Hilo amongst the most desirable bird-catching areas in the islands, implying that Kahauale'a by its location (in Puna and contiguous with Kilauea) and type of vegetative, cover was ideal bird country.

Hudson, while not mentioning Panau by name, says that "a few sites were also found in the upland forest region around Makaopuhi and Napau craters at an elevation of about 2,700 feet 6 miles from the sea". Unfortunately, he does not elaborate further on just where the sites were located or what type they were. He does, though, go on to describe other suspected and known sites, including a pulu factory, and possible religious and habitation sites in the Panau village vicinity.

These sites would all be very close to the border of Kahauale'a. Ellis mentions in 1823 a heiau to Pele near Kilauea-iki which is all but contiguous with the northern-most terminus of Kahauale'a.

Whatever the exact location of these other inland sites the point is firmly made. There was a variety of activities, such as canoe building, agriculture, and birdcatching, in the greater volcano area and regular travel through it along several trails. Kahauale'a mauka was an integral part of the physical and resource bounds of these early inhabitants, temporary workers, and transients. In summary, it would not be unreasonable to expect that there are archaeological sites in the mauka portions of Kahauale'a.

APPENDIX B

APPENDIX B

VEGETATION TYPE MAP OF KAHAUALE'A
(Source: U.S. Forest Service/State Div. of Forestry & Wildlife)

The map following page B-3 indicates different land and vegetation types. Numerical symbols within each delineated area show the broad land use class or vegetation type and, for forest land areas, the forest type. Density of tree cover, and tree stand size class are given for commercial forest lands. The legend prepared to accompany the forest type map shows that land areas were delineated to show the following defined classes of land and vegetation:

Land Use Class	Map Symbol
Commercial Forest Land	11
Productive-Reserved Forest Land	21
Noncommercial Forest Land	22
Noncommercial Forest Pali Land	23
Urban-Industrial Areas	30
Cultivated Land	31
Grassland, Forest Site	32
Grassland, Nonforest Site	33
Nonforest Pali	34
Rockland, Non-Pali	35
Marsh Land	36
Water	37
Other, Non Classified	99

All lands classed as forest lands are further classified as to defined forest cover types as follows:

Native or Naturalized Commercial Tree Types	Map Symbol
Ohia	11
Koa	12
Ohia-Koa	13
Silk-Oak	14
Monkeypod	16
Other	15

Planted Commercial Tree Types	Map Symbol
Eucalyptus Species	21
Cedrela-Albizia	22
Other Hardwood Species	23
Conifers	24

Noncommercial Tree and Shrub Types	Map Symbol
Kukui	81
Ohia-Koa	82
Kiawe	83
Other Tree Types	84
Haole Koa, Guava, Lantana and Other Lowland Brush Types	85
Mamani and Other Upland Brush Types	86
Herbaceous Types	87
Other Types	88

For areas classed as commercial and productive-reserved forest lands, the map shows by additional numerical symbols, the density class (percent crown cover) of tree stands and size class of the forest stand as follows:

Density of Tree Cover	Map Symbol
Dense	1
Semi-Dense	2
Open	3
Nonstocked	6

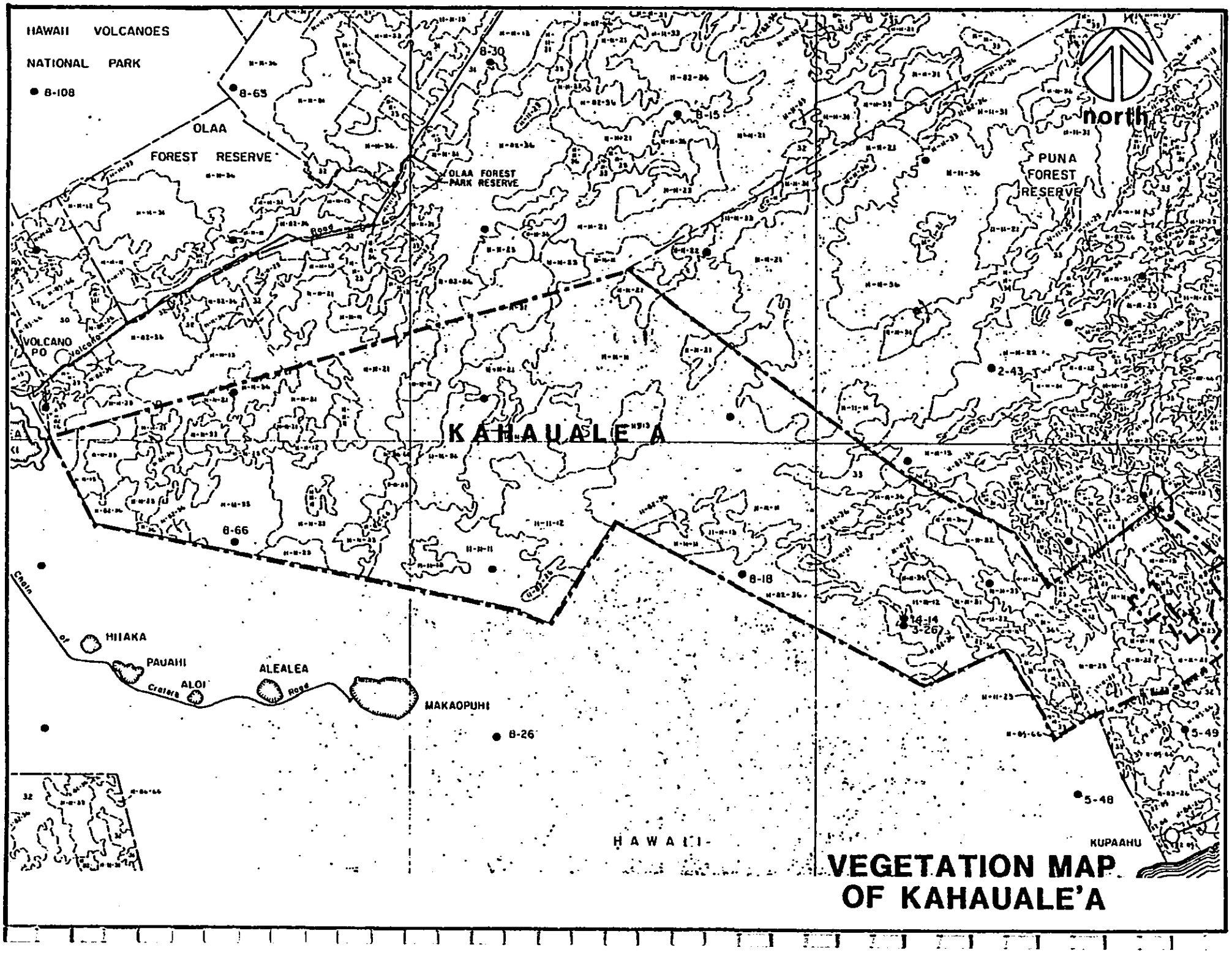
Stand-Size Class	Map Symbol
Light Sawtimber	1
Heavy Sawtimber	2
Pole Timber	3
Seedlings and Saplings	4
Nonstocked	6

Within each delineated area on the map are numerical symbols of two, four, or six digits. For example, the two-digit symbol 33 in a delineated area indicates the area is classed as grassland not having soils and climate suitable for growing timber. An area having the symbol 31 is cultivated land or improved pasture.

The four-digit symbol 22-83 in a delineated area indicates that the area is classed as noncommercial forest land (symbol 22) and the forest type is kiawe (83).

A six-digit symbol like 11-11-23 indicates that the area delineated on the map is classed as commercial forest land (11) having a stand of ohia trees (11), the tree canopy covering 40 to 69 percent of the ground (semi-dense, symbol 2) and the stand is of pole Timber size trees (symbol 3).

The map portrays land use and vegetation cover types at a point in time. With time, land uses and vegetation change. In some areas, change will be slow. In others, change will be rapid and drastic, as where forest is cleared for subdivisions or pasture development. Slow or fast, minor or major, continued change is inevitable.



VEGETATION MAP
OF KAHAUALE'A

A P P E N D I X C

COMMENTS AND RESPONSES MADE DURING THE CONSULTATION PERIOD

United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
P.O. Box 50166
Honolulu, Hawaii 96850

April 8, 1982

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

Dear Mr. Ono:

Subject: Conservation District Use Application for exploration and development of geothermal energy at Kahauale'a, Puna, Hawaii

Attached are comments by my staff on the subject "Conservation District Use Application". Principal reviewers were Paul Eyre and Kiyoshi J. Takasuki.

Thank you for giving us an opportunity to comment on this "Use Application".

Aloha,

Benjamin L. Jones

Enclosures

EXHIBIT A (Environmental Assessment)

Page	Paragraph	Remarks
8	5	Some discrepancies exist between statements in this paragraph and those in Exhibit B (Master Plan) (a) Liquid waste disposal Master Plan: Total injection Assessment: Injection only after surface disposal fails (b) Number of injection wells Master Plan: 1 for 3 production wells Assessment: 1 for 4 production wells "Existing regulations"? Shouldn't this be changed to read "regulations being prepared".
14		One of the items should include the ground-water hydrology as known in the Kahauale'a area. Also, possible fate of liquid waste following surface or subsurface disposal.
14	2	Although the bulk of the rocks are lava flows of the Hilina volcanic series, these lava flows are not exposed on the ground surface in the project area.
14	4	Show equivalent elevation in meters because the contours in figure 3 are in meters.
26	2	The possibility of degrading ground-water quality owing to the disposal of waste liquids on or into the ground should be mentioned under Adverse Impacts.

EXHIBIT B (Master Plan)

Page	Item	Remarks
21	7.2	A favorable hydrologic situation is necessary for successful geothermal wells. The better the understanding of local hydrology, the better the understanding of the geothermal resource. The development strategy should specify and include the collection of pertinent ground-water data during and after the completion of drilling. The data should include the determination of the initial water level and water chemistry and subsequent water levels and water chemistry at selected depths.

R. M. TOWILL CORPORATION

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May 3, 1982
Ref: 1-14075-00

Mr. Benjamin L. Jones
Geological Survey
Water Resources Division
P. O. Box 50166
Honolulu, Hawaii 96850

Dear Mr. Jones:

SUBJECT: Kahauale'a Geothermal Project
Conservation District Use Application

Thank you for your review and comments on the CDUA Application of the Kahauale'a Geothermal Porject. In response to the remarks, we offer the following:

1. Reinjection or disposal of liquid waste will be determined when the geothermal resource characteristic is fully known after tests have been completed.

2. The exact number of injection wells will be determined after tests have been completed. At this time one injection well for three to four production wells is still an estimate and should have been stated in the assessment.

3. Compliance with "existing regulations" is a goal of this project. If the reference is to the U.I.C. (Underground Injection Control) Regulations now being prepared, we regret not having such regulations on hand. In our case, we are referring to the State Geothermal Mining Lease and Drilling Regulations.

4. A section of hydrology of the Puna District will be included in the EIS. The effect of waste disposal will also be covered in the EIS.

5. The reference to exposed Hilina volcanic series refers to the Pali region. The Hilina flows are capped by Pahala ash, and not exposed in the project area.

6. The USGS maps are based on the metric system and we trust the readers will be able to make the necessary conversion.

7. Due to the cased injection wells extending into the geothermal resource withdrawal zone, we anticipate no adverse effects to the ground-water supply.

8. The developer will take measurements and maintain a drilling log to keep accurate records. We expect the USGS HVO scientists to participate in a portion of this work. The results of the Kahauale'a Geothermal Project is expected to add to the current geology and volcanology data of the Kilauea Volcano system.

We invite your further comments on the EIS which will be sent to you shortly.

Very truly yours,

William Y. Thompson, Manager
Planning and Land Development Department

WYT:cs
cc: Susumu Ono, Chairman
Board of Land and Natural Resources

John R. Rozett
P.O. Box 694
Kealakekua, Hawaii 96750
(808) 323-3318

Kahauale'a Geothermal Project
828 Fort Street Mall
Suite 500
Honolulu, Hawaii 96813

February 11, 1982

Dear Public Affairs Person,

I am a landowner in the Fern Forest Estates subdivision, and would like to pose some questions regarding your Kahauale'a project.

First, are the inevitable environmental matters. Regarding the effluent of sulpher gases into the surrounding atmosphere, can you give me some specific data from a similar facility, such as the Pohoiki well? Also, I would like to know specific data on noise levels within six miles of an operating well. I am a confirmed proponent of alternative energy, and I feel this project could be a boon to the community as well as the island. I am merely concerned that the environment should not be appreciably degraded. Lastly, could you give me an idea of the type of improvements to road access if our subdivision right of way is granted, and a general timetable for electrical power availability on the access road(s)?

I am also interested in what potential job opportunities would be available for myself. I am currently residing in Captain Cook (Kona), where I manage a botanical garden for the B.P. Bishop Museum. I have a B.S. in Tropical Horticulture, and concentrated much of my college studies in the natural sciences, (geology, geography, physics, botany).

I have research and practical experience in solar energy, and have worked as an installer and troubleshooter for domestic hot water and combined space heating, hot water and pool heating systems. I have also experimented in small scale production of fuel alcohol. Although I have no direct experience in the geothermal field I have read and understand the basic principles involved, and could certainly further prepare myself for employment with your organization. Please inform me as to whom to contact regarding such inquiries and I will send my complete resume and biographical materials.

Thank you for your time

Sincerely,

John R Rozett

John R. Rozett

THE ESTATE OF JAMES CAMPBELL

March 17, 1982

Mr. John R. Rozett
Post Office Box 694
Kealakekua, Hawaii 96750

Dear Mr. Rozett:

Kahauale'a Geothermal Project

Thank you for your letter expressing interest in our geothermal project at Kahauale'a and for your comments on its alternate energy potential. For your information, we have placed your name on our geothermal newsletter mailing list and you should have received a copy by now.

The answers to your many technical questions call for knowledge and expertise beyond what is available to me. I have, therefore, forwarded your letter to our geothermal engineering and planning consultant, William Y. Thompson of the R. M. Towill Corporation, for the proper response and action. Also, when the Environmental Impact Statement for the Kahauale'a project is completed, many of the concerns and questions you have expressed will be answered in detail along with the proposed mitigative measures to be undertaken.

In response to your inquiry regarding possible employment on the project, we have forwarded the letter to the True/Mid-Pacific Geothermal Development Corporation representatives for their review and response. The actual employment staffing requirements are being handled by True/Mid-Pacific Geothermal and, therefore, their response to you will be more appropriate.

Let me assure you that both The Estate of James Campbell and True/Mid-Pacific Geothermal Development Corporation share your concern over the potential adverse impacts of such a project and there is every intention to closely comply with every legal and regulatory requirement. Thank you again for your interest.

Very truly yours,

O. K. Stelder
Chief Executive Officer

AK/vy:214p

R. M. TOWILL CORPORATION

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677 ALA MOANA BOULEVARD SUITE 1016
HONOLULU, HAWAII 96813
TELEPHONE (808) 524-8200
CABLE ADDRESS "TOCOR"

BRANCH OFFICE:
1765 SCOTT BOULEVARD SUITE 210
SANTA CLARA, CALIFORNIA 95050
TELEPHONE (408) 985-1810

April 30, 1982

Mr. John R. Rozett
P. O. Box 694
Kealakekua, Hawaii 96750

Dear Mr. Rozett:

SUBJECT: Kahauale'a Geothermal Project
Environmental Impact Statement

I am happy to reply to your letter regarding the Kahauale'a Geothermal Project. In response to your questions, may I report the following:

Sulfer Gas and Noise Levels as Contained in Reports Describing the HGP-A Well

"During a subsequent test of the well, when pollution abatement equipment was installed, hydrogen sulfide emissions were reduced by approximately 97% and little if any smell attributed to the well discharge could be detected downwind of the test site. Thus it is entirely feasible to reduce sulfide emissions to acceptable levels during initial testing of well discharge characteristics." . . . "Installation of a geothermal power plant in a quiet rural agricultural area will unquestionably be an intrusion into what otherwise would be an extremely quiet environment. However, the levels produced are not considered to be intolerable and, in any event, are no greater than those associated with an electrical or industrial plant of similar scale not employing geothermal energy."

Environmental Degradation

Only land required for construction purposed will be cleared. The entire project may require slightly over 400 acres. The Kahauale'a project area within the conservation district totals 21,943 acres; or stated another way, only 19% of the conservation lands will be used for this project. From this you can gather that only a small area of the native 'ohi'a forest will be utilized for this project. Lava devastated lands are included in the 422 acres of the construction area requirement.

Fern Forest Estate Subdivision Access Road

On receiving permission to utilize the subdivision road, the developer will take over the maintenance of the road at such time as agreed upon. It will be improved to accommodate the traffic generated by the project at no cost to the residents. Should the project, after exploration and testing, become feasible, the developer will proceed to improve the road to dedicable County standards. This means the road will be paved to the width and thickness specified by the County and turned over to the County. Should power transmission lines be installed along the roadway, the developer will take steps to have distribution lines installed at the same time to serve residents along the road and others who wish to tap into the system. This final phase may take as much as 5 years to complete.

I am sure the Campbell Estate people appreciate your nice comments. Your name will be added to the project mailing list and in this fashion, you will be kept up to date on the progress of this project.

Aloha,

William Y. Thompson, Manager
Planning and Land Development Department

WYT:cs-10

Received 2/16/82

2/8/82
Alto Rt.
Capitan N.M.
88316

Dear Mr. Trotter:

We received information about the Geothermal Project thru the Lincoln Forest Comm. Assoc. We have had a cat there for 20 years and hope in the next 3 to 5 years to build.

We are delighted to hear about your project and wish you much success. We would appreciate being on your mailing list for bulletins. Our son is a geologist here and he would be interested in more technical information — so would my husband who is an Electronic Engineer.

Good luck & thanks for any information you can send

Jane Gale

THE ESTATE OF JAMES CAMPBELL

March 19, 1982

Mr. & Mrs. Sid Gale
Alto Route
Capitan, New Mexico 88316

Dear Mr. & Mrs. Gale:

Re: Kahauale'a Geothermal Project

Thank you for your recent letter to Mr. Fred Trotter expressing interest and encouragement for our proposed geothermal project on the Island of Hawaii. Mr. Trotter has kindly shared your letter with me and has asked me to respond to your individual requests and inquiries.

Your name has already been placed on our geothermal mailing list and you should have already received a copy of our second newsletter in the mail. The environmental, engineering, planning and other technical aspects of the proposed geothermal project and the mitigative measures to be undertaken to alleviate any adverse impacts will be addressed in our Environmental Impact Statement being presently prepared by our engineering and planning consultant, William Y. Thompson of the R. M. Towill Corporation of Honolulu. Our plans for public education and information dissemination is by way of periodically scheduled public meetings held in and around the communities surrounding Kahauale'a (some of which have already occurred) and through the availability of the draft and final revised Environmental Impact Statements at public libraries and community centers throughout the State. These meetings are being held in addition to the public hearings legally required pursuant to the Hawaii Revised Statutes and various State regulations.

Because of its anticipated bulkiness and size, we regretfully do not intend, presently, to send individual members of the public copies of the EIS.

Inasmuch as a copy of the EIS will not be made available in New Mexico, may I suggest that you specify your particular concerns in another letter to The Estate of James Campbell and your letter will be forwarded to our consultant for action and response. In that way, we hope that your most important concerns will be addressed.

Thank you again for your interest and generous words of encouragement. We look forward to your next letter.

Very truly yours,

O. K. Stender
Chief Executive Officer

AK/bw:214r

James Campbell Building Suite 500 [illegible] Fort Street Mall Honolulu, Hawaii [illegible] Telephone [illegible]

Public Affairs
828 Fort Street Mall suite 500
Honolulu, Hi 96813

Dear Sirs,

I am a landowner in the Fern Forest area and have just received information about your proposed geothermal wells in the area surrounding Fern Forest. I also have become aware of your request to use the main roads to the Forest.

I must commend your office for this project and although I currently live and work on Maui as a paramedic with the ambulances, my family and I have dreams of starting a nursery business on our property. So you can probably see where we may have some anxieties.

I would like to know if there is any danger of fumes being released into the air from your drilling sites which may deter plant growth. Specifically I am concerned about the sulfur levels and any danger they may bring. I also have questions as to what effect this tapping of the volcanoe will do to changing the activity levels and would there be any danger or should I say any more threat to its eruption becoming dangerous to our areathen it currently is.

Other questions I find myself asking is how will this effect land values and the land taxes we may have to incurr. How about traffic levels and how much would your company be using the roads. I now feel that the rural feeling there is benificial to my children and I will hope not to have to worry about congestion.

Are there going to be any job opportunities to the people of the islands or are we only starting a mass exodus of highly trained people from the mainland coming in and taking any jobs that could be earmarked for local people. I do feel your proposal would if successful open doors for business' to start plants to get cheap power. I see this a plus for the Big Island failing economy.

Since I just became aware of the project, I would greatly be appreciative if I may be added to a mailing list that I may be kept abreast of your project. Also I am interested in looking at the EIP proposal you have done and would like to get a copy if possible. If not will copies be available at the public libraries throughout the state?

Any information your office may steer my way would be appreciated and I am looking forward to hearing from you in the future. I only hope the dreams of your company and of my family to utilize the lands correctly will be reached.

Sincerely,
Dennis Fitzpatrick
Dennis Fitzpatrick

Address: Dennis Fitzpatrick
PO Box 945
Makawao, Hi. 96768
1 A 4 M-110 - Ohilani Road

THE ESTATE OF JAMES CAMPBELL

March 16, 1982

Mr. Dennis Fitzpatrick
Post Office Box 945
Makawao, Hawaii 96768

Dear Mr. Fitzpatrick:

Kahauale'a Geothermal Project - Campbell Estate

Thank you for your letter expressing interest in our geothermal project and for your words of encouragement. Your name has been placed on our geothermal newsletter mailing list and you should have received the second newsletter by now.

The answers to your many questions and concerns will be addressed in the Environmental Impact Statement being prepared by our engineering and planning consultant, Willam Y. Thompson, of R. M. Towill Corporation. I believe that Mr. Thompson is much more knowledgeable of the technical aspects of the project and I have, therefore, referred your letter to him for the proper response.

As you may anticipate, the E.I.S. will be a lengthy document and we regretfully cannot send everyone a copy. However, copies will be made available at public libraries, and Mr. Thompson will be made aware of your desire to be able to inspect the E.I.S. at a library in your area.

May I assure you that both the developers and The Estate of James Campbell are concerned about the potential impacts of a geothermal project and intend to follow the strict guidelines of the law and regulations in order to utilize the land at Kahauale'a correctly.

Again, thank you for your expression of interest and encouragement.

Very truly yours,

O. K. Stenmer
Chief Executive Officer

AK/ga:214m

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BRANCH OFFICE:
1765 SCOTT BOULEVARD SUITE 210
SANTA CLARA, CALIFORNIA 95050
TELEPHONE (408) 985-1810

April 30, 1982

Mr. Dennis Fitzpatrick
P. O. Box 945
Makawao, Hawaii 96768

Dear Mr. Fitzpatrick:

SUBJECT: Kahauale'a Geothermal Project
Environmental Impact Statement

Your inquiry to Campbell Estate has been forwarded to us for reply. I am happy to offer you the following answers in reponse to your questions:

Fumes

The natural emission of volcanic gases from the Kilauea Volcano and vents within the rift zone have been going on for years and years. The native forest in this vicinity is thriving and it appears that the volcanic gases are part of the ecological makeup of this region.

Land Values and Taxes

Land values, generally, have been rising. Even the original purchase price of the Fern Forest Estate Subdivision would seem ridiculously low today. The number of new jobs to be created by this project, is small. However, if the electricity generated by this project is to be utilized on the island of Hawaii, there will be impact on the County's economy. Land values will rise if there is a healthy real estate market. For the many persons who purchased lots for speculation or a nestegg, their realization of a return on their investment may come true. Since the Kahauale'a Geothermal Project is planned to be executed over a 14 to 20 year period, the change, if any, will be gradual.

Job Opportunities

The developer will bring in the drilling crew from the mainland. There will be about 15 persons to handle the drilling operations. However, it is expected that after a time local residents will be trained to replace the mainland work force for the most part. Construction will be handled by local contractors and those employed in the construction industry should benefit from the work generated by this project--land clearing, road construction and power plant construction.

Your positive outlook at the possible benefits to the Big Island by this project is appreciated. We will see that copies of the project newsletter are mailed to you. We feel we have a good thing going for the Big Island and want local residents to be fully informed on all aspects of this project.

Aloha,

William Y. Thompson, Manager
Planning and Land Development Department

WYT:cs-10

ALU LIKE
WORKING TOGETHER

HAWAII ISLAND CENTER
455 Pulani Street Hilo, Hawaii 96720
Telephone: (808) 961-2625

Febuary 4, 1982

Fred E. Trotter
Kahaule'a Geothermal Project
Campbell Estate
828 Fort St. Mall, Suite 500
Honolulu, Hawaii 96813

Dear Fred.

I have enclosed a copy of my report to my Executive Director. It was in response to the EIS we had received dated October 1981.

Some of the areas we touched on during our discussion at your office.

My feeling is that the EIS was hostily put together and had glaring omissions that we needed to address or be remiss in our responsibility to our consituency.

I am looking forward to the other report which I understand addresses some of these concerns.

Keep in touch, and if we can kokua this way, let us know.

Me Ke Aloha Pumehana

Betty

Betty Snowden
Island Center Administrator

A private non-profit social change organization striving toward native Hawaiian economic and social self-sufficiency.

E alu like mai kākou, e nā 'oiwi ō Hawai'i
Let us work together, natives of Hawaii

1/82

Concerns related to: KAHA'LE'A GEOTHERMAL PROJECT - Campbell Estate
Environmental Impact Statement - Tewill Report

Betty Snowden, Alu Like, Inc
Hawaii Island

page 7 para 3

"It is estimated that full development of the geothermal resource potential in the Kahaule'a project area may require up to 35 multiple well drilling sites assuming it is possible to conduct directional drilling of up to 6 wells per drilling site."

35 sites
6 wells per
210 wells

Remarks: The community needs to made aware of the fact that the problems they are now experiencing with the one well they have in the area (Bernwell) will be multiplied times 210. Presently, there are complaints about noise and smell.

. . . . . .

page 8 para 1

"All pipelines to transmit the geothermal fluids from the wells will be constructed adjacent to the connecting roads between well sites and power plants (or other consumer facility). These pipelines are planned to be fabricated of steel in dimensions up to 22 inches in diameter and will be mounted on steel support structures (saddles) approximately 4 feet above ground."

Mana'o:

This equates into a pipeline along the highway from the project in the area of the volcano to Hilo bay 6 feet above ground..... like the Alaskan pipeline. This would destroy the present esthetics of the 30 mile or so route, not to mention the flora and forests.

. . . . . .

page 8 last para

"It is planned that processed geothermal fluids which cannot be disposed of on the surface will be reinjected into a completely enclosed and sealed well bore to a depth that will ensure compliance with existing regulations. One injection well is planned for every four production wells."

Mana'o:

This equates into 50 for the 210 wells estimated. Questions needing to be asked: What kind of fluids, define processed fluids? What amounts? What degree of seepage is expected to reach the coastline? By what timeframe? Will these fluids contaminate the fresh water springs near the coastline? Justify response.

. . . . . .

page 11 para B

" The primary environmental objective is to assure that exploration and development of geothermal resources within the Kahaule'a project will not adversely affect the physical and biological environment to a significant degree."

Mana'o:

Define significant degree.

page 15 last para

" A large fraction of the rainfall sinks into the permeable lava surface and moves down to the water table. Some groundwater is perched above sea level on ash beds or other light layers, and some is impounded in the lava by dikes in the rift zones. The greatest groundwater reservoir is near sea level where fresh recharge from rainfall and from overflowing or leaking higher aquifers accumulates in wide spread bodies floating on the slightly heavier seawater. A part of the wter perched or impounded above sea level discharges into streams and flows into the ocean, but most of the ground-water escapes at sea level as diffused flow along the shores."

Mana'o:

This is precisely what we are concerned about in our concern on page 8 last paragraph. That the processed geothermal fluids will be disposed of on the surface and in capped wells and there is the distinct possibility that these fluids can enter the water tables and contaminate our shoreline.

. . . . . .

page 16 para 3

" The first Ecotrophics into Kahauale'a penetrated a native forest in the northeast sector which contained rare and endangered plants and an entirely new plant species."

Mana'o:

No mention is made as to the plans to protect this.

. . . . . .

page 17 para 1
List of birds commonly found in the area does not list the rare Hawaiian Hawk, known to frequent the area from Hamakua to Puna.

page 17 para 3

Lists chemicals found in geothermal water and steam: mercury, aerometry, fixed gas aerometry, soil chemistry- mercury, arsenic, soil chemistry-ph measurements.....

Mana'o:

Other poisons and pollutants prevail. Careful study by the community should be made to protect themselves and the environment. Volume exitted important.

. . . . . .

page 19 para 1

"Geothermal power production on the island of Hawaii will tend to stabilize the cost of electricity."

Mana'o:

There is no basis in fact to this statement.

. . . . . .

Some other concerns:

Should the wells or the project fail, are there plans to dismantle the structures and restore the areas?

Projected employment opportunities for residents are minimal. The work is technical and would mean workers would be brought in from elsewhere. The social and economic impact concommitant with migration would adversely affect the entire community.

The destruction of the vista of the terrain which is presently virgin forests, the mountain, would be irreversibly permanent to a large degree.

THE ESTATE OF JAMES CAMPBELL

February 9, 1982

Ms. Betty Snowden
Alu Like
455 Piilani Street
Hilo, HI 96720

Dear Betty:

Many thanks for your time and effort in coming to Honolulu to meet with us on our geothermal project. I have referred your letter of February 4 and questions therein to Mrs. Mendes and she will be responding to you shortly.

In any undertaking as large as this one, there needs to be strong leadership and I am fully prepared to give it to direct this project. At the same time I want you, as well as others, to know that it is not my style to steamroll over people and I am sure it isn't Os's style either. We need to have an open mind and a listening attitude so that we can learn of the people's concerns. I hope you will continue to voice your opinions on behalf of your group.

My thanks again for your time and concern.

Very truly yours,

F. E. TROTTER, INC.
TRUSTEE

Fred

Fred E. Trotter
President

FET:ag

James Campbell Building Suite 500 828 Fort Street Honolulu, Hawaii 96813 Telephone (808) 536 1961

JAN. 1 '82

Dear Mr. Trotter, I was very happy to receive the information you sent out concerning Campbell Estates Geothermal Efforts in Puna. I think your efforts to educate the public about the Estates plans are commendable.

I am especially heartened by your statement "The Kahavaka Geothermal Project must - and it will - address environmental & social concerns." Thats so good to hear and I am confident of your sincerity in this matter. I say this because I have made Puna my home and I would like to see it continue to be a "quality" place to live. I have lived in the Islands since I was tons and I love the peacefulness, beauty, and "country" setting of this district.

My worst fears are that development of this power

2

(which actually is of no benefit to me since my home is solar powered) will bring in with it fellow travelers such as heavy industries specifically a manganese processing factory. This is why I personally fear geothermal development because will it ultimately result in the despoliation of that which I hold dear??

You have a serious responsibility Mr Trotter as you are mandated by your position to reap benefits from your landholdings and at the same time balance the needs and concerns of the people who live in this district. I wish you all the success in your stated endeavor, especially since myself, my friends and family will be living with the results.

Best Regards; Aloha
Greg Owen

THE ESTATE OF JAMES CAMPBELL

February 12, 1982

Mr. Greg Owen
Post Office Box 795
Pahoa, Hawaii 96778

Dear Greg:

Thank you for your letter of January 1 regarding Campbell Estate and our geothermal interest in the Puna district. You are obviously an interested and sincere person who has a strong feeling for that area. I, too, have a deep and abiding concern for the land and the people who live in the area. These islands have been my home all my life and the home of my ancestors.

As you are undoubtedly aware, the search for a geothermal resource is a most difficult endeavor. In Hawaii, the search has been going on for well over 25 years, yet with only a limited degree of success. It is my belief that it will be a number of years from this date before a sizable resource is tested and developed. As you know, our property is in a conservation zone. For that reason, we are subject to much more stringent government and public scrutiny than the group who has been exploring in Kapoho. It will take us much longer to receive the necessary permits to begin the exploration of the first well site.

In your letter you mention that geothermal power would be of no benefit to you because of your solar-powered home, but think of the many others who are dependent upon fuel-derived power for their electricity which this resource may benefit.

In addition, the announcement of the closing of the Puna Sugar Company, while certainly not the end of life on your island, is notable since the plantation has been in existence for almost 100 years. The people who will be directly affected may well also profit from this geothermal resource as it may give them job opportunities to replace the jobs that are lost on the plantation.

As one who is appointed by the Court to oversee the direction of the Estate, I am very conscious of my responsibility. I also have a further, deep and abiding interest in Hawaii which is also of prime concern to me. Everything in our life must be balanced and it must also be good for people.

The question of heavy industry is one that I personally have very little knowledge of. I believe the heavy industry question is best addressed by the public and government officials, but I feel that that industry should be put in its proper place just as people are put in proper locations for their housing and other needs.

In closing, I thank you for your letter. I would like to meet you sometime, and I want you to know that I share your concern for the place you live in.

Very truly yours,

F. E. TROTTER, INC.
TRUSTEE

Fred E. Trotter
President

vy:301u

JACK K. SUWA
CHAIRMAN, BOARD OF AGRICULTURE

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
P. O. Box 22159
Honolulu, Hawaii 96822

January 28, 1982

MEMORANDUM

To: Mr. Susumu Ono, Chairman
Board of Land and Natural Resources

Subject: Environmental Impact Statement Preparation Notice for the Kahauale'a Geothermal Project

The Department of Agriculture has reviewed the subject Preparation Notice and while we realize that the deadline for comments has passed, we would like to offer a few suggestions.

We believe it would be desirable for the EIS to describe the soils by name and in more detail. In addition, large portions of the area have been classified as Other Important Agricultural Land by the Agricultural Lands of Importance to the State of Hawaii system. We suggest that this also be included.

We note that the notice states that the project area has had only limited agricultural use to date. It would be helpful to know whether the project would have any limiting effects on possible future agricultural use.

Thank you for the opportunity to comment.

Jack K. Suwa

JACK K. SUWA
Chairman, Board of Agriculture

cc: The Trustees of the Estate of James Campbell
Office of Environmental Quality Control

SPARK M. MATSUNAGA
HAWAII

WASHINGTON OFFICE
3121 DIRKSEN SENATE OFFICE BUILDING
WASHINGTON, D.C. 20510

HONOLULU OFFICE
3104 FEDERAL BUILDING
HONOLULU, HAWAII 96850

United States Senate
WASHINGTON, D.C. 20510

CHIEF DEPUTY
DEMOCRATIC WHIP

MEMBER:
COMMITTEE ON ENERGY AND NATURAL RESOURCES
COMMITTEE ON FINANCE
COMMITTEE ON VETERANS' AFFAIRS

January 25, 1982

Mr. Bryan Harry
Pacific Area Director
National Park Services
Box 50165
Honolulu, Hawaii 96850

Dear Mr. Harry:

Thank you for your call to my office requesting information on legislation related to geothermal energy, particularly with regard to the commercial drilling for this indigenous energy alternative next to the boundary of the Hawaii Volcanoes National Park.

I am enclosing for your information my press releases 80-58 and 81-60, and in addition, Senate Report Number 96-699, which elaborates on action taken by the 96th Congress. You will want to pay special attention to pages 24 and 51, which embellish the provisions of Section 124 of S. 1388, the "Geothermal Steam Act Amendments of 1980."

As you might know, I have been a strong advocate of energy self-sufficiency for the State of Hawaii. At this time, geothermal energy is closer to commercialization than the other renewable energy technologies, and I would like to see accelerated development of this option.

Hawaii today imports more than 90% of the energy consumed, mostly from OPEC nations. Of great concern to me is that we are continuing to import as much petroleum into our state as we did at the time of the 1973 oil crisis. The only difference is that we are now paying 1200% more. If we did not have an oil import bill, our state net balance of trade would be positive. The only way we can reverse this negative economic statistic is by reducing our dependence on imported energy.

I would like to note, though, that I would be opposed to any development that on balance would be detrimental to the population or the environment. I took special pains to obtain the advice of experts before inserting language into S. 1388 to permit geothermal energy exploration beyond the boundaries of the Hawaii Volcanoes National Park. Unlike Yellowstone National Park, the national parks in Hawaii do not have any unique thermal manifestations that in the language of the law would be considered to be of national significance. Sulfur Banks was at one time mentioned as possibly an interesting

surface manifestation, but it was determined that the discharge varied with rainfall, eruptions, earthquakes and the like, and by itself should not restrict geothermal development on private land.

The National Environmental Policy Act, Clean Air Act and a number of other environment related laws have in the past been cited by certain groups opposing geothermal energy. To my knowledge there has not been a court verdict that prevented exploration in the prospect of possible damage to the environment. I would certainly hope, anyway, that any geothermal development, at the boundary of a national park, or anywhere in Hawaii, will intelligently and safely handle the geothermal effluents to minimize adverse effects on the environment.

As a responsible director of the National Park Services in the Pacific Area, I trust that you will be watchful over the progress in geothermal energy development in Hawaii. Please do not hesitate to contact me should you feel that I can be of assistance to you in helping safeguard our national park environment.

Aloha and best wishes.

Sincerely,

Spark M. Matsunaga

Spark Matsunaga
U. S. Senator

Enclosures: Press Releases 80-58, 81-60
Senate Report 96-699, 96th Congress, 2d Session

Blind cc: Mr. Oswald K. Stender
Chief Executive Officer
The Estate of James Campbell
Suite 500
828 Fort Street
Honolulu, Hawaii 96813

NEWS from SPARK M. MATSUNAGA
U.S. Senator from Hawaii

81-60

FOR RELEASE: July 17, 1981

GEOTHERMAL AGE DAWNS IN HAWAII
ON THE BIG ISLE

Washington, D. C.--The U. S. Congress greeted the dawn of the geothermal age in Hawaii today as the Hawaii Geothermal Power plant in Puna was dedicated by Governor George Ariyoshi and the representatives of the sponsoring organizations of the Hawaii Geothermal Project (HGP). Well "A" will be generating three megawatts of electricity which will be fed into the Hawaii Electric Light Company grid.

In a speech on the Senate floor, Senator Spark Matsunaga (D-Hawaii) said the successful commercial operation of the HGP "A" well is the culmination of ten years of concerted work.

"It was nearly a decade ago that Dr. John Shupe, then the Dean of the College of Engineering at the University of Hawaii, visited me in my House office suite and urged me to introduce legislation which would promote the development of geothermal energy," Matsunaga recalled. "He was pleasantly shocked to learn that I had already introduced just such a bill and presented him with a copy.

"That first legislative effort launched Hawaii on its journey to energy self-sufficiency, and I have since introduced and seen enacted a number of bills relating to solar photovoltaics, windpower, and ocean thermal energy conversion; but I feel almost a parental sense of pride in Hawaii's first successful geothermal project," he said.

Planning for the Hawaii geothermal energy project started before the 1973 energy crisis, Matsunaga observed, and its success is due largely to a unique degree of cooperation between federal, state and local governments and the private sector. The federal government funded more than 80 percent of the project, which cost a total of $13.4 million. The Hawaii State government and the government of the County of Hawaii provided nearly 20 percent of the funding and, in addition, the University of Hawaii, a state institution, provided much valuable research and development assistance.

"One of the necessary responsibilities of government is to create a favorable economic and institutional climate from which our free enterprise system can innovate and prosper," said

-more-

Matsunaga. "The Hawaii Geothermal Project is an outstanding example of a government successfully at work, for, through the front-end injection of public funds, uncertainty and risk were greatly reduced, technical and financial creditability was established, and concerns about environmental, social, cultural and legal factors were resolved.

"During this period when oil imports could be terminated at the whim of a Middle East potentate, the federal, state and local governments should place high priority on accelerating the commercialization of energy alternatives which could reduce oil imports," said Matsunaga, predicting increased private sector interest in geothermal energy as a result of the HGP project.

"The early success of the HGP-A well at Puna does not mean that the energy battle is won," Matsunaga said. "To begin with, technical feasibility does not ensure commercial viability. Then, too, unproductive wells will be drilled. Similar discouragement will occur when oil prices temporarily stabilize or even drop, but these setbacks must be transcended. The only real alternatives to natural energy are oil, coal and nuclear power, all of which present definite environmental and economic problems.

"Natural energy, too, could offer some environmental difficulties, although there is evidence that natural recycling could be designed into the process," continued Matsunaga. "For example, in the case of geothermal energy, the two most prominent contaminents might well become valuable by-products. First, hydrogen sulfide, which has a distinctive and repulsive rotten-egg smell could be recaptured and converted into sulfur dioxide or sulfuric acid for industrial uses. Secondly, the silicon compounds recovered in the geothermal process can be refined into solar photovoltaic cells.

"Geothermal energy will also be used for direct heating and drying of agricultural products and to convert biomass into liquid fuel," said Matsunaga. "Several international consortia are investigating the prospects of processing manganese nodules and alumina using geothermal energy."

Hawaii is the second state in the union to generate electricity from geothermal energy. The first was California. In addition to its geothermal project on the Big Island of Hawaii, the Island State was first to generate electricity by ocean thermal energy conversion, and it will soon be the site of a major wind farm. Earlier this month, Matsunaga dedicated the first lived-in solar photovoltaic residence on the Island of Molokai, the home of retired public school principal Henry Wielke.

-30-

NEWS from SPARK M. MATSUNAGA
U.S. Senator from Hawaii

80-58

FOR RELEASE: June 26, 1980

SENATE PASSES GEOTHERMAL STEAM ACT AMENDMENTS
TO LIBERALIZE USE OF GEOTHERMAL ENERGY NEAR NATIONAL PARKS

Washington, D.C.--The United States Senate has passed the Geothermal Steam Act Amendments of 1980, to liberalize the Geothermal Steam Act of 1970, so as to permit the exploitation of Geothermal energy in the vicinity of National Parks.

The 1970 Act established a leasing system which made Federal lands available for geothermal development, and 1200 leases have been issued by the Department of Interior since then. However, with the exception of the Geysers and a single greenhouse in New Mexico, there is no commercial development of geothermal resources on Federal lands.

The 1980 Act is principally directed at removing impediments to development and is intended to result in widespread commercial activity on Federal lands and lands in the proximity of these lands in the near future.

Senator Spark Matsunaga (D-Hawaii), cosponsor of the measure with Senator Frank Church of Idaho, in a supporting speech on the Senate floor, provided clarification on a matter of strategic importance to Hawaii. He indicated that "two major national parks, the Hawaii Volcanoes National Park and the Haleakala National Park, adjoin areas with considerable geothermal promise.

"It is my understanding that the nature of the underground geothermal reservoir systems at both sites, coupled with a total absence of surface manifestation at Haleakala, and minimal and sporadic activity in the Hawaii Volcanoes region, is such that geothermal energy development should be a permissible activity on state and private lands in the proximity of these national parks. More specifically, I submit for the record, a letter from Ira Hutchinson of the National Park Service to Senator Dale Bumpers, Chairman of the Senate Subcommittee on Parks, Recreation, and Renewable Resources, dated March 14, 1980, which states that:

> '...there is very little likelihood that thermal features at the surface within the Hawaii Volcanoes National Park would be affected by the development of facilities outside the park.'

-more-

"This means that geothermal development would be an allowed activity immediately outside the Hawaii Volcanoes National Park, even though it is on the National Park Service's list of National Parks with active geothermal surface. The Haleakala National Park is not expected to make the list, so there should not be any Federal restriction to geothermal development on Maui."

The importance of this clarification can be better understood in the light of the options which are available to the Secretary of Energy in protecting nationally significant thermal features. One of the options would prohibit geothermal development in a fifty mile band around a protected national park. Should this extreme safeguard be implemented, geothermal activity in Hawaii would be seriously retarded. For example, the 3 megawatt geothermal generator at Puna, which is expected to begin producing electricity by March of next year, would probably be restricted. Activities of the Geothermal Exploration and Development Company, which has begun drilling in an adjoining reservoir, and of a Japanese investment firm, which has requested permission to drill nine wells in the Puna region, might also be restricted. The Church-Matsunaga bill just passed would permit such activities.

-30-

THE ESTATE OF JAMES CAMPBELL

February 10, 1982

Senator Sparky Matsunaga
5121 Dirksen Building
Washington, DC 20510

Dear Senator:

I received the copy of your letter dated January 25 to Mr. Bryan Harry, Pacific Area Director, National Park Services, regarding geothermal energy activities next to the boundary of the Hawaii Volcanoes National Park.

I feel compelled to acknowledge receipt of this letter, particularly because I was impressed with the points which you made in that letter which appear to me to be well stated and contained information which I was not aware of and, therefore, helped me to have a better understanding of the mission to achieve energy self-sufficiency by the State of Hawaii and the minimal impact of geothermal energy development on the environment.

Thank you for the courtesy of sending material to me and for your dedicated interest in alternative energy.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

James Campbell Building Suite 590 820 Fort Street Mall Honolulu, Hawaii 96813 Telephone 536-1961

United States Department of the Interior

NATIONAL PARK SERVICE

HAWAII VOLCANOES NATIONAL PARK

HAWAII 96718

IN REPLY REFER TO:

N40(HAVO)

January 19, 1982

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
James Campbell Building - Suite 500
828 Fort Street
Honolulu, Hawaii 96813

Dear Mr. Stender:

Your letter of January 15, 1982 requests the position of Hawaii Volcanoes National Park regarding the Kahauale'a geothermal project on the Campbell Estate property immediately adjacent to the national park. An official position by the National Park Service will not be possible until we have thoroughly reviewed the draft environmental impact statement currently in preparation.

We are certain that geothermal energy has a bright future on the Big Island. It appears to be a preferable alternative to fossil fuel or nuclear power generation.

We have concerns with this particular project as it is in an undeveloped native rainforest immediately adjacent to the park. The structures and roads involved in the project may be highly visible from within the park. Access to the remote Makaopuhi section of the park may be considerably increased. Exotic plants may have new corridors along which to invade the national park in increasing numbers. Since the project is upwind of the park, we have concerns regarding both air and noise pollution. What is the current air quality in the park and what impact will this project have on the plant and animal communities in the park? The project site and the park are considered to be habitat for the endangered O'u.

In light of the above concerns, our preliminary position is that given the variety of geothermal proposals current on the Big Island, we would prefer to see other properties further from the park developed for their geothermal potential. If geothermal energy is developed on the Campbell Estate

property, we would prefer to see it developed as far from the park boundary and as far down the rift zone as possible. In any case, we hope that the Campbell Estate will make every effort to mitigate all impacts this project would have upon Hawaii Volcanoes National Park.

Thank you for the opportunity to comment on the proposal.

Sincerely,

David B. Ames
Superintendent

January 28, 198218

Mr. David B. Ames
Superintendent
Hawaii Volcanoes National Park
Hawaii 96718

Re: KAHAUALE'A GEOTHERMAL PROJECT

Dear Mr. Ames:

Thank you for your letter of January 19 regarding our Kahauale'a project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and we will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

245 North Kukui Street, Honolulu, Hawaii 96817, Telephone (808) 537-5966

AMERICAN LUNG ASSOCIATION of Hawaii

December 23, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street - Suite 500
Honolulu, Hawaii - 96813

Dear Mr. Stender:

Subject: Kahauale'a Geothermal Project

We have reviewed the EIS Preparation Notice for the subject project and have a number of suggestions to make. In assessing the long-term air quality impact of the project, the EIS should include the following:

1. Identify principal air pollutant species expected to be emitted.
2. Estimate controlled and uncontrolled emission rates of each species.
3. Estimate short-term (hourly, daily) and long-term (seasonal, annual) maximum concentrations of each species.
4. Describe control technologies that will be employed including expected efficiencies.
5. Evaluate the significance of any health effects associated with the pollutant species identified.
6. Consider terrain, local meteorology, and location of existing and potential future inhabited areas in assessing the significance of air quality impact.

If our suggestions have raised any questions or you or your consultants desire additional clarification, please do not hesitate to contact us.

Sincerely yours,

James W. Morrow
Director
Environmental Health

JWM:jm
C2/LA6

Christmas Seals Fight TB, Asthma, Emphysema, Air Pollution

December 29, 1981

Mr. James W. Morrow
Director, Environmental Health
American Lung Association
245 North Kukui Street
Honolulu, Hawaii 96817

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Morrow:

Thank you for your letter of December 23 regarding our Kahaualea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

P.O. Box 665
Volcano, HI. 96785
December 15, 1981

Mr. Fred E. Trotter
Trustee, Campbell Estate
828 Fort Street Mall
Suite 500
Honolulu, HI. 96813

Dear Mr. Trotter,

Mahalo for coming to the Big Island to inform the people of Puna about Campbell Estate's proposed geothermal project. Unfortunately I was working on Oahu at the time and was unable to attend any of your public meetings.

I have read carefully the Environmental Impact Statement Preparation Notice for the Kahauale'a Geothermal Project. As a consulting party and in order to make a clearer judgment on the environmental impact of the project, I seek answers to the following questions.

1) What light and heavy industries does Campbell Estate see coming into the area upon successful generation of electricity, hot water and steam? Be specific please.

2) Have any industrial inquires been received by Campbell Estate? If so, please list all companies and their principal activities.

3) Specifically, what industries would stand to benefit from geothermal energy and its by-products?

4) At Campbell Industrial Park on Oahu, what industries are currently present and operating?

I don't mean to burden you with this request but answers to these questions will help me greatly to personally assess the environmental impact of this project.

Coming personally to the Big Island showed guts and class and I respect you for it. Thank you kindly for your time and help.

Sincerely,

Wayne Westlake

Wayne Westlake

THE ESTATE OF JAMES CAMPBELL

February 1, 1982

Mr. Wayne Westlake
Post Office Box 665
Volcano, Hawaii 96785

Dear Mr. Westlake:

Thank you for your letter concerning our Kahauale'a Geothermal Project. Your letter has been forwarded to me for the proper attention and response. I have enclosed a copy of our first newsletter in case you have not received one. I hope there will be future opportunities to meet and discuss our project with you.

The questions you pose in your letter of December 15, 1981 request very specific answers and I am not sure at this writing that we will be able to provide you with satisfactory answers. I will provide you, however, with as much as we can and hope that you will bear with us in anticipation of the Environment Impact Statement soon to be completed.

As you may know, the land at Kahauale'a is designated by the Land Use Commission as a Conservation District. Therefore, any use of the land for non-conservation related purposes will be subject to careful regulation and approval before such use, by the State Department of Land & Natural Resources through its Board of Land & Natural Resources. The procedure for acquiring approval from the Board of Land & Natural Resources for the development of geothermal energy on the land at Kahauale'a, requires the applicant to delineate the general scope of the project and relate the various contemplated uses.

The current plans for geothermal energy development at Kahauale'a and the focus of the preparation of the environmental impact statement is primarily to prove the existence of a geothermal resource and the development of that resource for the direct generation of electrical energy. The more immediate plans are for the generation of electricity by geothermal means to supply a part of the requirements for the County of Hawaii. The future projection is for the development of electrical energy beyond the requirements of the County of Hawaii, to be sent via the State's proposed submarine cable to the other counties to help supply their requirements. The precise extent of the use of this energy for the other counties is to be mainly a function of the planning of the various appropriate State and County officials and the feasibility of the implementation of the submarine cable.

The current plans for geothermal energy development at Kahauale'a do not immediately contemplate any direct use application of geothermal water or steam or their by-products, although those uses are perhaps viable future possibilities. For your information, however, the uses of geothermal heat are numerous and varied. For example, direct heat applications as summarized in a State geothermal report, range from fish hatcheries and refrigeration to sugar refining and fish meal drying. Also, residential homes and swimming pools have been heated for many years in Iceland and Russia through the use of geothermal heat. Other possibilities include lumber production, fruit puree processing or some forms of aquaculture. The State of Hawaii is presently researching other possible uses of geothermally produced electricity and heat, the results of such research should expand the current knowledge of the benefits of geothermal energy. Although we believe that many new opportunities for geothermal energy uses will in the future materialize, the most immediate State goal is to reduce our current unfavorable dependence on foreign oil for electrical generation and transportation needs.

In response to your inquiry regarding the various industries currently operating at James Campbell Industrial Park, we are enclosing a brochure which explains the current uses there. We apologize for the delay in responding to your request for information, but we are doing our best to respond timely to all such requests. Thank you for your interest in our project and taking the time to express your concerns. May I assure you that the Estate will continue to respond in good faith to the concerns of the people of Hawaii County and our plans are for the continuation of informational meetings in the various communities as the development progresses.

With warm regards,

Valerie L. Mendes
Director, Public
& Governmental Affairs

CS/bw:205-4b

Enclosures

University of Hawaii at Manoa

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

Office of the Director

December 7, 1981

PN:0015

Mr. O.K. Stender
Chief Executive Officer
The Trustees of the Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Stender:

EIS Preparation Notice
Kahauale'a Geothermal Project
Puna District, Island of Hawaii

The Environmental Center has briefly reviewed the above EIS Preparation Notice with the assistance of Donald Thomas, Hawaii Institute of Geophysics; Jacquelin Miller and Garret Kawamura, Environmental Center.

One of the more critical concerns which will need full coverage in the EIS is the potential effect of the geothermal project on air quality. To adequately assure that not only an acceptable level of protection is provided for the local environment but also that the developer is protected from unwarranted blame for variations in air quality arising from naturally changing geologic or atmospheric conditions, we would recommend a one-year program of air quality monitoring. This 1 year monitoring program need not be completed prior to initial drilling but should be initiated at the earliest possible stage so that sufficient meaningful data is available for evaluation prior to extensive well testing at the site.

The draft EIS should fully indicate plans for the recovery of abandoned drill sites, e.g. well plugging, removal of drill pad, replanting with native fauna, etc.

Surface disposal and injection wells are the two proposed methods for the disposal of processed geothermal fluids. In order to assess the impacts of these methods, several areas need careful examination. These include the groundwater hydrology of the project site and the effects of the fluids on the native flora, potential for evaporative pollutants to the atmosphere, odiferous pollutants, health hazards, and a description of the adjacent and neighboring land uses with appropriate maps, that could be affected by these wastes. We would suggest that the drafters of this EIS utilize to the fullest extent possible the information and concerns expressed in the review comments prepared for the Hawaii Geothermal Research Station Utilizing the HGP-A Well EIS. Use of this material should expedite this EIS documentation as well as help to focus this EIS toward the specific and more critical areas of concern.

AN EQUAL OPPORTUNITY EMPLOYER

Thank you for the opportunity to be a consulted party during the preparation of the draft EIS.

Sincerely,

Doak C. Cox
Director

cc: Department of Land and Natural Resources
Office of Environmental Quality Control
Jacquelin Miller
Garret Kawamura

December 17, 1981

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

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Cox:

Thank you for your letter of December 7, 1981, regarding our Kahaualea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

①

Dec. 3, 1981

Victor R. Becker
P.O. Box 477
Volcano, Hawaii
96785-0477

R.M. Towill Corporation
677 Ala Moana Blvd. #1016
Honolulu, Hawaii 96813
Attn: W.Y. Thompson

Dear Mr. Thompson:

I am writing in response to your recent presentation at the Volcano Visitor Center, concerning the development of geothermal energy on Campbell Estates lands in Puna on the Big Island. My interest in this matter is manyfold, and it is because of this that I am requesting to be put on your list of people who are to be kept informed as to the progress of the Kahauale'a Geothermal Project. I would also like to be provided with an Environmental Impact Statement when the statement is completed, and notice of all public hearings and presentations concerning the Kahauale'a Project and any other geothermal development which is anticipated or which comes about subsequent to the proposed mining lease to Campbell Estates, irregardless of where such hearings or presentations are held. Information disclosing existing noise level requirements would also be appreciated.

I would like to say that, although I am personally opposed to the development of geothermal energy

(2)

in Puna, I recognize the inevitability of such development and the ever-increasing need in Hawaii for an alternative to imported energy. This need is magnified by the financial instability of the sugar industry, which supplies a portion of the electrical power now available, and the probable cessation of sugar cultivation. Given the choice of fuel oil, nuclear or geothermal energy, I'll favor geothermal. I would much rather see the individual development of solar and wind power, but I doubt if the "people" could muster enough individual concern and interest to supply their own needs. My wife and I supply our electrical needs with a small gasoline generator and battery charging system. Our cost is minimized, as is our use. We intend to develop our own sources of solar and wind power, along with our present system. As we have no inspiration to hook up to HELCO lines, we do not expect to benefit directly from geothermal sources of energy. I am fully aware of the benefits of commercially available electricity in all aspects of modern life. Also, it is obvious that solar and wind power will not satisfy all of our needs, especially those of power hungry Oahu and such industrial installations as a manganese nodule plant, which is proposed to be located in the Kalapana area. Of course, without the availability of sufficient electrical energy, such a processing plant would not be feasable, and of course without the existance of a sizable "market", the development of a power source of the magnitude proposed, would not be

feasable. As I commented at the meeting of Dec. 2, 1981, if the "people" were willing to put up the money, they could claim control of the destiny of their electrical future, by the creation of some kind of Public Utility District, or by developing their own sources of energy, or both. But it was interesting to note that those at the meeting who spoke loudest in favor of conserving our "aina" and retaining ownership of the geothermal resource for the people of Hawai'i, concluded their comments with a plea that ran something like this," Just lower our electric rates". It seems unrealistic to me for anybody in this day and age to expect the electric rates to go down. From my observation, it is apparent that much of the opposition to the Kahauale'a Project could be easily bought with empty promises and paved roads.

As far as the rights of the native Hawaiians are concerned, it is a historical fact that the native Hawaiians had little or no rights until the appearance of Western Civilization, and are in the present possession of more rights than the average Hawaiian before 1778 could even have conceived of (God Bless America). In fact, eligible Hawaiians probably have more rights than most sovereign citizens of this State. All I see in the argument of the native Hawaiian people in this issue, is a ploy to usurp and deny the rights of those people who are willing to invest the capital neccessary to tap this resource and who deserve ample compensation. The Hawaiian people and the people of Hawaii would be well advised to "put their money where their mouth is" and endeavor to acquire the desired rights in a self-earned fashion, as a right denied to one is a right denied to all.

It is therefore not my intention to stand in the way of the "wheels of progress", but to have a positive input in the development of this resource. The opposition is weak and the "wheels" are already set in motion, and I feel that compromise and cooperation are by far the most effective and efficient means of accomplishing a desired goal, namely the economic installation of these generating plants in a responsible and workmanlike manner, in accordance with all applicable laws and regulations and with the rights and interests of ALL parties involved being protected and considered.

As I mentioned earlier, my interest in the development of the Kahauale'a Project is varied. First and foremost, I am a land owner and resident of lands which are located within five miles of the proposed project site. My wife and I plan to live here for an indefinitely long period of time (we have no other place we'd rather be at present). We have catchment water, livestock and crops under cultivation. Any adverse ecological effect from the proposed development of geothermal energy on Campbell Estate lands is bound to affect us in some way, and possibly cause us to decide to leave the area. It is for this reason that I am personally opposed to

the development of geothermal energy in Puna. I doubt that my fears for the environment will be sufficiently quieted, and I will not hesitate to initiate, or cause to be initiated, any legal action neccessary to prevent the selfish or irresponsible alteration of the environmental conditions which presently exist in Puna, by people who do not reside in the area, or local residents for that matter. In my mind, the rights of the residents of Puna, especially the residents of subdivisions adjacent to lands on which geothermal development is contemplated, are prior and paramount, since the residential use of these lands was established well before any talk of geothermal development began, and the land owners of these residential, or agricultural lands are entitled to the benefit of the quiet enjoyment and use of their lands. Use is the key issue. The established use of most of the land in Puna is agricultural and residential, or such use is intended or designated. No developer has the right to establish a subsequent use that would endanger the continuance of previously established uses, especially, as in the case of geothermal energy development in Puna, where such subsequent use is to benefit people outside the community affected, Oahu for instance, and industries not currently present, such as the proposed manganese nodule industry. I am quite sure that the people of Puna are not aware of the magnitude of these proposed projects, and the price they will have to pay for the benefit of others, who will not have to live with the unacceptable

negative affects to the environmental status quo. I am therefore committed to the education of the general public and myself concerning this matter, and intend to become actively envolved in any community or private effort to see that no added burden will be placed on the ecology of the Puna area, except of course, in the immediate proximity of the generating plant sites and absolutely confined to the private lands of Campbell Estates or any other similar interest.

My wife and I wish to be well informed, well in advance, so that we will know what to expect and can alter our future goals accordingly, if required. The emmission of noxious fumes and noise levels are of prime concern, not to mention the possible effects of altering the "plumbing" of the Volcano.

Also, nobody can give good constructive criticism unless they are well informed and objective. Superstition, heresay and outright ignorance are not the sources of rational thought, and not only cause one to lose respect in the eyes of clear thinkers, but also will not hold up in court. My goal is to acquire as much well-founded information about the project as possible in order that I will not be found guilty of perpetuating the heresay, rumor and emoticnalism which always surrounds developments of this nature.

Secondly, being a holder of a Hawaii State Supervising Electricion's license, being a member, since 1970, of Local #48 of the International Brotherhood of Electrical Workers of Portland, Oregon, and being currently registered for work with Local #1186 I.B.E.W. of Honolulu, I have a vested inter-

est in the development of the electrical industry in Hawaii, especially on the Big Island, and in any effect of the development of geothermal energy on the electrical industry. I must confess that the existance of interesting industrial-type electrical work in my own "back-yard" is appealling, as I have always preferred the challenge of industrial work over commercial and residential types of work. By being informed about the effects and proccesses of geothermal generation of electricity, I will be more valuable on the job, and in the promotion of the electrical industry.

Thirdly, due to the lack of work in the construction industry, both my wife and I are about to enter the real estate profession and are soon to receive our Hawaii State Real Estate Salesperson's Licenses. Naturally, in order to better represent and inform prospective buyers and sellers, we should be knowledgeable of all conditions which affect the value and living quality of the land we wish to sell. Only a well-informed agent can best serve his employer. We have, ourselves, invested in land in Puna and Ka'u, and are concerned about how these investments will be affected by the development of geothermal energy.

So you see, Mr. Thompson, that our request for the disclosure of all pertinent facts is not idle, and I can assure you that all correspondance will be studied, and will not wind up in the "round file", and will be available to anybody in our aquaintance who erpresses an interest in this project.

We will have numerous questions concerning the

Kahauale'a Project, many of which will probably be answered in the E.I.S. Future correspondance containing these questions and expressing specific concerns will be forthcoming. We will also be in touch with public officials and other bona-fide sources of information, and we will go to the HGP-A well site when it is put back on the line (as you suggested) and survey the situation for ourselves. We will look forward to seeing you at some future meeting, preferably at a reasonably close location to the site of the project, namely in the Hilo, Volcano area.

In closing, I would also like to request that the blue notebook, which was given to other people at the meeting, be provided for my wife and myself.

Sincerely,
Victor R. Becker

THE ESTATE OF JAMES CAMPBELL

December 23, 1981

Mr. Victor Becker
Post Office Box 477
Volcano, Hawaii 96785

Dear Mr. Becker:

Thank you for your letter of December 3, 1981 regarding our Kahauale'a project.

I have referred your comments to our EIS consultant to ensure your concerns are addressed in the EIS preparation process.

We appreciate receiving your comments and we shall respond to the matter which you raised prior to filing of the EIS.

Very truly yours,

O. K. Stender
Chief Executive Officer

CS/ga:214i

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1765 SCOTT BOULEVARD SUITE 210
SANTA CLARA, CALIFORNIA 95050
TELEPHONE (408) 985-1810

December 15, 1981

Mr. Victor R. Becker
P. O. Box 477
Volcano, Hawaii 96785-0477

Dear Mr. Becker:

SUBJECT: Environmental Impact Statement
Kahauale'a Geothermal Project

Thank you for attending the Kahauale'a Geothermal Project informational meeting held at the Volcano Visitor Center and also for your letter dated December 3, 1981. Your comments and evident interest in the project and in Hawaii's future are greatly appreciated and I hope to see you at future meetings.

Enclosed are the County's Geothermal Noise Level Guidelines and the Kahauale'a Geothermal Project Environmental Impact Statement Preparation Notice that you requested.

Aloha,

William Y. Thompson, Manager
Planning & Land Development Department

VT:cs
Encl: Noise Guidelines
EIS Preparation Notice

MR Thompson — 12-2-81

Noise level ordinance
what are the limits
State - County -
please give friend to
Charlotte A. Lewis
Box 33
Volcano, Hi. 96785

Mahalo! —

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December 7, 1981

Ms. Charlotte A. Lewis
P.O. Box 33
Volcano, Hawaii 96785

Dear Charlotte:

Here is a copy of the County's Geothermal Noise Level Guidelines you requested during the meeting at the National Park Headquarters. This item will be discussed in our E.I.S. Document. The developers have assured me they will comply with all Federal, State and County regulations to control noise levels. Since the project will be regulated by the State, compliance will be mandatory.

Hope to see you at our next meeting.

Aloha,

William Y. Thompson
Vice President

WYT:mh
Enc.

DEPARTMENT OF PLANNING
AND ECONOMIC DEVELOPMENT

GEORGE R. ARIYOSHI
Governor

HIDETO KONO
Director

FRANK SKRIVANEK
Deputy Director

Kamamalu Building, 250 South King St., Honolulu, Hawaii • Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

November 25, 1981

Ref. No. 3934

Mr. O.K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Stender:

Subject: Environmental Impact Statement (EIS) Preparation Notice for the Proposed Kahauale'a Geothermal Project, Hawaii County

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

As part of our Coastal Energy Impact Program component, we have been supporting energy developments based on Hawaii's unique and renewable resources. Given the magnitude of this project, however, there may be some significant adverse impacts relative to the statutory requirements of the Coastal Zone Management Program. The EIS, therefore, should thoroughly discuss the anticipated impacts relative to the objectives and policies of Chapter 205A, HRS, the Hawaii CZM Law.

In particular, the EIS should discuss the anticipated impacts on the visual environment and the natural biotic ecosystems. The discussion should include the effects of effluent and wastewater disposal on flora and underground water and the impacts of geothermal venting or air quality standards.

In view of the long range expansion plans for geothermal energy conversion, we also recommend increased communication with the public to ensure early public participation in the planning and review process.

We have no further comments to offer at this time, but would appreciate the opportunity to review the completed Environmental Impact Statement of this project.

Sincerely,

Frank Skrivanek
for Hideto Kono

cc: Office of Environmental Quality Control

December 4, 1981

Mr. Hideto Kono, Director
State Department of Planning and
Economic Development
P O Box 2359
Honolulu, Hawaii 96804

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Kono:

Thank you for your letter of November 25 regarding our Kahaualea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

In response to your recommendation for increased communication with the public, we have scheduled a series of community and business meetings for the Hilo area and will also have a series of newsletters approximating 6,000 per mailing concentrating in the project area.

We appreciate receiving your comments and will respond to the other matters which you raised prior to the filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

PUNA HUI 'OHANA
a non-profit Hawaiian organization

• PUNA HAWAIIAN ORGANIZATION
• HAWAIIAN PARENTS SOCIETY
• HUI OPIO
• YOUNG HAWAIIANS OF PUNA

November 23, 1981

Mr. O. K. Stender, Chief Executive Officer
The Trustees of the Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hi., 97813

Dear Mr. Stender,

Please find enclosed our comments with regard to your recently circulated Notice of Preparation in connection with geothermal development at Kahauale'a on the Big Island.

We hope we have been helpful in communicating the concerns expressed by members of the Kalapana Community Organization and the Puna Hui Ohana. Copies of this communication will be forwarded to the Kalapana Community Organization and the Volcano community association.

Thank you for the opportunity to participate in the preparation of the impact statement. If we can be of further assistance to you, please let us know.

Mahalo a nui loa and,

Aloha,

Everett Sonny Kinney
Planner/coordinator
Puna Hui Ohana

For the President
Peter Hauanio
Puna Hui Ohana

POST OFFICE BOX 611 • PAHOA, HAWAII 96778 • TELEPHONE (808) 965-9140

INTRODUCTION:

The Puna Hui Ohana, an aboriginal Hawaiian community organization based in Pahoa, Puna, in accordance with the State Environmental Quality Commission's EIS Regulations, is taking this opportunity to submit comments regarding the environmental effects of the proposed True/Mid-Pacific geothermal exploration activities announced in the Preparation Notice. Your comments, dated October 19, was received by our office on October 22, 1981. Comments were collected which we believe are relevant to the proposed development.

METHODOLOGY:

In a joint meeting with the Kalapana Community organization, also on the list of prospective consulting parties, on November 4, 1981, at Kalapana, the president of the Puna Hui Ohana, Peter Hauanio (who is also a resident member of the KCO), and Hui's planner/coordinator, Sonny Kinney, discussed the general concerns of the Kalapana organization's members with regard to the Kahauale'a environment and its relationship to the Kaimu/Kalapana community. The majority of the member/residents were completely unaware of the proposed geothermal program. A broad informational outreach led by the planner/coordinator added contributed to the group's information base in the process of gathering their perceptions of the project.

The KCO group was asked it they would be willing to participate in a verbal, on-the-spot, group questionaire survey which contained 52 questions requiring 68 answers generally pertaining to environmental concerns usually associated with

natural resource development. All members present indicated a willingness to participate. All participants were then instructed to consider their responses in connection with their perception of changes that might occur rather than on the level or degree of than change. In addition, the group was informed that technical data on probable effects was not yet available.

SAMPLE POPULATION/QUESTIONAIRE:

The survey population numbered 42, all active members and residents of the Kalapana/Kaimu community. The president of the Puna Hui Ohana and the planner/coordinator did not participate in the voting/response. A casual observation appeared to indicate that the population was nearly evenly distributed among, (1) ethnicity: between Caucasian and Hawaiian/part-Hawaiian, (2) male and female and, (3) with a general age range between 30-50 years. Many were retired. A social-economic status profile was not conducted.

Sample responses were recorded in four categories, "yes", "no", "I don't know", and "no response". The respondents were informed that a predominantly "no" vote would point to a "negative declaration" while a substantial "yes" vote would require the developer to submit an environmental impact statement, as far as the community was concerned. A copy of the questionaire and the reponse tabulation are attached.

SAMPLE RESULTS:

The results of the questionaire indicated overwhelming concerns regarding the adverse effects of the proposal---at this point in time. On 26 occasions the "yes" vote was unanimous. Deviations from unanimity averaged approximately three (3) points per response. There were only three (3) "no" responses---in areas showing definite non-application such as changes affecting sewers or septic tanks. Fairly large responses in the "don't know" category were reflected in questions concerning; (1) the nature of discharges altering surface water quality, (2) nature of new or replenishment of plant species, (3) use of fuel or energy in substantial amounts and, (4) over-all effect in solid waste disposal".

COMMENT:

To what extent these perceived changes will contribute to significant environmental effects are not known by the group. It is generally believed by the group that adverse effects will occur in relation to the level of changes and as a direct result of a failure to examine all possible conflicts (see effects attached).

In view of the limited time available the survey of community responses was conducted in a very casual manner It was intended to indicate to the developer that a level of concern could be casually measured to the extent where the developer is made aware that such concerns exist and probably require substantiation and further investigation.

Both the Kalapana Civic Organization and the Puna Hui Ohana are hopeful that the foregoing comments will be helpful to the preparation of the environmental impact statement. In addition, may we respectfully suggest the preparation of a social impact management program for both the Kalapana and

and the Volcano/Fern Acres area.

****

SIGNIFICANT EFFECTS:

A project will normally have a significant effect on the environment if it will:

(a) Conflict with adopted environmental plans and goals of an affected community;

(b) Cause a substantial negative aesthetic effect;

(c) Seriously affect an endangered species of animal or plant and its habitat;

(d) Interfere with the movement of any resident or migratory fish or wildlife species;

(e) Breach local, state or national solid waste or litter standards;

(f) Substantially degrade water quality;

(g) Contaminate a public water supply;

(h) Interfere substantially with ground water recharge;

(i) Disrupt or alter an archaeological, historic or a paleontological site except as part of a scientific study site;

(j) Induce substantial growth or concentration of population;

(k) Cause a substantial traffic increase in relation to existing traffic load and capacity of the street system.

(l) Displace a large number of people;

(m) Encourage activities resulting in use of large amounts of fuel, water, or energy;

(n) Use fuel, water, or energy in a wasteful manner;

(o) Substantially degrade or deplete ground water resources;

(p) Increase substantially the ambient noise levels;

(q) Cause substantially flooding, erosion or siltation;

(r) Expose people or structures to major geological hazards;

(s) Extends infrastructural capacity to serve new development;

(t) Substantially diminish habitat for fish, wildlife, plants;

(u) Disrupt or divide the physical arrangement of an established community;

(v) Create a public health hazard or a potential public health hazard;

(w) Conflict with established recreational, education, religious or scientific uses of the area;

(x) Violate any ambient air quality standard, contribute substantially to an existing or projected air quality violation, or expose sensitive receptors to substantial pollutant concentrations.

RESPONSES TO QUESTIONAIRE CONCERNING PERCEPTION OF CHANGES IN RELATION TO KAHAUALE'A PROPOSAL BY TRUE/MID-PACIFIC

Question	Yes	No	Don't Know	No Response
Will the proposal result in chages such as:				
(1) Unstable earth conditions or in changes in geological substructure:	37	0	5	0
(2) Disruptions, displacements, compaction or overcrowding of the soil?	41	0	1	0
(3) Destruction, covering or modification of unique physical or geological features?	30	0	12	0
(4) Change in topograhpy or ground surface relief features?	40	0	2	0
(5) Any increase in wind or water erosion on of off the site?	35	0	7	0
(6) Changes in deposition of beach sands or siltation, deposition or erosion modifying channel, river, stream or bed of any bay, inlet, lake or ocean?	Did not apply			
(7) Exposure of people or property to geological hazards such as earthquakes, landslides, mudslides, ground failure or similar hazards?	40	0	2	0
(8) Substantial air emissions or deterioration of ambient air quality?	42	0	0	0
(9) Creation of objectionable odors?	42	0	0	0
(10) Alteration of air movement, moisture or temperature, or changes in climate either locally or regionally?	40	0	2	0
(11) Changes in currents or course of water movements in marine or fresh water?	Did not apply			
(12) Changes in absorption rates, drainage patterns, or rate of surface run-off?	40	0	2	0
(13) Alterations to the course or flow of flood waters?	Did not apply			
(14) Change in the amount of surface water in any body of water?	Did not apply			
(15) Discharge into surface waters or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen or turbidity?	5	0	37	0
(16) Alteration of the direction or rate of ground waters?	30	0	12	0
(17) Change in quantity of ground waters, through direct additions or withdrawals or through interception of an acquifer by cuts or excavations?	0	0	42	0
(18) Substantial reduction in the amount of water otherwise available for public water supplies?	39	0	3	0
(19) Exposure of people or property to water-related hazards such as flooding or tidal waves?	Did not apply			
(20) Change in the diversity of species, number of species of plants (including trees, shrubs, grass, crops and aquatic plants)?	36	0	6	0
(21) Reduction in numbers of unique, rare or endangered species or plants?	37	0	5	0
(22) Introduction of new species into an area or in a barrier to the normal of replenishment of existing species?	0	0	42	0
(23) Reduction in acreage of agricultural crops?	42	0	0	0
(24) Change in the diversity of species or any number of any species of animals (birds, land animals including reptiles, fish and shellfish or insects)?	40	0	2	0
(25) Reduction of numbers of any unique or endangered species of animals?	38	0	4	0
(26) Introduction of new species of animals in the area or result in a barrier to the migration or movement of animals?	42	0	0	0
(27) Deterioration of existing fish or wildlife?	39	0	3	0
(28) Increases in existing noise levels?	42	0	0	0
(29) Exposure to people to severe noise levels?	41	0	1	0

(30) Changes in the production of new light or glare?	39	0	3	0
(31) Changes resulting in a substantial alteration of the present or planned land use of the area?	42	0	0	0
(32) Increase in the use of natural resources?	Did not apply			
(33) Substantial depletion of any non-renewable natural resources?	42	0	0	0
(34) Does it involve a risk of an explosiong or the release of hazardous substances (including but not limited to oil, pesticides, chemicals or radiation) in the event of of accident or upset conditions?	42	0	0	0
(35) Alteration of the location, distribution, density or growth rate of the human population of the area?	42	0	0	0
(36) Affecting existing housing, or create a demand for additional housing?	42	0	0	0
(37) Generating of substantial additional vehicular movement?	42	0	0	0
(38) Effects on existing parking facilities, or demand for new parking?	42	0	0	0
(39) Substantial impact upon existing transportation systems?	39	0	3	0
(40) Alterations to present patterns of circulation or people and goods?	42	0	0	0
(41) Alterations to waterborne, rail or air traffic?	Did not apply			
(42) Increase in traffice hazardous to motor vehicles, cyclists or pedestrians?	42	0	0	0
(43) Effecting upon or resulting in a need for new or altered governmental services in the following areas?				
a. Fire protection?	42	0	0	0
b. Police protection?	42	0	0	0
c. Schools	42	0	0	0
d. Parks or other recreational facilities	42	0	0	0
e. Maintenance of public facilities, roads?	42	0	0	0
f. Other government services?	42	0	0	0
(44) Use of substantial amounts energy?	0	0	0	42
(45) Substantial increase in demand upon existing				

(45) Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy?	30	0	12	0
(46) Resulting in a need for new systems or substantial alterations to the following utilities?				
a. Power or natural gas?	Did not apply			
b. Communication systems	34	3	5	0
c. Water?	42	0	0	0
d. Sewer or septic tanks?	1	0	41	0
e. Storm drainage?	Did not apply			
f. Solid waste and disposal?	5	0	37	0
(47) Creation of any health hazard or potential health hazards (excluding mental health)?	41	0	1	0
(48) Exposure of people to potential health hazards?	42	0	0	0
(49) Result in the obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to the public view?	42	0	0	0
(50) Result in an impact upon the quality or quantity of existing recreational opportunities?	40	0	2	0
(51) Result in an alteration of a significant archelogical or historic site, structure, object or building?	41	0	1	0
(52) Findings of significance:				
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or elimination of important aspects of the Hawaii/Kalapana history?	42	0	0	0
b. Does the project have the potential to achieve short-term, to the disadvantage of long-term environmental goals: (A short-term impact on the environment is one which occurs in a relatively brief definitive period of time while the long-term impacts will endure well into the future?	42	0	0	0

c. Does the project have impacts which are individually limited but cumulatively considerable? (A project may impact on two or more separate resources where the impact on each resource is relatively small, but where the effect of the total of those impacts on the environment is significant?	42	0	0	0
d. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	42	0	0	0

December 4, 1981

Mr. Everett Sonny Kinney
Planner/Coordinator
Puna Hui Ohana
P O Box 811
Pahoa, Hawaii 96778

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Kinney:

Thank you for your letter of November 23 regarding our Kahaualea project.

Your letter has been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We especially appreciate your enclosed comments and survey results, and will certainly be in touch with you to discuss the results of your survey and the project.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

United States Department of the Interior
NATIONAL PARK SERVICE
HAWAII VOLCANOES NATIONAL PARK
HAWAII 96718

IN REPLY REFER TO:

November 20, 1981

L7617(HAVO
x-N40

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
James Campbell Building - Suite 500
828 Fort Street Mall
Honolulu, Hawaii 96813

Dear Mr. Stender:

Please add us to your mailing list for all documents regarding your proposed geothermal drilling near Hawaii Volcanoes National Park. We did not receive a copy of your proposal to prepare an environmental statement, however, one was sent to the National Park Service office in Honolulu. They should remain on your mailing list.

We would also like to add our Regional Office in San Francisco to your mailing list. Their address is: Regional Director, National Park Service, Western Regional Office, 450 Golden Gate Avenue, Box 36063, San Francisco, California 94102-3491, Attention: Division of Environmental Quality.

Thank you very much.

Sincerely,

David B. Ames
Superintendent

December 3, 1981

Mr. David B. Ames
Superintendent
Hawaii Volcanoes National Park
Hawaii 96718

Re: Environmental Impact Statement
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Ames:

This is to acknowledge receipt of your letter of November 20, 1981, requesting that your name be included on our mailing list.

We have accordingly added your name to our mailing list as well as that of your Western Regional Office.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

For the Protection of Hawaii's Native Wildlife

HAWAII AUDUBON SOCIETY

P.O Box 902
Honolulu, Hawaii 96814
P. O. Box 275
Volcano, Hawaii 96785

November 19, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Stender:

Thank you for your letter of October 19 concerning the start of the Kahaualea's Geothermal Project on Campbell Estate lands in Puna and for the advance copy of the Environmental Impact Statement (EIS) Preparation Notice.

By this letter the Society requests to be a consulted party in the preparation of the EIS for the project.

The Society's concerns focus on the significant impacts that can be expected from industrial construction in a roadless wilderness area that is located in the conservation district. Lands on both sides of the project area have been permanently set aside and protected from development because of their wilderness qualities, and as rain forest habitats of native plants and animals straddling the active southeast rift zone of Kilauea volcano. Kahaualea's lands possess the same remarkable attributes as do the Hawaii Volcanoes National Park lands abutting on one side and the state-owned Wao Kele 'O Puna Natural Area Reserve lands abutting on the other side.

Because of the prevailing wind direction, we are especially concerned with the harmful impacts of air pollution and noise pollution emanating from the industrial project onto National Park lands and onto native wildlife habitats. By its Master Plan, the Volcanoes National Park has been authorized to acquire Tract 22, a long, wide stretch of Campbell Estate lands abutting the Park from Thurston Lava Tube southeast to the Rift Zone. This authorization indicates that the relatively undisturbed Kahaualea's lands meet the high standards of the National Park Service for wilderness acquisition.

We are also concerned with the negative impacts of industrial development on the habitats of native plants and animals within the extensive Kahaualea's Geothermal Project Area itself. The locations of newly-found (undescribed) plant species, and rare and potentially endangered plant species should be pinpointed in the project area. This calls for an intensive plant survey by qualified botanists.

The two-mile-apart transects for the bird surveys of the US Fish & Wildlife Service give general data, but an intensive survey appears mandatory to determine species present, population sizes and distribution. The endangered 'O'u has been sighted in the project area.

Sincerely yours, Mae E. Mull

Mae E. Mull
Island of Hawaii Representative

November 24, 1981

Ms. Mae E. Mull
Island of Hawaii Representative
Hawaii Audubon Society
P O Box 275
Volcano, Hawaii 96785

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Ms. Mull:

Thank you for your letter of November 19 regarding our Kahaualea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

GEORGE R. ARIYOSHI
GOVERNOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
[illegible] HALEKAUWILA ST.
ROOM 301
HONOLULU, HAWAII 96813

Melvin Koizum
Deputy Directo
TELEPHONE NO.
548-6915

November 23, 1981

O.K. Stender
The Estate of James Campbell
Suite 500
828 Fort Street Mall
Honolulu, Hawaii 96813

SUBJECT: EIS Preparation Notice for Kahauale'a Geothermal Well

Dear Mr. Stender:

We have reviewed the subject preparation notice and offer the following comments for your consideration:

1. The EIS should discuss the impact of odor generated by geothermal wells. The discussion should include what surrounding areas and residences will be affected.

2. The EIS should discuss the impact of heavy metals associated with geothermal energy on the environment.

3. The EIS should include discussion of a possible blow-out and what impacts it would have on the surrounding areas.

4. The EIS should note that the Corps of Engineers propose to divert lava to the Puna area should the lava threaten Hilo. If this is the case, the wells could be affected by such diversion. We recommend that you coordinate with the Corps of Engineers.

5. Page 24. The discussion of the EIS process is incorrect. The written comments on the EIS are not directed to this Office if the proposed project does not involve state funds or state lands. If the proposed action involves private lands and private funds, then the comments should be sent to the applicant and the Department of Land and Natural Resources.

The EIS and revised EIS are always filed with the Environmental Quality Commission. In addition, it is the Environmental Quality Commission who publishes the EQC Bulletin, not OEQC. Moreover, the EIS will be filed with the EQC prior to acceptance of the EIS by DLNR, and not as stated in the preparation notice.

We trust that these comments will be helpful to you in preparing the EIS. If you should have any questions regarding this matter, please do not hesitate to contact us.

Yours truly,

Melvin K. Koizumi

Melvin K. Koizumi
Deputy Director

December 1, 1981

Mr. Melvin Koizumi
Deputy Director
State Office of Environmental Quality Control
550 Halekauwila Street, Rm. 301
Honolulu, Hawaii 96813

Re: EIS Preparation Notice
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Koizumi:

Thank you for your letter of November 23 regarding our Kahaualea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

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

GEORGE Y. YUEN
DIRECTOR OF HEALTH

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

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

MELVIN K. KOIZUMI
DEPUTY DIRECTOR OF HEALTH

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

November 19, 1981

In reply, please refer to:
File: EPHS-SS

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Stender:

Subject: Request for Comments on Proposed Environmental Impact Statement (EIS) for Kahauale'a Geothermal Project, Puna, Hawaii

Thank you for allowing us to review and comment on the subject proposed EIS.

Consideration must be given to the effect of noise and odor (H_2S) associated with the proposed project on the residential community surrounding the project site.

Efforts to minimize noise impacts should be directed toward the following:

1. Noise associated with construction equipment during the construction phase. Construction equipment and on-site vehicles or devices having an exhaust of gas or air must have a muffler.

2. Traffic noise from heavy vehicles traveling to and from the project site must be minimized in residential areas.

3. Noise from drilling and other operations associated with the project. Every effort should be made to minimize these intrusions.

4. Location of drilling and power plant sites so that there are minimal adverse effects in terms of annoyances on adjacent residents.

5. Attenuation of noise from power plant sites through facility design.

Due to the continuous (24 hours) nature of the proposed project, maximum allowable noise levels for the drilling, construction, and operation phases should be stated. A noise monitoring program should be planned and instituted to insure that these allowable noise levels are not exceeded. The residents of the areas surrounding the project site should be kept informed of this program and subsequent noise-related activities.

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.

Sincerely,

Brian J.J. Choy

FOR MELVIN K. KOIZUMI
Deputy Director for
Environmental Health

cc: Chief Sanitarian, Hawaii

November 23, 1981

Mr. Melvin K. Koizumi
Deputy Director for Environmental Health
State Department of Health
P O Box 3378
Honolulu, Hawaii 96801

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr.Koizumi:

Thank you for your letter of November 19 regarding our Kahauālea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

HAWAIIAN ELECTRIC COMPANY, INC.
Box 2750 · Honolulu, Hawaii / 96840

RICHARD L. O'CONNELL, P.E.
MANAGER ENVIRONMENTAL DEPARTMENT

November 18, 1981

ENV 2-1
NV/G

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
Suite 500
828 Fort Street Mall
Honolulu, Hawaii 96813

Dear Mr. Stender:

Subject: EIS Preparation Notice
Kahauale'a Geothermal Project

The following are our comments on the EIS Preparation Notice for the Kahauale'a Geothermal Project:

1. Assuming that the power generated by the geothermal plants will service only the Big Island, a 69 kv switching station and two 69 kv transmission lines will be required to connect to HELCO's transmission system (p. 8).

   The switching station will be located in a low-risk area from volcanic hazards. Subsequent power plants will be connected to this switching station where the electrical power will be transmitted to HELCO's electrical system.

   Two separate 69 kv lines will be required to supply the 25 mw power to HELCO from this switching station. The additional line is to provide a contingency which allows the loss of one line and still maintain the ability to supply power. These lines will have to be constructed between the proposed switching station and to one or probably two existing HELCO switching stations. The route and termination points of the 69 kv lines will have to be determined by load flow simulations.

2. If power is to be exported to the other islands, additional transmission lines in the 138 kv to 230 kv range will be required. In addition, a converter station will be required to convert the AC (alternating current) to DC (direct current) for underwater power transmission from the Big Island. Presently, a study is being conducted to determine the feasibility of installing a deep sea submarine cable connecting the islands and the termination points (p. 10).

   The study of the deep water submarine cable has been initially funded by the State DPED. The contract has been awarded to HECO (p. 30).

3. Multiple wells at a single drilling site may not be appropriate at locations within or below the rift zone unless it is located in a protective area. A lava flow could cover the wells drilled at that pad which could amount to the loss of up to six wells. The EIS should address this potential situation (p. 7).

4. Pipelines placed above ground in the high volcanic hazard areas will be exposed to lava flows. Pipe routing is especially critical for the main headers which are connected to multiple wells. The EIS should address this situation since the loss of one main header could nearly shut down a power plant (p. 8).

5. An artist rendition of the well field, power plant, switching station, and transmission lines should be shown to show the impact of the project area.

6. The Big Island's present electrical demand is about 90 mw (p. 30).

Sincerely,

Richard L. O'Connell
Manager, Environmental Department

JFB:cal

November 19, 1981

Mr. Richard L. O'Connell
Manager, Environmental Department
Hawaiian Electric Company, Inc.
Box 2750
Honolulu, HI 96840

Dear Mr. O'Connell:

Re: ENVIRONMENTAL IMPACT STATEMENT
KAHAUALEA GEOTHERMAL PROJECT

Thank you for your comments dated November 18, 1981 in response to our EIS Preparation Notice for the Kahaualea geothermal project.

We appreciate your detailed comments. Your letter has been forwarded to R. M. Towill Corporation, which is responsible for the preparation of the EIS.

We will keep you advised as to our progress on the report and the project.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

JOHN R. ARIYOSHI
GOVERNOR

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

RYOKICHI HIGASHIONNA, Ph.D.
DIRECTOR

DEPUTY DIRECTORS
WAYNE J. YAMASAKI
DUANE R. CARRAS
JAMES B. McCORMACK
JONATHAN K. SHIMADA, Ph.D.

IN REPLY REFER TO

STP 8.7847

November 16, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Stender:

EIS Preparation Notice
Kahauale'a Geothermal Project

Thank you for the opportunity to comment on the subject proposal.

We have no substantive comments to offer to improve your document.

However, please be advised that the planning of the access road connection to Volcano Road should be coordinated with our Highways Division.

Very truly yours,

Ryokichi Higashionna

Ryokichi Higashionna
Director of Transportation

November 19, 1981

Mr. Ryokichi Higashionna
Director of Transportation
State Department of Transportation
869 Punchbowl Street
Honolulu, Hawaii 96813

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Higashionna:

Thank you for your letter of November 16 regarding our Kahaualea project.

Your comment concerning the planning of the access road connection to Volcano Road has been referred to our EIS consultant to ensure that this is addressed in the EIS preparation process.

We appreciate receiving this comment and will respond to the matter which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

University of Hawaii at Manoa

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

13 November 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, HI 96813

Dear Mr. Stender:

Subject: EIS Preparation Notice Kahaula'a Geothermal Project October 1981

We have reviewed the subject EIS Preparation Notice and have the following comment. The impact of the developed power transmission line on the environment should be addressed adequately.

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

Sincerely,

Edwin T. Murabayashi
EIS Coordinator

ETM:jm

cc: H. Gee
Y.S. Fok

November 19, 1981

Mr. Edwin T. Murabayashi
EIS Coordinator
Water Resources Research Center
University of Hawaii
Holmes Hall 283
2540 Dole Street
Honolulu, Hawaii 9682

Re: ENVIRONMENTAL IMPACT STATEMENT - KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Murabayashi:

Thank you for your letter of November 13 regarding our Kahaualea project.

Your comment regarding the power transmission line has been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving this comment and will respond to the matter which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

AN EQUAL OPPORTUNITY EMPLOYER

PLANNING DEPARTMENT

25 AUPUNI STREET • HILO, HAWAII 96720

COUNTY OF HAWAII

HERBERT T. MATAYOSHI
Mayor

SIDNEY M. FUKE
Director

DUANE KANUHA
Deputy Director

November 19, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
Suite 500, 828 Fort Street Mall
Honolulu, HI 96813

Dear Mr. Stender:

EIS Preparation Notice
Kahauale'a Geothermal Project

Thank you for the copy of the EIS preparation notice for the proposed Kahauale'a Geothermal Project and the solicitation for comments.

We reviewed the document and submit the following comments for your consideration:

1) The project description outlined in the preparation notice includes phases up to the commercial development of the geothermal resources. Our understanding, however, is that the Conservation District Use Application includes only the research, survey and exploratory phases of the project. The EIS should clearly delineate which phases of the long term projects are being included within the CDUA. Emphasis in detailed project descriptions should be given to those portions now under consideration such as the number of proposed exploratory wells covered by the CDUA and approximate locations.

2) While the EIS should outline the project on a conceptual level to its ultimate 250 MWe power production, nevertheless, until the exploration and testing plans are completed, it is premature to discuss the impacts of the total project in a meaningful way. It would likewise be inappropriate to apply for a CDUA to cover the total project at this initial stage. Should the exploratory well prove feasible for commercial development either a CDUA or Boundary Amendment should be applied for to cover these stages of the development.

3) Baseline environmental data should include:
   a) Measurement and analysis of existing level of hydrogen sulfide, mercury, heavy metals, and existing water resources in surrounding areas. In general, this data should be comparable to that collected by HGP-A.

   b) The EIS should specifically identify closest residences, subdivisions, other existing urban activities and agricultural farms to proposed drilling locations. Measurements shall be given in terms of linear distances and in relation to wind patterns.

   c) In addition to narrative descriptions of the flora and plant communities, vegetative maps should also be included within the EIS.

4) Discussion of the access road should include alternate routes (with locations) and a detailed discussion of impacts of the various alternatives.

Should you have any questions, please do not hesitate to contact us at 961-8288.

Sincerely,

SIDNEY FUKE
Planning Director

VKG:lrp

cc: Susumu Ono, Chairman
Department of Land & Natural Resources
Environmental Quality Commission
R. M. Towill Corporation
Research and Development

December 1, 1981

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

Subject: EIS Preparation Notice
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Fuke:

Thank you for your letter of November 19 in response to our EIS Preparation Notice.

We will respond specifically to the points which you raised prior to completion of the final EIS report.

It was a pleasure meeting you at our recent meeting in Hilo and I am certain we will be in touch with you again in the months to come.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

United States Department of the Interior

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

IN REPLY REFER TO:
ES
Room 6307

NOV 13 1981

Mr. O.K. Stender
Chief Executive Officer
James Campbell Estate
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Re: EIS Preparation Notice -
Kahaualea's Geothermal Project

Dear Mr. Stender:

We have reviewed the subject Environmental Impact Statement (EIS) Preparation Notice and offer the following comments.

In addition to the endangered Hawaiian Bat (Lasiurus cinereus semotus) mentioned in the notice, two listed endangered birds and two candidate plants are also found in the project area. The forest bird survey found an endangered 'O'u (Psittirostra psittacea) in the project area. The Hawaiian Hawk (Buteo solitarius) is also known to inhabit Kahaualea. The two candidate plants are Adenophorus periens (which has a high priority for listing), and Nothocestrum longifolium var. Rufipilosum.

The Service recommends that potential impacts on these species be assessed and discussed in the EIS, along with measures to mitigate adverse effects.

Our comments on endangered/threatened species constitute "technical assistance" as labeled in the regulations pursuant to Section 7 of the Endangered Species Act of 1973, as amended since there appears to be no Federal involvement in the project at the present time. If, in the future, Federal involvement in the project occurs, the Federal agency concerned must initiate formal consultation if they believe the project will have an effect on a listed or proposed species.

We appreciate this opportunity to comment.

Sincerely yours,

Derral Herbst

Derral Herbst
Acting Project Leader
Office of Environmental Services

cc: NMFS
HDF&G
EPA, San Francisco

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

November 19, 1981

Mr. Derral Herbst
Acting Project Leader
Office of Environmental Services
U.S. Fish and Wildlife Service
P O Box 50167
Honolulu, HI 96850

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Herbst:

Thank you for your comments dated November 13, 1981, in response to our EIS Preparation Notice for the Kahaualea geothermal project.

Your letter has been referred to R. M. Towill Corporation, which is preparing the EIS report.

For our own files and information I would appreciate receiving a copy of your report identifying the birds and plants which you mentioned in your letter, particularly the location of all the species located on the property. I believe this study was done some time in 1974.

Again, thank you for your comments.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

POLICE DEPARTMENT
COUNTY OF HAWAII
349 KAPIOLANI STREET
HILO, HAWAII 96720

GUY A. PAUL
CHIEF OF POLICE

MARTIN K. L. KAAUA
DEPUTY CHIEF

OUR REFERENCE 16511

YOUR REFERENCE

November 9, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

RE: EIS PREPARATION NOTICE - KAHAUALE'A GEOTHERMAL PROJECT

Enclosed is a copy of Captain Arthur Hoke's comments regarding the environmental effects of the proposed project in the Puna District.

Thank you for giving us the opportunity to review and comment on the project.

GUY A. PAUL
CHIEF OF POLICE

MARTIN K. L. KAAUA
DEPUTY CHIEF OF POLICE

RLP/k

Enc.

TO : RAYMOND GLORY, Inspector, Country Operations

FROM : ARTHUR A. HOKE, JR., District Commander, Puna

SUBJECT : E.I.S., KAHAUALE'A GEOTHERMAL PROJECT

The attached EIS notice was reviewed to determine what kind of an impact the project may have on law enforcement in the Puna district.

The area covered by this project is currently being used by persons other than the owners, as a marijuana growing area. Writer has made aerial flights over the property and personally noted numerous areas of marijuana plantings.

It is presumed at this time that the recent Green Harvest made some impact in the area, but in all probability, there is still much marijuana in the area. Because of this, the safety of the workers in the project area is a consideration, with a probable increase in crimes against persons and property being the result.

However, the projections for the Puna area indicate that all of the crime categories will probably increase, so the overall effect on law enforcement in the district will not be overly drastic.

ARTHUR A. HOKE, JR.
Captain, District Commander, Puna
11-4-81/1350Hrs.

University of Hawaii at Manoa

School of Public Health
1960 East-West Road • Honolulu, Hawaii 96822
Telephone (808) 948-8491

Office of the Dean

November 6, 1981

O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall
Suite 500
Honolulu, Hawaii 96813

Dear Colleague:

This is in response to your letter of October 19. The environmental health faculty of the School of Public Health have reviewed the environmental impact statement preparation notice dated October 1981 as prepared by R. M. Towill Corporation of Honolulu. The faculty concurs that such an environmental impact statement is appropriate. They also noted that the proposed EIS identifies most of the environmental problem areas.

The faculty indicated their hope that specific design problems related to the control of air and water pollutants be addressed in detail and noted that it was especially important to focus on the proposed disposal of waste hot water and related affluents. They feel that it is necessary to describe control procedures for disposal of chemicals used to prevent corrosion and scale formation in lines, condensers and the like.

Professor Dollar of the environmental health faculty group, indicated that he would be pleased to comment further as the EIS process proceeds.

Aloha,

Jerrold M. Michael
Dean and Professor
of Public Health

JMM:lmf

AN EQUAL OPPORTUNITY EMPLOYER

November 19, 1981

Mr. Jerrold M. Michael
Dean and Professor of Public Health
University of Hawaii
1960 East-West Road
Honolulu, HI 96822

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Professor Michael:

Thank you for your letter of November 6 regarding our Kahaualea project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving these comments and will respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720

November 9, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, HI 96813

EIS PREPARATION NOTICE
KAHAUALE'A GEOTHERMAL PROJECT

Thank you for the opportunity to review and comment on the subject matter.

Although we have no objections to the development of geothermal resources, the EIS should include a discussion on the effects of same on potential groundwater resources for domestic consumption. We understand that the State Department of Land and Natural Resources, Division of Water and Land Development, is working on regulations for geothermal well drilling for purposes of protecting domestic groundwater resources. Said agency should be contacted for more details.

H. William Sewake
Manager

QA

November 13, 1981

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

Re: EIS Preparation Notice
KAHAUALE'A GEOTHERMAL PROJECT

Dear Bill:

Received your letter of November 9 regarding our Kahaualo'a Geothermal Project.

I have forwarded your letter to Bill Thompson to assure that your comments are addressed in the EIS.

It was good to meet you in Hilo and I look forward to seeing you again. Please say hello to Edmund for me.

Sincerely,

O. K. Stender
Chief Executive Officer

BKS:kt

...Water brings progress...

CHARLES G. CLARK
SUPERINTENDENT

STATE OF HAWAII
DEPARTMENT OF EDUCATION
P. O. BOX 3860
HONOLULU, HAWAII 96804

OFFICE OF THE SUPERINTENDENT

November 6, 1981

Mr. O. K. Stender
Chief Executive Officer
Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, Hawaii 96813

Dear Mr. Stender:

SUBJECT: EIS Preparation Notice
Kahauale'a Geothermal Project

We have reviewed the subject project and have no comments to offer at this time. Thank you for the opportunity to review the project.

Sincerely,

CHARLES G. CLARK
Superintendent

CGC:HL:jl

cc: Hawaii District

AN EQUAL OPPORTUNITY EMPLOYER

IN REPLY REFER TO

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

HAWAII NATIONAL PARK, HAWAII 96718

November 4, 1981

O.K. Stender
Chief Executive Officer
James Campbell Building
Suite 500
828 Fort Street Mall
Honolulu, HI 96813

Dear Mr. Stender:

Thank you for sending the Hawaiian Volcano Observatory a copy of your Environmental Impact Statement Preparation Notice for the Kahauale'a Geothermal Project.

As you know, the area involved has been the location of several volcanic eruptions between 1963 and 1977. We agree that it is a favorable area to prospect for geothermal power, and we hope that our observatory will be able to use your proposed access road to continue our geological, geochemical, and geophysical observations of that part of the east rift of Kilauea Volcano. Our observatory supports your proposal, and we hope that by cooperation with your project, we can all learn more about the nature and benefits of volcanic and geothermal processes.

Sincerely,

R.W. Decker
Scientist-in-Charge

November 12, 1981

Mr. R. W. Decker
Scientist-in-Charge
U.S. Department of the Interior
Geological Survey
Hawaiian Volcano Observatory
Hawaii National Park, HI 96718

Subj: ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE/KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Decker:

This is to acknowledge receipt of your letter of November 4, 1981, regarding our EIS Preparation Notice for our Kahaualea geothermal project.

I have referred your letter to True/Mid-Pacific, who are responsible for the development of the geothermal resource and I am certain an arrangement can be worked out for your use of the access road to continue your geological, geochemical, and geophysical observations in the east part of the rift zone.

Thank you for your indication of support of our proposal.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

DANIEL K. AKAKA
SECOND DISTRICT, HAWAII

COMMITTEES:
APPROPRIATIONS
SUBCOMMITTEES:
AGRICULTURE, RURAL DEVELOPMENT, AND RELATED AGENCIES
TREASURY, POSTAL SERVICE, GENERAL GOVERNMENT
TOURISM CAUCUS

Congress of the United States
House of Representatives
Washington, D.C. 20515

WASHINGTON OFFICE:
1510 LONGWORTH HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
TELEPHONE: (202) 225-4906

DISTRICT OFFICE:
5104 PRINCE JONAH KUHIO KALANIANAOLE FEDERAL BUILDING
P.O. BOX 50144
HONOLULU, HAWAII 96850
TELEPHONE: (808) 546-8951

November 3, 1981

Mr. O. K. Stender
Chief Executive Officer
Estate of James Campbell
828 Fort Street Mall
Honolulu, Hawaii 96813

Dear Mr. Stender:

This is in response to your letter requesting my comments on the EIS Preparation Notice for the Kahauale'a geothermal project. I appreciate having the opportunity to comment on the project notice.

Hawaiian Bat: Because your initial field survey indicated the existence of one Hawaiian bat, an animal protected under the provisions of the Endangered Species Act, I believe that it will be necessary to monitor the existence of this animal and others in the area. Your intention to commence a control program for feral pigs may eventually encourage the renewal of the Hawaiian bat. However, I believe it is necessary to remain sensitive to the impact that the project may have upon the Hawaiian bat's habitat.

Social Impact: I am particularly pleased with the plans to provide training opportunities for the local residents. Such an effort is imperative, given, as you point out the high rate of unemployment in the Puna area.

Blowout Prevention: (Page 33) To what extent would the project rely on existing emergency equipment, such as the local fire department in the event of a blowout? This paragraph seems to assume that blowout prevention equipment installed on site would be adequate to contain any emergency.

Thank you for the opportunity to comment on your EIS preparation notice. I look forward to reviewing the final document.

Aloha pumehana,

Daniel K. Akaka

DANIEL K. AKAKA
Member of Congress

Phones-935 0031
935 0032

HAWAII COUNTY CIVIL DEFENSE AGENCY

34 A Rainbow Drive
HILO, HAWAII 96720

November 2, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, HI 96813

SUBJECT: KAHAUALE'A GEOTHERMAL PROJECT

The proposed project will be located in an area that is susceptible to two natural hazards. These are earthquake and volcanic eruptions. Proposed project is located in a high-risk area in relationship to these two natural hazards. Building plans should incorporate these factors.

Should this project be developed, it would be wise to insure development of emergency plans for the protection of employees as well as physical facilities.

Harry Kim

HARRY KIM, ADMINISTRATOR

Phones · 935 0031
935 0032

HAWAII COUNTY CIVIL DEFENSE AGENCY

34 A Rainbow Drive
HILO, HAWAII 96720

November 2, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
828 Fort Street Mall, Suite 500
Honolulu, HI 96813

SUBJECT: KAHAUALE'A GEOTHERMAL PROJECT

The proposed project will be located in an area that is susceptible to two natural hazards. These are earthquake and volcanic eruptions. Proposed project is located in a high-risk area in relationship to these two natural hazards. Building plans should incorporate these factors.

Should this project be developed, it would be wise to insure development of emergency plans for the protection of employees as well as physical facilities.

Harry Kim
HARRY KIM, ADMINISTRATOR

November 6, 1981

Mr. Harry Kim, Administrator
Hawaii County Civil Defense Agency
34-A Rainbow Drive
Hilo, Hawaii 96720

Subject: KAHAUALE'A GEOTHERMAL PROJECT

Dear Harry:

Thank you for your letter of November 2 in response to our EIS Preparation Notice.

It was good to meet you at our breakfast meeting at the Manilca. You provided us with valuable insight to the problems with which we must deal in connection with this project. We look forward to further discussions with you and appreciate your contribution in this effort.

Thanks again.

Sincerely,

O. K. Stender
Chief Executive
Officer

OKS:kt

PO Box 481, Pahoa, Hawaii 96778
Nov. 2, 1981

Mr. O.L.Stender, Chief Executive Officer
Campbell Estate
James Campbell Building, Room 500
828 Fort St. Mall
Honolulu, Hawaii 96813

Dear Mr. Stender:

Many thanks for sending me a copy of the Environmental Impact Statement Preparation Notice for the Kahauale'a Geothermal Project.

The statement seems to indicate most of the concerns expressed by local residents, public agencies and environmentalists regarding development of geothermal energy and related industries on the Big Island. If all the proposals are carried out in practice, residents of the Puna District should have little to complain about-- assuming they accept the necessity of gradual, regulated and relatively non-polluting growth about which they have a voice.

Of course many problems remain unresolved, such as the economic and technical feasibility of the submarine cable to Maui and Oahu. Is it technically possible? How much will it cost and who will pay for it?

Several minor questions came to mind as I read the statement:

Since the access road to the project will connect to the Hilo-Volcano Belt Highway, will there be excessive traffic and wear and tear on the highway during the construction period when tons of heavy pipe and drilling equipment must be hauled from the Hilo docks?

The plans indicate no egress or escape road from the project in case the access road is cut off by volcanic eruption. Shouldn't there be such a road or trail?

If there is no submarine cable, the energy must be used by local industries, preferably non-polluting, labor intensive light manufacturing or assembling. Does Campbell Estate plan a nearby industrial area or "park" for geothermal related industries?

There will be less opportunity in Kahauale'a than in the Pohoiki area to utilize spent steam and hot waste fluids for processing agricultural products or manufacturing ethanol (unless tree farms are developed in the vicinity). Have you thought of piping the spent hot fluids (and steam) by gravity to the ocean shore where it could be used to generate electricity by an OTEC-type process, using cold ocean water as the cooling agent?

It seems to me that the manufacture of hydrogen (from ocean water or ground water) would be an ideal industry to develop on the Big Island if plenty of low-cost geothermal energy becomes available. Hydrogen is an ideal fuel. Nearly any internal combustion engine can be adapted to it and it could be shipped in drums worldwide.

I believe most Big Island residents would oppose location of manganese nodule processing and refining plants here because of the difficulty of disposing the mountains of toxic tailings that would be generated. There would be pollution both in the mining and refining processes. The industry is capital intensive and would provide few jobs for the large amount of capital that is needed... and which would be provided by multi-national corporations who would exert tremendous political pressure on the Big Island and throughout Hawaii. There would also be international repercussions if the industrial nations or multi-national corporations disregard the wishes of undeveloped nations to have the industry developed under regulations devised by the Law of the Sea Conference of the United Nations.

Finally, as the Kahauale'a Project develops, many workers and their families will be settling in Volcano, Glenwood, Mountain View and other nearby communities. Housing, schools and other amenities will be needed. The character of these communities will be changed from rural or retirement to industrial. Will the present residents (especially those of Volcano) accept such changes?

I believe there should be a public hearing on the final environmental impact statement to be held in one of the villages near the project.

Aloha

William Reich

William Reich

November 6, 1981

Mr. William Reich
P O Box 481
Pahoa, Hawaii 96778

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Reich:

Thank you for your letter of November 2 regarding our Kahauale'a project.

Your comments have been referred to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

In reading your letter it appears that your knowledge of the project is beyond that of the ordinary citizen and, therefore, I look forward to meeting you at one of our planned community meetings. You raise a number of interesting issues we will address in the EIS and our response to your letter.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

JAMES K. DAHLBERG
Councilman

COUNTY COUNCIL
County of Hawaii
Hawaii County Building
Hilo, Hawaii 96720

October 29, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
James Campbell Building
Suite 500
828 Fort Street Mall
Honolulu, Hawaii 96813

Dear Mr. Stender:

I received your letter of October 19, 1981, along with the (EIS) Environmental Impact Statement Preparation Notice.

Please continue to keep me abreast of any information pertaining to this subject

If I can be of help to you at any time as one of your Council members, please do not hesitate to contact me at my Council office, telephone number 9618-265.

Sincerely with Aloha,

Jim Dahlberg

James L. K. Dahlberg
COUNCILMAN

JD:an

November 5, 1981

Councilman James L. K. Dahlberg
Hawaii County Building
Hilo, Hawaii 96720

Dear Councilman Dahlberg:

Thank you for your letter of October 29 in response to our EIS Preparation Notice for our Kahauale'a geothermal project.

We will certainly keep you advised as to our progress on this important project, and thank you for your offer of assistance.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

HERBERT T. MATAYOSHI
MAYOR

HAWAII COUNTY FIRE DEPARTMENT
466 KINOOLE STREET, HILO, HAWAII 96720
PHONE: 935-2978

SHOZO NAGAO
FIRE CHIEF
FRANCIS E. SMITH
DEPUTY FIRE CHIEF

October 28, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
James Campbell Building, Suite 500
828 Fort Street Mall
Honolulu, Hawaii 96813

Dear Mr. Stender:

SUBJECT: EIS PREPARATION NOTICE
KAHAUALE'A GEOTHERMAL PROJECT

We have no comments on the EIS Preparation Notice for the Kahauale'a Geothermal Project.

Yours very truly,

Shozo Nagao

SHOZO NAGAO
FIRE CHIEF

SN/mo

DRS. OTTO & ISA DEGENER
P.O. Box 154
Volcano, Hawaii
96785 U.S.A.

Oct. 26, 1981.

Dear Mr. Stender:

I have read your Oct. 19 letter and enclosure with interest.

With this chantly population pressure engulfing us, I believe it logical for Hawaii, or perhaps East Maui, to mine geothermal energy.

The flora and fauna of the Hawaiian Islands are largely different on the different islands as expected. The simple reason is mainly isolation and different ecological conditions stimulating evolution (change) in different directions. There was ample time, some organisms having had as much as 75,000,000 years to do so.

Without bother of identification, we know that the higher areas still harbor the more interesting endemic organisms unique to this part of the Island of Hawaii. I doubt you will find very many of the same Puna organisms even in Kohala. Except for a few cancer-spots of exotic weeds like the tibouchina from Brazil and the firetree from the Azores, such areas of unique land must be preserved - untouched. They are invaluable scientifically and, if some people don't appreciate that, they should remember they have attracted in the past and will in the future scientists liberally supplied with Mainland cash grants for spending in this State. The same applies to tourists.

What I am getting at is that the lower areas harbored originally plants not so much endemic to the Big Island, but endemic more or less to our archipelago as a whole. Furthermore, this lower elevation flora and fauna has been decimated from man's past and present actions; it is also overrun with noxious weeds.

The area above 2,000 feet (or perhaps 2,500 feet depending on precise locality) is so rich with remarkable endemics that to engage in Geothermal Venture activity there would be disastrous. Without effort, a rough idea of such biota can be glimpsed about the Thurston Lava Tube. On the contrary the areas below such elevation, not being so richly with endemics would not be a biological disaster if exposed to Venture activity. That does not mean, however, that such activity would not entail some regrettable biological loss.

Our Islands are full of superbly unique areas exposed to great injury for the simple reason that they are privately owned. As the Venture will eventually consist of one or more companies, I propose that the lower elevations be permitted some damage by geothermal activity ONLY ON CONDITION that the company or companies donate a reasonable fair block of shares in Trust to the Board of Land and Natural Resources. The income from the shares would be limited to purchase land of great biological value, perhaps adjacent to our National Parks, to help save for posterity endemics there. This in a way would assuage and offset the obvious biological damage occurring in Puna no matter the precautions.

The above compromise of permitting geothermal mining at lower elevations and conscientiously and liberally trading the life of endemics in one area for the death of a few others in Puna seems to me the best solution.

Aloha,

Dr. Otto Degener

October 29, 1981

Dr. Otto Degener
P O Box 154
Volcano, Hawaii 96785

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Dr. Degener:

Thank you for your letter of October 26 regarding our Kahaualea project.

I have referred your comments to our EIS consultant to ensure that your concerns are addressed in the EIS preparation process.

We appreciate receiving your comments and we shall respond to the matters which you raised prior to filing of the EIS.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt

bc V. Mendes (w/corres.)

HERBERT T. MATAYOSHI, MAYOR
H. STUART KEARNS, JR.
DIRECTOR

DEPARTMENT OF RESEARCH AND DEVELOPMENT
COUNTY OF HAWAII • 25 AUPUNI STREET • HILO HAWAII 96720 • TELEPHONE (808) 961-8366

November 19, 1981

Mr. O. K. Stender
Chief Executive Officer
The Estate of James Campbell
James Campbell Building Suite 500
828 Fort Street Mall
Honolulu, Hawaii 96813

SUBJECT: EIS PREPARATION NOTICE
KAHAUALE'A GEOTHERMAL PROJECT

We have no comments to the above mentioned subject.

H. Stuart Kearns Jr.
H. STUART KEARNS, JR.
DIRECTOR

November 24, 1981

Mr. H. Stuart Kearns, Jr.
Director
Department of Research and Development
County of Hawaii
25 Aupuni Street
Hilo, Hawaii 96720

Re: ENVIRONMENTAL IMPACT STATEMENT -
KAHAUALEA GEOTHERMAL PROJECT

Dear Mr. Kearns:

Thank you for your letter of November 19, 1981, regarding our Kahaualea geothermal project.

We appreciate the time spent in reviewing the document.

Sincerely,

O. K. Stender
Chief Executive Officer

OKS:kt