D. NAKANO

MAUNA LOA SOUTHWEST RIFT ZONE (KAHUKU RANCH)

There are no wind data in this rift zone. Under trade wind condition, during the day, the lower half of the rift zone is expected to have light to moderate easterly trades passing through the rift zone. The northern upper half of the rift zone will likely have light to moderate upslope winds from the south. During the night, light to moderate northerly mountain breeze-downslope winds are expected to flow through the rift zone.

Under non-trade wind condition, during the day, light to moderate southerly upslope winds are expected to pass through the rift zone. During the night, gentle to moderate drainage winds from the higher slopes are expected to pass through the rift zone from the north. Precipitation ranges from 40 to 50 inches decreasing at the upper elevations to 40 inches.

No surface streams are found within the subzone area. Dikes are found in the upper elevations of the subzone area; basal ground water is fresh, and the UIC line lies to the south outside the subzone area. There are no existing wells within the subzone area.

The subzone area is almost wholly owned by the S.M. Damon Estate, except for a small portion on the eastern subzone boundary which is state-owned.

Existing land uses within the potential subzone area include grazing land, a portion of the sparsely settled Hawaiian Ocean View Estates, and forest lands. The subzone boundary extends makai of Highway 11, to the Kahuku Ranch area. The nearest population centers are to the east, Waiohinu and Naalehu towns, and Kiolakaa-Keaa Homestead area. The subzone area is zoned agricultural and conservation.

Forested areas consisting mostly of mature native forest, with over 75% native cover are interspersed with areas of bare lava from flows dated 1886, 1887, 1907, 1916, and 1926.

Above the 5000 foot elevation, forested and bare lava areas provide habitat for the Nene and two species endangered forest birds,

Hawaiian Creeper and Akiapolaau. On the eastern boundary between the 3000' and 3600' elevations, three species of endangered forest birds (Akepa, Akiapolaau and Hawaiian Creeper) occupy an area designated as exceptional native forest, with a closed canopy and over 90% native forest cover. The subzone area lies to the east of the Manuka Natural Area Reserve; no portion of the reserve is included in the proposed subzone.

Historic sites are found only at the subzone perimeter at Kahuku Ranch. No significant archaeological or historic sites were recorded within the subzone boundaries.

Development of Geothermal Resources in the lower, agricultural-zoned portion of the proposed subzone will result in minimal environmental impact provided a buffer area is maintained between the geothermal development site and the Hawaiian Ocean View Estates.

HUALALAI NORTHWEST RIFT ZONE

Although no wind instrumentation exists on Hualalai, knowledge of other upland areas indicated that light to moderate upslope sea breezes converge on Hualalai during the day; at night, the reverse gentle to moderate downslope mountain breezes diverge in all directions from the Hualalai Summit. Rainfall varies from light to moderate, from 30 to 40 inches a year.

There are no known surface streams in this area, however south of the subzone area, man-made catchments and collecting ponds are used to provide water for ranch purposes. Dikes occur through this subzone. Elevations range from 3400 feet to 7200 feet.

Property within the subzone is wholly owned by Bishop Estate and zoned Conservation except for a triangular section on the southeast slope, and two small segments at the subzones northwest perimeter that are zoned Agricultural. The nearest residential areas occur along th Mamalahoa Highway to the west; Kailua-Kona is located 7 miles southwest of the subzone. Except for the triangular shaped

Agricultural land, which is grazed, all other land within the subzone is forested. Approximately one half of the forested area lies within the Kaupulehu Forest Reserve.

Forested areas consist of mature native forest, with over 75% native canopy. Exceptional native forest with over 90% native canopy is found along the subzone boundary between elevations of 4000 to 6500 feet. Species composition consist primarily of Metrosideros polymorpha (ohia lehua), Acacia koa (koa), and Sophora chrysophylla (mamane). The subzone is crossed by a single lava flow, the Kaupulehu Flow.

Hualalai slopes within the subzone area provide habitat for four endangered species. The species composition varies with elevation. Between 3200 feet and 6000 feet alala, Hawaiian creeper and akepa are found; between 6000 and 7000 feet, Hawaiian creeper, akepa and Nene are found and above the 7000 foot elevation, only nene.

No archaeological or historical sites have been recorded within the subzone area.

Development of geothermal resource in areas other than the grazed agricultural zoned portion of the subzone, would likely impact the endangered species known to exist within the proposed subzone area. Alala, the Hawaiian crow is reported to number fewer than 20 individuals. Disturbance of their Hualalai habitat may cause further decline of this species.

MAUNA LOA NORTHEAST RIFT ZONE (KULANI)

Tradewinds, during the day diverge around Mauna Loa. Tradewinds pass through the rift zone from the east to southeast. At night reverse flow results from drainage of mountain breeze-downslope winds. Under non- trade conditions, light to moderate sea breeze-upslope winds flow through the rift zone from southeast to east. At night, mountain breeze downslope winds flow from the west.

Rainfall is heavy - 150 inches a year at the 3,500 foot elevation to 60 inches a year at the 7000 foot elevation. Kulani Camp receives 102 inches a year (elevation 5,170 feet). Temperature at Kulani Camp ranges from an average annual maximum of 63.5°F up an average annual minimum of 46.5°F.

There are no known surface streams in this subzone area. Dikes occur alove the 5400 foot elevation. The subzone area ranges in elevation from 3600 feet to 7000 feet.

Property within the proposed subzone is owned by Bishop Estate and the State of Hawaii, and is zoned Agricultural and Conservation. The nearest residential area is Kaumana on the north, approximately 6 miles from the subzone boundary. Volcano House in the National Park is approximately 8 miles from the southern subzone boundary.

Existing land uses within the proposed subzone boundary include the Agricultural zoned grazing land belonging to Bishop Estate and the State's Kulani Honor Camp, located in the Conservation District, Resource Subzone. The remaining lands within the subzone are forested and included portions of the Mauna Loa, Kilauea, and Upper Waiakea Forest Reserves, and two game management areas on the northwest and southwest corners of the subzone. Puu Makaala Natural Area Reserve is included in the southeast corner of the subzone.

Forested areas consist of Category 1, exceptional native forest, closed canopy, with over 90% native corner. The remaining forest areas, consist of Category 2, mature native forest with over 75% native canopy. Forested areas in the upper and northern portion of the proposed subzone are dissected by recent lava flows dated 1852, 1942, and 1984.

Category 1 forests include tall Metrosideros polymorpha (Ohia lehua), and Acacia koa (koa) with native shrubs and tree ferns (Cibotium spp. hapuu). Category 2 includes moderate to tall Ohia lehua and koa, with native shrubs and ferns. Category 2A includes scattered Ohia lehua and Mamane, in some areas.

Mauna Loa forests within the subzone area provide habitat for four endangered forest bird species; the Hawaii Creeper, Akepa, Akiapola'au and the 'O'u, and the Nene. The Mauna Loa East Rift

forests have been designated as essential habitat for the four endangered forest birds. In addition, 'Io, the Hawaiian Hawk, is known to nest at two sites, one on the lower slopes of Kulani Cone and a second site directly due West at an elevation of 5500 feet.

It should be noted that the designated essential habitat area includes the grazed agricultural zoned areas belonging to Bishop Estate since these areas contain both Category 1 and 2 forests as well as open areas. There are no known archaeological sites within the subzone area.

Development of a geothermal resource in areas other than the cleared grazed agricultural area would likely impact the four endangered forest bird species and the Nene by disturbing essential habitat areas.

HALEAKALA EAST RIFT ZONE

In coastal areas, during tradewind conditions, northeast tradewinds prevail during the entire day and night. Wind speeds are moderate during the day, and light at night. During a non-tradewind condition, the winds are almost calm during the night and light during the day. The direction of the wind is from the south during the night and from the west during the day, which is opposite of what would be expected under the sea breeze-upslope winds during the day and mountain breeze-downslope winds during the night.

In upper areas, northeast tradewinds continue across the rift zone during the day and the night, however mountain breeze downslope winds meet the trades somewhere mid-level in the subzone. Under a non-trade wind condition, gentle to moderate daytime sea breezes flow upslope and night time mountain breezes move downslope.

The average annual rainfall in the upper half of the rift zone is 200 inches with a possible maximum of over 300 inches on the northern side of the zone. Rainfall decreases toward the east to 65 inches a year at the coast.

At Hana Ranch. average annual maximum temperature is 80°F, and the average anuual minimum is 67.4°F.

Extrapolated average annual maximum and minimum temperatures at upper elevations are 72.4°F/56.8°F at 2500 feet; and 58.9°F/45.4°F at 7000 feet.

Streams in the Haleakala East Rift Zone are ephermal in spite of the high rainfall. The rocks are highly permeable, allowing all but the heaviest rains to sink rapidly into the ground. Rising from sea level at Hana Bay to the 7000-foot level near the eastern rim of Haleakala Crater, the area's rugged topography contains the headwaters of the several tributaries of Kawaipapa Gulch along the resource area's northern boundary and of Moomoonui Gulch along the southern boundary. The makai area contains the intermittent Holoinawawae Stream that empties into Hana Bay.

Dikes occur throughout the middle and lower portions of the rift zone. The Underground Injection Control (UIC) line is set at an elevation of 200 feet.

Property within the rift zone is owned by the Hana Ranch, (lower elevations), the State of Hawaii (mid and upper elevations) and the United States of America (upper-most elevations). Smaller parcels in coastal areas belong to other landowners.

Lower elevation Hana Ranch land is zoned for agricultural use and is grazed. State land above the Hana Forest Reserve Boundary is zoned Conservation, Protective and Resource Subzones and is also designated as a Public Hunting area where wild pig and goat can be hunted year around.

Hana Town and rural community are located within the proposed subzone area along the coast.

Forested areas above 3000 feet uniformly consist of Category 1 exceptional native forest, closed canopy with over 90% native cover. Below the 3000 foot level the forest is more disturbed and gradually blends into Category 2, mature native forest with over 75% native canopy. Below the 1000 foot level the forest gives way to pastureland with occasional forested areas.

Forested areas above the 5000 foot level provide habitat for three endangered forest birds, the Maui Parrot bill, the Crested Honeycreeper, and the Akepa. Akepa habitat extends to lower elevations to the 4200 foot level.

All known archaeological sites are at or below the 200 foot level. Site No. 1078, at 200 feet is a fishing shrine which is on the State Register of Historic Places. Six other sites are located at lower elevations in coastal areas in rural and urban zoned areas.

Development of a geothermal resource in the Haleakala East Rift Zone in areas other than the grazed agricultural lands below 1000 foot level would likely impact native forest bird habitat and above 4200 feet, endangered forest bird habitat. However, development of a geothermal resource below the 1000 foot level in grazed agricultural land could place a well and power plant as close as 7000 feet from the center of Hana Town. Quite clearly, the rural lifestyle of the Hana Community would be affected.

HALEAKALA SOUTHWEST RIFT ZONE

Wind data for coastal sites indicate that under tradewind conditions, during the day,light to moderate sea breeze-upslope winds from the southeast and the west flow from the coast to upper elevations. At night the reverse, nountain breeze-downslope winds occur. Similar sea breeze, mountain breeze winds occur during non-trade wind conditions.

Rainfall in the rift zone ranges from 16 inches a year in coastal areas to 54 inches a year near Polipoli Spring.

Average annual maximum and minimum temperatures at the coast in the rift zone are expected to be about 84°F and 64°F respectively; at 3000 feet 72°F and 55°F could be expected, and at 7000 feet a maximum of 63°F and a minimum of 44°F.

There are no know surface streams in this geothermal resource area. Several srings along the mauka northern fringes of the area provided water for minor uses, including camp water for the Polipoli Mountain Park.

Ground water in the rift zone is brackish below 1600 feet level and fresh basal water above. However, the rift zone also contains dike-confined ground water.

Property within the rift zone is owned by the State of Hawaii, Ulupalakula Ranch and other individual holders of smaller parcels. The coastal portions of the rift zone and mountain areas above 5000 feet are zoned Conservation, Protective, and General Subzones, and Resource Subzone, respectively. All mid-level areas not zoned Conservation, are zoned for Agricultural use.

The Ahihi-Kinau Natural Area Reserve from Kanahena to Keoneoio, including near-shore submerged lands, is located in the coastal portion of the rift zone. This Natural Area Reserve contains anchialine pools, marine ecosystems and the last lava flow (dated 1790) on the Island of Maui. Upslope, Ulupalakua Ranch land is used for grazing. The upper most portion of the riftzone above 5000 feet is designated as the Kula and the Kahikinui Forest Reserves. Polipoli State Park is located along the northern rift zone boundary. The nearest urban or residential areas are Makena, one mile north of the rift zone boundary, Ulupalakua Ranch, immediately northwest of the rift-zone along the Kula/Piilani Highway, and Keokea, approximately 2 miles northwest of the upper portion of the rift zone. "Science City" and the perimeter of the Haleakala National Park are located five miles upslope of the upper boundary of the rift zone.

Vegetation in the Haleakala Southwest Rift Zone consists of native scrub vegetation and some exotic treeplantings as well as substantial areas of pastureland with occasional forested areas. The lower portions of the rift zone are barren lava with isolated pockets of Category 1, exceptional native forest with closed canopy of over 90% native cover.

There is no endangered species habitat in this rift zone, although the middle elevations contain some very valuable, although disturbed, dry native forest.

There are five known archaeological sites in or on the perimeter of the rift zone:

1. Poo Kanaka State (site #1021) is located near the Kula Highway and has been placed on the State Register of Historic Sites.
2. Puunalo Cave (site #1009) located on the southwest rift zone boundary at an elevation of 1100 feet is also on the State Register.
3. Kalua O Lapa Buriel Cave (site #1017) is located at the eastern boundary of the Ahihi-Kianu Natural Area Reserve.
4. Maonakala Village Complex (site #1018) is a coastal village site, also within the Natural Area Reserve).
5. La Perouse Archaeological District is located at the southern boundary of the rift zone and has been place on the State Register.

Development of geothermal resources within the grazed agricultural zoned portions of the rift zone will result in minimal environmental impact since no endangered species habitat is present.

Proximity to Makena residential and resort development, Ulupalakua Ranch and upslope, "Science City" may be affected aesthetically. Air quality in these urbanized areas will not be impacted since it is expected, given the current level of technology, that all air quality impacts will be abatted so as to comply with State Air Quality standards for geothermal resource development.

KILAUEA SOUTHWEST RIFT ZONE

Under trade wind condition, during the day, moderate to moderately strong northeast trade winds are expected to sweep through the rift zone. At night moderate drainage winds from the upper slopes of Mauna Loa should sweep through the rift zone from the north.

Under non-trade wind condition, during the day, light to moderate southerly sea breeze-upslope winds are expected to pass through the rift zone. At night, the light to moderate drainage winds from the north are expected to pass through the rift zone.

There is great variation in the amount of rainfall over this rift zone - from about 100 inches a year at the northern end of the rift zone near Hawaii Volcano National Park Headquarters to about 20 inches a year at the southern end of the rift zone near Hilina Pali in the Kau Dessert. The greatest variation in rainfall is at the upper end of the zone where in the short distance of about a mile from the National Park Headquarters to Halemaumau, the rainfall drops from 100 inches a year to 50 inches a year. There are no rainfall stations in the Kau Desset.

Hawaii Volcano National Park Headquarters, at 3,970 feet elevation, with an average maximum and minimum temperature of 68.1°F and 52.°F, respectively, is the only temperature station in the rift zone.

There are few streams in the Kilauea Southwest Rift Zone because the water quickly percolates into the young and highly permeable lava flows. The few well-defined stream channels are found only between Waiahaka Gulch, near Kapapala Ranch, and Hilea Gulch. No stream has continous flow into the sea, and flood flows reach the sea infrequently and only for short periods.

Ground water in the coastal areas of the rift zone is brackish; at higher elevations dike confined water is present. The Underground Injection Control line is set at an elevation of 200 feet in most of the coastal area but drops to an elevation of 100 feet within the rift zone near Waiapele Bay. Lava flows within the rift zone are dated 1823, 1868, 1920, 1971 and 1974.

Property within the Kilauea Southwest Rift Zone is owned by the State of Hawaii, United States of Amercia (Hawaii Volcano National Park), Bishop Estate, Ka'u Sugar, International Air Service, Seamountain Hawaii, C. Brewer, and a number of small parcel landowners.

Rift zone areas are zoned either Conservation, Resource and Limited Subzones, or Agricultural. All rift zone areas, except for National Park lands, are presently used for grazing.

The nearest urban or residential areas are Pahala town north of the rift zone boundary, and Punaluu, west of the boundary. Both communities essentially border the rift zone area.

This area is poorly characterized biologically. It was not included in USFWS vegetation mapping. The area is generally disturbed, with some pockets of native scrub along the coast and near the boundary of the national park, and is primarily of little biological significance since it contains no endangered species habitat.

There are no known archaeological sites within this subzone.

Development of geothermal resources in portions of this rift zone, outside the National Park, would probably result in minimal environmental impact.

Development proximity to the Pahala and Punaluu communities may result in aesthestic impact. Air Quality will not be impacted since it is expected, given the current technology level that all air quality impacts will be abatted so as to comply with State Air Quality standards for geothermal development.

KILAUEA EAST RIFT ZONE
(in general)

Under trade wind condition, during the day, northeast trade winds pass through the entire rift zone. Wind speeds vary from light to fast depending on the topography. The southern half of the rift zone will have moderate to fast trade winds, the northern half of the rift zone will have light to moderate wind speeds. At night, the moderate northeast trades pass through the eastern end of the zone. Gentle to moderate northerly drainage downslope winds pass through the remainder of the rift zone.

Under non-trade wind condition, during the day, gentle to moderate sea breeze-upslope winds from the southeast through southwest pass through the rift zone. At night, gentle to moderate downslope winds from the higher slopes drain down through the rift zone from the north through west.

Rainfall is heavy over most of the central northeast half of the rift zone - over 100 inches a year. Rainfall falls off sharply at the western end of the rift zone from 100 inches a year to 35 inches a year in a short distance of less than 2 miles. The western end of the rift zone has the lowest rainfall.

Hawaii Volcano National Park Headquarters, at 3,970 feet elevation, Paho, at an elevation of 650 feet, and Pohoiki, elevation 10 feet and with an annual rainfall of about 100 inches can be used as representative temperature stations in the rift zone. (table 7) Pahoa and Pohoiki have average annual maximum and minimum temperatures of 78.2°F and 63.4°F, and 81.2°F and 67.2°F, respectively. The average annual temperature at National Park Headquarters is 68.1°F and 52.9°F.

There are no known surface streams or natural water storage features in the Kilauea East Rift zone, with the exception of Green Lake in Kapoho Crater.

Ground water occurs as dike water and basal water in the Kaiuaea East Rift Zone. The only known perched water exist north of Mountain View.

Basal water underlies all of the Kilauea East Rift Zone except where dikes occur. Hydraulic graidents along the northeast coast of Puna range between 2 and 4 feet per mile, with water-table elevations of 12 to 18 feet above sea level 5 to 6 miles inland. Along the southeastern coast, gradients range between 1 and 2 feet per mile, with water-table elevations of 3 to 4 feet above sea level of a mile and a half inland. The main reason for the difference in hydraulic gradients between the northeast and southeast coasts is the amount of rainfall per unit of surface area and the barrier effect of the east rift zone on ground water movement. The effectiveness of the east rift zone as a barrier to ground water movement is demonstrated by the difference in basal water-table levels.

The only significant source of saline water that contaminates the basal aquifer is sea water, with a chloride content of approximately 19,000 mg/l. Because of the effects of mixing, most ground water at the coast is brackish. Salinity and temperature vary greatly north

and south of the rift zone. Wells and shafts north of the rift zone are characterized by lower temperatures and lower salinities. Wells in and near Keaau have water temperatures of 66° to 68°F. The water temperature of wells near Pahoa ranges between 72° and 74°F. Wells located more than 3 miles inland generally have a chloride conentration of less than 20 mg/l. South of the rift zone, high well-water temperatures and salinities are encountered. The water temperature of the Malama-Ki well, 2783-01, in 1962 was 127-130°F with salinity between 5500 and 7000 mg/l at pumping rates of 100 to 480 gpm. The water temperature of thermal test well No. 3 in 1974 was 199°F, with salinity of 2000 mg/l. The average chloride content of ground water south of the rift zone is probably greater than 3000 mg/l, probably due in part to heating of sea water by volcanic activity below the basal lens. The warmer, less dense sea water rises, contaminating the fresh water in the basal aquifer.

KILAUEA LOWER EAST RIFT ZONE

Property in the Lower portion of the Kilauea East Rift Zone is owned by six large area landowners and numerous small area landowners. Large area landowners include the State of Hawaii, Bishop Estate, Campbell Estate, Puna Sugar Company, Kapoho Land Development Corporation, and Tokyu Land Development Corporation.

Property within the Lower East Rift Zone is zoned Agricultural, Conservation, Urban and Rural. It should be noted that existing land uses in Agricultural zoned areas include both culturated and unculturated land, and agricultural subdivisions. Agricultural subdivisions are designated by the County of Hawaii as A-1a, meaning an agricultural subdivisionof one acre lots. Five one acre subdivisions are located within the rift zone boundaries, and include Leilani Estates, and Nanawale Subdivision. Conservation zoned areas include Forest Reserve lands, the Waokele O Puna Natural Area Reserve and the Kapoho Lava flow of 1960. Urban areas within the rift zone boundaries include Pahoa, Kaniahiku Village and a small portion of the Kapoho Beach Lots.

Lava flows in the Lower East Rift Zone include flows dated 1750, 1790, 1840, 1845, 1955, 1960, 1961, and 1983.

Forested areas in the Lower East Rift Zone consist primarily of Category 2 and 2A forest, mature native forest with over 75% native cover and native scrub and low forest. Isolated areas of Category 1 exceptional native forest with over 90% mature cover and closed canopies do exist in the Keauohana Forest Reserve consisting of ohi'a-lama forest, in the vacinity of Puu Kaliu and at higher elevations in the Wao Kele O Puna National Area Reserve. Category 3, bare lava, cleared land is more evident in coastal area, especially in the Kapoho area, at Cape Kamukahi.

There is no endangered species essential habitat in the Puna area, since large protions of the area are either cleared agricultual land or bare lava.

Five historic sites are lcoated in the Lower East Rift Zone:

Site No. 7388 - Pahoa District, town.

Site No. 4295 - Pualaa Complex, including an ancient holua slide

Site No. 2501 - Kapoho Petroglyphs, considered unique, and have been placed on the State Register of Historic Sites

Site No. 7492 - Lyman Historic Marker

Site No. 2500 - Kukii Heiay, reamins of heiau built by Umi on his tour of Hawaii after coming to power.

Development of geothermal resources in the Lower East Rift-Zone has been underway since 1973-74 with the issuing of goethermal resource mining leases fpr four acres, designated GRML R-1, R-2, R-3, and R-4. Development of additional sites in the Lower East Rift zone will not impact any endangered species essential habitat, but may impact existing communities in terms of noise and aesthetics. The provision of a buffer zone will help to mitigate such impacts. Air Quality will not be impacted, since it is expected that given current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

KILAUEA UPPER EAST RIFT ZONE

Property in the Upper East Rift Zone is owned by four large area landowners, the United States of America (Hawaii Volcanoes National Park), the State of Hawaii, Bishop Estate, and Campbell Estate. Smaller holdings owned by various individuals are found in the Royal Gardens Subdivision along the coast and in urban and agricultural zoned areas in the Kilauea-Olaa area at the mauka boundary of the rift zone.

The Upper East Rift Zone is primarily zoned Conservation Protective, Resource and Limited Subzones. Exceptions are the Aunahou Ranch land, Royal Gardens subdivision, zoned for agricultural use and the urban and Agriculatural zoned areas in the Kilauea-Olaa area.

Existing land used include the Hawaii Volcanoes National Park (the largest area), forested areas in Kahauale'a, a grazed area in the vacinity of Ainahou Ranch, a portion of the Wao Kele O Puna Natural Area Reserve, and the Volcano and Royal Gardens subdivisions. Also included are protions of the Kilauea Forest Reserve, Kilauea Military Camp, and Kilauea Golf Course.

Also included on the list of existing land uses is the Campbell Estate/True Mid-Pacific Geothermal Development area as approved by the Board of Land and Natural Resources in 1983.

Forested areas in the Upper portion of the East Rift Zone consist primarily of Category 1, exceptional native forest with over 90% native cover and closed canapy, and Category 2 mauture native forest with over 75% native cover interspersed with bare lava flows, dated from 1968-1973, 1977 and 1983-84.

Essential endangered species habitat for 'o'u encompasses a major portion of the Kahauale'a area, and extends into the Hawaii Volcanoes National Park land to the south. The Dark-runiped petrel is known to nest in Napua Crater and I'o have established territorial at Makapuhi Crater and at lower elevations in the vacinity of the Royal Gardens Subdivision.

There are no know archaeological sites within the Upper East Rift zone.

Development of goethermal resources in the Kilauea Upper East Rift zone will be limited to areas outside the Hawaii Volcanoes National Park. Air quality within surrounding areas will not be impacted since it is expected that, given the current level of abatement technology, geothermal facilities will comply with State Air Quality standards for geothermal development.

Site development may impact endangered o'u habitat however, as stated in the Kohanalea Environment Impact Statement (June 1982), "the minimal removal of vegetation and trees within the Kahau'alea project area should not significantly threaten the o'u". (pg. 5-11). It should also be noted that a portion of the o'u habitat has been lost due to recent lave flows.

APPENDIX A

Kilauea Lower East Rift Zone

The East Rift Zone of Kilauea Volcano stretches 28 miles east-northeast from just south of Kilauea Caldera to Cape Kumukahi near Kapoho, and then beyond undersea for 70 miles (MacDonald and Abbott, 1979). The area included in this discussion is the lower portion of the rift east of Hawaii Volcanoes National Park and south and east of Puna Forest Reserve (Pahoa South and Kapoho Quadrangles and portions of Kalapana and Pahoa North). Elevations within the study area range from 1400 feet east of the Puna Forest Reserve to almost sea level along the coast.

The climate along the lower East Rift and south to the coast is generally wet and warm. Mean annual rainfall ranges from almost 150 inches near Pahoa to 75 inches at Kalapana on the coast. Precipitation is moderately seasonal; summer months are somewhat drier than winter months. Mean annual temperature varies from below 70°F above Pahoa to more than 72°F along the coast (DLNR, 1970).

As Kilauea's East Rift is a geologically active region, much of the substrate here is composed of bare or sparsely vegetated recent flows. The on-going eruption of Puu O near the National Park boundary has produced flows in two directions; northeast into Kahau'alea and the Puna Forest Reserve, and southeast into Royal Gardens Subdivision and upper Kapa'ahu. Other notable historic flows in the lower East Rift Zone are the 1955 series of flows near Kapoho (Kii) and from above the Pahoa-Kalapana Road to the coast near Kehena, and the Kapoho flow of 1960 from Kapoho to Cape Kumakahi. Most soils of the lower East Rift (apart from recent flows and cinder cones) are either histosols, composed of a thin layer of organic material over rock, or inceptisols, formed from volcanic ash.

Vegetation of the lower East Rift cannot be simply characterized. Before human occupation most of this area was probably covered by closed lowland wet forest dominated by 'ohi'a (Metrosideros polymorpha), hala (Pandanus sp.), and lama (Diospyros ferrea) near

the coast grading into an 'ohi'a-lama forest with other native trees (Psychotria hawaiiensi, Xylosma hawaiiense, Tetraplasandra hawaiiensis), iie'ie (Freycinetia arborea), and tree ferns (Cibotium spp.) at higher elevations (around 800 ft.). Another vegetation type which undoubtedly was and still is prominent in the lower East Rift is open to scattered, low to moderate-stature 'ohi'a scrub with uluhe (Dicranopteris spp.), native shrubs, and 'uki (Machaerina mariscoides).

Remnants of these native vegetation types are still found on Kilauea's lower East Rift, but many forests and woodlands here have been disturbed to some degree or cleared for agriculture, towns, and subdivisions. Large tracts of land in this area are planted in sugar cane, papaya, and to a lesser extent, macadamia nuts. In addition to these cultivated fields, much old agricultural land has been abandoned and has a cover of weedy species of exotic trees, grasses, and shrubs. Apart from agricultural lands, several subdivisions have been developed in lower Puna, resulting in large parcels of forest and scrub cut by roads and clearings. Clearing and road-cutting in the East Rift has been followed by the invasion of forests and woodland by exotic plants, which are the major factor of disturbance in this area. Some of the most noxious of these exotic weeds are Malabar melastome (Melastoma malabathricum), christmasberry (Schinus terebinthifolius), waiawi (Psidium cattleianum), guava (P. guajava), thimbleberry (Rubus rosaefolius), melochia (Melochia umbellata), lantana (Lantana camara), California grass (Brachiaria mutica), Molasses grass (Melinis minutiflora), and broomsedge (Andropogon virginicus). Feral pigs are another major factor of disturbance in the upper forests of this region.

The most undisturbed and diverse remnants of vegetation noted during this survey were three areas in the Pahoa South Quadrangle. One of these is the closed 'ohi'a-lama forest of Keauohana Forest Reserve. The canopy of this forest is intact and the secondary tree layer is rich, containing two candidate endangered tree species ('ahakea-Bobea timonioides and 'ohe-Tetraplasandra hawaiiensis), as

well as diversity of other native trees such as opuhe (Urera sandvicensis), maua (Xylosma hawaiiense), mamaki (Pipturus sp), kopiko (Psychotria hawaiiensis), and others. Although the understory of this forest contains exotic plants, it also has many native components such as tree ferns and native shrubs.

The second most botanically rich area is in the southeast corner of Leilani Estates and the northern part of Malama-Ki Forest Reserve (ea. 700 ft). This is also a closed tall 'ohi'a-lama forest with 'ohe trees and tree ferns. The third most interesting area is a small fore above Kama'ili fronting a lobe of the 1955 lava flow at about 200 ft. elevation. This low-elevation 'ohi'a-lama forest is composed almost entirely of native plants and supports a predominantly native understory of ferns and shrubs, including the candidate endangered ko'oko'olau (Bidens skottsbergii).

Several other relatively diverse, mostly native forests were found in the lower East Rift Zone. The most notable of these were in Puulena and Kahawai Craters, on the east side of Nanawale Estates, on the slopes behind the quarry near Kalapana, in the Halepua'a section of Nanawale Forest Reserve, and on relatively recent substrate near Kaimu, Kehena, and Pualaa. These are 'ohi'a-lama or 'ohi'a dominated lowland forests with a predominance of native plants; all but the coastal forests with exposed aa are known to support candidate endangered plant species. In addition to these closed and open forests, several scrub vegetation types dominated by native shrubs and low trees (but lacking uluhe) were observed near the Hawaii Volcanoes National Park boundary past Kalapana, on the coast at the east end of Malama-Ki, and along the coast near Nanawale north of Kapoho and south of Hawaiian Beaches.

As this was a broad-scope brief survey to determine as many vegetation types within the lower East Rift Zone as possible, and not every area differentiated on aerial photographs was ground checked. In particular, closed forests not reached include those on the upland slopes above Kalapana, remnant stands on the rift between Leilani Estates and the Opihikao Road, areas bordering the east side of the Puna Forest Reserve and several coastal areas separated from roads by inhabited parcels near Kehena and Kapoho.

ASSESSMENT CRITERIA

LAND OWNERSHIP

DESCRIPTION	KILAUEA			MAUNA LOA		HUALALAI	HALEAKA	
	EAST (PAHOA)	MIDDLE (KAHALUALEI)	S.W. (PAHALA)	EAST	S.W.	N.W.	EAST	S.
FEDERAL		70%	60%				5%	
STATE	45%	<5%	20%	75%	<5%		50%	45
BISHOP ESTATE	5%	<5%		25%		100%		
CAMPBELL ESTATE	5%	20%						
DAMON TRUST ESTATE					95%			
HANA RANCH							35%	
ULUPALAKUA RANCH								50
PUNA SUGAR	5%							
TOKYU LAND DEVELOPMENT	5%							
KAPOHO LAND DEVELOPMENT	5%							
ROMAN CATHOLIC CHURCH	<5%							
OTHERS	25%	<5%					10%	5%
C. BROWER			<5%					
SEAMOUNTAIN HAWAII			<5%					
INT'L AIR SERVICE			<10%					

ASSESSMENT CRITERIA

LAVA FLOWS

DESCRIPTION	KILAUEA			MAUNA LOA		HUALALAI	HALEAKALA	
	EAST (PAHOA)	MIDDLE (KAHALUALEI)	S.W. (PAHALA)	EAST	S.W.	N.W.	EAST	S.
1981 TO PRESENT		○ ~~83-84~~		84				
1971 TO 1980	77	71-73						
1961 TO 1970	61	70						
1951 TO 1960	55 60							
1941 TO 1950				42	OUTSIDE OF AREA 50			
1931 TO 1940								
1921 TO 1930					26			
1911 TO 1920			○		16			
1901 TO 1910					07			
	1845			1852	1886-1887	1800-1801	490-10,000 YEARS AGO	179
	1840							
	1790?							
	1750?							

ASSESSMENT CRITERIA

PRESENT LAND USES

DESCRIPTION	KILAUEA EAST (PAHOA)	KILAUEA MIDDLE (KAHALUALEI)	KILAUEA S.W. (PAHALA)	MAUNA LOA EAST	MAUNA LOA S.W.	HUALALAI N.W.	HALEAKAL EAST	HALEAKAL S.W
URBAN: RESIDENTIAL	<5%	<5%					5%	
RURAL: RESIDENTIAL							5%	
AGRICULTURE: OTHER USES	35%							
CROPLAND	10%							
GRAZING		<5%	○	20%	60%	10%	30%	70%
RESIDENTIAL	5%	<5%			10%			<5%
CONSERVATION: FOREST RESERVE	5%	<5%		35%	<5%	40%	60%	<5%
NATIONAL PARK		65%	○					
STATE PARK								NO BOUNDA
OTHER FORESTS		20% ✓	○			50%		
OPEN OR OTHER USES	10%				20%			5%
WILDLIFE SANCTUARY				15%	<5%			
HUNTING AREA								<5%
NATURAL AREA RESERVE	30%	✓		10%				10%
HISTORICAL OR ARCHAEOLOGICAL SITES	8				2		7	5
WATER SOURCES								3
SPECIAL MANAGEMENT AREA				20%				

VEGETATION

ASSESSMENT CRITERIA

Brackish >250 ppm
15% seawater 2925 ppm
Seawater 19,500 ppm

DESCRIPTION	KILAUEA EAST (PAHOA)	KILAUEA MIDDLE (KAHALUALEI)	KILAUEA S.W. (PAIHALA)	MAUNA LOA EAST	MAUNA LOA S.W.	HUALALAI N.W.	HALEAKA EAST	HALEAKA S.
CATEGORY 1: EXCEPTIONAL NATIVE FOREST; CLOSED CANOPY, OVER 90% NATIVE COVER	5%	35%		60%	<10%	15%	50%	<5%
CATEGORY 2: MATURE NATIVE FOREST; OVER 75% NATIVE CANOPY	25%	○	✓	○	○	○	30%	
CATEGORY 2A: NATIVE SCRUB OR LOW FOREST	25%	○	✓	○	○	○		75%
CATEGORY 3: CLEARED LAND; NON-NATIVE FOREST; BARE GROUND OR LAVA	45%	○	✓	○	○	○	20%	5%
XX (BARE GROUND)					○			15%
BLF (BARE LAVA FLOW)								
NM (NOT MAPPED)								

ASSESSMENT CRITERIA

ENDANGERED BIRD HABITATS

DESCRIPTION	KILAUEA			MAUNA LOA		HUALALAI	HALEAKA	
	EAST (PAHOA)	MIDDLE (KAHALUALEI)	S.W. (PAHALA)	EAST	S.W.	N.W.	EAST	S.
ALALA (HAWAIIAN CROW)					◐	○		
HAWAII FOREST BIRDS: HAWAIIAN CREEPER				○	◐	○		
HAWAII AKEPA				○	◐	○		
AKIAPOLAAU				○	◐			
OU		(45%)		○				
NENE				○	○	○		
POS. DOWNGRADE TO THREATENED) IO (HAWAIIAN HAWK)		○		○				
MAUI FOREST BIRDS: AKOHEKOHE) CRESTED HONEYCREEPER							◐	
MAUI AKEPA							◐	
AUI PARROTBILL							◐	
HAWAIIAN DARK-RUMPLED PETREL (UA'U)		○						
A'O) (THREATENED) EWELL'S MANX SHEARWATER								
HAWAIIAN HOARY BAT								
ENDANGERED BIRDS (NONE)	(100%)				(50%)		(80%)	(100