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MARTIN MARIETTA

ARCHAEOLOGY IN THE KĪLAUEA EAST RIFT ZONE

PART II: A PRELIMINARY SAMPLE SURVEY

KAPOHO, KAMĀ'ILI AND KĪLAUEA GEOTHERMAL SUBZONES

PUNA DISTRICT, HAWAI'I ISLAND

by

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MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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PREFACE

This report was prepared by International Archaeological Research Institute, Inc., under subcontract to Oak Ridge National Laboratory. The report makes available and archives the background scientific data and related information collected on archaeological resources and prehistoric and historic settlement and land-use patterns during a sample survey of the Geothermal Resource Subzones located in the Puna District on the island of Hawaii. The study was undertaken during preparation of an environmental impact statement (EIS) for Phases 3 and 4 of the Hawaii Geothermal Project (HGP) as defined by the state of Hawaii in its April 1989 proposal to Congress. The U.S. Department of Energy (DOE) published a notice in the *Federal Register* on May 17, 1994 (*Fed. Regis.* **59**, 25638) withdrawing its Notice of Intent (*Fed. Regis.* **57**, 5433) of February 14, 1992, to prepare the HGP EIS. Since the state of Hawaii is no longer pursuing or planning to pursue the HGP, DOE considers the project to be terminated.

ABSTRACT

This report describes a preliminary sample inventory and offers an initial evaluation of settlement and land-use patterns for the Geothermal Resources Subzones (GRS) area, located in Puna District on the island of Hawai`i. The report is the second of a two part project dealing with archaeology of the Puna GRS area --or more generally, the Kīlauea East Rift Zone. In the first phase of the project, a long-term land-use model and inventory research design was developed for the GRS area and Puna District generally. That report is available under separate cover as *Archaeology in the Kīlauea East Rift Zone, Part I: Land-Use Model and Research Design* (Burtchard 1994). While salient points are summarized here, interested readers may wish to consult that document for additional background detail. The present report gives results of a limited cultural resource survey built on research design recommendations. It offers a preliminary evaluation of modeled land-use expectations and offers recommendations for continuing research into Puna's rich cultural heritage.

The present survey was conducted under the auspices of the United States Department of Energy, and subcontracted to International Archaeological Research Institute, Inc. (IARII) by Martin Marietta Energy Systems, Inc. The purpose of the archaeological work is to contribute toward the preparation of an environmental impact statement by identifying cultural materials which could be impacted through completion of the proposed Hawai`i Geothermal Project[1].

The original research design began the assessment process by 1) providing basic descriptive background into the region's prehistoric and historic record; 2) developing the selective environmental conditions for anticipating basic patterns in the distribution, character and abundance of cultural properties over the East Rift Zone landscape; and 3) establishing a research context for improving our understanding of long-term Puna settlement processes. The East Rift Zone land-use model (see Burtchard 1994) anticipates greatest evidence for prehistoric residence along a narrow coastal margin with diminishing indications of permanent settlement inland. One of the more important environmental conditions for anticipating site distribution is argued to be the presence of variably aged lava flows across the district. Both inland and coastal zones should exhibit agricultural use, but the inland zones are expected to demonstrate greater emphasis on agriculture with limited, shorter-term residence. Use of inland terrain is viewed as logistically tethered to primary residential communities near the coast throughout the pre and early post-contact periods. Furthest removed from the coast, the upland forest is expected to have served largely for overland travel, as a collecting and hunting area, and (until limited by clouds and cold) an emergency agricultural zone.

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[1]In its 1990 proposal to Congress, the State of Hawai`i outlined four phases for the Hawai`i Geothermal Project's development. The present project was contracted to assess archaeological impacts that would result from the last phase -- which originally proposed a series of wells, power plants and ancillary facilities to be built in various locations across the project area. Power was to be transmitted off-island via overhead and underwater transmission lines from the project area, across Maui Island, and on to other islands further northwest. A concurrent study (Erkelens 1995) examines the archaeological site distribution in the proposed transmission line corridor for Maui. At the time of publication of this report, the EIS (environmental impact statement) process has been terminated.

In order to examine model expectations, a block survey strategy was developed to sample modeled land-use zones in the three Puna geothermal resource subzones. The present survey is a first step in that sampling process. For this survey, a field three-person field crew completed pedestrian inventory of the three geothermal resource subzones in 20 working days in February and early March, 1994. Most of the areas surveyed consisted of isolated pockets of the oldest lava *(kīpuka)* within the project boundaries. Sediments in these survey units typically dated between 750 and 1250 years old (A.D. 500-1250). Selected units were widely dispersed across the project area in order to maximize environmental coverage. Where necessary, some younger flows dating to 750-400 years old (A.D. 1250-1600) were also examined. These procedures facilitated at least a limited inspection of all but one of the prehistoric land-use zones modeled in the research design. Omitted Zone 3a--leeward agriculture, coastal margin-- did not transect the project area.

Survey procedures facilitated identification and documentation of 15 new site localities. In particular, associations of native cultigens were a common site to several of the sample areas. Their prevalence may prove to be important for understanding the land-use history of the district. Due to the limited nature of this archaeological survey, the data do not constitute a satisfactory test of the model. However. the combination of new and existing archaeological data, and ethnohistorical information is generally consistent with it's expectations. The survey also enabled a greater understanding of how the East Rift zone model might be further evaluated. Suggestions and recommendations for future study of Puna archaeology are also included.

ACKNOWLEDGMENTS

We are indebted to the landowners and caretakers who both granted us permission to survey their lands and provided information pertaining to potential sites and history of the area. These individuals and organizations include John Aiona; Bill Anderson; Bill Dement and Campbell Estate; Lisa Heuer; Robert Lindsey and Kamehameha Schools/Bishop Estate; Arthur Lyman and Kapoho Land and Development Co.; David McEntee; Ray Shiroma; Gene and Diane Thomas; Rio; Floraine Van Orden; and David, Jim, Travis, Catherine, Christian and Erica at Upper Kaimū Homesteads.

Other individuals also facilitated our work by providing information concerning our survey areas: Gary Dahl and Wilton Shiraki at True Geothermal were most helpful in directing us toward several trails in the Kīlauea subzone, and in cautioning us unto their perils. René Siracusa was generous with her time in discussing the history of the Pāhoa railroad and her knowledge of its present remains. Davianna McGregor shared her ethnographic knowledge of the area and inspired our search for the *hōlua* slide at Kahōlua o Kahawali. Jon Matsuoka and Luciano Minerbi have been generous to share their insights about current land-use in the Puna District. Fred Stone shared his knowledge of cave sites in the Puna district, and has enlightened us concerning the fragility of these environments. Pali Kapu Dedman and Margaret McGuire listened carefully to our survey plans, offered constructive critical comments and helped put us in touch with others willing to pass-on bits of their knowledge of the area. U.S. Fish and Wildlife biologist Steve Miller coordinated that agency's work with our own and put us on the trail of an unrecorded lava tube cave. Holly McEldowney's assistance and comments have been invaluable. She inspired us to hunt for more lava tube caves, and was generous in sharing her personal notes on various aspects of Puna archaeology.

We also appreciate the continued interest in this project by the Oak Ridge National Laboratory. We particularly appreciate the close coordination maintained between Oak Ridge and Hawai`i by Lillian Trettin. Thanks to our third crew member, Audré Harlow, who took on the ambitious task of plant identification in a place with high biodiversity. She also provided good humor and good work in a wet and occasionally dangerous field effort. Roger Blankfein produced the final maps and David Welch coordinated efforts between IARII and Oak Ridge.

To these individuals and organizations, and others who share an interest in Puna's cultural heritage, we extend our thanks.

PUNA PAIA AALA

Puna's Bowery Walls Waltz Song No. 2:
composed by Lilioukalani, Queen Regent of Hawai`i

Ia Puna Paia Aala	Puna's bowery walls are
Pili maunake ona ona	Laden grove of sweet flowers
Ila ila ke kau nu	There my heart yearns to be
Ana Kaupono ana na a kamanao	To dwell there, my sincere desire
Hoohihi i ka nani	So I long for thy image
Pua mai a kale hua	Bright flower of the Lehua
Ane he au e kii	I would take thee, and pluck thee
I pua kau no kuu umauma	And press thee nearest to my heart
CHORUS	
Puna Paia Aala	Puna's shaded bowers
Kili hea i ke ona ona	are made redolent with perfume
Ona welai kea loha	Sweet in language full of love
Ua la wa ia ow me au	Binding ever thee to me.

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INTRODUCTION

This report summarizes the results of a walk-through survey undertaken in the Geothermal Research Subzones (GRS) Project Area in the Puna District on the Island of Hawai`i, and provides an initial evaluation of cultural and resource use-patterns for the District. The principal aim of the survey was to develop an understanding of the general extant prehistoric[2] and historic land-use patterns across a 9000 hectare area, spanning east to west across the region, which has been proposed for geothermal resource development (see Figure 1). This summary considers the archaeological data from the GRS Project Area in relation to an environmental/land-use model developed for the archaeological inventory research design (Burtchard 1994) that preceded the present effort. Based on present accumulated knowledge, this model adequately illustrates the extant land-use patterns for the region, and should be considered relevant to further planning or development within the region.

THE PRESENTLY UNDERSTOOD PAST: HAWAI`I ISLAND

The Island of Hawai`i, also called the "Big Island", is the largest and youngest island of the Hawaiian archipelago (Figure 1). It is also perhaps the best known of all the islands in terms of its archaeology and early history (Kirch 1985: 154). The Big Island was home of some of the most powerful and renown chiefs in the archipelago, and is the location of some of the more extensive archaeological investigations of Hawaiian settlement pattern systems (cf. Cordy 1981, Rosendahl 1972, Tuggle and Griffin 1972, Tuggle and Tomonari-Tuggle 1980). Much of the available synthetic ethnohistoric work (e.g., I`i 1959, Kamakau 1992, Malo 1951) devotes considerable attention to detailing the achievements of Hawai`i Island chiefs, in particular Kamehameha I's historic period *coup* during the 1780s and 1790s which ultimately united the island chain under his leadership.

Although our present knowledge of the history and archaeology of this island is greater than for the other main islands of the archipelago, this knowledge is not uniformly distributed. Many of the ethnohistoric accounts (see I`i 1959, Kamakau 1992, Malo 1951) describe the political activity centering around the leeward districts of the island where late pre-contact period social perturbations were most common. Archaeological work has also centered on the leeward side of the island, where a history of cattle ranching and coffee farming has contributed to a greater degree of site preservation than on the windward slopes which were developed for sugar plantations. The districts of Kona and Kohala are perhaps the best known in terms of their archaeological prehistory. Windward districts, such as Puna, are less known and less often studied by archaeologists.[3]

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[2]The term *prehistory*, as it is used in this context, refers to the time prior to European arrival in 1778 when written records about Hawai`i began to proliferate. It is used interchangeably with the term *pre-contact*.

[3]It should be noted, however, that Waipi`o Valley in the windward Hamakua district is believed to have been a political center prior to the rise of leeward chiefs. A large number of *heiau*, ritual structures associated with elite activities, are ethnohistorically known for the district, though few have actually been located (see Stokes 1991).

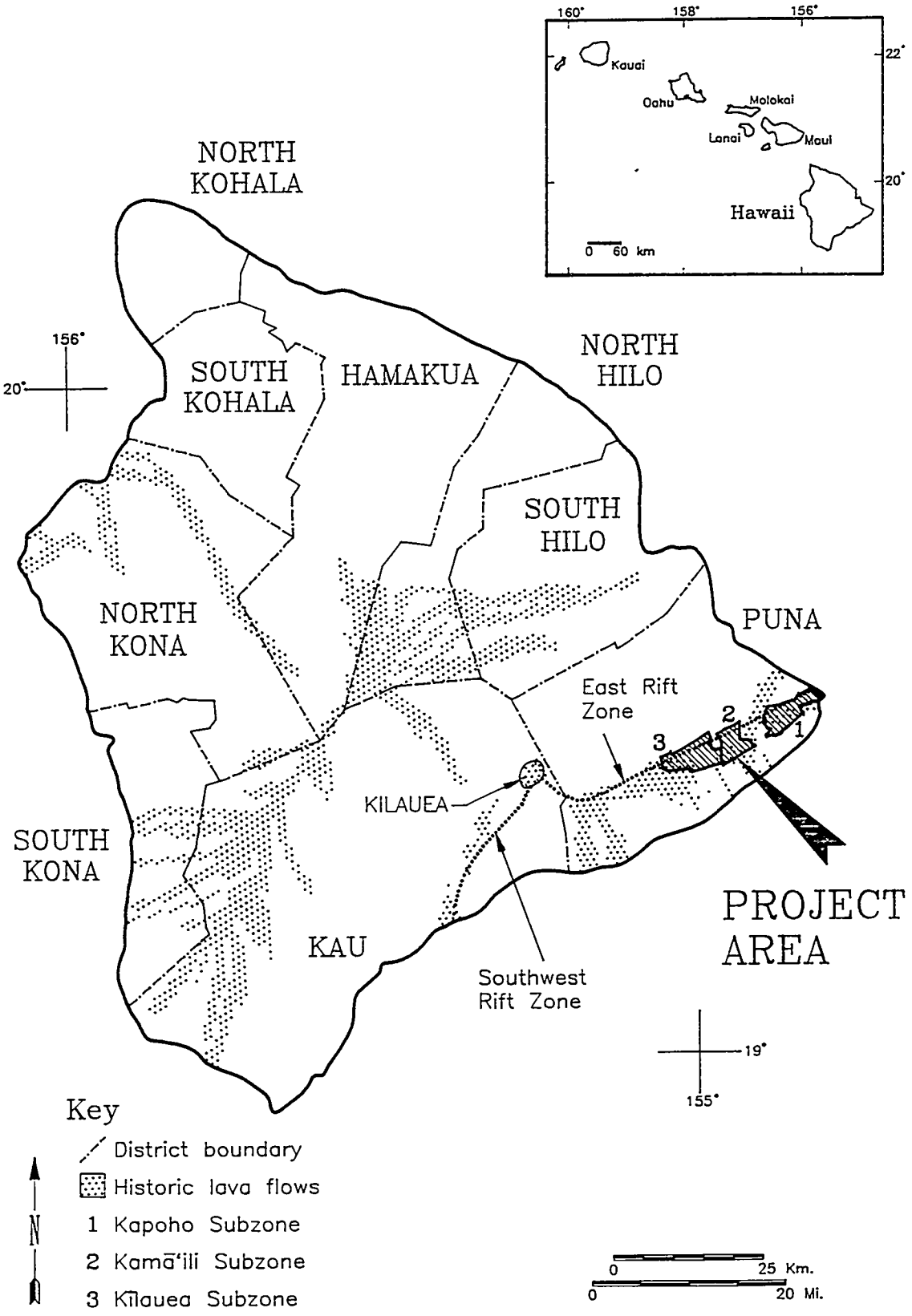

Figure 1. Map of the Geothermal Resources Subzones (GRS) Project Area

There are a variety of reasons why available information about the past is biased toward Leeward Hawai`i Island. First, large scale development projects requiring archaeological survey and data recovery have been focused on the leeward districts. Second, archaeological studies concerned with documenting settlement systems have employed the leeward areas which tend to be more accessible. Third, discussions of social complexity will necessarily focus on the archaeological evidence from the leeward areas, with their greater abundance of ritual and monumental structures, than in districts like Puna where these structures have been less often encountered (see Stokes 1991).

THE PRESENTLY UNDERSTOOD PAST: PUNA DISTRICT

Puna, poetically translated as "bowers fragrant with pandanus" and "the land in the heart of Kane" (Pukui et al. 1974),[4] has been described as an area of bounty despite the relative scarcity of visible monuments to cultural interventions with the landscape across the district. The region has been described as one the most fertile agricultural expanses on the island until more recent lava flows covered portions of the district (Handy and Handy 1972).[5] Despite the lack of archaeological sites known to the area, it was well traveled and fairly accessible via a series of trails wrapping around the coast and cutting through the inland.[6] Travel through the area was relatively quick. In 1833, Sarah Lyman clocked a two day journey by foot from Hilo to the Halemaumau Crater, within the present boundaries of the Hawai`i Volcanoes National Park, estimating a traveling rate of two miles an hour, with a "proper night's rest" in between (Lyman 1970: 55). More recently, an attempt to retrace the route taken by Ellis in 1823 corroborated this rate of travel (Friends of the William Ellis Trail 1974).

In 1985, Kirch aptly labeled the Puna area as an "archaeological void" in the prehistory of the Island of Hawai`i (1985:154). Not surprisingly, most areas within the archipelago associated with a rural history, and not yet subject to extensive modern economic development, have remained "voids" in our archaeological knowledge of the prehistory of the Hawaiian Islands. Although scattered site reports do exist for limited areas within the district,[7] archaeological coverage is quite sparse in comparison with that for the leeward districts (Figure 1). This is in part due to the delayed progress of industrial and tourist encroachment into the district. While major economic crops and historic attractions are more often listed to describe the other areas of Hawai`i Island, Puna is most often characterized as a place reflecting a bygone era (see Stone 1988: 4). Oddly enough, the bygone era seems to persist in an area with very modern geologic change and destruction of the physical remains of that past.

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[4]Translations for Hawaiian place-names are derived from Pukui et al. (1974). The spelling of Hawaiian words follows conventions set forth in Pukui et al. (1974), however the hyphens placed as aids to pronunciation have been omitted. Except for place names, proper nouns, and common geological terms (`a`ā and pāhoehoe), Hawaiian words, as well as other non-English words, appear in italics.

[5]This statement, based on familiarity with the ethnohistoric literature, cannot readily be corroborated due to the difficulty and expense in accurately dating prehistoric lava flows. The most recent lava flow maps (Holcomb 1981, Moore and Trusdell 1991) use various means to determine contemporaneity of various lava formations including geological data, radiocarbon dating and measuring the direction of flow magnetization.

[6]Notes concerning trails through the Puna district are found in several early missionary accounts. The trails followed by Ellis in 1823 and Wilkes in 1841 are perhaps the most comprehensively illustrated (see Fitzpatrick 1986). Ethnohistoric traditions also describe overland travel through the area (see Thrum 1923 and Kawaharada 1992).

[7]See Burtchard (1994) for summary of available archaeological reports related to the Puna district.

THE PUNA GEOTHERMAL SUBZONES PROJECT AREA

The original archaeological inventory research design (Burtchard 1994) and the current study of the Puna Geothermal Resource Subzones (GRS) Project Area (Figure 1) were both commissioned by the U.S. Department of Energy to help develop a more comprehensive understanding of the archaeological history of Puna District; specifically, the three GRS subzones --Kīlauea, Kamā`ili and Kapoho. The survey effort to be discussed in this report not only expands on our understanding of the archaeology of these subzones; it provides an initial evaluation of cultural and resource-use distribution patterns as predicted in the land-use model presented in the research design.

The environmental/land-use model developed for the research design builds on an earlier general land-use/settlement model for windward Hawai`i Island developed by McEldowney (1979). Information from McEldowney's effort was adjusted with more direct consideration of primary variables expected to influence the distribution, type and abundance of prehistoric features across the landscape, taking into account specific environmental variables affecting settlement in the Puna region[8]. Figure 2 shows the environmental/land-use zones proposed for the present survey effort. These zones are expected to model patterned similarities and differences in the character, distribution, and abundance of the region's archaeological remains. Reference may be made to the research design report (Burtchard 1994) for a detailed account of variables underlying the model structure. Table 1 summarizes salient points of that discussion.

Figure 2 also shows transition zones between windward and leeward sides of the district and between inland agricultural and upland forest zones. These zones incorporate areas in which environmental characteristics gradually become sufficiently critical to have an effect on the success of choosing certain land-use strategies over others. For present purposes, the most significant transition is between windward and leeward sides of the study area. Here, the southwestern coastline is sufficiently dry to preclude successful production of the full range of Hawaiian subsistence crops at low elevation --especially *kalo* (*Colocasia esculenta*, see Appendix B) -- (see Handy and Handy 539-543). The transition area marks that portion of the coastline along which taro is believed to become reliably productive in near-coastal context --essentially between Kaimū on the southwest and Kamā`ili on the northeast. Among other impacts, this environmental progression is expected to correlate with differences in land-use patterns and the archaeological record by creating a selective context favoring more thorough integration of upslope/downslope terrain in leeward zones versus greater settlement/agricultural aggregation in windward zones. It is plausible that, once initiated, stability gained by integration of varied ecozones, conferred some stability to leeward communities (complicated here by volcanic instability of Kīlauea's East Rift); making life there nearly as predictable as that on the windward coast. The transition area is not a land-use zone *per se,* but rather reflects uncertainty inherent in the gradual nature of this environmentally based land-use change.

More thorough discussion of the general land-use model and zones outlined above, as well as consideration of principal environmental variables underlying long-term regional settlement patterns, are available in the research design document (see especially Burtchard 1994:19-29). Interested readers are encouraged to consult that report for more detail than is practical here. For present purposes, we reemphasize two general constraints that the Puna environment poses for sustained human land-use and the archaeological record of that use.

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[8]For detailed discussion and clarification of differences between the two models, see Burtchard 1994.

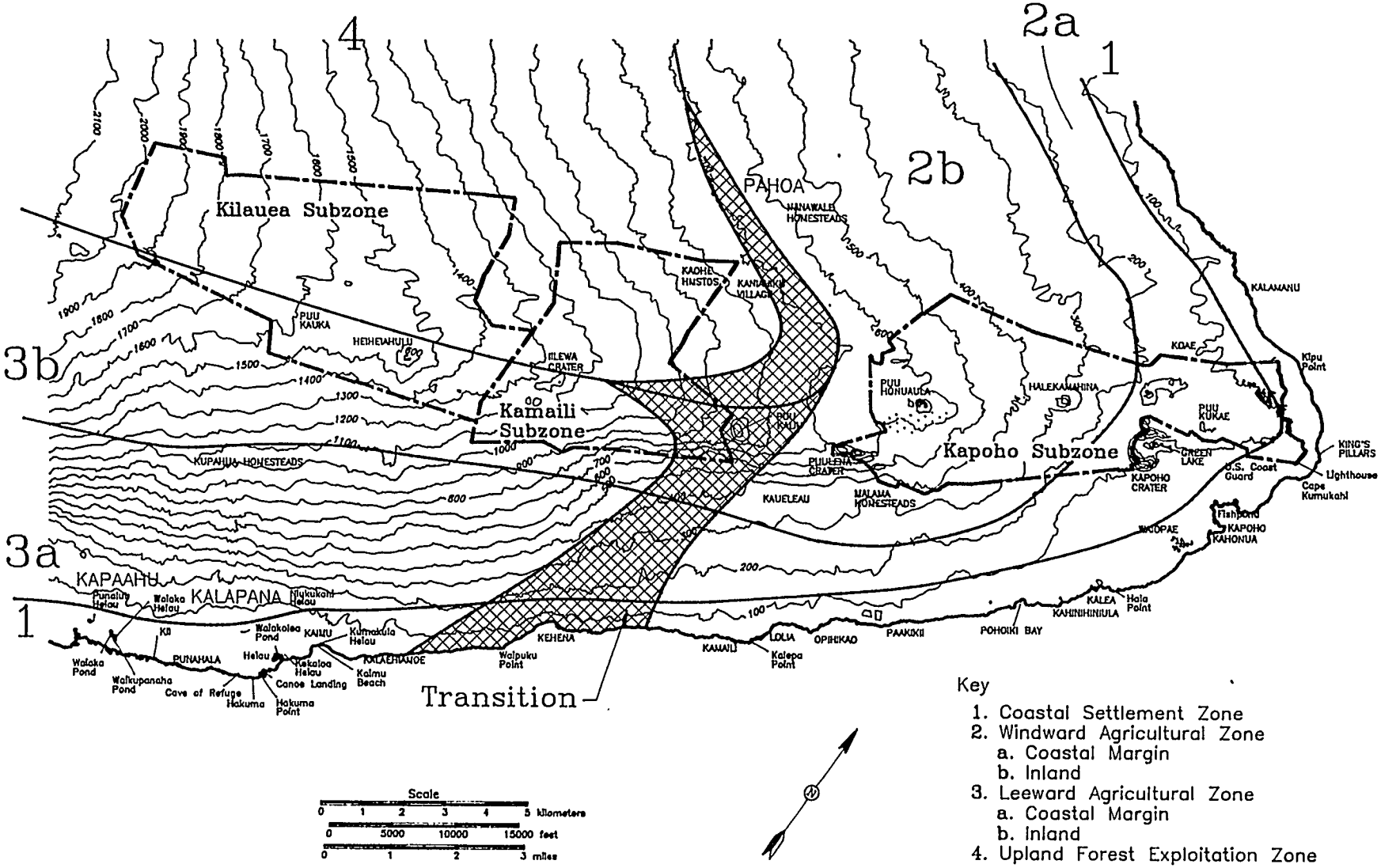

Figure 2. Map of the Geothermal Resources Subzones (GRS) Project Area

Table 1. Environmental Land-Use Model Zones and Expectations

Zone	Name	Location	Expectations
1	Coastal Settlement Zone	The seaward margin, forming a band ca. 0.8 km wide, up to 30-50 m elevation, following the entire coast of the Puna District	The greatest variety of prehistoric features, as well as the majority of permanently established residential features, are expected within this zone
2a	Coastal Margin of the Windward Agricultural Zone	Adjacent to Zone 1 in the eastern half of the Puna District, extending up to 2.4 km inland and ca. 61 m elevation	A high density of agricultural features linked to the coastal settlement areas, with evidence for temporary residential use
2b	Inland Portion of the Windward Agricultural Zone	Adjacent and inland of Zone 2a in the eastern half of the Puna District, extending from 5-10 km inland and 200 m elevation	A moderate density of agricultural structures, and temporary residential use
3a	Coastal Margin of the Leeward Agricultural Zone	Adjacent to Zone 1 in the western half of the Puna District, extending up to 5 km inland and 300 m elevation	A moderate to high density of agricultural features linked to coastal settlement with temporary residential use
3b	Inland Portion of the Leeward Agricultural Zone	Adjacent and inland of Zone 3b in the western half of the Puna District, extending up to the lower boundary of the East Rift and crossing a variety of elevations	A moderate to low density of agricultural features
4	Upland Forest Exploitation Zone	Innermost zone located in the western half of the Puna District, extending north and east of the East Rift	Low feature density and periodic use of area via exploitation of resources

> The environment of the East Rift Zone and its surrounding area affects the archaeological record in at least two ways: 1) through constraints imposed on human use of the region and hence on generation of the archaeological record during the past; and 2) on site integrity and our ability to accurately identify archaeological localities in the present (Burtchard 1994:19).

Prehistoric use of the region is influenced largely by combined effects of rainfall/temperature patterns and repeated volcanic eruptions. Climatic patterns are determined by the manner in which Mauna Loa's East Rift slope intercepts northeasterly trade winds. Elevation of the project area rises from sea level at Cape Kumukahi to 2000 ft asl at Kīlauea subzone's western boundary. At the rim of

Kīlauea volcano's central caldera, elevation is over 4000 ft asl. Adiabatic cooling[9] of the trade winds, due to the presence of the Kīlauea volcano, promotes high rainfall levels on the windward side, increasingly cool and cloudy conditions, and suppresses rainfall on the leeward coastal fringe. Interaction of these variables differentially influences the region's agricultural productive capacity, and in so doing necessarily imposes constraints on the distribution and character of Hawaiian settlements through time.

The Rift zone's volcanic activity impacts both settlement patterns and the preservation of material culture. Eruptive events along the rift repeatedly changed the landscape, altering terrain suitable for supporting agricultural and residential activities. Assuming human settlement was critically dependant on combined marine and terrestrial (especially agricultural) resources, the patterned availability of adequate arable ground almost certainly influenced places people lived and the population density that could be supported in a given area. Repeated volcanism also directly affects the integrity of the archaeological record by physically inundating prehistoric and historic remains. Historic period lava flows have obliterated archaeological sites, historically known towns, and resource areas throughout the project area. Indeed, it is in light of this activity that the present survey focuses on the oldest available flow zones to maximize the chance of locating pre-contact cultural materials in the project area. Figure 3 shows major flow patterns across the project area.

[9]Pianka (1974:32) cites "adiabatic cooling" as one subtle determinant of precipitation patterns at low latitudes and tropical settings. He describes the process as such: "as warm air rises, atmospheric pressure decreases, and the air expands and is cooled adiabatically, or without change in total heat content" (1974:26). In particular, when the coastal winds (or northeasterly trade winds) meet the warmer air masses formed above the still active Kīlauea Caldera, the warmer air rises and forms precipitation.

BACKGROUND TO THE GEOTHERMAL PROJECT

GEOTHERMAL PROJECT HISTORY

Geothermal development was proposed by the State of Hawai`i as an alternative energy resource for the state during the late 1980s. In its 1990 proposal to Congress, the State of Hawai`i outlined four phases for Hawai`i Geothermal Project development. In the plan, the state proposed a series of wells, power plants and ancillary facilities to be built in various locations across the project area. Overhead transmission lines were also envisioned from the well sites in the Puna GRS area to the north end of the island of Hawai`i. Submarine cables were planned to run from Māhukona Harbor to Maui island, and on to other islands farther northwest. Most recent subsurface planning exploration has focused on the innermost, Kīlauea subzone, a volcanically active area necessary for the development of this resource. This zone is presently the least developed for residential purposes; modern residential areas are located across the Kamā`ili and Kapoho subzones.

The present survey and the preceding research design were conducted under the auspices of the United States Department of Energy, and subcontracted to International Archaeological Research Institute, Inc. by Martin Marietta Energy Systems, Inc. In order to comply with state and federal legislation pertaining to the protection of cultural resources[10], research directed at exploring the archaeological landscape within the project area was necessary. The purpose of the archaeological work was to contribute toward the preparation of an environmental impact statement by identifying cultural materials which may be impacted by the proposed Hawai`i Geothermal Project. Environmental and ethnographic surveys of the project area also were conducted for the environmental statement.[11] In examining archaeological sections of that environmental impact statement, it should be recognized that the scope of the present survey is too limited to contribute meaningfully to possible mitigation decisions. The present project, rather, should be considered as a general overview and preliminary assessment of the proposed environmental/land-use model for the project area.

ECOLOGICAL HISTORY

The geologically active history of Puna District has created a mosaic of variably aged surface sediments across the project area. Throughout much of the prehistoric and historic past, this volcanic activity has impacted the availability of arable land. Volcanic flows in the immediate project area range from events as recent as 1991 to those dating to as early as A.D. 500, and possibly even earlier (Figure 3). This variation not only affects the general land-use history, but also the present distribution of visible archaeological sites. Several sources testify that historic period flows have obliterated formerly occupied areas (e.g., Hudson 1932, Hawaii Territory Survey 1952, Langlas 1990, Loebenstein 1898, Yent 1985). Historically known flows, such as those which destroyed Kapoho Village in 1960 and settlements in the Kalapana area from 1982-1990, are known to have covered much of the archaeological and historical landscape. Surviving amongst these newer landscapes are isolated pockets (or *kīpuka*) of older sediments preserving the signs of past Hawaiian occupation. Due to the fact that

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[10]Various legislative acts include the National Environmental Policy Act of 1969 (NEPA), the National Historic Preservation Act of 1966, as amended through 1992 (NHPA), the American Indian Religious Freedom Act of 1978 (AIRFA) and the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA). The environmental impact statement was required pursuant to a law suit filed in the federal court by the Sierra Club, Green Peace Hawai`i and the Blue Ocean Society in 1990.

[11]Environmental surveys have been conducted by the U.S. Department of Fish and Wildlife. A Native Hawaiian Ethnographic Survey, conducted by CanDo (Cultural Advocacy Network for Developing Options), was directed at the identification of known hunting, fishing, and gathering areas.

overall project boundaries encompass a large expanse of land (over 9000 hectares) and because much of this terrain is relatively young, the present study focused on survey of the oldest *kīpuka* located within each environmental/land-use zone. Older sediments would contain the highest possibility of preserving the widest range of prehistoric and historic period cultural remains and as such should better reflect the cumulative effects of cultural landscape use over time.

Due to it's location in a windward zone, the Puna region receives substantially more rainfall than Ka`ū or South Kona districts to the west. Accelerated chemical weathering contributes to more rapid regeneration of vegetation on newly formed lava (especially `a`ā) than would occur in the drier districts. Generally, precipitation increases with elevation with the greatest rainfall occurring in land-use zone 4, covering much of the Kīlauea subzone. Presently, nine ecosystem types have been identified for the area (Char and Lamoureux 1985) consisting of bare lava flows, scrub communities, agricultural lands and *`ōhi`a* forests. Rainfall is great enough on the coast to support a guava and shrub forest extending into both the Kapoho and Kamā`ili subzones --see Burtchard (1994:7-19) for a more extensive discussion of Puna ecology. Much inland underbrush is characterized by thickets of *uluhe* (false staghorn) fern, creating a near-impenetrable surface mat. This region is classified as a forest preserve; the *`ōhi`a lehua* forest is cited as environmentally significant for containing rare, threatened or endangered species of plant and wildlife (Char and Lamoureux 1985: 6).

Much of the East Rift Zone landscape is dissected by variably aged flows, lava cracks, cinder cones and craters. Lava tubes underlie many pāhoehoe flows with skylights and sinkholes occasionally providing light and entrance to Pele's[12] underground world. Throughout the contact, and undoubtedly pre-contact, period earthquakes have shaken the region. Lyman (1970), for example, mentions tremors in early historical times. The most recent earthquake, in early February 1994, measured over 5.2 Richter and was centered near Kīlauea. Hudson's (1932: 337-342) research lists several major environmental perturbations having affected the southern parts of Puna during recent history. A earthquake in 1868 caused coastal subsidence from Kapoho to `Āpua, resulting in a loss of 4 to 7 feet of coastal land and submersion of the fishponds in Kapoho Bay. Earthquakes near Kapoho in April 1924, again caused coastal subsidence and damage to the railroad tracks in the area (Wright et al. 1992: 73). Some areas also experienced uplift, creating extensions of the coast. Photo 1 shows a portion of the 1977 flow in southwestern Kīlauea GRS. Such events clearly obliterate forest, fields and the archaeological record in their path. Note, however, that remnant *kīpuka* survive, providing variably sized windows to the biological and, occasionally, the archaeological past.

One might expect that ecological (particularly volcanic) uncertainty would impede permanent settlement and other forms of labor investment within certain portions of the region. Although quakes might have devastating effects and the threat of destruction by lava flow remained a possibility, the coast is said to have been fairly densely populated and even dwelling areas were known several kilometers inland (see Ellis 1979:196-202; Hudson 1932:67). While at Kaimū in 1823, Ellis was surprised at the reaction of inhabitants to an earthquake which suddenly ripped the earth open for several miles. He entered a house where the ground had rent open while the family was sleeping:

> We asked them if they were not alarmed? They said they were at first, but after remaining awake some time, and finding the shock was not repeated, they lay down and slept till morning, when they filled up the fissure with grass and earth! (Ellis 1979: 195).

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[12]Several myths and legends about the goddess Pele, the volcano deity who inhabits Kīlauea, are documented in Beckwith (1970:167-200).

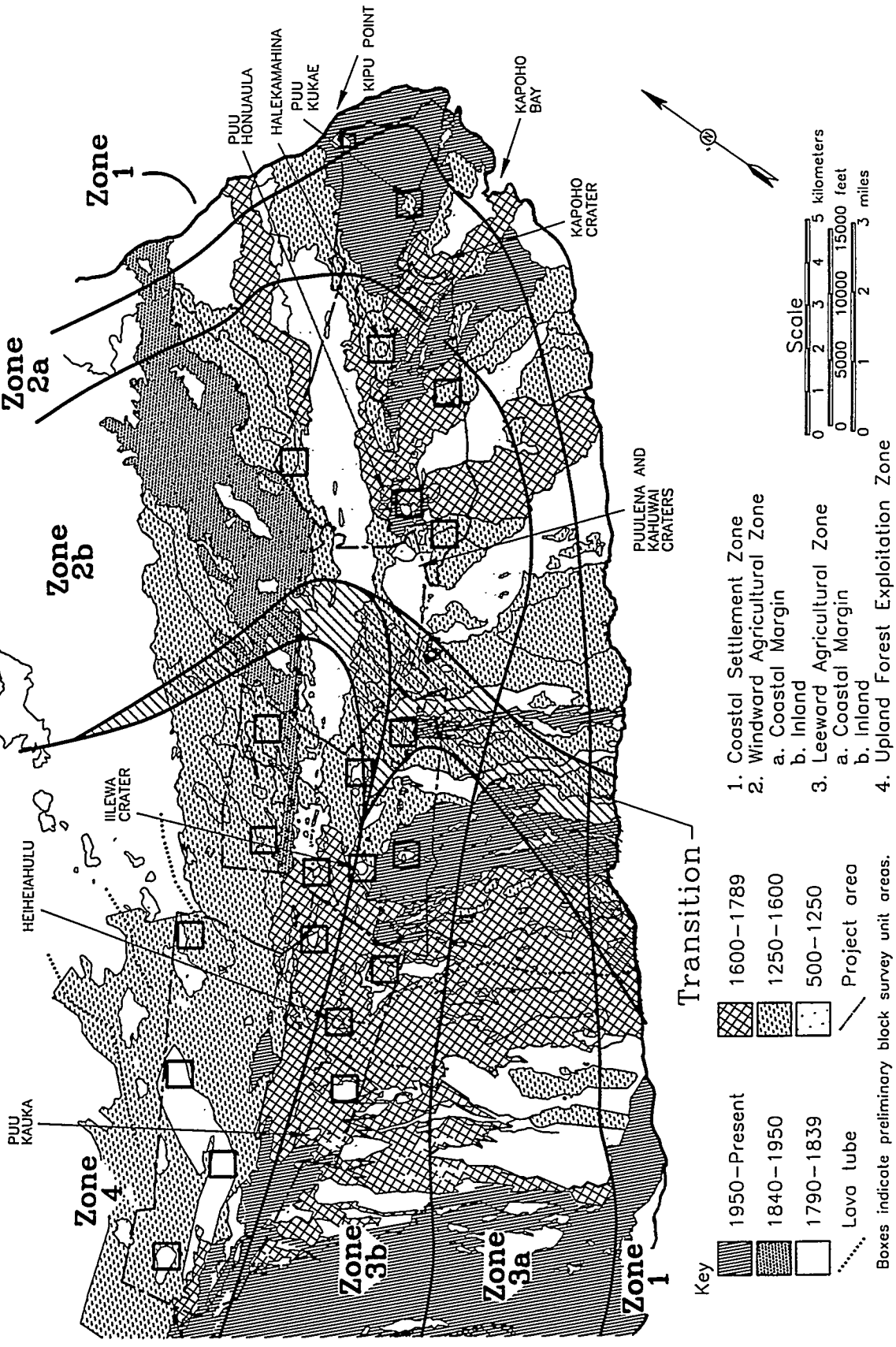

Figure 3. Rift Zone Lava Flow Mosaic in the Project Area

Photo 1. 1977 Lava Flow, Kīlauea GRS

Further, MacDonald cites that "few references to prehistoric lava flows have been preserved by the Hawaiian chroniclers" (in Holmes 1985:4) and suggests that the frequency of environmental perturbation may play a role in the construction of the historical record. Predictably frequent small scale perturbations, such as earthquakes, would not have precipitated the abandonment of permanently established residences. Large scale earthquakes were not very common. In addition, such earthquake activity is not restricted to the Puna District. Lava flows, while common on a geological scale, may not have occurred with sufficient frequency to more than temporarily suppress settlement. Just as today, the threat of irregular and relatively infrequent (on a human scale) ecological devastation may not have had a massive impact on settlement patterns in the area.[13]

CULTURAL HISTORY

Ecological uncertainty is not the only harbinger of a changing landscape. The various efforts of modern development in the district have contributed to the recession of Hawai`i's rainforest and created substantial local-level landscape changes. The late nineteenth century witnessed several economic ventures instituted mainly by non-Hawaiians taking advantage of the sale of interior Crown Lands (see Moblo in Burtchard 1994:46). Coffee, sugar, and pineapple were cultivated as potential crops for major export (see Figure 2). Rubber, at one time, was also considered a potential crop for

[13]Note that this observation is a bit speculative. We cannot be certain what Puna's coastal population might have been in the absence of volcanic perturbation, though the potential may have been for greater population density. The point remains, however, that in the early post-contact period, the region was still capable of supporting a substantial resident population despite Pele's periodic disturbances.

the region and several small-scale ventures were attempted.[14] The furthering of the Industrial Era during the early twentieth century and the exploitation of *`ōhi`a lehua* lumber pushed the intrusion further inland[15]. Mining for roads and cinder and the construction of railway systems in Puna District served to support the expansion of Hawai`i into the capitalist market place. Wood, for example, was being sent to the American mainland to be made into ties for the expanding railroad system. Sugar production persisted throughout the early twentieth century on a larger scale, and was later joined by various other products such as papaya and *cannabis*. While many of these industries persevered for various lengths of time, it has been the small-scale Puna farmer that has persisted most effectively throughout the prehistoric and all but the most recent historic period. Presently, plans to exploit the geothermal resources in the district, if realized, would quite likely induce further industrial/market-oriented change in the economic structure of the region.

A variety of subsistence strategies would have been practiced in the district during the pre-contact period. Marine exploitation is cited as the predominant activity. At Kealakomo, for example, the numerous inhabitants supported themselves by producing salt and dried fish, which was traded both inland and along the coast (Emory et al. 1959: 5). Agriculture was also practiced at this time, though less intensively than in the systems noted for Kona and Kohala if quantity of architectural remains can stand as evidence. Pāhoehoe flows are cited as poor areas for growing either sweet potato or *kalo* (see Appendix B), however `a`ā flows were particularly productive. Rycroft, one of the major coffee growers in the area, encouraged entrepreneurs to concentrate on cultivating old `a`ā flows, or places where old pāhoehoe has decomposed into a layer of soil at least 10 inches thick (Rycroft 1894).

The inhabitants of Puna are cited as being highly innovative with their agricultural practices. Examples include creation of portable agricultural plots so that plantations were in the proper position during the visit of the *ali`i*: "They wove very thick, coarse mats of pandanus leaf, laid these on racks, put earth on top, and in the earth planted sweet potatoes" (Handy and Handy 1972: 542). Agricultural use-areas are somewhat sparsely known from early contact accounts. On his journey through Puna, Ellis noted several cultivation areas supporting sweet potato and taro. Inland Puna (i.e., *upland* Puna) was known to receive "ample rainfall for raising taro wherever soil permits" (Handy and Handy 1972: 540). In particular, "the wet and sometimes marshy pandanus forests from Kapoho through Pohoiki to `Opihikao used to be planted with taro in places" (Handy and Handy 1972: 541) and *kalo* was seen in 1935 still growing up to 4 km inland. Upper Kaimū is cited as an area formerly supporting the cultivation of *kalo* (Handy and Handy 1972: 541). Sweet potato production, more suited to the drier coastal conditions in Kīlauea's lee.

Specialized strategies for acquiring resources are also known for the district. During the 1800s, the area was considered a good source of strong *kapa* (Holt 1979:60) and trade for this material occurred both within Puna and between districts. The inhabitants of coastal Puna were known to exchange their products for vegetables from Hilo and Hāmākua, and for the *kapa* from `Ōla`a (Ellis 1979: 190). A specialized strategy for canoe launching off the rough coast is also known, involving

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[14]Apparently, businessmen were anxious to exploit the Puna area after the overthrow of the Hawaiian monarchy and were willing to risk some capital investment. In 1909, "one company [had] already established itself without any noise, erected buildings, cleared lands and established a nursery, near the Puna plantation holdings. Trees planted out in 1907 are today [1909] from 20 to 24 feet high" (Thrum 1909:137).

[15]In 1907, the Pāhoa Lumber Company was formed with a contract from the Santa Fe railroad to produce the wood for railroad ties. It was believed that *`ōhi`a lehua* lumber was a suitable material, as it was harder than the fir and pine from the Pacific Northwest. By 1913, engineers for the Santa Fe railroad realized that *`ōhi`a lehua* wood would not last very long in the dry southwest climate, and the contract was not renewed. In 1917, after various economic setbacks, the mill producing the logs was sold to the Puna Sugar Company.

the use of ladders and proper timing of the ocean currents (see Thrum 1909 and Holmes 1985). Other indications of Puna subsistence are derived from ethnohistory. During Kalaniopu`u's reign, a chief from Puna named Imakakaloa known as "the choice young `awa [favorite son] of Puna" rebelled and "seized the valuable products of his district which consisted of hogs, gray tapa cloth (*`eleuli*), tapas made of *mamaki* bark, fine mats made of young pandanus blossoms (*`ahu hinalo*), mats made of young pandanus leaves (*`ahuao*) and feathers of the *`o`o* and *mamo* birds of Puna" (Kamakau 1992: 106). Resources such as *mamaki* and birds would have been collected from the inland zones.

Politically, Puna District was considered less significant than neighboring Hilo and Ka`ū from whence many ethnohistorically known members of the *ali`i* ascended to suzerainty at various points in time. While Puna is characterized as politically unimportant, the region is not devoid of features commonly associated with the imposition of political power and control. Archaeologists argue that *heiau* are significant indicators of chiefly hegemony (see Earle 1989, Hommon 1986, Kolb 1992 and 1994). The location of *heiau* across the landscape indicate places that at some time were important for one among a variety of reasons. The distribution and number of *heiau* in Puna, though not greater than in other districts (see Figure 4), is roughly comparable to that of the Hilo District.[16] According to oral traditions, Waha`ula Heiau (presently within the confines of the Hawai`i Volcanoes National Park) was thought to be one of the earliest constructed monuments to chiefly power (Dye 1989: 5), erected by Pa`ao. It seems that Puna was ruled by its own chief at certain times; prior to `Umi-a-Liloa's unification of Hawai`i island (between the fourteenth to sixteenth centuries according to ethnohistoric accounts), the district was ruled by Hua`a. The latter was killed by one of Umi's adopted sons on the battlefield of Kuolo in Ke`a`āu (Kamakau 1992: 17). At various times, Puna was ruled by chiefs from Ka`ū and from Hilo. At the time of Kalaniopu`u's (Kamehameha's older half brother) death, the rule of Hawai`i Island was ceded to Kiwala`o (Kamakau 1992:115). Due to Kiwala`o's (son of Kalaniopu`u) affiliations with Hilo and Ka`ū, the Kona chiefs feared they might be slighted and urged Kamehameha to claim his right to partial rule. After a period of fighting instigated by these chiefs and resulting in Kiwala`o's death, Kamehameha seized political control of the island (Kamakau 1992:124).

As noted in the recounting of Kaua`i history (Joesting 1984), areas playing less political importance in later times tend to be overlooked by historians. Commoner lineages in the Puna District may have drawn on different affiliations than the political lineages on the island. For example, worship of the major Hawaiian deities at large *heiau* sites is often reproduced as *`aumakua* worship among families and communities, which occurred at a less elaborate scale. The people of Ka`ū, Puna and Kona are said to trace their ancestry to Pele, the ancestral deity of the island's volcanoes (Nimmo 1990:43) and shared a common bond with this goddess despite political boundaries. Today the worship of this deity has spread to various places throughout the island.

Any discussion of Puna District and its past necessarily involves an appreciation of the present struggle of individuals existing within a changing environment. Perhaps the term *kīpuka* is an apt metaphor to understand these changes, where remnants of the past can be found in small and isolated, though well-protected, pockets surrounded by an entirely new landscape. Traditions persevering amidst social and economic change are a trademark for the area, as it is in many other rural settings. Notwithstanding early missionary efforts to 'civilize the natives', traditional Hawaiian practices such as the hula and tattooing were noted to resume not long after missionaries established themselves in Hilo (Lyman 1970:54). Western contact "was not accompanied by an immediate end to pre-contact Hawaiian culture. It must be recognized, therefore, that well into the historic period, sites were being formed within a traditional Hawaiian context" (Komori 1987:4). The natural forces of Pele may

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[16]Hudson (1932: 35) noted at least 73 possible Puna *heiau* from ethnohistoric sources. He estimated that the remains of 22 were still visible at the time of his study. He argues that there are no *heiau* located between Hilo and Kapoho.

present a threat to the uninsurable homes built in proximity to possibly eruptive areas, such as Kalapana, and even atop the rift zones (e.g. Leilani Estates). Residents must hope that many of the *kīpuka* saved from the onslaught of past volcanic activity will be spared future destruction. Photo 2 shows a modern shrine employing a traditional Hawaiian theme.

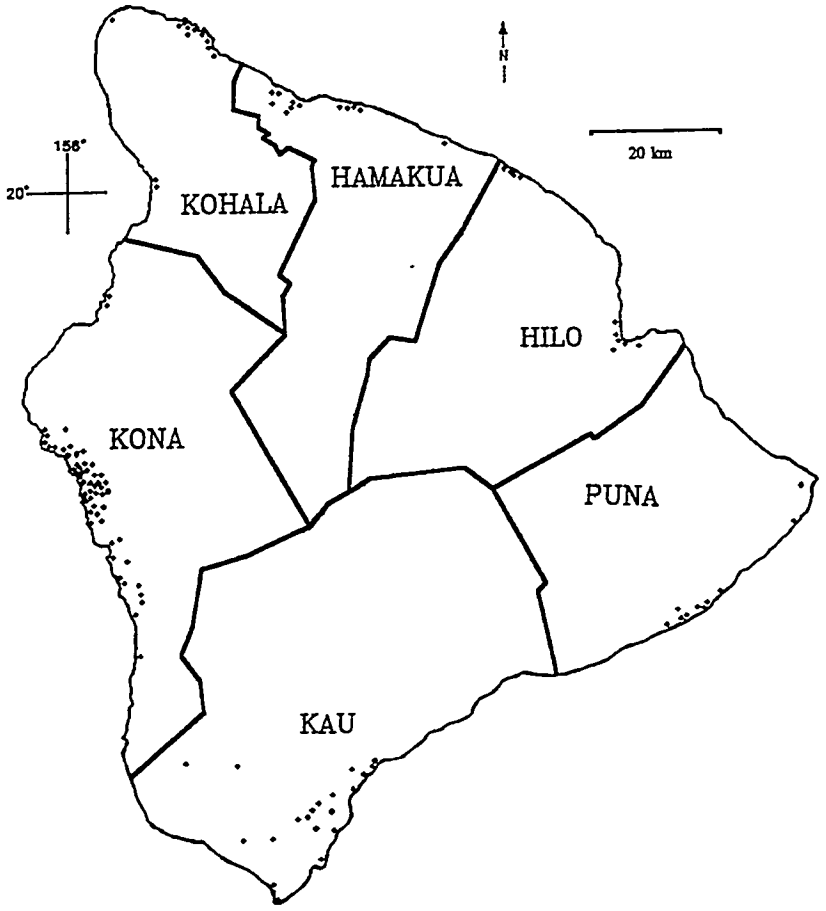

Figure 4. Known Distribution of *Heiau* on Hawai`i Island (adapted from Stokes 1991). This figure shows the location of *heiau* sites from survey and informant accounts completed by Stokes in the 1920s. Please note that several more *heiau* were known on the island. Their locations, however, remain unknown.

ARCHAEOLOGICAL HISTORY

The majority of archaeological work undertaken in Puna District until the mid-twentieth century has been focused on the documentation of highly visible features such as *heiau* and fishponds, mostly appearing at or near the coast. During the early part of this century, J.F.G. Stokes, "in one of the first detailed archaeological investigations in Hawai`i" (Dye 1989:5), visited and recorded material data about Waha`ula Heiau, attempting to gather information about a traditionally early monumental structure. Comprehensive studies covering the variability in site types over a large expanse are few, however several works (i.e., Hudson 1932, Lou and Bonk 1970) provide some information on coastal surveys and settlement, and informant-derived information for the location and description of inland sites.

Photo 2. Modern Shrine on the Road into Kīlauea Subzone

The most comprehensive list of both early and more recent contracted archaeological work in the project area was compiled by Burtchard in conjunction with the Kīlauea East Rift Zone land-use model and research design (Burtchard 1994:29-38). Reference should be made to that report for a chronicle of these studies. At the time the present survey began, 24 sites were known to fall within the Geothermal Subzones Project boundaries. Our effort added 15 new site localities to that count. Because the present study focuses solely on the three geothermal subzones, most of the new localities are situated in the inland zones. The coastal fringe was not considered in the present sample survey. Table 2 summarizes the presently known archaeological site total for the three GRS. Figure 5 shows their distribution.

The majority (ca. 69%) of known sites in the study area and summarized in Table 2 are likely to have been in use during the pre-contact period. These localities are situated entirely within the land-use model's windward and leeward agricultural zones (i.e., Zones 2a, 2b and 3b). Of these inland sites, perhaps only the lava tubes provide evidence for residential use --and that is presumed to be primarily for short-term refuge. More common are resource use areas or places characterized by aggregated associations of economically useful Hawaiian plants. Many of these latter site types contain no obvious structural remains. Indeed, the absence of built features in these planting areas reinforces the notion that, given sufficiently well developed soils and sufficient rainfall, successful production need not involve construction of terraces, mounds or other features typically affiliated with prehistoric and early historic Hawaiian agriculture. If so, the relative absence of inland architectural features, even in older *kīpuka* (perhaps especially in older *kīpuka*) does not necessarily indicate low intensity use in the past. Figure 5 shows the distribution of currently known archaeological localities in the project area.

Table 2. Presently Known Archaeological Sites in the Geothermal Resources Subzones[17]

Site Number	Site Name (Estimated Period)	Zone	Source	Comments
(1) no number	Lava Tube Cave (Prehistoric)	2a	Loebenstein 1895	Covered by 1960 lava flow
(2) 7492	Lyman Ranch and Grave (Historic)	2a	Hammatt 1989	Located at Kapoho Crater
(3) 2501	Kapoho Petroglyphs (Prehistoric)	2a	Loo and Bonk 1970	Bevacqua and Dye (1972) reported that the majority of petroglyphs were indistinguishable, though at least 12 were well-preserved
(4) no number	Koae Site (Historic)	2a	Hammatt 1989	Scant documentation. Hawai`i state inventory map (1965) indicates a church at the site; but it is not listed on early maps (e.g., Cook 1902, Loebenstein 1895). It may refer to a settlement in the area called Kula (McEldowney 1979: 16) noted by Ellis. Lyman (1924: 95) lists Koae as an inland village 5 miles from the coast, and thus it may actually fall into zone 2b.
(5) 2500	Kūki`i Heiau (Prehistoric)	2a	Stokes 1991; Current Survey	Multi-tiered *heiau* on Pu`u Kūka`e. Relocated and found *in situ*. Less deteriorated than previously reported. Previous maps misoriented. (see Site Data Appendix A)
(5) IARII 94-1; 50-10-46-19843	Pu`u Kūka`e Mounds (Prehistoric)	2a	Current Survey	Mounds, linear features and trail segment; possible agricultural area; at the base of Pu`u Kūka`e. (see Site Data Appendix A)
(5) IARII 94-2; 50-10-46-19844	Pu`u Kūki`i Cyst (Prehistoric)	2a	Hudson 1932; Current survey	Slab-lined cyst/crypt at crest of Pu`u Kūka`e, found *in situ*;(see Appendix A)
(6) no number	Kūki`ihelau Warm Springs (Prehistoric)	2a	Loebenstein 1895	Covered by 1960 lava flow
(7) 295	Unknown State Site[18]	2b	Hammatt 1989	Possibly covered by 1955 flow

[17]The site number listed in parentheses refers to the location on the accompanying map. Numbers listed outside of parentheses refer to the official state number for the site, or the field number assigned during survey. Older state numbers are designated by four digits; 7000 series numbers refer to historic period architectural sites (usually buildings). Field numbers, preceded by "94-" indicate sites assigned by IARII during this present survey. These are accompanied by new Hawai`i state designations (e.g., 50-10-55-19853; where 50 indicates the State of Hawai`i, 10 indicates Hawai`i Island, 55 is Pahoa Quad, and 19853 is the sequential site number here referring to Heiheiahulu Mounds).

[18]This particular site, and the accompanying site number, does not exist in state files. Documentary research failed to lead to the source for this site, other than Hammatt 1989. This unknown site should be discarded from further inventories.

Site Number	Site Name (Estimated Period)	Zone	Source	Comments
(8) no number	Coffee Patch (Historic)	2b	Loebenstein 1895	Possibly still *in situ*
(9) 5245	Kahōlua o Kahawali *hōlua* slide (prehistoric)	2b	Hammatt 1989; Rogers-Jourdane & Nakamura 1984	Site designated based on ethnohistoric literature; never archaeologically documented; Not located in current survey
(10) no number	*Hōlua* slide (Prehistoric)	2b	Hudson 1932	Possibly still *in situ*, not located in current survey
(11) no number	Lava Tube Sinkhole (Prehistoric)	2b	Bonk 1980	Located in flow dating 200-400 years, land access denied in current survey
(12) no number	Rycroft Coffee Plantation (Historic)	2b	Loebenstein 1895	Partially covered by 1955 flow
(13) no number	Leioumi *hōlua* slide (Prehistoric)	2b	Loebenstein 1895	Not located
(14) no number	Agricultural Complex (Prehistoric)	2b	Hudson 1932	Hudson's Site 110 consisting of stone piles and clearings; Possibly still in existence
(15) no number	Wilkes' Trail of 1840 (Historic)[19]	3b	Loebenstein 1895, Holmes 1985	Partially covered in areas by recent lava flows, Area shown has not been verified; relocation probably needed
(16) IARII 94-12; 50-10-55-19853	Heiheiahulu Mounds (Prehistoric)	3b	Haun et al. 1985; Current Survey	Seven mounds and a terrace platform on the southeast side of Heiheiahulu (see Site Data Appendix A)
(17) no number	Kaimū Trail (Prehistoric)	3b	Loebenstein 1895	Partially covered by 1977 lava flow
(18) no number	Forest Planting Areas (Prehistoric)	3b	Loebenstein 1895	Partially covered by 1977 lava flow
(19) 50-10-55-14900	Middle Lava Tube Cave (Prehistoric)	4	McEldowney and Stone 1991	Multiple features and entrances, part of larger tube complex in the massive Ail`a`āu flow ca. 1600 A.D. Not inspected during current inventory.
(20) 50-10-55-14901 & 50-10-55-14902	Southern Lava Tube Cave (Prehistoric)	4	McEldowney and Stone 1991	Multiple features and entrances, part of larger tube complex in the massive Ail`a`āu flow ca. 1600 A.D. Not inspected during current inventory.
(21) no number	Northern unnamed trail (Prehistoric)	4	Loebenstein 1895	Partially covered by 1977 flow; not located

[19]Wilkes' party was following a well-established trail and therefore this site could also be categorized as prehistoric.

Site Number	Site Name (Estimated Period)	Zone	Source	Comments
(22) IARII 94-4; 50-10-55-19845	Pu`ulena Crater (Prehistoric)	2b	Current Survey	Western lobe contains an aggregation of economically important Hawaiian plants: *`ape, `awa, olena, ti, kukui* and pandanus. *`Ape* dominates the center of the main crater (see Appendix A)
(22) IARII 94-5; 50-10-55-19846	Malama Burial Cave (Historic)	2b	Current Survey	Disturbed remains of at least 11 individuals in 1790 lava flow (see Appendix A); position is approximate on Figure 5
(23) IARII 94-15; 50-10-46-19855	Halekamahina Crater (Prehistoric)	2b	Current Survey	Association of *ti, kukui* and pandanus on crater floor. Coconut, *ti* and pandanus on crater rim (see Site Data Appendix A)
(24) IARII 94-6; 50-10-45-19847	Puna Orchards Mounds (Prehistoric)	2b	Current Survey	Possible agricultural mound and linear stacked rock features (see Appendix A). Linear feature may be modern.
(25) IARII 94-7; 50-10-45-19848	Bryson's Cinder Pit *kīpuka* (Prehistoric)	3b	Current Survey	Large patches of *`awa* associated with ti, *kukui, mamaki, hapu`u* and banana (see Appendix A)
(26) IARII 94-9; 50-10-55-19850	Branch of Upper Puna Road (Historic)	3b	Current Survey	Cut and fill roadbed coinciding with mapped location (Cook 1902). (see Site Data Appendix A)
(26) IARII 94-10; 50-10-55-19851	`Ī`īlewa Lava Tube (Prehistoric)	3b	Current Survey	Circular mound, tabular basalt path and a step platform in short lava tube cave (see Site Data Appendix A)
(26) IARII 94-11; 50-10-55-19852	Military Structure at `Ī`īlewa (Historic; World War II era)	3b	Current Survey	Storage bunker, concrete entry/ventilator shafts and communications tower area (see Site Data Appendix)
(26) IARII 94-16	Callaghan Land Grant and Coffee Plantation (Historic)	3b	Current Survey	Several acres dominated by feral coffee. (see Site Data Appendix)
(27) IARII 94-13[20]	Upper Kaimū Cave (Prehistoric)	3b	Current Survey	Lava tube with multiple skylights apparently originating near Heiheiahulu in 1795 flow. Interior not explored (see Site Data Appendix A)
(28) IARII 94-14; 50-10-54-19854	Pu'u Kauka *Kīpuka* (Prehistoric)	3b	Current Survey	Area adjacent to small crater with association of banana, *kukui, hapu`u, kopiko,* ti and *`ie`ie* (see Appendix A)
(29) IARII 94-8; 50-10-55-19849	Pāhoa Lumber Company Railroad Grade (Historic)	4	Kennedy 1991 and Current Survey	Railroad network associated with early 1900s *`ōhi`a* logging. Point shows three sections of larger system (see Site Data Appendix A)

[20]This is the same lava tube cave as reported by Burgett 1993 (pers. comm. in Burtchard 1994:Table 3).

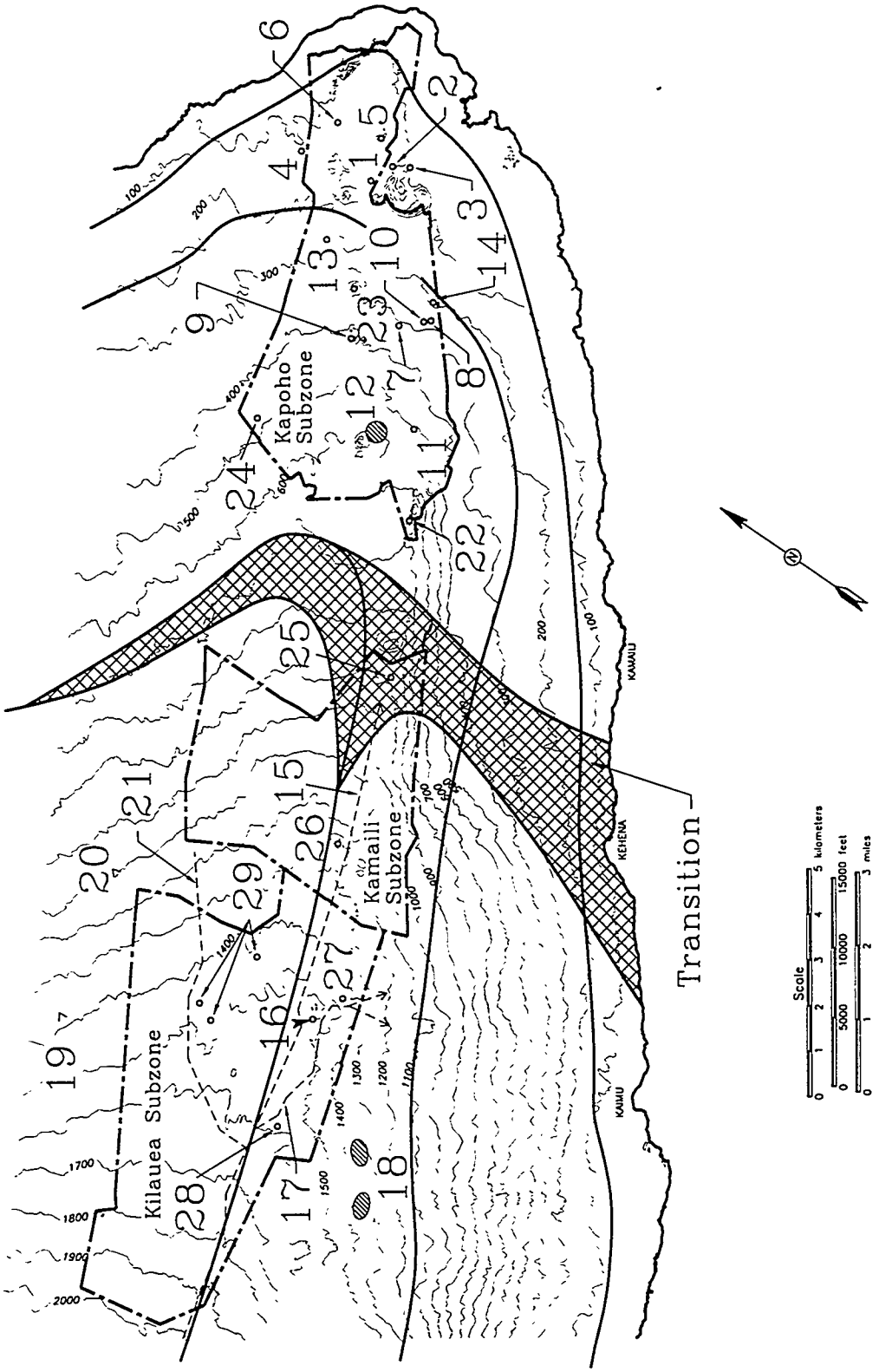

Figure 5. Known Site Distribution in the Three Geothermal Subzones

The dearth of coastal sites in the sample survey simply reflects the minimal amount of coastal terrain in the project area. Only the eastern margin of the Kapoho subzone intercepted this land-use zone. Of that, only a single ca. 10 acre *kīpuka* survived the 1960 Kapoho flow. This does not mean that the coast was not settled. Both historical accounts and the extant archaeological record suggest extensive settlement around Cape Kumukahi and along the southern Puna coast. Use of the Kapoho Bay vicinity was probably particularly intense during the pre-contact period. Figure 6 shows the distribution of known archaeological features within the coastal zone. Most of this information is drawn from Bevacqua and Dye (1972), Cordy (1989), Cox (1983), Ewart and Luscomb (1974), Ladd (1981) and Orr (1967). Please note that the map does not show archaeological features inland from the coast, other than those identified for the three geothermal subzones as shown on Figure 5 and outlined in Table 2.

While not the primary intent of the sample survey, some effort was given to relocating undocumented sites mentioned in past reports or plotted on older maps (e.g. Loebenstein 1895, Cook 1902 and Hawai`i Territory Survey 1952). Accessibility of these sites was a factor in the relocation attempts. Where map localities fell in areas covered by recent lava flows, or were otherwise inaccessible in the time available, they were not searched out. As our objectives were oriented primarily toward documentation of previously unrecorded sites, and because survey time was limited, most of the effort was given to new survey of old *kīpuka* (pockets of older volcanic sediments surrounded by new flow).

Because survey coverage was limited, documented site distribution for the three subzones might not reflect broader regional site variability and distribution. In particular, as the project area crosscuts, rather than follows, traditional Hawaiian land divisions (*ahupua`a*) which run from the coast to inland, a comprehensive understanding of certain land-use zones, especially at the coast, will be restricted. Thus, the results of the present survey must be considered within the context of known site distributions for the East Rift Zone area in general. An intensive *ahupua`a* based survey that crosscuts all land-use zones could provide interesting information relevant to the model offered in the research design (Burtchard 1994) and summarized above. Survey results in Kupahua *ahupua`a* (Barrera and Barer 1971), for example, while limited to coastal settlement and coastal agricultural zones (Zones 1 and 2a), demonstrate a pattern much like that anticipated in the model. The discussion of field survey and results, while geared to the general description of sites encountered during the walk-through survey, will be elaborated by assessing the distribution of known archaeological remains according to the environmental/land-use model.

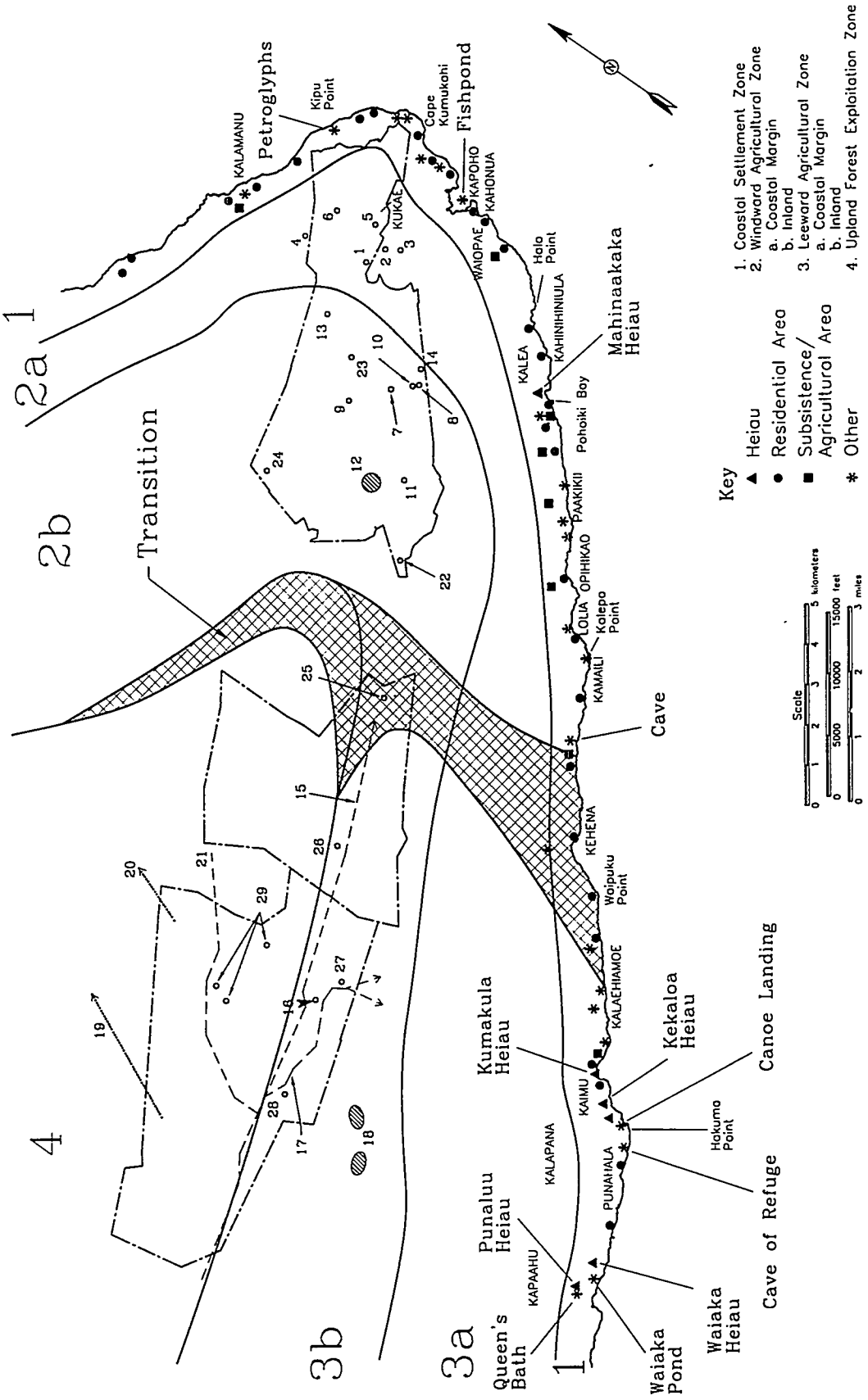

Figure 6. Known Prehistoric Sites in the Coastal Settlement Zone

FIELD STRATEGY AND RESULTS

Walk-through surveys involving a three member field crew were conducted in volcanic isolates, or *kīpuka,* containing pre-contact period aged sediments. Twenty field days were allotted to this effort. Sample areas were dispersed across the there geothermal resource subzones. Our intent was to gain a broadly-based glimpse at the project area's archaeological record within time constraints imposed by a limited survey. Procedures were designed to maintain consistency with recommendations of the Puna geothermal research design's for "Partial Survey" option (Burtchard 1994:64-65). Reference may be made to that document for discussion of general methodology. Information gained in the partial survey was to be used to 1) expand our general understanding of Kīlauea East Rift Zone archaeology; 2) provide a preliminary evaluation of research design's land-use model; and 3) to refine research design recommendations for more thorough "Stratified Verification Survey" (see Burtchard 1994:62-64). Discussion of these procedures follows below.

Survey locations were selected by reference to geological maps, aerial photographs and historical documents. Moore and Trusdell's (1991) and Holcomb's (1980) volcanic flow maps were useful for distinguishing general flow pattern and ages across the study area. Figure 3 is derived from these maps. A series of false infra-red aerial photographs taken over the subzone areas by Air Surveys Hawai`i in 1993 were also used to identify landscape features and vegetation boundaries. These and U.S.G.S. orthophoto quads provided information helpful in isolating older flows (by virtue of varying floral constituents), lava tube cave routes (by tracking the path of visible sink holes), modern disturbed areas, and land ownership boundaries.[21] They also proved to be of substantial value in orienting ourselves in the field, especially in Kamā`ili and Kīlauea subzones where vegetation was dense and the landscape relatively uniform. Finally older regional maps, while less precise, helped draw our attention to planting areas, *kīpuka,* trails and roads, and possible archaeological features (especially useful were Cook 1902, Hawaii Territory Survey 1952 and Loebenstein 1895).

Actual survey blocks were selected to maximize coverage of older flow zones as widely dispersed across the project area as possible given limitations of time and land entry permission. Figure 7 shows the project area, modeled land-use zones and areas investigated during the present effort. Each block shown was visually inspected through standard pedestrian survey techniques. Actual sizes and shapes vary to fit the characteristics of the particular area. In most survey blocks, crew members walked evenly spaced transects approximately 15 m abreast. In areas of extreme volcanic hazard and particularly poor ground visibility (i.e., heavily vegetated areas within a ca. 400 m band north or south of the rift), crew members worked in single file. These were survey units 10, 11, 13 and 14. In high gradient terrain such as craters, particular attention was paid to rims, floors and relatively flat sideslope benches. In all cases, feature and plant associations were recorded on site data forms, the area photographed and features sketch mapped. Site position was recorded electronically with a Trimble Pathfinder hand-held Global Positioning System (GPS) receiver, and manually onto U.S.G.S. 7.5 minute quad maps with the aid of aerial photographs. Data recorded for newly identified site localities is included in Appendix A to this report.

The total area surveyed is approximately 100 hectares, or approximately 1% of the entire project area. Note that while we were able to achieve a relatively broad sample of landforms and

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[21]The study area is owned or leased by a number of agencies and individuals. Entry permission was essential to completion of even a partial survey. We are indebted, therefore to the cooperation of both the largest landowners (especially Campbell Estate, Kapoho Land and Development Co. and Kamehameha Schools/Bishop Estate) and a substantial number of small parcel holders. AMFAC, Inc. and Puna Geothermal Venture, Inc. refused access to their lands.

model zones, the limited scope of the project precludes uncritical projection of results to the broader area. Even so, we believe that the results improve our understanding of the archaeology of the Kīlauea East Rift Zone, and provide a good foundation for continuing research. Issues relevant to site designation and survey results follow below.

ARCHAEOLOGICAL SITE DESIGNATION

Prior to the 1950s, much of the focus on archaeological site designation in Hawai`i was placed on major field monuments and ethnohistorically important structures (e.g., Stokes 1991, Bennett 1931, Walker 1933). The issue of what constitutes an archaeological site in Hawai`i has changed over the last few decades. During the past twenty years, a greater variety of site types have been recognized, with particular expansion in the range of agricultural features (see Carter and Somers 1990). Since the inception of settlement pattern archaeology in Hawai`i, an analytical structure encouraged by Green (see Green et al. 1967) for the Society Islands, the term site has been recognized as an archaeological construct referring to spatially associated structures and their artifactual remains (see Green 1969). As a spatial construct, a variety of proximately arranged structures and land-use areas have been categorized as sites. Such groupings are traditionally determined by in-field informal assessment of the contemporaneity and/or spatial aggregation of structural features, which can subsequently be tested by subsurface examination. Other considerations such as topography, proximity, and stylistic and functional differences/similarities between archaeological remains aid in determining these groupings.

Some archaeologists have argued for the abandonment of the site concept (e.g., Dunnell and Dancey 1983), as it is an archaeological decision based upon our present notions of human behavior. Other archaeologists concerned with cultural resource management issues argue expanding the concept of *site* to that of *land parcel* (e.g., Warren 1990) using a variety of both archaeological and environmental correlates to predict and designate areas of former occupation. Attempts to formalize the definition of "site" have met with debate concerning the value of the concept to archaeological modeling. In Hawai`i, sites have lately come to be replaced, or at least supplemented, with terms such as site/feature complex, which consists of an analytical unit composed of a cluster of structures, often associated with a residential or agricultural function (e.g., Ladefoged 1987, Burtchard 1993 and Kornbacher 1994). Ladefoged et al. suggest methods such as nearest neighbor analysis to establish boundaries. Their definition of features as "spatially discrete non-portable cultural remains" (Ladefoged et al. 1987:24) is a useful and unambiguous way to identify discrete material units. Loci of past human activity, however, need not involve generation of structural features at all. Other kinds of activities must be considered if we hope to understand the full range of past human use of the landscape. Accordingly, sites must not only be defined by the presence of structural features, but on the basis of other observable remains as well (e.g., midden and artifact associations), or (importantly for present purposes) clustered associations of feral Hawaiian cultigens.

The presence of native Hawaiian cultigens as a marker of former cultural activity has often been cited, but rarely used to officially designate a site. Stemmermann (1984:2), for example, cites a patch of *`ape*, *ki* and *noni* on the northeastern side of Kapoho Crater, as "evidence of previous Hawaiian cultivation in the area." The plant association, however, was not listed in the site inventory for the survey (see Bonk 1984:9). Temporal data related to such areas clearly is difficult to obtain, and such patches of native cultigens can reflect efforts ranging from the prehistoric era through to this century. Nonetheless, archaeologists may identify vegetation areas as sites if they are confident that such plant associations could not occur through natural dissemination processes.

In sum, an archaeological *site* as used here constitutes an assessment of the contemporaneity of spatially associated indications of human presence indicating past use of the area in question. Indices of past human intervention with the landscape can include both architectural features as well as the presence of native Hawaiian cultigens. Sites with historical significance are those supposed to be at least fifty years old, and deemed to have value in illustrating important aspects of the region's past. Significant sites are generally those associated with an historic event or person, ethnohistorically known, or which have research value toward understanding the past.[22] In Hawai`i, particular significance is also given to places with unusually high heritage value to Hawaiians or other ethnic groups. Since this project and report is preliminary in nature, significance of individual sites is not assessed. It should suffice to note that all sites discussed here should be considered potentially significant cultural properties until such time as full inventory survey procedures can be implemented.

ANALYTICAL UNITS AND THE ENVIRONMENTAL/LAND-USE MODEL

As the environmental/land-use model was designed to accommodate the spatial distribution of past cultural activity, the analytical unit of *site* is sufficient for a preliminary assessment of the model's utility. The results of this study also contribute to the general understanding of former land-use in Puna District, however they should not be considered adequate for substantive evaluation of predictive models. A model to predict both the spatial and temporal distribution of archaeological sites would require a theoretical framework directed toward the explanation of process and change in material culture. Data from a more limited reconnaissance of an area is better suited for the understanding of middle-range hypotheses (see Binford 1989), modeling a particular area or time. The aim of this project is to examine the spatial distribution of sites across the Puna Geothermal Resources Subzones Project Area and as such should be considered exploratory in nature.

SURVEY RESULTS BY MODELED LAND-USE ZONES

The following discussion presents the results of survey grouped by the environmental/ land-use categories described in the model (Burtchard 1994). The sites recorded within various survey units are discussed generally as evidence of cultural activities within each land-use zone. An evaluation of the expectations of the model in regard to the survey results is presented in the context of our general knowledge of the ecological, archaeological and cultural histories for each zone. An attempt to verify or falsify the model will not be made; emphasis is placed on establishing the plausibility of the predictions made. For more detailed information concerning site descriptions, the reader is referred to the site data appendix (Appendix A).

Figure 7 illustrates each of the areas surveyed within the Geothermal Resources Subzones area. Table 3 presents a breakdown of the number of survey areas within each modeled land-use zone, and the general nature of these surveys.

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[22]Significance criteria for cultural properties is outlined in NHRP Criteria Evaluation from the National Register Bulletin 16, U.S. Department of the Interior, National Park Service, Interagency Resources Division. See also State Historic Preservation Division (1993).

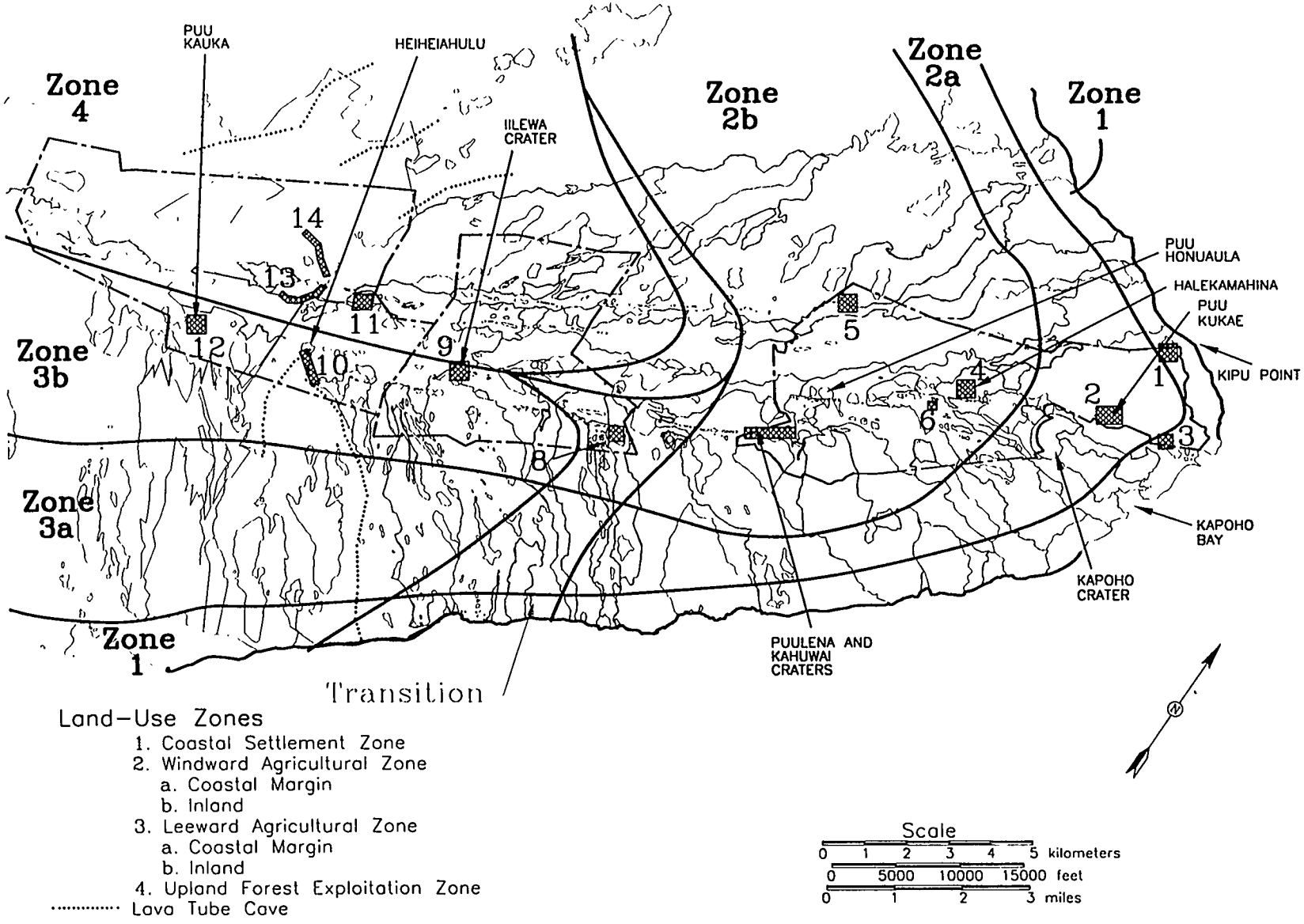

Figure 7. Map of Geothermal Subzones, Modeled Land-Use Zones and Survey Blocks

Table 3. General Survey Results Grouped by Land-Use Zone

Land-Use Zone	Approx. Area Surveyed (hectares)	Number of Units Surveyed	Number of Sites	Comments
1	31	2	0	Survey of two relatively level *kīpuka* near Cape Kumukahi
2a	11	1	3	Survey of well weathered spatter cone (Pu`u Kūka`e)
2b	49.3	4	4	Survey included three craters, one well weathered spatter cone, one lava tube and one relatively level area adjacent to modern orchard
3a	n/a	n/a	n/a	Land-use zone did not transect survey project boundaries
3b	50.4	4	8	Survey included one spatter cone, three craters and two relatively level areas; location of one lava tube established
4	39.5	3	1	Survey branched off from three trails, currently in use, into older flow zones

Zone 1: Coastal Settlement

This zone is represented at the easternmost tip of the Kapoho subzone within the project area. It extends along the coast forming a band about 0.8 km wide, including lands from the coast up to ca. 30-50 m in elevation (Figure 2)[23]. This zone was expected to yield the greatest variety and density of prehistoric features, mirroring Ellis' (1823) account of densely populated coastal villages extending from the present borders of Hawai`i Volcanoes National Park to Nānāwale Bay[24]. Survey areas 1 and 3 (Figure 6) both fell within this land-use zone, resulting in a total 31 hectares. Unfortunately, neither yielded discernable archaeological sites. Survey area 1, just west of Kīpū Point, is a 19 hectare *kīpuka* listed as composed of a pāhoehoe flow dating to A.D. 500-1250 (Moore and Trusdell 1991). The *kīpuka* is presently encircled by a 1960 lava flow which originated near the village of Kapoho and covers most of the Kula *ahupua`a*. Similarly, survey area 3 is a pāhoehoe and `a`ā *kīpuka* of 12 hectares encircled by the 1960 flow, estimated to date to A.D. 1250-1600. Despite their locations

[23]Lands within the Kapoho Subzone fall within the following Hawai`i County Tax Map Keys: 1-3-45 & 46; 1-4-1,2,5,6,7,8,9,12,13,14,15,16,17,18,19,20,21,22,23,34,78 & 90.

[24]Maps from the early 19th century, such as those produced by descriptions from Ellis in 1823, the Lahainaluna school in 1838 and the Wilkes Expedition in 1841 illustrate relatively evenly distributed settlement around the coast of the island of Hawai`i, with an average of 15-20 coastal villages for the Puna coast (see map reprints in Fitzpatrick 1986). The sparsest settlement was perceived to be in the Ka`ū district.

close to the coast, neither survey area would be expected to yield evidence for permanent agricultural use. Pāhoehoe flows weather more slowly than `a`ā flows and tend to be less productive.

Survey Area 1

Survey area 1 (Figure 7) is crossed by a west to east access road bordering a lava crack to the south. The crack extends from the eastern edge of the *kīpuka* to approximately its midpoint. Field survey determined the area to be disturbed by geologic perturbation and several more lava cracks were found to run northwest to southeast. The interior area bordering the 1960 `a`ā formation consists of a cinder underfooting of variable widths (ca. 20-50 m). This border is most extensive on the western side, where it forms a level surface. The eastern side of the cinder area is characterized by undulating mounds and depressions. A majority of the mounded areas correlate with sediments around pandanus roots and these features followed the general direction of the lava cracks. A small area at the center of the *kīpuka* is characterized by fine-grained sediments which may date differently, presumably representing the A.D. 500-1250 deposit, from the areas covered by cinder.

While Puna District is generally known to have been an important source for *lauhala* mats, the tree does not require human intervention for its propagation and is known to have grown throughout the area. The Wilkes' map of 1841, reproduced in Fitzpatrick (1986), shows a large pandanus forest extending from Kīpū Point almost to Hilo, covering most of the coastal area.[25] Aside from pandanus, the only economically useful plants observed were a single coconut tree on the eastern side of the *kīpuka* and one *mamaki* plant bordering the jeep trail. No clustered association of Hawaiian cultigens or other prehistoric or historic archaeological remains were found in the unit. However, it is still plausible that the area served as a source for the pandanus leaf (*lau hala*). Handy and Handy (1972: 541) note that "the wet and sometimes marshy pandanus forests from Kapoho through Pohoiki to `Opihikao used to be planted with taro in places", an agricultural practice which presently may leave no visible archaeological signature. It is plausible too, that given the cindery (i.e., incompletely weathered) nature of the sediments, this *kīpuka* may not be as old as indicated by Moore and Trusdell (1991).

Survey Area 3

Survey area 3, a *kīpuka* transected by Highway 132 near Cape Kumukahi[26] (Figure 7), is an artifact of mid-twentieth century attempts to control nature. Located east of the U.S. Coast Guard Reservation Area, it is cited as a pāhoehoe and `a`ā formation dating 400-750 years old (Moore and Trusdell 1991). However, bulldozing activity associated with the 1960 eruption outside of Kapoho Village has thoroughly erased older archaeological signatures in the area and created a number of newer feature-like mounds and alignments. Walls and piled rock barriers were built from Pu`u Kūka`e to Cape Kumukahi as diversion barriers to restrict the flow from moving south (MacDonald 1962). A walk-through of the *kīpuka* determined that the mechanically altered terrain was quite extensive, with

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[25]The actual location of this pandanus forest could possibly be further southeast along the coast, which would account for the pandanus grove in survey area 1. Fitzpatrick (1986) notes that the Wilkes' map is seriously flawed; prominent features such as Kīlauea and Hilo are misplaced. However, the map gives a relative idea of forest distribution.

[26]Pukui et al. (1974: 124) related that Kumukahi was "a migratory hero who stopped here and is represented by red stone. Two of his wives, also in the form of stones, manipulated the seasons by pushing the sun back and forth between them. One of the wives was names Ha`eha`e. Sun worshipers brought their sick to he healed here". Westervelt (1963: 28) relates that Cape Kumukahi was formed when Pele, in anger, threw lava over the chief.

resulting features often mimicking those from the prehistoric past. The result, however, remains as a testament to the effort to divert lava from enveloping a former lighthouse at Cape Kumukahi.[27]

Zone 1 Summary

Although no sites were found in the older *kīpuka* which have been spared destruction by recent lava flows, several archaeological features have been documented in the surrounding area (see Cox 1983 and general summary in Burtchard 1994:29-38). Reported features in the vicinity of Cape Kumukahi include platforms, small shelters and possible burials, several of which have been included in the Hawai`i state site inventory. The location of trails on maps prior to 1960 indicate that scattered villages along the coast around Cape Kumukahi were connected by access ways which at one time crossed into these areas (Cook 1902, Fitzpatrick 1986, Hawaii Territory Survey 1952, Loebenstein 1895). In particular, the trail followed by William Ellis in 1823, which has also been referred to as the Makahiki trail (Friends of the William Ellis Trail 1974) and was likely used prehistorically, transected this area. Today, the trail's route is best approximated by following the highway in the Kapoho area, and the country roads which wrap around the coast.

Larger settlements south and west of Cape Kumukahi which are presently buried under recent lava have also been documented. These include structures located within the boundaries of Hawai`i Volcanoes National Park (see Ladd 1969; Carter and Somers 1990), and those associated with Kalapana Village (Bevacqua and Dye 1972, Palama and Bordner 1977, Yent 1985). Many of the coastal villages described by Ellis (1979) have left archaeologically detectable traces (see Bevacqua and Dye 1972), and large sunken fishponds at Kaimū are still visible on aerial photos. A large settlement at Kahuwa`i on the coast northwest of Cape Kumukahi has also been documented (Cordy 1989, Orr 1967). Based on present archaeological knowledge, much of the Puna coast was prehistorically occupied on a permanent basis, save for the area between Cape Kumukahi and Kahuwa`i, which shows evidence for scattered and perhaps intermittent use.

Zone 2a: Windward Coastal Margin

This land-use zone, expected to yield a high density of agriculturally related features in conjunction with the high residential feature density expected for the coast, is located in the eastern Puna District (Figure 2), and transects the project boundaries in the Kapoho subzone area[28]. It forms a band adjacent to the coastal settlement zone from 0.8 km up to 2.4 km inland. Elevations in the area range from ca. 17 m to 61 m. Although several older *kīpuka* transect this zone, the 1960 flow covers much of the project area (Figure 5). This zone is represented by survey area 2 (Pu`u Kūka`e).

Survey Area 2: (Sites 94-1, 94-2 and Kūki`i Heiau --State Site 2500)

Pu`u Kūka`e (*Lit.*, excreta hill) is a spatter deposit estimated to date to A.D. 1250-1600 (Moore and Trusdell 1991). The feature presently is decomposing into several hill and gully formations with well-weathered sediments surrounded by the 1960 flow. Total area is ca. 11 hectares. The northern section of this deposit, named Pu`u Kūki`i (*Lit.*, standing image), forms two summits at its crest, one

[27]Ironically, in 1981 this lighthouse was determined to be surplus to the needs of the Coast Guard. Archaeological investigations (Ladd 1981) argued that the lighthouse and surrounding features were ineligible for the National Register of Historic Sites. Today, the lighthouse stands abandoned.

[28]Lands within the Kapoho Subzone fall within the following Hawai`i County Tax Map Keys: 1-3-45 & 46; 1-4-1,2,5,6,7,8,9,12,13,14,15,16,17,18,19,20,21,22,23,34,78 & 90.

on the east and one on the west, separated by an expanse of relatively level ground. A cemetery, at the easternmost end of the deposit, was only partly spared from the recent lava flow and is still currently in use. The northeastern side of the deposit was a source for cinder and the hill has been partially mined. In 1908, it was reported that 25,000 tons of rock were moved from a Puna quarry to Hilo (Thrum 1908: 165). Some of the construction material for the Hilo breakwater in the early twentieth century, requiring large stones as well as rectangular stones for the construction of the slopes (Thrum 1908: 165), may have been extracted from Pu`u Kūka`e though it is uncertain whether this area was the Puna quarry per se.

The three sites located in this survey area, two of which have been previously documented, were all clustered on or around Kūki`i Hill which is a distinct land formation on the north side of the *kīpuka*. Site 94-1, the Pu`u Kūka`e mounds, is a possible agricultural area with trail segments at the northeastern base of Kūki`i Hill, just south of the cinder mine area. The site consists of several circular mounds and linear stacked rock. Considering its location adjacent to the mined area, as well as disturbance due to the growth of new forest, the site may represent the remnant of a larger agricultural use-zone accessible to the inhabitants of the coast in the *ahupua`a* of Kula.

The Kūki`i Cyst, Site 94-2, located on the top of the hill at the southeast edge, was previously documented by Hudson (1932) as site 107 and was described at the time as a slab-lined crypt functioning as a stone chamber or grave, however he did not note any contents within the feature:

> The cyst is a coffin-shaped chamber, 8 feet long, 4 feet wide and 3 feet deep, lined with flat lava slabs... The upper surface of the slabs forming the roof, or cover, is flush with the level of the ground. From this cover one slab was omitted, or has been removed, to form an opening about a foot square (Hudson 1932: 331).

Presently, the cyst appears more like a slab-lined paving (see Site Data Appendix A); however landscape changes over the past sixty years may have altered the appearance of the feature. This site may be contemporaneous with the use of Kūki`i Heiau, located at the opposite end of the hill separated by a flat expanse devoid of structural features.

Kūki`i Heiau, State Site 2500, is an ethnohistorically known site previously described by Stokes early in the twentieth century (Stokes 1991), then by Hudson in 1932. and included in a site inventory for the region by Loo and Bonk (1970). The structure was reputedly built by `Umi to function as a fishing shrine (Loo and Bonk 1970). According to another local informant, the *heiau* was built by Paka`a, a generation after `Umi, and was used for poisoning (Stokes 1991:152). Later, Hudson (1932:330) argued that no information concerning its function could be ascertained. The well-chosen basalt used in the *heiau* construction, resembling cut stone, is cited as a trademark of this chief. According to traditional history, `Umi is a chief who united Hawai`i Island through wars (Kamakau 1992:1), and whose death is believed to have occurred during the late sixteenth century (Beckwith 1970:389). Paka`a was the favored personal attendant of Keawe-nui-a-`Umi (Kamakau 1992:36) who ruled Hawai`i after `Umi's death. In this case, ethnohistory would be congruent with the known age of the *kīpuka* (A.D. 1250-1600) and the probable construction period for the *heiau*.

Archaeologists describing the *heiau* have been unimpressed. For example, Stokes remarked that "anticipating the sight of an unusual example of stonework, I found this *heiau* disappointing" (Stokes 1991:151). In 1967, Hansen called the condition and accessibility of the *heiau* poor, suggesting that "perhaps a marker is only needed" (Hansen 1967: 5). Loo and Bonk (1970:63) listed the site under their category three for mitigation purposes, those sites "which need not be preserved because of their poor condition and integrity, and for which there are better examples" (Loo and Bonk 1970:3).

Notwithstanding personal evaluations of the *heiau*, its stones have been removed at various points in time testifying both to the importance of the structure and the quality of its materials. In the early 1900s, Stokes described the *heiau* as being paved with lava slabs (Stokes 1991:152) and in 1931 Hudson saw a fair amount of flat lava slabs remaining at the site (Hudson 1932:329). On their return, Loo and Bonk noted few remaining slabs, and none on the interior of the platform (Loo and Bonk 1970:59).[29] Our survey confirmed the lack of lava slabs on the platform. Two stones were removed from the *heiau* by Kalakaua in 1879 to be placed as veranda steps at Kapiolani's residence (Hudson 1932:329). One of the paving blocks was reported to be located in the Bishop Museum (Stokes 1991:152). During the 1930s, stones were also removed for the construction of the Lyman residence in Kapoho prior to Hudson's visit (Hudson 1932:329). Undoubtedly, lava slabs have been removed since Hudson's investigation.

It should be noted, that Hudson's description of the *heiau* most often cited in later inventories describes fewer remaining walls than recently seen, and seems to have been affected by an inversion of compass bearings. Subsequent inventories citing field checking (Loo and Bonk 1970) have failed to note this discrepancy. The *heiau* is a partially walled platform enclosure lying at the top of the northern edge of the western summit of Pu`u Kūki`i. In plan view, the structure encloses a rectangular area at the top of the hill (see site form in Appendix A). The enclosing walls encircle the *heiau* on all but the west side, which presumably forms an entrance to the structure. Currently, a grove of pandanus grows within the platform. Sources concerning the morphology of the *heiau* cite a dearth of structural features within the platform area, and a later absence of paving stones. A large depression on the north side of the platform may possibly be a feature, however the growth of pandanus atop the *heiau* may have altered the area. A series of approximately seven wide terraces extend down the east and south sides of the *heiau*. The two uppermost terraces are faced with angular basalt, and are certainly associated with the construction of the structure. The lower terraces might be associated with the *heiau*, however their position, lack of architectural definition, and large width is suspect due to their proximity to the cinder mining area. As such, they may be the result of bulldozing activity. At the base of Pu`u Kūka`e, partially encircling the south side of the hill, is a line of coconut trees bordering a ca. 5 m clearing which could possibly represent the prior existence of a road or trail giving access to the coast, or possibly the cemetery, prior to the 1960 flow.

Zone 2a Summary

Unfortunately, Pu`u Kūka`e was the only *kīpuka* located in the coastal margin of the windward agricultural zone with sediments older than modern historic flows. A large portion of this zone is also covered by historic period flows. However, the interior of Kapoho Crater is known from historic accounts to have been a residential and agricultural area (see Ellis 1979). Petroglyphs (State Site 2501, on Table 1), and two known sites presently covered by recent lava flows attest to use of the area. Perhaps the most detailed account documenting use of the area comes from Ellis, who describe the interior of Kapoho Crater and the lake he found inside it as "a scene of beauty":

> In the center was an oval hollow, about half a mile across, and probably two hundred feet deep, at the bottom of which was a beautiful lake of brackish water, whose margin was in a state of cultivation, planted with taro, bananas, and sugar-cane. The steep perpendicular rocks, forming the sides of the hollow, were adorned with tufts of grass, or blooming pendulous plants, while, along the narrow and verdant border of the lake at the bottom, the

[29]In their report, Loo and Bonk (1970) allege to have visited the sites included in their inventory, however they do not provide a current description for the *heiau*.

> bread-fruit, the kukui, and the ohia trees, appeared, with now and then a lowly native hut standing beneath their shade (Ellis 1979:206).

The settlement at Kapoho Crater may be atypical of settlement in the land-use zone due to the presence of the lake and its high agricultural productivity afforded by an amphitheater shaped valley.

Archaeological work in this environmental/land-use zone illustrates the varying uses for the area. Crozier and Barer (1971:71) were able to locate and trace the outline of a *hōlua* slide in the *ahupua`a* of Pualaa. In the *ahupua`a* of Kapahua, Barrera and Barer (1971:20) argue that emphasis on agriculture was located inland of settlement. The archaeological history of Zone 2a remains incomplete. An intensive survey of older *kīpuka* outside of the GRS project boundaries could likely yield a greater amount of information concerning agricultural use of this land zone. We recommend primary emphasis on Kapoho Crater and land between the crater and Kapoho Bay.

Zone 2b: Windward Inland Agriculture

The inland portion of the windward side of Puna District is adjacent to Zone 2a. The zone covers the western half of Kapoho GRS and is predicted to support a moderate density of agricultural features and temporary residences. A trail system linking inland agricultural areas to the coast is also expected in conjunction with former generalizations of *ahupua`a* subsistence organization (see Tuggle and Griffin 1972). Four survey areas were tested within this land-use zone (units 4 through 7). Sites were located within each sample survey area, except for Unit 6 earmarked for the location of an unrecorded state site. The total area covered in this zone amounted to about 49.3 hectares.

Survey Area 4: (Site 94-15)

Halekamahina Crater (*Lit.*, house of the moon) is the remnant core of a spatter cone estimated to be 400 to 750 years old (Moore and Trusdell 1991). It constitutes the entirety of survey area 4 (ca. 8 hectares). The steep sided crater is presently surrounded by papaya farming in areas that would have likely been optimal agricultural areas in the past. Two different periods of use may be indicated by the agricultural and structural features located at the crater, designated as Site 94-15. An association of Hawaiian domesticated plants including *ki, kukui*, coconut and pandanus was located along the sides and the floor of the crater rim, indicating historic and/or prehistoric agricultural use of the area. An overgrown road encircling much of the crater rim is a remnant of past historic period earth-moving events. The east side of the crater floor supports relatively mature forest growth. This is the location of observed cultigens. No structural features were observed. The western crater floor and rim is choked with *uluhe* fern and grasses covering a recent landslide of the western rim. Photo 3 shows the forested floor and eastern crater rim. The broad leaf trees are *kukui*. The surveyor is walking through *uluhe* in the western landslide area on the crater floor.

Survey Area 5: (Site 94-6)

Survey area 5, a relatively level area located in the Northwestern section of the Kapoho subzone, is composed of a pāhoehoe flow dating to A.D. 1250-1600. The particular area surveyed consists of an approximately 9.5 hectare parcel of land presently undeveloped by the owners (Puna Orchards). Much of the tract, however, appears to have been developed at one time, as a secondary growth of thimble berries, dense *uluhe* and *koa haole* is interspersed with patches of *ki*. Several features of unknown age are designated as Site 94-6. Documented components include rock mounds

and two linear stacked rock features. The latter features may be the result of bulldozer activity. Extensive clearing and subsurface testing would be required to establish antiquity and contemporaneity. See Appendix A for more thorough site description and a sketch map of the features.

Photo 3. Floor and East Rim of Halekamahina Crater. Surveyor walking on the crater floor in front of the tree line.

Survey Area 6: (State Site 5245)

Survey area 6 is a spatter deposit named Kahōlua o Kahawali formed between A.D. 1250-1600. The hill, ethnohistorically cited (Ellis 1979:208) as a *hōlua* slide area, measures 1.3 hectares. Beckwith's account of the legend is drawn from Green's (1928) collection of folktales:

> The handsome young chief Kawali lives near Kapoho in Puna district on Hawaii in the days of Kahoukapu the chief. He has a wife and two children named Paupoulu and Kaohe, a mother living at Kuki`i, and a sister Koae at Kula. His father and another sister named

> Kane-wahine-keaho live on Oanu. Kahawali is an expert in the hula dance and in riding the holua. At the time of the Lono festival, when the hula pupils have gathered for a public appearance, a sled race is arranged with his friend Ahua. Pele in the guise of an old woman offers to compete with him. Angry at the chief's rebuff, she pursues him down the hill in fire form. He flees first to the hill Pu`ukea, then hastens to bid goodby to his wife and children, pauses to say farewell to his favorite pig Aloi-pua`a, and has just time to greet his sister at Kula before escaping to the sea in a canoe which his brother has opportunely brought to land (Beckwith 1970:191).

The area was surveyed upon the realization that although it is designated as a state site (#5245), it has never been described, and thus presumably not located. Presently, the west side of the hill shows evidence of mining activities and the east side is under papaya cultivation. Material remains of the slide were not located. It is possible that they were destroyed by the mining activities or have become obliterated by present agricultural practices. An intensive walk-through and clearing will be needed to adequately establish or reject the presence of the slide on this hill.

Survey Area 7: (Sites 94-4 and 94-5)

Survey area 7 totaled ca. 32 hectares and included pedestrian survey of two craters and inspection of a known lava tube immediately west of the project boundary. Two sites (94-4 and 94-5) were identified. Pu`ulena (*Lit.*, yellow hill) and Kahuwa`i (*Lit.*, water tender) craters are covered by an unconsolidated 10 m thick tuff dating to A.D. 1250-1600 (Moore and Trusdell 1991). In some areas this has eroded to expose older flows in the crater walls. Pu`ulena actually contains three east to west crater lobes. The western lobe (with Site 94-4) is the deepest. It contains trapped fine-grained sediments supporting a variety of native Hawaiian cultigens: *`awa, ki, kukui* and *`ape*, and other plants of economic importance during the pre-contact period: *mamaki* and *hala*. *`Ape* dominates the center of the crater floor. It is possible that the edges of the crater base were used for temporary residence, however this large association of cultigens indicates it's importance as a resource area.

A lava tube (locally known as Malama Cave) lies under a 1790 A.D. pāhoehoe flow immediately west of Pu`ulena Crater. The cave was rumored to contain human burial remains. Upon inspection, the cave was indeed found to contain the skeletal remains of ca. 11 individuals (recorded as site 94-5 in Appendix A). Although interment of the individuals within the cave undoubtedly occurred during the post-contact period, it is possible that a reburial of individuals who deceased before the formation of the tube (1790) occurred. The variable preservation of the bones might suggest use of the burial area over a several generation span. In addition, a 1927 map (Hawaii Territory Survey 1927) notes at least four *ahu* (small cairns) in the vicinity. Burial remains in the cave have been disturbed. Due to its easy accessibility and ongoing damage, it is particularly important that the Malama Cave burials be protected.

Zone 2b Summary

The argument for listing zone 2b as a temporarily occupied and moderately agriculturally developed environmental zone during the prehistoric era is supported by the presence of various areas containing clusters of important native Hawaiian cultigens. Some evidence for labor investment in the area comes from Major's (1992:9) documentation of a large, double face, core-filled wall in the Pohoiki area, which he estimates demonstrates labor requirements for complex organization. However, the antiquity of the wall is debatable. Lava tubes documented by Major (1992:18) contain burials and ritual features attesting to use of the area by (presumably) coastal inhabitants.

Evidence for inland occupation is perhaps scanty, but Lyman's (1924) account of a visit to the area in 1846 indicates that some areas were permanently settled. Also, either exchange relationships were maintained with coastal inhabitants or travel between the inland and the coast was quite frequent at this time. At the village of Koae, which he cites as being five miles from the coast with a population between 200 and 300, he notes small plantations among "the stones and rocks" of the land, and the presence of calabashes of fish (Lyman 1924: 96).

Unfortunately, we were denied access to the Kapoho lands presently leased by Puna Geothermal Venture Inc., whose boundaries encompass Pu'u Honua`ula Crater ("red place of refuge") which reputedly contains a lava tube cave (see Bonk 1980). A radiocarbon date of 340±60 years is associated with the formation of the crater (Moore and Trusdell 1991). This near the coast, such tubes are likely to contain cultural materials, possibly burials.

Zone 3a: Leeward Coastal Margin

This zone, adjacent to the coastal settlement zone (Zone 1) in the western section of Puna District, extends from 0.8 km up to 5 km inland with elevations ranging from about 17 m to 300 m. The land-use zone is expected to contain a moderate to high density and variety of surface features related to agricultural practices linked to coastal settlement. Expectations are similar to the those for Zone 2a, though extending further inland (upslope) and perhaps used for production of a different suite of subsistence crops (especially sweet potatoes *[Ipomoea batatas]*). This zone, however, did not transect the project boundaries and, accordingly, was not sampled during the present project.

Expectations, however, can be discussed in regard to known site locations based on archaeological studies falling within this zone. While the coastal sites bordering this zone are fairly well known (cf. Bevacqua and Dye 1992), evidence for settlement for Zone 3a is best documented for the Puna-Ka`u Historic District of the Hawai`i Volcanoes National Park (Carter and Somers 1990) where eruptions continually threaten archaeological sites. Here, sites falling within the zone consist of temporary shelter features, a few permanent (higher labor investment) structures, and more frequently a variety of agricultural modifications to the existing pāhoehoe surface, such as excavated cracks, artificial pits, mounds of excavated rock, and shelter walls (wind breaks for planting) (Carter and Somers 1990:19).

Consistent with the environmental/land-use model, ethnohistoric sources indicate use of the zone as an agricultural area with scattered residential settlement. Ellis noted a settlement on his descent to Kealakomo, about 300 m from the coast. He claimed that it contained "several plantations of the sweet potato, belonging to the inhabitants of the coast" (Ellis 1979:183). Kealakomo itself is describes as a populous village with over 200 persons (Ellis 1979:188). There is little ethnohistoric or archaeological reference to the zone farther east.

Zone 3b: Leeward Inland Agriculture

The inland zone located in the western half of Puna District is expected to yield a moderate to low density of agricultural features dating to a late pre-contact or early post-contact context. It extends from 5 km from the coast to the lower margins of the East Rift Zone and transects the project boundaries in both the Kamā`ili and Kīlauea subzones.[30] Five sites were designated in this area, two

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[30]Property in the Kamā`ili subzone is located on Hawai`i County Tax Map Keys Zone 1-Section 2-Plats 8,9 & 10 (or 1-2-8,9 & 10); 1-3-1 and 1-5-1. The entire Kīlauea subzone is listed under TMK 1-2-8 &10.

of which are possibly pre-contact. The three other sites are historic period phenomena associated with the economic expansion of the coffee industry into the area, and Hawai`i's location as a strategic place during World War II. The total area surveyed within this land-use zone was 50.4 hectares.

Survey Area 8: (Site 94-7)

This survey area is located along 20-25° slopes below a present cinder pit area and an old geothermal well test site. The area is situated above the present `Opihikao homestead area. Local sediments are estimated to date to A.D. 500-1200. They are dominated by colluvial and limited alluvial silt to clay loam deposits. Four *`awa* patches are located in the area and have been designated as Site 94-7 (a to d). In association with the *`awa* are also patches of banana and *ki*. *Kukui* is located on the upper slopes; *mākaki* and *hapu`u* are fairly well distributed throughout the survey area. The entire survey area measures approximately 13 hectares; each patch of *`awa* totals an area of approximately 1500 $m^2$. These patches are presently tended by the local resident/owner. The antiquity of these patches is unknown, but the *`awa* is clearly fully developed.

Survey Area 9: (Sites 94-9, 94-10, 94-11, and 94-16)

Survey area 9 encompasses land around `Ī`īlewa Crater (formerly called `Ie`ie lewa, *Lit.*, swinging *`ie`ie* vine). The survey area, totaling 6.5 hectares, is located on a lava flow with an estimated age of A.D. 500-1250. However, we noted a variation in the texture of the sediments across the unit. In the northeastern portion of the *kīpuka*, sediments tended to be fine-grained while in the southwest they were substantially coarser. It is possible that either the sediments in the *kīpuka* are from differing ages or are an admixture of different flow types with varying rates of decomposition.

Site 94-9 is a 7 m wide cut and fill section of an abandoned road. For the most part, the roadbed is elevated on its eastern side. It has been labeled as a branch of the Upper Puna Road as it seems to extend from this same route illustrated on an early regional map (Cook 1902, see also Appendix A). The road was constructed after Rycroft, who held a land grant in the area, argued that a road to the upper areas was needed to serve coffee plantations (Rycroft 1894). Wilke's route also might be approximated by the Upper Puna road. The recorded section of road is probably contemporaneous with Site 94-16, which is a large area of feral coffee, covering several hectares and extending north and east of the end of Site 94-9 up to the slopes of `I`īlewa Crater. The location of Site 94-16 correlates with a land grant listed to A.Y. Callaghan (Cook 1902, see Appendix A).

While coffee cultivation was introduced early in the 1800s, production was mainly centered on the islands of O`ahu and Kaua`i until the 1890s. The California Gold rush of 1849, increasing labor costs, and a subsequent infestation of white scale and black fungus smut destroyed crops and led to a fear among *haoles* to invest in coffee (Goto 1982: 114). The coffee boom in the 1890s, instigated by foreign investment into Hawaiian lands related to the American and European financial backing of the overthrow of the Hawaiian monarchy, became centered on Hawai`i Island where coffee production had survived on a small scale (Goto 1982: 116). While former *kalo* fields in Kona became optimal areas for coffee cultivation, the location of crops in the Puna District was distributed among smaller land grants.

A probable prehistoric component is represented by Site 94-10. The site consists of several features in a short lava tube cave on the south side of `I`īlewa Crater. No artifactual remains were found inside the cave opening. The cave contains a single large mound, step platform and short stepping-stone trail. The cave appears to have served residential and/or burial functions. Presently, rock fall and downwashing from a large skylight threaten the integrity of the site.

Site 94-11 is located on the north rim of `Ī`īlewa Crater. The configuration of the site suggests a military origin dating to WWII. It possibly served as a storage area in conjunction with a transmitting station (see Site Data Appendix A). A bunker, excavated into the `a`ā formation of the crater, is reinforced by wooden beams and forms a tunnel into the crater wall. The former is capped by a concrete pyramidal roofed structure. The interior crater entrance to the tunnel is fronted by a steel door and concrete support. Two reinforced concrete shafts run from the rear of the tunnel up to the crater rim. Both provide ventilation, one provides an alternative exit/entrance to the tunnel. Concrete slabs, metal stakes and a basalt and concrete enclosure are located atop a flattened area of the crater rim. The configuration of the metal stakes seems to indicate the former presence of a communications tower. The owner of the property did not relate any account of the history of the features. He noted that a cache of morphine bottles had been removed from the environs.

Survey Area 10: (Sites 94-12 and 94-13)

The entire survey area encompasses 17 hectares. This total, however, does not represent the area actually surveyed, which was somewhat more limited and included the upper margin of Heiheiahulu Crater and a portion of a leasehold property in Upper Kaimu Homesteads. Photo 4 shows site 94-12.

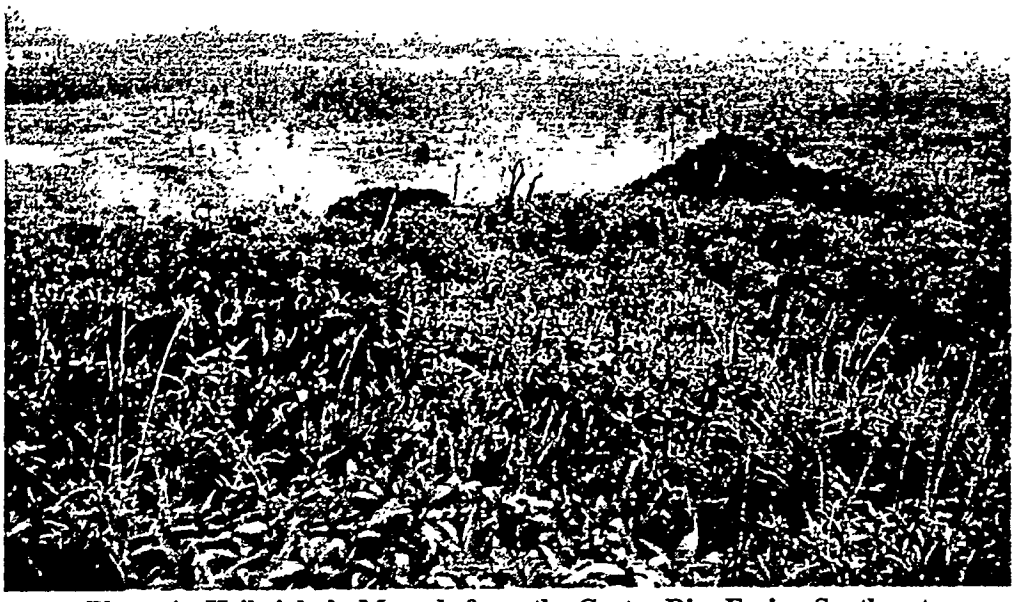

Photo 4. Heiheiahulu Mounds from the Crater Rim Facing Southeast

Located on sediments dating to A.D. 1600-1750, Heiheiahulu Crater was visited to reconfirm an earlier report citing the presence of large mounds on the crater rim (Haun et al. 1985). One large mound is visible from the Upper Kaimu Homestead area. These mounds are amidst presently active steam vents. The site is composed of a total of seven mounds, and one terrace platform which may have been partly destroyed by the placement of a trigonometric marker. The crater is believed to have formed during an eruption in 1750 and it is unlikely that these mounds predate that event. The mounds have been assigned a possible burial function by Haun et al. though casual construction style suggests

equal possibility for an alternative function, such as territorial or ritual markers. Photo 4 shows several of the mounds facing southeast. Steam originates from vents in and around the mounds.

Site 94-13 is a lava tube cave and associated skylights and sinkholes running from an area near Heiheiahulu, through Upper Kaimu Homesteads, and on toward the coast. The cave is presumed to date to the same time period as Heiheiahulu Crater. Despite locating two skylights, the cave was not explored during the present survey. Ten to fifteen meter vertical drops into the cave require ascent gear unavailable to the survey team at the time. The possibility that the cave contains late prehistoric to early historic cultural materials is high. Preservation potential for cultural materials in the tube is good. Efforts should be made to explore and document the cave and its contents in the near future.

Survey Area 12: (Site 94-14)

The antiquity of this *kīpuka*, dated to A.D. 500-1250, was indicated on older land maps (Holcomb 1981) and was identified on the false infrared aerial photographs by the presence of a large *kukui* tree. In order to reach the *kīpuka*, named Pu`u Kauka, we were required to cross three of the more recent lava flows separated by small vegetated areas (Photo 1 shows the flow). The entire *kīpuka* has been designated as Site 94-14 because of the abundance of Hawaiian native cultigens present. Banana populate a ravine crosscutting the *kīpuka*, and *ki* is also present in abundance. A small crater is located on the east side of the *kīpuka*, though does not seem to have been as extensively utilized as the rest of the area. Other plants of economic importance include *kukui, mamaki, `ie`ie,* and *hapu`u.* Particularly notable was the absence of milestoma and pluchea, which have infested many of the other areas in the Kīlauea and Kamā`ili subzones.

Zone 3b Summary

We were unfortunately denied access to all Kamā`ili lands under the ownership of AMFAC. The several Kamā`ili subzone *kīpuka* located on this property could contain cultural materials relevant to Twentieth Century coffee and sugar production and perhaps the route of the Wilkes Expedition, as well as prehistoric use of the landscape. The area around `Ī`īlewa Crater, in particular, seems to have been used for various purposes in the past. Its location affords a commanding view of the southern rift zone slope and coastline.

In the absence of more thorough archaeological research or ethnohistoric accounts about the zone, it is difficult to evaluate implications of the land-use model. We suggest that suitably productive agricultural sediments provided agricultural support to coastal communities. The planting area at Pu`u Kauka is consistent with that expectation. Accordingly, we see no reason to reject or substantively alter the land use model at this time.

Zone 4: Upland Forest Exploitation

This farthest inland zone, located to the northeast of the East Rift, begins 8 km from the coast. It encompasses a large portion of the Puna Forest Reserve area as shown on map Figure 7. The zone crosses the northern portion of the Kīlauea geothermal subzone[31] and is expected to have been exploited largely on a short-term, task-specific basis. Ornithological and botanical resources important to the Hawaiian economy were known to occur under these environmental circumstances (see

[31]The entire Kīlauea subzone is listed under TMK 1-2-8 & 10.

McEldowney 1979: 26-29). The zone is still known today among Puna's Hawaiian community as a good location for hunting and gathering (MacGregor, pers. comm.).

Survey Area 11: (Site 94-8[a])

A section of the Pāhoa Lumber Company Railroad Grade was located to the east of Kaumuki, a land area designated on the U.S.G.S. map and the Moore and Trusdell (1991) map as a small *kīpuka* below the present geothermal access road in the Kīlauea subzone. This portion of the railroad network consists of a 3-5 m wide cleared grade that is at times terraced on one side, but always discernible by rock wall pilings along it's edges. The grade seems to run south of the geothermal access road and form a U shape, by-passing the Kaumuki *kīpuka* to the east. It is very possible that other extensions of the railroad grade exist in this area. Our survey also diverged from the trail to pass south of Kaumuki and crossed the *kīpuka* in a northerly direction. No architectural features or cultigen associations were found. Being an older *kīpuka*, it is likely that Kaumuki was a site for early 20th century *`ōhi`a* logging. Figure 8 is a map of the Pāhoa Lumber rail system. Indicated are sections of the system we believe to be IARII Site 94-8a and 94-8b, and that portion of the line documented by Kennedy (1991).

Survey Area 13

A presently used trail extending south and west of the present True Geothermal well site in the Kīlauea subzone was followed in the attempt to sample an area with flows of various ages (A.D. 1250-1600 and A.D. 1600-1789). The trail crossed relatively old growth *`ōhi`a* and *`ōhi`a-uluhe* forest. An attempt was made to expand the survey by moving away from the trail, however, numerous lava cracks along the rift limited the extent to which the survey team was able to explore the area safely. Several times a field crew member was stranded on an island surrounded by lava cracks and was forced to retrace her/his steps. Even so, the survey team inspected along a ca. 5 km linear route. No structural features were found. Native Hawaiian cultigen plants were not noted in the survey area.

Survey Area 14: (Site 94-8[b])

Survey area 14 also followed, in part, a currently marked trail running north and west of the True Geothermal well site. Sediments in the area were variably derivative from pāhoehoe and *`a`ā* flows. According to present information (Holcomb 1981), the lava flow in the area dates to around A.D. 1250-1600. Both pig and cow markings were observed along the trail, and we had been told that it is presently used for pig hunting. A small stand of *ki* was noted halfway between the start of the trail and the end of the transect shown on Figure 7. Near the end of the transect is another section of the Pāhoa Lumber Company railroad system (see Figure 8 and Site Data Attachment A). According to maps of the area, the Pāhoa Lumber Company and Railroad was exploiting *`ōhi`a lehua* in this region. This section of the railroad was designated site 94-8(b) so that the entire railroad network can be recorded under a single site designation. A nearby section of the same rail system reported in Kennedy (1991) should be given the same designation.

Zone 4 Summary

The best evidence for prehistoric land-use in the upland forest exploitation zone remains ethnographic evidence. Holmes noted that the zone has been "viewed by both Hawaiians and non-Hawaiians, resident or visitor, as a less than desirable place in which to take up any kind of permanent residence or employ" (Holmes 1985:1). Relying on native testimony, he nonetheless alludes to at least two inland villages; each associated with a specialized industry. Panau is cited as the location where

canoes were made, and Ola`a, a settlement that later played an important role in the early sugar manufacturing industry in Puna, was an area for the fabrication of *tapa* and *olana*, as well an area known for bird catching (Holmes 1985:4). Several accounts list the gathering of *pulu* from the *hapu`u* tree fern, used as a substitute for hair and feathers, as an important economic activity of the mid 1800s (see Holmes 1985) in the forest reserve area. Other inland areas mentioned in accounts cite Kīlauea, Kahauale`a and Ke`eau as areas for feather gathering (Holmes 1985b:27).

Several studies have compiled lists of native plants and birds that have been identified within the Puna Natural Area Reserve and which are known to have had some economic significance in the past. In general, many of the bird species formerly exploited for their feathers are now extinct (Table 4). The particular timing for their extinction is unknown, but it is perhaps related to the reduction of native forests during the early twentieth century (but see Athens et al. 1991). Abbott and Lamoureux (1991:15) found 59 major Hawaiian medicinal plants within the Kīlauea East Rift Zone. Many other plants noted to occur in the area were also used in various craft-making endeavors such as canoe-making, tapa cloth making and *lei*-making (see Holmes 1985b; Merlin 1976). Few archaeological surveys have crossed this particular environmental/land-use subzone. These have been limited to small and specified areas related to the construction of the True Geothermal well site (Bonk 1988, 1989a, 1989b, 1990; Haun et al. 1985; and Kennedy 1991a and 1991b). A previous intensive survey at the proposed well site #2, east of survey area 14 (Figure 7), uncovered a portion of a railroad berm as noted above (Kennedy 1991). With the exception of the railroad section, no other types of sites were recorded for the Kīlauea subzone. No archaeological studies report signs of permanent prehistoric established use of the upland forest zone. While limited, extant results are consistent with general expectations of the environmental land-use model.

Table 4. Economically Significant Native Birds in the Puna Natural Reserve Area (adapted from Holmes 1985: 5, Freed 1990 and Jeffrey 1990)

Bird Name	Species	Comment
amakihi	*Loxops virens*	greenish-yellow feathers used in decoration. Species is extinct.
`apapane	*Himatione sanguinea*	red feathers used in decoration. Common in the area.
`elepaio	*Chasiempis sandwichensis*	a fair distribution in the project area.
i`iwi	*Vestiaria coccinea*	red feathers used in decoration.
mamo	*Drepanis pacifica*	yellow feathers used in decoration. Species is extinct.
oma`o	*Myadestes obscurus*	The Hawaiian thrush, common in the area.
`ō`ō	*Moho nobilis*	green feathers used in decoration. Species is extinct.

The possibility should not be discounted, however, for eventual identification of temporary dwellings in the upper forest zone. Holmes (1985b) notes that a few inland areas were used as either way-stations or semi-permanent dwelling locations for bird-catchers. McEldowney and Stone (1991) have documented three lava tube systems, all of which contain cultural material either in the form of burials or structures. They have also ascertained that at least one of these tube systems --the middle lava tube system-- extends southward into the project area. It is likely that the northern and southern

tubes extend into the Kīlauea subzone as well. As systematic survey in the area was limited during the present effort, these caves and a number of potential use areas have yet to be investigated. McEldowney and Stone (1991) are correct in noting that the lava tubes demonstrate prehistoric use of the area. The full range of that use has yet to be satisfactorily established.

We do know, however, that parts of the upland forest zone have been heavily used during the historic period. This zone was subject to exploitation during the early part of the nineteenth century by the Pāhoa Lumber Company and Railroad. It is possible that evidence for prehistoric exploitation has been obliterated by the construction of railroad berms and forest degradation. The infiltration of historically introduced plants across the zone demonstrates the fragility of the indigenous forest reserve. Archaeological work in the area remains sparse, largely on account of its present day inaccessibility, its size, and location on the East Rift Zone. Future work in the area should focus on delineating the course of the lava tubes known in the upper reaches of the land-use zone. Given the high correlation between locating a lava tube, and finding archaeological evidence for extended use of this type of feature, these data would provide perhaps the single greatest source of archaeological information about the prehistoric exploitation patterns within this forest area.

EVALUATION OF THE EAST RIFT ZONE LAND-USE MODEL

The empirical data required to assess the environmental/land-use model for Puna District is unevenly distributed as survey localities were restricted by the distribution of *kīpuka* (pockets of older flows across the three geothermal subzones. The goal of this section of the report is to examine evidence for the location and land-use behaviors of individuals and groups across the prehistoric cultural landscape, and to determine the ability of the model to reflect trends in unsurveyed areas. The coastal zone, which in the past was the most familiar to early historic period travellers and is today archaeologically the best known, certainly supports a denser concentration of residential sites. As distance increases from the coast, the instance of archaeologically recognizable features decreases sharply, though the instance of resource use-areas, identified in this report with native Hawaiian cultigen associations, increases. This pattern is plausible for an area that experienced sustained volcanic activity in the past, which may limit the establishment of permanent settlement further inland in areas at a greater risk of environmental perturbation. The pattern is also consistent with historical accounts and modeled expectations. We believe the coastal bias in residential aggregation reflects a long standing pattern, consistent with economic constraints of Hawaiian life prior to horse and vehicle assisted overland transport.

Adequate agricultural soils are unevenly distributed across Puna District. Assuming this pattern was true for the past as well, it would play an important role in the spatial distribution of agricultural use areas. `A`ā sediments are usually regarded as the fertile lands as opposed to pāhoehoe flows which weather at a slower rate. The lack of archaeological sites in old *kīpuka* expected to yield evidence for agricultural or residential land use can be re-examined with these considerations in mind. Survey Area 1 (see Figure 7), consisting of pāhoehoe based sediments, might *not* be expected to yield evidence for permanent agricultural use despite its location close to the coast. During prehistoric times, this area may simply have been insufficiently weathered to support productive agricultural use. The available geological data, however, do not provide information at the precision required to construct a working model to correlate with settlement patterns in the Puna region. While the basic timing for, and the general types of, lava flows are known, field experience demonstrates that variability in flow types are found within most of the recorded flows and thus each must be investigated on a case by case basis.

Interestingly, some ethnohistoric data reflects a changing perception of the Puna area, likely based on variation in lava flow patterns in the past. Some have considered Puna to have the most fertile agricultural land on the island until the more recent lava flows covered the area (see Handy and Handy 1972). In addition, there seems to be nearly a 300 year gap between the youngest known large-scale prehistoric lava flow and the historically known flows mentioned in missionary accounts. Smaller lava flows may not have precipitated the movement of populations from the region and it is quite possible that younger flows have since obliterated the signs of long-term residence in Puna.

The lack of perennial streams in the area may have been a limiting factor in the establishment of permanent settlement inland. Yet given the predictability of rainfall, it is reasonable to argue that populations used the inner region, at least for agriculture, if not for permanent residence. Kolb (1992), for example, argues that in Hana District on Maui, the development of a dry-land type of field system dependent on predictable rainfall patterns increased the productive potential in an area lacking perennial streams. We expect similar types of field systems to have been established in Puna if environmental perturbation from the volcano was either predictable, routinely small-scalè, or the temporal variation between environmental perturbations was longer during certain times in prehistory.

The absence of permanent structures within the project area might be further addressed with a consideration of both the ecological constraints particular to Puna and the nature of Hawaiian residential patterns. Long-term investment areas away from the coastline should be indicated by constructed rock enclosures and platforms. Given the location of the Kīlauea East Rift throughout much of the project area, long-term or sustained inland use may not have been as frequent as found in other districts on the island. While cave sites are possible options for temporary residence, they are more often found to have been used as refuge and burial areas (Major 1992) in this area. This, however, might be a reflection of their use during the late pre-contact or early post-contact era. If long-term residential investment was not made in inland areas, we also might not expect large-scale intensive agricultural systems within the project area. Consistent with the land-use model, neither were observed in the field.

The environmental/land-use model predicts for the spatial distribution of site types across the landscape according to the specific ecological character of homologously defined land-use zones. One assumption underlying this model is that the ecological character of the district has structured the extant land-use patterns, and these conditions have persisted over time. As very limited archaeological excavation work has been done in Puna, current evidence cannot evaluate this assumption fully. Whether the environmental context has structured the pattern of material culture throughout prehistory, or if variability in land-use patterns was subject to more random processes or localized ecological variations, remains subject to debate. Given the particularities of the Puna environment, however, we can still argue that the model adequately represents the spatial distribution of archaeological sites presently known across the district. Initial labor investment for intensive agricultural systems may not have been opted for, although rainfall is predictable and the land is particularly fertile in certain areas. Given geological unpredictability, agricultural usage might have been on a smaller scale, much of it localized on well-drained `a`ā soils; however the distribution of these sediments was different during the prehistoric era than today.

ARCHAEOLOGY OF THE GEOTHERMAL RESOURCES SUBZONES PROJECT AREA

The distribution of prehistoric and historic cultural remains within the modeled land-use zones and across the East Rift Zone, also has implications for site distribution in the three Geothermal Resources Subzones (GRS). Here, we summarize briefly implications of known and predicted archaeological remains for the GRS. In general, the greatest number of sites overall are found within the Kapoho Subzone (see Figure 5). This is consistent with expectations of the East Rift Zone Model, which predicts highest site/feature density near the coast --particularly in the vicinity of Kapoho Bay. The pattern, of course, reflects more intensive use of land closer to the coast in the past. Overall, the instance of prehistoric and early historic period sites decreases with distance from the coast.

In summarizing archaeological resources within each of the subzones, please recall that the GRS reflect modern land-use concerns with little bearing on remains reflecting use of the area in the more distant past. However, a general assessment of site distribution across the geothermal project area is warranted for considering the potential impact of geothermal development. Below, archaeological resources are broken down by location within each subzone, and presented in a tabular format (Tables 5, 6 and 7). A brief summary for each subzone is also included. The reader should refer to Table 2 for additional information and for the particular land-use zone with which they correlate. Numbers in parentheses in the tables refer to their map locations on Figures 5 and 6.

Kapoho Subzone Archaeology

Seven survey blocks were field checked within this subzone (see Figure 7). A total of 20 individual sites are known for the Kapoho Subzone area correlating with site distribution from land-use zones 2a (coastal margin windward agriculture) and 2b (inland windward agriculture). No sites are presently known for the coastal margin (Zone 1) within the GRS Project boundaries (most of which lies under the 1960 Kapoho flow). Table 5 lists the sites known for this subzone.

Few archaeological sites within the Kapoho Subzone fall within the easternmost portion of the area near Cape Kumukahi. Extant archaeological sites would not be expected in this part of the subzone, as it has been mostly covered by a 1960 lava flow (see Figure 3). Substantial additional land is in large scale agriculture (now principally papaya production). However, as was found during the survey work, isolated older volcanic *kīpuka* remain and may preserve older cultural remains. Known archaeological sites west of Kapoho Crater are fairly evenly distributed in comparison with those of the other two subzones (see Figure 5). They are also more variable in terms of their form and function, possibly reflecting a more frequent and varied use of this area during the pre-contact period.

Kamā`ili Subzone Archaeology

Two survey blocks were investigated in this subzone (see Figure 7). A total of 6 individual sites are known for the Kamā`ili Subzone area, all of which fall within land-use zone 3b (inland leeward agriculture). Table 6 lists sites known for this subzone.

Table 5. Archaeological Sites in the Kapoho Subzone

Site Number	Site Name	Comments
(1) no number	Lava Tube Cave	Covered by 1960 lava flow
(2) 7492	Lyman Ranch and Grave	Located at Kapoho Crater. Historic period site.
(3) 2501	Kapoho Petroglyphs	Located at Kapoho Crater. Prehistoric period site.
(4) no number	Koae Site	See Table 2 for discussion. Historic period site (debated).
(5) 2500	Kūki`i Heiau	See Appendix A. Prehistoric period site.
(5) IARII 94-1; 50-10-46-19483	Pu`u Kūka`e Mounds	See Appendix A. Prehistoric period site.
(5) IARII 94-2; 50-10-46-19844	Pu`u Kūki`i Cyst	See Appendix A. Prehistoric period site.
(6) no number	Kūki`ihelau Warm Springs	Covered by 1960 lava flow
(7) 295	Unknown State Site	Possibly covered by 1955 lava flow. See Table 2 for discussion.
(8) no number	Coffee patch	Possibly still *in situ*. Historic period site.
(9) 5245	Kahōlua o Kahawali *hōlua* slide	Possibly still *in situ* though not located during present survey. Prehistoric period site.
(10) no number	*Hōlua* slide	Possibly still *in situ*. Prehistoric period site.
(11) no number	Lava tube sinkhole	Possibly still *in situ* --land access was denied for present survey. Prehistoric period site.
(12) no number	Rycroft Coffee Plantation	Partially covered by 1955 lava flow. Historic period site.
(13) no number	Leioumi *hōlua* slide	Covered by 1790 lava flow. Prehistoric site.
(14) no number	Agricultural complex	Possibly still *in situ*. Prehistoric period site.
(22) IARII 94-4; 50-10-55-19845	Pu`ulena Crater	See Appendix A. Prehistoric period site.
(22) IARII 95-5; 50-10-55-19846	Malama Burial Cave	See Appendix A. Historic period site.
(23) IARII 94-15; 50-10-46-19855	Halekamahina Crater	See Appendix A. Prehistoric period site.
(24) IARII 94-6; 50-10-55-19847	Puna Orchards Mounds	See Appendix A. Prehistoric period site.

Table 6. Archaeological Sites in the Kamā`ili Subzone

Site Number	Site Name	Comments
(15) no number	Wilkes' Trail of 1840	Partially covered by recent lava flows. Note that it also extends into the southern portion of the Kīlauea subzone. Historic period site.
(25) IARII 94-7; 50-10-55-19848	Bryson's Cinder Pit *Kīpuka*	See Appendix A. Prehistoric period site.
(26) IARII 94-9; 50-10-55-19850	Branch of Upper Puna Road	See Appendix A. Historic period site.
(26) IARII 94-10; 50-10-55-19851	`Ī`īlewa Lava Tube	See Appendix A. Prehistoric period site.
(26) IARII 94-11; 50-10-55-19852	Military Structure at `Ī`īlewa	See Appendix A. Historic period site.
(26) IARII 94-16;	Callaghan Land Grant and Coffee Plantation	See Appendix A. Historic period site.

Table 7. Archaeological Sites in the Kīlauea Subzone

Site Number	Site Name	Comments
(16) IARII 94-12; 50-10-55-19853	Heiheiahulu Mounds	See Appendix A. Historic Period Site.
(17) no number	Kaimū Trail	Partially covered by 1977 lava flow. Prehistoric period site.
(18) no number	Forest Planting Areas	Partially covered by 1977 lava flow. Prehistoric period site.
(19) no number	Middle Lava Tube Cave	Not inspected during current survey. Prehistoric period site.
(20) no number	Southern Lava Tube Cave	Not inspected during current survey. Prehistoric period site.
(21) no number	Northern unnamed trail	Partially covered by 1977 lava flow. Prehistoric period site.
(27) IARII 94-13	Upper Kaimū Cave	See Appendix A. Prehistoric period site.
(28) IARII 94-14; 50-10-54-19854	Pu`u Kauka *Kīpuka*	See Appendix A. Prehistoric period site.
(29) IARII 94-8; 50-10-55-19849	Pāhoa Lumber Company Railroad Grade	See Appendix A. Historic period site.

The place with the single largest number of known site localities in Kamā`ili Subzone is `Ī`īlewa Crater and environs. Wilkes' Trail of 1840 is also believed to have passed close to the crater (see Figure 5). Please note, however, that our view of the broader distribution of cultural materials in the zone is limited by the small size of the present sample. In Kamā`ili, too, survey was somewhat

more limited than in other GRS by unwillingness of one of the largest landholders --AMFAC-- to permit land entry for the survey. Unfortunately, this precluded inspection of some of the largest and oldest *kīpuka* in the southern part of the subzone and much of the north. Future examination of younger flow areas (those dating to A.D. 1250-1600), and lands unsurveyed in the present project, will very likely yield a greater number of prehistoric and historic period features.

Kīlauea Subzone Archaeology

Two survey blocks and land accessible via three trails were investigated in this subzone (see Figure 7). Currently, a total of 10 individual sites are known for the Kīlauea subzone, falling within land-use zones 3b and 4. Table 7 lists the sites known for this subzone.

Three of the sites --94-12, 13 and 14-- are located in land-use zone 3b (inland leeward agriculture) on the south slope of the Kīlauea East Rift Zone. These are quite varied, presently including a cultigen association, lava tube cave, and mound and platform features. Rosendahl (in Haun et. al. 1985) alludes to other cultigens associations at unspecified locations in the general area. Available information, then, suggests that additional cultural remains are preserved along the rift slope in Kīlauea GRS.

All other reported cultural remains in Kīlauea subzone are located north of the rift in land-use zone 4 (upland forest). These upland forest sites include historical remains (Pāhoa Lumber railroad grade), lava tube caves, and features known only through ethnohistoric accounts that have yet to be verified in the field. The railroad, of course, reflects one of the primary uses of this portion of the upland forest in the early 1800s (see Figure 13 map of the rail system in Appendix A). The lava tube caves run northeast out of the Kīlauea GRS in the massive Aila`au pāhoehoe flow, ultimately terminating near the windward coast northeast of the project area. The full extent to which these caves penetrate the Kīlauea subzone and the character of cultural remains in the upper portion of these tubes has yet to be established. No other prehistoric sites have been documented in the middle and northern part of the subzone.

SUMMARY OF FIELD STRATEGY AND RESULTS

This section has provided an overview of the distribution of archaeological sites within the Geothermal Resources Subzones Project Area and has discussed the methods employed for locating sites and how they were designated. An evaluation of the East Rift Zone Model developed during the preliminary work for this survey (see Burtchard 1994) was also presented. In general, the presently known distribution of archaeological sites is in accord with the model, which predicts a greater variability and distribution of sites closer to the coast than would be found inland. The distribution of sites was broken down by both the environmental land-use zone as outlined in the East Rift Zone Model and the Geothermal Resources Subzone in which they were located. A greater emphasis was placed on summarizing archaeological site distribution as it related to the model, as this gives us a greater understanding of overall prehistoric land-use patterns for the district. The following section provides a summary of other models used to evaluate settlement patterns in Hawai`i which may bear on how we understand the archaeological site distribution for the Puna District. An attempt is made to discuss how they may be applicable for future work in the area.

PUNA SETTLEMENT PATTERNS RECONSIDERED

Various models have been proposed over the years to describe settlement patterns in pre-contact Hawai`i. Some of the models discuss general changes believed to have occurred in Hawai`i from the time of settlement to the arrival of Europeans. Other models examine the various reasons why settlement may vary in different localities. These will be considered briefly in relation to the accumulated data from Puna District. Most of these models have been developed out of the accumulated evidence about Hawaiian settlement patterns, and are largely based on the archaeology of the better known leeward areas. While this might possibly bias the applicability of these models to the Puna area, trends in both spatial and temporal site locations for Puna can be elaborated by these various models.

EVOLUTIONARY MODELS

Models for cultural evolution, as they have been applied to Hawaiian archaeology, generally attempt to describe changes in land use patterns over a long period of time. These changes are correlated with prehistoric population movements and demographic shifts. The goal of these models is to explain how an initially small settlement population evolved into the complex and populous society of contact period Hawai`i, known at European contact (e.g., Cordy 1981, Earle 1989, Hommon 1986). These models for Hawai`i are in agreement about the general patterns of change in land-use over time; they will differ in the timing of these events. They also tend to emphasize the importance of demographic shifts and agricultural innovations for explaining the transition between these events. Kirch's (1984) evolutionary model is the most widely known and applied, and will be discussed below.

Kirch (1984) proposes that the more fertile, windward valley environments were the first localities to be settled in the Hawaiian Islands. The spread of populations to the leeward coastal areas ensued. Once the drier environments were settled, the archipelago underwent a significant demographic expansion sometime between A.D. 1100-1400, with inland settlement co-occurring with agricultural expansion and intensification. At this time, previously unsettled marginal areas were also exploited. These areas, however, were never settled to as great an extent as the windward valleys or some of the more optimally exploitable leeward areas (see Kirch 1984: 245). Kirch's basic argument has been widely cited for explaining changes in pre-contact Hawai`i, and has been adapted in the research proposal (Burtchard 1994).

Although Puna is a windward area with relatively abundant and predictable rainfall, it is potentially classifiable as a marginal environment in relation to other areas around Hawai`i Island. That is, it would not have been as favorite a locality for permanent residence as compared to other locations around the island. The continual threat of ecological devastation by lava flows and the variable agricultural potential of the land would be two factors related to this marginality. If so, and according to the Kirch (1984) model, we would not expect the settlement of Puna (in general) before A.D. 1100-1400. Present radiocarbon evidence seems to lend plausibility to this hypothesis. The limited number of excavated coastal sites tend to date to the early fifteenth century in congruence with Kirch's demographic expansion phase or the intensification period in Burtchard's (1994:43-44) model of changing Puna settlement patterns. Radiocarbon dates for the Waha`ula Heiau, cited as the first monumental structure established on the island (see Loo and Bonk 1970, Stokes 1991), also date to this period, with the lowest stratigraphic levels dating to A.D. 1428-1492 (Carter and Somers 1990:31). The lowest levels from a residential feature at Ka`ili`ili Village, to the west of Waha`ula Heiau, have been dated to A.D. 1439-1637 (Carter and Somers 1990:31). These structures are located within the

Hawai`i Volcanoes National Park boundary. This park shares similar leeward environmental conditions with Ka`ū. Due to their proximity to the volcano, they would fall within the marginal environment category. No published accounts of excavated features in Puna District, with radiocarbon determinations, are available to further assess the model.

Support for this model is largely based on negative evidence. There is a lack of radiocarbon dates for structures in the Puna District, and thus the model can neither be supported nor rejected. Further explanatory work aimed at uncovering early sites in the Puna area can be helpful to further evaluate the model.

MODELS FOR DISTRIBUTION IN SPACE

Wetland/Dryland Agricultural Model

The major Hawaiian Islands are typified by similar rainfall patterns which create two general ecological zones. The windward zones located on the north and east coasts are typified by predictable and abundant rainfall patterns, making them suitable for the development of intensive agricultural practices both with and without irrigation (see Kirch 1984:168-179). The leeward zones, usually along the south and west coasts, were more suitable for the development of either irrigated systems where stream flow is adequate or elevationally stratified field systems where perennial streams do not exist. Kirch (1984) among others argues that around AD. 1000, the population of the Hawaiian islands underwent expansion.[32] The movement was from the more desirable areas (those with stable and predictable resources) to less desirable areas (those with less productive and/or less stable resources). In general, this model conceives a movement from the windward coasts, with their predictable terrestrial resources, to leeward zones, with a focus on terrestrial exploitation (i.e., agriculture and animal husbandry), and finally to marginal areas. By A.D. 1650 (Burtchard believes ca. A.D. 1400), this expansion phase was stabilized. If valid, certain patterns should be expected from this general model. First, coastal areas should exhibit the densest and most varied evidence for human land use. Second, settlement inland should be less dense than for the coast. Third, marginal areas with less productive potential for intensive agriculture should have the least dense evidence for land use.

Of course, variations exist for each island, and Puna does not fit the windward/leeward pattern neatly. It has characteristics of both, and is a volcanically dynamic landscape. Although it is in the windward zone, Puna's landscape is not typified by fertile valleys and permanent stream flow. The abundant rainfall in the area is offset by a bare, relatively undissected lava landscape containing pockets of older flows. Thus, Puna's landscape was not suitable for the intensive irrigation systems found in places like Hāmākua District, nor even the extensive dryland field systems such as in Kona. Here, we can expect a variation on dryland agriculture to have been practiced on a smaller scale, as anticipated in the environmental/land-use model. We may also expect agricultural innovations designed to cope with the district's unique volcanic problems, such as the use of mulch to contribute to the fertility of poorly weathered lava sediment.

Dry-land agricultural systems in Hawai`i are often associated with an intensified subsistence base, such as is evidenced by the Kona field system. However there is scant evidence from which to

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[32]Burtchard (1993 and 1994:42) sets early expansion processes more ambiguously at A.D. 600-1100.

infer that the Puna region was comparably intensively exploited[33]. First, there is little archaeological documentation of potential field systems in the Puna region. Second, although current models would suggest that the association between dryland agricultural systems and pig husbandry was high (Kirch 1984: 179), there is little data to suggest this is the case in Puna District. Evidence for agriculture in Puna is not correlated with evidence for pig husbandry. Present evidence suggests that a greater protein component was derived from fishing. However, although this form of aquaculture has been identified as one mode of intensification of production (Kirch 1985:211) related to the "development of complex and highly stratified Hawaiian chiefdoms" (Kirch 1985:131), no intensification of the marine component of food production occurred despite the presence of fishponds at Kapoho and Kalapana. While ethnohistoric accounts testify that marine resources were a major trade item for the district, fishpond development did not reach the extent that it had in other regions such as leeward Moloka`i and west Hawai`i. For Puna, then, we would not expect densely clustered settlement areas or extensive inland settlement.

The *Ahupua`a* System Model

Most regional scale analyses have difficulties in achieving a representative spatial sample sufficient to typify land-use patterns. Breaking a broader regional study down into the intensive study of an *ahupua`a* (the upslope-downslope traditional land division which cross-cuts a variety of ecological zones) has been thought to be a viable strategy for extrapolating Hawaiian land-use patterns. The key to the concept of *ahupua`a* is that of a self-contained political and economic unit whose members interacted to a great degree. It is reasoned that a single socio-political group would have exploited the full spectrum of resources available within the land unit (Clark and Kirch 1983:9, Hommon 1986:57).

The fact that rural histories are rarely documented or are unavailable in the ethnohistoric literature lends appeal to this kind of approach. Perhaps our only comprehensive source for commoner histories comes from Handy and Pukui's (1958) study at Ka`ū; however the majority of their information was collected during the 1930s within one district. As the basis for the *ahupua`a* model was derived from Handy and Pukui's (1958) work (see Clark 1987), the model might serve as one example of regional variation in land-use patterns in rural areas. In fact, while some have argued the applicability of this model (Cordy 1981), several archaeologists have found that this model does not apply to specific cases (Clark 1987, Riley 1973, Rosendahl 1972).

Clark (1987: 595) also notes that within an *ahupua`a* based model there are two debated residential patterns. The *`ili `ohana* mode of residence, suggested in Handy and Pukui (1958), places permanent settlement in both coastal and inland areas of an *ahupua`a* linked by a co-dependent trade network. A model for shifting residence, however, places permanent settlement at the coast with seasonal movement inland for agricultural purposes (see Rosendahl 1972).

Inherent problems in using the model of an *ahupua`a* to structure archaeological data gathering have not gone unnoticed. First, the antiquity of this type of land division remains unknown. Archaeologists seem to agree that the *ahupua`a* is a late thirteenth to fifteenth century development associated with expansion into the inland zones (e.g., Hommon 1986). It is also highly feasible that it is a relatively late prehistoric territorial division. The stability of *ahupua`a* boundaries through time

[33]An intensive exploitation is marked by a greater amount of cultivation over time in a given area whereas an extensive exploitation is marked by broader areal spread. Little is known about the possible extinction or extirpation of birds exploited for feathers in the Puna forest region which may have, in fact, undergone intensification at some time during prehistory.

is also unknown, and we might expect them to have been generally unstable given the propensity of accounts for warfare in the ethnohistoric literature (see Kamakau 1992). In addition, there is evidence that the boundaries were not stable during the historic period. Emory et al. (1959:12) note that some *ahupua`a* in Puna seem to have undergone subdivision between Ellis' time (1823) and the Great Māhele (1850).

Ahupua`a* based studies and comparisons can contribute to understanding land-use patterns in the Puna District, if their inherent problems are understood and then taken into account. Comparing *ahupua`a based patterns can help to reveal the variations in the way land was used. They can also serve as a basis for correlating such variation with ecological variables thought to structure the distribution of archaeological sites.

MODELS FOR SELECTIVE EVOLUTION [34]

Selectionist models have also been proposed as a way to examine change over time in the Pacific (cf. Allen 1992, Graves and Ladefoged 1994, Graves and Sweeney 1993, Hunt 1987). The actual differences between traditional evolutionary models used in archaeology and selectionist models are perhaps subtle, but are important because of the way each approaches the study of the past. The way that change over time is identified and conceptualized is different. Instead of a focus on modes of behavior through time, the focus is on the "persistence or loss of cultural variability through time" (Graves and Ladefoged 1994:16). A selectionist focus in archaeology is perhaps best typified as an integration between culture historical techniques for identifying change over time and evolutionary theory. A selectionist approach dispenses with the assumption that material culture is the result of proximal causes (e.g., such as an agricultural innovation or an increase in population density) and focuses on why certain aspects of variability may persist over time and space. These aspects of variability are explained by processes rather than events.

Traditional evolutionary models, such as described above, have emphasized the movement and spread of populations in relation to types of subsistence practices. The material culture identified by archaeologists for a given locality is placed within the context of a developmental phase. For example, the prehistoric material culture for the Puna district has been largely associated with Kirch's (1984) demographic expansion phase. In this way, change over time in settlement patterns is envisioned as the change from one type of activity or phase to another. Traditional evolutionary models will first emphasize the large scale changes occurring over time, and will then look to material culture for verification. Selectionist models, in the way that they have been more recently envisioned, will emphasize that change over time is change in material culture. A class of material culture to identify change over time is first selected. Once patterns of change in material culture are identified, then change in behavioral strategies will be hypothesized. Both types of evolutionary models focus on determining long-term process, and traditional evolutionary models provide a starting point for generating selectionist models. As such, one type of model can inform on the other.

Selectionist models are currently being developed and tested for the Pacific (cf. Graves and Ladefoged 1994, Graves and Sweeney 1994). Presently, archaeologists in Hawai`i seem to be having a measure of success in using architecture to examine a selectionist model. Cachola-Abad's (1994) seriation of *heiau* attributes, combined with Kolb's (1992) determination of construction sequences and radiocarbon dating for such structures, have refined the model for *heiau* temporal variation and can

[34]The authors disagree on the on the manner in which evolutionary models have been characterized and the utility of selectionist approaches as presented here. The opinions offered in this section are those of the senior author.

even help to predict the relative age of a structure. Temporal variability in *heiau*, as discussed by both Cachola-Abad (1994) and Kolb (1992), is used to discuss the proliferation of these structures during the late prehistoric period and to describe political activity prior to contact. Mechanistic processes such as integration or aggression that may account for this variability can be hypothesized[35]. Delineating this variation in material culture provides a model for further testing, and can help to structure data recovery procedures. Comparing the results at different scales of analysis (i.e., archipelago, island group, island, region, district, environmental region) will be required to evaluate the empirical sufficiency of each model and its applicability. Other architectural types, such as residential structures and agricultural components, might also yield temporally variable attributes that can be incorporated into these kinds of models. Thus, the applicability of selectionist models is largely reliant on the identification of variability in material culture.

OTHER CONSIDERATIONS

There are additional historical factors which do not appear in models for time and space in Hawaiian archaeology which deserve consideration. Archaeologists have generally argued that the pre-contact Hawaiian material culture record changes after European contact. This presumed difference does not merely involve the incorporation of European artifacts into Hawaiian material culture assemblages. Archaeologists have also noted a difference in residential architectural styles between the two time periods (e.g., Ladefoged 1991, Sweeney 1992, Weisler and Kirch 1985). This difference has been linked to rapid demographic changes caused by the introduction of Old World diseases (see Stannard 1989, Sweeney 1992). One question that might be addressed is to what degree would the introduction of European diseases within the archipelago have affected the inhabitants of this region, and subsequently the archaeological record? Further archaeological study of the pre-contact socio-economic structure of the district can begin to address questions about the relative degree of interaction between coastal dwellers and people from other districts (and even other islands), exchange patterns, social hierarchies and the impact of European arrival in this particular area.

In addition, models can be elaborated by interdisciplinary approaches for their understanding. Sweeney et al. (1994) discuss how a selectionist model positing a mechanism for explaining the occurrence and distribution of *heiau* in Hawai`i is better evaluated by considering ethnohistoric literature as a data set for testing its plausibility[36].

SUMMARY

Each of the models discussed above may contribute in some way to our understanding of Puna prehistory. Kirch's (1984) model for change throughout the archipelago gives a general overview of

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[35]Models incorporating evolutionary ecology with a focus on selective evolution may be particularly suitable for understanding Hawai`i's past cultural landscape (see Sweeney et al. 1994), especially given the different settlement trends noted between windward and leeward areas. In selectionist models thus far, differential ecological conditions within a region serve to model a selective basis for change in material culture (see Allen 1992, Graves and Sweeney 1993, Graves and Ladefoged 1994, Hunt 1987). The debate concerning the role of the environment in structuring archaeological data is not new for Hawai`i, however change in material culture has been explained as the result of human beings differentially manipulating their environments (e.g., Clark and Kirch 1983:9) or behavior being controlled by environmental conditions.

[36]Other archaeologists in the Pacific have reached similar conclusions with respect to evaluating models of evolution and process. Cachola-Abad (1993) argues that the model for the settlement of Hawai`i is enlightened by ethnohistoric data, giving a clearer idea of process. Ladefoged (1993) has also used ethnohistoric data to model strategies for mediation given conditions of uneven resource distribution.

the chronology of events thought to have occurred in Hawaiian prehistory. The wetland/dryland agricultural model describes the differences expected in the material culture in various areas on the island. The *ahupua`a* system model presents a spatial framework for organizing archaeological data. Selectionist models emphasize the importance of a material culture focus in testing and discussing models for change over time, and provide an alternative framework for testing traditional evolutionary models.

While various models can be proposed to explain the general patterns archaeologists might identify in the field, they should not all be extrapolated to explanations of process. Kirch (1986:22) has pointed out that there are "theoretical arguments against a simple A to B to C settlement sequence" for the settlement of the Polynesian islands. This point can easily be extended to our present understanding of Hawaiian settlement patterns. The link between the distribution of archaeological sites and cultural process may not be easily explained as an "A to B to C" sequence but will require models, which ask answerable questions and engage the appropriate data set.

A model elaborating the spatial distribution of archaeological sites in a region, such as the East Rift Zone model developed for this survey, provides a basis for exploring the range of variability for the district's material culture, discusses several of the selective criteria which may be important for understanding the particular distribution of archaeological sites in the area, and generates further questions we may want to answer. Depending on the particular question, different models can be used to structure data recovery procedures should they prove necessary to implement. For example, if we wanted to know about demographic change in Puna, we would choose to explore that aspect of material culture which should prove chronologically significant to answer the question (such as residential architecture). The variability within this material culture, tested against an appropriate model, will allow us to begin to infer the behavioral processes related to change over time. The East Rift Zone model provides some of the selective criteria, particular to the district, that will account for some of this variability. However, temporal variation in material culture must be assessed independently of the model constructed to explain it, thus in order to discuss "time", archaeological work should also focus on how reliably and accurately this material culture demonstrates temporal change.

RECOMMENDATIONS

While an overall goal of archaeological investigations is to understand the relationship between material culture and the human behavioral processes relating to its distribution, we are also charged with assessing its significance for situations in which cultural remains would be destroyed through completion of state or federally permitted projects. At this stage of the Puna geothermal development process, such considerations are not warranted. Indeed, information gathered during the present inventory generally is not sufficient to make such determinations in a fully informed way. For present purposes, we reemphasize that all sites identified in the three GRS are potentially significant on cultural heritage and/or scientific grounds. Both structural and non-structural sites (e.g., cultigen associations) are important to our understanding of general land-use patterns in Puna District.

Some recommendations for future work related to the documentation of Puna's archaeological history, however, can be made in the absence of formal significance determinations. First, expectations germane to the environmental/land-use model should be pursued in greater depth. Recall that the model postulates that each land-use area will correlate with basic differences in the character and distribution of material culture. Efforts should be made to increase survey coverage within all model zones, particularly those underrepresented in the present sample --the forest exploitation and leeward inland agricultural zones. In addition, further work in unexplored *kīpuka* closer to the coast, falling outside of the present GRS boundaries, would increase our knowledge of the diversity in archaeological features in the broader region. Relocating archaeological sites cited in the ethnohistoric literature, and a better documentation of known sites such as Kūki`i Heiau should also be a focus of future work within the project boundaries.

Included with a survey orientated at underrepresented land-use zones should be the ongoing effort of documenting lava-tube caves for documentation and preservation. Entrances to several of these caves, such as those mentioned in this report (Sites 94-5, 94-10, and 94-13), fall within private property boundaries. Preservation plans should be developed in accord with the landowner to protect both the cultural and biological resources they might contain. At present, the Malama Burial Cave (Site 94-5) is in danger of impact on a daily basis, and we recommend that a preservation plan be developed notwithstanding the pursuit of geothermal development.

Modeling the archaeological record and its relationship to change over time in Puna District will require survey and archaeological exploration on a regional level. Efforts should continue to be made to examine and refine both spatial and temporal models relating to differential distribution of archaeological sites. For example, the model presented by Burtchard (1994) is particularly suited to the application of a geographic information systems (GIS) method of analysis. Geographic information systems organize homogenous spatial data into several data "layers" which can be examined against one another in the attempt to correlate and understand spatial phenomena (see Allen et al. 1990). Types of spatial data, identified in the East Rift Zone model, that can be incorporated into a GIS relational database include:

1) the location of variously aged lava flows;
2) the location of `a`ā vs. pāhoehoe flows;
3) the location of known archaeological sites and types;
4) the location of ethnohistorically known settlements and use-areas;
5) the location of known resource types; and
6) the location of historically exploited districts.

While the potential for the exploration of co-varying data is great, several of these data layers require further field checking in order to increase their accuracy. Particularly pertinent is the refinement of the data locating `a`ā flows, which are believed to have been better suited for agricultural exploitation. These flows, as discussed previously, were not found to be uniformly distributed throughout the areas of generalized `a`ā formations. Field checking is perhaps the most time consuming task involved in creating a GIS, but it is also the most important in increasing the accuracy of models and predictions resulting from this kind of analysis.

While spatial data can provide models to begin to infer temporal processes, the development and testing of models of temporal change is ultimately necessary for the illustration of a dynamic past. A means commonly employed to gain temporal information is excavation within architectural features to ascertain the depth of past human occupation. An explicit excavation strategy devised toward constructing a chronology for architectural features across the Puna region can be developed. The ground work for identifying temporally sensitive attributes in material culture can also be lain.

In addition, the analysis of pollen and macrobotanical samples can expand our understanding of landscape change and human-induced alterations to the environment over time. Several of the survey areas are well suited for paleoenvironmental reconstruction. Pollen cores extracted from the craters in the area (such as Halekamahina and Pu`ulena) will serve to illustrate both volcanological history and human-induced landscape changes which affect our understanding of Puna District prehistory on both a local and regional scale. This kind of evidence will also prove useful in evaluating the persistence of the environmental conditions which are predicted to have affected the distribution of archaeological remains in Puna.

SUMMARY

This report has presented the results of a preliminary sample survey of archaeological resources within the boundaries of the Geothermal Resource Subzones Project Area located in the Puna District on the Big Island of Hawai`i. The survey focused on oldest available lava flow zones (or *kīpuka*) widely distributed across the three geothermal subzones --Kīlauea, Kamā`ili and Kapoho. The effort resulted in documentation of 15 new site localities. Site types include both those with surface evident structural remains and associations of economically useful Hawaiian cultigens.

In general, extant archaeological data in the study area and across the broader region are consistent with general expectations of the environmental/land-use model guiding the project. In essence, as distance from the coast increases, archaeological indications of permanent settlement and other land-use practices decrease. Judging from the overall density of archaeological remains, the leeward area seems to have supported a higher population density than windward Puna.

In addition to documentation of architectural remains, this report has also considered the importance of identifying extant native Hawaiian planting areas across the landscape. In light of ethnohistoric accounts alluding to the past importance of Puna agriculture, and the volcanic destruction that appears to have impacted that productive capacity, it is important that no information sources on past land-use practices be overlooked. While cultigen associations cannot be unambiguously linked to particular time periods, they provide useful data on the general distribution of farmed resources across the landscape.

This report has also made recommendations for future work in the Geothermal Resource Subzones Project Area, as well as for the entire region. These include a focus on intensive survey in older sediment flows, better documentation of lava tubes and known archaeological sites for the area, paleoenvironmental reconstruction and refinement of both spatial and temporal models designed to examine the distribution of archaeological remains.

Ultimately, the study of human settlement in a district such as Puna, with frequent environmental perturbations and changing landscapes, can only increase our knowledge of variation in Hawai`i settlement patterns. This variation expands our understanding the past, especially the relationship between behavioral strategies, and particular environmental and historical contexts.

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APPENDIX A: SITE DATA

This appendix includes all the sites located during the 1994 IARII field survey within the Geothermal Resources Subzones Project Area. It also includes additional information concerning State Site 2500, Kūki`i Heiau. For additional information about the survey area and history of a site, as well as a general summary concerning site associations and archaeological site trends in the project area, the reader is referred to the text.

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-46-19843
Field No.: 94-1
Ahupua`a: Kula

Site: Pu`u Kūka`e Mounds

Map Location Data: Kapoho subzone; land-use zone 2a; survey area 2; UTM coordinates-Northing 2158840, Easting 307410; Kapoho 7.5' USGS topographic quad.

Site Description: Four features consisting of four circular mounds and two linear stacked alignments of basalt. Feature 1 is a parallel linear stacked feature measuring 7 m by 2 m, and abuts the slope base. Feature 2, a large circular mound constructed of piled basalt (4 m by 2.5 m; 0.6 m high), dominates the center of the site. Feature 3 is a circular basalt pile mound (3 m by 3 m; 0.8 m high) presently supporting the growth of a coconut palm. Feature 4, at the southeast end of the site, is a low linear stacked rock feature 12 m long with small basalt pile mounds abutting either end (see Figure 8).

Dimensions: Entire site dimensions measure 25 m (E-W) by 15 m (N-S).

Site Integrity: Other possibly associated features were difficult to distinguish due to disturbance by the adjacent mining activity and rock displacement via the growth of new forest. The site may have been more extensive at another point in time.

Research Potential: The site could yield data concerning subsistence strategies in the area, or possibly activities associated with Kūki`i Heiau.

Topography: Located on a spatter deposit forming a cinder cone. Fine-grained sediments presently cover the relatively horizontal surface at the base of a 30^0 slope.

Elevation: 49 m amsl

Flow Type/ Sediment Structure: The granular and porous sediments covering the horizontal surface date to A.D. 1250-1600

Vegetation: The area is heavily populated with fern and vines. Also present in abundance are strawberry guava, trumpet tree, and melochia.

Field Markings: Blue flagging tape marked with the field number is placed in proximity to Feature 2.

Photographs: None

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 8, 1994

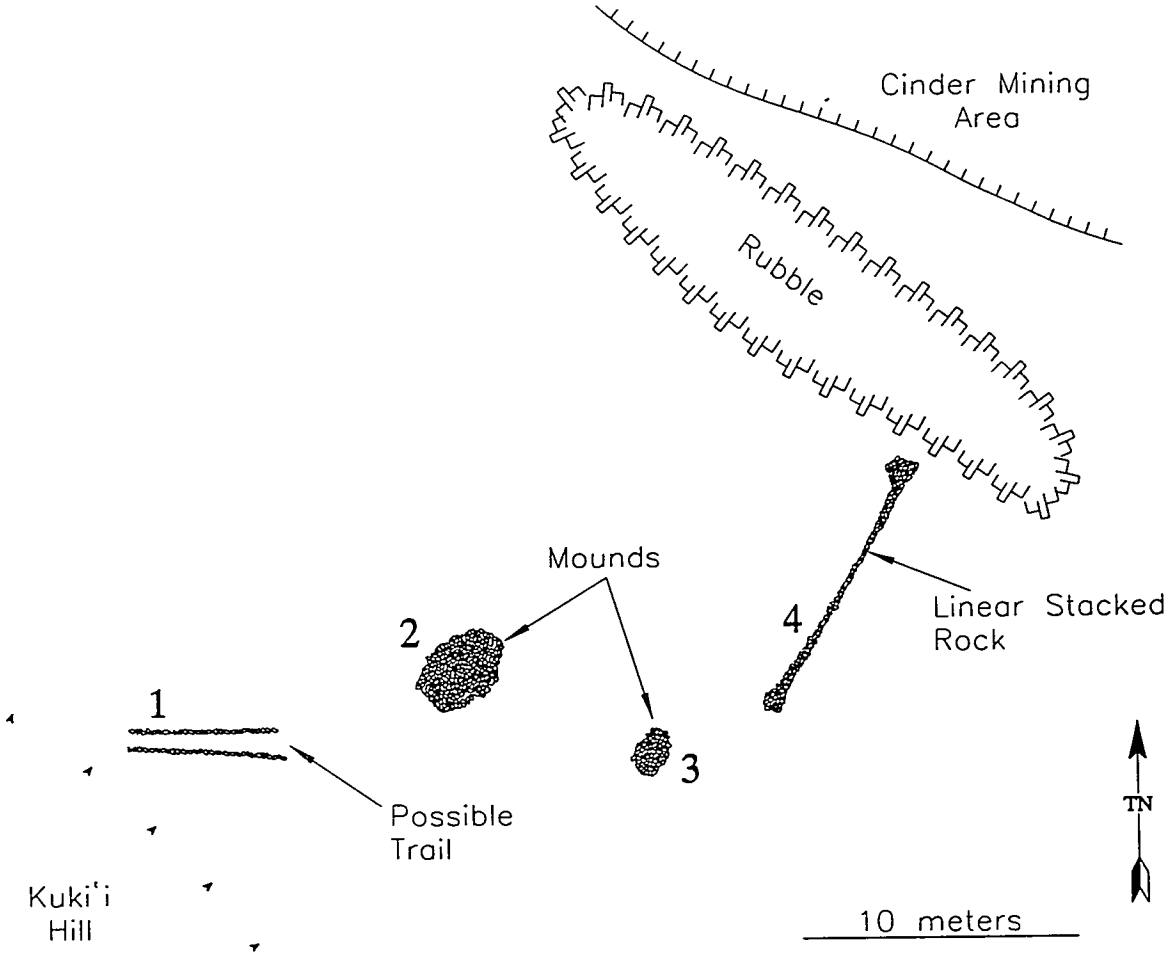


Figure 8. Pu`u Kūka`e Mounds

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-19844
Field No.: 94-2
Ahupua`a: Kula

Site: Kūki`i Cyst

Map Location Data: Kapoho subzone; survey area 2; GPS reading taken at a 1970 U.S.G.S. benchmark, located 5 m at 187° azimuth from the two largest slabs. UTM coordinates- Northing 2158740, Easting 307410; Kapoho 7.5' USGS topographic quad.

Site Description: Two large vesicular basalt slabs and four smaller slabs arranged as a horizontal surface in a semi-circular arrangement. One slab is slightly upraised due to the growth of a tree. The paving measures ca. 3 m (E-W) by 2 m (N-S) with the two largest slabs (approx. 1 m long, 0.6 m wide and 0.1 m thick each) located at the edge of the hill. These two slabs are possibly dressed, as they exhibited straight edge surfaces however the possibility that a nearby source for such rock formations is still debatable. In 1932, Hudson described this site as a slab-lined cyst (see Figures 8 and 9).

Dimensions: The entire area conforming to the top of this portion of the hill measures 20 m by 20 m.

Site Integrity: The site's morphology has evidently changed over the last 60 years, according to Hudson's (1932) previous description. The hollow area he observed may have been infilled. Landscape changes, and the site's proximity to present day hiking trails may have contributed to it's disturbance. However the site seemed to be mostly intact.

Research Potential: Hudson (1932) believed the site to possibly serve as a stone chamber or a grave. The function of the feature and associated artifactual and subsistence material would be more clearly discerned by subsurface examination.

Topography: The site is located on the southeasternmost edge of Kūki`i hill, on a small bench supporting a horizontal surface.

Elevation: 67 m amsl

Flow Type/ Sediment Structure: A spatter deposit forming a cinder cone dating to A.D. 1250-1600. Sediment is presently a shallow layer of coarse basalt.

Vegetation: A moderately dense population of *noni,* trumpet tree, ironwood, bamboo grass and vines. Hudson previously described the area as a dense guava forest (Hudson 1932) which presents evidence of forest change over the last seventy years.

Field Markings: Blue flagging tape inscribed with the field number.

Photographs: C1/2-3; BW1/1

Recorders: Greg Burtchard, Maria Sweeney and Audré Harlow

Date: February 8, 1994

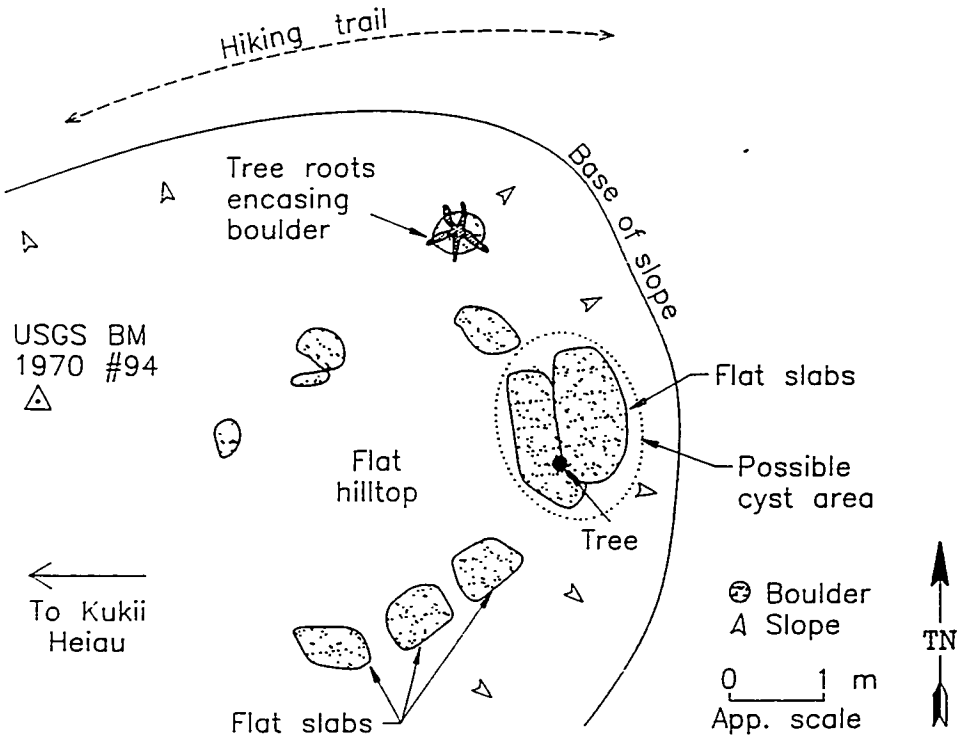


Figure 9. Sketch Map of Site 94-2

Photo 5. Kūki`i Cyst. Cyst feature is the uplifted slab at photo left and its immediate foreground.

ARCHAEOLOGICAL INVENTORY	Official Site No.:	State Site 2500
International Archaeological Research Institute, Inc.	Field No.:	None
Puna Geothermal Resources Survey Project	*Ahupua`a*:	Kula

Site: Kūki`i Heiau

Map Location Data: Kapoho subzone; land-use zone 2a; survey area 2; summit of Pu'u Kūki`i. No GPS reading was taken due to the vegetative cover in this area, however the *heiau* location is indicated on several recent maps, such as the U.S.G.S. Kapoho quadrangle map. UTM coordinates- Northing 2158840, Easting 307420.

Site Description: A partially walled rectangular platform enclosure located at the eastern summit of Pu`u Kūki`i. Walls are visible along three sides; the southwestern wall being partially removed or absent[1]. The walls are constructed of well-chosen basalt, often described as hewn stone by local informants (cf. Stokes 1991: 152). The height of walls varies up to 1 m high, and widths are approximately 1.45 m. In some places, a core fill of water-worn pebbles is evident. A series of up to seven large terraces run upslope to the *heiau;* the last two are faced with basalt. The unfaced terraces might be the result of bulldozing activity associated with cinder mining of the area (see Figures 8 and 10).

Dimensions: The platform enclosure measures ca. 37 m by 21 m[2]; southeastern wall ca. 35 m; southwestern section ca. 35 m long with intermittent wall segments and alignments; Northwestern wall section visible for 6 m; northeastern wall 25 m.[3]

Site Integrity: The southeastern walls of the *heiau* are the highest and best preserved and the last two terraces at the hilltop are particularly distinguishable. The Northwestern walls are partially collapsed due to the heavier vegetative growth on that side as well as it's situation on a steep sided slope which presently suffers erosion.

Research Potential: The debated source of the construction materials for the *heiau* and the availability of naturally rectangular stone in the area can be studied, as well as further attention focused on the architectural details of the structure. The varying descriptions for the *heiau* attest to the need for proper documentation of the site. Subsurface deposits could offer information about the function of the *heiau*, it's antiquity, possible varying building episodes and data concerning the changing landscape of the area having affected the integrity of the structure. Study of the surrounding landscape may help to determine the nature of the lower terraces and their association with the *heiau*.

Topography: The platform is located on the Northwestern side of Kūki`i hill on an artificially horizontal surface. Artificial terraces have been cut down the eastern and southern slopes.

Elevation: 61 m amsl

Flow Type/ Sediment Structure: A spatter deposit forming a cinder cone dating to A.D. 1250-1600 presently decomposing into a shallow layer of coarse basalt.

Vegetation: The interior of the platform enclosure is populated with *hala*. Coconut was also noted on the interior of the structure. The surrounding vegetation consists mainly of a strawberry guava forest. Coconut is also present in abundance on the northern slopes of Kūki`i hill.

Field Markings: None

Photographs: None

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 8, 1994

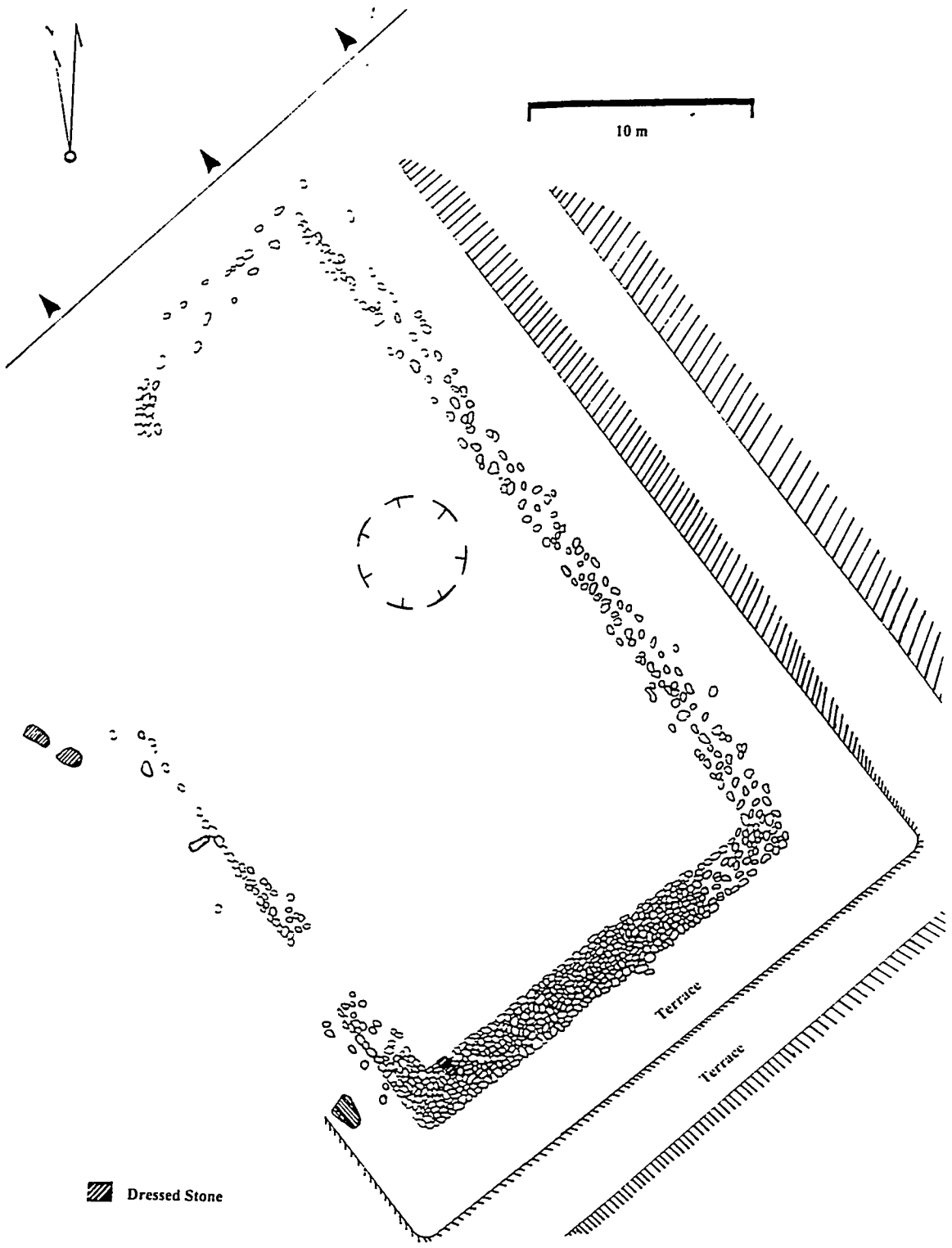


Figure 10. Plan view of Kūki`i Heiau (adapted from Bevacqua and Dye 1972)

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19845
Field No.: 94-4
Ahupua`a: Keahialaka

Site: Pu`ulena Crater

Map Location Data: Kapoho subzone; environmental/land-use zone 2b; survey area 7; GPS reading taken on the upper southwest rim of Pu`ulena Crater, between Pu`ulena and Kahuwa`i Craters. UTM coordinates- Northing 2153590, Easting 300950; Pahoa South 7.5' USGS topographic quad.

Site Description: The westernmost and deepest lobe of the Pu`ulena Crater contains an association of Hawaiian plant cultigens: *`ape, `awa, olena, ki, hala* and *kukui*. The center of this lobe is dominated by *`ape*. The plants are not presently being tended.

Dimensions: The area containing patches of Hawaiian cultigens is ca. 200 m in diameter.

Site Integrity: Although not presently tended, the patch of *`ape* is distinct. In general, the base of the crater is well-preserved with the exception of recent rock slides in the southwest end.

Research Potential: While structural features were not observed during survey, the edges of the crater base may have been used for temporary residence. Paleoenvironmentological data and cultural use of the area can be studied by means of subsurface examination.

Topography: Pu`ulena Crater is a steep-sided volcanic crater consisting of a tuff formation. The base of the crater is basin-shaped with a level central floor about 100 m in diameter. Pu`ulena is the westernmost crater within a complex of three contiguous formations.

Elevation: 183 m amsl (rim); 104 m amsl (bottom)

Flow Type/ Sediment Structure: The crater edges are dominated by unconsolidated vesicular basalt originating from a lava flow dating to A.D. 1250-1600, with intermittent pockets of older basalt protruding along the walls. The crater floor is presently composed of a substantial silt and clay loam deposit.

Vegetation: In addition to the aforementioned suite of Hawaiian cultigens dominating the site, the crater also supports the growth of several grasses and ferns (although no *uluhe* was noted), strawberry guava, thimble berries, vines, *ekaha, `ie`ie, `ōhi`a*, pandanus, sword ferns, *hapu`u*, melochia, bamboo orchid and several types of ginger. The western edge of the crater which experienced a landslide in 1988 is overgrown with melochia.

Field Markings: None

Photographs: C2/7-9; C3/1

Recorders: Greg Burtchard and Audré Harlow

Date: February 15, 1994

Photo 7. *`Ape (Alocasia Microrrhiza)* **in Pu`ulena Crater**

**Photo 6. Pu`ulena Crater Facing East.** *`Ape* on crater floor.

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19846
Field No.: 94-5
Ahupua`a: Malama

Site: Malama Burial Cave

Map Location Data: Kapoho subzone; Environmental/land-use zone 2b; survey area 7; GPS reading taken at the opening of the cave on Malama Drive in the Leilani Estates. UTM coordinates-Northing 2153180, Easting 300300; Pahoa South 7.5' USGS topographic quad.

Site Description: This lava tube formed within a 1790 pāhoehoe flow is partly sealed by roof collapse at it's entrance. It is possible that this tube extends down to the coast, however the lower passage is limited by natural flow constrictions. The cave contains the skeletal remains of ca. 11 individuals located 200 m downslope from the entrance. The remains have been arranged along the east wall of the tube in an area 10 m long by 2 m wide. The skulls have been removed and aligned on a ledge above the other remains.

Dimensions: The entire cave area measures ca. 400 m running NW to SE and is 15 m wide in most places. The burial area measures 10 m by 2 m.

Site Integrity: Easy access to the cave may have contributed to it's disturbance and heightens the possibility of continued damage. Several bone fragments were found to have been crushed by foot traffic however the major skeletal elements are intact, though have evidently been moved.

Research Potential: The variable preservation conditions of the bone may suggest an extended period of use for the interment site sometime after 1790 (estimated age of the lava tube formation) which may be verified by ethnographic survey. The remains can provide information relevant to ethnicity, cause of death, and age and sex distribution of the individuals particularly centered around the period of post-contact population decline.

Topography: The inner floor of the cave was of a varying slope (8-15^0) and is presently littered with roof fall.

Elevation: 207 m amsl

Flow Type/ Sediment Structure: Pāhoehoe formation dated to A.D. 1790

Vegetation: N/A

Field Markings: None

Photographs: None

Recorders: Greg Burtchard and Audré Harlow

Date: February 16, 1994

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-45-19847
Field No.: 94-6
*Ahupua`a*: Pu`ua

Site: Puna Orchards Mounds

Map Location Data: Kapoho subzone; environmental/land-use zone 2b; survey area 5; GPS reading taken on Feature 2. UTM coordinates- Northing 2157530, Easting 301510; Pahoa North 7.5' USGS topographic quad.

Site Description: A circular mound and two wall sections located amidst a secondary growth area containing fairly large patches of *ki*. Feature 1 is a large mound approximately 1.5 m in diameter and 0.8 m high. Feature 2 is a linear pile of rock, ca. 10 m long and might possibly be the result of earlier bulldozing activity. Feature 3 is a circular mound ca. 0.75 m in diameter and ca. 0.5 m high. Features 1 and 3 are both located in a woody area and might predate feature 2 (see Figure 11).

Dimensions: The extent of the site, including *ki* patches, is ca. 40 m in diameter.

Site Integrity: This area of secondary growth may have been disturbed by land clearing activities, however the presence of thick underbrush precludes the ability to determine the extent of site preservation or disturbance.

Research Potential: Subsurface examination and further intensive surface survey may produce information relevant to understanding subsistence practices in the area, the antiquity and contemporaneity of the features.

Topography: The entire area is composed of a fairly horizontal surface of partially decomposed `a`ā and pāhoehoe outcrops.

Elevation: 140 m amsl

Flow Type/ Sediment Structure: The flow age has been dated to A.D. 1250-1600.

Vegetation: Large patches of dense *uluhe* are mixed with pockets of *ki*, thimble berries and *koa haole*.

Field Markings: Blue flagging tape with field number located on Feature 1.

Photographs: C2/11

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 18, 1994

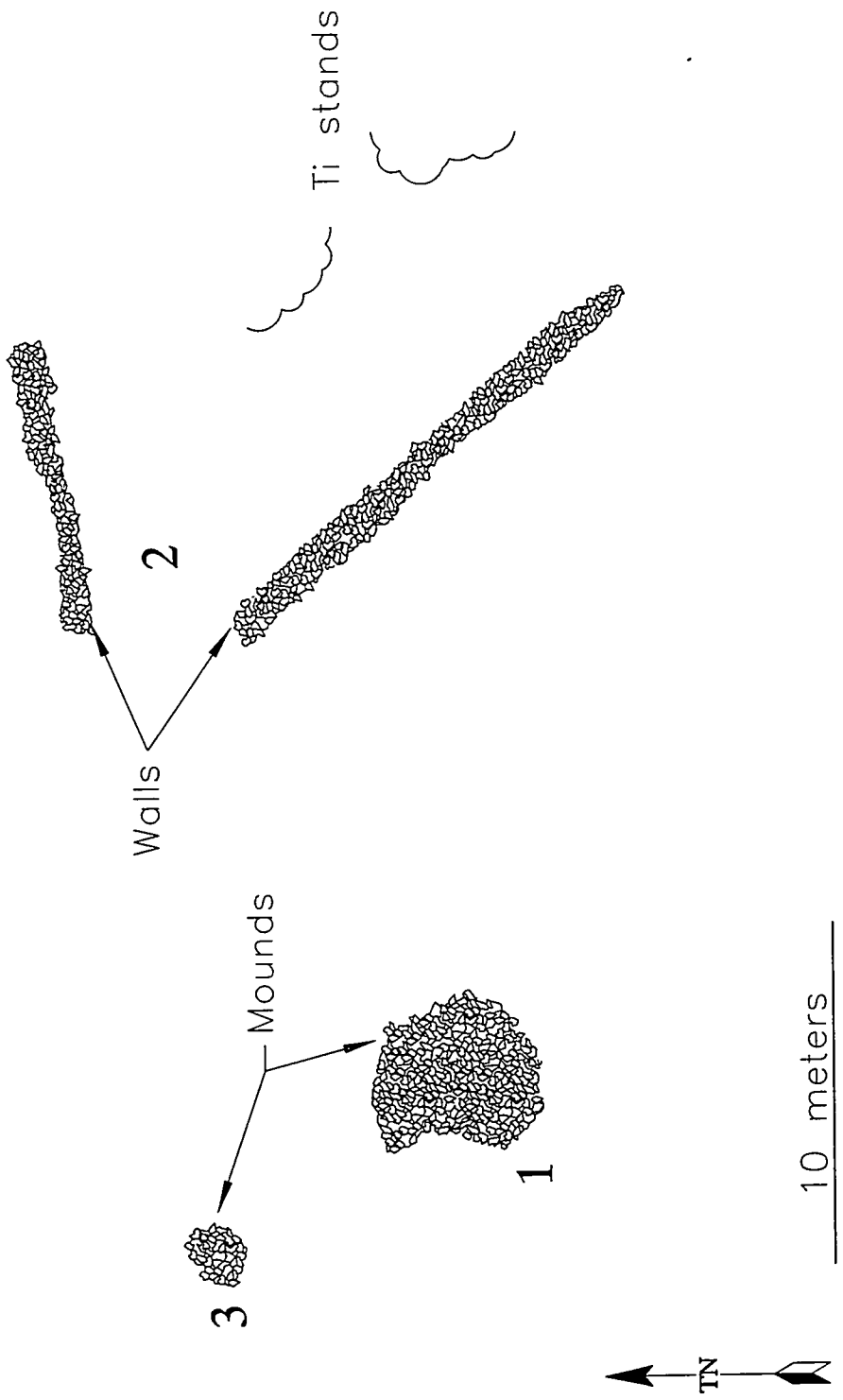


Figure 11. Plan view of Site 94-6

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19848
Field No.: 94-7
Ahupua`a: Kauele

Site: Bryson's Cinder Pit *Kīpuka*

Map Location Data: Kamā`ili subzone; environmental/land-use zone 3b; survey area 8; GPS readings taken 70 m at 340° azimuth, 70 m at 160° azimuth and at the center of three separate patches of *`awa*. UTM coordinates- Northing 2151800, Easting 298120;Pahoa South 7.5' USGS topographic quad.

Site Description: Four distinct and large *`awa* patches associated with other Native Hawaiian cultigens: *ki*, *kukui*, banana and *mamaki*, as well as *hapu`u*. The patches are all located on sloped areas amidst dissected ravine fissures.

Dimensions: *`Awa* patches measure approximately 10 m^2 respectively; the patch and associated cultigens on the eastern side of the slope (patch A) cover an area of 80 m (N-S) by 20 m (E-W), two intermittent patches and associated cultigens (patches B and C) measure 60 m (N-S) by 25 m (E-W) each and the western patch with associated cultigens (patch D) measures 60 m (N-S) by 25 m (E-W). Patch D is marked with an abundant presence of *ki*.

Site Integrity: The *`awa* patches are presently cared for and their boundaries are fairly distinct. There area few signs of modern disturbance in the area, except by colluvial runoff especially on the eastern end.

Research Potential: An absence of structural features suggests that subsurface excavation may not be productive in determining functional information for the site, though procuring paleoenvironmental data concerning changes in landscape would be feasible. Cultivated use areas may be better defined with an intensive survey and inventory of the location of Polynesian introduced plants in the area.

Topography: The *`awa* patches are located on slopes ranging from 20-25° and grow among fine-grained sediments interspersed with intermittent basalt outcroppings.

Elevation: 226 m amsl

Flow Type/ Sediment Structure: The slopes are composed mainly of silt to clay loam sediments deposited by colluvial and alluvial activity with the deepest accumulation of sediment located in the patch areas. The flow age of the area is estimated at A.D. 500-1200.

Vegetation: In addition to native cultigens, the area also supports a high population of strawberry guava, pluchea and melastoma, as well as *`ōhi`a* and *`ie`ie*.

Field Markings: Blue flagging tape with field numbers were placed at each *`awa* patch.

Photographs: C2/12-14

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 21, 1994

Photo 8. Site 94-7 Native Plant Cultigen Patch

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey

ProjectOfficial Site No.: 50-10-55-19849
Field No.: 94-8
Ahupua`a: Kaimū & Kīkala

Site: Pāhoa Lumber Company Railroad Grade

Map Location Data: Kamā`ili subzone; environmental/land-use zone 4; survey areas 11 and 14; GPS readings were taken where the grade intersected the present True Geothermal access road as well as five other areas along the grade affording satellite reception. In addition, a separate but associated area is noted in the Kīlauea subzone. UTM coordinates- site 94-8a: Northing 2151110, Easting 291560; site 94-8b: Northing 2151770, Easting 289120; Pahoa South 7.5' USGS topographic quad.

Site Description: The southern portion of the site (94-8a) is a 3-5 m wide cleared tract, located to the east of Kaumuki, creating a level surface intermittently associated with linear stacked or piled rock on either side. The grade is also frequently terraced on one side. No signs of artifactual material were noted. At the northernmost point, the grade dissects a wall with wire fence running east to west forming the southern boundary of the present Kaohe Homesteads. The grade runs southward of this end, and eventually reaches a cleared area before turning westward and northward. For the most part, the grade avoids a majority of the lava cracks in the area, however some have been filled in order to build the railroad. The northern area defined in this site (94-8b) consists of isolated remains of the Pahoa railroad. Two 4 m long parallel track segments (3 m apart) are situated atop a remnant of an elevated railroad grade running in an east to west direction. A metal rod was also noted protruding from the ground in between the tracks (see Figures 12 and 13).

Dimensions: The first segment consisting of the railroad grade in survey area 11 (94-8a; the southern grade) is approximately 4 km long. The second segment of railroad in survey area 14 (94-8b; the northern grade) is 4 m long.

Site Integrity: Presently used as a pig hunter's trail, the southern grade (94-8a) is clearly discernible and only at a few points does the density of forest growth obscure it's outlines. The majority of the railroad grade in the northern section (94-8b) is absent, however artifactual remains clearly delineate the morphology of the particular segment.

Research Potential: These particular grades might be used as a central point to study other branches of the railroad which might extend from this area. Intensive survey might serve to locate further artifactual material associated with the construction and use of the railroad and lumbering activities. Also possible would be an intensive survey of the *`ōhi`a* in the area to determine the extent of former logging activities.

Topography: Much of the terrain consisted of a fairly horizontal surface with low grade inclines and declines. The terrain extending cross-country of the southern grade was found to contain an abundance of east to west oriented lava cracks.

Elevation: 94-8a is 427 m amsl; 94-8b is 445 m amsl

Flow Type/ Sediment Structure: Two different lava flows cross the survey area 11. The northernmost portion is the oldest, dating to A.D. 1200-1650 while the southern portion dates to A.D. 1600-1789. The grade is located on an area of fine-grained sediments, occasionally built over patches of exposed pāhoehoe toward the southern portion. Survey area 14 is composed of pāhoehoe sediments dating to A.D. 1250-1600, presently decomposed into a mix of fine-grained sediments and outcroppings.

Vegetation: Much of the area consists of a strawberry guava and melastoma forest supporting a secondary growth of *`ōhi`a*. The predominance of foreign vegetation is undoubtedly related to the *`ōhi`a* logging activities early during this century and has been further abetted by the construction of modern roads during the late 1970s.

Field Markings: Red flagging tape was left to mark the trails. Blue flagging tape with the field number was left in several areas in proximity to the railroad tracks in survey area 14.

Photographs: C2/15; C3/14; BW1/18

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 23, 1994 and March 3, 1994

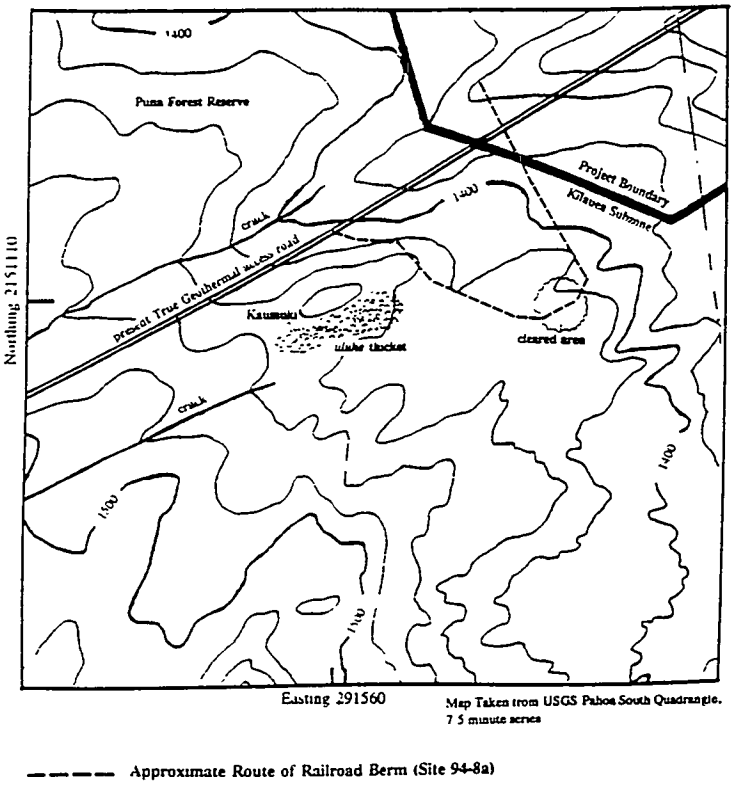


Figure 12. Approximate Route of Site 94-8a

Photo 9. Section of Railroad Track, Site 94-8

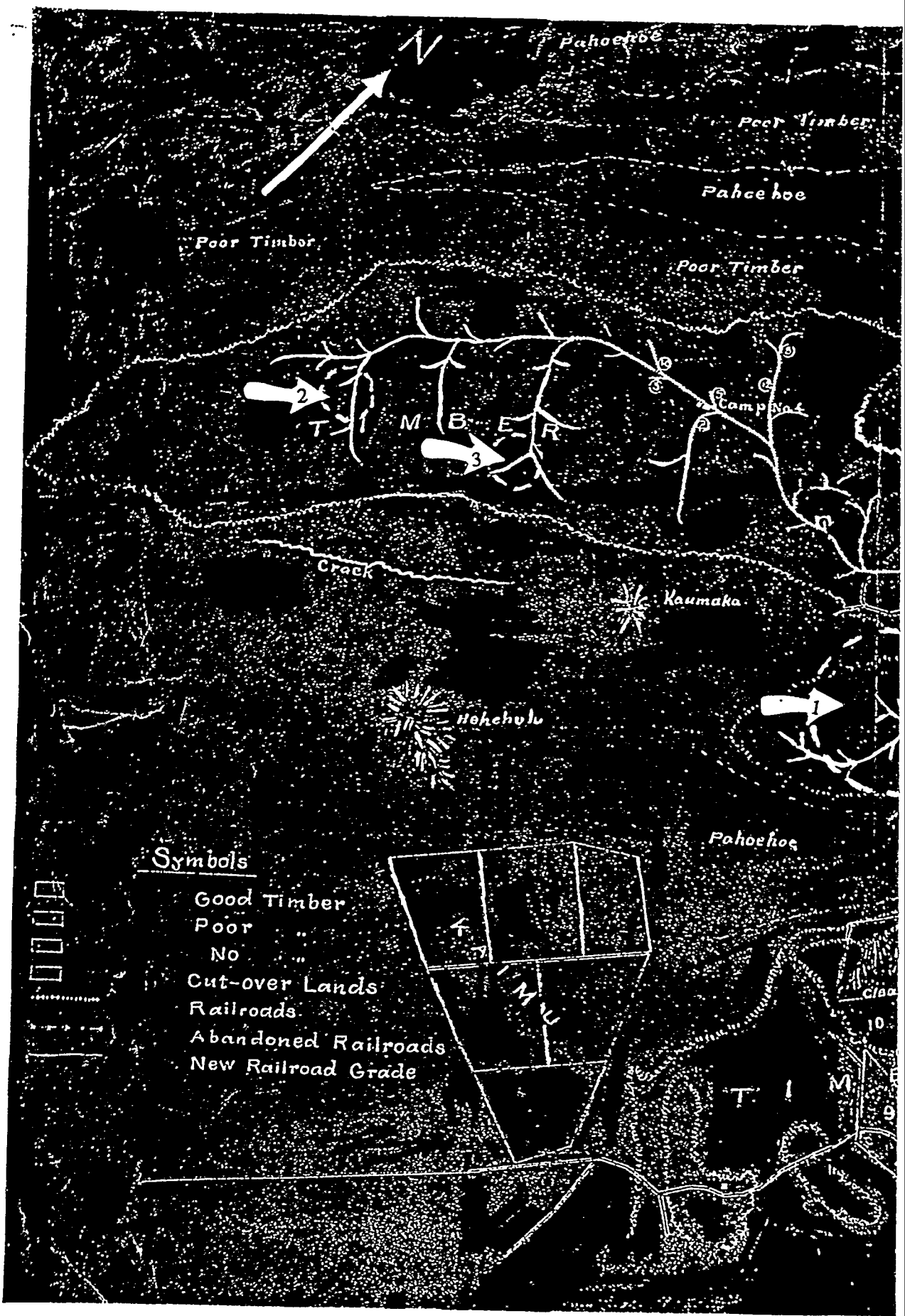
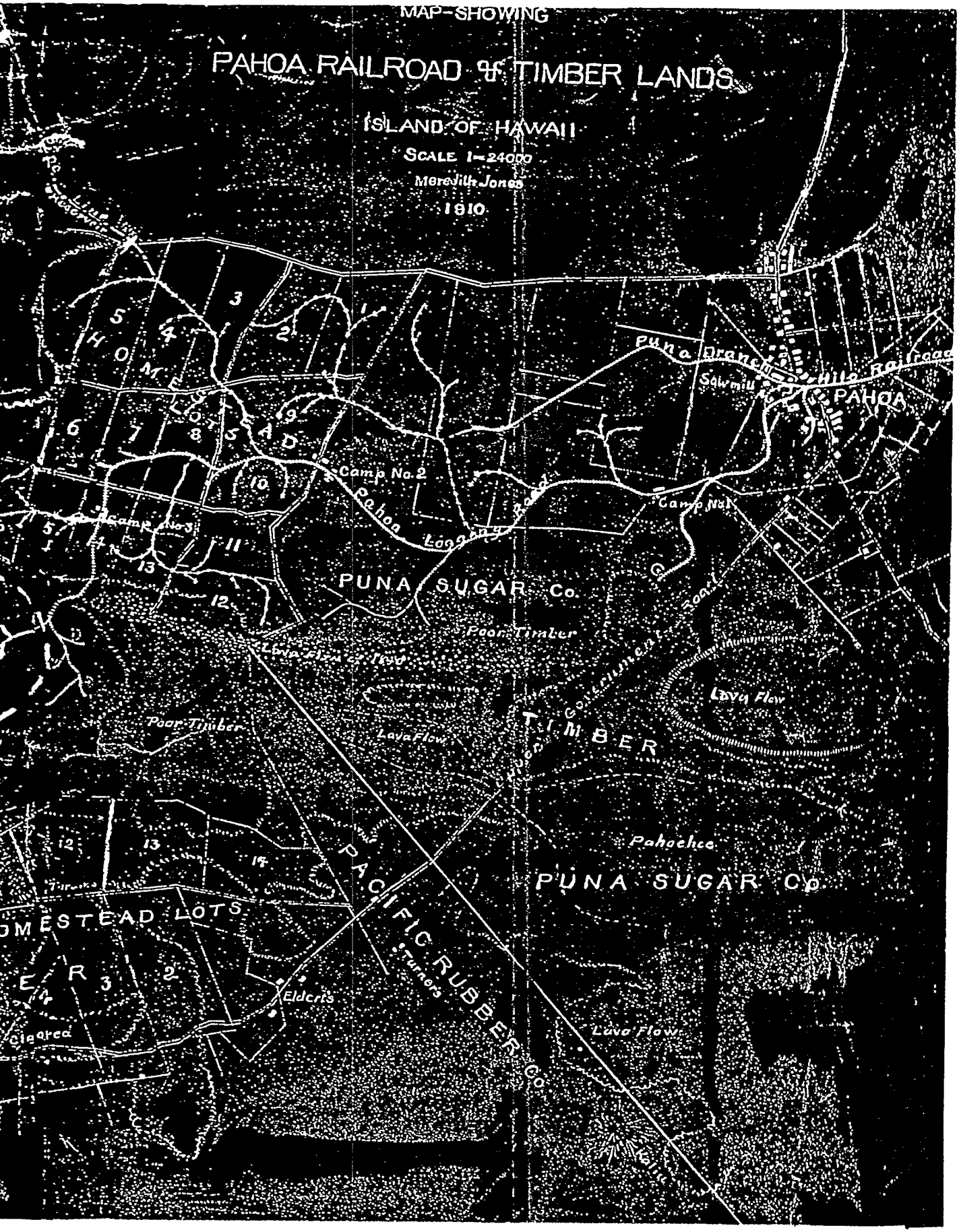


Figure 13. Relative Locations
1) Site 94-8a, 2)



Railroad Berms on Jones' 1910 Map
-8b, 3) Kennedy 1991

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19850
Field No.: 94-9
Ahupua`a: Kehena

Site: Upper Puna Road

Map Location Data: Kamā`ili subzone; environmental/land-use zone 3b; survey area 9; GPS readings taken both ends of road segment. UTM coordinates- Northing 2150660, Easting 294000; Pahoa South 7.5' USGS topographic quad.

Site Description: A 7 m wide cleared area is delineated at times by parallel rock piles at least two courses high, and at times by terracing on the northern side. The southern side of the road is bordered by the 1955 lava flow. The presence of this road may have been a factor in preventing the intrusion of lava further north. The site is located to the south of `Ī`īlewa Crater (see Figure 14).

Dimensions: The road is approximately 160 m long by 7 m wide.

Site Integrity: In most places the road is clearly discernible.

Research Potential: Further study might reveal the previous function of the road. The several historical access ways that have been documented for this area include the Wilkes' trail (1840) and the Upper Puna road. Intensive field survey might yield artifacts associated with the construction of the road or use of the adjacent area, especially with that associated with the feral coffee presently growing on Rycroft's land grant (site 94-16). Subsurface investigation may help to determine it's antiquity and yield further information concerning it's construction.

Topography: Gently sloping terrain with intermittent shallow gullies and small rises.

Elevation: 396 m amsl

Flow Type/ Sediment Structure: The southwest portion is located on a cinder underfooting. Moving northeasterly, sediments become finer grained. Flow age is estimated at A.D. 500-1250.

Vegetation: The majority of the road transects a strawberry guava forest mixed with other intrusive vegetation such as melastoma. A small *kukui* grove is located to the north, and an expanse of feral coffee abuts the road at the northeast (site 94-16). *Mamaki* and *`ōhi`a* were also encountered in the area.

Field Markings: The course of the road is marked with blue flagging tape.

Photographs: None

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 25, 1994

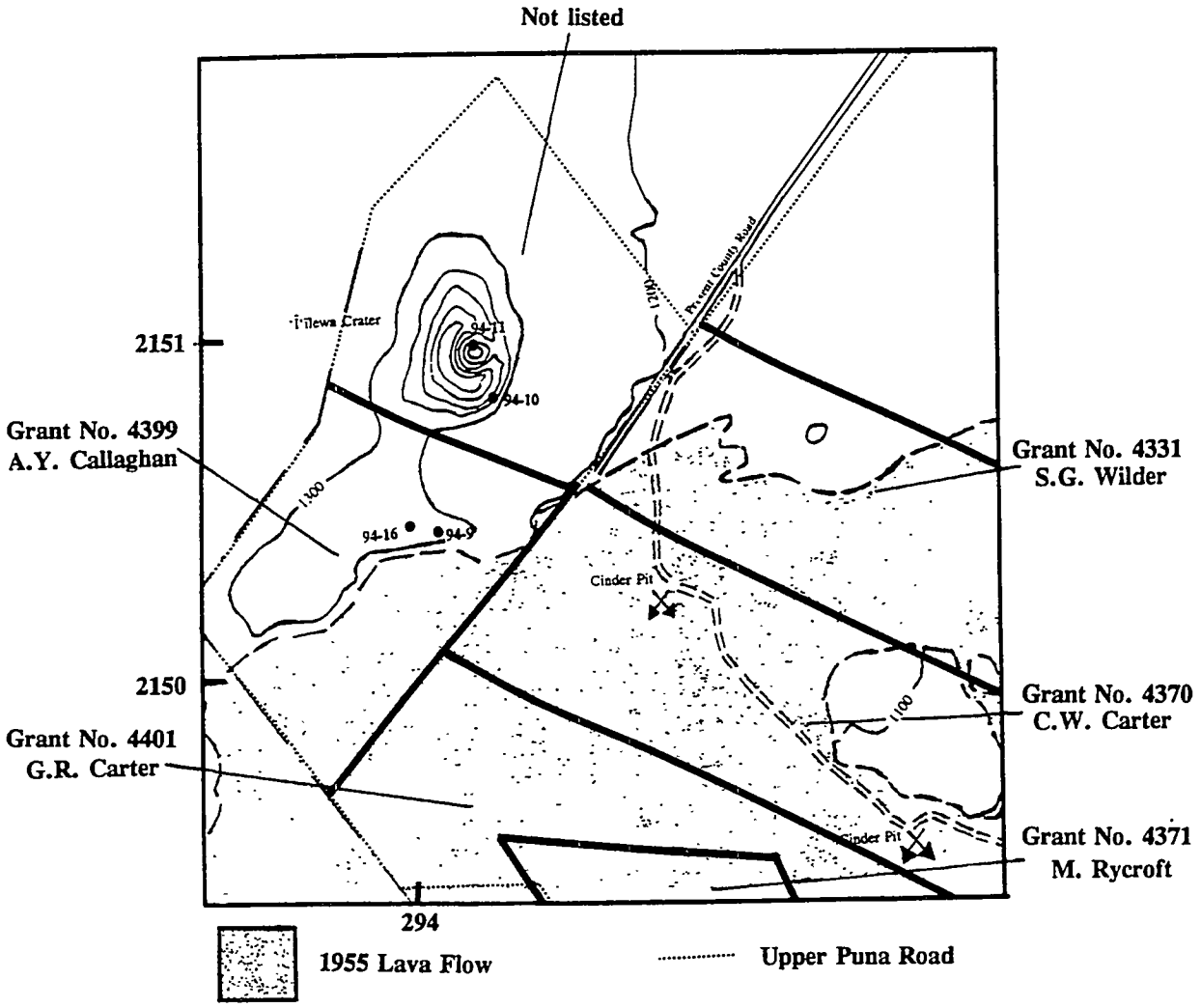


Figure 14. Site Distribution around `Ī`īlewa Crater: Sites 94-9, 94-10, 94-11, and 94-16
(U.S.G.S. topo map overlain with land grant boundaries from Cook 1902)

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19851
Field No.: 94-10
Ahupua`a: Kehena

Site: `Ī`īlewa Lava Tube

Map Location Data: Kamā`ili subzone; environmental/land-use zone 3b; survey area 9; GPS reading taken 20 m at 270^0 azimuth from the southern entrance to the cave. UTM coordinates-Northing 2150900, Easting 294100; Pahoa South 7.5' USGS topographic quad.

Site Description: Several associated features are located within a lava tube opening. Feature 1 is a circular rock pile mound 4 m (E-W) by 2.5 m (N-S) and 0.75 m high. Feature 2 is a tabular basalt flat stepping path 5 m long located to the east of the mound and running SW to NE. The path is abutted on the SW end by a perpendicular alignment of angular basalt. The NE end of the path is obliterated by rock fall. Feature 3, located at the NE end of the tube opening beneath the large skylight, is a step platform constructed of stacked angular basalt 0.6 m high, with a length of 3 m (E-W) and width of 2 m (N-S) (see Figures 14 and 15).

Dimensions: Lava tube dimensions are 35 m (N-S) with an interior width varying between 6-10 m.

Site Integrity: At present, the features are in good condition however the boundaries of feature 1 and 3 have been affected by rock fall and downwashing from the skylight area.

Research Potential: As a possible burial or refuge cave, an abundance of information can be obtained by further intensive surface and subsurface investigation of the lava tube.

Topography: A partially decomposing lava tube cave located downslope of `Ī`īlewa Crater.

Elevation: 409 m amsl

Flow Type/ Sediment Structure: A pāhoehoe lava tube located within a flow dated to A.D. 500-1250.

Vegetation: N/A

Field Markings: None

Photographs: C2/19-22; BW1/5-6

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 25, 1994

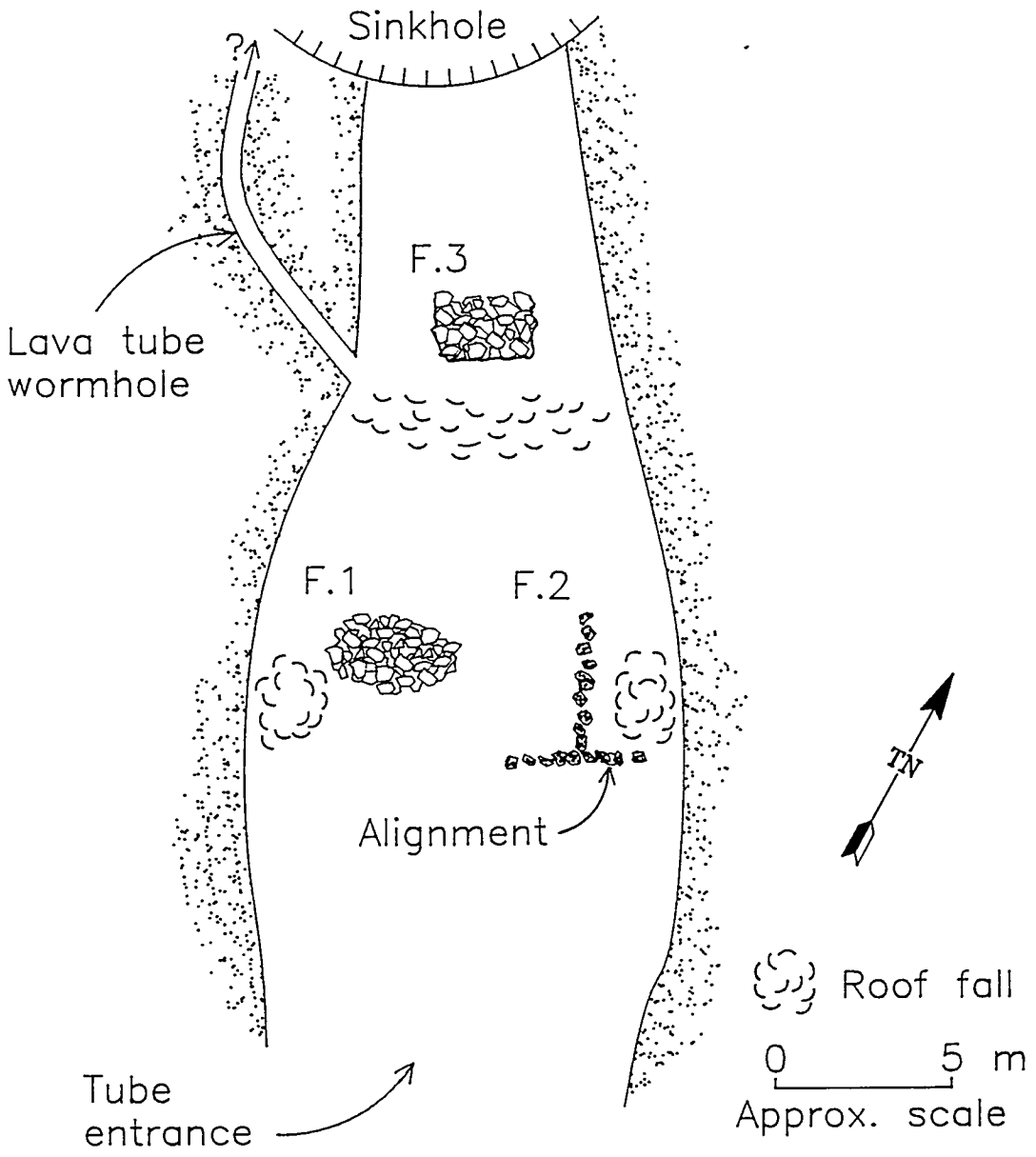


Figure 15. Plan view of Site 94-10
(see also Figure 14 for general location)

Photo 10. Site 94-10, Features 1 and 2. Facing South, Feature 1 on right and Feature 2 on left.

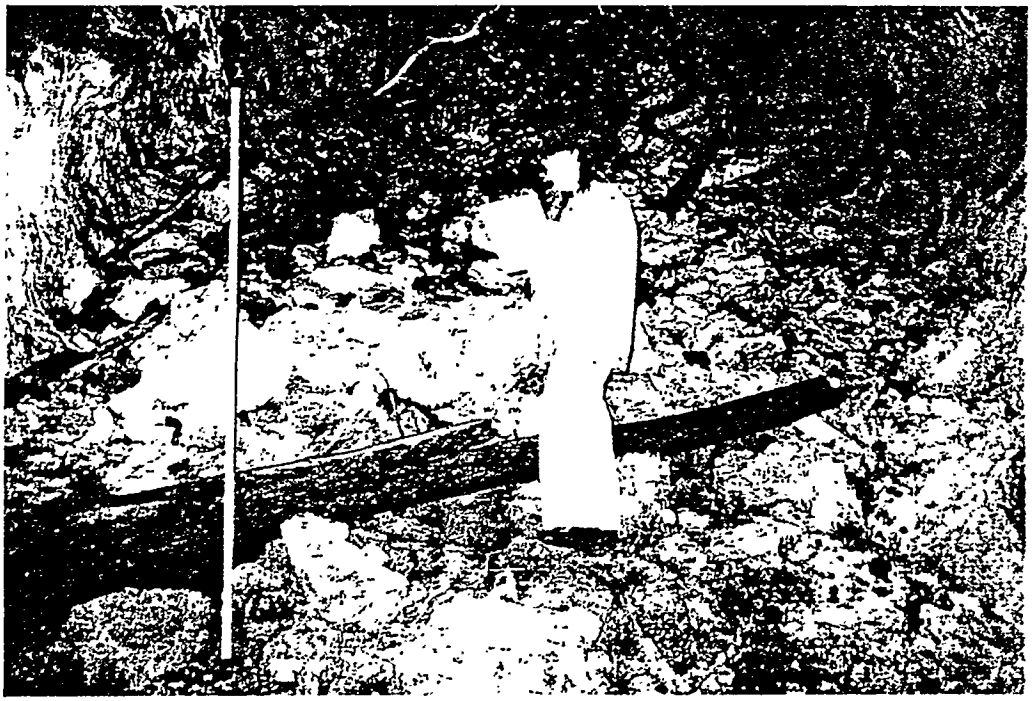


Photo 11. Site 94-10, Feature 3. Facing north, M. Sweeney standing on platform.

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19852
Field No.: 94-11
Ahupua`a: Kehena

Site: Military Structures at `Ī`īlewa Crater

Map Location Data: Kamā`ili subzone; environmental/land-use zone 3b; survey area 9; GPS reading taken midpoint between Features 1 and 2. UTM coordinates- Northing 2150090, Easting 294060; Pahoa South 7.5' USGS topographica quad.

Site Description: Two historic period structures with associated concrete blocks and metal stakes are located on a horizontal surface on the north rim of `Ī`īlewa Crater. Feature 1 is a small concrete, pyramidal roofed building located in a dug-out area on the eastern side of the flat. The entrance to the structure involves a metal hinged door (0.6 m high and 0.6 m wide) located on the north side. A large cement ventilation tube shaft (0.8 m diam.) begins at the south foundation wall and extends beneath the surface to emerge at the crater's exterior slope. At this point the tube elbow upwards and is cross-sected with another tube extension of the same size forming a 'T'. Large (ca. 1.3 cm mesh) screens cover the openings of the tube. Another smaller ventilation pipe, located beneath a small screened window opening, extends from the west side of the structure to emerge in the cleared area. The structure is built atop a subterranean opening which seems to have been mined into a poorly consolidated `a`ā formation. A metal rung ladder, bolted in four places to the concrete foundation, extends 6 m vertically to the floor of the opening. Within the subterranean chamber, a small opening in the `a`ā on the east side leads to a horizontal shaft, supported by 15 cm by 15 cm wooden braces, which turns northward to an exit/entrance on the interior of the crater. This entrance/exit is constructed of concrete supports and a heavy steel door. Feature 2 is a basalt stone semi-enclosure cemented with mortar and concrete located on the western side of the flattened area. The three sided structure opens to the south. Presently, a wooden structure has been fitted to the interior of the foundation. Several concrete blocks and metal stakes are located in the flattened area between features 1 and 2. While the blocks are likely not *in situ*, the patterned arrangement of 8 metal stakes in a square formation suggest a purposeful organization (see Figure 16).

Dimensions: The pyramidal roofed structure of Feature 1 measures 3 m by 2 m, and is 1 m high from the floor of the crater rim. The vertical shaft below forms a 25 m (E-W) by 5 m (N-S) opening into the `a`ā. The horizontal extension eastwards runs about 20 m with a width of 4 m. Feature 2 measures 3 m by 2.5 m with 1 m high walls.

Site Integrity: While the exterior concrete structures are well-preserved, the interior portion of the horizontal shaft of Feature 1 has collapsed, making access to the inner area extremely difficult without a great deal of clearing. All metal fixtures are rusted and deteriorating, especially the uppermost rung on the ladder. The east wall of Feature 2 is partially collapsed.

Research Potential: The configuration of the site suggests a military origin, most likely dating to WWII. Feature 1 may be a storage bunker. The arrangement of metal stakes on the flattened area may have supported guidelines for a communications tower (three electrical grounding rods were found on feature 2). Historical sources associated with military history as well as local informant survey, combined with further intensive material study and subsurface examination around the structure may help to reconstruct the recent history of the site, as well as establish the contemporeneity of the features.

Topography: The site is located on the flattened rim top of `Ī`īlewa Crater, providing an eastwards view of the coastline of Puna. Both Pu`ulena and Kapoho Craters are visible from this vantage point.

Elevation: 427 m amsl

Flow Type/ Sediment Structure: The flattened ridgetop is composed of a mix of fine-grained sediments and a cinder underfooting while the subterranean chamber of Feature 1 is mined into unconsolidated `a`ā.

Vegetation: The grassy rim top is devoid of other vegetation save for scattered thimble berry bushes and a row of *ki* recently planted by the landowner. The surrounding slopes of the crater supports strawberry guava.

Field Markings: None

Photographs: C3/15-21; BW1/9-13

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: February 28, 1994

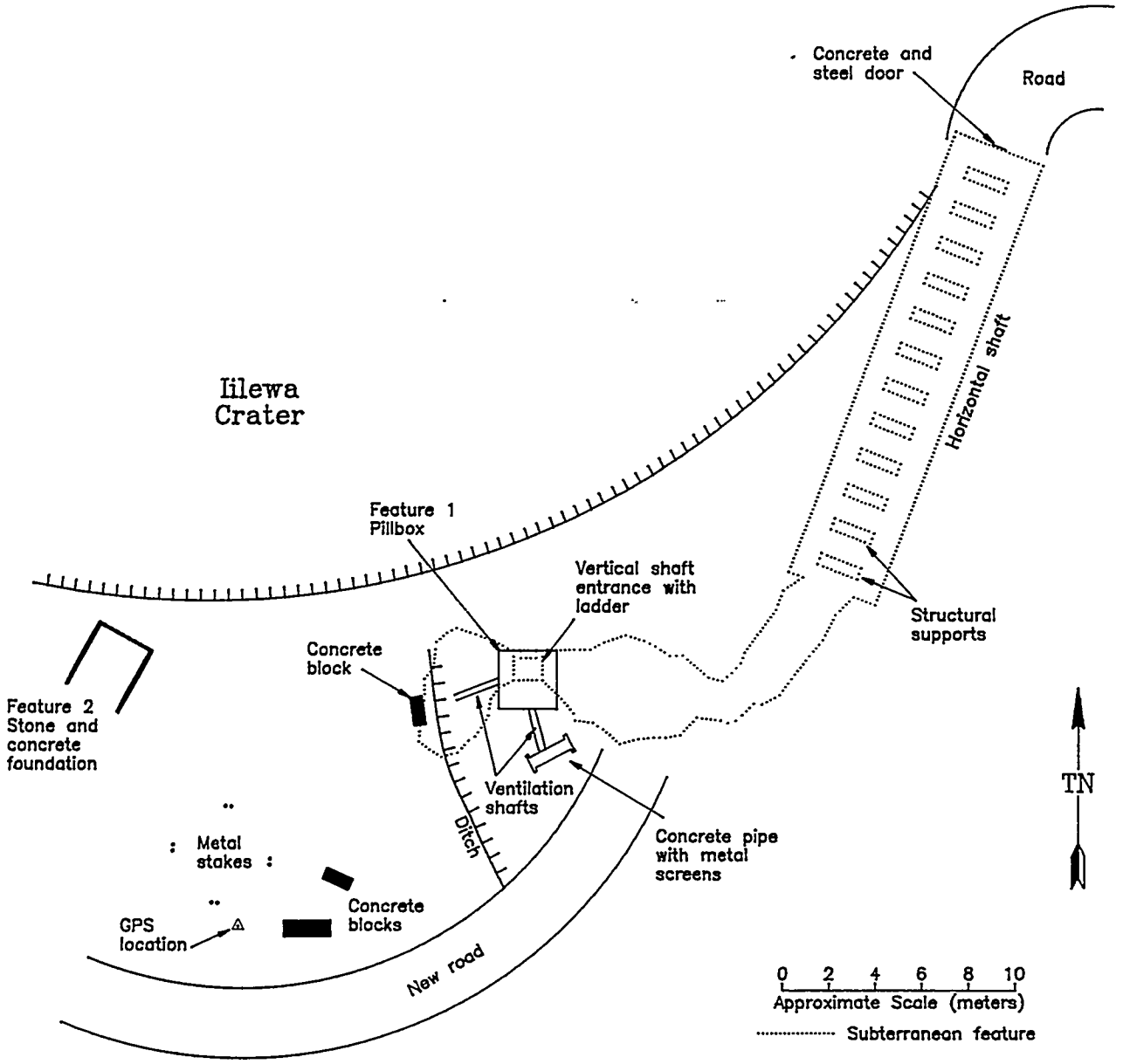


Figure 16. Plan view of Site 94-11

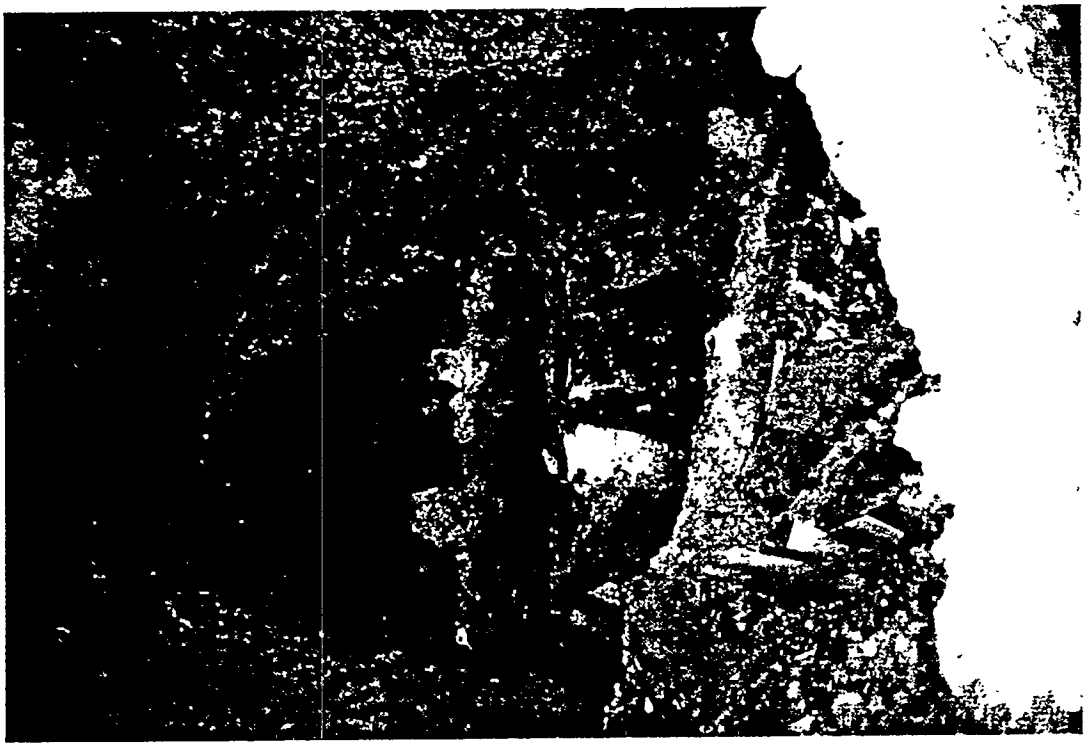


Photo 13. Interior of Feature 1 Shaft at Site 94-11. Wooden beams are the roof of an underlying partially collapsed enclosure.

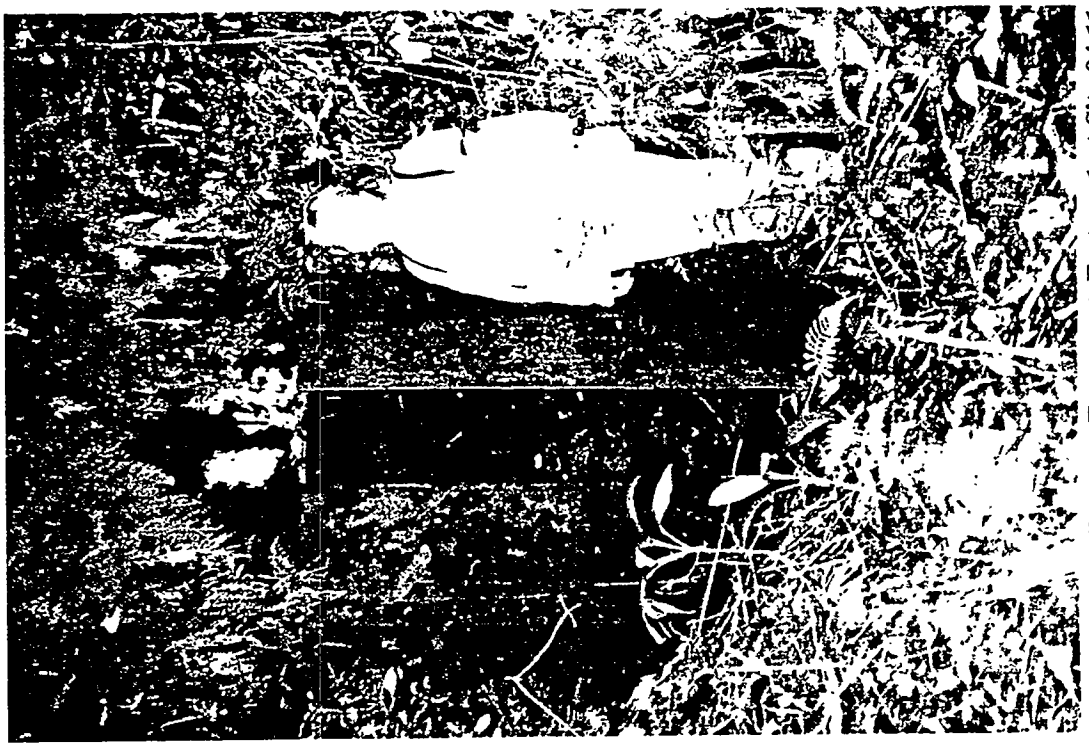


Photo 12. Steel Doors at Entrance toFeature 1 at Site 94-11

Photo 14. Vertical Entry/Ventilation Shaft to Site 94-11, Feature 1

Photo 15. Upper Facilities Area at Site 94-11. Support line stakes for probable communications tower in foreground. Feature 2 in background.

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-55-19853
Field No.: 94-12
Ahupua`a: Kaimū

Site: Heiheiahulu Mounds

Map Location Data: Kīlauea subzone; environmental/land-use zone 3b; survey area 10; GPS reading taken adjacent to Feature 1. UTM coordinates- Northing 2149320, Easting 290760; Pahoa South USGS topographic quad.

Site Description: Previously described as a possible burial area by Haun et al. in 1985, the site consists of a series of seven mounds and one flat-topped platform terrace located amongst presently active steam vents. The mounds have been built upon the cracked pāhoehoe. Each of the circular mounds (Features 1, and 3-8) were composed of piled basalt. The platform terrace (Feature 2), located nearest to the crater rim, may once have extended to the rim but was dissected by the establishment of the cement structure. It is also located the furthest from the steam vents.

Dimensions: The entire site covers an area of approximately 100 m^2. Feature 1, the largest mound, is 3.3 m diam. by 2.0 m high; this mound is visible from the trailhead. Feature 2 platform terrace is 3.2 m long (parallel with the crater rim), 1.6 m long and 0.85 m high on the downslope side; original length may have extended to the crater rim (ca. 3 m). Feature 3 mound is 1.15 m diam. by 1.4 m high. Feature 4 mound is 1.5 m diam. and 0.75 m high. Feature 5 mound is 1.5 m diam. and 0.7 m high. Feature 6 mound is 2.7 m diam. and 1.0 m high. Feature 7 mound is 1.6 m diam. and 1.0 m high. Feature 8 mound is 2.4 m diam. and 0.8 m high (see Figures 17 and 18).

Site Integrity: The mounds do not appear to have been disturbed and due to access limitations to the area it is likely that they have remained intact since they were built. The boundaries of feature 2, however, have been diffused by the construction of the concrete trig station.

Research Potential: Heiheiahulu reportedly erupted in 1750, and thus the site construction must postdate this event. Subsurface investigation may serve to establish the contemporaneity of the structures, however the enterprise would be difficult due to the pāhoehoe substrate. Further investigation of the features, however, may determine the probability of a burial function.

Topography: The site is located on the crater rim edge and is transected with small lava cracks and steam vent openings.

Elevation: 518 m amsl

Flow Type/ Sediment Structure: A shallow deposit of fine-grained sediment is located between pāhoehoe outcrops.

Vegetation: The slope is covered with low shrub (mostly melastoma), bamboo orchid, sword fern, machaerina and grass.

Field Markings: None

Photographs: C3/3-8; BW1/14-16

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: March 1, 1994

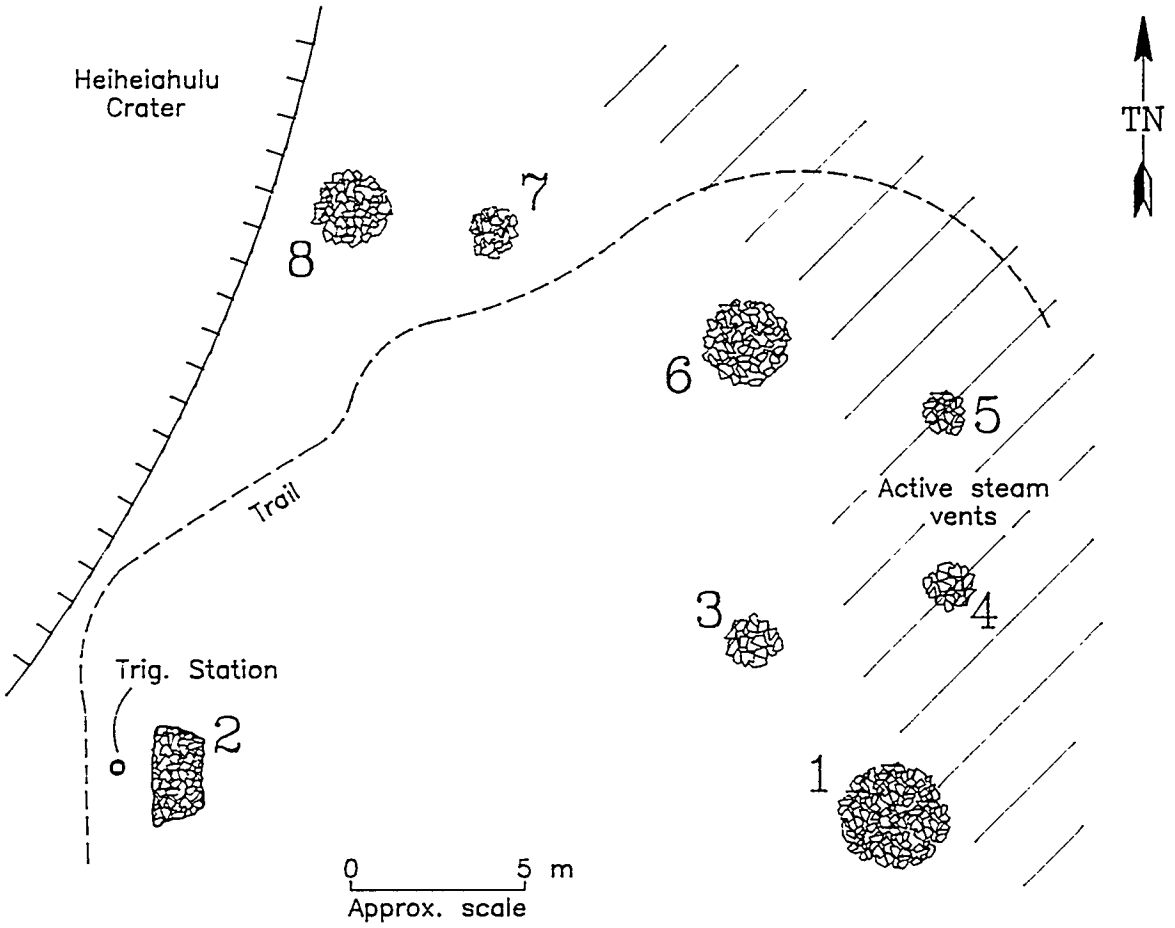


Figure 17. Site 94-12 Heiheiahulu Mounds (also see Figure 18)

Photo 16. Site 94-12 Facing East. Note fumarole activity among the mounds. See Photo 4 for another view of Heiheialulu mounds.

Photo 17. Site 94-12 Mound Feature 1

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: None
Field No.: 94-13
Ahupua`a: Kīkala

Site: Upper Kaimū Cave

Map Location Data: Kīlauea subzone; environmental/land-use zone 3b; survey area 10; GPS reading taken at sinkhole A opening. The second GPS reading was taken at the skylight opening, sinkhole B (it is hypothesized that they are portions of the same lava tube). UTM coordinates (at sinkhole B)- Northing 2148694, Easting 291590; Pahoa South USGS topographic quad.

Site Description: Two sinkholes south of Heiheiahulu Crater which may link into one lava tube formation. Sinkhole A is a large sinkhole/skylight exposing a pāhoehoe tube. The wall are undercut 2 m below the top of the opening requiring proper repelling equipment for descent and ascent to the floor 10 m below. A large underground cavern opens underneath which seems to run SE to NW. The height of the cave interior appears to be ca. 3-4 m; the width is at least 3 m. Sinkhole B is located to the north and is a 1.5 m diameter opening into the younger (ca. 1750) lava flow from Heiheiahulu Crater, and extending below this formation into a pāhoehoe formation. The floor of this sinkhole is approximately 10 m below. These sinkholes are in a series of skylight features which are presumed to map the route of the Upper Kaimū cave, and were visible as an alignment in the aerial photographs. The cave appears to begin at, or southwest of, Heiheiahulu Crater, proceeding downslope near the boundary of Kaimū *ahupua`a* and the Upper Kaimu Homesteads. From the western portion of the Homesteads it proceeds an unknown distance downslope. The upper sections of the cave lie underneath the Kīlauea geothermal resource subzone. The cave openings have been plotted as a site due to their high probability for containing cultural materials (see Figure 18). However, no features were documented during the present project.

Dimensions: Sinkhole A's surface dimensions are 5 m SE to NW and 2 m NE to SW. Sinkhole B is an opening ca. 1.5 m in diameter.

Site Integrity: The preservation potential for cultural materials within the cave is high. Examination of the aerial photographs evidences that the tube is largely intact.

Research Potential: The integrity of the tube can be determined by subterranean investigation and any cultural materials documented. The possibility that funerary features are located within the cave is high. The association between cultural materials found in the cave, and the surface features (site 94-12) of Heiheiahulu should be examined.

Topography: A pāhoehoe lava tube located under a gentle (ca. 3-6^0) slope.

Elevation: Sinkhole A is 366 m amsl; Sinkhole B is 409 m amsl

Flow Type/ Sediment Structure: The interior is composed of a pāhoehoe flow, possibly dating to around 1750 and formed during the eruption of Heiheiahulu. It is also possible that the cave represents a tube formation from an older flow, which has been covered by the later flow.

Vegetation: N/A. The vegetation of the upper surface is populated with *uluhe*, melastoma, and machaerina. Some *`ōhi`a lehua* and *kōpiko* grow in the area, and a *mamaki* plant was growing on the side wall of the cave.

Field Markings: Blue flagging tape with the field number placed at sinkhole A.

Photographs: C2/16; BW1/17

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: March 2, 1994

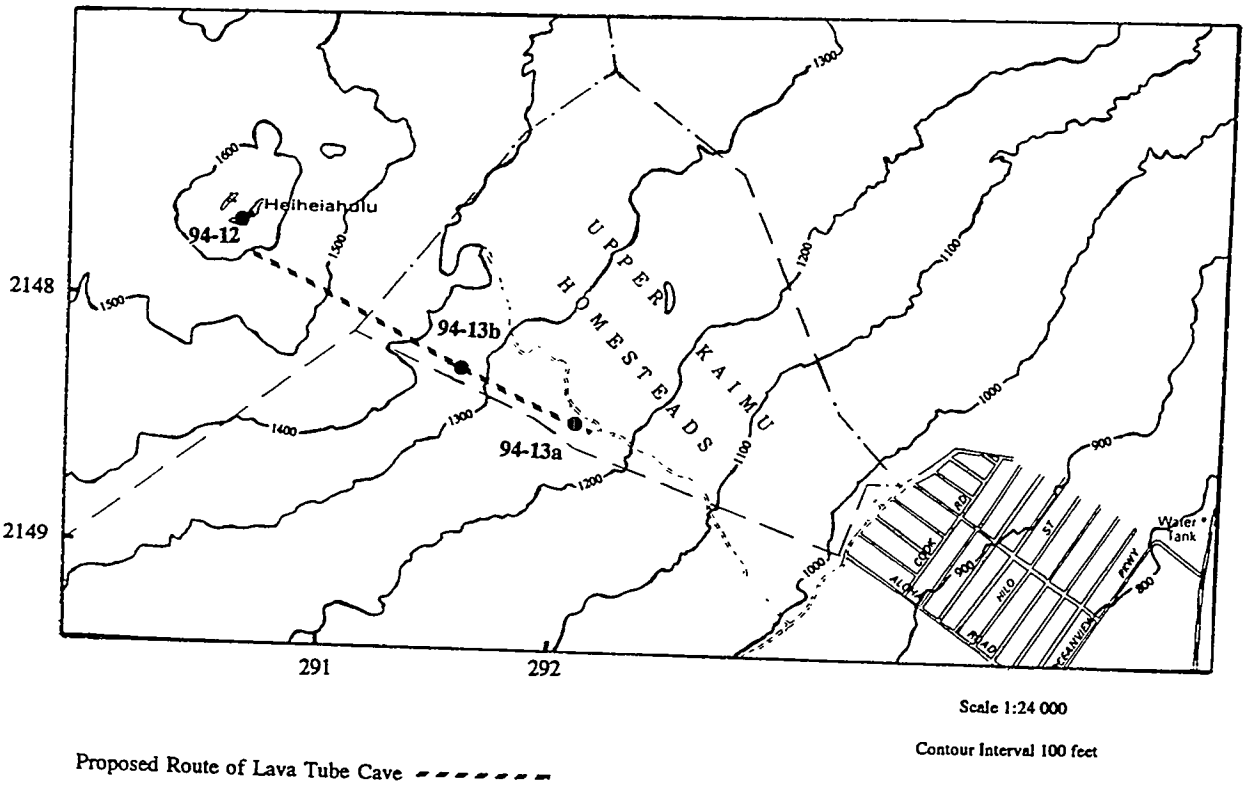


Figure 18. Plan Map of Site 94-13, with Plot of Skylights

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-54-19854
Field No.: 94-14
Ahupua`a: Kalapana

Site: Pu`u Kauka *Kīpuka*

Map Location Data: Kīlauea subzone; environmental/land-use zone 3b; survey area 12; GPS reading taken adjacent to the prominent *kukui* tree. UTM coordinates- Northing 2148310, Easting 288100; Kahala USGS topographic quad.

Site Description: A Hawaiian plant cultigen association consisting primarily of banana, and associated with *kukui, ki, hapu'u* and *mamake*. Also noted were *`ie`ie* and *kōpiko*. The banana are located in a ravine situated between two promontories. The majority of *kukui* were located to the south.

Dimensions: An area of approximately 2.7 ha covers the scattered planting locations.

Site Integrity: Particularly noticeable was the relative absence of melastoma and pluchea which have infiltrated most of the areas, as well as remaining *kīpuka* of the Kīlauea subzone, which suggest that this area has remained relatively protected from disturbance.

Research Potential: The older fine-grained sediments of the area may potentially contained stratified deposits that could yield both paleoenvironmental and cultural data pertinent to the understanding of the history of land use of the area. This would be particularly useful in uncovering how this *kīpuka* has remained virtually unaffected by the intrusion of foreign vegetation which threatens much of the native forest in other areas.

Topography: An undulating ridge and valley formation is located on the south side where the majority of cultigens were located. To the northwest is a small crater (Pu`u Kauka) .

Elevation: 488 m amsl

Flow Type/ Sediment Structure: The pāhoehoe dated to A.D. 500-1250 is presently broken down into a silt and clay loam.

Vegetation: In addition to the Hawaiian cultigens. the *kīpuka* supports a dense mixed *`ōhi`a* and strawberry guava forest.

Field Markings: Blue flagging tape with field number left at the GPS point taken at the *kukui* tree.

Photographs: C3/11-13

Recorders: Greg Burtchard, Maria Sweeney and Audré Harlow

Date: March 2, 1994

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-46-19855
Field No.: 94-15
Ahupua`a: Halekamahina 2

Site: Halekamahina Crater

Map Location Data: Kapoho subzone; environmental/land-use zone 2b; survey area 4; GPS reading taken on the northwest section of the crater floor. UTM coordinates- Northing 2157440, Easting 304280; Kapoho USGS topographic quad.

Site Description: The site is composed of two separate and likely non-contemporary cultural use areas. The first is a Hawaiian cultigen association consisting of *kukui, ki*, coconut and *hala* located within the confines of the crater. *Hala* is for the most part located along the slopes. *Ki* was found on the crater slopes and floor, and *kukui* was located on the flat crater floor. Coconut borders the rim of the crater. The second area is a now overgrown historic period road which is constructed around the rim of the crater and is missing only on the northern edge where the crater rim suddenly drops off.

Dimensions: The crater interior is an area of approximately 1.2 ha.

Site Integrity: The crater rim and exterior slopes have been disturbed by extensive agricultural development which is presently pursued. Apart from a recent landslide on the western side of the crater, the floor appears to be relatively undisturbed by modern activity.

Research Potential: The crater floor likely contains stratified deposits that would yield paleoenvironmental data important to the understanding of cultural land-use of the area, especially considering it's location relatively close to the coast. Subsurface investigation may reveal cultural use areas not visible on the surface.

Topography: The interior slopes of the crater are relatively steep, at a 30-35^0 slope with a natural bench about 10 m from the crater floor on the northwest side. The crater floor is horizontal.

Elevation: 152 m amsl (rim); 122 m amsl (floor)

Flow Type/ Sediment Structure: The crater floor is covered with fine-grained silt and clay loam composed of sediments dating to A.D. 1250-1600.

Vegetation: In addition to the Hawaiian cultigens, strawberry guava in and around the crater is moderately dense. Thimble berry bushes dominate the Northwestern side of the crater floor. Also found are several ferns and vines, thimble brushes and trumpet trees. Particularly notable was one lone fairly large *`ōhi`a lehua* tree among the thimble berry bushes.

Field Markings: None

Photographs: C2/1-4

Recorders: Greg Burtchard, Maria Sweeney and Audré Harlow

Date: March 3, 1994

Photo 18. Site 94-15 Crater Floor Facing East. Low vegetation in foreground due to recent landslide on Halekamahina's west crater wall.

ARCHAEOLOGICAL INVENTORY
International Archaeological Research Institute, Inc.
Puna Geothermal Resources Survey Project

Official Site No.: 50-10-46-19855
Field No.: 94-16
Ahupua`a: Kehena

Site: Callaghan Land Grant and Coffee Plantation

Map Location Data: Kamā`ili subzone; environmental/land-use zone 3b; survey area 9; GPS reading taken at the southern extent of the coffee area. UTM coordinates- Northing 2150670, Easting 293940; Kapoho USGS topographic quad.

Site Description: A large area of feral coffee partly encircled by a road (site 94-9) and extending north and east. The coffee grows up to the slopes of `Ī`īlewa Crater however the highest density is nearest where it borders the road. The area also correlates with A.Y. Callaghan's land grant listed on a 1902 map (Cook 1902, see also Figure 14).

Dimensions: The feral coffee presently covers an area of several acres

Site Integrity: Although the coffee is presently in a wild state, the boundary for the area is fairly distinct and few other plants have infiltrated the area.

Research Potential: Intensive survey of the area may uncover artifactual or structural remains associated with the coffee plantation. Subsurface survey could yield paleoenvironmental and cultural data important for reconstructing the land-use history of the area.

Topography: In the southwest end, where the coffee grows most densely, the terrain is relatively flat. North and east the terrain becomes dissected with gullies and hills and the presence of coffee diminishes.

Elevation: 396 m amsl

Flow Type/ Sediment Structure: Fine-grained silt and `a`ā sediment dominates the coffee area. The estimated age of the sediment is A.D. 500-1250.

Vegetation: The outer boundaries of the coffee area are intermixed with strawberry guava, *hapu`u* and some melastoma.

Field Markings: None

Photographs: C3/22

Recorders: Maria Sweeney, Greg Burtchard and Audré Harlow

Date: March 3, 1994

APPENDIX B: PLANTS MENTIONED IN THE TEXT

Hawaiian or Common Name	Botanical Name	Status
`ape	*Alocasia macrorrhiza*	Polynesian Introduction
`awa	*Piper methysticum*	Polynesian Introduction
bamboo orchid	*Arundina graminifolia*	Exotic
banana	*Musa* spp.	Polynesian Introduction
Christmas berry	*Schinus terebinthifolius*	Exotic
coffee	*Coffea* sp.	Exotic
coconut	*Cocos nucifera*	Polynesian Introduction
ekaha	*Asplenium nidus*	Indigenous
ginger	*Hedychium* spp.	Exotic
hala/ pandanus	*Pandanus* spp.	Indigenous
hapu`u fern	*Cibotium glaucum*	Endemic
Hilo grass	*Paspalum conjugatum*	Exotic
`ie`ie	*Freycinetia arborea*	Endemic
ironwood	*Casuarina equisitifolia*	Exotic
kalo (taro)	*Colocasia esculenta*	Polynesian Introduction
ki (ti)	*Cordyline fruticosa*	Polynesian Introduction
koa haole	*Lancaena leucocephala*	Exotic
kōpiko	*Psychotria hawaiiensis*	Endemic
Koster's curse	*Clidemia hirta*	Exotic
kukui tree	*Aleurites moluccana*	Polynesian Introduction
macadamia	*Macadenia ternifolia*	Exotic
machaerina	*Machaerina angustifolia*	Endemic
mamaki	*Pipturus* spp.	Endemic
mango	*Mangifera indica*	Exotic
melastoma	*Tibouchima urvilleana*	Exotic
melochia	*Melochia umbellata*	Exotic

noni	*Morinda citrifolia*	Polynesian Introduction
ʻōhiʻa lehua	*Metrosideros polymorpha*	Endemic
olana	*Touchardia latifolia*	Endemic
ʻōlena	*Curcuma longa*	Endemic
papaya	*Carica papaya*	Exotic
pluchea	*Pluchea odorata*	Exotic
strawberry guava	*Psidium cattleainum*	Exotic
sugar cane	*Saccharum officinarum*	Exotic
sword fern	*Nephrolepsis* spp.	Indigenous or Exotic
thimble berry	*Rubus risaefolius*	Exotic
uluhe fern	*Dicranopteris* spp.	Endemic or Indigenous

Endemic: native to Hawaiian Islands only
Indigenous: native to the Hawaiian Islands but also found elsewhere
Polynesian introduction
Exotic: historic period introduction

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