APPENDICES

Volume 2

Maalaea - Lahaina Third 69KV Transmission Line Project Maui, Hawaii

Environmental Impact Statement

Maui Electric Company, Ltd.

March 1994

Prepared by DAMES & MOORE

MAALAEA-LAHAINA THIRD 69KV TRANSMISSION LINE PROJECT

TECHNICAL APPENDICES

MAUI ELECTRIC COMPANY, LTD.

DAMES & MOORE
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INTRODUCTION TO REGIONAL STUDY

The regional study conducted for the Maalaea-Lahaina Third 69KV Transmission Line Project involved several steps: define the study area, characterize the existing conditions, and identify the resources and the unique environmental conditions within the study area. Data was collected between October 1991 and October 1992 from available published and mapped information supplemented with aerial photo interpretation, a helicopter flyover survey and ground reconnaissance of selected locations within the study area. Data collected for each resource group was mapped at a 1:24,000 scale and used in the corridor identification process. The maps are located at the end of this section A1. The corridor identification process involves the use of the regional scale environmental data base and maps to identify areas within the study area that present constraints and opportunities to the identification of linear corridors 1/4 to 3/4 mile wide. The primary objective is to identify and avoid sensitive or highly constrained areas and then to select alternative corridors that do not cross sensitive areas and that best utilize existing linear features and/or least constrained areas.

STUDY AREA

Definition

The Maalaea-Lahaina Third 69KV Transmission Line Project study area is located along the south and west shores of West Maui. The bow shaped study area is 18.9 miles long. It averages 3.4 miles wide at the ends (i.e. 3.7 miles wide at Kealaloloa Ridge in the Waikapu ahupuaa and 3.1 miles wide at Lahaina in Wahikuli) and narrows to 1.1 miles wide around Puu Hipa in Olowalu. It occupies approximately 57 square miles between Maalaea and Kaanapali from the shoreline to the about 1400 foot elevation. The study area boundary near Maalaea was defined to include the power plant, two existing 69KV transmission line right-of-ways, the intersection of Honoapiilani Highway (SR30) with both North Kihei Road and Kuihelani Highway (SR380), and the Maalaea Triangle in order to evaluate as many options for exiting the Maalaea Switching Station as possible. In the north, the study area boundary encompasses the proposed site for the Wahikuli Substation (i.e., the original end point of the proposed line) as well as the existing Puukolii Substation for reference.

The following general guidelines were used to define the study area:

- include Maalaea Power Plant and sufficient area around the power plant to explore as many exit options as possible
- include the shoreline and Honoapiilani Highway
- include Puukolii Substation[1]
- include sufficient area to allow for a corridor either mauka or makai of the existing Maalaea-Lahaina Nos. 1 & 2 transmission lines right-of-way
- exclude extremely steep terrain (slopes > 40%)

Study Area Sections

To provide an analytical tool for use in the Regional Study resource inventory and corridor identification and comparison, the study area was divided into four sections.

Power Plant, Study Section I extends from the eastern project boundary near the Maalaea Power Plant to the Honoapiilani Highway. The coastline near the power plant is the southern boundary of the study section and it includes the Maalaea community and small boat harbor, HC&S sugar cane fields, a small portion of pineapple fields, the N. Kihei Road and intersection with Honoapiilani Highway. The two existing Maalaea-Lahaina transmission lines traverse this study section and cross Honoapiilani Highway at the intersection with Kuihelani Highway.

Maalaea - Ukumehame, Study Section II extends from the Honoapiilani Highway to Ukumehame Gulch and from the coastline to the ridges approximately 2000 feet above sea level. From the shoreline Honoapiilani Highway the features of this study section include pineapple fields, the lighthouse at McGregor Point, Manuohule, Papawai Point, and Ukumehame Beach State Park. The upland area of this vast area includes the prominent Kealaloloa Ridge; three puu's (Anu, Moe, and Luau); several major gulches including Manawainui, Papalaua, Manawaipueo, Malaowaiaole, Hanaula and Ukumehame; and a portion of the West Maui Forest Reserve.

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[1] The inclusion of Puukolii Substation was later dropped as a criterion for system planning. The end point was modified from Wahikuli Substation to a site on the east side of Lahainaluna Road.

Olowalu-Makila, Study Section III extends from Ukumehame Gulch to the ahupuaa of Makila and Wainee and from the coastline to the mauka project boundary. The area is one to two miles wide and it includes two prominent puu's, i.e., Puu Mahanalua Nui and Puu Hipa, and Olowalu and Kauaula streams. A large portion of the study area is cultivated in sugar cane. Significant coastal features include the towns of Olowalu and Mopua, Launiupoko Point and State Park, Waianukole and Puamana Park.

Lahaina-Wahikuli, Study Section IV extends from the eastern boundary of section III in Makila to the project boundary just west of Puukolii Substation. The Kanaha Stream, Kahoma Stream and Hahakea Gulch are the major drainages. This study section includes Lahaina waterfront historic district and the outlying community of Lahaina, the Lahaina Civic Center, Lahainaluna School, sugar cane fields and the original endpoint of the transmission line, the site for the Wahikuli Substation.

As referenced throughout this appendix, the regional resource inventory and corridor evaluation were initially performed for the Wahikuli Substation site, the original endpoint of the project. However, a corridor to the proposed Wahikuli Substation site could not be agreed upon by the various landowners. MECO, therefore, decided to examine the possibility of an alternative switching station location near Lahaina. Alternative sites along Lahainaluna Road, just inside Bishop Estate property, were identified and evaluated through landowner meetings and field inspection. The proposed Lahainaluna Switching Station site was selected as the preferred site.

DATA EVALUATION FACTORS

To structure the regional analysis and provide a means for narrowing the study area to alternative corridors, a comprehensive range of resource inventory categories was identified, and within the categories, sets of data factors were established (Table A1-1). The data factors were selected because they were relevant to siting a linear construction project such as a transmission line. They include those environmental and land use data that influence the location of a corridor 1/4 to 3/4 mile wide, and when considered in total, form a comprehensive data base that characterizes environmental conditions and uses within the study area.

Table A1-1
ENVIRONMENTAL DATA FACTORS

	DATA FACTORS MAPPED	
1. Exclusion Areas	Landfills/Refuse Area	
2. Land Ownership	US Coast Guard State of Hawaii County of Maui Wailuku Agribusiness	Pioneer Mill Co. B.P. Bishop Trust Estate Alexander & Baldwin Maalaea Triangle Partnership Other Private
3. Land Regulation	State Land Use Districts - Urban - Agriculture - Conservation [Protective (CP) Subzone] - Conservation [Limited (CL) Subzone] - Conservation [Resource (CR) Subzone] - Conservation [General (CG) Subzone] Coastal Zone Management - *Special Management Area* (SMA)	
4. Maui County Zoning	No map prepared. County zoning does not expressly prohibit utility line development.	
5. Existing Land Use	Residential School Resort Parks/Recreation/Golf Course/Cemetery Public/Community Facility Commercial Industrial Agriculture Grazing Rock Pile	Quarry Landfill/Refuse Area Shooting Range Communication Site Flood Control Channel Gulch Stream Ditch Reservoir Undeveloped/Open Space Lahaina Pali Trail
6. Proposed Projects	Proposed Planned Approved Under Construction	

Table A1-1 (continued)
ENVIRONMENTAL DATA FACTORS

DATA MAP	DATA FACTORS MAPPED	
7. Existing Utilities	Power Plant Substation MECO 69KV Line MECO 23KV Line	
8. Biological Resources	Urban Agriculture Kiawe-Buffel Grass Association Mixed Grassland-Shrubland Shrubland Forest Vegetation	Forest Reserve Boundary Streams Gulches National Area Reserve ETS Species Habitat Plant Sanctuary
9. Topographic Features and Water Resources	Flood Prone Areas (100 year flood) *Tsunami Inundation Zone* Streams Gulches/Intermittent Streams Irrigation Ditches Reservoirs	Major Ridge Ditch *Puu's* Flume Quarry/Borrow Pit
10. Slope	Slopes less than or equal to 30% Slopes greater than 30%	
11. Geology/Soils	Soils with High Erosion Potential Areas of Landslide Deposits Areas Prone to Slope Instability Soft/Loose Materials - Recent Alluvium	
12. Cultural Resources	Recorded Pre-Contact Site Recorded Post-Contact Site Land Commission Award (LCA) Parcel Area with Good Cultural Resources Potential National Register or Hawaiian Register Site National Register District Lahaina Pali Trail	
13. Transmission Separation	250 Feet (minimum separation) 500 Feet 1,000 Feet	

During the process of identifying alternative corridors, each data factor was evaluated separately. The objective was to analyze the opportunities and constraints relative to each data factor as if all other factors were equal. No single factor determined corridor location.

Resource categories were identified and data factors defined for the entire study area. The parameters of each data factor were defined with respect to Maui's unique characteristics. Data factor definitions are provided in Section A3 of this report.

CONSTRAINT CRITERIA AND RATINGS

The conditions within each data factor, with the exception of "Exclusion Areas", were evaluated in terms of relative degrees of constraint for the location of a transmission corridor 1/4 to 1/2 mile wide. The corridor constraint criteria listed in Table A1-2 were used as the standards for assigning constraint ratings to the data factors. The constraint categories - high, medium or low - reflect the degree to which the data factor could affect the location of a transmission line corridor. If a particular factor precluded siting of transmission structures it was identified as an Exclusion Area. High and medium constraint ratings were applied if the data factor would conflict with or constrain transmission corridors. The low constraint rating was assigned to factors that were judged to be compatible with transmission lines or that could provide opportunities for siting. Generally, low constraint areas are considered areas of opportunity for the siting of a transmission corridor and include areas near or parallel to existing transmission lines, utility corridors, or major roadways. Table A1-3 shows the full range of data factors with constraint ratings assigned to each. The rationale for the assignment of exclusion, high, medium, or low is provided as support material in Section A3.

<u>RESOURCE INVENTORY AND CONSTRAINT EVALUATION</u>

EXCLUSION AREAS

<u>Siting Issues</u>

Certain regulatory restrictions on land use <u>preclude</u> rather than constrain the location of a transmission line. Consequently, such areas are excluded at the outset from consideration as potential locations for a transmission line. Areas where the siting of transmission lines is essentially precluded in this study area are within the sanitary landfills and refuse areas.

Table A1-2
CORRIDOR CONSTRAINT CRITERIA

EXCLUSION AREA Areas where the siting of transmission lines is essentially precluded. This category includes areas: o regulated by policies that legally protect resources, o where government regulation expressly prohibits encroachment, o where the ownership and use of the land preempts the siting of a transmission line, or o where there would be unacceptable hazards to the construction or operation of a transmission line.
HIGH CONSTRAINT Includes areas that have the following characteristics: o unique, highly valued, or complex resource areas o significant potential conflict with a current or planned use o areas possessing substantial hazards to construction or operation of a transmission line o resource areas or conflicts with identified hazards typically requiring long-term and costly mitigation or high design and construction costs o areas that require lengthy, complex review and permitting, with likelihood of approval uncertain or low
MEDIUM CONSTRAINT Includes areas that have the following characteristics: o important, valued resources o resource hazards o special status resources o resources with some potential conflict with current or planned use o areas possessing some hazard to construction or operation of a transmission line o resource areas or conflicts with identified hazards that may require potentially difficult mitigation
LOW CONSTRAINT Includes areas that have the following characteristics: o areas that have not been classified as exclusion, high constraint, or medium constraint o areas where required permits are routinely issued o areas with little or no conflict with a transmission line o no unique or special resources o resource conflicts or hazards to construction or operation can be routinely mitigated through compensation, location, or design NOTE: Generally, low constraint areas are considered areas of opportunity for the siting of a transmission corridor and include areas parallel to roads and other linear features.

Table A1-3

**MAALAEA-LAHAINA THIRD 69KV TRANSMISSION LINE PROJECT
ENVIRONMENTAL DATA FACTORS AND CONSTRAINT FACTORS**

DATA MAP	DATA FACTORS MAPPED	CONSTRAINT RATING
1. Exclusion Areas	Landfill/Refuse Areas	Active landfills are rated as EXCLUSION AREAS
2. Land Ownership	U.S. Fish and Wildlife Service U.S. Coast Guard State of Hawaii Lands County of Maui Lands Wailuku Agribusiness A&B Hawaii, Inc. Pioneer Mill Company B.P. Bishop Trust Estate Maalaea Triangle Partnership Other Private	• U.S. Fish and Wildlife Service and U.S. Coast Guard are rated as HIGH CONSTRAINT • All other areas are rated LOW CONSTRAINT
3. Land Regulation	State Land Use Districts - Urban - Agriculture - Conservation (Protective [P] Subzone) - Conservation (Limited [L] Subzone) - Conservation (Resource [R] Subzone) - Conservation (General [G] Subzone) Coastal Zone Management Special Management Area (SMA)	• State Conservation District lands (Protective [P] Subzone) are rated as HIGH CONSTRAINT • State Conservation District land (Limited [L] Subzone), (Resource [R] Subzone), and (General [G] Subzone), and Special Management Area (SMA) are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT
4. Maui County Zoning	No map prepared. County of Maui zoning does not expressly prohibit utility line development	County of Maui zoning does not influence transmission line siting
5. Existing Land Use	- Residential - School - Resort - Parks/Recreation/Golf Course/ Cemetery - Public/Community Facility - Commercial - Industrial - Agriculture - Grazing - Rock Pile - Quarry - Landfill/Refuse Area - Shooting Range - Communication Site - Ditch - Reservoir - Gulch - Stream - Flood Control Channel - Undeveloped Open Space - Lahaina Pali Trail	• Shooting range is rated HIGH CONSTRAINT • Residential, resort, parks/recreation/golf course/cemetery, reservoir, quarry, school, communication site, public facilities, Lahaina Pali Trail, and commercial are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT NOTE: Active landfills are rated as EXCLUSION AREAS
6. Proposed Projects	Proposed Planned Approved Under Construction	• Projects under construction are rated as if they were existing projects. The HFDC project is considered under construction and rated MEDIUM CONSTRAINT • Approved planned and proposed projects are rated LOW CONSTRAINT
7. Existing Utilities	Power Plant Substation MECO 69KV Line MECO 23KV Line	• Areas within 250 feet of existing 69KV line are rated HIGH CONSTRAINT • Areas within 500 feet of existing 69KV line are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT NOTE: See transmission separation category and map for desired distances for existing 69KV lines and constraint rating

Table A1-3 (cont'd)

MAALAEA-LAHAINA THIRD 69KV TRANSMISSION LINE PROJECT
ENVIRONMENTAL DATA FACTORS AND CONSTRAINT FACTORS

DATA MAP	DATA FACTORS MAPPED	CONSTRAINT RATING
8. Transmission Separation	250 Feet (minimum separation) 500 Feet 1,000 Feet	• Areas within 250 feet of existing 69KV line are rated HIGH CONSTRAINT • Areas within 500 feet of existing 69KV line are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT
9. Biological Resources	<u>Vegetation Types</u> - Urban - Agriculture - Kiawe-Buffel Grass Association - Mixed Grassland-Shrubland - Shrubland - Forest Vegetation - Forest Reserve Boundary - Stream - Gulch - Natural Area Reserve - ETS Species Habitat - Plant Sanctuary	• Natural area reserves, plant sanctuaries and ETS species are rated HIGH CONSTRAINT • All other areas are rated LOW CONSTRAINT
10. Topographic Features and Water Resources	- Tsunami Inundation Zone - Flood Prone Area (100-year flood) - Streams - Gulches/Intermittent Streams - Irrigation Ditches - Reservoirs - Major Ridges - Ditches - Puus - Flumes - Quarry/Borrow Pits	• Tsunami inundation zones are rated HIGH CONSTRAINT • Flood prone areas (100-year flood zone) are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT NOTE: Gulches/streams called out to aid in determining possible locations of greater than average span length and special pole requirements
11. Slope	Slopes less than or equal to 30 percent Slopes greater than 30 percent	• Slopes greater than 30 percent are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT
12. Geology/Soils	Soils with High Erosion Potential Areas of Landslide Deposits Areas Prone to Slope Instability Soft, Loose Materials - Recent Alluvium	• Areas of landslide deposits are rated HIGH CONSTRAINT • Soils with high erosion potential, areas prone to slope instability, and soft, loose materials are rated MEDIUM CONSTRAINT
13. Cultural Resources	National Register District National Register or Hawaiian Register Site Recorded Pre-Contact Site Recorded Post-Contact Site Land Commission Award (LCA) Parcel Area with Good Cultural Resources Potential Lahaina Pali Trail	• National Register Districts, Lahaina Pali Trail and National Register and/or Hawaiian Register sites are rated HIGH CONSTRAINT • Surveyed and recorded pre-contact and post-contact sites are rated MEDIUM CONSTRAINT • All other areas are rated LOW CONSTRAINT

These areas are excluded from the siting of a transmission line because of safety considerations, i.e., landfill operations in close proximity to transmission lines.

Inventory

The State of Hawaii owns and the County of Maui, Department of Public Works operates the Olowalu Sanitary Landfill that occupies approximately 64 acres in the Olowalu-Makila study section near Awalua. It can be accessed from State Route 30, the Honoapiilani Highway.

This facility is planned for closure in June 1993. Closure activities include capping the filled area with large quantities of excavated fill material and installing a passive methane extraction system. Following closure, the site will continue to be used for a recycling convenience area and refuse drop-off and West Maui's residents will use the Central Maui landfill. (Dept. of Public Works, County of Maui, Personal Communication, January 24, 1992)

Constraint Rating

Landfills and Refuse Areas - EXCLUSION AREA

Active landfills are rated exclusion because continuous earth movement in connection with landfill operations effectively precludes the ability to locate transmission lines within them. After closure of the site, the operation of recycling trucks and other machinery would be a potential hazard to the transmission poles and conductors.

LAND OWNERSHIP

Overview

Land ownership does not in itself constrain corridor location, however parcel size and ownership can affect right-of-way location and acquisition. The acquisition of a right-of-way for a 69KV line (usually 50-75 feet wide) would have a more significant impact on the potential use of small parcels than it would on large ones. Landowners are primarily concerned that transmission line rights-of-way would divide their landholdings and reduce the value of their property or interfere with current or proposed operations. It is possible that current sugar cane production and grazing in West Maui could be significantly interrupted if the transmission lines were sited across open fields. In addition, the negotiations involved in acquiring the right-of-way easements through an area with numerous small parcels, each with different owners, could take substantially longer than through areas with a single owner.

Other land ownership factors that influence corridor location include the permits, policies and guidelines that regulate development within certain jurisdictions. For example, some portions of State lands are designated as protective due to environmental factors that may be incompatible with transmission lines or that may require special permits for use. These requirements vary by owner, i.e., federal, state, county or private landowner. Therefore, identifying and mapping major jurisdictional boundaries within the study area determines ownership patterns and helps to establish the broad guidelines that can influence corridor location.

Inventory

The study area includes property under the jurisdiction of the United States government, the State of Hawaii, the County of Maui and private landowners (Figure A1-1). Approximately 46 percent of the study area is under private ownership and used primarily for agriculture and 64 percent is under State jurisdiction and undeveloped either leased for grazing or in forest reserve. Landowner data, including lease information and property boundary lines were obtained from 1991 Real Estate Atlas Tax Key Maps (TMK). The TMK data was then verified with most of the individual property owners.

U.S. Fish and Wildlife Service

The Kealia Pond and adjacent Maalaea mud flats, an environmentally sensitive area owned by U.S. Fish and Wildlife Service, is located mauka of North Kihei Road between Maalaea and Kihei. This wetlands area, bordered by cane fields and the coastline, is approximately 700 acres and managed as a wildlife sanctuary.

U.S. Coast Guard

The U.S. Coast Guard has jurisdiction over the McGregor Point lighthouse facility in the Maalaea-Ukumehame study section.

State of Hawaii

The State of Hawaii is the dominant owner in the project area; they own and administer multiple uses in over 60 percent of the study area. The majority of the land is undeveloped, open conservation land; many acres within the West Maui Forest Reserve. Several individuals or companies lease the land from the State. Grazing leases have been granted to both Stephen Perreira or the Perreira Ranch and Ernest Nunes.

Pioneer Mill Company (PMCo) leases large tracts of land from the State of Hawaii in the Lahaina area. Some of this land is proposed for future development by the Housing Finance and Development Corporation, a State-owned developer.

Several other smaller parcels of land are owned by the State of Hawaii and used for public facilities such as the Lahaina Harbor, Lahainaluna High School, the Olowalu Sanitary Landfill and several beach parks (see Existing Land Use section below for more detail).

County of Maui

In study section III, the Olowalu Sanitary Landfill is operated by the County Public Works Department although owned by the State.

In study section IV, land owned by the County of Maui consists of a few parcels used for parks and recreation facilities that are located within the coastal zone or waterfront development area.

Private

Over 40 percent of the land within the study area is privately owned. PMCo., a subsidiary of Amfac, and Amfac/JMB Hawaii, Inc. either own or have long term leases on most of the land in the northern half of the study area. Amfac/JMB Hawaii, Inc. owns the Kaanapali Resort. PMCo owns significant acreage interior to the Honoapiilani Highway between Ukumehame and Lahaina and leases land from the State of Hawaii and the B.P. Bishop Trust Estate in the Lahaina area.

The next largest private property owners are Wailuku Agribusiness and B.P.Bishop Trust Estate. Alexander & Baldwin, parent company to Hawaiian Commercial & Sugar Company (HC&S) owns the land adjacent to the Maalaea Power Plant that is used for agriculture by HC&S. This area must be crossed as the transmission lines exit the power plant area.

Maalaea Triangle Partnership and other private landowners own smaller parcels within the Maalaea triangle, the towns of Olowalu, Mopua, Lahaina and several subdivisions along the shoreline.

<u>Constraint Ratings</u>

U.S. Coast Guard Lands and U.S. Fish and Wildlife Service - HIGH CONSTRAINT

Lands owned by the federal government including the U.S. Coast Guard and U.S. Fish and Wildlife Service are rated high constraint because of the potential for lengthy negotiations, reviews and approvals required to site a transmission line within federal lands.

State of Hawaii - LOW CONSTRAINT

Typically, lands owned by State of Hawaii, even if leased to a private landowner, present a medium constraint to transmission siting because "use of state land" in most cases requires preparation of a State EIS. In addition, the State routinely requires the utility to agree to easement documents requiring the utility to pay for line relocation should the State deem it necessary for its future use of the land. In the case of the Lahaina Project the large amount of State land within the study area and the fact that siting the proposed transmission line within State land cannot be avoided, means that State land cannot be considered a constraint to locating a transmission corridor; therefore, State is assigned a low constraint rating.

County of Maui - LOW CONSTRAINT

Lands owned by the County of Maui within the Lahaina study area consist of a few small shoreline parcels used for parks and recreation facilities. Siting of a transmission line within County of Maui lands is typically not prohibited but would be subject to negotiation and permit requirements of the individual County Departments, and County Planning Commission review. Because of the high public use of beach parks and recreation facilities, these uses are rated medium constraint under the existing land use category and rated as low within the land ownership category.

Private Lands - LOW CONSTRAINT

Private lands represent about half of the total land area within the Lahaina study area. Negotiations and acquisition of an easement from the private landowners is required to the site the line; therefore, they are rated low constraint.

LAND REGULATION

Overview

The category, land regulation, identifies areas that are subject to regulatory controls of state and county governmental agencies in order to protect resources and to guide future development. In Hawaii's Environmental Impact Statement (EIS) Law, HRS Chapter 343, there are eight actions or "triggers" of the environmental review process, four of which may apply to this project depending on the specific siting of the transmission line. If any of these criteria are met, an environmental assessment must be prepared.

The following criteria may apply to this project:

- Use of State or County lands or funds
- Use within State Conservation District Lands
- Uses within Shoreline Setback Area
- Use within any Historic Site or District

For example, if the transmission line were to be constructed through Conservation District lands, approval would be required from the Board of Land and Natural Resources (BLNR). The process usually requires a submittal of an environmental impact statement, a Conservation District Use Application (CDUA), a quasi-judicial hearing by the BLNR and issuance of a CDUA permit.

Under the Coastal Zone Management Act, a Special Management Area (SMA) Use Permit is required for any development that occurs within the SMA.

Inventory

Data factors mapped are State Land Use Districts (LUD), as designated by the State of Hawaii Land Use Commission, and the SMA, as defined by the County of Maui (Figure A1-2). LUD boundaries were mapped from the Land Use District Maps prepared by the State Land Commission and Conservation District Subzones were mapped from the Department of Land and Natural Resources (DLNR) maps. SMA boundaries were mapped from the County of Maui SMA maps. The location of these areas were the basis for identifying potential constraint areas and the agency, regulatory requirements and permits that may be required for this project.

State Land Use Districts

The State of Hawaii Land Use Commission, pursuant to Hawaii Revised Statutes Chapter 205, has established LUDs throughout the State. Three LUD designations: Agriculture, Conservation, and Urban, apply to lands within the study area. Overhead transmission lines are a permitted use within the Urban and Agricultural LUD designations, however siting a new transmission line in a Conservation LUD requires submittal of a CDUA for review and approval by the BLNR and issuance of a CDUA Permit.

Conservation LUD

Lands are classified, by Title 13, Chapter 2 (State of Hawaii Department of Health Administrative Rules) into various subzones and special districts varying in their degree of restrictiveness. The most restrictive is the Protective Subzone. The objective of this subzone is to protect valuable resources in such designated areas as restricted watersheds; marine, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas. Near the power plant is a small portion of Protective Subzone. Approximately 435 acres of land known as the Kealia Pond and Maalaea mudflats is designated as a Protective Subzone. The Kealia Pond and adjacent mudflats provide feeding, rearing and nesting habitat for a variety of waterbirds.

Two interior areas designated as Conservation Protective include a portion of the Manawainui Gulch and Hanaula Gulch in Ukumehame and the area surrounding the Paupau plant sanctuary (not actually within the study area boundary). The Hanaula Gulch had been considered for inclusion in the Natural Area Reserve system;however, at this time there are no surface resources that warrant the Protective Subzone designation according the DLNR, Division of Forestry and Wildlife, Maui District Office (R. Hobdy, District Forester, Personal Communication January 22, 1992).

The second most restrictive Conservation District Subzone is the Limited Subzone. While regulations governing Limited Subzones do not preclude a transmission line, their stated objectives and narrow range of permitted uses for these areas suggest a high regulatory constraint. The objective of the Limited Subzone is to limit uses where natural conditions suggest constraints on human activities.

Within the study area just west of the Protective Subzone, the Limited Subzone begins and extends for the entire coastline between Maalaea Bay and Puamana Park near Lahaina. This area is bordered by cane fields and the coastline. There is one interior area designated Limited Subzone found surrounding the Manawainui Gulch. Consultation with the resource managers from the Maui District Office of the DLNR revealed this area currently has no significant surface features that demonstrate the sensitive nature of this gulch over any other within the study area.

Conservation District - Resource Subzone objective is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. It includes land used for parks and set aside for future parks and lands and territorial waters not in an Resource Subzone. Resource Subzone lands exist in the mauka portion of the study area. The boundary of this subzone extends makai to the edge of cane in most cases. These lands are owned and managed by the State of Hawaii as the West Maui Forest and Forest Reserve.

Conservation District - General Subzone is the least restrictive of the Conservation District subzones. The objective of this subzone is to designate open space where specific conservation uses may not be defined, put where urban use would be premature.

A large tract of land designated General Subzone is located in the ridges and gulches mauka of McGregor and Papawai points and bordered by the Ukumehame Gulch in the west.

Urban LUD

Urban LUD lands make-up the Lahaina Waterfront and Historic District as well as the outlying areas used for resorts, residential and proposed residential projects. At the Maalaea end of the study area, there are small tracts of Urban LUD which include the Maalaea Power Plant, Maalaea small boat harbor and adjoining residential and commercial properties.

Land uses within the Urban LUD consist of low and medium density residential, schools, churches, utilities, resorts, public service facilities, cemeteries, light industrial and commercial.

Agricultural LUD

Agricultural LUD lands cover approximately half of the study area located primarily along the shoreline and gently sloping foothills. The agricultural uses consist mainly of sugar cane and pineapple cultivation and cattle grazing, with a few areas dedicated to diversified agriculture. Agricultural support facilities are scattered throughout the study area.

Special Management Area (SMA)

Chapter 205A Hawaii Revised Statutes, part of the State's Coastal Zone Management Policies, created SMAs for the purpose of controlling development within an area along the coastline "...to avoid permanent losses of valuable resources and the foreclosure of management options and to assure that adequate access by dedication or other means to publicly owned or used beaches, recreation areas and natural reserves is provided".

In Maui County, the Planning Department administers the SMAs and related permits. Any development which exceeds "a total cost or fair market value" of $125,000 or which may have substantial adverse environmental or ecological effect within the designated SMA requires a Special Management Area Use Permit (SMA Permit).

The SMA Permit is issued by the Planning Commission and approved by the County Council. The SMA Permit is the first permit required for a project.

The SMA includes the entire coastline within the study area proceeding inland an average of 4,000 feet. The SMA includes the Kealia Pond and the coincident Conservation District Protective and Limited subzones, the Maalaea Power Plant and all the communities, parks, and facilities along the shoreline including the greater part of Lahaina.

Constraint Ratings

State Conservation District Land Protective (CP) Subzone - HIGH CONSTRAINT

Title 13, Chapter 2 (State of Hawaii Department of Health Administrative Rules) classifies Conservation District Lands into various subzones varying in their degree of restrictiveness. The most restrictive is the Protective Subzone. The objective of this subzone is to protect valuable resources in such designated areas as restricted watersheds, marine, plant and wildlife sanctuaries, significant historic, archaeological, geological and volcanological features, and sites and other designated unique areas.

Permitted uses are limited to research, recreational and educational uses requiring no physical facilities and discretionary government use where public benefit outweighs any impact on the Conservation District or uses approved by the BLNR. Construction of a transmission line within a Protective Subzone may be difficult, requiring an approval by the BLNR. This requires a submittal of a CDUA, a quasi-judicial public hearing by the BLNR (however, public utilities are exempt from the hearing requirement), HRS 183 and issuance of a CDUA permit.

State Conservation District Land Limited (CL) Subzone - MEDIUM CONSTRAINT

Next in the Conservation District subzone hierarchy of restrictiveness is the Limited Subzone. The objective of this subzone is to limit uses where natural conditions suggest constraints on human activities. Permitted uses include all those in the Protective Subzone and emergency warning and telephone systems, flood, erosion control projects and growing and harvesting of forest products. Regulations governing this subzone do not expressly preclude a transmission line, however, the narrow range of permitted uses for this area suggest regulatory constraint. Submittal of a CDUA application would be required, and BLNR review and approval and issuance of a CDUA permit.

State Conservation District Land Resource (CR) Subzone - MEDIUM CONSTRAINT

Next in the Conservation District subzone hierarchy of restrictiveness is the Resource Subzone. The objective of this subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. It includes land used for parks and future parks and lands and territorial waters not in an Resource Subzone. Permitted uses include those in Permitted and Limited Subzones, aquaculture, artificial reefs and commercial fishing operations. While regulations governing this subzone do not expressly preclude a transmission line, the narrow range of permitted uses for this area suggest regulatory constraint. Submittal of a CDUA application, and BLNR review and approval and issuance of a CDUA permit, would be required.

State Conservation District Land General (CG) Subzone - MEDIUM CONSTRAINT

This is the least restrictive of the Conservation District subzones. The objective of this subzone is to designate open space where specific conservation uses may not be defined, put where urban use would be premature. Permitted uses include those in Protective, Resource, and Limited Subzones and development of water collection, pumping, storage, control and transmission. This subzone provides the least regulatory restrictions to transmission line siting. It is rated medium solely because a CDUA application, BLNR review, approval and issuance of a CDUA permit would be required.

Special Management Area (SMA) - MEDIUM CONSTRAINT

Chapter 205A, part of the State's Coastal Zone Management policies, created SMA's for the purpose of controlling development within an area along the shoreline "...to avoid permanent losses of valuable resources and the foreclosure of management options and to ensure that adequate access by dedication or other means to publicly owned or used beaches, recreation areas and natural reserves is provided". In Maui County, the Planning Department administers the Special Management Use Areas and related permits. Any development which exceeds $125,000 or which may have substantial adverse environmental or ecological effect within the designated Special Management Area requires a Special Management Area Use Permit (SMA Permit), approved by the Planning Commission and County Council. Development includes construction, reconstruction, demolition or alteration of the size of any structure. Structure includes both transmission and distribution lines.

Agricultural District - LOW CONSTRAINT

The permitted uses under the State Agricultural District are the same as those permitted within the County Agricultural Land Use District. County of Maui "Interim Zoning Ordinance" (1987) states, "As provided by the regulations of the Land Use Commission, except as otherwise provided, the following land use and building uses are compatible and permitted within this district. ... Public, private, quasi-public utility lines, but not including offices or yards for equipment, material, vehicle storage, repair, or maintenance". Since the proposed transmission line is a public utility facility, the agricultural district zoning should present no constraint to siting the line.

Urban District - LOW CONSTRAINT

County zoning preempts the State Land Use District designation in Urban District. Transmission lines are a permitted use within all zoning districts within the study area (County of Maui, 1987).

EXISTING LAND USE

Overview

To facilitate the land use analysis, the Maalaea-Lahaina Project study area was divided into four study sections. The study section boundaries were identified through analysis of principle land uses, land ownership, development patterns and natural and physical features.

Color aerial photographs of the study area were taken in October 1991 at a scale of 1 inch = 2,000 feet. The aerial photographs were used to delineate major land use types and their boundaries within the project area. The aerial photo interpretation of land uses was verified with field checks and discussions with the major landowners within the study area.

Meetings with landowners also served to identify opportunities and constraints to transmission line siting. In addition, helicopter surveys were conducted in September and November 1991. Photographs and a video taken during the helicopter flyover were used to verify use data obtained during landowner meetings and through the aerial photo analysis.

Inventory

There are twenty different land use categories within the project study area. (Figure A1-3). The principal land uses are agriculture, consisting of sugar cane, pineapple, cattle grazing, and undeveloped open space. Sugar cane production is the largest agricultural activity. Land use categories and acreages are summarized on Table A1-4.

Residential

There is one residential area within the Power Plant Study Section I. A multi-family residential development is located along the shoreline in the Maalaea community, occupying approximately 11 acres. The area is bounded by the coastline and the coastal access road and the development consists of clustered condominium units surrounded by open space, recreational facilities and parking.

Table A1-4
EXISTING LAND USE

CATEGORY	APPROXIMATE Area (acres)
Residential	640
School	88
Resort	159
Parks/Recreation/Golf Course/Cemetery	847
Commercial	224
Industrial	46
Agriculture	12,132
Grazing	4,862
Quarry	163
Landfill/Refuse Area	47
Shooting Range	119
Undeveloped/Open Space	17,077
Public/Community Facility, Power Plant	N/A
Communication Site	N/A
Rock Pile	N/A
Gulch	N/A
Stream	N/A
Ditch	N/A
Reservoir	N/A
Lahaina Pali Trail (4.5 miles long)	N/A
Total:	36,404

Residences within the Olowalu-Makila Study Section III include the communities of Mopua, Olowalu and several rural private residences associated with the Pioneer Mill plantation.

A major portion of the Lahaina-Wahikuli Study Section III is used for both multi-family and single family housing. The residential areas include: Lahaina Town, Wainee, Kelawea and Kapunakea.

Schools

There are no schools within Study Sections I, II and III.

In Study Section IV, Kamehameha III School is in Lahaina and the Lahainaluna School exists mauka of Lahaina Town Center. It is owned and operated by the State of Hawaii and includes classrooms, dormitories, playing fields and a tree farm.

Resort

Three small resort areas exist within the study area: 1) in Puamana at the Maalaea end of Lahaina town where several beach hotel complexes are located, 2) a small portion of Kaanapali Resort at the far north end of the study area and 3) hotels/condominiums near Maalaea Harbor.

Parks, Recreation, Golf Courses and Cemeteries

One of West Maui's finest features is the recreational attributes of the resort golf courses and the beach parks. The study area contains beach parks along most of the shoreline between Maalaea and Lahaina. The State-owned beach parks and recreational shorelands include: the land surrounding the McGregor Point and Coast Guard lighthouse, Papawai Point, Ukumehame Beach State Park, Hekili Point and Olowalu Wharf, Launiupoko Beach State Park, Puunoa Point, Wahikuli State Wayside Park.

County owned parks include Puamana Park on the shoreline and several small parks and playing fields within the town of Lahaina.

There are two golf courses at opposite ends of the study area: C. Brewer owns a golf course in Study Section I and Amfac JMB Hawaii, Inc. owns the Kaanapali Golf Course in Study Section IV.

A few cemeteries are scattered throughout Lahaina usually adjacent to church facilities.

Commercial

A 30-acre commercial district surrounds the Maalaea Small Boat Harbor in Study Section I. The area has a restaurant, harbor support facilities, general store, fishing equipment stores and other facilities that support the commercial and private harbor and docks.

Lahaina, an historic whaling/fishing town has now become West Maui's commercial district. The central area of the town is entirely tourist oriented retail shops, restaurants, boutiques, recreational kiosks and galleries. The Cannery is another mall-like commercial area mauka of the Lahaina town center.

Industrial

There are very few industrial areas in West Maui and the only industrial use within the study area is in the center of Lahaina town. Light industrial warehousing exist around the Pioneer Mill.

Agriculture and Rock Piles

Approximately two thirds of the land within the project study area is used for agricultural purposes, including sugar cane and pineapple production or ranching operations.

In Study Section I, Hawaiian Commercial & Sugar Company (HC&S) cultivates sugar cane within the study section between the shoreline and Honoapiilani Highway.

The remainder of the sugar cane fields are owned and operated by PMCo, the plantation company for Amfac. PMCo owns or leases hundreds of acres for sugar production within Study Sections III and IV. These lands extend from the coast highway mauka to the lower slopes of the West Maui Mountains.

Some areas within the sugar cane fields are unusable due to: rocky soil conditions, the presence of paved and dirt roads, gulches and adjacent densely vegetated areas and rock piles. A network of irrigation pipes, pumps, reservoirs and ditches spans the cane fields. Rock piles are so common that they are shown on the Existing Land Use map (Figure A1-3) as a separate data category. Agricultural support facilities such as maintenance shops and equipment storage yards are located throughout the sugar cane fields; these facilities are typically setback from the major cane haul roads. PMCo owns an airstrip near a crater adjacent to Field No 550; however, they have not used it for three years. It could be used on a limited basis in the future if needed (K. Falconer, PMCo, Personal Communication, December 12, 1991).

Sugar cane planting occurs year round. Harvesting starts in February/March and continues through November. Herbicides are typically applied aerially by helicopter as required year round. Ripener is also applied by helicopter between January and September, 6 to 8 weeks prior to harvesting a field. Burning occurs prior to each harvest to reduce the leaf material, thereby reducing mass that must be harvested and production costs. The cane trucks (tournhaulers) are 16 feet wide. Fully loaded, with 50 to 60 tons of cane, the width increases to 30 feet. Cane haul roads vary in width ranging from 30 to 60 feet wide.

Within Study Sections I and II, Wailuku Agribusiness uses land located on both sides of the Honoapiilani Highway from Maalaea to the mauka boundary of the study area for pineapple production. The fields are setback over twenty feet from the edge of the highway shoulder in most instances.

Pineapple does not require aerial spraying, however the plants are sprayed by a tractor with a 50-foot boom. There is continuous harvesting throughout the year. Night harvesting operations occur from June through December. Siting of a transmission line near pineapple fields must consider the potential for conflicts with boom spraying operations.

Cattle grazing occurs on approximately 8,000 acres of land owned by the State of Hawaii and leased to Perreira Ranch Company within Study Section II. There are currently 1,000 head of cattle grazing. Access to this steep grazing area is by jeep trail passable only by four wheel drive vehicles.

Quarry

This category includes rock quarries, borrow pits and cinder pits used within the study area for development and landfill operations. There are two quarries within the Lahaina study area, these are the Maui Concrete & Aggregate Quarry located adjacent to the Olowalu landfill and the abandoned cinder pit located at the intersection of Honoapiilani Highway and Kihei Road. The Maui Concrete & Aggregate Quarry is operated for the production of building and road construction materials. The other quarry is not active, however the pit remains in place and there are no current plans for reclamation (C. Brewer, Personal Communication, 1992).

Landfill/Refuse Area

The Olowalu Sanitary Landfill and refuse area in Study Section III is described above under Exclusion Area.

Shooting Range

The County of Maui, Department of Parks and Recreation administers the permits for use of a shooting range in Study Section II. This 24-acre parcel is surrounded by open space owned by the State of Hawaii. Currently the range is shared by the West Maui Skeet Club and the Valley Isle Gun Club; the site is also used by the Maui Police and occasionally by National Guard for training. There is a rifle range and a skeet range on the site and the shooting occurs toward the mountains between two large 12-foot high berms.

Communication Site

There are at least three radio towers in the study area. According to the engineer for KPOA radio, two or three towers exist near the Lahainaluna Road makai of the high school and there is an 100-foot tower near Launiupoko as well as a 60-foot tower near Olowalu. The operator and use of these towers is not known to the Federal Communications Commission (A. Kawasaki, Personal Communication, January 6, 1991).

Flood Control Channel

The U.S. Army Corps of Engineers designed and constructed a flood control channel at the mouth of the Kahoma Stream in Lahaina. The County Department of Public Works maintains the channel.

It is designed to exceed the requirements of the 100-year flood. (John Palauski, U.S. Army Corps of Engineers, Personal Communication, January 6, 1991).

Lahaina Pali Trail

The State of Hawaii, Department of Land and Natural Resources adopted the Lahaina Pali Trail as the demonstration trail for the Na Ala Hele, Trails and Access System Program. This historic pathway was used for travel between Ukumehame Beach and the Maalaea area, Study Section II.

The DLNR has completed archaeological surveys, environmental compliance and begun improvements to the 4.5-mile trail. They plan to have parking improvements completed and open to the public for interpretive hikes some time in 1993.

Gulches and Streams

The entire study area is characterized by gulches, streams and ravines. They drain the slopes of the West Maui Mountains and traverse the project study area terminating at the shoreline highway and open ocean. There are several perennial streams that cross the study area. These natural surface water systems run perpendicular to the slope of the terrain.

Since these topographic and water features of the landscape are common and unavoidable, they are not considered a high constraint in siting of a transmission corridor. They do play an important role, however, in determining the final alignment location, as described in Section A2, Field Evaluation, Field Survey and Staking.

Ditch

A network of open irrigation ditches exists throughout the sugar cane fields. These ditches are used throughout the year for the irrigation of cane and are linked to many reservoirs through the sugar cane fields. Water is gravity fed from the reservoirs into the ditches and distributed to the fields. The ditches are also used to control runoff and divert water from the many natural gulches that are present in the project study area. The ditches vary in width ranging from 5 to 15 feet wide. Maintained dirt access roads parallel many of the ditches.

Reservoir

Reservoirs used for irrigation of sugar cane and pineapple fields are located through study sections I, III and IV and linked by a network of irrigation ditches. Water is gravity fed from the reservoirs to the irrigation ditches. In some cases, water is pumped through pipelines to areas requiring water at higher elevations.

Undeveloped/Open Space

Most of the land in this category is under the State of Hawaii jurisdiction and in the Conservation Land Use District. Some of it is also within the West Maui Forest Reserve mauka of the sugar cane fields. Although there is no specific existing use of these lands, activities are regulated by the landowner.

Constraint Ratings

Shooting Range - HIGH CONSTRAINT

The West Maui shooting range should be avoided for two reasons: 1) siting a transmission line in or close to the range is an incompatible use because of safety considerations and 2) siting the transmission line in close proximity to the range could present an irresistible target and could result in damage to the line or insulators. For these reasons the shooting range is rated as a high constraint and an area that should be avoided.

Residential, Resort, Schools, Parks/Recreation/Golf Course/Cemetery, Public/Community Facilities, Lahaina Pali Trail, Commercial Areas - MEDIUM CONSTRAINT

Because of perceived factors related to the health, aesthetics and property values, a number of land uses have been rated medium constraint. Included in this grouping are areas where people spend a significant amount of time outdoors, i.e. residential areas; elementary, intermediate or high schools; golf courses; and resorts. Recreation areas that receive intense use include parks, hiking trails, beaches/picnic areas, playgrounds, and playing fields adjoining schools. Because of aesthetic and social considerations, public/community facilities and cemeteries are included as medium constraint areas. Commercial areas are rated medium constraint because this category includes restaurants, tourist business and offices where significant groups of people are present.

Quarries, Reservoirs, and Communication Sites - MEDIUM CONSTRAINT

There are two quarries within the Lahaina Study Area. Siting in quarries should be avoided because of the conflicts with equipment and operations and potential damage to poles. They do not however, greatly constrain location of a transmission corridor 1/4 to 3/4 mile since an alignment can usually be identified which can avoid the quarry.

There are numerous reservoirs and large irrigation ponds within the Lahaina study area. Reservoirs should be avoided, if possible, in corridor identification. The Lahaina study area reservoirs are generally small and can be avoided or lines can easily span the reservoirs if necessary, thus, they do not significantly affect eventual transmission line location.

Facilities in the communication sites category include antennas, transmitters and receivers operated by radio stations and the Federal Communications Commission (FCC). FCC planning guidelines state that electric fields near the monitor should be avoided where possible. Transmission lines have the potential to affect the radio receivers by causing electrical interference and, in some cases, errors in the direction finder. The communications equipment must be sited beyond measurable electromagnetic radiation from any other source (e.g., transmitters or transmission lines). For these reasons, the design of transmission line alignments and pole placement near the communications equipment requires careful planning and negotiations with the operators, and therefore communication sites are considered a medium constraint to siting.

Grazing, Agriculture, Rock Piles, Streams, Gulches, Ditches and Industrial - LOW CONSTRAINT

Large areas of the study area are dedicated to cattle grazing. Dryland grazing does not constrain transmission corridor siting and the existing 69KV transmission lines pass through the grazing areas. It should be noted that these dryland areas are susceptible to fire. Fire hazard potential needs to be considered in alignment siting.

A major land use in the Lahaina study area is agriculture, with sugar cane the primary crop. Some land is unusable due to rocky conditions, and rock piles in cane fields are evidence of past clearing activities. Agriculture is rated low constraint because of the presence of existing transmission lines in agriculture areas and grazing areas. However, careful siting of poles within cane is required to minimize difficulties and hazards in mechanical harvesting, risks to the line from cane burns, and safety of aircraft performing aerial spraying.

Ditches and the flood control channels should be avoided, but they may not constrain the location of a transmission corridor 1/2 mile wide. In this situation the Kahoma flood control channel could present a siting opportunity, as the transmission line could parallel the channel.

Due to the steep terrain, portions of the study area contain many gulches which the proposed transmission line must span. Gulches are mapped to call attention to the number of longer spans requiring taller poles and in some cases helicopter stringing of conductors. All these activities add additional cost to line construction and maintenance. Since there are so many gulches and ravines within the study area, they are unavoidable and therefore, do not constrain transmission corridor location.

PROPOSED PROJECTS

Overview

The County of Maui General Plan is supported by plans for each of the communities on the islands of Maui, Lanai and Molokai. The community plans are long-range planning documents that include zoning that has been adopted through ordinance by the County Council.

Portions of two community plan districts fall within the study areas:

- Kihei - Makena Community Plan District
- Lahaina Community Plan District

A determination was made of all planned, proposed and approved projects, and projects under construction that were noted in the community plans or through consultation with County of Maui planners or landowners in the study area. Each project proponent was contacted to determine the size, location and current status of the project. These communications were documented in "Proposed Project Profiles" and are provided in Appendix B. Table A1-5, identifies the projects that fall into one of the following categories:

- **Proposed** - Projects proposed by a government agency or private developer not included in the community plans.
- **Planned** - Projects proposed by a government agency or private developer included in the community plans.
- **Approved** - Projects included in the community plans which have received the necessary State and County approvals and permits.
- **Under Construction** - Refers to those projects where construction permits are approved and groundbreaking or other construction activities have occurred.

Proposed projects can influence corridor location and selection. Where possible these areas should be avoided to prevent siting conflicts.

Inventory

The projects described in this section were identified through research by Chris Hart & Partners and Dames & Moore from October 1991 through January 1992. Each of the proposed projects is identified on Table A1-5 and has been mapped on the Proposed Projects map (Figure A1-4).

Project District 1 - Industrial Expansion Area

This Project District is the expansion area for the Maalaea Power Plant. MECO has no plans for major expansion in this area at this time. The improvements to the Maalaea Switching Station can be accomplished without using additional property. The land within Project District 1 has been incorporated in A&B Hawaii's master plan for the Maalaea Village Development (Stan Kuriyama, A&B Hawaii, Inc. October, 1992).

Table A1-5
PROPOSED PROJECTS

PROJECT	OWNER/DEVELOPER	STATUS	SIZE	PROJECT ESTIMATED COMPLETION
Project District 1 (Industrial Expansion Area)	Alexander & Baldwin/County of Maui	Planned	4.36 acres	Incorporated into Maalaea Village Project
Kealia Pond Wildlife Refuge	U.S. Fish and Wildlife Service	Planned	700 acres	Improvements continuous
Maalaea Village (formerly Kealia Pond) Development	A&B Hawaii, Inc.	Proposed	650 acres	2005
Maalaea Triangle Project	Maalaea Triangle Partnership	Approved	18 acres	uncertain
Olowalu Planned Community	Amfac/JMB Hawaii, Inc.	Proposed	500 acres	undetermined
Puu Hipa Golf Course	Amfac/JMB Hawaii, Inc.	Proposed	440 acres	undetermined
Lahaina Bypass Corridor and Ikena Avenue Relocation Project	State Department of Transportation; B.P. Bishop Trust Estate	Planned	7.9 miles	1995
Lahaina Watershed Flood Control Project	Soil Conservation Service and County of Maui	Under Construction	3500 feet	1992
Wainee Housing Residential Development	B. P. Bishop Estate Trust	Proposed	450 acres	undetermined
HFDC Lahaina Planned Community (Mixed Use Residential)	State of Hawaii Housing Finance and Development Corporation	Phases I, II - Under Construction Phases III-VI planned	1122 acres	2000

Kealia Pond (Maalaea Village Mixed Use) Development

A&B Hawaii, Inc. proposed a resort residential development that included the Kealia Pond area. Their plans for development included using the Kealia Pond. Since it is one of the two remaining ponded wetlands on Maui, the U.S. Fish and Wildlife and Corps of Engineers disallowed development of the area and condemned the land. The U.S. Fish and Wildlife Service now have jurisdiction over 700 acres of coastal wetlands including the 435-acre Kealia Pond; therefore, A&B Hawaii, Inc. downscaled their development to 650 acres near the Maalaea area.A&B Hawaii's preliminary development plans for this 650-acre project now referred to as Maalaea Village include single and multi-family housing, one golf course, beach park, nature trails and environmental interpretive center. The build-out schedule for this project is 10-15 years. This project is not reflected in the Kihei-Makena Community Plan and, therefore, falls under the proposed project category.

Kealia Pond National Wildlife Refuge

The Kealia Pond and land surrounding the pond is a Conservation District Protective Subzone, designated by the State of Hawaii Land Use Commission, pursuant to Hawaii Revised Statutes Chapter 205. In 1989 the Federal Government filed suit to condemn the Kealia Pond and wetlands for a National Wildlife Refuge. The suit between the U.S. Fish and Wildlife Service (USFWS) and Alexander & Baldwin (the owner of Kealia Pond) was settled in May 1992. The USFWS now own and manage the pond and associated wetlands (700 acres) as a National Wildlife Refuge for the protection of habitat and enhancement of endangered waterbird species. Since the project is proposed by a federal agency, none of the proposed project categories apply; USFWS representatives report that the ecological monitoring studies and refuge planning commenced in summer 1992 (J. Leinecke, USFWS Personal Communication, May 18, 1992).

Maalaea Triangle Project

This parcel located between Maalaea Road, Honoapiilani Highway and the Small Boat Harbor has been permitted as a site for a Mixed Use Commercial Center.

Olowalu Planned Community

Amfac JMB Hawaii, Inc. has proposed a development plan for 50 acres within the historic community of Olowalu.

Puu Hipa Golf Course

This project is proposed in the area of Puu Hipa by Amfac JMB Hawaii, Inc. It was not proposed during the 1992 update of the Lahaina Community Plan.

Lahaina Bypass - Honoapiilani Highway Bypass

This highway bypass project is being planned and constructed by the State of Hawaii Department of Transportation. The new highway will extend around the mauka side of Lahaina to join with Honoapiilani Highway at Honokawai.

Lahaina Watershed Flood Control Project - Kauaula Stream

This project will serve to control the flooding of Kauaula Stream through the Lahaina area. The project will be constructed by end of 1993.

Wainee Residential Development

Bishop Estate proposed a new residential development in the area of Wainee. This project was again reviewed during the 1992 update of the Lahaina Community Plan.

HFDC Lahaina Master Planned Community

Phases I and II of this six phase project are under construction. This residential planned community with recreational amenities was approved. It is being developed on state land by the Housing Finance and Development Corporation.

<u>Constraint Ratings</u>

Projects proposed for development can influence corridor location and selection. Where possible, these areas should be avoided to prevent siting conflicts.

Projects Under Construction - MEDIUM CONSTRAINT

1. Projects under construction have a higher probability of being completed than those that have not yet broken ground. Effectively projects under construction can be viewed as existing uses.
2. Costs associated with easement acquisition and mitigation measures are likely to be higher than for projects still being planned.

3. The potential exists for hazards or other conflicts if construction of the transmission lines occurs concurrently with construction of a project.
4. The HFDC Lahaina Master Planned Community Project is under construction and is rated medium constraint.

Approved Projects - LOW CONSTRAINT

These are projects for which most of the permits and approvals required for construction have been obtained by the developer. Projects in this category are rated low constraint because of the possibility that the transmission line could be accommodated in the final stages of these planning and construction.

Planned Projects - LOW CONSTRAINT

Projects in this category have been successfully incorporated into the Maui County Community Plan, however the permits and approvals have not been granted. These projects are rated low constraint. Although they may be built, the construction would likely take place sometime after the transmission line.

Proposed Projects - LOW CONSTRAINT

These projects have been proposed by a private developer or government agency, but for some reason, have not been successfully incorporated in the Maui County Community Plans. They are rated low constraint because of the possibility that they may never be built due to financial, market or other factors.

EXISTING UTILITIES, TRANSMISSION SEPARATION AND ROADS AND ACCESS

<u>Overview</u>

Transmission lines and distribution lines within the study area present both constraints and opportunities for siting of the new 69KV transmission line. An important criterion in siting a 69KV transmission line is to provide adequate separation from other 69KV lines in order to reduce the possibility of a multiple line outage due to a major storm event, fire or other catastrophic event. The Public Utilities Commission General Order No. 6 are rules for overhead line construction, which require that transmission lines be separated by at least the height of the tallest pole in order to prevent one line from coming in contact with another line in the event of a downed pole. Therefore, siting a new line in proximity of an existing 69KV transmission lines should be avoided, if possible. Because transmission lines must enter and exit substations, often with other transmission lines, the separation criteria does not apply to line entry or exit from substations.

Improved roads, lower voltage distribution lines and other linear features within the study area present opportunities for siting of the new 69KV transmission line. The major advantage in conforming with pre-existing linear facilities (i.e., siting within or adjacent to an existing right-of-way) is that it avoids the disruption that new transmission lines might create in areas where lines do not now exist. Also construction and maintenance costs associated with access and easement acquisition would in most instances be less than for new easements.

The typical width of a right-of-way for linear facilities within the Lahaina study area ranges from 10 feet for distribution lines to over 100 feet for the state highways. The desired width for a study corridor is 1/4 to 3/4 mile wide. Since some of the existing transportation corridors provide opportunities for siting, the corridors selected for further study should include the major roads between the Maalaea Power Plant and the Lahaina end-point.

The opportunities for siting a new line across private, State, or county roads varies according to the jurisdiction. The State Department of Transportation regulations allow utility lines to parallel roadways but there are certain setback restrictions (State of Hawaii, Department of Transportation, 1987). MECO's franchise agreement with the State allows construction of a transmission line adjacent to State and County roads (State of Hawaii, S.B. No. 1522, 1991).

__Inventory__

MECO Transmission Lines and Transmission Separation

The Maalaea Power Plant is located near the shoreline of Maalaea Bay, mauka of North Kihei Road, in the western portion of the study area. Five 69KV lines exit the Maalaea Power Plant; these lines are:

- Maalaea - Lahaina No. 1
- Maalaea - Lahaina No. 2
- Maalaea - Waiinu
- Maalaea - Puunene
- Maalaea - Kihei

MECO Substations

There are three substations owned by MECO within the Lahaina study area: Puukolii, Lahaina and the Maalaea switching station associated with the power plant.

MECO Generation Facilities

The Maalaea Power Plant is the primary power generating facility within the study area. The Maalaea Power Plant is capable of generating 163.7 MW from 15 diesel, two combustion turbine, and one steam turbine generators.

Pioneer Mill Co. Transmission System and Power Plant

PMCo owns and operates a small transmission system throughout their lands in West Maui to serve power to the irrigation system for the cane lands.

State Routes

There are three primary two-lane paved surface highways maintained by the State of Hawaii, in the study area: Honoapiilani Highway and portions of Kuihelani and North Kihei Road.

Secondary Roads

Two-lane asphalt or a graded dirt or gravel roadbed make-up most of the secondary roads in the study area. Most secondary roads are usually under County of Maui jurisdiction although some are privately owned and County maintained.

Major Cane Haul Roads

Major cane haul roads occur within HC&S and PMCo lands. They generally consist of two 20-foot lanes with asphalt paving or gravel and 8 to 10 foot shoulders. These roads were identified by PMCo engineers and are regularly used by tournhauler trucks as they transport cane from the fields to the sugar mill at Puunene. The roads are used almost exclusively for hauling cane because the trucks are 16 feet wide and this width can triple under a full load of cane. Also they travel at fairly high speeds both to and from the mill. In some cases the road surface changes to gravel if the road is some distance away from the sugar mill. Along most of the length of these roads through cane fields, a one to two foot high berm separates the edge of the road from the edge of the cane and acts to prevent water used to irrigate fields from flooding the roadway.

Other Cane Haul Roads

The roads consist of a network of dirt roads through fields cultivated for sugar cane, ranging from 10 feet to 25 feet wide, that are used exclusively by PMCo trucks, seed harvesters, and operations and maintenance vehicles. They are maintained by PMCo by trimming the cane back along the roadway edge. The roads are typically not graded or surfaced.

Jeep Trails and Unimproved Access

Jeep trails and unimproved access roads occur outside of the PMCo cane fields in undeveloped lands and in areas used for grazing cattle. As the name implies these roads are not improved, nor are they regularly maintained.

Constraint Ratings

Areas within 250 feet from an Existing 69KV Transmission Line - HIGH CONSTRAINT

One of the primary purposes of the Maalaea-Lahaina Third 69KV Line is to maintain reliable service to Lahaina if one of the two existing 69KV transmission lines is out of service. Since the two lines currently are sited within the same easement, a primary criterion in siting the third line is to site it in a physically separate power corridor. The Public Utilities Commission's General Order No. 6 specifies a minimum separation distance equal to the height of the tallest structure (in this case 70 - 80 feet).

The experience of MECO and other utilities is to increase separation to reduce the possibility of a multiple line outage due to a major storm event, fires or other catastrophic event. For this project, a minimum separation distance of 250 feet from existing 69KV lines has been adopted (Figure A1-5). Separation greater than 250 feet is preferable. Because transmission lines must enter and exit substations, often with other transmission lines, the separation criteria does not apply to line entry or exit from substations.

Areas within 500 feet from Existing 69 KV Lines - MEDIUM CONSTRAINT

One of the primary purposes of the Maalaea-Lahaina Third 69KV line is to maintain reliable service to West Maui if the existing 69KV line between Maalaea and Lahaina is out of service by establishing a physically separate power corridor. The Public Utilities Commission's General Order

No. 6 specifies a minimum separation distance equal to the height of the tallest structure (in this case 70-80 feet).

Areas within 500 feet of an existing 69KV transmission line (Figure A1-5) are rated medium constraint because span lengths of 400 feet to 600 feet or greater are typical. In a catastrophic event a broken conductor could come in contact with existing lines, i.e. within 500 feet.

Linear Features: Distribution Lines, State Routes, Secondary Roads, Major Cane Haul Roads, Other Connecting Roads and Jeep Trails and Unimproved Access - LOW CONSTRAINT
Other linear features such as easements occupied by MECO 23KV or distribution lines and PMCo lines present siting opportunities. Except in a few cases where two lines already occupy the same poles, overbuilding with 23KV lines and joint pole use with PMCo is a siting option. State Routes and County roads present siting opportunities because the line can be sited adjacent to the roadway thereby providing good access for construction and maintenance. Cane haul roads also present siting options. Some haul roads are more heavily travelled than others, presenting a slight constraint due to the possibility of cane haul trucks causing damage to transmission poles. Identification of lighter travelled cane haul roads with landowners is required for siting along cane roads.

BIOLOGICAL RESOURCES

Overview

The Maalaea-Lahaina study area includes land zoned "Conservation", certain portions of which provide habitat for endangered native plant species. At least five officially listed endangered species occur within or near the study area. Hawaii State Law (Chapter 195-D, Hawaii Revised Statutes) protects all federal and state listed threatened and endangered plants on all lands within the State. Any projects or actions that may adversely affect these plants should be coordinated with the DLNR (Division of Forestry and Wildlife, Memorandum 01, November 1991). In addition to the five listed species, there are six Category 1 candidate endangered species and six Category 2 species within or near the project area. The Category 1 candidate endangered plants are expected to be proposed for endangered species status sometime in FY1992. Although the Category 2 plants are rare, there are not enough data to support listing proposals at this time. [Note: The USFWS FY92 endangered species review did not list any of the study area Category 1 Plants as Endangered or Threatened].

Because of the federal and state endangered species laws and regulations, the proposed transmission line alignment should avoid areas which support these listed and Category 1 endangered species. If these areas cannot be avoided entirely, then the primary impact to the vegetation is expected to be due to the construction and maintenance of access roads and the chances of fire in the area may also increase.

The methods for preparing the resource inventory and map are provided as a separate technical report, Appendix D-1, Botanical Resources Technical Report, Char and Associates.

Inventory of Vegetation Types

Five general vegetation types are recognized below. The two vegetation types which cover the most area are the agricultural lands (sugar cane and pineapple fields), which occur on the more or less level areas and gently sloping lands, and the mixed grassland/shrubland which occur on the slopes from above Maalaea to Papalaua.

Agricultural lands

These are lands which are in active cultivation. Pineapple fields are found in the area between Highway 30 and the foothills of the West Maui Mountains. Sugar cane fields occur on the coastal plains and foothills from about the Ukumehame Beach Park to the project's Puukolii boundary area. Agricultural lands support very little of botanical interest; weedy species dominate on the less frequently disturbed areas such as alongside roads and irrigation ditches, rockpiles, etc. The principal investigator has conducted a number of surveys in these agricultural areas (Char 1986a, 1986b, 1988a, 1988b, 1989a, 1989b, 1990a, 1990b, 1991); no ETS plants were found on actively cultivated agricultural lands.

Kiawe-buffel grass association

This vegetation type occurs on moderately sloping lands and on smooth alluvial fans. Typically the physiognomy is of an open woodland with dense grass cover filling in the matrix between the trees. The kiawe trees are scattered or may form small stands, from 15 to 25 feet tall. The trees become denser in small gullies and low-lying areas. In the larger gulches other tree species such as Java plum and 'opiuma are found and the canopy is denser.

Mixed grassland/shrubland

This vegetation type occurs on the steeply sloping areas dissected by large, deep gulches. Scattered shrubs occur throughout an extensive grassland. In places, as on the tops of ridges, the grassland is replaced by shrubland. Stands of ironwood can be found in this vegetation type on the slopes facing Maalaea. Large erosion scars are a prominent feature on the sides of gulches.

Shrubland

This vegetation type occurs on the steeper slopes usually above the kiawe-buffel grass association. Its composition varies widely depending on the degree of past disturbances (e.g. fires, grazing), steepness of slopes, substrate types and rainfall. Native species may be the dominant components on areas with gray colored soils of trachyte and mugearite. Such mixed lowland dry shrublands support plants of *Dodonaea viscosa*, pili grass (*Heteropogon contortus*), 'ilima (*Sida fallax*), *Gouania hillebrandii*, naio (*Myoporum sandwicense*), sandlewood (*Santalum elliupticum*), etc. Puu Hipa and the adjacent slopes (*Lihau-Olowalu*) support areas of native shrubland and several ETS species.

Forest

Dry to mesic forests can be found on the slopes above the shrubland vegetation. Usually there is no sharp delineation between shrubland and forest and one type grades into the other with elements from both sides present. Large blocks of forestry plantings can be found in some areas. These include ironwood (*Casuarina equisetrifolia*), *C. Glauca*, various *Eucalyptus* species, and Norfolk Island pine (*Araucaria heterophylla*).

<u>**ETS Plants**</u>

Table A1-6 presents the ETS plants found on the project area; the general plant locations have been plotted on Figure A1-6. From the information obtained from the State's Division of Forestry and Wildlife (C. Corn, State Botanist, personal communication), four areas are of concern:

Puu Hona

Koaia (*Acacia koaia*) and *Hibiscus brackenrigei* have been recorded from this area. From the flyover, this area has been heavily grazed and the plants may no longer occur at the site. There is some chance that they could occur on more steeply sloping areas like the nearby Pohakea Gulch.

State DLNR Reserve

This reserve contains significant population of ETS species and should be excluded from any alignment plans.

Puu Hipa-Kihau-Olowalu area

Significant ETS plant populations are located in this area adjacent to the project boundaries. In addition, the Lihau Section of the West Maui Natural Area Reserve (NAR) occurs here. About 16 individuals of *Gouania hillebrandii* are found on the summit of Puu Hipa (Char 1990; Wagner *et al.* 1990).

Paupau Ridge

Located on the slopes above Lahainaluna School, this area supports eight ETS plant species. The ridge is also included in the Panaewa Section of the West Maui NAR (Figure A1-6).

<u>Constraint Ratings</u>

Natural Area Reserves and Plant Sanctuaries - HIGH CONSTRAINT

The State DLNR Natural Area Reserves, Paupau Plant Sanctuary, the State DLNR Reserve at Manawainui and the Puu Hipa area should be avoided as the reserve is regulated by state policies that legally protect resources. A critical habitat designation was made for *Gouania hillebrandii* which includes the Puu Hipa site, thus, the puu may fall under federal and state regulatory policies. The plant has also been reported at the 900 feet elevation along the lower south east slopes of Olowalu. Because Reserves are areas where ETS species are known to occur, it is likely that some ETS species might also be found outside of the boundaries of the reserve area. The DLNR Division of Forestry and Wildlife may require a more intensive field survey in lands adjacent to the reserves and plant sanctuaries as well as showing good cause why the lines have to be located in this area only. This may increase review and approval time, therefore they are considered high constraint.

Endangered, Threatened, or Sensitive Plant Species/Habitat - HIGH CONSTRAINT

Known occurrences of ETS plants in this study area (Table A1-6) were identified through a search of botanical records and literature from the Nature Conservancy and the State of Hawaii, no field work was conducted to verify the plant's existence. These areas historically have contained communities of plants designated by the Federal Government or the State of Hawaii as threatened or endangered or candidate. Even though these species are protected under the Federal Endangered Species Act (1973) and HRS 195-D, "Conservation of Wildlife and Plants" (as interpreted by Administrative Rule, Title 13, Subtitle 5, Chapter 124, "Indigenous Wildlife, Endangered and Threatened Wildlife and Plants and Introduced Wild Birds") which aim to conserve the species and the habitat, any action in these

Table A1-6
ENDANGERED, THREATENED OR SENSITIVE PLANTS WITHIN THE STUDY AREA

# ON MAP	SPECIES NAME	* STATUS
1	Acacia koaia	2
2	Diellia erecta	1
3	Exocarpus gaudichaudii	2
4	Gouania hillebrandii	E
5	Gouania vitifolia	1
6	Hesperomannia arbuscula	E
7	Hibiscus brackenridgei	1
8	Hibiscus kokio	2
9	Neraudia sericea	1
10	Remya mauiensis	E
11	Santalum freycinetianum var. lanaiensis	E
12	Schiedea menziesii	2
13	Schiedea salicaria	2
14	Spermolepis hawaiiensis	1
15	Tetramolopium capillare	1
16	Tetramolopium remyi	E
17	Torulinium odoratum	2

* Status

E - Officially listed as endangered.
1 - Category 1 candidate endangered species; will be proposed as endangered in FY 1992
2 - Category 2 taxa; plants for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time (U.S. Fish and Wildlife Service 1990).

areas would require a thorough field investigation to confirm the presence or absence and exact location of the protected resource. Therefore, for purposes of locating a corridor 1/4 to 3/4 mile wide, they are rated high constraint.

Lands Adjacent to the Plant Reserves and Sanctuaries - MEDIUM CONSTRAINT

Lands adjacent to the Puu Hipa, Manawainui Reserve, Paupau Sanctuary and the Natural Area Reserves areas discussed above are considered a medium constraint. Because they lie in close proximity to areas where ETS species are known to occur, it is likely that some ETS species might also be found within the boundaries of the project area. DLNR Division of Forestry and Wildlife may require a more intensive field survey in these areas as well as showing good cause why the lines have to be located in this area only which may increase review and approval time.

TOPOGRAPHIC FEATURES AND WATER RESOURCES

Overview

The Maalaea-Lahaina Third 69KV transmission line study area topography ranges from gently sloping on coastal plains and alluvial fans (from sea level to about 400 feet above mean sea level), to mountainous terrain dissected by numerous steep, V-shaped valleys and gulches. Towards the uphill portion of the study area, ground elevations increase to approximately 1,200 feet to 2,000 feet above mean sea level. The location of a transmission line corridor is generally not constrained by topography; however, terrain does influence the design, engineering and construction cost of the line.

Water resources such as streams can usually be spanned or crossed; however, some hydrologic features such as tsunami inundation zones and flood prone areas can present hazards to a transmission line. Because flood waters can erode and scour soils surrounding the poles, areas prone to frequent flooding should be located and avoided if possible or carefully considered in selecting alignments and pole locations. The risk of flooding can, however, be mitigated by proper design of the pole foundations and by adjusting span lengths. Tsunami inundation zones are areas that would potentially be inundated by tsunami waves. It is therefore important to locate the inundation zones and avoid siting the line within the zone if possible because of the added risk that a line could be heavily damaged or destroyed if a significant tsunami wave were to inundate coastal and nearby inland areas.

Inventory

Streams, Gulches and Surface Water Boundaries

The locations of surface water bodies that may impact transmission line routing are shown on Figure A1-7, Topographic Features and Water Resources. The potential influence of streams and gulches in flooding the study areas is discussed in the following section. The locations of streams, gulches, irrigation ditches, ponds and reservoirs are based on topographic maps prepared by the U.S. Geological Survey, dated 1983.

Floods from Storm Runoff

A flood is the inundation of lands not normally covered by water. Some flood flows are due to storm runoff, which causes a temporary rise of the water level in a stream or other water courses in excess of the physical limits of the channel. Such flood result in the inundation of adjacent lands generally referred to as flood plains.

Rainfall in West Maui and the study area generally varies from about 20 inches near the coast to about 400 inches at higher elevations. There are many streams, both perennial and intermittent, in the study area. Most of the perennial flow is diverted in the upstream reaches for irrigation. However, during heavy rains, many of the streams overflow and inundate the lower coastal areas (DLNR, 1971).

Potential 100-year flood areas as indicated by the Federal Emergency Management Agency or FEMA (1981), are shown on Figure A1-7, Topographic Features and Water Resources Map. These potential flood zones appeared to occur primarily in low-lying areas at and near the mouth of the Hahakea Gulch, Kahoma Stream and Olowalu Stream, and part of Lahaina and the Kealia Pond areas. The recent completion of the Kahoma stream flood control project in April 1990 appeared to reduce potential flooding areas to the general vicinity of the stream channel and some low-lying coastal areas (FEMA, 1991).

Tsunami

Seismic sea waves, or tsunami, is an extraordinary type of ocean wave produced by a sudden tectonic displacement of huge earth mass on the ocean floor. Tsunami activity causes destruction by a violent and turbulent mass of water, referred to as the bore type. Documented tsunami activities that have affected the study area are summarized below:

Date	Location	Approximate Wave Height
November 7, 1837	Lahaina	11 feet
May 17, 1841	Lahaina	3 feet
April 1, 1946	Maalaea	8 to 10 feet
April 1, 1946	Lahaina	up to 12 feet
April 1, 1946	Olowalu	8 to 10 feet
May 23, 1960	Lahaina to Maalaea	9 to 10 feet

The FEMA maps (1981) indicated that only narrow zones along the coastal areas are prone to 100-year coastal flood with velocity (Zone V-12) or tsunami inundation. The FEMA flood boundaries were estimated based on data and topography at the time of their evaluation. Potential tsunami run-up heights may vary if the topography in these areas changes.

Wind Factor

Although only three Hurricanes (Dot, Iwa and Iniki) have struck the Hawaiian Islands in the last 35 years, recent weather satellite observations have shown that there are much more tropical cyclones approaching but passing the islands than known earlier (U.S. Army Corps of Engineers, 1984). Further, Hurricane Iniki destruction and damage particularly to the island of Kauai in September 1992 emphasized the need to consider wind factors in transmission line routing and design.

Hurricane wind speeds are substantially higher (over 100 miles per hour) than the trade winds (generally 4 to 20 miles per hour). Further, wind speed may be amplified because of terrain effects (University of Hawaii, 1990: Professor Art Chiu, personal communication, 1991):

- **Valleys:** When winds enter a valley, wind speed may amplify in the narrow part of the valley. This situation may resemble the "Venturi effect".

- **Hills or mountains:** In general, wind speed tends to increase on the windward slope and reaches a maximum at or near the summit.

- **Mountain downslope winds:** Wind speed also accelerates downhill. The acceleration of winds to the lee of the Koolau and the Waianae mountain ranges on Oahu occurred during hurricane Iwa (National Research Council, 1983).

However, no analytical procedure is currently available to calculate the amplification of winds through valleys, or the acceleration of winds to the lee of mountain ranges (University of Hawaii, 1990). Nevertheless, quantitative data on wind amplification effects can be obtained using wind tunnel analysis (A. Chiu, personal communication, 1991), if such information is required for structural design.

The U.S. Army Corps of Engineers (1984) indicated that during Hurricane Iwa, much of the wind-damaged properties in Kauai could be related to winds that were topographically enhanced much more than the sustained wind speeds. In Kauai, damages were mainly to transmission and distribution systems and structures. Most of the island was without electricity during the height of the storm (U.S. Army Corps of Engineers, 1983).

In Oahu, Iwa's winds damaged eight of Hawaiian Electric's fourteen 138KV transmission lines, more than 100 poles supporting 46KV circuits were toppled, and at least an equal number of distribution circuit poles were also reported down (U.S. Army Corps of Engineers, 1983). Ninety one percent of Oahu was without electricity at the height of the storm.

The island of Maui was further away from Iwa's track and the damages were much less compared to Kauai and Oahu. However, based on a worst case hurricane scenarios developed by the U.S. Army Corps of Engineers (1984), the maximum gust could be 145 knots for a hurricane that approaches the Hawaiian Islands from the southeast or east, and a 120 knots maximum gust for a hurricane approaching from the southwest or south. In developing possible scenarios for hurricanes approaching the Hawaiian Islands from the southwest, the U.S. Army Corps of Engineers (1984) suggested that on Maui, certain regions may have stronger winds than other areas because of topographic enhancement of the wind speeds. These areas of enhanced winds include: the southern coast from Cape Hanamanioa to Kihei to Kaanapali, the southwestern slopes of Haleakala, and the West Maui Mountains. Thus, the concept of potential local terrain effect on wind speed, such as steep and narrow valleys within the study area, is considered in this constraint evaluation.

Constraint Ratings

Tsunami Inundation Zone - HIGH CONSTRAINT

Historical tsunami data (DLNR 1971) and FEMA (1981) described above indicate that only narrow zones along the coastal areas and some nearby inland areas in the Maalaea Bay area will be prone to inundation by tsunami waves. Tsunami inundation zone is rated a high constraint because the waves can destroy or damage transmission lines and poles in these areas.

Flood Prone Areas (100 year flood zone) - MEDIUM CONSTRAINT

A flood is the inundation of lands not normally covered by water. Some flood flows are due to storm runoff, which causes a temporary rise of the water level in a stream or other water courses in excess of the physical limits of the channel. Such floods result in the inundation of adjacent lands generally referred to as flood plains.

Flood prone areas do not preclude construction of transmission lines but may require special siting and engineering to minimize the potential loss of poles during a major storm event. Therefore, these hydrologic factors are rated medium constraint.

SLOPE, GEOLOGY AND SOILS

Overview

Geology and soils factors that could influence the siting of a transmission line include hazards that may cause difficulty and added expense during design and construction. In addition hazards related to slope and slope stability could affect the reliability of the transmission line after its installation. Three geologic and soils factors were identified as relevant to locating a transmission line corridor: geologic and seismic hazards, slope-related factors and soil characteristics.

Geologic and Seismic Hazards

This category includes such factors as fault rupture, earthquakes, volcanism and other ground movement-related hazards. The Hawaiian islands are of volcanic origin but the hazards related to active volcanism are primarily confined to the island with the youngest geologic age, Hawaii.

However, geologic and seismic hazards were reviewed at the regional level to ensure that these types of hazards would not significantly affect the siting of the line.

Slope-Related Factors

Slope can substantially affect the length of the line, position of poles and substations, length of access roads, construction methods required for access roads, and the amount of earth-work for road and pole line construction. Although construction in steep slopes can generally be accomplished, it tends to increase project construction and maintenance costs.

It is self evident that gentler slopes are more suitable than steeper slopes for pole line construction and access road location. A common threshold used to distinguish "steep" slopes are those greater than 30 percent.

Areas with severe slope instability can also present constraints to siting because of the potential for losing a pole in a landslide and the consequences of having to shut down the transmission line for extensive repairs.

Erosion - Related Factors

Soils that are subject to severe erosion potential and soft, loose or wet soils can make construction difficult and can potentially affect the stability of the pole line in a severe storm event.

Inventory

Geologic Formations

The USGS geologic map (Stearns, 1942) indicates that six main geologic formations are present in the study area.

Recent alluvial deposits, primarily consisting of stream or flood deposited silt, sand and gravel. Soft silts and loose sand deposits may occur within these younger sedimentary deposits. Typical transmission pole design may not be adequate in areas where soft or loose sediments occur at or near the ground surface, due to potential low bearing capacity and low resistance to lateral and uplift forces.

Older alluvial deposits, primarily consisting of stiff, bouldery clayey silts. The older alluvium mainly occur on alluvial outwash fans, along the valley floors and at the mouth of the major streams and gulches. Clay soils may be potentially unstable in areas of excessively steep slope, and/or excessive porewater pressure conditions.

Basaltic a'a and pahoehoe lava flows of the Wailuku Volcanic Series. Competent rock formation generally can provide firm support for transmission line structures.

Local cinder cones, consisting primarily of fire fountain type deposits of cinder, spatter, and pumice, of the Lahaina, Honolua and Wailuku Volcanic Series.

Thin beds of friable vitric tuff of the Wailuku Volcanic Series. Daylighting of adversely oriented friable tuff beds on valley walls may pose potential threat to rock slope stability.

Weathered andesitic lava flows of the Honolua Volcanic Series. Based on helicopter reconnaissance, these lava flows appear highly susceptible to weathering and erosion.

Slope

General topography and slope gradients in the study area were evaluated based on maps prepared by the United States Geological Survey (1983) and the Soil Conservation Service (1972).

Along the coastal and alluvial plains, the general topography is gently sloping (mostly 5% to 13% slope) towards the shore. Above an elevation of approximately 400 feet, the slope of the terrain range from about 15% to over 50% In these areas, numerous deeply dissected major valleys and gulches trend across the study area. Steep terrain may impact the proposed transmission line by increasing the potential for landslide and progressive slope movements, particularly in areas where expansive soils and erosion prone deposits occur.

Steep terrain can result in poor accessibility, and potentially significant increase in construction costs. Another effect that results from steep terrain with long deep ravines and gulches is the potential for amplification of wind speed.

Soil Factors

The U.S. Department of Agriculture's soil survey map of Maui (Soil Conservation Service, 1972) classified the surface and near-surface soils in the study area into 37 types. The soil types were reviewed for potential for slope instability, particularly in areas with abundant landslide scars and a history of soil slips; erosion potential, some fine sand and silt deposits may be prone to erosion when the protective vegetation cover is removed, for example, during construction; shrink/swell potential, expansive clays can be unstable on slopes and can become very soft upon saturation.

The geology/soils maps, Figure A1-8, shows the distribution of soils with these characteristics.

Seismic Hazards

Seismic risk maps have been prepared for all of the Hawaiian Islands by the U.S. Coast and Geodetic survey. The island of Maui is classified as seismic zone 2A by the Uniform Building Code (1989). The design and construction of the new transmission line system should conform to requirements outlined in the Uniform Building Code.

The island of Maui consists of two volcanoes, West Maui and Haleakala (Stearns and MacDonald, 1942). The study area is located mainly in the southern and southwestern foothill of the West Maui volcano. The ages of lavas of the West Maui volcano are estimated to range from about 2 million years (McDougall, 1964) to more than 25,000 years old (Crandell, 1983). The likelihood of a future eruption on West Maui appears to be remote (Mullineaux et. al., 1987).

Since the study area is located in areas that has not been affected by lava flows for at least 25,000 years, the potential of volcanic hazards affecting the study area in the future is considered to be very low.

<u>Constraint Ratings</u>

Slopes Greater than 30% - MEDIUM CONSTRAINT

Slopes in the range greater than 30 percent (Figure A1-9) are of significance to transmission line projects because of the additional engineering effort needed to design a line that passes through these areas. Slope substantially affects the length of transmission lines, location of the line, positions of poles and substations, length of access roads, the amount of earth movement for road and utility pole construction and vegetation removal and construction methods. Gentler slopes are more suitable than steeper slopes for pole erection and access road construction because the road and line distances are generally shorter and exposed areas are less likely to erode. While the poles do not occupy a large area, the stability of these structures may be undermined by erosion or stressed by accumulated soil deposits at their base. The increased difficulty in constructing stable structures, stringing conductors, and maintaining the lines in steeper areas creates a situation where slopes of 30% or greater are considered a medium constraint to transmission corridor siting.

Topographic data received from the U.S. Geological Survey Digital Elevation Model (DEM) were used to determine areas that are greater than 30 percent slope. DEM data is generated from satellite imagery and recorded digitally as cells. The resolution of the cell data is approximately 30 x 30 meters; therefore, narrow ravine areas that may be at a steeper gradient than 30 percent may not appear on the slope map.

Areas of Landslide Deposits - HIGH CONSTRAINT

In general, these are areas of relatively steep slopes (40% to 70%), active erosion, relatively high rainfall (25 to 200 inches per year) and where past landslides probably occurred (Soil Conservation Services 1972).

Due to the generally remote and difficult terrain, slope stabilization work in these areas could be prohibitively expensive. Transmission line routing should avoid siting transmission poles in these areas; therefore, they are rated high constraint.

Areas Prone to Slope Instability - MEDIUM CONSTRAINT

In general, these are areas of steep and bouldery terrain, active erosion, and moderate rainfall (20-40 inches), (Soil Conservation Service, 1972).

Although past landslides appeared not detected in these areas (Soil Conservation Service, 1972), the bouldery soil mantle covering steep terrain may be prone to slope instability. Site specific geotechnical investigation and slope stability evaluation should be performed before transmission poles are located in these areas; therefore, they are rated medium constraint.

Soils with High Erosion Potential - MEDIUM CONSTRAINT

These areas generally include clayey silts with moderate shrink/swell potential, located over 3 to 35% slopes, and extremely weathered, friable volcanic rock outcrops.

Transmission pole siting in these areas will require site specific investigation of subsurface conditions and evaluation of slope stability. In some areas, shallow depth to rock and careful transmission pole siting may help to mitigate or reduce potential erosion related problems.

Soft Loose Materials/Recent Alluvial Deposits - LOW CONSTRAINT

These areas generally include recent alluvial and dune sand deposits. Recent alluvium may contain soft silts and may not provide adequate support to the standard transmission pole foundation. Loose sand deposits may be prone to erosion when the vegetation cover is removed.

The potential occurrence of soft silts and loose sand deposits may require special consideration in transmission pole design. These areas should be explored during subsequent geotechnical investigation, to develop appropriate foundation design parameters for these soil types, if necessary.

CULTURAL RESOURCES

Overview

In general, a single archaeological or historic site is usually too small to influence corridor location. Furthermore, a single site can usually be avoided in locating a transmission line alignment. However, it is possible that national historic districts or areas containing large complexes of archaeological resources may have an effect on corridor location. At the regional study level, it is helpful to identify and map known archaeological and historic sites and districts and evaluate the study area in terms of the probability of occurrence of undiscovered archaeological resources.

A study was conducted by Cultural Surveys Hawaii (September 1991) with the objective of identifying known and potential archaeological sites in the study area extending from the *ahupuaa* of Hanakaoo in the Lahaina District to the ahupuaa of Waikapu in the Wailuku District. The study area extends between 1.2 to 3.5 miles mauka from the shoreline.

A map was prepared (Figure A1-10) that located the cultural resources of the study area including currently registered (at the State Historic Preservation Division) archaeological sites and site areas and potential site areas observed during a low elevation, aerial reconnaissance conducted by helicopter in September, 1991.

Cultural Surveys Hawaii provided the historical context of the study area and review of previous archaeological studies as well as recommendations in a separate technical report. Results of their work are summarized in this section.

Cultural and Historical Background

A rudimentary comparative picture of the pre-western contact (*i.e.*, before 1778) population of the southwestern section of Maui comprising the present study area is adumbrated by figures in nineteenth century missionary censuses (Schmitt, 1973). Results of the 1832 census, in which the total population of Maui is 35,062, give the following populations: for Lahaina, 4028; for Ukumehame, 573; and for Olowalu, 832. These three figures, when combined, represent 15 percent of the total Maui population. Allowing for post-western contact (*i.e.*, after 1778) distortions (e.g., disease and commercially-inspired population shifts), the population totals suggest that this portion of Maui may have accommodated a substantial portion of the island's pre-contact population.

The lands between Lahaina and Mā'alaea indeed encompass areas known traditionally to have been the residences of the *ali'i* and centers of population of the *maka'ainana*. Up to the end of the eighteenth century Lahaina was indeed a pre-eminent residence of the *ali'i* of Maui and, after the consolidation of the rulership of the Hawaiian Islands by Kamehameha early in the nineteenth century, Lahaina became the "capital" of the kingdom until the 1840s when the government moved to Honolulu.

The nineteenth century changes - commercial, social and religious - induced by the burgeoning foreign influx. During the year 1819 the first whaling ships arrived in Hawaiian waters and Lahaina became a primary harbor - along with Honolulu - for the provisioning of ships in the islands. The whaling trade flourished until the 1860s and gave impetus to the development and growing population of Lahaina. Between 1824 and 1861, 4747 whaleship arrivals are recorded for Lahaina, representing forty-seven percent of the total arrivals in all ports of the Hawaiian Islands. An 1846 census of Lahaina document the changes brought to the area midway through the nineteenth century: 3,445 Hawaiians, 112 foreigners, 600 seamen, 155 adobe houses, 822 grass houses, 59 straw and wooden houses and 529 dogs.

The first Protestant missionaries and their families arrived in Lahaina in 1823.

Sugar cane became the basis for a commercial venture that would reshape the landscape within much of the present study area in the second half of the nineteenth century. James C. Campbell, an Irish entrepreneur who had come to Lahaina in 1852, during the 1860s established, in partnership with Henry Turton, the Pioneer Mill plantation in West Maui. The plantation fields would eventually extend from Kahana to Ukumehame.

Inventory

Previous Archaeological Study

The first island-wide systematic archaeological survey was conducted by Winslow Walker of the Bishop Museum working between 1928 and 1929. Walker noted: "Terraces for the cultivation of taro were seen on West Maui in the vicinity of... Lahaina, Olowalu, and Ukumehame" (Walker, 1931: 71).

Walker also identified eleven archaeological sites within the present study area. All eleven sites are *heiau* of which only two were described by Walker as in "good condition." The remainder were either partially or totally destroyed. Three of the *heiau* are presently recorded (at the State Historic Preservation Division) sites within the study area: Hikii *heiau* (State Site No. 50-50-08-2); Ukumehame *heiau* (50-50-08-3); and Kawailoa *heiau* (50-50-03-4).

More sites were located and mapped during the Maui portion of the state-wide archaeological inventory survey in 1973 and, during subsequent years, as the result of contracted archaeological studies.

Recorded Archaeological Sites

Archaeological sites within the study area and recorded at the State Historic Preservation Office were located and mapped (Figure A1-10) and are listed in Tables A1-7 and A1-8 including both pre-contact and post-contact sites.

The names of the archaeological sites in Table A1-7 are given as they are recorded on maps and documents at the State Historic Preservation Division. The appellation "historic" appearing in some of these names refers only to the age of the sites - i.e., they date from the post-contact (post-1778) era - and not to any special historical significance.

As indicated at the bottom of the table, two sites: the *Hale Pa'i* building (Hawaii Register of Historic Places: May 18, 1981; National Register of Historic Places: May 13, 1976) and the Lahaina Historic District (National Register of Historic Places: December 29, 1962) have been deemed "historic places", i.e., they are of considerable historical, architectural, archaeological, or cultural importance. The Lahaina Historic District encompasses approximately 60 buildings and other structures of private and public ownership within Lahaina Town.

The *heiau* sites listed in the above table are traditional Hawaiian places of worship and shrines. The petroglyphs are rock carvings that may date to either pre- or post-contact periods.

The terrace, wall, enclosure and platform features that comprise many of the sites in the preceding table are generally traditional Hawaiian constructions of basalt boulder alignments or boulder-constructed levelled areas. Free-standing alignments created walls delineating property areas or, in the case of smaller constructs, enclosures for house sites or animal pens. Alignments retaining soil areas created terraces for planting. Piled and stacked boulders created level raised foundations for house building. The durability of these basalt constructions makes them the most ubiquitous and perceptible archaeological remnants in areas of Hawai'i where modern development has not yet encroached.

Table A1-7

RECORDED KNOWN ARCHAEOLOGICAL SITES

MAP NO.	SITE NO.	DESCRIPTION
1	50-50-08-2	Hiki'i *heiau*
2	50-50-08-3	Ukumehame *heiau*
3	50-50-08-4	Kawailoa *heiau*
4	50-50-03-226	Cemetery/graveyard*
5	50-50-09-1169	Petroglyphs; rock outcrop
6	50-50-09-1199	Petroglyphs; rock outcrop
7	50-50-03-1200	Petroglyphs
8	50-50-03-1201	Petroglyphs
9	50-50-03-1203	Complex including petroglyphs, terraces, habitation terraces, cave
10	50-50-03-1204	Grinding stone
11	50-50-09-1287	Complex of 17 features (including full and C-shape enclosures)
12	50-50-03-1596	Historic building; *Hale* Pa'i*
13	50-50-03-1776	Agricultural complex
14	50-50-03-2005	3 Agricultural terraces
15	50-50-03-2006	3 Agricultural terraces
16	50-50-03-2007	Agricultural/historic wall*
17	50-50-03-2008	Historic agricultural road*
18	50-50-03-2009	12 Agricultural terraces
19	50-50-03-2010	Agricultural/historic wall*
20	50-50-03-2478	Agricultural terrace
21	50-50-03-2479	2 Agricultural terraces
22	50-50-03-2480	2 Walled enclosures
23	50-50-03-2481	2 Agricultural terraces
24	50-50-03-2482	Agricultural terrace
25	50-50-03-2483	Walled enclosure; 8 ag terraces
26	50-50-03-2484	Walled enclosure
27	50-50-03-2485	Walled enclosure
28	50-50-03-2486	Platform; 13 grave markers
29	50-50-03-2487	Historic agricultural road*
30	50-50-03-2488	Walled enclosure
31	50-50-09-2708	Historic cemetery*
32	50-50-09-2709	Irrigation ditch*
33-50	50-50-09-2816 to 50-50-09-2833	Eighteen sites along the Lahaina Pali Historic Trail (See Table A1-9)
51	50-50-03-3001	Lahaina Historic District*
52	50-50-03-2489	Footpath trail; walled enclosure; grave; 19 agriculture terraces
53	50-50-03-2490	Wallen enclosure; habitation terrace; 2 agriculture terraces

* post-contract (after 1778) site (note: all other sites could fall into either the pre-contact or post-contact period)

Map No. 12, Site 50-50-03-1596
Hale Pa'i, the oldest printing house west of the Rockies and located outside of Lahaina on Lahainaluna Road, was placed on the National Register of Historic Places on May 13, 1976 and on the Hawai'i Register of Historic Places on May 18, 1981.

Map No. 51, Site 50-50-03-3001
The Lahaina Historic District, comprising approximately 60 sites, was placed on the National Register of Historic Places on December 29, 1962.

Table A1-8				
SITES SURVEYED ALONG LAHAINA PALI TRAIL				
MAP NO.	SITE NO.	COMPONENT FEATURES	TOTAL SITE AREA	FUNCTION
33	2816	midden, coral	3x6 m	habitation
34	2817	wall, culvert in road diversion wall,	2x7 m	road/water
35	2818	modified outcrop	2x6 m	road/rock quarry
36	2819*	terrace, petroglyph	15x5 m	shelter/art
37	2820	C-shape, wall, encl	30x50 m	shelter/unknown
38	2821	petroglyphs, crockery, glass	10x10 m	art/shelter
39	2822	alignment	50 m lg	alternate trail
40	2823	alignment, 1 pc. shell	25 m lg	alternate trail
41	2824	cupboards	30x10 m	storage
42	2825	petroglyphs, walls	20x10 m	art/shelter
43	2826*	encl, walls, glass	24x10 m	shelter
44	2827	enclosure, glass	1.5x.5 m	storage
45	2828	C-shapes, 1 pc. crockery	25x8 m	shelter/storage
46	2829	paved terrace	4.5x1 m	trail
47	2830	paved terrace	4x1 m	trail
48	2831	alignment	6.5 m lg	alternate trail
49	2832	wall, alignments	2.2x1 m	trail
50	2833	rock shelter, 1 pc. shell & coral	2x3 m	habitation

* tested

NOTE: A complex of probable traditional Hawaiian dryland agriculture features was observed in Manawaipueo Gulch, inland of the historic paved road. It was not recorded because it is located about 45 m outside of the survey corridor.

The Lahaina Pali Historic Trail, apparently constructed in the mid-nineteenth century, is a 4.5 mile long foot and horse trail connecting Lahaina and Wailuku. It is a demonstration trail of the Statewide Trail and Access System. It may be the precursor of a late nineteenth century road between Ukumehame and Ma'alaea. The trail is stone curbed and walled in open areas and cut and faced in gulches. A recently completed archaeological survey (Tomonari-Tuggle and Tuggle, 1991) recorded eighteen sites along the trail route (within a 50 foot wide buffer zone on each side of the trail) (Table A1-8).

The survey report summarizes the sites:

With two exceptions (Site No. 2816 and 2833), all sites are related to construction and use of the trail or the old coastal road. These 16 trail or road-related sites include alignments, enclosures, walls, petroglyphs, terraces, and C-shaped structures. They appear to have functioned as alternate trail routes, for water diversion, quarrying, trailside art, storage, and shelters...These sites are in fair to excellent condition...Sites 2816 (a midden scatter) and 2833 (a rock shelter) may be pre-contact Hawaiian sites that may also have been used into the post-contact period. (Tomonari-Tuggle and Tuggle, 1991: 3)

The report also describes the trail's condition: "The trail is heavily overgrown but it is in fair to excellent structural condition, with exceptional preservation along some sections" (*Ibid.*). The trail may, in the future, be developed and access opened for recreation and hiking by the public.

Areas of Good Cultural Resources Potential

A low-level aerial (helicopter) reconnaissance survey of the entire study area was completed by Cultural Surveys Hawaii on September 25, 1991 for the purpose of identifying and plotting previously unrecorded or potential site areas, and obtaining a general knowledge of present conditions within the study area.

Two site areas, designated Site Area 1 and Site Area 2 on Figure A1-10, were observed within the study area during the aerial survey.

Site Area 1 is located at the *makai* end of the west ridge and on the alluvial fan of Ukumehame Gulch, roughly between the 100 to 500 foot elevation. A rectangular enclosure was positively identified and it is suspected that similar sites are located within the bounds of the site area.

Site Area 2 is located on the flood plain of Launiupoko Stream at an elevation of 400 to 600 feet. Plentiful habitation sites and agricultural terraces were observed within this area.

Ms. Agnes Griffin of the State Historic Preservation Division reports that an archaeological study presently in preparation has found similar sites within Launiupoko (A. Griffin, personal communication, October 1991).

Conclusions and Recommendations

The archaeological investigations indicate the presence of a substantial pre-contact (pre-1778) Hawaiian population within the southwestern portion of Maui encompassing the present study area. Such a population would have created religious, habitation, craft and agricultural structures associated with a vibrant, coherent, regenerative society. Many of these structures have remained intact within the study area despite years of modern impacts, as evidenced by the number of sites already recorded, demonstrating the concentration of activity along the western slopes and lowlands of West Maui.

As an adjunct to the task of locating archaeological sites, Cultural Surveys Hawaii has included a preliminary delineation of mid-nineteenth century Land Commission Awards (LCA) within the present study area. The majority of these awards, given out following the Great Mahele of 1848, were *kuleana*, i.e. parcels of land conferred to native non-*ali'i* Hawaiians able to prove that they lived upon or actively farmed these lands. Individual LCA parcels, the locations of which were derived from modern tax maps, are plotted on the accompanying study area map. The points marking LCA locations on the map, though not indicating the size of the individual parcels, represent house lots and agricultural fields that were actively utilized by native Hawaiians up to and beyond the 1850s. The use of these parcels in the nineteenth century probably follows the same patterns developed in pre-contact (pre-1778) times. Thus the parcels may represent ancient settlement patterns within the study area and may give clues to the potential location of structures and artifacts associated with both the pre-contact and post-contact Hawaiian population.

The population distribution indicated by the LCA patterns suggests widely dispersed habitation and agricultural activities throughout major portions of the present study area. The populace appears to have been scattered across alluvial fans with activity concentrated in the well-watered drainages and along the coastline.

Based on the sites already recorded, site areas observed during the aerial reconnaissance, and the LCA information discussed above, we would expect some impact to archaeological sites within the present study area regardless of the route proposed for the transmission line. This is especially true for the Lahaina area, all stream valleys, alluvial fans and coastal areas within the study area. However, the upper elevations of the valley walls and the ridge crests between valleys are generally considered to have low probability of archaeological site occurrence.

Wherever the transmission line corridor crosses archaeological sites it is probable that the State Historic Preservation Division will minimally require archaeological surface survey. LCA parcels are considered locales of potential archaeological concern as they represent areas where habitation and agricultural activities are known to have occurred. Thus any specific LCA parcels to be impacted by a potential transmission line corridor will also require archaeological surface survey and archival research.

An additional concern of the State Historic Preservation Division is traditional Hawaiian site remnants and artifact scatters in existing sugar cane fields. This concern can be addressed by surface inspection of the transmission line corridor where it passes through cane fields.

Also, older plantation constructions and structures such as flumes, irrigation ditches and camp buildings are of archaeological concern because of their age and value in the recording of a fast-disappearing segment of Hawaiian history. Any of these elements of plantation life potentially affected by the transmission line corridor would likely require some effort to document their history and use.

Several recommendations resulted from the regional study phase of the project:

1) The transmission line corridor should be routed to avoid known archaeological sites. Of special concern is the avoidance of any impact to *heiau* and petroglyph sites as they are of particular cultural significance.
2) Where the corridor must pass across known archaeological sites, placement of the poles should be such that impact to these sites is avoided.
3) Consider placing the transmission line corridor at as high an elevation as possible to reduce impact to archaeological sites likely to be located in the valleys.
4) The Lahaina Pali Historic Trail, a nineteenth century foot and horse trail is currently a demonstration trail of the Statewide Trail and Access System. It will be developed in the future with access open to the public for hiking and recreation. Thus a potential transmission line corridor should avoid any impact to the trail, the archaeological sites associated with it, and the trail's immediate surroundings.

Constraint Ratings

National Register District, Lahaina Pali Trail and National or Hawaiian Register Sites - HIGH CONSTRAINT

Within the Lahaina Study Area there are two areas that have National Register Status. Having been placed on historic registers, two sites: the Hale Pai building (Hawaii Register of Historic Places: May 18, 1981; National Register of Historic Places: May 13, 1976) and the Lahaina Historic District (National Register of Historic Places: December 29, 1962) require special attention if they would be affected by any projected transmission line corridor. Of specific concern in planning, according to a guide prepared by the State Historic Preservation Division, the Hawaii Register "require(s) review of privately funded projects that may affect historic properties. This review is done under state and county laws and permit procedures: (State Historic Preservation Division [n.d.]). At the same time, "the Hawaii and National Registers do not stop county, state and federally assisted development projects" (Ibid.). Because of the lengthy review and permit process with low probability of approval, these areas are rated high constraint.

Recorded Pre-Contact and Post-Contact Sites - MEDIUM CONSTRAINT

Cultural resources do not usually constrain transmission line siting, because their locations are usually small or discrete units that can be avoided during the alignment and right-of-way selection. However, any sites on the National Register fall under the protection of the Historic Preservation Act (1984), and known archaeological locations are of public concern. As such, they must be avoided during construction of the line. Reviews, studies, and approvals during the design of the line may mean time and potential financial delays; thus they are considered a medium constraint to siting. It is important to identify and avoid these areas during the corridor identification stage.

CORRIDOR IDENTIFICATION

COMPOSITE CONSTRAINT ANALYSIS

The data analysis and constraint ratings described in the previous section classify each mapped data factor according to its suitability for transmission line siting as exclusion, high, medium, or low constraint areas. Exclusion, high and medium constraint ratings are summarized in Table A1-9; all other factors are considered low constraint or opportunities for siting.

After each data factor had been assigned a constraint rating data factors with exclusions, high and medium constraint ratings were separated from data factors with a low constraint rating by the computer mapping system.

Table A1-9
CONSTRAINT RATING SUMMARY

DATA CATEGORY	CONSTRAINT RATING
	— EXCLUSION AREAS —
Existing Land Use	Active Landfills
	— HIGH —
Land Ownership	U.S. Coast Guard Land
Land Regulation	State Conservation District Lands [Protective (CP) Subzone]
Existing Land Use	Shooting Range
Existing Utilities/ Transmission Separation	Areas Within 250 Feet From Existing 69KV Transmission Lines
Biological Resources	Natural Area Reserve Plant Sanctuary or Reserve Endangered, Threatened or Sensitive Plant Species Habitat
Topography and Water Resources	Tsunami Inundation Zone
Geology & Soils	Areas of Landslide Deposits
Cultural Resources	National Register District National Register Site (Hawaii Register Site) Lahaina Pali Trail
	— MEDIUM —
Land Regulation	State Conservation District Lands [Limited (CL) Subzone] State Conservation District [Resource (CR) Subzone] State Conservation District [General (CG) Subzone] Special Management Area (SMA)
Existing Land Use	Residential Commercial School Resort Parks/Recreation/Golf Course/Cemetery Lahaina Pali Trail Public/Community Facility Quarry Communication Site Reservoir
Existing Utilities/ Transmission Separation	Areas Within 500 Feet From Existing 69KV Lines
Proposed Projects	Projects Under Construction
Biological Resources	Lands Adjacent to Plant Reserves and Sanctuaries
Topography and Water Resources	Flood-prone Areas (100-year flood zone)
Slope	Slopes Greater than 30%
Geology and Soils	Areas of High Erosion Potential Areas Prone to Slope Instability
Cultural Resources	Surveyed & Recorded Pre-Contact Site Surveyed & Recorded Post-Contact Site

Plots of the constraint categories were generated by computer. The exclusion and high constraints were plotted on one overlay and medium constraints were divided into two groups and plotted on separate overlays. The two groups were: 1) land use and land controls constraints and 2) engineering, biology and cultural resource constraints. Low constraint areas were not plotted since these were considered opportunities for siting.

The constraint overlays were then used to identify areas of high constraint and to highlight areas of least constraint which could provide opportunities for the location of transmission corridors. Areas having multiple exclusion, high, or medium constraints were considered to be the least suitable for siting a transmission line corridor. Generally, the most highly constrained areas were along the shoreline and in areas of steep terrain. In the remaining portion of the study area there were isolated areas that contained multiple constraints to be considered in identifying corridors.

SITING ISSUES AFFECTING CORRIDOR LOCATION

The siting issues noted below pertain to the potential for locating a transmission corridor (1/4 to 3/4 miles wide) within which alternative alignments (200 - 500 feet wide) will be selected and the transmission line right-of-way (50 - 75 feet wide) will eventually be found. Because the corridors cover large areas, broad general siting issues will be emphasized in the constraint analysis although sensitive site-specific issues (eg. an historic building located in a particular valley) will also be considered.

Some general considerations:

- State of Hawaii Department of Land and Natural Resources has jurisdiction over approximately 60% of the project area.
- More than one half of the study area is within public jurisdiction by the State of Hawaii and the other half is privately owned. Most of the private land is in large parcels (greater than 250 acres). Pioneer Mill Co. (Amfac JMB/Hawaii) is the largest private landowner.
- Honoapiilani Highway, State Route 30, is the only travel route to West Maui from the southern portion of the Island. It connects Lahaina and the north shore with the central areas of Kahului and Wailuku. It is a scenic, coastal road with aesthetic and recreational values.

- With exception of Lahaina, Kaanapali Resort, and several small townships like Olowalu and Mopua, the area is of rural character and contains primarily open undeveloped rugged lands, grazing area, and cane fields.
- Electrical system reliability is increased by maintaining separation between the transmission elements in the electrical system. In the event of one pole falling, the lines from one line would not damage the adjacent line. The Public Utilities Commission's minimum separation requirement is the length of the tallest structure, in this case, 70 feet. For purposes of this planning study, the minimum separation from the existing 69KV transmission line is 250 feet.
- The entire study area contains rough terrain most of which is dissected by gulches running perpendicular to the proposed corridor. These gulches range between 35 - 2000 feet wide and they often form deep ravines.
- The sensitive biological resources are generally found in the upper reaches of the watershed and within the West Maui Forest Reserve mauka of the study area. A few scattered areas of endangered and candidate plant species occur around Puu Hona, Manawainui Gulch, Puu Hipa, and Paupau.
- The SMA (Special Management Area) extends across the entire study area along the shoreline. Due to regulatory requirements, siting within the SMA should be avoided.
- Limited and Resource subzones of the Conservation District occur along the shoreline between Maalaea and Lahaina.
- One-third of the study area is within terrain of slopes greater than 30 percent; the steepest portion being within the Maalaea-Ukumehame study section.
- Soft loose materials/recent alluvial deposits occur along most of the shoreline and near shore areas. Steeper terrain contains areas of landslide deposits, areas prone to slope instability and soils with high erosion potential.
- Almost the entire shoreline is prone to flooding and much is within the tsunami inundation zone.
- The two existing 69KV transmission line corridors are located in the center of the study area from Maalaea to Wainee, near Lahaina, where they branch to a makai and mauka corridor.

In the Power Plant Study Section I, siting is influenced by the presence of other 69KV lines and the shoreline:

- Maalaea Power Plant is within the SMA, requiring SMA approval to construct the new line.
- Ninety percent of this study section is cultivated for sugar cane.
- Four transmission lines exit the Maalaea Power Plant and traverse the power plant study section to converge at the Honoapiilani Highway at a single crossing.
  Siting at this crossing will require coordination with Wailuku Agribusiness and the State Dept. of Transportation.
- High density multifamily residential and commercial use exists on the shoreline near Maalaea power plant, confining any shoreline corridor alternative.
- Borrow pit/quarry area with slopes greater than 30% is located near the Honoapiilani Highway crossing.
- Crossing is further congested near the borrow pit/quarry by the presence of two post-contact historic sites, a historic cemetery and an historic irrigation ditch.
- Tsunami inundation zone exists makai of the Maalaea Power Plant.

Within the Maalaea-Ukumehame Study Section II, the siting issues relate to terrain, land ownership and regulation, and protection of viewplanes and recreational and archaeological resources:

- The majority of the State of Hawaii owned land is in Conservation Land Use District. Use of these lands will require a Conservation District Use Permit.
- Limited and Resource subzones are located along the shoreline as well as inland areas while two Protective Subzone areas occur inland. The existing 69KV transmission lines cross the area designated Protective Subzone surrounding the Manawainui Gulch. The transmission lines cross Hanaula Gulch which is designated Limited Subzone. Transmission lines are not specifically a permitted use in these subzones and conditional use will require Board of Land and Natural Resources approval.
- Lahaina Pali Historic Trail traverses the Ukumehame area between Ukumehame Beach Park on the Honoapiilani Highway and Wailuku Agribusiness property. Since this trail has both recreational and historic preservation values, crossing or paralleling of the trail may be an incompatible use.

- A shooting range is located in the makai portion of the study section across the Honoapiilani Highway from the Ukumehame Beach Park.
- Recreational facilities include the Lahaina Pali Historic Trail, C. Brewer golf course, shooting range, Ukumehame Beach Park.
- Pineapple is cultivated in the fields west of the Honoapiilani Highway both north and south of the existing 69KV lines. The new corridor should avoid these fields.
- Endangered and candidate plant species have been reported around Puu Hona, although it is suspected that the populations have diminished due to overgrazing and off road vehicle use.
- A complex of pre-contact archaeological features are located above McGregor Point and numerous post-contact sites are located along the Lahaina Pali Trail.
- The area is characterized by steep terrain consisting of slopes greater than 30 percent slope and dissected by gullies and ravines. The steep slopes rise up quickly from the narrow shoreline highway, and cover approximately 50% of the study section.
- The upper Manawainui Gulch is surrounded by soils with high erosion potential and areas prone to slope instability.
- DLNR owns a native plant reserve at upper Manawainui Gulch.
- A few areas of landslide deposits exist in the area between Ooawa Kilika Gulch and Paleaohu Gulch.
- Areas prone to slope instability exist on the Kaunoahua Ridge.

In the Olowalu-Makila Study Section III, the siting issues relate to geology and soils, existing and proposed land use:

- Pioneer Mill Co. cultivates most of their lands for sugar cane production, and the edge of cane fields presents an opportunity for siting the line.
- Townships of Mopua and Olowalu and surrounding private residential areas are located in this study section and recreational beach parks are located in several shoreline areas.
- Since the terrain is not as steep as in other study sections, gulches are usually narrow and shallow.
- Makila Stream contains numerous Land Commission Award Parcels and two areas with good cultural resources potential occur under the existing 69KV lines.

- Puu Hipa and Puu Mahanalua Nui and a quarry area contains steep slopes and soils with high erosion potential.
- Areas prone to slope instability occur near Luakoi Ridge and landslide deposits occur north of Luakoi Ridge.
- Pioneer Mill Co.'s irrigation ditches run parallel to the proposed transmission corridor.
- Pioneer Mill Co.'s distribution lines extend along the shoreline from the mill in Lahaina to the Ukumehame Beach Park.

In the Lahaina-Wahikuli Study Section IV, the existing land use is more complex and some of the siting issues relate to land ownership and jurisdiction:

- Lahaina Town and Puamana dominate the western portion of the study section. Lahaina Historic Town Center is a National Register District, highly developed with residential, churches, schools, commercial, and public facilities throughout.
- The Lahainaluna School is in the foothills of the West Maui mountains and the urban area extends from the town center of Lahaina to the school property.
- Cane fields cover approximately 60% of the study section and surround Lahaina and extend inland to the steeper slopes; the transmission corridor cannot avoid cane.
- The Lahaina Bypass (Honoapiilani Highway Bypass) is in the final design engineering phase. It will be constructed within the next five years between Launiupoko and Honokowai.
- State of Hawaii Housing and Finance Development Corporation (HFDC) is developing the Lahaina Master Planned Community; Phase I is under construction and Phase II is delayed due to ceded lands issue.
- The proposed Wahikuli Substation, original endpoint of the project, is located within the HFDC Lahaina Master Planned Community.
- Kahoma and Kanaha Streams cross the study section. Kahoma Stream flows in to a flood control channel which ends at the coast near the harbor. This linear feature is designed to control flooding in central Lahaina. Another flood control project is planned for Kauaula Stream.
- A National Register site, *Hale pai*, the oldest printing shop west of the Rockies is located on Lahainaluna Road.

- Hahakea Stream has been surveyed and contains numerous recorded pre-contact archaeological sites.
- The Paupau plant sanctuary is located makai of Paupau puu.
- Steep slopes (> 30%) occur along the study area boundary and along Hahakea, Kahoma, and Kanaha streams, and some landslide deposits occur in the upper reaches of the above mentioned streams.
- Several Pioneer Mill Co. irrigation ditches parallel the transmission corridor representing potential siting opportunities; two large reservoirs occur within the study section.
- Pioneer Mill Co and MECO share transmission poles in several locations within the study section

ALTERNATIVE CORRIDOR IDENTIFICATION

The results of the constraint and opportunities analysis along with additional evaluation of the data maps was used to identify alternative corridors 1/4 to 3/4 mile wide. These alternative corridors generally followed three main routes (i.e. mauka, central and makai) from the Maalaea Power Plant to the vicinity of the proposed Wahikuli Substation. These alternatives had numerous opportunities to cross between the three main routes and subalternative routes to exit the power plant and to enter the proposed substation site.

The alternative corridors were identified as individual segments and the segments were labeled with letters referring to the study section in which they are located as well as a sequential number. For example those segments labeled "MU" indicate the corridor segments are within the Maalaea-Ukumehame study section. The alternative corridors are shown in Figure A1-11. The following is a brief description of the corridor segments in the four sections of the study area.

Power Plant Study Section I

In the Power Plant section, four corridor segments were identified. Segments PP-1 and PP-2 are parallel to each other and to the existing transmission lines exiting the power plant toward West Maui. PP-1 is on the Wailuku side of the existing transmission lines while PP-2 is on the Maalaea side. PP-3 follows the shoreline between the power plant and the Honoapiilani Highway. Segment PP-4 is a connecting segment between the intersection of PP-1 or PP-2 and the makai corridor segments; it follows the Honoapiilani Highway for the entire length of the segment.

Maalaea-Ukumehame Study Section II

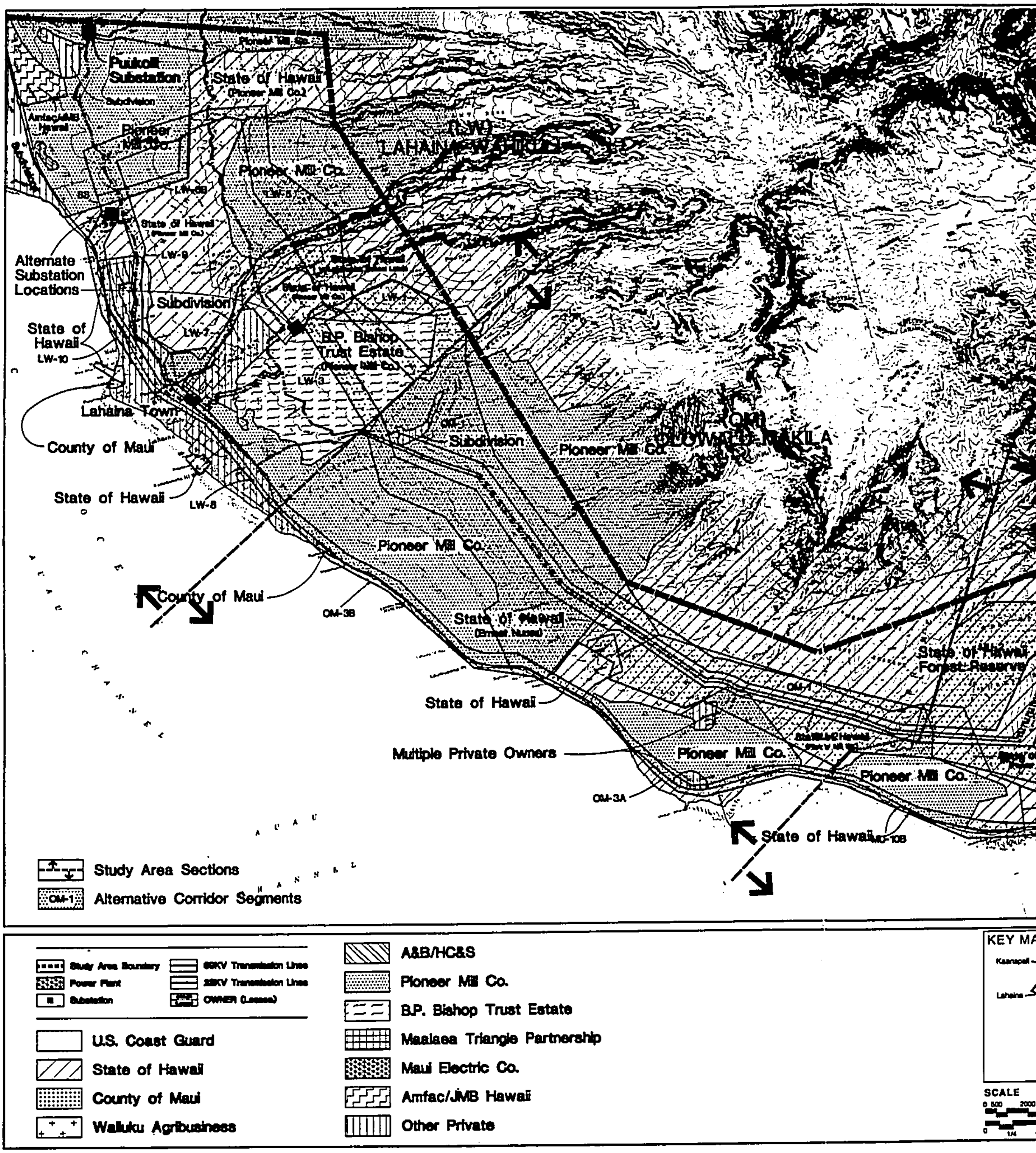
This section consists of thirteen (13) corridor segments. The segments combine to form three basic corridor alternatives over the West Maui mountains, mauka (MU-1 & 2), central (MU-3A & 3B, MU-4, 5, 6, 7, 8 and 9) and makai (MU-10A, 10B).

Olowalu-Makila Study Section III

Three long corridor segments were identified across the study section. OM-1 is the mauka corridor, OM-2 is the central corridor and OM-3A and OM-3B make up the coastline corridor.

Lahaina-Wahikuli Study Section IV

Because of the commercial and residential land use constraints in this study section, there are numerous (11) short corridor segments that follow the perimeter of existing and proposed developments. Here again, there is essentially a mauka, central and coastal alternative, with a segment following the flood control channel that connects mauka and central corridor segments with the coastal alternative.


Puukolii Substation
State of Hawaii (Pioneer Mill Co.)
Subdivision
Amfac/JMB Hawaii
Pioneer Mill Co.
(LW) LAHAINA-WAHIKULI
Pioneer Mill Co.
LW-3B
State of Hawaii (Pioneer Mill Co.)
LW-9
Alternate Substation Locations
Subdivision
LW-7
B.P. Bishop Trust Estate (Pioneer Mill Co.)
LW-3
State of Hawaii
LW-10
Lahaina Town
County of Maui
Subdivision
Pioneer Mill Co.
(OM) OLOWALU-MAKILA
State of Hawaii
LW-8
Pioneer Mill Co.
County of Maui
OM-3B
State of Hawaii (Ernest Nunes)
State of Hawaii Forest Reserve
State of Hawaii
OM-1
Multiple Private Owners
Pioneer Mill Co.
Pioneer Mill Co.
OM-3A
State of Hawaii
MO-10B
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
OWNER (Lessee)
U.S. Coast Guard
State of Hawaii
County of Maui
Wailuku Agribusiness
A&B/HC&S
Pioneer Mill Co.
B.P. Bishop Trust Estate
Maalaea Triangle Partnership
Maui Electric Co.
Amfac/JMB Hawaii
Other Private
KEY MA
SCALE

XEROX COPY

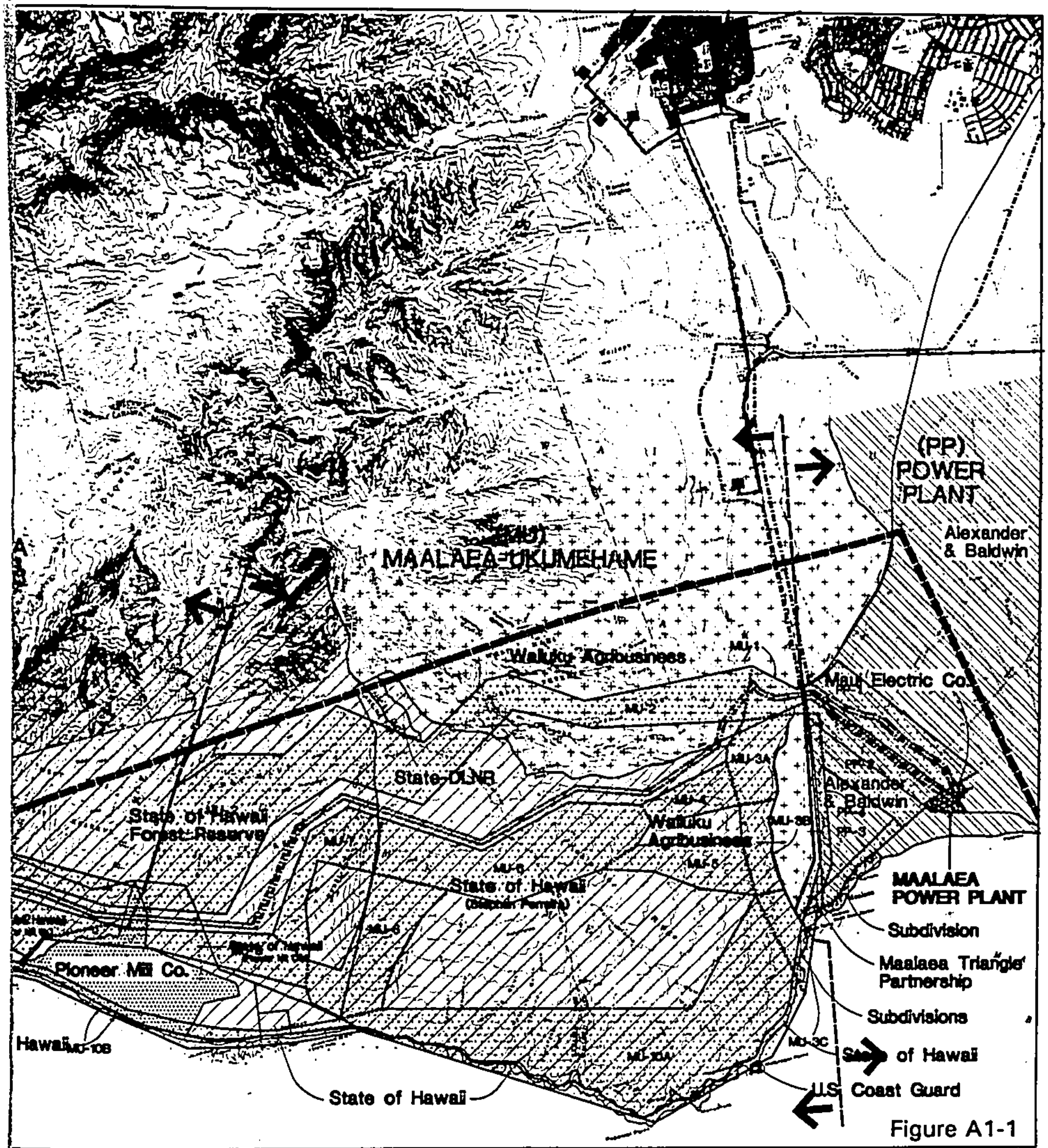
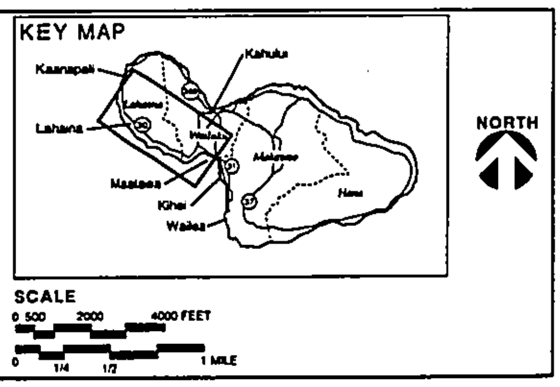


Figure A1-1



Alternative Corridors and Land Ownership

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

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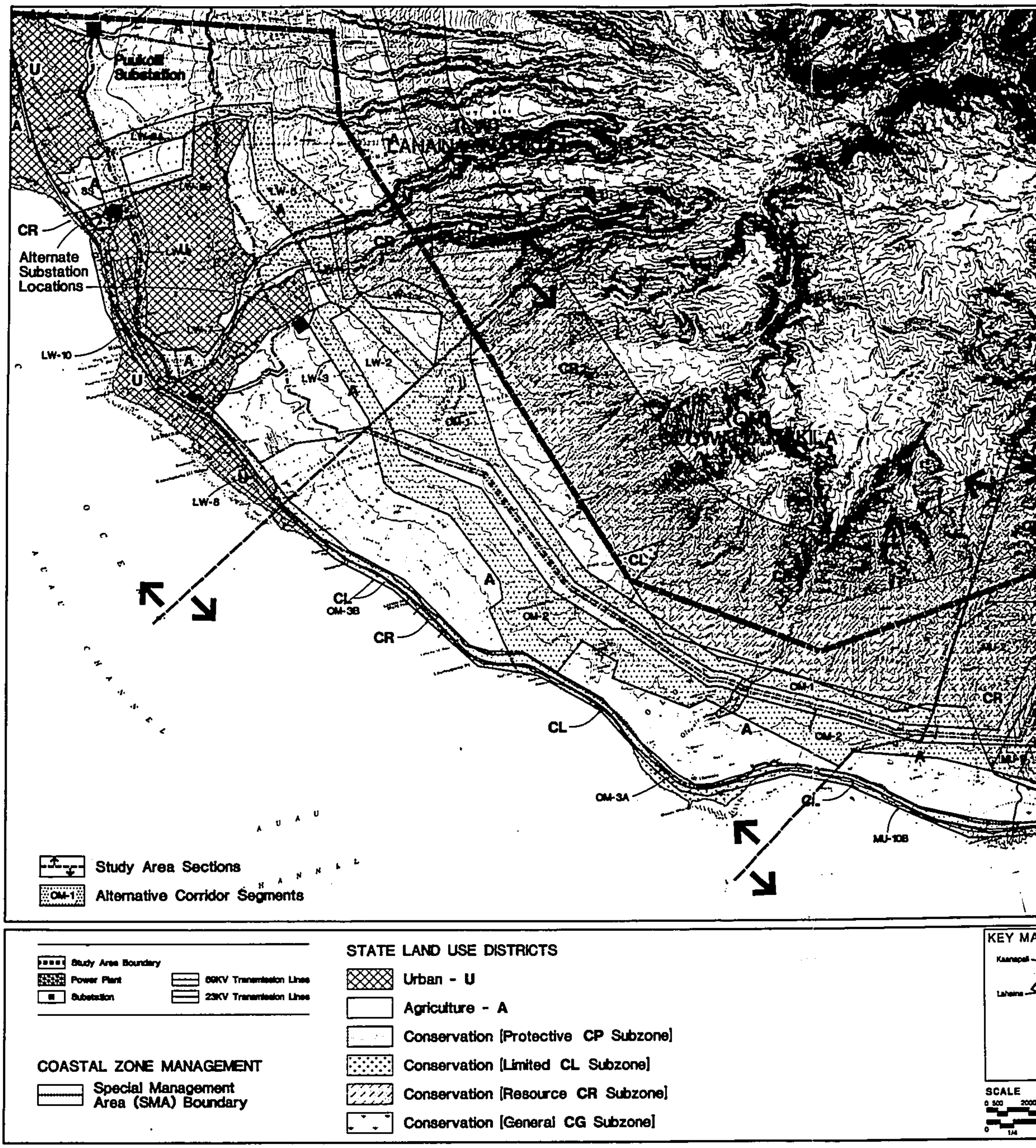


Puukolii Substation
CR
Alternate Substation Locations
LW-10
LW-8
LW-3
LW-2
CL
OM-3B
CR
CL
OM-3A
MU-10B
OM-2
OM-1
A
U
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
COASTAL ZONE MANAGEMENT
Special Management Area (SMA) Boundary
STATE LAND USE DISTRICTS
Urban - U
Agriculture - A
Conservation [Protective CP Subzone]
Conservation [Limited CL Subzone]
Conservation [Resource CR Subzone]
Conservation [General CG Subzone]
KEY MA
SCALE

XEROX COPY

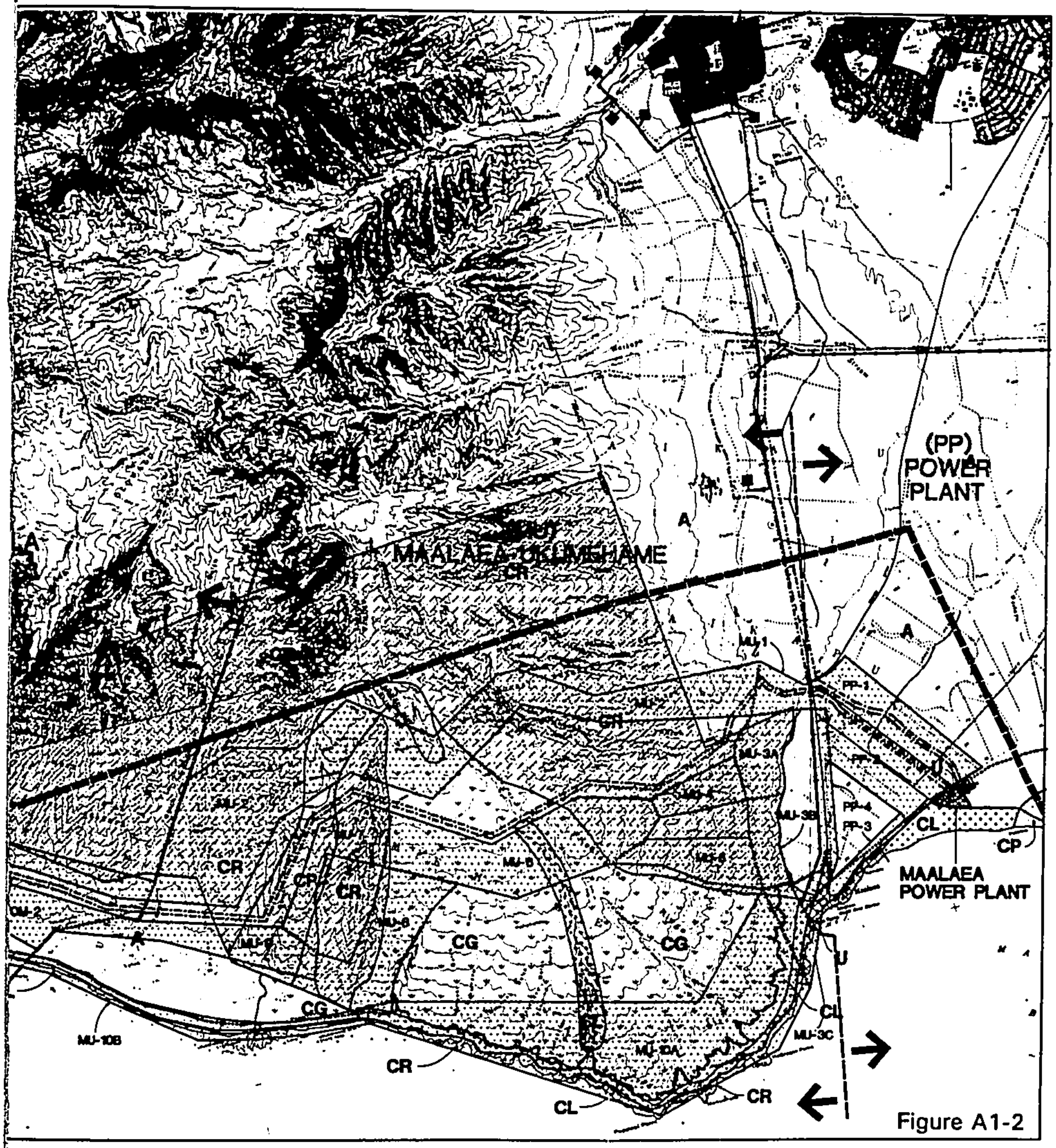
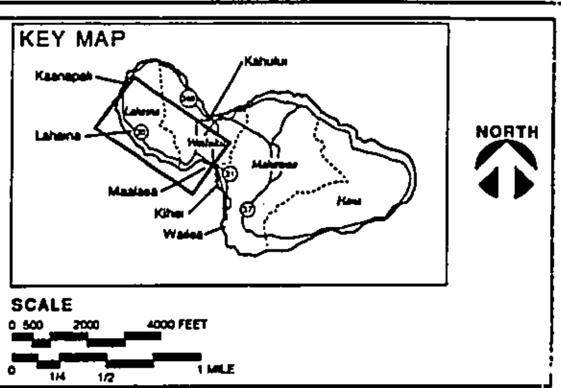


Figure A1-2



Alternative Corridors and Land Regulation

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

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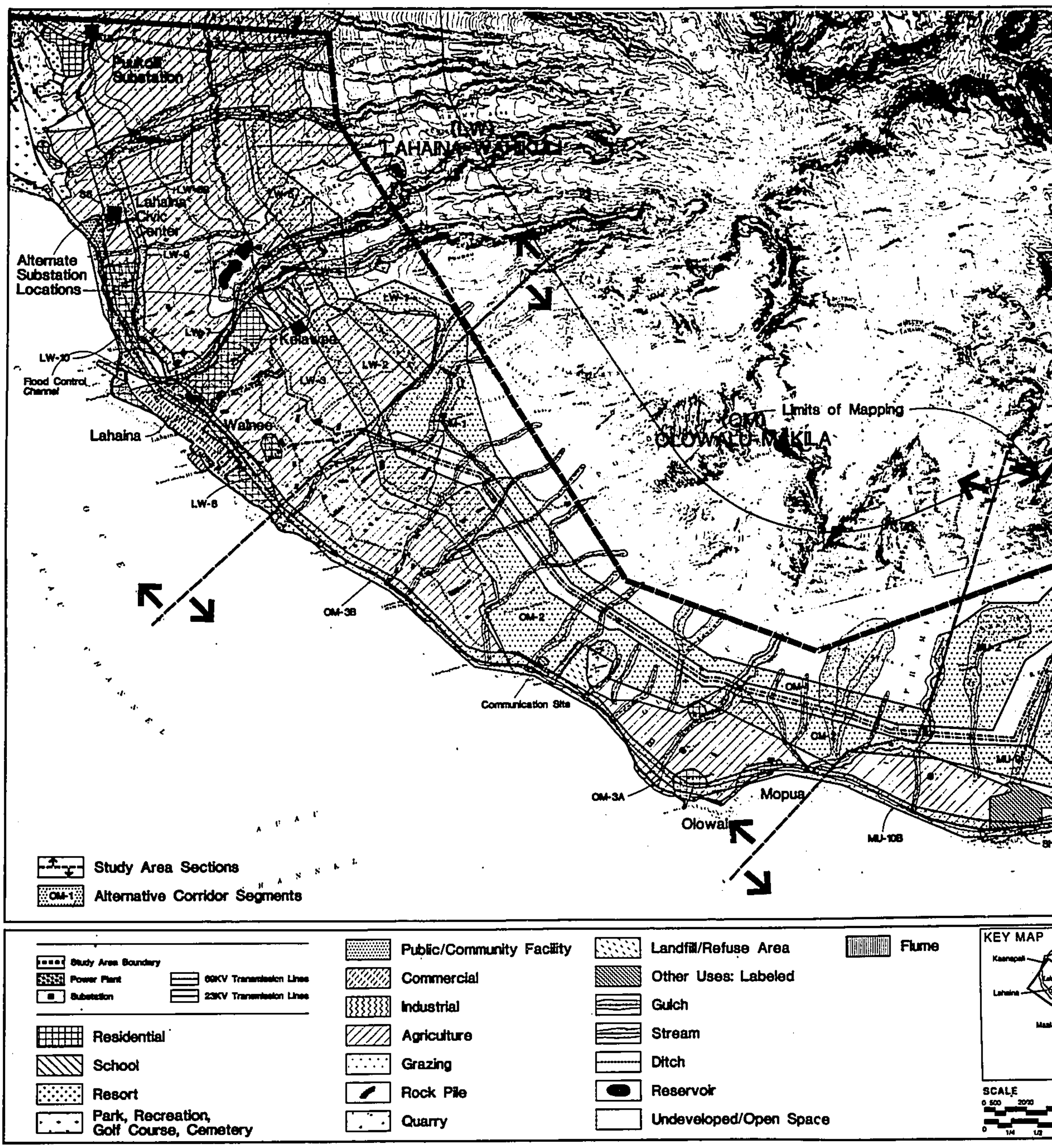

Puukolii Substation
(LW)
LAHAINA-WAIHIKULI
Lahaina Civic Center
Alternate Substation Locations
LW-9
LW-7
LW-1
LW-2
LW-3
LW-10
Flood Control Channel
Kelawea
Lahaina
Wainee
LW-6
OM-3B
OM-2
Communication Site
OM-3A
Olowalu
Mopua
MU-10B
Limits of Mapping
(OM)
OLOWALU-MAKILA
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Residential
School
Resort
Park, Recreation, Golf Course, Cemetery
Public/Community Facility
Commercial
Industrial
Agriculture
Grazing
Rock Pile
Quarry
Landfill/Refuse Area
Other Uses: Labeled
Gulch
Stream
Ditch
Reservoir
Undeveloped/Open Space
Flume
KEY MAP
Kaanapali
Lahaina
SCALE

XEROX COPY

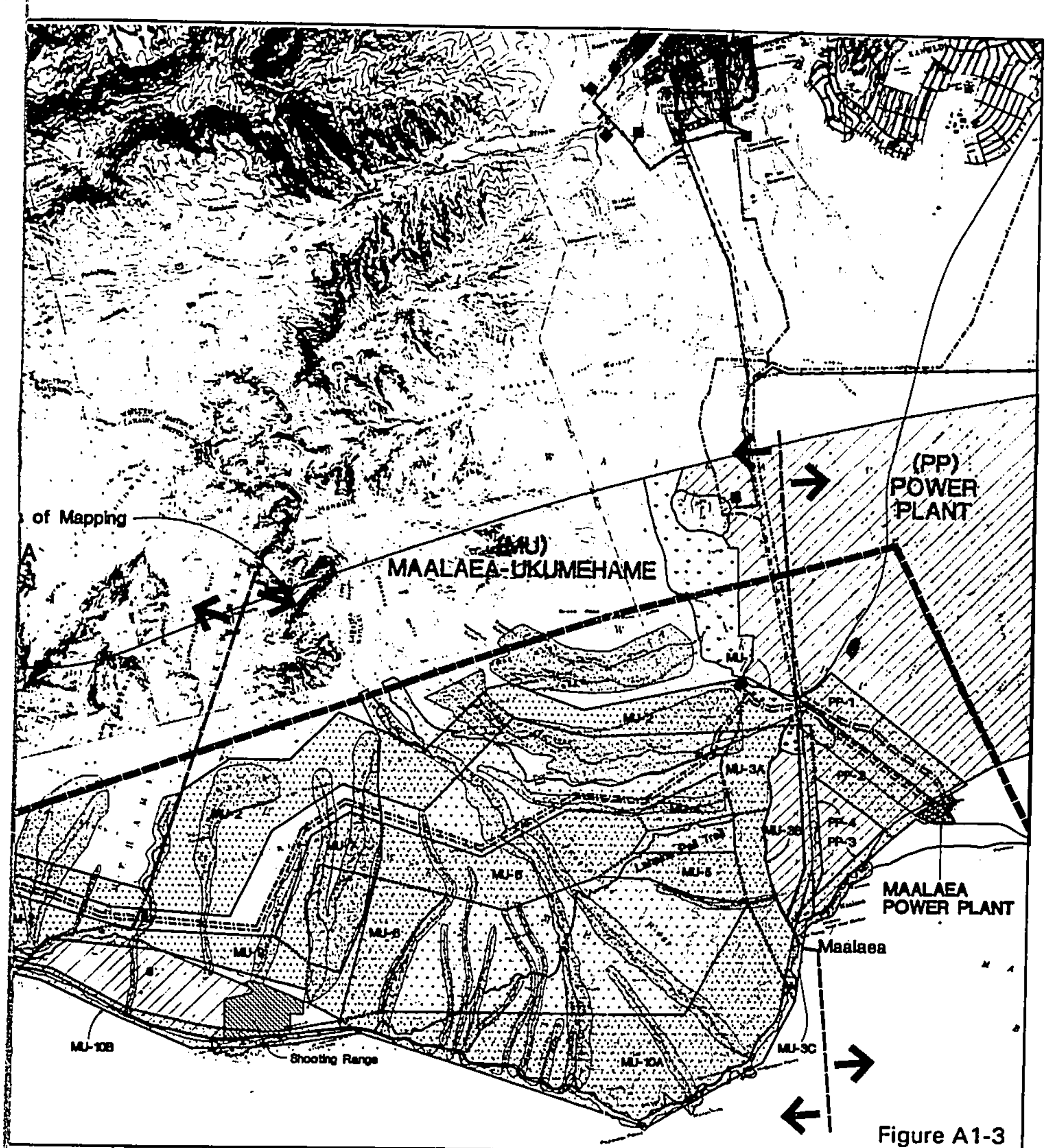
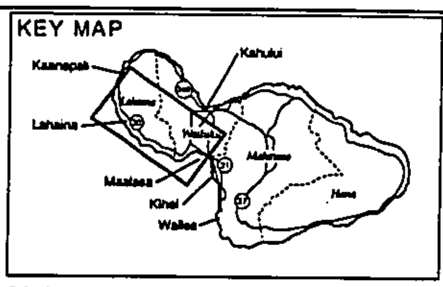


Figure A1-3

Flume



NORTH

SCALE
0 500 2000 4000 FEET
0 1/4 1/2 1 MILE

Alternative Corridors and Existing Land Use

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

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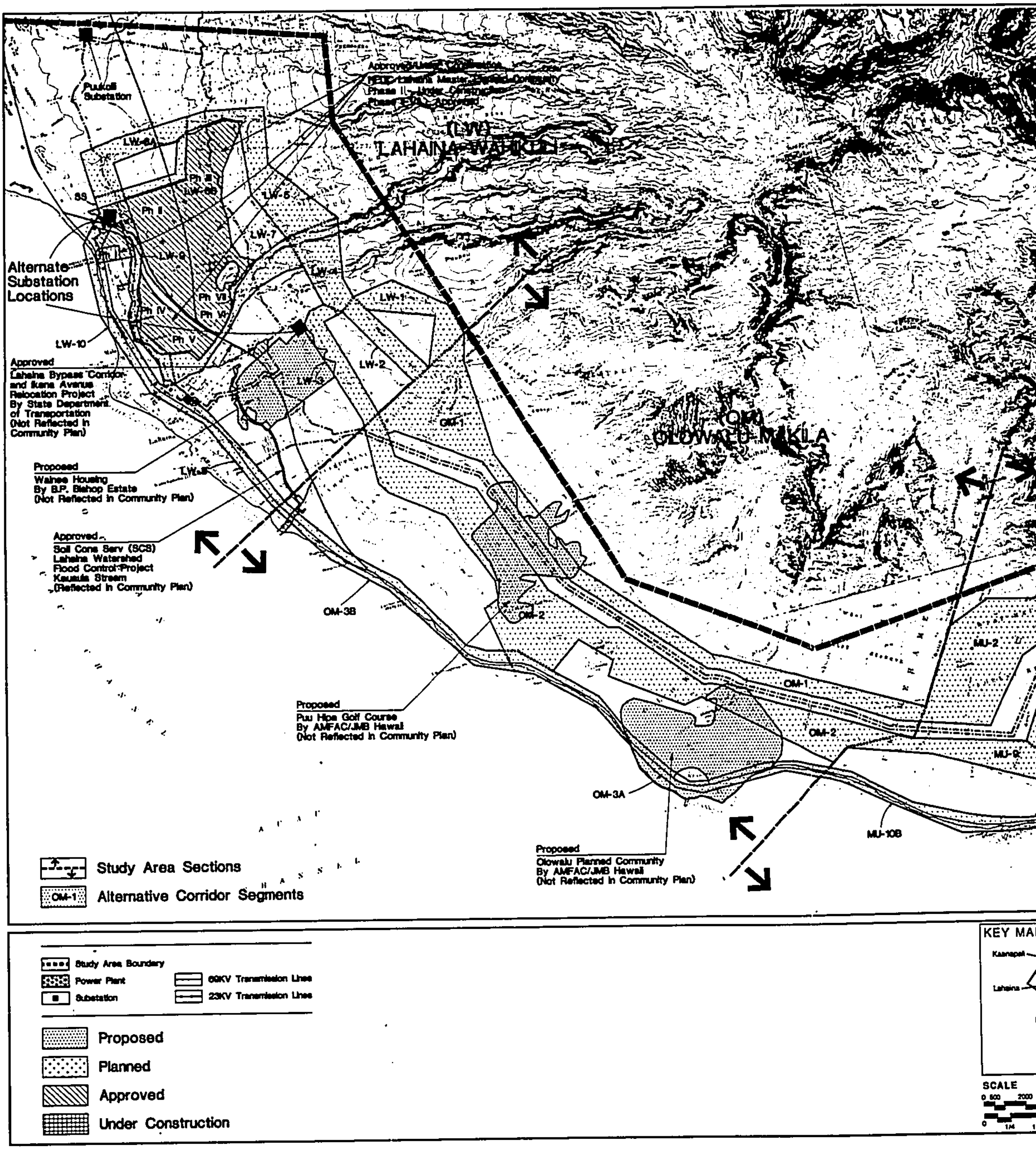

(LW)
LAHAINA-WAHIKULI
(OM)
OLOWALU-MAKILA
Puukolii Substation
LW-6A
LW-6B
LW-5
LW-7
LW-9
LW-4
LW-1
LW-2
LW-3
LW-8
LW-10
Ph III
Ph II
Ph IV
Ph V
Ph VI
Ph VII
SS
Alternate Substation Locations
Approved
Lahaina Bypass Corridor and Ikena Avenue Relocation Project By State Department of Transportation (Not Reflected in Community Plan)
Proposed
Wainee Housing By B.P. Bishop Estate (Not Reflected in Community Plan)
Approved
Soil Cons Serv (SCS) Lahaina Watershed Flood Control Project Kauaula Stream (Reflected in Community Plan)
OM-1
OM-2
OM-3B
OM-3A
Proposed
Puu Hipa Golf Course By AMFAC/JMB Hawaii (Not Reflected in Community Plan)
Proposed
Olowalu Planned Community By AMFAC/JMB Hawaii (Not Reflected in Community Plan)
MU-2
MU-9
MU-10B
Study Area Sections
OM-1
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Proposed
Planned
Approved
Under Construction
KEY MA
Kaanapali
Lahaina
SCALE

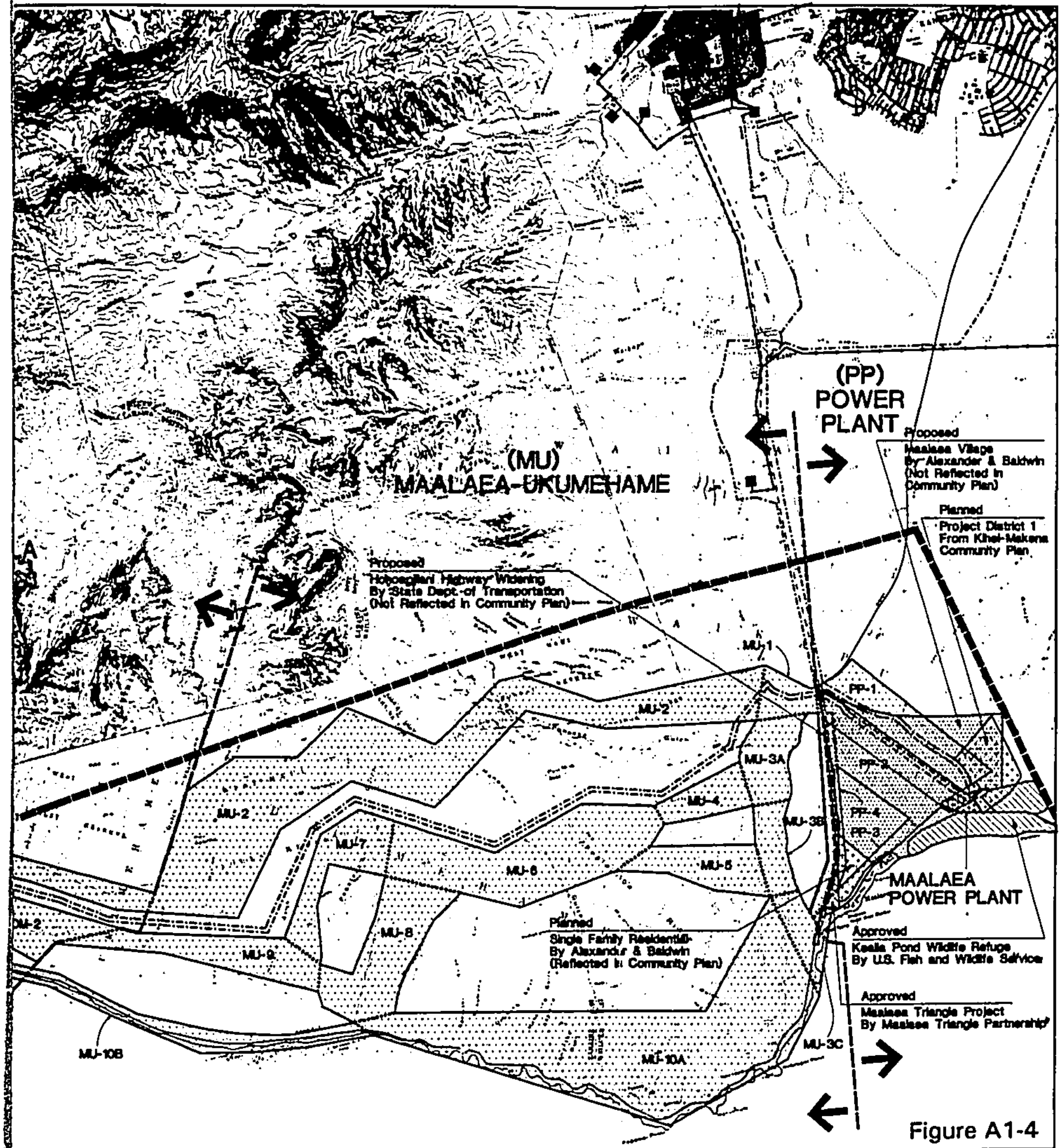
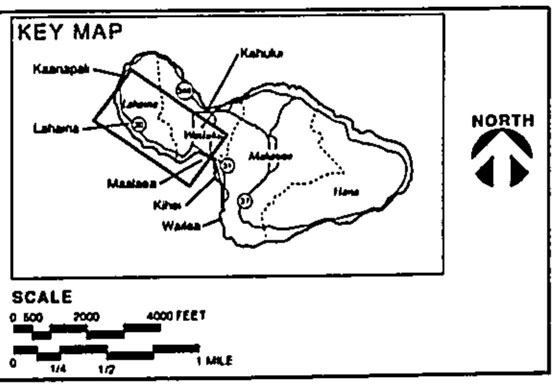


Figure A1-4

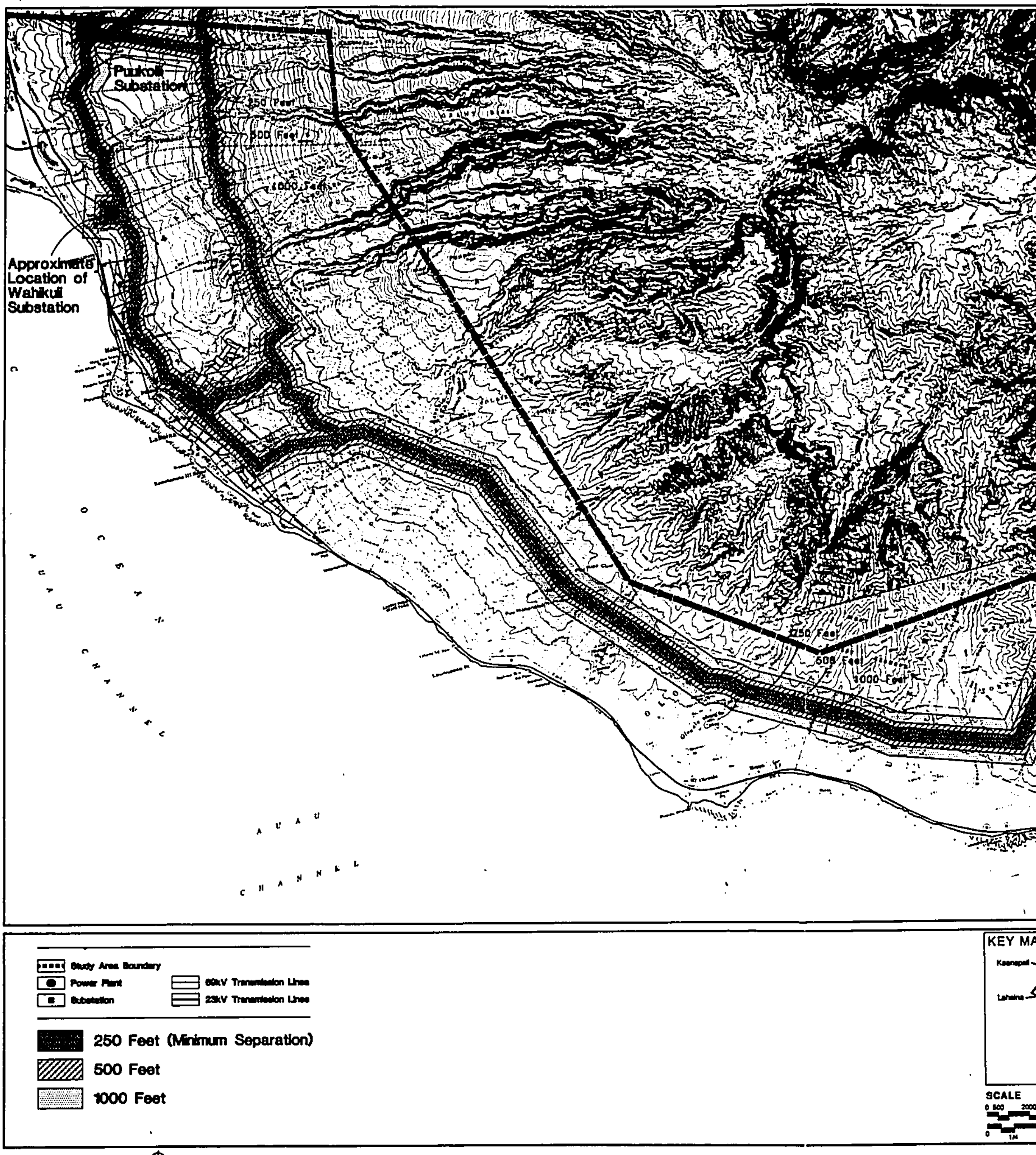


Alternative Corridors and Proposed Projects

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore


Puukolii Substation
250 Feet
500 Feet
1000 Feet
Approximate Location of Wahikuli Substation
AUAU CHANNEL
AUAU CHANNEL
Study Area Boundary
Power Plant
Substation
69kV Transmission Lines
23kV Transmission Lines
250 Feet (Minimum Separation)
500 Feet
1000 Feet
KEY MA
Kaanapali
Lahaina
SCALE

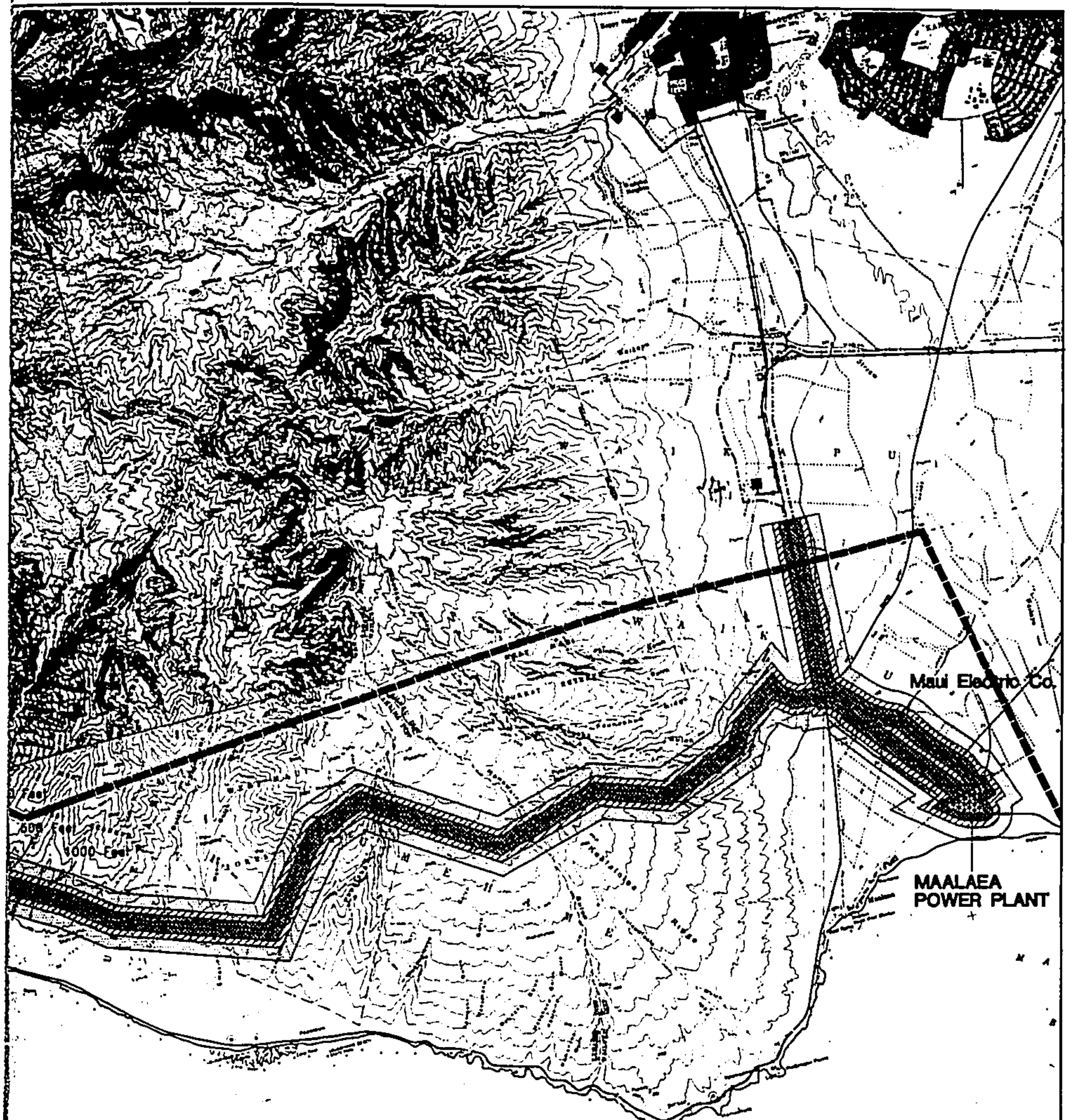
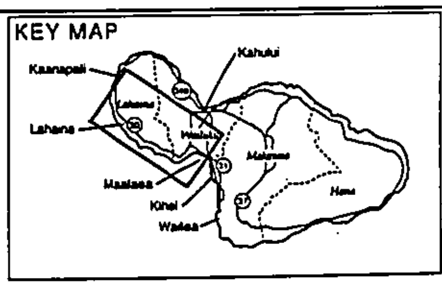


Figure A1-5



SCALE

0 500 2000 4000 FEET

0 1/4 1/2 1 MILE

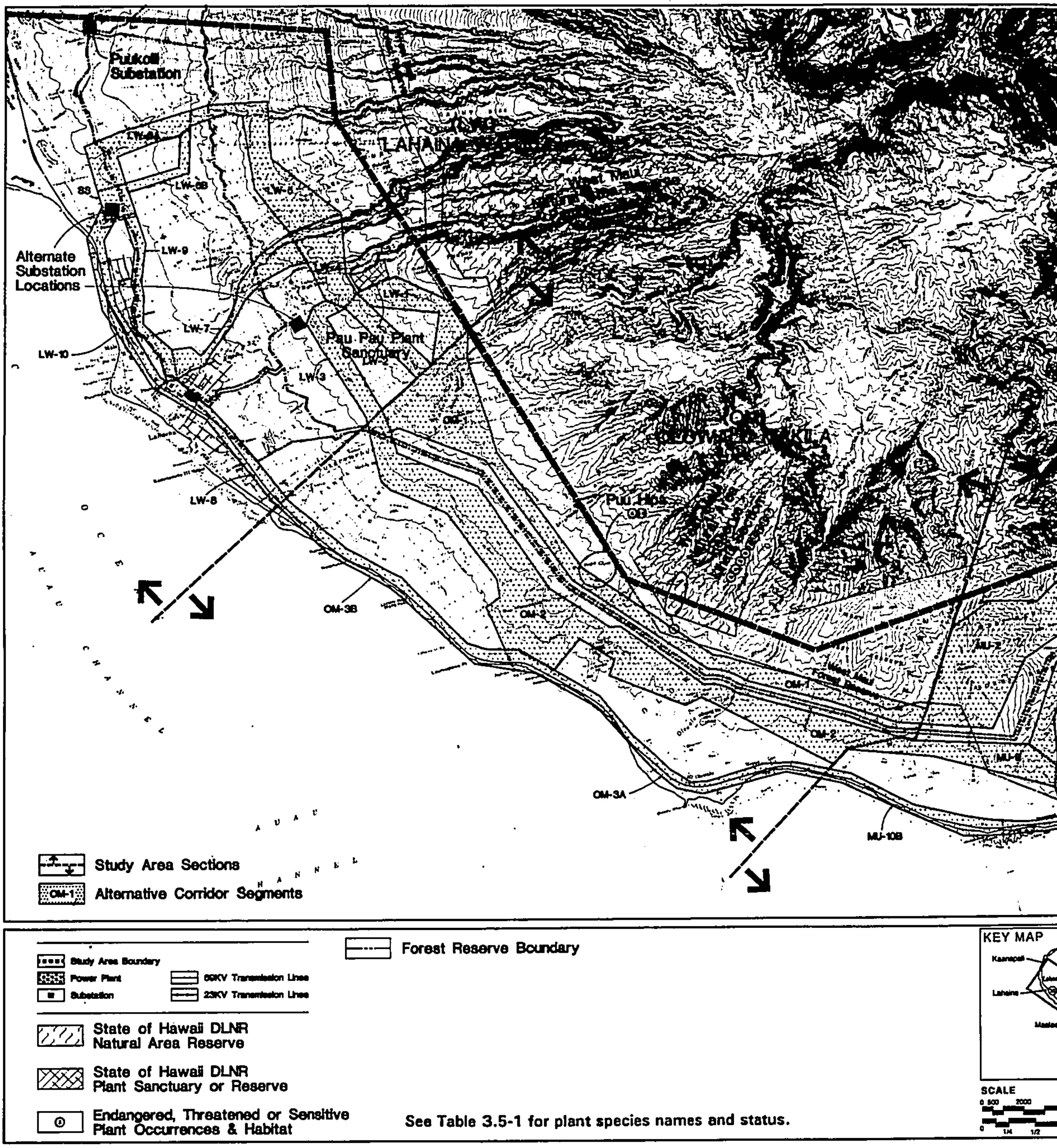
NORTH

Transmission Separation

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE


Puukolii Substation
LW-6B
LW-5
SS
Alternate Substation Locations
LW-9
LW-7
LW-10
LW-3
Pau Pau Plant Sanctuary
LW-8
OM-3B
OM-3A
OM-1
OM-2
MU-10B
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Forest Reserve Boundary
State of Hawaii DLNR Natural Area Reserve
State of Hawaii DLNR Plant Sanctuary or Reserve
Endangered, Threatened or Sensitive Plant Occurrences & Habitat
See Table 3.5-1 for plant species names and status.
KEY MAP
SCALE

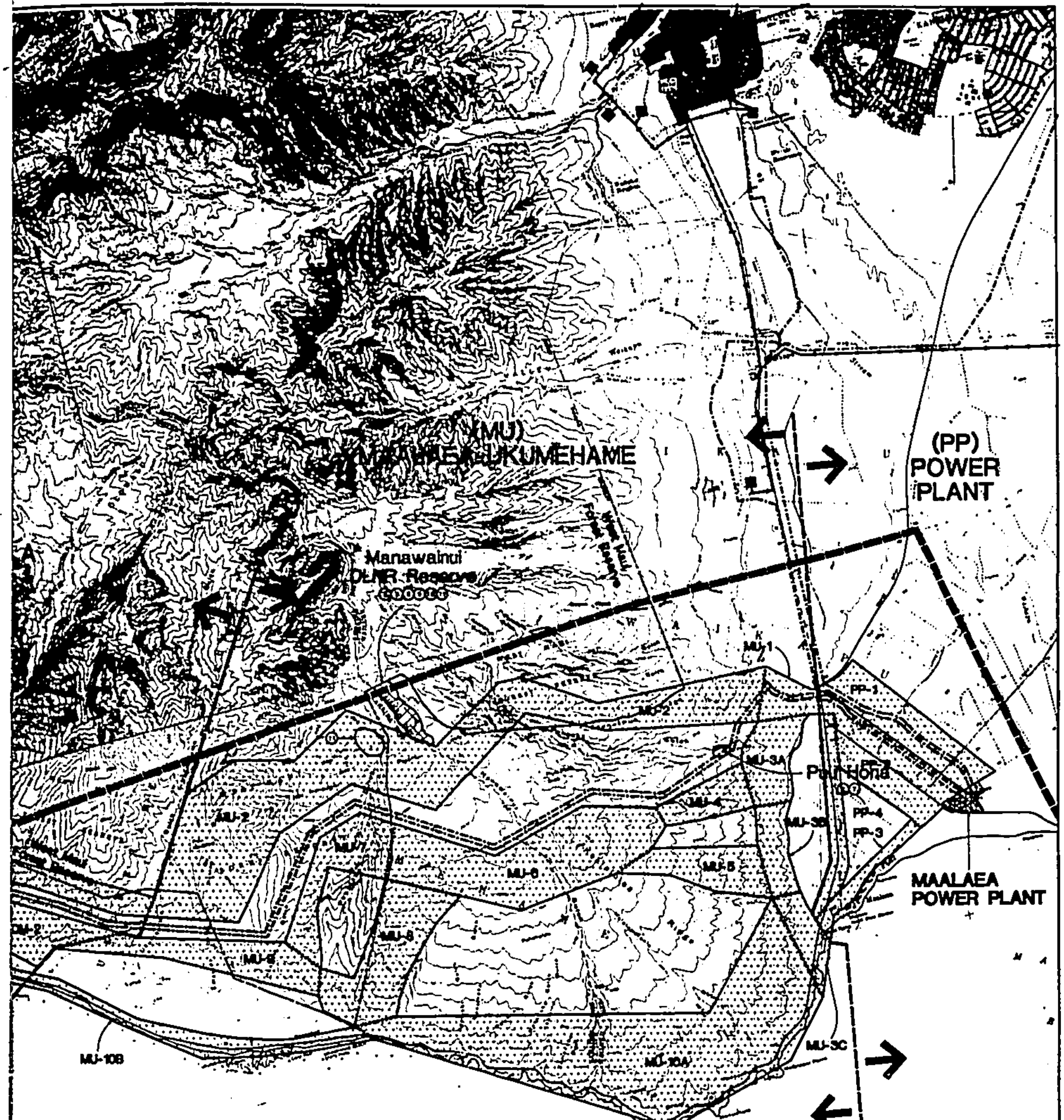
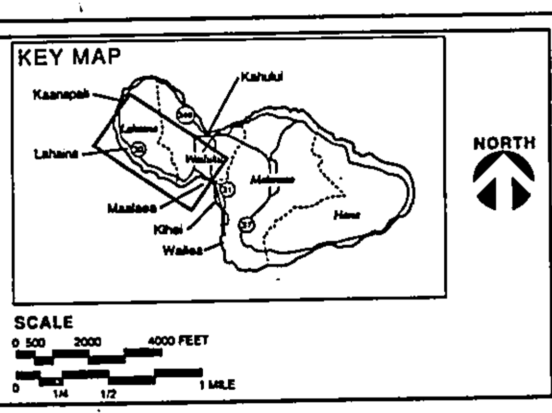


Figure A1-6

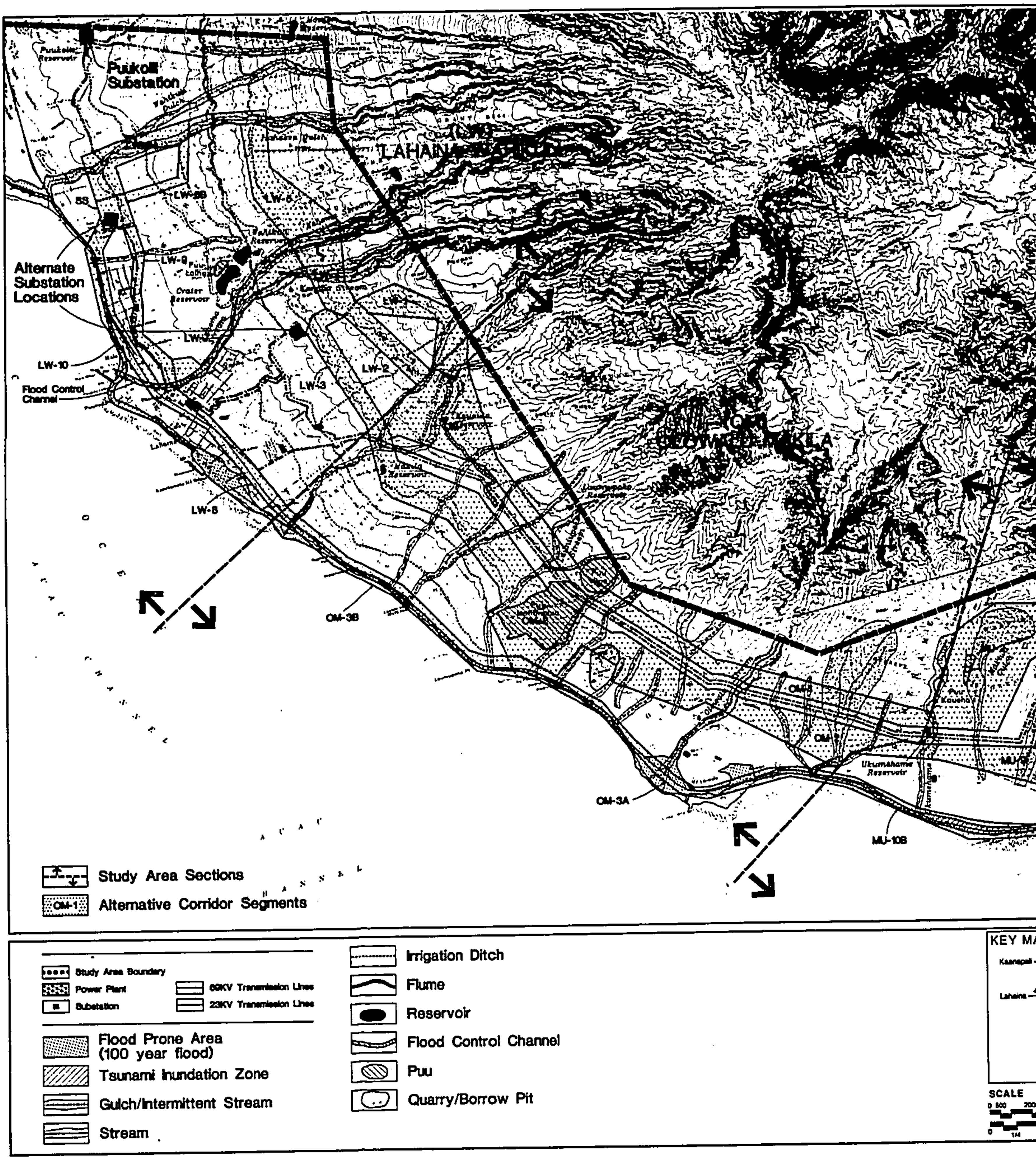


Alternative Corridors and Biological Resources

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE


Puukolii Substation
Alternate Substation Locations
LW-10
Flood Control Channel
LW-9
LW-6B
LW-5
LW-3
LW-2
LW-8
Crater Reservoir
OM-3B
OM-3A
MU-10B
Ukumehame Reservoir
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Flood Prone Area (100 year flood)
Tsunami Inundation Zone
Gulch/Intermittent Stream
Stream
Irrigation Ditch
Flume
Reservoir
Flood Control Channel
Puu
Quarry/Borrow Pit
SCALE

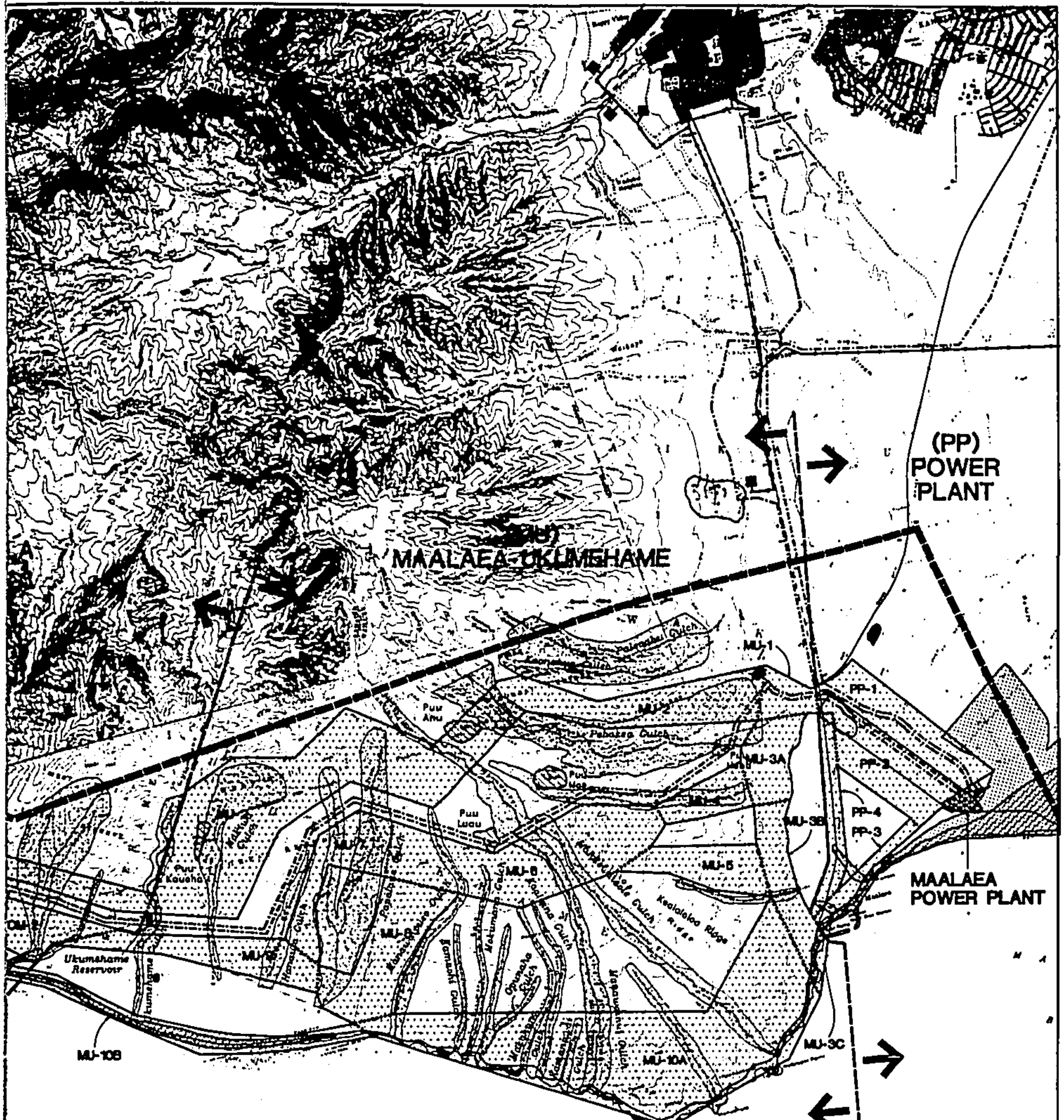
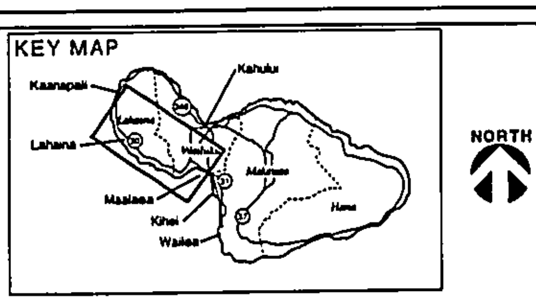
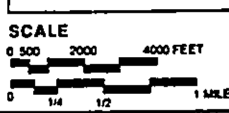


Figure A1-7



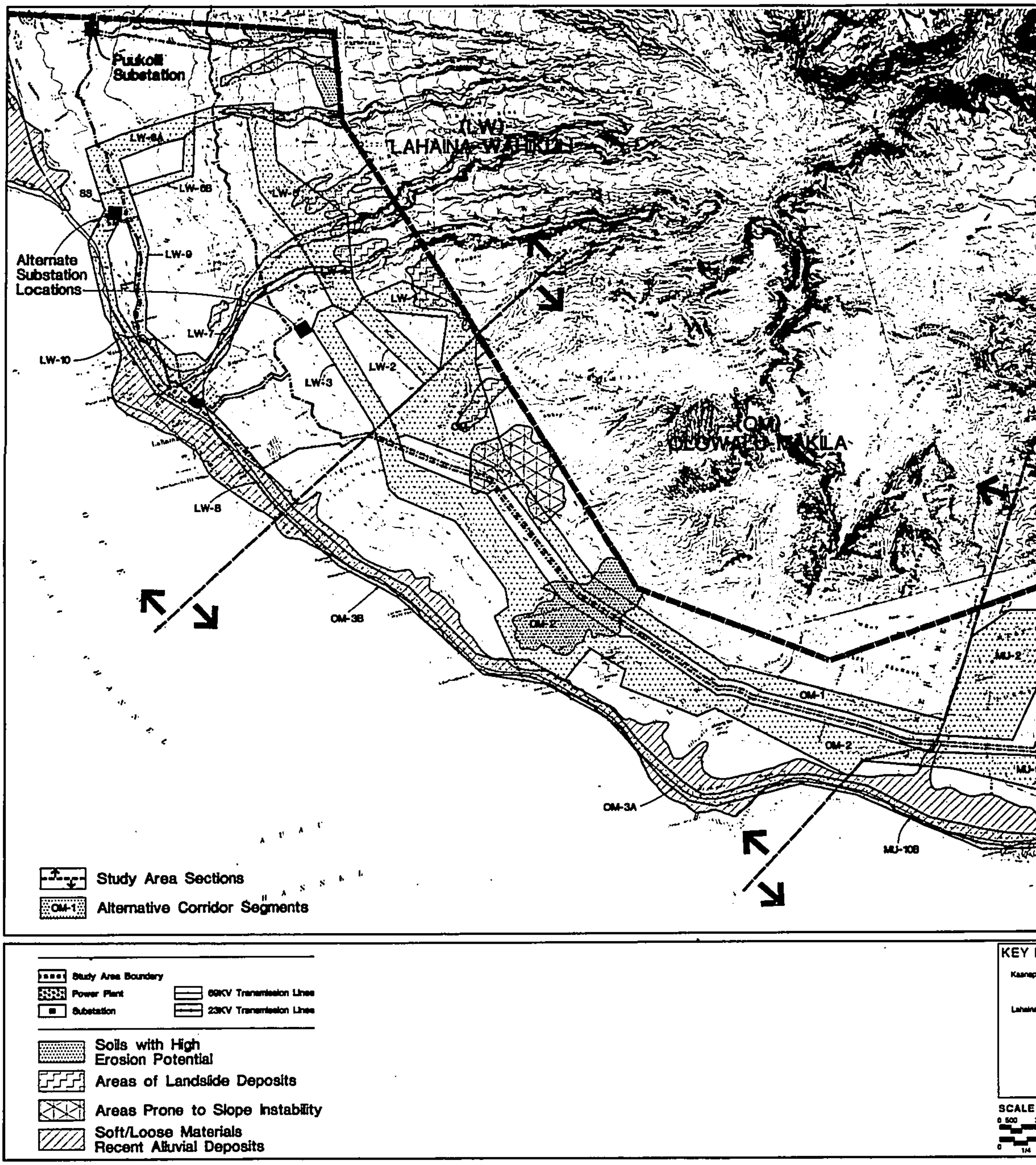


Alternative Corridors and Topographic Features and Water Resources

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE


Puukolii Substation
(LW)
LAHAINA-WAHIKULI
(OM)
OLOWALU-MAKILA
Alternate Substation Locations
LW-6A
LW-6B
LW-9
LW-10
LW-7
LW-3
LW-2
LW-8
OM-3B
OM-1
OM-2
OM-3A
MU-10B
MU-2
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Soils with High Erosion Potential
Areas of Landslide Deposits
Areas Prone to Slope Instability
Soft/Loose Materials Recent Alluvial Deposits
KEY
SCALE

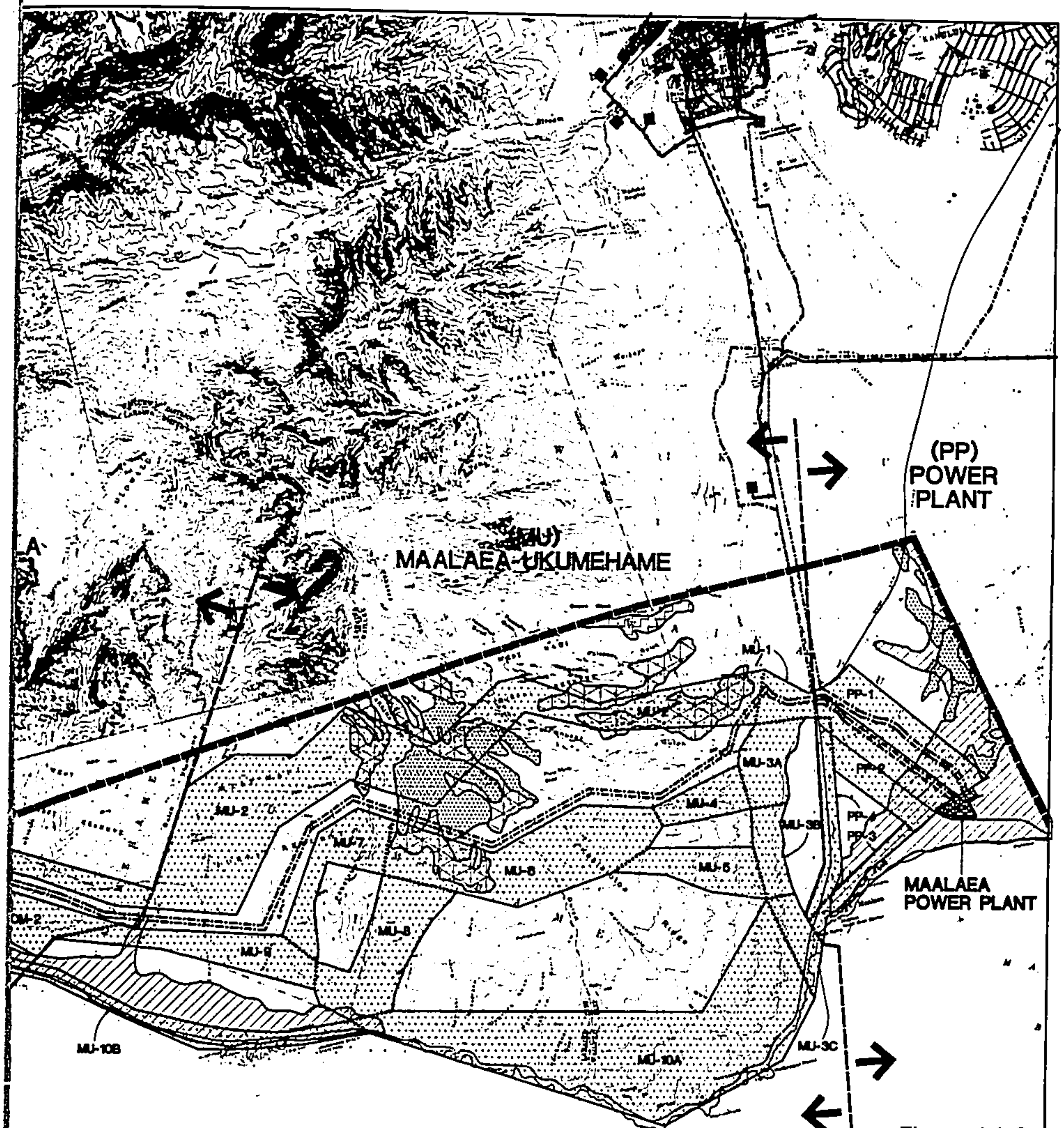
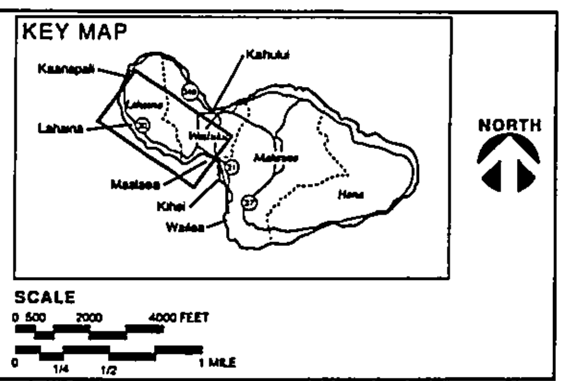


Figure A1-8

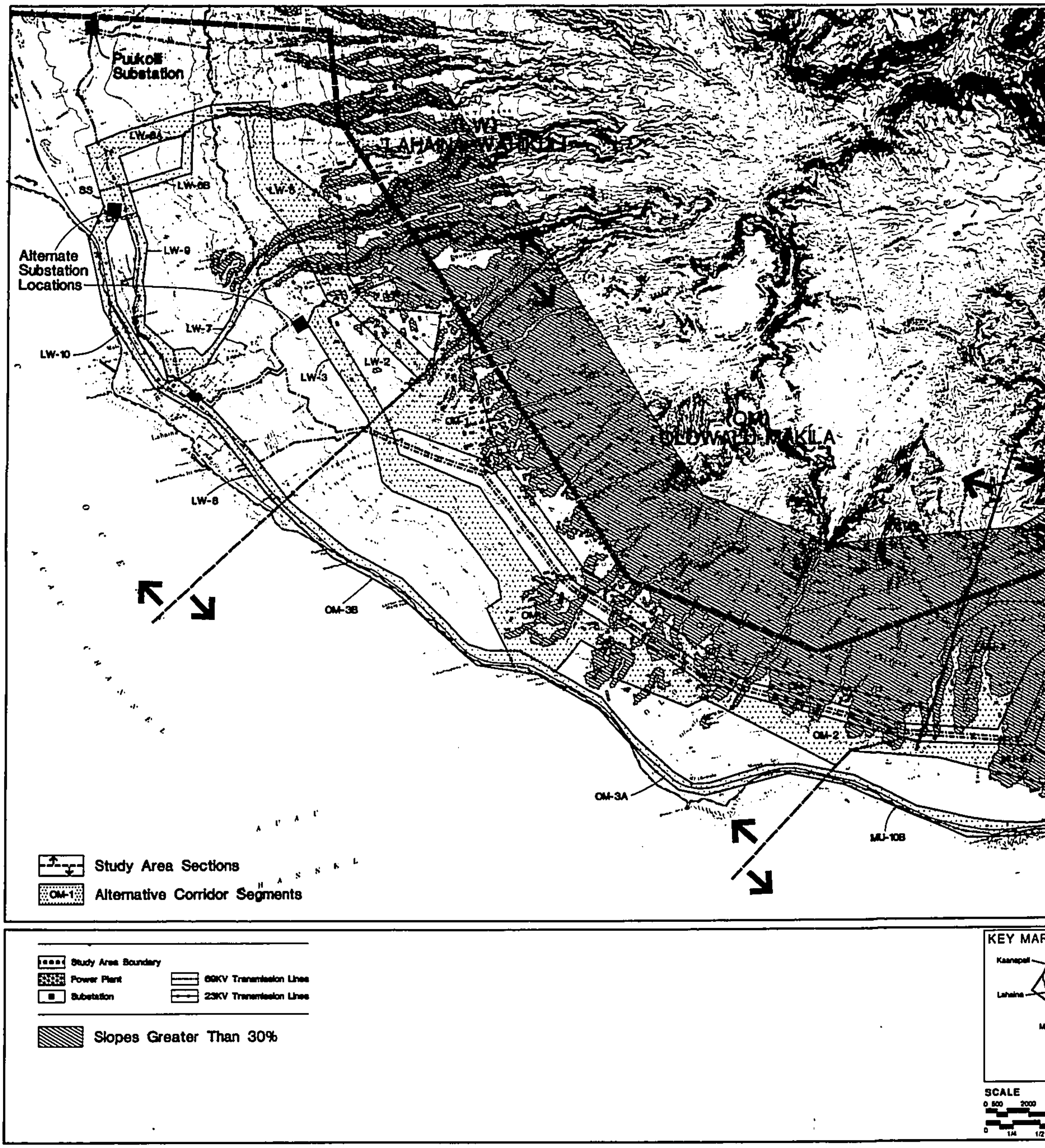


Alternative Corridors and Geology/Soils

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore


Puukolii Substation
LW-8A
SS
LW-8B
LW-5
Alternate Substation Locations
LW-9
LW-7
LW-10
LW-3
LW-2
LW-6
OM-3B
OM-2
OM-3A
MU-10B
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Slopes Greater Than 30%
Kaanapali
Lahaina
SCALE

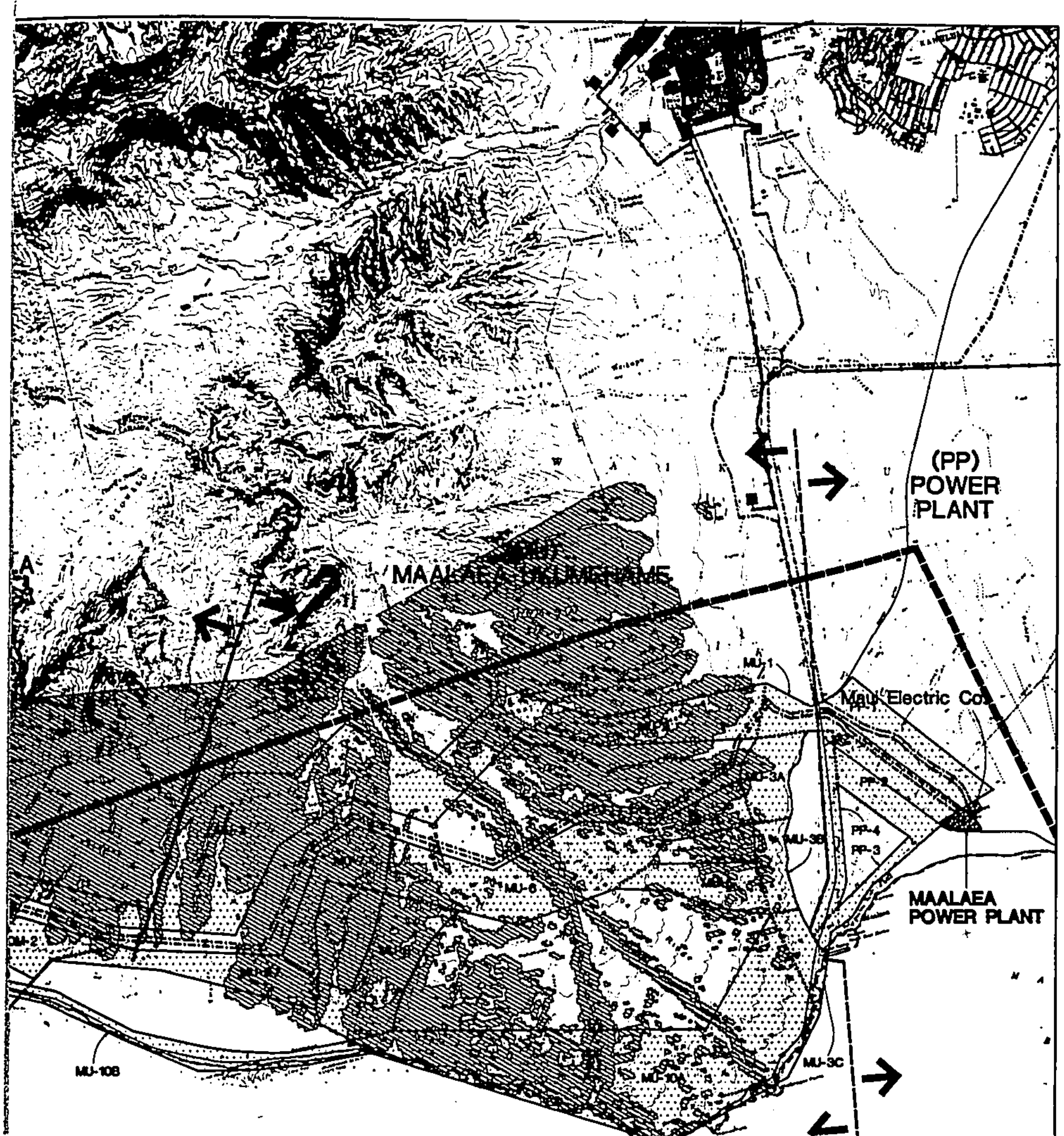
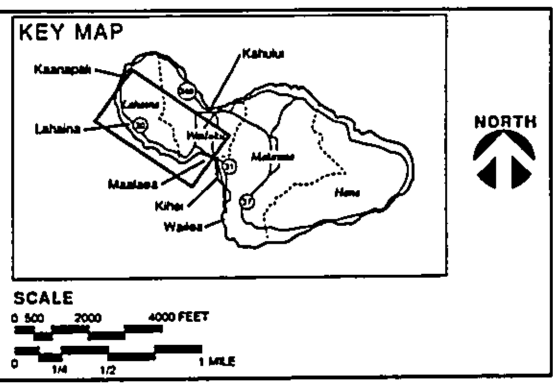


Figure A1-9

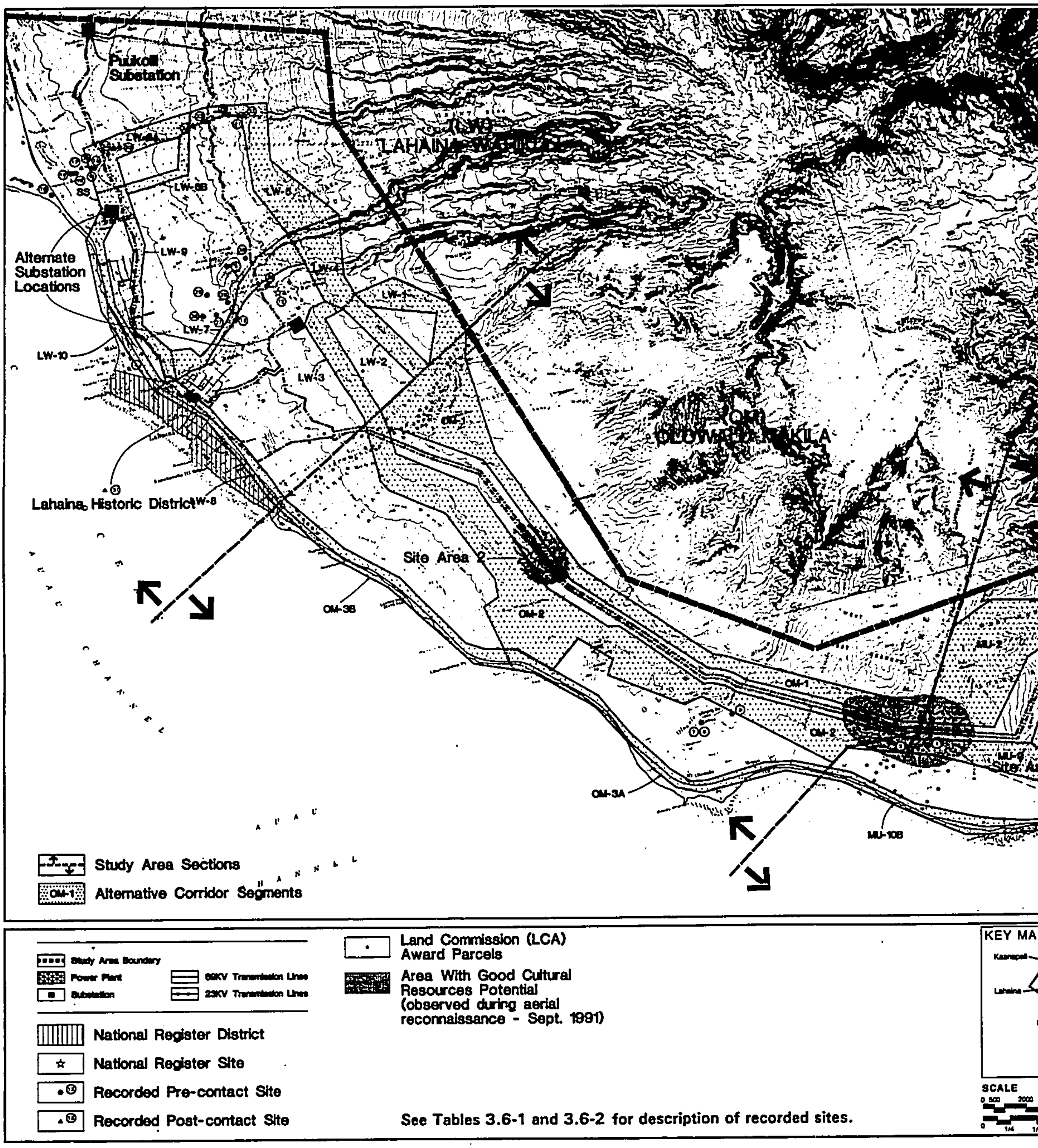


Alternative Corridors and Slope

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore


Puukolii Substation
LAHAINA-WAINEE
Alternate Substation Locations
LW-6B
LW-6
LW-9
LW-4
LW-1
LW-7
LW-10
LW-3
LW-2
LW-8
OLOWALU-MAKILA
Lahaina Historic District
Site Area 2
OM-3B
OM-2
OM-1
OM-3A
MU-10B
Study Area Sections
Alternative Corridor Segments
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Land Commission (LCA) Award Parcels
Area With Good Cultural Resources Potential (observed during aerial reconnaissance - Sept. 1991)
National Register District
National Register Site
Recorded Pre-contact Site
Recorded Post-contact Site
See Tables 3.6-1 and 3.6-2 for description of recorded sites.
KEY MA
SCALE

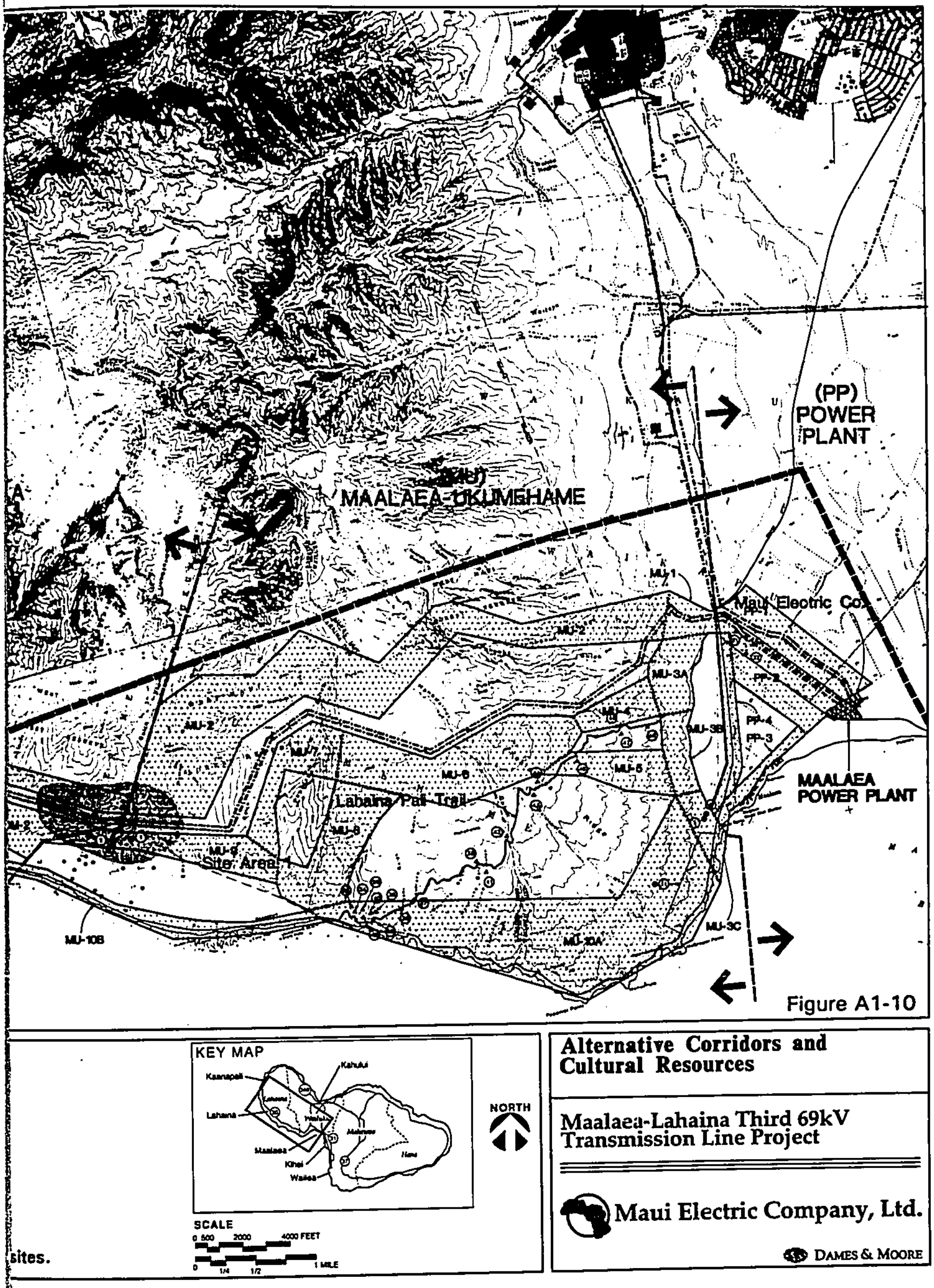


Figure A1-10

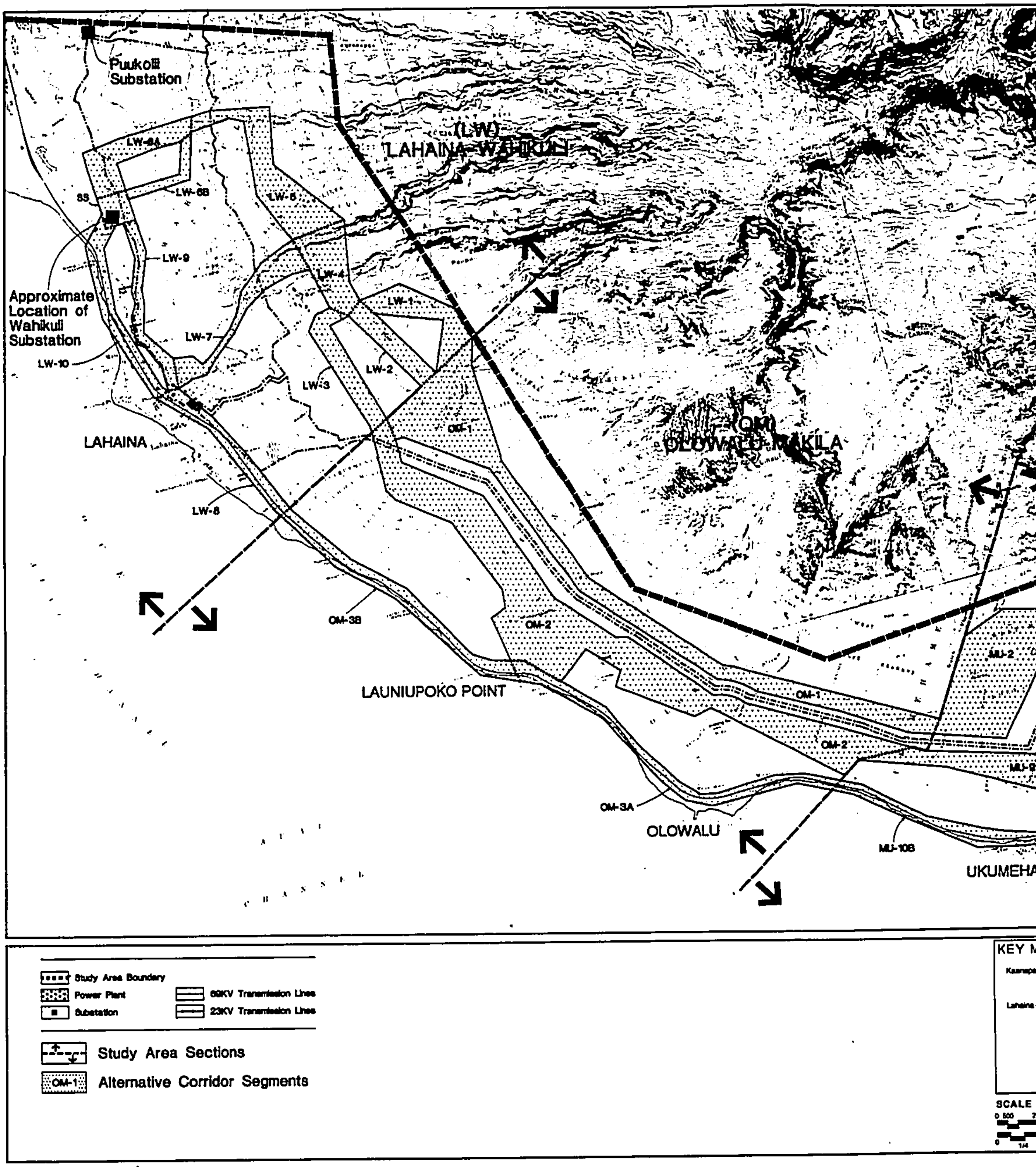
sites.

Alternative Corridors and Cultural Resources

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE


Puukolii Substation
(LW) LAHAINA-WAHIKULI
LW-6A
LW-6B
SS
LW-5
LW-9
LW-4
LW-1
Approximate Location of Wahikuli Substation
LW-7
LW-2
LW-10
LW-3
OM-1
LAHAINA
(OM) OLOWALU-MAKILA
LW-8
OM-3B
OM-2
LAUNIUPOKO POINT
OM-1
MU-2
OM-2
OM-3A
OLOWALU
MU-10B
UKUMEHA
Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Study Area Sections
Alternative Corridor Segments
KEY M
SCALE

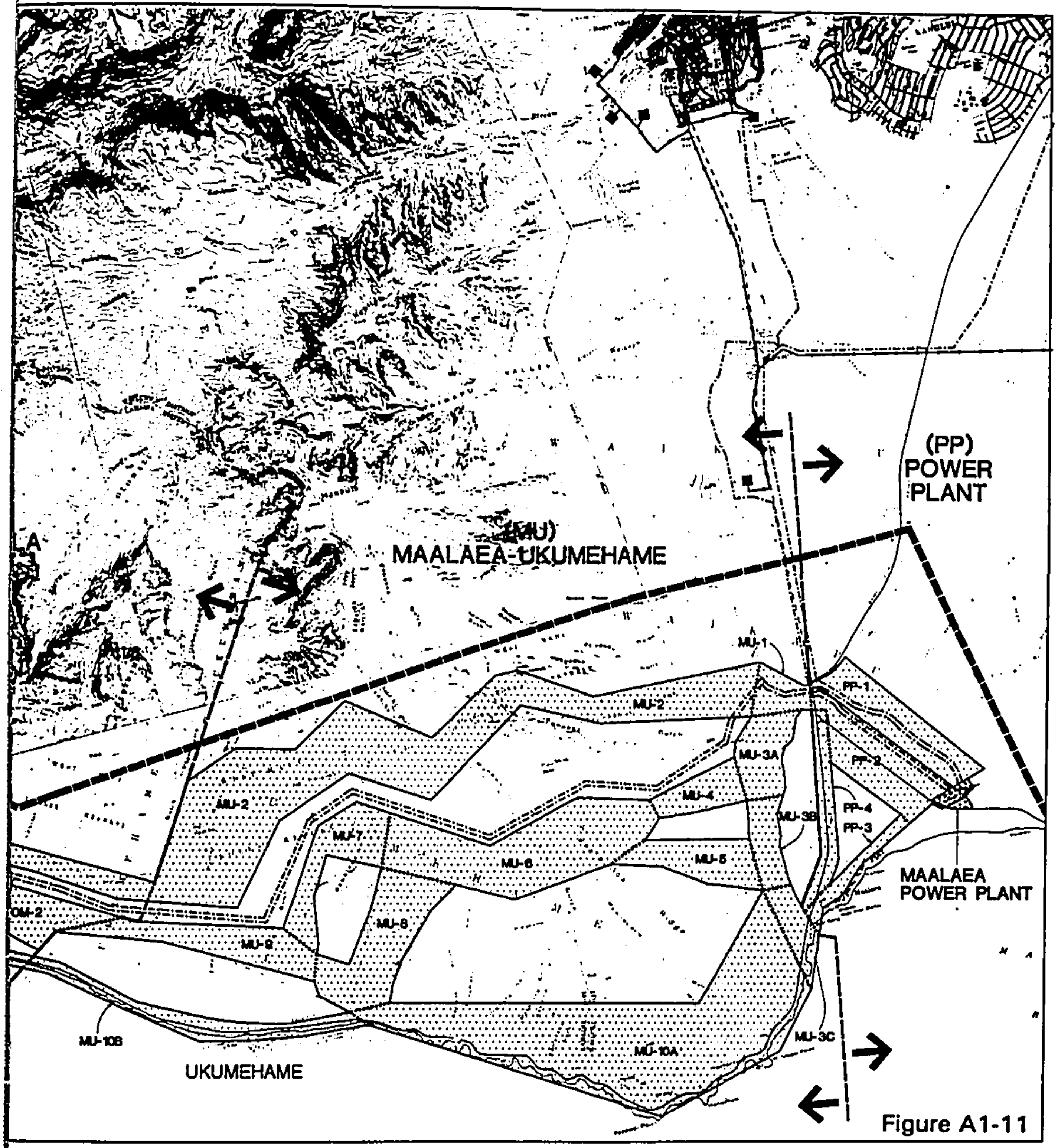
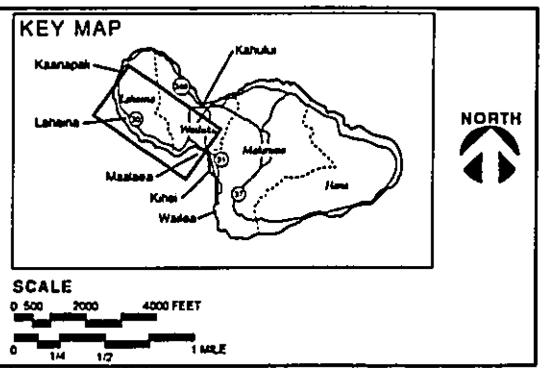


Figure A1-11



Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

A2. ALTERNATIVE CORRIDOR EVALUATION, PREFERRED CORRIDOR SELECTION AND ALIGNMENT IDENTIFICATION

ALTERNATIVE CORRIDOR EVALUATION

Both qualitative and semi-quantitative methods were used to compare the corridors, with the objective of selecting a preferred corridor that balanced engineering, environmental and economic factors as well as landowner preferences and concerns. A qualitative assessment (see Corridor Segment Comparison below) was made by examining the existing resources within each corridor segment and through discussions with landowners (and lessees) and agricultural operations personnel. A semi-quantitative assessment (see Sensitive Analysis, page A2-9) was made by conducting a numerical sensitivity analysis of the various feasible corridor alternatives. The sensitivity analysis was designed to compare the constraints and opportunities of the alternative corridor segments and to assist in the evaluation and screening of alternative corridors and the selection of a preferred corridor.

CORRIDOR SEGMENT COMPARISON

Alternative corridor segments, as identified through the constraint analysis, were compared for their feasibility for siting a transmission line. Environmental resources within each corridor segment were recorded in a corridor comparison matrix (Table A2-1) by overlaying the corridor segments on each regional data map and recording the conditions within each segment. Construction cost for wood pole line designed to withstand 60 mph wind loads was estimated at $250,000 per mile for flat to moderate terrain which was accessible and $350,000 per mile for steep or inaccessible terrain (HECO Engineering, March 1992). A more definitive estimate of the cost was deemed necessary to more adequately compare the cost of the various alternatives; this cost comparison is presented in later sections of this Appendix.

The matrix (Table A2-1) provides a summary of the major land jurisdiction and use, environmental resources and engineering factors by individual corridor segments.

TABLE A2-1
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	POWER PLANT STUDY SECTION CORRIDOR SEGMENTS			
	PP-1	PP-2	PP-3	PP-4
LAND OWNERSHIP	A & B/HC&S	A&B/HC&S	A&B/HC&S	A&B/HC&S State of Hawaii-HP Hwy ROW Wailuku Agribusiness
LAND REGULATION	Agricultural	Primarily Agricultural Limited Subzone (H) crosses corner (2%) of segment may be avoided. SMA covers 3% of segment may be avoided.	Agricultural for 50% of segment. Urban for 30% of segment. SMA covers 80% of segment.	HP Highway ROW in Center Agricultural LUD
EXISTING LAND USE	Sugar cane quarry (M)	Sugar cane quarry (M)	Maalaea Commercial Area (M) Small Boat Harbor Kanaio Town PR	
PROPOSED LAND USE	Project District 2 Kealia Pond Development A&B	Kealia Pond Development A&B	Maalaea Triangle Project Kealia Pond Development A&B SF Residential	SF Residential Housing A&B HP Hwy Widening
BIOLOGICAL RESOURCES	Agricultural	Agricultural	Agricultural	Ruderal Vegetation
CULTURAL RESOURCES	No recorded sites	2 Recorded post - Contact Sites (M) under lines historic cemetery	No recorded sites	No recorded sites
SLOPE, GEOLOGY AND SOILS	Flat Terrain	Flat except for quarry Soft loose soils at power plant end of segment	Flat soft loose soils for entire segment.	Flat Terrain
TOPOGRAPHY AND WATER RESOURCES	Flood prone area (100 year flood) (M) covers small portion of segment Quarry at Wailuku end of segment	Quarry at Wailuku end of Segment	Flood prone area (100 year flood) (M) and tsunami inundation zone (H) crosses top of segment, 5%.	Crosses flood prone area (M) of two places
EXISTING TRANSMISSION LINES AND SUBSTATIONS	Parallels 69KV Line for Entire Segment (H) 150 ft buffer zone (H) for entire segment 500 ft buffer zone (M) for entire segment	Parallels 69KV Line for Entire Segment (H) 150 ft buffer zone (H) for entire segment 500 ft buffer zone (M) for entire segment	None	12KV line parallels HP Hwy for entire length?

TABLE A2-1 (Continued)
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	MAALAEA - UKUMEHAME STUDY SECTION CORRIDOR SEGMENTS				
	MU-1	MU-2	MU-3A	MU-3B	MU-3C
LAND OWNERSHIP	Wailuku Ag	Wailuku Ag 45% State of Hawaii 55%	State of Hawaii (Perreira Lessee)	State of Hawaii (Perreira Lessee)	State of Hawaii (Perreira Lessee) Other Private along coast
LAND REGULATION	Agricultural LUD	Conservation LUD: Protective Subzone (H) crosses segment in 2 places. Resource (M) & General (M) Subzones cover most of segment. Agricultural LUD for 2,000 ft.	Conservation LUD: Resource Subzone (M) covers entire segment.	Conservation LUD: Resource Subzone (M) covers entire segment	Urban LUD along coast conservation: Resource Subzone (M) crosses segment 10%. Limited Subzone (H) covers 30% of segment. General Subzone (M) covers 40% of segment. SMA covers 90% of segment.
EXISTING LAND USE	Rock piles unused land	Undeveloped open Reservoir (M)	Grazing	Grazing Lahaina Pali Trail access from pineapple fields	Grazing Residential (M) along coast.
PROPOSED PROJECTS	None	None	None	None	HP Hwy widening at Maalaea Boat Harbor Entrance
BIOLOGICAL RESOURCES	Mixed grassland Shrubland	Endangered plant species (M) Near Papalaua Gulch and at DLNR Reserve	Mixed Grassland Shrubland	Mixed Grassland Shrubland	Mixed Grassland Shrubland
CULTURAL RESOURCES	No recorded sites	No recorded sites	No recorded sites	No recorded sites	2 recorded pre-contact site (M). Partial complex of recorded pre-contact sites (M).
SLOPE, GEOLOGY AND SOILS	Less than 30% slope	Soils with high erosion potential (M) and areas prone to slope instability (M) cross segment in several locations. Slopes greater than 30% (M) cover 80% of segment	Slopes greater than 30% (M) cover 25% of segment.	Slopes greater than 30% (M) cover 30% of segment.	4 small areas of slopes greater than 30% are scattered throughout segment.
TOPOGRAPHY AND WATER RESOURCES	Gentle slopes	Steep terrain Reservoir (M) Numerous Gulches (5) Puu Anu and Puu Kauoha within segment	Gentle slope	Gentle slope	Tsunami inundation zone (H) covers coastal area of segment. Flood prone areas (100 year flood) (M) cover coastal area of segment.
EXISTING TRANSMISSION LINES AND SUBSTATIONS	Parallels 69KV Line (H), through entire segment.	69KV Line crosses corner of segment 250 ft (H) and 500 ft (M) buffer zones cross segment.	None	None	None

TABLE A2-1 (Continued)
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	MAALAEA - UKUMEHAME STUDY SECTION CORRIDOR SEGMENTS			
	MU-4	MU-5	MU-6	MU-7
LAND OWNERSHIP	State of Hawaii Perreira Lessee	State of Hawaii Perriera Lessee and Forest Reserve	State of Hawaii Perreira Lessee	State of Hawaii Forest Reserve
LAND REGULATION	Conservation LUD: Resource Subzone (M) covers entire segment.	Conservation LUD: Resource Subzone (M) covers entire segment.	Conservation LUD: Limited Subzone (H) crosses segment 10% in Manawainui Gulch.	Conservation LUD: Protective Subzone (H) covers 50% of segment along Hanalua Gulch. Resource (M) subzone covers 50% of segment.
EXISTING LAND USE	1,000 ft. mauka of Lahaina Pali Trail parallels Gulch Grazing	Lahaina Pali Trail crosses segment (M). Grazing	Grazing segment crosses 4 gulches	Open undeveloped forest reserve land segment crosses 2 gulches parallels Hanalua Gulch
PROPOSED PROJECTS	None	None	None	None
BIOLOGICAL RESOURCES	Mixed grassland Shrubland	Mixed grassland Shrubland	Mixed grassland Shrubland	Mixed grassland Shrubland Entire segment in forest reserve
CULTURAL RESOURCES	1 recorded post-contact site (M) along Lahaina Pali Trail	1 recorded post-contact site (M) along Lahaina Pali Trail which passes through the segment	No recorded sites	No recorded sites
SLOPE, GEOLOGY AND SOILS	Slopes greater than 30% (M) cover 90% of segment.	Slopes greater than 30% (M) cover 20% of segment.	Areas prone to slope instability (M) cross 50% of segment. Slopes greater than 30% (M) cover 20% of segment.	Slopes greater than 30% (M) cover entire segment.
TOPOGRAPHY AND WATER RESOURCES	Gulch within center of corridor segment.	No gulches or streams	Crosses Manawainui Malalowaiaole Mokumana Manawaipueo Gulch	Steep terrain segment is on ridge between Papalaua and Hanaula Gulches
EXISTING TRANSMISSION LINES AND SUBSTATIONS	500 ft buffer zone covers 10% of segment.	None	500 ft buffer zone (M) parallels segment	500 ft buffer zone (M) parallels segment

TABLE A2-1 (Continued)
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	MAALAEA - UKUMEHAME STUDY SECTION CORRIDOR SEGMENTS			
	MU-8	MU-9	MU-10A	MU-10B
LAND OWNERSHIP	State of Hawaii 75% leased to Perreira 25% Forest Reserve	State of Hawaii Forest Reserve and leased to Pioneer Mill Co. Crosses Pioneer Mill Co. land 1,000 ft.	State of Hawaii Highway and leased to Perreira	Multiple Owners - State of Hawaii - highway, State parks leased to Pioneer Mill Co. Pioneer Mill Co.
LAND REGULATION	Conservation LUD: Resource subzone (M) covers 50% of segment. General subzone (M) covers 50% of segment.	Conservation LUD: Protective subzone (H) covers 45% of segment. Resource subzone (M) covers 15% of segment. Agricultural LUD covers 40% of segment.	Conservation LUD: The shoreline is designated Resource Subzone for the entire segment and the land immediately makai of the highway is designated Limited Subzone. Manawainui Gulch is designated Limited Subzone. The remainder of the segment is general subzone SMA boundary covers coast for entire segment.	Conservation LUD: Limited Subzone (H) parallels entire segment on Makai side of highway. General subzone parallels mauka side of highway for 4,000 ft. and agricultural LUD parallels mauka highway for 8,000 ft. coastal highway. SMA boundary covers coast for entire segment.
EXISTING LAND USE	Grazing crosses 1 gulch	Open undeveloped forest reserve land crosses 3 gulches.	Small area of residential along coast (M) and HP Highway. Lahaina Pali Trail (M) crosses segment. Grazing	Shooting Range (H) and mauka side of highway. Parks and recreation (M) on makai side of highway. Cane fields along 60% of segment.
PROPOSED PROJECTS	None	None	None	None
BIOLOGICAL RESOURCES	Mixed grassland Shrubland partially in forest reserve	Agricultural Partially in forest reserve	Mixed grassland Shrubland	Agricultural
CULTURAL RESOURCES	No recorded sites	Area of good cultural resources potential 2 recorded pre-contact sites (M)	9 recorded post-contact sites (M) Cluster of recorded pre-contact sites (M) at Lahaina Pali Trail near coast line	Some land commission awards around Ukumehame Gulch
SLOPE, GEOLOGY AND SOILS	Slopes greater than 30% (M) cover 90% of segment	Soft loose materials along Ukumehame Gulch. Slopes greater than 30% cover 40% (M) of segment	Slopes greater than 30% cover 50% (M) of segment	Soft loose soils along entire segment
TOPOGRAPHY AND WATER RESOURCES	Segment is on ridge between Manawaipueo and Papalaua Gulches	Segment crosses Hanaula, Makiua, Ukumehame Gulches	Tsunami inundation zone (H) and flood prone areas (100 year flood) (M) parallel segment along 20% of coast.	Tsunami inundation zone (H) and flood prone areas (100 year flood) (M) parallel segment along 90% of coast.
EXISTING TRANSMISSION LINES AND SUBSTATIONS	None	500 ft buffer zone parallels portion of segment	None	None

TABLE A2-1 (Continued)
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	OLOWALU - MAKILA STUDY SECTION CORRIDOR SEGMENTS			
	OM-1	OM-2	OM-3A	OM-3B
LAND OWNERSHIP	50% State of Hawaii 50% Pioneer Mill Co. Private subdivision crosses part of segment	State of Hawaii: leased to Pioneer Mill Co. leased to E. Nunes Pioneer Mill Co.	Primarily Pioneer Mill Co. with two places owned by State of Hawaii and one area multi private	Mauka side of Highway Pioneer Mill Co. Makai side of Highway State of Hawaii
LAND REGULATION	Conservation LUD: Resource subzone (M) crosses segment at Olowalu Stream and covers 1/2 segment for 4,000 ft. Remainder of segment is Agricultural LUD.	Conservation LUD: Resource Subzone (M) crosses segment of Olowalu Stream. Agricultural LUD is remainder of segment.	Conservation LUD: Limited Subzone (H) parallels segment, makai of highway and Resource Subzone (M) exists in one location on coast. SMA boundary covers 100%	Conservation LUD: Limited Subzone (H) parallels segment. SMA boundary covers 100% of segment. Urban LUD: Small area along coast above Paumana Place
EXISTING LAND USE	Open undeveloped forest reserve land crosses 17 gulches, 3 irrigation ditches, 1 reservoir (M)	Mostly open land 2 Reservoirs (M) Quarry (M) Communication Site (M) Crosses 18 gulches, 3 areas of cane	Coastal Highway Residential (M) zones as Parks & Recreation (M), 3 Landfill (Exclusion) crosses 6 gulches	Coastal Highway Resort (M) near Lahaina crosses 4 gulches
PROPOSED PROJECTS	Puu Hipa Golf Course proposed by AMFAC	Puu Hipa Golf Course proposed by AMFAC	Olowalu planned community proposed by AMFAC	Kauaula Street Flood Control Channel crosses segment. Alignment for Lahaina bypass crosses segment. Dept. of Transportation project approved.
BIOLOGICAL RESOURCES	Shrubland Endangered Species (M) Candidate Endangered Species (M) around Puu Hipa. Partially within Forest Reserve	Shrubland surrounding agricultural lands	Agricultural and coastal vegetation	Agricultural and coastal vegetation
CULTURAL RESOURCES	No recorded sites. Two areas of good cultural resources. Potential numerous land commission awards along Kauaula Gulch	No recorded sites. A few land commission awards near transmission line crossing Kauaula Gulch	No recorded sites	No recorded sites Land commission awards near Paumana Park
SLOPES, GEOLOGY AND SOILS	Soils with high erosion potential (M) at Puu Hipa and areas prone to slope instability (M) and areas of landslide deposits (H) cross portions of the segment. Slopes >30% cover 15% of segment.	Soils with high erosion potential cross segment at Puu Manhanalua Nui. Slopes greater than 30% cover 20% (M) of segment.	Soft loose materials cover entire segment.	Soft loose materials cover entire segment.
TOPOGRAPHY AND WATER RESOURCES	Crosses Olowalu Stream and Kauaula Stream. Puu Hipa is within 1/2 of segment.	Crosses Olowalu Stream contains Makila Reservoir and irrigation ditches Puu Mahanalua Nui	Tsunami, inundation zone (H) covers 50% of segment along coast. Flood prone areas (100 year flood) (M) parallel entire segment along coast	Tsunami, inundation zone (H) covers 50% of segment along coast. Flood prone areas (100 year flood) (M) parallel entire segment along coast
EXISTING TRANSMISSION LINES AND SUBSTATIONS	500 ft. buffer zone (M) parallels segment	500 ft buffer zone (M) parallels segment	None	None

TABLE A2-1 (Continued)
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	LAHAINA - WAHIKULI STUDY SECTION CORRIDOR SEGMENTS				
	LW-1	LW-2	LW-3	LW-4	LW-5
LAND OWNERSHIP	B.P. Bishop Trust Estate leased by Pioneer Mill Co. State of Hawaii	B.P. Bishop Trust Estate leased by Pioneer Mill Co. State of Hawaii Pioneer Mill Co.	B.P. Bishop Trust Estate leased to Pioneer Mill Co.	State of Hawaii Lahainaluna School leased to PM Co Bishop Estate	PM Co and State of Hawaii leased to PM Co.
LAND REGULATION	Conservation LUD: Protective Subzone (H) through 80% of segment. Agricultural LUD for 20%	Agricultural LUD	Agricultural LUD	Conservation LUD Resource Subzone (M) covers 50% of segment. Agricultural LUD	Agricultural LUD
EXISTING LAND USE	Open land on edge of cane crosses 1 gulch Irrigation ditches	Cane fields 2 Reservoirs (M) and irrigation ditches	Cane fields Irrigation ditches	Mixed Use 1 Reservoir (M) at edge of cane crosses 2 gulches flume - grounds of state school	Cane fields with irrigation ditches crosses transmission line parallels Hanaula Gulch
PROPOSED PROJECTS	None	None	None	None	None
BIOLOGICAL RESOURCES	Shrubland	Agricultural	Agricultural	Agricultural Shrubland/Forest	Agricultural
CULTURAL RESOURCES	No recorded sites	No recorded sites	No recorded sites	No recorded sites	5 Recorded pre-contact sites (M) along Hahakea Gulch.
SLOPE, GEOLOGY AND SOILS	Areas of landslide deposits (H) cover 30% of segment at Paupau. Slopes greater than 30% (M) cover 80% of segment	Isolated slopes of greater than 30% (M) over 10% of segment	Isolated slopes of greater than 30% (M) cover 5% of segment	Areas of landslide deposits (H) cover 20% of segment within gulches. Slopes greater than 30% (M) cover 50% of segment.	Areas of landslide deposits (H) cover 10% of segment. Areas prone to slope instability (M) cross small portion of segment. Slopes greater than 30% cover 10% of segment.
TOPOGRAPHY AND WATER RESOURCES	Crosses a gulch contain an irrigation ditch for most of the length	Irrigation ditch parallels segment for entire length	Irrigation ditch parallels segment for entire length	Crosses Kanaha and Kahoma streams	Irrigation ditch parallels 4,000 ft of length Kahakea Gulch is in center for 4,000 ft.
EXISTING TRANSMISSION LINES AND SUBSTATIONS	None	None	500 ft buffer zone crosses corner of segment	None	Crosses 69KV Line (H)

TABLE A2-1 (Continued)
CORRIDOR SEGMENT COMPARISON

EVALUATION CATEGORY	LAHAINA - WAHIKULI STUDY SECTION CORRIDOR SEGMENTS					
	LW-6A	LW-6B	LW-7	LW-8	LW-9	LW-10
LAND OWNERSHIP	P.M. Co.	P.M. Co.	Bishop Estate P.M. Co. State of Hawaii leased to P.M. Co. Private adjacent	Private Owners in Lahaina P.M. Co. on mauka side of segment	State of Hawaii leased to P.M. Co.	Lahaina Town Private Owners State of Hawaii leased to P.M. Co.
LAND REGULATION	Agricultural LUD	Agricultural LUD	Agricultural or Urban LUD	SMA boundary covers 70% of segment Urban LUD on Makai side and Agricultural on Mauka side	Urban LUD for 90% of segment. Agricultural LUD near Kahana Stream	Urban LUD. SMA boundary covers 90% of segment.
EXISTING LAND USE	Parallels Hahakea Gulch and Wahikuli Gulch cane fields with irrigation flume parallels 69KV transmission line	Cane fields crosses 3 irrigation ditches	Kahoma Stream and Flood Control Channel Residential to South Cane to North	HP Highway through Residential (M) Parks & Recreation (M) Commercial (M) Cane, Industrial Commercial	Parallels 69KV line Residential (M) on Makai side cane fields on Mauka side	Coastal highway for 1/2 length Residential (M) Parks & Recreation (M) Public/Com. Facility (M) Commercial (M) Mixed urban use
PROPOSED PROJECTS	None	None within but parallels HFDC planned development for entire segment	None	None	Crosses HFDC planned development and parallels on Makai side	HFDC Phase I under construction (M) covers small portion of segment
BIOLOGICAL RESOURCES	Agricultural	Agricultural	Agricultural Stream side vegetation	Urban and agricultural	Agricultural	Urban
CULTURAL RESOURCES	4 recorded pre-contact site (M) 1 recorded post-contact site (M) along Hahakea Gulch	No recorded sites	Cluster of recorded pre-contact sites (M) either side of Kahoma Stream	Lahaina Historic District (H) covers 50% of segment.	No recorded sites	Lahaina Historic District (H) crosses end of segment, 5%
SLOPE, GEOLOGY AND SOILS	Slopes <30%	Slopes <30%	Slopes greater than 30% (M) cover 10% of segment	Soft loose materials across 50% of segment		Soft loose materials across 30% of segment
TOPOGRAPHY AND WATER RESOURCES	Two flumes Flood prone area (M) covers small portion of segment. Confluence of Wahikuli and Hahakea Gulch	Crosses two irrigation ditches	Kahoma Stream and Flood Control Channel extends entire length	None	Kahoma Flood Control Channel crosses segment	Tsunami inundation zone (H) and flood prone area (100 year flood) (M) cover 20% of segment.
EXISTING TRANSMISSION LINES AND SUBSTATIONS	Crosses two 69KV Line (H) and parallels it for 2,000 ft	None	Crosses 69KV Line (H)	Parallels 69KV Line (H) for 3/4 of the segment. Lahaina substation w/i segment	Parallels 69KV Line (H) for entire segment	500 ft buffer zone (M) covers several small portions of segment

SENSITIVITY ANALYSIS

Purpose

The purpose of the analysis was to provide a semi-quantitative comparison of constraints and opportunities of the alternative corridor segments and to assist in the evaluation and screening of alternative corridors and the selection of the least constrained corridor or the environmentally superior corridor.

Results

The constraint ratings assigned during the course of the regional study and constraint analysis were used to compare the corridor segments. Feasible corridor segment combinations were developed, and these combinations were linked across the four study sections to derive 58 different alternatives and a sensitivity evaluation was conducted on the 58 feasible corridors.

Feasible corridors are defined as the combinations of corridor segments that represent the consultant team's judgement of the most logical and practical options among the many possible combinations of corridor segments. The net constraint units (weighted) and the net constraint units expressed as a % of linear units (total length) were calculated for the feasible corridors.

Those corridors with the lowest (%) score were ranked environmentally superior in terms of their potential for siting the transmission line. Those corridors with a higher percentage score had a higher number of constraints in the corridor.

By measuring the straight line distance across areas of constraint within each corridor segment for each data category and taking the sum, the total constraint units for each corridor segment was derived. These constraint units by evaluation factor for each corridor segments are shown on Table A2-2.

An "unweighted" score was the measured linear straight-line distance across any area of constraint: exclusion, high or medium. Whereas, a "weighted" score accounted for the fact that high constraint areas should be considered "more constrained" than medium (or low) and the high constraint areas were measured as the linear straight-line distance across the constraint area multiplied by 2 and the medium constraint areas were multiplied by 1. Please note, the low constraint areas were not included in the analysis as they do not constrain transmission corridor location. The weighted constraint scores were used in the final analysis comparing feasible corridor alternatives.

Table A2-2
CONSTRAINT UNITS BY EVALUATION FACTOR FOR CORRIDOR SEGMENTS

CORRIDOR SEGMENT	LAND REGULATION (High)	LAND REGULATION (Medium)	EXISTING LAND USE (Exclusion)	EXISTING LAND USE (High)	EXISTING LAND USE (Medium)	PROPOSED PROJECTS (Medium)	UTILITIES TRANS. SEPAR (High)	UTILITIES TRANS. SEPA (Medium)	BIOLOGIC RESOURC (Medium)	CULTURAL RESOURC (High)	CULTURAL RESOURCES (Medium)	SLOPE (Medium)	GEOLOGY SOILS (High)
	CP/CL Subzones	SMA CR/CG Subzones	Active Landfills	Shooting Range	R, C, P/R, Qry, Res. PF, Comm.S.	Projects Under Const.	w/in 250ft from 69 KV	w/in 500ft from 69 KV	ETS Habitat	National Register District	Recorded Arch. Sites	Slopes > 30%	Areas Landslide Deposits
Power Plant													
PP-1	0.00	0.00	0.00	0.00	0.00	0.00	3.25	3.25	0.00	0.00	0.00	0.00	0.00
PP-2	0.50	0.50	0.00	0.00	0.75	0.00	0.00	2.90	0.00	0.00	0.40	0.60	0.00
PP-3	0.00	2.60	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maalaea – Ukumehame													
MU-1	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.20	0.00	0.00	0.00	0.00	0.00
MU-2	1.00	10.00	0.00	0.00	0.50	0.00	0.50	0.00	1.10	0.00	0.00	11.20	0.00
MU-3A	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
MU-3B	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MU-3C	0.50	1.90	0.00	0.00	1.75	0.00	0.00	0.30	0.00	0.00	1.60	0.00	0.00
MU-4	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00
MU-5	0.00	2.40	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.20	1.50	0.00
MU-6	0.25	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00
MU-7	2.10	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.20	0.00
MU-8	0.00	2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00
MU-9	1.20	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	3.50	0.00
MU-10A	10.00	9.50	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	1.50	12.00	0.00
MU-10B	5.00	9.00	0.00	1.25	3.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Olowalu – Makila													
OM-1	0.00	2.00	0.00	0.00	0.30	0.00	0.00	0.00	1.50	0.00	0.00	7.25	1.00
OM-2	0.00	0.10	0.00	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00
OM-3A	9.00	9.00	0.00	0.00	2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OM-3B	4.00	8.00	0.50	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lahaina – Wahikuli													
LW-1	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	1.00
LW-2	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00
LW-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LW-4	0.00	2.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.50
LW-5	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	1.00	0.50	0.30
LW-6A	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	1.00	0.00	0.00
LW-6B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LW-7	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.40	0.00	0.00
LW-8	4.10	0.00	0.00	0.00	4.90	0.00	4.75	0.00	0.00	4.00	0.00	0.00	0.00
LW-9	0.00	0.00	0.00	0.00	2.40	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00
LW-10	4.10	1.25	0.00	0.00	4.90	0.60	0.00	0.00	0.00	0.40	0.00	0.00	0.00

CONSTRAINT UNITS are variable measures of linear distance dependent on the scale of the map. In this case, they were calculated as inches on a 1:24,000 scale map. UNWEIGHTED total constraint units are a total of all constraint units in each of the listed categories. This assumes that "exclusion", "medium" and "high" constraints have equal importance. WEIGHTED total constraint units are a total of all constraint units in each of the categories with "exclusion" given a weighting of 3; "high" constraints, a weighting of 2; and "medium" constraints a rating of one. This assumes that "high" constraints are twice as important as "medium" constraints.

Table A2-2 (cont.)

CORRIDO SEGMENT	GEOLOGY SOILS (Medium)	WATER RESOURCES (High)	WATER RESOURCE (Medium)	TOTAL CONSTRAIN	UNITS
	Unstable Slopes & Erosion	Tsunami Inundation Zone	Areas Flood Prone	Unweighted	Weighted
Power Plant					
PP-1	0.00	0.00	0.00	6.50	9.75
PP-2	0.00	0.00	0.00	5.65	6.15
PP-3	0.00	0.00	0.50	3.60	3.60
Maalaea-Ukumehame					
MU-1	0.00	0.00	0.00	2.20	3.20
MU-2	7.10	0.00	0.00	31.40	32.90
MU-3A	0.00	0.00	0.00	2.80	2.80
MU-3B	0.00	0.00	0.00	1.60	1.60
MU-3C	0.00	0.00	1.80	7.55	8.05
MU-4	0.00	0.00	0.00	3.45	3.45
MU-5	0.00	0.00	0.00	5.35	5.35
MU-6	0.90	0.00	0.00	4.95	5.20
MU-7	1.80	0.00	0.00	11.10	13.20
MU-8	0.00	0.00	0.00	8.90	8.90
MU-9	0.00	0.00	0.00	5.60	6.80
MU-10A	0.00	0.00	0.00	35.00	45.00
MU-10B	0.00	6.00	6.00	30.50	42.75
Olowalu - Makila					
OM-1	5.50	0.00	0.00	17.55	18.55
OM-2	2.20	0.00	0.00	6.60	6.60
OM-3A	0.00	3.50	9.00	33.25	45.75
OM-3B	0.00	4.00	7.00	26.00	35.00
Lahaina - Wahikuli					
LW-1	1.00	0.00	0.00	5.75	6.75
LW-2	0.00	0.00	0.00	1.00	1.00
LW-3	0.00	0.00	0.00	0.00	0.00
LW-4	1.50	0.00	0.00	6.20	7.70
LW-5	0.30	0.00	0.00	2.90	4.00
LW-6A	0.00	0.00	0.00	3.50	6.00
LW-6B	0.00	0.00	0.00	0.00	0.00
LW-7	0.00	0.00	0.00	1.20	2.00
LW-8	0.00	0.00	0.00	17.75	30.60
LW-9	0.00	0.00	0.00	6.40	10.40
LW-10	0.00	5.00	0.00	16.25	25.75

Through a series of calculations as demonstrated in Tables 2 and 3 of Sensitivity Analysis Tables, Section A3, the net constraint units (weighted) and the net constraint units expressed as a % of linear units (total length) were calculated for the 58 feasible corridors. Those corridors with the lowest (%) score are ranked environmentally superior in terms of their potential for siting the transmission line. Those corridors with a higher (%) score have a higher number of constraints in the corridor or a low number of opportunity units.

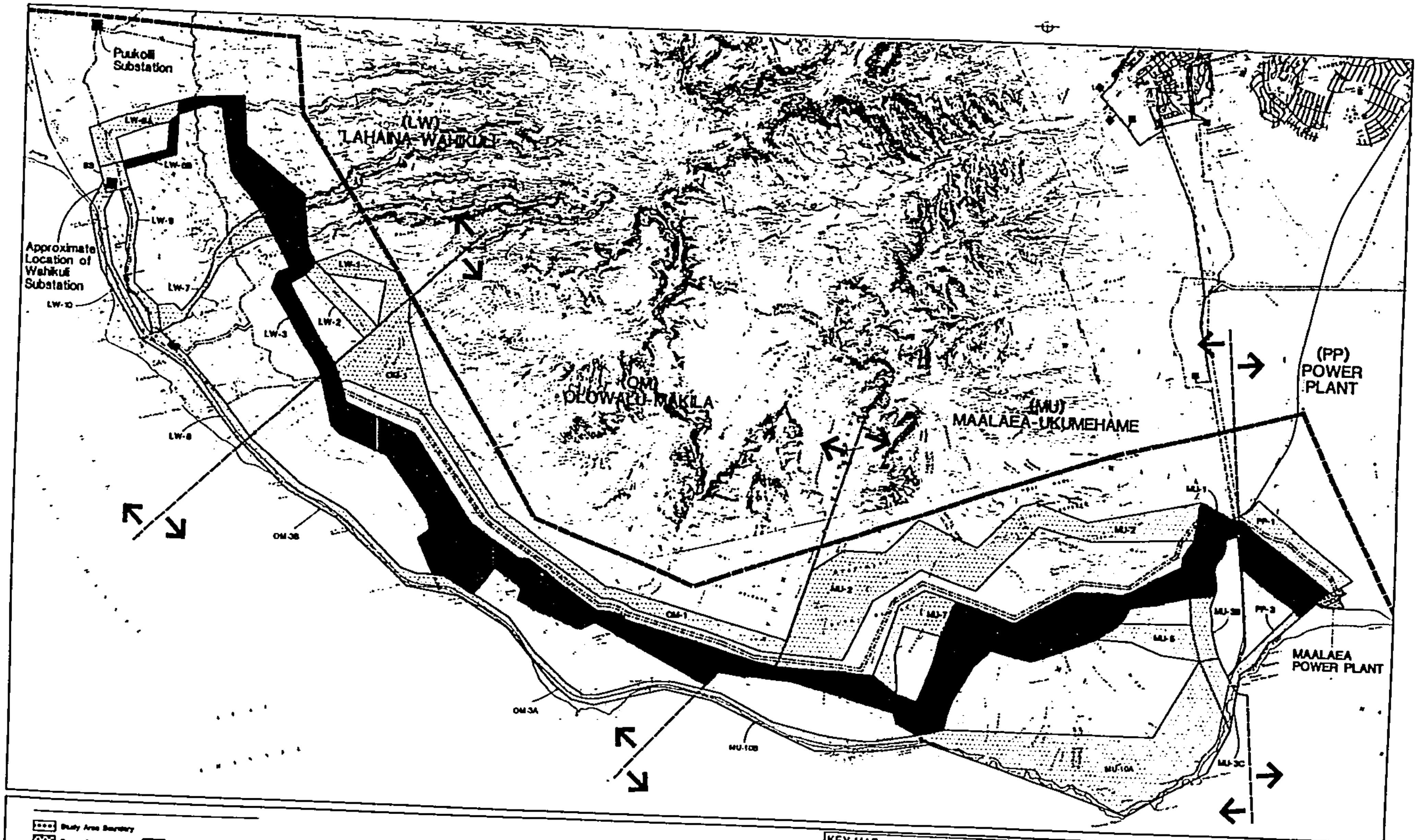
Opportunity units were defined as developed access and approximated the linear distance that a corridor paralleled existing developed rights-of-way (excluding 69KV transmission lines but including cane field edge roads). If a corridor segment paralleled developed access, the linear distance was included as one opportunity unit for each one unit of access (see Table 3, in Sensitivity Analyses Tables, Section A3).

The percentage (%) scores for all the corridors fell within a range of 89.6 to 487.9. The highest percentage scores indicate corridors with combinations of higher scored (multiple constraint factors) corridor segments. For example, corridors involving segment MU-2 or segment combinations of two or more of the following: MU-10A, MU-10B, OM-3A, OM-3B, or LW-10 ranked high.

Of the 58 analyzed, nineteen ranked less than 117, representing 7% of the total range of scores and clustered around an arithmetic mean of 101. Six ranked between 141 and 150, representing approximately 15% of the total scores; eleven ranked between 153 and 168, or within 20% of the total scores; and twenty-two (22) combinations scored 169 and above, greater than 20% of the total score. Table A2-3 shows corridors within the top 7% total score of those evaluated.

The least constrained corridor (Figure A2-1) and top ranking alternatives had a number of characteristics in common:

- They did not include the shoreline or coastal segments.
- They avoided extremely steep terrain.
- They avoided biologically sensitive habitats and natural reserves in the mauka areas of the study area.
- They avoided crossing cane or pineapple fields, but in some cases utilized cane field edge roads or irrigation ditches.
- They avoided developed lands used for residential, commercial or recreational purposes.



Study Area Sections
Alternative Corridor Segments

LOWEST CONSTRAINT

ENVIRONMENTAL SENSITIVITY ANALYSIS

KEY MAP

SCALE

NORTH

Figure A2-1

Alternative Corridors 2C 5N 89.67%

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore

- They followed the perimeter of the HFDC development in Lahaina to the Wahikuli Substation site (Segment LW-6B).

Construction cost was also considered as a corridor evaluation factor. Based on an approximate cost of $250,000 per mile for construction of a 69KV transmission line in terrain with slopes (0-20%) and $350,000 per mile for construction in terrain with greater than (>) 20% slope, the approximate construction cost was calculated for each of the top ranked corridor alternatives (Table A2-3). This estimated cost was based on a wood pole designed to withstand 60 mph wind loads (the original design concept) and it did not include the cost to construct or improve access roads. The estimated costs ranged between $4.12 million and $5.00 million with mean cost of $4.65 million.

PRIMARY CORRIDOR ALTERNATIVES

Within the 58 feasible corridor combinations analyzed in the sensitivity analysis, four primary corridor alternatives emerged and are shown in Figures A2-2 through A2-5 and noted below:

Alternative 1 - Mauka Corridor
Alternative 2 - Central Corridor
Alternative 3 - Makai - Central Corridor
Alternative 4 - Coastal Corridor

The least constrained corridor from the sensitivity analysis approximates Alternative 2, Central Corridor.

PUBLIC MEETINGS, AGENCY REVIEW AND LANDOWNER CONSULTATION

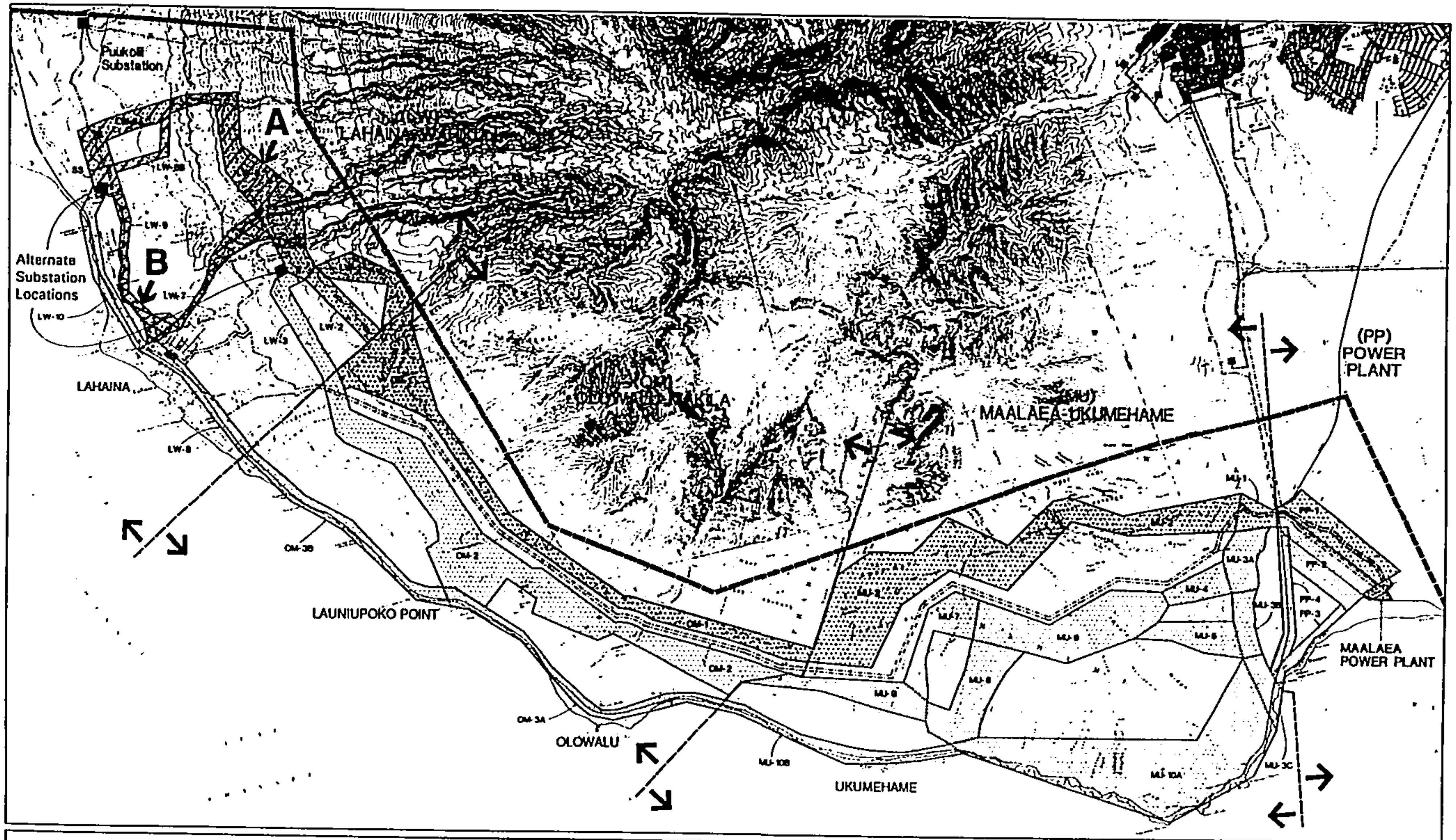
The four primary corridor alternatives were reviewed and discussed with the major landowners, presented in a project newsletter, and presented and discussed at the public meetings. The groups were asked to provide comments on the alternatives and to express a corridor preference.

Public Meetings

A public meeting announcement letter was sent to community groups, agencies, elected officials and landowners inviting them to attend a public information meeting on the project. A project fact sheet describing the project, routing studies and maps showing the primary corridor alternatives were prepared and distributed at the public meetings.

Table A2-3
TOP RANKED ALTERNATIVE CORRIDORS

REFERENCE CODE	FEASIBLE CORRIDORS	NET CONST WITH OPPOR WEIGHTED	LINEAR UNITS	NET CONST AS A % OF LINEAR UNITS (Weighted)	LENGTH (miles)	CONST. COST ($M)	REFERENCE CODE
2 C 5 N	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	42.10	46.95	89.67	17.78	4.45	2 C 5 N
2 E 5 N	PP-2/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	45.60	49.45	92.21	18.73	4.68	2 E 5 N
2 C 5 M	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	44.90	48.05	93.44	18.20	4.55	2 C 5 M
2 E 5 M	PP-2/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	48.40	50.55	95.75	19.15	4.79	2 E 5 M
1 C 5 N	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	45.70	47.60	96.01	18.03	4.51	1 C 5 N
2 D 5 N	PP-2MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	49.90	51.05	97.75	19.34	4.83	2 D 5 N
1 E 5 N	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	49.20	50.10	98.20	18.98	4.74	1 E 5 N
2 B 5 M	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	49.20	49.65	99.09	18.81	4.70	2 B 5 M
3 H 5 N	PP-3/MU-3C/MU-10A/MU-8(part)/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	45.25	45.45	99.56	17.22	4.30	3 H 5 N
1 C 5 M	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	48.50	48.70	99.59	18.45	4.61	1 C 5 M
2 D 5 M	PP-2/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	52.70	52.15	101.05	19.75	4.94	2 D 5 M
1 E 5 M	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	52.00	51.20	101.56	19.39	4.85	1 E 5 M
1 D 5 N	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	53.50	51.70	103.48	19.58	4.90	1 D 5 N
1 B 5 M	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	52.80	50.30	104.97	19.05	4.76	1 B 5 M
2 B 5 N	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	46.40	43.55	106.54	16.50	4.12	2 B 5 N
1 D 5 M	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	56.30	52.80	106.63	20.00	5.00	1 D 5 M
2 B 5 S	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-7/LW-9	56.10	50.35	111.42	19.07	4.77	2 B 5 S
1 B 5 N	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	50.00	44.20	113.12	16.74	4.19	1 B 5 N
1 B 5 S	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-7/LW-9	59.70	51.00	117.06	19.32	4.83	1 B 5 S



ALTERNATIVE #1

Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Study Area Sections
OM-1 Alternative Corridor Segments

KEY MAP

NORTH

SCALE

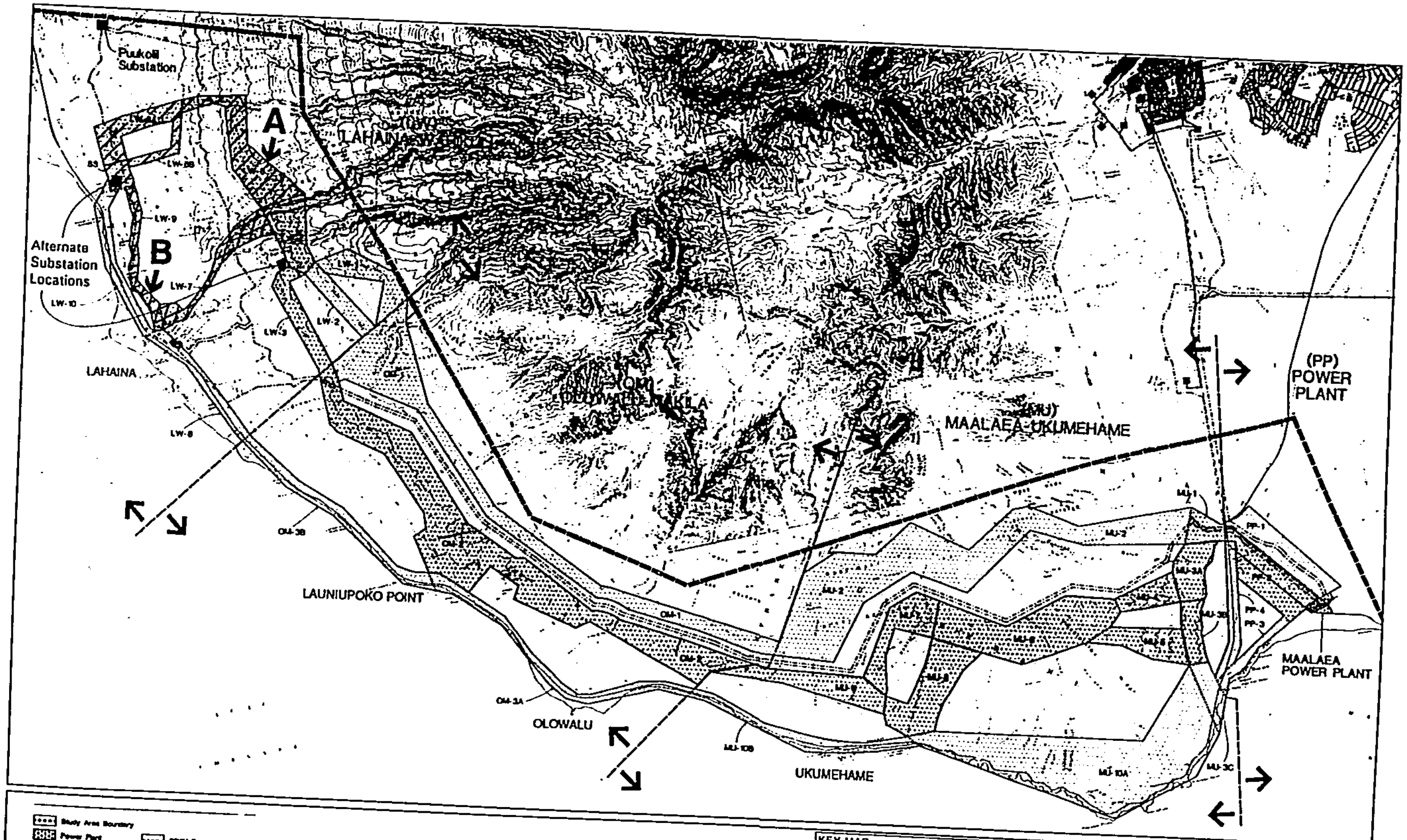
Figure A2-2

Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore



Study Area Boundary
Power Plant
Substation
69KV Transmission Line
23KV Transmission Line
Study Area Sections
Alternative Corridor Segments

ALTERNATIVE #2

KEY MAP

NORTH

SCALE

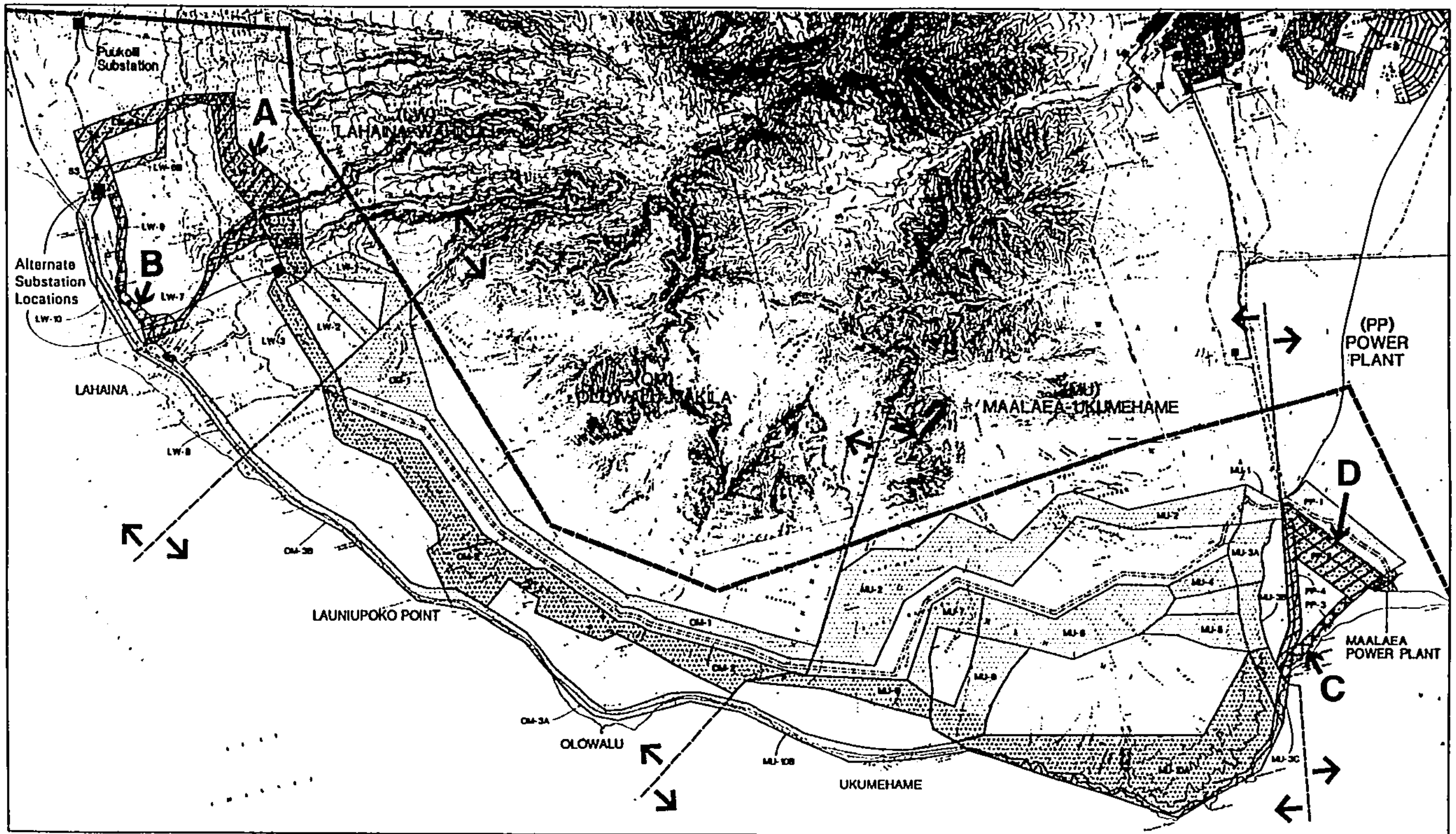
Figure A2-3

Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore



Study Area Sections

Alternative Corridor Segments

ALTERNATIVE #3

KEY MAP

NORTH

SCALE

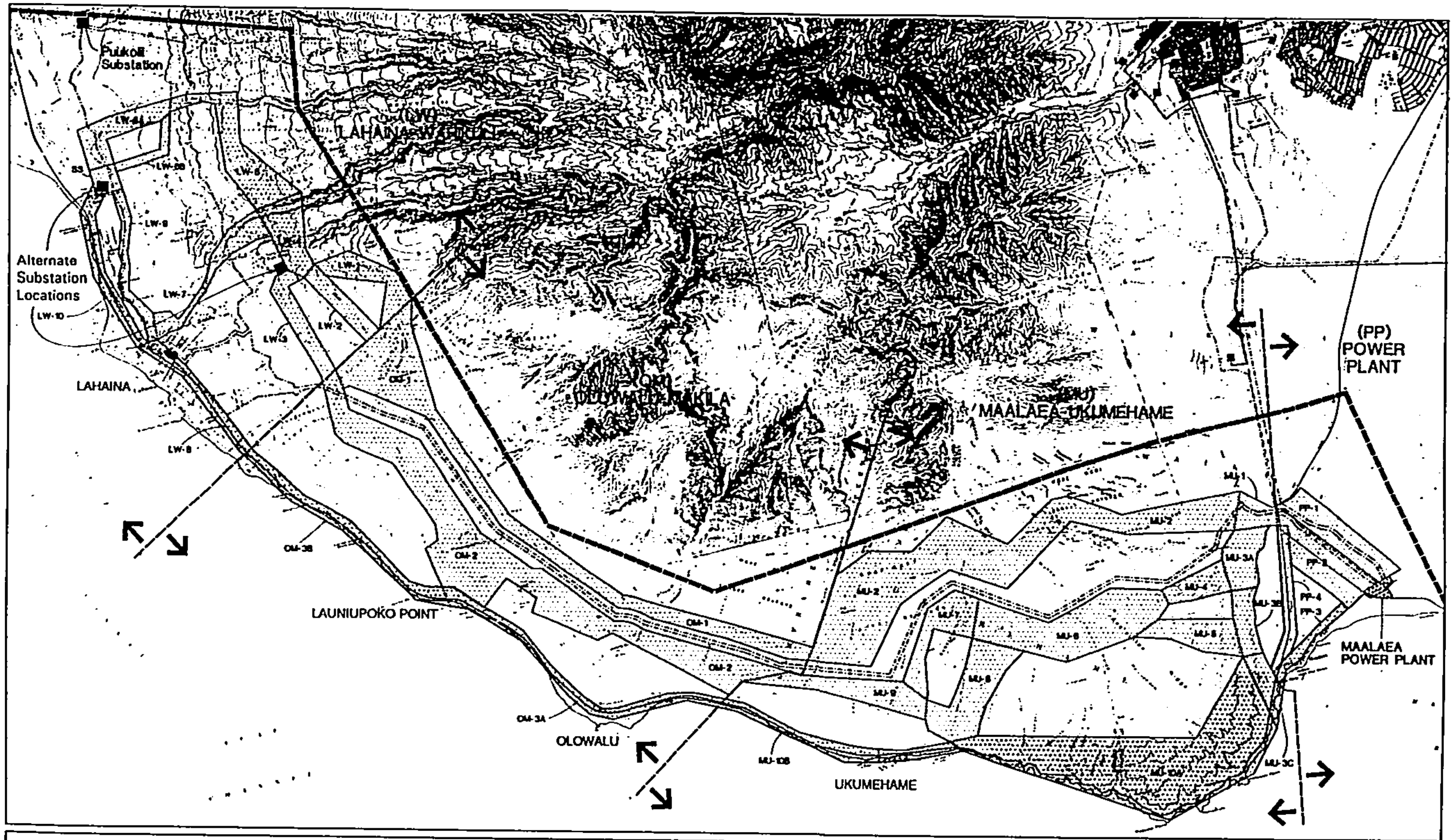
Figure A2-4

Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore



Study Area Sections

Alternative Corridor Segments

ALTERNATIVE #4

Figure A2-5

Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore

Public meetings were held on March 11, 1992, in Lahaina and March 12, 1992, in Kahului to present and discuss the route selection process and the alternative corridors. Environmental data and constraint maps and slides were used to present the results of the corridor identification process and to show the location of the corridor alternatives.

The public was asked to provide input on each of the corridor alternatives that would assist MECO in selecting a final preferred corridor. The project fact sheet containing maps of the corridors and a mail back response form were handed to each meeting attendee so if they did not provide input during the meeting, they could send a written response to MECO. The response form was structured so that individuals could indicate a preferred corridor.

Questions raised during the two meetings included, why not locate the new line on the same poles within the same corridor as the existing two lines? The purpose of the new line is to increase capacity and maintain reliability even under increased loads. Reliability is maintained by separating the existing and proposed transmission lines. MECO's minimum separation for planning purposes is 250 feet.

Several individuals spoke out against siting the line along the coastal highway because of aesthetic impacts and possible need to relocate it in the future to accommodate future highway widening on project development.

Of the twenty-one total meeting attendees, eleven written responses were received. The ranking of preferences was Alternative 2 (5), Alternative 3 (3), Alternative 1 (2) and Alternative 4 (1). Five responses received expressed opposition to Alternative 4, the coastal alternative, as well as their preference for either Alternatives 1 or 2.

Landowner Consultation

Individual meetings were held with major landowners: the State Department of Land and Natural Resources (DLNR), State HFDC, A&B Hawaii, Inc. and Hawaiian Commercial & Sugar Company, Wailuku Agribusiness and C. Brewer Properties, Inc., the State Department of Transportation, Pioneer Mill Company and AMFAC/JMB Hawaii, Inc. and B.P. Bishop Estate. Comments received from the landowners included corridor preferences, areas to avoid and possible conflicts with existing and proposed land uses.

Specific siting issues discussed included: agricultural operations and safety requirements, use of existing state highway right-of-ways, protection of viewplanes from the Lahaina Pali Trail, protection of the future utility of the land currently used for sugar cane production, the proposed Lahaina Bypass Road as a possible transmission line alignment and the status of the HFDC's land acquisition for development of the Lahaina Master Planned Community.

Several consultation meetings were held with DLNR representatives from DOFAW, Land Management, OCEA, Historic Preservation and Lahaina Pali Trail Program Specialists between December 1991 through March 1993, to review the alternative corridors.

Alternative 1 was rejected because it was in steep terrain and contained endangered plant species habitat and dense areas of native dryland forest adjacent to a Natural Area Reserve.

With respect to the Lahaina Pali Trail, Alternatives 3 and 4 were not preferred because of concerns regarding possible line visibility from the trail and crossing of the trail. Preference was expressed for locating the line mauka of the Lahaina Pali Trail (See discussion of Lahaina Pali Trail Viewshed Analysis).

A&B Hawaii, Inc. and Hawaiian Commercial & Sugar Company recommended using a corridor that paralleled the North Kihei Road through their property.

Amfac/JMB Hawaii and Pioneer Mill Company sent a letter identifying a preference for locating the line in a mauka corridor segment just above their cane lands and along the proposed Lahaina Bypass Road alignment. Their recommended corridor involved crossing the existing 69KV transmission lines in the vicinity of Ukumehame Gulch.

The State Department of Transportation discouraged the use of the Lahaina Bypass Road as a potential corridor stating the coordination of planning for the two linear facilities could be difficult since the route for the bypass was not finalized.

SELECT PRELIMINARY PREFERRED CORRIDORS

The various comparative corridor evaluations and discussions with public, agencies and landowners resulted in the identification of two additional corridors. Corridor Alternatives 5 and 6 are shown on Figures A2-6 and A2-7. The two corridors were similar except in the Maalaea-Ukumehame study section, where Alternative 5 proceeded along the lower slopes of the West Maui mountains and Alternative 6 proceeded above the Lahaina Pali Trail through the Central West Maui mountains. These two alternatives became the preliminary preferred corridors for routing the new transmission line.

MECO determined that additional evaluation of several issues was warranted to provide more information upon which to select a final corridor. Key areas that were evaluated further were the overall advantages and disadvantages within each corridor segment including the cost differences between the corridors, the potential visual effect of the new line from the Lahaina Pali Trail, landowner opinion, constructibility and access.

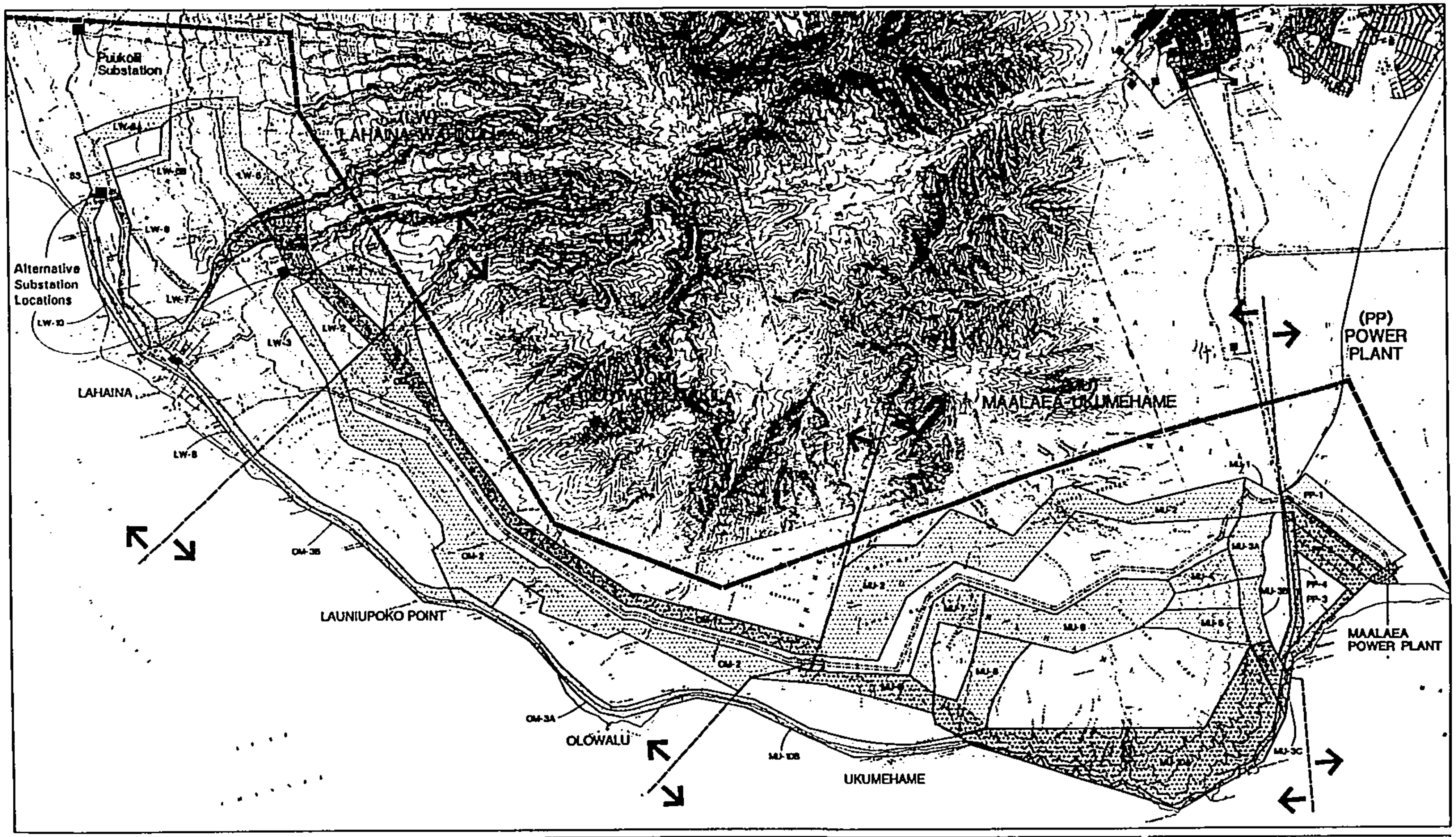
ADVANTAGES AND DISADVANTAGES

All six corridors with subalternatives were individually evaluated for their advantages and disadvantages in providing a route for the 69KV transmission line. The factors examined included construction cost based on estimates provided to MECO by Stone & Webster, landowner and public comments, regulatory controls, engineering factors such as length, constructibility, probable operations and maintenance cost. Each factor was measured against the test (criteria) provided in Table A2-4 to determine if it was an advantage or a disadvantage to transmission line siting. Table A2-5 shows the results of these tests for transmission line siting by study section.

Unresolved issues were noted. The consultant recommended a preferred segment and through consultation with MECO, a decision for the preferred segment was made.

CONSTRUCTION COST COMPARISON

Based on Stone & Webster's calculations, a separate construction cost estimate was prepared to include the labor, material, engineering and contingency for each corridor alternative (Table A2-6). The estimate assumed wood pole construction. Since the project was to be constructed across



ALTERNATIVE #5

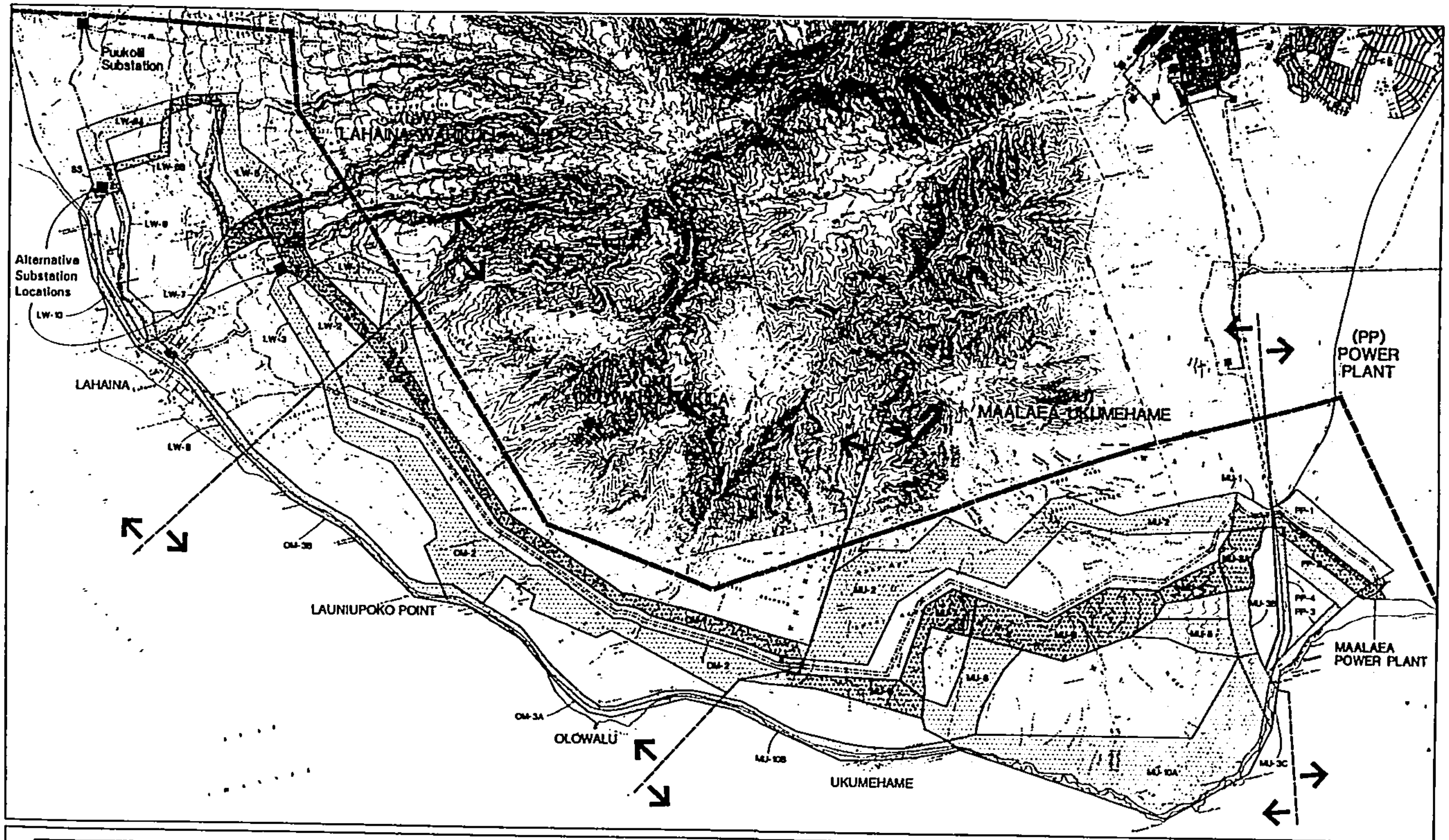
Figure A2-6

Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore



Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines
Study Area Sections
Alternative Corridor Segments

ALTERNATIVE #6

KEY MAP

NORTH

SCALE

Figure A2-7

Alternative Corridors

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore

Table A2-4
ENVIRONMENTAL FACTORS AND SIGNIFICANCE TO SITING A TRANSMISSION LINE

FACTOR	TEST	SIGNIFICANCE
Landowner Preference	Yes, No, Unknown	
Regulatory Requirements	Many, few, none	Many requirements is a disadvantage
Existing Land Use		
Agriculture	Crosses	Disadvantage
	Parallels boundary	Advantage
Undeveloped/Open	Crosses	Advantage
Residential	Presence	Avoid, if possible
	Crosses or proximity	Disadvantage
Schools Presence	Avoid, if possible	
	Proximity to	Disadvantage
Other Unique Uses	Presence	Avoid, if possible
Proposed Projects	Presence	Avoid, if possible
Biological Resources		
ETS Habitat or plants	Presence	Disadvantage Requires survey to avoid impact
Reserves or Sanctuaries	Presence	Avoid, if possible
	Crosses	Major Disadvantage
Native vegetation type	Absence	Advantage
	Presence	Potential Disadvantage Subject to Survey
Cultural Resources		
Archaeological Sites	Many sites within corridor	Disadvantage, detailed survey required
Lahaina Pali Trail	Parallels	Major Disadvantage
	Crosses	Disadvantage
Areas with good potential	Crosses	Survey required
Constructibility		
Steep slopes/Terrain	Crosses	Potential disadvantage
Landslide Potential	Crosses	Disadvantage
Access	Presence	Advantage
	Absence	Potential disadvantage
Maintenance	From ground	Advantage
	From helicopter	Disadvantage
Length	Short	Advantage/lower cost
Cost	Long	Disadvantage/higher cost
EMF as a concern	Near sensitive Receptors	Prudent avoidance of residential, schools, existing & proposed projects
Visual Issues	Subjective case by case	
Lahaina Pali Trail		
Coastal views		
Scenic Highways		
Scenic Point		

Table A2-5
POWER PLANT STUDY SECTION ALTERNATIVES

DESCRIPTION	PP-1	PP-2	PP-3	PP-2/PP-4
COST (thousands, 1992) LENGTH (miles)	$260.00 1.63	$108.50 0.68	$165.90 1.04	$335.00 2.1
DISADVANTAGES	Not preferred by landowner HC & S Preferred by C.Brewer Crosses Ag land but adjacent to edge of field	Crosses Ag land but adjacent to edge of field Potential visual issues if sited along Kihei Rd.	SMA use permit Potential CDUA Maalaea Triangle Project A & B Single Family Residential In proximity of residential Kanaio Soft loose materials throughout May interfere with coastal views	Not preferred by C. Brewer SMA use permit Crosses ag land and parallels Hono-apiilani Hwy. which is is proposed for widening A & B Single Family Residential May interfere with coastal views
ADVANTAGES	Few permits C. Brewer has offered to assist in finding alignment at highway crossing Would not substantively charge visual character Uses existing rights-of-way	Preferred by HC & S along Kihei Rd. Shortest route in study section	Parallels Ag land & avoid use existing secondary road right-of-way Shortest route and most direct route to Makai corridor	Existing 12KV easement along HP Hwy framed for 23KV 69/12KV overbuild uses existing right-of-way
UNRESOLVED ISSUES	Recommended alignment by C. Brewer to avoid pineapple field			
DECISION: RECOMMENDATION:	PP-2/PP-4 to use existing right-of-way; PP-2 if if central corridor is preferred PP-2			

Table A2-5
OLOWALU – MAKILA STUDY SECTION ALTERNATIVES

LOCATION DESCRIPTION COST (thousands, 1992) LENGTH (miles)	MAUKA OM-1 $1,582.90 6.12	CENTRAL OM-2 $962.10 6.03	MAKAI OM-3A/OM-3B $970.10 6.08	MAKAI-CENTRAL OM-3A/OM-2(half) $997.35 6.25
DISADVANTAGES	PMCo preferred although partially owned by State Puu Hipa Golf Course (proposed by AMFAC) Native vegetation and potential ETS plants near Puu Hipa Some slopes >30% Crosses small areas of landslide deposits, unstable slopes and erosion potential to crosses Two areas with good cultural resource potential–survey required	PMCo opposed Crosses cane fields in three places, quarry, landfill must be sited around Olowalu Planned Community (proposed by AMFAC) One area of high erosion potential at Puu Mahanalua Nui	PMCo opposed Within SMA for entire length Residential, landfill cane are within corridor Olowalu Planned Community (proposed by AMFAC) Lahaina Bypass and Flood Control Channel (Kauaula Stream) Soft loose materials throughout *Visual impact from* scenic highway	PMCO opposed Within SMA for half length Communication site near boundary between OM-3A & OM-2 Olowalu Planned Community (AMFAC project) Soft loose materials over ½ route *Visual imapct from* scenic highway
ADVANTAGES	PMCO preferred Can avoid intrusion into Conservation LUD if span Olowalu Stream Open/undeveloped land No existing uses that would conflict Avoids West Maui NAR No visual impact Good Access	Can span Conservation LUD near Olowalu Stream Shortest route Least expensive Good Access	Flat terrain Few cultural resources Good Access	Flat terrain Few cultural resources Good Access
UNRESOLVED ISSUES	Aquifer near Puu Hipa Span across Conservation LUD of Olowalu Stream Archaeological Resources at Crossover (OM-2 to OM-1) Biological Resources at Puu Hipa			

DECISION: OM-1
RECOMMENDATION: OM-1

Table A2–5 (cont.)
MAALAEA – UKUMEHAME STUDY SECTION ALTERNATIVES (Page One of Two)

LOCATION	MAUKA	CENTRAL–1	CENTRAL–2	CENTRAL–3
SEGMENTS	MU–1/MU–2	MU–1/MU–3A/MU–4/ MU–6/MU–7/MU–9	MU–1/MU–3A/MU–4/ MU–6/MU–8/MU–9	MU–1/MU–3A/MU–3B/ MU–5/MU–6/ MU–7/MU–9
COST (thousands 1992)	3674.5	3461.7	3661.1	3746.9
LENGTH (miles)	5.98	6.73	7.05	7.48
DISADVANTAGES	DLNR–DOFAW opposed State owned Forest Reserve for most of length Potential ETS Species and habitat Slopes >30% for entire length Much of corridor has landslide potential Unstable slopes Higher construction cost very poor access	Crosses large area of protective and limited subzone, Conservation land use district Steep ridges and gulches Crosses an area prone to slope instability	Steep ridges and gulches Crosses an area prone to slope instability	DLNR–DOFAW opposed (MU–5 below Pali Trail) Crosses Lahaina Pali Trail Numerous archaeological sites Steep ridges and gulches Crosses area prone to slope instability Visual impact from Lahaina Pali Trail
ADVANTAGES	No visual impact from travelways on proposed projects No archaeological sites	DLNR–DOFAW Preferred Few archaeological sites Access from maintenance roads for existing 69KVs	DLNR DOFAW & land management preferred MU–8 avoids most of protective subzone Few archaeological sites Some access from maintenance roads for existing 69KVs	
UNRESOLVED ISSUES				Visual impact from the Lahaina Pali Trail– field inspection required

Table A2-5 (cont.)
MAALAEA – UKUMEHAME STUDY SECTION ALTERNATIVES (Page Two of Two)

LOCATION SEGMENTS	CENTRAL-4 MU-1/MU-3A/MU-3B/ MU-5/MU-6/MU-8/MU-9	MAKAI-CENTRAL MU-3C/MU-10A/MU-9	COASTAL MU-3C/MU-10A/MU-10B
COST (thousands 1992)	3946.3	3062.9	2739.1
LENGTH (miles)	7.8	5.42	6.5
DISADVANTAGES	DLNR-DOFAW (MU-5 below Pali Trail) Crosses Lahaina Pali Trail Steep ridges and gulches Crosses area prone to slope instability Visual impact from Lahaina Pali Trail	DLNR-DOFAW opposed Crosses Lahaina Pali Trail Numerous archaeological sites clustered in MU-10A	Within SMA entire length Crosses a shooting range, cane fields Crosses Lahaina Pali Trail Visual impact to scenic highway Soft loose materials adjacent to highway
ADVANTAGES		Can avoid SMA intrusion for most of length Good access by jeep trail Shorter fewer spans	
UNRESOLVED ISSUES	Visual impact from the trail Inspection required	Visual impact from the trail Inspection required	

DECISION: Defer decision until after field inspection
RECOMMENDATION: Central-1 or Central-2

Table A2-5 (cont.)
LAHAINA – WAHIKULI STUDY SECTION ALTERNATIVES (Page One of Three)

DESCRIPTION COST (thousands 1992) LENGTH (miles)	LW-1 436.6 1.32	LW-2 258.7 1.00	LW-3 346.6 1.34
DISADVANTAGES	CDUA required Possible native or rare plants Slopes >30 percent throughout Areas of landslide deposits	Crosses cane but along irrigation ditch	Crosses cane but along irrigation ditch
ADVANTAGES	Avoids cane Undeveloped open land	PMCo Lease preference Shortest route Terrain suitable for construction Good Access	Flat terrain
UNRESOLVED ISSUES	Bishop Preference unknown	Bishop Preference unknown	

DECISION: Depends on the selection of the terminal route

RECOMMENDATION: LW-2

Table A2-5 (cont.)
LAHAINA - WAHIKULI STUDY SECTION ALTERNATIVES (Page Two of Three)

DESCRIPTION COST (thousands 1992) LENGTH (miles)	OPTION A - 6A 1063.5 4.1	OPTION A - 6B 1144.8 3.84	OPTION B 931 3.61
DISADVANTAGES	PMCo opposed Crosses cane Numerous archaeological sites along Hahakea Gulch	PMCo opposed Crosses cane	HFDC opposed In proximity of school (Lahainaluna) double circuit 69kv required from Lahaina substation to Wahikuli (easement widening required) Stream protection may be required along Kahoma Stream Numerous archaeologica sites along Kahoma Stream Areas of landslide deposit Visual impact to existing & proposed HFDC project
ADVANTAGES	No proposed projects Avoids HFDC project	Avoids many of the archaeol. sites along Hahakea Gulch Avoids HFDC project	Uses existing ROW provided by Flood Control Channel & existing 69kv line
UNRESOLVED ISSUES			

DECISION: Depends on the selection of the terminal route

RECOMMENDATION: None

Table A2-5 (cont.)
LAHAINA – WAHIKULI STUDY SECTION ALTERNATIVES (Page Three of Three)

DESCRIPTION COST (thousands 1992) LENGTH (miles)	HFDC PERIMETER (assumes 6B) 1339 3.84	BYPASS RD. 846.1 3.61	COASTAL 568 3.56
DISADVANTAGES	PMCo opposed Double circuit of existing 69KV, additional easement required In proximity of Lahainaluna School Crosses cane	HFDC opposed State Dept. of Trans – portation (SDOT) not preferred Coordinated design with SDOT to site along Lahaina Bypass Numerous archaeological sites along Kahoma Stream Visual impact to HFDC planned development	HFDC opposed SMA use permit required CZM Crosses residential, commercial, historic buildings, resort and other uses Corridor is within National Register District Lahaina Historic District Likely opposition from Lahaina community (High visual impact)
ADVANTAGES	HFDC preferred Avoids interference with HFDC development Accomodates future development Avoids areas of landslide deposit Limits visual impact	PMCo/AMFAC preferred Uses proposed hwy. MECO franchise to use highway rights-of-way	Good Access Shortest route
UNRESOLVED ISSUES	Additional cost to double circuit and relocate existing 69KV line		

DECISION: No selection made; decision to find another endpoint and avoid crossing HFDC project.
RECOMMENDATION: HFDC Perimeter or Bypass Rd.

variable terrain, the estimate included cost of construction in five terrain categories: extreme mountainous, rugged mountainous, moderate mountainous, mountainous and level moderate terrain.

The cost estimate revealed that all the alternative corridors fell within the range of $4.4 million to $7.3 million depending on the various possible combinations of corridor segments that could be used in any particular alternative. Alternative 4, the coastal alternative, was the least expensive at $4.4 million and Alternative 1, the mauka corridor, was the highest at $6.3 million to $7.3 million. The two central corridors, Alternatives 2 and 3, ranged from $5.3 million to $6.5 million again depending on the subalternatives selected near the endpoints. The cost for the preliminary preferred corridors Alternatives 5 and 6 was $5.9 million and $6.7 million, respectively.

Based on better access for construction and maintenance and lower overall cost, MECO preferred Alternative 5. However, DLNR and Na Ala Hele had expressed concerns regarding the potential visibility of the line from the Lahaina Pali Trail.

To more fully understand the potential visual impact issues and attempt to come to an agreement on an acceptable corridor, MECO conducted a computerized viewshed analysis to provide an assessment of corridor visibility from the trail. This analysis is discussed further in the Preferred Corridor Selection section below and the results are contained in a separate technical report.

ALTERNATE SUBSTATION SITE

Amfac/JMB Hawaii and Pioneer Mill Company provided a recommended corridor; however, a corridor to the proposed Wahikuli Substation site could not be agreed upon by the various landowners as illustrated in the advantages and disadvantages Table A2-5. Pioneer Mill Company wanted MECO to use the Lahaina Bypass Road alignment through the HFDC project. HFDC wanted the new line to be sited on the perimeter, but outside of their proposed residential community. Pioneer Mill Company wanted limited crossing of cane lands and recommended placing the line within the HFDC property. MECO, therefore, decided to examine the possibility of an alternative switching station location near Lahaina. Alternative sites along Lahainaluna Road, just inside Bishop Estate property, were identified and evaluated through landowner meetings and field inspection. When electrical service beyond the existing system capacity is required for the HFDC development, MECO will construct a distribution substation within the development.

Table A2-6
CONSTRUCTION COST
LAHAINA ALTERNATIVE CORRIDORS JUNE 1992

ALTERNATIVE 1 – MAUKA								Range: $6.362 to 7.295 M	
PP-1	260.0								
MU-1/2	3674.5								
OM-1	1582.9								
LW-1	438.6	LW-2	258.7						
OPTION A-6A	1063.5	OPTION A-6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
LW-1 Totals	7019.5		7100.9		6887.0		7295.0		6802.1
LW-2 Totals	6579.6		6661.0		6447.1		6855.1		6362.2
ALTERNATIVE 2 – CENTRAL								Range: $5.725 to 6.504 M	
PP-2	108.5								
MU-1/3A/4	951.2	MU-1/3A/3B/5	1236.4						
MU-6/7/9	2510.5	MU-6/8/9	2709.9						
OM-2	962.1								
LW-3	346.6								
OPTION A-6A	1063.5	OPTION A-6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
MU-4&7 Totals	5942.4		6023.8		5809.9		6217.9		5725.0
MU-4&8 Totals	6141.8		6223.2		6009.3		6417.3		5924.4
MU-5&7 Totals	6227.6		6309.0		6095.1		6503.1		6010.2
MU-5&8 Totals	6426.9		6508.4		6294.5		6702.5		6209.6
ALTERNATIVE 3 – MAKAI CENTRAL								Range: $5.384 to 6.046 M	
PP-2/4	335.0	PP-3	165.9						
MU-3C/10A/9	3062.9								
OM-2	962.1								
LW-3	346.6								
OPTION A-6A	1063.5	OPTION A-6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
PP-4 Totals	5770.1		5851.5		5637.6		6045.6		5552.7
PP-3 Totals	5601.0		5682.4		5468.5		5876.5		5383.6
ALTERNATIVE 4 – COASTAL								Cost: $ 4.443 M	
PP-3	165.9								
MU-3C/10A/10B	2739.1								
OM-3A/3B	970.1								
LW-8/10/SS	568.0								
Total	4443.1								
ALTERNATIVE 5 – AMFAC (w/underground of existing 69KV corridor) plus LOWER WEST MAUI MTNS.								Range: $ 5.917 to 6.579 M	
PP-2/4	335.0	PP-3	165.9						
MU-3C/10A/9	3062.9								
OM-1	1582.9								
LW-2	258.7								
OPTION A-6A	1063.5	OPTION A-6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
PP-4 Totals	6303.0		6384.4		6170.5		6578.5		6085.6
PP-3 Totals	6133.9		6215.3		6001.4		6409.4		5916.5
ALTERNATIVE 6 – LANDOWNER RECOMMENDATIONS (w/ underground of existing 69KV corridor)								Cost: $ 6.751 M	
PP-2	108.5								
MU-1/3A/4	951.2								
MU-6/7/9	2510.5								
OM-1	1582.9								
LW-2	258.7								
HFDC	1339.0								
Total	6750.8								

Source: Adapted from Stone & Webster 69KV Transmission Line Costs for Designated Land Areas on Maui
Corridor segments LW-9 and 1.46 miles of the HFDC perimeter alternative are assumed to be double circuit.
Construction Cost Range: $ 4.4 to 7.3 Million
Lowest = Alternative 4 – Coastal Corridor
Highest = Alternative 1 – Mauka Corridor with HFDC Perimeter Option

PREFERRED CORRIDOR SELECTION AND ALIGNMENT IDENTIFICATION

FIELD EVALUATION

In September 1992, MECO and their consultants conducted an additional field reconnaissance of the Maalaea-Ukumehame study section for the purpose of evaluating alternative corridors 5 and 6. Photographs were taken of the location of the two possible corridors in relation to the Lahaina Pali Trail. It was decided that a computer viewshed analysis would be necessary to confirm how the presence of a new line would affect the views from the trail.

VIEWSHED ANALYSIS OF LAHAINA PALI HISTORIC TRAIL

A computerized viewshed visibility study was conducted to provide a factual rather than speculative basis for evaluating issues and concerns of transmission line visibility from the trail, and to aid in selecting a preferred corridor for detailed study to locate a suitable alignment for the transmission line.

The methodology and results of the Lahaina Pali Trail Viewshed Analysis are described in the Viewshed Analysis technical report.

The results of the viewshed study were presented and discussed with DLNR in October 1992. MECO and DLNR agreed that Corridor Alternative 6, the central corridor, would have the least visual impact to the trail. Construction of the line would not require crossing the trail and would not parallel the trail in close proximity resulting in none to low visibility.

SELECT PREFERRED CORRIDOR AND SWITCHING STATION SITE

As a result of consultations with major landowners (HC&S, Wailuku Agribusiness, DLNR, Pioneer Mill/Amfac and Bishop Estate) corridor Alternative 6 was selected as the preferred corridor (Figure A2-8). The corridor was selected because it:

- Minimized visual concerns associated with the Lahaina Pali Trail;
- Avoided crossing cane fields for most of its distance;
- Met MECO's separation criteria from existing 69KV lines; and
- Afforded reasonable access for construction and maintenance by using existing access roads for more than two-thirds of the corridor.

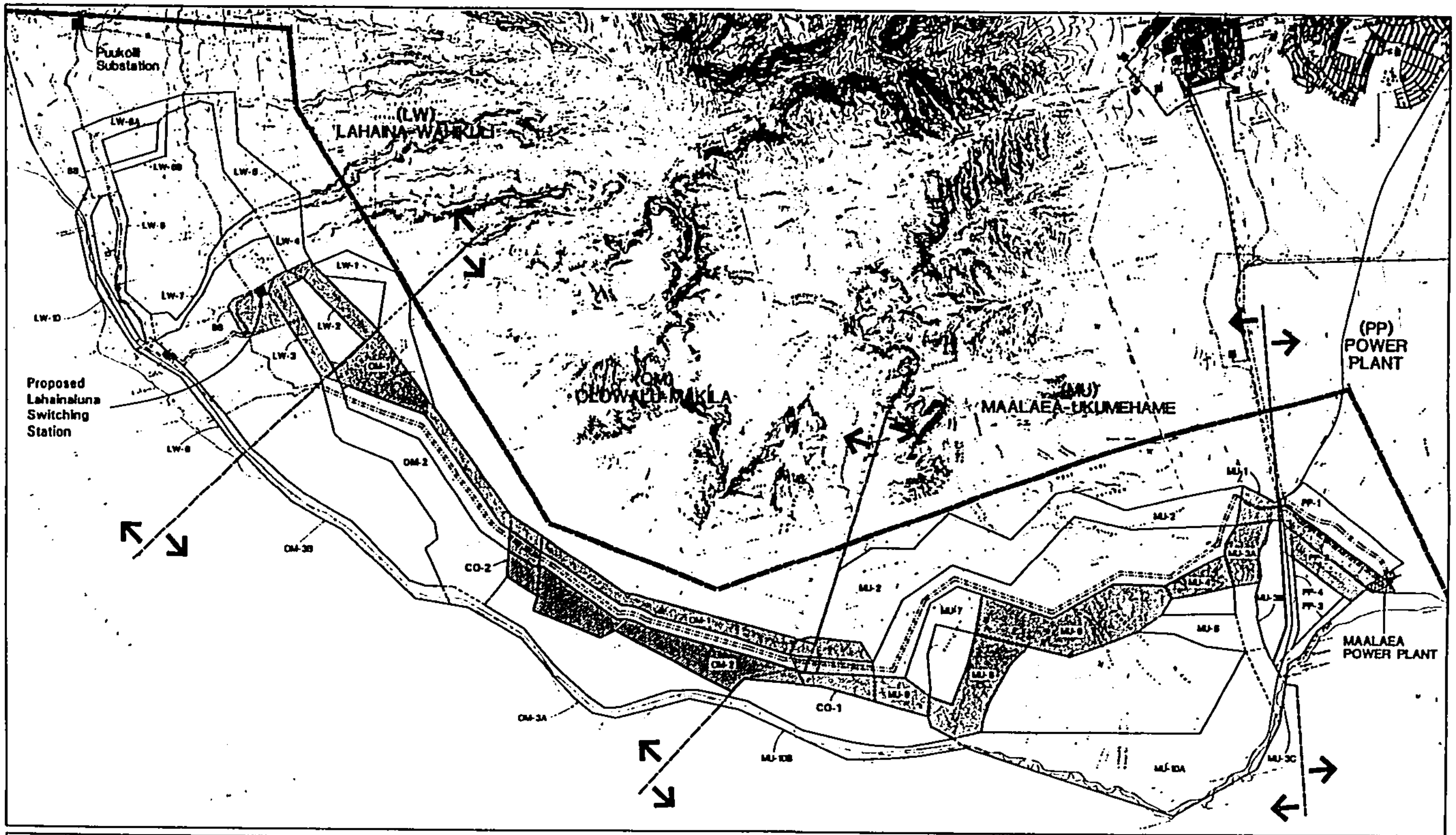


Figure A2-8

Preferred Corridor

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore

Corridor Alternative 6 included a location in the vicinity of Ukumehame reservoir where the new line would crossover from makai of the existing 69KV lines to mauka of the existing lines (CO-1). The purpose of the crossover was to accommodate Pioneer Mill's request that the new line not be sited through cane fields from Launiupoko to Lahaina. An alternative crossover point (CO-2) in the vicinity of Puu Hipa and Puu Mahanalua was also identified because of terrain and possible archaeological resource constraints at the Ukumehame crossover location.

The preferred corridor segments within State lands make up over 60 percent of the total corridor length with the remainder in private ownership. The preferred corridor is shown on Figure A2-8 and its segments are summarized in Table A2-7.

Table A2-7
PREFERRED CORRIDOR

Study Section	Corridor Segment	Location
Power Plant	PP-2	Maalaea Power Plant to N. Kihei Rd.
Maalaea-Ukumehame	MU-1	Honoapiilani Highway crossing
	MU-3A	Lower slopes of Kealaloloa Ridge
	MU-4	Slopes of Kealaloloa Ridge
	MU-6	Kealaloloa Ridge and Manawainui Gulch crossing
	MU-8	Downslope on the ridge adjacent to Manawaipueo Gulch
	MU-9	Edge of cane field
	CO-1	Ukumehame Gulch-Alternative Crossover 1
Olowalu-Makila	OM-1 or	Corridor segment mauka of existing 69KV lines
	OM-2	Corridor segment makai of existing 69KV lines
	CO-2	Puu Hipa-Alternative Crossover 2
Lahaina - Wahikuli	LW-2 or	Piilani Ditch Road
	LW-3	Lahainaluna Ditch Road
	SS	Lahainaluna Switching Station

Since an alternative endpoint was deemed necessary, several potential sites were identified, field checked and discussed with the landowner. The Maalaea-Lahaina Third 69KV transmission line will terminate at a new switching station from which power can be delivered into the West Maui transmission grid. A 2.0- to 3.0-acre site off of Lahainaluna Road near a county water storage tank has been identified that is acceptable to Bishop Estate, the landowner.

IDENTIFY AND EVALUATE ALTERNATIVE ALIGNMENTS

The next step in the route selection process involved investigation of characteristics and features within the preferred corridor to identify alignment alternatives approximately 100 to 150 feet wide.

Criteria used in identifying potential alignments included:

- To the extent possible, minimize the span length of required gulch crossings.
- Minimize the number of angles and turns.
- Locate alignments to ensure no or low visibility from the Lahaina Pali Trail.
- Avoid to the extent possible, crossing cane fields.
- Locate alignments to take advantage of existing access roads for construction and maintenance.

Using the environmental data base developed for corridor identification and large scale aerial photographs (1 inch = 1,000 feet and 1 inch = 500 feet), potential alignments were identified and mapped for use in the field survey.

FIELD SURVEY AND STAKING

The next step was to inspect the alternatives identified from maps and photographs in the field.

On January 28 and February 3, 1993, using helicopters, MECO and Dames & Moore engineers and environmental specialists conducted a field engineering reconnaissance to refine project siting requirements in the field and to stake key control points of a preferred alignment.

A preferred alignment was located during this field engineering effort and the staked locations were recorded using a global positioning system (GPS) to facilitate accurate mapping and future archaeological and biological surveys.

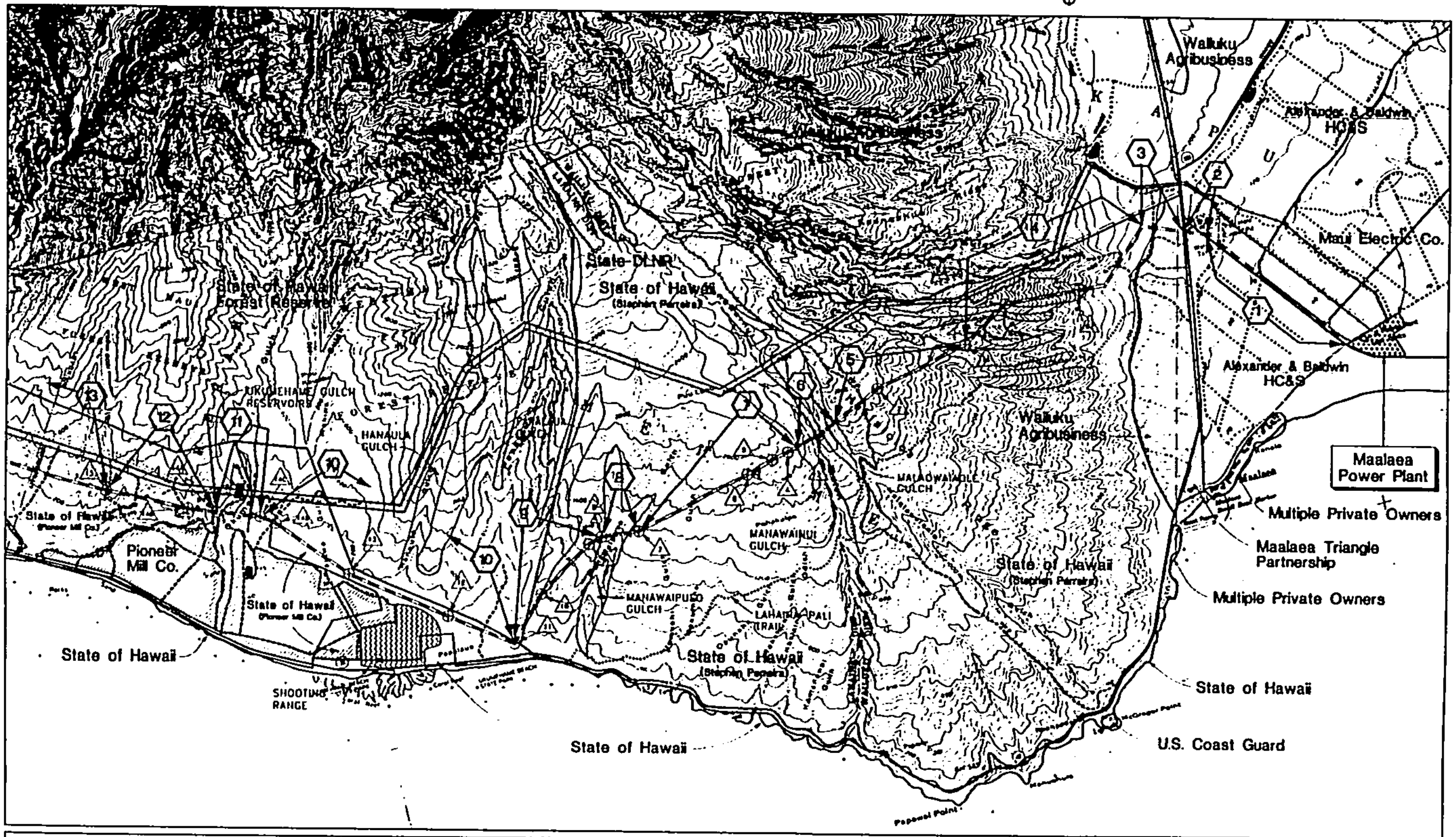
During the field survey, the two alternative locations for the crossover of existing lines were carefully examined. Because MECO proposes to underground the new line to cross the existing lines, a crossover at the Ukumehame Gulch was determined to be unfeasible due to steep terrain. The crossover in the vicinity of Puu Hipa was selected because of a more level terrain condition.

AGENCY REVIEW AND LANDOWNER CONSULTATION

Additional consultation with government agencies and landowners was conducted during February and March 1993, to review the findings of the field survey and present and discuss the preferred alignment. Meetings were held with Wailuku Agribusiness/C. Brewer Properties, Inc., DLNR, Pioneer Mill Company, Amfac/JMB Hawaii, Inc. and B.P. Bishop Estate to confirm the preferred alignment across their various properties. The State Department of Transportation and State Department of Education were also consulted regarding the preferred alignment, highway crossings and the proximity to Lahainaluna School respectively.

SELECT PREFERRED ALIGNMENT

Based primarily on the response from the landowners during the consultation task, the preferred alignment was refined and then mapped at 1:12,000 scale (1 inch = 1,000 feet). The preferred alignment, shown in Figure A2-9, became the route for discussion within the environmental assessment and permit documents.



- Preferred Alignment
- Stake Location & I.D. Number*
- Power Plant
- Substation (Existing)
- Substation (Proposed)
- Double Circuit 69KV Transmission Line
- Single Circuit 69KV Transmission Line
- Landowner (Lessee)
- Access Roads & Jeep Trails
- Gulch
- Gulch Crossing
- Reservoir
- Pineapple
- Cane
- Lahaina Pali Trail
- Alignment Segment Identifier

NOTES:
1) Helicopter & ground staking conducted 1/28/93, 2/3/93 & 6/22/93.
2) GPS readings available for stake locations.

KEY MAP

NORTH

Figure A2-9
MAP 1

Preferred Alignment

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore

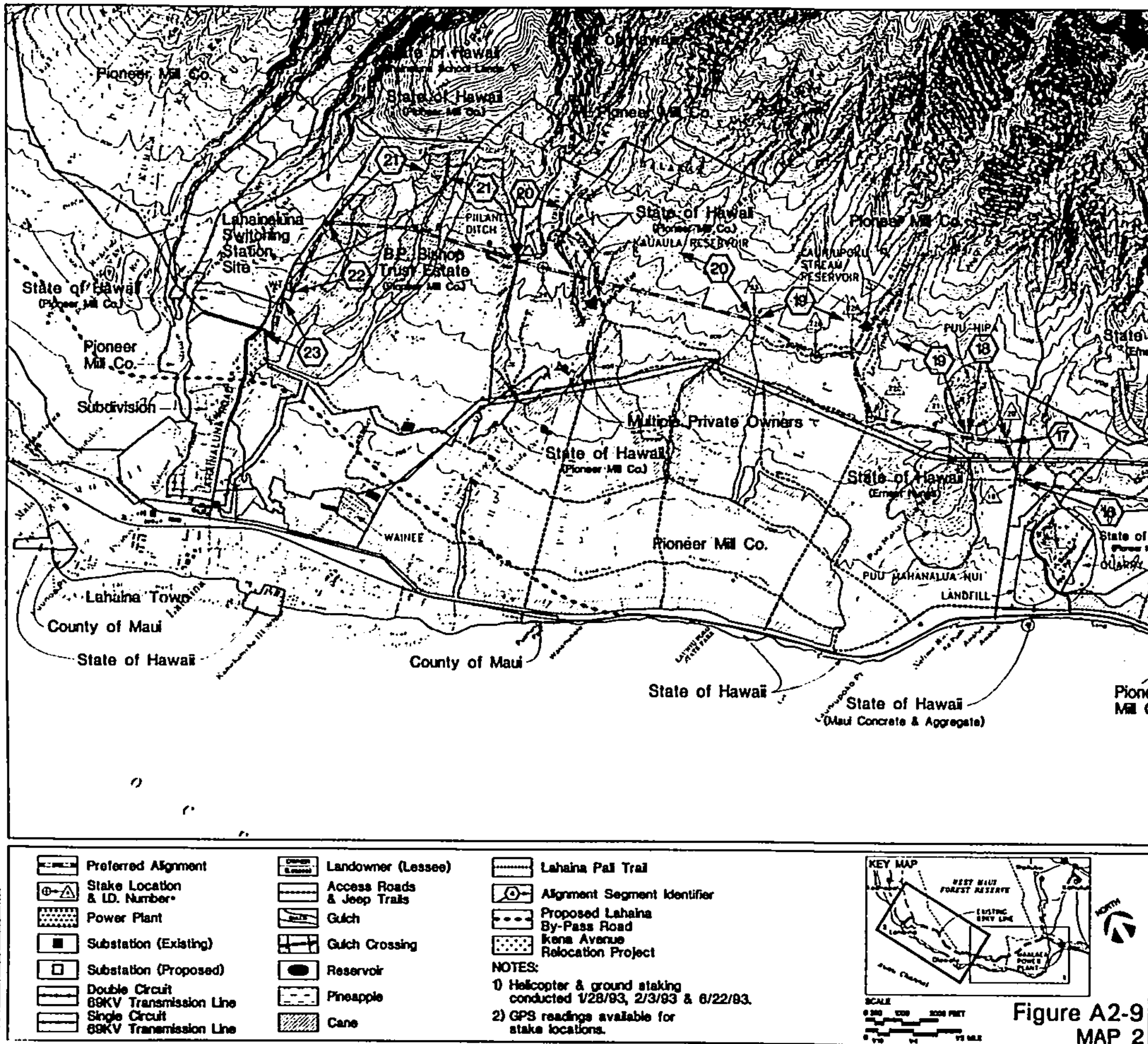


Figure A2-9
MAP 2

Preferred Alignment

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

Dames & Moore

A3. SUPPORT MATERIAL

ENVIRONMENTAL DATA FACTOR DEFINITIONS

EXCLUSION AREAS

Landfills/Refuse Area

Active Landfills are exclusion areas. Please refer to Existing Land Use section for a definition.

LAND OWNERSHIP

U.S. Fish and Wildlife Service and U.S. Coast Guard Lands

Public lands owned by the United States Government, but not necessarily used for military purposes. These lands may be leased to another entity that administers the use of the land.

State of Hawaii Lands

Public lands owned by the State of Hawaii and administered by the Department of Land and Natural Resources or the Department of Transportation. These lands may be leased to private or other governmental agency who then administers the use of the land.

County of Maui Lands

Public lands owned and administered by the County of Maui.

Wailuku Agribusiness

Private lands owned by Wailuku Agribusiness a subsidiary of C. Brewer and Associates

Maalaea Triangle Partnership

Private lands owned by Maalaea Triangle Partnership

Pioneer Mill Co.

Private lands owned by Amfac/JMB Hawaii, Inc. and operated by Pioneer Mill Company.

B.P. Bishop Trust Estate

Private lands owned and managed by B.P. Bishop Estate. Decisions made on development within these lands would require approval by the Bishop Estate Board of Trustees.

Other Private

Lands owned by private individuals, families, businesses, or other non-governmental entities other than those private owners specifically notated on the map.

LAND REGULATION

State Land Use Districts

Urban

Land designated as Urban Land Use District by the State of Hawaii, Land Use Commission.

Agriculture

Land designated as Agricultural Land Use District by the State of Hawaii, Land Use Commission.

Conservation

Land designated as Conservation Land Use District by the State of Hawaii, Land Use Commission. Conservation Land Use Districts are further subdivided into General, Resource, Limited, and Protective subzones pursuant to HRS 183-41.

Conservation [Protective (CP) Subzone]

Lands within the Conservation District, Protective Subzone. The State of Hawaii has identified valuable resources within these areas that require protection. Resources could be any one or more of the following: restricted watersheds, marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas (Administrative Rules Title 13 Chapter 2 Section 11).

Conservation [Limited (CL) Subzone]

Lands within the Conservation District, Limited Subzone. The State of Hawaii's objective of these lands is to limit uses where natural conditions suggest constraints on human activities. The boundaries for these lands usually encompass flood prone areas and lands susceptible to soil erosion, or lands within the tsunami inundation zone (Administrative Rules Title 13 Chapter 2 Section 12).

Conservation [Resource (CR) Subzone]

Lands within the Conservation District, Resource Subzone. The State of Hawaii has identified these areas as lands where development can occur with proper management as long as the sustained use of the natural resources is ensured. These lands include such areas as State Parks, Forest Reserve, Recreation Areas, offshore islands, and territorial waters that area not otherwise assigned a subzone designation (Administrative Rules Title 13 Chapter 2 Section 13).

Conservation [General (CG) Subzone]

Lands within the Conservation District, General Subzone. The State of Hawaii's objective in this subzone is to designate open space where specific conservation uses may not be defined, but where urban use would be premature. This category includes lands that are suitable for farming, flower gardening, nurseries, orchards, grazing and facilities associated with these uses are permitted when they are compatible with the natural physical environment (Administrative Rules Title 13 Chapter 2 Section 14).

Coastal Zone Management

Special Management Area (SMA) Boundary - The inland boundary designating lands as a Special Management Area pursuant to the State of Hawaii Coastal Zone Management policies (HRS Chapter 205A). These lands are publicly owned but use within them is administered by the County of Maui Planning Department. Any development which exceeds $125,000 or which may have substantial adverse environmental or ecological effect within the designated Special Management Area requires a Special Management Area Use Permit issued by the Maui Planning Commission and approved by the County Council.

MAUI COUNTY ZONING

No data mapped. County zoning does not expressly prohibit utility line development.

EXISTING LAND USE

Residential

Single-family detached residences, duplexes, low density apartment areas, low density multi-family residential structures, medium density apartment areas, medium density multi-family residential structures, high density apartment areas. Primary residential area is located in Lahaina with small residential areas located in Olowalu or Maalaea.

School

Schools include lower, middle, and high schools both public and private. Playgrounds and play fields adjacent to the school yards are also part of this land use category.

Resort

Facilities for transient accommodations. Facilities such as restaurants or small shops serving guests are permissible accessory uses. Resort facilities are located in and around Lahaina or Kaanapali.

Park/Recreation/Golf Course/Cemetery

All cemeteries, public parks, recreation facilities and public/private golf courses. Parks and recreation facilities are further defined to include beach parks, neighborhood and district parks, botanical gardens, soccer fields, softball fields and pedestrian malls. Facilities under this category are located throughout the study area.

Public/Community Facility

Government office buildings, community centers, major health care facilities, maintenance yards for public agencies, religious and social service institutions, and other public facilities such as fire stations and police stations. Public/Community facilities are located primarily in Lahaina. The Lahaina Civic Center is located north of the Lahaina Urban Area.

Commercial

Retail stores, offices, entertainment enterprises and accessory uses related to the principal commercial uses. All commercial uses are located in Lahaina except the Maalaea Boat Harbor.

Industrial

Principally for processing, construction, manufacturing, transportation, wholesaling, and/or similar activities. The industrial uses are located in the Lahaina Industrial Corridor and include the Pioneer Mill Company Sugar Mill.

Agriculture

Agriculture areas are those areas that are used for sugar cane or pineapple and include agricultural support facilities.

Grazing

Grazing areas area those used for cattle grazing and the raising of livestock. The primary grazing area is located near McGregor Point near Maalaea.

Rock Pile

A consolidation of large rocks removed from agricultural lands during soil preparation for cultivating crops. Rock piles exist throughout the project area in most of the sugar cane and pineapple fields.

Quarry

Existing gravel extraction or other mineral extraction. Two quarries exist within the project area:

1) adjacent to the Olowalu Landfill, and
2) abandoned cinder pit located near the intersection at Kihei Road and Honoapiilani Highway.

Landfill/Refuse area

Public and private facilities associated with solid waste including landfills, refuse collection centers and recycling centers. The only landfill in the project area is the Olowalu Landfill located on the Lahaina side of Olowalu.

Shooting Range

An outdoor area used for small firearms target practice by two private gun clubs. The West Maui shooting range is located South of the Ukumehame Gulch.

Communication Site

Radio towers, transmitters receivers and FCC monitoring stations.

Gulch

An intermittent stream between ridges consisting of a narrow deep ravine.

Stream

A body of running water that flows continuously throughout the year.

Ditch

An artificial channel used to transport water for agricultural irrigation. Ditches exist throughout the sugar cane fields.

Reservoirs

An artificial lake where water is collected, stored and used for irrigation of agricultural lands.

Undeveloped/Open Space

Land that is undeveloped and free of structures. This category includes lands that may have natural resource value and landscape buffers. Most of the undeveloped/open space lands are located mauka of the sugar cane fields.

Lahaina Pali Trail

An historic hiking trail being redeveloped as part of the State Department of Land and Natural Resources Na Ala Hele Program as Maui's demonstration trail.

PROPOSED PROJECTS

Proposed

Projects proposed by a government agency or private developer not included in the Lahaina or Kihei-Makena Community Plans.

Planned

Projects proposed by a government agency or private developer included in the Lahaina or Kihei-Makena Community Plans.

Approved

Projects included in the Community Plan which have received the necessary State and County approvals and permits.

Under Construction

Refers to those projects where construction permits are approved and groundbreaking or other construction activities has occurred.

EXISTING UTILITIES, ROADS AND ACCESS

Power Plant

In this study, refers to the Maalaea Power Plant, an oil fired power generating facility on the island of Maui.

Substation

An assemblage of equipment designed for switching, changing, or regulating the voltage of electricity. This definition does not include service equipment, line transformers, line-transformer installations, or minor distribution or transmission equipment.

69 KV Line

The major element of Maui Electric Co. transmission system. These lines have the capacity to transfer 69,000 volts of electricity from the generating source to the substations, where the voltage is stepped down to the subtransmission voltage of 23 KV.

23 KV Line

The major element of Maui Electric Co. subtransmission system. These lines carry 23,000 volts of electricity and are the middle link in the power delivery system between 69 KV transmission lines and 12 KV distribution lines.

State Route

Roadways under State of Hawaii jurisdiction, generally with greater than 50 feet wide right-of-ways.

Secondary Road

Roadways under the County of Maui jurisdiction, usually less than 50 feet wide right-of-way.

Major Cane Haul Road

Well-maintained secondary roadways used for hauling sugar cane from the fields to the Pioneer Mill for sugar processing. These roads are used by tournahaulers that require 20 foot wide lanes for passage; therefore, the roadbed right-of-way is usually 40 feet wide with wide shoulders.

Other Connecting Road

Relatively narrow, unsurfaced roadways that serve the purpose of connecting areas between major roads. Field edge roads within cane fields, neighborhood streets that are not major throughways, and gravel bed roads fall into this category

Jeep Trails and Unimproved Access

Unsurfaced, ungraded, trails or throughways that usually pass over rugged terrain, but are passable by four wheel drive vehicles. These trails were mapped using 1991 color aerial photographs.

TRANSMISSION SEPARATION

250 feet (minimum separation)

Areas within 250 feet from an existing 69 KV transmission line.

500 feet

Areas within 500 feet from an existing 69 KV transmission line.

1000 feet

Areas within 1000 feet from an existing 69 KV transmission line.

BIOLOGICAL RESOURCES

Urban

Developed lands including residential, commercial, industrial, business parks, landfills and refuse areas, recreational parks, landfills, quarries, schools and playgrounds, public facilities, and resorts.

Agricultural

Lands used for agricultural purposes including cultivated lands, fallow fields, nurseries, gardens, and agricultural support facilities.

Kiawe-Buffel Grass Association

Vegetation where the kiawe trees are the dominant upper story plant and buffel grass is the principal ground cover plant. The trees are scattered or may form small stands from 15 to 25 feet tall and the trees become denser in small gullies and low-lying areas. This association often occurs on the gently sloping lands and on smooth alluvial fans in lower elevations of the study area.

Mixed Grassland-Shrubland

Vegetation type that occurs on the steeply sloping areas dissected by large, deep gulches. Scattered shrubs occur throughout an extensive grassland; the density and height of the shrub and canopy plants varies throughout the type according to aspect and other physical features.

Shrubland

A vegetation type that occurs on the steeper slopes usually above the kiawe-buffel grass association. Lowland dry shrubs are the dominant feature throughout although the composition of this type is varied. This type occurs around Puu Hipa, Olowalu, and Lihau and often are the habitat where endangered, threatened, or sensitive species are found.

Forest

Vegetation type that contains dry to mesic forest species. The shrubland and forest vegetation types are not easily distinguished in this region and the two types often grade into one another. In some places forest trees have been planted and occur in relatively dense, mature stands.

Stream, Gulch, Reservoir

See Topographic Features and Water Resources below

Forest Reserve Boundary

In this study, the boundary and lands that encompasses the State Department of Land and Natural Resources lands designated as West Maui Forest Reserve

Natural Area Reserve

One of thirteen reserves, comprising 108,328 acres, as established by the State of Hawaii for purposes of protecting Hawaii's natural habitats and native ecosystems. The West Maui Natural Area Reserve is 6,702 acres comprised of four sections, two of which occur in or near the study area, Lihau Section (960 acres) mauka of Puu Hipa and Olowalu Stream and Panaewa Section (1,717 acres) mauka of the upper reaches of the Kanaha and Kahoma streams.

Plant Sanctuary

Refers to an area established by the State Department of Land and Natural Resources, Forestry and Wildlife Division for purposes of preserving the plant life within these boundaries. In this study, there are two plant sanctuaries: Paupau (34 acres) outside of Lahainaluna School and a DLNR Reserve (56 acres) between Manawainui Gulch and Papalaua Gulch Ukumehame.

Endangered, Threatened, and Sensitive Plant Species Habitat

Areas that contain numerous occurrences of rare and endangered plant species as reported to the State DLNR Division of Forestry and Wildlife and the Nature Conservancy, Hawaii. The following general locations are recognized in this study area: Puu Hona and environs including Pohakea Gulch, the DLNR Reserve between Manawainui and Papalaua Gulches, Puu Hipa-Lihau-Olowalu Area and Paupau Ridge.

ETS Plants

These are officially listed threatened and endangered species, Category 1 candidate endangered species, and Category 2 (rare) plants, according to the federal and state registry of endangered species. Species of concern that have been found in significant numbers are listed in Table 1.

Table 1
ENDANGERED OR SENSITIVE PLANTS KNOWN FROM THE STUDY AREA

Species Name	Status*
Acacia koaia	2
Diellia erecta	1
Exocarpus gaudichaudii	2
Gouania hillebrandii	E
Gouania vitifolia	1
Hesperomannia arbuscula	E
Hibiscus brackenridgei	1
Hibiscus kokio	2
Neraudia sericea	1
Remya mauiensis	E
Santalum freycinetianum var. lanaiensis	E
Schiedea menziesii	2
Schiedea salicaria	2
Spermolepis hawaiiensis	1
Tetramolopium capillare	1
Tetramolopium remyi	E
Torulinium odoratum	2

Status*:

E = officially listed as endangered by the U.S. Fish and Wildlife Service
1 = Category 1 candidate endangered species; will be proposed as endangered in FY1992
2 = Category 2 taxa; plants for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time

Source: U.S. Fish and Wildlife Service, Correspondence from Robert C. Smith, Pacific Islands Administrator 1990.

TOPOGRAPHY AND WATER RESOURCES

Flood Prone Areas (100 Year Flood)

Any area surrounding the mouth or upper reaches of a stream or waterway that is subject to inundation by a 100 year flood, as identified by the Flood Insurance Rate Maps.

Coastal Flooding and Tsunami Inundation

Seismic sea waves, an extraordinary type of ocean wave produced by a sudden tectonic displacement of huge earth mass on the ocean floor.

Stream

A body of running water that flows continuously throughout the year.

Gulch

An intermittent stream between ridges consisting of a narrow deep ravine.

Ditch

An artificial channel used to transfer water for agricultural irrigation.

Reservoir

An artificial lake where water is collected, stored and used for irrigation of agricultural lands.

Major Ridge

The line of intersection at the top between the opposite slopes or sides of a hill or mountain.

Puu

A Hawaiian word for hill, small mountain.

Flume

An inclined channel for conveying water for irrigation or power.

Quarry

Existing gravel extraction or other mineral extraction.

SLOPE

Less than 30%

Lands with slopes less than 30 percent as determined from the U.S. Geological Survey Digital Elevational Model (DEM) data. The resolution in this model is 35 X 35 pixels.

Greater than or Equal to 30%

Lands with slopes greater than or equal to 30 percent as determined from the U.S. Geological Survey Digital Elevational Model (DEM) data. The resolution in this model is 35 X 35 pixels.

GEOLOGY/SOILS

Soils with High Erosion Potential

In general, these areas include clayey silts with moderate shrink/swell potential, located over 3% to 35% slopes, and extremely weathered, friable volcanic rock outcrops (Soil Conservation Service, 1972).

Areas of Landslide Deposits

In general, these include areas of relatively steep slopes (40% to 70%), active erosion, relatively high rainfall (25 to 200 inches per year), and where past landslides probably occurred (Soil Conservation Service, 1972).

Areas Prone to Slope Instability

In general, these include areas of steep and bouldery terrains, active erosion, and moderate rainfall (20 to 40 inches, Soil Conservation Service, 1972).

Soft/Loose Materials - Recent Alluvium

In general, areas defined as younger on recent alluvium in the Soil Conservation Service Survey of Maui. (SCS, 1972)

CULTURAL RESOURCES

National Register District

Refers to the area and features within the district as established by the National Historic Preservation Office pursuant to the criteria for determining significance and National Register eligibility set forth in Title 36 CFR 60.4.

National/Hawaiian Register Site and Lahaina Pali Trail

In this study refers to a site (or complex of sites) that is determined to have significance and has met the eligibility criteria for the Hawaiian Historic Places Register pursuant to HRS CH6E, Historic Preservation and the National Historic Preservation Act of 1966 (P.L. 89-665), as amended and has been determined significant and met National Register eligibility pursuant to Title 36 CFR 60.4.

Recorded Pre-Contact Sites

Surveyed areas that contain surface features that identify it as an archaeological site originating prior to settlement by western man in the late 1800's. These sites have been surveyed, recorded on maps and documents, and assigned a site number by the State Historic Preservation Office. They are not on the State of Hawaii or the National Register of archaeological sites.

Recorded Post-Contact Sites

Surveyed areas that contain surface features that identify it as an archaeological site originating after 1850, the year that Hawaiian Islands were first discovered by western man. These sites have been surveyed, recorded on maps and documents, and assigned a site number by the State Historic Preservation Office. They are not on the State of Hawaii or the National Register of archaeological sites.

Land Commission Award (LCA) Parcels

Parcels of land varying in size that were given out in the mid-nineteenth century following the Great Mahele of 1848. These kuleanas were parcels of land conferred to native no-alii (not of the royal family lineage) Hawaiians able to prove that they lived upon or actively farmed these lands.

Area with Good Resources Potential

Areas where there is a good chance that archaeological remains could be found if surface and subsurface investigations were conducted. These areas were observed from the air during a helicopter reconnaissance conducted on September 25, 1991.

SENSITIVITY ANALYSIS

PURPOSE

The sensitivity analysis was designed to provide a semi-quantitative comparison of constraints and opportunities of the alternative corridors and to assist in the evaluation and screening of alternative corridors and the selection of a preferred corridor for the Maalaea-Lahaina Third 69KV Transmission Line Project.

METHODOLOGY

The constraint ratings assigned during the course of the resource inventory and constraint analysis (Table 1) were used to compare the corridor segments. Feasible corridor segment combinations were developed and these combinations were linked across the four study sections to derive the 58 different feasible corridors.

To prepare for the measurement of constraints, a "hypothetical alignment" was drawn through each of the alternative corridor segments (e.g. M-1, K-1, P-1, etc...) to provide a point of reference from which to evaluate each segment (or combination of segments) against the previously mapped opportunity and constraint data. This hypothetical alignment used solely for the purpose of the sensitivity analysis was derived from an assessment of possible alignment locations within each corridor segment. The hypothetical alignment was then overlaid onto each of the environmental data maps. Each time the hypothetical alignment passed through an area that had been identified "exclusion", "high" or "medium" constraint, the linear distance through the constraint area was measured (in inches) and summed for each corridor segment.

The number of inches crossed by the hypothetical alignment through a constraint area became the "score" or the number of "constraint units" for that data category in the particular segment where it was encountered. If the hypothetical alignment passed along the edge of a constraint area (e.g.

along the boundary of a wetlands area), the number of inches along the edge was not included in the constraint unit calculation. It was assumed that constraints could be avoided by placing the alignment on the other side of the corridor segment or outside the specific area of concern.

Constraint units for each data category were calculated for each corridor segment. The total score of constraint units from all the categories reflects the overall level of constraint or sensitivity of that segment. These scores represent one quantitative measure for comparing the relative sensitivity of the alternative corridor segments and combinations of segments. The larger the score, the greater the constraint.

Another quantitative measure for comparing alternative corridor segments involved weighting of the constraints. Where the hypothetical alignment passed through an "exclusion" area, the number of constraint units or score was tripled. When the hypothetical alignment passed through a "high" constraint area, the number of constraint units or score for that category was doubled. Both weighted and unweighted scores are presented in Table 1 and the subsequent tables.

Yet another measure involved the analysis of opportunities for siting the transmission line. In this project, "opportunities" were defined as developed access. To measure these opportunities, the distance in inches in which the hypothetical alignment paralleled existing developed access (defined as State routes, secondary roads and cane haul roads) was calculated (Table 3). The number of inches, or "opportunity units", was then subtracted from the number of constraint units, to provide the number of "net constraint" units for each corridor segment.

Finally, in order to allow a direct or equivalent comparison of corridor segments of different lengths, the net constraint units were divided by the linear units (i.e. inches) of the corridor segment. This normalized the results and expressed the "net constraint score" of the corridor segment as a percent of the total length. This percentage provides an overall measure of sensitivity of each alternative corridor segment, regardless of its length. Table 6 presents the ranking of feasible corridors and Table 7, the top ranking of alternative corridors.

The formula used for these calculations are:

$$\text{Net Constraint Score (weighted)} = [\text{Length of Exclusion Area X 3}] + [\text{Length of High Constraint X 2}] + [\text{Length of Medium Constraint}] - [\text{Length of Opportunity Units}]$$

$$\text{Percent Constraint} = \frac{[\text{Net Constraint Score}]}{[\text{Length of Corridor Segment}]} \text{ X } 100$$

Table 1
MAALAEA–LAHAINA THIRD 69 KV TRANSMISSION LINE PROJECT
CONSTRAINT UNITS BY EVALUATION FACTOR FOR CORRIDOR SEGMENTS

CORRIDOR SEGMENT	LAND REGULATION (High)	LAND REGULATION (Medium)	EXISTING LAND USE (Exclusion)	EXISTING LAND USE (High)	EXISTING LAND USE (Medium)	PROPOSED PROJECTS (Medium)	UTILITIES TRANS. SEPAR. (High)	UTILITIES TRANS. SEPAR (Medium)	BIOLOGICA RESOURCI (Medium)	CULTURAL RESOURCI (High)	CULTURAL RESOURCES (Medium)	SLOPE (Medium)	GEOLOGY SOILS (High)
	CP/CL Subzones	SMA CR/CG Subzones	Active Landfills	Shooting Range	R, C, P/R, Qry, Res. PF, Comm.S.	Projects Under Const.	w/in 250ft from 69 KV	w/in 500ft from 69 KV	ETS Habitat	National Register District	Recorded Arch. Sites	Slopes > 30%	Areas Landslide Deposits
Power Plant													
PP–1	0.00	0.00	0.00	0.00	0.00	0.00	3.25	3.25	0.00	0.00	0.00	0.00	0.00
PP–2	0.50	0.50	0.00	0.00	0.75	0.00	0.00	2.90	0.00	0.00	0.40	0.60	0.00
PP–3	0.50	2.60	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maalaea – Ukumehame													
MU–1	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.20	0.00	0.00	0.00	0.00	0.00
MU–2	1.00	10.00	0.00	0.00	0.50	0.00	0.50	0.00	1.10	0.00	0.00	11.20	0.00
MU–3A	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
MU–3B	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MU–3C	0.50	1.90	0.00	0.00	1.75	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00
MU–4	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	1.40	0.00
MU–5	0.00	2.40	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.20	1.50	0.00
MU–6	0.25	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00
MU–7	2.10	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.20	0.00
MU–8	0.00	2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00
MU–9	1.20	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	3.50	0.00
MU–10A	0.00	9.50	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	1.50	12.00	0.00
MU–10B	5.00	9.00	0.00	1.25	3.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Olowalu – Makila													
OM–1	0.00	2.00	0.00	0.00	0.30	0.00	0.00	0.00	1.50	0.00	0.00	7.25	1.00
OM–2	0.00	0.10	0.00	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00
OM–3A	9.00	9.00	0.00	0.00	2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OM–3B	4.00	8.00	0.50	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lahaina – Wahikuli													
LW–1	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	1.00
LW–2	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00
LW–3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LW–4	0.00	2.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.50
LW–5	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	1.00	0.50	0.30
LW–6A	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	1.00	0.00	0.00
LW–6B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LW–7	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.40	0.00	0.00
LW–8	4.10	0.00	0.00	0.00	1.25	0.00	2.40	0.00	0.00	0.10	0.00	0.00	0.00
LW–9	0.00	0.00	0.00	0.00	2.40	0.00	4.60	0.00	0.00	0.00	0.00	0.00	0.00
LW–10	4.10	1.25	0.00	0.00	4.90	0.60	0.00	0.00	0.00	0.20	0.00	0.00	0.00

CONSTRAINT UNITS are variable measures of linear distance dependent on the scale of the map. In this case, they were calculated as inches on a 1:24,000 scale map. UNWEIGHTED total constraint units are a total of all constraint units in each of the listed categories. This assumes that "exclusion", "medium" and "high" constraints have equal importance. WEIGHTED total constraint units are a total of all constraint units in each of the categories with "exclusion" given a weighting of 3; "high" constraints, a weighting of 2; and "medium" constraints a rating of one. This assumes that "high" constraints are twice as important as "medium" constraints.

Table 1 (cont.)

CORRIDOR SEGMENT	GEOLOGY SOILS (Medium)	WATER RESOURCES (High)	WATER RESOURCE (Medium)	TOTAL CONSTRAINT UNITS	
	Unstable Slopes & Erosion	Tsunami Inundation Zone	Areas Flood Prone	Unweighted	Weighted
Power Plant					
PP-1	0.00	0.00	0.00	6.50	9.75
PP-2	0.00	0.00	0.00	5.65	6.15
PP-3	0.00	0.00	0.50	4.10	4.60
Maalaea – Ukumehame					
MU-1	0.00	0.00	0.00	2.20	3.20
MU-2	7.10	0.00	0.00	31.40	32.90
MU-3A	0.00	0.00	0.00	2.80	2.80
MU-3B	0.00	0.00	0.00	1.60	1.60
MU-3C	0.00	0.00	1.80	7.55	8.05
MU-4	0.00	0.00	0.00	3.45	3.45
MU-5	0.00	0.00	0.00	5.35	5.35
MU-6	0.90	0.00	0.00	4.95	5.20
MU-7	1.80	0.00	0.00	11.10	13.20
MU-8	0.00	0.00	0.00	8.90	8.90
MU-9	0.00	0.00	0.00	5.60	6.80
MU-10A	0.00	0.00	0.00	25.00	25.00
MU-10B	0.00	6.00	6.00	30.50	42.75
Olowalu – Makila					
OM-1	5.50	0.00	0.00	17.55	18.55
OM-2	2.20	0.00	0.00	6.60	6.60
OM-3A	0.00	3.50	9.00	33.25	45.75
OM-3B	0.00	4.00	7.00	26.00	35.00
Lahaina – Wahikuli					
LW-1	1.00	0.00	0.00	5.75	6.75
LW-2	0.00	0.00	0.00	1.00	1.00
LW-3	0.00	0.00	0.00	0.00	0.00
LW-4	1.50	0.00	0.00	6.20	7.70
LW-5	0.30	0.00	0.00	2.90	4.00
LW-6A	0.00	0.00	0.00	3.50	6.00
LW-6B	0.00	0.00	0.00	0.00	0.00
LW-7	0.00	0.00	0.00	1.20	2.00
LW-8	0.00	0.00	0.00	7.85	14.45
LW-9	0.00	0.00	0.00	7.00	11.60
LW-10	0.00	5.00	0.00	16.05	25.35

Table 2
MAALAEA – LAHAINA THIRD 69 KV TRANSMISSION LINE PROJECT
CORRIDOR SEGMENT ANALYSIS

CORRIDOR SEGMENT	TOTAL CONSTRAINT UNITS		OPPORTUNITY UNITS (inches)	SEGMENT LINEAR UNITS (inches)	NET CONSTRAINT UNITS		NET CONSTRAINT UNITS AS % OF LINEAR UNITS	
	Unweighted	Weighted			Unweighted	Weighted	Unweighted	Weighted
Power Plant								
PP–1	6.50	9.75	0.00	3.40	6.50	9.75	191.18	286.76
PP–2	5.65	6.15	0.00	2.75	5.65	6.15	205.45	223.64
PP–3	3.60	3.60	0.00	2.60	3.60	3.60	138.46	138.46
Maalaea–Ukumeham								
MU–1	2.20	3.20	0.00	1.25	2.20	3.20	176.00	256.00
MU–2	31.40	32.90	0.00	13.75	31.40	32.90	228.36	239.27
MU–3A	2.80	2.80	0.00	1.40	2.80	2.80	200.00	200.00
MU–3B	1.60	1.60	0.00	1.80	1.60	1.60	88.89	88.89
MU–3C	7.55	8.05	0.00	2.00	7.55	8.05	377.50	402.50
MU–4	3.45	3.45	0.00	1.80	3.45	3.45	191.67	191.67
MU–5	5.35	5.35	0.00	2.50	5.35	5.35	214.00	214.00
MU–6	4.95	5.20	0.00	3.80	4.95	5.20	130.26	136.84
MU–7	11.10	13.20	0.00	5.00	11.10	13.20	222.00	264.00
MU–8	8.90	8.90	0.00	3.40	8.90	8.90	261.76	261.76
MU–9	5.60	6.80	0.00	4.50	5.60	6.80	124.44	151.11
MU–10A	25.00	25.00	0.00	6.80	25.00	25.00	367.65	367.65
MU–10B	30.50	42.75	0.00	9.40	30.50	42.75	324.47	454.79
Olowalu – Makila								
OM–1	17.55	18.55	0.00	15.50	17.55	18.55	113.23	119.68
OM–2	6.60	6.60	5.20	15.60	1.40	1.40	8.97	8.97
OM–3A	33.25	45.75	0.00	7.00	33.25	45.75	475.00	653.57
OM–3B	26.00	35.00	0.00	9.20	26.00	35.00	282.61	380.43
Lahaina – Wahikuli								
LW–1	5.75	6.75	2.20	2.80	3.55	4.55	126.79	162.50
LW–2	1.00	1.00	2.25	2.25	–1.25	–1.25	–55.56	–55.56
LW–3	0.00	0.00	3.00	3.25	–3.00	–3.00	–92.31	–92.31
LW–4	6.20	7.70	0.00	2.10	6.20	7.70	295.24	366.67
LW–5	2.90	4.00	4.50	5.00	–1.60	–0.50	–32.00	–10.00
LW–6A	3.50	6.00	3.20	3.00	0.30	2.80	10.00	93.33
LW–6B	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00
LW–7	1.20	2.00	3.20	4.30	–2.00	–1.20	–46.51	–27.91
LW–8	17.75	30.60	0.00	4.10	17.75	30.60	432.93	746.34
LW–9	6.40	10.40	0.00	4.60	6.40	10.40	139.13	226.09
LW–10	16.25	25.75	0.00	4.90	16.25	25.75	331.63	525.51

Table 3
COMBINATIONS OF CORRIDOR SEGMENTS AND REFERENCE CODES

REFERENCE CODE	SEGMENT COMBINATION	LENGTH (inches)	CONSTRAINT UNITS UNWEIGHTED	CONSTRAINT UNITS WEIGHTED	OPP. UNITS	NET CONSTRAINT UNITS UNWEIGHTED	NET CONSTRAINT UNITS WEIGHTED	REFERENCE CODE
	POWER PLANT							
1	P-1	3.40	6.50	9.75	0.00	6.50	9.75	1
2	P-2	2.75	5.65	6.15	0.00	5.65	6.15	2
3	P-3	2.60	3.60	3.60	0.00	3.60	3.60	3
	MAALAEA-UKUMEHAME							
A	MU-1/MU-2	15.00	33.60	36.1	0.00	33.60	36.10	A
B	MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9	17.75	30.10	34.65	0.00	30.10	34.65	B
C	MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9	16.15	27.90	30.35	0.00	27.90	30.35	C
D	MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9	20.25	36.90	38.15	0.00	36.90	38.15	D
E	MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9	18.65	34.70	33.85	0.00	34.70	33.85	E
F	MU-1/MU-3A/MU-3B/MU-3C/MU-10A/MU-10B	22.65	79.65	103.4	0.00	79.65	103.40	F
G	MU-1/MU-3A/MU-3B/MU-3C/MU-10A/MU-8(partial)/MU-9	22.65	57.75	70.45	0.00	57.75	70.45	G
H	MU-3C/MU-10A/MU-8(partial)/MU-9	14.80	51.15	62.85	0.00	51.15	62.85	H
	OLOWALU-MAKILA							
4	OM-1	15.50	17.55	18.55	0.00	17.55	18.55	4
5	OM-2	15.60	6.60	6.60	5.20	1.40	1.40	5
6	OM-3A	7.00	33.25	45.75	0.00	33.25	45.75	6
7	OM-3B	9.20	26.00	35.00	0.00	26.00	35.00	7
	LAHAINA-WAHIKULI							
I	LW-1/LW-4/LW-5/LW-6A	13.10	18.35	24.45	9.90	8.45	14.55	I
J	LW-1/LW-4/LW-5/LW-6B	12.00	14.85	18.45	6.70	8.15	11.75	J
K	LW-2/LW-4/LW-5/LW-6A	12.55	13.60	18.7	9.95	3.65	8.75	K
L	LW-2/LW-4/LW-5/LW-6B	11.65	10.10	12.7	6.75	3.35	5.95	L
M	LW-3/LW-4/LW-5/LW-6A	13.55	12.60	17.7	10.70	1.90	7.00	M
N	LW-3/LW-4/LW-5/LW-6B	12.45	9.10	11.7	7.50	1.60	4.20	N
O	LW-1/LW-4/LW-7/LW-9	13.80	19.55	26.85	5.40	14.15	21.45	O
P	LW-1/LW-4/LW-7/LW-10	14.10	29.40	42.2	5.40	24.00	36.80	P
Q	LW-2/LW-4/LW-7/LW-9	13.25	14.80	21.1	5.45	9.35	15.65	Q
R	LW-2/LW-4/LW-7/LW-10	13.55	24.65	36.45	5.45	19.20	31.00	R
S	LW-3/LW-4/LW-7/LW-9	14.25	13.80	20.1	6.20	7.60	13.90	S
T	LW-3/LW-4/LW-7/LW-10	14.55	23.65	35.45	6.20	17.45	29.25	T
U	LW-8/LW-9	8.70	24.10	41	0.00	24.10	41.00	U
V	LW-8/LW-10	9.00	34.00	56.35	0.00	34.00	56.35	V
W	LW-8/LW-7/LW-5/LW-6A	16.60	25.35	42.6	10.90	14.45	31.70	W
X	LW-8/LW-7/LW-5/LW-6B	15.50	21.85	36.6	6.40	15.45	30.20	X

Table 4
MAALAEA–LAHAINA THIRD 69 KV TRANSMISSION LINE PROJECT
OPPORTUNITIES FOR CORRIDOR LOCATION

CORRIDOR SEGMENT	REFERENCE	OPPORTUNITY UNITS
LW–3	Lahainaluna Ditch	3.00
LW–1	Ditch and Aqueduct and Flume	2.20
LW–7	Flood Control Channel (partial)	3.20
LW–5	Honokowai Ditch Road	4.50
LW–6A	Hahakea Gulch	3.20
OM–2	Makila Reservoir Ditch to Puu Mahanalua Nui	5.20

Table 5

ENVIRONMENTAL SENSITIVITY OF FEASIBLE ALTERNATIVE CORRIDORS

Reference Code	Feasible Corridors	(+) Constraint Units Unweighted	(+) Constraint Units Weighted	(−) Opportunity Units	(=) Net Constraint Units Unweighted	(=) Net Constraint Units Weighted	Linear Units	Net Constraint Units as Percent of Linear Units Unweighted (%)	Net Constraint Units as Percent of Linear Units Weighted (%)	Reference Code
	MAUKA CORRIDORS (16 USING EITHER PP−1 OR PP−2)									
1A 4I	PP−1/MU−1/MU−2/OM−1/LW−1/LW−4/LW−5/LW−6A			0.00	0.00	78.95	47.00	0.00	167.98	1A 4I
1A 4J	PP−1/MU−1/MU−2/OM−1/LW−1/LW−4/LW−5/LW−6B			0.00	0.00	76.15	45.90	0.00	165.90	1A 4J
1A 4K	PP−1/MU−1/MU−2/OM−1/LW−2/LW−4/LW−5/LW−6A			0.00	0.00	75.40	46.45	0.00	162.33	1A 4K
1A 4L	PP−1/MU−1/MU−2/OM−1/LW−2/LW−4/LW−5/LW−6B			0.00	0.00	72.60	45.55	0.00	159.39	1A 4L
1A 4M	PP−1/MU−1/MU−2/OM−1/LW−3/LW−4/LW−5/LW−6A			0.00	0.00	71.40	47.45	0.00	150.47	1A 4M
1A 4N	PP−1/MU−1/MU−2/OM−1/LW−3/LW−4/LW−5/LW−6B			0.00	0.00	68.60	46.35	0.00	148.00	1A 4N
1A 4O	PP−1/MU−1/MU−2/OM−1/LW−3/LW−4/LW−7/LW−9			0.00	0.00	85.85	47.70	0.00	179.98	1A 4O
1A 4P	PP−1/MU−1/MU−2/OM−1/LW−3/LW−4/LW−7/LW−10			0.00	0.00	101.20	48.00	0.00	210.83	1A 4P
1A 4Q				0.00	0.00	82.30	47.15	0.00	174.55	1A 4Q
1A 4R				0.00	0.00	97.65	47.45	0.00	205.80	1A 4R
1A 4S				0.00	0.00	78.30	48.15	0.00	162.62	1A 4S
1A 4T				0.00	0.00	93.65	47.45	0.00	197.37	1A 4T
				0.00						
	CENTRAL CORRIDORS (20 USING EITHER PP−1 OR PP−2)			0.00						
1B 5M	PP−1/MU−1/MU−3A/MU−4/MU−6/MU−7/MU−9/OM−2/LW−3/LW−4/LW−5/LW−6A			0.00	0.00	52.80	50.30	0.00	104.97	1B 5M
1B 5N	PP−1/MU−1/MU−3A/MU−4/MU−6/MU−7/MU−9/OM−2/LW−3/LW−4/LW−5/LW−6B			0.00	0.00	50.00	44.20	0.00	113.12	1B 5N
1C 5M	PP−1/MU−1/MU−3A/MU−4/MU−6/MU−8/MU−9/OM−2/LW−3/LW−4/LW−5/LW−6A			0.00	0.00	48.50	48.70	0.00	99.59	1C 5M
1C 5N	PP−1/MU−1/MU−3A/MU−4/MU−6/MU−8/MU−9/OM−2/LW−3/LW−4/LW−5/LW−6B			0.00	0.00	45.70	47.60	0.00	96.01	1C 5N
1D 5M	PP−1/MU−1/MU−3A/MU−3B/MU−5/MU−6/MU−7/MU−9/OM−2/LW−3/LW−4/LW−5/LW			0.00	0.00	56.30	52.80	0.00	106.63	1D 5M
1D 5N	PP−1/MU−1/MU−3A/MU−3B/MU−5/MU−6/MU−7/MU−9/OM−2/LW−3/LW−4/LW−5/LW			0.00	0.00	53.50	51.70	0.00	103.48	1D 5N
1E 5M	PP−1/MU−1/MU−3A/MU−3B/MU−5/MU−6/MU−8/MU−9/OM−2/LW−3/LW−4/LW−5/LW			0.00	0.00	52.00	51.20	0.00	101.56	1E 5M
1E 5N	PP−1/MU−1/MU−3A/MU−3B/MU−5/MU−6/MU−8/MU−9/OM−2/LW−3/LW−4/LW−5/LW			0.00	0.00	49.20	50.10	0.00	98.20	1E 5N
1B 5S	PP−1/MU−1/MU−3A/MU−4/MU−6/MU−7/MU−9/OM−2/LW−3/LW−4/LW−7/LW−9			0.00	0.00	59.70	51.00	0.00	117.06	1B 5S
1B 5T	PP−1/MU−1/MU−3A/MU−4/MU−6/MU−7/MU−9/OM−2/LW−3/LW−4/LW−7/LW−10			0.00	0.00	75.05	51.30	0.00	146.30	1B 5T
				0.00						
	MAKAI CORRIDORS (6 CORRIDORS)			0.00						
1F6 7U	PP−1/MU−1/MU−3A/MU−3B/MU−3C/MU−10A/MU−10B/OM−3A/OM−3B/LW−8/LW−9			0.00	0.00	234.90	50.95	0.00	461.04	1F6 7U
1F6 7V	PP−1/MU−1/MU−3A/MU−3B/MU−3C/MU−10/OM−3/LW−8/LW−10			0.00	0.00	250.25	51.25	0.00	488.29	1F6 7V
2F6 7U	PP−2/MU−1/MU−3A/MU−3B/MU−3C/MU−10/OM−3/LW−8/LW−9			0.00	0.00	231.30	50.30	0.00	459.84	2F6 7U
2F6 7V	PP−2/MU−1/MU−3A/MU−3B/MU−3C/MU−10/OM−3/LW−8/LW−10			0.00	0.00	246.05	50.60	0.00	486.26	2F6 7V
3H 5N	PP−3/MU−3C/MU−10A/MU−8(partial)/MU−9/OM−2/LW−3/LW−4/LW−5/L−6B			0.00	0.00	45.25	45.45	0.00	99.56	3H 5N
3H 5S	PP−3/MU−3C/MU−10A/MU−9/OM−2/LW−3/LW−4/LW−7/L−9			0.00	0.00	78.75	45.75	0.00	172.13	3H 5S
3H 5T	PP−3/MU−3C/MU−10A/MU−9/OM−2/LW−3/LW−4/LW−7/L−10			0.00	0.00	94.10	46.05	0.00	204.34	3H 5T
3H6 7U	PP−3/MU−3C/MU−10/OM−3/LW−8/LW−10			0.00	0.00	185.20	40.80	0.00	453.92	3H6 7U
3H6 7V	PP−3/MU−3C/MU−10/OM−3/LW−8/LW−10			0.00	0.00	200.55	41.10	0.00	487.96	3H6 7V
2G 5I−T	PP−2/MU−1/MU−3A/MU−3B/MU−3C/MU−10A/MU−9/OM−2 + LW COMBOS			0.00	0.00	88.75	51.50	0.00	168.45	2G 5J
1F6 5J	PP−1/MU−1/MU−3A/MU−3B/MU−3C/MU−10A/MU−10B/OM−3A/OM−2 +LW COMBOS			0.00	0.00	172.05	60.65	0.00	283.68	1F6 5J
2F6 5J	PP−2/MU−1/MU−3A/MU−3B/MU−3C/MU−10A&B/OM−3A/OM−2/ +LW COMBOS			0.00	0.00	168.45	60.00	0.00	280.75	2F6 5J
2G 5Q				0.00	0.00	92.90	52.75	0.00	176.11	2G 5Q
1F6 5Q				0.00	0.00	176.80	61.90	0.00	285.62	1F6 5Q
2F6 5Q				0.00	0.00	173.20	61.25	0.00	282.78	2F6 5Q

Table 5 (continued)
ENVIRONMENTAL SENSITIVITY OF FEASIBLE ALTERNATIVE CORRIDORS

Reference Code	Feasible Corridors	(+) Constraint Units Unweighted	(+) Constraint Units Weighted	(–) Opportunity Units	(=) Net Constraint Units Unweighted	(=) Net Constraint Units Weighted	Linear Units	Net Constraint Units as Percent of Linear Units Unweighted (%)	Net Constraint Units as Percent of Linear Units Weighted (%)	Reference Code
	MAUKA CORRIDORS (16 USING EITHER PP–1 OR PP–2)									
2A 4I	PP–1/MU–1/MU–2/OM–1/LW–1/LW–4/LW–5/LW–6A			0.00	0.00	75.35	46.35	0.00	162.57	2A 4I
2A 4J	PP–1/MU–1/MU–2/OM–1/LW–1/LW–4/LW–5/LW–6B			0.00	0.00	72.55	45.25	0.00	160.33	2A 4J
2A 4K	PP–1/MU–1/MU–2/OM–1/LW–2/LW–4/LW–5/LW–6A			0.00	0.00	71.80	45.80	0.00	156.77	2A 4K
2A 4L	PP–1/MU–1/MU–2/OM–1/LW–2/LW–4/LW–5/LW–6B			0.00	0.00	69.00	44.90	0.00	153.67	2A 4L
2A 4M	PP–1/MU–1/MU–2/OM–1/LW–3/LW–4/LW–5/LW–6A			0.00	0.00	67.80	46.80	0.00	144.87	2A 4M
2A 4N	PP–1/MU–1/MU–2/OM–1/LW–3/LW–4/LW–5/LW–6B			0.00	0.00	65.00	45.70	0.00	142.23	2A 4N
2A 4O	PP–1/MU–1/MU–2/OM–1/LW–3/LW–4/LW–7/LW–9			0.00	0.00	82.25	47.05	0.00	174.81	2A 4O
2A 4P	PP–1/MU–1/MU–2/OM–1/LW–3/LW–4/LW–7/LW–10			0.00	0.00	97.60	47.35	0.00	206.12	2A 4P
2A 4Q				0.00	0.00	78.70	46.50	0.00	169.25	2A 4Q
2A 4R				0.00	0.00	94.05	46.80	0.00	200.96	2A 4R
2A 4S				0.00	0.00	74.70	47.50	0.00	157.26	2A 4S
2A 4T				0.00	0.00	90.05	46.80	0.00	192.41	2A 4T
	CENTRAL CORRIDORS (20 USING EITHER PP–1 OR PP–2)			0.00						
2B 5M	PP–1/MU–1/MU–3A/MU–4/MU–6/MU–7/MU–9/OM–2/LW–3/LW–4/LW–5/LW–6A			0.00	0.00	49.20	49.65	0.00	99.09	2B 5M
2B 5N	PP–1/MU–1/MU–3A/MU–4/MU–6/MU–7/MU–9/OM–2/LW–3/LW–4/LW–5/LW–6B			0.00	0.00	46.40	43.55	0.00	106.54	2B 5N
2C 5M	PP–1/MU–1/MU–3A/MU–4/MU–6/MU–8/MU–9/OM–2/LW–3/LW–4/LW–5/LW–6A			0.00	0.00	44.90	48.05	0.00	93.44	2C 5M
2C 5N	PP–1/MU–1/MU–3A/MU–4/MU–6/MU–8/MU–9/OM–2/LW–3/LW–4/LW–5/LW–6B			0.00	0.00	42.10	46.95	0.00	89.67	2C 5N
2D 5M	PP–1/MU–1/MU–3A/MU–3B/MU–5/MU–6/MU–7/MU–9/OM–2/LW–3/LW–4/LW–5/LW			0.00	0.00	52.70	52.15	0.00	101.05	2D 5M
2D 5N	PP–1/MU–1/MU–3A/MU–3B/MU–5/MU–6/MU–7/MU–9/OM–2/LW–3/LW–4/LW–5/LW			0.00	0.00	49.90	51.05	0.00	97.75	2D 5N
2E 5M	PP–1/MU–1/MU–3A/MU–3B/MU–5/MU–6/MU–8/MU–9/OM–2/LW–3/LW–4/LW–5/LW			0.00	0.00	48.40	50.55	0.00	95.75	2E 5M
2E 5N	PP–1/MU–1/MU–3A/MU–3B/MU–5/MU–6/MU–8/MU–9/OM–2/LW–3/LW–4/LW–5/LW			0.00	0.00	45.60	49.45	0.00	92.21	2E 5N
2B 5S	PP–1/MU–1/MU–3A/MU–4/MU–6/MU–7/MU–9/OM–2/LW–3/LW–4/LW–7/LW–9			0.00	0.00	56.10	50.35	0.00	111.42	2B 5S
2B 5T	PP–1/MU–1/MU–3A/MU–4/MU–6/MU–7/MU–9/OM–2/LW–3/LW–4/LW–7/LW–10			0.00	0.00	71.45	50.65	0.00	141.07	2B 5T

Table 6
RANKING OF FEASIBLE CORRIDORS
FEBRUARY 1992

CODE	CORRIDOR REFERENCE		WEIGHTED CONSTRAINT W/O OPPORTUNITY UNITS	NET CONSTRAINT % LINEAR	CONST. COST ($M)
2A	MPP/M−1/M−3/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	18.10	−44.92	3.31
1A	MPP/M−1/M−2/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	17.75	−44.62	3.34
2B	MPP/M−1/M−3/M−4	P−1/P−1C/P−1E/P−1G/K−1	18.10	−38.50	2.96
1B	MPP/M−1/M−2/M−4	P−1/P−1C/P−1E/P−1G/K−1	17.75	−38.23	3.00
4A	MPP/M−5/M−6/M−2/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	21.90	−34.02	3.23
3A	MPP/M−5/M−6/M−3/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	22.65	−33.04	3.20
4B	MPP/M−5/M−6/M−2/M−4	P−1/P−1C/P−1E/P−1G/K−1	21.90	−26.11	2.88
3B	MPP/M−5/M−6/M−3/M−4	P−1/P−1C/P−1E/P−1G/K−1	22.65	−24.92	2.85
2C	MPP/M−1/M−3/M−4	P−1/P−1C/P−1F/P−1G/K−1	19.60	−24.12	3.00
1C	MPP/M−1/M−2/M−4	P−1/P−1C/P−1F/P−1G/K−1	19.25	−24.01	3.00
5A	MPP/M−5/M−7/M−8/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	27.95	−23.66	3.44
2E	MPP/M−1/M−3/M−4	P−1/P−1C/P−1F/P−1G/K−1	19.60	−23.02	3.11
1E	MPP/M−1/M−2/M−4	P−1/P−1C/P−1F/P−1G/K−1	19.25	−22.93	3.14
5B	MPP/M−5/M−7/M−8/M−4	P−1/P−1C/P−1E/P−1G/K−1	27.95	−15.14	3.10
4C	MPP/M−5/M−6/M−2/M−4	P−1/P−1C/P−1F/P−1G/K−1	23.40	−11.33	2.88
1D	MPP/M−1/M−2/M−4	P−1/P−1D/P−1E/P−1G/K−1	24.25	−11.06	3.00
2D	MPP/M−1/M−3/M−4	P−1/P−1D/P−1E/P−1G/K−1	24.60	−11.02	2.96
4E	MPP/M−5/M−6/M−2/M−4	P−1/P−1C/P−1F/P−1G/K−1	23.40	−10.80	3.03
3C	MPP/M−5/M−6/M−3/M−4	P−1/P−1C/P−1F/P−1G/K−1	24.15	−9.97	2.85
3E	MPP/M−5/M−6/M−3/M−4	P−1/P−1C/P−1F/P−1G/K−1	24.15	−9.49	2.99
5C	MPP/M−5/M−7/M−8/M−4	P−1/P−1C/P−1F/P−1G/K−1	29.45	−1.38	3.10
5E	MPP/M−5/M−7/M−8/M−4	P−1/P−1C/P−1F/P−1G/K−1	29.45	−1.32	3.44
4D	MPP/M−5/M−6/M−2/M−4	P−1/P−1D/P−1E/P−1G/K−1	28.40	2.13	2.88
6A	MPP/M−9/M−10/M−8/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	31.95	2.58	3.30
1F	MPP/M−1/M−2/M−4	P−1/P−1D/P−1F/P−1G/K−1	25.75	3.02	3.14
2F	MPP/M−1/M−3/M−4	P−1/P−1D/P−1F/P−1G/K−1	26.10	3.20	3.11
3D	MPP/M−5/M−6/M−3/M−4	P−1/P−1D/P−1E/P−1G/K−1	29.15	3.65	2.85
7A	MPP/M−9/M−11/M−12/M−8/M−4	P−1/P−1A/P−1B/P−1E/P−1G/K−1	34.30	5.60	3.38
5D	MPP/M−5/M−7/M−8/M−4	P−1/P−1D/P−1E/P−1G/K−1	34.45	11.16	3.10
6B	MPP/M−9/M−10/M−8/M−4	P−1/P−1C/P−1E/P−1G/K−1	31.95	11.55	3.73
4F	MPP/M−5/M−6/M−2/M−4	P−1/P−1D/P−1F/P−1G/K−1	29.90	16.12	3.03
7B	MPP/M−9/M−11/M−12/M−8/M−4	P−1/P−1C/P−1E/P−1G/K−1	34.30	17.63	3.04
3F	MPP/M−5/M−6/M−3/M−4	P−1/P−1D/P−1F/P−1G/K−1	30.65	17.72	2.99
6C	MPP/M−9/M−10/M−8/M−4	P−1/P−1C/P−1F/P−1G/K−1	33.45	22.97	3.73
5F	MPP/M−5/M−7/M−8/M−4	P−1/P−1D/P−1F/P−1G/K−1	35.95	23.83	3.24
6E	MPP/M−9/M−10/M−8/M−4	P−1/P−1C/P−1F/P−1G/K−1	33.45	27.68	3.10
7E	MPP/M−9/M−11/M−12/M−8/M−4	P−1/P−1C/P−1F/P−1G/K−1	35.80	30.25	3.18
7C	MPP/M−9/M−11/M−12/M−8/M−4	P−1/P−1C/P−1F/P−1G/K−1	35.80	31.67	3.04
6D	MPP/M−9/M−10/M−8/M−4	P−1/P−1D/P−1E/P−1G/K−1	38.45	33.38	3.73
7D	MPP/M−9/M−11/M−12/M−8/M−4	P−1/P−1D/P−1E/P−1G/K−1	40.80	44.46	3.04
6F	MPP/M−9/M−10/M−8/M−4	P−1/P−1D/P−1F/P−1G/K−1	39.95	53.98	3.10
7F	MPP/M−9/M−11/M−12/M−8/M−4	P−1/P−1D/P−1F/P−1G/K−1	42.30	55.89	3.18
	MPP/M−5/M−6/M−3/M−8/M−12/M−13/P−3/K−2		36.00	60.57	3.31
	MPP/M−5/M−7/M−12/M−13/P−3/K−2		29.50	67.40	2.80
	MPP/M−5/M−7/M−12/P−2/K−1		34.00	77.48	2.67
	MPP/M−9/M−11/M−13/P−3/K−2		30.85	106.05	2.50
	MPP/M−9/M−10/M−12/M−13/P−3/K−2		34.95	109.96	2.66
	MPP/M−9/M−11/M−12/P−2/K−1		38.10	119.58	2.49

Table 7
TOP RANKING OF ALTERNATIVE CORRIDORS

REFERENCE CODE	FEASIBLE CORRIDORS	NET CONST WITH OPPOR WEIGHTED	LINEAR UNITS	NET CONST AS A % OF LINEAR UNITS (Weighted)	LENGTH (miles)	CONST. COST ($M)	REFERENCE CODE
2C 5N	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	42.10	46.95	89.67	17.78	4.45	2C 5N
2E 5N	PP-2/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	45.60	49.45	92.21	18.73	4.68	2E 5N
2C 5M	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	44.90	48.05	93.44	18.20	4.55	2C 5M
2E 5M	PP-2/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	48.40	50.55	95.75	19.15	4.79	2E 5M
1C 5N	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	45.70	47.60	96.01	18.03	4.51	1C 5N
2D 5N	PP-2MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	49.90	51.05	97.75	19.34	4.83	2D 5N
1E 5N	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	49.20	50.10	98.20	18.98	4.74	1E 5N
2B 5M	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	49.20	49.65	99.09	18.81	4.70	2B 5M
3H 5N	PP-3/MU-3C/MU-10A/MU-8(part)/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	45.25	45.45	99.56	17.22	4.30	3H 5N
1C 5M	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	48.50	48.70	99.59	18.45	4.61	1C 5M
2D 5M	PP-2/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	52.70	52.15	101.05	19.75	4.94	2D 5M
1E 5M	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-8/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	52.00	51.20	101.56	19.39	4.85	1E 5M
1D 5N	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	53.50	51.70	103.48	19.58	4.90	1D 5N
1B 5M	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	52.80	50.30	104.97	19.05	4.76	1B 5M
2B 5N	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	46.40	43.55	106.54	16.50	4.12	2B 5N
1D 5M	PP-1/MU-1/MU-3A/MU-3B/MU-5/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6A	56.30	52.80	106.63	20.00	5.00	1D 5M
2B 5S	PP-2/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-7/LW-9	56.10	50.35	111.42	19.07	4.77	2B 5S
1B 5N	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-5/LW-6B	50.00	44.20	113.12	16.74	4.19	1B 5N
1B 5S	PP-1/MU-1/MU-3A/MU-4/MU-6/MU-7/MU-9/OM-2/LW-3/LW-4/LW-7/LW-9	59.70	51.00	117.06	19.32	4.83	1B 5S

Table 8
CONSTRUCTION COST
LAHAINA ALTERNATIVE CORRIDORS

JUNE 1992

ALTERNATIVE 1 – MAUKA Range: $6.362 to 7.295 M

PP–1	260.0								
MU–1/2	3674.5								
OM–1	1582.9								
LW–1	438.6	LW–2	258.7						
OPTION A–6A	1063.5	OPTION A–6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
LW–1 Totals	7019.5		7100.9		6887.0		7295.0		6802.1
LW–2 Totals	6579.6		6661.0		6447.1		6855.1		6362.2

ALTERNATIVE 2 – CENTRAL Range: $5.725 to 6.504 M

PP–2	108.5								
MU–1/3A/4	951.2	MU–1/3A/3B/5	1236.4						
MU–6/7/9	2510.5	MU–6/8/9	2709.9						
OM–2	962.1								
LW–3	346.6								
OPTION A–6A	1063.5	OPTION A–6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
MU–4&7 Totals	5942.4		6023.8		5809.9		6217.9		5725.0
MU–4&8 Totals	6141.8		6223.2		6009.3		6417.3		5924.4
MU–5&7 Totals	6227.6		6309.0		6095.1		6503.1		6010.2
MU–5&8 Totals	6426.9		6508.4		6294.5		6702.5		6209.6

ALTERNATIVE 3 – MAKAI CENTRAL Range: $5.384 to 6.046 M

PP–2/4	335.0	PP–3	165.9						
MU–3C/10A/9	3062.9								
OM–2	962.1								
LW–3	346.6								
OPTION A–6A	1063.5	OPTION A–6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
PP–4 Totals	5770.1		5851.5		5637.6		6045.6		5552.7
PP–3 Totals	5601.0		5682.4		5468.5		5876.5		5383.6

ALTERNATIVE 4 – COASTAL Cost: $ 4.443 M

PP–3	165.9
MU–3C/10A/10B	2739.1
OM–3A/3B	970.1
LW–8/10/SS	568.0
Total	4443.1

ALTERNATIVE 5 – AMFAC (w/underground of existing 69KV corridor) plus LOWER WEST MAUI MTNS. Range: $ 5.917 to 6.579 M

PP–2/4	335.0	PP–3	165.9						
MU–3C/10A/9	3062.9								
OM–1	1582.9								
LW–2	258.7								
OPTION A–6A	1063.5	OPTION A–6B	1144.9	OPTION B	931.0	HFDC	1339.0	BYPASS	846.1
PP–4 Totals	6303.0		6384.4		6170.5		6578.5		6085.6
PP–3 Totals	6133.9		6215.3		6001.4		6409.4		5916.5

ALTERNATIVE 6 – LANDOWNER RECOMMENDATIONS (w/ underground of existing 69KV corridor) Cost: $ 6.751 M

PP–2	108.5
MU–1/3A/4	951.2
MU–6/7/9	2510.5
OM–1	1582.9
LW–2	258.7
HFDC	1339.0
Total	6750.8

Source: Adapted from Stone & Webster 69KV Transmission Line Costs for Designated Land Areas on Maui
Corridor segments LW–9 and 1.46 miles of the HFDC perimeter alternative are assumed to be double circuit.
Construction Cost Range: $ 4.4 to 7.3 Million
Lowest = Alternative 4 – Coastal Corridor
Highest = Alternative 1 – Mauka Corridor with HFDC Perimeter Option

Table 9
FEASIBLE SEGMENT COMBINATIONS FOR ALTERNATIVES

SEGMENT COMBINATIONS	LENGTH (mi.)	CONSTRAINT UNITS	COST ($K)	ALT. #1	ALT #2	ALT #3	ALT #4	ALT #5	ALT #6
Power Plant Study Section									
PP-1	1.63	9.75	260.0	X					X
PP-2	0.68	6.2	108.5		X				X
PP-2/PP-4	2.10	3.2	335.0			X		X	
PP-3	1.04	4.6	165.9			X	X	X	
Maalaea – Ukumehame Study Section									
MU-1/MU-2	5.98	36.1	3674.5	X					
MU-1/MU-3A/MU-4	2.36	9.5	951.2		X				X
MU-1/MU-3A/MU-3B/MU-5	3.11	13.0	1236.4		X				
MU-6/MU-7/MU-9	4.37	25.2	2510.5		X				X
MU-6/MU-8/MU-9	4.69	20.9	2709.9		X				
MU-3C/MU-10A/MU-9	5.42	39.9	3062.9			X		X	
MU-3C/MU-10A/MU-10B	6.50	75.8	2739.1				X		
Olowalu – Makila Study Section								CROSS OVER	CROSS OVER
OM-1	6.12	18.6	1582.9	X				X	X
OM-2	6.03	6.6	962.1		X	X			
OM-3A/OM-3B	6.08	80.8	970.1				X		
Lahaina – Wahikuli Study Section									
LW-1	1.32	6.8	438.6	X					
LW-2	1.00	1.0	258.7	X				X	X
LW-3	1.34	0.0	346.6		X	X			
LW-4/LW-5/LW-6A/SS	4.10	17.7	1063.5	X	X				
LW-4/LW-5/LW-6B/SS	3.84	11.7	1144.9	X	X				
LW-4/LW-5 (dbl. cir.)/LW-6B/SS	3.84	11.7	1339.0			X		X	X
LW-4/LW-7/LW-9/SS	3.61	21.3	931.0	X	X				
LW-4/LW-7/LW-9(single circuit)/SS	3.61	21.3	846.1			X		X	
LW-8/LW-10/SS	3.56	39.8	568.0				X		

APPENDIX B
PROPOSED PROJECT PROFILES

APPENDIX B

PROPOSED PROJECT PROFILES

BY

CHRIS HART & PARTNERS

AND

DAMES & MOORE

February 1992

INTRODUCTION

Proposed development in the study area was identified through a variety of sources. Each project was identified by name and profile sheets were developed to consolidate information about the project description, status and land use. The following table provides a summary of the projects that were mapped and data about the development status, project proponent and description. Information obtained through phone interviews or meetings with planners or developers of each of the projects is provided in the proposed Project Profiles that follow.

PROPOSED PROJECTS				
PROJECT	OWNER/DEVELOPER	STATUS	SIZE	PROJECT ESTIMATED COMPLETION
Project District 1 (Industrial Expansion Area)[a]	Alexander & Baldwin/County of Maui	Planned	4.36 acres	Incorporated into Maalaea Village Project
Kealia Pond Wildlife Refuge[a]	U.S. Fish and Wildlife Service	Planned	700 acres	Improvements continuous
Maalaea Village (formerly Kealia Pond) Development	A&B Hawaii, Inc.	Proposed	650 acres	2005
Maalaea Triangle Project	Maalaea Triangle Partnership	Approved	18 acres	uncertain
Olowalu Planned Community	Amfac/JMB Hawaii, Inc.	Proposed	500 acres	undetermined
Puu Hipa Golf Course	Amfac/JMB Hawaii, Inc.	Proposed	440 acres	undetermined
Lahaina Bypass Corridor and Ikena Avenue Relocation Project	State Department of Transportation; B.P. Bishop Trust Estate	Planned	7.9 miles	1995
Lahaina Watershed Flood Control Project	Soil Conservation Service and County of Maui	Under Construction	3500 feet	1992
Wainee Housing Residential Development	B. P. Bishop Estate Trust	Proposed	450 acres	undetermined
HFDC Lahaina Planned Community (Mixed Use Residential)	State of Hawaii Housing Finance and Development Corporation	Phases I, II - Under Construction Phases III-VI planned	1122 acres	2000

[a] No project profile is developed for this project as it is either part of or adjacent to the Maalaea Village, formerly Kealia Pond development.

PROJECT PROFILE
RESIDENTIAL PROJECT

DEVELOPMENT PROJECT: Maalaea Village (Formerly Kealia Pond)

LOCATION: Adjacent to Maalaea Bay between Maalaea Harbor and the Maui Electric Power Plant.

TMK: 3-8-05:2

SIZE: 650 acres

TOTAL # OF THE DWELLING UNITS PROPOSED:

Single Family: 1138-1722
Multi-Family: 145-215
Resort (Multi-Family): 350-500
Commercial (acres): 24

STATUS: Proposed by Alexander and Baldwin, Inc.; not reflected in the Kihei-Makena Community Plan.

BUILD OUT SCHEDULE BY YEAR: 10-15 years

STATUS OF INFRASTRUCTURE IMPROVEMENTS NEEDED:

Water: 3.0 million gallon storage reservoir will be required. The County is committed to developing new sources. The existing 42/36-inch transmission line has the capacity to transport water from the Waiehu/Waihee areas to Maalaea.

Sewage Disposal: Options include the installation of a new sewerage system from Maalaea to either the Kihei STP, to the proposed sewage treatment plant in Puunene, or to the main interceptor in Kahului. Alternatively, the developer could build a Wastewater Treatment Facility adjacent to the project area.

Roads: Realignment of North Kihei road is proposed.

Electrical/Power: Power is not anticipated to be a problem because Maui Electric's Power Plant is near the project area.

DESCRIPTION:

Preliminary development plans include a residential housing, one golf course, vehicle parking and access routes, beach park and nature trails and some commercial establishments primarily for residents use.

PRINCIPAL CONTACT AND PHONE:

Stanley Kuriyama
A&B Hawaii, Inc.
822 Bishop Street
P.O. Box 3440
Honolulu, HI 96801

(808) 525-6671

PROJECT PROFILE
RESIDENTIAL PROJECT

DEVELOPMENT PROJECT: Maalaea Triangle Project

LOCATION: Maalaea Triangle, is a triangular shaped parcel bordered by Maalaea Road and Honoapiilani Highway adjacent to Maalaea Boat Harbor. The site is seven miles south of Wailuku.

TMK: 3-6-01:1 and 19

TYPE OF DEVELOPMENT: Commercial Center

SIZE: 18.484 acres

STATUS: Approved

STATUS OF INFRASTRUCTURE IMPROVEMENTS NEEDED:

Sewer System: Presently, there are no sewage collection facilities in the Maalaea area. The County's sewer master plan calls for sewage from Maalaea to be pumped into the North Kihei collection and transportation system for treatment and disposal at the Kihei Treatment Plant. Until such time as the installation of a collection, transportation and pumping facility from Maalaea to North Kihei is installed, the developer plans to build and operate a package sewage treatment facility to accommodate project needs. This facility would be located at the most northerly corner of the project site. Effluent would be processed through the secondary treatment plant, chlorinated and discharged into a set of injection wells for disposal.

Water: The 8-inch line which services Maalaea branches off from the 24- and 18-inch transmission line which transports water from the source in Mokuhau to Kihei. Storage is presently provided by a 50,000-gallon and two, 12,000-gallon steel storage tanks at an elevation of 120 feet. The developer plans to increase the existing storage facility to 300,000 gallons.

Roadways and Access: The site is bordered by Honoapiilani Highway along its westerly boundary and Maalaea Road along its easterly and southerly boundaries. The following improvements are being considered:

- Construction of a new access road which meets Honoapiilani Highway at a right angle
- Signalization of the new intersection
- Deceleration/turn lane and protected phasing for southbound highway traffic wishing to turn into Maalaea
- Widening Honoapiilani Highway in the northbound direction to two lanes across the signalized intersection
- Provisions of separate left and right turn lanes for exiting traffic from the Maalaea Road approach
- Widening Maalaea Road along the project frontage

Drainage System: Off-site runoff from two basins flow across the project site. Plans are to intercept this off-site runoff and convey it to the open ocean south of Maalaea Harbor. Drainage plans are being refined with the Department of Land and Natural Resources, the Department of Transportation, Harbors Division and C. Brewer.

Electrical and Telephone Systems: There are overhead electrical and telephone distribution lines on Maalaea Road and Honoapiilani Highway. These utilities will be able to accommodate the power and communications needs for the project.

DESCRIPTION:

The proposed Maalaea Triangle Project is a mixed use commercial development. It is envisioned to include restaurants, retail, and office space, a museum, food and retail kiosks, parking areas, a service station, theaters, marine exhibits, marina oriented uses, extensive landscaping improvements, and other associated uses permitted within B-2 zones areas.

APPROXIMATE FLOOR AREA

	Square Feet
Retail/Service	87,550
Restaurants	33,950
Museum	3,200
Offices	35,000
Service Station	2,000
Kiosks	1,260

The preliminary development plans call for the commercial buildings to be situated parallel to Honoapiilani Highway to buffer the trade winds and to create protected landscaped courtyards and mall spaces. Three acres of the site will remain in open space.

PROPONENT'S NAME AND ADDRESS:

Maalaea Triangle Partnership
75-B, North Church Street
Wailuku, HI 96793

PRINCIPAL CONTACT:

Michael Spalding, CCIM
General Partner, Maalaea Triangle Partnership

(808) 242-5788

PROJECT PROFILE
NON RESIDENTIAL DEVELOPMENT

DEVELOPMENT PROJECT: Proposed Olowalu Planned Community by AMFAC/JMB Hawaii, Inc.

LOCATION: Olowalu, Maui

Midway between Maalaea and Lahaina is the site of the historical community of Olowalu; the site of Olowalu Wharf, a small residential community and the Olowalu General Store.

TMK: 4-8-03 Olowalu, Maui

AREA: Approximately 500 acres in the ultimate development plan; the majority of the site is owned by AMFAC/JMB Hawaii, Inc. and the remainder by the Department of Hawaiian Homelands.

DEVELOPMENT DENSITY:

This has not been defined. However, AMFAC/JMB Hawaii has indicated that the new planned community would be primarily residential with secondary lodge-type hotel development and adequate commercial and pubic facilities to support a self-sufficient community.

STATUS: During the 1981 update of the Lahaina Community Plan, community development at Olowalu was proposed in a limited form to the citizens advisory committee and the Maui Planning Commission and accepted. However, the proposal was subsequently rejected from the Community Plan by the Maui County Council.

Because the ten (10) year Lahaina Community Plan update process begins in 1992, I would suspect that the landowner will propose the establishment of a new planned community at Olowalu, once again.

INFRASTRUCTURE IMPROVEMENTS:

Nearly all infrastructural components must be developed, in order to support urbanization.

PROPONENTS NAME AND ADDRESS:

Mr. Don Fujimoto, P.E.
Director of Development
Maui Properties
AMFAC/JMB Hawaii, Inc.
2530 Kekaa Drive
Lahaina, Maui, Hawaii 96761

Telephone: 667-7411
Fax: 667-7183

PROJECT PROFILE
RESIDENTIAL PROJECT

DEVELOPMENT PROJECT: AMFAC/JMB Hawaii, Inc.
Proposed Puu Hipa Golf Courses

LOCATION: Launiupoko, Lahaina, Maui

Mauka of the sugar cane fields and the existing 69KV transmission lines near Launiupoko Beach Park and Honoapiilani Highway.

TAX MAP KEY: 4-7-01 Launiupoko, Lahaina, Maui

PROPOSED SIZE: 440 Acres

	Acres
Golf Course No. 1	194.1
Club House No. 1	12.3
Golf Course No. 2	209.4
Club House No. 2	11.3
Maintenance Facilities	3.8
Road Right-of-way	9.4
Total	440.3

PROJECT DESCRIPTION

The subject project has never been publicly presented in a formal manner; however, during discussion and formulation of a golf course zoning ordinance for Maui, AMFAC/JMB announced they are considering it for a future golf course site. The site is currently in the Agricultural LUD and not on the Community Plan. Park District No. IV zoning required prior to approval and development.

STATUS: The proposal is on hold. It may be proposed during the update of the Lahaina Community Plan.

PROPONENTS NAME AND ADDRESS:

Mr. David Gleason, or Mr. Don Fujimoto, P.E.
Director of Development - Maui Properties
AMFAC/JMB Hawaii, Inc.
2530 Kekaa Drive
Lahaina, Maui, Hawaii 96761
Phone: 667-7411
Fax: 667-7183

PROJECT PROFILE
NON RESIDENTIAL DEVELOPMENT

DEVELOPMENT PROJECT: Lahaina Bypass
Honoapiilani Highway (FAP Route 30)
(Honoapiilani Highway Bypass)

LOCATION: Puamana Park to Honokowai

TYPE OF DEVELOPMENT: Highway Bypass

SCHEDULE: **Estimated Construction Start Date:** Earliest 1994
Estimated Construction Completion Date: 1996

STATUS : Supplemental EIS being prepared April 1992
Design Phase (14 months) begins July 1992

RELATED INFRASTRUCTURE TO BE COMPLETED:

Telephone and electrical line adjustments will be necessary where the alternative alignment crosses the urbanized area adjacent to Lahainaluna Road.

STATUS OF INFRASTRUCTURE:

Telephone and electrical lines are presently found overhead on utility service poles along the existing highway and along interior roads.

DESCRIPTION:

This project would bypass Honoapiilani Highway between Honokowai and Launiupoko Point. The roadway will have a 150-foot minimum right-of-way with two travel lanes. The length of the bypass will total 8.3 miles; 2.8 miles between Launiupoko and Lahainaluna Road, and 5.5 miles between Lahainaluna Road and Honokowai.

Alignment: According to the Supplemental Environmental Impact Statement Preparation Notice: Modification to Honoapiilani Highway Bypass Corridor. The State DOT proposes to modify the alignment of the proposed Lahaina Bypass as it was defined in the Final EIS. On the northern end of the project, the Bypass corridor will be extended to Honokowai. The revised alignment will eliminate the need for widening Honoapiilani Highway between Kaanapali and Honokowai as proposed in the Final EIS. The alignment will primarily pass through upland agricultural areas with a section passing through a residential area requiring increased rights-of-way. The existing Honoapiilani Highway would be closed between Launiupoko State Wayside Park and Puamana Park to through traffic.

The realignment as described in the *Supplemental Environmental Impact Statement Preparation Notice: Modification to Honoapiilani Highway Bypass Corridor* has been reevaluated and realigned. The alignment will begin at Puamana Park rather than Launiupoko and extend to Honokowai as described in the Supplemental EIS.

Estimated Construction Cost:	$45.5 million 2 lane highway $28.0 million expansion to 4 lanes

PROPONENT'S NAME AND ADDRESS:

William R. Lake
Division Administrator
Federal Highway Administration
Box 50206
300 Ala Moana Blvd.
Honolulu, HI 96850

PRINCIPAL CONTACT:

Ron Tsuzuki, Chief of Planning, State Department of Transportation, 587-1830

References:

U.S. Department of Transportation Federal Highway Administration and Hawaii Department of Transportation, November, 1990. Final Environmental Impact Statement: Honoapiilani Highway (FAP) Route 30) Puamana to Honokowai. Lahaina District, Maui County, Hawaii.

Hawaii State Department of Transportation, April 1991. Draft Environmental Assessment and Supplemental Environmental Impact Statement Preparation Notice: Modification to Honoapiilani Highway Bypass Corridor. Prepared by Michael Munekiyo Consulting.

Telephone conversation with Mike Munekiyo, September 1991 and January 21, 1992.

PROJECT PROFILE
NON RESIDENTIAL DEVELOPMENT

DEVELOPMENT PROJECT: Lahaina Watershed Flood Control Project

LOCATION: Lahaina

TYPE OF DEVELOPMENT: Flood Control

SCHEDULE: **Estimated Construction Start Date:** 1992
Estimated Construction Completion Date: 1994

STATUS:

Planned: the Lahaina Community Plan "supports the implementation of flood control projects to address present problem areas." No mention of this specific project is made however.

Residents of Puamana objected to the location of the proposed outlet, thus alternatives are being considered to address these community concerns. One alternative being considered would involve an additional channel parallel to Honoapiilani Highway which would extend 3500 feet towards Wailuku. This alternative would increase estimated costs by $1 million. The startup and completion dates are uncertain pending resolution of the channel alignment issue.

DESCRIPTION (as provided in the Draft Environmental Assessment, does not account for possible revisions based on community concerns):

The plan proposes the installation of a 6,824-foot long floodwater diversion channel that starts at Lahainaluna Road, extends across the Lahaina subwatershed, and outlets into Kauaula Stream. 1,024 feet of the channel would be reinforced concrete and 5,800 feet would be earth. Associated structures include an inlet basin, an energy dissipating basin and three sediment basins. A debris basin at Kauaula Stream would capture cobble to boulder size rocks. The Kauaula Stream cement rock masonry outlet channel would be replaced with rectangular reinforced concrete channel.

The purpose of the project is to provide a 50-year level of flood protection to a 100-year floodplain benefited area which includes 168 homes, 152 businesses, two schools, two parks and 80 acres of irrigated sugar cane. Flooding is a major problem in the Lahaina Watershed, resulting in floodwater and sediment damage to homes, businesses and roads in LahainaTown and to sugar cane crops, fields, roads, irrigation systems and ditches. Sedimentation and floodwater runoff are also recognized as detrimental to coral reef ecosystems.

ESTIMATED PROJECT COST:

Cost Item	Cost ($)
Structural Measures for Flood Prevention	3,799,500
Engineering	569,900
Project Administration	304,000
Land Rights	892,200
Household Relocation	250,000
Total	5,815,600

PROPONENT'S NAME AND ADDRESS:

County of Maui
200 High Street
Wailuku, HI 96793

West Maui Soil and Water Conservation District
P.O. Box 1170
Wailuku, HI 96793

U.S. Department of Agriculture
Soil Conservation Service
P.O. Box 50004
Honolulu, HI 96850

PRINCIPAL CONTACT:

Neil Fujiwara
Soil Conservation Service
Wailuku Field Office
244-3729

References:

U.S. Department of Agriculture, Soil Conservation Service, December 1990. Draft Watershed Plan and Environmental Assessment: Lahaina Watershed. Maui County.

Telephone conversation Neil Fujiwara September 26, 1991.

PROJECT PROFILE
RESIDENTIAL PROJECT

DEVELOPMENT PROJECT: B.P. Bishop Estate
Proposed S.F. Residential Wainee Housing

LOCATION: Wainee, Maui

Mauka of Honoapiilani Highway and south of Dickenson Street in the vicinity of Wainee Village.

TMK: 4-6-18-3 Lahaina, Maui

SIZE: Estimated proposed project site 450 acres

PROJECT DESCRIPTION:

During the 1981 Lahaina Community Plan update, representatives from B.P. Bishop Estate proposed to the Citizen's advisory committee that approximately 450 acres of TMK 4-6-18:3 should be designated for single family residential development. Designation on the community plan would have opened the way to a land use district boundary amendment from Agriculture to Urban.

STATUS: Pioneer Mill Company, Ltd., the I.L.W.U., representing the advisory committee voted not to include the proposed project as a designation on the community plan for the following reasons:

1. The soil capability rating is Class A & B, and the acreage is highly productive.

2. Strategically, the site is located in the center of the plantation.

3. The loss of such highly productive land could jeopardize the economic viability of Pioneer Mill Company, Ltd.

PROPONENTS NAME AND ADDRESS

Kapu Smith, Land Manager
B.P. Bishop Trust Estate
567 South King Street, 2nd Floor
Honolulu, Hawaii 96813

Phone: (808) 523-6250

BUILD OUT SCHEDULE BY YEAR: (See attached Exhibit B)

PROJECT PROFILE
RESIDENTIAL PROJECT

DEVELOPMENT PROJECT: Housing Finance and Development Corporation's Lahaina Master Planned Project

LOCATION: Wahikuli, Lahaina

Mauka of Honoapiilani Highway and located adjacent to Lahaina town, mauka of the Lahaina Civic Center and Wahikuli subdivision and north of the Kelawea subdivision and Lahainaluna High School.

TMK: 4-5-21-9; portion of 3, portion of 4, portion of 5; and 4-5-14-58

SIZE: 1,125.564 acres (1)

TOTAL # OF THE DWELLING UNITS PROPOSED: 4,284 units (1)

STATUS: EIS accepted. Granted Land Use Amendment from agriculture to urban by the State Land Use Commission on May 18, 1990.
Phase I and II under construction.
HFDC is unable to construct the additional phases until the unavailable land is transferred from DLNR to HFDC ownership. Land transfer is complicated by the ceded to Hawaiian Natives. A decision is pending legislative action.

BUILD OUT SCHEDULE BY YEAR: (See attached Exhibit B)

STATUS OF INFRASTRUCTURE IMPROVEMENTS NEEDED:

Highways and Public Access:

Honoapiilani Highway serves as the only improved surface transportation link between the Kapalua/Kaanapali/Lahaina areas in West Maui and Central Maui. With the project area, Honoapiilani Highway is a four-lane arterial roadway that is signal controlled at its intersection with Civic Center Road, Kaniau Road, Front Street/Flemming Road and Kapunakea Street. The project will be intersected by the proposed State Department of Transportation's Honoapiilani Bypass Highway. Until the Bypass Highway is constructed, traffic generated by the proposed project will use the existing Honoapiilani Highway and internal roadway systems to be constructed as part of the project. The following roadway improvements would be made and mitigation measures taken to serve the project and surrounding area:

- Widening of Civic Center Road to a four-lane roadway with left turn channelization.
- Widening of Honoapiilani Highway to provide two northbound right turn lanes onto Civic Center Road.
- Widening of Honoapiilani Highway to provide a second southbound left turn lane onto Civic Center Road.
- Upgrading of existing traffic signal at the Civic Center Road/Honoapiilani Highway intersection.
- Construction of the Lahaina Bypass Highway in a timely manner.

- Crossing at the intersections of the Civic Center Road and Kapunakea Street should be grade-separated.
- Design and construct internal roadways serving the project in accordance with applicable state and country standards (2).

Portable Water System:

The country water system in West Maui is served by three surface sources and eight wells. In order to satisfy the maximum projected water demand of the project, a new groundwater source will have to be developed. Six wells rated at 400-450 gpm will be required. Two reservoirs will be required for water storage/a 2.5 MG reservoir and a 1.0 MG reservoir. Approximately 8,000 feet of the 16-inch diameter transmission line will be required to convey water from the proposed well source to the project and the 1.5 MG County reservoir at Wahikuli (2).

Wastewater Treatment and Disposal:

The existing wastewater transmission system between the project site and the Lahaina Wastewater Treatment Plant at north Kaanapali consists of three major sewage pump stations and force mains the two gravity transmission sewers. The Lahaina WWTP has a design average daily flow capacity of 6.7 MGD. The current average daily flow is 5.6 MGD. Improvements to the transmission and treatment facilities will be necessary to accommodate the HFDC project. Transmission system improvements would require a new transmission and pumping system be installed between the project site and the Lahaina WWTP. There is adequate capacity at the Lahaina WWTP to accommodate the first phase of the HFDC project. To augment the treatment facility's capabilities for future project phases, a modular package treatment plant will be erected adjacent to the present WWTP. The packaged treatment plant would be abandoned following improvements to the Lahaina WWTP. Proposed improvements to the Lahaina WWTP are estimated to expand its capacity to 10.2 MGD (2). The projected total sewage treatment demand from this project is 1.8 mgd (1).

Surface Water and Drainage:

Sugar cane is grown on nearly all of the project site and on the slopes above the site, limiting surface runoff from the project site. A small gully on the north borders the project site while Kahoma Stream represents its southerly demarcation. Two large irrigation reservoirs for Pioneer Mill Co. are situated at the southeast corner of the site, adjacent to Kahoma Stream. Two other drainage ways bisect the project site in a east to west (mauka-makai) direction. These gullies converge south of the Lahaina Civic Center. Retention basins will be designed as part of open spaces to absorb the peak surface runoff volumes and provide sediment settling before the runoff is released at controlled rates to designated outlets.

Schools:

Two elementary school sites and four church/day care centers are planned for the project(2).

Recreational Facilities:

Included in the project are a regional park, a golf course, five neighborhood parks, two elementary school sites and civic center expansion lands. The recreation/open space plan proposed for the project is characterized by selective improvement of the existing drainage ways and steep slope areas as recreational and scenic amenities (2).

DESCRIPTION:

The basic concept involves developing the Lahaina Master Planned Project as a master planned residential community with a high level of amenities and services available to people of all income levels. The concept includes developing a mix of housing for rent and for sale, including both single family and clustered multifamily residential units. In addition to residential development, the project will develop five neighborhood parks of at least six acres each. There will be an eighteen hole golf course included in the project located in a linear configuration to serve as: (1) a buffer between existing residential areas and a cane haul road, (2) a major component of the drainage and sewer system, and (3) as a logical transition between project phases. There will also be a 5.9 acre commercial center (2).

Land Use Summary

Land Use		*Area (Acres)*
Residential		489.2
Community Parks		33.4
Retail/Commercial		5.9
Elementary Schools		19.5
Church/Day Care		7.4
Golf Course		150.0
Open Space		420.1
	Total	1,125.5

PROPONENT'S NAME AND ADDRESS:

Housing Finance and Development Corp.
State of Hawaii
Seven Waterfront Plaza, Suite 300
500 Ala Moana Blvd.
Honolulu, Hawaii 96813

PRINCIPAL CONTACT AND PHONE:

Mr. Neal Wu
Project Coordinator, HFDC
587-0538

EXHIBIT "B"

LAHAINA PLANNED COMMUNITY

REVISED UNIT PRODUCTION SCHEDULE

# Units	Village	Plan/FFP	Design	Appr.	Precon.	Site	Unit
103	1-A	08/90	06/91	08/91	08/91	05/92	11/92
446	1-B	02/91	10/91	12/91	12/91	09/92	10/93
	G.C.	10/91	02/92	04/92	04/92	04/93	---
154	2	01/92	04/92	06/92	07/92	06/93	12/93
272	3	02/92	05/92	07/92	09/92	08/93	03/94
379	4	06/92	06/92	08/92	11/93	11/94	06/95
495	5	10/91	08/92	10/92	01/94	01/95	12/96
155	6	04/94	04/95	06/95	09/95	09/96	03/97
187	7	04/95	04/96	06/96	09/96	09/97	06/98
238	8	04/96	04/97	06/97	09/97	09/98	06/99
537	9	04/97	04/98	06/98	09/98	09/99	06/00
195	10	04/98	09/99	06/99	09/99	09/00	06/01
271	11	04/99	04/00	06/00	09/00	09/01	06/02
333	12	04/00	04/01	06/01	09/01	09/02	09/03
239	13	04/01	04/02	06/02	09/02	09/03	09/04
280	14	04/02	04/03	06/03	09/03	09/04	09/05
4284 (Total)	14						

Source: HFDC Lahaina Master planned Project EIS

REFERENCES:

(1) State of Hawaii, Housing Finance and Development Corporation, Department of Budget and Finance, September 1991. 1991 Annual Report on the Status of the Lahaina Master Planned Community Development.

(2) State of Hawaii, Housing Finance and Development Corporation, Department of Budget and Finance, February 1990. Lahaina Master Planned Community: Draft Environmental Impact Statement. Prepared by PBR Hawaii.

(3) Land Use District Boundary Amendment Petition, February 1990.

(4) Offsite Infrastructural Component LMPP, June 1990.

APPENDIX C

GEOLOGIC AND WATER RESOURCES TECHNICAL REPORT REGIONAL ASSESSMENT

APPENDIX C

GEOLOGIC AND WATER RESOURCES TECHNICAL REPORT REGIONAL ASSESSMENT

PREPARED BY
PACIFIC GEOTECHNICAL ENGINEERS

January 1992

Engineering Geologic and Hydrologic Evaluation
Routing Study (Phase I)
Maalaea-Lahaina Third 69KV Transmission Line Project

1.0 INTRODUCTION

This report presents the results of an engineering geologic and hydrologic evaluation performed for the Phase I Maalaea-Lahaina Third 69KV Transmission Line Project routing study in West Maui, Hawaii.

2.0 PROJECT CONSIDERATIONS

The Maalaea-Lahaina Third 69KV transmission line study area is located along the south and western flanks of the West Maui Mountains. This study area covers an approximately 18 by 3 mile area between Puukolii and Maalaea. The topography ranges from gently sloping on coastal plains and alluvial fans (from sea level to about 400 feet above mean sea level), to mountainous terrain dissected by numerous steep, V-shaped valleys and gulches. Towards the uphill portion of the study area, ground elevations increase to approximately 1,200 feet to 2,000 feet above mean sea level.

The new transmission line would be approximately 20 miles long, from the existing Maalaea Power Plant to a new substation to be constructed near Lahaina.

The new single circuit 69KV line is required to serve growing loads and to maintain adequate service to West Maui in the event that one of the existing lines from Maalaea to the region is out of service under emergency or scheduled outage conditions. The new transmission line is needed by June 1994.

This Phase I portion of the routing study consisted of regional studies and identification of potential transmission line corridors. The up-coming Phase II portion of the study will include corridor evaluation and selection of the preferred and alternative transmission line alignments.

3.0 PURPOSE AND SCOPE OF STUDY

The purpose of this regional study is to identify engineering geologic and hydrologic factors that pertain to route selection; to prepare resource data maps of pertinent engineering geologic and hydrologic factors; and to evaluate geologic and hydrologic constraints for the location of a transmission corridor 1/4 to 1/2 mile wide.

The following work tasks were performed and will be described herein for the Maalaea-Lahaina regional study:

a. A search and review of pertinent, available existing geologic, soils, and hydrologic information;

b. An approximately one hour helicopter aerial reconnaissance of the study area and a preliminary study of aerial photographs taken by Air Survey Hawaii on September 24 and 28, 1991;

c. Preparation of engineering geologic and hydrologic factors maps;

d. Evaluation and establishment of relative degrees of constraint to transmission line routing.

e. Preparation of a letter report to provide general definitions of engineering geologic and hydrologic factors, constraint criteria, evaluation of potential geologic hazards, relevant constraints and references used in this study.

4.0 ENGINEERING GEOLOGIC FACTORS

Based on a review of available published information and our past engineering experience on the Island of Maui, we judge that the following engineering geologic factors are important to the transmission line regional routing study:

- General slope gradients in the study area,
- Major geologic deposits and depth to rock,
- Surface and near-surface soil types, in particular, susceptibility of surface soil to landslide and erosion, and soil shrink/swell potential.

These engineering geologic factors were considered in our evaluation of potential engineering geologic constraints that may impact transmission line routing. A general discussion and definition of these factors are presented in the following sections. A discussion on earthquake design requirements and potential volcanic hazards in the study area is presented in Section 4.4 of this report.

4.1 Slope Factor

General topography and slope gradients in the study area were evaluated based on maps prepared by the United States Geological Survey (1983), and the Soil Conservation Service (1972).

Along the coastal and alluvial plains, the general topography is gently sloping (mostly 5% to 13% slope) towards the shore. Above an elevation of approximately 400 feet, the slope of the terrain range from about 15% to over 50% In these areas, numerous deeply dissected major valleys and gulches trend across the study area. These steep terrains may impact the proposed transmission line in the following ways:

- Increase the potential for landslide and progressive slope movements, particularly in areas where expansive soils and erosion prone deposits occur.

- Poor accessibilty, potential significant increase in construction costs.

- Amplification of wind speed due to terrain effects.

Potential impact of wind effect on transmission line routing is discussed in section 6.0 of this report.

4.2 <u>Geologic Factor</u>

The USGS geologic map (Stearns, 1942) indicates that six main geologic formations are present in the study area. These include:

- Recent alluvial deposits, primarily consisting of stream or flood deposited silt, sand and gravel. Soft silts and loose sand deposits may occur within these younger sedimentary deposits. Typical transmission pole design may not be adequate in areas where soft or loose sediments occur at or near the ground surface, due to potential low bearing capacity and low resistance to lateral and uplift forces.

- Older alluvial deposits, primarily consisting of stiff, bouldery clayey silts. The older alluvium mainly occur on alluvial outwash fans, along the valley floors and at the mouth of the major streams and gulches. Clay soils may be potentially unstable in areas of excessively steep slope, and/or excessive porewater pressure conditions.

- Basaltic a'a and pahoehoe lava flows of the Wailuku Volcanic Series. Competent rock formation generally can provide firm support for transmission line structures.

- Local cinder cones, consisting primarily of fire fountain type deposits of cinder, spatter, and pumice, of the Lahaina, Honolua and Wailuku Volcanic Series.

- Thin beds of friable vitric tuff of the Wailuku Volcanic Series. Daylighting of adversely orientated friable tuff beds on valley walls may pose potential threat to rock slope stability.

- Weathered andesitic lava flows of the Honolua Volcanic Series. Based on helicopter reconnaissance, these lava flows appear highly susceptible to weathering and erosion.

A geologic factor map indicating the probable nearsurface occurrence of these geologic units and areas where rock may occur at shallow depths (less than 5 feet) was earlier submitted as a working drawing. These units were transferred from a much larger scale 1942 map, the geologic map boundaries are therefore very approximate and should be verified in the field. Some of the geologic data pertinent to this study are presented in the Geology/Soils Map, in Appendix A.

4.3 <u>Soil Factors</u>

The U.S. Department of Agriculture's soil survey map of Maui (Soil Conservation Service, 1972) classified the surface and near-surface soils in the study area into 37 types (Table 1). The soil types have been reviewed and summarized into 18 groups for this regional study based primarily on the following soil characteristics:

- Potential for slope instability, particularly in areas with abundant landslide scars and a history of soil slips.
- Erosion potential, some fine sand and silt deposits may be prone to erosion when the protective vegetation cover is removed, for example, during construction.
- Shrink/swell potential, expansive clays can be unstable on slopes and can become very soft upon saturation.

A soil factor map indicating the general distribution of these soil types was earlier submitted as a working drawing. Some of the soil factors pertinent to this study are presented on the Geology/Soils Map.

4.4 <u>Earthquakes and Potential Volcanic Hazards</u>

The island of Maui is classified as seismic zone 2A by the Uniform Building Code (1989). The design and construction of the new transmission line system should conform to requirements outlined in the Uniform Building Code.

The island of Maui consists of two volcanoes, West Maui and Haleakala (Stearns and Macdonald, 1942). The study area is located mainly in the southern and southwestern foothill of the West Maui volcano. The ages of lavas of the West Maui volcano are estimated to range from about 2 million years (McDougall, 1964) to more than 25,000 years old (Crandell, 1983). The likelihood of a future eruption on West Maui appears to be remote (Mullineaux et. al., 1987).

Since the study area is located in areas that has not been affected by lava flows for at least 25,000 years, the potential of volcanic hazards affecting the study area in the future is considered to be very low.

5.0 <u>HYDROLOGICAL FACTORS</u>

Based on a review of available published information, the following hydrologic factors were considered in this Phase 1 study:

° Locations of streams, gulches, and surface water boundaries,

- Floods due to storm runoffs, and

- Potential tusnami inundation zones.

5.1 Streams, Gulches and Surface Water Boundaries

The locations of surface water bodies that may impact transmission line routing are shown on the Water Resources Map. The potential influence of streams and gulches in flooding the study area is discussed in the following section. The locations of streams, gulches, irrigation ditches, ponds and reserviors are based on topographic maps prepared by the U.S. Geological Survey, dated 1983.

5.2 Floods From Storm Runoffs

A flood is the inundation of lands not normally covered by water. Some flood flows are due to storm runoff, which causes a temporary rise of the water level in a stream or other water courses in excess of the physical limits of the channel. Such floods result in the inundation of adjacent lands generally referred to as flood plains.

Some floods from storm runoff, such as flash floods, occur where drainage areas are small and slopes are relatively steep. A flash flood is caused by rainfall of high intensity and short duration which produces maximum runoff and recession within a short period of time. Flood flows due to storm runoff may cause significant erosion of erodible soils, and may affect transmission line repair and maintenance operations, particularly during and after rainstorms. The duration of a flood would partly depends on the duration and intensity of related rainstorms.

Rainfall in West Maui and the study area generally varies from about 20 inches near the coast to about 400 inches at higher elevations. There are many streams, both perennial and intermittent, in the study area. Most of the perennial flow is diverted in the upstream reaches for irrigation. However, during heavy rains, many of the streams overflow and inundate the lower coastal areas (DLNR, 1971).

Potential 100-year flood areas as indicated by the Federal Emergency Management Agency or FEMA (1981), are shown on the Water Resources Map, in the main text of the routing study report. These potential flood zones appeared to occur primarily in lowlying areas at and near the mouth of the Hakakea Gulch, Kahoma stream, and Olowalu stream, and part of Lahaina and the Kealia pond areas. The recent completion of the Kodama stream flood control project in April 1990 appeared to reduce potential flooding areas to the general vicinity of the stream channel and some lowlying coastal areas (FEMA, 1991).

Detailed hydrologic analysis to evaluate flooding potential of local areas in the region is beyond the scope of this study. However, additional information regarding areas that were affected by past flooding may be obtained from discussions with local landowners and possibly site specific reconnaissance. These information would be useful in providing local, site specific data for later transmission pole siting considerations.

5.3 Tsunami

Seismic sea waves, or tsunami, is an extraordinary type of ocean waves produced by a sudden tectonic displacement of huge earth mass on the ocean floor. Tsunami activity causes destruction by a violent and turbulent mass of water, referred to as the bore type. Documented tsunami activities that had affected the study area are summarized below:

Date	Location	Approximate Wave Height
November 7, 1837	Lahaina	11 feet
May 17, 1841	Lahaina	3 feet
April 1, 1946	Maalaea	8 to 10 feet
April 1, 1946	Lahaina	up to 12 feet
April 1, 1946	Olowalu	8 to 10 feet
May 23, 1960	Lahaina to Maalaea	9 to 10 feet

As shown on the Water Resources Map, the FEMA maps (1981) indicated that only narrow zones along the coastal areas are prone to 100-year coastal flood with velocity (Zone V-12) or tsunami inundation. The FEMA flood boundaries were estimated based on data and topography at the time of their evaluation. Potential tsunami run-up heights may vary if the topography in these areas changes.

6.0 WIND FACTOR

Although only two hurricanes (Dot and Iwa) have impacted the Hawaiian Islands in the last 34 years, recent weather satellite observations have shown that there are much more tropical cyclones approaching but passing the islands than known earlier (U.S. Army Corps of Engineers, 1984). Further, the approach of a strong hurricane Raymond in October 1983 to within several hundred miles of the islands empasized the need to consider wind factors in transmission line routing and design.

Hurricane wind speed is substantially higher (over 100 miles per hour) than the trade winds (generally 4 to 20 miles per hour). Further, wind speed may be amplified because of terrian effects (State of Hawaii, 1990, Professor Arthur Chiu, personnal communication, 1991):

- **Valleys:** When winds enter a valley, wind speed may amplify in the narrow part of the valley. This situation may resemble the "Venturi effect".

- **Hills or mountains:** In general, wind speed tends to increase on the windward slope and reaches a maximum at or near the summit.

- **Mountain downslope winds:** Wind speed also accelerates downhill. The acceleration of winds to the lee of the Koolau and the Waianae mountain ranges on Oahu occurred during hurricane Iwa (National Research Council, 1983).

However, no analytical procedure is currently available to calculate the amplification of winds through valleys, or the acceleration of winds to the lee of mountain ranges (State of Hawaii, 1990). Nevertheless, quantitative data on wind amplification effects can be obtained using wind tunnel analysis (Professor Arthur Chiu, personnal communication, 1991), if such information is required for structural design.

The U.S. Army Corps of Engineers (1984) indicated that during hurricane Iwa, much of the wind-damaged properties in Kauai could be related to winds that were topographically enhanced much more than the sustained wind speeds. In Kauai, damages were mainly to transmission and distribution systems, structures, and underground cables. Most of the island was without electricity during the height of the storm (U.S. Army Corps of Engineers, 1983).

In Oahu, Iwa's winds damaged 8 of Hawaiian Electric's 14 138KV transmission lines, more than 100 poles supporting 46KV circuits were toppled, and at least an equal number of distribution circuit poles were also reported down (U.S. Army Corps of Engineers, 1983). Ninety one percent of Oahu was without electricity at the height of the storm.

The island of Maui was further away from Iwa's track and the damages were much less compared to Kauai and Oahu. However, based on a worst case hurricane scenarios developed by the U.S. Army Corps of Engineers (1984), the maximum gust could be 145 knots for a hurricane that approaches the Hawaiian Islands from the southeast or east, and a 120 knots maximum gust for a hurricane approaching from the southwest or south. In developing possible scenerios for hurricanes approaching the Hawaiian Islands from the southwest, the U.S. Army Corps of Engineers (1984) suggested that on Maui, certain regions may have stronger winds than other areas because of topographic enhancement of the wind speeds. These areas of enhanced winds include: the southern coast from Cape Hanamanioa to Kihei to Kanapali, the southwestern slopes of Haleakala, and the West Maui Mountains.

For this routing study, the concept of potential local terrain effect on wind speed, such as steep and narrow valleys within the study area, are considered in the constraint evaluations.

7.0 ENGINEERING GEOLOGIC AND HYDROLOGIC CONSTRAINTS

Based on the above information and discussions, potential constraints to transmission line routing were evaluated on the basis of:

a. Potential of severe damage or destruction of transmission line,

b. Potential disruption to or interference with transmission line repair and maintenance, and

c. Potential mitigation methods.

7.1 High Constraint

Historical Tsunami data (DLNR, 1971), and the FEMA maps (1981) indicated that most coastal zones along the study area shoreline will be prone to inundation by Tsunami waves. Significant Tsunami waves can destroy, or damage transmission lines and poles in these areas. Transmission line routing should avoid these potential flood zones.

Transmission towers or poles siting should also avoid the walls and bottom of deep valleys or gulches, due to potential adverse wind effects and potential high velocity flash floods. Wider transmission pole or tower spacings to span over these high constraint areas is recommended.

Based on available information, areas of landslide deposits are shown on the Geology/Soils Map. In general, these include areas of relatively steep slopes (40% to 70%), active erosion, relatively high rainfall (25 to 200 inches per year), and where past landslides probably occurred (Soil Conservation Service, 1972). Due to the generally remote and difficult terrain, slope stabilization work in these areas could be prohibitively expensive. Transmission line routing should avoid siting transmission poles in these areas.

7.2 Moderate Constraint

The FEMA maps (1981) and the Water Resources Map also indicated that low lying areas around main streams and gulches and adjacents areas are prone to 100-year floods (due to storm runoff). In areas where the topography is generally level, potential flooding in these areas probably would not damage transmission poles, but may affect repair and maintenance operations during flooding. Depending on the operation requirement, and if practical, it may be prudent to minimize construction of transmission poles in these flood prone areas.

Since the flood zones presented on the FEMA maps are for insurance purposes only, the maps, and therefore the Water Resources Map may not show all potential flood zones within the study area. Based on site topography and the relative size of the catchments, some of the potential flood zones have been extended for the purpose of constraint ranking for this study.

Areas that may be prone to slope instability are shown on the Geology/Soils Map. In general, these include areas of steep and bouldery terrains, active erosion, and moderate rainfall (20 to 40 inches, Soil Conservation Service, 1972). Although past landslides appeared not detected in these areas (Soil Conservation Services, 1972), the bouldery soil mantle covering steep terrain may be prone to slope instability. It is recommended that site specific geotechnical investigation and slope stability evaluation should be performed for transmission poles located in these areas.

The approximate locations of soils with high erosion potential are also shown on the Geology/Soils Map. In general, these areas include clayey silts with moderate shrink/swell potential, located over 3% to 35% slopes, and extremely weathered, friable volcanic rock outcrops (Soil Conservation Service, 1972). Transmission pole siting in these areas will require site specific investigation of subsurface conditions and evaluation of slope stability. In some areas, the shallow depths to rock and careful transmission pole siting may help to mitigate or reduce potential erosion related problems.

7.3 Slight Constraint

Soft and/or loose materials may occur in the younger alluvial deposits. The potential occurrence of such soft zones may require special transmission pole design, and should be explored during subsequent subsurface investigation. Areas of younger or recent alluvial and dune sand deposits are shown on the Geology/Soils Map.

Due to the generally hilly terrain, potential erosion is expected to impact areas affected by construction activities, and if the areas remain unprotected, eroding may continue to spread. Loose sand deposits may be prone to erosion when the vegetation cover is removed. Appropriate erosion control measures should be planned and implemented before and during construction.

It is recommended that field engineering geological reconnaissance be performed along the selected alignment, particularly in areas of difficult terrain, and where erosion or slope instability may impact siting of transmission poles.

REFERENCES

Crandell, D.R., 1983. Potential Hazards From Future Volcanic Eruptions On The Island of Maui, Hawaii. U.S. Geological Survey Miscellaneous Investigations Series Map I-1442.

Department of Land and Natural Resources, 1971. Flood Hazard Information, Island of Maui, Report R39. Prepaired by Department of The Army, Pacific Ocean Division, Corps of Engineers, for The State of Hawaii, Department of Land And Natural Resources, Division of Water and Land Development.

Federal Emergency Management Agency, 1981. Flood Insurance Rate Maps, Maui County, Hawaii, Panels 255, 163, 170, 235, 161, 153, 330, 227, 229, 265, 260, of 400.

Federal Emergency Management Agency, 1991. Revised Flood Insurance Rate Map, Maui County, Panel 161 of 400, dated December 6, 1991.

McDougall, Ian, 1964. Potassium-Argon ages from lavas in the Hawaiian Islands: Geological Society of America Bulletin, V. 75, p. 107-128.

Mullineaux, D.R. , Peterson, D.W., and Crandell, D.r., 1987. Volcanic Hazards in the Hawaiian Islands in: Volcanism in Hawaii, edited by Decker, R.W., Wright, T.L., and Stauffer, P.H., U.S. Geological Survey Professional Paper 1350, p. 599-621.

Naughton, J.J., Macdonald, G.A., and Quenberg, U.A., 1980. Some additional potassium-argon ages of Hawaiian rocks: The Maui Volcanic Complex of Molokai, Maui, Lanai, and Kohoolawe: Journal of Volcanology and Geothermal Research, V. 7, p. 339-355.

National Research Council, 1983. Hurricance Iwa, Hawaii, November 23, 1982. National Academy of Science, National Academy Press.

Soil Conservation Service, 1972. Soil Survey of Islands of Kaui, Oahu, Maui, Molokai, and Lanai, State of Hawaii, U.S. Department of Argiculture, p. 232 plus map.

State of Hawaii, 1990. Impact of Hurricane Strength Winds on Typical Dwelling Structures, Windward Oahu. Prepared by Alvin Zane & Associates, Inc., for Department of Defense, State of Hawaii, under U.S. Army Corps of Engineers Contract No. DACA 83-89-D-005.

Stearns, H.T., 1942. Geological and Topographic Map, Island of Maui, Hawaii. Geological Survey, United States Deparment of The Interior.

U.S. Army Corps of Engineers, 1983. Post Disaster Report, Hurricane Iwa, 23 November 1982. Report by U.S. Army Corps of Engineers, Pacific Ocean Division.

U.S. Army Corps of Engineers, 1984. Hurricanes in Hawaii. Prepared by Pacific Weather, Inc., for the Department of the Army, Pacific Ocean Division, Corps of Engineers, P.O. No. DACW84-83-M-0651.

U.S. Geological Survey, 1983. Maalaea, Olowalu, Lahaina, and Puu O Kali Quadrangles, Hawaii-Maui County, Island of Maui, 7.5 Minute Series (Topographic) maps, U.S. Department of The Interior.

APPENDIX D

BOTANICAL RESOURCES TECHNICAL REPORTS

APPENDIX D

BOTANICAL RESOURCES
TECHNICAL REPORTS

D-1 REGIONAL ASSESSMENT
and
D-2 SURVEY OF PREFERRED ALIGNMENT

PREPARED BY
CHAR & ASSOCIATES

APPENDIX D-1

REGIONAL ASSESSMENT OF BOTANICAL RESOURCES

PREPARED BY
CHAR & ASSOCIATES
October 1991

REGIONAL STUDY
BOTANICAL RESOURCES
MA'ALAEA-LAHAINA THIRD 69KV TRANSMISSION LINE

A. OVERVIEW

The Ma'alaea-Lahaina study area includes land zoned "Conservation", certain portions of which provide habitat for endangered native plant species. At least five officially listed endangered species occur on or near the study area. Hawaii State Law (H.R.S. 195-D) protects all federal and state listed threatened and endangered plants on all lands within the State. Any projects or actions that may adversely affect these plants should be coordinated with the Department of Land and Natural Resources (DOFAW memorandum 01 Nov. 1991). Besides the five listed species, there are six Category 1 candidate endangered species and six Category 2 species on or near the project area. The Category 1 candidate endangered plants are expected to be proposed for endangered species status sometime in FY 1992. Although the Category 2 plants are rare, there are not enough data to support listing proposals at this time.

Because of federal and state endangered species laws and regulations, the proposed new powerline alignment will need to avoid areas which support these listed and Category 1 endangered species. If these areas cannot be avoided than the primary impact to the vegetation is expected to be due to the construction and maintenance of the access road. The chances of fire in the area may also increase.

B. METHODS

A helicopter flyover the study area was conducted on 25 September 1991. The flyover provided a "quick inspection" of the broad vegetation types present on the study area. Later, photographs and slides were taken by HECO personnel. Colored aerial photographs were prepared by Air Survey Hawaii. These resources were used in preparing the preliminary vegetation map.

A short description of the broad vegetation types recognized within the study area was prepared using information from botanical studies prepared for other projects in the area, from other botanical literature, and from photographs and slides taken during the helicopter flyover.

Personal interviews were conducted with government agency representatives and other botanists familiar with the locations of threatened and endangered species known from or near the study area. Locations given in the most recent treatment of the Hawaiian flora by Wagner et al. (1990) were also noted. The general locations for endangered, threatened, and sensitive (ETS) species were mapped.

C. DATA FACTOR DEFINITIONS

Vegetation types: For this regional phase of the studies, the general physiognomy of the dominant plant life-form is used for classification and mapping. Where more detailed information is available, the plant community has been identified, e.g. kiawe-buffel-grass association.

ETS plants: These are officially listed threatened and endangered species, Category 1 candidate endangered species, and Category 2 (rare) plants. See Appendices 1 and 2.

D. RESOURCE INVENTORY

1. Vegetation types : Five general vegetation types are recognized below. The two vegetation types which cover the most area are the agricultural lands (sugar cane and pineapple fields),

which occur on the more or less level areas and gently sloping lands, and the mixed grassland/shrubland which occur on the slopes from above Ma'alaea to Papalaua.

a. Agricultural lands: These are lands which are in active cultivation. Pineapple fields are found in the area between Highway 30 and the foothills of the West Maui Mountains. Sugar cane fields occur on the coastal plains and foothills from about the Ukumehame Beach Park to the project's Pu'ukoli boundary area. Agricultural lands support very little of botanical interest; weedy species dominate on the less frequently disturbed areas such as alongside roads and irrigation ditches, rockpiles, etc. The principal investigator has conducted a number of surveys in these agricultural areas (Char 1986a, 1986b, 1988a, 1988b, 1989a, 1989b, 1990a, 1990b, 1991); no ETS plants were found on actively cultivated agricultural lands.

b. Kiawe-buffel grass association: This vegetation type occurs on moderately sloping lands and on smooth alluvial fans. Typically the physiognomy is of an open woodland with dense grass cover filling in the matrix between the trees. The kiawe trees are scattered or may form small stands, from 15 to 25 ft. tall. the trees become denser in small gullies and low-lying areas. In the larger gulches other tree species such as Java plum and 'opiuma are found and the canopy is denser.

c. Mixed grassland/shrubland: This vegetation type occurs on the steeply sloping areas dissected by large, deep gulches. Scattered shrubs occur throughout an extensive grassland. In places, as on the tops of ridges, the grassland is replaced by shrubland. Stands of ironwood can be found in this vegetation type on the slopes facin Ma'alaea. Large erosion scars are a prominant feature on the sides of gulches.

d. Shrubland: This vegetation type occurs on the steeper slopes usually above the kiawe-buffel grass association. Its composition varies widely depending on the degree of past disturbances (fires, grazing), steepness of slopes, substrate types, and rainfall. Native species may be the dominant components on areas with gray-colored soils of trachyte and mugearite. Such mixed lowland dry shrublands support plants of *Dodonaea viscosa*, pili grass (*Heteropogon contortus*), 'ilima (*Sida fallax*), *Gouania hillebrandii*, naio (*Myoporum sandwicense*), sandalwood (*Santalum ellipticum*), etc. Pu'u Hipa and the adjacent slopes (Lihau-Olowalu) support areas of native shrubland and several ETS species.

e. Forest: Dry to mesic forests can be found on the slopes above the shrubland vegetation. Usually there is no sharp delineation between shrubland and forest and one type grades into the other with elements from both sides present. Large blocks of forestry plantings can be found in some areas. These include ironwood (*Casuarina equisetrifolia*, *C. glauca*, various *Eucalyptus* species, and Norfolk Island pine (*Araucaria heterophylla*).

2. ETS plants: Table 1 presents the ETS plants found on the project area; the general plant locations have been plotted on Figure 1. From the information obtained from the State's Division of Forestry and Wildlife (C. Corn, state botanist, pers. comm.), four areas are of concern;

Pu'u Hona: Koaia (*Acacia koaia*) and *Hibiscus brackenrigei* have been recorded from this area. From the flyover, this area has been heavily grazed and the plants may no longer occur at the site. There is some chance that they could occur on more steeply sloping areas like the nearby Pohakea Gulch.

State DLNR Reserve: This reserve contains ~~are~~ significant population of ETS species and should be excluded from any alignment plans.

TABLE 1.

LIST OF ENDANGERED, THREATENED OR SENSITIVE PLANTS

# on map	Species name	* Status
1	Acacia koaia	2
2	Diellia erecta	1
3	Exocarpus gaudichaudii	2
4	Gouania hillebrandii	E
5	Gouania vitifolia	1
6	Hesperomannia arbuscula	E
7	Hibiscus brackenridgei	1
8	Hibiscus kokio	2
9	Neraudia sericea	1
10	Remya mauiensis	E
11	Santalum freycinetianum var. lanaiensis	E
12	Schiedea menziesii	2
13	Schiedea salicaria	2
14	Spermolepis hawaiiensis	1
15	Tetramolopium capillare	1
16	Tetramolopium remyi	E
17	Torulinium odoratum	2

* Status

E = officially listed as endangered

1 = Category 1 candidate endangered species; will be proposed as endangered in FY 1992

2 = Category 2 taxa; plants for which there is some evidence of vulnerability, but for which there are not enough data to support listing proposals at this time (U.S. Fish and Wildlife Service 1990).

3. Pu'u Hipa-Lihau-Olowalu area: Significant ETS plant populations are located in this area adjacent to the project boundaries. In addition, the Lihau Section of the West Maui Natural Area Reserve (NAR) occurs here. About 16 individuals of *Gouania hillebrandii* are found on the summit of Pu'u Hipa (Char 1990; Wagner *et al*. 1990).

4. Pa'upa'u Ridge: Located on the slopes above Lahainaluna School, this area supports eight ETS plant species. The ridge is also included in the Panaewa Section of the West Maui NAR.

REFERENCES

Char, W. P. 1986a. Botanical reconnaissance survey, Proposed widening and realignment alternatives, Hono-a-Pi'ilani Highway, Puamana to Ka'ana-pali. Prepared for Environmental Communications, Inc. March 1986.

________ . 1986b. Biological reconnaissance survey, Ma'alaea Triangle, Maui. Prepared for PBR HAWAII. April 1986.

________ . 1988a. Botanical survey, Hono-a-Pi'ilani Highway, Island of Maui, Proposed widening and realignment alternatives. Prepared for Environmental Communications, Inc. March 1988.

________ . 1988b. Botanical survey, North Beach Mauka, Ka'ana-pali, Maui. Prepared for Helber, Hastert & Kimura. December 1988.

________ . 1989a. Botanical survey, South Beach Mauka, Ka'ana-pali, Maui. Prepared for Helber, Hastert, & Kimura. January 1989.

________ . 1989b. Botanical survey, Lahaina HFDC project, Lahaina District, Island of Maui. Prepared for PBR HAWAII. September 1989.

________ . 1990a. Botanical survey, Launiupoko Golf Course, Lahaina District, Maui. Prepared for Helber, Hastert, & Kimura. September 1990.

________ . 1990b. Botanical survey, Ma'alaea project (±604 acres), Wailuku District, Maui. Prepared for A&B Properties, Inc. December 1990.

________ . 1991. Botanical assessment survey, Lahaina HFDC off-site improvements, Lahaina District, Maui. Prepared for PBR

HAWAII. May 1991.

Corn, C. 1991. Personal communication. State Department of Land and Natural Resources, Division of Forestry and Wildlife. Meeting of 13 November 1991 -- locations of ETS species and areas of potential concern or problems.

Herbst, D. R. 1991. Personal communication. U.S. Fish and Wildlife Service, Honolulu office. Telephone conversation. Status of ETS plants.

U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; Review of plant taxa for listing as Endangered and Threatened Species; Notice of review. Federal Register 55(35): 6184-6229.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the flowering plants of Hawai'i. 2 vols. University of Hawai'i Press and Bishop Museum Press. Bishop Museum Special Publication 83. Honolulu.

Welton, P. 1991. Personal communication. University of Hawai'i, Manoa. Nov.-Dec. (various) informal meetings -- vegetation on Lihau NAR.

APPENDIX D-2

BOTANICAL SURVEY
OF
PREFERRED ALIGNMENT

PREPARED BY
CHAR & ASSOCIATES
June 1993

BOTANICAL SURVEY
MA'ALAEA - LAHAINA THIRD 69 KV
TRANSMISSION LINE PROJECT

by

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Prepared for: DAMES & MOORE
MAUI ELECTRIC COMPANY, LTD.

June 1993

BOTANICAL SURVEY
MA'ALAEA - LAHAINA 69KV
TRANSMISSION LINE PROJECT

INTRODUCTION

System planning studies conducted by Maui Electric Company, Ltd. (MECO), to correct existing and future system limitations and problems have identified a need for a third 69kV transmission line from the MECO Ma'alaea Power Plant to Lahaina. The proposed Ma'alaea-Lahaina Third 69kV Transmission Line is needed to maintain reliable electric service to West Maui in the event that one or both of the existing 69kV lines from the Ma'alaea Power Plant to the region is out of service and to provide additional transmission capacity to serve load growth in the West Maui areas.

The total distance of the line from the Ma'alaea Power Plant to its termination at the new Lahainaluna Switching Station is approximately 14.7 miles. Assuming a right-of-way width of 75 feet, the proposed transmission line would require 9.09 acres per mile, or a total of about 134 acres. Over 60% of the 14.7-mile alignment is located on lands designated Agriculture; the remaining portions are on lands in the Conservation Land Use District. The preferred alignment crosses a number of different vegetation types, including actively cultivated sugar cane fields and native-dominated shrublands.

Field studies to assess the botanical resources found along the preferred alignment were conducted on 27 April and 06-07 May 1993. Four botanists, working in teams of two each, were used to gather the data summarized in this report.

SURVEY METHODS

Prior to selection of the preferred alignment, a routing study of the Ma'alaea-Lahaina area was conducted by MECO to evaluate oppurtunities and constraints of several alternative alignments. During this phase of the studies, a helicopter flyover to provide an overview of the broad vegetation types present within the regional study area was made on 25 September 1991. A search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the Ma'alaea-Lahaina area. Personal interviews were conducted with government agency representatives and other botanists familiar with the locations of threatened and endangered plant species known from or near the regional study area. This information was used in selecting the preferred alignment.

After the preferred alignment (proposed route) was selected, topographic maps and very recent, colored aerial photographs were examined to determine access, vegetation cover patterns, terrain characteristics, boundaries, and reference points. A helicopter dropoff on Kealaloloa Ridge was used for the more inaccessible portions of the alignment, that is, the area between segments 4 and 9. Cane haul roads and several, existing powerline service roads provided access to the remaining segments of the alignment. Where native plants were common, as in the mixed native shrubland and the mixed grassland/shrubland vegetation types, a more intensive survey was conducted since threatened and endangered species, as well as rare and vulnerable plants, were more likely to occur in such areas. Actively cultivated sugar cane fields were not surveyed in detail as sensitive native plant communities were not likely to occur in such situations.

A walk-through survey method was used. For most places, a 100-foot wide corridor was surveyed. At gulch crossings and where the transmission line will go underground, segment 17 near Pu'u Hipa, a 300-foot wide corridor was surveyed. Notes were made on plant associations and distribution, substrate types, topography, rainfall gradients, exposure, drainage, etc. Plant identifications were made in the field; plants which could not be positively determined were collected for identification in the herbarium (University of Hawai'i, Manoa -- HAW), and for comparison with the most recent taxonomic literature.

The species recorded are indicative of the season ("rainy" vs. "dry") and the environmental conditions at the time of the survey. A survey taken at a different time of the year, and under varying environmental conditions, would no doubt yield slight variations in the plant species list. A number of weedy species associated with the cane fields may have been overlooked as the survey focused on the uncultivated areas.

DESCRIPTION OF THE VEGETATION

To our knowledge, there have not been any reports which cover all of the area within the preferred alignment corridor. However, there have been a number of earlier botanical and biological surveys which included portions of the alignment corridor. The cane fields mauka of the Ma'alaea Power Plant, about 604 acres, were surveyed in 1990 for a proposed master-planned community (Char 1990b); this study included the areas covered by segments 1 and 2 of the alignment. The alignment follows further up mauka of the Old Lahaina Pali Trail in segments 4 and 5; some of the plant communities described in the Environmental Assessment report prepared for the trail (Division of Forestry and Wildlife 1992) are also found within these segments of the alignment. A botanical survey which included segment 19, in the Launiupoko-Pu'u Hipa area, was made by Char (1990a). A kiawe-buffel grass community formed the major plant cover on the uncultivated portions of the property; the area around Pu'u Hipa supported a mixed shrubland dominated largely by native species. The sugar cane fields near the proposed new Lahainaluna Switching Station site were examined during feasibility studies for several alternative alignments for the proposed Lahaina By-pass Road (Char 1988).

Within the preferred alignment corridor, five vegetation types are recognized. The distribution of these vegetation types is strongly influenced by several environmental factors; these include elevation and rainfall, substrate types, and disturbance by grazing animals. The more gently sloping agricultural lands with deep soil are used for sugar cane cultivation. The uncultivated, rocky lands along the leeward portions of the alignment support mostly a kiawe-grass association, and, in a few places, mixed native shrublands. The upper elevation, windward portions of the alignment support a mixed grassland/shrubland vegetation with a number of native plant components. A minor vegetation type, the riparian or streamside vegetation, occupies only a small area, and is found where the alignment crosses over a few of the broader gulches with streams, such as Olowalu and Ukumehame gulches.

A more detailed description of the five vegetation types is presented below. A checklist of all those vascular plants inventoried within the alignment corridor during the field studies is presented at the end of the report.

<u>Agricultural Lands</u>

These are lands which are in active cultivation. Sugar cane fields occupy most of these lands. Occasionally, a few recently fallowed fields can also be found. Pineapple fields are located makai of segment 3, outside the alignment. Agricultural lands support little of botanical interest; weedy species dominate on the less frequently disturbed areas such as along roadsides and ditches, rockpiles, etc.

The sugar cane (Saccharum officinarum) fields, along with their associated network of cane haul roads and irrigation systems, are found on the broad isthmus behind the Ma'alaea Power Plant and on the coastal plains and foothills from about the Ukumehame Beach Park to the project's Lahainaluna Switching Station site. When crossing these agricultural lands, the alignment, for the most part, follows along existing cane haul roads, irrigation ditches, and the margins of fields. These areas support a weedy mix of plants; among the most commonly observed species are swollen finger grass (Chloris barbata), spiny amaranth (Amaranthus spinosus), false mallow (Malvastrum coromandelianum), Guinea grass (Panicum maximum), pualele (Emilia fosbergii), and sow thistle (Sonchus oleraceus). Irrigation ditches provide a wetter habitat and support a denser growth of plants along their sides. Growing in these ditches are plants such as primrose willow (Ludwigia octovalvis) and Job's tears (Coix lachryma-jobi); these species require these wetter conditions. The cane fields themselves support few weedy species because the fast-growing sugar cane plants tend to shade out many of the weedy plants.

Large trees such as mango (Mangifera indica), Cook pine (Araucaria columnaris), and kiawe (Prosopis pallida) can be found as small, scattered stands around some reservoirs and major ditches.

Riparian (Streamside) Vegetation

This minor vegetation type is found along the bottoms of Olowalu Gulch, Ukumehame Gulch, and Launiupoko Gulch. The first two gulches have streams with running water, while the later supports an intermittent stream. Where the alignment crosses over these gulches and streams, the vegetation consists of a forest composed primarily of 'opiuma (Pithecellobium dulce) and Java plum (Syzygium cumini) trees, 18 to 25 ft. high. Kiawe trees may occur as scattered patches, or may form a dense thicket in the areas immediately behind the 'opiuma and Java plum trees. A few kukui trees (Aleurites moluccana) can also be found along the stream-sides. Because of the denser canopy cover, the ground cover beneath tends to be patchy, with barren soil, litter, and boulders frequent. Some of the more common ground cover plants found in this vegetation type include buffel grass, hairy abutilon (Abutilon grandifolium), woodfern (Christella parasitica), sour grass (Digitaria insularis), Guinea grass, West Indian sage (Salvia occidentalis), and castor bean. Plants growing alongside the stream or in the stream include Job's tears, honohono (Commelina diffusa), pamakani (Ageratina riparia), and primrose willow.

Kiawe-Grass Association

The kiawe-grass association is found on the lower slopes, just above the cane fields, and most of the preferred alignment passes through this vegetation type. The substrate is primarily exposed rocky outcrops and very shallow soils. These areas have been mapped as rock land (rRK) and stony alluvial land (rSM) on the soil maps (Foote et al. 1973). Between Launiupoko and the Lahaina Switching Station site, the soils become less stony.

Typically, the physiognomy is of an open woodland with dense grass cover filling in the matrix between the kiawe trees (Prosopis pallida). The kiawe trees are scattered, or may form small stands, from 15 to 25 ft. tall; tree cover varies from 5 to about 30%. In the gulches and on the more level, flat areas, the trees become denser and taller. The associated grass cover appears to vary with topography, substrate type, and the amount of disturbance. On the more steeply sloping, narrow ridges with much rocky outcroppings, pili grass (Heteropogon contortus) is the dominant grass cover. Smaller, scattered clumps of buffel grass are occasionally found. 'Ilima (Sida fallax), a small, native shrub with orange flowers and fuzzy leaves, is locally common. On some pili grass dominated slopes, such as around stake 13, the native Hawaiian cotton or ma'o (Gossypium tomentosum) and nehe (Lipochaeta lavarum) are occasional. A few of the native shrubs associated with the mixed native shrubland vegetation type are present in many of the pili grass dominated areas.

On the broader ridges and stony alluvial fans with somewhat less rocky outcrops, buffel grass is the most abundant grass cover. It forms dense, clumping mats, from 2 to 3 ft. tall. Common associates include scattered shrubs of koa-haole (Leucaena leucocephala) and klu (Acacia farnesina), as well as smaller plants of 'uhaloa (Waltheria indica), virgate mimosa (Desmanthus virgatus), 'ilima, and rattlepod (Crotalaria pallida).

Although there are remnants of old fencelines in this vegetation on the leeward side, segments 10 through 21, these areas have not been used for grazing for some time so the grass cover is dense. Along the lower half of segment 4, however, the kiawe-grass association is currently used for grazing cattle. In this area, the pili grass and buffel grass are replaced by less palatable grasses such as sour grass (Digitaria insularis) and pitted beardgrass (Bothriochloa pertusa). Tough, weedy, and spiny plants also are more munerous; these include lion's-ear (Leonotis nepetifolia), spiny amaranth (Amaranthus spinosus), false mallow (Malvastrum coromandelianum), and cocklebur (Xanthium strumarium).

Mixed Native Shrubland

This vegetation type is uncommon along the preferred alignment. It is found on the steep gulch walls below stakes 1 and 1A, on the gray-colored soils of trachyte and mugearite on Pu'u Hipa, and on the ridges near stake 23. This vegetation type is characterized by low, scattered native shrubs, 3 to 7 ft. tall, which form an open shrubland. The most abundant shrub is a'ali'i (Dodonaea viscosa); other native elements associated with this shrubland include naio (Myoporum sandwicense), lowland or coastal sandalwood (Santalum ellipticum), pili grass, 'ilima, and ko'oko'olau (Bidens menziesii). Introduced or alien species occasional to common in this shrubland include klu, lantana (Lantana camara), buffel grass, Natal redtop (Rhynchelytrum repens), and partridge pea (Chamaecrista nictitans). Trees of wiliwili (Erythrina sandwicensis) can usually be found in the gulch areas adjacent to or near the mixed native shrublands. The small gulch to the southeast of stake 23 supports a good stand of wiliwili trees.

The shrubland on the gulch walls below stakes 1 and 1A also supports a large population of Achyranthes splendens, an attractive endemic shrub with silvery, tomentose leaves, and 'akoko shrubs, an endemic member of the spurge or poinsettia family. On the very summit of Pu'u Hipa, outside the alignment, are 16 individuals of Gouania hillebrandii, an officially listed endangered species (U.S. Fish and Wildlife Service 1989; Wagner et al. 1990; Char 1990a).

Mixed Grassland/Shrubland

The mixed shrubland/grassland is found along the upper elevation portion of segment 4 and continues across the slopes to segment 7 where it ends near Manawaipueo Gulch. The soils on this section of the alignment are deep, well-drained, gently sloping to moderately steep. Because of the higher elevations and the windward exposure, it is cooler and relatively wetter along this portion of the alignment.

The vegetation is a patchwork or mosaic of grassy areas interspersed among low thickets of a'ali'i shrubs. Scattered along the ridgetops throughout the grassland/shrubland vegetation are small stands of ironwood trees (Casuarina equisetifolia), 12 to 20 ft. tall. Barren, eroded areas with sparse vegetation are also a common feature along this portion of the alignment.

On the upper elevation, windward facing slopes, the grassy areas are dominated by African dropseed grass (Sporobolus africanus) and Natal redtop grass. Locally common in small patches are molasses grass (Melinis multiflora) and sour grass. On the drier leeward slopes, from about stake 6 on, and on the windward slopes at about the 800-foot elevation, pili grass gradually becomes the most abundant grass. Scattered through the grassy areas are shrubs of 'ilima, klu, a'ali'i, at least three species each of Bidens and Lipochaeta, 'akia (Wikstroemia oahuensis), and 'ulei (Osteomeles anthyllidifolia). Shallow swales are often filled with a dense thicket of lantana and sour grass.

The patches of a'ali'i shrubland are low and windswept, about 2 to 3 ft. tall, and are found mostly along the ridgetops and windward facing slopes. 'Akia and a few plants of sandalwood and 'akoko (Chamaesyce celastroides), as well as Bidens and Lipochaeta are found here. Rocky outcrops with large boulders support a few ferns such as kumu-niu (Doryopteris decipiens), silver fern (Pityrogramma calomelanos), and pala'a (Sphenomeris chinensis); shrubs of pukiawe (Styphelia tameiameiae) and 'akoko; and an endemic sedge, Carex wahuensis.

DISCUSSION AND RECOMMENDATIONS

Five major vegetation types are recognized along the preferred alignment corridor. Actively cultivated agricultural lands support sugar cane fields along with a number of associated weedy species. A minor vegetation type, the riparian or streamside vegetation, is found along the bottom of Olowalu, Ukumehame, and Launiupoko gulches. The rocky, lower slopes and stony alluvial fans, just above the cane fields, support a kiawe-grass association; the greater part of the alignment passes through this vegetation type. Mixed native shrubland is found near stake 23, on Pu'u Hipa, and on the steep gulch walls between stakes 1 and 1A. The upper elevation, somewhat cooler and wetter portions of the alignment, support a mixed grassland/shrubland vegetation.

Although native species are the dominant components of the mixed native shrubland and the mixed grassland/shrubland, no threatened and endangered species (U.S. Fish and Wildlife Service 1989, 1990, 1992), or rare and vulnerable plants (Wagner et al. 1990) were found in these vegetation types along the preferred alignment. All of the native species inventoried within the alignment corridor can be found in similar environmental habitats throughout the West Maui Mountains.

Given the limited nature of the project, it is not expected to have a significant negative impact on the botanical resources. Certain sections of the alignment may need to be shifted to avoid archaeological sites or to lessen the visual impact on the Lahaina Pali Trail. If this occurs, then additional botanical studies should be made to inventory these new alignment sections. This is especially critical in the areas dominated by native plant communities.

PLANT SPECIES LIST -- Ma'alaea-Lahaina Transmission Line

A checklist of all those terrestrial, vascular plant species inventoried along the proposed transmission line corridor during the field studies is presented below. The species are arranged alphabetically by families within each of four groups: Ferns, Gymnosperms, Monocots, and Dicots. The taxonomy and nomenclature of the Ferns follow Lamoureux (1984); the Gymnosperms are in accordance with Little and Skolmen (1989); and the flowering plants, Monocots and Dicots, follow Wagner <u>et</u> <u>al</u>. (1990), for the most part.

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name(s), when known.
3. Biogeographic status. The following symbols are used:
   - E = endemic = native <u>only</u> to the Hawaiian Islands
   - I = indigenous = native to the Hawaiian Islands and also elsewhere throughout the Pacific
   - P = Polynesian = plants originally of Polynesian introduction prior to Western contact (Cook's discovery of the islands in 1778); not native
   - X = introduced or alien = all those plants brought by humans, intentionally or accidentally, after Western contact; not native.
4. Presence (+) or absence (-) of a particular species within each of five vegetation types recognized on the project site (see text for discussion):
   - ag = Agricultural Lands
   - r = Riparian (Streamside) Vegetation
   - kg = Kiawe-Grass Association
   - ns = Mixed Native Shrubland
   - g/s = Mixed Grassland/Shrubland

Scientific name	Common name	Status	ag	r	kg	ns	g/s
FERNS							
HEMIONITIDACEAE (Gold Fern Family)							
Pityrogramma calomelanos (L.) Link	silver fern	X	-	-	-	-	+
LINDSAEACEAE (Lace Fern Family)							
Sphenomeris chinensis (L.) Maxon	pala'a	I	-	-	-	-	+
NEPHROLEPIDACEAE (Sword Fern Family)							
Nephrolepis multiflora (Roxb.) Jarrett ex Morton	hairy sword fern	X	-	+	-	-	+
SINOPTERIDACEAE (Cliffbrake Fern Family)							
Doryopteris decipiens (Hook.) J. Sm.	kumu-niu, 'iwa'iwa	E	-	-	+	-	+
THELYPTERIDACEAE (Woodfern Family)							
Christella parasitica (L.) Levl.	woodfern, oakfern	X	-	+	-	-	-
GYMNOSPERMS							
ARAUCARIACEAE (Kauri Family)							
Araucaria columnaris (Forst. f.) Hook.	Cook pine	X	+	-	-	-	-
FLOWERING PLANTS							
MONOCOTS							
AGAVACEAE (Sisal Family)							
Furcraea foetida (L.) Haw.	Mauritius hemp	X	-	+	-	-	-
COMMELINACEAE (Dayflower Family)							
Commelina diffusa N.L. Burm.	honohono	X	+	+	-	-	-

Vegetation types: ag, r, kg, ns, g/s

Scientific name	Common name	Status	ag	r	kg	ns	g/s
CYPERACEAE (Sedge Family)							
Carex wahuensis C.A. Mey.		E	–	+	–	–	+
MUSACEAE (Banana Family)							
Musa X paradisiaca L.	banana, maia	P	+	–	–	–	–
POACEAE (Grass Family)							
Andropogon virginicus L.	broomsedge	X	–	–	–	–	+
Avena fatua L.	wild oak	X	–	–	–	–	+
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	X	–	–	+	–	+
Brachiaria subquadriparia (Trin.) Hitchc.		X	+	–	–	–	–
Cenchrus ciliaris L.	buffel grass	X	+	+	+	+	+
Cenchrus echinatus L.	common sandbur, 'ume'alu	X	+	–	–	–	+
Chloris barbata (L.) Sw.	swollen finger grass, mau'ulei	X	+	–	+	–	–
Chloris radiata (L.) Sw.	radiate finger grass	X	+	–	–	–	–
Chrysopogon aciculatus (Retz.) Trin.	golden beardgrass, pilipili-'ula	I?	–	–	–	–	+
Coix lachryma-jobi L.	Job's-tears	X	+	+	–	–	–
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X	+	–	–	–	+
Digitaria adscendens (HBK.) Henr.	Henry's crabgrass	X	–	–	–	–	+
Digitaria ciliaris (Retz.) Koeler	hairy crabgrass	X	+	–	–	–	–
Digitaria insularis (L.) Mez ex Ekman	sour grass	X	+	+	+	+	+
Eleusine indica (L.) Gaertn.	wiregrass, goosegrass	X	+	–	–	–	–
Eragrostis variabilis (Gaud.) Steud.	'emo-loa, kawelu	E	–	–	–	–	+
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	pili, pili grass	I	–	–	+	+	+
Melinis minutiflora P. Beauv.	molasses grass	X	–	–	–	–	+
Panicum maximum Jacq.	Guinea grass	X	+	+	+	–	+
Panicum maximum var. trichoglume Eyles ex Robyns	green panicgrass	X	+	–	–	–	–
Paspalum scrobiculatum L.	ricegrass, mau'u laiki	I?	–	–	–	–	+
Pennisetum clandestinum Chiov.	kikuyu grass	X	–	–	–	–	+
Rhynchelytrum repens (Willd.) Hubb.	Natal redtop	X	+	+	+	+	+

Scientific name	Common name	Status	ag	r	kg	ns	g/s
			Vegetation types				
Saccharum officinarum L.	sugar cane, ko	P	+	–	–	–	–
Setaria verticillata (L.) P. Beauv.	bristly foxtail	X	+	+	+	–	+
Sporobolus africanus (Poir.) Robyns & Tournay	African dropseed, rattail grass	X	–	–	–	–	+
Vulpia bromoides (L.) S.F. Gray	brome fescue	X	–	–	–	–	+
Indet. (Festucoideae)		?	–	–	–	+	–
DICOTS							
AMARANTHACEAE (Amaranthus Family)							
Achyranthes splendens Mart. ex Moq.		E	–	–	–	+	–
Amaranthus spinosus L.	spiny amaranth, pakai kuku	X	+	+	+	–	–
Amaranthus viridus L.	slender amaranth, pakai	X	+	–	–	–	–
ANACARDIACEAE (Mango Family)							
Mangifera indica L.	mango, manako	X	+	+	–	–	–
APIACEAE (Parsley Family)							
Anethum graveolens L.	dill	X	–	–	–	–	+
ASTERACEAE (Sunflower Family)							
Acanthospermum australe (Loefl.) Ktze.	spiny-bur, star-bur	X	–	–	+	–	+
Ageratina riparia (Regel) R. King & H. Robinson	pamakani	X	–	+	–	–	+
Ageratum conyzoides L.	maile hohono	X	+	–	+	–	–
Bidens cynapifolia Kunth	West Indian beggar's tick	X	–	–	+	–	–
Bidens mauiensis (A. Gray) Sherff	ko'oko'olau	E	–	–	–	–	+
Bidens menziesii (A. Gray) Sherff	ko'oko'olau	E	–	–	–	+	–
Bidens menziesii X mauiensis	ko'oko'olau hybrid	E	–	–	–	–	+
Bidens sp. (simple leaves)	ko'oko'olau	E	–	–	–	–	+
Bidens pilosa L.	Spanish needle, ki nehe	X	+	+	+	–	+
Centaurea melitensis L.	Napa thistle, yellow star thistle	X	–	–	–	–	+
Cirsium vulgare (Savi) Ten.	bullthistle	X	–	–	–	–	+

Scientific name	Common name	Status	ag	r	kg	ns	g/s
			Vegetation types				
Conyza bonariensis (L.) Cronq.	hairy horseweed, 'ilioha	X	+	–	–	–	–
Crassocephalum crepidioides (Benth.) S. Moore	crassocephalum	X	+	+	–	–	–
Emilia fosbergii Nicolson	pualele	X	+	–	+	–	+
Heterotheca grandiflora Nutt.	telegraph plant	X	–	–	–	–	+
Lipochaeta lavarum (Gaud.) DC.	nehe	E	–	–	+	+	–
Lipochaeta lavarum X lobata ?	nehe hybrid	E	–	–	–	+	+
Lipochaeta lobata (Gaud.) DC.	nehe	E	–	–	–	+	+
Pluchea symphytifolia (Mill.) Gillis	pluchea, sourbush	X	–	+	–	–	–
Sonchus oleraceus L.	sow thistle, pua-lele	X	+	–	+	–	+
Synedrella nodiflora (L.) Gaertn.	synedrella	X	–	–	+	–	–
Tridax procumbens L.	coat buttons	X	+	–	+	–	+
Xanthium strumarium var. canadense (Mill.) Torr. & A. Gray	cocklebur, kikania	X	–	–	+	–	+
Zinnia peruviana (L.) L.	wild zinnia	X	–	+	+	–	+
BRASSICACEAE (Mustard Family)							
Sisymbrium altissimum L.	Jim Hill mustard	X	–	–	–	–	+
Sisymbrium officinale (L.) Scop.	hedge mustard	X	–	–	–	–	+
BUDDLEIACEAE (Butterfly Bush Family)							
Buddleia asiatica Lour.	dog tail, huelo 'ilio	X	+	+	–	–	–
CACTACEAE (Cactus Family)							
Opuntia ficus-indica (L.) Mill.	panini	X	–	–	+	–	+
CARYOPHYLLACEAE (Pink Family)							
Polycarpon tetraphyllum (L.) L.	allseed	X	–	–	–	–	+
Silene gallica L.	small-flowered catchfly	X	–	–	–	–	+
CASUARINACEAE (Ironwood Family)							
Casuarina equisetifolia L.	ironwood, paina	X	–	–	–	–	+
CHENOPODIACEAE (Goosefoot Family)							
Atriplex semibaccata R. Br.	Australian saltbush	X	–	–	–	+	–
Chenopodium murale L.	nettle-leaved goosefoot, 'aheahea	X	+	–	+	–	+

Scientific name	Common name	Status	Vegetation types ag	r	kg	ns	g/s
CONVOLVULACEAE (Morning-glory Family)							
Ipomoea indica (J. Burm.) Merr.	koali	I	–	+	+	–	–
Merremia aegyptia (L.) Urb.	hairy merremia, koali kua hulu	X?	+	–	+	–	–
CUCURBITACEAE (Squash Family)							
Momordica charantia L.	wild bittermelon, balsam pear	X	+	+	+	–	–
EPACRIDACEAE (Heath Family)							
Styphelia tameiameiae (Cham. & Schlechtend.) F.v. Muell	pukiawe	I	–	–	–	–	+
EUPHORBIACEAE (Spurge Family)							
Aleurites moluccana (L.) Willd.	kukui	P	–	+	–	–	–
Chamaesyce celastroides (Boiss.) Croizat & Degener	'akoko	E	–	–	–	+	+
Chamaesyce hirta (L.) Millsp.	hairy spurge, garden spurge	X	+	–	–	–	–
Euphorbia heterophylla L.	kaliko	X	+	–	–	–	–
Ricinus communis L.	castor bean, koli	X	+	+	+	–	–
FABACEAE (Pea Family)							
Acacia farnesiana (L.) Willd.	klu	X	–	+	+	+	+
Chamaecrista nictitans (L.) Moench	partridge pea, lauki	X	+	–	+	+	+
Crotalaria incana L.	fuzzy rattlepod, kukaehoki	X	+	–	+	–	+
Crotalaria pallida Aiton	smooth rattlepod, pikakani	X	+	–	+	–	–
Desmanthus virgatus (L.) Willd.	slender mimosa	X	–	–	+	–	+
Desmodium tortuosum (Sw.) DC.	Florida beggarweed	X	+	+	–	–	–
Erythrina sandwicensis Degener	wiliwili	E	–	+	+	–	–
Indigofera suffruticosa Mill.	indigo, 'iniko	X	–	–	+	+	+
Leucaena leucocephala (Lam.) de Wit	koa-haole	X	+	–	+	+	+
Macroptelium lathyroides (L.) Urb.	wild bushbean, cow pea	X	+	–	+	–	–
Pithecellobium dulce (Roxb.) Benth.	'opiuma	X	–	+	+	–	–
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe	X	+	+	+	–	–
Senna surattensis (N.L. Burm.) H. Irwin & Barneby	kolomona	X	–	–	+	+	–

Scientific name	Common name	Status	Vegetation types ag	r	kg	ns	g/s
LAMIACEAE (Mint Family)							
Leonotis nepetifolia (L.) R. Br.	lion's-ear	X	+	−	+	−	−
Salvia occidentalis Sw.	West Indian sage	X	−	+	−	−	−
LAURACEAE (Laurel Family)							
Cassytha filiformis L.	kaunaoa pehu	I	−	−	+	+	−
MALVACEAE (Mallow Family)							
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	X	+	+	+	−	+
Abutilon incanum (Link) Sweet	hoary abutilon, ma'o	I?	−	−	+	−	−
Gossypium tomentosum Nutt. ex Seem.	Hawaiian cotton, ma'o, huluhulu	E	−	−	+	−	−
Malvastrum coromandelianum (L.) Garcke	false mallow, hauuoi	X	+	−	+	−	+
Sida fallax Walp.	'ilima	I	+	+	+	+	+
Sida rhombifolia L.	Cuba jute	X	−	−	+	−	−
MORACEAE (Mulberry Family)							
Ficus microcarpa L. f.	Chinese banyan	X	−	+	−	−	−
MYOPORACEAE (Myoporum Family)							
Myoporum sandwicense A. Gray	naio	I	−	−	+	+	−
MYRTACEAE (Myrtle Family)							
Psidium guajava L.	guava	X	−	+	−	−	−
Syzygium cumini (L.) Skeels	Java plum, palama	X	−	+	−	−	−
NYCTAGINACEAE (Four-o'clock Family)							
Boerhavia repens L.	alena	I	−	−	+	−	−
ONAGRACEAE (Evening Primrose Family)							
Ludwigia octovalvis (Jacq.) Raven	primrose willow, kamole	P?	+	+	−	−	−
OXALIDACEAE (Wood Sorrel Family)							
Oxalis corniculata L.	yellow wood sorrel, 'ihi	P?	−	−	−	−	+
PAPAVERACEAE (Poppy Family)							
Argemone glauca (Nutt. ex Prain) Pope	pua kala, kala	E	−	−	−	−	+

Scientific name	Common name	Status	Vegetation types ag	r	kg	ns	g/s
PASSIFLORACEAE (Passion Flower Family)							
Passiflora foetida L.	scarlet-fruited passion flower, pohapoha	X	–	–	+	–	–
PIPERACEAE (Pepper Family)							
Peperomia leptostachya Hook. & Arnott	'ala'ala wai nui	I	–	–	–	–	+
PLANTAGINACEAE (Plantain Family)							
Plantago lanceolata L.	narrow-leaved plantain	X	–	–	–	–	+
PLUMBAGINACEAE (Leadwort Family)							
Plumbago zeylanica L.	'ilie'e, hilie'e	I	–	–	+	–	–
PORTULACACEAE (Purslane Family)							
Portulaca oleracea L.	pigweed, common purslane	X	+	–	+	–	+
PRIMULACEAE (Primrose Family)							
Anagallis arvensis L.	scarlet pimpernel	X	–	–	–	–	+
PROTEACEAE (Protea Family)							
Grevillea robusta A. Cunn. ex R. Br.	silk oak, 'oka kilika	X	–	–	–	+	+
ROSACEAE (Rose Family)							
Osteomeles anthyllidifolia (Sm.) Lindl.	'ulei, u'ulei	I	–	–	–	–	+
SANTALACEAE (Sandalwood Family)							
Santalum ellipticum Gaud.	'iliahialo'e	E	–	–	+	+	+
SAPINDACEAE (Soapberry Family)							
Dodonaea viscosa Jacq.	a'ali'i	I	–	–	+	+	+
SOLANACEAE (Tomato Family)							
Lycopersicon pimpinellifolium (Jusl.) Mill.	currant tomato, wild tomato	X	+	–	+	–	–
Nicandra physalodes (L.) Gaertn.	apple-of-Peru	X	–	+	–	–	–
Solanum americanum Mill.	popolo	I?	+	–	+	–	+
Solanum linnaeanum Hepper & P. Jaeger	apple-of-Sodom, yellow kikania	X	–	–	+	–	+

Scientific name	Common name	Status	Vegetation types ag	r	kg	ns	g/s
STERCULIACEAE (Cacao Family)							
Waltheria indica L.	'uhaloa, hi'aloa, kanakaloa	I?	+	-	+	+	+
THYMELAEACEAE ('Akia Family)							
Wikstroemia oahuensis (A. Gray) Rock	'akia	E	-	-	-	+	+
TILIACEAE (Linden Family)							
Triumfetta semitriloba Jacq.	bur bush	X	-	-	-	-	+
VERBENACEAE (Verbena Family)							
Lantana camara L.	lantana, lakana	X	-	+	+	-	+
Stachytarpheta dichotoma (Ruiz & Pav.) Vahl	owi, oi	X	-	-	+	-	+
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain, owi, oi	X	-	-	-	-	+

LITERATURE CITED

Char, W.P. 1988. Botanical survey, Hono-a-Pi'ilani Highway, Island of Maui, Proposed widening and realignment alternatives. Prepared for Environmental Coomunications, Inc. March 1988.

__________ . 1990a. Botanical survey, Launiupoko Golf Course, Lahaina District, Maui. Prepared for Helber, Hastert & Kimura. September 1990.

__________ . 1990b. Botanical survey, Ma'alaea project (±604 acres), Wailuku District, Maui. Prepared for A&B Properties, Inc. December 1990.

Division of Forestry and Wildlife, Na Ala Hele Trails and Access Program, State of Hawai'i. 1992. Final Environmental Assessment for reestablishing public use of the Old Lahaina Pali Trail. December 1992.

Foote, D.E., E.L. Hill, S. Nakamura, and F. Stephens. 1972. Soil survey of the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Lamoureux, C.H. 1984. Checklist of the Hawaiian pteridophytes. Unpublished manuscript, University of Hawai'i, Manoa.

Little, E.L., Jr. and R.G. Skolmen. 1989. Common forest trees of Hawaii (native and introduced). U.S. Department of Agriculture, Agricultural Handbook 679: 1-321.

U.S. Fish and Wildlife Service. 1989. Endangered and threatened wildlife and plants. 50 CFR 17.11 & 17.12.

U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; Review of plant taxa for listing as Endangered and Threatened Species; Notice of review. Federal Register 55(35): 6184-6229.

__________ . 1992. Endangered and threatened wildlife and plants; Determination of endangered or threatened status for 15 plants from the island of Maui, HI. Federal Register 57(95): 20772-20788.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the flowering plants of Hawai'i. 2 vols. University of Hawai'i Press and Bishop Museum Press, Honolulu. Bishop Museum Special Publication 83.

APPENDIX E

AVIFAUNAL AND FERAL MAMMAL SURVEY OF PREFERRED ALIGNMENT

APPENDIX E

AVIFAUNAL AND FERAL MAMMAL SURVEY
OF
PREFERRED ALIGNMENT

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May 1993

AVIFAUNAL AND FERAL MAMMAL SURVEY OF THE PREFERRED ALIGNMENT FOR MAALAEA-LAHAINA THIRD 69KV TRANSMISSION LINE PROJECT, MAUI

Prepared for

Dames and Moore

by

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12 May 1993

INTRODUCTION

The purpose of this report is to summarize the findings of a three day (7-9 May 1993) bird and mammal field survey for the proposed Maalaea - Lahaina Third 69 KV Transmission Line Project, Maui (Fig. 1,2). Also included are references to pertinent literature and unpublished reports.

The objectives of the field survey were to:

1- Document what bird and mammal species occur on the property or may likely be found there given the type of habitats available.

2- Provide some baseline data on the relative abundance of each species.

3- Determine the presence or likely occurrence of any native fauna particularly any that are considered "Endangered" or "Threatened". If such occur or may likely be found on the property identify what if any features of the habitat may be important for these species.

4- Determine if the property contains any special or unique habitats that if lost or altered by development might result in a significant impact on the birds and mammals in this region of the island.

GENERAL SITE DESCRIPTION

Figure One and Two present the area covered by this faunal survey. Three general habitats dominate the majority of the lands along the proposed alignment: sugarcane fields with grass and weed lined ditches and irrigation reservoirs; parkland with dry grass and scattered trees, mostly kiawe; and dry gulches with brush and trees.

Weather during the survey was partly cloudy with occasional light passing showers at higher elevations and strong gusty trade-winds 20-35 mph.

STUDY METHODS

Field observations were made with the aid of binoculars and by listening for vocalizations. These observations were concentrated during peak bird activity periods of early morning/late afternoon and evening.

At various locations along the proposed alignment eight minute counts were made of all birds seen or heard (Fig. 1,2). Between these count (census) stations any special or unusual observations of birds were also noted. These data provide the basis for the relative abundance estimates given in this report. Unpublished reports of birds known from similar habitat in this region and elswhere on Maui were also consulted in order to acquire a better perspective of the possible fauna that could occur and their potential relative abundance (Bruner 1986, 1988a, 1988b, 1989a, 1989b, 1991, 1992a, 1992b). Observations of feral mammals were limited to visual sightings and evidence in the form of scats and tracks. No attempts were made to trap mammals in order to obtain data on their relative abundance and distribution.

Scientific names used herein follow those given in Hawaii's Birds (Hawaii Audubon Society 1989); A Field Guide to the Birds of Hawaii and the Tropical Pacific (Pratt et al. 1987) and Mammal Species of the World (Honacki et al. 1982).

RESULTS AND DISCUSSION

Resident Endemic and Indigenous (Native) Birds:

No native birds were seen along the acutal alignment. A Pueo (Asio flammeus sandwichensis) was observed by W. Char during her botanical survey of this area (pers. comm.). Pueo forage in agricultural fields as well as in forested upland habitats (Hawaii Audubon Society 1989). Several reservoirs and irrigation ditches occur throughout the sugarcane fields. Eleven Black-crowned Night Heron (Nycticorax nycticorax) were recorded at these sites over the course of the survey. This species is the only native waterbird that is not listed as endangered. Four Black-necked Stilt (Himantopus mexicanus knudseni), an endangered species, were recorded on a pond near the main highway at Awalua. This site is some distance from the proposed alignment. Nevertheless, since these were the only endangered birds seen during the course of the survey their occurrence was noted. Stilt also utilize the wetland habitat adjacent to Maalaea Power Plant.

Migratory Indigenous (Native) Birds:

Migratory shorebirds winter in Hawaii between the months of August through May. Some juveniles will stay over the summer months as well (Johnson et al. 1981, 1983, 1989). The most abundant shorebird species which winters in Hawaii is the Pacific Golden Plover (Pluvialis fulva). Plover forage in open areas such as mud flats, lawns, pastures, plowed fields and roadsides. They arrive in Hawaii from their breeding grounds in the arctic during early August. Their departure back to the arctic takes place in late April. Bruner (1983) has also shown plover are extremely site-faithful and many establish foraging territories which they defend vigorously. Such behavior makes it possible to acquire a fairly good estimate of the abundance of plover in any one area. These populations likewise remain relatively stable over many years (Johnson et al. 1989). Only one plover was recorded on the survey. This bird was a male in nearly complete breeding plumage. Most plover left Hawaii at the end of April. This individual may still attempt to migrate north or may remain on Maui through the summer. No other shorebirds were recorded. Ruddy Turnstone (*Arenaria interpres*) and Wandering Tattler (*Heteroscelus incanus*) also been found in this area. Turnstones will forage in plowed fields and tattler will utilize irrigation ditches and reservoirs (Hawaii Audubon Society 1989; Bruner 1986, 1988a, 1988b, 1989a, 1989b, 1991, 1992a, 1992b).

Resident Indigenous (Native) Seabirds:

No seabirds were recorded nor would any be expected at this location. Predators such as dogs, cats and the Small Indian Mongoose (*Herpestes auropunctatus*), along with human disturbance inhibit seabird nesting at all but a few isolated and protected locations on the main Hawaiian Islands. W. Char saw three White-tailed Tropicbirds (*Phaethon lepturus*) flying overhead during her botanical survey.

Exotic (Introduced) Birds:

A total of 17 species of exotic birds were recorded during the field survey. Table One shows the relative abundance of each species. In addition to these species other exotic birds which potentially could occur in this region include: Eurasian Skylark (*Alauda arvensis*) and Orange-cheeked Waxbill (*Estrilds melpoda*) (Pratt et al. 1987; Hawaii Audubon Society 1989; Bruner 1992b).

Feral Mammals:

Several Mongoose were observed on the survey. Two feral cats were also noted. The endemic and endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) is known from Maui (Tomich 1986; Kepler and Scott 1990; Duvall and Duvall 1991). None were observed on this field survey. This species is known to roost solitarily in trees and often is observed foraging over ponds and bays. The life history of this species is poorly known. Kepler and Scott (1990) suggest that bats occur on Maui only as a "migrant , probably from the Big Island". Others (Duvall and Duvall 1991), report evidence that would suggest there may be resident breeding population of bats on Maui.

CONCLUSION

A short field survey can only provide a limited view of the wildlife that may use the site. Not all species will necessarily be found and information on their use of the area must be drawn together from observations, the available literature and from unpublished reports. The number of species and the relative abundance of each species may vary throughout the year due to resource (food, water) availability and reproductive success. Species which are migratory will only be an important part of the faunal picture at certain times during the year. Exotic species sometimes prosper for a time only to later disappear or become a less significant part of the faunal community (Williams 1987; Moulton 1990). Thus only long term studies can provide an indept view of the bird and mammal populations in a particular area. However, some general conclusions related to bird and mammal activity at this iste can be made.

1- Sugarcane and parkland habitat of dry grass and scattered trees dominate this region. Seventeen exotic species of birds were recorded. Nutmeg Mannikin and Warbling Silverbill were especially abundant which was to be expected given the types of habitats available.

2- The only native species recorded were the Black-crowned Night Heron and Pacific Golden Plover. These birds are common in agricultural lands and open habitat. Pueo (Hawaiian Owl) may also forage in this area. The Black-necked Stilt seen during the survey were located far from the actual alignment but were reported for informational purposes only. Stilt are also common at Kealia wetlands adjacent to the Maalaea power plant.

3- Several Mongoose and cats were recordedon the survey. No trapping was conducted in order to determine their relative abundance. However, no unusual concentrations were noted. No endangered species such as the Hawaiian Hoary Bat were observed.

4- No particularly unusual or exceptional wildlife habitats were found on the survey. Parkland habitat composed of dry grass and scattered Kiawe trees along with sugarcane fields are abundant in this region of Maui.

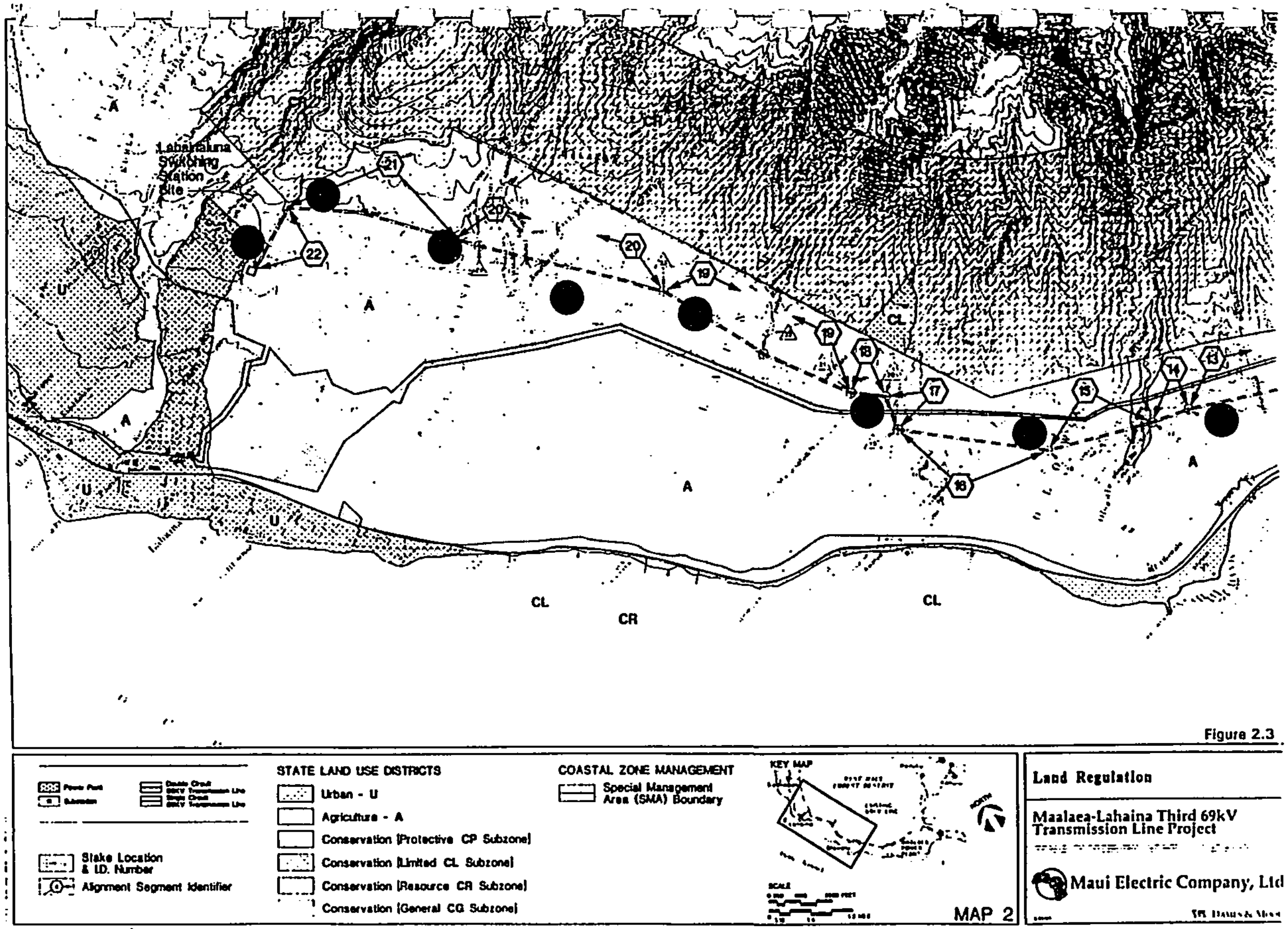


Fig. 1. Location of faunal survey with census stations marked as solid circles.

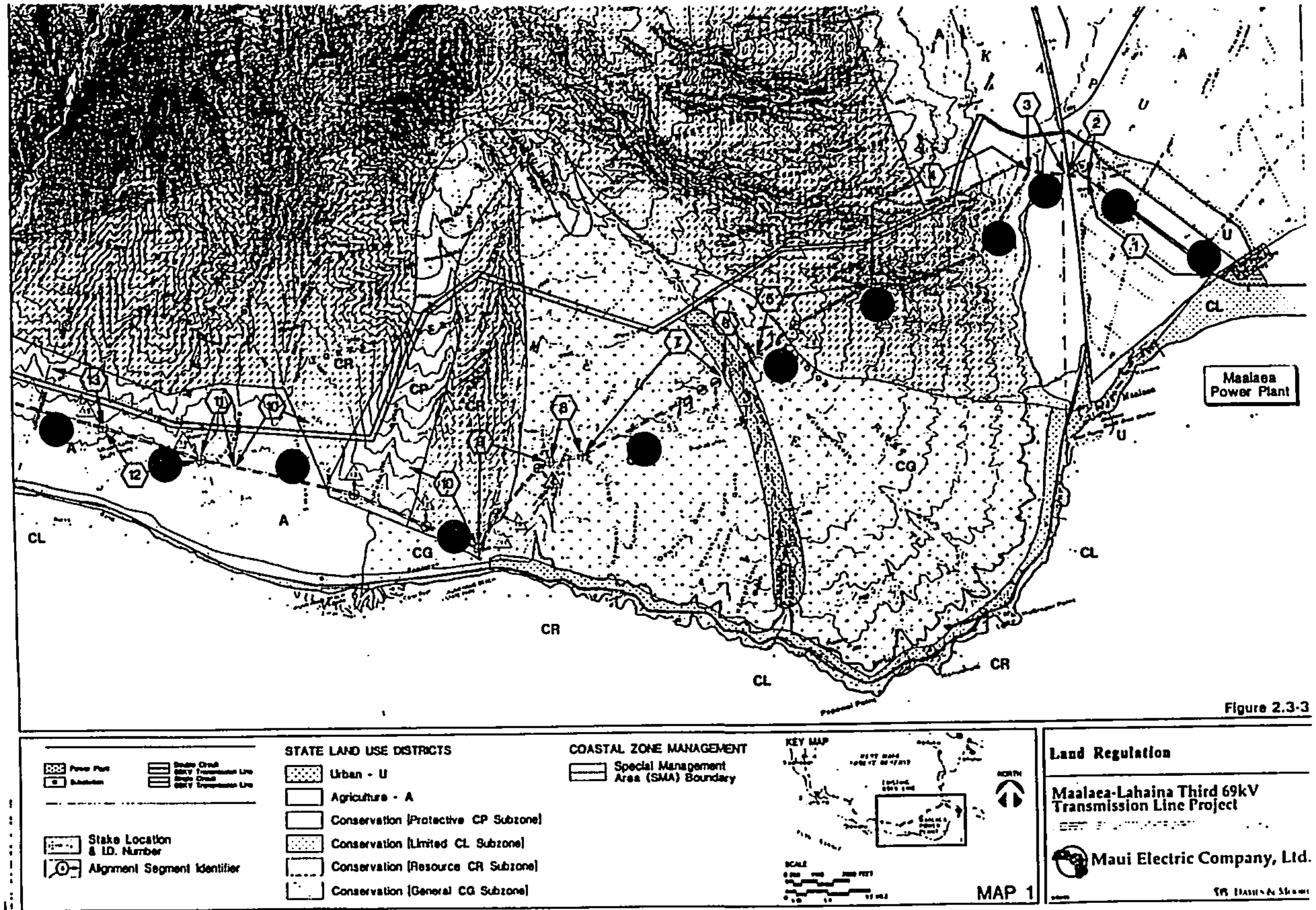


Fig. 2. Location of faunal survey with census stations marked as solid circles.

TABLE 1

Exotic species of birds recorded on the Lahaina - Maalaea Third 69 KV Transmission Line Project Preferred Alignment , Maui.

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Barn Owl	*Tyto alba*	R = 1
Cattle Egret	*Bulbulcus ibis*	R = 3
Ring-necked Pheasant	*Phasianus colchicus*	R = 2
Black Francolin	*Francolinus francolinus*	U = 2
Gray Francolin	*Francolinus pondicerianus*	C = 7
Spotted Dove	*Streptopelia*	U = 4
Zebra Dove	*Geopelia striata*	A =11
Rock Dove	*Columba livia*	R =16
Common Myna	*Acridotheres tristis*	A =13
Northern Mockingbird	*Mimus polyglottus*	U = 3
Northern Cardinal	*Cardinalis cardinalis*	C = 5
Red-crested Cardinal	*Paroaria coronata*	R = 8
Japanese White-eye	*Zosterops japonica*	A =11
Nutmeg Mannikin	*Lonchura punctulata*	A =24
Warbling Silverbill	*Lonchura malabarica*	A =17
House Finch	*Carpodacus mexicanus*	A =10
House Sparrow	*Passer domesticus*	R =12

(see page 12 for key to symbols)

KEY TO TABLE 1

Relative abundance = number of times observed during the survey or frequency on eight minute counts in appropriate habitat.

A = abundant (ave. 10+)

C = common (ave. 5-10)

U = uncommon (less than 5)

R = recorded (seen or heard on one count only or at times other than on 8 min. counts. Number which follows is the total number of individuals seen or heard)

SOURCES CITED

Bruner, P.L. 1983. Territorial behavior of wintering Pacific Golden Plover in Hawaii. Ms. (Paper presented at 100th meeting of the Amer. Ornth. Union).

______ 1986. An avifaunal and feral mammals survey of Kapalua development subdivision, Honokahua, Lahaina, Maui. Unpubl ms.

______ 1988a. Survey of the avifauna and feral mammals at South Beach Mauka, Kaanapali, Maui. Unpubl. ms.

______ 1988b. Survey of the avifauna and feral mammals at North Beach Mauka, Kaanapali, Maui. Unpubl.ms.

______ 1989a. Field survey of the avifauna and feral mammals at Kapalua, Maui. Unpubl. ms.

______ 1989b. Field survey of the avifauna and feral mammals for the Lahaina HFDC Master Plan, Maui. Unpubl. ms.

______ 1991. Survey of the avifauna and feral mammals at Lahaina, Maui for the Lahaina HFDC Master Plan Project/Offsite sewer and water improvements. Unpubl. ms.

______ 1992a. Survey of the avifauna and feral mammals at the proposed site of Puukolii Village, Lahaina, Maui. Unpubl. ms.

______ 1992b. Survey of the avifauna and feral mammals for the MECO 1995 unit addition, Maui. Unpubl. ms.

Duvall, F. and R.G Duvall 1991. No Bats on Maui? Look again. 'Elepaio 51(3):1-2.

Hawaii Audubon Society. 1989. Hawaii's Birds. Fourth Edition. Hawaii Audubon Society, Honolulu.

Honacki, J.H., K.E. Kinman and J.W.Koeppl ed. 1982. Mammal species of the World: A taxonomic and geographic reference. Allen Press, Inc. and the Association of Systematic Collections, Lawrence, Kansas.

Johnson, O.W., P.M. Johnson, and P.L. Bruner. 1981. Wintering behavior and site-faithfulness of Golden Plovers on Oahu. 'Elepaio 41(12):123-130.

Johnson, O.W. and P.M. Johnson. 1983. Plumage-molt-age relationships in "Over-summering" and migratory Lesser Golden-plovers. Condor 85:406-419.

Johnson, O.W., M.L. Morton, P.L. Bruner, and P.M. Johnson. 1989. Winter range fat cyclicity in Pacific Golden-Plovers (Pluvialis fulva) and predicted migratory flight ranges. Condor 91:156-177.

Kepler, C.B. and J.M. Scott. 1990. Notes on distribution and behavior of the endangered Hawaiian Hoary Bat (Lasiurus cinereus semotus). 'Elepaio 50(7):59-64.

Moulton, M.P., S.L. Pimm and M.W. Krissinger. 1990. Nutmeg Mannikin (Lonchura punctulata): a comparison of abundance in Oahu vs. Maui sugarcane fields: evidence for competitive exclusion? 'Elepaio 50(10):83-85.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. A field guide to the birds of Hawaii and the Tropical Pacific. Princeton Univ. Press.

Tomich, P.Q. 1986. Mammals in Hawaii. Bishop Museum Press. Honolulu.

Williams, R.N. 1987. Alien Birds on Oahu 1944-1955. 'Elepaio 47(9):87-92.

APPENDIX F

CULTURAL AND HISTORIC RESOURCES REGIONAL ASSESSMENT

APPENDIX F

CULTURAL AND HISTORIC RESOURCES REGIONAL ASSESSMENT

PREPARED BY
CULTURAL SURVEYS HAWAII
January 1992

ARCHAEOLOGICAL ASSESSMENT
OF A PROPOSED TRANSMISSION LINE,
MĀʻALAEA TO LAHAINA, MAUI, HAWAIʻI
(PHASE I - REGIONAL STUDY AND CORRIDOR IDENTIFICATION)

Prepared by

Hallett H. Hammatt, Ph.D.
and
Rodney Chiogioji, B.A.

for

DAMES & MOORE

CULTURAL SURVEYS HAWAII
October 1991
Revised January 1992

INTRODUCTION

At the request of Dames & Moore, Cultural Surveys Hawaii has conducted investigations aimed at identifying known and potential archaeological sites within a study area on the island of Maui extending from the ahupua'a of Hanaka'ō'ō in the Lahaina District to the ahupua'a of Waikapū in the Wailuku District. The study area extends between 1.2 to 3.5 miles mauka from the coastline.

The study area represents those lands that may be impacted by a new 20-mile long Maui Electric Company transmission line between the Mā'alaea Power Plant and a new substation to be located within the Lahaina Master Planned Community at Wahikuli.

Procedures undertaken by Cultural Surveys Hawaii included: (1) a study of documentary resources detailing traditional Hawaiian usage of the area; (2) a review of previous archaeological studies within the area; (3) a consultation with Ms. Agnes Griffin of the State Historic Preservation Division; (4) an aerial reconnaissance survey of the study area; and (5) formulation of recommendations based upon the results of these procedures.

These procedures resulted in the preparation of a map of the study area locating: (1) all presently recorded (at the State Historic Preservation Division) archaeological sites; and (2) all site areas and potential site areas observed during the aerial reconnaissance.

This report documents the results of Cultural Surveys Hawaii's investigations.

CULTURAL AND HISTORICAL BACKGROUND

A rudimentary comparative picture of the pre-western contact (i.e., before 1778) population of the southwestern section of Maui comprising the present study area is adumbrated by figures in nineteenth century missionary censuses (Schmitt, 1973). Results of the 1832 census, in which the total population of Maui is 35,062, give the following populations: for Lahaina, 4028; for Ukamehame, 573; and for Olowalu, 832. These three figures, when combined, represent 15 percent of the total Maui population. Allowing for post-western contact (i.e., after 1778) distortions (e.g., disease and commercially-inspired population shifts), the population totals suggest that this portion of Maui may have accommodated a substantial portion of the island's pre-contact population.

The lands between Lahaina and Mā'alaea indeed encompass areas known traditionally to have been the residences of the ali'i and centers of population of the maka'ainana. E.S. Craighill and Elizabeth Handy summarize these areas' character:

> Lahaina District was a favorable place for the high chiefs of Maui and their entourage for a number of reasons: the abundance of food from both land and sea; its equable climate and its attractiveness as a place of residence; it had probably the largest concentration of population, with its adjoining areas of habitation; easy communication with the other heavily populated areas of eastern and northeastern West Maui, 'The Four Streams,' and with the people living on the western, southwestern and southern slopes of Haleakala; and its propinquity to Lanai and Molokai.
>
> Southeastward along the coast from the ali'i settlement were a number of areas where dispersed populations grew taro, sweet potato, breadfruit and coconut on slopes below and in the sides of valleys which had streams with constant flow. All this area, like that around and above Lahaina, is now sugar-cane land. Ukumehame had extensive terraces below its canyon, some of which

> were still planted with taro in 1934; these terrace systems used to extend well down below the canyon. ʻOlowalu, the largest and deepest valley on southwest Maui, had even more extensive <u>loʻi</u> lands both in the valley and below. Just at the mouth of the valley we found in 1934 a little settlement of five <u>kauhale</u> (family homes) surrounded by their flourishing <u>loʻi</u>. There are said to be abandoned <u>loʻi</u> far up in the valley. In and below the next valley, Launuipiko [<u>sic</u>], there were no evidences of <u>loʻi</u>, and the people of ʻOlowalu said there had never been any. But we think there must have been a few, although the land is, in general, dry and rough. Next beyond this, going along the coast toward Lahaina, is Kauaʻula Gulch above Waineʻe, and here in 1934 there were a few <u>loʻi</u> in which Hawaiians were still growing taro. (Handy and Handy, 1972: 492)

The Handys present a picture of the pre-western (pre-1778) contact traditional Hawaiian life within the present study area. Up to the end of the eighteenth century Lahaina was indeed a pre-eminent residence of the <u>aliʻi</u> of Maui and, after the consolidation of the rulership of the Hawaiian Islands by Kamehameha early in the nineteenth century, Lahaina became the "capital" of the kingdom until the 1840s when the government moved to Honolulu.

The nineteenth century brought to Lahaina and other portions of the present study area changes - commercial, social and religious - induced by the burgeoning foreign influx. During the year 1819 the first whaling ships arrived in Hawaiian waters and Lahaina became a primary harbor - along with Honolulu - for the provisioning of ships in the islands. The whaling trade flourished until the 1860s and gave impetus to the development and growing population of Lahaina. Between 1824 and 1861, 4747 whaleship arrivals are recorded for Lahaina, representing forty-seven percent of the total arrivals in all ports of the Hawaiian Islands. Figures from an 1846 census of Lahaina document the changes brought to the area midway through the nineteenth century: 3,445 Hawaiians, 112 foreigners, 600 seamen, 155 adobe houses, 822 grass houses, 59 straw and wooden houses and 529 dogs.

The first Protestant missionaries and their families arrived in Lahaina in 1823. The missionary William Ellis, who visited Lahaina during the 1820s, described the landscape that had entranced both the Hawaiians themselves and the nineteenth century newcomers:

> The appearance of Lahaina from the anchorage is singularly romantic and beautiful. A fine sandy beach stretches along the margin of the sea, lined for a considerable distance with houses and adorned with shady clumps of kou-trees, or waving groves of cocoanuts. . .The level land of the whole district, for about three miles, is one continued garden, laid out in beds of taro, potatoes, yams, sugar-cane, or cloth-plants. The lowly cottage of the farmer is seen peeping through the leaves of the luxuriant plantain and banana tree, and in every direction white columns of smoke ascend, curling up among the wide-spreading branches of the bread-fruit tree. The sloping hills immediately behind, and the lofty mountains in the interior, clothed with verdure to their very summits, intersected by deep and dark ravines, frequently enlivened by waterfalls, or divided by winding valleys, terminate the delightful prospect. (Ellis, 1969: 76-77)

The sugar cane Ellis observed in the environs of Lahaina would become, during the second half of the nineteenth century, the basis for a commercial venture that would reshape the landscape within much of the present study area. James C. Campbell, an Irish entrepreneur who had come to Lahaina in 1852, during the 1860s established, in partnership with Henry Turton, the Pioneer Mill plantation in West Maui. The plantation fields would eventually extend from Kahana to Ukumehame.

PREVIOUS ARCHAEOLOGICAL STUDY

The first attempt at an island-wide systematic archaeological survey - Winslow Walker of the Bishop Museum working between 1928 and 1929 - confirmed the Handys' portrait of pre-contact (pre-1778) Hawaiian life within the present study area. Corroborating the Handys' observation of taro lo'i in ahupua'a within the study area, Walker noted: "Terraces for the cultivation of taro were seen on West Maui in the vicinity of... Lahaina, Olowalu, and Ukumehame" (Walker, 1931: 71).

Walker also identified eleven archaeological sites within the present study area. All eleven sites are heiau of which only two were described by Walker as in "good condition." The remainder were either partially or totally destroyed. Three of the heiau are presently recorded (at the State Historic Preservation Divi- sion) sites within the study area: Hikii heiau (State Site No. 50-50-08-2); Ukumehame heiau (50-50-08-3); and Kawailoa heiau (50-50-03-4).

More archaeological sites were located and mapped during the Maui portion of the state-wide archaeological inventory survey in 1973 and, during subsequent years, as the result of contracted archaeological studies.

All archaeological sites presently recorded at the State Historic Preservation Division are located on the accompanying study area map and are listed in the table below. Both pre-contact (pre-1778) and post-contact (post-1778) sites are included.

Table 1

RECORDED KNOWN ARCHAEOLOGICAL SITES

MAP NO.	SITE NO.	DESCRIPTION
1	50-50-08-2	Hiki'i heiau
2	50-50-08-3	Ukumehame heiau
3	50-50-08-4	Kawailoa heiau
4	50-50-03-226	Cemetery/graveyard*
5	50-50-09-1169	Petroglyphs; rock outcrop
6	50-50-09-1199	Petroglyphs; rock outcrop
7	50-50-03-1200	Petroglyphs
8	50-50-03-1201	Petroglyphs
9	50-50-03-1203	Complex including petroglyphs, terraces, habitation terraces, cave
10	50-50-03-1204	Grinding stone
11	50-50-09-1287	Complex of 17 features (including full and C-shape enclosures)
12	50-50-03-1596	Historic building; Hale Pa'i*
13	50-50-03-1776	Agricultural complex
14	50-50-03-2005	3 Agricultural terraces
15	50-50-03-2006	3 Agricultural terraces
16	50-50-03-2007	Agricultural/historic wall*
17	50-50-03-2008	Historic agricultural road*
18	50-50-03-2009	12 Agricultural terraces
19	50-50-03-2010	Agricultural/historic wall*
20	50-50-03-2478	Agricultural terrace
21	50-50-03-2479	2 Agricultural terraces
22	50-50-03-2480	2 Walled enclosures
23	50-50-03-2481	2 Agricultural terraces
24	50-50-03-2482	Agricultural terrace
25	50-50-03-2483	Walled enclosure; 8 ag terraces
26	50-50-03-2484	Walled enclosure
27	50-50-03-2485	Walled enclosure
28	50-50-03-2486	Platform; 13 grave markers
29	50-50-03-2487	Historic agricultural road*
30	50-50-03-2488	Walled enclosure
31	50-50-09-2708	Historic cemetery*
32	50-50-09-2709	Irrigation ditch*
33-50	50-50-09-2816 to 50-50-09-2833	Eighteen sites along the Lahaina Pali Historic Trail (See Table 2)
51	50-50-03-3001	Lahaina Historic District*
52	50-50-03-2489	Footpath trail; walled enclosure; grave; 19 agriculture terraces
53	50-50-03-2490	Wallen enclosure; habitation terrace; 2 agriculture terraces

* post-contact (after 1778) site (note: all other sites could fall into either the pre-contact or post-contact period)

Map No. 12, Site 50-50-03-1596
Hale Pa'i, the oldest printing house west of the Rockies and located outside of Lahaina on Lahainaluna Road, was placed on the National Register of Historic Places on May 13, 1976 and on the Hawaii Register of Historic Places on May 18, 1981.

Map No. 51, Site 50-50-03-3001
The Lahaina Historic District, comprising approximately 60 sites, was placed on the National Register of Historic Places on December 29, 1962.

Some explanations and comments concerning the preceding table are detailed below:

A) The names of the archaeological sites in the table are given as they are recorded on maps and documents at the State Historic Preservation Division. The appellation "historic" appearing in some of these names refers only to the age of the sites - i.e., they date from the post-contact (post-1778) era - and not to any special historical significance.

B) However, as indicated at the bottom of the table, two sites - the Hale Pa'i building (Hawaii Register of Historic Places: May 18, 1981; National Register of Historic Places: May 13, 1976) and the Lahaina Historic District (National Register of Historic Places: December 29, 1962) - have been deemed "historic places" - i.e., they are of considerable historical, architectural, archaeological, or cultural importance.
The Lahaina Historic District encompasses approximately 60 buildings and other structures - of private and public ownership - within Lahaina Town.

C) The heiau sites listed in the above table are traditional Hawaiian places of worship and shrines. The petroglyphs are rock carvings that may date to either pre- or post-contact periods.

D) The terrace, wall, enclosure and platform features that comprise many of the sites in the preceding table are generally traditional Hawaiian constructions of basalt boulder alignments or boulder-constructed levelled areas. Free-standing alignments created walls delineating property areas or, in the case of smaller constructs, enclosures for house sites or animal pens. Alignments retaining soil areas created terraces for planting. Piled and stacked boulders created level raised foundations for house building. The durability of these basalt constructions makes them the most ubiquitous and perceptible archaeological remnants in areas of Hawaiʻi where modern development has not yet encroached.

E) The Lahaina Pali Historic Trail, apparently constructed in the mid-nineteenth century, is a 4.5 mile long foot and horse trail connecting Lahaina and Wailuku. It is a demonstration trail of the Statewide Trail and Access System. It may be the precursor of a late nineteenth century road between Ukumehame and Maʻalaea. The trail is stone curbed and walled in open areas and cut and faced in gulches.

A recently completed archaeological survey (Tomonari-Tuggle and Tuggle, 1991) recorded eighteen sites along the trail route (within a 50 foot wide buffer zone on each side of the trail) (Table 2 and Figure 17). The survey report summarizes the sites:

> With two exceptions (2816 and 2833), all sites are related to construction and use of the trail or the old coastal road. These 16 trail or road-related sites include alignments, enclosures, walls, petroglyphs, terraces, and C-shaped structures. They appear to have functioned as alternate trail routes, for water diversion, quarrying, trailside art, storage, and shelters...They sites are in fair to excellent condition...Sites 2816 (a

Table 2

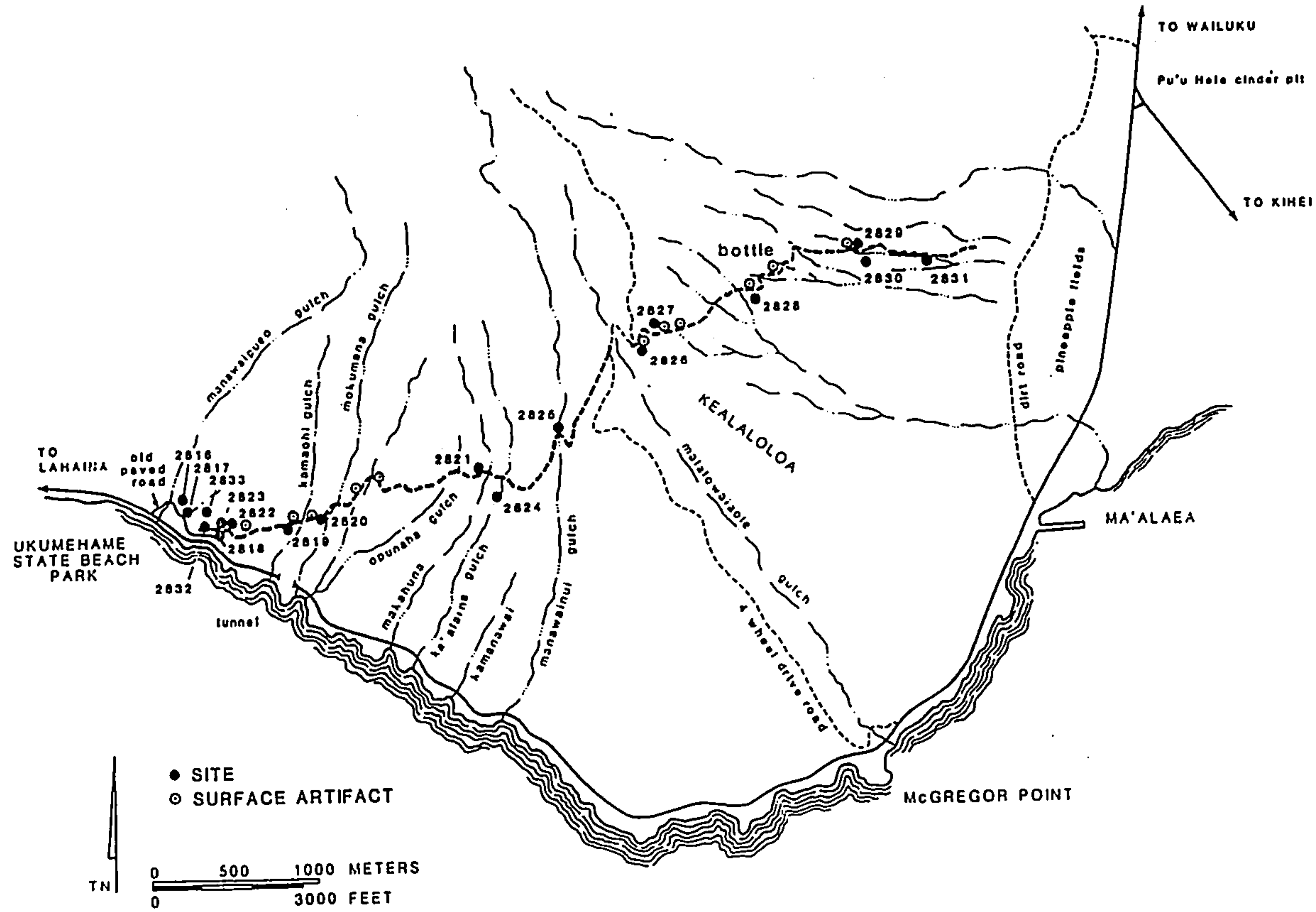
SUMMARY OF SITES SURVEYED ALONG LAHAINA PALI TRAIL

MAP NO.	SITE NO.	COMPONENT FEATURES	TOTAL SITE AREA	FUNCTION
33	2816	midden, coral	3x6 m	habitation
34	2817	wall, culvert in road diversion wall,	2x7 m	road/water
35	2818	modified outcrop	2x6 m	road/rock quarry
36	2819*	terrace, petroglyph	15x5 m	shelter/art
37	2820	C-shape, wall, encl	30x50 m	shelter/unknown
38	2821	petroglyphs, crockery, glass	10x10 m	art/shelter
39	2822	alignment	50 m lg	alternate trail
40	2823	alignment, 1 pc. shell	25 m lg	alternate trail
41	2824	cupboards	30x10 m	storage
42	2825	petroglyphs, walls	20x10 m	art/shelter
43	2826*	encl, walls, glass	24x10 m	shelter
44	2827	enclosure, glass	1.5x.5 m	storage
45	2828	C-shapes, 1 pc. crockery	25x8 m	shelter/storage
46	2829	paved terrace	4.5x1 m	trail
47	2830	paved terrace	4x1 m	trail
48	2831	alignment	6.5 m lg	alternate trail
49	2832	wall, alignments	2.2x1 m	trail
50	2833	rock shelter, 1 pc. shell & coral	2x3 m	habitation

* tested
Source: Tomonari-Tuggle and Tuggle, 1991

NOTE: A complex of probable traditional Hawaiian dryland agriculture features was observed in Manawaipueo Gulch, inland of the historic paved road. It was not recorded because it is located about 45 m outside of the survey corridor. Site LP-1 may be related to this complex.

(DEIS.APP)



SITE LOCATIONS LAHAINA PALI TRAIL

> midden scatter) and 2833 (a rock shelter) may be pre-contact Hawaiian sites that may also have been used into the post-contact period. (Tomonari-Tuggle and Tuggle, 1991: 3)

The report also describes the trail's condition: "The trail is heavily overgrown but it is in fair to excellent structural condition, with exceptional preservation along some sections" (Ibid.).

The trail may, in the future, be developed and access opened for recreation and hiking by the public.

AERIAL SURVEY

A low-level aerial (helicopter) reconnaissance survey of the entire study area was completed by Hallett Hammatt of Cultural Surveys Hawaii on September 25, 1991. The objectives of the aerial survey were: (1) to identify and plot previously unrecorded or potential site areas, and (2) to obtain a general knowledge of present conditions within the study area.

Two site areas - designated 1 and 2 on the accompanying map - were observed within the study area during the aerial survey and are located on the accompanying study area map.

Site Area 1 is located at the makai end of the west ridge and on the alluvial fan of Ukumehame Gulch, roughly between the 100 to 500 foot elevation. A rectangular enclosure was positively identified and it is suspected that similar sites are located within the bounds of the site area.

Site Area 2 is located on the flood plain of Launiupoko Stream at an elevation of 400 to 600 feet. Plentiful habitation sites and agricultural terraces were observed within this area.

Ms. Agnes Griffin of the State Historic Preservation Division reports that an archaeological study presently in preparation has found similar sites within Launiupoko (personal communication: October 1991).

SUMMARY AND RECOMMENDATIONS

The archaeological investigations conducted by Cultural Surveys Hawaii indicate the presence of a substantial pre-contact (pre-1778) Hawaiian population within the southwestern portion of Maui encompassing the present study area. Such a population would have created religious, habitation, craft and agricultural structures associated with a vibrant, coherent, regenerative society. Many of these structures have remained intact within the study area despite years of modern impacts, as evidenced by the number of sites already recorded, demonstrating the concentration of activity along the western slopes and lowlands of West Maui.

As an adjunct to the task of locating archaeological sites, Cultural Surveys Hawaii has included a preliminary delineation of mid-nineteenth century Land Commission Awards (LCAs) within the present study area. The majority of these awards - given out following the Great Mahele of 1848 - were kuleana: parcels of land conferred to native non-ali'i Hawaiians able to prove that they lived upon or actively farmed these lands. Individual LCA parcels, the locations of which were derived from modern tax maps, are plotted on the accompanying study area map. The points marking LCA locations on the map, though not indicating the size of the individual parcels, represent house lots and agricultural fields that were actively utilized by native Hawaiians up to and beyond the 1850s. The use of these parcels in nineteenth century probably follows the same patterns developed in pre-contact (pre-1778) times. Thus the parcels may represent ancient settlement patterns within the study area and may give clues to the potential location of structures and artifacts associated with both the pre-contact and post-contact Hawaiian population.

The population distribution indicated by the LCA patterns suggests widely dispersed habitation and agricultural activities throughout major portions of the present study area. The populace appears to have been scattered across alluvial fans with activity concentrated in the well-watered drainages and along the coastline.

Based on the sites already recorded, site areas observed during the aerial reconnaissance, and the LCA information discussed above, we would expect some impact to archaeological sites within the present study area regardless of the route proposed for the transmission line. This is especially true for the Lahaina area, all stream valleys, alluvial fans and coastal areas within the study area. However, the upper elevations of the valley walls and the ridge crests between valleys are generally considered to have low probability of archaeological site occurrence.

Wherever the transmission line corridor crosses archaeological sites it is probable that the State Historic Preservation Division will minimally require archaeological surface survey. Land Commission Award parcels are considered locales of potential archaeological concern as they represent areas where habitation and agricultural activities are known to have occurred. Thus any specific LCA parcels to be impacted by a potential transmission line corridor will also require archaeological surface survey and archival research.

An additional concern of the State Historic Preservation Division is traditional Hawaiian site remnants and artifact scatters in existing sugar cane fields: this concern can be addressed by surface inspection of the transmission line corridor where it passes through cane fields.

Also, older plantation constructions and structures - such as flumes, irrigation ditches and camp buildings - are of archaeological concern because of their age and value in the recording of a fast-disappearing segment of Hawaiian history. Any of these elements of plantation life impacted by the transmission line corridor would likely require some effort to document their history and use.

The following general recommendations for routing of the proposed transmission line corridor are made, based on this phase of archaeological investigations, as detailed in this report:

1) The transmission line corridor should be routed to avoid known archaeological sites shown on the accompanying study area map. Of special concern is the avoidance of any impact to heiau and petroglyph sites as they are of particular cultural significance.
2) Where the corridor must pass across known archaeological sites, placement of the poles should be such that impact to these sites is avoided.
3) Placing the transmission line corridor at as high an

elevation as possible could reduce impact to archaeological sites likely to be located in the valleys.

4) Having been placed on historic registers, two sites - the Hale Pa'i building (Hawai'i Register of Historic Places: May 18, 1981; National Register of Historic Places: May 13, 1976) and the Lahaina Historic District (National Register of Historic Places: December 29, 1962) - require special attention if they would be impacted by any projected transmission line corridor. Of specific concern in planning, according to a guide prepared by the State Historic Preservation Division, the Hawai'i Register "require[s] review of privately funded projects that may affect historic properties. This review is done under state and county laws and permit procedures" (State Historic Preservation Division [n.d.]). At the same time, "the Hawaii and National Registers do not stop county, state and federally assisted development projects" (Ibid.).

5) The Lahaina Pali Historic Trail - a nineteenth century foot and horse trail - is currently a demonstration trail of the Statewide Trail and Access System. It may be developed in the future with access open to the public for hiking and recreation. Thus a potential transmission line corridor should avoid any impact to the trail, the archaeological sites associated with it, and the trail's immediate surroundings.

REFERENCES

Ellis, William
1969 Polynesian Researches: Hawaii. Charles E. Tuttle Company, Rutland, Vermont.

Folk, William H. and Hallett Hammatt
1991 Archaeological Survey at Ma'alaea, Waikapu, Maui. Cultural Surveys Hawaii, Kailua.

Handy, E.S. Craighill and Elizabeth Green
1972 Native Planters in Old Hawaii. B.P. Bishop Museum Bulletin 233. B.P. Bishop Museum, Honolulu.

Jensen, Peter
1989 Archaeological Inventory Survey, Lahaina Master Planned Project Site, Land of Wahikuli, Lahaina District, Island of Maui. PHRI, Hilo.

Jensen, Peter
1990 Archaeological Inventory Survey, South Beach Mauka Development, Land of Hanakaoo, Lahaina District, Island of Maui. PHRI, Hilo.

Schmitt, Robert C.
1973 The Missionary Censuses of Hawaii. Pacific Anthropological Records No. 20. B.P. Bishop Museum, Honolulu.

State Historic Preservation Division
[no date] A Guide to Registering Historic Properties in Hawai'i. Department of Land and Natural Resources, Honolulu.

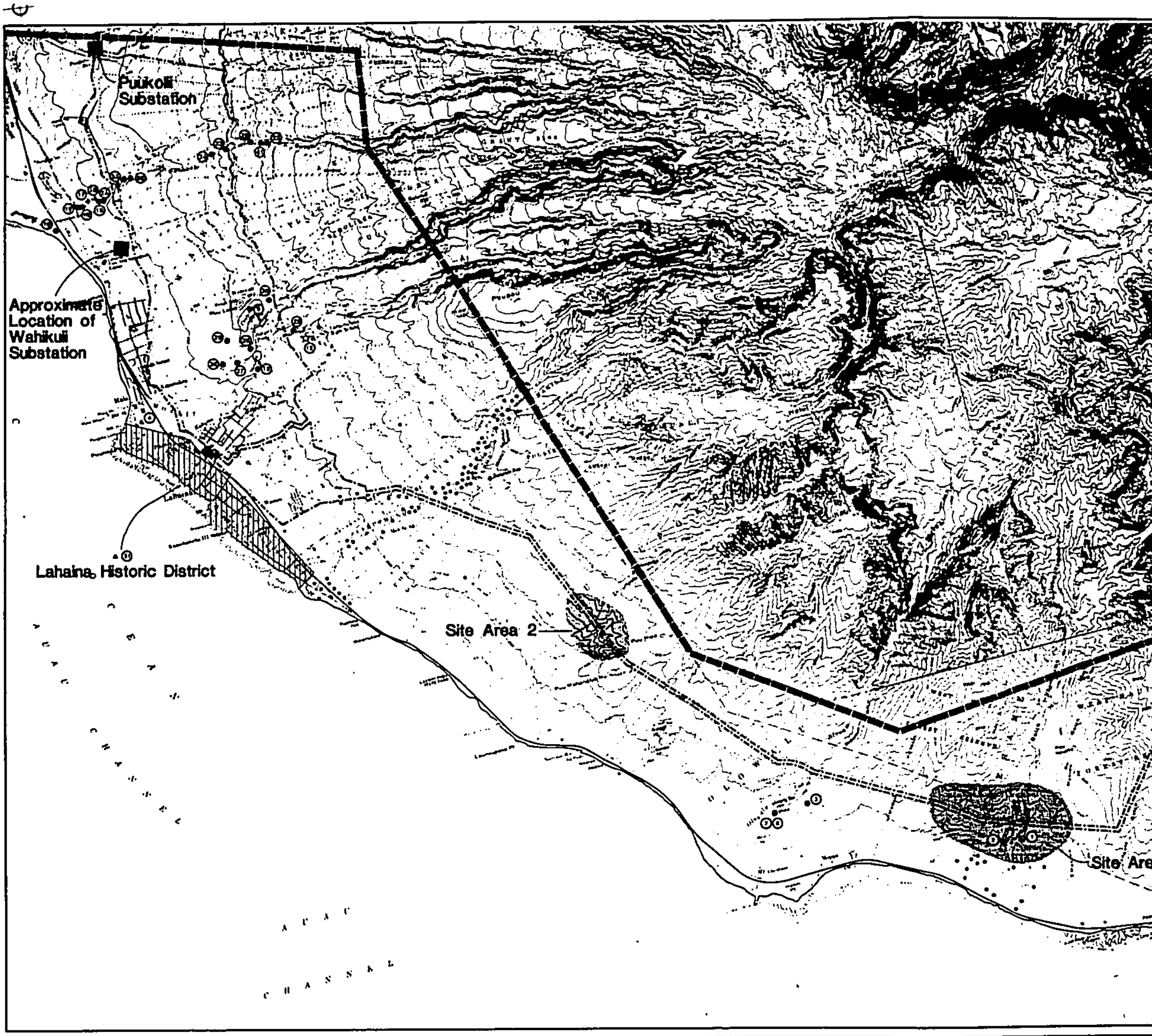
Tomonari-Tuggle, M.J. and H.D. Tuggle
1991 Archaeological Survey of Two Demonstration Trails of the Hawaii Statewide Trail and Access System: Lahaina Pali Trail, Island of Maui, Kaiolohia-Kahue Coastal Trail, Island of Lana'i. International Archaeological Research Institute, Honolulu.

Walker, Winslow
1931 Archaeology of Maui. Manuscript in B.P. Bishop Museum Archives, Honolulu.

PERSONAL COMMUNICATIONS

State Historic Preservation Division
Ms. Agnes Griffin Discussion of archaeological sites within study area (October 1991).

Discussion of Lahaina Pali Historic Trail (January 13, 1992).

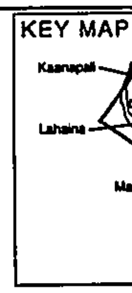


Study Area Boundary
Power Plant
Substation
69KV Transmission Lines
23KV Transmission Lines

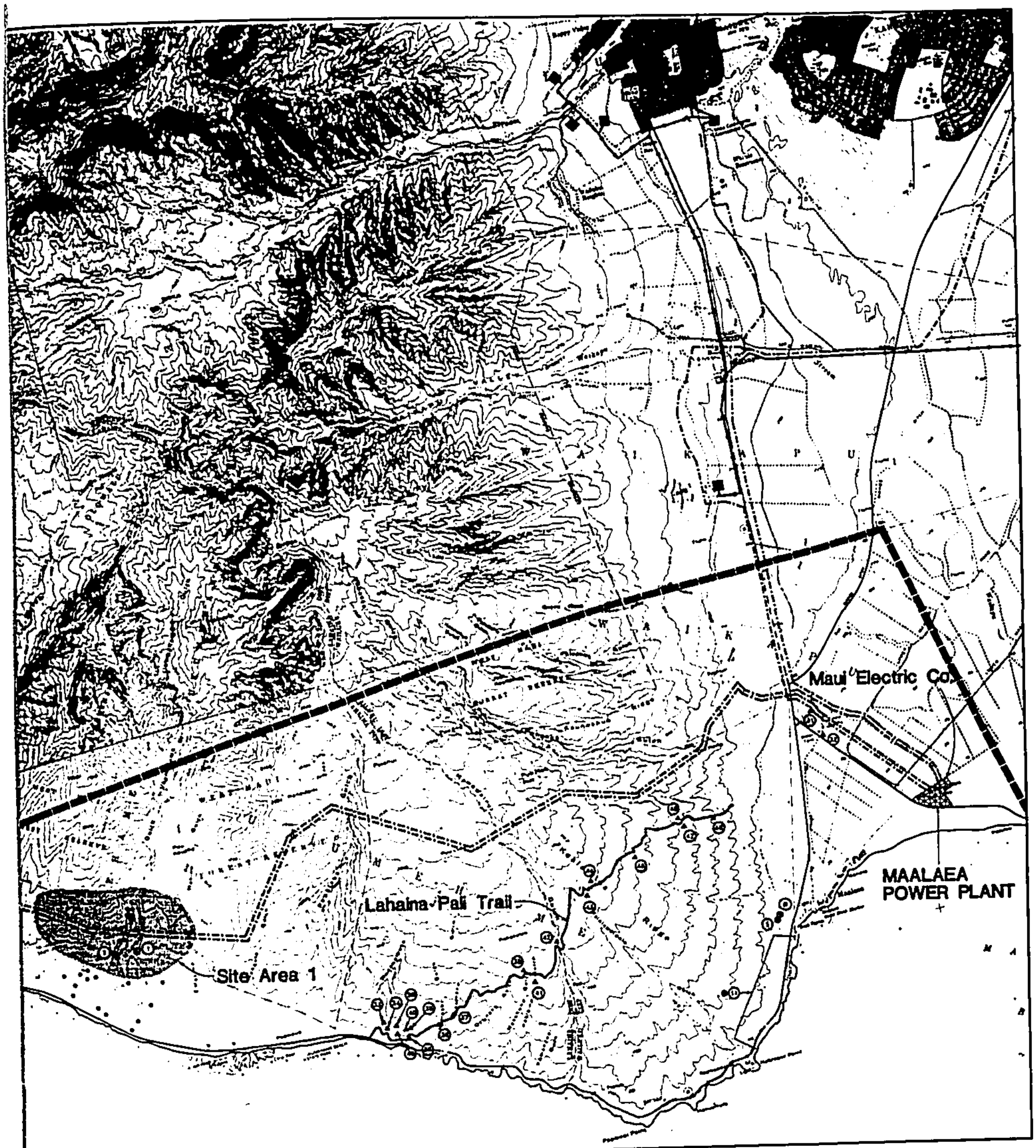
National Register District
National Register Site
Recorded Pre-contact Site
Recorded Post-contact Site

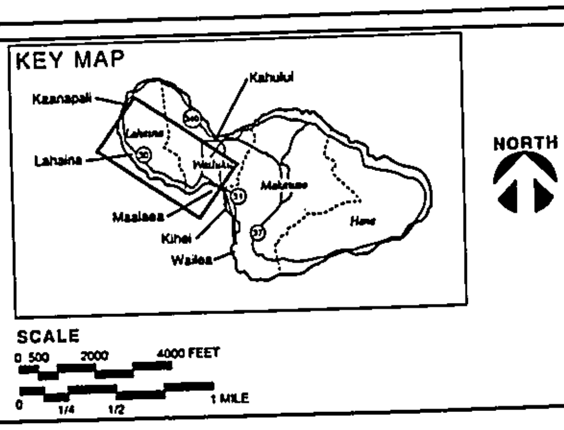
Land Commission (LCA) Award Parcels
Area With Good Cultural Resources Potential (observed during aerial reconnaissance - Sept. 1991)

Note: See Tables 1 and 2 for description of recorded sites.



SCALE





Cultural Resources

Maalaea-Lahaina Third 69kV
Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

APPENDIX G

CULTURAL AND HISTORIC RESOURCES ARCHAEOLOGICAL INVENTORY SURVEY OF PREFERRED ALIGNMENT

APPENDIX G

CULTURAL AND HISTORIC RESOURCES

ARCHAEOLOGICAL INVENTORY SURVEY

OF PREFERRED ALIGNMENT

PREPARED BY

CULTURAL SURVEYS HAWAII

SEPTEMBER 1993

AN ARCHAEOLOGICAL INVENTORY SURVEY OF AN APPROXIMATELY 14.7 MILE PROPOSED TRANSMISSION LINE, FROM MĀ'ALAEA TO LAHAINA, MAUI, HAWAI'I

by

Jennifer J. Robins, B.A.
William H. Folk, B.A.
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Hallett H. Hammatt, Ph.D

prepared for

DAMES & MOORE

CULTURAL SURVEYS HAWAII
Revised March 1994

ABSTRACT

An archaeological inventory survey with limited subsurface testing was conducted by Cultural Surveys Hawaii within the proposed single circuit 69KV transmission line project, for Dames and Moore, on behalf of their client Maui Electric Co. The proposed transmission line project crosses over several *ahupua'a* from just north of Mā'alaea, Wailuku District to Lahaina Town in the District of Lahaina, Island of Mau'i, Hawai'i.

The survey and testing were conducted between the months of April and June 1992, over approximately 13 days. During the survey 34 sites and site complexes were identified within the project area. The project area comprises two survey areas: preferred alignment surveyed April 1993, and the final preferred alignment rerouted and surveyed during June, 1993. The archaeological sites identfied in both survey areas contained numerous formal site types, including agricultural features characteristic of intensive non-irrigated agriculture, temporary and permanent habitation sites, major *heiau* and shrine sites, a travel route, a marker site, a possible human burial, historic ranching walls, and irrigation canals, flumes and a possible railroad bed associated with historic large-scale cane agriculture.

Limited testing was conducted at two temporary habitation sites: State site 50-50-08-3165 and 50-50-08-3168. Testing results from site 50-50-08-3165 reveal that lithic reduction was the primary activity at one of its component features.

The 34 recorded sites in the project area are evaluated as having varied levels of archaeological significance. The preferred alignment has been located to avoid all of the archaeological sites in its course and its location was modified to provide appropriate buffer zones between the sites and proposed transmission line. Future mitigative measures are recommended to assure that no archaeological sites are disturbed during construction of the transmission line.

ACKNOWLEDGEMENTS

Completion of the inventory survey was made possible by the assistance and hard work of a multitude of individuals.

The archaeological field crew - at various times - consisted of Alika Anixt, Douglas Borthwick, Joy Collins, William Folk, and Edward Novack, and Mark Stride. Artifact analysis was completed by John Winieski. Victoria Creed and Rodney Chiogioji gathered important information pertaining to the historical background of the project area. Site maps were drafted by Bryce Myers and Brian Colin. The authors thank all of these individuals for their quality work. A special note of thanks is given to Joy Collins who cheerfully assisted in many aspects of report production.

Don Shearer of Windward Aviation piloted all of the helicopter flights conducted during the inventory survey; the Cultural Surveys Hawaii staff are grateful for his excellent piloting skills and usual good spirit. We also thank Michael Baker (Trails and Access Specialist of the State Division of Forestry and Wildlife, Department of Land and Natural resources) who shared essential information concerning the Lahaina Pali Trail and his general knowledge of the region.

The Pioneer Mill was especially helpful to this study by allowing access through the cane fields and dispensing necessary gate keys. We are especially grateful tc Kimo Falconer who assisted the project field director with the perusal of Pioneer Mill cane maps.

Finally, we wish to extend our sincere gratitude to John Everingham, Nancy Olmsted and Ricardo Bressanutti of Dames and Moore who were essential for the successful completion of this study. Dames and Moore produced the project site location maps included in this report and assisted in plotting the site locations using the Global Positioning System coordinates.

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I. INTRODUCTION

A. Inventory Survey Overview and Location

Cultural Surveys Hawaii conducted an archaeological inventory survey and limited testing of an approximately 14.7-mile transmission line alignment (300 ft. wide) spanning between the Ma'alaea Power Plant Switching Station, Wailuku District, to a proposed Lahainaluna Switching Station in upper cane fields of Lahaina Town, in the District of Lahaina, Island of Maui, Hawai'i (Figures 1-4). The Mā'alaea-Lahaina Third 69KV Transmission Line is a new single circuit 69KV transmission line to be constructed on steel poles proposed by Maui Electric Company. The inventory survey was done at the request of Dames and Moore, on behalf of their client Maui Electric Company.

The inventory survey field work was conducted between April 26 and June 25, 1993, during which 37 person days were expended with a crew of three individuals. The field work was conducted under the supervision of Jennifer Robins and overall guidance of Dr. Hallett H. Hammatt.

The inventory survey consisted of two consecutive phases of work: 1) survey of the preferred alignment (April 1993 survey area); 2) adjustment of three sections of the preferred alignment and additional inventory survey of the realignment sections (June 1993 survey work). The second, supplemental phase of work was devised so that all archaeological sites near or in the preferred alignment would not be directly impacted by construction of the proposed transmission line. Likewise, placement of the realignment sections of the preferred alignment were chosen in the field based on the absence of sites or to provide a buffer between the proposed transmission line and existing sites. For descriptive purposes, each realignment section will be referred to in this report by the following locality designation: 1) Mā'alaea realignment; 2) Ukumehame realignment; and 3) Launiupoko realignment. The project description presented below is a general description of the preferred alignment.

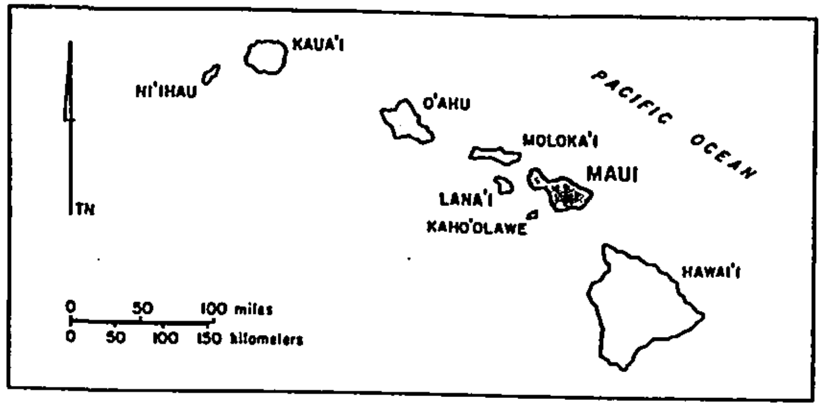


FIGURE 1
Map of the State of Hawai'i

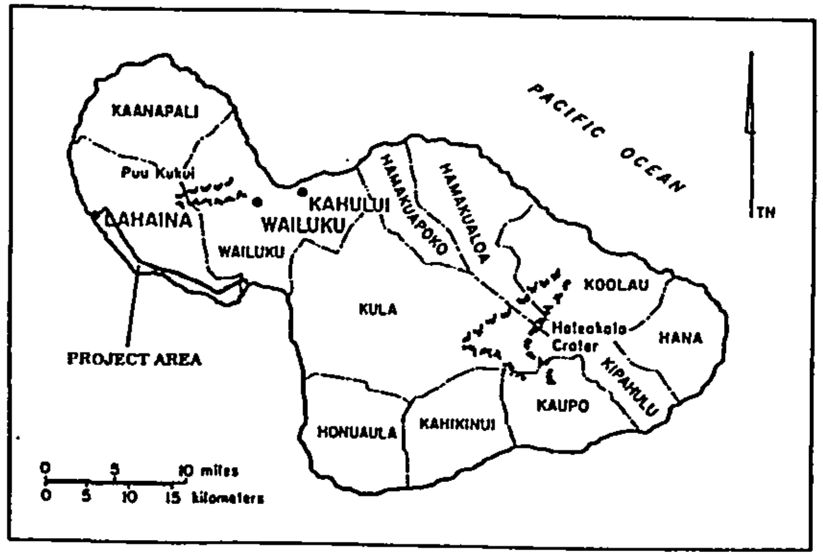
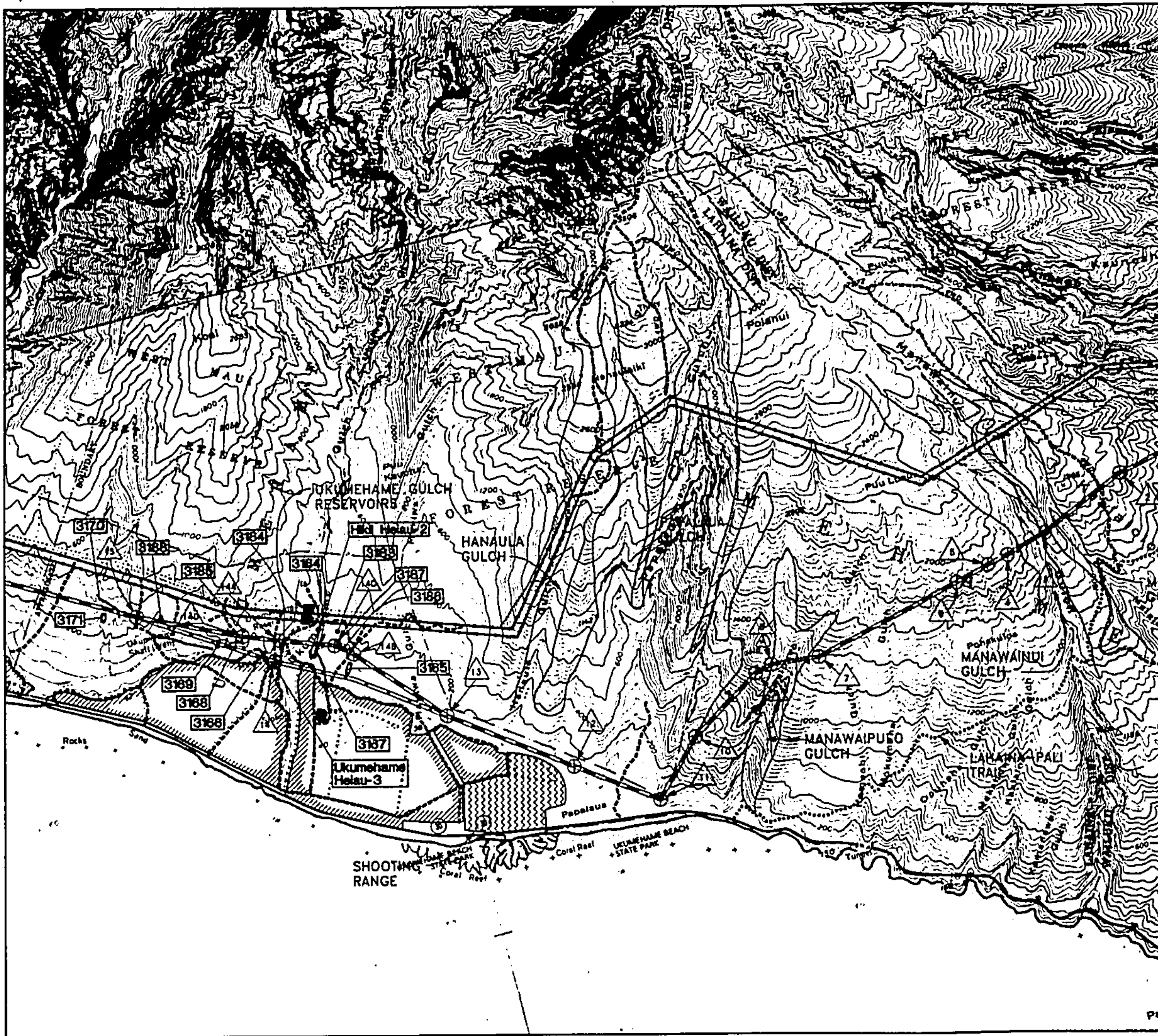


FIGURE 2
General Location Map, Maui Island



Preferred Alignment Before Adjustments - 3/93	
Preferred Alignment After Adjustments - 6/93	
Power Plant	
Substation (Existing)	
Substation (Proposed)	
Double Circuit 69KV Transmission Line	
Single Circuit 69KV Transmission Line	
Stake Location & I.D. Number	
Access Roads & Jeep Trails	
Gulch	
Reservoir	
Pineapple	
Cane	
Lahaina Pali Trail	
Archaeological Resource Location/State Site Number	
Rock Wall or Flume	

NOTES:

1) Survey's performed 4/26/93 thru 5/7/93 and 6/22/93 thru 6/24/93.
2) 100% coverage ground survey within 300 foot wide area (150 feet either side of centerline of alignment).
3) Alignment location adjusted in supplemental inventory survey (6/22-6/24/93) to avoid or provide buffer to sites identified in initial inventory survey (4/26-5/7/93).

KEY MAP

SCALE

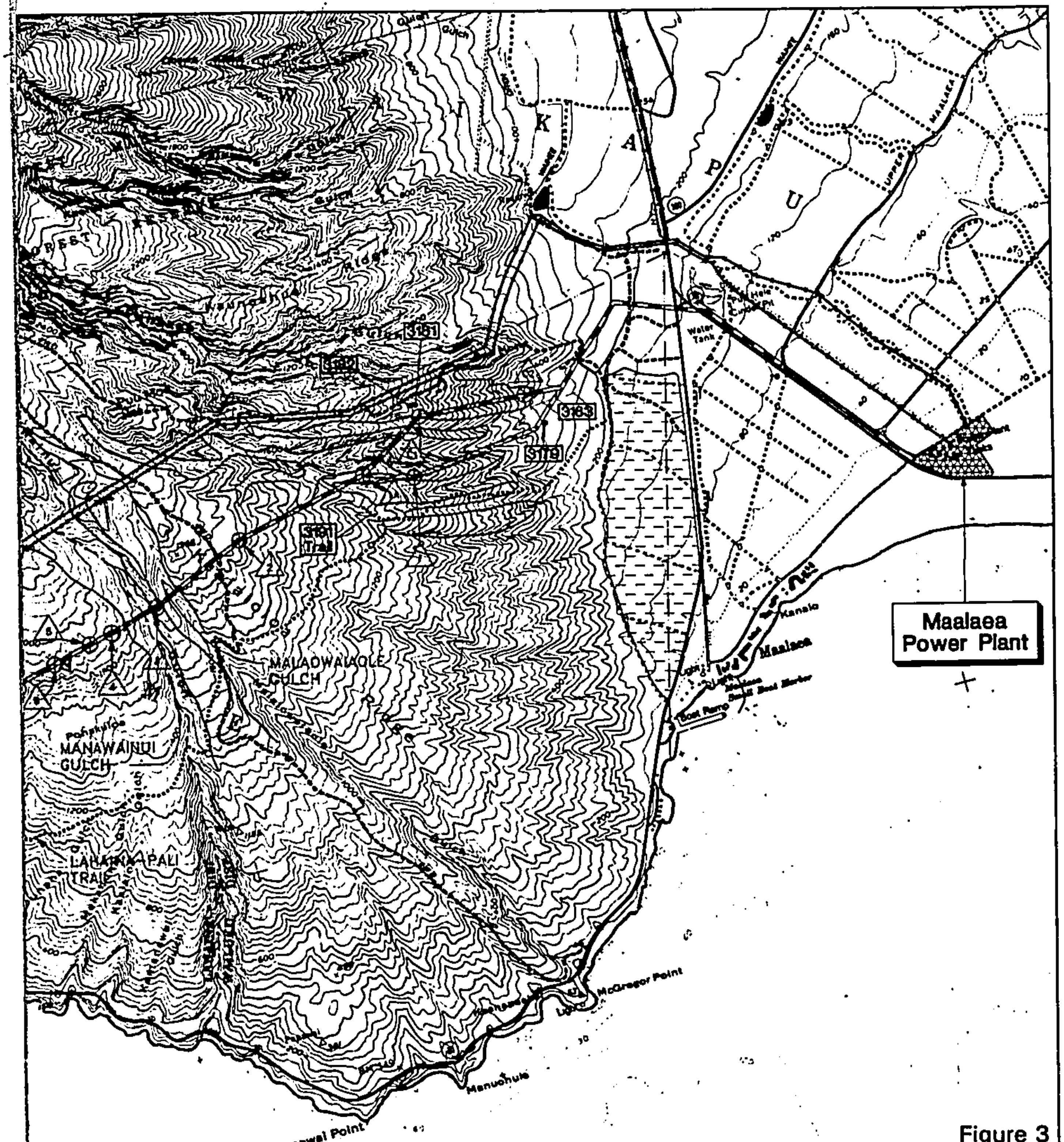


Figure 3

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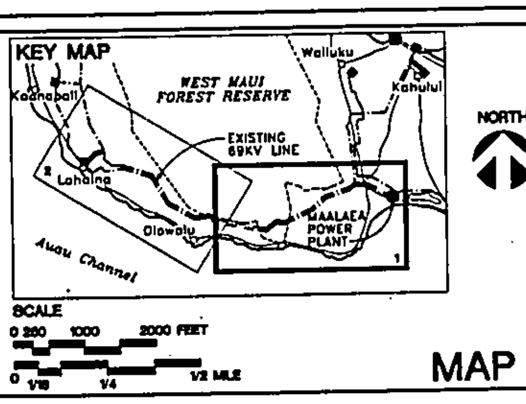


MAP 1

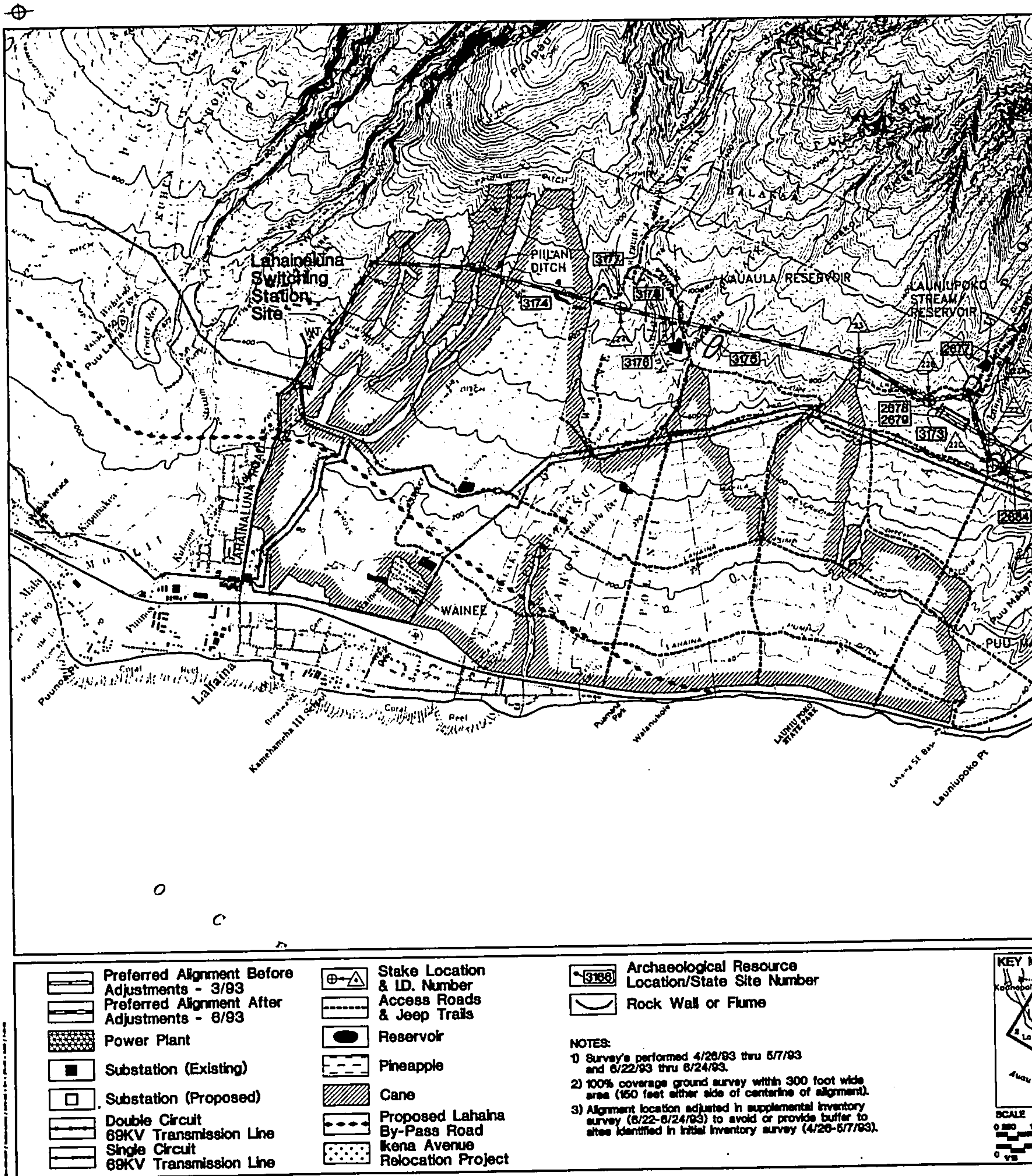
Archaeological Inventory Survey

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

9/10/93

DAMES & MOORE



Lahainaluna Switching Station Site
PIILANI DITCH
KAUAULA RESERVOIR
LAUNIUPOKO STREAM RESERVOIR
3177
3174
3178
3175
3176
2677
2678
2679
3173
2684
LAHAINALUNA ROAD
WAINEE
Lahaina
Puunoa Pt
Coral Reef
Kamehameha III School
Puamana Park
Waianukole
LAUNIUPOKO STATE PARK
Launiupoko Pt
Preferred Alignment Before Adjustments - 3/93
Preferred Alignment After Adjustments - 6/93
Power Plant
Substation (Existing)
Substation (Proposed)
Double Circuit 69KV Transmission Line
Single Circuit 69KV Transmission Line
Stake Location & I.D. Number
Access Roads & Jeep Trails
Reservoir
Pineapple
Cane
Proposed Lahaina By-Pass Road
Ikena Avenue Relocation Project
3166
Archaeological Resource Location/State Site Number
Rock Wall or Flume
NOTES:
1) Survey's performed 4/26/93 thru 5/7/93 and 6/22/93 thru 6/24/93.
2) 100% coverage ground survey within 300 foot wide area (150 feet either side of centerline of alignment).
3) Alignment location adjusted in supplemental inventory survey (6/22-6/24/93) to avoid or provide buffer to sites identified in initial inventory survey (4/26-5/7/93).
KEY
SCALE

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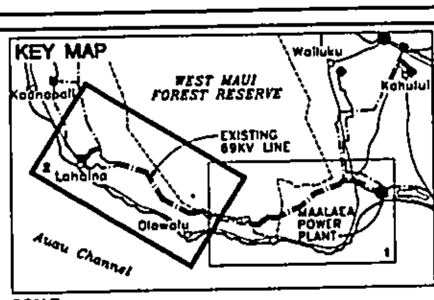


SCALE
0 250 1000 2000 FEET
0 1/8 1/4 1/2 MILE

MAP 2

Archaeological Inventory Survey

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

B. Project Description and Survey Location

The preferred transmission line alignment is located between approximately 0.9 and 2.0 miles *mauka* from the coastline. It extends through the *ahupua'a* of Waikapū, Ukumehame, Olowalu, Launiupoko, Polanui, Polaiki, Pahoa, Wainee, and Kuia. According to modern boundaries, Waikapū *ahupua'a* and the eastern portion of Ukumehame *ahupua'a* are located within the judicial Wailuku District, while the remaining project *ahupua'a* are in the District of Lahaina.

Beginning at its eastern end, the alignment extends along the east side of North Kihei Road to the intersection at Hono-a-Pi'ilani Highway. It then proceeds in a westerly direction, across pineapple fields, where it ascends to an elevation of approximately 1800 ft. above mean sea level (a.m.s.l.) to Kealaloloa Ridge and then turns, descending to approximately 200 ft. a.m.s.l. to the flood plain of Papalaua Gulch. From Papalaua Gulch the alignment stretches along the foothills of the West Maui Mountains passing generally *mauka* of existing cane fields and crossing over the major stream gulches of Olowalu, Ukumehame, Launiupoko and Kaua'ula, respectively. The northwestern end of the alignment passes through Pioneer Mill cane fields along existing cane roads running adjacent to Piilani Ditch. The proposed Lahainaluna Switching Station is located in a cane field at the west end of the preferred alignment, *makai* of Piilani Ditch.

C. Scope of Work

The principle objective of the inventory survey was the identification of any and all cultural resources within the project area. The inventory survey is necessary for assessing the impacts of the project and planning for appropriate mitigation and was designed to meet the requirements of the State Historic Preservation Division, Department of Land and Natural Resources (SHPD-DLNR). Survey procedures included:

(1) A complete (100%) ground survey of the entire preferred alignment for the purpose of site inventory. Inventoried sites were located, described and mapped with evaluation of function, interrelationships, and significance. Field documentation included photographs and scale drawings of selected sites and complexes. All sites were assigned state site numbers. Interpretive evaluations - including the archaeological significance and recommended treatment of each site were formulated.

(2) Limited subsurface testing was conducted to obtain datable charcoal

samples for chronological information (if none were available from previous studies in the area) and to assist in functional determination of sites.

(3) Research on historic and archaeological background, including investigation of historic maps, written records, and Land Commission Award documents was conducted. This research assisted in depicting a general settlement pattern in the region, but not a detailed study of each of the nine *ahupua'a* that the preferred alignment crosses (personal communication with Ms. Agnes Griffin, SHPD-DLNR 5/93).

(4) Laboratory analysis of all collected artifacts and midden. Artifacts will remain curated at Cultural Surveys Hawaii until a location is chosen for permanent curation by the respective landowners in agreement with the DLNR-SHPD.

This report presents the results of archaeological work completed by Cultural Surveys Hawaii and also includes:

(a) a topographic map of the survey area showing all archaeological sites and site areas;

(b) description of all archaeological sites with selected photographs, scale drawings, and discussion of function;

(c) historical and archaeological background sections summarizing prehistoric and historic land use as they relate to the archaeological features.

(d) a summary of site categories, considering their significance in an archaeological and historical context; and

(e) A summary on the findings and potential project effects. Recommendations will be presented which specify what steps should be taken to mitigate impact of development on archaeological resources.

D. Methods

Phase I - Regional Study and Corridor Identification

Prior to the inventory survey, Cultural Surveys Hawaii conducted an archaeological assessment in October 1991. The assessment was aimed at identifying known and potential archaeological sites within the West Maui study area extending from the *ahupua'a* of Hana'ō'ō in the Lahaina District to the *ahupua'a* of Waikapū in the Wailuku District. the study area extended between 1.2 to 3.5 miles *mauka* from the coastline.

The study area represented an area of West Maui being evaluated for the location of the proposed transmission line between the Mā'alaea Power Plant and a new switching station to be located within the Lahaina Master Planned Community at Wahikuli.

Procedures undertaken by Cultural Surveys Hawaii included: (1) a study of documentary resources detailing traditional Hawaiian usage of the area; (2) a review of previous archaeological studies within the area; (3) consultation with Ms. Agnes Griffin of the State Historic Preservation Division; (4) an aerial reconnaissance survey of the study area; and (5) formulation of recommendations based upon the results of these procedures.

These procedures resulted in the preparation of a map of the study area locating: (1) all presently recorded (at the State Historic Preservation Division) archaeological sites; and (2) all site areas and potential site areas observed during the aerial reconnaissance.

Inventory Survey of the Preferred Alignment (April 1993)

The preferred transmission line alignment was subjected to a 100% ground survey using a three-person team. An area 300 ft. wide (150 feet either side of the transmission line alignment centerline) was surveyed. The survey proceeded primarily in a west to northwesterly direction from the intersection of North Kihei Road and Hono-a-Pi'ilani Highway in Mā'alaea to the upper cane fields of Lahaina. The three-person crew walked transects parallel to the corridor centerline at approximately 50 foot intervals between surveyors. Thus, two parallel transects covered the 300-foot wide corridor.

The archaeologists were dropped at the higher elevations of the preferred alignment in Ukumehame *ahupua'a* by helicopter. All other access was achieved through Pioneer Mill cane roads and associated jeep roads.

The in-field location of the preferred alignment was determined by shooting

compass bearings (using Silva hand-held compasses) between PVC pipe survey stakes, and review of aerial photographs and project contour maps. The locational stakes were placed in the field by Dames and Moore and Maui Electric personnel using a helicopter Global Positioning System (GPS). The stakes were situated at variable distances - usually at junctures in the alignment - between 152.0 m. (500 ft.) to 1829.0 m. (6000 ft.) apart.

All identified sites were plotted onto a 1 inch = 1000 ft. project map by using compass bearings to prominent landmarks and visible locational stakes. Subsequent to the ground survey a helicopter reconnaissance of the preferred alignment was undertaken to record site locations with a Global Positioning System (GPS), to facilitate accurate mapping of the site locations.

Selected sites were subjected to subsurface archeological testing, by hand, to provide data on the content and depth of cultural strata within specific site types. Excavation controls were by arbitrary 10 cm. levels within 50 cm. square horizontal units. All sediments excavated from the test units were passed through a 1/8 inch mesh of galvanized wire screen. Charcoal, midden and artifacts were collected from the screening and catalogued by site, feature, trench, stratum and depth. Cataloging in the laboratory included basic descriptive analysis of the items recovered. This data is presented in the Artifact and Midden Catalogues on page 143. The items recovered are stored at Cultural Surveys Hawaii's laboratory in Kailua, O'ahu.

The archaeological sites assigned State Inventory of Historic Places (SIHP) site numbers are marked in the field with semi-permanent (5 year ultraviolet protected), white 3 x 4 inch, plastic tags inscribed with the Cultural Surveys Hawaii (CSH) temporary field numbers (These tags have space for the SIHP number to be added).

Adjustments to Preferred Alignment - Supplemental Phase of Inventory Survey (June 1993)

As discussed previously, the inventory survey included a supplemental phase of work in which three sections (Ma'alaea, Ukumehame, and Launiupoko) of the preferred alignment were realigned to avoid impacting archaeological sites by construction of the proposed transmission line.

The Mā'alaea realignment was designed to preserve the view plane of the Lahaina Pali Trail located south of the preferred alignment. Similarly, the Ukumehame realignment was designed to preserve the view plane of Ukumehame and Hiki'i *Heiau* and to create a 100 ft. buffer zone from the identified sites in the original corridor. The Launiupoko realignment was necessitated due to engineering constraints in which a dense concentration of archaeological features could not be avoided (spanning or specific pole placement) without adjusting the preferred alignment.

The orientation of the realignments and actual pole placements within them were determined in the field using helicopter reconnaissance and ground inspection. This work was accomplished by two Maui Electric engineers, John Everingham of Dames and Moore, Cultural Surveys Hawaii archaeologist Jennifer Robins and, during the Mā'alaea realignment design, Michael Baker - Trails and Access Specialist of the Division of Forestry and Wildlife, DLNR.

The methodology of the archaeological inventory survey during this second phase of work differed somewhat between the three alignments due to various elements.

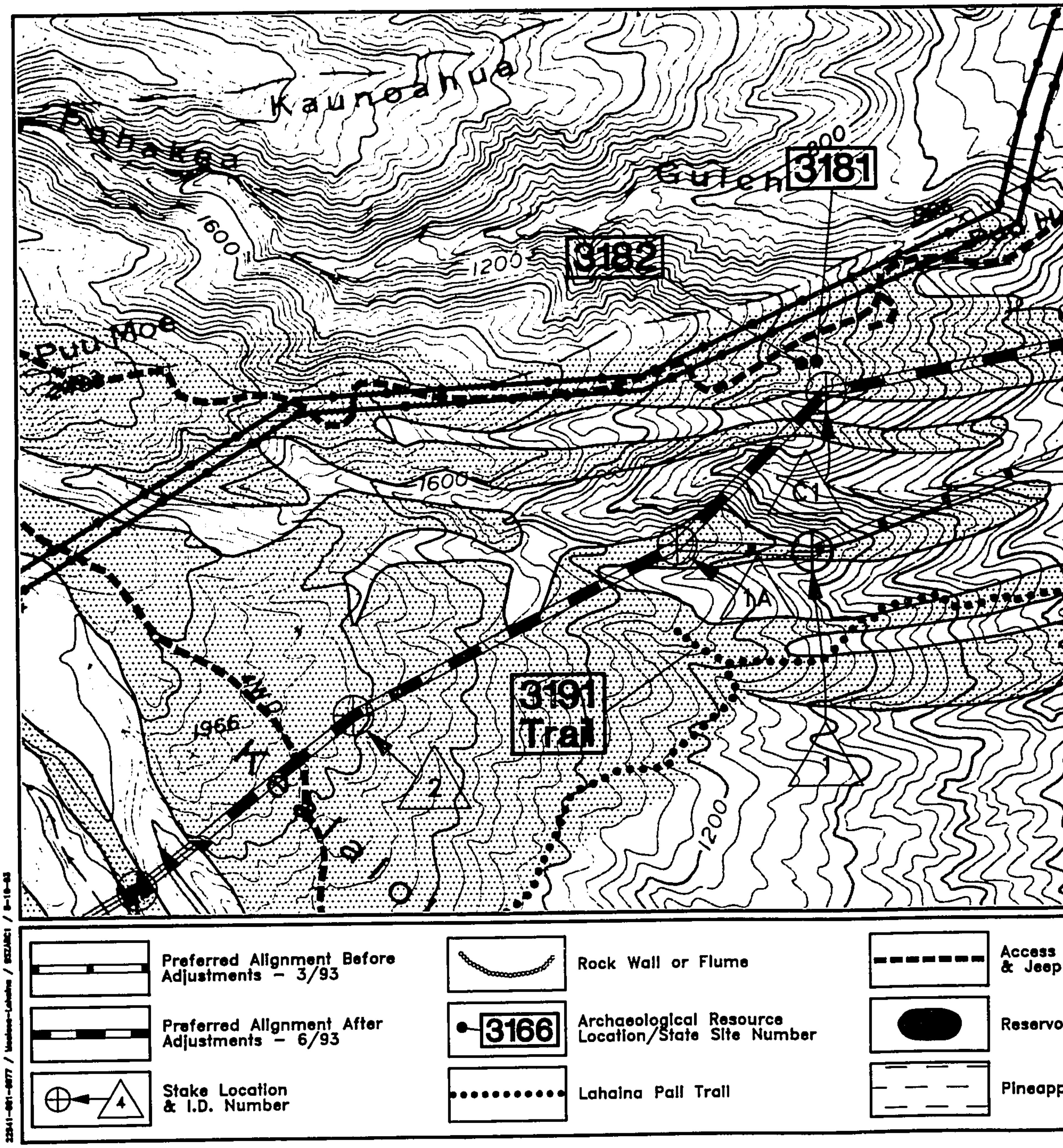
Mā'alaea Realignment

The Mā'alaea realignment (Figure 5) was subjected to a complete ground survey during the time when the realignment orientation and pole locations were being chosen. The ground survey was conducted over the sparsely vegetated ridgetop between newly established locational stakes designated C-1 and C-2. The specific stake areas, representing proposed transmission line pole locations, (using a rough radius of 10.0 m. [30 ft.]) were thoroughly inspected. When a site was located along the Mā'alaea realignment, the proposed pole locations were adjusted to ensure a 100 ft. buffer zone from the sites. Aerial reconnaissance was also conducted over the Mā'alaea realignment and the identified sites were located on the project map using the helicopter GPS. No ground survey was done along the alluvial flats east of locational stake C-2 with the understanding that no poles will be placed in this approximately 244.0 m. (800.0 ft.) long unsurveyed area.

Ukumehame and Launiupoko Realignments

The orientation and pole placements of the Ukumehame and Launiupoko realignments (Figure 6 and 7) were completed using basically the same procedure described above, with some exceptions. To preserve the view plane of two *heiau* on the east and west sides of Ukumehame Gulch, a buffer zone of at least 400 ft. *mauka* of the sites was established. In the northwest portion of the Launiupoko realignment, the pole locations were placed along an existing cane road. In this area (between newly established locational stakes 22A and 22B) only the proposed pole locations were subjected to a complete ground survey (covering a minimum radius of 10.0 m. (30.0 ft.). One of the poles (locational stake 22A) was placed within the confines of a site complex previously identified by Paul H. Rosendahl, Inc. archaeologists. The location of the pole was plotted on PHRI's site map and its placement was at least 15.0 m. (50.0 ft.) from any observed or PHRI documented site structures. With the exception of the northwest portion of Launiupoko realignment described above, a 100% ground survey was performed in the Ukumehame and Launiupoko realignments using a team of three archaeologists.

All of the identified sites in the preferred alignment survey (April 1993) and subsequent realignment survey (June 1993) were described and photographed. Maps were drawn to scale for all sites, except for previously documented sites or complexes.


Kaunoahua
Gulch
3181
3182
1200
1600
Puu Moe
3191
Trail
C1
1A
2
1
Preferred Alignment Before Adjustments – 3/93
Preferred Alignment After Adjustments – 6/93
Stake Location & I.D. Number
4
Rock Wall or Flume
3166
Archaeological Resource Location/State Site Number
Lahaina Pali Trail
Access
& Jeep
Reservo
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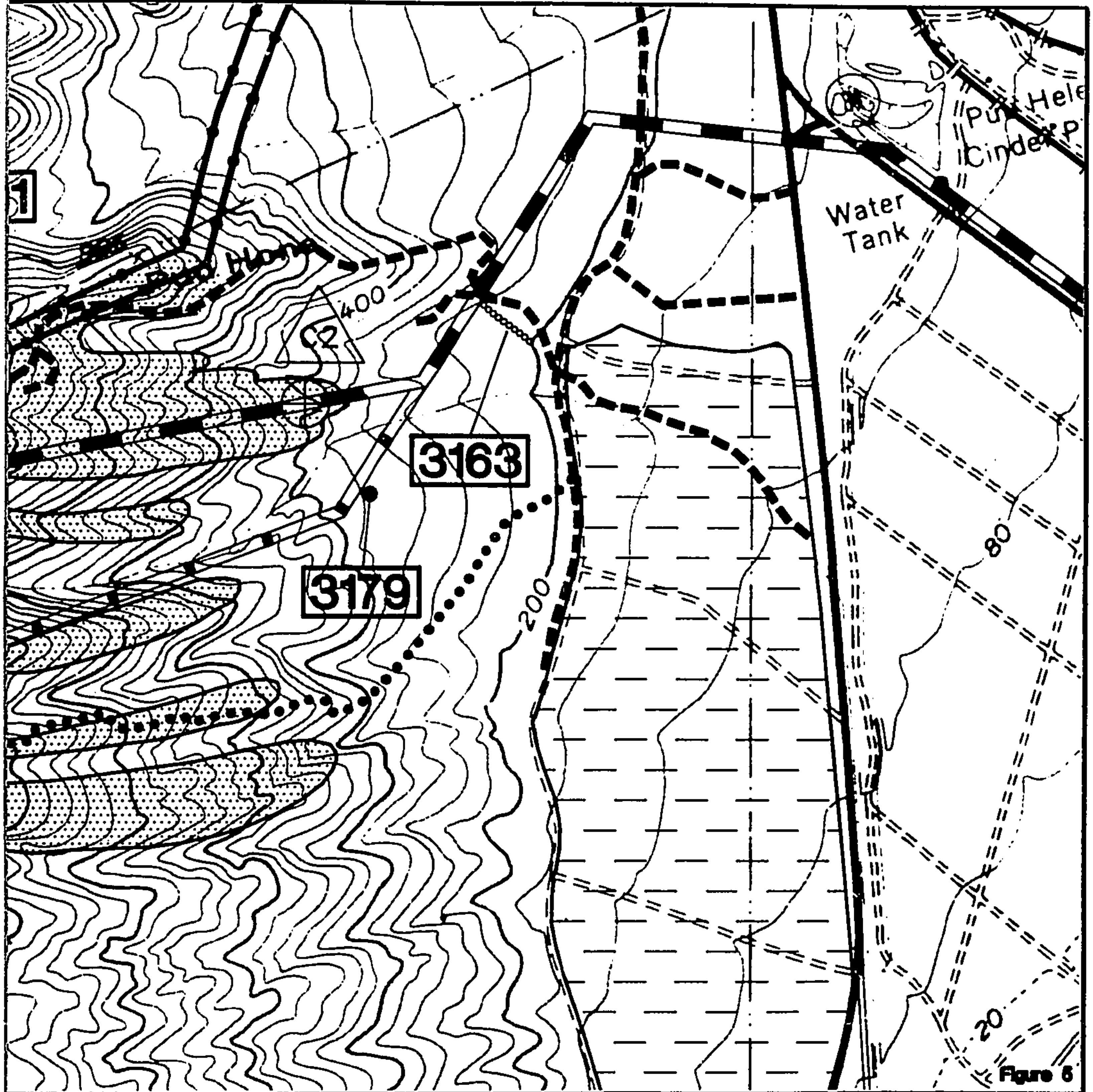


Access Roads & Jeep Trails

Cane

Reservoir

Pineapple

0 200 800 1600

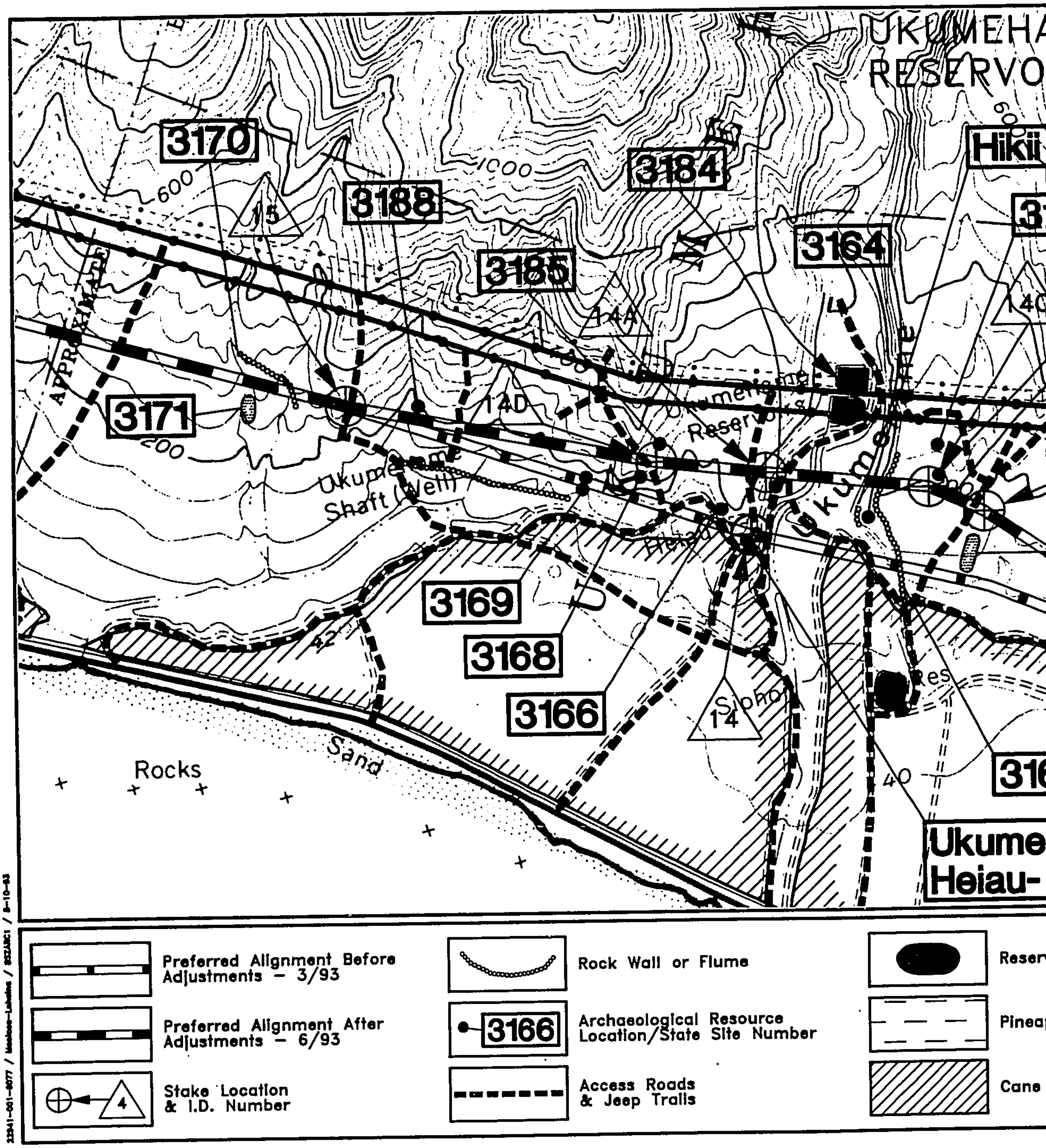
SCALE IN FEET

Maalaea Realignment & Archaeological Sites

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE



UKUMEHA
RESERVO
3170
3188
3184
Hikii
3164
3185
15
14A
14D
14C
600
1000
200
APPROXIMATE
3171
Ukumehame Reservoir
Ukumehame Shaft (Well)
Heiau
3169
3168
3166
Siphon
14
Res
Rocks
Sand
42
40
Ukume
Heiau-
Preferred Alignment Before Adjustments – 3/93
Preferred Alignment After Adjustments – 6/93
Stake Location & I.D. Number
4
Rock Wall or Flume
3166
Archaeological Resource Location/State Site Number
Access Roads & Jeep Trails
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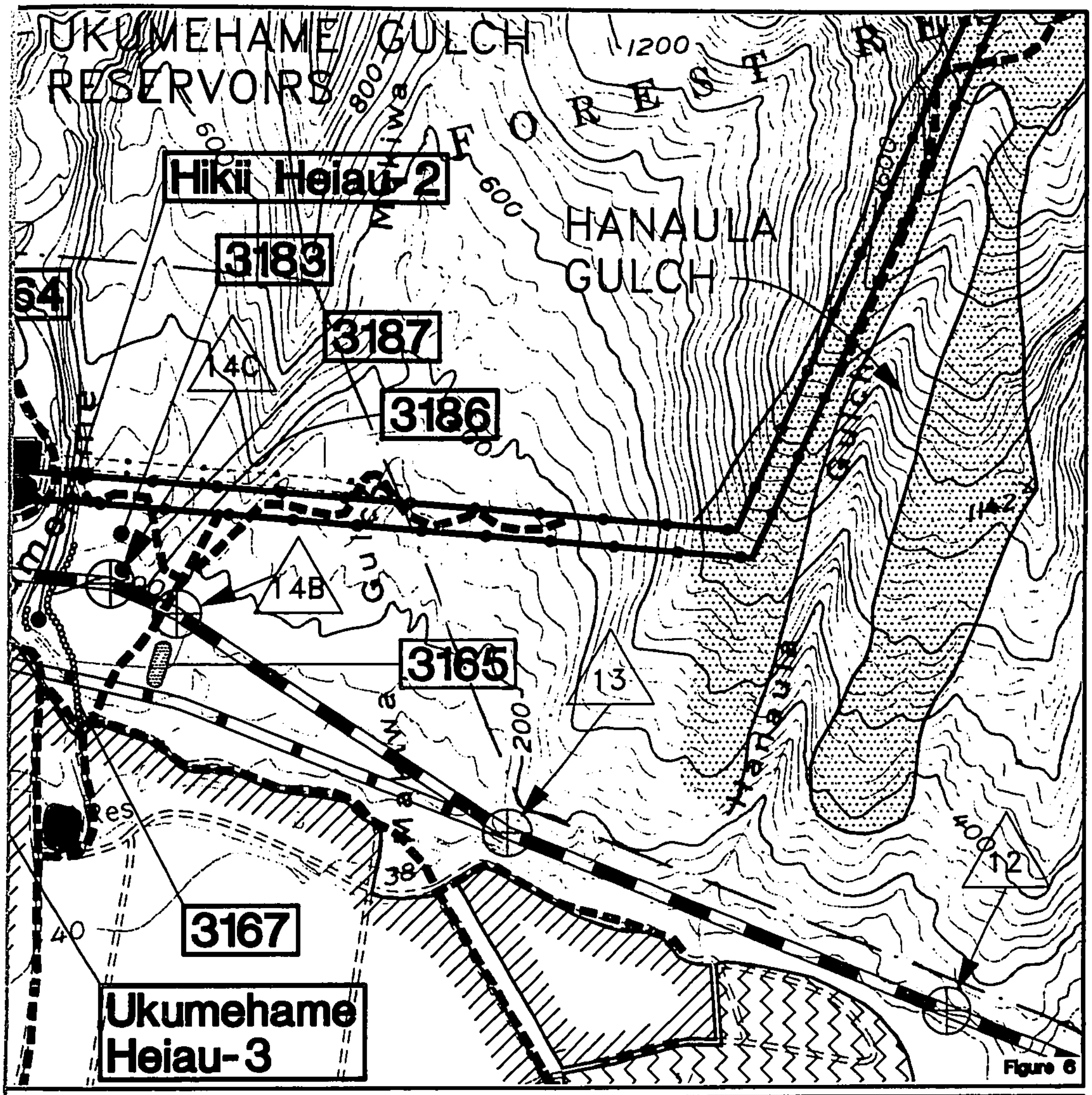


Reservoir

Pineapple

Cane

0 200 800 1600

SCALE IN FEET

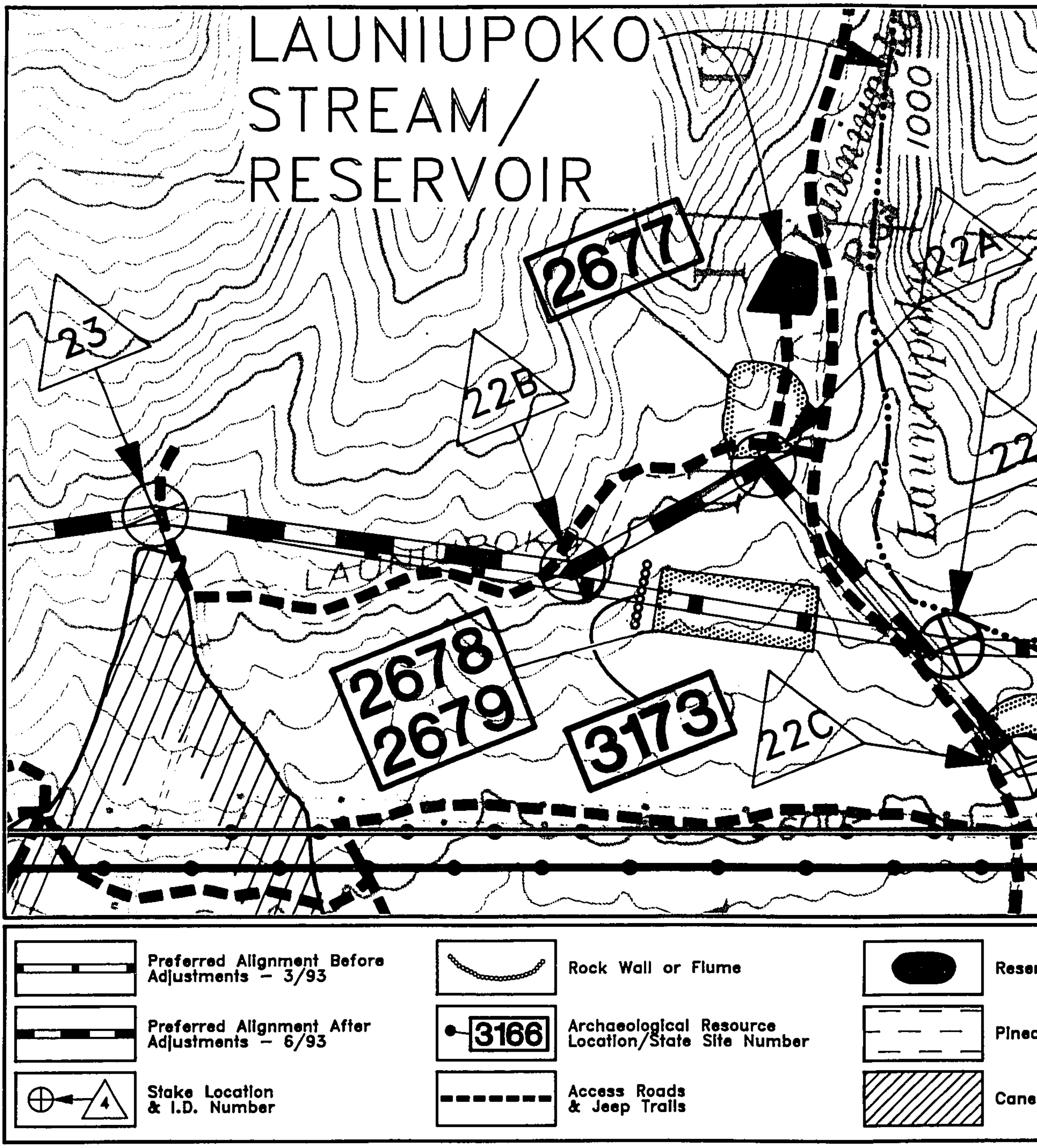
Ukumehame Realignment & Archaeological Sites

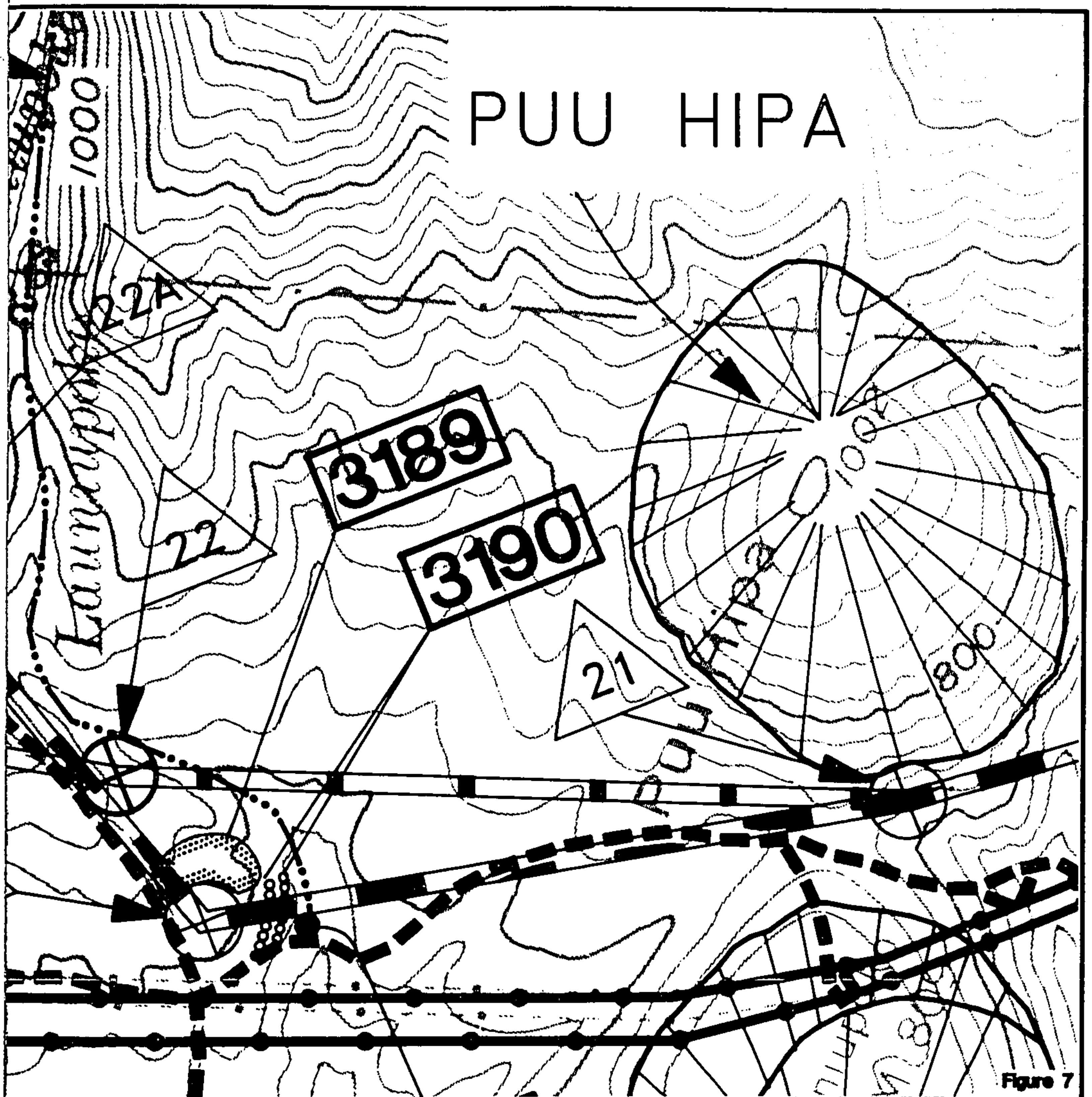
Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

8/10/93


LAUNIUPOKO
STREAM/
RESERVOIR
2677
23
22B
22A
22C
1000
2678
2679
3173
Preferred Alignment Before Adjustments – 3/93
Preferred Alignment After Adjustments – 6/93
Stake Location & I.D. Number
4
Rock Wall or Flume
3166
Archaeological Resource Location/State Site Number
Access Roads & Jeep Trails



Reservoir

Pineapple

Cane

0 125 500 1000
SCALE IN FEET

Launiupoko Realignment & Archaeological Sites

Maalaea-Lahaina Third 69kV Transmission Line Project

Maui Electric Company, Ltd.

DAMES & MOORE

MĀ'ALAEA - LAHAINA TRANSMISSION LINE PROJECT
Table 1 - Archaeological Site Summary

STATE SITE NO.	CSH SITE NO./FEATURE	FORMAL SITE TYPE	FUNCTION	SIGNIFICANCE
50-50-08-2	2	Site complex	Heiau (Hikii Heiau)	A, B, C, D, E
50-50-08-3	3	Site complex	Heiau (Ukumehame Heiau)	A, B, C, D, E
50-50-03-2677	none	Site complex	Agriculture-habitation (T/P)	D
" "	21/C	Metal flume	Cane irrigation	D
50-50-03-2678 & 2679	13	Site complex	Agriculture-habitation (T/P)	C, D
50-50-09-2684	33	Rockshelter	Habitation (T)	D
50-50-08-3163	1	Canal	Cane irrigation	D
50-50-08-3164	4	Canal	Cane irrigation	D
50-50-08-3165	5	Site complex	Habitation (T)	C, D
" "	A	Rectangular enclosure		
" "	B	Rectangular enclosure		
" "	C	L-shaped enclosure		
" "	D	C-shaped enclosure		
50-50-08-3166	6	Irregular-shaped enclosure		D
50-50-08-3167	7	Cattle wall and chute	Ranching	D
50-50-08-3168	8	Site complex	Ritual-Habitation (T)	C, D, E
" "	A	Wall & Platform	Habitation (T)	
" "	B	Terrace	Ritual	
50-50-08-3169	9	Site complex	Habitation (T)	D
" "	A	Wall		
" "	B	Circular enclosure		
" "	C	Wall		
" "	D	C-shaped enclosure		
" "	E	Circular enclosure		
50-50-08-3170	10	Cattle wall	Ranching	D
50-50-08-3171	11	Railroad berm	Cane transport	D
50-50-08-3172	12	Canal	Cane irrigation	D
50-50-03-3173	14	Wall	Cane irrigation	D
50-50-03-3174	15	Wall	Agriculture	D
50-50-03-3175	16	Site complex	Agriculture	D
50-50-03-3176	17	Wall	Cane irrigation	D
50-50-03-3177	18	Wall	Cane irrigation	D

Temporary site numbers (prefixed by CSH) and feature designations, if necessary, were assigned to most sites or site complexes. Yellow flagging tape labelled with the temporary site number and other pertinent information was tied above the site and a second marker - using a white plastic tag - was placed on the site structure itself; the location of the white plastic site tags was plotted onto the site map. Each site was recorded by formal site type using descriptive categories. Significance and recommended treatment were determined on the basis of site complexity, configuration, and apparent function. As a result of the inventory survey, a total of 34 sites and complexes were identified (Table 1).

MĀ'ALAEA - LAHAINA TRANSMISSION LINE PROJECT
Table 1 - Archaeological Site Summary (cont.

STATE SITE NO.	CSH SITE NO./FEATURE	FORMAL SITE TYPE	FUNCTION	SIGNIFICANCE
50-50-03-3178	19	Canal	Cane irrigation	D
50-50-09-3179	20	Circular enclosure	Habitation (T)	D
50-50-08-3180	22	Cattle wall	Ranching	D
50-50-09-3181	23	Wall	Habitation (T)	D
50-50-09-3182	24	Upright	Marker	D
50-50-08-3183	25	Rectangular enclosure	Habitation (P)	D
50-50-08-3184	26	Site complex	Habitation (P)-possible burial	D, E*
" "	A	L-shaped enclosure		
" "	B	Irregular enclosure		
" "	C	C-shaped enclosure		
" "	D	Mound		
50-50-08-3185	27	Site complex	Agriculture-habitation (T)	D
" "	A	C-shaped enclosure	Habitation (T)	
" "	B	Rectangular enclosure	Habitation (T)	
" "	C	Enclosure network	Agriculture	
50-50-08-3186	28	C-shaped enclosure	Habitation (T)	D
50-50-08-3187	29	Site complex	Habitation (T)	D
" "	A	C-shaped enclosure		
" "	B	Wall		
50-50-08-3188	30	Modified rockshelter	Habitation (T)	D
50-50-03-3189	31	Site complex	Agriculture	D
50-50-03-3190	32	Retaining walls	Agriculture	D
50-50-09-3191	34	Kerbstone trail	Travel route	D

KEY:
(P) Permanent
(T) Temporary

Significance Criteria:
A Site reflects major trends or events in the history of the state or nation
B Site is associated with the lives of persons significant in the past
C Site is an excellent example of a site type
D Site is likely to yield information important to prehistory and history
E Site has cultural or religious significance
E* Possible Burial

II. NATURAL SETTING

The preferred alignment extends approximately 14.7 miles from Mā'alaea to Lahaina, crossing the foothills and lower alluvial plains of the West Maui Mountains. The alignment crosses six major gulches, four of which - Ukumehame, Olowalu, Launiupoko, and Kaua'ula - are perennial streams (State of Hawaii & National Park Service 1990). The upper portions of these perennial streams flow year-round, but intermittently at lower elevations (*ibid.*). Cane irrigation also decreases the flow of these streams at lower elevations.

The surface mantle of the preferred alignment comprises two primary lava formations (MacDonald and Abbott 1974:322). The shield building Wailuku volcanic series is the dominant lava type characterized by thin pahoehoe and a'a flows of tholeiite, olivine tholeiite and oceanite, with an upper layer of alkalic olivine basalt. Pleistocene lava flows of the Honolua volcanic series overlie the Wailuku volcanic series lava within Manwainui and Malalowailoe gulches, and between the Olowalu and Launiupoko gulch areas. The Honolua volcanic series is mostly a'a lava composed of mugearite, trachyte and to a lesser degree Hawaiite. Two of the pu'u near the preferred alignment (Pu'u Mahanaluanui and Pu'u Hipa) are trachyte domes associated with the Honolua volcanic series formation. Pu'u Hele, a cinder-and-spatter cone of the Lahaina volcanic series, is located in close proximity to the east end of the preferred alignment on Maui's central isthmus. This cone has been quarried since the 1940's to such an extent that only a deep pit remains in place of the former pu'u (Folk and Hammatt 1991).

The major stream valleys crossed by the alignment are composed of alluvial deposits (MacDonald and Abbott 1974). Alluvial fan formations comprise all lands from the base of the West Maui Mountains to the coast, between Papalaua and Kaua'ula Gulch and on the central isthmus in Mā'alaea. Most of the alluvial deposits are of pleistocene age, derived from the igneous rocks of the Wailuku volcanic series. The alluvial deposits along the shore are more recent, derived from reworking of the older alluvium by present day stream activity.

The majority of the flora within the preferred alignment, typically along the lower mountain slopes and uncultivated alluvial fans, is classified under the "Kiawe-grass association" (Char 1993: 6-7). The primary plant species in this category include the following: *kiawe (Propsopis pallida)*; *koa haole (Leucaena leucocephala)*; klu (*Acacia* *farnesina*); and *'ilima*. A variety of grasses are also abundant and predominantly include *pili* grass (*Heteropogon contortus*) and buffel grass (*Cenchrus ciliaris*).

Flora along the upper elevations of the alignment - between Maui's central isthmus and Manawaipueo Gulch - is classified as a "Mixed Grassland/Shrubland vegetation" (*ibid.*: 8-9). This vegetation classification is characterized by patches of grasses - including primarily African dropseed grass (*Sporobolus africanus*) and *pili* grass - interspersed with low thickets of *a'ali'i* shrubs (*Dodoneae viscosa*). Stands of Ironwood (*Casuarina equisetifolia*) are also present on the upper ridgetops.

Riperian Vegetation represents the least abundant flora in the project area, located within the moist stream gulches. Here, the vegetation is predominated by a forest of primarily *'opiuma* (*Pithecellobium dulce*) and java plum (*Syzygium cumini*), with some *kiawe* and a few *kukui* trees (*Aleurites moluccana*).

Patches of native vegetation species - including a prevailing shrub, *a'li'i* (*Dodanaea viscosa*) - were identified along two specific steep ridges in the project area and on Pu'u Hipa. Other native plant species include: *naio* (*Myoporum sandwicence*); lowland or coastland sandalwood (*Satalum ellipticum*); and *ko'oko'olau* (*Bidens menziesii*). Also included in the native species category are *pili* grass and *'ilima* discussed above. An endangered plant species - *Achyranthes splendens* - was identified on the summit of Pu'u Hipa, outside the project area. For a more detailed summary of the project area flora, the reader is referred to Ms. Winona Char's report (1993).

III. CULTURAL SETTING

A. Prehistory and Early History

Traditional Accounts

Maui, being the second largest island in the Hawaiian island chain, was a major center for political development during prehistoric and early historic times (Kirch 1985:135). Many battles were fought between the two island polities, centered in the Wailuku District of west Maui and the Hana District of east Maui. The earliest conflicts primarily centered on the east coast of Maui as the Pi'ilani clan fought over the Maui reign.

Upon the death of Pi'ilani, ruler of Maui during the early 1500's (A.D. 1525 (Fornander in Walker 1931:13)), conflict ensued between the sons of Pi'ilani (Lono-a-Pi'ilani and Kiha-a-Pi'ilani) as they battled for individual control over the Maui chiefdom. Under Lono-a-Pi'ilani's tentative reign of Maui, Kiha-a-Pi'ilani was forced to flee the island where he sought refuge on Moloka'i and subsequently Lana'i. Mā'alaea is briefly mentioned by Kamakau (1992:22) as the place in which Kiha-a-Pi'ilani first landed while secretly returning to Maui.

Umi, ruler of Hawai'i and brother-in-law to the Pi'ilani's, eventually aligned with Kiha-a-Pi'ilani and sent an invasion fleet to Hana to battle Lono-a-Pi'ilani's forces. The mission was successful and the Maui reign was abdicated to Kiha-a-Pi'ilani (Kamakau 1992:22-33). Kiha-a-Pi'ilani is credited with completing construction of the portion of the *alaloa* (island-wide road) which encircled western Maui (Ashdown 1970:5).

Two centuries after Kiha-a-Pi'ilani's reign, Mā'alaea is mentioned for the second time as a crossroad taken when Kekaulike's remains were carried to 'Iao for burial (Kamakau 1992:69).

During the reign and following the death of Maui ruler Kekaulike in the early 1700's, the chiefs of Maui and Hawai'i were once again at war, this time bringing the battles closer to the present study area. After Kamehameha-nui, the original successor of Kekaulike, was defeated in battle at Lahaina by his older brother Kauhi, Alapa'i (ruling chief of Hawai'i) brought Kamehameha-nui back to Hawai'i and began making plans for battle against Kauhi. Around 1738 Alapa'i and his Hawaiian forces occupied the Lahaina region and, interestingly, obstructed major streams for the purpose of warfare:

A whole year Alapa'i spent in preparation for the war with Maui. It was in

> 1738 that he set out for the war in which he swept the country. What was the war like? It employed the unusual method in warfare of drying up the streams of Kaua'ula, Kanaha, and Mahoma (which is the stream near Lahainaluna). The wet taro patches and the brooks were dried up so that there was no food for the forces of Ka-uhi or for the country people. Alapa'i's men kept close watch over the brooks Olowalu, Ukumehame, Wailuku, and Honokowai. (Kamakau 1992:74)

Kahekili was one of the more powerful and notorious chiefs of Maui, who by 1786 - following western contact - ruled O'ahu, Moloka'i and Lana'i (Daws 1968:31). John Papa I'i accounts that during the reign of Kahekili, at a time when King Kalaniopu'u was warring with Maui, a Hawaiian warrior named Kekuhaupio took a stand "at Kama'alaea [Mā'alaea] on the ridge of Pu'uhele", where he fought the Maui warriors (Ii 1959:10).

During the reign of Kahekili, the traditional Hawaiian lifestyle changed rapidly after the first western contact was made and western goods - particularly weapons and coveted metals - became obtainable through trade or thievery. As Daws comments, several of the early traders "saw nothing wrong in arming one Hawaiian chief against another. They sold guns to as many factions as they could find and then encouraged them to fight" (Daws 1968:32).

The "Olowalu massacre", one of the more infamous early historic accounts specific to the Lahaina region, reveals how conflicts between early western traders and native Hawaiians were easily provoked as western goods became the focus of Hawaiian needs. The Olowalu conflict began in late January of 1791 when the American Merchantman *Eleanora*, under the command of Simon Metcalfe, landed off the coast of Honuaula to barter for food. During the night, natives killed the ship's watchmen and stole a boat tied to the stern of the *Eleanora*, after which it was burned on shore for the iron fittings. After the murder and thievery was discovered the next day, Metcalfe dispelled all of the Hawaiian women off of the ship, then fired on the village of Honuaula with grapeshot, and set its huts and *heiau* afire. Consequently, the *Eleanora* set sail to Olowalu where a chief offered in trade to return the stolen boat and the bones of the killed watchmen. To Metcalfe's dissatisfaction, only a piece of the boat's keel and leg bones of the watchmen were given by the chief. In revenge, the angered Metcalfe and shipmates tricked the Olowalu natives to bring their trade canoes to the ship's starboard and fired upon them all, killing and wounding at least 100 Hawaiians (*ibid.* 33-34).

Mythological reference to Pu'uhele in the east end of the project area include two myths accounted in *Hawaiian Mythology* (Beckwith 1971)

> Pu'uhele (Traveling hill) is a child born in the form of a bloody foetus to Ka-hina-l'i, mother of Pele and Hi'iaka. The sisters throw it away. The child crosses the channel of Alanuihaha between Hawaii and Maui and lands at Nu'u in Kaupo in the form of a beautiful woman. She passes on without speaking to Nu'u and makes friends with the beautiful Pu'u-o-maiai. Manawai-nui recognizes her and calls her by name. Kanahaha sees her and falls dead and a spring gushes to this day to the hill of that name. Leho-ula follows her as she continues her route along the coast. A Wananalua Pu'uhele vows to remain. When Kaihualele reproves her for trespass she dies and through her power as a god her spirit body lives on in the form of the hill Kauiki at the seashore (*ibid.*:188)

The second myth refers to Puu'hele and Pu'uokai as being *mo'o* or lizard gods:

> The two hills beyond Ma'alaea bay on Maui are named Pu'u-hele and Pu'u-o-kali. They are mo'o beings and their first child is a daughter born of Pu'u-o-kali and named Pu'u-o-inaina. She is placed on the scared island of Kahoolawe, called at that time Kohe-malamalama. She becomes the wife of the two sons of the kahuna of Hua, Kaakakai and Kaanahua, who take the form of birds and retreat to Hana-ula, when the great drought comes and there alone rain falls. Pu'u-o-inaina takes Lohiau for her husband while he is living at Maalaea. Pele is angry and cuts her in two in the middle. The tail becomes the hill Pu'u-o-lai at Makena, the head becomes the rock islet of Molokini. (*ibid.*:189)

The name Lahaina according to Inez Ashdown means "land [of] prophesy", referring to "ancient *ali'i* prophets who made their predictions there" (in Graves 1991:A1). It was told in myth that Pele first arrived on Maui at Lahaina, leaving her footprint on the hill of Laina (Ashdown 1970: 10). The mountain tops above Launiupoko are named for the mythological chiefess Lihau (Mauna Lihau), and her husband (Ke'eke'ehia Peak) and daughter (Pu'u Ko-a'e) (*ibid.*). Through name, the two ridges forming Ukumehame valley are associated with the stars. Hoku'ula, the highest mountain ridge on the west side of Ukumehame means "sacred star" and Hoku Waiki, a smaller ridge extending through the center of Ukumehame valley, was named for the smaller stars in the Taurus constellation (*ibid.*).

Mā'alaea as a crossroads is suggested not only by its geographical location on the southern coastal route from Mā'alaea where Kapoli served as canoe landing and spring (Kamakau 1991) to Lahaina, but also by the place names Pu'uhele, "traveling hill" and Kealaloloa, the "long pathway". The former landmark, Pu'uhele - located within close proximity to the present study area - is geographically positioned on the logical route from Mā'alaea to Wailuku, noted previously in Kamakau's (1992:69) account of the carrying of Kekaulike's bones to Mā'alaea, Pu'uhele, to Waikapū, etc., to 'Iao for burial. Kealaloloa, located within the modern boundaries of Ukumehame *ahupua'a*, is a broad ridge of the southeast flank of West Maui which ascends *mauka* of a traditional Hawaiian coastal settlement (Walker 1931:43). Following the ridge *mauka*, it provides a direct and easily navigated route (now a jeep road) to the West Maui summit area, at the headwaters of Pohakea stream on the east and Ukumehame stream on the west. From this point, at Hana'ula, the trail probably continued along the summit ridge to intersect the inland Olowalu-Pu'u Kukui-Waiehu trail (Handy and Handy 1972:490). In addition to the Kealaloloa route being used to cross the West Maui Mountain range, Folk and Hammatt (1991:17) suggest that Kealaloloa may have allowed access to wetter upland environs more suitable for agriculture. *Mauka-makai* trails have been observed on neighboring ridges of Kealaloloa (Michael Baker, personal communication); however, to the best of our knowledge, the more accessible areas of the Kealaloloa trail itself were probably destroyed by the present jeep trail.

As emphasized by E.S. Craighill and Elizabeth Handy in the following summary, the *ali'i* and *maka'āinana* were attracted to the Lahaina District by its natural resources and geographic position:

> Lahaina District was a favorable place for the high chiefs of Maui and their entourage for a number of reasons: the abundance of food from both land and sea; its equable climate and its attractiveness as a place of residence; it had probably the largest concentration of population, with its adjoining areas of habitation; easy communication with the other heavily populated areas of eastern and northeastern West Maui, 'The Four Streams,' and with the people living on the western, southwestern and southern slopes of Haleakala; and its propinquity to Lanai and Molokai.

The Handy's indicate that the four major waterways in the Lahaina District (Ukumehame, Olowalu, Launiupoko, Kaua'ula streams) provided a productive leeward environment for the cultivation of a wide range of agricultural goods:

> Southeastward along the coast from the *ali'i* settlement were a number of areas where dispersed populations grew taro, sweet potato, breadfruit and coconut on slopes below and in the sides of valleys which had streams with constant flow. All this area, like that around and above Lahaina, is now sugar-cane land. Ukumehame had extensive terraces below its canyon, some

> of which were still planted with taro in 1934; these terrace systems used to extend well down below the canyon. 'Olowalu, the largest and deepest valley on southwest Maui, had even more extensive *lo'i* lands both in the valley and below. Just at the mouth of the valley we found in 1934 a little settlement of five *kauhale* (family homes) surrounded by their flourishing *lo'i*. There are said to be abandoned *lo'i* far up in the valley. In and below the next valley, Launuipiko [*sic*], there were no evidences of *lo'i*, and the people of 'Olowalu said there had never been any. But we think there must have been a few, although the land is, in general, dry and rough. Next beyond this, going along the coast toward Lahaina, is Kaua'ula Gulch above Waine'e, and here in 1934 there were a few *lo'i* in which Hawaiians were still growing taro. (Handy and Handy, 1972: 492)

An "overland" trail allowed pedestrian access between Lahaina and the north coast of West Maui, as well as providing access into the upper forests for bird-catching and the collection of wild plant goods. According to E.S Craighill Handy and Elizabeth Green Handy (1972:490), the trail extended *mauka* in Olowalu Valley to the highest point of the West Maui summit at Mauna Kukui, and then descended to Waiehu on the northern side of West Maui (*ibid.*).

A rudimentary comparative picture of the pre-contact population of the southwestern section of Maui comprising the present study area is intimated by figures in nineteenth century missionary censuses (Schmitt 1973). Results of the 1832 census, in which the total population of Maui is 35,062, give the following populations: for Lahaina, 4028; for Ukumehame, 573; and for Olowalu, 832. These three figures, when combined, represent 15 percent of the total Maui population. Allowing for post-contact distortions (e.g., disease and commercially-inspired population shifts), the population totals suggest that this portion of Maui accommodated a substantial portion of the island's pre-western contact population.

B. Early 19th Century

The nineteenth century brought to Lahaina and other portions of the present study area commercial, social and religious changes induced by the burgeoning foreign influx. During the year 1819 the first whaling ships arrived in Hawaiian waters and Lahaina became a primary harbor - along with Honolulu - for the provisioning of ships in the islands. The whaling trade flourished until the 1860's and gave impetus to the development and growing population of Lahaina. Between 1824 and 1861, 4747 whaleship arrivals are recorded for Lahaina, representing 47 percent of the total arrivals in all ports of the Hawaiian Islands. Figures from an 1846 census of Lahaina document the changes brought to the area midway through the nineteenth century: 3,445 Hawaiians, 112 foreigners, 600 seamen, 155 adobe houses, 822 grass houses, 59 straw and wooden houses and 529 dogs. With the increased population of foreigners coming to Lahaina came a need to increase the traditional agricultural surplus for economic trade, which was primarily under the control of the *ali'i* class. The Pacific Commercial Advertiser (February 12, 1857) accounts that western vegetables were a common and abundant constituent of the Hawaiian gardens:

> ...Fruits are generally abundant. The grape seems to luxuriate in the rich soil, and the sunny, clear weather of Lahaina is, par excellence, the fruit of this place or Islands. Figs, bananas and melons are produced in abundance, and pumpkins enough for all New England to make pies for a general Thanksgiving...(in Wong-Smith, Graves 1991:A5)

Nevertheless, the increasing demand for agricultural produce to be sold for cash in the new economy in Lahaina markets could not be satisfied by Lahaina gardens along. Land Commission testimony in the mid-19th century established that in Kula (Folk and Hammatt 1993) and Waikapū (Creed 1993) produce was being grown for transfer to Lahaina markets prior to the Mahele of 1848. Throughout this early period of change from Hawaiian subsistence economy to the cash economy of western culture, major changes were necessary in routes and capabilities of trails between populations centers. The *mauka/makai* trails, such as Kaalaloloa probably continued to be used to connect the more direct point to point historic trails to the shore at landings and villages as at Kapoli in Māalaea.

The first Protestant missionaries and their families arrived in Lahaina in 1823. The missionary William Ellis, who visited Lahaina during the 1820's, described the landscape that had entranced both the Hawaiians themselves and the nineteenth century newcomers:

> The appearance of Lahaina from the anchorage is singularly romantic and beautiful. A fine sandy beach stretches along the margin of the sea, lined for a considerable distance with houses and adorned with shady clumps of kou-trees, or waving groves of cocoa-nuts. . .The level land of the whole district, for about three miles, is one continued garden, laid out in beds of taro, potatoes, yams, sugar-cane, or cloth-plants. The lowly cottage of the farmer is seen peeping through the leaves of the luxuriant plantain and banana tree, and in every direction white columns of smoke ascend, curling up among the wide-spreading branches of the bread-fruit tree. The sloping hills immediately behind, and the lofty mountains in the interior, clothed with verdure to their very summits, intersected by deep and dark ravines, frequently enlivened by waterfalls, or divided by winding valleys, terminate the delightful prospect. (Ellis 1969:76-77)

After the consolidation of the rulership of the Hawaiian Islands by Kamehameha I early in the nineteenth century, Lahaina became the "capitol" of the kingdom until the 1840's when the government moved to Honolulu.

C. Mid 19th Century through Mid 20th Century

The Mahele

By the mid 1800's Hawai'i - particularly Lahaina - was infiltrated by a growing foreign community of business entrepreneurs, transient whalers, and Calvinist-minded missionaries; all of whom had interests to protect and virtues to advocate upon the traditional Hawaiian people. Encouraged by these foreign factions, the western-like land divisions of the Mahele were instigated under Kamehameha III (King Kauikeaouli). Beginning in 1848, the Land Commission oversaw land divisions of three groups: Crown Lands (for the King); Konohiki Lands; and Government Lands, all of which were "subject to the rights of native tenants" (Wong-Smith in Graves 1991). In the lands between Mā'alaea and Lahaina, only two of the project area's *ahupua'a* - Olowalu and Ukumehame - are listed as Crown Lands and none are listed as Government Lands.

Between 1849 and 1855, the Land Commission began awarding fee simple titles, termed *kuleana*, to the natives or *maka'āinana* who occupied or cultivated plots on the Crown, Konohiki, or Government Lands (*ibid.*). In theory, the land claims were to be awarded on the condition that the claimants could prove that "they cultivated their land for a living" with no intention of expanding their land boundaries (*ibid.*). However, despite the effort to allocate lands to the *maka'āinana*, *ali'i* control of Lahaina lands persevered and as the future indicated, much of these lands were ultimately obtained by foreigners specifically for sugarcane enterprises. The Euro-American pressures to obtain Lahaina property is evidenced prior to the Great Mahele - in 1840 - in which the entire *ahupua'a* of Launiupoko was "conveyed" by the King to Thomas Phillips and his heirs born in Hawai'i (Native Register files, Vol. 1:163):

> I, Kamehameha II do hereby convey absolutely to Thomas Phillips and his heirs born in Hawaii, a certain parcel of land outside of Lahaina, Maui, named Launiupoko, and all the rights pertaining thereto.
>
> Said land to Thomas Phillips and his heirs born in Hawaii and shall be for them forever.
> It is agreed that this land shall not be conveyed to a haole or one who does not reside in Hawaii.
>
> In testimony whereof, we sign our names and set our seals on this 19th day of September, 1840, at Lahaina, Maui.
>
> Kamehameha II
> Kekauluohi
> Thomas Phillips

Of the *kuleana* awarded in the Lahaina District (specifically within *ahupua'a*

crossed by the preferred alignment) most land claims were made for agricultural plots and some houselots along Ukumehame, Olowalu and Kaua'ulu Stream, and scattered throughout the alluvial plains and coastline associated with these streams. Perusal of the Land Commission Awards within the preferred alignment reveal that *lo'i* and *kula* crops (or *kihapai*) were under cultivation. The transmission line will only pass overhead of a few of these lands (Figures 8A and 8B).

Based on the distribution of Mahele period LCA's shown on modern tax maps of Kaua'ula stream valley and more accurately on early cane maps of the general region of Olowalu and Ukumehame Valleys, inland occupation and agricultural use is also indicated along the major stream gulches and upper alluvial plains. Again, these land claim testimonies account that *lo'i* were cultivated in the wetter gulch basins adjacent to streams and *kula* crops or *kihapai* presumably along the dryer upper alluvial plains (the most commonly mentioned *kula* crop types were sweet potatoes, *wauke*, and dryland taro). Although the modern tax maps generally do not reveal LCA's which were likely present on the alluvial plains adjacent Kaua'ula stream, an early cane map (ca. 1887) developed prior to expansive cane agriculture in Olowalu and Ukumehame valleys does show a significant pattern of land use differentiation between the alluvial plains and stream gulch areas. LCA's are generally side-by-side adjacent to the streams and upper gulch perimeter, while LCA's within the alluvial plains have a more scattered distribution which still cluster nearby to the stream areas.

References to adjunct *po'alima*, or agricultural lands tended for the *ali'i*, and *konohiki* lands are accounted in the above native or foreign testimonies. One of these testimonies claims that the *konohiki*, had three *lo'i* plots in the middle of his land. Following the Mahele, in 1871, surveyors noted that "140 konohiki lois" were present on one side of Olowalu stream (Letter to J.O. Dominis from Nahaolelua, September 14, 1871- State Archives files).

The Sugarcane Era

The sugar cane Ellis observed in the environs of Lahaina in the 1820's would become, during the second half of the nineteenth century, the basis for a commercial venture that would reshape the landscape within much of the present study area. Three primary sugarcane enterprises developed during the mid to late 1800's between the lands of Lahaina and Mā'alaea: Pioneer Mill Company; Olowalu Sugar Company; and Hawaiian

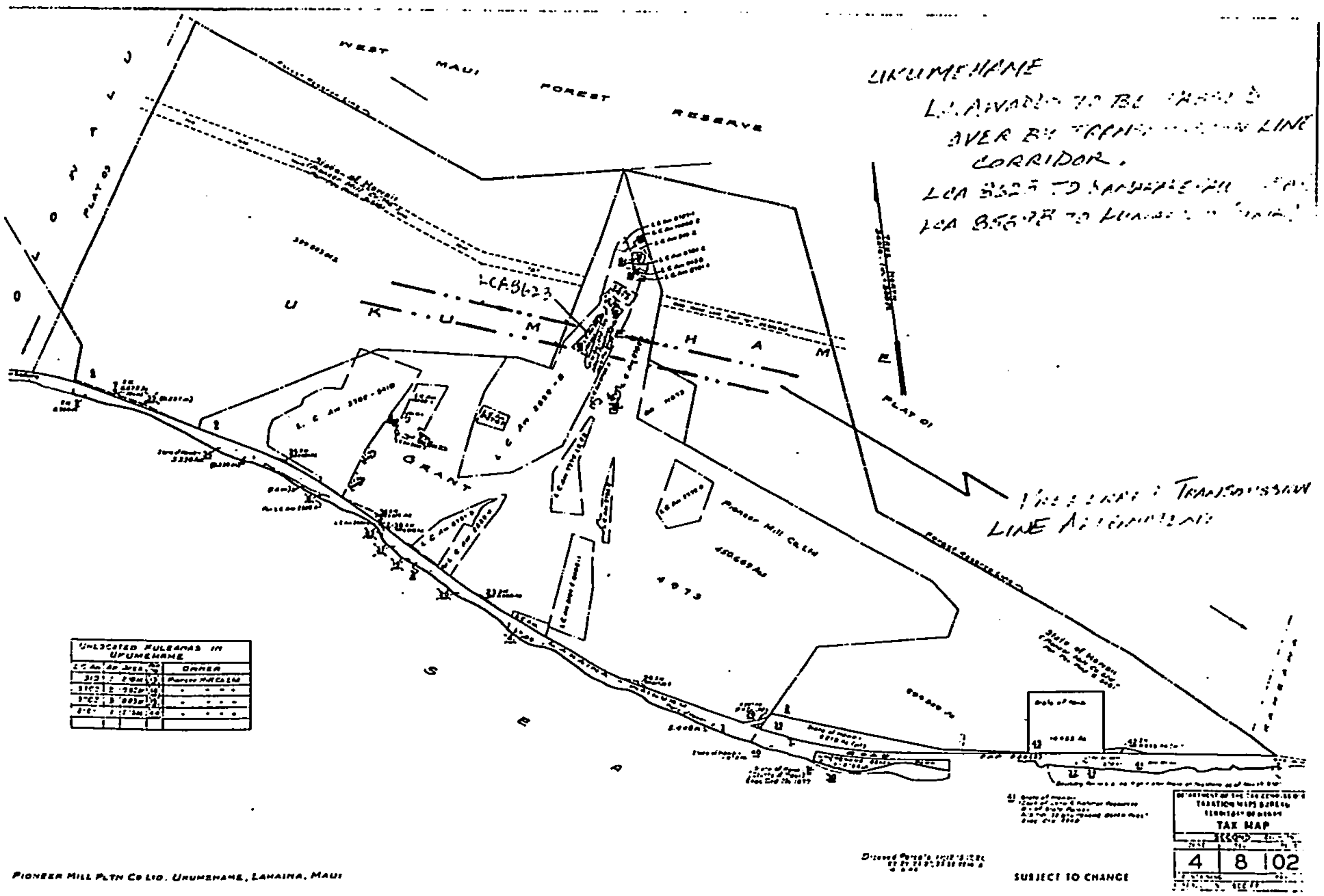


Figure 8A Maui County Tax Map 4-8-02 Showing LCAs In Ukumehame Crossed by Preferred Transmission Line Alignment

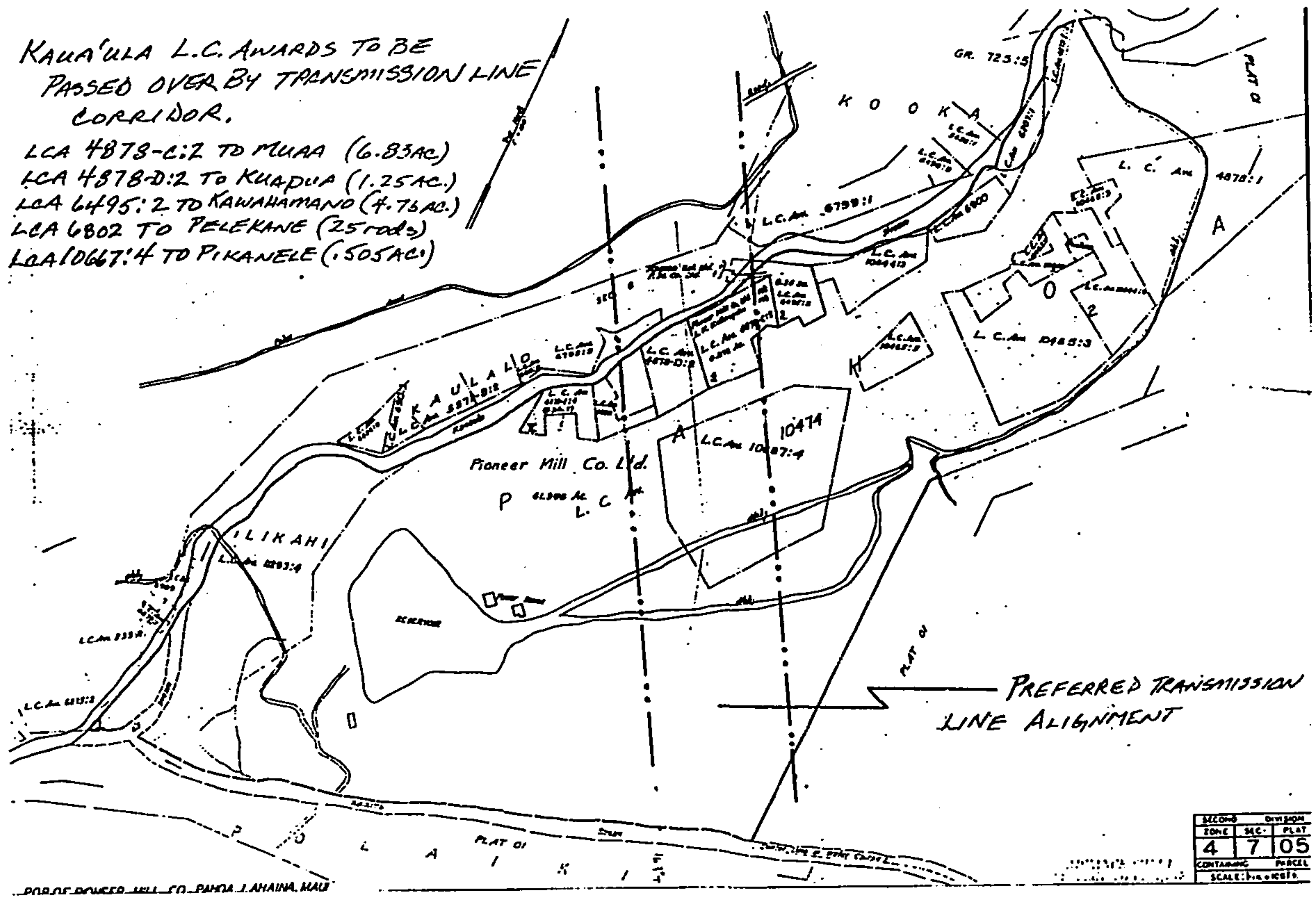


Figure 8B Maui County Tax Map 4-7-05 Showing LCAs in Kaua'ula Crossed by Preferred Transmission Line Alignment

Commercial and Sugar Company.

Pioneer Mill Company

Lahaina was the location of some of the earliest sugarcane ventures in Hawai'i. The first Lahaina mill was operated by Judge A.W. Parsons in 1849. This mill plus 1000 acres of land was subsequently auctioned to O.H. Gulick. The Lahaina Sugar Company was established in 1859, under the direction of Henry Dickenson (Wong-Smith in Graves 1991:A6).

James C. Campbell, an Irish entrepreneur arriving in Lahaina in 1852, founded the Pioneer Mill Company in partnership with Henry Turton in 1865 (Condé and Best 1973:252). The first Pioneer Mill plantation lands were deeded to the partners by Benjamin Pittman for the price of $30,000 (*ibid.*). How Pittman obtained such a sizable piece of land is unknown, however, one may posit that the first Pioneer Mill lands were in Launiupoko *ahupua'a* which was acquired by Thomas Phillips in 1840. (Wong-Smith in Graves 1991:A6). Helen Wong-Smith suggests that transferral of the Launiupoko land to Pittman may be documented in the Probate of the will of Thomas Phillips [2nd Circuit Court] presently on file at the State Archives (*ibid.*).

In 1877, the entire Pioneer Mill plantation holdings were evaluated as being worth $500,000 (Wong-Smith in Graves 1991:A6-7). Henry Turton is credited during the early 1880's with planning construction of the first railway in Lahaina to facilitate cane hauling from the cane fields in Kā'anapali to the Lahaina-based mill. The Pioneer Mill was incorporated in 1885 and sold to H. Hackfeld & Company, the predecessor of Amfac, Inc. (Wong-Smith in Graves 1991:A9).

General reorganization of the Pioneer Mill Company began around the turn of the 20th century. A prospectus for change describes assets of the four main cane fields composing the company at that time (Condé and Best 1973:253):

> Lahaina - 1,000 acres of land on the flat and outside of small kuleanas, (land areas claimed by the Hawaiians under Royal grants), the land is fee simple (could be deeded).
>
> Launiupoko - 2,900 acres of fee simple land, lying between Lahaina and Olowalu.
>
> Wahikuli - A tract of government land of 5,000 acres, under lease for eighteen years, lies between Lahaina and Kaanapali.

> Kaanapali - Some 3,600 acres at various levels, fee simple land, beyond Wahikuli.

An immediate result of the reorganization was construction of "twenty miles" of new railroad replacing old lines and extending the entire length of the plantation, with branches emanating *mauka* into the upper elevations of the cane fields (*ibid.*). By the late 1920's, the Pioneer Mill Company developed a complex of irrigation systems including flumes used to transport cane to railroad "car loading stations" (Condé and Best 1973:254). The preferred alignment crosses numerous concrete and stone-masoned irrigation ditches probably dating to this period from Ukumehame stream to Kaua'ula stream. As suggested by archaeological evidence and respective cane maps, the Pioneer Mill may have developed irrigation canals and flumes at an earlier time in Launiupoko; two of these structures (a metal flume and irrigation canal or ditch) are located within the present study area and were previously recorded by PHRI (Graves 1991). The Graves Report (*ibid.*:5) suggests that this flume (State site 50-50-03-2677A) and contiguous irrigation canal (State site 50-50-03-3173 [PHRI designated site # 2677B]) may have been constructed in Launiupoko as early as 1906. This is based on a 1906 inscription located at the head of the flume. However, examination during the present study of an unlabelled Pioneer Mill map (possibly titled: *Canefield Map - 1918 MC-10 to 33*) differentiates the irrigation canal and flume as the "new flume" and "old flume, respectively. Thus, suggesting that both structures are not contemporaneous in origin.

In May of 1931 the Pioneer Mill Company expanded their cane enterprise as far as Ukumehame to the east through the purchase of Olowalu Sugar Company (Condé and Best 1973:264). During this same period, less lucrative cane fields - specifically in upper Launiupoko (in the preferred alignment area) - were abandoned for the most part due to labor shortages "imposed by World War II" (Graves 1991:5).

A dramatic technological change to cane production of the Pioneer Mill occurred in 1946 when it became more economical to use trucks to transport the harvested cane instead of railroad carts. As reported in a Pioneer Mill Co. annual, the year of 1953 marked the final elimination of railroad use in the Pioneer Mill Company (in Condé and Best 1973:255):

> Change in the operation - as a result of an exhaustive study by the combined staffs of Pioneer Mill Company, and American Factors, Ltd.,

Plantation Division, the railroad system was eliminated. All cane will be hauled by truck on a shift basis.

During the 1930's the Pioneer Mill Co. also began cattle ranching, specifically in the abandoned cane fields of Launiupoko. According to Herbert Kinores, Pioneer Mill Co. ranch foreman, ranching infrastructure including walls, fences, and wooden and stone-walled corrals were constructed in the Launiupoko region above the cultivated cane fields (Graves 1991:7).

Olowalu Sugar Company

The Olowalu Sugar Company - originally named the West Maui Sugar Company - was established by King Kamehameha V in the 1870's (Condé and Best 1973:263) on lands between Olowalu and Ukumehame *ahupua'a*. A June 2, 1871 letter from P. Nahaolelua to the Commission of Crown Lands documents that the West Maui Sugar Company acquired the lands of Ukumehame and Olowalu through a lease of $300 a year (State Archives files). An 1887 *Olowalu Sugar Plantation* map shows that the cane fields were distributed somewhat erratically among *kuleana* between the alluvial flats of Olowalu and Ukumehame streams. The company's mill was located on the Olowalu shoreline peninsula.

The *Hawaiian Gazette* reported in 1882 that "Olowalu Mill has just completed its railroad to Ukumehame" (in Condé and Best:263). The Olowalu Sugar Company railroad is revealed on the 1887 cane map as extending from the mill and diverting into two *mauka*-directed lines in east and west portions of the Olowalu cane fields (Figure 9A and 9B). Only a section of railroad is displayed adjacent to the Government Road in Ukumehame (the latter likely indicates that the map is somewhat incomplete). The earlier method of using mules for transporting harvested cane is evidenced on the 1887 cane map by the existence of a mule pen adjacent to the Mill.

As noted above, the Olowalu Sugar Company was purchased by the Pioneer Mill Company in 1930-1931. A brief hint of economic hardship for the Olowalu Sugar Company is given in a 1930 company annual stating that a gas-operated locomotive was ordered to replace the old steam locomotive "which proved itself too expensive in upkeep during the 1930 crop" (Condé and Best 1973:263).

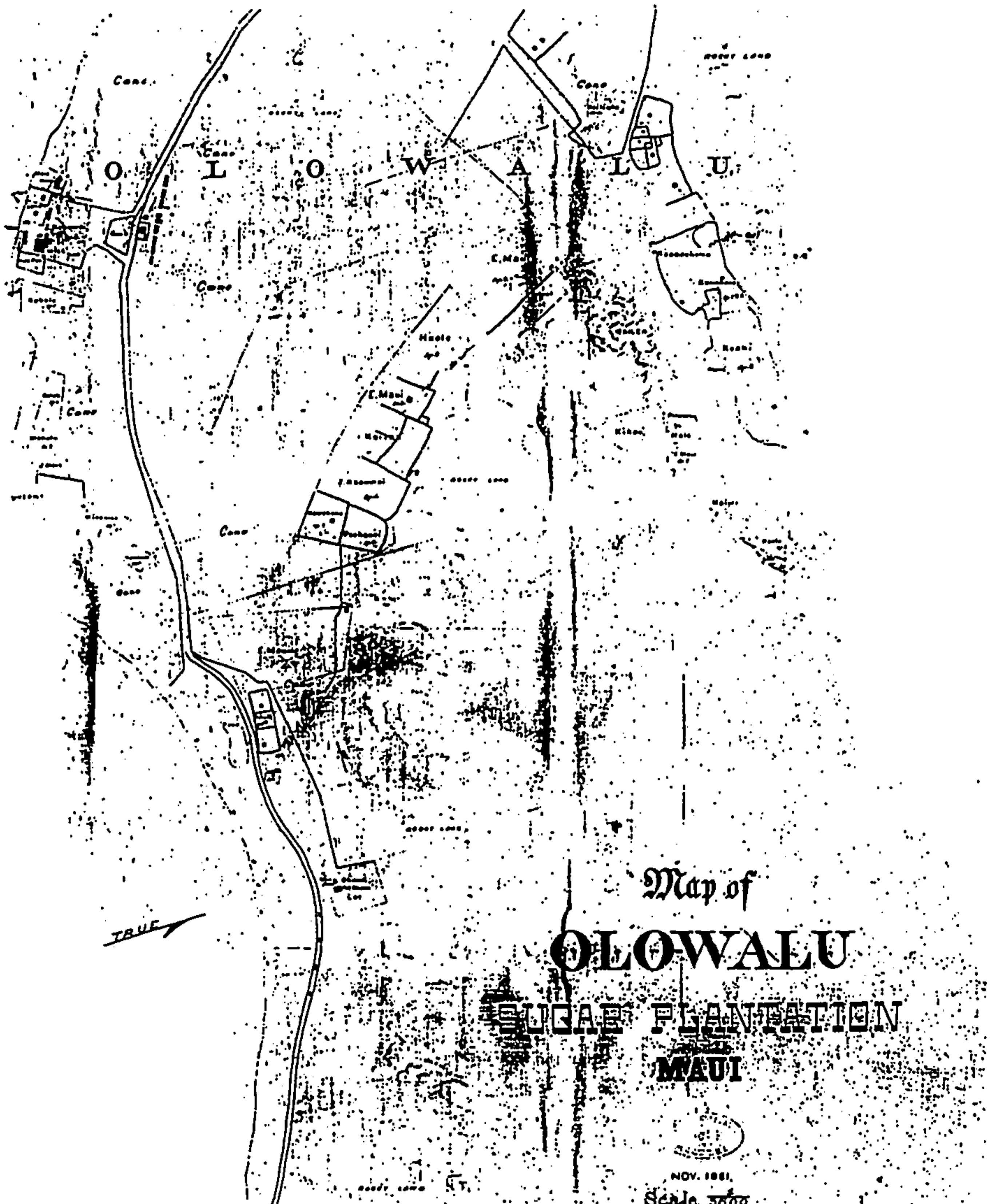


Figure 9A Ukumehame Portion of Olowalu Sugar Co. Plantation Map 1887, Showing Locations of Railroad Tracks, Cane Fields and *kuleana*

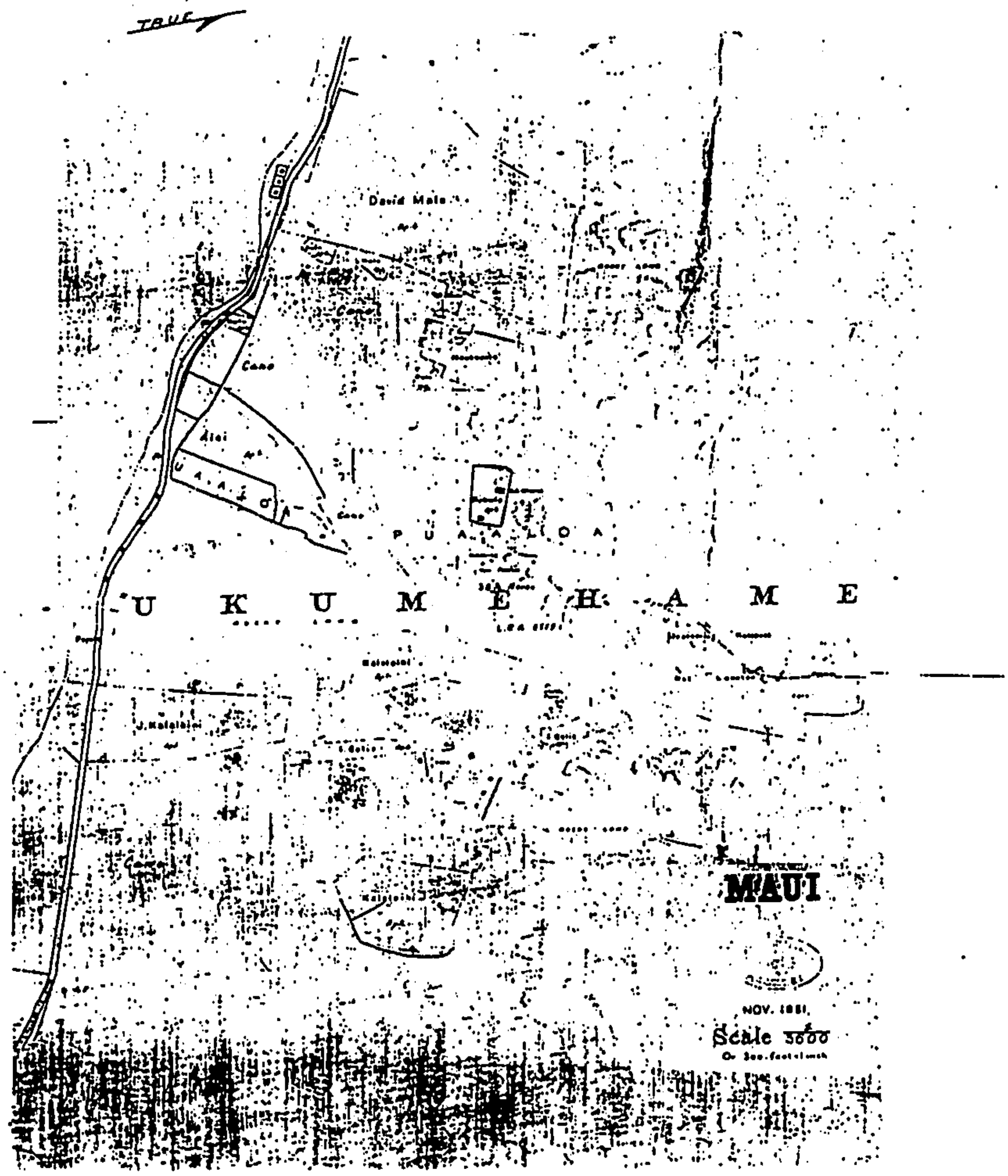


Figure 9B Olowalu Portion of Olowalu Sugar Co. Plantation Map 1887, Showing Locations of Mill, Railroad Tracks, Cane Fields and *Kuleana*

Hawaiian Commercial and Sugar Company

Sugar plantation agriculture in East Maui expanded quickly to the central isthmus under the direction of the Hawaiian Commercial and Sugar Company, first incorporated in September of 1878 (Condé and Best 1973). This brought about major changes to the landscape of Mā'alaea, located at the east end of the preferred alignment.

In addition to widespread plowing of the alluvial fans of Mā'alaea, major irrigation ditches and associated reservoirs were built to bring water from Wailuku to Mā'alaea. Hawaiian Commercial & Sugar Company's railroad system in central Maui was completed in the early 1880's and continued to deliver cane to the Puunene Mill until 1950 when it was completely phased out. However, from 1918 and on the plantation began using motorized vehicles which ultimately replaced the railroad (*ibid.*).

Although none of the old railroad bed or track remains in the Mā'alaea area other "than twisted pieces of rail imbedded in concrete" (Folk and Hammatt 1991), a section of the railroad once crossed the preferred alignment on South Kihei Road. Mining for road building materials at Pu'uhele, located adjacent to the preferred alignment, was also undertaken by the Hawaiian Commercial & Sugar Company.

D. Modern Landuse - *ca.* 1950 to Present Day

The intensive sugarcane agriculture under the direction of Pioneer Mill continues to operate in the present day in the areas between Kahana and Ukumehame valleys of the Lahaina District, and in the Mā'alaea region by A & B Properties. The cultivation of pineapple is actively pursued in Mā'alaea

on the west side of Hono-a-Pi'ilani Highway.

The upper elevations of Ukumehame *ahupua'a* are currently used for cattle grazing by Perreira Ranch. Existing fences exclude the roaming cattle from *makai* localities of Ukumehame, and at least two known access gates are located off Hono-a-Pi'ilani Highway just *mauka* of McGregor's Point and inland of the pineapple fields at Mā'alaea.

Ranching in the Launiupoko region was apparently terminated by the Pioneer Mill Co. during the 1970's due to drought and "falling market prices" (Graves 1991:7). At present the old ranch land of Launiupoko is abandoned - except for gaining access along existing jeep roads to upper cane fields.

Scattered residential units are currently present within the Ukumehame, Olowalu and Kaua'ula stream areas. These isolated house lots are referred to as *kuleana* (Kimo Falconer, personal communication 1993) and likely represent original boundaries of land claims made during the Mahele. For example, the preferred alignment crosses directly over a *kuleana* currently used as a piggery in Ukumehame Gulch.

During the 1970's Maui Electric installed a powerline between Mā'alaea and the town of Lahaina. The existing line stretches over elevations of between roughly 600 and 2600 feet above mean sea level.

An unnamed *pu'u* located between Olowalu and Launiupoko is presently a quarry or "borrow pit". Immediately west of the *pu'u* is an old landfill site which is currently being buried.

Summary

The cultural setting presented above clearly indicates that the lands between Mā'alaea and Lahaina, particularly in the Lahaina District, were used intensively during prehistoric and early historic times. These lands offered abundant ocean resources and productive agricultural lands to sustain a thriving Hawaiian community and as a result, many battles ensued between warring chiefs to gain control over these valuable properties. Although the Mā'alaea area was less inhabited than the Lahaina region, it was an early important crossroads for travelers due to its advantageous geographical location, notable canoe landing, and well-known Kapoli Spring in Mā'alaea Bay. By-passed by the historic Wailuku to Lahaina trail, Mā'alaea seems to have lost some of its importance in the later historic period.

Traditional Hawaiian agricultural practices are noted by Land Commission Awards (*kuleana*) of the Mahele. Additionally, archaeological and ethnographic evidence also reveal that wet-land taro or *lo'i* and *kula* crops were intensively cultivated by the *maka'āinana* in the stream valleys and flood plains of Ukumehame, Olowalu, Kaua'ula, and possibly Launiupoko. The *konohiki* and other *ali'i* likely controlled the maintenance and surplus of certain crops as is revealed by references in Native and Foreign Testimonies to adjacent *poalima* and *konohiki* crops. Such control over the surplus agricultural goods following western contact was certainly lucrative for the *ali'i*. Agricultural produce in great demand by whalers and sea-faring explorers was traded for western goods coveted by the Hawaiians.

Following western contact the scene at Lahaina and surrounding environs changed drastically as Euro-Americans plagued the Hawaiian populace with disease, as well as the introduction of a different method of economics through the trade of western goods. Perhaps the biggest change experienced by the Hawaiian people was the western style of land ownership culminating in the Mahele of the mid 1800's.

Assisted by the land divisions of the Great Mahele, foreigners were able to obtain land through either lease or actual purchase. Consequently, a majority of the prime agricultural lands between Mā'alaea and Lahaina were ultimately appropriated by foreign entities for the sole purpose of large-scale sugarcane agriculture.

Sugarcane agriculture continues in present days to encompass the majority of the prime agricultural lands (alluvial fans) of the Lahaina and Mā'alaea areas, while the coastal regions are the focus of a booming tourist industry and continued residential use.

IV. PREVIOUS ARCHAEOLOGICAL RESEARCH

Four separate archaeological studies were previously conducted in the Ukumehame, Olowalu, Launiupoko, and Mā'alaea areas of the preferred alignment (Walker 1931; State Historic Division files (1973); Tomanari-Tuggle and Tuggle 1991); Graves 1991; and Folk and Hammatt 1991).

Previous Studies of Ukumehame and Olowalu Stream Areas

The first attempt at an island-wide systematic archaeological survey was undertaken by Winslow Walker of the Bishop Museum between 1928 and 1929. Corroborating the Handys' later observation of *lo'i* in *ahupua'a* within the study area, Walker (1931:71) noted: "Terraces for the cultivation of taro were seen on West Maui in the vicinity of... Lahaina, Olowalu, and Ukumehame"

Walker also recorded three *heiau* which are within or in close proximity to the preferred alignment: Hiki'i *Heiau* (State Site No. 50-50-08-2); Ukumehame *Heiau* (50-50-08-3); and Kawai'aloa *Heiau* (50-50-08-4). All three *heiau* were originally identified by John F.G. Stokes in 1916 and recorded in Thomas G. Thrum's *Hawaiian Annual* of 1918. Walker mentions in his site descriptions that the three *heiau* contained graves, all of which were reportedly of "recent date". In Thomas Thrum's report on Ukumehame *Heiau* he "questions the use of this structure as a heiau on the advice of his informant, Kaahi, who says it was only a graveyard" (*ibid.*:107). No other information about the origin of the three *heiau* is given other than that Hiki'i *Heiau* was built for a chief named Hiki'i.

Approximately 62 years later in 1973 the Department of Land and Natural Resources, State Parks Division conducted a similar island-wide archaeological survey, as a follow-up to Winslow Walker's study. As a result of the 1973 survey, Hiki'i, Ukumehame and Kawai'aloa *Heiau* were thoroughly documented and the sites were established in the Hawaii Inventory of Historic Places (in State Historic Preservation Division files).

Previous Study of Upland Ukumehame

An archaeological inventory survey along the historic-era Lahaina Pali Trail was completed by International Archaeological Research Institute, Inc. (Tomanari-Tuggle and Tuggle 1991). The project was undertaken as part of the Na Ala Hele program to establish a Hawaii statewide trail and access system. Na Ala Hele is under the direction of the State of Hawaii, Division of Forestry and Wildlife, Department of Land and Natural Resources.

The Lahaina Pali trail presently spans 4.5 miles across the "lower southern slopes of the West Maui Mountains" between Hono-a-Pi'ilani Highway east of Ukumehame State Beach Park to the inland edge of the pineapple fields near Mā'alaea Harbor (*ibid.*:5). The trail crosses a range of elevations between 100 to 1600 feet above mean sea level. During the survey, 18 sites were identified adjacent to the trail, including the following formal functional types: alternate trail routes, water diversion, quarrying, trailside art (petroglyphs), storage and shelters. Tomanari-Tuggle and Tuggle suggest that all sites (except for two sites: a midden scatter and a rockshelter) were related to the use of the trail. The Lahaina Pali Trail itself was reportedly constructed around 1841 and used for approximately 50 years as a main roadway between Lahaina and the Maui isthmus (*ibid.*:13). The midden scatter and rockshelter sites are located on the western end of the trail at a location that allows direct access to the traditional farm lands of Ukumehame valley.

A traditional Hawaiian *mauka-makai* trail was observed along the eastern portion of the Lahaina Pali trail subsequent to the Tomanari-Tuggle and Tuggle study (Michael Baker, personnel communication 1993). Only remnants of this trail are visible. The trail is intersected by the Lahaina Pali trail at approximately 800 feet above mean sea level. The *mauka-makai* orientation of the Lahaina Pali trail and the traditional Hawaiian trail *makai* of their point of intersection suggests that the Lahaina Pali Trail may have been constructed over the traditional trail to as far as Pu'uhele.

Launiupoko Previous Study

Paul H. Rosendahl, Inc. conducted an archaeological inventory survey of an approximately 440-acre project area encompassing the alluvial plain of Launiupoko stream (Graves 1991). The survey identified 47 sites consisting of over 70 component

features. A variety of functions were assigned to the component features including: agricultural, animal husbandry, habitation, temporary habitation, and marker.

Agricultural features (composing 60% of Grave's sites) - especially terraces, contouring "virtually every slope north of Launiupoko Gulch" (*ibid.*:29) - were the most predominate functional type identified in the Lauinupoko project area. In addition to the terrace feature type, agricultural plots, mounds, cleared areas, irrigation canals and retaining walls were also identified. Some of the terraces and irrigation canals may be historic in origin (the metal flume undoubtedly) and associated directly with the large-scale cane agriculture developed by the Pioneer Mill Co.

Habitation sites (representing 19% of Grave's sites) include rock-filled terraces, uprights, overhangs, enclosures (e.g. C-shapes and L-shapes), and rock alignments. Agricultural features were present at all of the habitation complexes and overhangs (rockshelters) were primarily located within Launiupoko Gulch.

All of the archaeological remains related to animal husbandry in the project area (represented by six of the sites) are attributable to historic cattle ranching, initiated by the Pioneer Mill Co. in the 1930's (*ibid.*:7).

Radiocarbon dates obtained from subsurface testing at the Launiupoko sites fall into two discrete temporal periods: A.D. 1170-1510 and A.D. 1650-1950. One site produced a radiocarbon date range between these two periods (A.D. 1420-1700)(Goodfellow in Graves 1991:20).

In sum, Graves (1991) suggests that the ubiquitous terraces indicate that extensive agriculture occurred over all fertile land open for cultivation. Based on absolute and relative dating of the sites - in addition to historic accounts - Graves posits that two distinct periods of traditional Hawaiian occupation and landuse are indicated for the Launiupoko sites, during the "Expansion Period" (A.D. 1100-1650) and subsequent "Proto-Historic Period" (A.D. 1650-1790)(after Kirch 1985:306).

The "Expansion Period", Graves explains, is characterized by extensive irrigation and dryland farming practiced in "newly exploited environmental zones" of upland and leeward localities (Graves 1991:30). During this period, habitation in the area may have been limited to seasonal or temporary occupation (*i.e.* using C-shaped and L-shaped enclosures). The "Proto-Historic Period", on the other hand, is distinguished from the former period by an increase in permanent occupation of the upland and leeward localities, while intensive agricultural continued to be practiced.

Ms. Graves admits that some uncertainty remains as to whether the widespread terrace complex is indigenous Hawaiian in origin or it was constructed for large-scale cane agriculture. In conclusion Graves speculates that some of the "more useful elements of earlier indigenous agricultural features" were incorporated into use by the large-scale cane agriculturalists (*ibid.*).

Mā'alaea Previous Study

Cultural Surveys Hawaii conducted an archaeological inventory survey of an approximately 600-acre parcel of Hawaiian Commercial & Sugar Company immediately north of Mā'alaea Bay (Folk and Hammatt 1991). As a result of the survey two historic sites - a cemetery (Site 2708) and an irrigation ditch (Site 2709) - were identified. Two additional historic sites are mentioned in the Folk and Hammatt Report as once existing in the project area. These sites include a Hawaiian Commercial & Sugar plantation railroad system and a group of plantation workers houses known as "Camp Seven".

Site 2708 cemetery still contains seven tombstones inscribed in Japanese idiographic characters, and two adjacent mounds may be graves. The cemetery is located immediately north of Pu'uhele where, according to a local informant who lived at "Camp Seven", individuals of different religious groups, including Portuguese, Catholics, Japanese Buddhist, Filipinos, were buried. Informants thought the burials at the cemetery had been relocated long ago.

The plantation irrigation ditch (Site 2709) was identified between Pohakea Gulch along the east side of Pu'uhele and the modern North Kihei Road. The ditch was once part of the Hawaiian Commercial & Sugar Co. plantation's extensive irrigation system of reservoirs and canals for irrigation. The ditch was probably abandoned after the plantation switched to drip irrigation (*ibid.*:23).

"Camp Seven" is described by Folk and Hammatt as once containing a laborers housing area, a *luna* house, and stable area. None these structural components remain intact above ground except for fragments of concrete, culvert pipe, and rails.

The railroad system once present in the Cultural Surveys Hawaii project area was constructed by Hawaiian Commercial & Sugar Co. to transport cane from the fields to Puunene mill. The original track and railbed were not identified during the survey having been removed by the plantation when turnohaulers came into use (*ibid.*:28).

In conclusion, Folk and Hammatt postulate - based on prehistoric and post-contact accounts and natural environment - that it is unlikely the project area was ever used for habitation in ancient times. Prehistoric accounts and place names, however, portray the general area as an important crossroad for travelers.

Implications of Previous Archaeological Studies

Results of the previous archaeological studies conducted within the vicinity of the preferred alignment imply that traditional Hawaiian settlement patterns and landuse described in the prehistoric and historic accounts are also evident in the archaeological record. According to Walker (1931) at least two of the major stream drainages (Olowalu and Ukumehame streams) were the focus of intensive wetland farming, principally in *lo'i*. The survey by Graves (1991) describes a complex of agricultural features which she believes to be non-irrigated or "dryland agriculture" on the old alluvium of Launiupoko stream. One would expect to find similar archaeological evidence in the drier surroundings of the other three major streams and minor stream drainages of the Lahaina District. If so, some degree of irrigation practices may be found in association with these dryland agriculture features. Based on radiocarbon age periods of traditional Hawaiian occupation and landuse are indicated for the Launiupoko sites; one during the "Expansion Period" (A.D. 1100-1650) and another during the "Proto-Historic Period" (A.D. 1650-1790). Following Grave's description, landuse during the Expansion Period would likely be evidenced by the presence of temporary habitation sites among intensive dryland agriculture, with dates falling within the A.D. 1100-1650 range. Occupation of permanent habitation sites in these same localities should date to the Proto-historic Period or the A.D. 1650-1790 range. While the agricultural features should show continuous use from A.D. 1100 through 1790. Thus, a same pattern of chronological development of leeward Maui, particularly the Lahaina District, is expected to have occurred in other arable, *mauka* lands of the project area.

A marked difference in prehistoric and early Hawaiian landuse between the southwestern Lahaina District area described above, and the inland isthmus north of Mā'alaea and upland elevations of Ukumehame *ahupua'a* is depicted by the previous studies presented above (Folk and Hammatt 1991; and Tomonari-Tuggle and Tuggle 1991). The areas dealt with in both of these projects are portrayed as marginal agricultural lands which lack evidence of permanent habitation, except along the coast. Based on prehistoric accounts and place name meanings, Folk and Hammatt emphasize that the Mā'alaea area was a significant crossroad for travelers.

The majority of the sites adjacent to the Lahaina Pali Trail (built *ca.* 1840) are contemporaneous with the trail and are related to construction or use of the trail. The

only exceptions are two prehistoric or pre-1840 sites located at the western end of the historic trail and a remnant *mauka-makai* trail crossed by the eastern portion of the Lahaina trail. Thus, the identification of sites in upper Ukumehame predicts that temporary shelters attributable to both prehistoric and historic use would exist adjacent to trails. Difficulty in recognizing the traditional Hawaiian trail that intersects with, and is in part superimposed by the Lahaina Pali Trail, shows that other traditional Hawaiian trails may be unrecognizable due to the impact of cattle grazing.

Finally, the identification of three major *heiau* (Thrum 1918; Walker 1931; and DLNR 1973) on the upper edges of Ukumehame and Olowalu Gulch, suggests that the Lahaina region - clearly being a significant locality for settlement and agricultural production - was highly valued by the Hawaiian *ali'i* and *maka'āinana*. Although the existence of other *heiau* comparable to Hiki'i, Ukumehame and Kawai'aloa *Heiau* is improbable, permanent habitation sites of *heiau kahuna* or *ali'i* may be found in proximity to the *heiau*.

V. SURVEY RESULTS

A total of 34 sites and complexes were identified during the present study. The following analysis includes all sites located during the inventory survey in the preferred alignment before adjustments (April 1993) and in the preferred alignment after adjustments (June 1993). For the sake of simplicity the term "project area" will refer to both of these survey areas.

A. Formal Site Types

Of the 34 sites identified within the project area 12 represent site complexes which comprise a total of 20 component features. However, this total number of features does not account for the component features of the three site complexes (State site 50-50-03-2677, 50-50-03-2678/2679 [combined site], and 50-50-03-3175) with ubiquitous concentrations of agricultural features and the internal features of the two previously identified *heiau* (State site 50-50-08-2 and 50-50-08-3). The formal site types represented in the project area are presented below (Table 2)

Table 2 - Occurrences of Formal Feature/Site Types

FORMAL FEATURE/SITE TYPE	QUANTITY
Canals	4
Cattle walls	3
Enclosures (C-shaped)	6
Enclosures (L-shaped)	2
Enclosures (irregular-shaped)	3
Enclosures (rectangular)	4
Enclosures (circular)	3
Kerbstone trail	1
Mound	1
Railroad berm	1
Terrace	1
Rockshelter	2
Upright stone	1
Wall-platform	1
Walls	9

B. Functional Site Types

Function of a site or feature is determined by criteria which include: site construction techniques and complexity; context (association with other sites or geographical determinants); cultural content (surface and subsurface); and external

correlations with other archaeological sites of known function in Hawai'i.

Seven primary functional categories were identified among the sites within the present project area. These are: agriculture; cane irrigation and transportation; temporary and permanent habitation, *Heiau*; marker; ranching; and travel route. Some sites have more than one function. Table 3 presents the occurrences of these functional categories identified among the individual sites.

Table 3 - Occurrences of Functional Categories

FUNCTIONAL CATEGORY	QUANTITY
Agriculture	4
Agriculture-temporary habitation	1
Agriculture-temporary and permanent habitation	2
Cane irrigation/transportation	8
Heiau	2
Marker	1
Permanent habitation	1
Permanent habitation-possible burial	1
Ranching	3
Ritual-Temporary habitation	1
Temporary habitation	8
Travel route	1

Summaries of each functional category and their suspected chronological use are presented below.

Agriculture

Four of the project area sites are interpreted as primarily agricultural in function. Two of these sites (Site 50-50-03-3174 and Site 50-50-03-3190) are walls which retain relatively steep slopes on sides of gulches. The other two sites (Site 50-50-03-3175 and Site 50-50-03-3189) are complexes of intensive dryland agriculture features located along older alluvium adjacent to two streams (Launiupoko stream and an unnamed stream to the northwest). The complex features are characterized by a network of rough terraces - generally oriented across slope - and wall alignments which form small planting fields.

Temporary habitation features may be present within the latter dryland agricultural complexes; however, the high concentrations of features in the complexes make it difficult to identify those specific structures in the survey phase. Formal constructions of permanent residences were clearly not present.

One site (Site 50-50-08-3185) contains evidence of agricultural use in association with temporary habitation. Agricultural use at the site is delineated by a single, small feature of interconnected planting enclosures which likely functioned to supply vegetable goods directly to the temporary occupants of the site (occupation at the site was probably associated with traveling *mauka-makai* along the prominant ridge upon which the site is located-see Temporary Habitation summary below).

Two other sites (Site 50-50-03-2677 and Site 50-50-03-2678/2679) have evidence of combined temporary and permanent habitation in association with agriculture. These sites consist of densely concentrated complexes of dryland agricultural features (*e.g.* terracing across slope, agricultural plots, and irrigation canals) with associated temporary and permanent structures. Although some of the features are attributable to large-scale cane irrigation developed during the late 19th and early 20th centuries (*e.g.* irrigation canals and flume), the majority of the complex features appear to be indigenous Hawaiian ones and were likely reused by the cane agriculturists. Temporary and permanent habitation features among the two site complexes are typified by C-shaped enclosures and paved terraces. As suggested by the previous archaeological study conducted at the sites (Graves 1991), the habitation components of the complex were likely utilized primarily during the prehistoric period, with temporary occupation perhaps being the antecedent to permanent occupation.

Cane Irrigation/transportation

Eight sites in the project area are attributable to large-scale cane agriculture of the late 19th and early to mid 20th centuries. Seven of these sites (sites 50-50-09-3163; 50-50-08-3164; 50-50-08-3172; 50-50-03-3173; 50-50-03-3176; 50-50-03-3177; and 50-50-03-3178) are irrigation canals or ditches situated along minor and major (Olowalu, Ukumehame streams) drainages and on the alluvial plains of abandoned cane fields. The irrigation

canals which appear to be older are constructed of parallel or single stone-wall alignments, while the more recent canals are typically comprised of concrete and stone masonry.

One site (Site 50-50-08-3171) is believed to have functioned as a railroad bed used to transport cane from fields to either the Olowalu Sugar Co. mill at Olowalu, or to the Pioneer Mill Co. mill in Lahaina. The railbed is a solid stone-constructed berm which extends along an old stream drainage in between the valleys of Ukumehame and Olowalu. Pioneer Mill personnel had no knowledge of a rail system in the site area and were in fact surprised that cane may have been cultivated in the region due to the rocky surroundings (Kimo Falconer, personnel communication 1993). Nonetheless, its analogous size and architecture to other railroad beds in Hawai'i suggests this functional interpretation. The site's linear extent beyond the confines of the project area was not determined during the survey.

Permanent Habitation

The two sites in the project area that are classified as permanent habitation units (Site 50-50-08-3183 and Site 50-50-08-3184) are located on either side of Ukumehame Gulch; the latter site is associated with a possible burial monument. Permanent occupancy of the two sites are suggested by formally constructed bi-faced walls and paved terraces with living floors ranging between 5.0 $m.^2$ to 40.0 $m.^2$; the 5.0 m^2 living floor size represents the smallest component of a three-feature habitation complex (Site 50-50-08-3184). A possible burial mound is also a component feature of the site.

It is probable, based on Land Commission Award testimony given from this area, that residents of both of these sites maintained agricultural plots of *lo'i* within the Ukumehame stream bottom and planted dryland crops upon the ancient, drier alluvial fan on which the habitation sites are situated. Based on the lack of observed historic-era artifacts, and on the traditional Hawaiian architecture, the sites were likely occupied during prehistoric or early historic times.

Temporary Habitation

Eight of the project sites are classified as temporary habitations. One site (Site 50-50-08-3168) is a complex of temporary habitation features and a possible shrine. Another of the temporary habitation sites (Site 50-50-08-3185) is associated with a small agricultural plot which may have functioned to provide vegetable goods to the temporary occupants of the site.

All of the temporary habitation sites in the project area, with the exception of Site 50-50-03-2684, are believed to be prehistoric or early historic in age. This interpretation is based on the absence of historic artifacts and on the observed traditional Hawaiian techniques used in site construction. The living floor areas of the temporary habitation structures range between approximately 3.0 m^2 (324.0 $ft.^2$) and 45.0 m^2 (486.0 $ft.^2$). The large size of the latter floor measurement (Feature A of Site 50-50-08-3165) is unique among the other temporary habitation structures identified in the project area. However, it is placed in this category based on the predominant type of cultural materials (lithics) in the site that suggests a specialized use other than permanent habitation. The association of Site 50-50-08-3165 Feature A with three other temporary habitation structures was also used for assigning its functional category. Site 50-50-08-3165 is a complex of features used for temporary habitation possibly on a recurrent basis.

The temporary habitation sites consist of between one and six structural features which are typically C-shaped, L-shaped and small circular enclosures, or single wall sections forming shelters against natural landforms, such as cliff overhangs or caves. This last type of shelter is often called a rockshelter. The geographical location of the temporary habitation sites, the predominant functional category of sites in the project area, indicates they were used primarily while traversing on *mauka-makai* travel routes.

Two temporary habitation sites were located in the Mā'alaea portion of the project area, along a conspicuous ridge top of the West Maui Mountains (Site 50-50-09-3182) and on the alluvial plain at the foot of the same ridge (Site 50-50-09-3179). Each of these sites has small floor areas ranging from 1.0 m^2 (10.8 $ft.^2$) to 6.0 m^2 (19.8 $ft.^2$).

Immediately upslope of Site 50-50-09-3182 shelter is an upright stone (Site 50-50-09-3181). The upright stone is situated on an elevated outcrop and likely marked the location of the site downslope and perhaps an old ridge trail.

It is not clear what associations Site 50-50-09-3179 had in the past, whether a part of a travel route as rest stop or as a field shelter in an agricultural landscape now gone.

Seven of the temporary habitation sites are located within the region of Ukumehame gulch in three different settings: on the higher elevations of the alluvial fan

east and west of the gulch; ridge top west of the gulch; and along the slope and basin of a prominent valley immediately west of Ukumehame Gulch.

Three sites of the seven sites are situated on the alluvial fan east of the Gulch (sites 50-50-08-3165, 50-50-08-3186, and 50-50-08-3187). Limited subsurface testing at Site 50-50-08-3165 revealed a cultural layer consisting predominantly of tools and debitage associated with stone-tool manufacturing.

Two of the seven sites are located on the first ridge to the west of Ukumehame Gulch (Site 50-50-08-3168 and Site 50-50-08-3185). The location of these two sites on a traversable but steep ridgetop which ascends the west side of Ukumehame Valley suggests that a *mauka-makai* trail once existed there. A commanding view of the Lahaina coastline and Ukumehame valley is also afforded by the sites' position.

Site 50-50-08-3168 is unusual in the configuration of one of its features. The feature (Feature A) consists of two structures - a platform and a bifaced wall - aligned parallel to each other - approximately 1.5 m. (4.9 ft.) apart - on a small bluff of the ridge. If a travel route once existed on this ridge it would have led between the two structures of this feature and was probably utilized as a shelter or temporary habitation.

Site 50-50-08-3169, located along the valley slope west of Ukumehame Gulch, represents a temporary habitation complex with the greatest quantity of component features (6) in the project area. The individual features of the complex are small and rough construction of walls, alignments and enclosures built upon or modifying boulder outcrops dominating the terrain.

Site 50-50-08-3188, a rockshelter, is located adjacent to a dry streambed on an alluvial fan west of Site 50-50-08-3169. The rockshelter contains a well-constructed semi-circular wall abutting the vertical face of a large boulder.

Atypical to the general pattern of the other temporary habitation sites in the Ukumehame valley area, the latter two sites do not appear to be located on terrain of potential travel routes. The specific locations of the features do indicate, however, that the prominant outcrops of bedrock were selected for site locations.

The last sites identified as temporary habitations in the project area is Site 50-50-03-2684. It is a major rockshelter located in the cliff face of the gulch of Launiupoko Stream. The site was previously identified by Graves (1991), who argues that the site was modified and occupied primarily during the historic period by ranchers. Prehistoric use of the site is also suggested by Graves based on its proximity to another rockshelter primarily prehistoric in age.

Heiau

Two major *heiau* (Ukumehame and Hiki'i *heiau*) are located in the project area on the east and west sides of Ukumehame Stream and third *heiau* (Kawai'aloa *Heiau*) is located in proximity, but outside of the project area on the east side of Olowalu Gulch. All three of these sites have been previously documented by a succession of archaeological studies (Thrum 1917; Walker 1931; and DLNR 1973).

The location of the three *heiau* overlooking the fertile agricultural lands of Ukumehame and Olowalu stream valleys could be used to support Michael Kolb's arguments that "the most elaborate monuments were constructed in the regions with important but restricted resources" (Kolb 1991:360).

Kawai'aloa *Heiau* (Site 50-50-08-4) represents the largest and most formally constructed of the three *heiau*. It measures approximately 2,400 $m.^2$ (25,920 $ft.^2$). The *heiau* perimeter consists of a massive wall forming a walled rectangular enclosure. The perimeter enclosure wall measures up to 3.6 m. (12.0 ft.) wide by 3.3 m. (10.0 ft.) high. Within the perimeter walls is a network of smaller enclosures, platforms, and stone-lined depressions. Shelf-like terraces are present along the outside perimeter of the main enclosure wall. The size and complexity of Kawai'aloa *Heiau* (indicating a large labor expenditure) suggests that it was under the direction of high-ranked *ali'i*.

Hiki'i *Heiau* (Site 50-50-08-2), located on the east side of Ukumehame Gulch, has a similar construction style as Kawai'aloa *Heiau*, but is smaller in size, measuring approximately 768.0 $m.^2$ (8,294 $ft.^2$). Winslow Walker observed two distinct building episodes in the *heiau* construction: "The outline of the edge of the old wall can be seen below the modern wall" (Walker 1931:106). Hiki'i *Heiau* is oriented with its long axis extending parallel to the edge of the gulch (SW-NE) and its ascending topographical surface faces towards the southwest. According to a local informant, Hiki'i *Heiau* was named for a chief Hiki'i (Thrum 1918:128) under whom the *heiau* was likely constructed. Given its orientation overlooking Ukumehame Stream - where abundant *lo'i* plots were likely located - the *heiau* may have been utilized as an agricultural temple (*i.e. hale-o-Lono*), hence being situated "relative to the domain of a particular god" (Kolb 1991:81). On

the other hand, with Kawaia'loa *Heiau* also located above potential *lo'i* plots in Olowalu Stream, both of these promontory locations may have been chosen because they represent some type of religious "sanctity" (*ibid.*:82). With the higher grounds in essence serving to affirm "the divine and inaccessible nature of high-ranking *ali'i* (*ibid.*). If it is indeed an agricultural *heiau* then one would expect to find through subsurface excavation a sufficient decline in the quantity of sacrificial remains and paucity of pig bones - typically recovered at sacrificial *heiau or luakini* (*ibid.*:276).

Ukumehame *Heiau* takes its name from the DLNR archaeologists who recorded the site in 1973. Presently and during early documentation of the site in 1931 (Walker) the *heiau* is only partly preserved due to destructive historic activities probably specific to ranching and large-scale cane agriculture. The *heiau*, as it was observed by Walker, consisted of a network of wall sections delineating the northeast and southwest perimeter of the site. Inside the *heiau* wall were at least six platforms, an enclosure, linear terraces and one "pit" or constructed depression. Similar to Hiki'i *Heiau*, Walker observed that a modern wall was built on top of an older wall. Overall, Ukumehame *Heiau*, during the time of Walker's study, measured 975.0 $m.^2$ (10,530 $ft.^2$). A local informant living during the early 1900's doubted that Ukumehame *Heiau* was indeed a *heiau*, but rather that it was a graveyard. Walker emphasized, however, that many Maui *heiau* contained graves, and for that reason it was difficult for "modern" Hawaiians to distinguish between a *heiau* and graveyard (*ibid.*:107).

Burials of historic age were noted by Walker within the interior of all three of the *heiau* discussed above. Although the burials post-date actual religious use of the *heiau*, it may suggest that *heiau* were perpetuated throughout time as being sanctities which were connected to the gods and possibly afterlife.

Michael Kolb speculates that enclosure *heiau*, as opposed to terrace or platform *heiau*, were constructed *ca.* A.D. 1600, at the same time that human sacrificial *heiau* (*luakini*) were being built (Kolb 1991:370). Kolb also believes that construction of leeward *heiau* were "relatively late, when population growth forced expansion into marginally productive environments" (*ibid.*:259). Thus, a similar temporal period of construction is suggested for Hiki'i, Ukumehame, and Kawai'aloa *Heiau*. However, this does not account for the possibility that an earlier structural component - particularly at Kawai'aloa and Hiki'i *Heiau* - exists beneath or within the *heiau* enclosures.

Marker

One site (Site 50-50-09-3181) in the project area is interpreted as a marker for delineating the location of a temporary habitation Site 50-50-09-3182 (discussed previously) or a logical travel route to *mauka* localities, however, no constructed trail feature was observed in the area). The sites are situated on a conspicuous ridge top of the West Maui Mountains of Ukumehame which descends easterly to the central isthmus of Maui near Mā'alaea. Site 50-50-09-3182 is a single slab-shaped boulder that is set upright in an outcrop.

Ranching

Three sites in the project area (sites 50-50-08-3167, 50-50-08-3170, and 50-50-08-3170) are sections of bifaced stone walls crossed by the preferred alignment in between the valley areas of Ukumehame and Olowalu. These walls, based on their location immediately above existing cane fields, are suggested to be exclusion walls to confine cattle upland of the cane fields. Cattle ranching in the Launiupoko area began in the early 1930's under the direction of the Pioneer Mill Co. It seems likely that the range land would have extended at least as far as the cane fields, *i.e.* Ukumehame valley.

Transportation Route

One traditional Hawaiian trail remnant (Site 50-50-09-3191) was identified just *makai* of the project area along a prominant ridge of the West Maui Mountains. This ridge descends towards the central isthmus inland of Mā'alaea. The trail could not be identified within the preferred alignment, however, the *mauka-makai* orientation of the trail remnant indicates that it once crossed the preferred alignment, and possibly intersected with a major travel route along Kealalaloa Ridge to Pu'u Kukui.

Site 50-50-09-3191 trail was pointed out from the air by Michael Baker of the Division of Forestry and Wildlife, DLNR. It consists of two parallel alignments of stones comparable in character to known kerbstone trails (*e.g.* Robins *et al.* 1993). This type of kerbstone trail is classified as a "Type AB" trail and described as a traditional Hawaiian pedestrian trail which was subsequently modified with a perimeter of stone curbing and extended in width for use as a horse trail (Apple 1973). Site 50-50-09-3191 trail diverges from the Lahaina Pali trail at approximately 800 feet above mean sea level and heads *mauka* towards the project area. The Lahaina Pali trail appears to have been constructed over Site 50-50-09-3191 trail.

C. Site Descriptions

State Site #:	50-50-08-2	**CSH Site #: 2**
Site Type:	Complex	(See Figure 39)
Function:	*Heiau* (Hiki'i *Heiau*)	
Probable Age:	Prehistoric-early historic	
Condition:	Fair to good	
Dimension:	734.8 m.^{2} (7,935.8 ft.^{2})	
***Ahupua'a*:**	Ukumehame	
Elevation:	160 ft. a.m.s.l.	

Description: Site -2 is a *heiau* located on the east side of Ukumehame Gulch. The *heiau* is known as Hiki'i *Heiau* and was apparently named after a chief for whom it was built. A historic ditch crosses the *heiau's* northwest corner. Vegetation consists primarily of overgrown grasses, *koa haole* and *kiawe*. The *heiau* is currently being cleared of vegetation and religious offerings have been placed in coffee cans on the site's surface.

The site is a complex of platforms, enclosures and paved areas integrated within a roughly rectangular enclosure. The outer enclosure wall is absent in the *heiau's* northeast side and in a section of its northwest side. Portions of the wall are bifaced, but most of the wall retains the interior floor of the *heiau* and upslope ground surface. Several internal features are present inside the *heiau* (see below). The *heiau* complex measures 33.4 (109.5 ft.) N/S by 22.0 m. (72.2 ft.) E/W (on file at the State Historic Preservation Division).

Hiki'i *Heiau* was originally recorded by John F.G. Stokes in 1916 and subsequently described by Thomas G. Thrum in the Hawaiian Annual (Thrum 1918:128):

> Hikii heiau at Ukumehame; on knoll east side of stream about a mile from the sea and 200 feet elevation. Northwest and northeast walls changed and interior used for graveyard. Two remaining walls would indicate a size of 55 feet square. Named after chief Hiki'i (Kaahui, informant aet.93)

In the 1930's Winslow Metcalf Walker recorded and mapped the site (Figure 10). Walker mentions in his description of the site that "graves of recent date" were present inside the *heiau* enclosure. He also observed a modern wall built on top of an older wall of the *heiau* (Walker 1931: 60-61).

Department of Land and Natural Resources State Parks Division archaeologists recorded Hiki'i *Heiau* in 1973 (on file at the State Historic Preservation Division). Nine platforms and two enclosures were documented inside the *heiau*. Three of the platforms and a mound inside the *heiau* were believed to have been the "modern graves" recorded by Thrum and Walker. Interestingly, the possible burial mound is constructed on top of a

CORRECTION

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

Marker

One site (Site 50-50-09-3181) in the project area is interpreted as a marker for delineating the location of a temporary habitation Site 50-50-09-3182 (discussed previously) or a logical travel route to *mauka* localities, however, no constructed trail feature was observed in the area). The sites are situated on a conspicuous ridge top of the West Maui Mountains of Ukumehame which descends easterly to the central isthmus of Maui near Mā'alaea. Site 50-50-09-3182 is a single slab-shaped boulder that is set upright in an outcrop.

Ranching

Three sites in the project area (sites 50-50-08-3167, 50-50-08-3170, and 50-50-08-3170) are sections of bifaced stone walls crossed by the preferred alignment in between the valley areas of Ukumehame and Olowalu. These walls, based on their location immediately above existing cane fields, are suggested to be exclusion walls to confine cattle upland of the cane fields. Cattle ranching in the Launiupoko area began in the early 1930's under the direction of the Pioneer Mill Co. It seems likely that the range land would have extended at least as far as the cane fields, *i.e.* Ukumehame valley.

Transportation Route

One traditional Hawaiian trail remnant (Site 50-50-09-3191) was identified just *makai* of the project area along a prominant ridge of the West Maui Mountains. This ridge descends towards the central isthmus inland of Mā'alaea. The trail could not be identified within the preferred alignment, however, the *mauka-makai* orientation of the trail remnant indicates that it once crossed the preferred alignment, and possibly intersected with a major travel route along Kealalaloa Ridge to Pu'u Kukui.

Site 50-50-09-3191 trail was pointed out from the air by Michael Baker of the Division of Forestry and Wildlife, DLNR. It consists of two parallel alignments of stones comparable in character to known kerbstone trails (*e.g.* Robins *et al.* 1993). This type of kerbstone trail is classified as a "Type AB" trail and described as a traditional Hawaiian pedestrian trail which was subsequently modified with a perimeter of stone curbing and extended in width for use as a horse trail (Apple 1973). Site 50-50-09-3191 trail diverges from the Lahaina Pali trail at approximately 800 feet above mean sea level and heads *mauka* towards the project area. The Lahaina Pali trail appears to have been constructed over Site 50-50-09-3191 trail.

C. Site Descriptions

State Site #:	50-50-08-2	**CSH Site #: 2**
Site Type:	Complex	(See Figure 39)
Function:	*Heiau* (Hiki'i *Heiau*)	
Probable Age:	Prehistoric-early historic	
Condition:	Fair to good	
Dimension:	734.8 m.^{2} (7,935.8 ft. ^{2})	
***Ahupua'a*:**	Ukumehame	
Elevation:	160 ft. a.m.s.l.	

Description: Site -2 is a *heiau* located on the east side of Ukumehame Gulch. The *heiau* is known as Hiki'i *Heiau* and was apparently named after a chief for whom it was built. A historic ditch crosses the *heiau's* northwest corner. Vegetation consists primarily of overgrown grasses, *koa haole* and *kiawe*. The *heiau* is currently being cleared of vegetation and religious offerings have been placed in coffee cans on the site's surface.

The site is a complex of platforms, enclosures and paved areas integrated within a roughly rectangular enclosure. The outer enclosure wall is absent in the *heiau's* northeast side and in a section of its northwest side. Portions of the wall are bifaced, but most of the wall retains the interior floor of the *heiau* and upslope ground surface. Several internal features are present inside the *heiau* (see below). The *heiau* complex measures 33.4 (109.5 ft.) N/S by 22.0 m. (72.2 ft.) E/W (on file at the State Historic Preservation Division).

Hiki'i *Heiau* was originally recorded by John F.G. Stokes in 1916 and subsequently described by Thomas G. Thrum in the Hawaiian Annual (Thrum 1918:128):

> Hikii heiau at Ukumehame; on knoll east side of stream about a mile from the sea and 200 feet elevation. Northwest and northeast walls changed and interior used for graveyard. Two remaining walls would indicate a size of 55 feet square. Named after chief Hiki'i (Kaahui, informant aet.93)

In the 1930's Winslow Metcalf Walker recorded and mapped the site (Figure 10). Walker mentions in his description of the site that "graves of recent date" were present inside the *heiau* enclosure. He also observed a modern wall built on top of an older wall of the *heiau* (Walker 1931: 60-61).

Department of Land and Natural Resources State Parks Division archaeologists recorded Hiki'i *Heiau* in 1973 (on file at the State Historic Preservation Division). Nine platforms and two enclosures were documented inside the *heiau*. Three of the platforms and a mound inside the *heiau* were believed to have been the "modern graves" recorded by Thrum and Walker. Interestingly, the possible burial mound is constructed on top of a

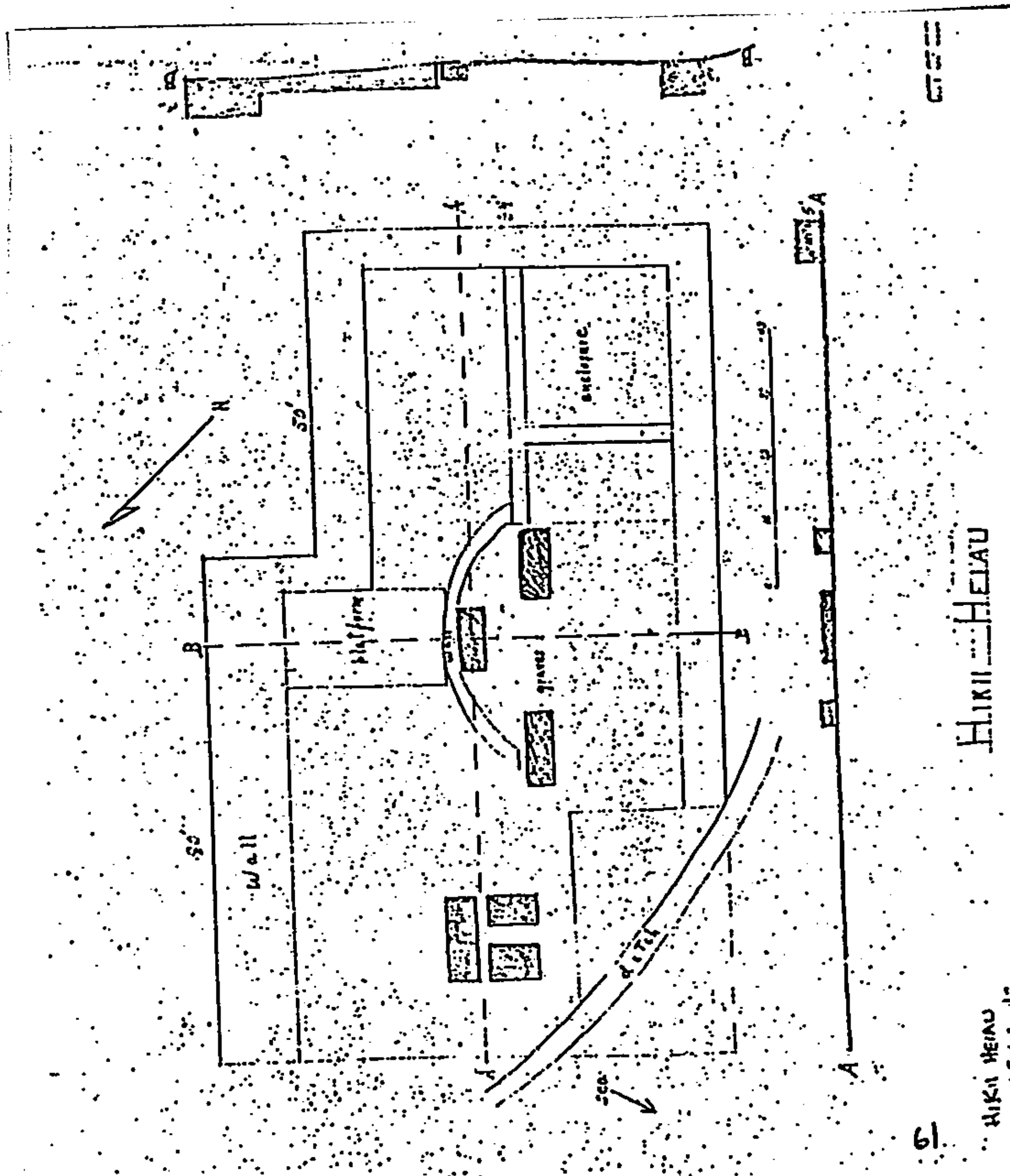


Figure 10 State Site 50-50-08-2, Hiki'i *Heiau*; Plan View (Source: Walker 1931)

platform and is composed of a red soil that is different than the soil inside the *heiau*.

CSH Site #: 3
(See Figures 40 & 41)

State Site #:	50-50-08-3
Site Type:	Complex
Function:	*Heiau*
Probable Age:	Prehistoric-early historic
Condition:	Fair-remnant
Dimension:	874 m.^{2} (9,439.2 ft.^{2})
***Ahupua'a*:**	Ukumehame
Elevation:	160 ft. a.m.s.l.

Description: Site -3 is a previously recorded *heiau* located on the west side of Ukumehame Gulch, immediately north of Pioneer Mill cane fields. A historic ditch and cane-ranch access roads have destroyed the southern portion of the site. Vegetation on the site consists primarily of overgrown grasses and *kiawe*. The site was named Ukumehame *Heiau* in 1973 by the DLNR Historic Preservation Division archaeologists.

Ukumehame *Heiau* was originally inspected by John F.G. Stokes in 1916. Based on Stokes' field records, Thomas G. Thrum provided the following site description in the Hawaiian Annual (Thrum 1918:128):

> A reputed heiau, located on west side of the stream [Ukumehame], opposite Hikii; also used as a grave-yard. Kaahui [informant] denies that it was a heiau.

In 1931 Winslow Metcalf Walker recorded and mapped (Figure 11) Ukumehame *heiau* in detail. Walker describes the *heiau* as being an irregular-shaped enclosure with walls present only on the west and north sides; a rectangular enclosure was incorporated into the northwest corner of the *heiau* and, according to Walker's map, six platforms (possible graves?) were observed inside the *heiau*. Walker comments that the *heiau* was "partially destroyed" and that new walls were built atop older walls for use as a cattle pen. He also mentions the presence of terraces and platforms inside the *heiau* walls which had been impacted by the modern graves.

In 1973, approximately 62 years after Walker's site inspection, the Department of Land and Natural Resources Historic Preservation Division archaeologists recorded Ukumehame *Heiau* and observed that about half of the site that Walker documented had been destroyed by construction of cane roads. (on file at the Historic Preservation Division

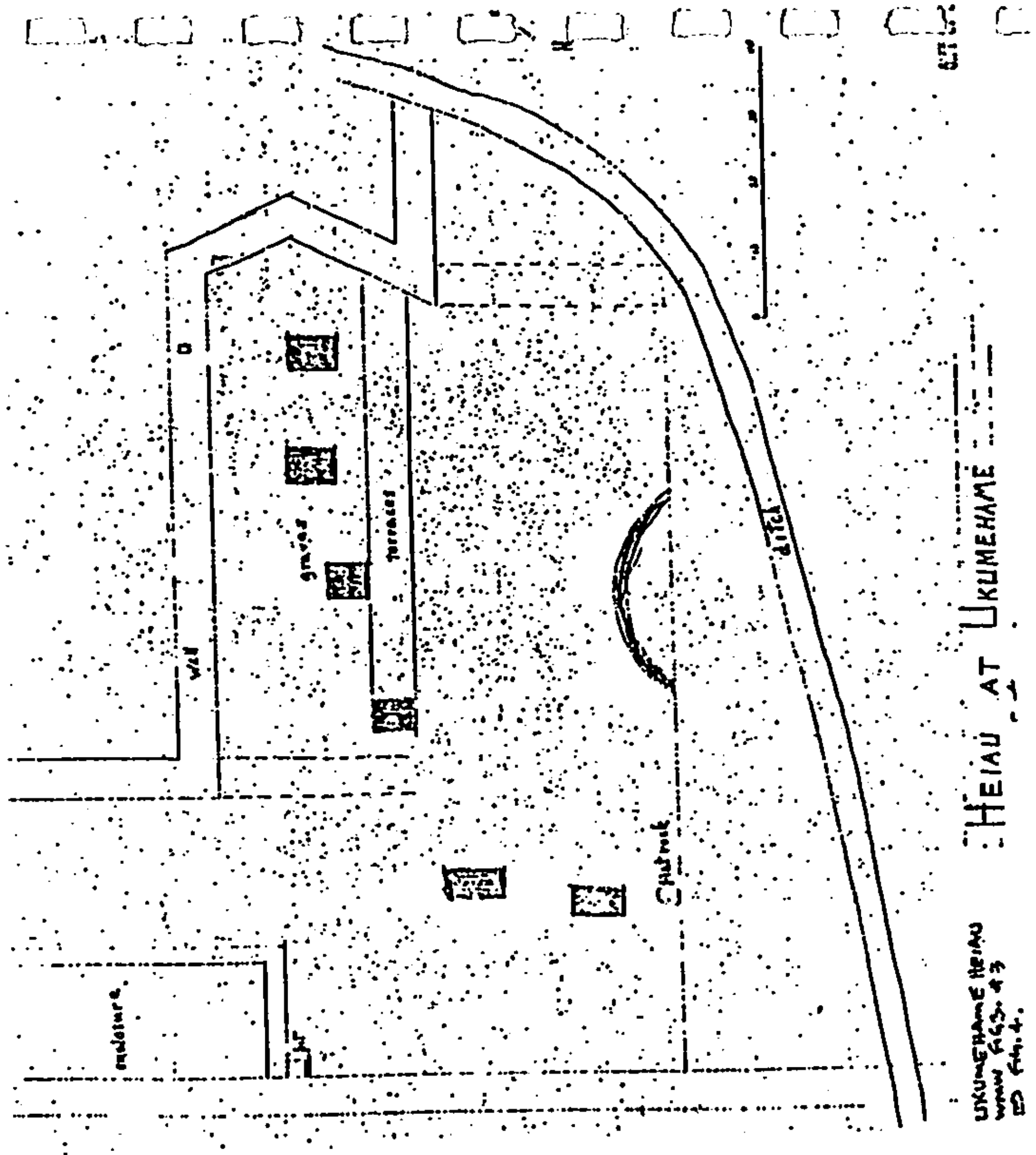


Figure 11 State Site 50-50-08-3, Ukumehame *Heiau*; Plan View (Source: Walker 1931)

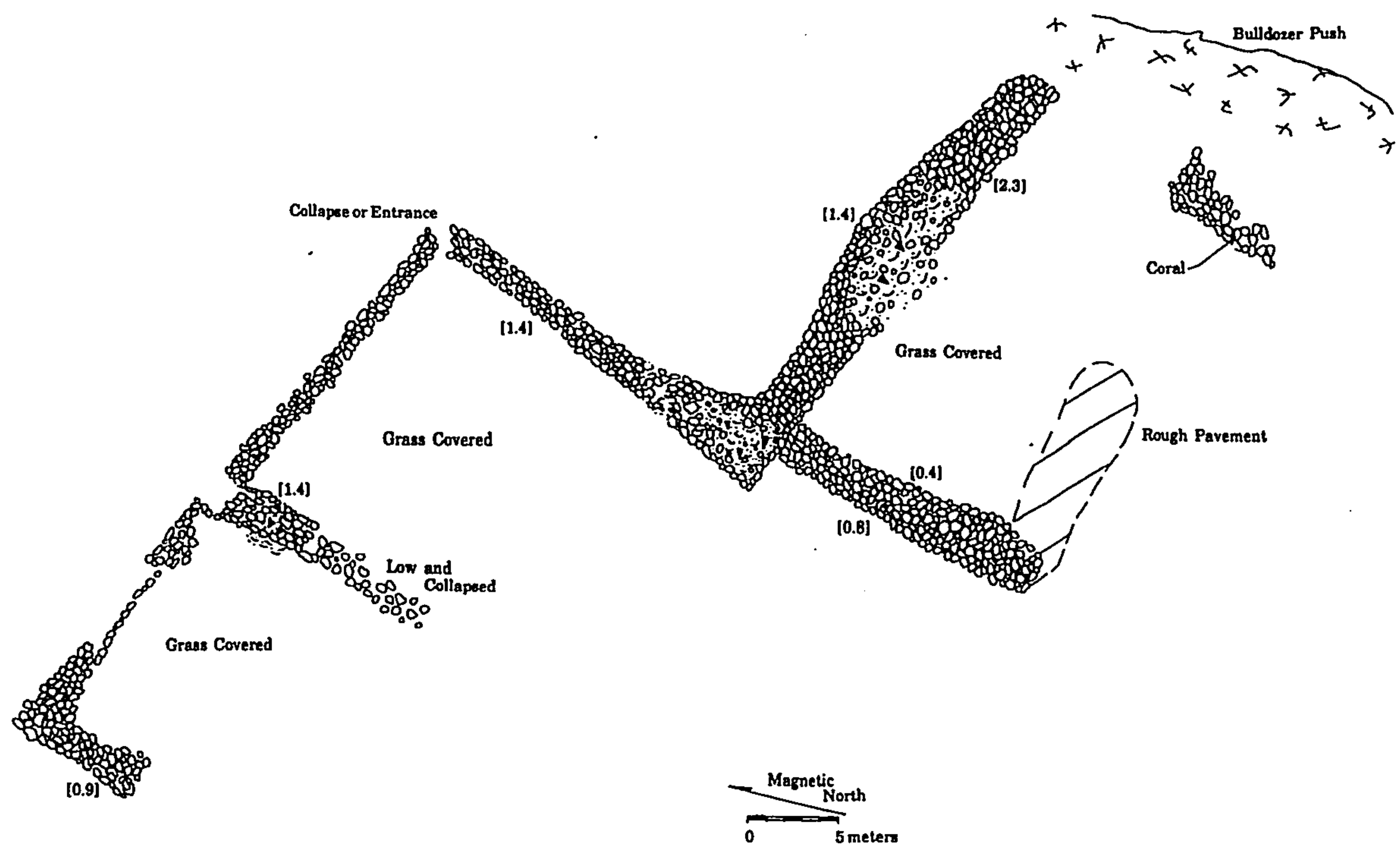


Figure 12 State Site 50-50-08-3, Plan View

office).

At present the *helau* is an irregular-shaped enclosure - which due to site destruction - is open to the south (see Figure 12). This site remnant measures approximately 38.0 m. (124.6 ft.) E/W by 23.0 m. (75.4 ft.) N/S and consists of three primary connecting walls, forming the original northern side of the *helau* (based on Walker's site records). Three wall segments also extend to the south, but are in dilapidated condition and difficult to discern due to dense grass cover on the site. A terrace and portion of a platform (presently mounded) were observed in the eastern portion of the site remnant. The platform correlates with a grave monument recorded by Walker, but is presently bisected by the existing jeep road. Coral was observed on the platform surface. In comparing the 1973 DLNR-SHPD site map and the present survey site map, it appears that the east side of the site - especially the possible grave feature - continues to be impacted due to road maintenance.

State Site #:	50-50-03-2677	**CSH Site #:** none designated
Site Type:	Complex	
Function:	Agriculture/Habitation (T/P)	
Features (#):	19	
Probable Age:	Prehistoric-Historic	
Condition:	Fair	
Dimension:	See Appendix A	
***Ahupua'a*:**	Launiupoko	
Elevation:	820 ft. a.m.s.l.	

Description: Site -2677 complex consists of a multitude of structural features situated northeast of the gulch at Launiupoko Stream. The site was previously identified by PHRI (Graves 1991). A jeep road extends through the lower east portion of the site complex in a northwest-southeast direction. The terrain has a level to moderate slope descending to the southwest and is cut with at least two seasonal drainages.

Realignment of the preferred alignment will only impact a bulldozed area along the southwest side of the existing jeep road. Therefore, no formal inspection of the site's extent or integrity was investigated during the present study other than determining a specific locality for pole placement of the proposed transmission line. PHRI presents a detailed description of the site complex (see Appendix A of this report).

In summary of PHRI's analysis (Graves 1991:B-23), the site complex consists of

both prehistoric (or traditional Hawaiian) agricultural features and two historic irrigation structures. Habitation structures (C-shape enclosures and terraces) were also recorded. Both of the irrigation structures were recorded during the present study beyond the confines of the site complex. The majority of PHRI's Feature C is a metal flume elevated on a wooden trestle which continues in a generally northwest direction beyond the site complex boundary; it runs generally parallel to the jeep road. The second irrigation structure is a stone-walled canal (designated by PHRI as Feature B) which extends southwest of the site complex, where it is denoted in the present study as Site 50-50-03-3173. Continuation of the stone-walled canal was determined through aerial reconnaissance (photos and helicopter inspection) and is also shown on early 20th-century cane maps. The latter source refers to the canal as the *old flume* - in reference to the metal flume labelled *new flume*. PHRI suggests that one or both of the irrigation structures were constructed in 1906 as evidenced by a dated inscription on a boulder located at the head of the metal flume.

State Site #:	50-50-03-2677C	**CSH Site #:** 21
Site Type:	Metal flume	
Function:	Cane irrigation	
Features (#):	-	
Probable Age:	Historic	
Condition:	Fair	
Dimension:	See below	
***Ahupua'a*:**	Launiupoko	
Elevation:	1000 ft. a.m.s.l.	

Description: Site -2677C is a metal flume extending parallel with the most northern jeep/cane access road in Launiupoko. It is supported by a wooden trestle. The terrain is rocky and has a gentle to moderate slope descending southwest. PHRI recorded the flume as a component feature of a complex of 19 features (Graves 1991). A Pioneer Mill map labelled *Canefield Map - 1918 MC-10 to 33* refers to Site -2677C flume as the "new flume" and State site -3173 as the "old flume".

LAUNIUPOKO COMPLEX

The Launiupoko Complex refers to two site complexes (Site 50-50-03-2678 and Site 50-50-03-2679) previously identified in the Launiupoko region by PHRI (Graves 1991).

During the PHRI inventory survey site boundaries were "arbitrarily drawn ... due to the thick vegetation and also because it was difficult to discern actual site boundaries since the sites were generally part of an extensive agricultural complex that overlays the project area" (*ibid.*). During the survey of the present study a similar predicament arose. As a result of the unclear site boundaries documented by the PHRI work and inability to locate PHRI site tags, site/feature correlations between the two studies were not effectively accomplished. Thus, the following site description reflects an overall description of the three sites based on abbreviated observations made during the present study's survey. For a more detailed description of these individual sites, the reader is referred to PHRI's site description presented in Appendix A of this report.

State Site #: 50-50-03-2678 and -2679 — **CSH Site #:** 13
Site Type: Complex
Function: Agriculture/Habitation (T/P)
Features (#): -
Probable Age: Prehistoric-historic
Condition: Fair to good
Dimension: Not determined
***Ahupua'a*:** Launiupoko
Elevation: 710-820 ft. a.m.s.l.

Description: Sites -2678 and -2679 are situated on moderately sloped terrain which is intersected by three primary gulches or dry drainages. Vegetation consists of dense grasses, *koa haole*, klu and *kiawe* trees. Together these sites appear to be laid out in four discrete locations, designated Areas A through D. For location and geographic reference, the three gulches - beginning in the southeast - will be referred to as Gulches 1 through 3.

Area A features are situated within Gulch 1. The complex is characterized by a network of terrace-retaining walls constructed roughly perpendicular to the northwest slope of the gulch and by a wall extending parallel with the gulch at its base. The gulch is approximately 10.0 to 15.0 m. (32.8 to 49.2 ft.) wide by 15.0 m. (49.2 ft.) deep. The terraces are oriented so that the downslope ends could have diverted water from the once

active stream. The wall along the southeast side is situated approximately 3.0 m. (9.8 ft.) above the base of the gulch. The wall is well faced with small boulders 3 to 4 courses high by a maximum width of 1.0 m. (3.3 ft.).

Area B is situated along the plain between Gulch 1 and 2. The terrain is level and slopes gently to the south. Area B features consist of agricultural and habitation structures densely covering the area between Gulch 1 and 2, over a distance of approximately 91.4 m. to 152.4 m. (300 to 500 ft). The agricultural features include walls and terraces constructed across the slope, mounds and planting depressions in outcrop rubble piles. Habitation features are generally contiguous and consist of walled enclosures and platforms with vertical facing.

Area C is located on a gently sloping plain between Gulch 2 and 3. Its features are characterized primarily by agricultural walls oriented across the slope to form narrow planting fields. The walls are typically one course and one row of boulders.

Area D features are situated within Gulch 3 and on the rocky plain immediately northwest of Gulch 3. The gulch is approximately 10.0 m. (32.8 ft.) deep and contains a well-constructed retaining wall along its southeast slope. The wall is a 4-course face of boulders retaining 3 to 4 rows of cobbles; the wall has a maximum width of 1.0 m. (3.3 ft.). On the northwest side of the gulch the primary features are a roughly constructed platform and a modified outcrop. The platform is rectangular and measures approximately 8.0 m. (26.2 ft.) NE/SW by 4.0 m. (13.1 ft.) NW/SE. A wall alignment extends towards the gulch from the platform's southeast corner. The platform surface is uneven and filled with cobbles and boulders. Two post-hole size depressions and a larger 1.0 m. (3.3 ft.) in diameter depression are present in the platform surface. A PHRI test unit was observed in the platform's southeast corner. The modified outcrop is located 10.0 m. (32.8 ft.) southwest of the platform and is defined by an expanse of outcrop rubble with various depressions excavated in its surface.

State Site #: 50-50-08-2684 — **CSH Site #:** 33 (See Figure 42)
Site Type: Rockshelter
Function: Temporary habitation
Features (#): 2
Probable Age: Prehistoric-historic
Condition: Good
Dimension: 64.5 m.^{2} (696.6 ft.^{2})
***Ahupua'a*:** Launiupoko
Elevation: 560 ft. a.m.s.l.

Description: Site -2684 is a rockshelter and adjacent wall located within the north side of Launiupoko Gulch. The rockshelter is at the base of a steep-sided cliff face composed of stratified alluvial deposits. The Launiupoko Stream bed is within 15.0 m. (49.5 ft.) of the site. The site was previously recorded by Paul H. Rosendahl Inc. (Graves 1991). PHRI provides a detailed description of the site (see Appendix A of this report).

State Site #: 50-50-08-3163 — **CSH Site #:** 1 (See Figure 43)
Site Type: Canal
Function: Cane irrigation
Features (#): 1
Probable Age: Historic
Condition: Fair
Dimension: 2.0 - 4.0 m. wide
Location: Corridor segment 4
***Ahupua'a*:** Ukumehame
Elevation: 240-280 ft. a.m.s.l.

Description: Site -3163 is a historic ditch segment constructed for sugar cane irrigation. The surrounding terrain is generally level and covered with scattered *kiawe*, grasses and thistle plants. The ground surface is relatively clear of stone rubble, suggesting that the area was cleared for land use - likely for historic cane cultivation.

The ditch, constructed along the crest and slope of an old stream bed, extends in a southeast-northwest direction. The ditch consists of a stone wall constructed along the northeast side of the stream bed and a steep-sided embankment on the southeast side. The embankment rises a maximum of 1.5 m. (4.9 ft.) high. The width of the ditch (between the wall and embankment) ranges from 2.0 to 4.0 m. (6.6 to 13.1 ft.). The stone wall is constructed of small and medium boulders and is well faced within intermittent preserved sections. The wall measures a maximum of 0.8 m. wide and 1.0 m. high.

A modern ditch in the pineapple fields to the southeast of the preferred alignment

aligns with the orientation of this site. No concrete was observed in the site's construction. Thus, the site likely represents the *mauka* segment of a ditch which was used primarily in historic times, during the earlier period of commercial sugar cane cultivation.

No artifacts or midden were observed at Site -3163.

State Site #: 50-50-08-3164 — **CSH Site #:** 4
Site Type: Canal
Function: Cane Irrigation
Features (#): -
Probable Age: Late Historic
Condition: Good
Dimension: 1.5 m. (4.9 ft.) wide
***Ahupua'a*:** Ukumehame
Elevation: 80-120 ft. a.m.s.l.

Description: Site -3164 is a historic ditch situated along the upper edge of the west side of Ukumehame Gulch. The ditch has a concrete infrastructure measuring 1.5 m. (4.9 ft.) wide by roughly 0.4 m. (1.3 ft.) deep. The ditch is no longer in use; it was bisected by the construction of a jeep road next to Ukumehame *Heiau*. The ditch once transported water from Ukumehame Reservoir to the cane fields to the south.

State Site #: 50-50-08-3165 — **CSH Site #:** 5
Site Type: Complex
Function: Temporary habitation
Features (#): 4
Probable Age: Prehistoric
Condition: Good
Dimension: 1,512 m.^{2} (16,329.6 ft^2)
***Ahupua'a*:** Ukumehame
Elevation: 160 ft. a.m.s.l.

Description: Site -3165 is a complex (Figure 13) of four features (designated A through D) situated on an alluvial fan east of Ukumehame Gulch. Site vegetation consists of a few *kiawe* trees, klu and dense grasses.

Feature A is a rectangular enclosure with interior measurements of 8.0 m. (26.2 ft.) SE/NW by 5.0 m. (16.4 ft.) NE/SW. The enclosure wall is bifaced with large cobbles and small boulders and rises a maximum height of 0.6 m. (2.0 ft.). A short wall segment (4.0 m. [13.1 ft.] SE/NW) extends from the southwest corner of the enclosure, forming a possible entryway. A basalt hammerstone was observed near the possible entryway and a fine-grain basalt flake was observed on top of the northwest wall of the enclosure.

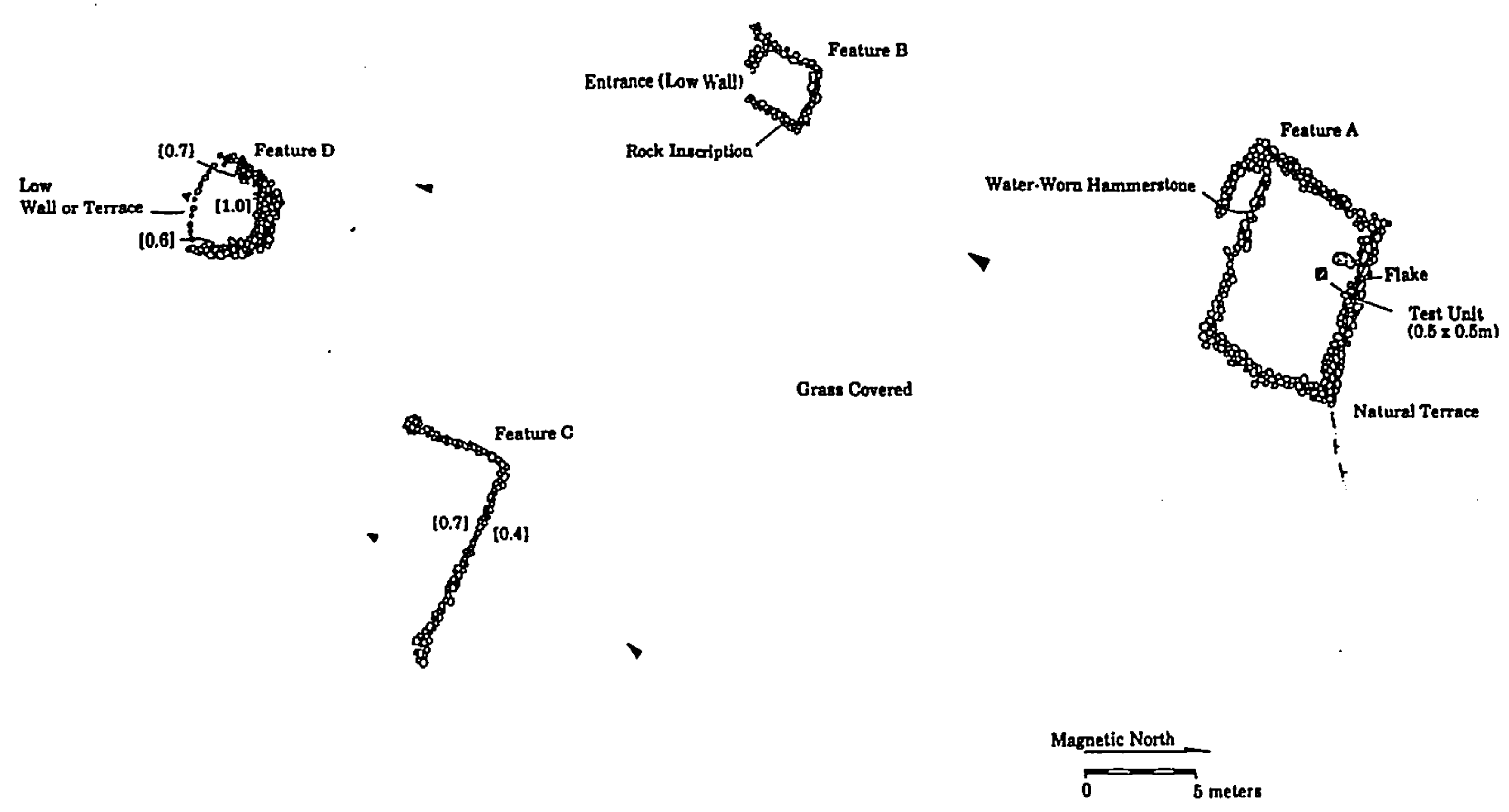


Figure 13 State Site 50-50-08-3165, Plan View

A 0.5 m. by 0.5 m. test unit was excavated within the northeast corner of Feature A enclosure (see Testing Results below).

Feature B is a small rectangular enclosure located 20.0 m. (65.6 ft.) southwest of Feature A. The enclosure has interior dimensions of 2.0 m. (6.6 ft.) SE/NW by 2.5 m. (8.2 ft.) NE/SW. The wall is bifaced with large cobbles and is 0.5 m. (1.6 ft.) wide by a maximum of 1.1 ft. high. A probable entrance is located in the southeast corner; it measures 1.0 m. (2.3 ft.) wide. An inscribed cobble was present on top of the enclosure wall near the northeast corner; the inscription is as follows:h

"C. ARON 136TH INFANTRY 33RD DIVISION 12/28/43"

Feature C is an L-shaped enclosure located 20.0 m. (65.6 ft.) southeast of Feature C. The northeast wall measures 9.0 m. (29.5 ft.) and the northwest wall measures 5.0 m. (16.4 ft.). Both wall sections have an average width of 0.5 m. (1.6 ft.) and a maximum height of 0.7 m. (2.3 ft.). The walls are constructed of large cobbles and are partially faced. The feature partially encloses a gentle to moderate sloped surface and it is open to the south.

No artifacts or midden were observed at Feature C.

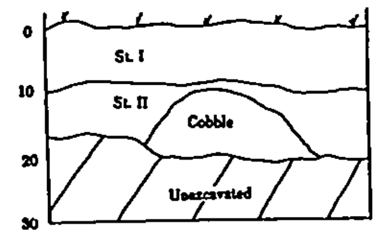
Feature D is a C-shaped enclosure located 9.0 m. (29.5 ft.) southwest of Feature C. The enclosure wall is constructed of large cobbles, enclosing an area roughly 3.0 m. NE/SW by 3.5 m. (11.5 ft.) NW/SE. The C-shape is open to the southwest. The wall is an average of 1.0 m. (3.3 ft.) wide by a maximum of 1.0 m. (3.3 ft.) high. The enclosure interior is level with a soil base.

No artifacts or midden were observed at Feature D.

The site is interpreted as a cluster of temporary habitation structures which may have been utilized by travellers heading *mauka*. Based on the testing results presented below, primary activities at Feature A focused on lithic reduction and sparse food consumption.

Testing Results

Limited testing was conducted at Feature A of Site -3165 (Figure 14) to assist in functional interpretation of the site and to attempt collecting charcoal for radiocarbon dating analysis. A 0.5 m. by 0.5 m. test unit was excavated 2.0 m. (6.6 ft.) northeast of Feature A's northwest corner. The test unit was placed on a level soil surface and excavated to a maximum depth of 20 cm. below the ground surface. The base of excavation was determined upon reaching a sterile C-horizon soil layer.



Stratum I - Dark reddish brown (5YR 3/3) silt intermixed with subangular and angular cobbles, rounded pebbles, and abundant rootlets. Cultural material present includes basalt flakes, volcanic glass, bone, shell, and charcoal

Stratum II - Dark reddish brown (2.5YR 2.5/4) silt intermixed with subangular cobbles (increase from Stratum I) and rounded cobbles. At base is saprolitic rock material. Cultural material (decrease from Stratum I) is found only in upper 5 cm of Stratum II.

Figure 14 State Site 50-50-08-3165 Test Unit Profile, West Face

Two soil layers, Stratum I and II, were revealed during the excavation. Indigenous artifacts and midden were recovered from both strata, with the majority of cultural material collected from Stratum I (see APPENDIX C).

Stratum I - 10 cm. thick - was a dark reddish brown silt intermixed with subangular and angular cobbles, and water-rounded pebbles. The recovered artifacts from Stratum I include: one volcanic glass flake (Acc. #1); one coral abrader (Acc. #2); and 66 basalt flakes (Acc. #3). Stratum I yielded the following midden types: 0.6 gm. of *Cellana* sp.; 0.6 gm. of *Nerita picea*; 0.4 gm. of unidentified shell; 3.1 gms. of *kukui*; and 1.2 gms. unidentified bone. A sparse amount of charcoal (0.4 gm.) and coral fragments (11.2 gms.) were also collected.

Stratum II - 10 cm. thick - was a dark reddish silt (2.5 YR-2.5/4) intermixed with an increasing amount of subangular cobbles. The base of Stratum I was a compacted surface of decomposing basalt cobbles. A decrease in cultural material was observed and confined to the upper 5 cm. of Stratum II. Stratum II artifacts and midden include: one volcanic glass core (Acc. # 4); two basalt hammerstones (Acc. #5 and 6); 16 basalt flakes (Acc. #8); 0.1 gm. of *Nerita picea* sp.; 0.5 gm. of unidentified shell; and 0.5 gm. of unidentified bone.

CSH Site #: 6

State Site #:	50-50-08-3166
Site Type:	Enclosure
Function:	Temporary habitation
Features (#):	-
Probable Age:	Prehistoric
Condition:	Poor
Dimension:	70.0 m.^{2} (756.0 ft.^{2})
***Ahupua'a*:**	Ukumehame
Elevation:	160 ft. a.m.s.l.

Description: Site -3166 (Figure 15) consists of an irregular-shaped enclosure located on the west side of Ukumehame Gulch. Ukumehame *Heiau* is approximately 90.0 m. (300 ft.) southeast of the site. The site vegetation consists primarily of a dense grass cover with a few *kiawe* and klu. Boulders are scattered over the surrounding terrain.

The enclosure interior measures 12.0 m. (39.4 ft.) SE/NW by 4.0 m. (13.1 ft.) SW/NE. The wall ranges from being an alignment of small boulders to partially bifaced with large cobbles. The bifaced portion of the wall measures a maximum width of 0.7 m. (2.3 ft.) and height of 0.8 m. (2.6 ft.) high. Two indistinct parallel alignments (2.5 m. [8.2 ft.] apart) extend roughly 2.0 m. (6.5 ft.) off the southwest wall. The enclosure interior is

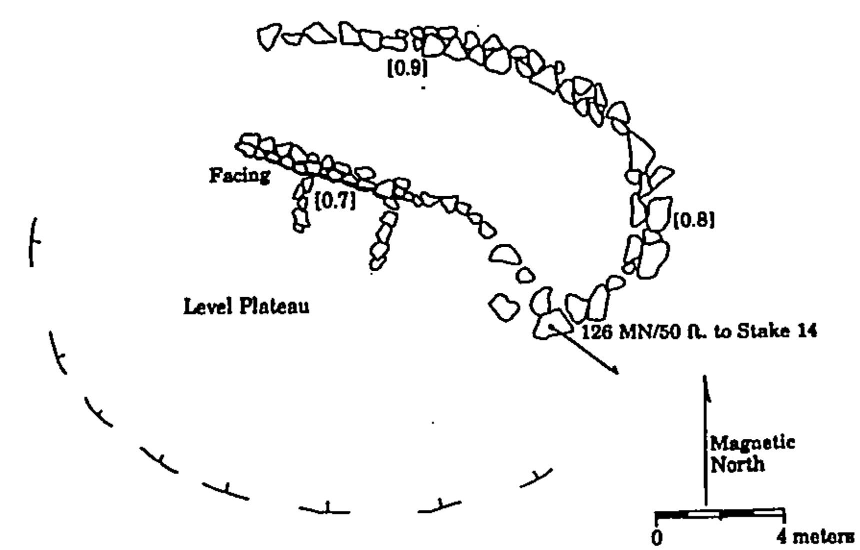


Figure 15 State Site 50-50-08-3166, Plan View

relatively level with scattered cobbles and boulders from wall collapse.

No artifacts or midden were observed at the site. The irregular configuration and variable condition of the site's construction suggests that it has been previously disturbed.

CSH Site #: 7

State Site #:	50-50-08-3167
Site Type:	Cattle wall and chute
Function:	Ranching
Features (#):	None designated
Probable Age:	Historic
Condition:	Good
Dimension:	See below
***Ahupua'a*:**	Ukumehame
Elevation:	120 ft. a.m.s.l.

Description: Site -3167 is a cobble-boulder wall which extends along the west side of Ukumehame Gulch just *mauka* of the cane fields to the south. The wall is bifaced and has a range in heights and widths between 1.0 m. (3.3 ft.) and 1.5 m. (4.9 ft.). A wooden cattle-chute is present at the southern end of the wall. Beyond the chute the wall is truncated by a cane access road. The wall bypasses Hiki'i *Heiau* along its eastern side.

A fence-line is present along the *mauka* edge of the cane fields to the east of the wall. The wall, in conjunction with the fence-line, was probably constructed by ranchers (or the respective sugarcane company) to keep cattle away from the steep edge of Ukumehame Gulch and outside of maintained cane fields.

CSH Site #: 8

State Site #:	50-50-08-3168
Site Type:	Complex
Function:	Ritual/Temporary habitation
Features (#):	2
Probable Age:	Prehistoric
Condition:	Good
Dimension:	168.0 m.^{2} (1,814.4 ft.^{2})
***Ahupua'a*:**	Ukumehame
Elevation:	200 ft. a.m.s.l.

Description: Site -3168 is a complex of two features (Figure 16) situated on the ridge top immediately west of Ukumehame Gulch. The site affords a commanding view of the Ukumehame Gulch area and *makai*. The terrain slopes moderately to the south and is intermittently scarred by surface erosion. Vegetation consists of shrubs and grasses, and occasional *kiawe* trees.

Feature A (See Figure 47) consists of two parallel structures: a wall to the north and platform to the south. The long axis of both structures is oriented across the slope. The two structures partially enclose a level surface area of 3.0 m.^{2} and form a barrier to

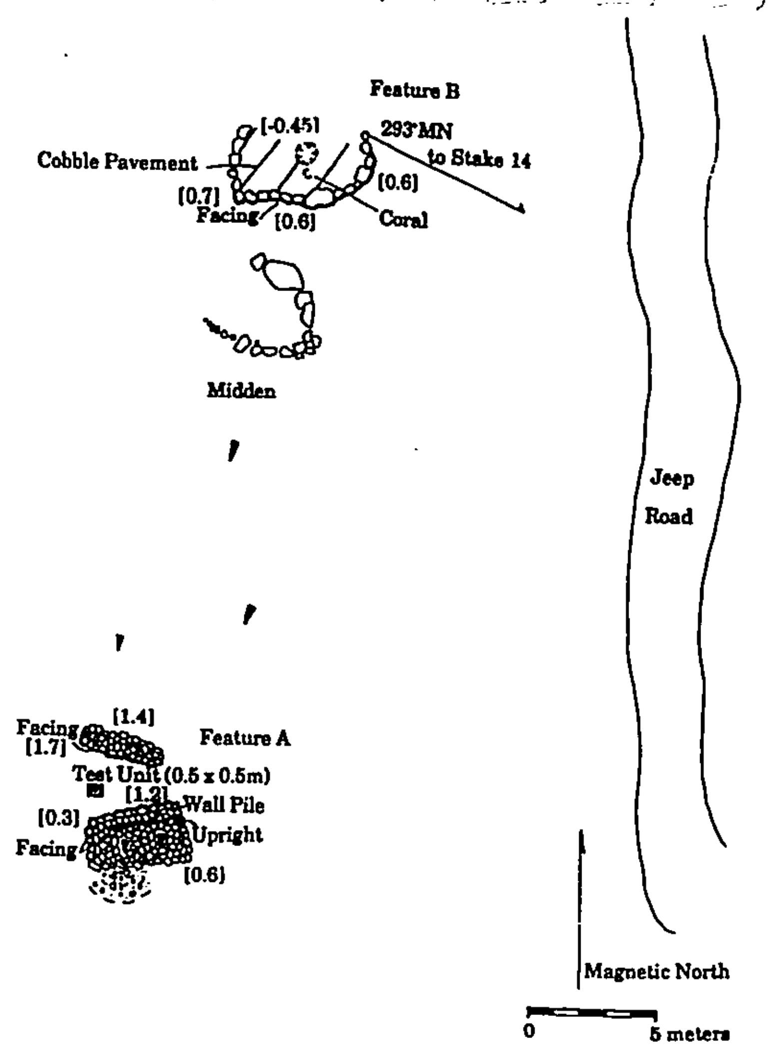


Figure 16 State Site 50-50-08-3168, Plan View

the north and south,respectively. A 0.5 m. (1.6 ft.) by 0.5 m. (1.6 ft.) test unit was excavated between the wall and platform (see Testing Results).

The wall measures 3.0 m. (9.8 ft.) SE/NW by 1.0 m. (3.3 ft.) wide. It is constructed of stacked cobbles and boulders and has a maximum height of 1.7 m. (5.6 ft.). Vertical facing is preserved on both sides of the wall.

The platform is constructed of large cobbles and small boulders. Its surface slopes moderately to the south. It measures 2.0 m. (6.5 ft.) N/S by 4.0 m. (13.1 ft.) E/W with a maximum height of 1.0 m. (3.3 ft.) along its north, vertically faced side. A rough wall - approximately 0.6 m. (2.0 ft.) wide - is constructed along the north edge of the platform surface.

Feature B (See Figure 48) is a terrace located 21.0 m. (69.0 ft.) north of Feature A. The terrace measures 5.0 m. (16.4 ft.) E/W by 3.0 m. (9.8 ft.) N/S and it is raised along its west, south and east sides. The south side reaches a maximum height of 0.6 m. (2.0 ft.). The terrace is constructed of a level cobble pavement retained by a small boulder facing along its raised sides. A depression, measuring approximately 0.5 m. (1.6 ft.) in diameter by 0.45 m. (1.5 ft.) deep, is present in the center of the pavement.

One piece of coral was observed on the terrace surface. Waterworn pebbles were present approximately 4.0 m. east of Feature B.

A roughly constructed C-shaped enclosure was located 2.0 m. (6.5 ft.) south of Feature B. It is composed of a single alignment of large cobbles and small boulders and is open to the east. The C-shape encloses an area of 4.0 (13.1 ft.) NW/SE by 2.0 m. (6.4 ft.) NE/SW. Scant midden was observed 2.0 m. (6.5 ft.) southwest of the C-shape.

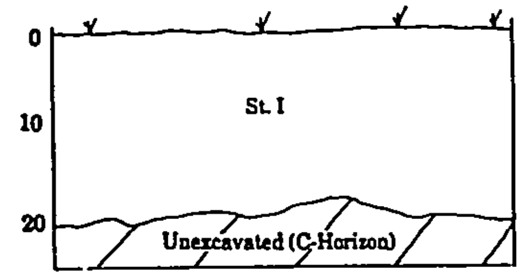
Features A and B are interpreted as temporary shelters. However, given the unusual alignment of Feature A's structures, it may have functioned as an *ahu* visible from the coast. This latter interpretation may be further substantiated by the lack of artifacts and paucity of midden recovered from the limited testing described below. Feature B is considered to be a possible shrine based on the presence of coral on its surface and depression at its center (perhaps representing an idol holder).

<u>Testing Results</u>

Limited testing was conducted at Feature A of Site -3168 (Figure 17) to assist in determining the feature's function and to collect a sufficient amount of charcoal for radiocarbon dating analysis. Neither of these goals was accomplished by the testing.

A 0.5 m. (1.6 ft.) by 0.5 m. (1.6 ft.) test unit was placed in between the two structures of Feature A on a level soil surface. The test unit was excavated to a maximum depth of 20 cm. where a compact C-horizon was encountered. Only one stratigraphic layer,

Stratum I, was revealed above the sterile C-horizon. Stratum I was a slightly compacted, dark reddish brown (5YR 3/2) silt loam intermixed with angular small cobbles and pebbles. A sparse amount of *Nerita picea* (0.2 gm.) was recovered from Stratum I (See APPENDIX C).



Stratum I - Dark reddish brown (5YR 3/2) loam slightly compact with few rootlets, small angular cobbles and pebbles (colluvium). Sparse amount of *Nerita picea* recovered.

Figure 17 State Site 50-50-08-3168 Test Unit Profile, West Face

State Site #:	50-50-08-3169	**CSH Site #: 9**
Site Type:	Complex	
Function:	Temporary habitation	
Features (#):	5	
Probable Age:	Prehistoric	
Condition:	Fair	
Dimension:	715.0 m.^{2} (2,345.2 ft.^{2})	
***Ahupua'a*:**	Ukumehame	
Elevation:	160-200 ft. a.m.s.l.	

Description: Site -3169 is a complex of 5 separate features (Figure 18) located on the west side of the ridge immediately west of Ukumehame Gulch. The terrain slopes moderately to the south and is characterized by a boulder-scattered surface (colluvium) over a mostly rocky substrate. Vegetation is sparse in the site area and consists of grasses, klu and occasional *kiawe*.

Feature A is a wall section constructed between two large boulders (colluvium). The wall is an alignment of large cobbles and small boulders. It retains a relatively level area upslope to the north. The wall measures 6.0 m. (19.6 ft.) long.

Feature B is a circular enclosure located 26.0 m. (85.3 ft.) southeast of Feature. Its wall is constructed of piled large cobbles reaching a maximum height of 0.4 m. (1.3 ft.). The feature encloses an area 3.0 m. (9.8 ft.) E/W by 1.5 m. (4.9 ft.) N/S; the wall is 0.5 m. (1.6 ft.) wide.

Feature C (See Figure 49) is a wall located 24.0 m. (78.7 ft.) southeast of Feature B. It is constructed of stacked cobbles and boulders. The wall measures 4.0 m. (13.1 ft.) long (N/S) and extends between two large colluvium boulders. The terrain to the east is level.

Feature D is a C-shaped enclosure located 23.0 m. (75.4 ft.) south of Feature C. The enclosure wall is constructed of stacked cobbles and boulders with vertical facing preserved along the interior side of the wall. The wall measures 0.5 m. (1.6 ft.) wide and has a maximum height of 0.8 m. (2.6 ft.). The wall encloses an area approximately 2.0 m. (6.5 ft.) in diameter. The C-shape is open to the southeast.

Feature E (See Figure 50) is a circular enclosure located 6.0 m. (19.7 ft.) south of Feature C. It is constructed of stacked small boulders and encloses an area of 2.5 m. (8.2 ft.) in diameter. The wall has a maximum height of 0.7 m. (2.2 ft.). The enclosure interior is level.

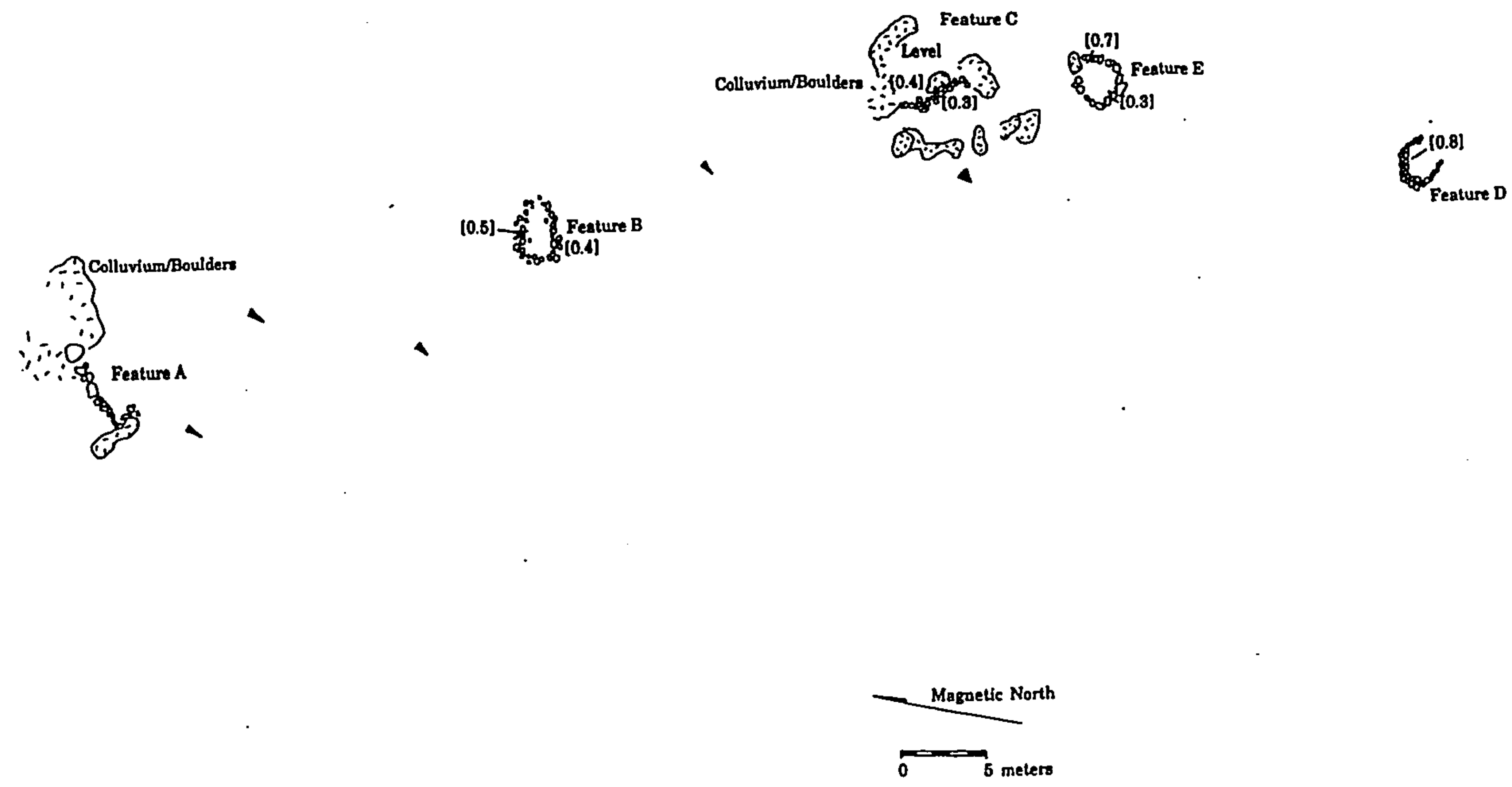


Figure 18 State Site 50-50-08-3169, Plan View

State Site #: 50-50-08-3170 — **CSH Site #:** 10 (See Figure 51)

State Site #:	50-50-08-3170
Site Type:	Cattle wall
Function:	Ranching
Features (#):	-
Probable Age:	Historic (ca. 1930's)
Condition:	Fair to good
Dimension:	Undetermined
***Ahupua'a*:**	Ukumehame
Elevation:	240-320 ft. a.m.s.l.

Description: Site -3170 is a cattle wall extending in a roughly east-west direction *mauka* of existing cane fields and Site -3171 cart road or railroad berm. The wall is intermittently preserved and crosses the corridor centerline at only one point.

Site -3170 is a bifaced-boulder wall averaging 1.0 m. (3.3 ft.) wide by 1.0 to 1.3 m. (3.3 to 3.3 ft.) high.

Site -3170 wall is likely related to other wall sections identified to the east beyond Ukumehame Gulch (Site -3167) and to the west beyond Olowalu Gulch (Site -3180). Thus, the walls functioned to keep cattle *mauka* of the cane fields. The fact that Site -3170 wall lies some distance *mauka* of modern cane fields and just above Site -3170 cart road or railroad berm suggests that cane was once grown at these higher elevations during historic times.

CSH Site #: 11 (See Figure 52)

State Site #:	50-50-08-3171
Site Type:	Railroad berm
Function:	Cane transport
Features (#):	-
Probable Age:	Historic
Condition:	Good
Dimension:	Not determined
***Ahupua'a*:**	Ukumehame
Elevation:	240-280 ft. a.m.s.l.

Description: Site -3171 is a stone constructed berm oriented in a north-south direction, located approximately 610.0 m. (2000 ft.) *mauka* of existing cane fields. The surrounding terrain is rocky and slopes gently to the south. Vegetation consists of overgrown grasses, klu, *koa haole* and scattered *kiawe* trees.

The corridor centerline crosses the berm where it spans a curve in a gulch or presently dry stream bed. At this location the berm measures approximately 4.0 m. (13.1

ft.) wide and rises a maximum of 2.2 m. (6.6 ft.) high above the base of the gulch. The berm is characterized by a level cobble and boulder-paved surface retained on its east and west side by a vertical face of boulders rising 8 to 10 courses high. Two building episodes are apparent in the berm surface in which the later episode increased the berm's width by approximately 1.0 m. (3.3 ft.) along it west side.

CSH Site #: 12

State Site #:	50-50-08-3172
Site Type:	Canal
Function:	Cane irrigation
Features (#):	-
Probable Age:	Historic
Condition:	Excellent
Dimension:	Linear extent not determined
***Ahupua'a*:**	Olowalu
Elevation:	200 ft. a.m.s.l.

Description: Site -3172 is a historic ditch located on the southeast side of Olowalu Stream. The terrain southeast of the ditch descends steeply to the Olowalu stream bed. The stream bed was dry during the survey. Vegetation consists of an assortment of introduced fruit trees and grasses.

The ditch is constructed of cemented stone on its southeast side and concrete on its northwest side. It measures approximately 0.8 m. (2.6 ft.) by 0.5 m. (1.6 m.) deep and is currently used for cane irrigation.

CSH Site #: 14 (See Figure 53)

State Site #:	50-50-03-3173
Site Type:	Wall
Function:	Cane irrigation ditch
Features (#):	1
Probable Age:	Historic
Condition:	Fair
Dimension:	See below
***Ahupua'a*:**	Launiupoko
Elevation:	800 ft. a.m.s.l.

Description: Site -3173 is a boulder wall extending in an east-west direction (cross-slope) across the preferred alignment. The site is located beyond the northern boundary of Launiupoko Complex. The terrain slopes moderately to the south and is covered with klu, *'ilima*, *koa haole* and dense buffelo grass.

The orientation of the wall correlates with an irrigation flume labelled "old flume" on a cane map possibly drawn in 1918. Identified during aerial reconnaissance of the Launiupoko area, Site -3174 wall continues to the east where it was recorded by PHRI as Feature B of Site -2677 (Graves 1991:B-23).

The wall is constructed of stacked boulders and measures 0.8 m. (2.6 ft.) by 1.0 m. (3.3 ft.) wide. Downslope or south of the wall is a level surface likely representing the base of the irrigation canal.

CSH Site #: 15
(See Figure 54)

State Site #:	50-50-03-3174
Site Type:	Wall
Function:	Agriculture
Features (#):	1
Probable Age:	Prehistoric-historic
Condition:	Good
Dimension:	See below
***Ahupua'a*:**	Kuia
Elevation:	880-920 ft. a.m.s.l.

Description: Site -3174 is a northeast-southwest trending wall located in a deep drainage gulch surrounded by cane fields. The wall is intersected by a cane access road and adjacent Piilani Ditch which extends in a northwest-southeast direction through the cane fields. The gulch terrain is rocky and descends steeply. Vegetation consists primarily of *koa haole* scrub and grass.

The wall is situated along the upper slope of the northwest side of the gulch and extends across the slope. It is constructed of one row of stacked boulders and measures an average width of 0.8 m. (2.6 ft.) by 1.0 m. (3.3 ft.) high along its downslope side.

CSH Site #: 16
(See Figure 55)

State Site #:	50-50-03-3175
Site Type:	Complex
Function:	Agriculture
Features (#):	-
Probable Age:	Prehistoric
Condition:	Good
Dimension:	Not determined
***Ahupua'a*:**	Polanui
Elevation:	850 ft. a.m.s.l.

Description: Site -3175 complex is located adjacent to the north side of a major gulch or

dry drainage. The drainage may be known as Waiolimu Stream (see Maui Island Tax Map). The gulch is steep-sided and contains a dense thicket of *wili-wili* trees at its base. The plain above the gulch is level terrain which slopes gently to the southwest. Vegetation in the site area includes *wili-wili, kiawe, koa haole, 'ilima* and grass.

The site is composed of a maze of retaining walls - generally oriented across the slope - forming narrow planting areas 1.0 to 2.0 m. (3.3 to 6.5 ft.) wide. The walls are roughly stacked with small and medium boulders averaging 1.0 m. (3.3 ft.) high to a maximum 2.0 m. (6.5 ft.) wide. Small enclosures are incorporated into the field complex by the addition of perpendicular walls on to the retaining walls. Mounds are also present and are generally 1.0 to 2.0 m. (3.3 to 6.5 ft.) in diameter. One C-shaped enclosure was observed in the complex; it is likely a field shelter or storage shed.

A bifaced boulder wall extends along the crest of the gulch along its south side. It is constructed of 2 to 3 rows of small boulders and rises a maximum of 1.2 m. (3.9 ft.) high. This wall is plotted on a Pioneer Mill cane map labelled *Canefield Map - 1918 MC-10 to 33*. According to this map, cane was cultivated immediately north of the wall among the complex features described above.

CSH Site #: 17
(See Figure 56)

State Site #:	50-50-03-3176
Site Type:	Wall
Function:	Cane irrigation
Features (#):	-
Probable Age:	Historic
Condition:	Fair
Dimension:	Undetermined
***Ahupua'a*:**	Wainee
Elevation:	820-860 ft. a.m.s.l.

Description: Site -3176 is a wall section which runs parallel with the preferred alignment for approximately 61.0 m. (200.0 ft.). The site is located *mauka* (north) of Kaua'ula Reservoir. The site construction and overall configuration is obscured by dense, high grass cover.

The wall is stacked with small and medium boulders. It measures an average 0.8 m. (2.6 ft.) high by 1.0 m. (3.3 ft.) wide. The wall surface is sunken at its center, suggesting that it functioned as a foundation for an irrigation flume.

State Site #:	50-50-03-3177	**CSH Site #: 18** (See Figure 57)
Site Type:	Wall	
Function:	Cane irrigation	
Features (#):	-	
Probable Age:	Historic	
Condition:	Good	
Dimension:	Extent not determined	
***Ahupua'a*:**	Wainee	
Elevation:	900-920 ft. a.m.s.l.	

Description: Site -3177 is a wall extending in a northeast-southwest direction. The site is located on the second ridge area northwest of Kaua'ula Gulch, just southeast of the preferred alignment locational stake #24. The terrain slopes moderately to the east and has a vegetation cover of *koa haole*, klu, and dense grass.

The wall is constructed of cobbles and small boulders and has a level surface and vertically faced sides. It measures a maximum of 1.2 m. (3.9 ft.) wide by 0.8 m. (2.6 ft.) high. The level surface of the wall and its location in context with other irrigation canals in an area once cultivated with cane, suggests that Site -3177 functioned as a foundation for an irrigation flume.

State Site #:	50-50-03-3178	**CSH Site #: 19** (See Figure 58)
Site Type:	Canal	
Function:	Cane irrigation	
Features (#):	-	
Probable Age:	Historic	
Condition:	Good	
Dimension:	Extent not determined	
***Ahupua'a*:**	Wainee	
Elevation:	800-850 ft. a.m.s.l.	

Description: Site -3178 is a historic ditch located along a northwest descending slope of the ridge northwest of Kaua'ula Gulch. Site vegetation consists primarily of dense grass with some *koa haole* and klu.

The ditch interior is excavated into the slope and retained along its northwest side by a faced wall. The wall is constructed of small boulders and measures approximately 0.6 m. (2.0 ft.) wide by 1.0 to 1.3 m. (3.3 to 4.3 ft.) high. The base of the ditch is roughly 0.4 m. (1.3 ft.) below the wall surface.

State Site #:	50-50-09-3179	**CSH Site #: 20** (See Figure 59)
Site Type:	Circular enclosure	
Function:	Temporary habitation	
Features (#):	1	
Probable Age:	Prehistoric	
Condition:	Good	
Dimension:	9.0 m.^{2} (97.2 ft.^{2})	
***Ahupua'a*:**	Ukumehame	
Elevation:	360 ft. a.m.s.l.	

Description: Site -3179 is a modified outcrop located at the foot of the West Maui Mountain ridges that descend towards Mā'alaea. The site is situated on alluvial-based terrain. The ground surface is intersected by minor drainages; large boulders are scattered on the surface. A dry stream bed is located approximately 91.5 m. (300.0 ft.) north of the site.

The modified outcrop is defined by a C-shaped enclosure abutting two large boulders. The site encloses an area of approximately 3.0 m. (9.8 ft.) E-W by 2.0 m. (6.6 ft.) N/S. The wall is constructed of 2 rows of stacked small boulders, rising a maximum height of 0.8 m. (2.6 ft.). Interior of the site is covered with grass.

State Site #:	50-50-08-3180	**CSH Site #: 22**
Site Type:	Cattle wall	
Function:	Ranching	
Features (#):	-	
Probable Age:	Historic	
Condition:	Fair to good	
Dimension:	See below	
***Ahupua'a*:**	Olowalu	
Elevation:	240-400 ft. a.m.s.l.	

Description: Site -3180 is a wall which is crossed by the preferred alignment just beyond the west side of Olowalu Stream. The wall extends along the *mauka* perimeter of the cane fields, and like Sites -3167 and -3170, was probably constructed to keep cattle outside of the cane fields and *kuleana*. The terrain is rocky and slopes moderately to the southwest.

The wall is stacked and vertically faced with basalt boulders. It measures an average width and height of 1.0 m. (3.3 ft.).

State Site #:	50-50-08-3181	CSH Site #: 23
Site Type:	Wall	(See Figure 60)
Function:	Temporary habitation	
Features (#):	1	
Probable Age:	Prehistoric	
Condition:	Good	
Dimension:	10.0 m.² (108 ft.²)	
Ahupua'a:	Ukumehame	
Elevation:	1125 ft. a.m.s.l.	

Description: Site -3181 (Figure 19) is a small wall section situated atop a ridge which descends towards Mā'alaea. Site -3182 is located approximately 20.0 m. (65.6 ft.) upslope or east. The ridge top slopes moderately to steeply to the east and is relatively barren of vegetation except for low shrubs and grasses. The ground surface contains patches of exposed substrate due to surface erosion.

The wall is placed adjacent to outcrop boulders located upslope. It is constructed of roughly stacked, large basalt cobbles and small boulders. The wall measures 2.0 m. (6.6 ft.) NE/SW by 0.6 m. (2.0 ft.) wide with a maximum height of 0.7 m. (2.3 ft.). A small level area, roughly 0.5 m. (1.6 ft.) wide, occurs downslope of the wall.

State Site #:	50-50-08-3182	CSH Site #: 24
Site Type:	Upright stone	
Function:	Marker	
Features (#):	1	
Probable Age:	Prehistoric	
Condition:	Good	
Dimension:	See below	
Ahupua'a:	Ukumehame	
Elevation:	1135 ft. a.m.s.l.	

Description: Site -3182 is an upright stone situated atop a ridge which descends towards Mā'alaea. Site -3181 is located approximately 20.0 m. (65.6 ft.) downslope or east. The ridge top slopes moderately to steeply to the east and is relatively barren except for low shrubs and grasses. The ground surface contains patches of exposed substrate due to surface erosion.

Site -3182 is an elongated, small basalt boulder positioned upright in a crack in the outcrop. The outcrop is a prominent high spot in the surrounding terrain. Because of the site's proximity to Site -3182 temporary shelter and its elevated location, it is interpreted as a trail or site marker.

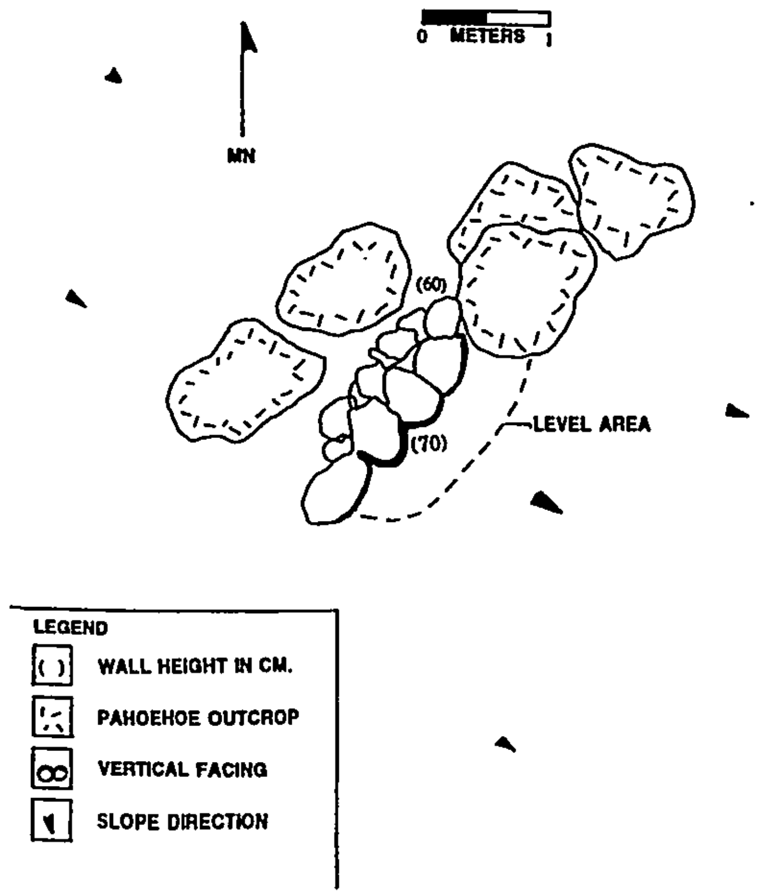


Figure 19 State Site 50-50-09-3181, Plan View

State Site #:	50-50-08-3183	**CSH Site #: 25**
Site Type:	Enclosure	
Function:	Permanent habitation	
Features (#):	1	
Probable Age:	Prehistoric	
Condition:	Fair	
Dimension:	216.0 m.^{2} (2332.8 ft.^{2})	
***Ahupua'a*:**	Ukumehame	
Elevation:	230 ft. a.m.s.l.	

Description: Site -3183 is a rectangular enclosure (Figure 20) located on the east side of Ukumehame Gulch. The terrain is level and composed of alluvial deposits. The site is located within a *kiawe* thicket and is covered with grass.

The enclosure is rectangular in shape and is open on its southeast side with a 2.0 m. (6.5 ft.) wide passageway. The enclosure wall is stacked with basalt cobbles and boulders; vertical facing is preserved along the northeast and rises a maximum height of 0.8 m. (2.6 ft.). The site encloses a level ground surface measuring approximately 9.0 m. (29.5 ft.) NW/SE by 4.0 m. (13.1 ft.) NE/SW. Two basalt flakes were observed on the outside of the enclosure's north corner.

State Site #:	50-50-08-3184	**CSH Site #: 26**
Site Type:	Complex	
Function:	Permanent habitation; Possible burial	
Features (#):	4	
Probable Age:	Prehistoric	
Condition:	Fair	
Dimension:	900.0 m.^{2} (9720.0 ft.^{2})	
***Ahupua'a*:**	Ukumehame	
Elevation:	160 ft. a.m.s.l.	

Description: Site -3184 is a complex of four features (Figure 21) located on the west side of Ukumehame Gulch. The site is situated on a moderately sloped terrain descending to the southeast. Site vegetation consists of a dense grass cover and scattered *koa haole* and *kiawe*.

Feature A is an L-shaped enclosure located on the north perimeter of the site complex. The L-shape is open to the west and is composed of southeast and northeast wall sections. The northeast wall is constructed of three rows of piled small boulders. It measures 3.0 m. (9.8 ft.) SE/NW by 0.5 m. (1.6 ft.) wide and rises a maximum 0.85 m. (2.8

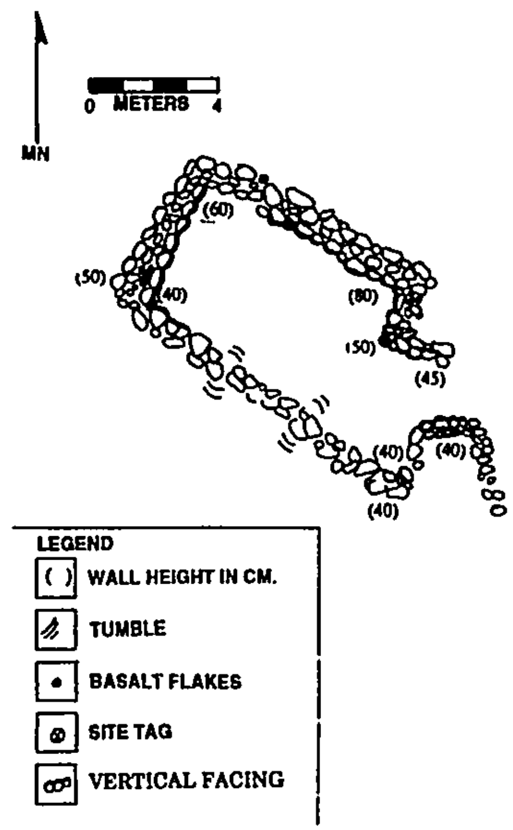


Figure 20 State Site 50-50-08-3183, Plan View

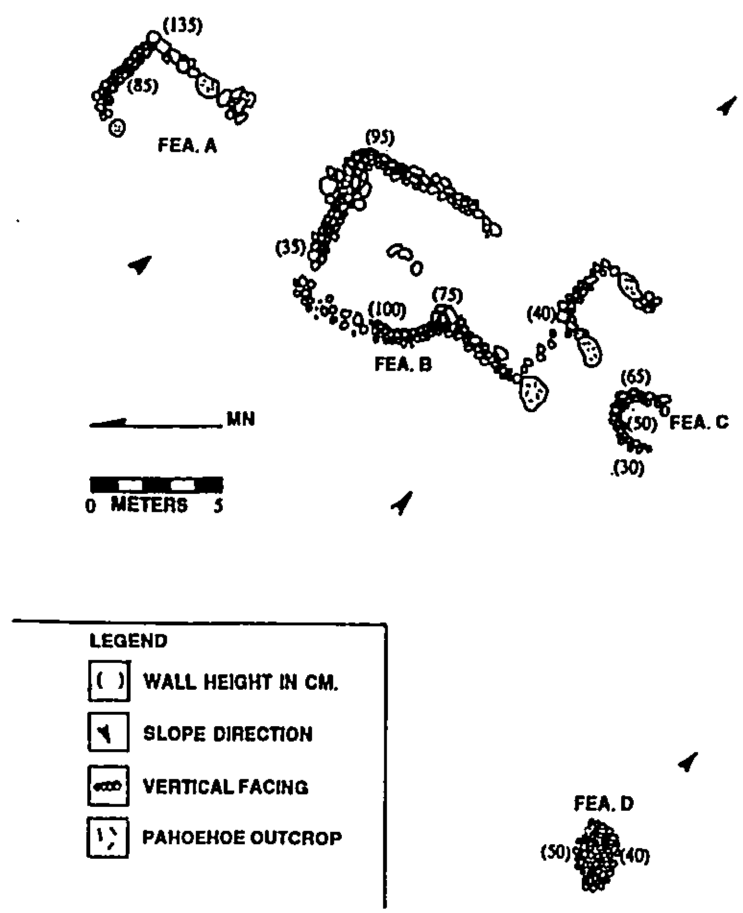


Figure 21 State Site 50-50-08-3184, Plan View

ft.) high. The L-shape's southeast wall is constructed of medium boulders stacked on outcrop with a few collapsed boulders present in the south. This wall measures 4.5 m. (14.8 ft.) NE/SW by 0.8 m. (2.6 ft.) wide and rises a maximum height of 1.3 m. (4.4 ft.). The L-shape surrounds a level soil area measuring 12.0 m.² (130.0 ft.²).

Feature B is a irregular enclosure located 4.0 m. (13.1 ft.) southwest of Feature A. A gap, measuring 4.0 m. (13.1 ft.) wide, occurs in the enclosure wall's southeast corner. The feature encloses a level surface measuring 9.0 m. (29.5 ft.) NE/SW by 4.0 m. (13.1 ft.) NE/SE. The enclosure northwest wall is curved and is constructed of stacked cobbles and small boulders. It has a maximum width of 0.6 m. (2.0 ft.) and faced along its interior side at a maximum height of 1.0 m. (3.3 ft.). The northeast end of this wall section is collapsed and may represent a second opening into the enclosure. The northeast and southwest walls of the enclosure are similar in size and construction but the interior side of the southeast wall is flush to the ground surface. A 3-sided enclosure is incorporated into the enclosure's southwest wall and is open to the southwest.

Feature C is a C-shaped enclosure located 2.0 m. (6.6 ft.) southwest of Feature B. Its wall is constructed of piled large cobbles and small boulders and measures 0.5 m. (1.6 ft.) wide by a maximum of 0.6 m. (2.0 ft.) high. The feature partially encloses an area measuring 1.5 m. (4.9 ft.) in diameter and is open to the southwest.

Feature D is a mound located 14.0 m. (46.0 ft.) west of Feature C. It is constructed of a mix of loosely piled small and medium boulders. Its surface is roughly level and contains a depression at its center. The mound measures 3.0 m. (9.8 ft.) E/W by 2.0 m. (6.6 ft.) N/S.

No artifacts or midden were observable at the site. Features A through C are likely permanent habitation structures, while Feature D may represent a burial monument.

State Site #:	50-50-08-3185	**CSH Site #: 27** (See Figure 61)
Site Type:	Complex	
Function:	Agriculture/Temporary habitation	
Features (#):	3	
Probable Age:	Prehistoric	
Condition:	Fair	
Dimension:	532.0 m.² (5,746.0 ft.²)	
***Ahupua'a*:**	Ukumehame	
Elevation:	400 ft. a.m.s.l.	

Description: Site -3185 is a complex of three features (Figure 22) located atop a prominent ridge immediately west of Ukumehame Gulch. The site affords a commanding view of the Ukumehame Gulch area and Lahaina coast and is situated within 5.0 m. west of a steep slope descending towards the Gulch. The terrain slopes moderately to the south and is intermittently scarred by surface erosion and boulder movement. A transmission-line access road leading *mauka* is located to the west of the complex. Vegetation consists of shrubs, grasses and occasional *kiawe* trees.

Feature A is a C-shaped enclosure open to the west. It is located at the *makai* end of the complex. The C-shape is composed of two wall sections extending roughly 3.0 m. (9.8 ft.) west of two large boulders (the boulders form the east side of the enclosure). The walls are constructed of piled large cobbles and small basalt boulders and measure a maximum of 1.0 m. (3.3 ft.) wide by 0.7 m. (2.2 ft.) high. Collapse has occurred to the south side of the northern wall. The enclosure interior slopes gently *makai*.

Feature B is a small rectangular enclosure is located 12.0 m. (39.4 ft.) north of Feature B and is the most formally constructed feature of the complex. The enclosure is terraced to the interior ground surface on its downslope or southwest side and incorporates three large boulders in its southeast side. The terrace wall is constructed of a 1.3 m. (4.3 ft.) high face of small boulders and interior fill of large cobbles measuring 1.0 m. (3.3 ft.) wide. The northeast wall is bifaced and constructed of 2 to 3 rows of large cobbles. It measures 0.5 m. (1.6 ft.) wide by a maximum of 0.8 m. (2.6 ft.) high. The northwest wall section measures 0.7 m. (2.3 ft.) wide by 0.6 m. (2.0 ft.) high and is piled with small boulders. A crevice - possible cupboard - is located beneath a large boulder on the southeast side of the enclosure. Overall, Feature B encloses a level surface measuring 2.0 m. (6.6 ft.) across.

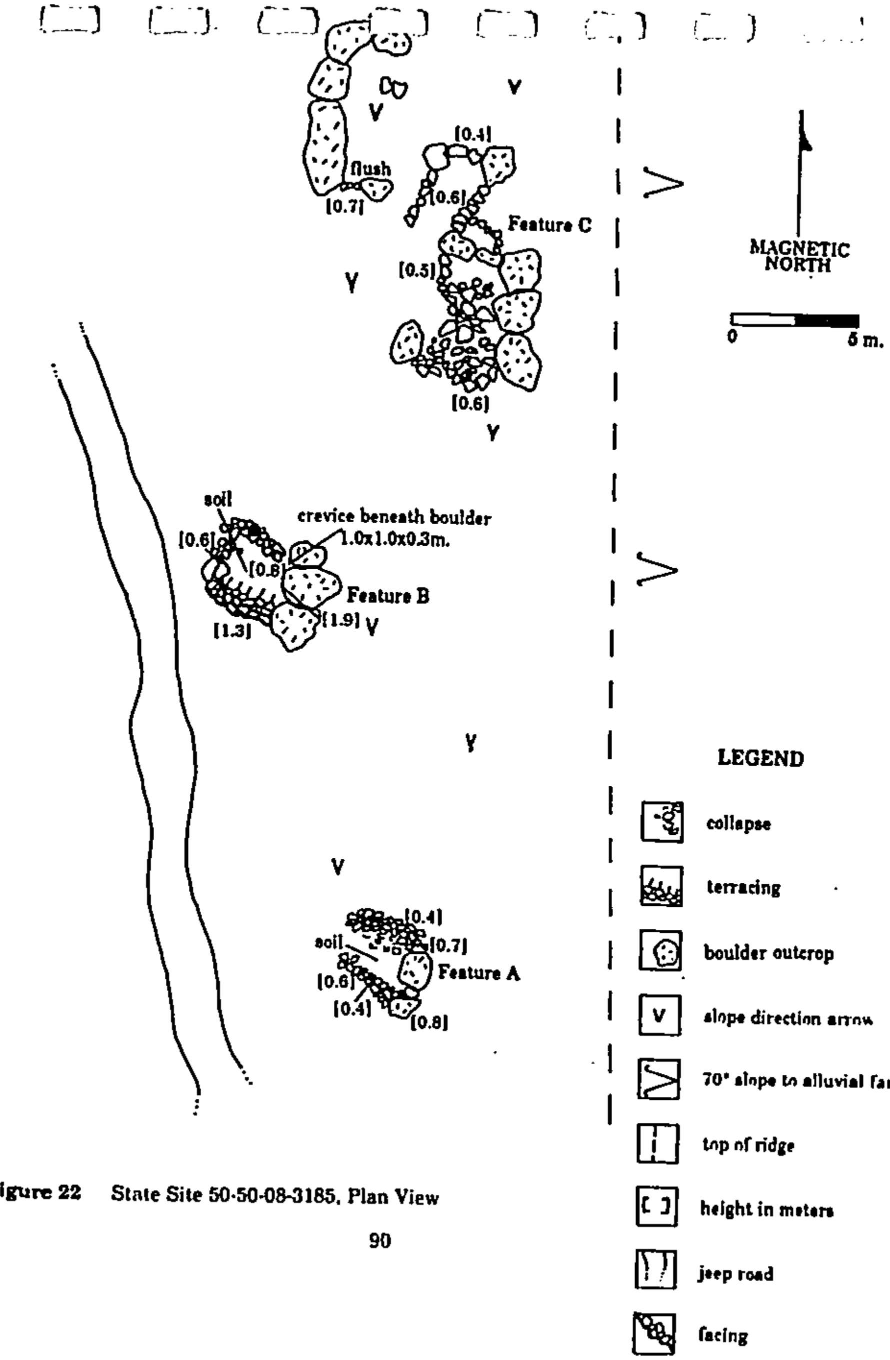


Figure 22 State Site 50-50-08-3185, Plan View

Feature C is located on the *mauka* (north) end of the complex, approximately 9.0 m. (29.5 ft.) northeast of Feature B. The feature is a network of interconnecting wall sections and alignments which modify outcrop boulders to form small enclosed areas. It is situated on moderately sloped terrain with few level areas present. The south portion of the feature consists of boulder rubble which is modified with indistinct depressions. The enclosed areas range from 1.0 (3.3 ft.) in diameter to 3.0 m. (9.8 ft.) N/S by 2.0 m. (6.6 ft.) E/W. The walls and alignments are one row of boulders and the walls are stacked 2 to 3 courses high, reaching a maximum height of 0.7 m. (2.2 ft.). Feature C is a possible agricultural feature; its primary function is to retain soil on the sloped surface.

Features A and B of Site -3185 are interpreted as recurrent habitation structures that may have been utilized while traveling *mauka-makai* on the ridge top and/or as look-outs during times of civil strife.

No artifacts or midden were observed at the site complex.

State Site #: 50-50-08-3186 **CSH Site #: 28**

State Site #:	50-50-08-3186
Site Type:	Enclosure
Function:	Temporary habitation
Features (#):	1
Probable Age:	Prehistoric
Condition:	Fair
Dimension:	12.0 $m.^2$ (39.3 $ft.^2$)
***Ahupua'a*:**	Ukumehame
Elevation:	200 ft. a.m.s.l.

Description: Site -3186 is a C-shaped enclosure (Figure 23) located on the alluvial flats to the east of Ukumehame Gulch. Site vegetation consists of grass, *koa haole*, klu and lantana. The terrain is mostly level and is scattered with boulders.

The C-shape is constructed of a rough wall of piled boulders and cobbles which is vertically faced along its interior side. The wall has a maximum width of 0.6 m. (2.0 ft.) and height of 0.7 m. (2.3 ft.). The C-shape is open to the southwest and partially encloses an area of 3.0 m. (9.8 ft.) E/W by 2.0 m. (6.6 ft.) N/S. The interior is level with a few boulders scattered on the surface.

No artifacts or midden were observed at the site.

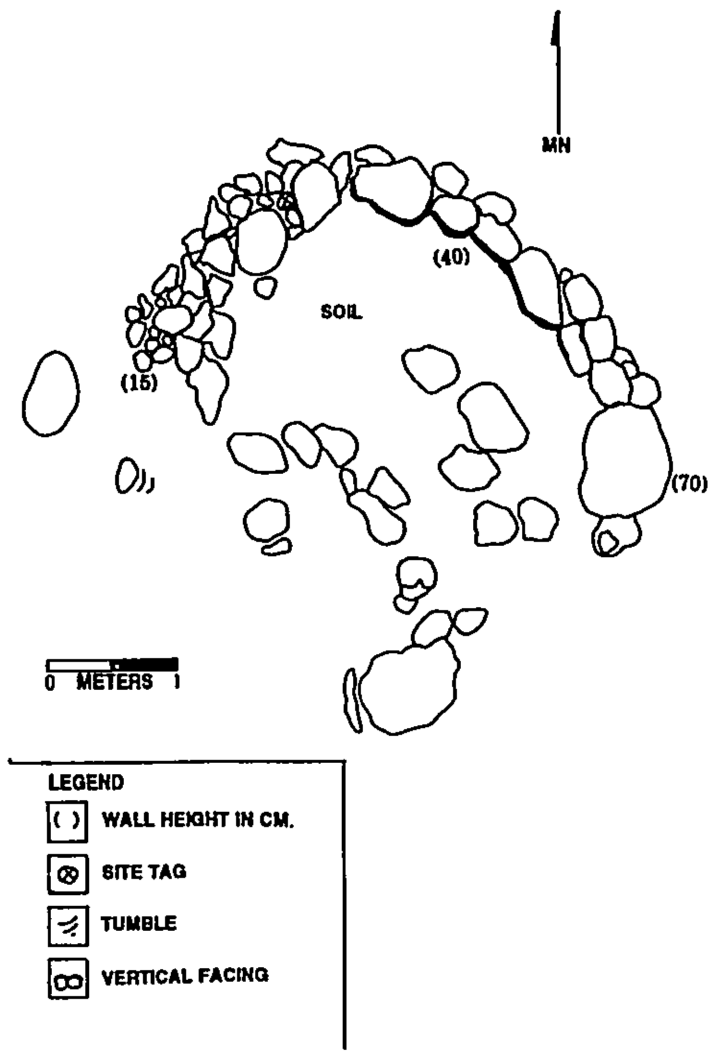


Figure 23 State Site 50-50-08-3186, Plan View

State Site #:	50-50-08-3187	**CSH Site #:** 29 (See Figure 62)
Site Type:	Complex	
Function:	Temporary habitation	
Features (#):	2	
Probable Age:	Prehistoric	
Condition:	Fair to poor	
Dimension:	48.0 m.^{2} (518.8 ft.^{2})	
Ahupua'a:	Ukumehame	
Elevation:	200 ft. a.m.s.l.	

Description: Site -3187 is a complex of two features (Figure 24) located on the alluvial flats east of Ukumehame Gulch. The terrain slopes gently to the southeast; boulders are scattered on the surface. Vegetation in the site area consists primarily of grass, *koa haole*, klu and lantana.

Feature A is a C-shaped enclosure open to the southeast. It encloses an area roughly 2.0 m. (6.5 ft.) NE/SW by 3.0 m. (9.8 ft.) NW/SE. The enclosure wall is constructed of piled large cobbles and small boulders. The wall incorporates a large boulder into its northeast side. The wall measures 0.4 m. (1.3 ft.) wide by a maximum of 0.7 m. (2.3 ft.) high. The interior is a level soil surface.

Feature B is an indistinct structure (possible enclosure) characterized by a wall section measuring 3.0 m. (9.8 ft.) SE/NW by roughly 0.5 m. (1.6 ft.) wide. A contiguous, low alignment of cobbles extends to the southwest of the wall forming a roughly enclosed area measuring approximately 2.0 m. (6.6 ft.) in diameter. The alignment is obscured by a dense grass cover.

No artifacts or midden were observed in the site area.

State Site #:	50-50-08-3188	**CSH Site #:** 30 (See Figure 64)
Site Type:	Modified rockshelter	
Function:	Temporary habitation	
Features (#):	1	
Probable Age:	Prehistoric	
Condition:	Good	
Dimension:	6.0 m.^{2} (64.8 ft.^{2})	
Ahupua'a:	Ukumehame	
Elevation:	200 ft. a.m.s.l.	

Description: Site -3188 is a modified rockshelter (Figure 25) situated immediately east of a dry drainage gully. The surrounding terrain slopes gently to the southeast. Much

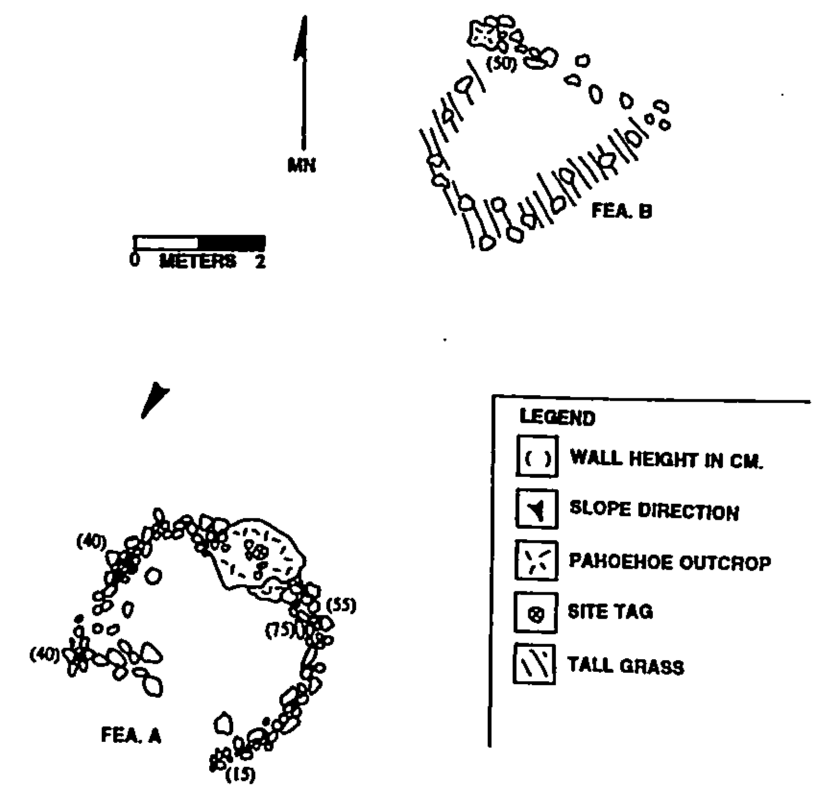


Figure 24 State Site 50-50-08-3187, Plan View

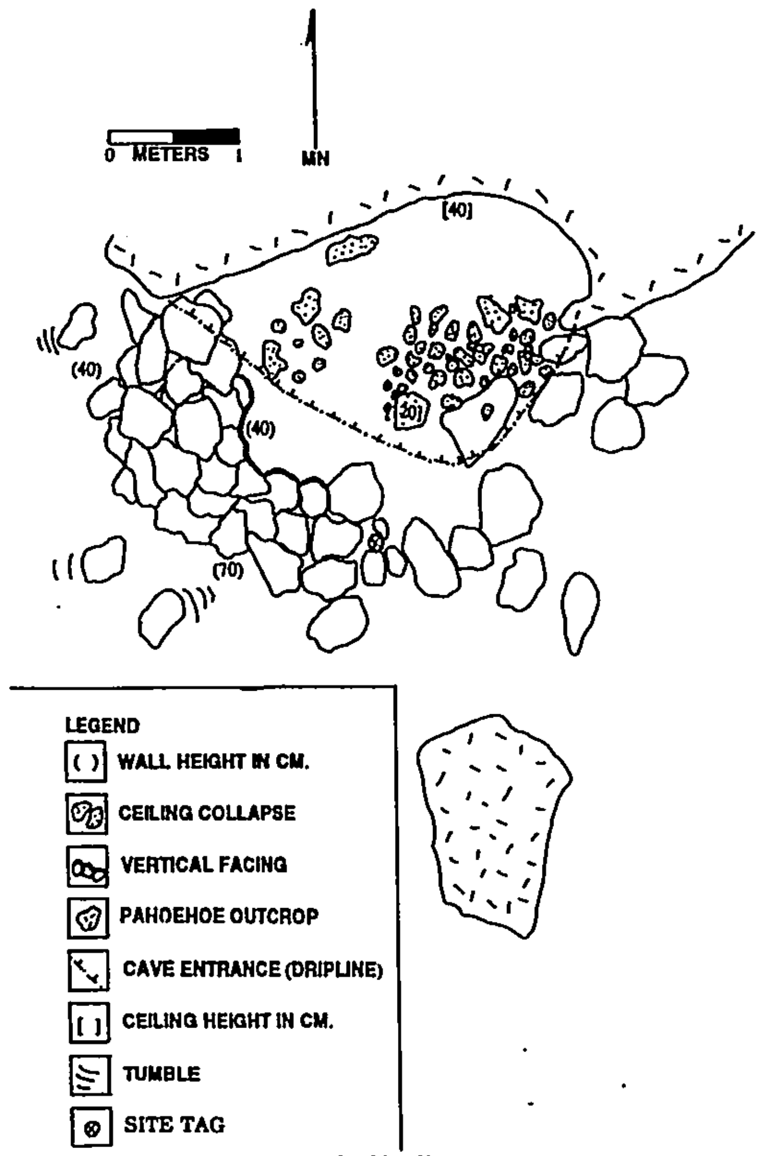


Figure 25 State Site 50-50-08-3188, Plan View

of the ground surface is severely eroded as indicated by boulder rubble on exposed soil areas and drainage cuts. A recent forest fire has charred and uprooted some of the trees in the area. The site vegetation consists primarily of *kiawe*, klu and grass.

The shelter is formed by the south face of a large boulder which is enclosed to the south with a semi-circular wall. The boulder face reaches a height of roughly 3.0 m. (10.0 ft.). The boulder slopes inward, forming a natural 2.0 m. (6.6 ft.) wide by 1.2 m. (3.9 ft.) high ceiling. The wall is roughly piled with small boulder slabs; it measures a maximum 1.0 m. (3.3 ft.) wide by 0.7 m. (2.3 ft.) high. The large boulder face in conjunction with the wall encloses in area of 2.5 m. (8.2 ft.) in diameter.

Water-worn pebbles and coral fragments were observed to the south of the shelter.

State Site #:	50-50-03-3189	**CSH Site #:** 31
Site Type:	Complex	
Function:	Agriculture	
Features (#):	-	
Probable Age:	Prehistoric-historic	
Condition:	Fair	
Dimension:	Undetermined	
***Ahupua'a*:**	Launiupoko	
Elevation:	565-575 ft. a.m.s.l.	

Description: Site -3189 is an agricultural complex (Figure 26) situated on a plateau gently sloping southeast towards Launiupoko Gulch. The overall structural integrity of the site is obscured by a dense ground cover of grass. Vegetation also includes *koa haole*, klu and a few *kiawe* trees. The complex features appear to extend at least 152.4 m. (500.0 ft.) NW/SE from the *mauka-makai* jeep road to the crest of Launiupoko Gulch. According to a Pioneer Mill cane map labelled *Canefield Map - 1918 MC-10 to 33*, this area of Launiupoko was cultivated in cane during the early 1900's.

The complex features are typified by a network of parallel, boulder alignments oriented across the slope. In general, the alignments are spaced about 1.0 m. (3.3 ft.) to 2.0 m (6.6 ft.) apart and retain roughly level surfaces of loose sediment. Other feature types observed in the complex include small enclosures and C-shape structures. Those features which were visible in the dense grass were roughly constructed of piled boulders and lacked any formal facing.

Because the site area is known to have been cultivated in cane at one time, it is

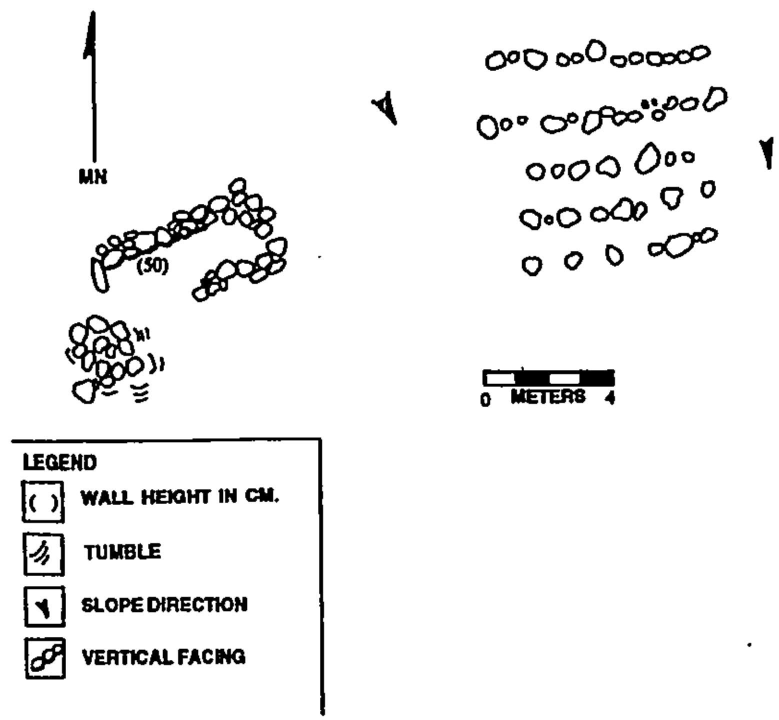


Figure 26 State Site 50-50-03-3189, Plan View

suggested that the majority of the features - in particular the boulder alignments - are attributable to this activity.

State Site #:	50-50-08-3190	**CSH Site #: 32**
Site Type:	Retaining walls	
Function:	Agriculture	
Features (#):	2	
Probable Age:	Historic	
Condition:	Fair	
Dimension:	See below	
***Ahupua'a*:**	Launiupoko	
Elevation:	600-640 ft. a.m.s.l.	

Description: Site -3190 consists of two walls extending across the steep slope descending to the base of Launiupoko Gulch. The terrain is rocky and at the base of the slope consists of a steep-sided face of stratified alluvial deposits. Vegetation consists primarily of grass, klu and *koa haole.*

The walls are located approximately 10.0 m. (33.0 ft.) apart and are constructed of 1 to 2 rows of stacked cobbles and boulders rising an average height of 0.8 m. (2.6 ft.).

State Site #:	50-50-08-3191	**CSH Site #: 34**
Site Type:	Kerbstone trail	
Function:	Travel route	
Features (#):	-	
Probable Age:	Prehistoric-historic	
Condition:	Poor-remnant	
Dimension:	Not determined	
***Ahupua'a*:**	Ukumehame	
Elevation:	800 ft. a.m.s.l.	

Description: Site -3191 refers to a trail section located on a prominant ridge of the West Maui Mountains descending towards the central isthmus inland of Mā'alaea. The trail was previously identified adjacent to the Lahaina Pali Trail (Michael Baker, personal communication 1993).

The trail was observed outside of the preferred alignment during aerial reconnaissance of the upland Ukumehame region. At this time, two poorly preserved parallel stone-alignments, oriented *mauka-makai*, were observed along the ridge top at approximately 244.0 m. (800.0 ft.) a.m.s.l. At this location site -3191 trail diverges from the Lahaina Pali trail and heads *mauka* towards the project area. The Lahaina Pali trail appears to have been constructed over site -3191 trail.

VI. SITE DISTRIBUTION AND SETTLEMENT PATTERN

Site Distribution

The present study allowed the identification of archaeological sites over a narrow elevational band 91.5 m. (300 ft.) wide extending between Mā'alaea on the isthmus to the area of Lahainaluna above Lahaina town. The preferred alignment ranges in elevation from 20 ft. above mean sea level (a.m.s.l.) on the isthmus to approximately 1800 ft. a.m.s.l. in Ukumehame *ahupua'a*. The majority of the preferred alignment extends along the juncture of the foothills of the West Maui Mountain range and the ancient alluvial fans between Ukumehame valley and Kaua'ula Stream to the north. This portion of the corridor ranges between approximately 200 to 600 ft. a.m.s.l. in elevation.

The traditional Hawaiian sites identified during the present survey are clustered in the Ukumehame and Launiupoko valley regions, with more isolated sites located near Kaua'ula Stream and in upland Ukumehame *ahupua'a*. Sites primarily associated with historic, large-scale agriculture (cane) were located adjacent to the four major streams of Lahaina (Ukumehame, Olowalu, Launiupoko, and Kaua'ula streams) and the upper alluvial fans of Launiupoko and Kaua'ula streams.

The paucity of traditional Hawaiian sites in the Olowalu valley area is undoubtedly due to the destructive nature of large-scale cane agriculture which presently encompasses almost all of Olowalu that the preferred alignment crosses.

Settlement Pattern

A difference in prehistoric and early historic settlement patterns is revealed in two specific regions of the lands between Mā'alaea and Lahaina Town: 1) Mā'alaea and Upper Ukumehame region; and the 2) Southwest Lahaina District (alluvial flats of Ukumehame, Olowalu, Launiupoko and Kaua'ula streams). This regional dichotomy undoubtedly resulted from the differing landscapes and differential availability of productive agricultural lands. The settlement pattern presented below is based on the cultural background, previous archaeological research, and present study survey results detailed in this report. Information from previous archaeological studies conducted in the coastal region of Lahaina District and Waikapū *ahupua'a* also contribute to the character and chronological analysis of the settlement pattern.

<u>Mā'alaea-Upper Ukumehame-Traditional Hawaiian Setting</u>

In discussing the Mā'alaea section of the central isthmus of Maui Island it is important to note that the political boundaries of the *ahupua'a* of Waikapū impound the southern portion and coast of the isthmus.

The south coast of the isthmus of Waikapū *ahupua'a*, although ostensibly devoid of intensive agricultural use and permanent occupation, except at Mā'alaea on the coast, was undoubtedly an important cross-roads of travel between distant destinations, and important for its coastal resource to the Waikapū *ahupua'a* residents. Only one land claim gives testimony that traditional crop of *wauke* was grown inland nearby Pu'uhele in Waikapū *ahupua'a*. However, this paucity in land claims on the Maui isthmus may be because the lower lands were being subject to large-scale sugarcane or pasture use during the Mahele and thus, not available for traditional Hawaiian use (Creed 1993:74).

The settlement in Waikapū *ahupua'a* appears to be centered on the upland, fertile alluvial lands bounding Waikapū Stream. A multitude of previous archaeological studies show that this upland Waikapū settlement supported an intensive dryland field system upon the ancient alluvial fans and wetland agriculture field systems on the recent alluvial terraces of Waikapū Stream. Other lesser stream drainages in Waikapū adjacent to Waikapū *ahupua'a* were utilized in a similar manner.

The earliest radiocarbon dates in Waikapū were excavated from upper elevation dryland sites and date to the 11th century A.D. (Kennedy 1991). In general, the development of intensive dryland field systems - which apparently existed in Waikapū at elevational ranges between at least 400 and 1000 ft. above mean sea level - is considered to have been a result of population increase, as well as a consequence to growing socio-political Hawaiian hierarchy (to provide an agricultural surplus to the *ali'i* for economic and political control (Kirch 1985:235). Thus, in corresponding to a period of presumed population increases and development of the Hawaiian class system, the Waikapū Field System was likely utilized primarily during the Expansion Period (A.D. 1100-1650) and certainly by the mid 15th century (*ibid.*:305).

Based primarily on Winslow Walker's island-wide survey of Hawaiian sites, occupation of the Ukumehame *ahupua'a* between the alluvial flats of Ukumehame Gulch and the Maui Island isthmus, seems to be focused on the coastal zone, particularly between Mā'alaea Bay and McGregor's Point. This settlement comprises at least 45 "house and shelter" sites, some of which may have been fishing shrines or *koa* (Walker 1931:43). It seems likely a major focus of this village was fishing, given the shrines, its cliff side location, and the lack of abundant agricultural land. A major *heiau* and extensive panels of petroglyphs were also identified by Walker just inland of the village complex.(*ibid.*:43).

The steep topography and arid environment of the upper, *mauka* elevations of Ukumehame *ahupua'a* (east of the broad coastal plain fronting Ukumehame Gulch) presents a relatively inhospitable and unproductive agricultural landscape. However, as indicated by a traditional Hawaiian trail present on the Mā'alaea side of the region and the possible existence of a network of comparable trails (Michael Baker, personal communication 1993) ascending *mauka* of Walker's coastal settlement, the upper elevations of Ukumehame provided a way to the summit of West Maui and hence to the other side. Kealaloloa "long pathway" Ridge, as its name suggests, may have been the main land travel route used during prehistoric and early historic times to cross the West Maui Mountain, with auxiliary trails once serving to connect with the main travel route. This prominant landform ascends above McGregor's Point, which apparently represents the western extent of the coastal settlement observed by Walker. The main travel route of Kealaloloa and auxiliary *mauka-makai* trails probably provided coastal residents with access to *mauka* resources (*e.g.* wild plant goods, bird catching, and stone materials), and communication with other West Maui regions.

Southwest Lahaina District-Traditional Hawaiian Setting

The broad alluvial plains of the Lahaina District fronting Ukumehame, Olowalu, Launiupoko and Kaua'ula streams - and Kanaha and Kahoma streams to the northwest - were clearly the center of widespread occupation and intensive agriculture during prehistoric times. As E.S. Craighill Handy and Elizabeth Green Handy pointedly suggest, the *ali'i* and *maka'āinana* were drawn to the Lahaina region for its abundant marine resources and productive agricultural lands, pleasurable environment, easy communication with other major population centers on Maui, and proximity to Moloka'i and Lana'i. Hence, the ancient name for Lahaina - Lele (literally "to jump from place to place") - may refer its advantageous location in close propinquity to Lana'i, Moloka'i and other localities (Klieger 1993:32).

The profusion of early historic voyagers to the Lahaina region provide an

exhaustive account of the natural and cultural setting of Lahaina at the time of western contact. These accounts describe a luxuriant agricultural landscape which encompassed the Lahaina area "about three leagues in length, [nine miles] along the coast, and one three miles] at its breadth" (Handy and Handy 1972:493). Beyond this expanse, the lands were reportedly dry and barren (*ibid.*). These early accounts also enumerate a complete variety of traditionally cultivated crop types characterizing the agricultural landscape of late prehistory, including: breadfruit, *kou*, coconut, sugarcane, sweet potatoes, taro, *wauke*, and banana (Wong-Smith, in Graves 1991:A3 [Diaries of Rev. C.S. Stewart]). Ethnographic studies by Handy and Handy indicate that intensive wetland agriculture (*lo'i*) was managed within the stream gulches and alluvial plains of Ukumehame, Olowalu and Kaua'ula streams. The main Lahaina taro land was centered around the Kanaha and Kahoma streams and extended far into the valley to the west slope of Pu'u Kukui (Handy and Handy 1972:492).

The archaeological evidence of prehistoric land use in the Lahaina region is relatively meager within the alluvial plains since much, if not all of the prime agricultural land has since been taken over by large-scale sugarcane agriculture. Nonetheless, some comments may be made based on the apparent distribution of Mahele period LCA's (Land Commission Awards), and on the nature of archaeological sites still present or previously recorded in the area.

The *ali'i*, especially the *ali'i nui* preferred to reside on the shore near the confluence of streams and sea. This place is now the center of Lahaina town. As indicated in traditional and early historic accounts, the coastal region was under extensive cultivation and in contrast to the inland region, natural underground springs and major streams flowing into the sea enabled the development of aquaculture (fishponds). One of the more notorious *ali'i nui* residences used by the Kamehameha dynasty during the 19th century was at Moku'ula Island, built in the ancient fishpond of Loko Mokuhinia. Traditionally Moku'ulu Island and Loko Mokuhinia were associated with the *'aumakua* of the royal Pi'ilani clan: the *mo'o* or water dragon spirits (giant lizards) (Klieger 1993:7). The coastal locality of Lua'ehu, bordered on the north by Pahu-mana-mana stream (presently Dickenson Street in Lahaina town) and to the south by Kaua'ula stream, was known as the chiefly region of Lahaina (*ibid.*:13). Apparently the southern and northern boundaries of Lua'ehu were once demarcated by *heiau* (*ibid.*). It is important to note here, that the lands of Lua'ehu reportedly encompassed *mauka* territory including Kaua'ula and Launiupoko valleys, and as posited by Klieger, Lua'ehu may have represented a traditional self-sufficient *ahupua'a* (*ibid.*) with Moku'ula and Loko Mokihinia situated at its center.

A second "zone" of permanent occupation and intensive agricultural landuse is revealed along the inland region of the Lahaina alluvial plains and stream gulch areas. As discussed previously in the Cultural Setting section of this report, some degree of landuse differentiation is revealed by the distribution of LCA's shown on a 1887 Olowalu Sugar Co. cane map. This map indicates that the most tightly concentrated LCA's occurred along the stream banks, whereas LCA's among the alluvial plains were scattered - with the latter remaining somewhat clustered in proximity to the streams. It is speculated that the *maka'āinana* were the main occupants of the inland region of Lahaina for two reasons: 1) the preferable coastal regions were primarily reserved for the *ali'i*, and 2) the *maka'āinana* were the primary tenders of the agricultural lands which were - in traditional times - ultimately under the control of the varying levels of the *ali'i* class. Thus, occupation in close proximity to the crop lands would seem to have been a choice of convenience.

The three major *heiau* in the inland region of Lahaina attest that these prime agricultural lands were an eminent resource for both the *maka'āinana* and *ali'i* of the Lahaina populace.

A previous archaeological inventory survey (Graves 1991) and the present study identified what appears to be intensive dryland agriculture upon the ancient alluvial fans of the Launiupoko drainage and to the southeast, the Kaua'ula drainage. The fact that intensive dryland agriculture was only identified within these two specific regions does not eliminate the possibility that it was developed on the old fans of the other drainages crossed by the preferred alignment. The absence of sites on the other fans may be due to the location of the powerline corridor or the location of sugarcane fields. If traditional agriculture was confined to the Launiupoko and Kaua'ula stream areas, one could hypothesize that pressures to increase agricultural surplus were provoked by the *ali'i* upon residents of Lua'ehu, which once encompassed these lands.

A third "zone" of occupation in the Lahaina region is centered along the juncture of the mountain ridges and more *mauka* section of the older alluvial fan of Ukumehame.

This zone is characterized by temporary habitation use, most of which appears to be directly associated with travel routes proceeding *mauka* to the center of the mountain.

These three "zones" of differential landuse together characterize settlement in the Lahaina District at its height of development during late prehistoric times. During this period, Lahaina was clearly an important political and cultural center on the island of Maui, and a diversity and abundance of subsistence resources - including aquaculture, wetland and dryland agriculture, and fishing - were maintained to support a large and thriving Hawaiian population. How Lahaina became a major political and cultural center may be examined based on the speculated evolution of Hawaiian culture (Kirch 1985) in correlation with a few dated archaeological sites in the region.

Occupation of leeward localities of the Hawaiian islands is generally believed to have ensued during the Expansion period (A.D. 1100-1650) (Kirch 1985:303) when an increased population - originally centered on favorable windward localities - forced the settlement of more marginal environments. This demographic factor coupled with the advancement of the socio-political Hawaiian *ali'i* class, provoked the development of intensive dryland and wetland field systems, irrigation systems, and aquaculture. Radiocarbon dates obtained from sites in the Lahaina region correlate with occupation during the Expansion period. Previous archaeological studies and radiocarbon dating of sites on the Lahaina coast (Haun 1988) suggest that occupation of the coast may have occurred at least as early as A.D. 1260. In contrast, two temporal periods of habitation in association with intensive dryland agriculture development in upper Launiupoko valley is intimated during A.D. 1170-1510 and A.D. 1650-1950 (Graves 1991). A primary permanent occupation of the more favorable coastal regions would seem likely to pre-date or occur during the initial development of upland agriculture, especially since the earlier period of occupation at Launiupoko appears to be primarily of a temporary nature.

During the early part of the Expansion period in Lahaina, prior to the development of *ahupua'a* land divisions *ca.* A.D. 1400 (Kolb:43), land tenure was likely characterized by "*maka'ainana*" or proto-districts of which the geographical boundaries were based more on environmental factors (*ibid.*). As the "Hawaiian society grew increasingly complex and absolute ranking replaced relative ranking of chiefs" (*ibid.*) the political boundaries of *ahupua'a* were consequently established.

During the latter part of the Expansion period - likely marked by occupation and intensive agriculture over most of the productive lands of the Lahaina alluvial plains - the Hawaiian *ali'i* class system was well established and religious practices became elaborated in various ways, so to support the new socio-political system. We know, based on traditional and historical accounts, that efforts to gain control over the Lahaina region was undertaken by many warring chiefs and their respective polities, and construction of major *heiau* - such as Hiki'i, Ukumehame, and Kawai'aloa *Heiau* in Lahaina - became one of the methods used to legitimate political power of chiefs. Consequent to all of these factors, development during the Expansion period ultimately replaced the ancestral Hawaiian cultural system with a strictly ranked society coupled with new technologies and social customs (Kirch 1985: 306) facilitated to support a large and complex populace.

During the period prior to western contact (Protohistoric period A.D. 1650-1795)(*ibid.*1985: 306) intensification of dryland and wetland agriculture was likely perpetuated and permanent settlement - evidenced by the latter period dates at Launiupoko - radiated within the upland areas. Political rivalry between chiefs reached a heightened intensity, as many attempted to expand their reign beyond their districts and islands.

In sum, it would appear that Lahaina represented one of the main political centers of Maui during at least the later Expansion period, when the ranked social stratification was well in place and technological development of subsistence resources were great enough to sustain and empower a thriving community.

Although the earliest settlement of Maui was likely centered along the more favorable windward coast, it is not unlikely that small communities also occupied the Lahaina coast during this time. The Lahaina region offered an abundance of marine goods and wetland areas for the development of *lo'i* for the cultivation of *kalo* or taro, the primary subsistence crop cultivated by the Hawaiians.

Non-Traditional Hawaiian Setting

The prevailing change to the traditional Hawaiian setting of Mā'alaea and the southwest Lahaina region was - through western introduction - the development of large-scale agriculture over what eventually became all of the prime agricultural lands of the alluvial plains. General abandonment of habitation and traditional agriculture in the

regions inland of Mā'alaea and the southwest Lahaina District - with the exception of a few homesteads still existing along the banks of Kaua'ula, Olowalu, and Ukumehame streams - likely occurred by the end the 19th century. It is hard to say whether abandonment of these areas was a direct result of pressures to expand the large-scale cane industry or *vice versa* -- that the cane fields took over already abandoned lands. The latter scenario seems to be more credible since the native population underwent a severe depopulation following western contact, and those who survived the fatal diseases were likely drawn to fast developing economic centers, such as Lahaina town, or in closer proximity to major roadways and localities of churches and schools established by the missionaries. Western-style roadways also magnified parts of the old patterns of travel providing quicker and more accessible routes for articles of trade between economic centers, such as between Wailuku and Lahaina via the Lahaina-Pali Trail.

Change in the non-traditional settlement pattern since the turn of the 20th century has resulted in the abandonment of many plantation camps in favor of the expansion of urban centers, and construction of modern roadways, and recent efforts to preserve the remaining early historic structures in Lahaina Town itself. These latter efforts of preservation ultimately associated with tourism have become the main entity for supporting the Maui economy, replacing large-scale plantation agriculture of the 19th century.

VI. SIGNIFICANCE ASSESSMENTS

A total of 34 sites of varied archaeological significance (see Table 1) were located in the project area. (The "project area" refers to the preferred alignment surveyed during April 1993 and the supplemental survey area of June 1993.) Sites were evaluated for significance according to the broad criteria established for the National and State Registers. The five criteria are:

A Site reflects major trends or events in the history of the state or nation.

B Site is associated with the lives of persons significant in our past.

C Site is an excellent example of a site type.

D Site may be likely to yield information important in prehistory or history.

E Site has cultural significance; probable religious structures (shrines, heiau) and/or burials present.

All of the 34 sites within the project area are considered likely to yield information important to prehistory and history (Criterion D). The project sites are expected to yield varying types of scientific data which may include some or all of the following categories: 1) subsurface cultural deposits; 2) site architecture and function analysis; and 3) site distribution and settlement patterns of inland land use. Because few dated archaeological sites are presently recorded in the Lahaina area, radiocarbon analyses of cultural deposits (*i.e.* charcoal) are especially significant data potentially obtainable from the sites.

Seven site complexes in the project area meet multiple significance criteria presented below:

STATE SITE #	FUNCTION	SIGNIFICANCE CRITERIA COMBINATION
50-50-08-2	Hikii Heiau	A, B, C, D, E
50-50-08-3	Ukumehame Heiau	A, B, C, D, E
50-50-08-3165	Habitation	C, D
50-50-03-2678 & 2679	Agriculture-habitation	C, D
50-50-08-3168	Ritual-Habitation	C, D, E
50-50-08-3184	Habitation-possible burial	D, E*

*possible burial

The two sites embracing all five of the criteria (sites 50-50-08-2 and 50-50-08-3) are monumental *heiau*. These monumental *heiau* are embodiments of "major trends or events in the history of the state or nation" (Criterion A), possibly illustrating competition between chiefs during development of the Hawaiian monarchal hierarchy. The two project *heiau* are also likely associated with "lives of persons significant in the past" (Criterion B). Hiki'i *Heiau* was reportedly named after the chief for whom it was built.

Five of the sites meeting multiple significance criteria are evaluated as "excellent site types" (Criterian C). These sites include the two *heiau* (sites 50-50-08-2 and 50-50-08-3), a dryland agriculture and residential complex (Site 50-50-03-2678/2679), a temporary habitation complex (50-50-08-3165), and a temporary habitation and possible shrine complex (Site 50-50-08-3168). These sites are evaluated as "excellent site types" because they represent the best examples of functional and formal site types within the project area. With the exception of Ukumehame *Heiau*, all of the "excellent site type" sites are well preserved. Most of Ukumehame *Heiau* has been disturbed by road building and activities associated with ranching and cane agriculture.

Four of the project sites with multiple significance criteria are evaluated as having "cultural or religious significance" (Criterian E). These sites include the two *heiau* sites (50-50-08-2 and 50-50-08-3), and possible shrine and burial components of site complexes (site 50-50-08-3168 and 50-50-08-3184, respectively).

Although thirteen (38%) of the sites are located within close proximity to the preferred alignment, none of these sites will be directly impacted by construction of the line (see FINDINGS AND CONCLUSIONS section and Table 4 below).

VII. FINDINGS AND CONCLUSIONS

Of the 34 archaeological sites identified in the project area, 13 sites are located along the preferred alignment centerline or within close proximity to the centerline. Table 4 provides the locations of all of the sites relative to the preferred alignment centerline and proposed pole locations in the realignment sections. All of the identified sites are evaluated as significant archaeological resources.

The preferred alignment (April 1993 survey area) was rerouted and new areas surveyed in June 1993. The final location of the preferred alignment was chosen to avoid structural impact to all of the identified archaeological sites and, in addition, to avoid visual impact to the two *heiau* (sites 50-50-08-2 and 50-50-08-3) in the project area. To assure that sites would not be adversely impacted by construction of the transmission line, particularly by placement of the transmission line poles, the project realignment was focused on three archaeologically sensitive areas (Mā'alaea, Ukumehame, and Launiupoko sections) where sites were densely concentrated or highly significant (*e.g. heiau* and the Lahaina Pali Trail). Criteria for buffer zones between sites and the preferred alignment and selected pole locations were devised by Cultural Surveys Hawaii. These criteria were utilized in adjusting the location of the preferred alignment. (Prior to the realignment and related survey work, the criteria were discussed and informally approved by Ms. Agnes Griffin of the State Historic Preservation Division-DLNR [personal communication, June 2, 1993]). The buffer zone criteria are as follows:

1) A buffer zone of at least 100.0 ft. (30.4 m.) will be established between all isolated sites or complexes and pole locations.

2) A buffer zone of at least 50.0 ft. (15.2 m.) will be established between complexes with concentrated agricultural features (*e.g.* Launiupoko site complexes) and pole locations.

3) Preservation of the view plane of Ukumehame and Hiki'i *heiau* has been preserved by rerouting the transmission line alignment *mauka* of the sites (the *heiau* are structurally oriented *makai*). A buffer zone of at least 400.0 ft. (121.9 m.) will be established between the *heiau* and the proposed transmission line poles and lines.

We feel confident that the present location of the preferred alignment will not impact the archaeological resources if the buffer zones described above are maintained in the final design of the transmission line. Partial mitigation for site protection was accomplished during the site inventory survey phase by establishing the above buffer zones between chosen pole locations and archaeological sites in the Mā'alaea,

MA'ĀLAEA-LAHAINA TRANSMISSION LINE PROJECT
Table 4 - Archaeological Site Summary, Significance and Distance from Alignment

State Site Number	Formal Site Type	Function	Applicable Buffer Zone Criteria (Feet)	Applicable Eligibility Criteria	Distance from Alignment Centerline (Feet)
50-50-08-2	Site complex	Heiau (Hiki'i Heiau)	400	A,B,C,D,E	400' S of centerline/600' SW of Stake 14C
50-50-08-3	Site complex	Heiau (Ukumehame Heiau)	400	A,B,C,D,E	500' S of centerline and Stake 14A
*50-50-03-2678/2679	Site complex	Agriculture-habitation (T/P)	50	C, D	200' S of centerline
50-50-08-3165	Site complex	Habitation (T)	100	C, D	200' S of centerline
50-50-08-3168	Site complex	Ritual-habitation (T)	100	C, D, E	125' SW of stake 14D
*50-50-03-2677	Site complex	Agriculture-habitation (T/P)	50	D	75' S of centerline
50-50-03-3173	Wall	Cane irrigation	100	D	150' W of centerline
50-50-03-3174	Wall	Agriculture	100	D	Centerline crosses site
50-50-03-3175	Site complex	Agriculture	50	D	100'W of centerline
50-50-03-3176	Wall	Cane irrigation	100	D	50' W of centerline
50-50-03-3177	Wall	Cane irrigation	100	D	Centerline crosses site
50-50-03-3178	Canal	Cane irrigation	100	D	Centerline crosses site
50-50-03-3189	Site complex	Agriculture	50	D	Centerline crosses site
50-50-03-3190	Retaining walls	Agriculture	50	D	Centerline crosses site
50-50-08-3163	Canal	Cane irrigation	100	D	50' SE of centerline
50-50-08-3164	Canal	Cane irrigation	100	D	250' S of centerline
50-50-08-3166	Irregular-shaped enclosures	Habitation (T)	100	D	300' S of centerline/400' SW of Stake 14A
50-50-08-3167	Cattle wall and chute	Ranching	100	D	Centerline crosses site
50-50-08-3169	Site complex	Habitation (T)	100	D	200' S of centerline/500' SW of Stake 14D
50-50-08-3170	Ranching	Ranching	100	D	Centerline crosses site
50-50-08-3171	Railroad berm	Cane transport	100	D	100' S of centerline
50-50-08-3172	Canal	Cane irrigation	100	D	Centerline crosses site
50-50-08-3180	Cattle wall	Ranching	100	D	Centerline crosses site
50-50-08-3183	Rectangular enclosure	Habitation (P)	100	D	300' N of centerline & stake 14C
50-50-08-3184	Site complex	Habitation (P)-possible burial	100	D, E*	100' SE of stake 14D
50-50-08-3185	Site complex	Agriculture-habitation (T)	100	D	100' N of centerline & stake 14D

MA'ĀLAEA-LAHAINA TRANSMISSION LINE PROJECT
Table 4 - Archaeological Site Summary, Significance and Distance from Alignment (Cont.)

State Site Number	Formal Site Type	Function	Applicable Buffer Zone Criteria (Feet)	Applicable Eligibility Criteria	Distance from Alignment Centerline (Feet)
50-50-08-3186	C-shaped enclosure	Habitation (T)	100	D	Centerline crosses site/200' SE of stake 14C
50-50-08-3187	Site complex	Habitation (T)	100	D	100' N of centerline
50-50-08-3188	Modified rockshelter	Habitation (T)	100	D	100' N of centerline
50-50-09-[illegible]	Rockshelter	Habitation (T)	100	D	In gulch 50' SW of centerline
50-50-09-3179	Circular enclosure	Habitation (T)	100	D	600' S of centerline/200' SE of stake C2
50-50-09-3181	Wall	Habitation (T)	100	D	200' N of centerline
50-50-09-3182	Upright stone	Marker	100	D	300' NW of centerline
50-50-09-3191	Kerbstone trail	Travel route	100	D	600' SE of centerline

Key: Shading denotes sites crossed by the centerline of the preferred alignment or sites whose distance from the centerline is less than applicable buffer zone criteria.
See text for discussion of potential impacts and mitigation (report section VIII)

* Site complex boundaries not determined within the Launiupoko realignment section of the preferred alignment. Associated complex features likely present within the preferred alignment.
See text for discussion of survey methodology (report section II) and potential impacts and mitigation (report section VIII).

(P) Permanent
(T) Temporary

National Register of Historic Places/Hawaii Register of Historic Places eligibility criteria:

A Site reflects major trends or events in the history of the state or nation
B Site is associated with the lives of persons significant in the past
C Site is an excellent example of a site type
D Site is likely to yield information important to prehistory and history
E Site has cultural or religious significance
*E Possible burial

Buffer zone criteria:

400 feet mauka of heiau
100 feet from isolated sites and site complexes
50 feet from concentrated agricultural features

Ukumehame, and Launiupoko sections of the preferred alignment. It is suggested that the 10 proposed pole locations chosen in the realignment sections (*i.e.* locational stakes: C-1, C-2, 14-A through 14-E, and 22-A through 22-C) remain in their present locations and that any additional poles or alternate pole locations utilize the same criteria for buffer zones outlined above.

VIII. POTENTIAL IMPACTS AND RECOMMENDED MITIGATION

A. Potential Impacts

As described above, special care was taken in locating the preferred alignment to avoid archaeological sites. This was done particularly in the Ma'alaea, Ukumehame, and Launiupoko areas where sites were densely concentrated and two *heiau* and the Lahaina Pali Trail were in close proximity to the preferred alignment.

Using the buffer zone criteria presented above (see FINDINGS AND CONCLUSIONS section of this report), physical disturbance of all sites will be avoided in final pole locations of the proposed transmission line. In addition, intrusion into the view planes of the two *heiau* and the Lahaina Pali Trail will be avoided.

As indicated in Table 4, twenty-one (21) of the identified 34 sites and site complexes are located outside of the preferred alignment and would be separated from the transmission line by distances that meet or exceed established buffer zone criteria. (Measured distances between the sites and the centerline of the preferred alignment may be conservative. Actual distances may be greater due to topographic relief.)

Two of these 21 sites (50-50-03-2677 and 50-50-03-2678/2679) are extensive agriculture complexes previously identified by Paul H. Rosendahl, Inc. north of Launiupoko Gulch (Graves 1991). Because the site complexes cover a large area of Launiupoko and contain densely concentrated features beneath a thick, obscuring grass cover, the boundaries of sites 50-50-03-2677 and 50-50-03-2678/2679 were not completely established during the PHRI inventory survey nor during the present study. As the methodology section of this report explains, the northern portion of the Launiupoko realignment was subjected to a 100% ground survey only around proposed pole locations, since - based on the PHRI survey results and aerial reconnaissance undertaken during the present study - the complex features were known to extend throughout this area of Launiupoko. Thus, to avoid damage to either of these site complexes, the proposed transmission line should span above the sites and poles would be placed only in the currently proposed pole locations (locational stakes 22-A and 22-B) adjacent to the Launiupoko access road.

Thirteen sites would definitely be crossed by the preferred alignment or would be closer to the preferred alignment than the prescribed buffer zone criteria (Table 4). Eight of the sites are rock walls or irrigation ditches associated with historic ranching or large-

scale cane agriculture. These are linear sites generally located perpendicular to and across the preferred alignment. Three sites are agricultural in function (State site 50-50-03-3174, 50-50-03-3189, and 50-50-03-3190), two of which may be associated with cane agriculture: 50-50-03-3189 is a complex of agricultural features (walls and terraces) and rough enclosures located on a plateau above Launiupoko, and site 50-50-03-3190 consists of two bifaced walls which retain a steep embankment along the edge of Launiupoko Gulch. Site 50-50-03-3174 is a stone wall constructed along the upper crest of a gulch.

The remaining two sites are temporary habitations. These sites include a rockshelter (50-50-03-2684) located on the north side of Launiupoko Gulch and a C-shaped enclosure (50-50-08-3186) located on the alluvial plain east of Ukumehame Gulch.

Final pole locations would maintain an adequate buffer zone between the poles and these 13 sites; all sites crossing the preferred alignment would be spanned by the transmission line. Thus, no adverse impacts to any of the sites would be expected.

B. Recommended Mitigation

If construction of access roads - whether temporary or permanent - are necessary within surveyed areas (*i.e.* the preferred alignment surveyed in April 1993 and alignment adjustments subjected to supplemental survey in June 1993), these plans should be submitted to the State Historic Preservation Division-DLNR and consulting archaeologists for review. If deemed necessary, archaeological monitoring would be done during road construction, especially in the archaeologically sensitive areas of the Mā'alaea, Ukumehame, and Launiupoko realignment sections. This monitoring would ensure that existing sites are avoided and appropriate buffer zones maintained.

If construction of access roads, spur roads or helicopter pads is to occur outside of surveyed areas, additional survey work comprising 100% ground coverage will be required and results of such work submitted for review to the State Historic Preservation Division-DLNR.

To avoid potential impacts in the sensitive Mā'alaea, Ukumehame, and Launiupoko areas of dense site concentrations and significant archaeological sites, the ten currently proposed pole locations in these areas (identified by locational stakes C-1, C-2, 14-A through 14-E, and 22-A through 22-C) should be maintained through final design and construction of the preferred alignment.

Following final design and selection of pole locations, final plans should be reviewed by a qualified archaeologist to verify that all sites have been avoided in the location of the poles (and construction staging areas, helicopter pads, and access roads should they be planned) and that impacts to identified sites would not be expected.

Prior to construction, all sites and site boundaries should be flagged to avoid inadvertant site disturbance. This measure is of particular importance to site complexes with dense feature concentrations and the two *heiau*.

Finally, if previously undetected prehistoric or historic sites are found during transmission line or switching station construction, construction activity in the site area(s) is to be halted and the State Historic Preservation Division will be notified to determine appropriate action. Field personnel involved in project construction should be informed about the potential for uncovering archaeological sites and about proper procedures to follow if a previously unidentified site is encountered.

VIII. REFERENCES CITED

Apple, Russell A.
1965 *Trails: From Steppingstones to Kerbstones*, B.P. Bishop Museum, Special Publication 53, Bishop Museum Press, Honolulu.

Ashdown, Inez
1971 *Ke Ala Loa o Maui*, Ace Printing Col, Wailuku, Maui.

Beckwith, Martha W.
1970 *Hawaiian Mythology*, University of Hawaii Press, Honolulu.

Char, Winona P.
1993 *Botanical Survey Mā'alaea - Lahaina Third 69 KV Transmission Line Project*, Char and Associates Botanical Consultants, Honolulu

Condé, Jesse C. and Gerald M. Best
1973 *Sugar Trains: Narrow Gauge Rails of Hawaii*, Glenwood Publishers, Felton Calif.

Creed, Victoria S.
1993 *Settlement Pattern for the Waikapū, Wailuku District, Maui, Hawaii*, in Partial Fulfillment for the Certificate of Historic Preservation, U.H. Manoa, Honolulu.

Daws, Gavan
1968 *Shoal of Time*, University of Hawaii Press, Honolulu.

Department of Land and Natural Resources (DLNR) and the National Park Service (NPS)
1990 *Hawaii Stream Assessment: Hawaii's Streams and their Instream and Riparian Resources: A Conservation Point of View*, A Draft, Honolulu.

Ellis, William
1969 *Polynesian Researches: Hawaii*, Charles Tuttle, Tokyo.

Folk, William H. and Hallett H. Hammatt
1991 *Archaeological Survey at Mā'alaea Waikapū, Maui*, Cultural Surveys Hawaii, Kailua

Graves, Donna K.
1991 *Archaeological Inventory Survey Launiupoko Golf Course*, Paul H. Rosendahl Inc., Hilo. (Draft report)

Haun, Alan E.
1988 *Subsurface Archaeological Reconnaissance Survey, Lahaina Cannery Makai and Mauka Parcels, Land of Moalii, Lahaina District, Island of Maui (TMK:4-5-05:9, 10, 11; 4-5-11:13)*, Paul H. Rosendahl, Inc., Hilo.

Handy, E.S. Craighill and Elizabeth G. Handy
1972 *Native Planters in Old Hawaii: Their Life, Lore, and Environment*, Bishop Museum Bulletin 233, Honolulu.

Ii, John Papa
1983 *Fragments of Hawaiian History*, Bishop Museum Press, Honolulu.

Kamakau, Samuel Manaiakalani
1992 *Ruling Chiefs of Hawaii (Revised Edition)*, Kamehameha Schools Press, Honolulu.

Kennedy, Joseph
1991 *Archaeological Inventory Survey Report for the Waikapū Mauka Water Tank and Access Road Located at Waikapū, Island of Maui, TMK 3-6-03:Portion of 2 and TMK 3-6-02:Portion 2, July 1992 with addendum November 1991*, Archaeological Consultants of Hawaii, Inc., Honolulu.

Kirch, Patrick V.
1985 *Feathered Gods and Fishhooks*, University of Hawaii Press, Honolulu.

Klieger, Paul C.
1993 *Moku'ula: The Last Resort, A Preliminary Report on the History of the Private Residential Complex of King Kamehameha III in Lahaina, Maui*, Department of Anthropology, B.P. Bishop Museum, Honolulu.(Draft report)

Kolb, Michael J.
1991 *Social Power, Chiefly Authority, and Ceremonial Architecture, in an Island Polity, Maui, Hawaii*, Ph.D Dissertation, University of California, Los Angeles.

Macdonald, G.A. and A.T. Abbott
1970 *Volcanoes in the Sea*, University of Hawaii Press, Honolulu.

Robins, Jennifer J., Joy Collins, Rodney Chiogioji, Ingrid Carlson, Ian Masterson, and Hallett H. Hammatt
1993 *An Archaeological Inventory Survey of an Approximately 803-Acre Subject Parcel in the Ahupua'a of Honokōhau I and II, North Kona District, Island of Hawai'i (TMK 7-4-08:por. 5,13,34)*, Cultural Surveys Hawaii, Kailua.

Schmitt, Robert C.
1973 *The Missionary Censuses of Hawaii*, Bishop Museum, Honolulu.

Thrum, Thomas G.
1918 "Maui's Heiaus and Heiau Sites Revised," *Hawaiian Almanac*, Honolulu.

Tomanari-Tuggle, M.J. and H.D. Tuggle
1991 *Archaeological Survey of Two Demonstration Trails of the Hawaii Statewide Trail and Access System, Lahaina Pali Trail, Island of Maui/Kalolohia-Kahue Trail, Island of Lana'i*, International Archaeological Research Institute, Inc., Honolulu.

Walker, Winslow
1931 *Archaeology of Maui*, Manuscript at B.P. Bishop Museum, Honolulu.

APPENDIX A - PAUL H. ROSENDAHL, INC. SITE DESCRIPTIONS (Grave 1991)

SITE NO.: State: 2677 (*Figures B-10, B-11*)PHRI: 66
SITE TYPE: Complex (19 Features)

TOPOGRAPHY: Valley between two ridges, the site is primarily on the east side of the intermittent drainage gully. Bedrock outcrop is common within the site area. The intermittent drainage feature on the north side of the site is very deep (+/-3.0 m) to the east.
VEGETATION: *Koa-haole, kiawe, 'ilima*, lantana, buffelgrass, *wiliwili, pili* grass, and *klu*
CONDITION: Fair-good
INTEGRITY: Disturbed
PROBABLE AGE: AD 1650-1950
FUNCTIONAL INTERPRETATION: Agriculture
DESCRIPTION: The site complex appears to be multicomponent, consisting of terraces and agricultural plots, canals and an elevated flume, and habitation features (i.e., rock- filled terraces and C-shapes). The wall/canal feature may be historic and the flume feature is historic (+ 50 years). Historic activities have altered the prehistoric component.

FEATURE A: Terraces (4 loci)
FUNCTION: Agriculture
DESCRIPTION: Feature A consists of agriculture terraces and clearedareas at various locations throughout the site (see map). Two kinds of terrace predominate: stepped terraces leading into drainage areas, and cleared areas with rock alignments.

Probe holes around the terraces at locus 4 produced an ashy soil, and charcoal was present near the surface. Some of the older trees show burn marks on their trunks.

FEATURE B: Canal/wall
FUNCTION: Agriculture
DESCRIPTION: Feature B appears to be a canal with a bifaced and core-filled wall on the uphill side, and a stacked boulder berm on the downhill side. There are two discontinuous segments associated with Feature B (another segment is associated with Feature R).

The wall may have served as a barrier to sediments from the slope. The feature may have originated when the agricultural features, consisting of terraces and agricultural plots, were introduced. It may also have been constructed historically, perhaps in 1906, the date which is inscribed on a large boulder associated with the canal and flume. At some time it may also have been used as a cattle enclosure, based on the barbed wire and posts.

Feature B is constructed of large basal boulders with smaller, medium-sized boulders stacked to six courses high to form the wall faces. Smaller cobbles form the interior portions of the wall.

The location of SIHP 2677 near the head of the Launiupoko Valley appears to be critical for distribution of water resources both prehistorically and historically.

Although the area west of the flume is extensively disturbed, it can yield important information about prehistoric/historic water control and distribution as well as agricultural methods.

The boundaries for SIHP 2677 are drawn arbitrarily on the basis of topography and continuity of features. Feature types described at SIHP 2677 are similar to those observed throughout the project area, thus all sites should be considered as 1-complex, reflecting intensive use of the landscape through several temporal periods.

Agricultural features extend northeast outside of the project area, along the northwestern base of the ridge that separates Launiupoko Gulch from an intermittent drainage to the north. The site extends beyond the project boundaries, with one overhang shelter located just below the cliffs on the northeast side, and unrecorded rock alignments along the top of the ridge.

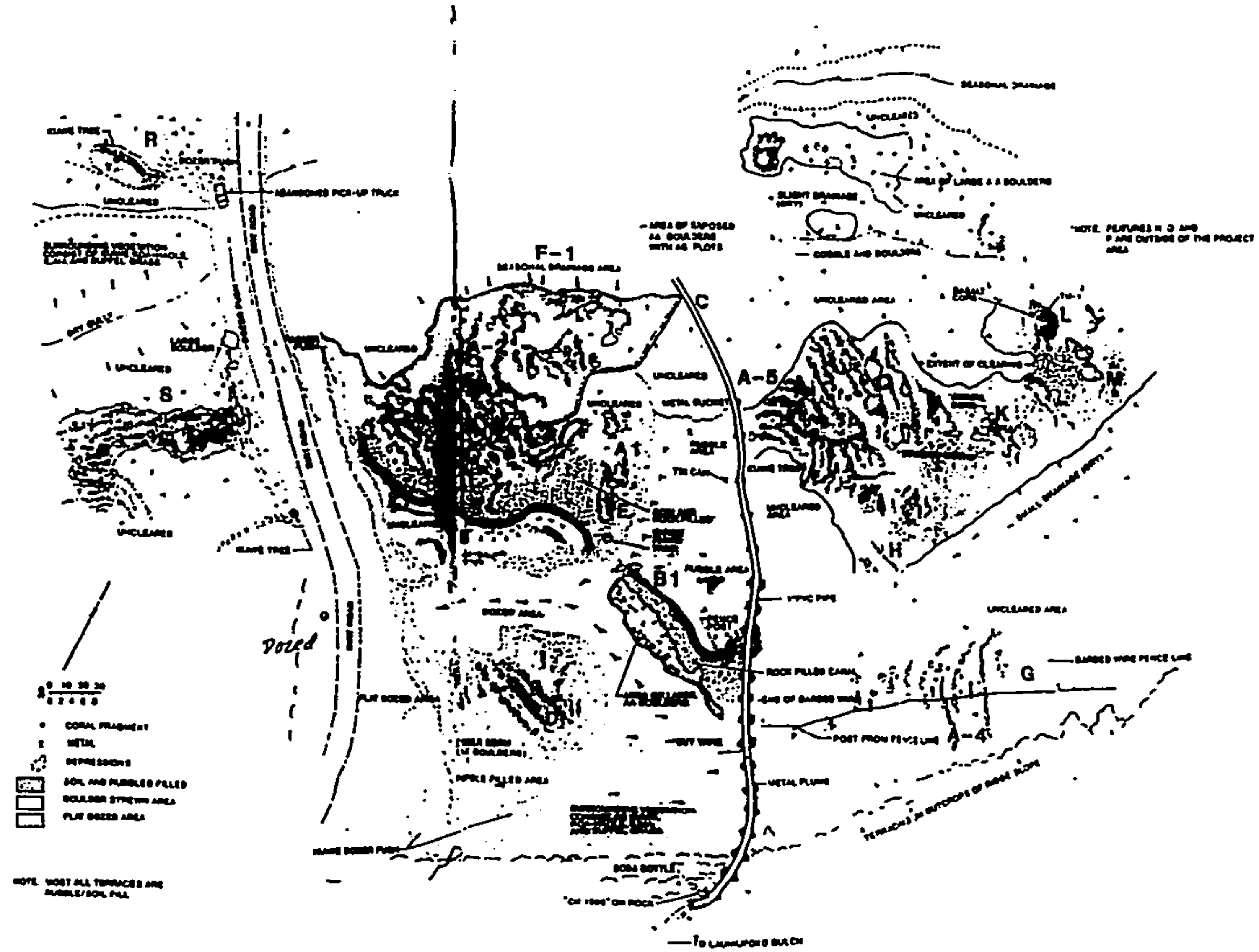


Figure B-10. SITE 2677, PLAN VIEW

Figure B-11. HISTORIC FLUME. (Neg.1576:17)

Segment one measures c. 20.0 m (NW-SE) in length, with an average width of c. 1.20 m. The height ranges from 0.20 m at the west end to a maximum height of c. 1.3 m.

The west end of segment one terminates in a low rubble pile. The east end of segment one makes a sharp curve to the north, then terminates into a rubble pile.

A 4 inch by 4 inch fence post with one railroad spike and three strands of barbed wire lies on top of the wall just before the rubble pile. The post was apparently lodged in the wall fabric at one time.

Flume construction may account for the termination of the walls; however, the wall does not continue on the north side of the trestle, or to the east where it might have connected with the canal. Flume construction may have robbed stones from the wall to provide supports for trestle legs.

A rock-filled canal bordered by a large pile of boulders parallel to the canal lies on the south side of segment one. This may have formed the south side of the canal, but has been added to by a bulldozer swath.

Segment one lies east of segment two, separated by a distance of c. 4.0 m. This space may represent bulldozer disturbance as the area is relatively free of boulders and contains only *koa-haole* saplings and buffelgrass instead of mature *kiawe* and *wiliwili* trees noted in other areas of the site.

Segment two is the longest of the intact wall, at c. 56.0 m, with an average width of c. 1.0 m and heighs ranging from 0.90 m to 1.20 m high. It traces a sinuous path through the site complex.

The eastern end of segment 2 terminates in a rubble pile that is probably a result of bulldozer disturbance, as a pile of scarred boulders runs parallel to the cleared area. The wall incorporates large boulders, probably bedrock, at its base. On the south side of the wall there is a rock-lined canal, probably formed by removing boulders that had been used in the wall construction. A rock and earth berm forms the south side of the canal. Mature *koa-haole* and *kiawe* trees grow in the canal, as well as on the south bank. North of the wall there are cleared areas, probably formed when rocks were collected for the wall.

An upright post, 8 inches by 3 1/2 inches, with a railroad spike driven through, is by the wall termination - at the west, near the road, adjacent to a bulldozer push pile that parallels the road. The post appears to have been incorporated in the wall fabric.

The wall is assumed to have continued across the drainage area to segment three, although road construction activities have obliterated any continuity. There is a shallow berm on the north side of the push pile that may be canal remnants.

The wall/canal and its position perpendicular to the slope is similar to that at SIHP 2680, further down the same drainage area. SIHP 2680 was not interpreted as a canal, but a water impound/control device.

FEATURE C: Flume segments one and two
FUNCTION: Agriculture
DESCRIPTION: Feature C consists of flume segment one, a concrete and basalt canal that extends west of Launiupoko Gulch, north across a narrow ridge, and ultimately into a wooden/metal flume that carries to the northwest. This portion of the historic canal includes a ditch excavated into the hillside. It incorporates bedrock on the uphill side, and rock and concrete on the downhill side and at the bottom.

Northeast of the reservoir there is a "partial" flume that measures water flow to the canal. Further up into the valley, the canal diverts water from an unaltered stream. There appears to have been several phases of canal-building and maintenance, based on older pieces of concrete incorporated into newer concrete.

Construction is primarily of small hand-sized cobbles and medium-sized (0.50-1.00 m) boulders cemented in a patchwork fashion. Where the canal bottom is exposed, there are small (less than 0.05 m), angular pieces of basalt apperently pressed onto the new, wet concrete, instead of being incorporated. The average depth of the canal is c. 0.60 m, the wall is single stacked and buttressed around the curve by a bank of stacked boulders. Where segment one and two meet, there is a headgate that may have allowed excess water to be channeled away before it reaches the wooden flume. The headgate may also have been used to divert water to agricultural fields.

Segment two includes a metal flume elevated on a wooden trestle. Again, there appears to have been many phases of building and repair, based on wood fragments littering the area surrounding the flume. Although there is a basic construction technique, there are many sections of the trestle that appear to have boards haphazardly nailed together with no appearance of structural integrity.
The metal flume is c. 0.62 m wide and c. 0.38 m deep. The metal portions, 0.92 m long, look preformed, and are held in place by long metal staves attached to the wood rail. Distance between the trestles varies, but the average is c. 2.50 m. Trestle legs are supported by piles of vesicular basalt cobbles and boulders, and in some places further supported by concrete casing. Steel guide wires of varying lengths are anchored to large boulders, giving more stability to the structure. Supporting braces were also noted. Metal joints were sealed with a tar-like substance on the interior. A black ABS plastic pipe extends the length of the flume, and may have been used when the flume was in disrepair.

Portable remains consist of a 7 oz. glass soda bottle marked *Tahitani Star Soda*, and several buckets that may have held a sealant for the flume.

FEATURE D: Canal segment one and two
FUNCTION: Agriculture
DESCRIPTION: Feature D is rock-lined canals separated by a stacked rock berm. They are obliterated on the east and west by bulldozer disturbance. The canals are oriented c. east-west.

Canal segment one measures c. 18.0 m in length, averages c. 0.80 m in width at the bottom, and of 0.80 m. in depth. The line of boulders comprising the north wall of segment one are larger than 0.60 m and aligned rather than stacked. Canal segment two measures c. 16.0 m in length, averages c. 0.60 m at the base, and has an average depth of 0.50 m. The south wall of segment two is composed of smaller boulders, generally less than 0.40 m, and stacked to four courses high at the west.

A stacked berm, c. 1.5 m wide, separates segments one and two. The berm is primarily of medium to large boulders with some fist-sized cobbles. The courses are from one to three boulders high.

FEATURE E: Clearing-pile
FUNCTION: Agriculture
DIMENSIONS: 10.00 m by 2.00 m by 1.50 m (approx.)
DESCRIPTION: Feature E is built of various sizes of vesicular basalt boulders, randomly stacked. The pile may have been created in an effort to clear the shallow drainages areas, or to act as a retaining wall to protect (Feature A) terraces from flooding. Some portions of the clearing-pile may have been altered by bulldozing.

FEATURE F: Agricultural plots, two 2 loci
FUNCTION: Agriculture
DESCRIPTION: Feature F consists of cleared areas, semicircular in shape, and formed by removing stones. They are bounded by stacked walls, especially along the northeast side. Rocks used are primarily small basalt boulders, slightly larger at the base. The walls may have served as windbreaks for plants.

Feature F, locus one, is north of Feature B, segment two, and south of Feature A, locus two. Three semicircular plots are bounded by stacked walls perpendicular to the slope. Large (greater than c. 0.60 m) boulders were used as basal stones, with smaller stones stacked to four courses high. Small diameter koa-haole trees grow in the cleared areas.

Feature F, locus two, is located c. 10.0 m of Feature A, locus two. The plots are not as well defined as those at locus one, and vary greatly in size and shape. Generally, they are semicircular and built of large boulders, c. 0.60 m in size, and encompass an area about 1.0 m. The plots are in an area of mixed terracing on the east bank of a small drainage gully. The Feature A, locus three, terraces and streambanks, are c. 4.0 m away.

FEATURE G: Fenceline
FUNCTION: Animal husbandry
DIMENSIONS: 63.70 m by 0.00 m by 1.60 m (approx.)
DESCRIPTION: This historic fenceline is constructed of milled wood posts set into the ground and joined by barbed wire. Four strands of wire are still attached low on the western posts. The fence extends north of a high ridge, and may be associated with ranching in the area. Some of the posts have fallen, barbed wire is detached and lying on the ground, but the posts continue east toward a gully.

FEATURE H: Upright
FUNCTION: Indeterminate
DIMENSIONS: 1.50 m by 0.20 m by 0.90 m (approx.)
DESCRIPTION: Feature H is a rectangular stone set upright into the ground. It is c. 18.0 m east of the flume at the bottom of a small rise to the east.

The upright is on a flat area between two stacked walls measuring c. 4.5 m north-south and 3.0 m east-west. Small pebbles to small cobble-size stones are stacked against and surround the base. There are a few scattered cobbles in the area that may be a portion of pavement. The area behind the upright rises to the east and is extensively terraced and has walls with stones stacked two to three courses high. The terraces extend to the north and east toward gullies.

FEATURE I: Rock-filled terrace
FUNCTION: Indeterminate
DIMENSIONS: 7.40 m by 3.00 m by 0.70 m (approx.)
DESCRIPTION: A paved/filled terrace is c. 7.0 m north of Feature H, an upright; and east of the flume. It is on the side of a west-sloping hill that is entirely covered with terraces. The walls are constructed of basalt boulders loosely stacked against a hill, and following the contours across the slope. A coral fragment was found on the southeast side of this feature.

FEATURE J: Agricultural plot
FUNCTION: Agriculture
DIMENSIONS: 3.30 m (E-W) exterior measurements by 1.00 m interior measurements by 0.40 m maximum height
DESCRIPTION: A C-shaped structure is c. 56 m east of the flume on a flat area between two gullies. It consists of two terraces whose east and west walls create a C-shape. The north wall, between the two terraces, was partially filled and stacked higher to create a windbreak. The south end is open.

FEATURE K: Rock-filled Terrace
FUNCTION: Indeterminate
DIMENSIONS: 3.40 m by 2.20 m by 0.60 m (approx.)
DESCRIPTION: Feature K is on a slope surrounded by shallow gullies to the north, south, and east, and by the flume to the west.

Terraces in this area are generally oriented north-south and divided by alignments of field stones. In the area, cobbles have been stacked between two terraces to form a C-shape (Feature J), and a filled terrace (Feature K).

Bedrock outcrops, boulder-size, were used in making the terrace. In a hollow area formed by the juncture of these large boulders, there are some immature animal bones.

FEATURE L: C-shape
FUNCTION: Habitation
DIMENSIONS: 6.70 m by 3.80 m (approx.)
DESCRIPTION: The structure is on a hill sloping west, and is constructed of loosely stacked field stones which form a wide, low, C-shaped wall. On the north, stones are stacked five to six courses and c. 0.80 m high. An alignment of stones crosses the mouth of the structure, creating a terraced effect inside. Low-stepped terraces, parallel to this alignment, continue down the slope to the west.

Inside, the structure is leveled and cleared. A basalt core was present along the stacked north wall. It was flaked on three faces, several large flakes having been removed. It measured c. 0.12 m by 0.11 m, and was heavily weathered, even on fractured areas. It may have been incorporated into the wall fabric.

FEATURE M: Possible structure
FUNCTION: Indeterminate
DIMENSIONS: 1.70 m by 1.00 m by 0.85 m (approx.)
DESCRIPTION: Feature M is an area cleared of rocks that were, probably, stacked on the filled terrace area to the east. There are filled terraces around this feature, and on the east the walls are especially high.

The area appears to be divided in two. The north portion measures c. 1.7 m east-west by 1.1 m north-south, having walls to 0.80 m. in height. The south portion measures c. 1.7 m east-west by 1.0 m north-south, and with a wall height of c. 0.85 m. The portions share the same center wall.

The area is situated on a slope, east of the flume at the northeast end of the site. There are many *wiliwili* trees surrounding the feature, scattered *kiawe* and *klu* trees, and *'ilima*, lantana, and dense buffelgrass.

FEATURE N: Retaining wall (2)
FUNCTION: Agriculture
DESCRIPTION: Feature N consists of two segments of retaining walls along a stream bank. They are c. 40.0 m at 252o downstream from Feature P (a rock-filled terrace).

FEATURE O: Rock-filled terrace
FUNCTION: Indeterminate
DIMENSIONS: 4.00 m by 2.00 m by 0.75 m (approx.)
DESCRIPTION: Feature O is located perpendicular to a streambank. It is constructed of basalt boulders and cobbles, and is raised along the southwest side.

FEATURE P : Rock-filled terrace wall
FUNCTION: Indeterminate
DIMENSIONS: 6.00 m by 5.00 m by 0.80 m (approx.)
DESCRIPTION: A rock-filled retaining wall, also perpendicular to the stream. Constructed of basalt boulders, cobble filled, it is raised on the southwest side.

FEATURE Q: Rock pile
FUNCTION: Indeterminate
DIMENSIONS: 2.0-9.0 m by 2.80 m by 0.80 m (approx.)
DESCRIPTION: A rock pile situated amid stepped terraces, it is roughly rectangular, the center only slightly higher than the edges. It is of loosely stacked basalt boulders and cobbles.

The surrounding area may have been modified by clearing and stacking stone to create a series of stepped terraces. This feature may be associated with the construction of terraces.

FEATURE R: Wall (Segment 3)
FUNCTION: Indeterminate
DESCRIPTION: On the north bank of an intermittent drainage area, the wall is bifaced and core filled. It is similar in construction to Feature B, segments one and two, and may be a part of this. Medium to large boulders form the facing on the north and south sides. The interior of the wall is filled with hand-sized cobbles.

No canal is associated with this segment; the drainage area may have served as canal. Similarly stacked walls were been recorded along the drainage area further downstream. No cultural deposit was noted, and the only portable remains consisted of a 1970s rusted truck cab in the drainage area c. 15.0 m upstream.

FEATURE S: Probable canal
FUNCTION: Agriculture
DIMENSIONS: 18.00 m by 1.00 m by 1.50 m (approx.)
DESCRIPTION: The narrow canal is constructed in conjunction with a rock outcrop. It is oriented northeast-southwest, immediately southwest of the cane road and the bulldozer berm, and southeast of an intermittent gulch. At the far southwest, the canal splits into terraces that follow

the contours of the terrain. The rock outcrop is modified with small to large cobble-size, subangular basalt, loosely stacked between large bedrock boulders. The feature appears to be an irrigation canal leading to agricultural terraces downslope.

SITE NO.: State: 2678 **PHRI:** 67
SITE TYPE: Modified rock pile
TOPOGRAPHY: Small ridge sloping west-southwest
VEGETATION: *Koa-haole, wiliwili, klu,* lantana, buffelgrass, *klawe*
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Indeterminate
FUNCTIONAL INTERPRETATION: Agriculture
DIMENSIONS: 33.30 m by 9.00 m by 1.5-2.0 m (approx.)
DESCRIPTION: The feature is on a basalt outcrop, on a ridge that slopes to the west-southwest, and is oriented c. northeast-southwest. The ridge is between a deep gully and a shallow drainage area, separating these features. The outcrop on the ridge is modified with loosely stacked, subangular, basalt boulders and cobbles. Also, modifying the area are four large depressions, 2.0-4.0 m apart, averaging c. 1.3 m by 1.1 m across, and with a depth of 0.50-0.90 m. And there are three small holes which average c. 0.90-1.0 m in diameter, are 0.50 m deep, and are c. 2.0 m from the large depressions. These features were built and formed of basalt boulders. Some of the boulders were set upright.

SITE NO.: State: 2679 (*Figure B-12*) **PHRI:** 68
SITE TYPE: Complex (6 Features)
TOPOGRAPHY: The site is on an area that slopes gradually to the west; it is bounded on the north by a deep, intermittent drainage feature, and on the south by a shallower drainage feature.
VEGETATION: *Wiliwili, kiawe, koa-haole,* buffelgrass
CONDITION: Poor-fair
INTEGRITY: Collapsed walls and extensive rubble suggests disturbance
PROBABLE AGE: AD 1630-1900
FUNCTIONAL INTERPRETATION: Habitation/Agriculture
DESCRIPTION: The complex consists of terraces, Feature A; a modified rock pile, Feature B; a paved terrace, Feature C); a C-shape, Feature D; a circular structure, Feature E; and a D-shaped structure, Feature F.

This site is immediately east of SIHP 2685. It appears that the deep drainage to the north has been deeply cut/eroded in the recent past.

FEATURE A: Terraces
FUNCTION: Agriculture
DESCRIPTION: Feature A terraces are associated with stacked and aligned vesicular basalt built from boulders and small cobbles c. 0.05 m to 1.00 m in diameter. They are one to three courses high. The terraces are perpendicular to slopes and extend to broad drainage areas that border the site to the north and south.

FEATURE B: Modified rock pile
FUNCTION: Agriculture
DIMENSIONS: 46.00 m by 12.00 m by 3.00 m (approx.)
DESCRIPTION: Feature B is a modified rock pile, oriented roughly east-west. Removal of rock from the interior created a C-shaped depression, with a built-up height of c. 0.80, and a southeast opening. Agriculture plots surround the pile, and terraces extend from it, east to west, along the south edge of the small drainage area.

It is possible that Feature B supplied base materials used in the construction of other features at the site. No portable remains or cultural deposits were visible at Feature B.

FEATURE C: Paved terrace
FUNCTION: Indeterminate
DIMENSIONS: 12.00 m by 8.00 m (approx.)
DESCRIPTION: The feature is a part of the modified rock pile, but more level and with paving of a more regular size than other portions of the pile. It is constructed of vesicular basalt, small boulders to large cobbles. The west side of Feature C is bounded by a stacked wall built of medium sized boulders three courses high.

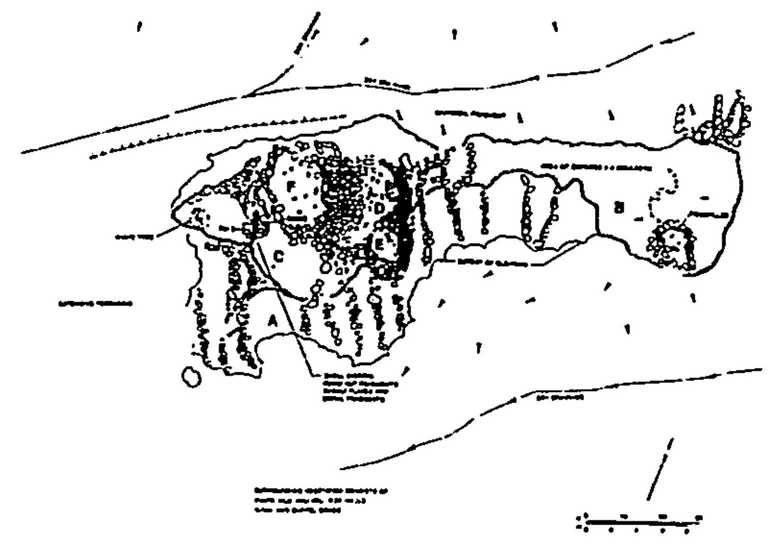
Portable remains consisted of *kukui* nuts, coral fragments, basalt flakes, and a cowrie shell.

FEATURE D: C-shape
FUNCTION: Habitation
DIMENSIONS: 5.75 m by 2.00 m (interior measurements) by 1.36 m (approx.)
DESCRIPTION: The wall around the The C-shape is built of loosely stacked rock on the northeast, and collapsed rubble to the northwest. It opens to the south-southwest. The C-shape abuts Feature E on the east-southeast, and Feature F on the west-northwest.

Feature D is built of loosely stacked subangular basalt boulders and cobbles. A single stacked, oval-shaped feature, measuring c. 1.10 m by 0.70 m, was noted within the structure. Charcoal and a possible cultural deposit containing a silty clay matrix with small charcoal pieces were present within.

FEATURE E: Enclosure
FUNCTION: Habitation
DIMENSIONS: 2.50 m by 2.25 m (approx.)
DESCRIPTION: The roughly circular enclosure is constructed of loosely stacked, subangular, basalt cobbles and boulders. Walls are standing on the northeast and southwest; the west wall is collapsed. The floor of the enclosure is partially covered with subangular basalt cobbles. These may be pavement. The feature has a single opening, to the west. The northwest wall abuts Feature D. No portable remains were present.

FEATURE F: Enclosure
FUNCTION: Indeterminate
DIMENSIONS: 5.75 m by 4.40 m by 0.80 m (approx.)
DESCRIPTION: Feature F is located west of Feature D and north of Feature C. Roughly circular, the alignment is constructed of loosely stacked vesicular basalt boulders and cobbles. It is bounded on the east and west by a single-stacked wall three courses high. No portable remains or definite cultural deposits were visible, however such deposits could be present subsurface.



SITE 2679, PLAN VIEW.

SITE NO.: State: 2684 PHRI: 74
SITE TYPE: Complex (2 Features)

TOPOGRAPHY: The rock shelter is on the north bank of Launiupoko gulch; the wall within the gulch.
VEGETATION: *Klawe, klu,* dense buffelgrass, some *'ilima*
CONDITION: Good
INTEGRITY: Unaltered
PROBABLE AGE: Multicomponent
FUNCTIONAL INTERPRETATION: Temporary Habitation
DESCRIPTION: The site area measures c. 20.0 m by 10.0 m. The complex consists of a rock shelter, Feature A; and a faced wall, Feature B. The wall is built with one to three courses of large boulders, and is situated in front of the rockshelter.

Portable remains consist of an historic plank and nails scattered below the overhang. Charcoal was also present east in the rock shelter. The condition of the wall is generally good. There has been a considerable amount of roof fall inside the shelter. A large metal box, and a wood box with nails inside, are c. 7.0 m southeast of the site. On the ridge above the gully, a fence extends to an historic corral.

After clearing the area from rock shelter to faced wall, Feature B, it was determined that a wall had been constructed in front of the rock shelter and extended beyond it, from the gulch to both the east and west. Rock between the shelter and the wall appears to be fall from the shelter roof and from the slope above the gulch.

FEATURE A: Modified rock shelter
FUNCTION: Habitation
DIMENSIONS: 21.50 m by 3.00 m by 2.10 m (approx.)
DESCRIPTION: The shelter is associated with historic artifacts, reflecting cattle ranching activities. The rock shelter is on the second alluvial terrace above the Launiupoko Gulch. It was probably created naturally by erosional wash down the slopes, or by stream action in the gulch. The shelter roof is composed of conglomerate rock/soil, and is highly unstable. There has been considerable rock fall from the roof and the cliff at the side.

There are several pieces of milled lumber below the rock shelter, including part of a nailed frame, a fence post fragment, and a long plank leaning against the cliff. This latter could have been used in the construction of a temporary windbreak. There is a circle of stones which may have contained a campfire.

In historic times, the wall in front of the rock shelter may have been intended to retard further erosion of the bank. The presence of historic artifacts under and around the rock shelter indicates use during that time, although the proximity to SHIP 2683 indicates that site may also have a prehistoric history obscured by historic use.

FEATURE B: Wall
FUNCTION: Indeterminate
DIMENSIONS: 20.00 m by 1.00 m by 0.90 m (approx.)
DESCRIPTION: The wall, oriented east to west, is in front of and extends beyond the rock shelter, (Feature A). It is constructed of tighly stacked stones with large, rectangular boulders at the base and smaller stones at the top. There are three courses of stones along several places on the wall, but most of the west side are two courses wide. The east end of the wall has only one course, of large boulders. The west the wall abuts the cliff.

APPENDIX B - SITE AND GENERAL PROJECT AREA PHOTOGRAPHS

Figure 27 East Portion of Preferred Alignment Along Northeast Side of North Kihei Road; View Northwest

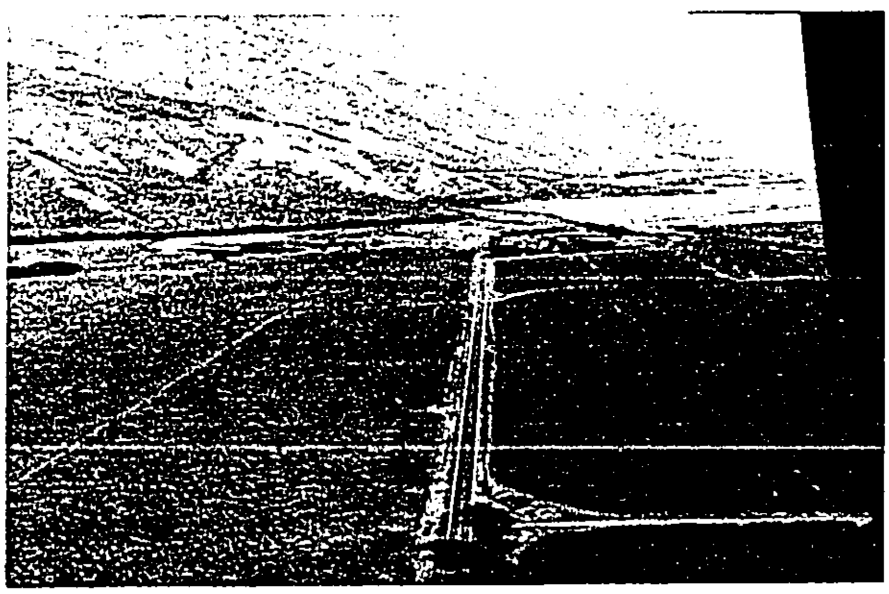


Figure 28 Aerial View of East End of Preferred Alignment Overlooking Cane Fields

Figure 29 Preferred Alignment in Pineapple Fields West of Hono-a-Pi'ilani Highway; View West Showing Eastern Slope of West Maui Mountain Range

Figure 30 Preferred Alignment in *Kiawe* Thicket at the Base of the Eastern Slope of the West Maui Mountain Range; View Northeast

Figure 31 Preferred Alignment Along the Upper Ridge of the West Maui Mountain Range Descending East Above Mā'ālaea; View East (Note Locational Stake 1A in Foreground)

Figure 32 Preferred Alignment Along Upper Ridge of West Maui Mountain Above Mā'ālaea, Showing Severe Erosion on Slope of Ridge; View West

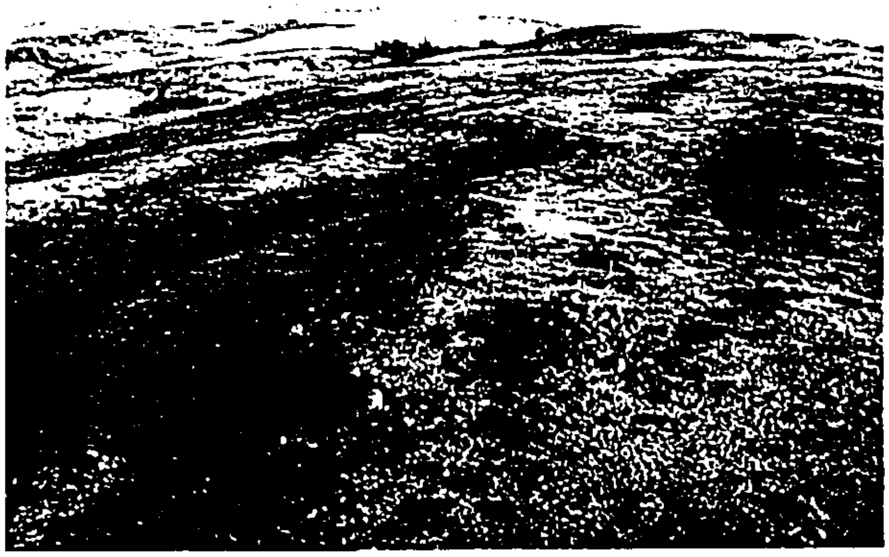


Figure 33 Aerial View of Upper Elevations of Preferred Alignment Between Mā'ālaea and Ukumehame Valley; View North (Note Locational Stake 6 in Right-Center)

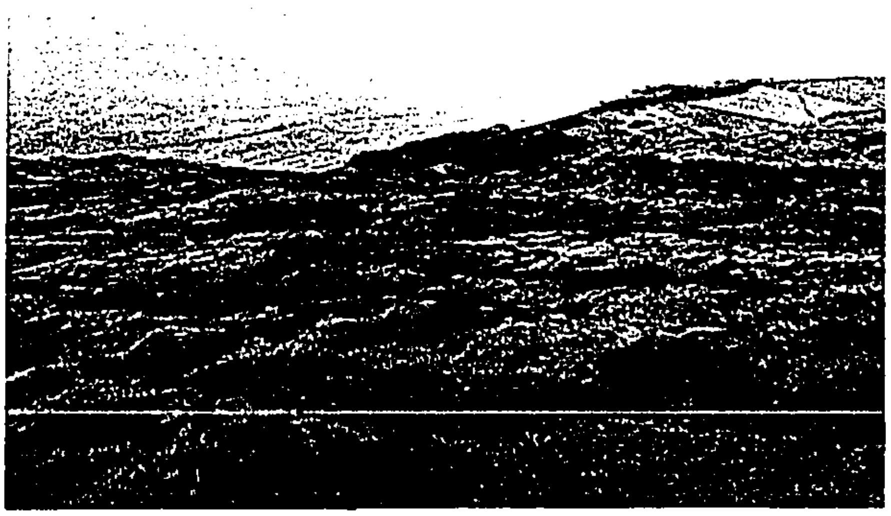


Figure 34 Preferred Alignment Extending Southwest Towards Papalaua Gulch; View Southwest

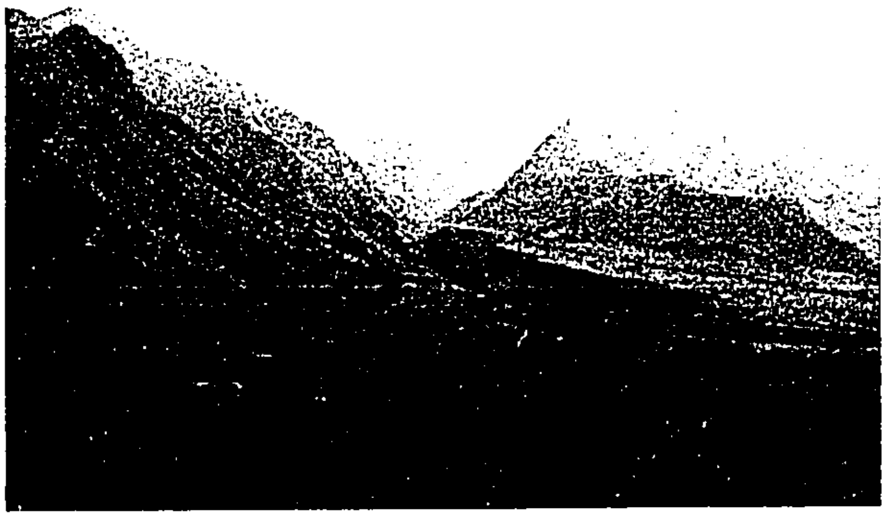


Figure 35 Ukumehame Gulch Area; View North

Figure 36 Preferred Alignment Southeast of Pu'u Hipa; View Northeast (Actual Alignment Located on upper Ridge Above Pu'u on Left)

Figure 37 Preferred Alignment Between Pu'u Hipa and Launiupoko Valley (Pu'u Hipa in Background); View Southeast

Figure 38 Launiupoko Valley, Preferred Alignment in Upper Elevations Above Cane Fields; View Northeast.

Figure 39 State Site 50-50-08-2, Hiki'i *Heiau*; View Northeast

Figure 40 State Site 50-50-08-3, Ukumehame *Heiau*; Aerial View

Figure 41 State Site 50-50-08-3, Kawai'aloa *Heiau*; Aerial View

Figure 42 State Site 50-50-03-2684 Modified Rockshelter Showing Exterior Wall; View East

Figure 43 State Site 50-50-09-3163 Walled Irrigation Ditch; View East

Figure 44 State Site 50-50-08-3165 Complex; Aerial View

Figure 45 State Site 50-50-08-3165, Feature A Enclosure, View East

Figure 46 State Site 50-50-08-3165 Feature B Enclosure; View West

Figure 47 State Site 50-50-08-3168 Complex, Feature A; View Southwest

Figure 48 State Site 50-50-08-3168 Feature B Terrace; View East

Figure 49 State Site 50-50-08-3169 Feature C; View Northeast

Figure 50 State Site 50-50-08-3169 Feature E; View Northwest

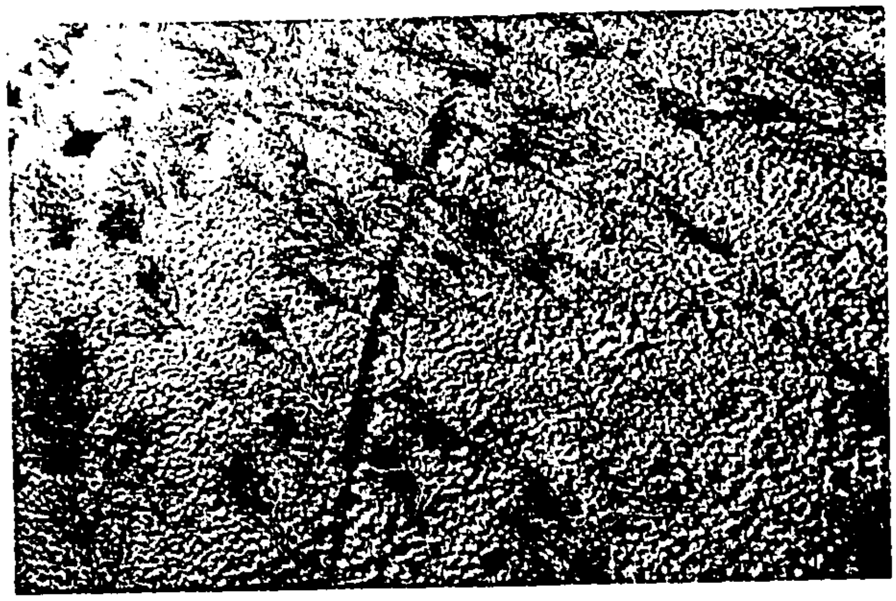


Figure 51 State Site 50-50-08-3170 Cattle Wall; Aerial View

Figure 52 State Site 50-50-08-3171, Possible Railroad Berm; View Southwest

Figure 53 State Site 50-50-03-3173 Wall; View North

Figure 54 State Site 50-50-03-3174 Wall; Aerial View

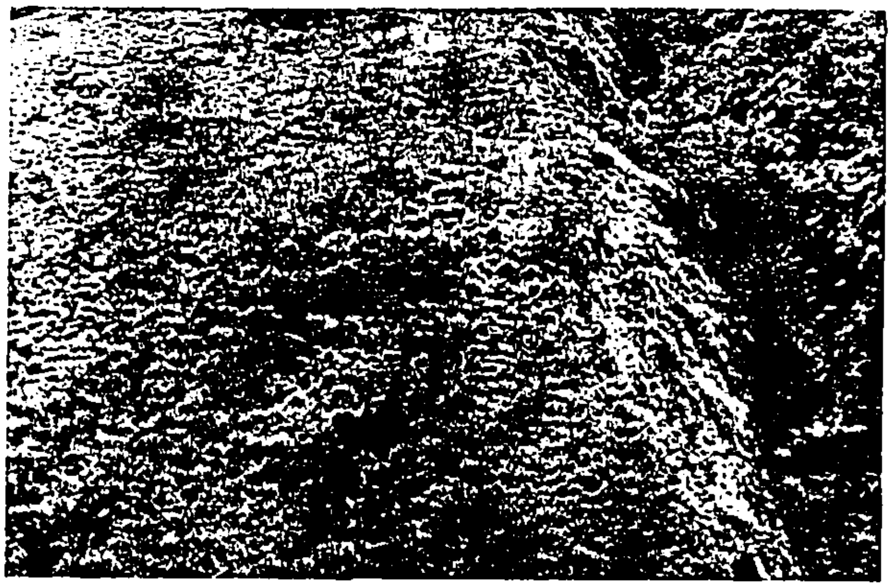


Figure 55 State Site 50-50-03-3175 Agriculture Complex; Aerial View

Figure 56 State Site 50-50-03-3176 Wall; View North

Figure 57 State Site 50-50-03-3177 Wall; View Northeast

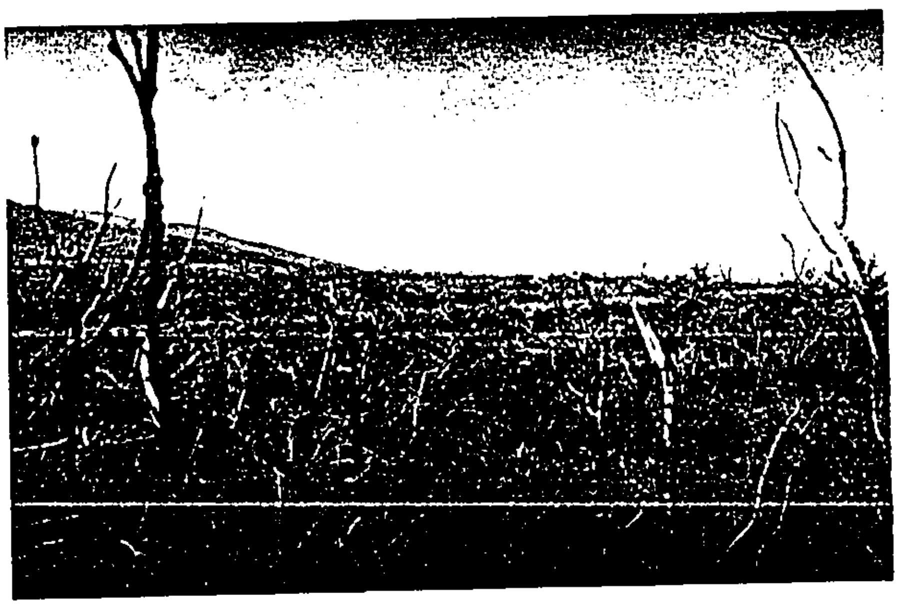


Figure 58 State Site 50-50-03-3178 Irrigation Canal; View South

Figure 59 State Site 50-50-09-3179 Enclosure; Aerial View

Figure 60 State Site 50-50-09-3181 Wall; View Northwest

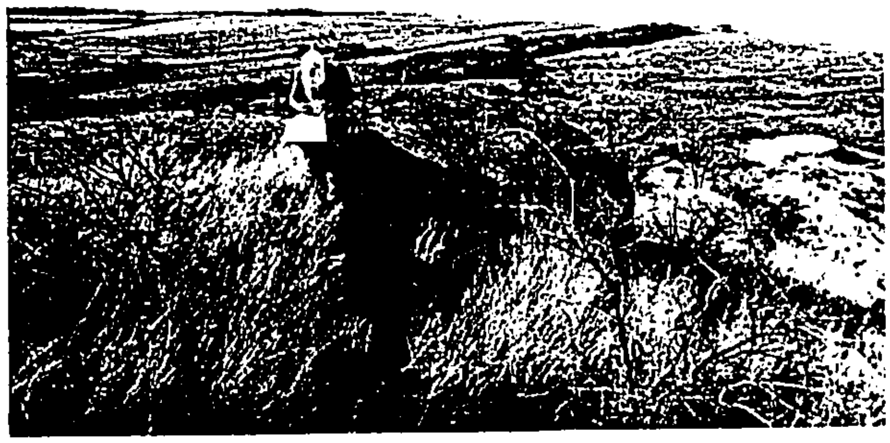


Figure 61 State Site 50-50-08-3185, Feature A Enclosure; View Southeast

Figure 62 State Site 50-50-08-3187, Feature A Enclosure; View Northeast

Figure 63 Possible Shrine (*heiau*) Located Outside the Preferred alignment on Central Ridge of Ukumehame Vally; Aerial View

Figure 64 State site 50-50-08-3188 Rockshelter; View North

APPENDIX C - ARTIFACT AND MIDDEN CATALOG

Table 4 - Indigenous Artifact Catalog

Project: Maalaea - Lahaina Transmission Line

Acc #	State site # 50-50-08-	Feature	Stratum	Depth (cm)	# pcs	Length (cm)	Width (cm)	Thickness (cm)	Weight (gms)	Material	Function
1	3165	A	I	0-10	1	1.2	0.5	0.3	0.1	V-glass	flake
2	3165	A	I	0-10	1	5.5	3.3	1.4	13.6	Coral	abrader
3	3165	A	I	0-10	66	0.9/5.9	0.6/4.5	0.2/1.6	158.4	Basalt	flakes
4	3165	A	II	10-20	1	1.4	1.1	0.8	1.8	V-glass	core
5	3165	A	II	10-20	1	5.5	5.0	2.9	74.4	Basalt	hammerstone
6	3165	A	II	10-20	1	4.8	3.0	2.5	40.5	Basalt	hammerstone
7	3165	A	II	10-20	16	0.6/5.9	0.4/3.5	0.1/2.7	71.0	Basalt	flakes

Table 5 - Midden Catalog

Project: Maalaea - Lahaina Transmission Line

State site # 50-50-08-	3165	3165	3168
Feature	A	A	
Depth/Stratum	0-10/I	10-20/II	0-10/I
Cellana sp.	0.6		
Nerita picea	0.6	0.1	0.2
Unident. shell	0.4	0.5	
Total marine midden	1.6	0.6	0.2
Kukui endocarp	3.1		
Total terrestrial midden	3.1	0	0
Unidentified bone	1.2	0.5	
Total midden	5.9	1.1	0.2
Land snail			0.1
Coral	11.2		
Charcoal	0.4		

APPENDIX C - ARTIFACT AND MIDDEN CATALOG

Table 4 - Indigenous Artifact Catalog

Project: Maalaea - Lahaina Transmission Line

Acc #	State site # 50-50-08-	Feature	Stratum	Depth (cm)	# pcs	Length (cm)	Width (cm)	Thickness (cm)	Weight (gms)	Material	Function
1	3165	A	I	0-10	1	1.2	0.5	0.3	0.1	V-glass	flake
2	3165	A	I	0-10	1	5.5	3.3	1.4	13.6	Coral	abrader
3	3165	A	I	0-10	66	0.9/5.9	0.6/4.5	0.2/1.6	158.4	Basalt	flakes
4	3165	A	II	10-20	1	1.4	1.1	0.8	1.8	V-glass	core
5	3165	A	II	10-20	1	5.5	5.0	2.9	74.4	Basalt	hammerstone
6	3165	A	II	10-20	1	4.8	3.0	2.5	40.5	Basalt	hammerstone
7	3165	A	II	10-20	16	0.6/5.9	0.4/3.5	0.1/2.7	71.0	Basalt	flakes

Table 5 - Midden Catalog

Project: Maalaea - Lahaina Transmission Line

State site # 50-50-08-	3165	3165	3168
Feature	A	A	
Depth/Stratum	0-10/I	10-20/II	0-10/I
Cellana sp.	0.6		
Nerita picea	0.6	0.1	0.2
Unident. shell	0.4	0.5	
Total marine midden	1.6	0.6	0.2
Kukui endocarp	3.1		
Total terrestrial midden	3.1	0	0
Unidentified bone	1.2	0.5	
Total midden	5.9	1.1	0.2
Land snail			0.1
Coral	11.2		
Charcoal	0.4		

APPENDIX H

ELECTRIC AND MAGNETIC FIELDS TECHNICAL REPORT

APPENDIX H

ELECTRIC AND MAGNETIC FIELDS

TECHNICAL REPORT

PREPARED BY

ENERTECH CONSULTANTS

OCTOBER 1993

Technical Information Paper
on
Electric and Magnetic Field Effects

for

Maui Electric Company Limited
Proposed Lahainaluna Switching Station
and
Maalaea - Lahaina Third 69 kV Transmission Line

Prepared by

Enertech Consultants
Campbell, California

October 1993

NOTICE

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Prepared by
Enertech Consultants of Santa Clara, Inc.
Campbell, California

Executive Summary

An evaluation was performed of the power-frequency electric and magnetic fields from the proposed Maalaea - Lahaina Third 69 kV Transmission Line Project. This analysis included computer calculations and field modeling of the electric and magnetic fields from the proposed 69 kV transmission line (for four different transmission line configuration and phasing arrangements and for three different loading conditions) and the proposed Lahainaluna Switching Station (for two different designs). Several different configurations and phasing arrangements were studied to determine the lowest magnetic field levels (as opposed to using other horizontal or vertical configurations which could produce higher magnetic field levels). This report describes these calculation results, as well as a general discussion of electric and magnetic fields, and a related overview concerning potential health effects.

Calculated electric fields from the proposed single circuit Maalaea - Lahaina Third 69 kV transmission line range from about 0.001 kV/m (at a distance of 550 feet from centerline) to a maximum of about 0.506 kV/m underneath of the conductors at midspan. Calculated electric fields from the proposed Lahaina & Puukolii double circuit 69 kV transmission line range from about 0.001 kV/m (at a distance of 325 feet from centerline) to a maximum of about 0.248 kV/m underneath of the conductors at midspan for the UNLIKE and DELTA phasing arrangements. Calculated electric fields were higher for the LIKE phasing arrangement, where levels ranged from 0.001 kV/m to a maximum of 0.846 kV/m at centerline.

Electric field calculations could not be performed for the proposed switching station (since no modeling software exists). However, the major source of electric fields outside of switching stations are typically the overhead transmission lines associated with the facility. Electric fields around switching stations and substations are usually between 0.001 - 0.050 kV/m due to electric field shielding. The grounded metallic housings and switching station walls constitute effective electric field shields, thereby reducing electric fields from internal equipment and buswork.

Calculated magnetic fields from the proposed single circuit Maalaea - Lahaina Third 69 kV transmission line range from about 0.1 mG (at a distance of 800 feet from centerline) to a maximum of about 14.1 mG directly under the conductors at midspan for Normal loading conditions. Under Emergency Case #1 and Case #2 loading conditions, maximum magnetic fields reach about 21 mG and 14.6 mG respectively. Calculated magnetic fields for the Lahaina & Puukolii double circuit 69 kV transmission line range from about 0.1 mG (at a distance of 800 feet from centerline) to a maximum of about 11.8 underneath the conductors at midspan for Normal loading conditions and for a LIKE phasing arrangement. For the Normal and Emergency Case #2 loading conditions, calculated magnetic fields are lower for the LIKE phasing arrangement (rather than the UNLIKE or DELTA configurations), since the direction of current flow provides more effective field cancellation. For Emergency Case #1, calculated magnetic fields are lower for the UNLIKE phasing configuration (a calculated maximum of about 11.8 mG directly under the conductors at midspan). For Emergency Case #2, calculated maximum magnetic fields reach about 18.8 mG under the conductors at midspan for the LIKE phasing arrangement.

Magnetic field modeling was performed for the proposed Lahainaluna switching station. For the proposed design under Normal loading, calculated magnetic fields reach a maximum of about 47.2 mG inside the station in the area of the 69 kV buswork. For Emergency Case #1 and #2, calculated magnetic fields ranged from about 0.0 mG to 57.6 mG and from about 0.0 mG to 77.5 mG respectively for the proposed design. For the alternate switching station design, magnetic fields reached a maximum of about 44.8 mG, 56.0 mG, and 74.5 mG for Normal, Emergency Case #1, and Emergency Case #2 loading conditions respectively. These maximum values occur inside the station in the area of the 69 kV buswork. Along the northern perimeter of the switching station, calculated magnetic fields reached a maximum of about 10.7 mG, 15.9 mG, and 11.1 mG for the three loading conditions respectively.

Research to date has not demonstrated conclusive evidence of health hazards due to electric and magnetic fields from switching stations and electrical power lines. Nevertheless, the proposed Maalaea - Lahaina Third 69 kV Transmission line Project is designed to minimize public exposure to electric and magnetic fields. Electric and magnetic fields associated with this project should be within the range or less than electric and magnetic fields produced by other similar voltage electrical facilities.

1. Introduction

Transmission lines and switching stations are a part of the electric system that is used to distribute electric service to homes and businesses. In recent years, interest has grown about what effects may be associated with the electrical environment around electric power facilities--in particular, the potential health effects that may be associated with the electric and magnetic fields in the vicinity of transmission and distribution lines and substations. Because the issues are technically complex, this paper was prepared to summarize and explain the issues.

The paper begins by generally describing electric power transmission lines and substations, and electric and magnetic field fundamentals. Next, it presents electric and magnetic field calculations for the proposed Maalaea - Lahaina Third 69 kV transmission line, the associated Lahaina and Puukolii 69 kV transmission lines, and Lahainaluna switching station. Finally, it provides an overview of the current state of knowledge about scientific research and standards or regulations for field strengths in states other than Hawaii, and typical field levels encountered in everyday activities.

2. Transmission Line Voltage Classifications

The high-voltage transmission or bulk power lines are an important element in the electric energy distribution system. The first "long" transmission line in the United States was built in Colorado to serve the Gold King Mine. The line operated at 40 kilovolts (kV) and was placed in service in 1891. As the demand for power has increased, so has the transmission line operating voltage and the miles of electric power lines in service. Higher operating voltages are used to reduce electric losses and thereby provide more economical delivery of power.

Today, a network of about 338,000 circuit miles of transmission lines are in service in the United States. The proposed Maalaea - Lahaina Third Transmission Line will be energized at 69 kV, which is lower than the highest voltage classification (of 138 kV) used in Hawaii. This 69 kV voltage is a subtransmission voltage and as such is below the classification range for transmission lines in operation elsewhere in the United States; where transmission line voltages range from about 115 kV up to 765 kV.

Table 1 summarizes the circuit miles of electric transmission lines in service of different voltage classifications.

Table 1 Transmission Line Circuit Miles in Service in the United States	
Voltage Classification (kV)	Circuit Miles in Service
115 to 161	193,383
230	70,511
345	47,958
500	23,958
765	2,428
Total	338,228

Sources: North American Reliability Council[1] and National Electric Manufacturers Association[2].

3. Electric Power Substations

High-voltage substation and switching station facilities are an important element in the electric energy distribution system. Substations receive higher-voltage electrical power from incoming transmission lines and convert it to lower-voltage electrical power for distribution to commercial and residential customers. Substations are classified by the voltage of the incoming transmission lines and outgoing distribution lines.

Substations are also locations where safety devices can be installed to quickly disconnect electric circuits or equipment in the event of a fault (short circuit or other problem). The voltage of the outgoing distribution lines can be regulated at a substation and system operation is monitored at substations. Substations can have a number of components, including power transformers (for changing voltage), switches, circuit breakers, lightning arresters, and relay and metering equipment. The energized portions of a substation are generally connected by rigid metal tubing called buswork. A substation has two or more incoming supply transmission lines for reliability. The layout of a substation is planned so that power lines or components can be taken out of service for maintenance without affecting the continuity of service to the utility customers. Switching stations are a type of substation which distribute electrical power between similar voltage transmission lines.

4. Proposed Transmission Line Designs

Three 69 kV transmission lines are associated with the proposed Lahainaluna switching station : 1) the Maalaea - Lahaina Third 69 kV line, 2) the Lahaina - Lahainaluna 69 kV line, and 3) the Puukolii - Lahainaluna 69 kV line. The Maalaea - Lahaina Third transmission line would transfer power from the Maalaea power plant in central Maui to the proposed switchyard. The Lahaina - Lahainaluna and Puukolii - Lahainaluna transmission lines would transfer power to and from the proposed switchyard to their associated substations. Figure 1 presents the proposed line configuration for the single circuit Maalaea - Lahaina Third 69 kV transmission line. The other two 69 kV transmission lines associated with the Lahainaluna switching station would be arranged in a double circuit configuration, also shown in Figure 1.

The basic electrical design for the Maalaea - Lahaina Third transmission line is a single circuit, three phase, nominal 69,000 volt (69 kV) electric transmission line, with the circuit arranged in a delta phase configuration (to mitigate magnetic field levels). The Maalaea 69 kV electrical conductors are single (1 conductor per phase) 652.4 KCM-AAAC (thousand circular mils, all-aluminum alloy concentric), 19-strand, 0.927-inch diameter "Elgin" conductors. The minimum ground clearance for this line is 35 feet at midspan, with an attachment height of 45 feet at the poles and span length ranging from 400 to 600 feet. A shield wire of single 195.7 KCM-AAAC is placed at the top of the supporting steel poles. This transmission line is designed to comply with the State of Hawaii Public Utilities Commission (PUC) General Order No. 6 and the National Electrical Safety Code.

The basic electrical design for the Lahaina and Puukolii transmission lines is a double circuit, three phase, nominal 69,000 volt (69 kV) electric transmission line, with each circuit arranged in a vertical phase configuration with unlike phasing (to mitigate magnetic field levels). Each circuit is comprised of electrical conductors which are single (1 conductor per phase) 336.5 KCM-AAC (thousand circular mils, all-aluminum concentric), 19-strand, 0.666-inch diameter "Tulip" conductors. The minimum ground clearance for this line is 35 feet at midspan, with an attachment height of 45 feet at the poles and span length ranging from 400 to 600 feet. Two shield wires of single 195.7 KCM-AAAC are placed above each circuit at the top of the supporting steel poles. This double circuit transmission line is designed to comply with the State of Hawaii Public Utilities Commission (PUC) General Order No. 6 and the National Electrical Safety Code.

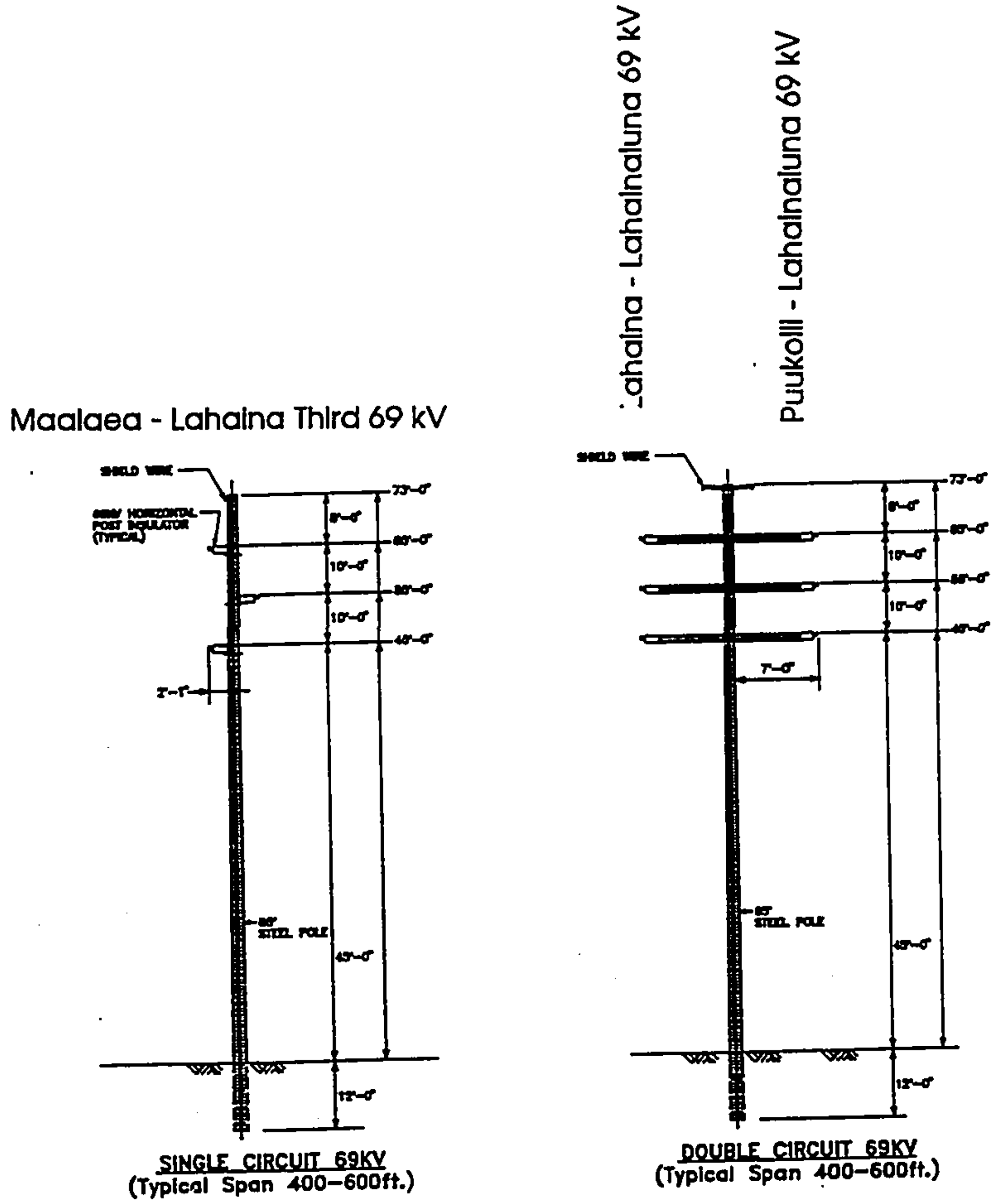

Figure 1. Typical 69 kV Transmission Line Configurations

5. Proposed Lahainaluna Switching Station Design

Maui Electric Company is proposing to construct a new switching station facility at the western portion of the island near Lahaina. The proposed switching station would transfer 69 kV electric power between three 69 kV transmission lines. The switching station would be approximately 360 feet wide by 350 feet long, and consist of a control house, 69 kV buswork, disconnect switches, circuit breakers, station power and potential transformers, insulators, and lightning arresters. The switching station will be a low profile design with support structures approximately 35 feet high. The loading of the substation is based upon the combined load of the three 69 kV transmission lines. Table 2 presents three potential loading conditions for the three transmission lines associated with this facility (as provided by Hawaiian Electric Company [HECO]). Due to differences in power factors and other transmission line operational parameters, the power input does not exactly equal the power output in all cases.

For all three loading cases, the direction current flow for the Maalaea - Lahaina Third transmission line is consistently into the switching station. Similarly, the direction of current flow for the Puukolii - Lahainaluna transmission line is consistently out of the switching station for all three loading conditions. However, the direction of current flow for the Lahaina - Lahainaluna line changes, depending upon the load case. During Emergency Case #1 loading conditions, the current flows out of the switchyard; whereas for the Normal and Emergency Case #2 loading conditions, the current flows into the switchyard. Figure 2 presents a generic diagram of the switching station with the three transmission lines and direction of current flow indicated.

Table 2
Loading Conditions for 69 kV Transmission Lines

Transmission Line	Normal Load (Amperes)	Emergency Load #1 (Amperes)	Emergency Load #2 (Amperes)
Maalaea - Lahaina Third	178 (in)	264 (in)	184 (in)
Lahaina - Lahainaluna	44.2 (in)	76.3 (out)	146 (in)
Puukolii - Lahainaluna	198 (out)	201 (out)	330 (out)

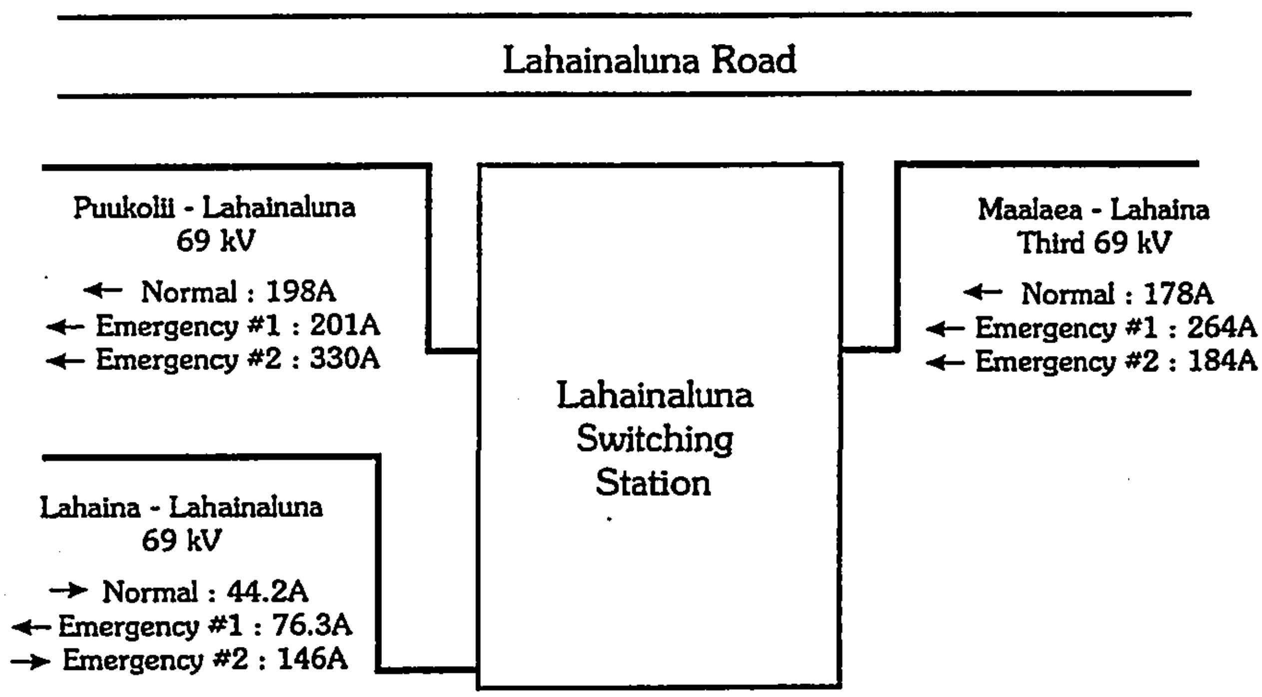

Figure 2. Generic Switching Station Diagram with Transmission Line Loading and Direction of Current Flow

Two configurations have been proposed for the Lahainaluna switchyard. Figure 3 presents a diagram of the preferred 69 kV switching station facility design. An alternate design has also been prepared in the event that logistical problems and/or other concerns develop with the preferred design. Figure 4 presents the optional station design with alternate locations for the 69 kV buswork and control house.

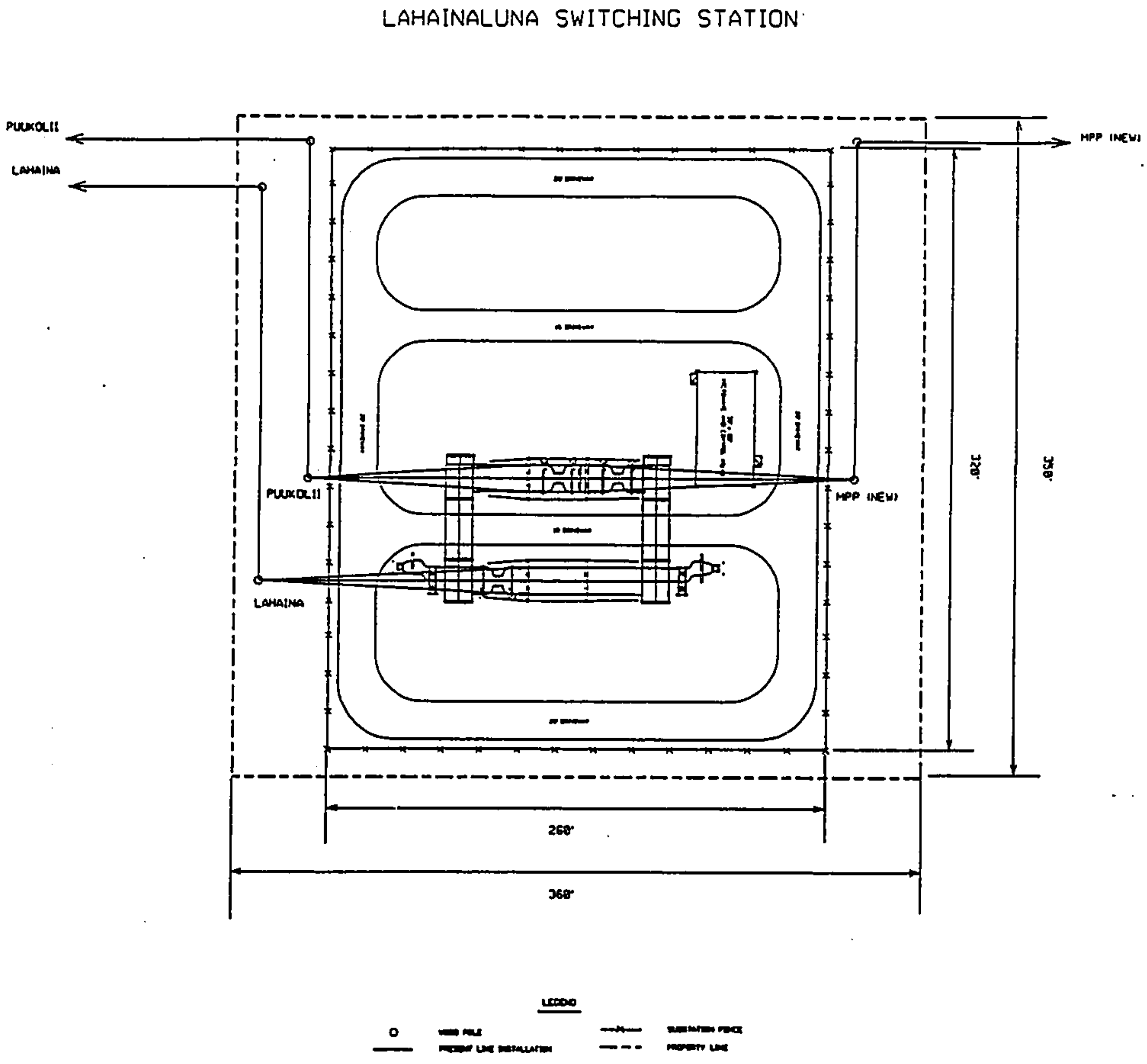

Figure 3. Preferred Lahainaluna Switching Station Diagram

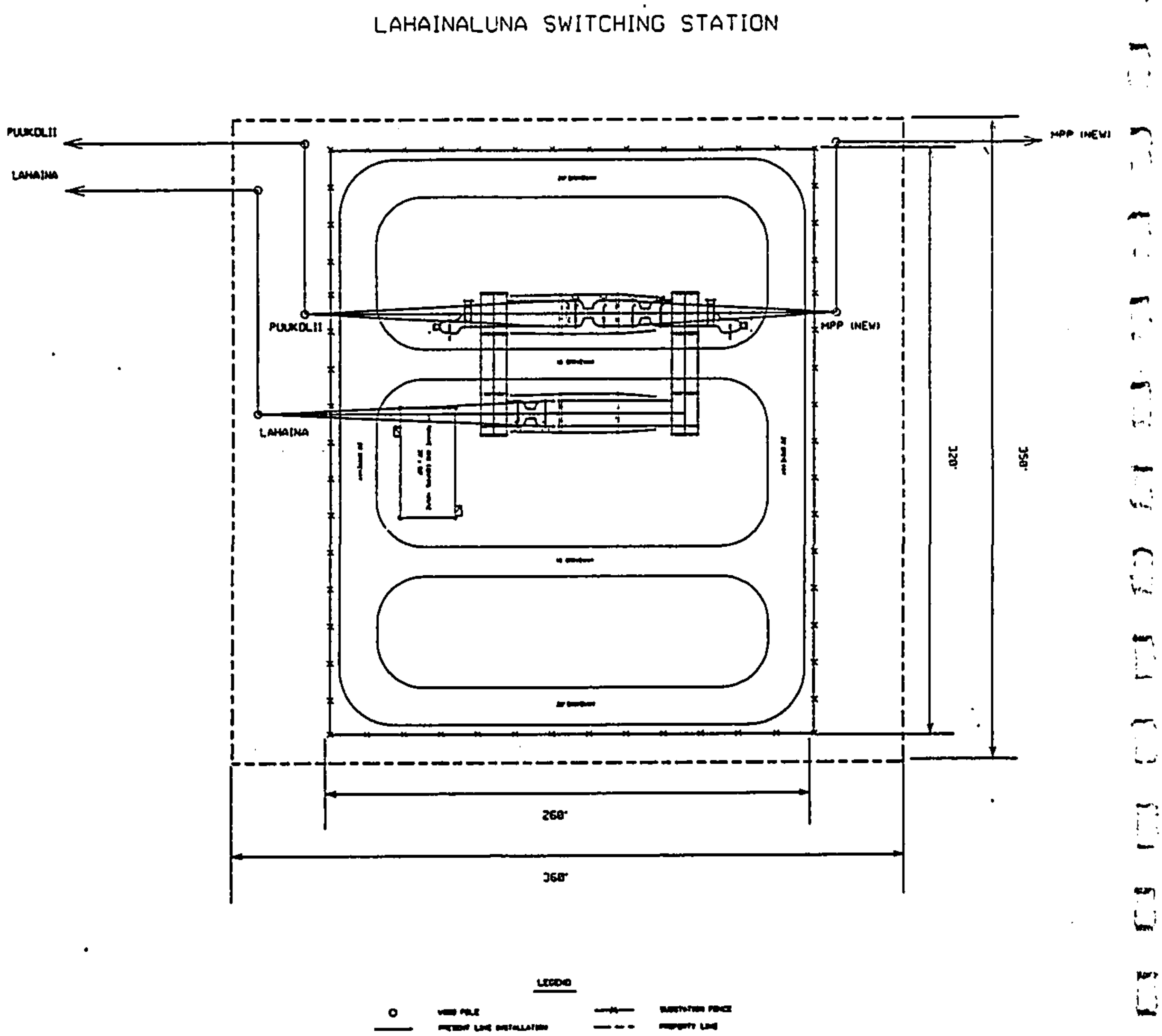

Figure 4. Optional Lahainaluna Switching Station Diagram

6. Electric Fields

Definition and Description

Electric fields are caused by the potential or voltage (electrical pressure) on an object. Any object with an electric charge on it has a voltage (potential) at its surface, caused by the accumulation of more electrons on that surface as compared with another object or surface. The voltage effect is not limited to the surface of the object but exists in the space surrounding the object. Electric fields can exert a force on other charges. The change in voltage over distance is known as the electric field. The units describing an electric field are volts per meter (V/m) or kilovolts per meter (kV/m). This means that a difference in electrical potential or voltage exists between two points one meter apart. The electric field becomes stronger near a charged object and decreases with distance away from the object.

Electric fields are a very common phenomenon. Static electric fields can result from friction generated when taking off a sweater or walking across a carpet. Body voltages have been measured as high as 16,000 volts due to walking on a carpet[3]. The earth creates a natural static field in fair weather of about 150 volts/meter (0.15 kV/m) at ground level due to the 300,000 to 400,000 volt potential difference between the ionosphere and the surface of the earth[4,5]. This means that a 6-foot-tall person would have a static potential of about 275 volts across the top and bottom of their body.

The normal fair weather static electric field of the earth varies from month to month, reaching a maximum of about 20 percent above normal in January, when the earth is closest to the sun, and falling to about 20 percent below normal by July, when the earth is farthest from the sun. Much stronger static electric potentials can exist underneath clouds, where the electric potential with respect to earth can reach 10 to 100 million volts. Natural static electric fields under clouds and in dust storms can reach 3 to 10 kV/m[5,6].

Almost all household appliances and other devices that operate on electricity create electric fields. However, these fields are different from the earth's static or dc (direct current) field. Power frequency appliance fields reverse direction at a rate of 60 times per second (60 Hertz [60 Hz]) because of the alternating current (ac) used to operate them. (In some other countries, this frequency is 50 Hz). The electric field is caused by the voltage on the appliance, and the field decreases rapidly with distance from the device. The field caused by point-source (small-dimension) household appliances generally attenuates more rapidly with distance than do line-source fields such as from power lines (transmission line electric fields attenuate at a rate of about $1/r^2$, where r is distance). Appliances need not be in operation to create an electric field. Just plugging an appliance into an electrical outlet creates an electric field around it. Typical values measured 1 foot away from some common appliances[7] are shown in Table 3.

Table 3
Typical Electric Field Values for Appliances, at 12 Inches

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

* 1 to 10 kV/m next to blanket wires[8].

7. Magnetic Fields

Definition and Description

An electric current flowing in any conductor (electric equipment, household appliance or otherwise) creates a magnetic field. The most commonly used magnetic field intensity unit is the Gauss (or mG, meaning milliGauss, or one-thousandth of a Gauss), which is a measure of the magnetic flux density (intensity of magnetic field attraction per unit area). As a reference, the earth has a natural static direct current magnetic field of about 0.36 Gauss, or 360 mG, in the Hawaiian Islands[9].

Transmission lines also have magnetic fields, but the characteristics are different from dc fields because the power line field is due to alternating currents (ac). The magnetic field under transmission lines is relatively low -- at least in comparison with measurements near many household appliances and other equipment. The magnetic field near an appliance decreases rapidly with distance away from the device. The magnetic field also decreases with distance away from line sources, such as power lines, but not as rapidly as it does with appliances. Transmission line magnetic fields attenuate at a rate of about $1/r^2$ (similar to power line electric fields), whereas magnetic fields from appliances attenuate at a rate of about $1/r^3$ or $1/r^4$ (within a much shorter distance). Since the magnetic field is caused by the flow of an electric current, a device must be operated to create a magnetic field. The magnetic field of a large number of typical household appliances was recently measured by the Illinois Institute of Technology Research (IITRI) for the U.S. Navy[10] and by Enertech Consultants[11] for the Electric Power Research Institute (EPRI). Typical values are presented in Table 4 as numerical examples to understand magnetic field values. The Enertech Consultants study for EPRI also found that mean resultant magnetic fields in residential homes was about 0.9 mG (at about 1 meter above ground level)[11].

Unlike electric fields, which are easily shielded by physical objects, magnetic fields cannot easily be shielded. Objects such as buildings, trees, and the ground do not shield magnetic fields (i.e., directly burying an underground transmission line cable effectively shields the electric field but does nothing to shield magnetic field effects). Magnetic fields from underground transmission cables may be generally lower than from overhead lines because of the close proximity of the conductors. Technology developed by the Electric Power Research Institute called ferromagnetic shielding offers the opportunity for a further reduction of magnetic fields from underground transmission cable circuits. Data provided in EPRI report number TR-102003 June 1993 "Transmission Cable Magnetic Field Management"[12] page 3-1 indicated that a 25 to 1 reduction in field strength can be achieved by placing the cables in an iron pipe. The pipe acts as a shield thus reducing the field. Cables placed in ducts or directly in the earth would not experience these reductions because concrete used in construction of duct banks and the earth itself do not provide any shielding for magnetic fields. This means that if the field one meter above the ground over an underground transmission cable circuit were 10 mG without ferromagnetic field shielding, the field with this type of shielding would be reduced to 0.4 mG.

Table 4 Magnetic Field From Household Appliances[10]		
	Magnetic Field (mG)	
Appliance	12" Away	Maximum
Electric Range	3 to 30	100 to 1,200
Electric Oven	2 to 5	10 to 50
Garbage Disposal	10 to 20	850 to 1,250
Refrigerator	0.3 to 3	4 to 15
Clothes Washer	2 to 30	10 to 400
Clothes Dryer	1 to 3	3 to 80
Coffee Maker	0.8 to 1	15 to 250
Toaster	0.6 to 8	70 to 150
Crock Pot	0.8 to 1	15 to 80
Iron	1 to 3	90 to 300
Can Opener	35 to 250	10,000 to 20,000
Mixer	6 to 100	500 to 7,000
Blender, Popper, Processor	6 to 20	250 to 1,050
Vacuum Cleaner	20 to 200	2,000 to 8,000
Portable Heater	1 to 40	100 to 1,100
Fans/blowers	0.4 to 40	20 to 300
Hair Dryer	1 to 70	60 to 20,000
Electric Shaver	1 to 100	150 to 15,000
Color TV	9 to 20	150 to 500
Fluorescent Fixture	2 to 40	140 to 2,000
Fluorescent Desk Lamp	6 to 20	400 to 3,500
Circular Saws	10 to 250	2,000 to 10,000
Electric Drill	25 to 35	4,000 to 8,000

Some local magnetic field measurements were made on three different occasions to characterize everyday magnetic field levels : 1) in February 1992 at several public locations in Waipahu on Oahu, 2) in January 1990 at several public locations on the Island of Hawaii, and 3) in October 1992 at several public locations in Honolulu. These measurements were made using an EMDEX II magnetic field meter (developed for EPRI by ENERTECH). This meter can be worn at the waist; the meter automatically records data every 1.5 seconds and stores the results for readout to a personal computer. The measurement results are summarized in Table 5.

Table 5 Summary of Everyday Magnetic Field Levels at Selected Oahu & Big Island Locations	
Location	Magnetic Field (mG)
Waipahu - Oahu	
Gem's Department Store	0.2 to 2.5
Gem's Jewelry	10 to 300
Gem's Parking Lot	0.5 to 2.0
Times Supermarket	0.5 to 14
"Skill Crane" Game	12 to 50
Tokyo Deli	0.5 to 8
Bakery	2 to 5
Driving on Farrington Highway	0.5 to 10
McDonalds Restaurant	0.5 to 15
Waipahu Sporting Goods	1 to 5
Arakawa's Department Store	0.5 to 5
Arakawa's Jewelry	4 to 120
Honolulu - Oahu	
Dole Pineapple Cannery Shops	0.1 to 42
K-Mart Department Store	0.2 to 22
Safeway Grocery Store	0.6 to 38
McDonalds Restaurant	0.1 to 77
Ala Moana Shopping Mall	0.1 to 176
- Sears Department Store	0.1 to 4.6
- Longs Drug Store	0.3 to 22
- The Nature Company	0.8 to 63
- Food Court	0.3 to 18
- Honolulu Book Shop	2.5 to 13
Hilo - Big Island	
McDonalds Restaurant	1 to 32
Post Office	0.5 to 34
State Building	0.2 to 12
Sure Save Supermarket	0.2 to 57
Ben Franklin Department Store	0.5 to 70
J.C. Penney Department Store	0.2 to 5
7-11 Convenience Store	0.5 to 8
Liberty House Department Store	0.3 to 3
Tilt-Video Arcade	1 to 40
Kay Bee Toy Store	0.5 to 28
Puna - Big Island	
Pahoa Post Office	0.3 to 10
Dairy Queen Restaurant	0.5 to 12
Da Store -- Convenience Shop	0.5 to 5
Walking Past Stores on Highway No. 130	0.2 to 7

8. Electric and Magnetic Field Calculations

Electric and magnetic field calculations were performed for the three proposed 69 kv transmission lines associated with the proposed Lahainaluna switching station. The purpose of these calculations was to characterize the range of field levels which could exist for the proposed transmission lines, under normal and two emergency loading conditions. Several different configurations and phasing arrangements were studied to determine the lowest magnetic field levels (as opposed to using other horizontal or vertical configurations which could produce higher magnetic field levels). In addition, calculations were performed for the proposed Lahainaluna switching station, for both the preferred and optional station designs under the three loading conditions. All calculations were performed at 1 meter above ground level in accordance with ANSI/IEEE Standard #644-1987[13] for measurements of electric and magnetic fields.

Calculated Transmission Line Electric Fields

The electric field values were calculated for the proposed single circuit Maalaea - Lahaina Third 69 kV transmission line and the proposed double circuit Lahaina and Puukolii 69 kV transmission line. Since electric fields are based strictly on the voltage of the transmission line, calculations were performed for each configuration only without regard to loading conditions. However, calculations for the double circuit 69 kV transmission line were performed for three different configuration/phasing arrangements, to determine the arrangement which would produce the lowest field values. The three phasing configurations included : 1) vertical phasing arrangements with LIKE phasing, 2) vertical phasing arrangements with UNLIKE phasing, and 3) a mixed DELTA phasing arrangement with UNLIKE phasing. Figure 5 presents a diagram of the three phasing configurations analyzed for the double circuit 69 kV transmission line. Calculation results are presented for each of the configurations in Figures 6 and 7 as electric field lateral profiles of the field extending away from the line on both sides at midspan. A lateral profile is a plot of the calculated maximum field as a function of distance away from the ROW center. Table 6 presents a tabular summary of the electric field calculations.

The electric field for the proposed Maalaea - Lahaina Third 69 kV transmission line will be approximately 0.001 kV/m at a distance of about 525 feet from centerline to a maximum value of 0.506 kV/m underneath the conductors near midspan. For the double circuit Lahaina and Puukolii transmission lines, calculated electric fields range from 0.001 kV/m at a distance of about 325 feet from centerline to a maximum value of 0.248 kV/m underneath the conductors near midspan both for the UNLIKE and DELTA phasing configurations (since the phasing is the same for both configurations, calculated electric fields are the same). Calculated electric fields for the double circuit line were higher for the LIKE phasing arrangement, where levels ranged from 0.001 kV/m to a maximum of 0.846 kV/m at centerline. Calculated electric fields are dependent on phasing arrangement (as shown in Figure 5) and are not affected by changes in loading or direction of current flow.

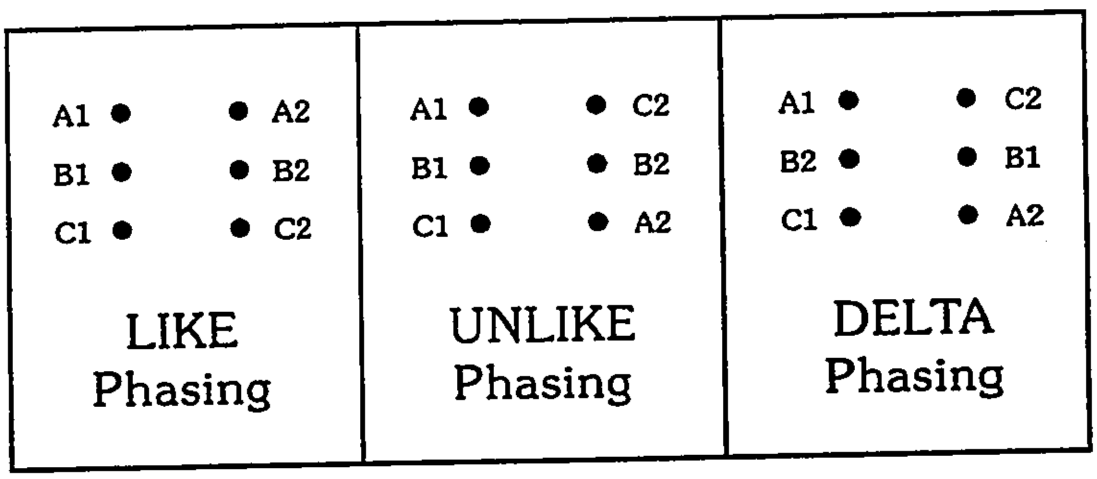

Figure 5. Phasing Configurations for the Proposed Lahaina and Puukolii Double Circuit 69 kV Transmission Line

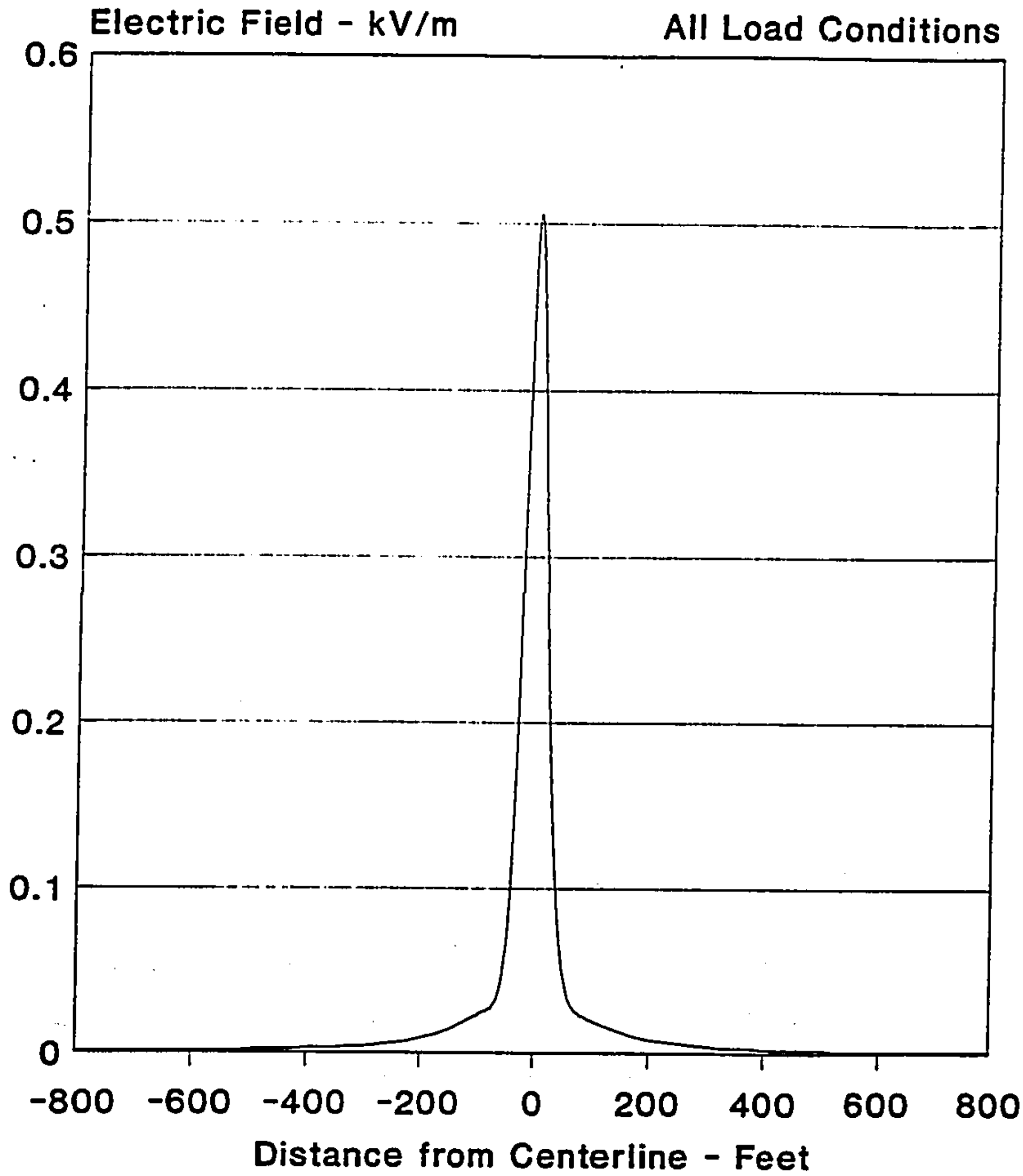

Figure 6. Electric Field Calculations for the Proposed Single Circuit Maalaea - Lahaina Third 69 kV Transmission Line

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near midspan both for the UNLIKE and DELTA phasing configurations (since the phasing is the same for both configurations, calculated electric fields are the same). Calculated electric fields for the double circuit line were higher for the LIKE phasing arrangement, where levels ranged from 0.001 kV/m to a maximum of 0.846 kV/m at centerline. Calculated electric fields are dependent on phasing arrangement (as shown in Figure 5) and are not affected by changes in loading or direction of current flow.

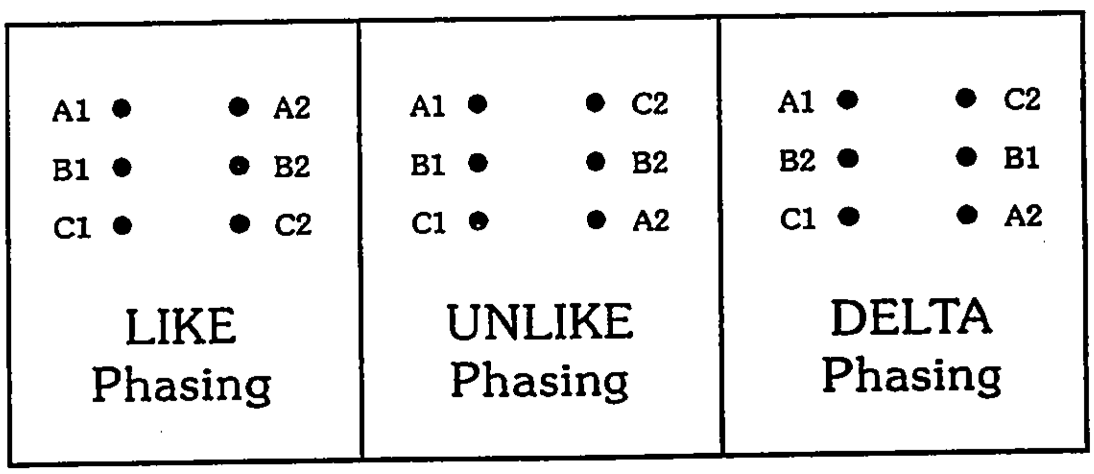


Figure 5. Phasing Configurations for the Proposed Lahaina and Puukolii Double Circuit 69 kV Transmission Line

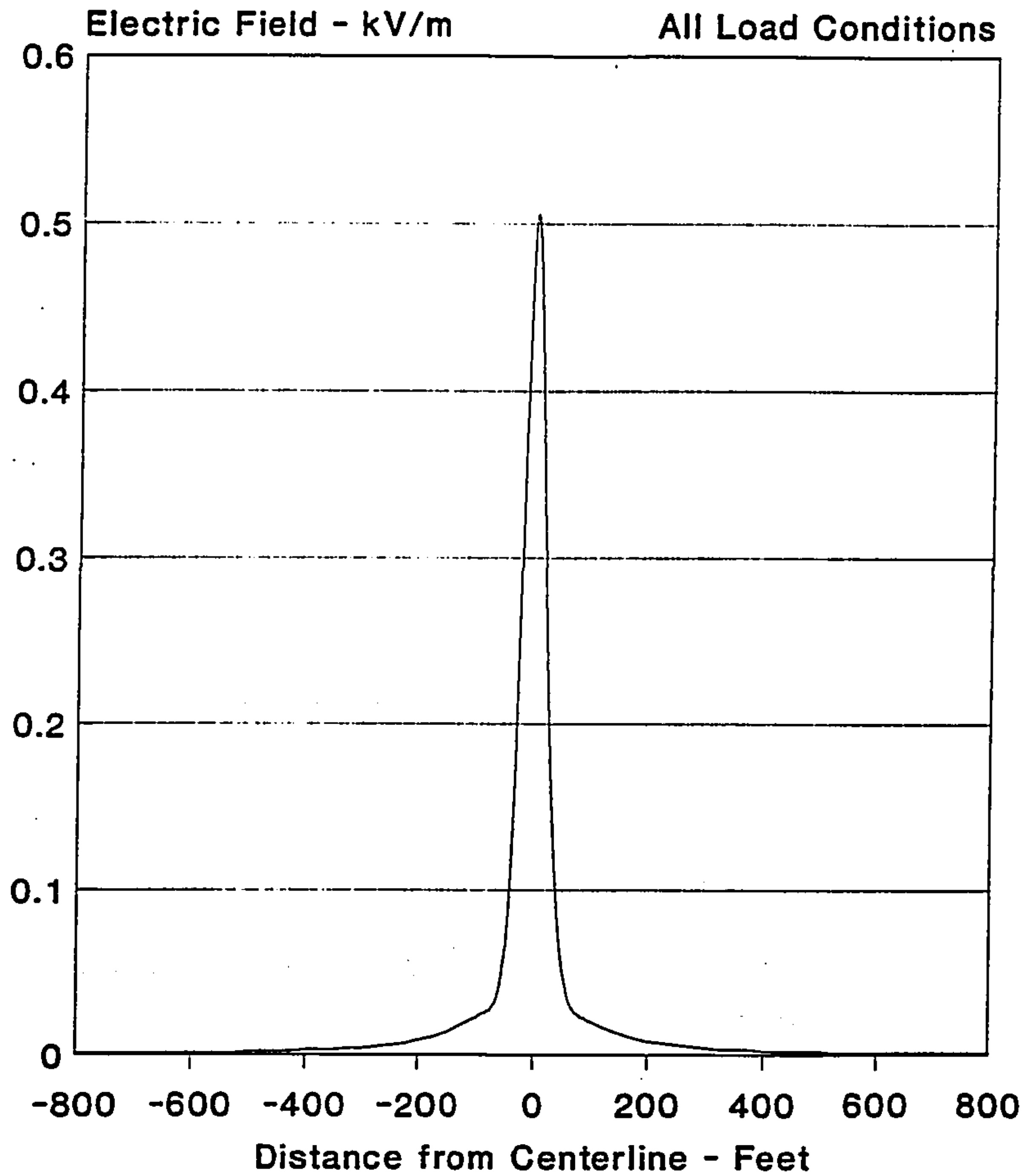


Figure 6. Electric Field Calculations for the Proposed Single Circuit Maalaea - Lahaina Third 69 kV Transmission Line

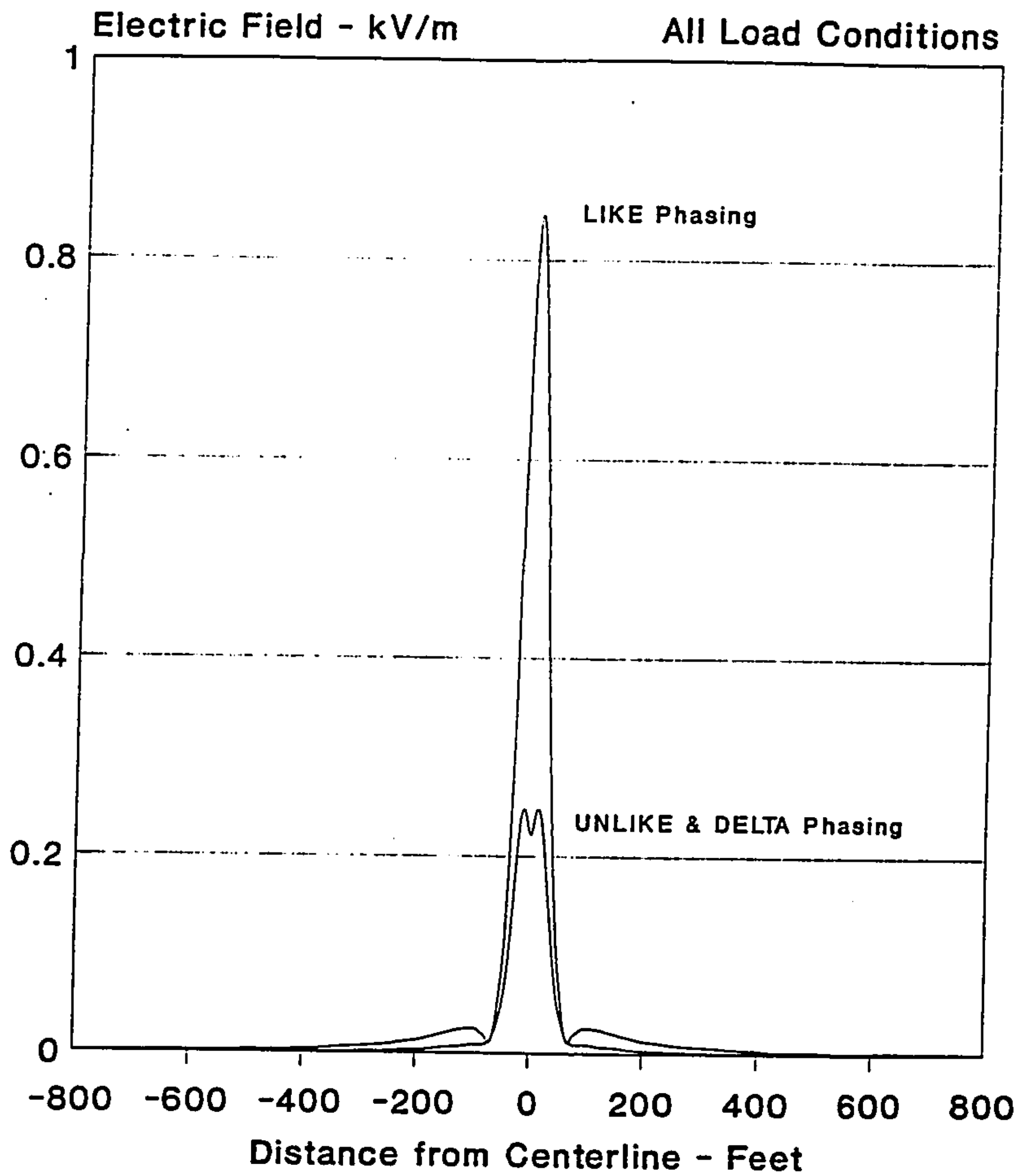


Figure 7. Electric Field Calculations for the Proposed Lahaina and Puukolii Double Circuit 69 kV Transmission Line

Table 6. Electric Field Calculations for 69 kV Transmission Lines Associated with the Proposed Lahainaluna Switching Station				
Distance from Centerline (Feet)	Calculated Electric Field - kV/m			
	Maalaea-Lahaina Third Single Circuit 69 kV Line	Lahaina & Puukolii Double Circuit Line		
		UNLIKE Phasing	LIKE Phasing	DELTA Phasing
-800.0	0.001	0.000	0.001	0.000
-750.0	0.001	0.000	0.001	0.000
-700.0	0.001	0.000	0.001	0.000
-650.0	0.001	0.000	0.002	0.000
-600.0	0.001	0.000	0.002	0.000
-550.0	0.001	0.000	0.002	0.000
-500.0	0.002	0.001	0.003	0.001
-450.0	0.002	0.001	0.003	0.001
-400.0	0.003	0.001	0.004	0.001
-350.0	0.003	0.001	0.005	0.001
-300.0	0.004	0.002	0.007	0.002
-250.0	0.006	0.002	0.009	0.002
-200.0	0.009	0.003	0.013	0.003
-150.0	0.014	0.006	0.020	0.006
-100.0	0.023	0.009	0.026	0.009
-90.0	0.025	0.009	0.024	0.009
-80.0	0.027	0.009	0.019	0.009
-70.0	0.030	0.012	0.011	0.012
-60.0	0.039	0.023	0.029	0.023
-50.0	0.064	0.047	0.079	0.047
-40.0	0.117	0.091	0.173	0.091
-30.0	0.209	0.157	0.328	0.157
-20.0	0.342	0.227	0.544	0.227
-10.0	0.470	0.246	0.755	0.246
-8.0	0.487	0.241	0.787	0.241
-6.0	0.498	0.235	0.812	0.235

-4.0	0.505	0.228	0.830	0.228
-2.0	0.506	0.224	0.842	0.224
0.0	0.500	0.222	0.846	0.222
2.0	0.490	0.224	0.842	0.224
4.0	0.474	0.228	0.830	0.228
6.0	0.454	0.235	0.812	0.235
8.0	0.430	0.241	0.787	0.241
10.0	0.404	0.246	0.755	0.246
20.0	0.263	0.227	0.544	0.227
30.0	0.153	0.157	0.328	0.157
40.0	0.085	0.091	0.173	0.091
50.0	0.050	0.047	0.079	0.047
60.0	0.033	0.023	0.029	0.023
70.0	0.027	0.012	0.011	0.012
80.0	0.024	0.009	0.019	0.009
90.0	0.022	0.009	0.024	0.009
100.0	0.020	0.009	0.026	0.009
150.0	0.013	0.006	0.020	0.006
200.0	0.008	0.003	0.013	0.003
250.0	0.006	0.002	0.009	0.002
300.0	0.004	0.002	0.007	0.002
350.0	0.003	0.001	0.005	0.001
400.0	0.002	0.001	0.004	0.001
450.0	0.002	0.001	0.003	0.001
500.0	0.002	0.001	0.003	0.001
550.0	0.001	0.000	0.002	0.000
600.0	0.001	0.000	0.002	0.000
650.0	0.001	0.000	0.002	0.000
700.0	0.001	0.000	0.001	0.000
750.0	0.001	0.000	0.001	0.000
800.0	0.001	0.000	0.001	0.000

Calculated Transmission Line Magnetic Fields

Magnetic fields were calculated for the proposed single circuit Maalaea - Lahaina Third 69 kV transmission line and the proposed double circuit Lahaina and Puukolii 69 kV transmission line. Calculations were performed for the three different loading conditions (Normal, Emergency Case #1, and Emergency Case #2). The results are presented as lateral profiles of the magnetic field on both sides of the line (as a function of distance from the line center) in Figures 8 through 11. These calculations are at midspan with the proposed minimum ground clearance. Tabular results of the magnetic field calculations are presented in Tables 7 and 8.

The lateral profiles shown in Figure 8 depict the calculated maximum magnetic field levels for both normal and emergency loading cases for the single circuit Maalaea - Lahaina Third 69 kV line. For Normal loading, the calculated magnetic field ranges from about 0.1 mG at a distance of 800 feet from centerline to a maximum of about 14.1 mG directly under the conductors at midspan. For Emergency Case #1 loading, the calculated magnetic field ranges from about 0.2 mG at a distance of 800 feet from centerline to a maximum of about 21 mG directly under the conductors. For Emergency Case #2 loading, the calculated magnetic field ranges from about 0.1 mG at a distance of 800 feet from centerline to a maximum of about 14.6 mG. It should be noted that, for the two Emergency load cases, these conditions would be rare and only occur for a short duration.

Calculated maximum magnetic field levels for the Normal, Emergency Case #1, and Emergency Case #2 loading conditions for the double circuit Lahaina and Puukolii 69 kV line are presented in Figures 9 through 11 respectively. For each loading condition, calculated magnetic field plots are presented for each of three different phasing arrangements. For Normal and Emergency Case #2 loading, calculated magnetic fields are lower for the LIKE phasing configuration, since load flows are in opposite directions. For Emergency Case #1, calculated fields are lower for the UNLIKE phasing configuration (since load flows are in the same direction). As demonstrated, changing the direction of current flow from the same direction to opposite directions produces the same effect as changing from UNLIKE phasing to LIKE phasing with respect to magnetic fields. Under Normal loading conditions, calculated magnetic fields range from about 0.1 mG at a distance of 800 feet from centerline to a maximum of about 13.4 mG directly under the conductors at midspan. Under Emergency Case #1 loading, calculated magnetic fields range from about 0.1 mG at a distance of 800 feet from centerline to a maximum of about 11.8 mG directly under the conductors. For Emergency Case #2 loading, calculated magnetic fields range from about 0.1 mG at a distance of 800 feet from centerline to a maximum of about 18.8 mG. Again, it should be noted that, for the two Emergency load cases, these conditions would be rare and only occur for a short duration.

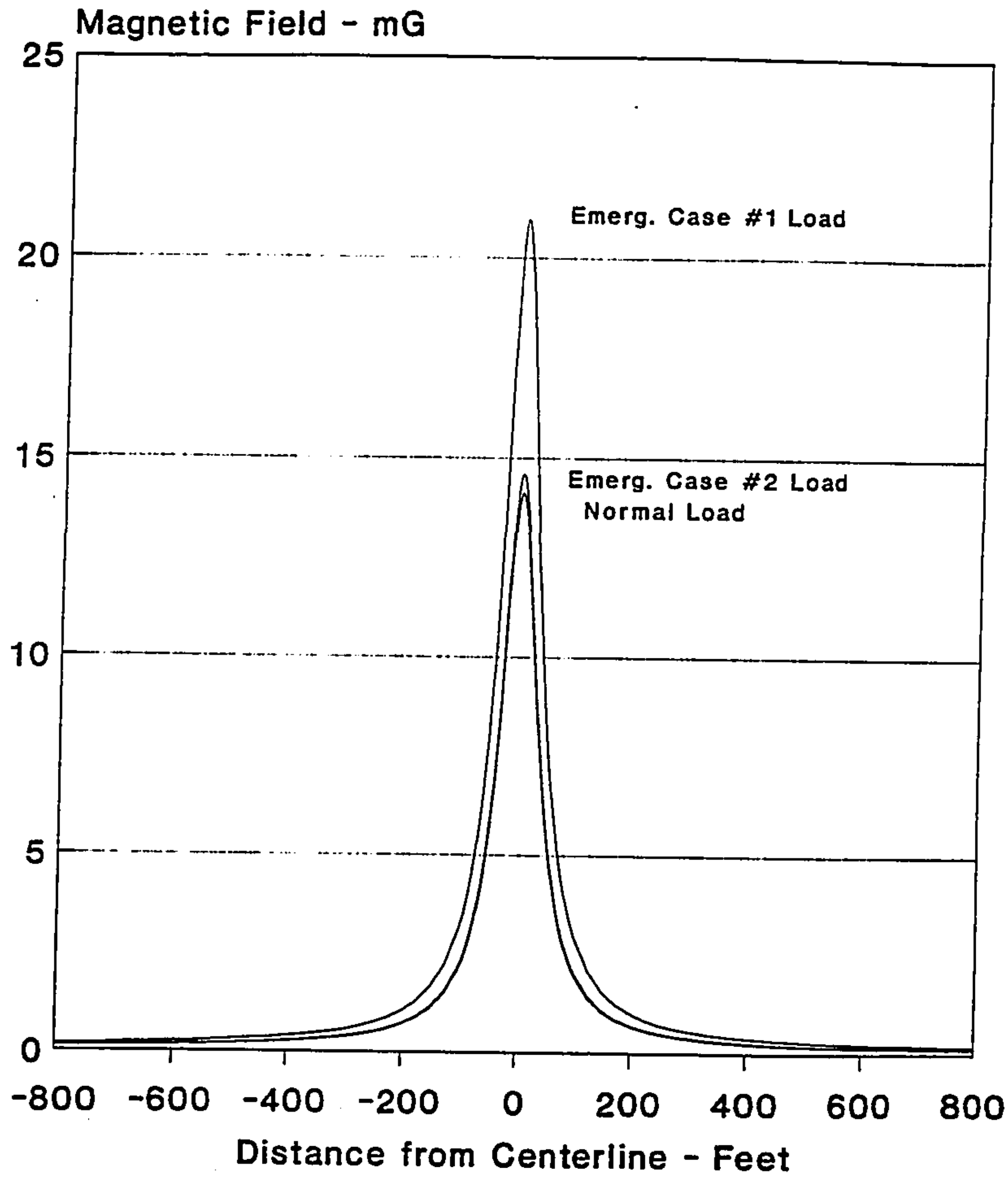


Figure 8. Magnetic Field Calculations for the Proposed Single Circuit Maalaea - Lahaina Third 69 kV Transmission Line

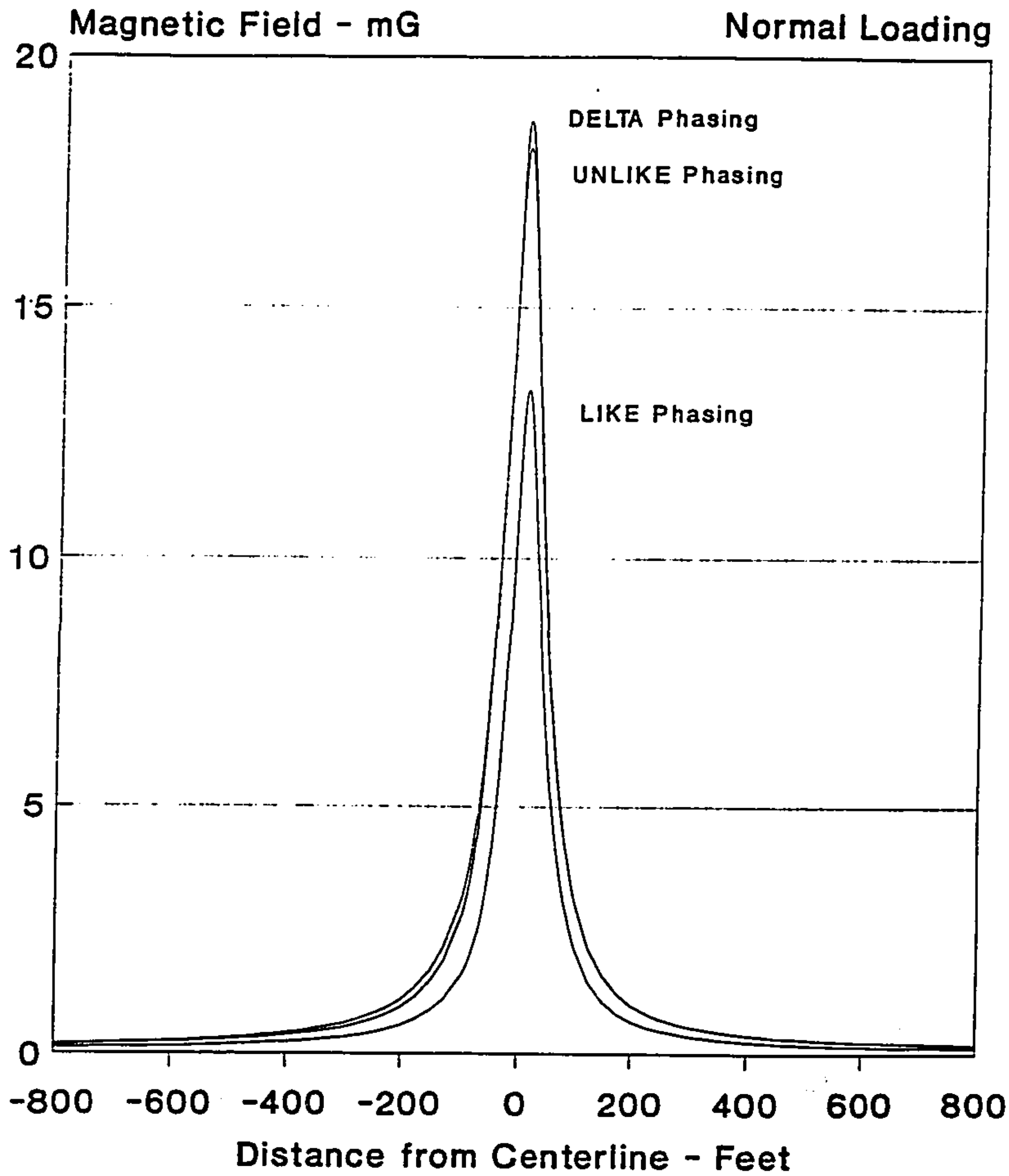


Figure 9. Magnetic Field Calculations for the Proposed Lahaina and Puukolii Double Circuit 69 kV Transmission Line Under Normal Loading

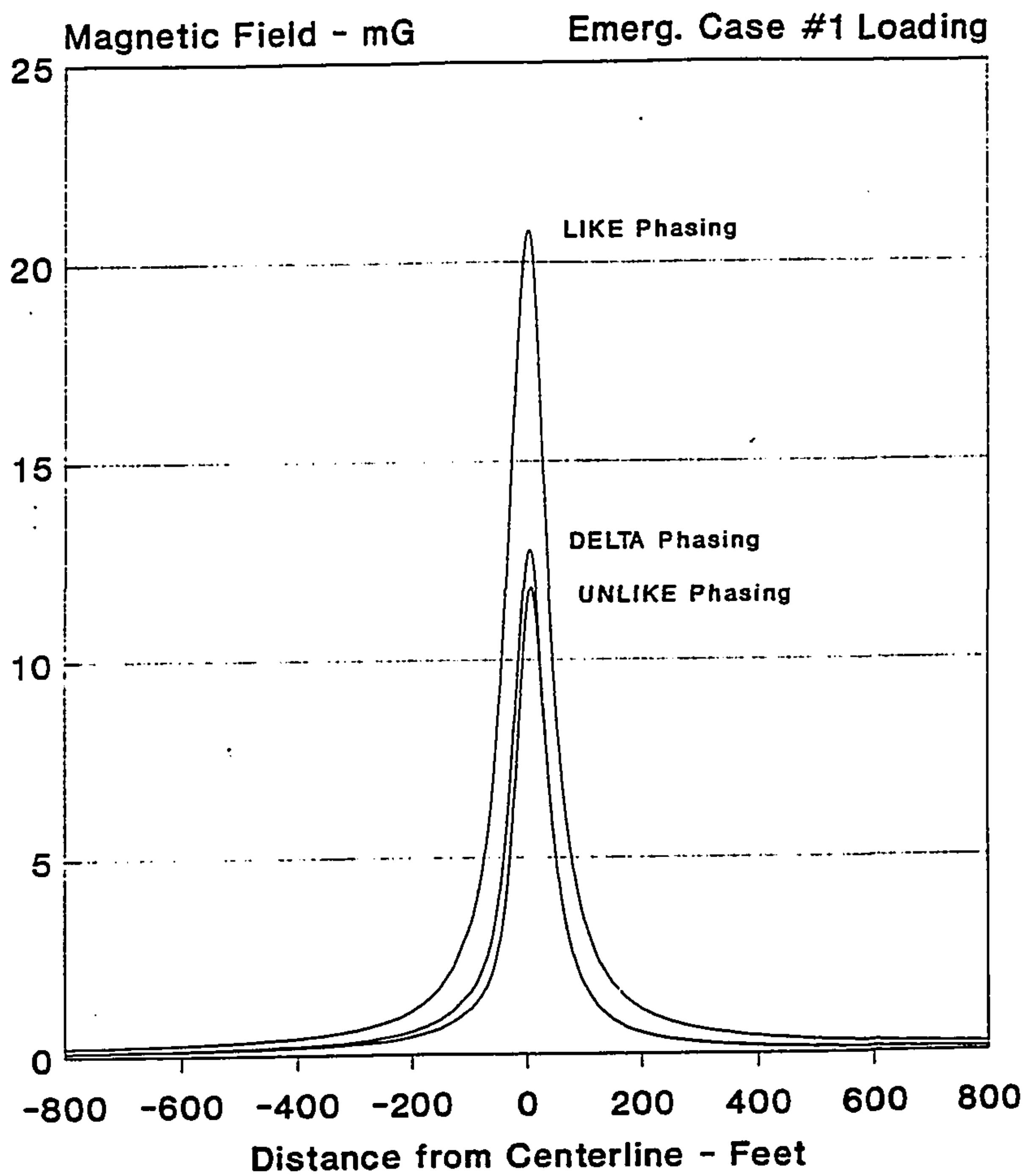


Figure 10. Magnetic Field Calculations for the Proposed Lahaina and Puukolii Double Circuit 69 kV Transmission Line Under Emergency Case #1 Loading Conditions

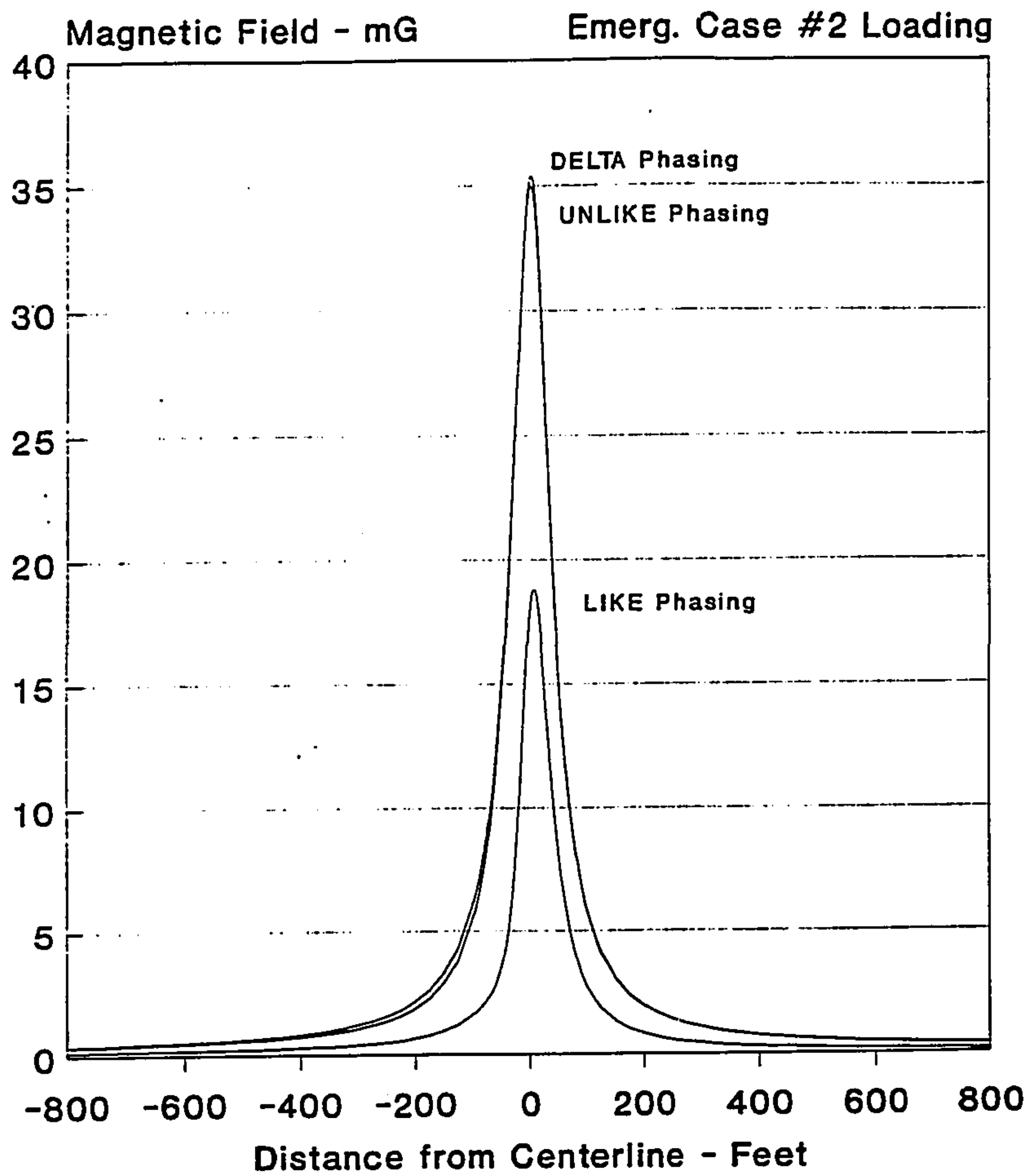


Figure 11. Magnetic Field Calculations for the Proposed Lahaina and Puukolii Double Circuit 69 kV Transmission Line Under Emergency Case #2 Loading Conditions

Table 7. Magnetic field Calculations for Single Circuit Maalaea - Lahaina Third 69 kV Transmission Line			
Distance from Centerline (Feet)	Maximum Magnetic Field - mG		
	Normal Load	Emergency Case #1 Load	Emergency Case #2 Load
-800.0	0.12	0.18	0.13
-750.0	0.13	0.20	0.14
-700.0	0.14	0.21	0.15
-650.0	0.15	0.23	0.16
-600.0	0.17	0.25	0.17
-550.0	0.19	0.27	0.19
-500.0	0.21	0.31	0.21
-450.0	0.23	0.35	0.24
-425.0	0.25	0.37	0.26
-400.0	0.27	0.40	0.28
-350.0	0.32	0.48	0.33
-300.0	0.39	0.58	0.41
-250.0	0.51	0.75	0.52
-200.0	0.71	1.05	0.73
-150.0	1.11	1.65	1.15
-100.0	2.13	3.16	2.20
-90.0	2.52	3.74	2.60
-80.0	3.02	4.48	3.12
-70.0	3.68	5.45	3.80
-60.0	4.56	6.76	4.71
-50.0	5.73	8.50	5.93
-40.0	7.30	10.83	7.55
-30.0	9.31	13.81	9.62
-20.0	11.60	17.21	11.99
-10.0	13.55	20.09	14.00
-8.0	13.80	20.46	14.26
-6.0	13.98	20.74	14.45

-4.0	14.09	20.90	14.57
-2.0	14.13	20.96	14.61
0.0	14.09	20.89	14.56
2.0	13.97	20.71	14.44
4.0	13.77	20.43	14.24
6.0	13.51	20.04	13.97
8.0	13.19	19.57	13.64
10.0	12.83	19.03	13.26
20.0	10.60	15.73	10.96
30.0	8.38	12.42	8.66
40.0	6.55	9.72	6.77
50.0	5.16	7.66	5.34
60.0	4.13	6.12	4.27
70.0	3.36	4.98	3.47
80.0	2.78	4.12	2.87
90.0	2.33	3.46	2.41
100.0	1.99	2.95	2.05
150.0	1.05	1.56	1.09
200.0	0.68	1.00	0.70
250.0	0.49	0.72	0.50
300.0	0.38	0.56	0.39
350.0	0.31	0.46	0.32
400.0	0.26	0.39	0.27
450.0	0.23	0.34	0.23
500.0	0.20	0.30	0.21
550.0	0.18	0.27	0.19
600.0	0.16	0.24	0.17
650.0	0.15	0.22	0.16
700.0	0.14	0.21	0.15
750.0	0.13	0.19	0.14
800.0	0.12	0.18	0.13

Table 8. Magnetic Field Calculations for the Lahaina and Puukolii Double Circuit 69 kV Transmission Line									
Distance from Centerline (Feet)	Maximum Magnetic Field - mG								
	Normal Load			Emergency Case #1 Load			Emergency Case #2 Load		
	UNLIKE	LIKE	DELTA	UNLIKE	LIKE	DELTA	UNLIKE	LIKE	DELTA
-800.0	0.18	0.12	0.19	0.09	0.21	0.10	0.35	0.14	0.37
-750.0	0.19	0.12	0.20	0.10	0.22	0.11	0.38	0.15	0.39
-700.0	0.21	0.13	0.22	0.11	0.24	0.12	0.41	0.16	0.42
-650.0	0.22	0.14	0.24	0.12	0.26	0.13	0.44	0.17	0.46
-600.0	0.24	0.15	0.26	0.13	0.28	0.14	0.48	0.18	0.51
-550.0	0.27	0.17	0.29	0.14	0.31	0.16	0.52	0.20	0.56
-500.0	0.29	0.19	0.32	0.15	0.34	0.18	0.58	0.22	0.63
-450.0	0.33	0.21	0.37	0.17	0.39	0.20	0.65	0.25	0.72
-400.0	0.38	0.24	0.43	0.20	0.44	0.23	0.75	0.29	0.83
-350.0	0.45	0.28	0.51	0.23	0.52	0.28	0.88	0.33	0.99
-300.0	0.54	0.34	0.62	0.28	0.63	0.34	1.07	0.40	1.22
-250.0	0.69	0.43	0.80	0.34	0.81	0.43	1.37	0.50	1.57
-200.0	0.95	0.58	1.10	0.46	1.11	0.59	1.88	0.67	2.16
-150.0	1.45	0.87	1.67	0.66	1.70	0.88	2.89	0.96	3.29
-100.0	2.67	1.53	2.99	1.12	3.15	1.53	5.40	1.59	5.95
-90.0	3.12	1.76	3.46	1.27	3.69	1.75	6.33	1.80	6.91
-80.0	3.69	2.06	4.05	1.46	4.38	2.04	7.52	2.06	8.13
-70.0	4.44	2.44	4.80	1.71	5.28	2.41	9.08	2.39	9.69
-60.0	5.43	2.94	5.77	2.04	6.47	2.92	11.14	2.84	11.73
-50.0	6.75	3.61	7.01	2.53	8.06	3.64	13.88	3.51	14.40
-40.0	8.48	4.56	8.62	3.29	10.15	4.69	17.47	4.59	17.86
-30.0	10.71	5.93	10.70	4.52	12.80	6.19	22.00	6.44	22.19
-20.0	13.34	7.89	13.36	6.40	15.86	8.21	27.14	9.52	27.12
-10.0	15.99	10.40	16.26	8.88	18.76	10.55	31.88	13.74	31.85
-8.0	16.46	10.91	16.79	9.39	19.24	11.00	32.64	14.61	32.67
-6.0	16.89	11.40	17.28	9.88	19.67	11.41	33.32	15.45	33.40

-4.0	17.28	11.87	17.71	10.33	20.05	11.79	33.90	16.23	34.05
-2.0	17.60	12.29	18.08	10.75	20.35	12.12	34.36	16.94	34.59
0.0	17.86	12.65	18.37	11.10	20.58	12.39	34.70	17.56	35.00
2.0	18.05	12.95	18.58	11.40	20.73	12.59	34.91	18.06	35.27
4.0	18.16	13.17	18.70	11.61	20.79	12.72	34.97	18.44	35.39
6.0	18.19	13.31	18.72	11.75	20.76	12.77	34.88	18.69	35.35
8.0	18.13	13.37	18.65	11.81	20.63	12.73	34.65	18.80	35.14
10.0	17.98	13.34	18.48	11.79	20.41	12.63	34.26	18.78	34.77
20.0	16.12	12.12	16.48	10.69	18.17	11.16	30.47	17.01	30.92
30.0	13.31	9.97	13.53	8.75	14.95	9.00	25.10	13.87	25.44
40.0	10.56	7.84	10.71	6.84	11.87	6.97	19.96	10.79	20.20
50.0	8.32	6.11	8.43	5.30	9.35	5.36	15.76	8.32	15.95
60.0	6.60	4.79	6.68	4.13	7.43	4.17	12.54	6.46	12.70
70.0	5.31	3.82	5.38	3.27	5.99	3.29	10.12	5.10	10.26
80.0	4.34	3.09	4.40	2.63	4.91	2.64	8.30	4.09	8.43
90.0	3.61	2.55	3.66	2.16	4.09	2.16	6.92	3.34	7.03
100.0	3.05	2.13	3.09	1.80	3.46	1.80	5.85	2.78	5.96
150.0	1.57	1.06	1.59	0.88	1.79	0.87	3.04	1.34	3.10
200.0	0.99	0.66	1.00	0.54	1.14	0.53	1.94	0.82	1.97
250.0	0.71	0.47	0.71	0.38	0.82	0.37	1.40	0.57	1.41
300.0	0.55	0.36	0.55	0.29	0.64	0.28	1.09	0.44	1.09
350.0	0.45	0.29	0.45	0.24	0.53	0.22	0.89	0.35	0.88
400.0	0.38	0.25	0.38	0.20	0.45	0.19	0.75	0.30	0.74
450.0	0.33	0.21	0.33	0.18	0.39	0.16	0.66	0.26	0.64
500.0	0.30	0.19	0.29	0.16	0.34	0.14	0.58	0.23	0.57
550.0	0.27	0.17	0.26	0.14	0.31	0.13	0.52	0.20	0.51
600.0	0.24	0.16	0.24	0.13	0.28	0.12	0.48	0.19	0.47
650.0	0.22	0.14	0.22	0.12	0.26	0.11	0.44	0.17	0.43
700.0	0.21	0.13	0.20	0.11	0.24	0.10	0.41	0.16	0.40
750.0	0.19	0.12	0.19	0.10	0.22	0.09	0.38	0.15	0.37
800.0	0.18	0.12	0.18	0.10	0.21	0.09	0.35	0.14	0.35

Calculated Switching Station Electric Fields

Typically the major source of electric fields outside of electric power switching stations are the overhead transmission and/or distribution lines associated with the facility. Electric fields around switching stations and substations are usually between 0.001 - 0.050 kV/m due to electric field shielding. The grounded metallic equipment housings and substation/switching station walls constitute effective electric field shields, thereby reducing electric fields from internal equipment and buswork.

Electric field calculations for the three 69 kV transmission lines associated with the proposed Lahainaluna switching station ranged from approximately 0.001 kV/m (at a distance of 800 feet from the transmission line center) to a maximum of about 0.506 kV/m for the proposed Maalaea - Lahaina Third 69 kV line and 0.246 - 0.846 kV/m for the proposed Lahaina and Puukolii double circuit 69 kV line (depending upon phasing arrangement). Figures 6 and 7 present the results of these electric field calculations. Electric fields from the proposed Lahainaluna switching station should be limited to within the range of values calculated for the overhead 69 kV transmission lines associated with the station (most locations will probably be lower due to electric field shielding from nearby objects).

Calculated Switching Station Magnetic Fields

Magnetic field calculations were conducted for the Lahainaluna switching station using the EPRI "RESICALC" software program. The RESICALC program allows the user to input transmission and distribution line configurations and custom conductors to model substation lines and buswork. Fields from equipment such as transformers is presently not modeled by the software. However, for estimating fields outside of the substation, neglecting these point-sources does not seriously affect accuracy because the field due to them decreases very quickly with distance. Using the RESICALC software, equi-field contour maps and three - dimensional plots of the calculated magnetic field were produced. The Lahainaluna switching station was modeled for both the preferred and alternate station designs and for Normal and Emergency Case #1 and #2 loading conditions. Figure 12 presents an overhead view of the preferred switching station design, with the proposed Maalaea - Lahaina Third 69 kV transmission line entering the switchyard from the right side and the proposed Lahaina - Lahainaluna and Puukolii - Lahainaluna double circuit 69 kV transmission line entering the left side of the station. Figure 13 presents an overhead view of the alternate switching station design, with the 69 kV buswork and control house located closer to Lahainaluna road.

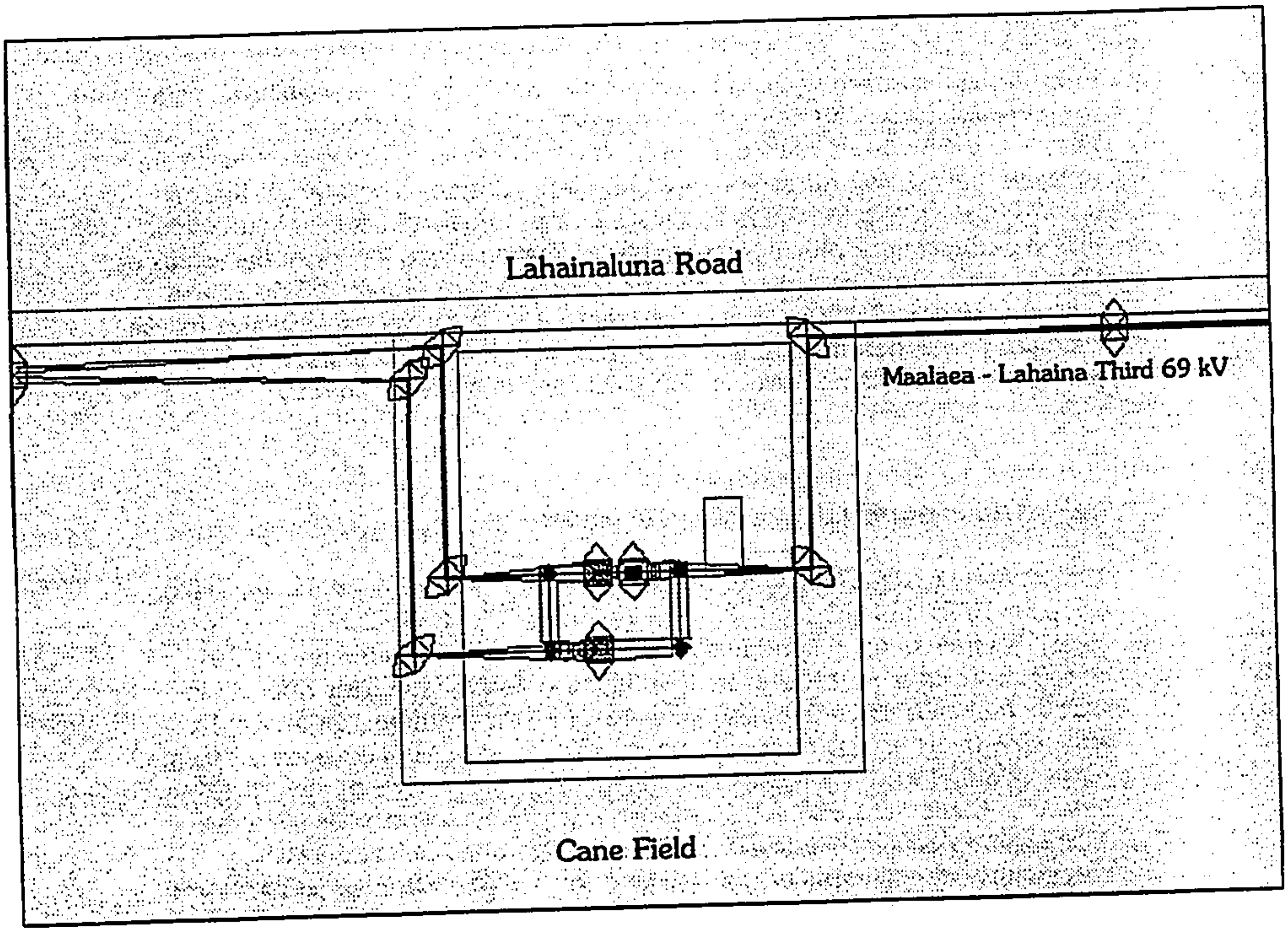


Figure 12. Diagram of the Preferred Lahainaluna Switchyard Design

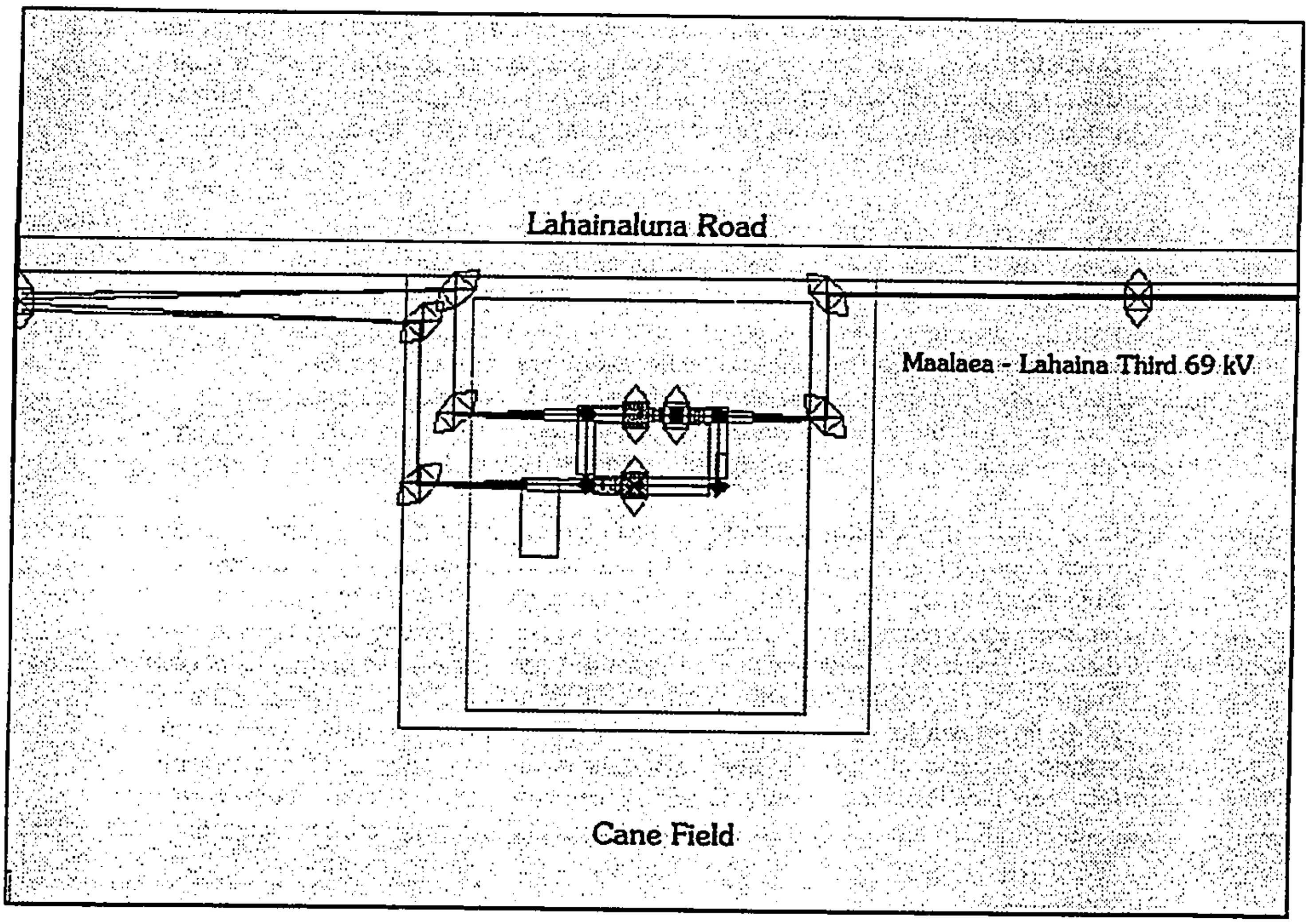


Figure 13. Diagram of the Alternate Lahainaluna Switchyard Design

For purposes of modeling, only the three associated transmission lines and the internal 69 kV buswork were considered as strong magnetic field sources. As explained earlier, the other switching station equipment was not included in the magnetic field model. Equipment, such as station power and potential transformers, lightning arresters, and circuit breakers, do not substantially increase the magnetic field beyond the fence (magnetic field levels outside of the station are primarily due to the buswork and overhead power lines). The grounding pad, which might have some neutral current, would be very small and not a dominant field source. The microwave telemetry equipment would have a frequency much higher than the 60 Hz power frequency, and therefore was not considered in this model.

Magnetic field calculations were performed at the switching station perimeter and extending away from the station. Figure 14 presents an equi-field contour map of the magnetic field for the proposed Lahainaluna switching station under Normal loading conditions. As shown, the calculated magnetic field inside the station reaches a maximum of about 47.2 mG, in the area of the 69 kV buswork. Under Emergency Case #1 load conditions, magnetic fields range from about 0 to 57.6 mG, as shown in Figure 15. Figure 16 presents an equi-field contour map for Emergency Case #2, where calculated magnetic fields range from 0 to 77.5 mG. As shown in these figures, the maximum magnetic field occurs within the switchyard in the area of the 69 kV buswork, and the dominant source of magnetic fields outside of the switching station are the incoming 69 kV transmission lines. Fields from the internal 69 kV buswork are primarily contained within the switching station boundaries. Table 9 presents a summary of the magnetic field calculations for the proposed Lahainaluna switching station.

In order to better determine the range of magnetic field influence from the station, detail contour maps were prepared for the northern perimeter of the station. Figures 17 through 19 present the calculated magnetic field contour maps for Normal, Emergency Case #1, and Emergency Case #2 loading conditions along the northern station perimeter. As shown in these figures, the highest calculated magnetic field levels occur underneath the proposed Maalaea - Lahaina Third 69 kV transmission line as it enters the switchyard (on the lower right corner of the graph). Calculated magnetic fields along the station perimeter itself range from less than 1 mG to about 5 mG, depending upon loading conditions. Additional contour and 3-dimensional magnetic field maps and diagrams are presented in Appendix A. Table 9 also presents a summary of the northern perimeter calculations.

Magnetic field calculations were also performed for the alternate switching station design. Figures 20 through 22 present equi-field contour maps of the calculated magnetic field for the alternate Lahainaluna switching station design under Normal, Emergency Case #1, and Emergency Case #2 loading conditions respectively. Maximum magnetic field levels within the station perimeter range from about 44.8 mG to 74.5 mG, depending on load condition. Again, the dominant source of magnetic fields within the switching station are in the area of the 69 kV buswork, whereas field levels outside the station are primarily due to the incoming 69 kV transmission lines. Calculated field levels for the alternate design are slightly lower than those calculated for the preferred design, primarily due to the precision of the grid resolution for the computer model. In the RESICALC modeling program, calculated field values are used to construct a magnetic field grid at specified distance intervals. For the preferred design, the location of the 69 kV buswork was probably closer to a grid calculation point than for the alternate design. Therefore, slightly higher magnetic field levels were calculated for the preferred design than for the alternate design. A summary of calculation results for the alternate Lahainaluna switching station design is also shown in Table 9.

As with the preferred station design, detail contour maps were prepared for the northern perimeter for the alternate station design. Figures 23 through 25 present magnetic field contour maps for Normal, Emergency Case #1, and Emergency Case #2 loading conditions respectively. As shown, the highest calculated magnetic field levels again occur underneath the proposed Maalaea - Lahaina Third 69 kV transmission line as it enters the switchyard (on the lower right corner of the graph). Calculated magnetic fields along the station perimeter itself range from less than 1 mG to about 5 mG, depending upon loading conditions. These calculated values are identical to those calculated along the northern perimeter for the preferred switchyard design. The location of the 69 kV buswork would therefore have negligible impact, if any, on magnetic field levels outside of the switchyard for these two designs. Additional contour and 3-dimensional magnetic field maps and diagrams of the alternate switchyard design are presented in Appendix A. Table 9 also presents a summary of the northern perimeter calculations for this alternate design.

Table 9 presents a summary of the magnetic field calculations for the proposed Lahainaluna Switching Station for the three different loading conditions and both design types. Magnetic field levels presented in this table represent a range of values as modeled by the magnetic field contour maps. The lower values (of 0.0 mG) represent field levels distant from the 69 kV transmission line and switchyard, whereas the larger values represent the maximum measurable magnetic field levels as calculated within or near the switchyard and/or underneath the 69 kV transmission line (as opposed to a calculated resultant or single axis value).

Table 9 Summary of Magnetic Field Calculations for the Proposed Lahainaluna Switching Station		
Location	Magnetic Field (mG)	Substation Loading Description
<u>Proposed Design</u>		Normal Loading
Overall Site	0.0 to 47.2	
North Perimeter	0.0 to 10.7	
<u>Proposed Design</u>		Emergency Case #1 Loading
Overall Site	0.0 to 57.6	
North Perimeter	0.0 to 15.9	
<u>Proposed Design</u>		Emergency Case #2 Loading
Overall Site	0.0 to 77.5	
North Perimeter	0.0 to 11.1	
<u>Alternate Design</u>		Normal Loading
Overall Site	0.0 to 44.8	
North Perimeter	0.0 to 10.7	
<u>Alternate Design</u>		Emergency Case #1 Loading
Overall Site	0.0 to 56.0	
North Perimeter	0.0 to 15.9	
<u>Alternate Design</u>		Emergency Case #2 Loading
Overall Site	0.0 to 74.5	
North Perimeter	0.0 to 11.1	

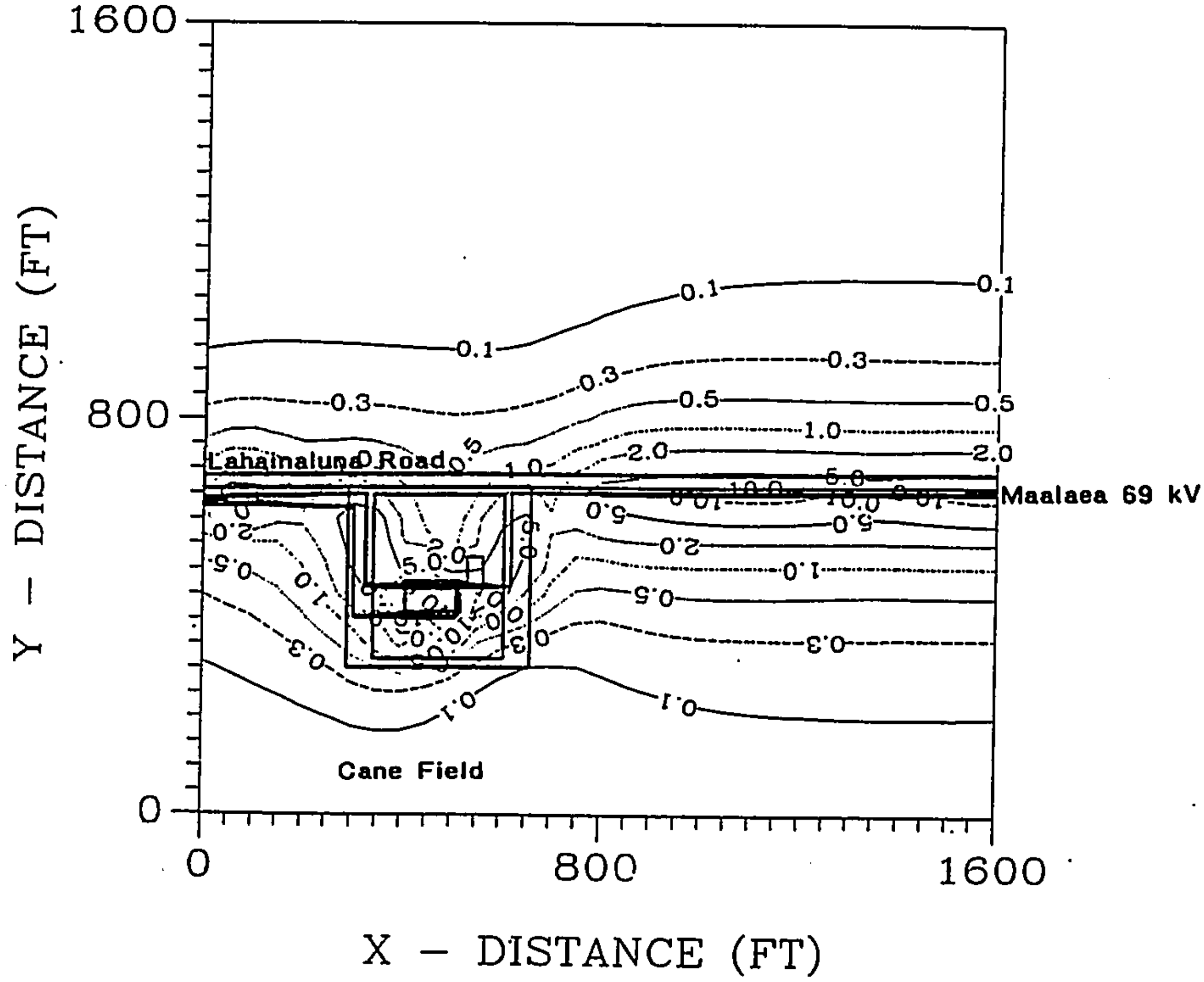


Figure 14. Magnetic Field Contour Map for Preferred Lahainaluna Switchyard Under Normal Loading Conditions

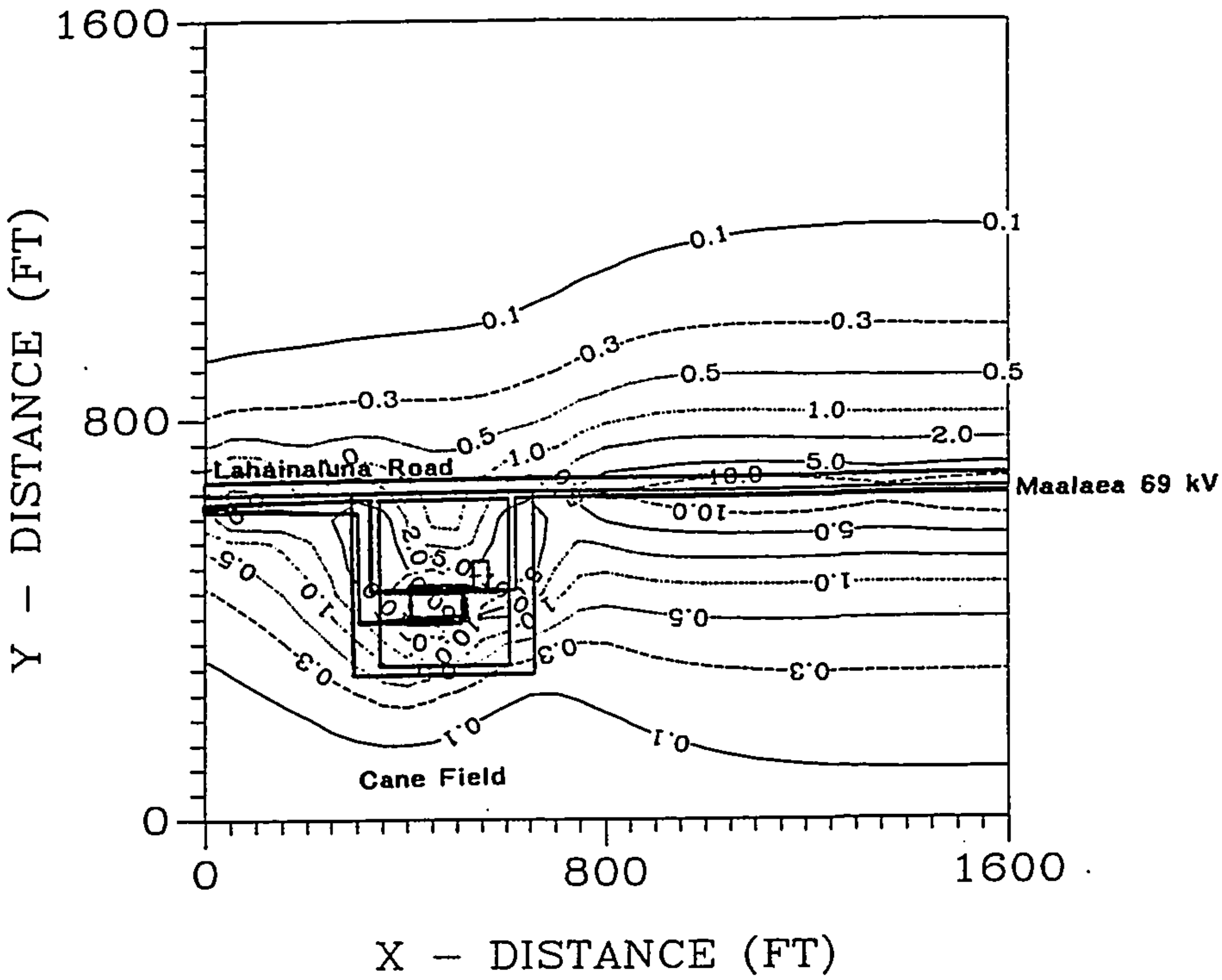


Figure 15. Magnetic Field Contour Map for Preferred Lahainaluna Switchyard Under Emergency Case #1 Loading Conditions

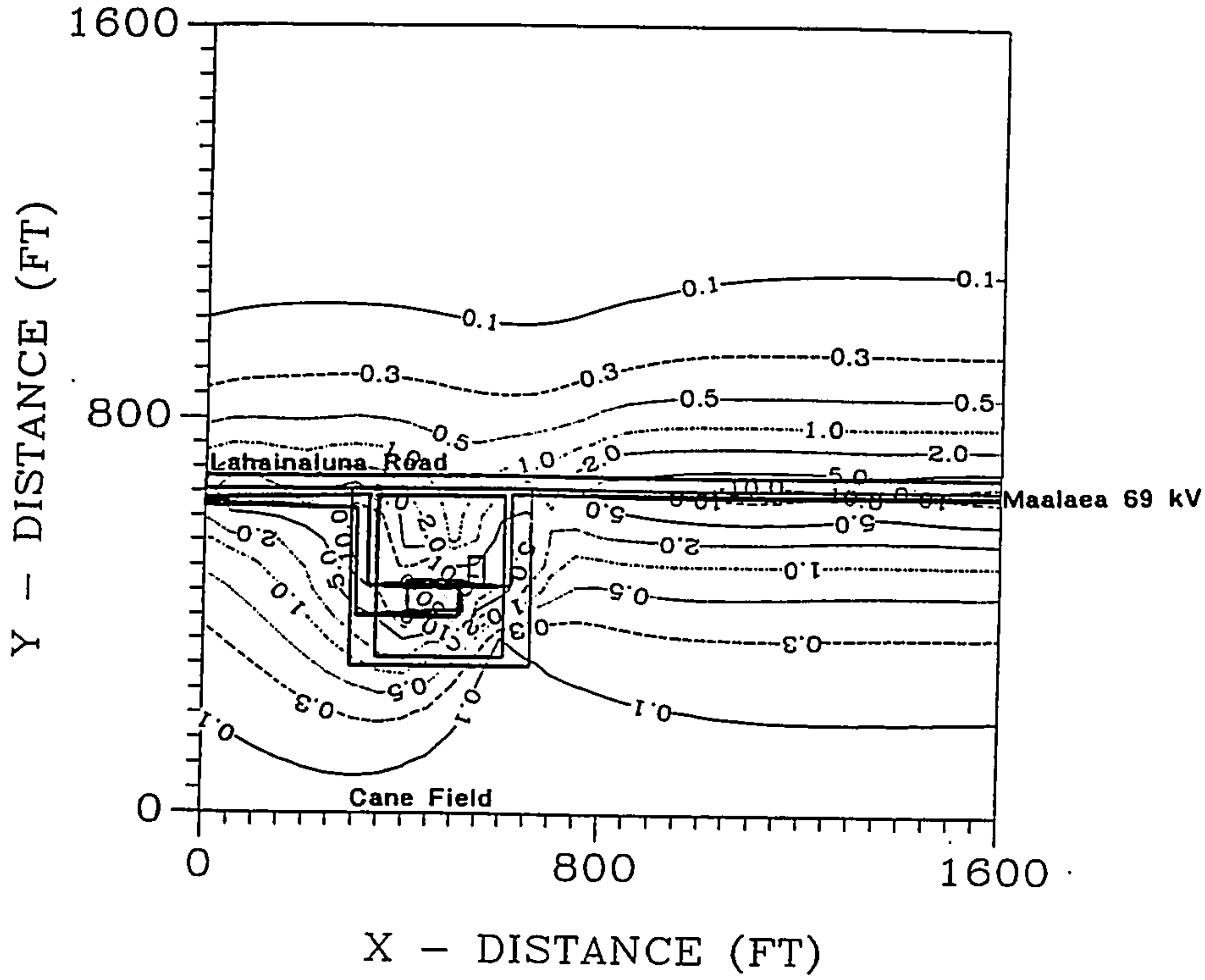


Figure 16. Magnetic Field Contour Map for Preferred Lahainaluna Switchyard Under Emergency Case #2 Loading Conditions

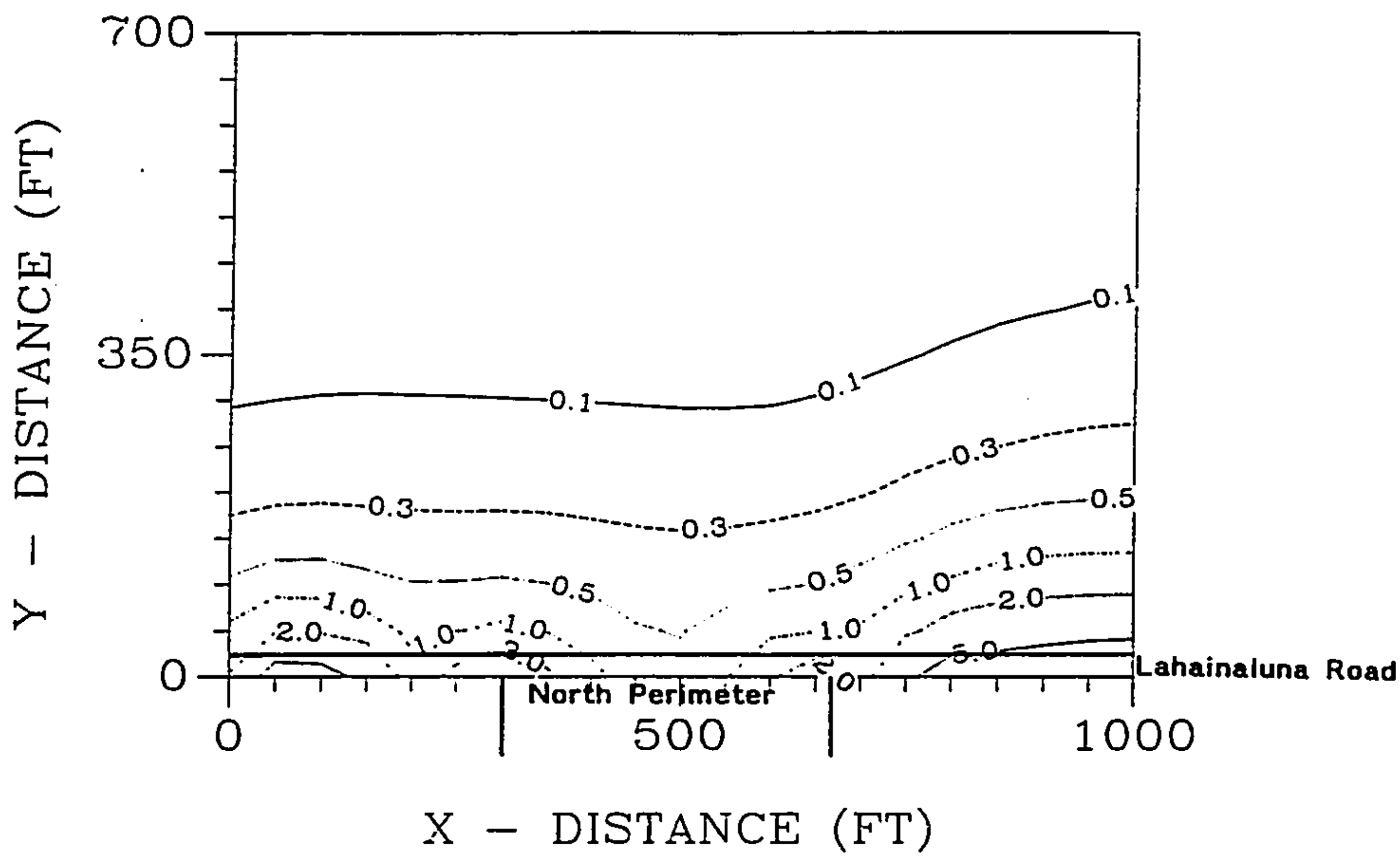


Figure 17. Detail of the Northern Perimeter Magnetic Field Contour Map for the Preferred Lahainaluna Switchyard Under Normal Loading Conditions

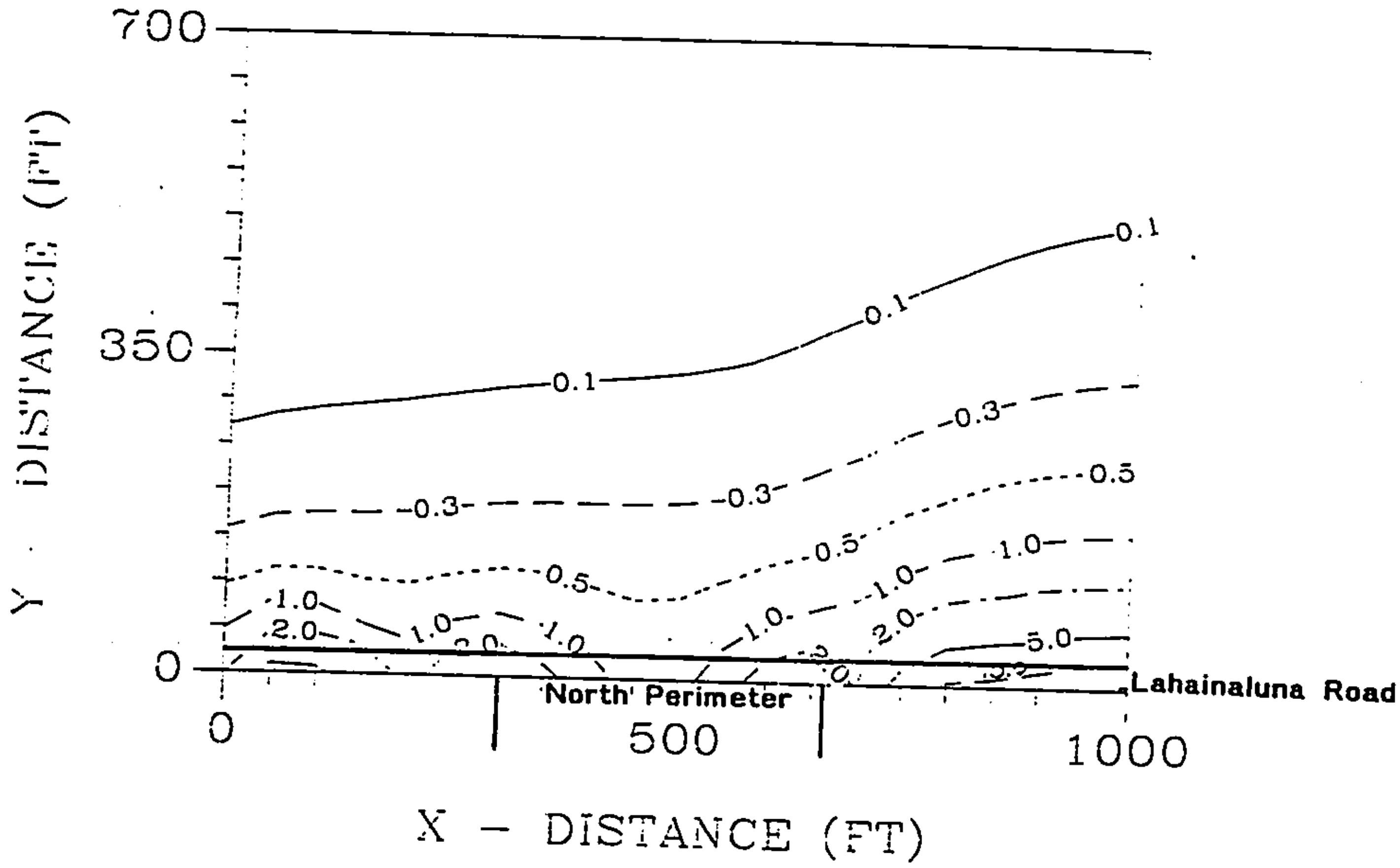


Figure 18. **Detail of the Northern Perimeter Magnetic Field Contour Map for the Preferred Lahainaluna Switchyard Under Emergency Case #1 Loading Conditions**

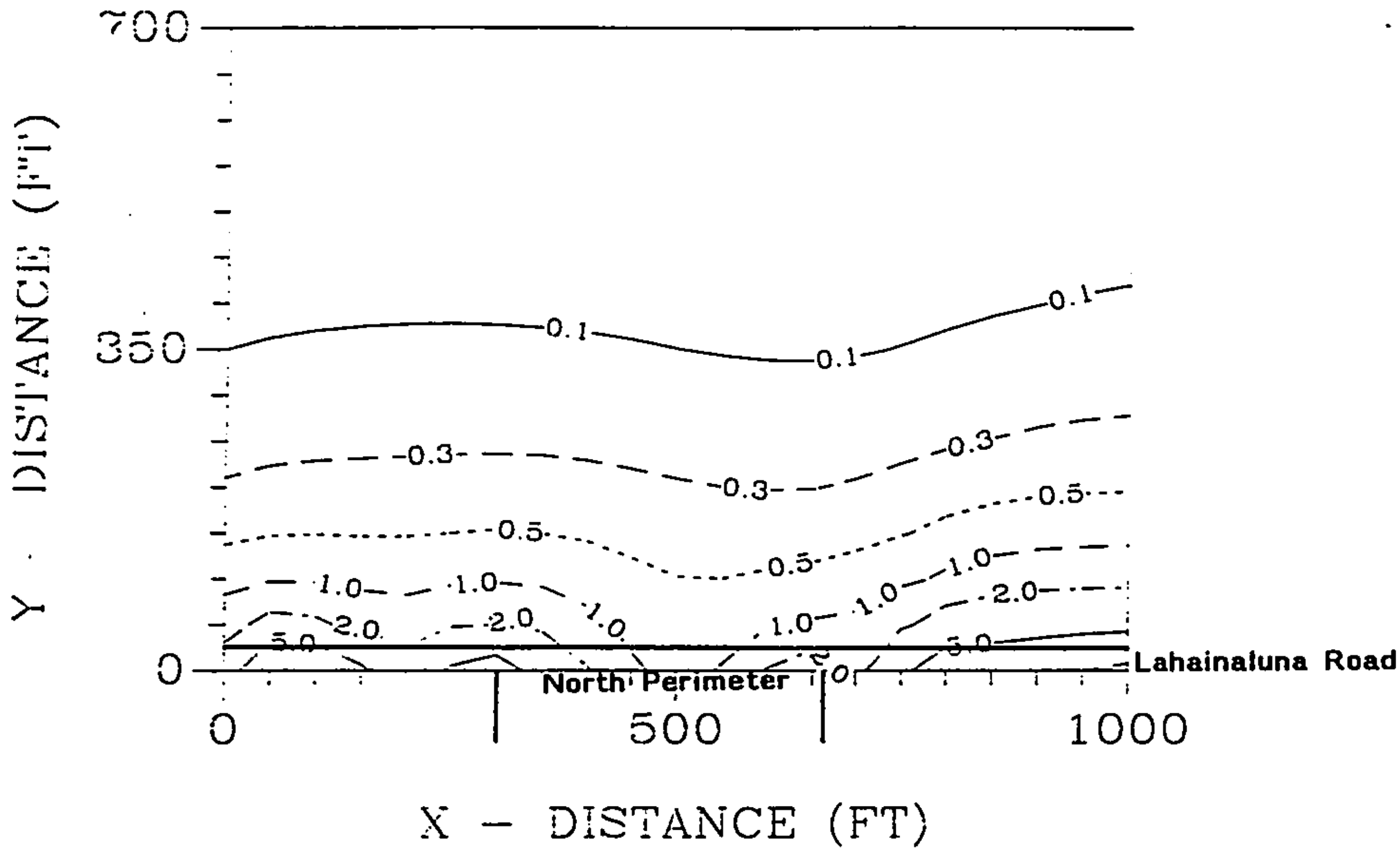


Figure 19. Detail of the Northern Perimeter Magnetic Field Contour Map for the Preferred Lahainaluna Switchyard Under Emergency Case #2 Loading Conditions

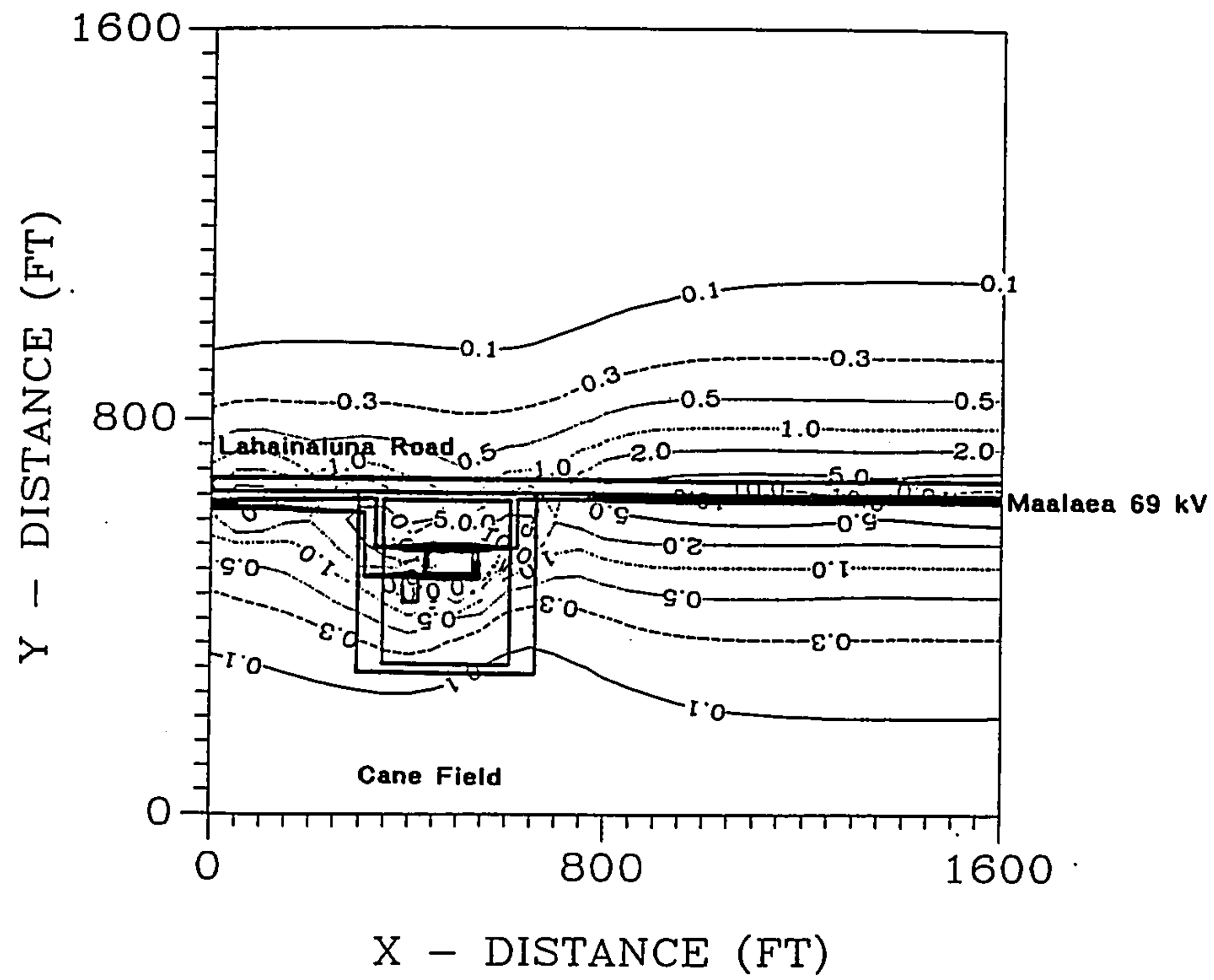


Figure 20. Magnetic Field Contour Map for Alternate Lahainaluna Switchyard Under Normal Loading Conditions

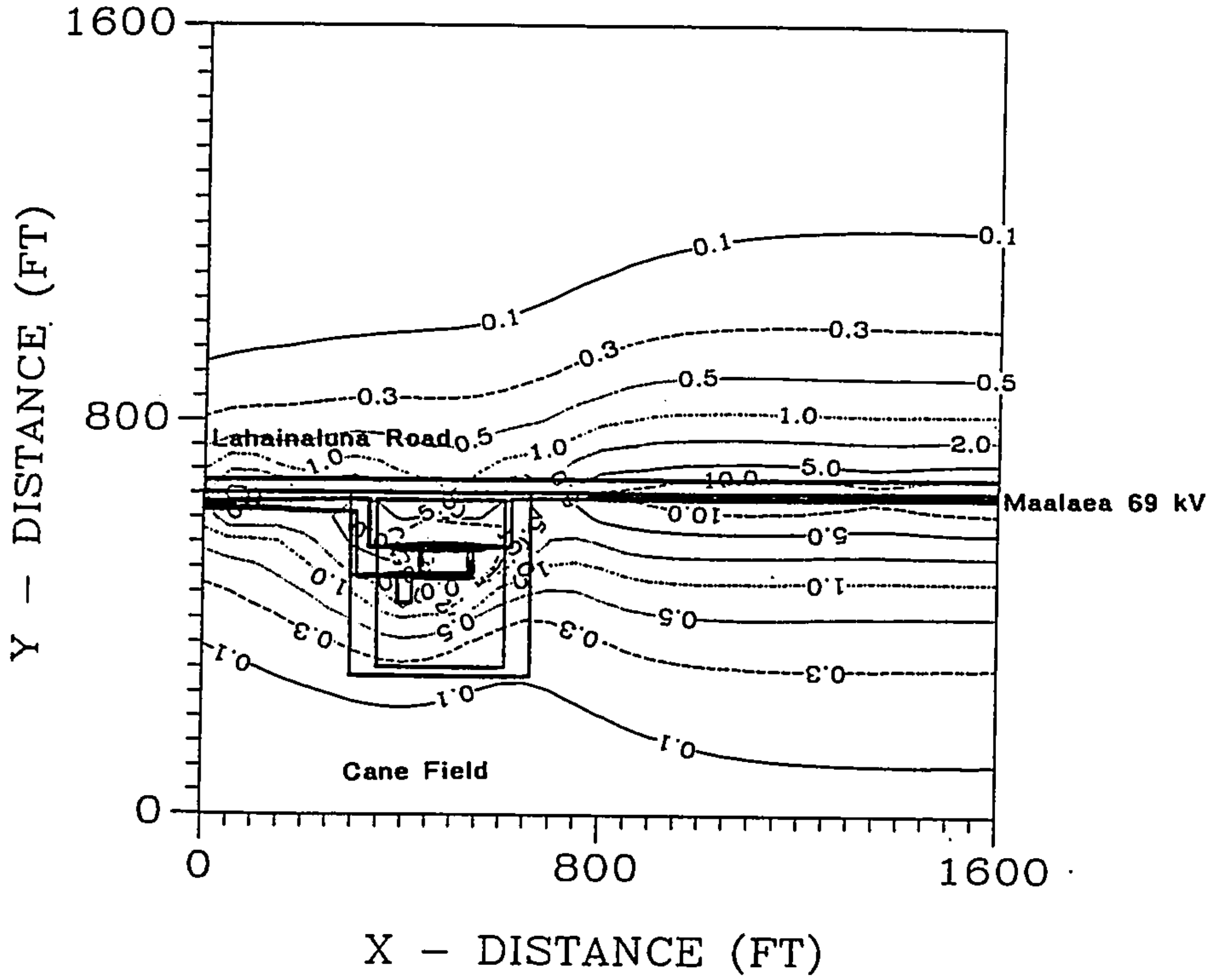


Figure 21. Magnetic Field Contour Map for Alternate Lahainaluna Switchyard Under Emergency Case #1 Loading Conditions

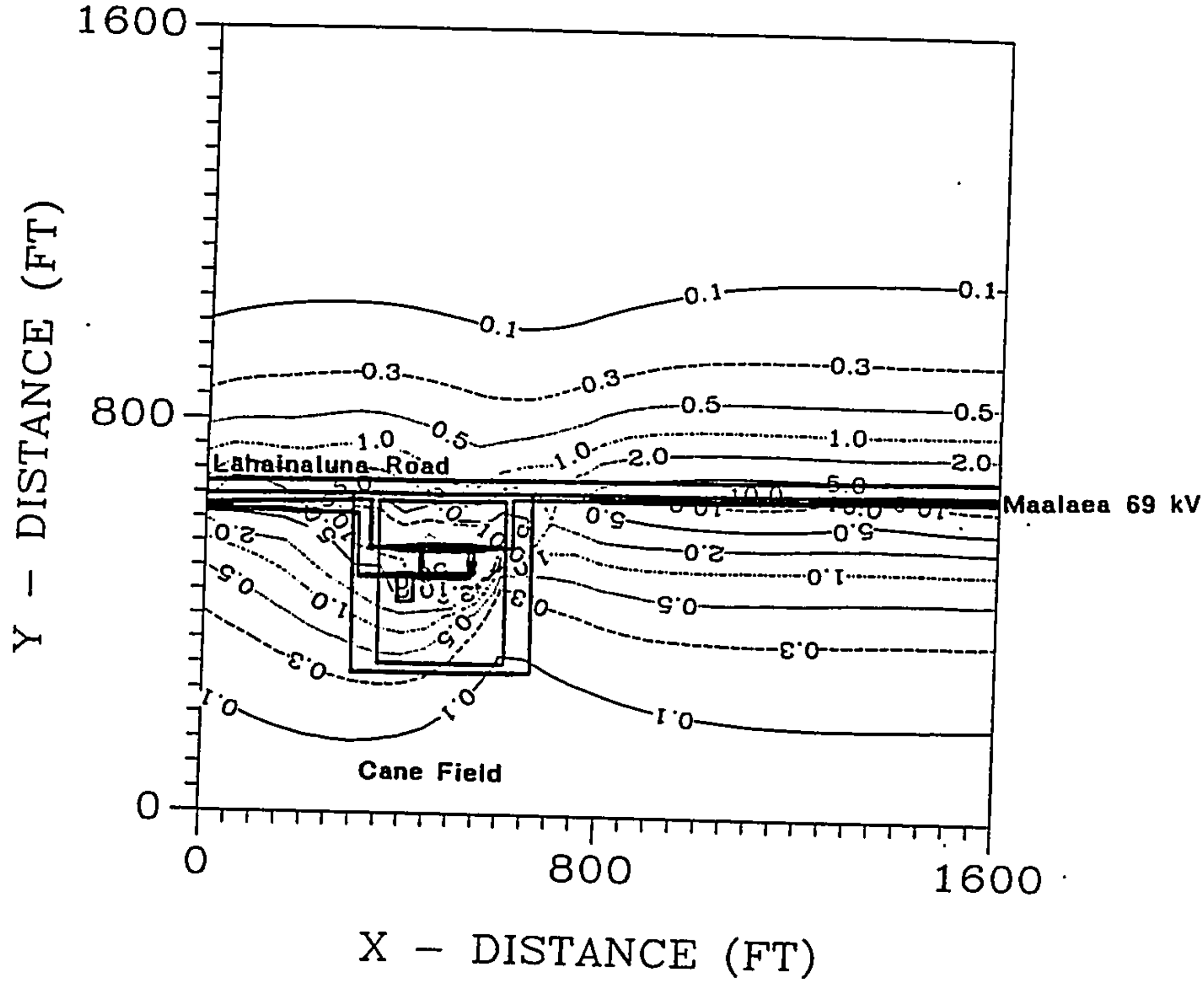


Figure 22. Magnetic Field Contour Map for Alternate Lahainaluna Switchyard Under Emergency Case #2 Loading Conditions

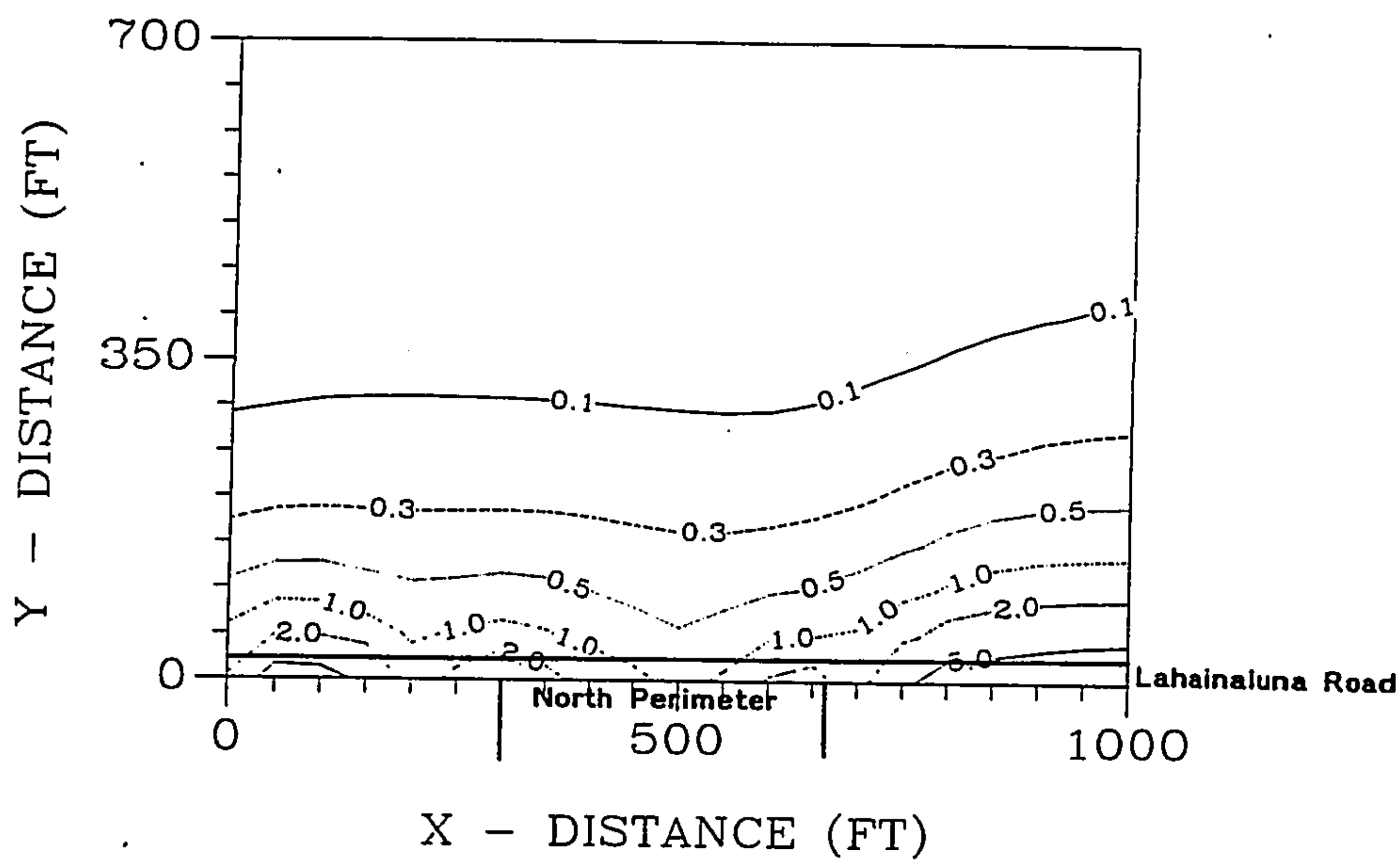


Figure 23. Detail of the Northern Perimeter Magnetic Field Contour Map for the Alternate Lahainaluna Switchyard Under Normal Loading Conditions

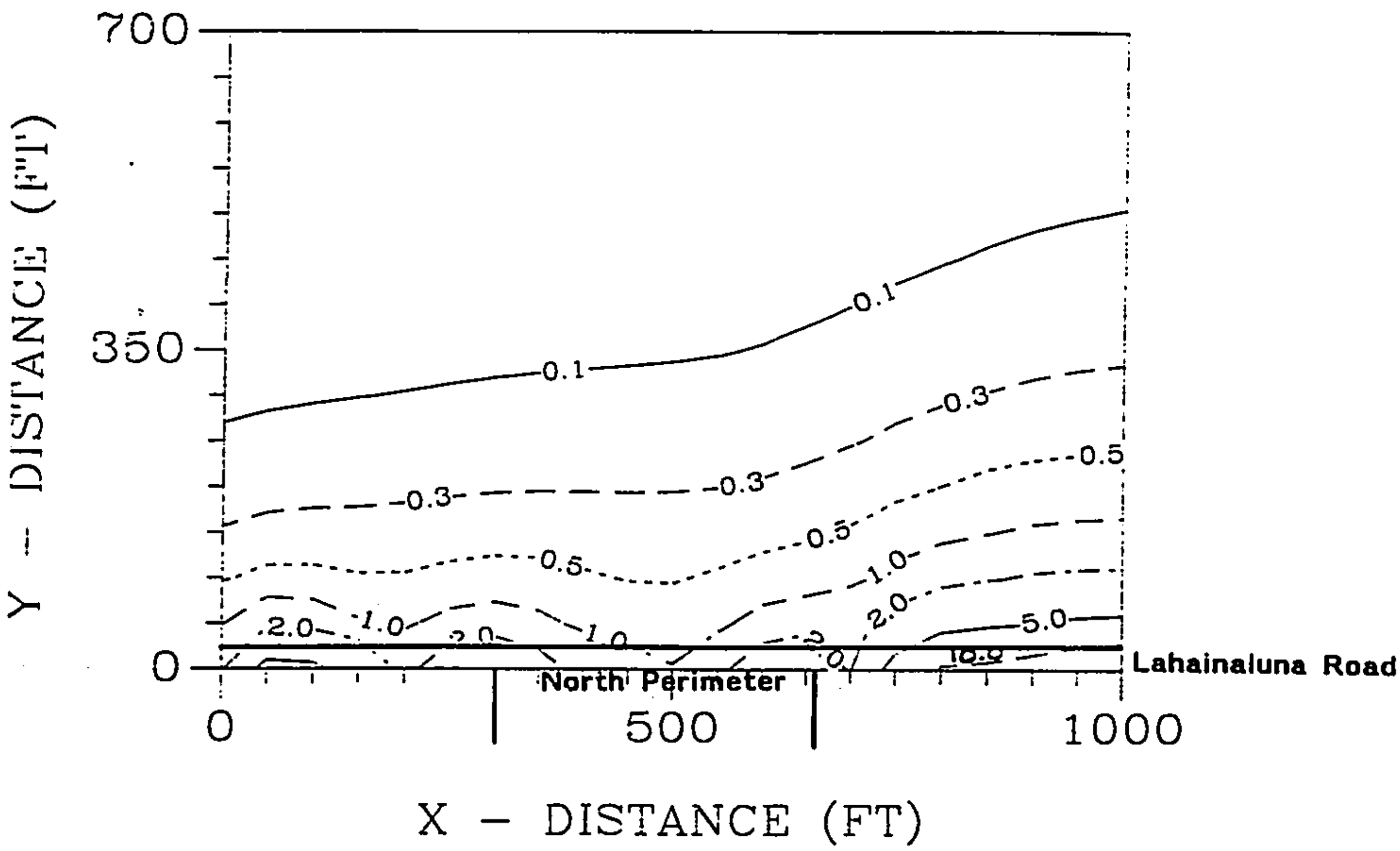


Figure 24. **Detail of the Northern Perimeter Magnetic Field Contour Map for the Alternate Lahainaluna Switchyard Under Emergency Case #1 Loading Conditions**

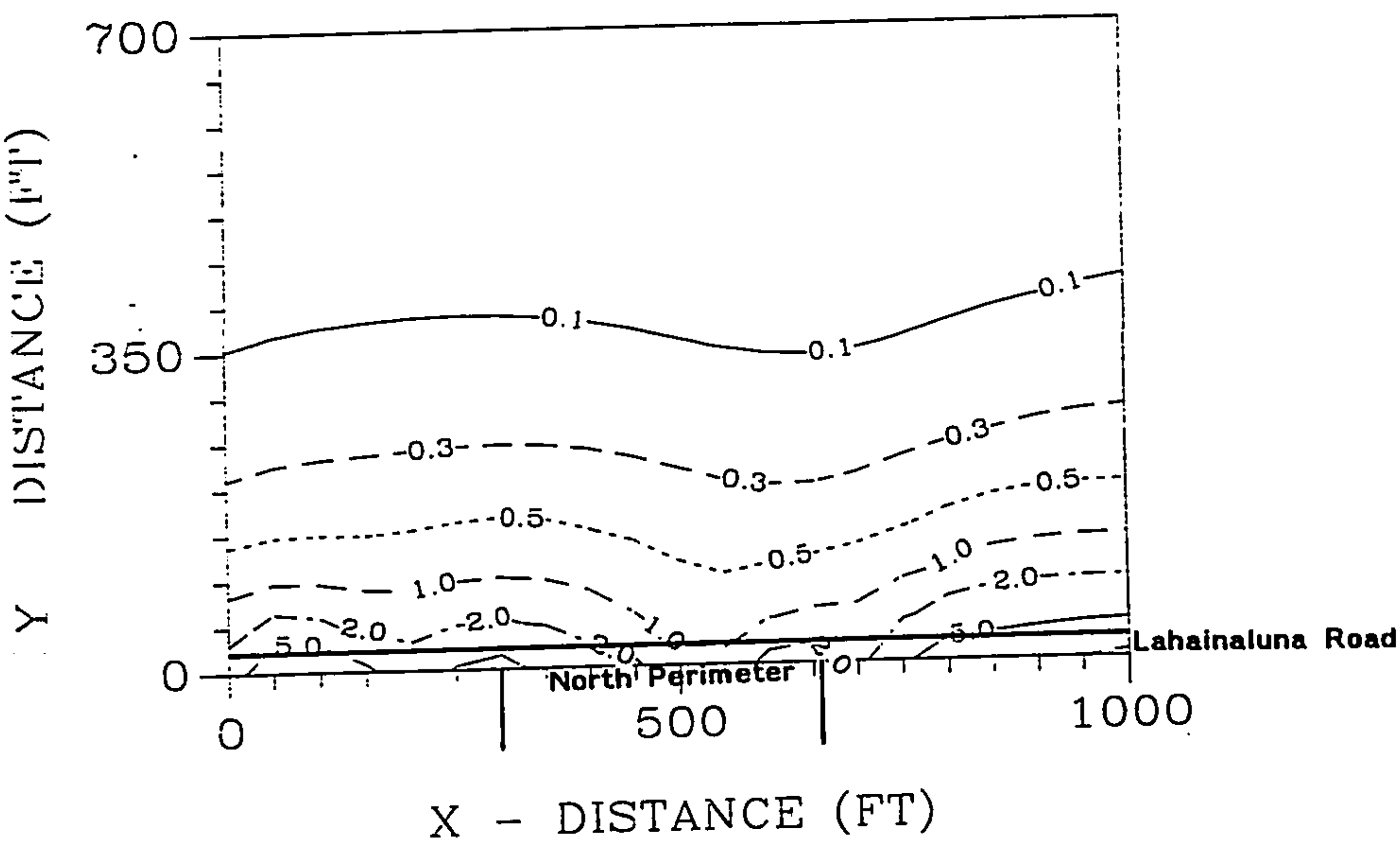


Figure 25. Detail of the Northern Perimeter Magnetic Field Contour Map
for the Alternate Lahainaluna Switchyard
Under Emergency Case #2 Loading Conditions

9. Health Effects of Electric and Magnetic Fields

Overview

A number of studies in the 1960's and early 1970's generally found no conclusive evidence of harmful effects from typical power line and substation electric fields. Some studies during this period did report the potential for harmful effects. These studies focused primarily on electric fields, rather than magnetic fields. However, more recent reports (since about 1979) have suggested a possible association between occupational and residential exposure to magnetic fields and adverse health effects, including cancer. The evidence for such an association is still inconclusive, and studies are underway to obtain more definitive information on this subject. Although most of the research has been prompted by concern about the effects of transmission lines, some of the recent research results are of interest in assessing potential health concerns for other electrical facilities, such as substations.

New York State Power Lines Project

One of the more comprehensive recent programs of research was made up of sixteen studies and two follow-up projects conducted during the period from 1985 through 1987. These studies, administered by the New York State Power Lines Project[14], were undertaken "to determine whether there are health hazards associated with electric and magnetic fields produced by 60 Hz power transmission lines (especially 765 kV lines)". The $5 million research effort was funded by electric utilities that serve the State of New York and supervised by a scientific advisory panel reporting to the New York State Health Department. In general, the field levels used in the laboratory studies were larger than typical fields because of the 765 kV lines.

The studies generally fall into the broad areas of epidemiology, laboratory animal, and cellular research. None of the studies showed significant adverse effects on reproduction, growth, or development due to the laboratory-created fields. The studies also showed no significant evidence of genetic or chromosomal damage that might lead to inherited effects or that might cause cancer. Two of the project's epidemiological studies, however, also examined the effects of lower voltage distribution lines. These two studies, of childhood cancer in Denver and adult cancer in Seattle, have generated much public interest and follow-up work.

The Denver Study

The Denver study evaluated the incidence of cancer among children living in homes near different kinds of electric power lines (mostly distribution lines and a few transmission lines). Measurements were taken inside the home with appliances turned off (low-power condition) and turned on (high-power condition). Distribution "wiring configuration codes" are based on external visual observations and were used as a surrogate for likely magnetic field exposures over time in the home due to external power lines. The wiring code is an index loosely based on the type, number and diameter of conductors, the distance from house to power line, and the number of nearby service drops. The wire code scheme was originally developed by Dr. Nancy Wertheimer and Mr. Ed Leeper in their seminal work on the relationship between electrical wiring configurations and cancer[15,16]. The Denver study by Dr. David Savitz was essentially a replication of the earlier work.

The New York Scientific Advisory Panel interpreted the Denver study to show an association between the household wiring codes and street addresses of the childhood cancer cases. The New York Panel reported that the study appeared to show an increase in the frequency of childhood cancer in Denver from about 1 in 10,000 children per year to about 1.7 in 10,000. However, the study results were puzzling in several respects. There appeared to be no correlation when high-power condition measurements were used (that is, with many electrical appliances turned on). No clear relationship between the level of exposure and the increased incidence of cancer could be discovered for the low-power conditions (appliances turned off) for which a correlation with childhood cancer was found. The New York Scientific Advisory Panel was also concerned about the study's low interview response rate and possible coincidental factors, such as traffic density, that could also affect the incidence of cancer. Nevertheless, this study was seen as a positive study (confirming the earlier work by Wertheimer and Leeper) and as a cause to conduct more research.

The Seattle Study

The other epidemiological cancer study funded by the New York State Power Lines Project was conducted in the Seattle area. The design of this study shared many features with the Denver study; for example, exposure to magnetic fields was assessed by field measurements and by the same wire coding system. In the Seattle study, the New York Scientific Panel found that "regardless of how exposure was characterized, no relationship with cancer incidence was disclosed"[14]. In other words, the results of this study were negative -- no association between cancer and magnetic field exposure (as estimated by the wire code system).

In evaluating the research results, the New York Scientific Advisory Panel cautioned that research has not found any biological mechanisms that could explain the role of magnetic fields in the development of cancer. The Panel also noted that methodological uncertainties exist in quantifying magnetic field exposure levels. The panel concluded that the findings to date could not and should not be translated into specific recommendations for regulating right-of-way widths, line heights, or the location of lines near homes.

The Los Angeles Study

A residential epidemiology study funded by EPRI in an attempt to replicate the Denver Study was completed in 1990 in Los Angeles, California. The results generally confirm the results of the Denver study (and the Wertheimer-Leeper work). There was an increased risk of cancer associated with certain wire codes, but not for direct field measurements.

Results of this study of childhood leukemia, conducted by Dr. John Peters in Los Angeles County, have been presented at conferences and were recently published[17,18]. This study was essentially a replication of the Denver study, but in a different location. The researchers concluded that: "our data offer no support for a relationship between measured electric field and leukemia risk, little support for the relationship between measured magnetic field exposure and leukemia risk, some support for a relationship between wiring configuration and leukemia risk, and considerable support for a relationship between children's electrical appliance use and leukemia risk". The reason why wiring configuration correlates with leukemia risk better than measured exposure are not clear.

It remains unresolved why an indirect magnetic field measure such as wire code is associated with a positive finding, while direct field measurements are not. This is even more perplexing since this Los Angeles study had the most sophisticated direct measurements of magnetic fields to date. Possible explanations for these apparently contradictory research findings are:

- Wire configuration coding is a better predictor of long-term average magnetic field exposure than 24-hour measurements.
- Wire code categories are a marker for some as-yet-unidentified biologically effective characteristics of the magnetic field (e.g., transient pulses or intermittent fields).

- Some wire configuration code categories are associated with some confounding factor or set of factors in the urban environment that are the true cause of the increased risk, but are unrelated to magnetic fields.

- Relatively subtle biases in subject selection (especially for the controls) have produced a spurious association between wire codes and leukemia risk in the Denver and Los Angeles studies.

Swedish Studies

Two new epidemiological studies were released in September, 1992 in Sweden. The first study, "Magnetic Fields and Cancer in People Residing Near Swedish High Voltage Power Lines" was a residential study of children and adults who live within 300 meters of 220 kV and 400 kV transmission lines in Sweden[19]. The authors are Dr. Maria Feychting and Dr. Anders Ahlbom. This residential study evaluated average magnetic field exposure via actual measurements and magnetic field calculations (for both contemporary and historical line loadings). The study also included an evaluation based on various distances from the power lines. The study found a statistical association between childhood leukemia and calculated historical fields (the main exposure metric was selected as the annual average of the calculated magnetic field generated by the power line). The study also found an association with distance from the power lines. No association was found with actual magnetic field measurements. For brain tumors and all childhood cancers together, there was little support for an association. The findings of an association with a surrogate, namely calculated historical magnetic fields, but not with actual field measurements, are consistent with earlier studies in Denver and Los Angeles. Similar results are achieved in this study by using distance from the power line. In this respect, this study is another "wire code" study since a distance criteria is used as the surrogate for magnetic field exposure.

The second study, "Occupational Exposure to Electromagnetic Fields in Relation to Leukemia and Brain Tumors: A Case-Control Study" is an occupational study of adult males[20]. The authors are Dr. Birgitta Floderus, Dr. Tomas Persson, et.al. Based on the job held longest during the 10-year period before diagnosis, a statistical association between a certain subtype of leukemia and estimated magnetic field exposure was observed. (No association was found with the leukemia subtype most often discussed in other occupational EMF studies). The exposure assessment details were not sufficiently reported to allow a complete evaluation, but in general, some contemporary magnetic field exposure measurements were used as a surrogate to estimate historical exposure for selected job categories. In the occupational study, the exposure metrics included the mean field exposure value, median, standard deviation and time above 0.2 μT (2 mG) for exposure categories that included quartiles of exposure intensity and the 90th percentile.

Both studies reported that they have essentially confirmed earlier residential and occupational study findings, with some exceptions (e.g., in the residential study there were no positive findings for brain tumors). The most interesting features of these new studies is the exposure assessment, which includes contemporary measurements and historical field calculations for the residential study; and job category personal exposure measurements for the occupational study. An important issue for both studies is that if the exposure surrogates prove to be accurate in estimating historical exposure then this may suggest that future exposure assessment attention is directed to average magnetic field values. In any event, these studies add to our overall scientific knowledge, would seem to confirm portions of earlier work, and will direct future research to understand what aspect of wire codes and other surrogates are related to health risks.

EPA Preliminary Draft Report

(This report has been under review by the EPA Science Advisory Board. It will be rewritten and submitted for further scientific review before it is published again.)

The U.S. Environmental Protection Agency prepared a preliminary draft report in 1990 on electric and magnetic fields that was based on a review of the scientific literature[21]. The preliminary draft report evaluated the likelihood that electric and magnetic fields pose a risk for the development of cancer in humans. In this preliminary draft report, the EPA concluded that "with our current understanding, we can identify 60 Hz magnetic fields from power lines and perhaps other sources in the home as a possible, but not proven, cause of cancer in people." One problem cited by EPA is a poor understanding of the basic nature of the interaction between magnetic fields and biological processes. The EPA preliminary draft report states, "For example, a real possibility exists that exposure to higher field strengths is actually less hazardous than exposure to low field strengths. Because of this uncertainty, it is inappropriate to make generalizations about the carcinogenicity of EM fields".

More recently, the EPA has reviewed the research needs for electric and magnetic fields and published a report which identifies the major research topics and their relative priorities[22]. Exposure assessment research and research into possible biophysical mechanisms were listed as two "high-priority" areas of future study. Definitive exposure data will be required to judge the validity of the suggested causal link between magnetic field exposure and cancer. A better understanding of possible biophysical mechanisms is needed to quantify which, if any, aspect of magnetic field exposure might be related to adverse health outcomes.

EPA Science Advisory Board

On January 29, 1992, the Nonionizing Electric and Magnetic Fields Subcommittee of the Science Advisory Board's Radiation Advisory Committee submitted to the EPA Administrator its report on the EPA's draft report on electric and magnetic fields. In its report, the Science Advisory Board (SAB) Subcommittee concluded that "... there is insufficient information to designate specific values of magnetic-field strength that may be hazardous to human health." The SAB Subcommittee made two specific policy recommendations:

Policy Recommendation No. 1. The Subcommittee is unanimous in its belief that the question of electric and magnetic field effects on biological systems is important and exceptionally challenging, and that the Subcommittee's advice to the EPA should be that the report be rewritten by the EPA and then reviewed by the Science Advisory Board.

Policy Recommendation No. 2. The EPA should complete its efforts with regard to radio frequency (RF) electromagnetic fields (including microwaves) and issue exposure guidelines independent of present issues pertaining to lower frequencies. The current EPA report inadvertently leads even the careful reader to conclude that the potential carcinogenicity of electric and magnetic fields of extremely low-frequency (ELF) (i.e., power line) frequencies is the only -- or at least the principal -- subject of concern with regard to nonionizing fields. Such a conclusion would reinforce the skewed and somewhat sensationalized picture presented to the public in recent years by the news media and government agencies responding to this publicity. The report should therefore declare explicitly that the attention given to nonionizing electric and magnetic fields derives, in the first place, from longstanding concern over the hazards of RF (including microwave) radiation. The EPA has expended substantial resources on the study of such radiation over a period dating back to the EPA's inception and the EPA should complete its efforts directed toward the issuance of RF exposure guidelines. RF fields present long-known and well-understood hazards such as temperature elevation in tissue and heat stress resulting from acute exposures against which users and the general public must be warned and protected. Any published exposure guideline should specifically identify the hazards from RF exposure.

Office of Technology Assessment - Background Paper

A fairly comprehensive background paper on the biological effects of electric and magnetic fields[23] was recently prepared for the U.S. Congress' Office of Technology Assessment (OTA). This extensive paper discusses the present state-of-knowledge on the health effects of extremely low-frequency (60 Hz) electric and magnetic fields. A small brochure[24] was also prepared that more concisely summarizes the OTA report and various policy options.

The OTA report provides a good overview of the sources and nature of electric and magnetic field exposure. It points out that we do not yet know what field attribute, or combination of attributes, if any, could produce public health effects. This means that the simple assumption that "more is worse" may not be true. Because of this, simple field strength standards "can not be adequately supported by the science that is now available".

The OTA report also provides a summary of the basic areas for research: cellular experiments, whole animal experiments, exposure assessment, and epidemiological studies. Using the review of the scientific literature, the report states that:

> As recently as a few years ago, scientists were making categorical statements that on the basis of all available evidence there are no health risks from human exposure to power-frequency fields. In our view, the emerging evidence no longer allows one to categorically assert that there are no risks. But it does not provide a basis for asserting that there is a significant risk.
>
> If exposure to fields does turn out to pose a health risk, it is unlikely that high voltage transmission lines will be the only sources of concern. Power-frequency fields are also produced by distribution lines, wall wiring, appliances, and lighting fixtures. These non-transmission sources are much more common than transmission lines and could play a far greater role than transmission lines in any public health problems.

The OTA report and brochure also consider the public policy question of what should be done, given our present knowledge. Three basic approaches are suggested[24]:

- **Do nothing.** Conclude that there is not yet enough evidence to warrant any action.

- **Prudent avoidance.** Adopt strategies that can limit field exposures with small investments of money and effort. Don't do anything drastic or expensive until research provides a clearer picture of whether there is any risk at all.

- **Aggressive regulation.** Conclude that there is a problem and spend some serious time and money on an aggressive program to limit field exposure, while recognizing that we may eventually learn that some or all of this effort and money has been wasted. This would be either because it wasn't needed or we spent it the wrong way because we did not understand the science well enough to spend it effectively.

Continuing Research

One might ask why scientists continue research if the findings so far indicate that there are no certain health hazards?

Almost all researchers are careful to point out that it is very difficult to identify health hazards that may be subtle to detect or evident only after long periods of time. The converse is also true: no experiment, no matter how well designed, can prove no health hazards at all from any source studied. The studies that do suggest a health effect are usually repeated to verify the results. Because any one study can be fallible, a study needs to be replicated before any conclusions can be reached about health hazards.

Because of the difficulty of reaching any meaningful conclusions about health hazards from the current studies, most researchers (including the New York Scientific Advisory Panel and EPA) recommend carrying out additional research. Several areas, in particular, merit further research.

- So far, research has not been able to discover the biological mechanism by which electric or magnetic fields might cause adverse health effects. Additional basic laboratory research is needed to determine if physiological changes result from exposure to electric or magnetic fields, and how such changes might affect health.

- Another exposure assessment subject deserving further research is the effect of the fields typically experienced in homes--fields due to televisions, electric blankets, hair dryers, other appliances, and electric wiring in house walls. As noted earlier in this paper, although field strengths near some of the larger transmission lines may be larger than field strengths at home, people can experience significant exposure to magnetic fields at home. The Denver and Los Angeles studies found evidence of an association between the incidence of childhood cancer and the configuration of electric power line wiring (mostly distribution lines) outside the home. Further study will help clarify the relative risk (if any) due to fields at home and near transmission or distribution lines.

10. Electric and Magnetic Field Standards

Currently there are no electric and magnetic field standards for transmission line or substation facilities. However, there are guidelines and standards regarding field levels from overhead power lines (which could originate or terminate at a substation facility). General transmission line safety standards are imposed by the State of Hawaii Public Utilities Commission General Order No. 6 (Rules for Overhead Electric Line Construction) and the National Electrical Safety Code (NESC). These documents are presently not written to address concerns about the potential for health effects of electric and magnetic fields, nor address fields generated by switching station/substation facilities.

The Hawaii State Department of Health issued on April 3, 1991, a policy relating to electromagnetic fields from electric power lines. The policy states:

> A prudent approach is needed at this time to regulate electric and magnetic fields around low-frequency electric power facilities, including high-voltage transmission lines. The existing research data are inconclusive and not sufficient enough for adequate, accurate risk assessment. However, the data suggest that a "prudent avoidance" approach to siting new facilities is

appropriate. Where technically feasible and practical, public exposures should be minimized. Too little is presently known to be able to determine where or what rules would provide useful public-health protection.

Implementing actions:

(a) All newly-installed power lines should be constructed with engineering controls to reduce exposure (for example, the "delta" configuration).

(b) The Department of Health will continue to collect and evaluate research data on electromagnetic fields in order to be aware of significant findings with public-health implications.

There are no national or federal government standards in the United States for electric or magnetic field exposure. A few states have some type of electric field guideline and two states have a magnetic field standard. These standards were compiled[23,24] and are summarized in Table 10. The purpose of most of the standards is to make the field levels from new power lines similar to the field levels from existing lines or to avoid nuisance effects from the electric fields of the larger transmission lines.

The International Non-Ionizing Radiation Committee of the International Radiation Protection Association (IRPA) has published "Interim Guidelines on Limits of Exposure to 50/60-Hz Electric and Magnetic Fields" in the January 1990 issue of *Health Physics*. The guidelines were approved by the council on May 3, 1989; those guidelines relating to the general public are summarized below:

IRPA General Public Exposure Characteristics	Electric Field Strength (kV/m)	Magnetic Flux Density (mG)
Up to 24 hours/day	5	1,000
Few hours/day	10	10,000

Table 10 State Regulations that Limit Field Strengths on Transmission Line Rights-of-Way[23,24]	
State	Field Limit
Montana	1 kV/m at edge of ROW in residential areas
Minnesota	8 kV/m maximum in ROW
New Jersey	3 kV/m at edge of ROW
New York	1.6 kV/m at edge of ROW; 200 mG at edge of ROW
North Dakota	9 kV/m maximum in ROW
Oregon	9 kV/m maximum in ROW
Florida	10 kV/m maximum for 500 kV lines in ROW; 2 kV/m maximum for 500 kV lines at edge of ROW; 8 kV/m maximum for 230 kV and smaller lines in ROW; 3 kV/m maximum for 230 kV and smaller lines at edge of ROW; 200 mG for 500 kV lines at edge of ROW; 250 mG for double circuit 500 kV lines at edge of ROW; and 150 mG for 230 kV and smaller lines at edge of ROW

11. Conclusions

Research to date has not demonstrated conclusive evidence of health hazards due to electric and magnetic fields from switching stations, substations, substation equipment, and associated electrical power lines. Nevertheless, the proposed Lahainaluna switching station designs, the proposed Maalaea - Lahaina Third 69 kV single circuit transmission line, and the proposed Lahaina and Puukolii 69 kV double circuit transmission line are all designed to minimize public exposure to electric and magnetic fields. In the absence of more concrete scientific information and state and/or federal guidelines, the proposed designs will take modest and prudent steps to minimize exposure that are consistent with the approach suggested by the Office of Technology Assessment of the U.S. Congress. Electric and magnetic field levels outside of the proposed Lahainaluna switching station should be within the range of electric and magnetic fields present at other existing switching station/substation facilities. For the associated 69 kV transmission lines, the proposed phasing arrangements and configurations are designed to minimize electric and magnetic field impacts, and should be within the range or less than electric and magnetic fields produced by other similar voltage transmission lines (several different configurations and phasing arrangements were studied to determine the lowest magnetic field levels - as opposed to using other horizontal or vertical configurations which could produce higher magnetic field levels).

12. References

1) Electrical Supply and Demand For 1991-2000, North American Electric Reliability Council, New Jersey, July, 1991.

2) Tenth Biennial Survey of Power Equipment Requirements of the U.S. Electric Utility Industry 1985-1994, NEMA, March, 1986.

3) "The Measurement of Carpet Static", K. Chakravarti and G. J. Pontrelli, Textile Research Journal, February 1976.

4) The Lightning Book, Peter E. Veimeister, MIT Press, 1972.

5) The Earth's Electrical Environment, National Research Council, National Academy Press, Washington, D.C., 1986.

6) CRC Handbook of Chemistry and Physics - Atmospheric Electricity, CRC Press, 1981.

7) Carstensen, E.L. Biological Effects of Transmission Line Fields. New York: Elsevier Press. 1985.

8) "AC Field Exposure Study: Human Exposure to 60 Hz Electric Fields", EPRI Report EA-3993, Enertech Consultants, 1985.

9) The Earth's Magnetic Field, International Geophysics Series -Vol. 32, R.T. Merrill and M.W. McElhinny, Academic Press, New York, 1983.

10) Gauger, J.R. "Household Appliance Magnetic Field Survey", IEEE Transactions on Power Apparatus and Systems. Vol. PAS-104, No. 9:2436-44. 1985.

11) Silva, J.M., Hummon, N.P., Rutter, D.A., Hooper, H.C., "Power Frequency Magnetic Fields in the Home", IEEE Transactions on Power Delivery, Vol. PWRD-4, No. 1, pp.465-478, January, 1989.

12) "Transmission Cable Magnetic Field Management", EPRI Report TR-102003, Power Technologies, Inc., June 1993.

13) "IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines", IEEE/ANSI Standard #644-1987, 1987.

14) New York State Power Lines Project. Biological Effects of Power Line Fields: Scientific Advisory Panel Final Report. 1987.

15) Wertheimer N, Leeper E (1979) : Electrical wiring configurations and childhood cancer, American Journal of Epidemiology. Vol. 109, pages 273-284.

16) Wertheimer N, Leeper E (1982) : Adult cancer related to electrical wires near the home, International Journal of Epidemiology. Vol. 11, pages 345-355.

17) "USC Statement on Data Release on Childhood Leukemia in Los Angeles County", University of Southern California - Department of Preventive Medicine, Los Angeles, 1991. and "EPRI Commentary of Initial Results from the USC Study of Childhood Leukemia and Exposure to Electric and Magnetic Fields", Electric Power Research Institute, Palo Alto, CA, February, 1991.

18) "Exposure to Residential Electric and Magnetic Fields and Risk of Childhood Leukemia", S.J. London, et al., American Journal of Epidemiology, vol. 134, No. 9, Nov. 1, 1991, pp. 923-937.

19) "Magnetic Fields and Cancer in People Residing Near Swedish High Voltage Power Lines", Dr. Maria Feychting, Dr. Anders Ahlbom, Published Research Report, Stockholm, Sweden, September, 1992.

20) "Occupational Exposure to Electromagnetic Fields in Relation to Leukemia and Brain Tumors: A Case-Control Study", Dr. Birgitta Floderus, et.al., Published Research Report, Solna, Sweden, September, 1992.

21) "Evaluation of the Potential Carcinogenicity of Electromagnetic Fields", United States Environmental Protection Agency, EPA/600/6-90/005A, Washington, DC, June, 1990.

22) "A Research Strategy for Electric and Magnetic Fields: Research Needs and Priorities", United States Environmental Protection Agency, EPA/600/9-91/016A, Washington, DC, June 1991.

23) "Biological Effects of Power Frequency Electric and Magnetic Fields - Background Paper", Office of Technology Assessment, U.S. Congress, prepared by Carnegie Mellon University, Washington, D.C., 1989.

24) "Electric and Magnetic Fields from 60 Hertz Electric Power: What Do We Know About Possible Health Risks?", Carnegie Mellon University, Pittsburgh, PA, 1989.

APPENDIX I
VIEWSHED ANALYSIS

APPENDIX I

LAHAINA PALI TRAIL
VIEWSHED ANALYSIS

PREPARED BY
DAMES & MOORE
September 1992

INTRODUCTION AND PURPOSE

The Old Lahaina Pali Trail is a cultural and recreational resource to be considered in the siting of the proposed Maalaea-Lahaina Third 69 KV Transmission Line Project.

Na Ala Hele (Hawaii Trail and Access System) is a statewide trails program administered by the Division of Forestry and Wildlife, Department of Land and Natural Resources. Na Ala Hele is planning the restoration of the Old Lahaina Pali Trail located in the West Maui Mountains as a "demonstration" trails project.

The transmission line routing studies for the Maalaea-Lahaina Third 69 KV Transmission Line Project have identified a number of alternative corridors through the West Maui Mountains. The Maui Advisory Council of Na Ala Hele has expressed concerns regarding the potential visibility of the new line especially the wood poles if the line were to be located within corridors above or below the trail.

Dames & Moore has conducted a computerized viewshed study to provide a preliminary assessment of corridor visibility from the trail. The purpose of the viewshed/visibility study is to: 1) provide for a factual rather than speculative basis for evaluating issues and concerns of transmission line visibility from the trail, 2) aid in discussions with DLNR and Na Ala Hele and 3) assist in the selection of a preferred corridor for detail study to locate a suitable alignment for the transmission line.

METHODOLOGY

A viewshed map was prepared to show those areas in which poles would be visible from viewpoints on the Lahaina Pali Trail.

A series of 29 viewpoints were chosen along the trail to represent areas with the greatest potential visibility. Spacing of viewpoints ranges from approximately 330 ft. on the west end of the trail, to almost 1,300 ft. on the east end. The closer spacing of view points was used for the west end of the trail because of the greater diversity of terrain, and closer proximity to corridors.

The Dames & Moore GIMS geographic information computer system was used to produce the viewshed map. A digital terrain model for the study area was generated from USGS 1:24000 scale digital mapping. From each trail viewpoint the computer "looked" at the whole study area to calculate if a pole 49 ft. (15m) or higher would be visible from that viewpoint. The first viewshed modelling exercise involved making a "yes" or "no" visibility determination from each viewpoint. The data from all viewpoints was then combined to produce the final composite viewshed map. The attached composite visibility map illustrates the results of the computer analysis. For example, areas with a visibility category of 3-4 shows that only 3 to 4 of the 29 viewpoints (10 percent) can see a pole located at any given point within the 3-4 visibility range. This represents a low visibility value. In areas shown as <u>not visible</u> it would be possible to have poles that would not be visible from any of the 29 viewpoints.

The 49 ft. (15m) pole represents the approximate height of the cross member and insulators on the proposed "H-frame" structures. Thus, if a pole is shown on the map as visible, it means that the top of the pole cross-member, and insulators would be visible. A viewer height of 5 ft. (1.5m) was used to represent eye level of a person standing on the trail.

Please note that while the viewshed map is a useful tool for determining whether or not poles can be seen from selected viewpoints, it does <u>not</u> communicate what the potential visual effect or project appearance will be from these selected viewpoints. Other appropriate techniques for this purpose are identified in the Options for Further Analysis section.

<u>ANALYSIS AND CONCLUSIONS</u>

The viewshed map of the Lahaina Pali Trail shows relative visibility of a pole 49 ft. (15m) or greater from the trail viewpoints. It also shows which areas are most and least visible from selected viewpoints on the trail. For the 29 representative viewpoints, visibility values range from 0 to 14. Thus, those areas of greatest visibility are only visible from 14 viewpoints or less than 50 percent of the total viewpoints.

A pole 49 ft. or greater located in areas shown as "not visible" would not be seen by viewers from any of the representative trail viewpoints. A pole located closer to the trail (foreground) would have a greater potential visual impact than a pole located further away with a very distant view (middleground). To compare the various corridors with respect to visibility from the trail the viewing distance was divided into two categories: less than 0.5 miles (foreground) and greater than 0.5 miles (middleground).

The attached visibility table summarizes the results of the viewpoint/visibility analysis applied to the alternative corridors. To further refine the results, the trail was divided into three sections: East, Central, and West. Visibility is divided into four classes: None, Low (seen from 1-4 viewpoints), Moderate (5-6 viewpoints), and High (7 or more viewpoints). In general, the potential visual impact of high visibility at foreground distance (less than 0.5 miles) is greater than high visibility at middleground distances (greater than 0.5 miles). To summarize, an additional category of "Overall Visibility" is included which combines the visibility frequency and viewing distance.

OPTIONS FOR FURTHER ANALYSIS

1) CAD perspective plots illustrating a proposed powerline from representative viewpoints on the trail would be useful to conceptually show what a trail user might see. Plots from a range of viewpoints would show how visual impacts would vary with distance, terrain, scale of towers, and skyline visibility.

2) Overlays of CAD perspective plots onto photographs would more accurately represent the potential visibility of a proposed powerline. This technique is a more refined version of the basic CAD perspective plot.

(11:124a)

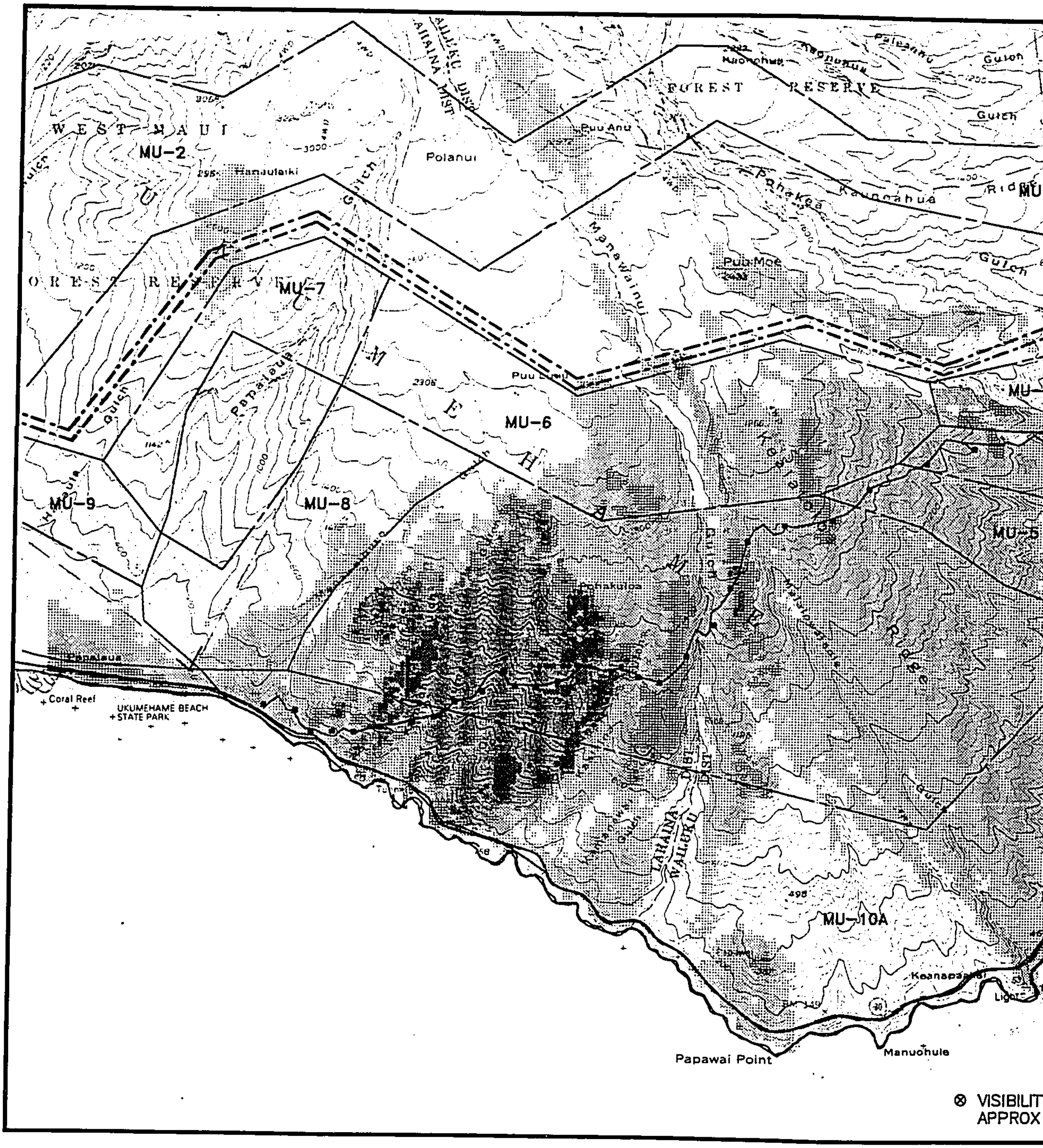
Visibility of Powerline Corridors
From Lahaina Pali Trail

Corridor	Trail Segment	Distance	Visibility	Overall Visibility
MU-1	E C W	M M M	Low None None	Low None None
MU-2	E C W	M M M	None None-Low None	None None None
MU-3	E C W	F-M M M	None Low None	None Low None
MU-4	E C W	F M M	None-Low None None	None-Moderate None None
MU-5	E C W	F M M	Low-Moderate None None	Moderate-High None None
MU-6	E C W	F-M F-M M	Moderate Low-Moderate None	High Moderate-High None
MU-7	E C W	M M M	None None None	None None None
MU-8	E C W	M M F-M	None None None-Low	None None None-Moderate
MU-10A	E C W	M M F-M	Low-Moderate None-Low None-High	Low-Moderate Low High

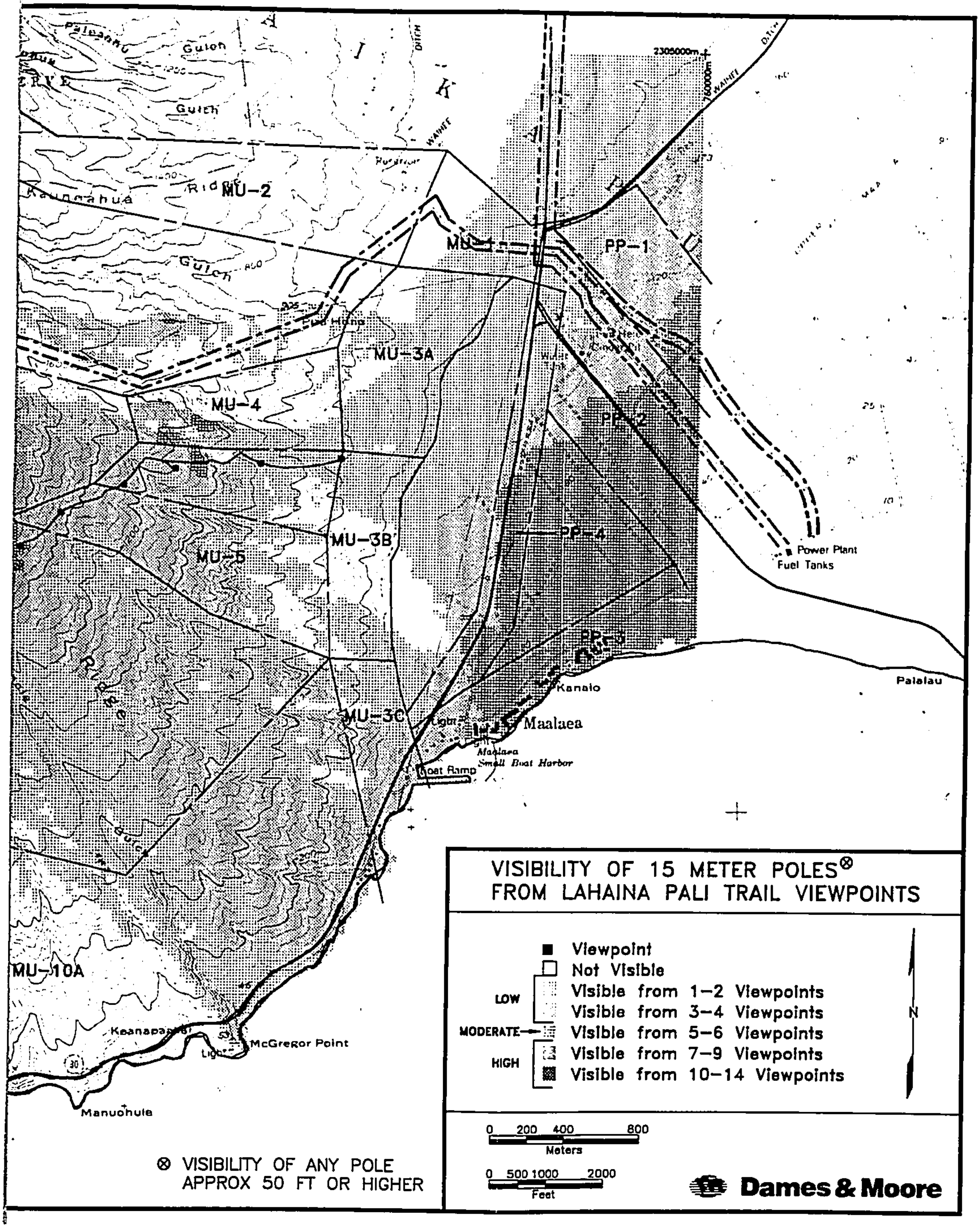
(11:124a)

CENTRAL CORRIDOR	DISTANCE WITHIN VISIBILITY CATEGORY (feet) (Distance from Trail in feet)				
CORRIDOR/ALIGNMENT	TOTAL DISTANCE	NOT VISIBLE	LOW	MODERATE	HIGH
START – HP HWY	0				
MU–1	1,750		1,750		
MU–3A	2,250	1,600	650		
MU–4	3,700	2,900	800 (1000–1500)		
MU–6	10,250	6,000	4,250 (750–3000)		
MU–8	4,250	4,250			
FEET	22,200	14,750	7,450	0	0
MILES	4.20	2.79	1.41	0.00	0.00

MAKAI CORRIDOR	DISTANCE WITHIN VISIBILITY CATEGORY (feet) (Distance from Trail in feet)				
CORRIDOR/ALIGNMENT	TOTAL DISTANCE	NOT VISIBLE	LOW	MODERATE	HIGH
START – HP HWY	0				
MU–3C	1,500		1,500 (5200)		
MU–10A	18,600	8,450	7,700 (6250 –7600)	500	1,950 (0–2300)
MU–8	1,250	700	550		
FEET	21,350	9,150	9,750	500	1,950
MILES	4.04	1.73	1.85	0.09	0.37



WEST MAUI
FOREST RESERVE
MU-2
MU-5
MU-6
MU-7
MU-8
MU-9
MU-10A
Polanui
Puu Anu
Hanaulaiki
Puu Moe
Manawainui
Papalaua
Pahakea
Kaunoahua
Gulch
Ridge
Coral Reef
UKUMEHAME BEACH STATE PARK
LAHAINA DIST
WAILUKU DIST
Papawai Point
Manuohule
Keanapapa
Light
⊗ VISIBILIT
APPROX



VISIBILITY OF 15 METER POLES⊗
FROM LAHAINA PALI TRAIL VIEWPOINTS
Viewpoint
Not Visible
LOW
Visible from 1–2 Viewpoints
Visible from 3–4 Viewpoints
MODERATE
Visible from 5–6 Viewpoints
HIGH
Visible from 7–9 Viewpoints
Visible from 10–14 Viewpoints
N
0 200 400 800
Meters
0 500 1000 2000
Feet
Dames & Moore
⊗ VISIBILITY OF ANY POLE
APPROX 50 FT OR HIGHER
MU-2
MU-1
MU-3A
MU-4
MU-3B
MU-5
MU-3C
MU-10A
PP-1
PP-2
PP-4
PP-3
Power Plant
Fuel Tanks
Palalau
Kanaio
Maalaea
Maalaea Small Boat Harbor
Boat Ramp
McGregor Point
Manuohule
Gulch
Ridge
2305000m.