Final Environmental Impact Statement Auwahi Wind Farm ‘Ulupalakua Ranch Maui, Hawai‘i

Volume II: Appendix Part 1 of 2
Appendices A through E

Prepared for
Maui Planning Commission

Prepared by
Tetra Tech EC, Inc.

On behalf of Auwahi Wind Energy LLC

August 2011

Appendix A
Fire Management Plan

Auwahi Wind Farm Project
Fire Management Plan

Prepared by:

Center for Environmental Management of Military Lands
Colorado State University

on behalf of:

Auwahi Wind Energy LLC

February, 2011

Executive Summary

Auwahi Wind Energy, LLC (Auwahi Wind Energy) has proposed constructing and operating a wind farm, generator tie-line, an interconnection substation and associated infrastructure on lands owned by Ulupalakua Ranch on the Island of Maui. Adding wind turbines, electrical and other infrastructure, and additional human presence all potentially increase the fire risk. Implementation of this Fire Management Plan (FMP) is intended to mitigate this fire threat.

The FMP analyzes available pertinent information including fuel conditions, weather and climate conditions, fire history of Maui, terrain, firefighter access, and other factors. Through a program of engineering, maintenance, and fuels management, the fire risk posed by the Auwahi Wind Farm and the associated infrastructure can be mitigated to acceptable levels. Mitigation measures include education of Auwahi Wind Farm employees of the fire risk, standard regular maintenance of all wind turbine and electrical components, fuels reduction in high priority areas via grazing, construction of firebreaks in high priority areas, and construction of a water source for aerial resources and ground based firefighters near high priority areas. The FMP also establishes the responsibilities of each stakeholder.

I hereby acknowledge that I understand the contents of this FMP and agree to implement the provisions herein:

_____ Date: _____
Name
Auwahi Wind Energy

_____ Date: _____
Sumner Erdman
President
Ulupalakua Ranch

_____ Date: _____
Name
Construction Manager
Company Name

Table of contents

1. INTRODUCTION 1

1.1. SETTING 1
1.2. STAKEHOLDERS 1
1.2.1. Auwahi Wind Energy 1
1.2.2. Ulupalakua Ranch 1
1.2.3. State of Hawai'i Department of Land and Natural Resources 2
1.2.4. State of Hawai'i Department of Hawaiian Homelands 2
1.2.5. Leeward Haleakalā Watershed Restoration Partnership 2
1.2.6. Neighboring Private Land Owners 2
1.3. GOALS AND OBJECTIVES 2
1.4. FIRE MANAGEMENT PLAN UPDATES 2

2. DATA ANALYSIS 4

2.1. WEATHER 4
2.1.1. Wind Farm Site 4
2.1.2. Pinch Point 4
2.1.3. Interconnection Substation 8
2.2. FUELS 8
2.2.1. Fuel Type 8
2.2.2. Fuel Load 9
2.3. FIRE HISTORY 11
2.4. VALUES AT RISK 12
2.4.1. Ulupalakua Ranch 12
2.4.2. Kanaio NAR 12
2.4.3. Auwahi Restoration Areas 12
2.4.4. Private Lands 13
2.5. RISK ANALYSIS 13
2.5.1. The Tropical Grass/Fire Cycle 14
2.5.2. Wind Farm Site 14
2.5.3. Generator tie-line 15

3. PRE-SUPPRESSION ACTIONS 15

3.1. IGNITION PREVENTION 15
3.1.1. Construction Phase 15
3.1.2. Generator tie-line Corridor 16
3.1.3. Wind farm and Collection Substation Sites 17
3.2. FIREBREAKS, FUELBREAKS, FUELS MANAGEMENT, AND SUPPRESSION PREPARATION 17
3.2.1. Wind farm site 17
3.2.2. Generator tie-line 17
3.2.3. Interconnection Substation Area 18
3.2.4. Invasive Species Control 18
3.2.5. Employee Training 19
3.3. COOPERATIVE AGREEMENTS 19
3.4. RESPONSIBILITIES 19

4. FIRE SUPPRESSION INFORMATION 20

4.1. FIRE REPORTING PROCEDURES 20
4.2. FIRE FIGHTING EQUIPMENT 20
4.2.1. Fire Tools 20
4.2.2. Fire Extinguishers and Equipment on Trucks, Tractors, etc. 21
4.3. FIRE FIGHTING COMMAND AND CONTROL 21
4.4. CONTACT INFO 21
4.5. MAUI FIRE FIGHTING RESOURCES 22
4.6. WATER SOURCES 22
4.7. SAFETY 22

5. POST FIRE ACTIONS 23

5.1. INFRASTRUCTURE INSPECTION 23
5.2. IGNITION SOURCE IDENTIFICATION 23
5.3. POST-FIRE REPORTS 23

6. REFERENCES 25

APPENDIX 1 - GENERATOR TIE-LINE FIRE PROBABILITY CALCULATIONS 26

List of Figures

FIGURE 1. LAND OWNERSHIP 3
FIGURE 2. TEMPERATURE DATA AT THE WIND FARM SITE 5
FIGURE 3. WIND ROSE FOR THE WIND FARM SITE 5
FIGURE 4. MONTHLY AVERAGE MAXIMUM AND MINIMUM TEMPERATURE, MAXIMUM AND MINIMUM RELATIVE HUMIDITY, AND PRECIPITATION FROM THE AUWAHI 141 WEATHER STATION 6
FIGURE 5. WIND ROSE FROM THE AUWAHI 141 WEATHER STATION 6
FIGURE 6. PINCH POINT AND VEGETATION SAMPLE LOCATIONS 7
FIGURE 7. MONTHLY AVERAGE TEMPERATURE AND PRECIPITATION FROM THE MAKENA GOLF COURSE WEATHER STATION 8
FIGURE 8. VEGETATION TYPES 10
FIGURE 9. NUMBER OF FIRES IN THE MAUI DISTRICT OF MAUI COUNTY BY FIRE CAUSE 11
FIGURE 10. WATER SOURCES 23

List of Tables

TABLE 1. KIKUYU GRASS FUEL LOAD DATA. 9
TABLE 2. NATIONAL FIRE DANGER RATING ADJECTIVES AND ASSOCIATED FUEL CONDITIONS AND FIRE BEHAVIORS 17
TABLE 3. RESPONSIBILITIES OF AUWAHI WIND ENERGY AND ULUPALAKAU RANCH. 19
TABLE 4. TOOLS REQUIRED IN EACH FIREFIGHTING TOOLBOX. 20
TABLE 5. AGENCIES AND INDIVIDUALS THAT MAY BE CONTACTED FOR ASSISTANCE DURING WILDFIRES 22

List of Acronyms

CFPA	Confederation of Fire Protection Associations
DLNR	Department of Land and Natural Resources
DHHL	Department of Hawaiian Homelands
DOFAW	Division of Forestry and Wildlife
EIS	Environmental Impact Statement
FMP	Fire Management Plan
IC	Incident Commander
ICS	Incident Command System
LHWRP	Leeward Haleakalā Watershed Restoration Partnership
NAR	Natural Area Reserve
ac	Acres
ch/hr	Chains per hour
ha	Hectares
in	Inches
gal	Gallon
gal/min	Gallons per minute
g/m^2	Grams per square meter
km	Kilometers
l	Liters
l/min	Liters per minute
m	Meters
mi	Miles
Mg/ha	Megagrams per hectare
mph	Miles per hour
mm	Millimeters
m/min	Meters per minute
m/s	Meters per second
t/ac	Tons per acre

Agencies and Organizations Contacted

Auwahi Wind Energy
Leeward Haleakala Watershed Restoration Partnership
Maui County Fire Department
Maui Electric Company
State of Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife
Tetratech International
Ulupalakua Ranch
United States Air Force Combat Climatology Center
United States Fish and Wildlife Service, Pacific Islands
Wailea Fire Department
Western Regional Climate Center

1. Introduction

1.1.Setting

The Auwahi Wind Farm Project, as proposed by Auwahi Wind Energy, consists of the following elements: the wind farm site, the generator tie-line, the interconnection substation, and reconfiguration of Papaka Road. The project will be located primarily on private property, the majority of which is owned by Ulupalakua Ranch (Figure 1). The wind farm site is located entirely on land owned by Ulupalakua Ranch. The wind farm will consist of 8 to 15 wind turbines. The generator tie-line is also located on Ulupalakua Ranch property, although it crosses Pi'ilani Highway, which is within a Maui County easement, and Kula Highway, which is owned by the State. The generator tie-line will be 14.4 kilometers (km) (9 miles (mi)) in length. The interconnection substation is sited on Ulupalakua Ranch property at the terminus of the generator tie-line. Papaka Road will be used to transport construction materials and crosses a total of 14 parcels, most of which are owned by Ulupalakua Ranch. Four of the parcels are jointly owned by Ulupalakua Ranch and the State, one is jointly owned by Ulupalakua Ranch and another private party, and two are owned entirely by ATC Makena Holdings, LLC. Papaka Road is 7.4 km (4 mi) in length.

Areas to be developed include a wind farm site, generator tie-line corridor, interconnection substation site, facilities infrastructure, and roadway improvements for construction access. Development areas span an array of vegetation types and moisture regimes. The wind farm site and the interconnection substation site are characterized by low moisture and introduced perennial grasses. The generator tie-line corridor traverses varying moisture regimes ranging from roughly 500 millimeters (mm) (20 inches (in)) to almost 1,000 mm (39 in) annually that support introduced perennial grasslands, introduced deciduous shrublands, introduced dry forest, and small patches of native subalpine dry shrublands. Papaka Road traverses very dry moisture regimes at low elevation populated by introduced perennial grasslands, introduced deciduous shrublands, and introduced dry forest. Elevation ranges from approximately 180 meters (m) (591 feet (ft)) at the wind farm site to roughly 1,200 m (3,937 ft) at the highest point of the generator tie-line corridor, then back down to approximately 180 m at the interconnection substation site. The western end of Papaka Road lies at 23 m (75 ft). Topography varies widely across the sites to be developed as the volcanic lava origins have created diverse micro-topographies, but overall, slopes vary from 10% to over 40%.

1.2. Stakeholders

1.2.1. Auwahi Wind Energy

Auwahi Wind Energy is the proponent of the wind farm project and is responsible for its construction, operations, and maintenance. Auwahi Wind Energy is also responsible for implementation of this Fire Management Plan (FMP). Auwahi Wind Energy will work in coordination with Ulupalakua Ranch to ensure the fire mitigation measures identified by this FMP are properly implemented.

1.2.2. Ulupalakua Ranch

Ulupalakua Ranch owns the land on which the wind farm, the interconnection substation, and most of the generator tie-line will be built. Ulupalakua Ranch will work in coordination with Auwahi Wind Energy to maintain fire mitigation measures defined by this FMP.

1.2.3. State of Hawai'i Department of Land and Natural Resources

The State of Hawai'i Department of Land and Natural Resources (DLNR) manages land adjacent to Ulupalakua Ranch and a small portion of land adjacent to the proposed generator tie-line including an adjacent Natural Area Reserve (NAR). This land could potentially be affected in the unlikely event of a wildfire.

1.2.4. State of Hawai'i Department of Hawaiian Homelands

The State of Hawai'i Department of Hawaiian Homelands (DHHL) owns considerable acreages of land to the east of the project area. Though highly unlikely, it is possible this land could be affected by a wildfire.

1.2.5. Leeward Haleakalā Watershed Restoration Partnership

The Leeward Haleakalā Watershed Restoration Partnership (LHWRP) has worked closely with Ulupalakua Ranch to establish two restoration areas on Ulupalakua Ranch Property. A great deal of time and effort has been expended to plant trees, remove non-native species, and collect native seeds in these areas (LHWRP 2010). They both could potentially be affected in the unlikely event of a wildfire.

1.2.6. Neighboring Private Land Owners

A number of privately owned land parcels could potentially be affected in the unlikely event of a wildfire. The largest of these parcels are owned by Haleakalā Ranch to the north of Ulupalakua Ranch and WCPT/GW Land Associates LLC to the west.

1.3.Goals and Objectives

The goal of this FMP is to successfully mitigate the fire risk posed by construction and operation of the Auwahi Wind Farm through a program of engineering, fuels management, and pre-suppression fire fighting coordination, including the risk to federally and state-protected species.

The objectives of this plan are:

1. Use engineering and maintenance of the wind farm infrastructure and generator tie-line to limit fire ignitions from the wind farm infrastructure to an average of less than one per decade.
2. Use best management practices to minimize the probability of ignitions during construction.
3. Limit potential fire spread to less than 6.7 meters per minute (m/min) (20 chains per hour (ch/hr)) under 90th percentile weather and fuel conditions at the "pinch point" where the generator tie-line passes through a narrow area between the NARS land and the Auwahi Forest Restoration Project.
4. Within the generator tie-line pinch point, create a series of firebreaks and implement fuels management to prevent fire spread into the NAR and the Auwahi Forest Restoration Project under 90th percentile weather and fuel conditions.

1.4.Fire Management Plan Updates

This FMP shall be updated annually from the time construction of the Auwahi Wind Farm begins to its completion. After construction is completed, this FMP shall be updated once every five years throughout the life of the Auwahi Wind Farm. The FMP shall also be reviewed after every fire and updated as necessary to incorporate lessons learned.

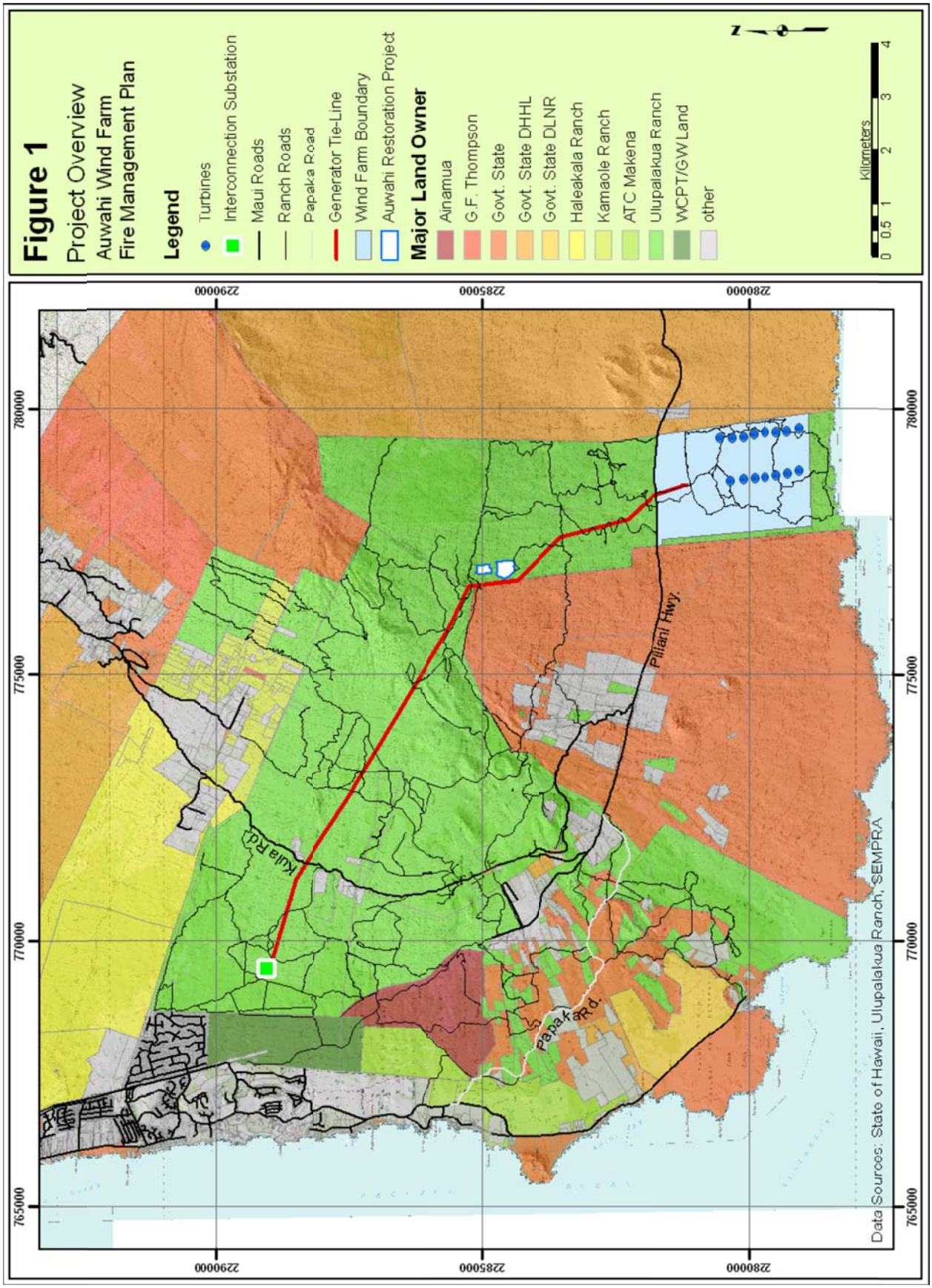


Figure 1
Project Overview
Auwahi Wind Farm
Fire Management Plan
Legend
Turbines
Interconnection Substation
Maui Roads
Ranch Roads
Papaka Road
Generator Tie-Line
Wind Farm Boundary
Auwahi Restoration Project
Major Land Owner
Ainamua
G.F. Thompson
Govt. State
Govt. State DHHL
Govt. State DLNR
Haleakala Ranch
Kamaole Ranch
ATC Makena
Ulupalakua Ranch
WCPT/GWLand
other
Kilometers
0 0.5 1 2 3 4
N
Kula Rd.
Pillani Hwy.
Papaka Rd.
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA
765000
770000
775000
780000
228000
228500
229000

2. Data Analysis

2.1.Weather

The areas to be developed span a wide range of elevations, each with their own weather conditions. Climate data does not exist for all areas within the project area. However, there are weather stations in the areas of interest that provide sufficient climate data for the scope of this plan. Areas of focus are the wind farm site, the pinch point along the generator tie-line, and the power interconnection substation. Available weather station data was utilized to provide insights into climatic variables that affect fire.

Period of record data was acquired for a number of weather stations within and near the project areas. Only two of these provided a full suite of meteorological data. Given that weather conditions, particularly moisture regimes, change substantially over very short distances in Hawaiʻi, this leaves some room for uncertainty in the weather conditions that occur throughout the project area. However, the critical locations of the pinch point and wind farm site are well documented, though periods of record are short, meaning long term trends and annual variability remain unknown.

Wind monitoring heights varied between stations. We used corrective factors to adjust for wind friction with surface features and vegetation to give estimates of wind speeds at 6.09 m (20 ft), a standard height used for most fire weather observations.

2.1.1. Wind Farm Site

The wind farm site includes a meteorological tower (hereafter 'met tower') that holds instrumentation at 30 m (98 ft) and 48 m (157 ft) above the ground. The met towers are primarily designed to measure various wind attributes and they do not record relative humidity. We utilized wind and temperature data from the 30 m height from the 'Maui 3' met tower.

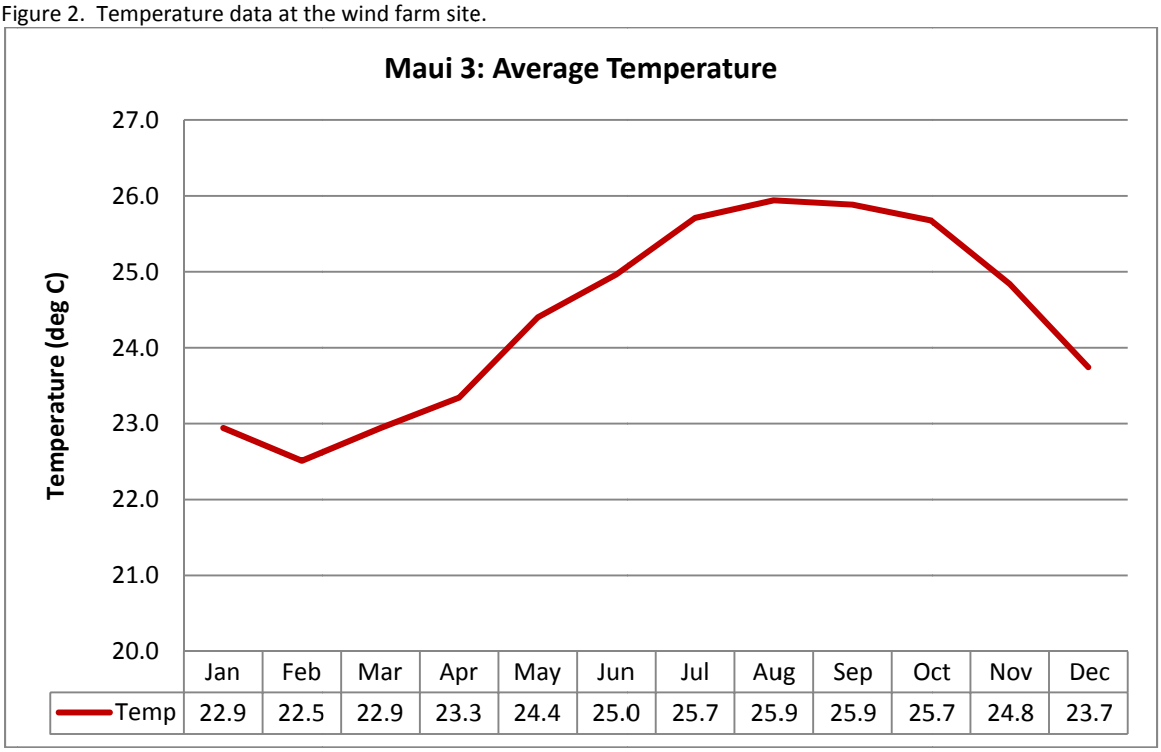
Temperature is relatively constant throughout the year (Figure 2). Winds are strongly dominated by the easterly trade winds with wind blowing directly from the east over 40% of the time (Figure 3). Winds from the west are exceedingly rare.

2.1.2. Pinch Point

A weather station maintained by the University of Hawaiʻi has been in place within the Auwahi Forest Restoration Project since 2001. This station is ideally located to provide weather information for the pinch point along the generator tie-line (Figure 6). The station stands approximately 2 m (6.6 ft) and records a full array of climate variables. Wind speeds were corrected to approximate speeds at 6.09 m (20 ft).

Temperature and relative humidity are relatively constant throughout the year (Figure 5). Minimum relative humidity is high, with average minimums near or above 60%. Precipitation shows a marked dry season from June through August. Wind speeds are comparable to the wind farm site, though the wind direction is more variable with a larger northerly component.

Figure 2. Temperature data at the wind farm site.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	22.9	22.5	22.9	23.3	24.4	25.0	25.7	25.9	25.9	25.7	24.8	23.7

Figure 3. Wind rose for the wind farm site.

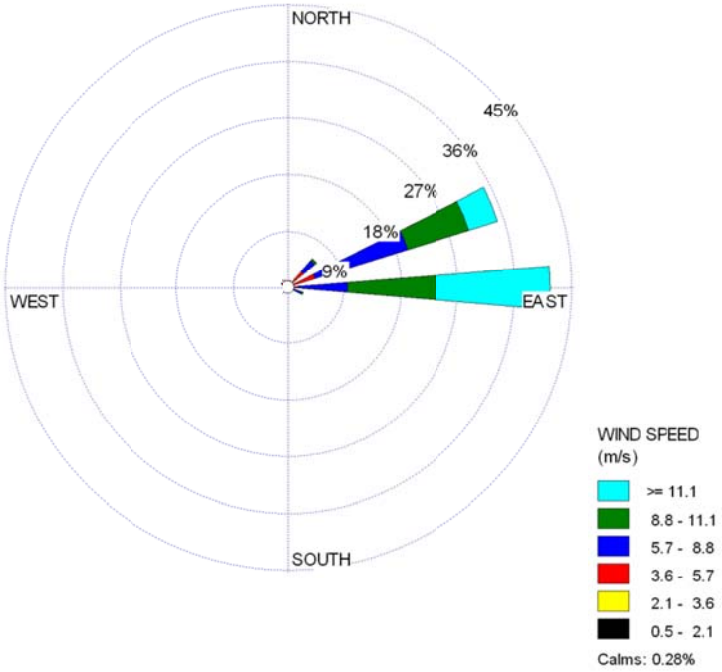
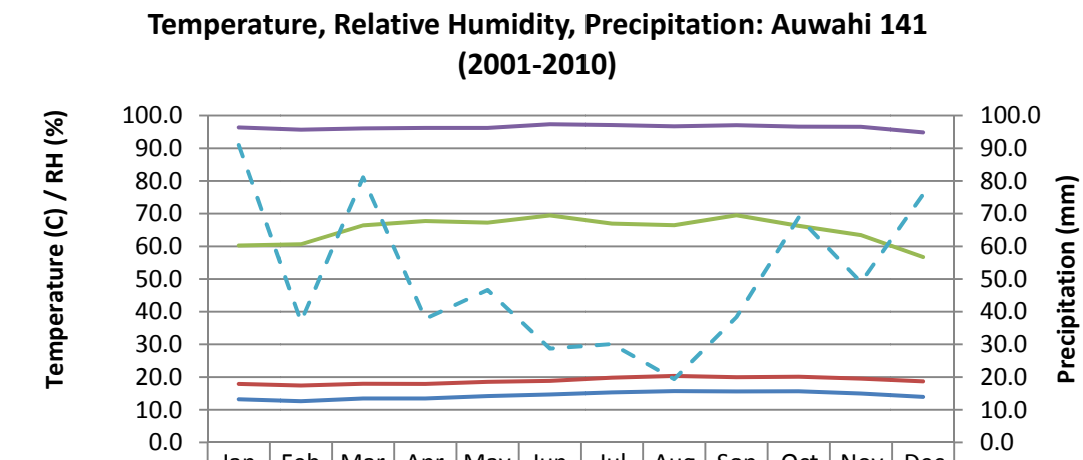
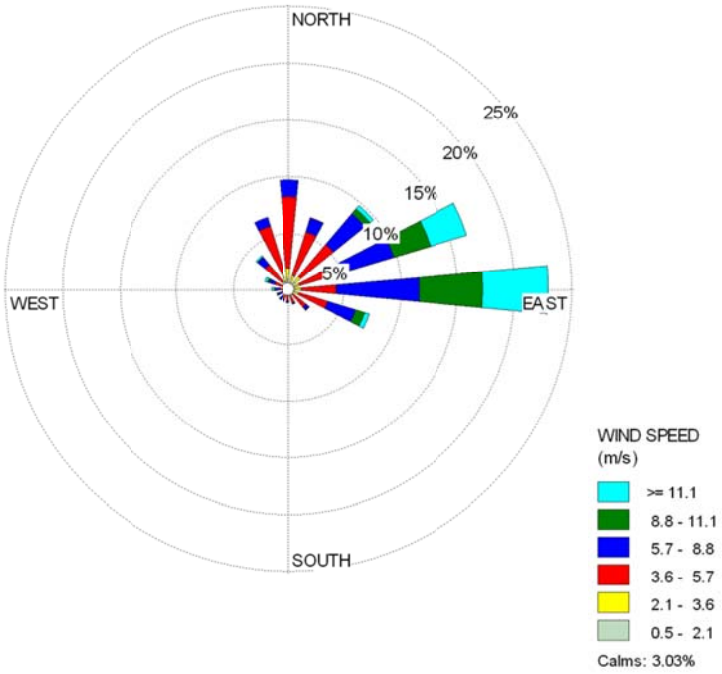


Figure 4. Monthly average maximum and minimum temperature, maximum and minimum relative humidity, and precipitation from the Auwahi 141 weather station.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MinTemp	13.2	12.6	13.4	13.4	14.2	14.7	15.3	15.7	15.6	15.6	14.9	13.9
MaxTemp	17.9	17.4	17.9	17.9	18.6	18.8	19.8	20.3	20.0	20.1	19.5	18.7
MinRH	60.2	60.6	66.4	67.7	67.2	69.5	67.0	66.5	69.5	66.3	63.4	56.7
MaxRH	96.4	95.7	96.1	96.2	96.2	97.3	97.1	96.7	97.1	96.6	96.5	94.9
Precip	91.0	37.0	81.1	37.8	46.6	28.7	30.1	19.4	38.4	68.9	49.0	75.9

Figure 5. Wind Rose from the Auwahi 141 weather station. Wind readings were adjusted to account for the low height at which they were measured.



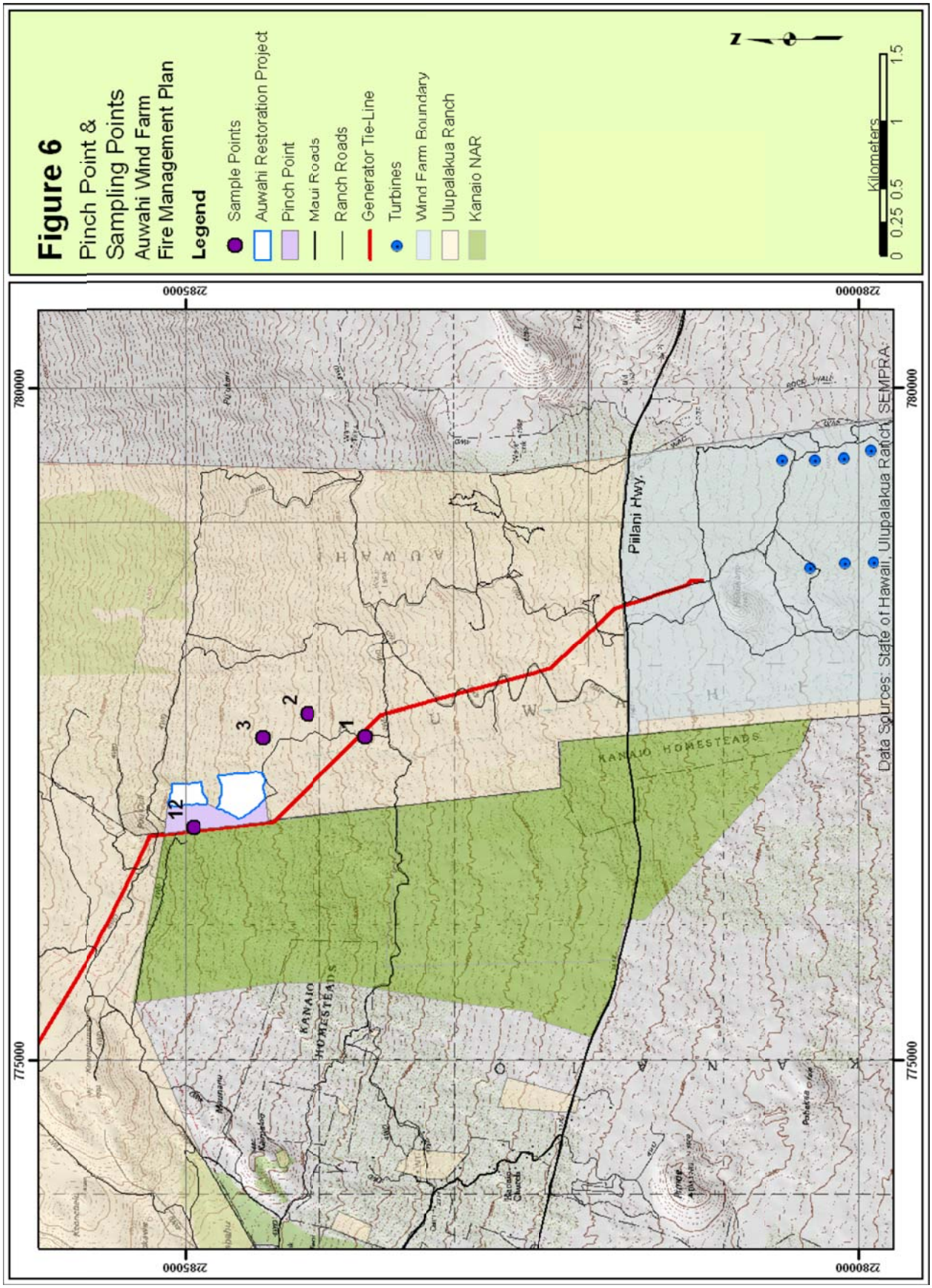


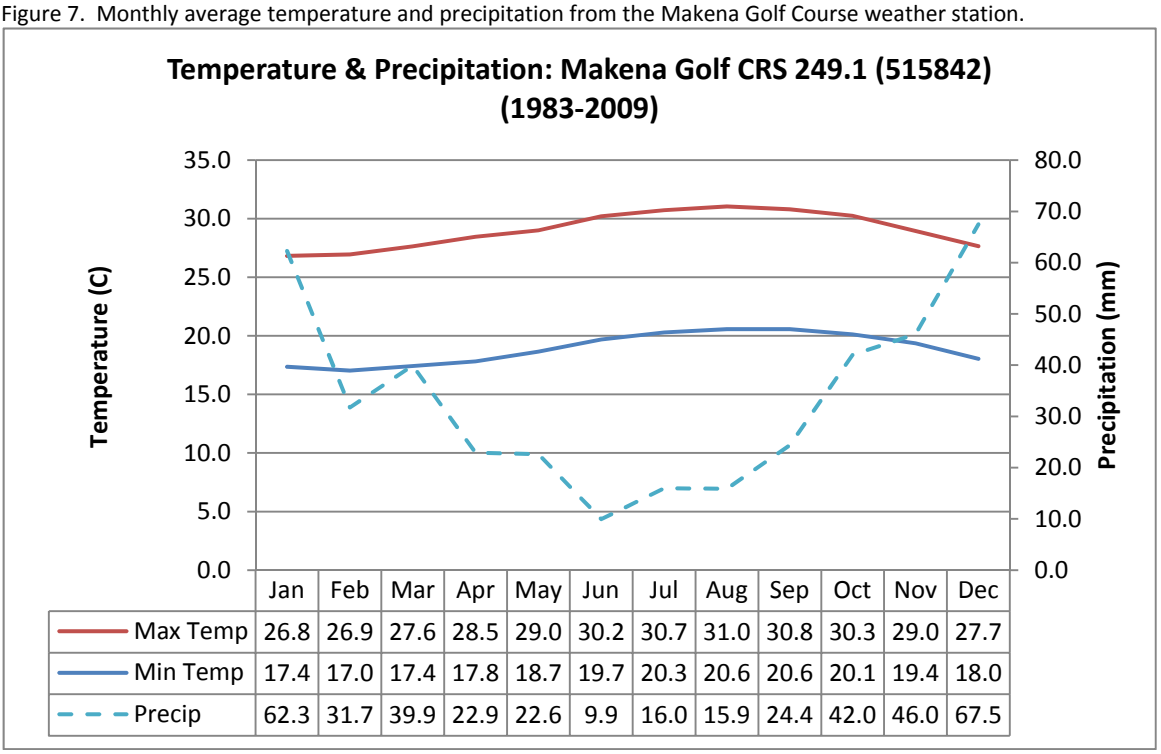
Figure 6
Pinch Point &
Sampling Points
Auwahi Wind Farm
Fire Management Plan
Legend
Sample Points
Auwahi Restoration Project
Pinch Point
Maui Roads
Ranch Roads
Generator Tie-Line
Turbines
Wind Farm Boundary
Ulupalakua Ranch
Kanaio NAR
Kilometers
0 0.25 0.5 1 1.5
N
Piilani Hwy.
KANAIO HOMESTEADS
KANAIO HOMESTEADS
AUWAHI
1
2
3
12
775000
780000
285000
280000
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA

2.1.3. Interconnection Substation

There are no weather stations with a full suite of weather variables near the interconnection substation. We utilized data from the Makena Golf Course weather station, approximately 7 kilometers (km) (4.4 miles (mi)) to the southwest of the interconnection substation, which only records daily values for temperature and precipitation. Wind and relative humidity are unknown in this location.

As at the other weather stations, temperature is relatively constant throughout the year, though it is substantially warmer in this locale. Precipitation is sparse in the summer months with less than 20 mm (0.9 in) per month falling from June through August on average. There is no wind data available for this site.

Figure 7. Monthly average temperature and precipitation from the Makena Golf Course weather station.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Temp	26.8	26.9	27.6	28.5	29.0	30.2	30.7	31.0	30.8	30.3	29.0	27.7
Min Temp	17.4	17.0	17.4	17.8	18.7	19.7	20.3	20.6	20.6	20.1	19.4	18.0
Precip	62.3	31.7	39.9	22.9	22.6	9.9	16.0	15.9	24.4	42.0	46.0	67.5

2.2.Fuels

2.2.1. Fuel Type

Fuels vary by elevation and moisture regime (Figure 8). Low elevation sites are characterized by pyrophytic non-native grasses interspersed with patches of shrublands and small treelands. Trees and shrubs in these locales will not contribute significantly to fire spread though they may pose some fire containment issues.

Upper elevations receive more moisture and are characterized by extensive stands of kikuyu grass (*Pennisetum clandestinum*). Kikuyu is a perennial, rhizomatous, mat forming grass. Kikuyu produces thick beds of herbaceous fuels capable of carrying wildfire. As elevation and moisture increase, kikuyu grass is able to produce more biomass. During times of drought, these fuels can

become desiccated and pose a wildfire hazard. Most of the kikuyu grass on Ulupalakua Ranch is frequently grazed, minimizing the fire threat.

The higher elevations also harbor remaining patches of native trees and shrubs. The native vegetation is also capable of carrying wildfire, particularly pukiawe (*Styphelia tameiameiae*). This shrub is quite flammable and when mixed with a grass fuelbed, as is the case here, it can produce substantial fire containment difficulties due to torching and spotting.

There are stands of a variety of eucalyptus species scattered throughout the western half of Ulupalakua Ranch. While fires in these timber stands are difficult to contain due to the heavy fuel load, flammability of the fuels and ease with which the tree canopy becomes involved in the fire, the stands are isolated and are located in areas where they do not threaten important resources other than the timber itself.

2.2.2. Fuel Load

We measured kikuyu grass fuel loads at three randomly located plots within and near the generator tie-line corridor (Figure 6). Each plot consisted of a single 100 m transect with five fuels sampling quadrats evenly spaced along the transect. Our results (Table 1) indicate a pattern of increasing fuel load with increasing elevation. This pattern is not statistically significant primarily because of the limited number of samples, but professional judgment of the author as well as the ranch owner both support the trend. We collected data from a fourth plot (plot 12) which was sited inside the State NAR land at 1,156 m (3792 ft) where no grazing occurs. This plot had a fuel load of 18.0 Megagrams per hectare (Mg/ha) (8.1 tons per acre (t/ac)), much higher than any of the plots located on Ulupalakua Ranch lands, indicating the importance of grazing to maintaining lower fuel loading.

Table 1. Kikuyu grass fuel load data.

Transect #	Fuel Load (Mg/ha)	Elevation (m)
1	5.7	867
2	11.7	951
3	12.4	1011
12	18.0	1159

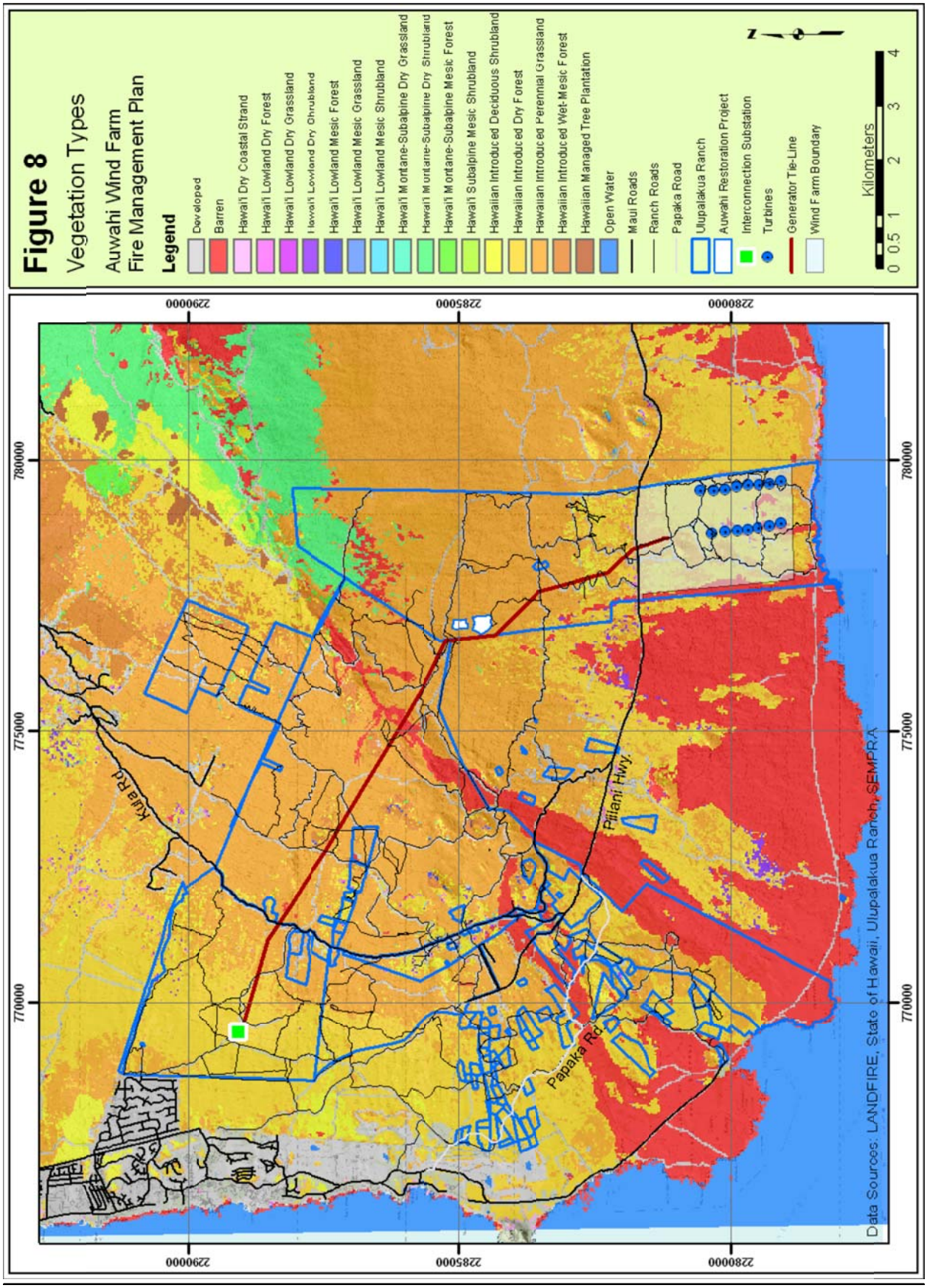


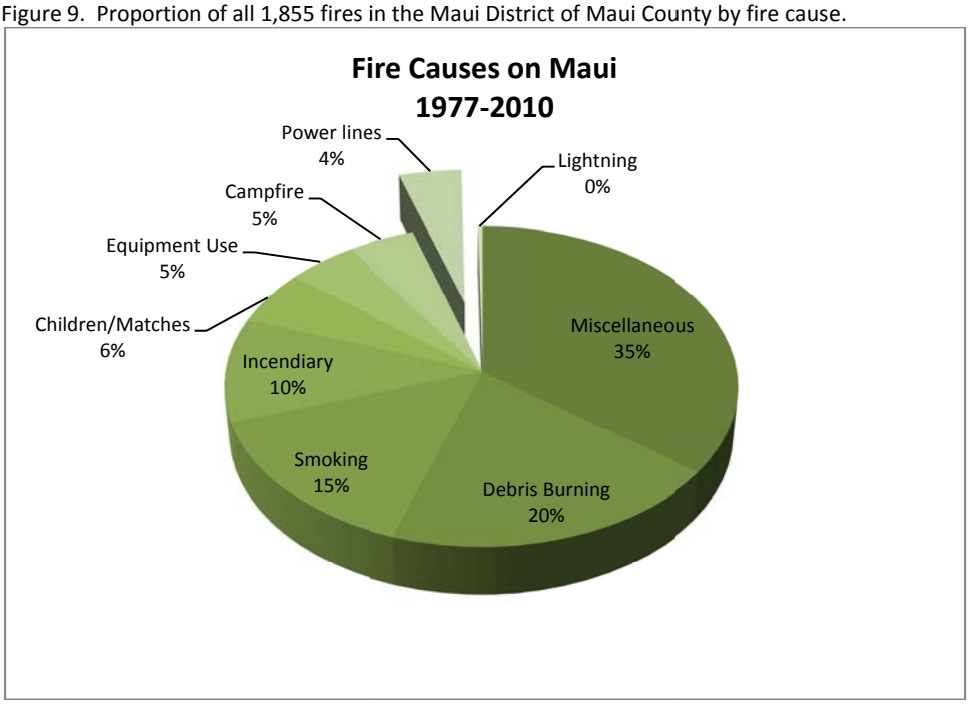
Figure 8
Vegetation Types
Auwahi Wind Farm
Fire Management Plan
Legend
Developed
Barren
Hawai'i Dry Coastal Strand
Hawai'i Lowland Dry Forest
Hawai'i Lowland Dry Grassland
Hawai'i Lowland Dry Shrubland
Hawai'i Lowland Mesic Forest
Hawai'i Lowland Mesic Grassland
Hawai'i Lowland Mesic Shrubland
Hawai'i Montane-Subalpine Dry Grassland
Hawai'i Montane-Subalpine Dry Shrubland
Hawai'i Montane-Subalpine Mesic Forest
Hawai'i Subalpine Mesic Shrubland
Hawaiian Introduced Deciduous Shrubland
Hawaiian Introduced Dry Forest
Hawaiian Introduced Perennial Grassland
Hawaiian Introduced Wet-Mesic Forest
Hawaiian Managed Tree Plantation
Open Water
Maui Roads
Ranch Roads
Papaka Road
Ulupalakua Ranch
Auwahi Restoration Project
Interconnection Substation
Turbines
Generator Tie-Line
Wind Farm Boundary
Kilometers
0 0.5 1 2 3 4
N
780000
775000
770000
229000
228500
228000
Kula Rd
Piiiani Hwy.
Papaka Rd
Data Sources: LANDFIRE, State of Hawaii, Ulupalakua Ranch, SEMPRA

2.3.Fire History

There are limited records of fires in and around the project area. Anecdotal records of wildfires on and around Ulupalakua Ranch have come from Mr. Sumner Erdman, the ranch owner, and the causes have been traced to anthropogenic sources such as campfires, burning debris, and automobiles. The fires that Mr. Erdman can recollect have started in non-native fuels and were fought by hand or, in rare cases, with the help of bull dozers.

The Maui District of the Hawai‘i DLNR Division of Forestry and Wildlife (DOFAW) maintains fire reports with information about all wildfires that have been reported on Maui. Reports from 1977 to 2010 indicated that there were 1,855 wildfires within Maui County. Over 99% of these fires were human caused, but only 85, or just 4%, have been caused by power lines. Due to limited staff, none of these 85 fires were formally investigated so a power line cause was never confirmed. Many of the power lines that have caused fires are decades old and were not built to the higher standards of current power lines. Additionally, many of these fires were caused by distribution lines rather than generator tie-lines. Distribution lines, which are not a component of this project, would be expected to cause more fires than generator tie-lines because they are not as well maintained and there are many more miles of them.

Figure 9. Proportion of all 1,855 fires in the Maui District of Maui County by fire cause.



2.4.Values at Risk

2.4.1. Ulupalakua Ranch

The majority of lands to be developed and at risk of fire are within Ulupalakua Ranch property (Figure 1). Ulupalakua Ranch occupies roughly 8,094 hectares (ha) (20,000 acres (ac)) and operates on approximately 7,285 ha (18,000 ac) of that area. The Ranch runs 2,300 brood cows in its pastures. Calving occurs during winter, spring, and summer to concur with production of the various ecosystems found on the ranch properties (UR 2010). Ulupalakua Ranch depends on their lands to provide the forage needed to produce the high quality beef for which they are known. The development of the Auwahi Wind Farm will pose a wildfire risk to the ranch lands and, should a fire occur, could have negative effects on the land's productivity. The generator tie-line corridor represents the most extensive fire risk because of its length. The nine-mile corridor passes through a number of pastures and areas of high forage production which potentially could be negatively affected by fire.

2.4.2. Kanaio NAR

The State of Hawaiʻi owns land immediately adjacent to the generator tie-line corridor (Figure 1). The Kanaio NAR was established in 1990 to protect areas of native dry tropical forest and shrubland (Medeiros et al 1993) and is currently being expanded to include a large area of State land to the north of the currently designated area. A biological survey published in 1993 (Medeiros et al) identified three endangered native vegetative communities: *`A`ali`i* (*Dodonaea*) lowland shrublands, *Lama* (*Diospyros*) forest, and *Wiliwili* (*Erythrina*) forest. Several species listed under the Endangered Species Act occur within the NAR. These species are protected by federal law. Any area burned in the Kanaio NAR would severely impact the native vegetation and listed species occurring there and likely result in increased dominance of non-native perennial grasses.

2.4.3. Auwahi Restoration Areas

The Auwahi Forest Restoration Project is considered a high value property for its ecological and cultural significance. Since 2000, over 127 public and private volunteer trips have resulted in over 2,888 volunteers donating a total of over 10 years worth of labor to help plant 60,621 native plants (ARR 2010), giving an indication of the importance of this project to the local community. The Auwahi Forest Restoration Project lies adjacent to the State NAR on Ulupalakua Ranch property in two small parcels. These are remnants of biologically diverse native forest that have been restored by planting native species, fencing out mammalian herbivores, and controlling non-native species. The proposed route of the generator tie-line skirts along the western edge of the Auwahi parcel before it turns west and heads back down the mountain (Figure 1).

Beginning in 1997, the Leeward Haleakala Watershed Restoration Partnership was created. It is a partnership between landowners, government resource managers and scientists to develop methods in which to restore the unique and dwindling dryland forest ecosystem before it was lost entirely (Madeiros 2006). Since that time, a substantial effort has been undertaken to restore and improve the native forest within fenced exclosures.

Historically, this area had been considered to be one of the most biologically rich native Hawaiian ecosystems. Currently, less than 5% of the native dryland forest ecosystem remains on Maui (Medeiros & vonAllmen 2006) and the Auwahi parcel is an especially diverse example of these remnants. The native forest has experienced varying levels of habitat destruction,

grazing by ungulates, competition from invasive plants, and wildfires. Because of the severe reduction of native forest cover, actions were taken to preserve the Auwahi parcel. The Auwahi parcel was fenced in 1997 to exclude ungulates in order to examine potential methods of restoring the native ecosystem. In addition to excluding ungulates the four acre parcel was weeded of kikuyu grass (*Pennisetum clandestinum*), broadcast seeded and outplanted with nursery stock of native species. The experimental restoration methods tested in the Auwahi parcel have yielded unassisted natural establishment of seedlings and saplings of native shrub-tree species.

Since the treatments have been applied, the exclosure has provided refugia for five endangered plant species. The Auwahi parcel has also protected two species of native tree, a`e (*Zanthoxylum hawaiiense*) and alani (*Melicope knudsenii*), with the alani tree being the only known survivor in its natural setting on Maui or Kaua`i. The non-native kikuyu grass that once covered over 70% of the ground now only covers 5% and native shrubs and trees are predicted to increase in dominance. The increase of native shrubs and trees will also harbor native shade-tolerant understory species that rely on the micro climate created by native overstory species.

These exclosures define one side of the pinch point and lie within 50 m (164 ft) of the proposed generator tie-line at the nearest point and 213 m (699 ft) at the furthest point. The NAR defines the other side. The area between the State NAR land and the Auwahi Forest Restoration Project was originally, and still is, used as a means to move cattle from one side of the ranch to the other.

2.4.4. Private Lands

There is minimal risk to private land holdings, but it is worth noting that a large fire could burn off of Ulupalakua Ranch lands and onto private land. The greatest risk is posed by construction traffic on Papaka Road. It passes through and very close to several private land holdings and the very dry climate in this area makes the probability of an ignition high.

2.5.Risk Analysis

Fuels throughout nearly all of Ulupalakua ranch are grazed regularly, reducing fuel loads though the possibility of a wildfire is still present. At low elevations where bunch grasses predominate and the mat forming Kikuyu grass is absent, grazing also helps to reduce fuel continuity, leaving clumps of grass rather than a continuous bed of vegetation. Grazing is a vital fire mitigation measure and no major changes in the grazing regime are expected at this time.

Kikuyu grass is a major component of the vegetation within the project area. A study of kikuyu grass by Blackmore and Vitousek (2000) found that ungrazed kikuyu grass produced 770 grams per square meter (g/m^2) (3.4 t/ac)) of biomass that was up to approximately 27 centimeters (cm) (10.6 in) deep. The resulting fuel loads were modeled to determine flame lengths and rate of spread. They determined that ungrazed kikuyu could carry capable of covering greater than 75 ha (173 ac) after one hour. They also tested grazed kikuyu areas where they found fuel loads of 229 g/m^2 (1 t/ac)that were unable to carry fast-spreading fires, though they could still carry fires that could to burn 1.4 ha (3.5 ac) in an hour.

We sampled fuels at several sites near the most important values at risk. Fuel loads at Ulupalakua ranch are typically higher than those we sampled due to drought conditions during the sampling period. Thus, they are also generally higher than the grazed grass measurements documented by

Blackmore and Vitousek and we can assume fire behavior would be somewhat more vigorous as a result. However, even substantial increases in fire behavior from the values calculated by Blackmore and Vitousek would not pose serious containment challenges.

2.5.1. The Tropical Grass/Fire Cycle

The non-native perennial grasslands that are found throughout the areas to be developed have a strong relationship with fire. They produce copious biomass that, when dried by lack of moisture, provides substantial fuels to carry wildfire. Fires often burn through these fuels and into native vegetation. When this occurs, the native plant species, which are poorly adapted to wildfire when compared to their non-native competitors, almost never recover entirely. They do not regenerate as quickly or vigorously as many of the non-native species. This allows non-native species to establish or reestablish communities in burned areas where native plants previously dominated. Usually two to three successive fires is sufficient to completely remove native species from the system and as a result, there are almost no instances where a fire burning in a native ecosystem is considered acceptable.

2.5.2. Wind Farm Site

Ignition probability from the wind turbines is close to zero. Though there is no reporting requirement for fires in wind turbines, it is typical to report fires to the manufacturer. This is in the turbine owner's interest as each turbine represents a substantial financial investment. Auwahi Wind Energy is considering three possible wind turbines, two from Siemens and one from GE. Siemens has never received a report from anywhere in the world of a fire in the a nacelle of the type being considered for the Auwahi Wind Farm. These turbines include smoke detectors, a substantial lightning protection system, and the temperature of key components are monitored at all times. One of the Siemens turbines includes a design that does not require a gearbox, reducing the possibility of a fire even further. The GE designed turbine is widely used and over 15,000 of them have been installed in the past 10 years. During this time period, there were four reported fires representing a fire probability of 0.027%. GE fixed the problem in 2004 and since then there have been no reported fires. The GE turbines have similar fire prevention measures to the Siemens design.

Many locations within the wind farm site will not carry fire for extended distances due to a lack of contiguous fuels. The rocky substrate prevents a continuous cover of grasses and herbaceous plants. Shrub fuels are more evenly distributed but lack the density necessary to carry a well organized fire. Fires in this area are likely to creep and finger through the fuels, seeking out areas with more fuel, flaring up momentarily, then lying back down to smolder their way forward again. While unpredictable, these types of fires do not typically pose major fire suppression challenges except under the worst conditions.

Additionally, the predominant winds blow out of the east at this site and will push the vast majority of fires to the west where they will be halted by a large lava flow with insufficient fuel to carry fire.

To the north is Pi‘ilani Highway, which provides quick access to the area and a logical firebreak to prevent fires from moving upslope. There are also several existing 4x4 roads within Ulupalakua Ranch south of Pi‘ilani Highway and more roads will be constructed for construction and maintenance of the wind farm. These interior roads will provide access and some will be large enough to serve as substantial firebreaks.

2.5.3. Generator tie-line

The risk of an ignition anywhere along the proposed generator tie-line for the life of the project is 0.29%. This figure is calculated from the fire history in section 2.3 and figures provided by the Maui Electric Company. A full set of calculations is available in Appendix 1.

Auwahi Wind Energy is committing to mitigate the very low risk of a fire ignition in two primary areas of concern along the generator tie-line. The first, and most important, is the pinch point between the land owned by the State of Hawai'i and the Auwahi Forest Restoration Project. The generator tie-line as planned will run less than 100 m (328 ft) east of the NAR. The proposed generator tie-line ranges from a maximum of 213 (699 ft) m to a minimum of 50 m (164 ft) from the western boundary of the Auwahi Forest Restoration Project. Given that response times to this area are on the order of 40 to 60 minutes at a minimum, in unaltered fuels fires could reach into both the State land and the Auwahi exclosures before firefighters arrive on scene.

The other primary risk area is on the last 2.5 km (1.5 mi) of the generator tie-line from the intersection with Kula Road to the power interconnection substation. In this area, pyrophytic grasses, including guinea grass (*Urochloa maxima*), make up the bulk of the herbaceous species. These grasses can produce heavy fuel loadings in a short period of time provided sufficient moisture is available. If extended rainfall is followed by a period of extended dry weather, these fuels could represent a serious fire risk.

Just east of Kula Road, there also exists a patch of barbed wire grass (*Cymbopogon refractus*) of roughly several hectares. This bunch grass produces extremely dense bunches that are highly flammable. The current distribution is insufficient to pose a serious fire containment threat, but it is near the generator tie-line corridor and is spreading every year (Erdman, 2010). If this species begins colonizing larger areas of 10 ha (25 ac) or more, some pre-suppression fire mitigation measures may be in order.

3. Pre-Suppression Actions

3.1. Ignition Prevention

A copy of this FMP shall be posted in a conspicuous location by Auwahi Wind Energy or its contractors so that all workers will be aware of its provisions and their responsibilities for fire prevention and suppression. Preventing ignitions at the wind farm site, along the generator tie-line, at the interconnection substation, and during any stage of construction is a top priority. The following mitigation measures can help to reduce the risk of ignition.

3.1.1. Construction Phase

The construction of the wind farm poses the most significant ignition potential of the project due to the requirement for large numbers of people, vehicles, and equipment and activities such as welding. Hot catalytic converters, exhaust systems, sparks, cigarettes, and other ignition sources will be present throughout the construction period. Proper ignition prevention procedures will be followed by all workers.

Vehicles will not be parked in vegetation of any kind whenever possible. In some locations, particularly along the transmission corridor this may not be feasible. In these locales non-diesel

vehicles will not park in vegetation greater than 10 cm (4 in) in height. Smokers shall field strip their cigarettes immediately after smoking (remove tobacco from the butt and scatter it, ensuring that the tobacco is not lit), or properly dispose of cigarettes inside their vehicle. All welding, grinding, and other spark producing activities will occur no less than 9 m (30 ft) from the nearest contiguous vegetation. Exposed aerial welding (e.g. not inside the tower or the nacelle) at more than 15 m (50 ft) above the ground will be restricted to days when sustained winds are less than 11 meters per second (m/s) (approximately 25 miles per hour (mph)). A fire watch shall be put in place for no less than 30 minutes after any exposed welding ceases. All internal combustion engines will utilize spark arrestors.

3.1.2. Generator tie-line Corridor

As stated earlier, although fires have been documented from power lines, it appears that more have been caused by distribution lines rather than generator tie-lines. Generator tie-lines are built and maintained to a higher standard than distribution lines and thus are less likely to be damaged or worn and produce fires. Downed generator tie-lines represent a serious ignition threat but usually stem from a weather event or hazard tree coming into contact with the line itself. In addition to downed lines, poorly maintained power lines can produce sparks and arcing that may cause a fire ignition in rare cases. These circumstances will be mitigated through a program of regular generator tie-line and generator tie-line corridor maintenance as defined by the Auwahi Wind Farm EIS. There are few locations where trees or shrubs grow tall enough to threaten the line, but maintenance will nonetheless include an area cleared of combustible materials of no less than 5 m in radius around the conductor. The generator tie-line will be inspected no less than once annually and cleaned or repaired at the discretion of Auwahi Wind Energy. Though not required by this FMP, much of the land this generator tie-line crosses is regularly grazed, reducing fuel load, continuity, and height and associated fire risk.

Within the pinch point area, the proximity of the generator tie-line to State NAR land and the Auwahi Forest Restoration Project requires additional ignition mitigation. An irrigation system will be established to reduce the ignition probability of fuels in that zone by keeping the vegetation green. Irrigation will only be used during times of drought when the fire danger is high or greater (Table 2). The irrigation system will be utilized at the discretion of Ulupalakua Ranch in coordination with Auwahi Wind Energy. The irrigation system will cover the area within the pinch point to a width of no less than 20 m (66 ft) from either side of the generator tie-line - 40 m (131 ft) in total width. In addition to its fuels management utility, the irrigation system may also be turned on in the event of a fire in the vicinity of the pinch point. Though it is not properly aligned for this purpose and should not be relied upon as a primary fire fighting resource, it may reduce fire behavior in the unlikely event of a fire. Auwahi Wind Energy will finance the irrigation system's construction and maintenance costs and Ulupalakua Ranch will run it.

Water for the irrigation system will come from the 50,000 gallon (gal) (189,271 liters (l)) tank located roughly 2 km (1.2 mi) to the west. Water used for irrigation and electricity used to pump it to tank and from the tank to the irrigation system will be paid for by Auwahi Wind Energy. Water for irrigation will be moved through the existing ranch water infrastructure to its intersection with the new irrigation water lines at the pinch point. Water from the tank will also be utilized during firefighting operations as a water source for both ground based and aerial resources (see section 3.2.2 for more detail).

3.1.3. Wind farm and Collection Substation Sites

As established in Section 2.5.2, the likelihood of a fire in a wind turbine is exceedingly remote. Nonetheless, maintenance of mechanical and electrical systems within the turbine and nacelle will occur regularly, as recommended by the manufacturer, to limit mechanical failures. An emergency plan in accordance with CFPA guidelines (2010) will also be prepared to help limit equipment losses and possible fire spread.

Table 2. National Fire Danger Rating adjectives and associated fuel conditions and fire behaviors

Fire Danger Adjective Rating	Typical Fuel Conditions	Typical Fire Behavior
Low	Vegetation is moist to the touch. Live herbaceous fuel moisture is greater than 150%.	Ignitions very unlikely. Fires will not spread.
Moderate	Dead vegetation is dry, but live vegetation is green and has a moisture content greater than 100%.	Ignitions are possible. Fires will spread with minimal severity.
High	Dead vegetation is dry, roughly half of the herbaceous vegetation is cured.	Ignitions are probable. Fires will spread with some intensity and will pose difficulties to containment crews in some situations.
Very High	Dead vegetation is dry and brittle. Dead twigs snap easily. Herbaceous vegetation is nearly completely cured.	Ignitions are a near certainty. Fires will spread with high intensity and will be difficult to control. Large fires are probable.
Extreme	Severe, extreme, or exceptional drought conditions exist. Herbaceous vegetation is completely cured. Leaves on shrubs may wilt during mid-day or fall off altogether.	Ignitions are a near certainty. Fires will spread with very high intensity and cannot be controlled.

3.2. Firebreaks, Fuelbreaks, Fuels Management, and Suppression Preparation

3.2.1. Wind farm site

As noted in section 2.5.1, there are several existing barriers to fire spread. Additionally, construction and operation of the wind farm will require several additional roads to be built. These roads will improve firefighter access and help to further compartmentalize the wind farm site. Roads directly related to the operation of the wind farm will be maintained by Auwahi Wind Energy to sufficiently allow passage of a Type VI brush engine (e.g. F-350 carrying 300 gal (1,135 l) of water). There is no requirement for additional firebreaks.

3.2.2. Generator tie-line

Where conductors are used along the generator tie-line a 5 m (16 ft) radius will be cleared of combustible material to reduce ignition potential from any sparking that may occur. This is the responsibility of Auwahi Wind Energy.

The generator tie-line will be placed in the middle of the pinch point corridor, equidistant from the State NAR boundary and the Auwahi Forest Restoration Project parcels. This requirement is subject to alteration based on engineering requirements.

The area between the NAR and the Auwahi Forest Restoration Project will be grazed to reduce the fuel depth to no more than 10 cm (4 in). This will likely remove the few remaining native plants from the pinch point. Ulupalakua Ranch shall have discretion to determine the appropriate animals and the grazing prescription necessary to accomplish this objective. Chemical and mechanical treatments may also be utilized to achieve the desired fuel height,

though these are considerably more expensive and can have undesirable environmental consequences. Ulupalakua Ranch is responsible for financing and implementing this requirement.

Two firebreaks will be established within the pinch point. One will follow the State land boundary to the west and the second will follow the Auwahi Forest Restoration Project fence lines to the east. The alignment may deviate from the fence lines due to topography, erosion considerations, and other factors. These firebreaks will be a minimum of 3 m (10 ft) in width and will be engineered utilizing best management practices for roads including erosion prevention features. The roads will be maintained in a fuel-free state at all times utilizing methods at the discretion of Ulupalakua Ranch. This requirement will be financed by Auwahi Wind Energy and implemented by Ulupalakua Ranch.

The water tank used for irrigation will also be used to fight fires in the area. The water level in the tank will be maintained at 50% of capacity (25,000 gal (94,635 l)) or better at all times. The tank will be retrofitted with two valves spaced far enough apart to allow access by two fire fighting apparatus simultaneously. Each valve will be capable of quickly filling a fire engine or tender (minimum 200 gallon per minute (gpm) (757 liters per minute (l/min)) capacity). During aerial bucket operations, water from the tank will also be pumped to a dipping site for use by aerial resources. The exact location of the dipping site will be determined by Ulupalakua Ranch in coordination with State and contract helicopter pilots to ensure it is properly sited, but it will be within 1,000 m (3,281 ft) of the water tank. A pump or gravity feed system with a minimum capacity of 100 gpm (378 l) will be retrofitted to the tank to allow water to be pulled from the tank into the dipping site. The dipping site may be a permanent structure or a portable dip tank stored at the dipping site and protected from the weather and sun.

3.2.3. Interconnection Substation Area

There are numerous ranch roads in this area that will act as firebreaks. Fuels management where the generator tie-line connects with the interconnection substation will be considered, though it is not required since there are few resources at risk in the immediate vicinity and fire response times and access are much better than in the pinch point area. Fuel loads directly under the line from Kula Highway to the substation, or any portion of this length, could be reduced by more intensive grazing, and/or by making this a priority area to graze after moisture events when most grass growth occurs. Irrigation under the generator tie-line is also a possibility, though it would need to be accompanied by increased grazing pressure to account for the additional grass growth. Ulupalakua Ranch shall retain the discretion to make these decisions and is responsible for financing and implementing any grazing plan deemed necessary.

3.2.4. Invasive Species Control

Auwahi Wind Energy will conduct annual surveys for invasive species of fire prone grasses, with an emphasis on barbed wire grass, buffelgrass (*Pennisetum ciliare*) and fountaingrass (*Pennisetum setaceum*). The survey extent will include, at a minimum, all areas within 10 m (33 ft) of disturbance resulting from construction within the wind farm site and the connection substation site, and within 10 m (33 ft) of all roadways constructed or utilized more than once monthly for wind farm construction or maintenance. Any individuals or colonies observed will be expeditiously exterminated by Auwahi Wind Energy via a means that includes killing the root system. Consideration will also be given to killing individual plants before they produce seed whenever possible. Auwahi Wind Energy will consult Ulupalakua Ranch prior to application of

any herbicide to ensure the ranch is aware of the location of application and the extent and types of herbicides being applied.

If any individuals are found, additional semi-annual surveys of the colonized area will be conducted for 2 years post-discovery and any additional individuals will be destroyed. Semi-annual surveys of colonized sites will continue until 2 years passes without any individuals being found.

3.2.5. Employee Training

Employees will receive basic instruction in the proper use of firefighting tools. These tools and training will allow crews to rapidly respond to any ignition that may occur. Early response to any ignition will greatly increase the likelihood that it will not escape containment efforts. Every new employee will receive this training within 3 months of beginning work. Refresher training will be provided to all employees bi-annually. Training may be provided by an Ulupalakua Ranch employee experienced in firefighting, or by a professional wildland firefighter. A record of training courses including dates, times, skills taught, teacher's name, and attendees will be kept by Auwahi Wind Energy.

3.3.Cooperative Agreements

Ulupalakua Ranch maintains informal agreements with other private land owners for mutual aid when wildfires break out. This arrangement has been highly successful in the past (Erdman, 2010). Ulupalakua Ranch will continue to maintain these relationships and will establish additional agreements and/or formalize existing agreements at their discretion.

3.4.Responsibilities

Auwahi Wind Energy and Ulupalakua Ranch share responsibilities for implementation of this plan. Each is responsible for the tasks listed in Table 3.

Table 3. Responsibilities of Auwahi Wind Energy and Ulupalakau Ranch.

	Auwahi Wind Energy		Ulupalakua Ranch	
	Financing	Implementation	Financing	Implementation
Wind farm site road maintenance	X	X		
Clearing fuels at conductor locations	X	X		
Grazing of fuels at pinch point			X	X
Construction and maintenance of pinch point firebreaks	X			X
Construction and Maintenance of irrigation system	X			X
Reducing fuels at interconnection substation			X	X
Fire prone invasive species control	X	X		

#

4. Fire Suppression Information

4.1.Fire Reporting Procedures

Anyone detecting a fire shall immediately report it by calling 911. After reporting the fire, they shall expeditiously notify Ulupalakua Ranch of the fire at 808-878-1202.

4.2.Fire Fighting Equipment

All construction, operations, and maintenance personnel shall carry in their vehicles a fire extinguisher, flapper, and shovel. Tools shall also be maintained at the designated locations described below. The contractor's water truck will be made immediately available to firefighters when a fire is detected.

4.2.1. Fire Tools

Construction Contractor(s) shall furnish fire tools to equip all of the personnel employed at each work site. Once construction is completed, Auwahi Wind Energy will be responsible for supplying tools for the life of the wind farm. During construction, fire tools shall be in serviceable condition and kept in two storage sheds at the wind farm site, one shed at the top (north end) and one at the bottom (south end) of the turbines. These locations may be adjusted at the discretion of Auwahi Wind Energy. The sheds may be used for other purposes as well. The door of the sheds shall be marked "Fire Tools" with letters at least 75 mm (3 in) high. A list of the fire tools contained in the sheds shall be posted on the inside of the door so it is visible when opened. The sheds shall be locked to prevent theft. Auwahi Wind Energy shall ensure that every employee or contractor has a key to the sheds or has access to a location on the wind turbine site where a key is kept. The sheds shall contain the numbers and types of tools in table 4.

In addition, for the duration of construction, one fire toolbox shall be maintained on each conductor pulling/tensioner machine used for the construction of the generator tie-line, at each turbine site during its installment, and near the pinch point. Toolboxes shall be marked "Fire Tools" with letters at least 75 mm (3 in) high. A list of the fire tools contained in the tool box shall be posted on the inside each box so it is visible when opened. The boxes shall contain the numbers and types of tools in table 4. The boxes at the turbine sites shall be locked and every employee or contractor will have a key to the lock or access to a location on the turbine site where a key is kept.

Table 4. Tools required in the fire tools shed and fire tools boxes.

Tool	Sheds	Boxes
Mcleod	2	1
Flapper	4	2
Shovel	4	2
Bastard File	4	2
10 lb. Fire Extinguisher	2	1
5-gallon backpack fire pump (filled with water)	2	1

Fire Extinguishers shall be located inside or immediately adjacent to the toolbox in a safe, readily available area. Fire toolboxes shall be placed at the following locations:

- Each pulling operation.
- Each turbine during its construction/installation.

For the duration of construction, a water/helicopter support location shall be located at the edge of the primary laydown area where it does not interfere with construction. At the discretion of Auwahi Wind Energy, a minimum of 100 gal (378 l) of water and four backpack pumps OR a helicopter water bucket with a minimum capacity of 50 gal (189 l) will be positioned at the water/helicopter support location. If a helicopter bucket is chosen, the water/helicopter support location shall be large enough to land a light lift helicopter (20 m (65 ft) diameter) and accessible to vehicles.

4.2.2. Fire Extinguishers and Equipment on Trucks, Tractors, etc.

In addition to the tools and fire extinguishers required in 4.2.1, each grader, truck, and/or tractor, shall be provided with chemical fire extinguishers meeting one of the following specifications:

- 1 each – 1.1 kilogram (kg) (2.5 pound (lb)) size or larger extinguisher of dry chemical type, or
- 1 each – 1.8 kg (4 lb) size or larger extinguisher of the carbon dioxide type.

All fire extinguishers required by this FMP will be tested at least once annually.

4.3.Fire Fighting Command and Control

Larger fires will require the assistance of County and State firefighters. Once County and State firefighters are in place, Ulupalakua Ranch firefighters will turn over fire fighting duties to them. It may be helpful to have a knowledgeable Ulupalakua Ranch employee present at the State or County Incident Command Post to help provide the Incident Commander (IC) with information about important resources to be protected, water and roads available, and other facts.

4.4.Contact Info

The following key individuals may be contacted during a fire fighting operations, during construction operations, or at other times to discuss fire related issues. Except during fires, individuals should contact Ulupalakua Ranch prior to reaching out to State or County fire departments.

This contact information will be updated once monthly during construction and a minimum of once per year after construction is completed. Contact information will also be updated prior to annual maintenance activities to ensure the viability of contact information for key personnel and designated firepersons.

Table 5. Firefighting agencies and individuals. Report all fires to 911 first. All area codes are 808.

Name	Agency/Company	Work Phone	Mobile Phone	Firefighting Resources Available
	DOFAW	984-8100		Personnel, Engines, Dozers, Helicopters
Ray Skelton	Goodfellow Brothers	879-7708	268-8153	Dozers
	Kula Fire Department	876-0044		Personnel, Engines
Al Duarte	Maui County Wildland Fire Crew	224-6400		Personnel, Engines
	NARS	873-3506		None
Bill Evanson	NARS	264-9325		None
Sumner Erdman	Ulupalakua Ranch	878-1202	280-0840	Personnel
Kaimi Konaaihele	Ulupalakua Ranch	878-1202	357-0082	Personnel
Jimmy Gomes	Ulupalakua Ranch	878-1202	268-8062	Personnel
	Wailea Fire Department	874-8520		Personnel, Engines

4.5.Maui Fire Fighting Resources

Wildland fire fighting duties on Maui depend on the location of the fire, but typically are the responsibility of the Maui County Fire Department and the State DLNR. Between these agencies, a full suite of fire fighting personnel and apparatus are available, including heavy machinery (dozers and graders) and helicopter support. Contact information is identified in Table 5 above.

4.6.Water Sources

Ulupalakua Ranch has a substantial water infrastructure that can support fire fighting operations. Throughout the ranch property there are numerous water tanks that are used to supply livestock with fresh water. Many of these tanks hold less than 10,000 gallons and may not support certain firefighting tactics, though any water source is potentially useful during a wildfire. There are a number that are over 10,000 gal (37,854 l), most of which can be used to pump water from and a few of which may be used as dip tanks. Figure 10 shows the location of the water sources in relation to areas that will be developed for the Auwahi Wind Farm. Near the wind farm site are a number of tanks that hold less than 10,000 gal (37,854 l) of water and may be useful for firefighters on the ground. Along the eastern leg of the generator tie-line there are few water tanks and no water tanks within 1.6 km (1 mi) of the pinch point. The western leg of the generator tie-line passes near a number of water tanks, two of which have a 10,000 gal (37,854 l) capacity. The interconnection substation location is near a single tank with a capacity of 10,000 gal (37,854 l).

4.7.Safety

Any fire fighting that is carried out by private resources (Ulupalakua Ranch and/or Auwahi Wind Energy) shall utilize the ICS with a single Incident Commander (IC), usually the most experienced person, and a hierarchical command system. Ulupalakua Ranch personnel shall take command of any fire on which they are present until relieved by County or State firefighters.

Personnel fighting fires shall ensure they have at least one escape route and a safety zone. Human safety is the top priority in every fire suppression operation. Ranch and wind farm employees should keep in mind that they are not professional firefighters and will retreat from any fire which they feel poses a substantial threat to their safety.

5. Post Fire Actions

5.1.Infrastructure Inspection

After every fire, an inspection of all wind farm infrastructure within the burn area shall be executed. All ignition producing deficiencies shall be immediately rectified.

5.2.Ignition Source Identification

Immediately following the cessation of fire fighting activities, an effort will be made by Ulupalakua Ranch, Auwahi Wind Energy, and, if present, an individual identified by the State or County IC to identify the fire's ignition source. Each fire's ignition source will be documented including the reasoning that led to the identification of the ignition source. Some fires may have multiple possible ignition sources and these will be noted. This need not be a formal investigation and will only be utilized to better protect resources, including wind farm infrastructure, from future fires. The report shall be kept on file by Auwahi Wind Energy as part of the post-fire report (see 5.3).

5.3.Post-Fire Reports

After every fire, Auwahi Wind Energy will write a short narrative of the fire. The report will include the following information at a minimum:

- Date fire reported
- Time fire reported
- Description of fire location and/or lat/long. Include a simple map (write on a printed image from Google maps or other web-based mapping application)
- Estimated acres burned
- Suspected ignition source

A copy of the report will be supplied to Ulupalakua Ranch.

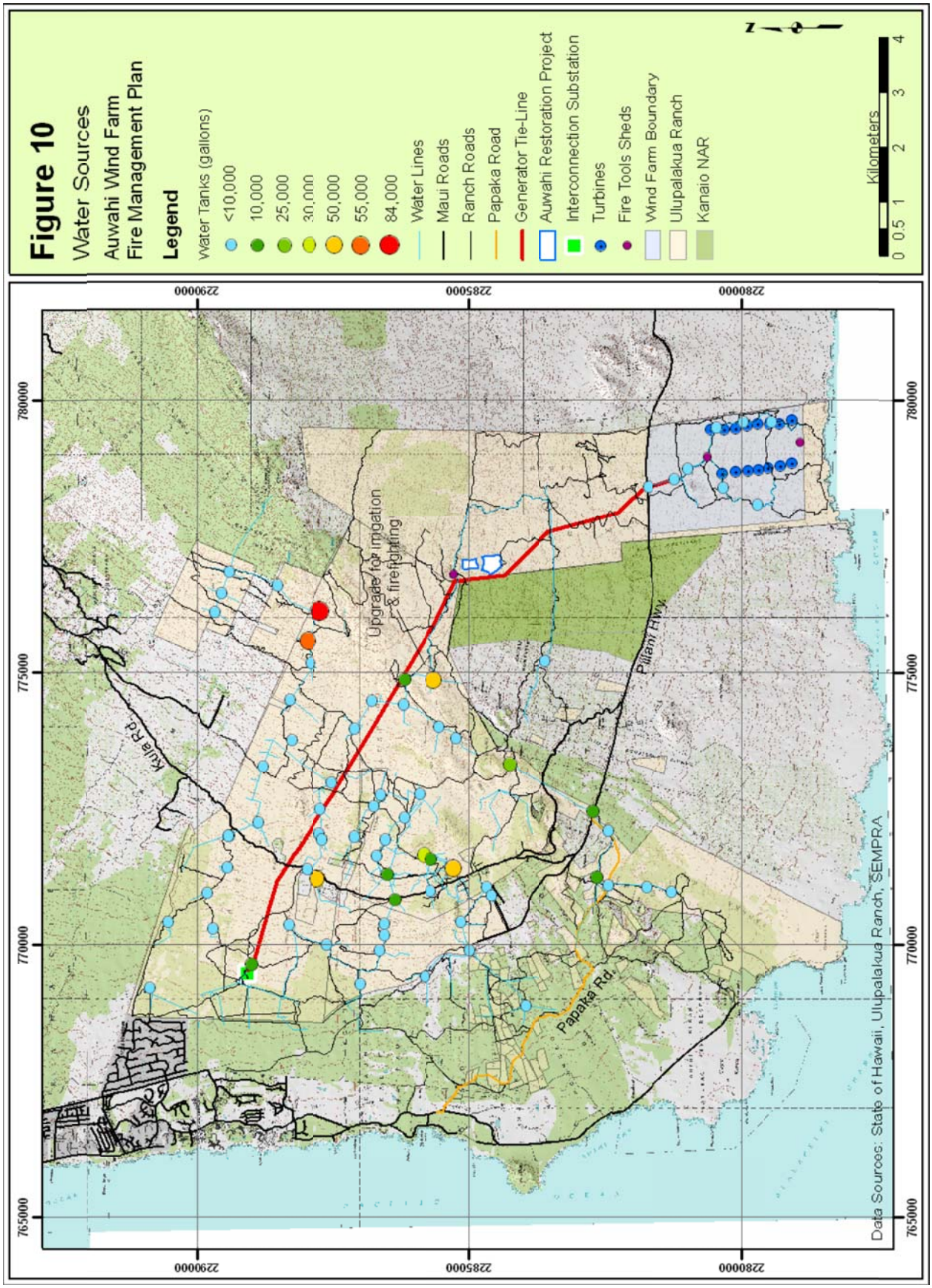


Figure 10
Water Sources
Auwahi Wind Farm
Fire Management Plan
Legend
Water Tanks (gallons)
<10,000
10,000
25,000
30,000
50,000
55,000
84,000
Water Lines
Maui Roads
Ranch Roads
Papaka Road
Generator Tie-Line
Auwahi Restoration Project
Interconnection Substation
Turbines
Fire Tools Sheds
Wind Farm Boundary
Ulupalakua Ranch
Kanaio NAR
Kilometers
0 0.5 1 2 3 4
N
Upgrade for irrigation & firefighting
Kula Rd.
Piilani Hwy.
Papaka Rd.
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA
765000
770000
775000
780000
228000
228500
229000

6. References

Auwahi Restoration Reserve (ARR) (2010) Available at: http://www.auwahi.org/

Blackmore, M. and P.M. Vitousek. 2000. Cattle Grazing, Forest Loss, and Fuel Loading in a Dry Forest Ecosystem at Pu`u Wa`aWa`a Ranch, Hawai`i. Biotropica 32(4a): 625-632.

CFPA. 2010. Wind turbines and fire protection guideline. Confederation of Fire Protection Associations in Europe. CFPA-E 22:2010.

Erdman, S. (2010) Personal Communication.

Leeward Haleakalā Watershed Restoration Partnership (LHWRP) (2010) available at: http://www.lhwrp.org/

Medeiros, A.C., L.L. Loope, and C.G. Chimera. 1993. Kanaio Natural Area Reserve Biological Inventory and Management Recommendations. Natural Area Reserve System State of Hawai`i.

Medeiros, A.C. and E. vonAllmen. 2006. Restoration of Native Hawaiian Dryland Forest at Auwahi, Maui. USGS FS 2006-3035.

IEEE (Institute of Electrical and Electronic Engineers). 2010. Wind farm electrical systems. Power Point Presentation available at www.ieee.org.

Ulupalakua Ranch (UR) (2010) Available at: http://www.UlupalakuaRanch.com.

Appendix 1 - Generator tie-line Fire Probability Calculations

Inputs

***Historic fire occurrence data from DLNR*.**
Stripped 1975 through 1981 out of the database because of the appearance of incomplete recording.

There were 82 fires over 29 years.
The maximum number of fires in a given year is 7 fires in 2010
The minimum number of fires in a given year is 0 fires in multiple years.

***Miles of electrical line from MECO*.**
Generator tie-line (T-line) has been measured. MECO is in the process of measuring primary and secondary distribution line (D-line). They suggested estimates of 2 x miles of T-line as an estimate for miles of primary D-line and said there was 'exponentially' more miles of secondary D-line. To develop a conservative estimate of miles of electrical line, I assumed secondary D-line to be 10 times the miles of T-line. The proposed Auwahi T-line is 9 miles.

234.75 miles of T-line
469.5 miles of primary D-line
2347.5 miles of secondary D-line
3051.75 total miles of MECO electrical line
3060.75 total miles of MECO electrical line plus Auwahi T-line mileage

***Duration of the Auwahi Wind Farm from Tetra Tech*.**
Minimum lifetime is roughly 25 years. For these calculations the lifetime of the project is assumed to be 50 years.

Calculations

Probability of a fire occurring anywhere within the electrical system in any given year:

1 - (prob of no fire). In 29 years, there were 3 years with no fire. So, prob of no fire = 3/29 = 0 .1034.

Prob of a fire somewhere within the electrical system over the lifetime of the Auwahi Wind Farm project:

1 - (prob of no fire)^50 = 1 - (.1034^50) = ~1 (e.g. nearly 100%).

Prob of a fire along the 9 miles of T-line associated with the Auwahi Wind Farm Project in the next 50 years = prob of fire somewhere within the electrical system * (number of miles of Auwahi T-line / total number of miles of electrical line):

1 * (9/3060.75) = 0.0029 (e.g. 0.29%)

Assumptions

1. This accounts for fires started during the operation of the T-line **only.** Other potential fire sources are construction activities and operation of the wind turbines.
2. Miles of line of electrical line is unchanged from 1982. This is obviously incorrect, but these calculations underestimate the miles of secondary D-line (10x rather than 'exponentially more'), and thus the total mileage, to help account for this.
3. The fire records record all fires that have occurred. There have likely been some fires that were never recorded, particularly in the 80's and early 90's.
4. There is no difference in the probability of a fire start from a T-line as compared to a D-line (there is anecdotal evidence that D-lines produce more fires).
5. There is no trend in fire occurrence in the historical record.
6. There will be no increase in fire occurrence in the future as a result of climate change.

Appendix B
Jurisdictional Waters Considerations

Auwahi Windfarm Project
Jurisdictional Waters Considerations

Eric Guinther, AECOS Consultants May 20, 2010

Jurisdictional Waters or so–called "Waters of the U.S." are aquatic features (streams, lakes, wetlands, seas, and oceans) within the jurisdiction of the United States of America, authority over which is granted to the Department of the Army, Army Corps of Engineers (USACE) by Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act of 1972. The Rivers and Harbors Act grants permit authority for certain activities in all tidal waters (coastal waters subject to the tide) and other navigable waters. USACE jurisdiction was greatly extended by the Clean Water Act to include all waters of the U.S. within certain defined limits and including many features not navigable in fact (such as wetlands and small perennial or even intermittent streams). These limits were more carefully defined after Rapanos[1] as detailed in Grumbles & Woodley (2008).

Owing to the relatively recent lava flows and generally dry climate that characterize the southwest rift zone of East Maui Mountain below 4000 ft (1220 m), flowing streams, natural ponds, and wetlands are absent, with but a very few exceptions. These exceptions are all located close to the coastline where either tidal flooding occurs or the basal water table is exposed by depressions in the ground surface (fish ponds and anchialine features). Inland and upslope, above a few meters elevation, and therefore in all of the areas potentially impacted by the Auwahi Windfarm Project (including the windfarm site, construction access roads, and electrical transmission lines), occurrences of surface water are limited to manmade ranch watering structures and infrequent surface flows occurring during heavy rains. Even where the climate is somewhat wetter far upslope—at and above the highest point reached by the transmission line—atmospheric moisture is delivered as cloud drip and does not generate surface water flows.

The land in the project area shows some weathering, with evidence of surface flow within swales that extend to the coast. The USGS topographic map (Makena Quadrangle) shows only a single intermittent stream in the area. This unnamed "stream" is indicated as arising around the 3200-ft (975-m) elevation and descending to the coast east of Kanaloa. The feature appears to be following along the eastern edge of the lava flow dated 3000 to 5000

[1] U.S. Supreme Court's decision in the consolidated cases Rapanos v. United States and Carabell v. United States.

years before present (BP) on the much older surface of the mountain dated at between 13,000 and 50,000 years BP (Sherrod, et al., 2007). On May 17, 2010, this "stream" was visited in the area where it crosses Pi'ilani Highway, but which of several swales in this area was the stream could not be determined. The most likely swale (lowest apparent dip in the road) was photographed (Fig. 1).

Swale suspected to represent USGS intermittent stream near Kanaio/Auwahi boundary looking upslope from Pi'ilani Highway (May 2010).

This feature is located on the site property, but in an area (western edge) where no project elements would be located. This feature, like several other gullies and swales on the project parcel, carries water only during exceptional storms, with flow ceasing soon after the rainfall quits. While it is possible that rainstorms of sufficient strength occur at least once each year, it is also the case that owing to drought cycles, flow in these tributaries may be absent for several years running. This feature is defined as a non-navigable tributary that is not relatively permanent, and thus requiring a determination that a significant nexus with a traditional navigable water exists (Grumbles & Woodley, 2008). Or it, and certainly all other swales on the property, are swales or erosional features characterized by low volume, infrequent, or short duration flow and not jurisdictional. Final determination rests with the local District Engineer. In my judgment, no aquatic features within the definitions of wetlands and streams subject to USACE jurisdiction are present on the project property or vicinity, and certainly none would be impacted by the proposed project.

References Cited

Grumbles, B. H., and J. P. Woodley, Jr. 2008. Clean Water Act jurisdiction following the U. S. Supreme Court's decision in *Rapanos v. United States* & *Carabell v. United States*. Issued by USEPA & USACOE. 13 pp.

Sherrod, D. R., J. M. Sinton, S. E. Watkins, and K. M. Brunt. 2007. Geologic map of the State of Hawai'i, Sheet 7—Island of Maui. U.S. Geological Survey, Open-File Report 2007-1089. Sheet 7 of 8. Available at URL: http://pubs.usgs.gov/of/2007/1089/Maui_2007.pdf; Last viewed May 11, 2010.

Appendix C
Preliminary Drainage Report and Hydrogeology and Water Well Development Report

RMT

• ENVIRONMENT • ENERGY • ENGINEERING

Preliminary Drainage Report

Auwahi Wind Farm
Maui County, Hawaii

January 2011

CREATING BALANCE℠

• ENVIRONMENT • ENERGY • ENGINEERING

Preliminary Drainage Report

Auwahi Wind Farm

Maui County, Hawaii

January 2011

Prepared For
Auwahi Wind Farm, LLC

BRIAN S. SEDGWICK
LICENSED PROFESSIONAL ENGINEER
No. 13899-C
HAWAII U.S.A.
1/28/11

Brian Sedgwick, PE
Civil Engineer

Nate Viste, P.E. - CA
Civil Engineer

Joel Schittone, P.E. - WI
Project Manager

© 2011 RMT, Inc.
All Rights Reserved

744 Heartland Trail (53717-1982) • PO Box 8923 (53708-8923) • Madison, WI • (608) 831-4444 • (608) 831-3334 FAX • www.rmtinc.com

CREATING BALANCE℠

Table of Contents

Section 1 Introduction 1
1.1 Background 1
1.2 Location 1
1.3 Purpose and Scope 2

Section 2 Existing Conditions 3
2.1 Vegetation and Site Soil Conditions 3
2.1.1 Wind Farm Site 3
2.1.2 Interconnection Substation and Interconnection Substation Access Road 3
2.1.3 Pāpaka Access Road 3
2.2 Mapping and Topography 4
2.3 Regional Watersheds 4
2.4 Groundwater 4

Section 3 Developed Conditions 5
3.1 Wind Farm Site 5
3.2 Interconnection Substation, Interconnection Substation Access Road, and Transmission Line 5
3.3 Pāpaka Access Road 6

Section 4 Stormwater Runoff Modeling 7
4.1 Stormwater Runoff Modeling 7
4.2 Hydrologic Modeling of Basins Greater Than 100 Acres 7
4.3 Hydrologic Modeling of Basins Less Than 100 Acres 8
4.4 Hydraulic Modeling 9
4.4.1 Culverts 9
4.4.2 Retention Basins 10

Section 5 Conclusions and Recommendations 12
5.1 Conclusions 12
5.2 Recommendations 13

Section 6 References 14

List of Tables

Table 1 Basin Peak Flow Rate Comparison
Table 2 Modeling Parameters
Table 3 Preliminary Culvert Schedule

List of Figures

Figure 1 Site Plan
Figure 2 Existing Soil and Vegetation
Figure 3 Existing Conditions Wind Farm Site
Figure 4 Existing Conditions Interconnection Substation
Figure 5 Existing Conditions Pāpaka Access Road
Figure 6 Regional Watersheds and Aquifers
Figure 7 Wind Farm Site Layout
Figure 8 Developed Conditions Wind Farm Site
Figure 9 Developed Conditions Interconnections Substation

List of Appendices

Appendix A The Rules for the Design of Storm Drainage Facilities in the County of Maui
Appendix B Photos – Typical Existing Conditions
Appendix C HydroCAD Model Output Information
Appendix D NOAA Point Precipitation Frequency Estimates
Appendix E HY8 Culvert Modeling

Section 1
Introduction

1.1 Background

Auwahi Wind Energy, LLC (Auwahi Wind), a wholly owned subsidiary of Sempra Generation, proposes to construct and operate a wind farm with a net generating capacity of 21 megawatts (MW), augmented with a battery energy storage system (BESS), on the island of Maui, Hawaii. In addition to the wind turbine generators (WTG) and the BESS, the proposed Auwahi Wind Farm Project (Project) would include an underground electrical collection system, a collector switchyard, an operations and maintenance (O&M) facility, an approximately 9-mile 34.5-kilovolt (kV) Transmission Line, an interconnection substation, and a four mile improved access road referred to as Pāpaka Road as shown in Figure 1 - Site Plan. The proposed Project is expected to be operational in December 2012. This Preliminary Hydrologic Assessment Report was prepared pursuant to Title MC-15, County of Maui, *The Rules for the Design of Storm Drainage Facilities in the County of Maui* (Appendix A).

Development of the Project was originally proposed by Shell Wind Energy, Inc. (SWE). SWE signed a 25-year property lease agreement with ʻUlupalakua Ranch in 2006, securing the Auwahi parcel for construction and operation of the proposed Project. Auwahi Wind was purchased from SWE in October 2009. Sempra Generation is a subsidiary of Sempra Energy, a Fortune 500 energy services holding company based in San Diego, California. Sempra Generation acquires and develops power plants and renewable energy projects that generate electricity for the competitive market. Sempra Generation has more than 2,700 MW of generating capacity in operation including natural gas, wind, and solar photovoltaic projects.

1.2 Location

The proposed Project, located almost entirely on ʻUlupalakua Ranch, approximately 10 miles south of Kula, in the Hāna District of Maui, consists of three major components: the wind farm site, a transmission line corridor with an interconnection substation, and improved pastoral roads for turbine delivery referred to as Pāpaka Road. Project infrastructure is illustrated on Figure 1 - Site Plan.

The wind farm site is located on the Auwahi parcel of ʻUlupalakua Ranch that is bordered by the Pacific Ocean to the south and Piilani Highway to north. State-owned undeveloped lands are adjacent to the west and east of the wind farm site. As shown in Figure 1, the proposed Project would be located within the southern portion of the parcel, with the northern edge of the site defined by Piilani Highway and the southern edge located more than 1,000 feet from the shoreline. The primary construction access route to the wind farm site consists of existing state and county highways as well as approximately 4 miles of improved pastoral roads between

Makena Road and Piilani Highway. These pastoral roads are collectively referred to as Pāpaka Road, and are located on ʻUlupalakua Ranch and several other private and publicly owned parcels.

1.3 Purpose and Scope

The purpose of this report is to complete the preliminary hydrologic and hydraulic assessment of the project site.

The scope of this report includes the following:

- Description of existing and developed hydrologic conditions
- Preliminary stormwater runoff modeling of existing and developed conditions
- Preliminary design of hydraulic drainage features.

Section 2
Existing Conditions

2.1 Vegetation and Site Soil Conditions

Figure 2 – Existing Soil and Vegetation illustrates the existing vegetation and surficial soil conditions for the Project. Information contained on this figure was collected from the United States Geological Service and Hawaii Geographic Approach to Planning (GAP) Program, a program to promote conservation by providing broad geographic information on biological diversity to resource managers, planners, and policy makers who can use the information to make informed decisions. Representative photographs of typical existing conditions, obtained during November 2010 site visit, are presented in Appendix B.

2.1.1 Wind Farm Site

Drainage areas located within the wind farm site are comprised mainly of extremely stony pasture land consisting of recent basalt lava flows of the Hana Volcanic series (Black and Veatch 2008). The wind farm site is dominated by non-native shrubs and other short woody plants, with occasional pockets of grassland or barren land. The upper regions of the drainage areas are mainly grasslands and native shrubs (Tetra Tech 2011). Soils in upper regions consist of very stony silt loam and very to extremely stony sandy loam. Lower regions of the wind farm site are primarily very to extremely stony sandy loam. Just north of the Hokukano Pu'u, the location of the O&M Building/Collector Switchyard/Laydown Area, alluvial deposits exist to a depth of 5 feet of sandy silt with cobbles (Black and Veatch 2008). See Figure 3 for basins modeled for existing conditions.

2.1.2 Interconnection Substation and Interconnection Substation Access Road

Drainage areas located within the interconnection substation and associated access roads are primarily grasslands and pasture land for grazing cattle (Tetra Tech 2011). Soils are loams to very stony silt loam, (USGS). See Figure 4 for basins modeled for existing conditions.

2.1.3 Pāpaka Access Road

Drainage areas around Pāpaka Road are primarily pastureland containing shrubs and grassland. Soils range between extremely stony silt loam, rocky loam, extremely stony fine sandy loam, to silt loam. See Figure 5 for basins modeled for existing conditions.

2.2 Mapping and Topography

An aerial survey of project infrastructure was conducted by Aerometric in December of 2007. The accuracy of the survey reported per the national Standard for Spatial Data Accuracy for the horizontal axis should not exceed 3.84-foot and for the vertical axis, 1.96-foot at 95% confidence level. Where this flight data was not available for upper regions of watersheds, the best publically available data was utilized to identify drainage areas.

The Project lies within geologically young terrain that features very rough stony features that are difficult to map and have not been weathered to a large extent. Existing flow lines are typically not definable and can begin and end as well as shift locations for no definitive reason. The majority of infrastructure is in areas of sheet flow to shallow flow with difficult to define drainage basins. RMT used engineering judgment to identify both drainage basin extents and alignments of flow lines.

2.3 Regional Watersheds

The wind farm site infrastructure is located in two watersheds; Kanai'o on the westerly half of the site and the Kipapa on the easterly half of the site. The transmission line spans the Kanaiʻo and Wailea watersheds, with the boundary located along the southwest rift zone. Pāpaka Road spans several regional watersheds; the Kanaiʻo, Ahihi Kinau, Moʻoloa and Wailea. Refer to Figure 6 – Regional Watersheds and Aquifers for regional watershed locations.

2.4 Groundwater

The Project is located in the Lualailua hydrologic subunit of the Kahikinui hydrologic unit and has a sustainable yield of 11 million gallons per day (MGD) (CWRM 2011). The transmission line and Pāpaka Road both cross into the Kamaole subunit of the Central hydrologic unit, and has a sustainable yield of 11 MGD (CWRM 2011). Groundwater was not encountered in borings conducted during the preliminary soil investigation by Black and Veatch in 2008. The ground borings ranged between 32 to 42 feet in depth. Refer to Figure 6 – Regional Watersheds and Aquifers for hydrologic unit locations.

Section 3
Developed Conditions

The Project development will be graded to maintain existing watersheds and flow lines. Linear features such as access roads will match existing grade where possible to maintain existing flow patterns to the greatest extent practicable. Figure 1- Site Plan identifies locations of developed site infrastructure.

3.1 Wind Farm Site

The developed conditions for the wind farm site, as illustrated in Figure 7 –Wind Farm Site Layout and Figure 8 – Developed Conditions Wind Farm Site, consist of an impervious operations and maintenance building (O&M building), a semi-impervious collector switchyard, semi-impervious aggregate access roads, meteorological (MET) tower, and impervious wind turbine generators (WTGs). The existing site primarily consists of sheet flow and shallow concentrated flow, with intermittent channels that are typically lava flow features. The Project development will be graded to maintain existing watersheds and existing grades to the greatest extent practicable. Impervious areas are minimal; areas modeled as impervious include the WTGs, and the O&M building. Access roads and the collector switchyard are modeled as compacted aggregate base. An underground electrical collection system will also be part of the site infrastructure but was not modeled since it will be physically below existing grade.

3.2 Interconnection Substation, Interconnection Substation Access Road, and Transmission Line

The interconnection substation is the point of interconnection to Maui Electric Company's (MECO's) existing 69-kV Transmission Line. A semi-impervious gravel access road will be constructed for access to the interconnection substation. The interconnection substation consists of various electrical equipment, including main power transformers, and is modeled as semi-impervious gravel. Impervious areas within the interconnection substation were also included, such as the battery energy storage system (BESS) building and the control building. Off-site runoff will be diverted around the interconnection substation, and will stay within the same watershed. A proposed retention basin is located just west of the interconnection substation to hold the increased stormwater runoff from the interconnection substation. See Figure 9 – Developed Conditions Interconnection Substation for proposed developed conditions and areas modeled that would be considered to have an effect on the existing peak flow.

An overhead collector line, referred to as the transmission line, runs from the collector switchyard to the interconnection substation. The transmission line pole structures are

considered not to have an effect on stormwater runoff in regards to its surrounding due their minimal footprint.

3.3 Pāpaka Access Road

Existing pastoral roads will be improved to provide access for the delivery of WTG components to the Project site. The access road will be constructed at existing grade to minimize its impact on site hydrology, and will be constructed of native crushed aggregate. Since the road is a linear feature, with an alignment following existing pastoral roads, and will be constructed at grade, the impact from Existing to Developed peak flows for the respective basins are minimal and are considered to have no discernable effect on stormwater runoff from the site. At locations of major wash crossings, the peak flow has been modeled for hydraulic design of culverts that will convey flow underneath the road. Three locations have been identified and are illustrated on Figure 5 – Existing Conditions Pāpaka Road.

Section 4
Stormwater Runoff Modeling

4.1 Stormwater Runoff Modeling

Stormwater runoff was modeled by the Rational Method for watersheds less than 100 acres, and the Natural Resource Conservation Service's (NRCS's) Method for basins greater than 100 acres per the *Rules for the Design of Storm Drainage Facilities in the County of Maui.*

4.2 Hydrologic Modeling of Basins Greater Than 100 Acres

The NRCS Unit Hydrograph method was used to simulate the stormwater runoff of a 100-year 24-hour storm event for drainage areas greater than 100 acres. HydroCAD is a computer-aided design program for modeling hydrology and hydraulics of stormwater runoff for the NRCS Unit Hydrograph Method. The peak flow and volume of stormwater runoff contained within the hydrograph can be utilized for hydraulic computations. HydroCAD models stormwater runoff in relation to time in the form of a hydrograph. See Appendix C for HydroCAD output, Table 1 for comparison of existing versus developed flows, and Table 2 for modeling parameters.

Existing information on the physical characteristics and soil properties at the site was determined and incorporated into the HydroCAD rainfall-runoff model to estimate the peak flow of stormwater runoff for a 100-year 24-hour storm event. The following inputs/assumptions were used for the stormwater runoff model (refer to Table 2 for summary of modeling input):

- Drainage areas were determined using a combination of the best available topographic data for the areas evaluated.
- The 100-year, 24-hour storm event was modeled utilizing the NRCS Rainfall Distribution. Point precipitation for a 100-year rainfall event was collected from National Oceanic and Atmospheric Association (NOAA) Atlas 14 (Appendix D). Three different point precipitations were used for modeling based on three main areas of the site:
    - Pāpaka Access Road: 100-year, 24-hr rainfall = 10.06 inches
    - Wind Farm Site : 100-year, 24-hr rainfall = 10.74 inches
    - Interconnection Substation: 100-year, 24-hr rainfall = 9.71 inches
- Curve numbers (CN) were identified based on existing and developed conditions, as described in Sections 2 and 3. Curve numbers were assigned based on hydrologic soil group and land use classification. A study establishing Curve Numbers in the Pearl

Harbor-Honolulu Basin on the regional island of Oahu (Giambelluca 1983) was referenced for this site along with runoff curve numbers from NRCS TR-55 as follows:

	Hydrologic Soil Group			
Land Use Classification	**A**	**B**	**C**	**D**
From Regional Curve Numbers (Giambelluca 1983)				
Forest/grazing/vacant	36	60	73	79
From NRCS TR-55				
Impervious Areas	98	98	98	98
Streets and Roads: Gravel	76	85	89	91

- The antecedent moisture constant (AMC) was assumed to be 2, normal conditions.
- The time of concentration (Tc) was estimated using the Velocity Method (NRCS 2010). Sheet flow was modeled for the first 100 feet of watershed, followed by shallow flow for the remaining length of the watershed. Due to rocky terrain in many areas of the site, flow lines are not discernable or intermittent, for this reason Shallow Flow was generally assumed. In some locations channel flow was calculated if identifiable.
- This hydrologic assessment report was based on preliminary infrastructure design, thus the following assumptions were made:
  - For developed conditions, linear features such as access roads do not alter the existing drainage areas.
  - WTGs and the O&M building were assumed impervious.
  - Switchyard, Access Roads, and Interconnection Substation used CN values for gravel.

4.3 Hydrologic Modeling of Basins Less Than 100 Acres

Stormwater modeling of basins less than 100 acres was performed for a 50-year storm using the Rational Method, based on *Rules for the Design of Storm Drainage Facilities in the County of Maui*.

The Rational Method predicts the peak runoff according to the formula: Q = C*i*A where:

Q = peak flowrate in cubic feet per second (cfs)
C = runoff coefficient
i = rainfall intensity in inches per hour
A = watershed area in acres

The Rational Method assumes that runoff begins at the start of the storm and increases linearly to the peak value. The peak runoff is sustained until the event duration has elapsed, and then decreases linearly to zero. The critical duration is set equal to the time of concentration (Tc) for each drainage area, and is used to determine the intensity of rainfall based on Intensity-Duration-Frequency (IDF) data from the NOAA's Point Precipitation – Frequency Atlas 14 of the United States. Rainfall intensity is assumed constant throughout the storm event and spatially uniform.

Runoff coefficients were determined based on Tables 1 and 2 in the *Rules for the Design of Storm Drainage Facilities in the County of Maui*. Runoff coefficients chosen for modeling are as follows:

- Unimproved Areas: 0.30
- Drive and walks: 0.85
- Roofs: 0.95
- Streets: Asphaltic .95

An area-weighted average of the of the runoff coefficients for the site was calculated and used in the Rational Method equation for the (C) value.

The rainfall duration for the 50-year storm event was set equal to each watershed's time of concentration. Time of concentration was determined in accordance with Plate 3 located in the *Rules for the Design of Storm Drainage Facilities in the County of Maui.* Due to the majority of areas being rocky and/or well vegetated, the Well Forested Areas on Plate 3 was used to establish Tc.

4.4 Hydraulic Modeling

Hydraulic features were designed per the *Rules for the Design of Storm Drainage Facilities in the County of Maui.*

4.4.1 Culverts

Preliminary culvert locations were identified at Pāpaka Road, on the wind farm site, and at the interconnection substation. Refer to Table 3 – Culvert Schedule for location of culverts. Sizing is preliminary and in accordance with *Rules for the Design of Storm Drainage Facilities in the County of Maui.*

- All culverts were designed to accommodate the flow from a 100-year frequency storm for drainage areas greater than 100 acres and a 50-year frequency storm for drainage areas less than 100 acres. Since these features are not meant for public use a smaller design storm may be more appropriate for sizing culverts for this project. Also, other alternative

crossings, such as at-grade Arizona crossings are another option to use depending on how defined the existing channel is.

The peak flows derived from the hydrologic modeling were used to design the culverts and channels. Culverts were sized using the Federal Highway Administration's HY-8 program (see Appendix E). The following assumptions were used for culvert sizing:

- Culvert's Manning's coefficient assumed to be 0.024, based on corrugated metal pipe (FHWA, 2009)
- Culvert cover = 1 ft of material
- Design flow passes through culvert with no backwater
- Culverts are sloped at 5%

4.4.2 Retention Basins

Wind Farm Site

The wind farm is composed of Hana volcanics, typically A'a lava. The volcanic terrain acts as rip-rap on the wind farm site, which protects against erosion by reducing runoff velocities. Because of these existing conditions, reduced velocity of stormwater runoff, the lack of developed areas downstream, the majority of the ground coverage being a'a lava, and the relative marginal increase in stormwater runoff peak flow and volume; RMT does not believe that a retention basin would be required within the wind farm site. In particular, at the location of the O&M Building/Collector Switchyard/Laydown Area, the difference between existing versus developed peak flows for both drainages are negligible.

Interconnection Substation

RMT recommends a retention basin at the interconnection substation. In that area the soils are less rocky and more susceptible to erosion, there is downstream development, and the calculated increase in stormwater runoff volume due to the proposed development is relatively larger.

On-site runoff is collected east of and adjacent to the interconnection substation, Drainage Basin C-2, see Appendix C. Retention basin volumes are based on a recurrence interval of 50 years for a 1 hour storm for drainage areas less than 100 acres per the *Rules for the Design of Storm Drainage Facilities in the County of Maui*. The interconnection substation retention basin should hold the following volume based on a 50-year, 1-hour storm:

- Existing Runoff Volume = 0.343 acre-ft
- Developed Runoff Volume= 0.553 acre-ft
- Increase in Runoff Volume = Developed – Existing = **0.21 acre-ft**

Section 5
Conclusions and Recommendations

5.1 Conclusions

Increase in peak flow of stormwater runoff from existing to developed conditions is minimal for this project relative to the size of the watersheds, see Table 1. The relative increase in peak flow ranges from 0.3 cfs to 11.6 cfs. Table 2 lists modeling parameters and the design storm utilized to compare existing and developed stormwater runoff.

The wind farm site primarily consists of recent basalt flows of the Hana Volcanic series, which is extremely rough terrain that will decrease the velocity of stormwater runoff during a storm event. The rocky terrain acts like armoring, minimizing the effects of erosive forces. This is reflected in the native topography, where flow lines are intermittent and, in most locations indiscernible, due to the armoring effects of the rocky surface. There is no development downstream of the wind farm project area and the terrain remains rocky until outfall into the ocean. The minimal increase in peak flow and volume of runoff will have a negligible effect on erosive forces relative to existing conditions. Retention basins are not recommended for watersheds at the wind farm site: including Basins A, B, D, E, F, and G.

Soil conditions at the location of the O&M Building/Collector Switchyard/Laydown Area, located within Basins A and B at the northern end of the wind farm site, consist of alluvium. The delta for peak flow for stormwater runoff in these basins relative to existing conditions is within 3.0 cfs. Since the change in peak flow is minimal relative to existing conditions and since the outfall of these basins is extremely rocky, a retention basin is not required.

The increase in peak flow and volume for stormwater runoff at the Interconnection Substation (Basin C) will require a retention basin. The reasons for the detention basin at the Interconnection Substation include the presence of downstream development, and terrain downstream that is less rocky which makes it more susceptible to erosion for increased flows. The Interconnection Substation Access Road follows an existing access road and is considered to have minimal impact to stormwater runoff after development compared to the existing conditions.

Development along Pāpaka Road (Basins I, J, and K) includes linear improvements of existing pastoral roads to allow for the delivery of wind turbine generator components. Existing grades are being maintained and the roads will primarily follow existing pastoral roads. These

improved roads are not expected to have an increase in stormwater runoff peak flow or volume. Culverts will be utilized to reduce maintenance of roadway during storm events.

5.2 Recommendations

Provisions will need to be made to control erosion and protect structures, both during and after construction of the Auwahi Wind Farm facility, particularly conditions resulting from high-intensity, short-duration storm events.

Specific recommendations include the following:

1. During final design, hydrologic watersheds and hydraulic structures should be reevaluated and designed based on proposed grades.
2. Outlet protection should be designed for culverts, retention basins and channels.
3. During final design, a smaller intensity storm such as 10-year event should be considered for the design of culverts meant only for use during construction.
4. During final design the use of earthen channels to convey stormwater runoff and to protect site infrastructure should be evaluated for the following features: Interconnection Substation, O&M Building/Collector Switchyard/Laydown Area, and along access roads.
5. During final design, a retention basin adjacent to the Interconnection Substation should be constructed to have a capacity of 0.21 acres-ft, and provide an outfall that can handle the design storm with 1 ft of free board.

Section 6
References

Black and Veatch 2008. Preliminary Geotechnical Report - Auwahi Wind Farm. February 2008.

Commission on Water Resource Management (CWRM), http://www.state.hi.us/dlnr/cwrm/, information available as of 01/14/11.

Giambelluca, T.W. 1983. Water balance of the Pearl Harbor-Honolulu Basin, Hawaii 1946-1975. Technical Report No.151, Water Resources Research Center, University of Hawaii at Manoa, Honolulu. 151p.

HydroCAD Software Solutions (HydroCAD). 2006. Version 8.0 computer program.

Lau, Stephen and Mink, John. 2006. *Hydrology of the Hawaiian Islands*. Honolulu, HI: Hawaii Press.

Maui County. 1995. Department of Public Works and Waste Management. *Rules for the Design of Storm Drainage Facilities in the County of Maui*. July 14, 1995.

National Oceanic and Atmospheric Administration (NOAA). 2006. NOAA Atlas 14. Point Precipitation- Frequency Atlas of the United States.

Tetra Tech EC, Inc. 2011. Draft Environmental Impact Statement – Auwahi Wind Farm. January 2011.

United States Department of Agriculture, Natural Resources Conservation Service (NRCS). 2002. WinTR-55, Version 1.0 computer program. 19 April 2002.

United States Department of Agriculture, Natural Resources Conservation Service (NRCS). 2004. WinTR-20, Version 1.0 computer program. 23 July 2004.

United States Department of Agriculture, Natural Resources Conservation Service (NRCS). 2010. Part 630 Hydrology, Chapter 15 – Time of Concentration. May 2010.

Table 1
Basin Peak Flow Rate Comparison

Table 2
Modeling Parameters

Table 3
Preliminary Culvert Schedule

TABLE 1
BASIN PEAK FLOW RATE COMPARISION
AUWAHI WIND FARM, MAUI COUNTY, HAWAII

DESIGN POINT	EXISTING PEAK FLOW RATE (CFS)	DEVELOPED PEAK FLOW RATE (CFS)	INCREASE IN PEAK FLOWRATE (CFS)
A	73.2	70.2	-3.0
B	312.6	312.9	0.3
C	79.7	95.2	15.5
D	122.2	125.7	3.5
E	49.6	57.9	8.3
F	303.5	305.0	1.5
G	130.2	133.4	3.3
I	117.0	117.0	0.0
J	167.9	167.9	0.0
K	50.0	50.0	0.0

Notes:
Refer to Figures 3, 4, 5, 8, and 9 for locations of Design Points

Created by: J. Omernik 01/11/11
Checked by: M. Wessale 01/13/2011

© 2009 RMT, Inc. All rights reserved.

TABLE 2
MODELING PARAMETERS
AUWAHI WIND FARM, MAUI COUNTY, HAWAII

	DESIGN POINT	DESCRIPTION	BASINS CONTRIBUTING TO DESIGN POINT	AREA (ACRES)	AREA TYPE A VACANT/GRAZING (CN = 36)	AREA TYPE B VACANT/GRAZING (CN = 60)	AREA TYPE C VACANT/GRAZING (CN = 73)	AREA TYPE A GRAVEL (CN = 76)	AREA TYPE B GRAVEL (CN = 85)	AREA TYPE C GRAVEL (CN = 89)	AREA IMPERVIOUS (CN = 98)	AREA UNIMPROVED (ACRES) (C=.3)	AREA GRAVEL (ACRES) (C=.85)	AREA IMPERVIOUS (ACRES) (C=.95)	WEIGHTED "CN" FOR TR-20 OR "C" FOR RATIONAL	FLOW LENGTH (FT)	ELEV. CHANGE (FT)	SLOPE (FT/FT)	TIME OF CONCENTRATION (MIN)	DESIGN FLOWRATE (CFS)
100-YR 24 HR STORM (NRCS Method)	EXISITNG SITE CONDITIONS																			
	B	Laydown East	B	234.41	0.18	6.10	227.30	0.00	0	0.00	0.83	--	--	--	72.7	10348	1632	0.158	141.4	312.60
	D	Wind Farm	D	141.88	0	132.81	9.07	0	0	0	0	--	--	--	60.8	9052	1190	0.131	173.7	122.20
	F	Wind Farm	F	387.20	0	130.08	255.92	0	0	0.00	1.20	--	--	--	68.7	16210	2393	0.148	288.2	303.49
	G	Wind Farm	G	151.98	0	103.90	47.64	0	0	0.00	0.44	--	--	--	64.2	10750	1434	0.133	203.4	130.17
	I	Papaka Road	I	104.21	0	104.21	0	0	0	0	0	--	--	--	60.0	6228	777	0.125	110.2	116.95
	J	Papaka Road	J	108.10	0	108.1	0	0	0	0	0	--	--	--	60.0	6179	1477	0.239	64.8	167.93
	DEVELOPED SITE CONDITIONS																			
	B	Laydown East	B-1, B-2	235.63	0.40	6.30	227.30	0.00	0.61	0.00	1.02	--	--	--	72.7	10348	1632	0.158	141.4	312.90
		Laydown East Basin B-1	--	232.43	0	4.21	227.30	0	0.09	0.00	0.83	--	--	--	72.9	10348	1632	0.158	141.4	311.24
		Laydown East Basin B-2	--	3.20	0.4	2.08	0	0.00	0.53	0	0.19	--	--	--	63.4	439	15	0.034	27.8	9.03
	D	Wind Farm	D	141.88	0	127.84	9.07	0	4.96	0	0.012	--	--	--	61.7	9052	1190	0.131	173.7	125.70
	F	Wind Farm	F	387.20	0	126.93	255.92	0	3.15	0.00	1.204	--	--	--	68.9	16210	2393	0.148	288.2	304.95
	G	Wind Farm	G	151.98	0	98.15	47.64	0	5.73	0.00	0.46	--	--	--	65.1	10750	1434	0.133	203.4	133.43
50-YR 1-HR STORM (RATIONAL METHOD)	EXISITNG SITE CONDITIONS																			
	A	Laydown West	A	47.17	--	--	--	--	--	--	--	46.62	0	0.55	0.308	3700	506	0.137	16.35	73.22
	C	Interconnect Substation	C	39.54	--	--	--	--	--	--	--	39.54	0	0	0.300	3549	516	0.145	8.87	79.72
	E	Wind Farm	E	33.87	--	--	--	--	--	--	--	33.87	0	0	0.300	4230	610	0.144	17.76	49.62
	K	Papaka Road	K	34.06	--	--	--	--	--	--	--	34.06	0	0	0.300	4747	940	0.198	17.20	50.03
	DEVELOPED SITE CONDITIONS																			
	A	Laydown West	A-1, A-2	45.90	--	--	--	--	--	--	--	43.56	1.79	0.55	0.329	3921.1	523	0.133	--	70.24
		Laydown West Basin A-1	--	40.20	--	--	--	--	--	--	--	38.16	1.49	0.55	0.329	3921.1	523	0.133	17.29	61.06
		Laydown West Basin A-2	--	5.70	--	--	--	--	--	--	--	5.40	0.30	0	0.329	664	28	0.042	5.20	16.05
	C	Interconnect Substation	C-1, C-2	39.54	--	--	--	--	--	--	--	35.69	3.67	0.17	0.354	3576	516	0.144	--	95.23
		Interconnect Substation Basin C-1	--	34.60	--	--	--	--	--	--	--	32.35	2.25	0	0.336	3576	516	0.144	8.95	79.06
		Interconnect Substation Basin C-2	--	4.94	--	--	--	--	--	--	--	3.34	1.43	0.17	0.482	670	134	0.200	2.17	22.3
	E	Wind Farm	E	33.87	--	--	--	--	--	--	--	30.94	2.92	0.01	0.348	4230	610	0.144	17.76	57.89

Notes:

1. Areas, flow lengths, and elevation change measured using GIS software.
2. Curve numbers for vacant/grazing areas from Hydrology of the Hawaiian Islands, Table 7.5.
3. Curver numbers for gravel and impervious areas from SCS TR-55, Table 2-2a.
4. Runoff Coefficients from Maui County Hydrology Manual, Table 2.
5. Time of Concentration for NRCS Method models calculated per the velocity method, USDA - Part 630 Hydrology.
6. Time of Concentration for Rational Method models calculated using Maui County Hydrology Manual, Plate 3.
7. NRCS Method 100-YR 24-HR storm used for areas greater than 100 acres as required in the Maui County Hydrology Manual.
8. Rational Method 50-YR 1-HR storm used for areas smaller than 100 acres as required by the Maui County Hydrology Manual.
9. Design flowrate generated using HydroCAD version 8.0.

Created by: J. Omernik, 01/11/11
Checked by: M. Wessale 01/13/2011

© 2009 RMT, Inc. All rights reserved.

TABLE 3
PRELIMINARY CULVERT SCHEDULE
SEMPRA AUWAHI WIND FARM, MAUI COUNTY, HAWAII

CULVERT ID	DESIGN FLOW (CFS)	NO. OF BARRELS	SIZE (IN)
Culvert B	312.90	1	5'x12' box
Culvert C	79.06	3	36
Culvert C-1	79.06	3	36
Culvert I	116.95	2	48
Culvert J	167.93	3	48
Culvert K	50.03	2	36

Notes:
1. Culvert IDs deteremined by basin location.
2. Design flow is the peak flowrate determined using HydroCAD version 8.0 for both Rational Method and NRCS Hydrograph Method.
3. Culverts sized using the Federal Highway Administration's HY-8 culvert modeling software.
4. Assumptions include - corrugated steel for cirrcular culvert & concrete for box culvert
   - 60 ft culvert length @ 5% slope
   - existing landslope used for downstream conditions
5. Culverts sized to pass entire design flow, i.e. no backwater.

Created by: J. Omernik 01/11/2011
Checked by: M. Wessale 01/13/2011

Figure 1
Site Plan

Figure 2
Existing Soil and Vegetation

Figure 3
Existing Conditions Wind Farm Site

Figure 4
Existing Conditions Interconnection Substation

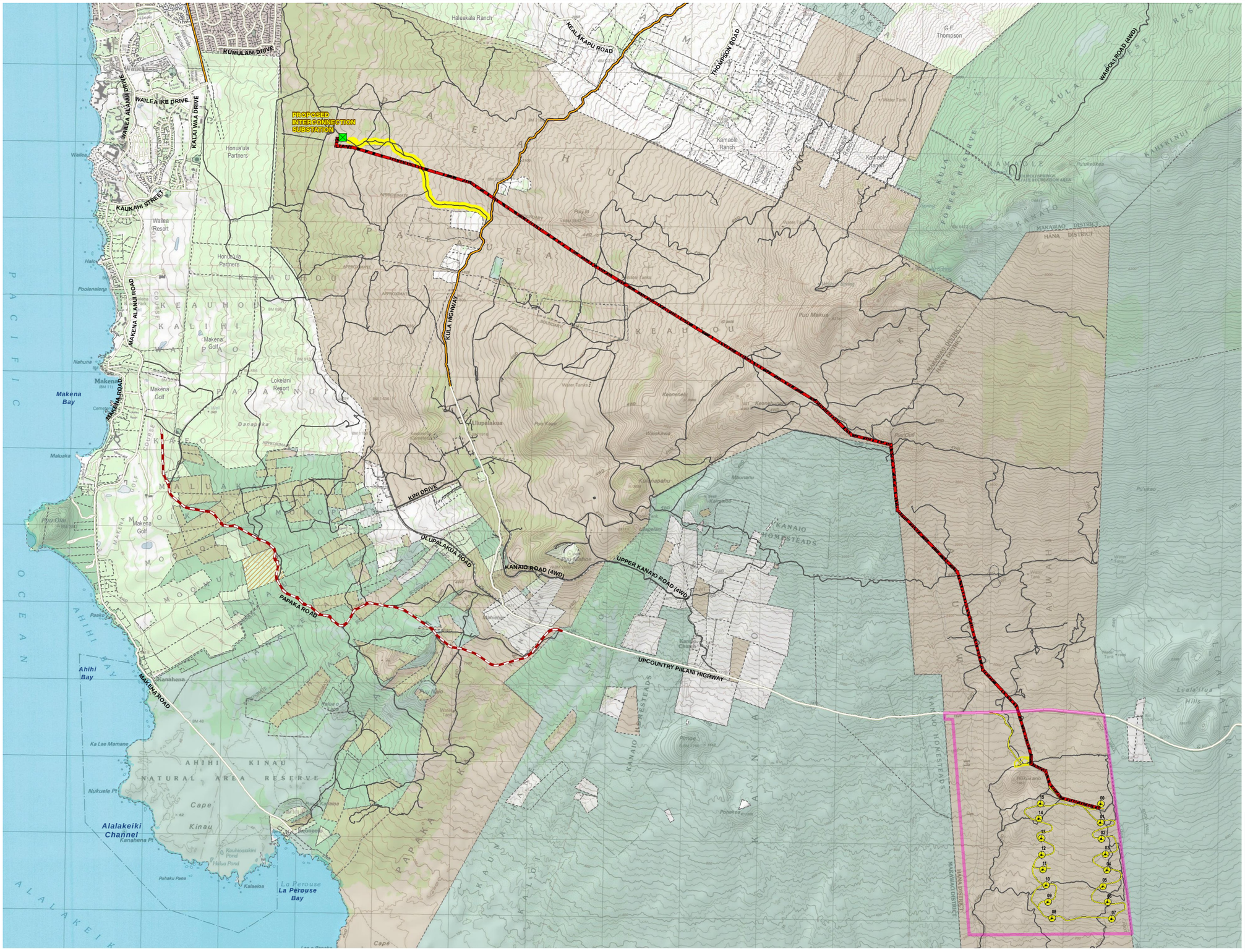
Figure 5
Existing Conditions Pāpaka Access Road

Figure 6
Regional Watersheds and Aquifers

Figure 7
Wind Farm Site Layout

Figure 8
Developed Conditions Wind Farm Site

Figure 9
Developed Conditions Interconnections Substation



LEGEND

- WIND FARM SITE
- PROPOSED WTG LOCATION
- PROPOSED SITE ACCESS ROAD
- PROPOSED COLLECTOR SWITCHYARD/LAYDOWN AREA
- PROPOSED GENERATOR-TIE LINE
- PROPOSED PAPAKA ROAD ACCESS ROUTE
- PROPOSED INTERCONNECTION SUBSTATION ACCESS ROUTE
- MAJOR ROAD
- MINOR ROAD
- PASTURE ROAD
- PARCEL BOUNDARY
- ULUPALAKUA RANCH PARCEL
- ULUPALAKUA RANCH PARCEL - PARTIAL INTEREST
- GOVERNMENT PARCEL

NOTES

1. BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES
2. ROADS DATA FROM STATE OF HAWAII, PASTURE ROADS DATA FROM CLIENT. HILLSHADE FROM STATE OF HAWAII.
3. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET

SITE LOCATOR

N

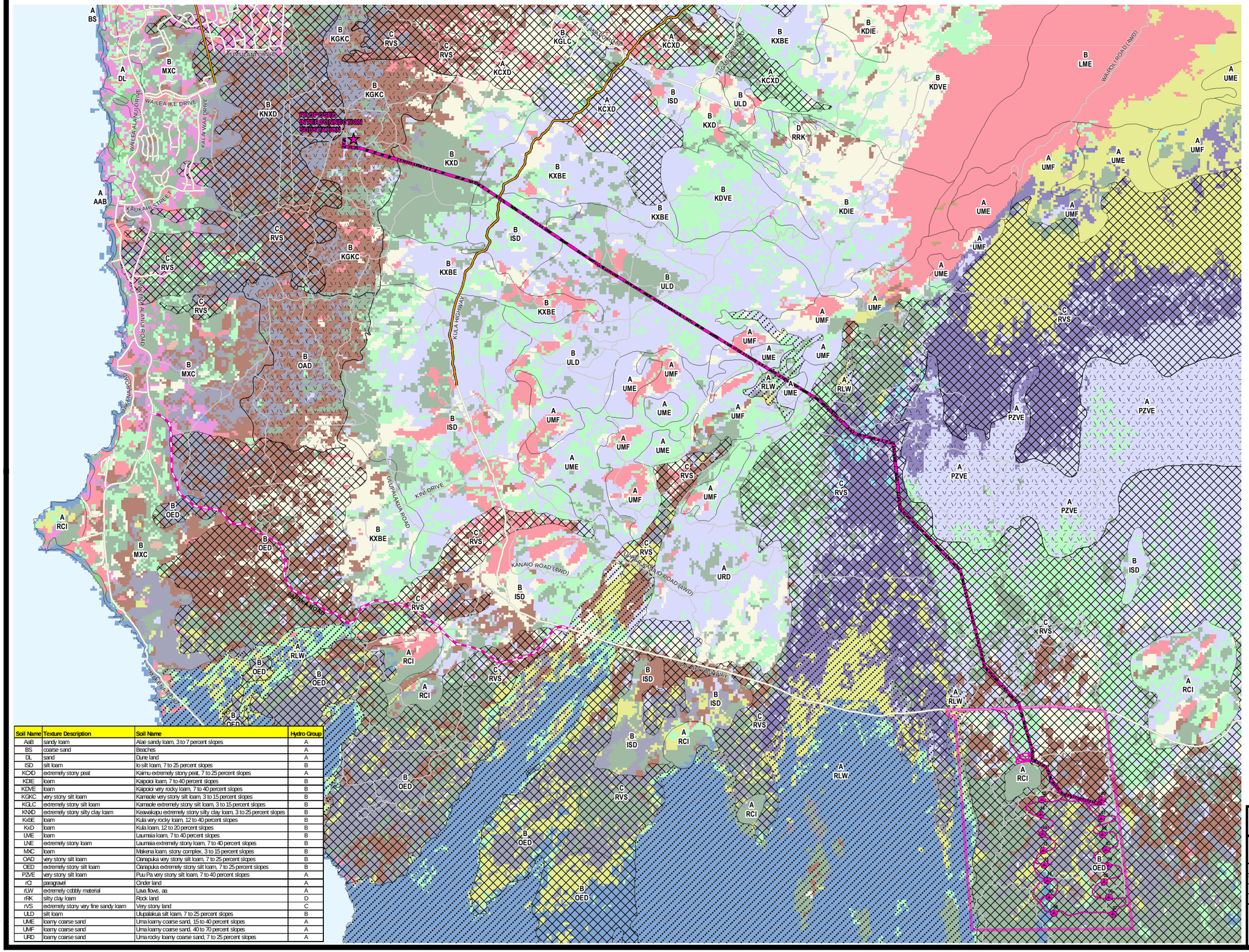
0 2,000 4,000 FEET

WORKING COPY

PROJECT: AUWAHI WIND FARM MAUI, HAWAII			
SHEET TITLE: SITE PLAN			
DRAWN BY: BENTON K	SCALE: AS NOTED	PROJ. NO. 06447.01	
CHECKED BY:		FILE NO. 064470124_SitePlanHYDRO.mxd	
APPROVED BY:	DATE PRINTED: 1/20/2011	FIGURE 1	
DATE: JANUARY 2011			

RMT
744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\064470\\064470124_SitePlanHYDRO.mxd 1/20/2011 15:26:02
Printed By: bentonk on 20 Jan 2011, 15:26:07



LEGEND

- PROJECT BOUNDARY
- PROPOSED WTG LOCATION
- PROPOSED WTG ACCESS ROAD
- LAYDOWN, COLLECTOR SWITCHYARD, AND OPERATIONS AND MAINTENANCE BUILDING AREA
- PROPOSED INTERCONNECTION SUBSTATION ACCESS ROAD
- PROPOSED PAPAKA ROAD ACCESS ROUTE
- PROPOSED GEN-TIE LINE

COBBLY AND STONY SOILS

- COBBLY
- EXTREMELY COBBLY
- EXTREMELY STONY
- STONY
- VERY STONY

A B C D = HYDRO CLASS

VALUE

- 8 - NATIVE SHRUBLAND (ALIEN GRASSES)
- 9 - NATIVE SHRUBLAND / SPARSE OHIA (NATIVE SHRUBS)
- 12 - ULUHE SHRUBLAND
- 39 - WATER
- 46 - HIGH INTENSITY DEVELOPED
- 47 - LOW INTENSITY DEVELOPED
- 48 - ALIEN GRASSLAND
- 50 - KIKUYU GRASS GRASSLAND / PASTURE
- 51 - ALIEN SHRUBLAND
- 57 - ALIEN FOREST
- 58 - CLOSED KIAWE-KOA HAOLE FOREST AND SHRUBLAND
- 64 - OPEN KIAWE-KOA HAOLE FOREST AND SHRUBLAND (ALIEN GRASSES)
- 66 - UNCHARACTERIZED FOREST
- 69 - UNCHARACTERIZED OPEN-SPARSE VEGETATION
- 70 - UNCHARACTERIZED SHRUBLAND
- 71 - VERY SPARSE VEGETATION TO UNVEGETATED
- MAJOR ROAD
- MINOR ROAD
- UNPAVED ROAD

NOTES

1. SOILS/HYDRO DATA OBTAINED FROM USGS. VEGETATION DATA FROM STATE OF HAWAII GAP PROGRAM 2005.
2. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET

N

0 2,000 4,000 FEET

Soil Name	Texture Description	Soil Name	Hydro Group
AeB	sandy loam	Alae sandy loam, 3 to 7 percent slopes	A
BS	coarse sand	Beaches	A
DL	sand	Dune land	A
ISD	silt loam	Ioli silt loam, 7 to 25 percent slopes	B
KCXD	extremely stony peat	Kairu extremely stony peat, 7 to 25 percent slopes	A
KDIE	loam	Kaipoioi loam, 7 to 40 percent slopes	B
KDVE	loam	Kaipoioi very rocky loam, 7 to 40 percent slopes	B
KGKC	very stony silt loam	Kamaole very stony silt loam, 3 to 15 percent slopes	B
KGLC	extremely stony silt loam	Kamaole extremely stony silt loam, 3 to 15 percent slopes	B
KNXD	extremely stony silty clay loam	Keawakapu extremely stony silty clay loam, 3 to 25 percent slopes	B
KxbE	loam	Kula very rocky loam, 12 to 40 percent slopes	B
KxD	loam	Kula loam, 12 to 20 percent slopes	B
LME	loam	Laumaia loam, 7 to 40 percent slopes	B
LNE	extremely stony loam	Laumaia extremely stony loam, 7 to 40 percent slopes	B
MXC	loam	Makena loam, stony complex, 3 to 15 percent slopes	B
OAD	very stony silt loam	Oanapuka very stony silt loam, 7 to 25 percent slopes	B
OED	extremely stony silt loam	Oanapuka extremely stony silt loam, 7 to 25 percent slopes	B
PZVE	very stony silt loam	Puu Pa very stony silt loam, 7 to 40 percent slopes	A
rCI	paragravel	Cinder land	A
rLW	extremely cobbly material	Lava flows, aa	A
rRK	silty clay loam	Rock land	D
rVS	extremely stony very fine sandy loam	Very stony land	C
ULD	silt loam	Ulupalakua silt loam, 7 to 25 percent slopes	B
UME	loamy coarse sand	Uma loamy coarse sand, 15 to 40 percent slopes	A
UMF	loamy coarse sand	Uma loamy coarse sand, 40 to 70 percent slopes	A
URD	loamy coarse sand	Uma rocky loamy coarse sand, 7 to 25 percent slopes	A

WORKING COPY

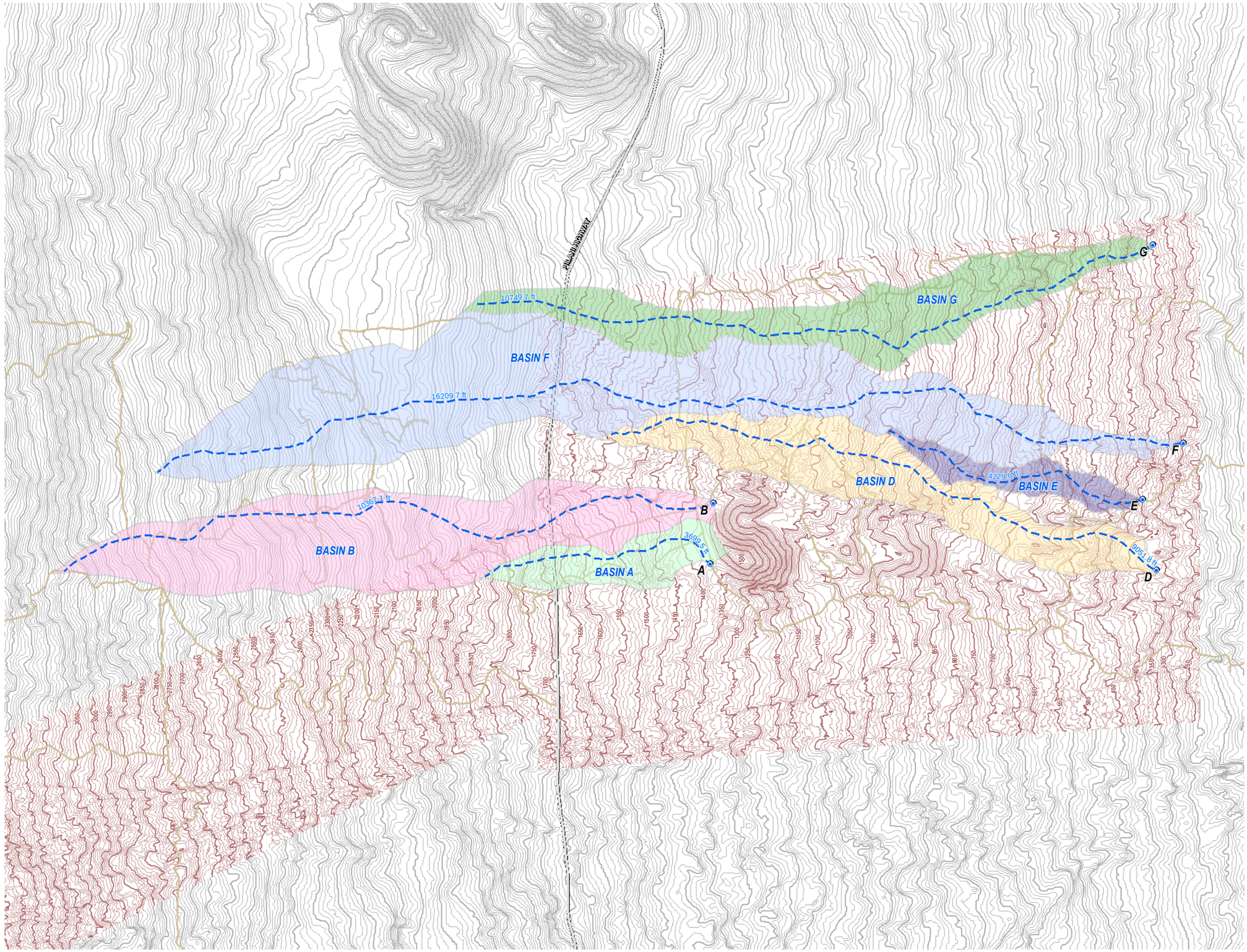
PROJECT: Auwahi Wind Farm, Maui, Hawaii

SHEET TITLE: EXISTING SOIL AND VEGETATION

DRAWN BY: bentonk	SCALE: AS NOTED	PROJ. NO. 06447.01	
CHECKED BY:		FILE NO. 06447011Veg.mxd	
APPROVED BY:	DATE PRINTED: 1/20/2011	FIGURE 2	
DATE: JANUARY 2011			

RMT
744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\06447011Veg.mxd 1/20/2011 15:29:21
Printed By: bentonk on 20 Jan 2011, 15:29:23



LEGEND

- DESIGN POINT
- FLOW LINE
- MAJOR ROAD
- MINOR ROAD
- PASTURE ROAD
- 50FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 10FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 50FT CONTOUR (GENERATED FROM CLIENT 10MDEM OBTAINED 10/18/2010)
- 10FT CONTOUR (GENERATED FROM CLIENT 10MDEM OBTAINED 10/18/2010)

NOTES

1. CONTOURS IN RED GENERATED FROM AERIAL STUDY BY AEROMETRICS, DECEMBER 18, 2007. COMPILED AT 1:1200 SCALE WITH 2 FT CONTOURS.
2. ROADS DATA FROM STATE OF HAWAII, PASTURE ROADS DATA FROM CLIENT.
3. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET

0 700 1,400 FEET

WORKING COPY

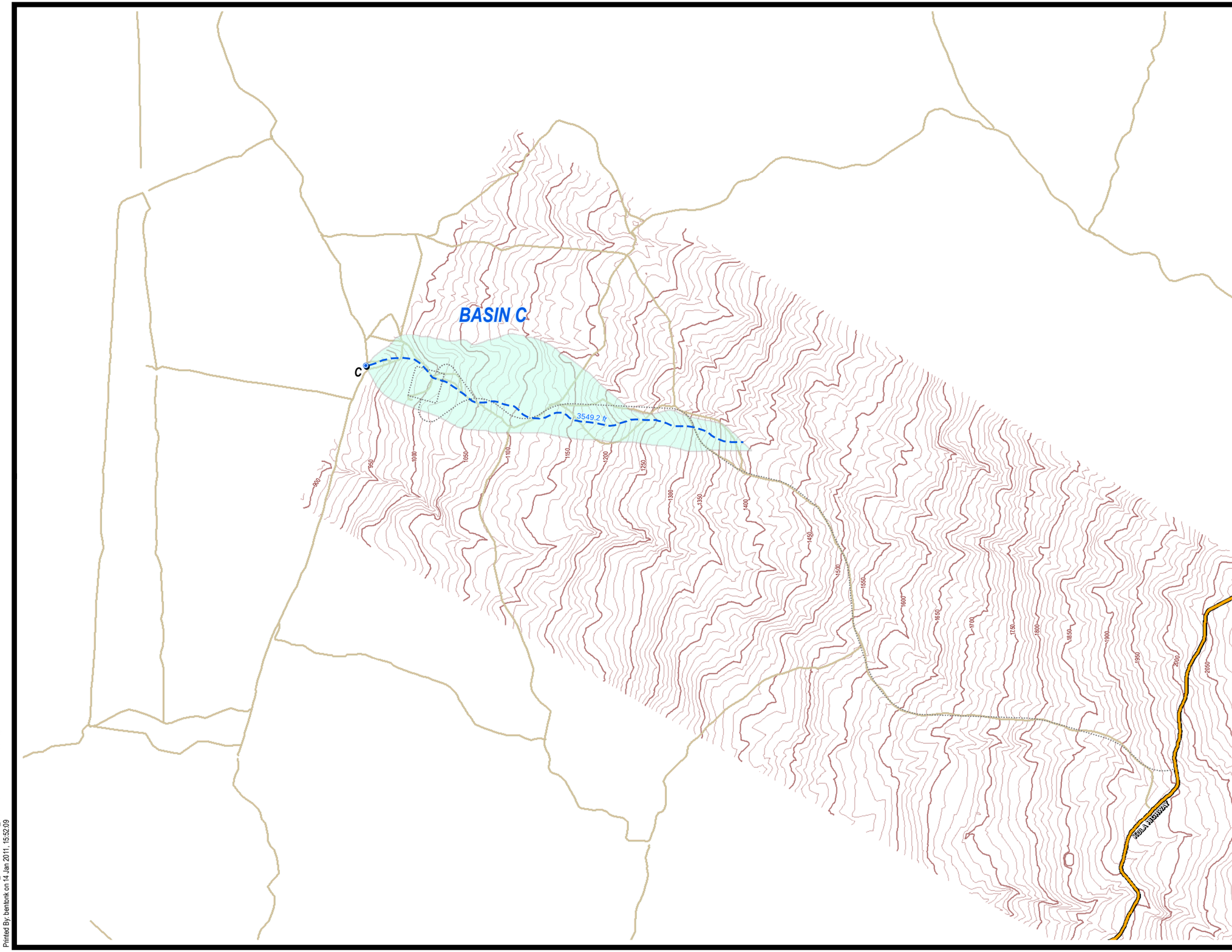
PROJECT:
Auwahi Wind Farm
Maui, Hawaii

SHEET TITLE:
EXISTING CONDITIONS
WIND FARM SITE

DRAWN BY: BENTON K	SCALE:	PROJ. NO. 06447.01	
CHECKED BY:	AS NOTED	FILE NO. 06447.01\21_watershedsEXIST_windfarm.mxd	
APPROVED BY:	DATE PRINTED:	FIGURE 3	
DATE: JANUARY 2011	1/14/2011		

RMT
744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\06447\01\21_watershedsEXIST_windfarm.mxd 1/14/2011 16:00:37
Printed By: bentonk on 14 Jan 2011, 16:00:44



LEGEND

- DESIGN POINT
- FLOW LINE
- PROPOSED INTERCONNECTION SUBSTATION AND ACCESS
- MAJOR ROAD
- MINOR ROAD
- PASTURE ROAD
- 50FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 10FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)

NOTES

1. CONTOURS IN RED GENERATED FROM AERIAL STUDY BY AEROMETRICS, DECEMBER 18, 2007. COMPILED AT 1:1200 SCALE WITH 2 FT CONTOURS.
2. ROADS DATA FROM STATE OF HAWAII, PASTURE ROADS DATA FROM CLIENT.
3. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET

N

0 400 800 FEET

WORKING COPY

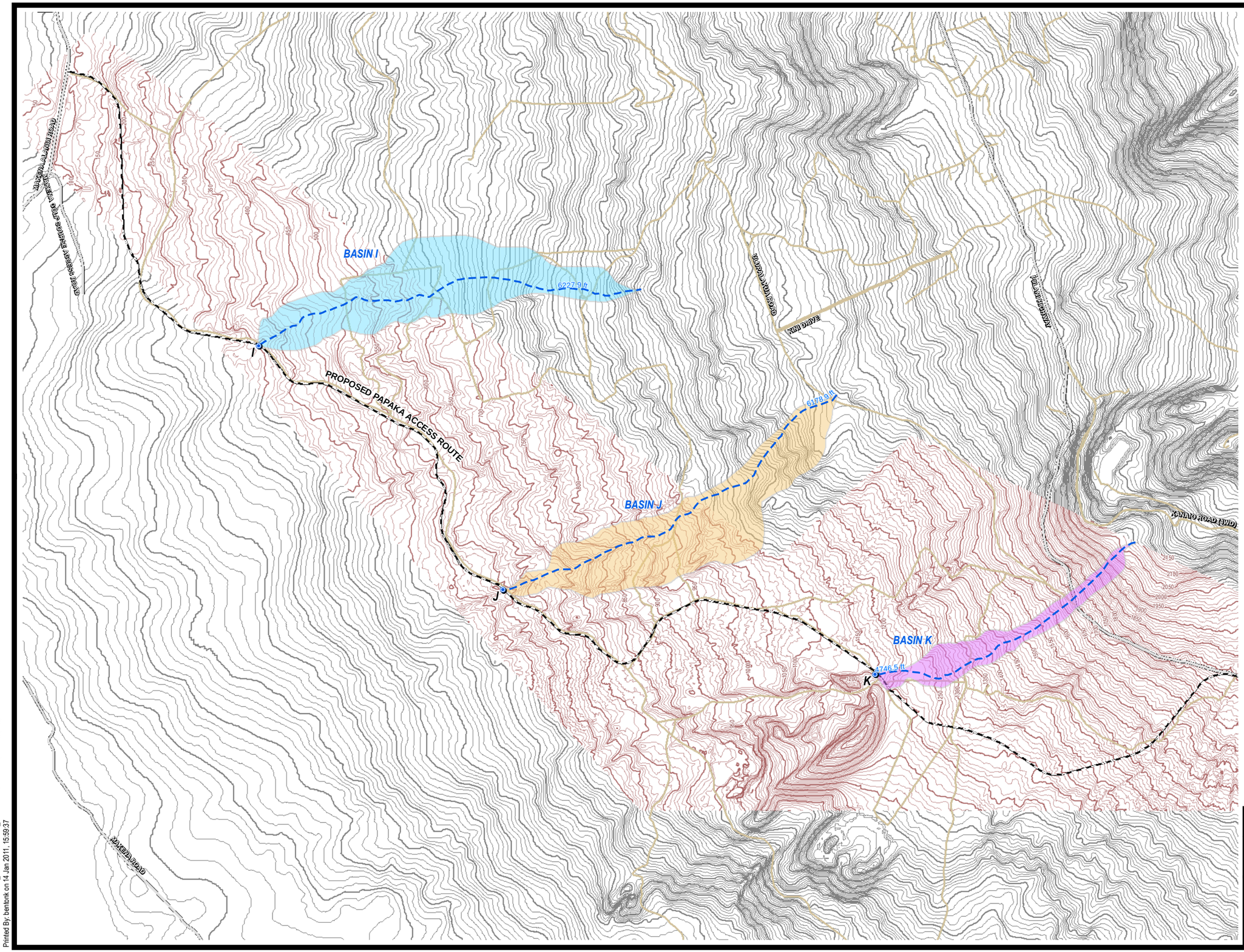
PROJECT:
Auwahi Wind Farm
Maui, Hawaii

SHEET TITLE:
EXISTING CONDITIONS
INTERCONNECTION SUBSTATION

DRAWN BY: BENTON K	SCALE:	PROJ. NO.	06447.01
CHECKED BY:	AS NOTED	FILE NO.	06447\01_watershedsEXIST_SUB.mxd
APPROVED BY:	DATE PRINTED:	FIGURE 4	
DATE: JANUARY 2011	1/14/2011		

RMT
744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\06447\01\21_watershedsEXIST_SUB.mxd 1/14/2011 15:52:06
Printed By: bentonk on 14 Jan 2011, 15:52:09



LEGEND

- DESIGN POINT
- FLOW LINE
- MAJOR ROAD
- MINOR ROAD
- PASTURE ROAD
- 50FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 10FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 10 FT CONTOUR (GENERATED FROM THE NATIONAL ELEVATION DATASET 10MDEM)
- 10 FT CONTOUR (GENERATED FROM THE NATIONAL ELEVATION DATASET 10MDEM)

NOTES

1. CONTOURS IN RED GENERATED FROM AERIAL STUDY BY AEROMETRICS, DECEMBER 18, 2007. COMPILED AT 1:1200 SCALE WITH 2 FT CONTOURS.
2. ROADS DATA FROM STATE OF HAWAII, PASTURE ROADS DATA FROM CLIENT.
3. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET

SITE LOCATOR

N

0 700 1,400 FEET

WORKING COPY

PROJECT: Auwahi Wind Farm, Maui, Hawaii			
SHEET TITLE: EXISTING CONDITIONS PAPAKA ACCESS ROAD			
DRAWN BY: BENTON K	SCALE: AS NOTED	PROJ. NO. 06447.01	
CHECKED BY:		FILE NO. 06447\01\21_watershedsEXIST_PAPAKA.mxd	
APPROVED BY:	DATE PRINTED: 1/14/2011	FIGURE 5	
DATE: JANUARY 2011			

RMT

744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\06447\01\21_watershedsEXIST_PAPAKA.mxd 1/14/2011 15:59:33
Printed By: bentonk on 14 Jan 2011, 15:59:37

LEGEND

- STREAM
- WATER FEATURE
- AQUIFER BOUNDARY
- WATERSHED BOUNDARY
- PROPOSED WTG LOCATION
- PROPOSED WIND FARM INFRASTRUCTURE
- PROPOSED GENERATOR-TIE LINE

NOTES

1. HYDRO DATA AND HILLSHADE FROM STATE OF HAWAII GIS DATA CLEARINGHOUSE. INCLUDES USGS DATA.

N

0 1 2 Miles

1 " = 1 MILES
1:63,360

WORKING COPY

PROJECT:
AUWAHI WIND FARM
MAUI, HAWAII

SHEET TITLE:
REGIONAL WATERSHEDS AND AQUIFERS

DRAWN BY: BENTON K	SCALE:	PROJ. NO.	06447.01
CHECKED BY:	AS NOTED	FILE NO.	HydroDataExplore.mxd
APPROVED BY:	DATE PRINTED:	**FIGURE 6**	
DATE: JANUARY 2011	1/14/2011		

RMT
744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\HydroDataExplore.mxd
Printed By: bentonk on 1/14/2011, 16:06 PM

PIILANI HIGHWAY

GOVT. STATE DHHL TMK 219001003
ULUPALAKUA RANCH TMK 219001006

OTHER TMK 219001005
OTHER TMK 219001004

COLLECTOR SWITCHYARD

443FT WTG SETBACK FROM PROPERTY LINE

WTG Pad 00
WTG Pad 01
WTG Pad 02
WTG Pad 03
WTG Pad 04
WTG Pad 05
WTG Pad 06
WTG Pad 07
WTG Pad 08
WTG Pad 09
WTG Pad 10
WTG Pad 11
WTG Pad 12
WTG Pad 13
WTG Pad 14
WTG Pad 15

LEGEND

- WIND FARM SITE BOUNDARY
- WTG PAD
- PROPOSED SITE ACCESS ROAD
- PROPOSED ELECTRICAL COLLECTION
- PROPOSED COLLECTOR SWITCHYARD
- COLLECTOR SWITCHYARD/ LAYDOWN AREA AND OPERATIONS AND MAINTENANCE BUILDING AREA
- PROPOSED GENERATOR-TIE LINE
- PROPOSED MET TOWER
- PROPOSED MET TOWER ACCESS ROAD
- PROPOSED MET TOWER DISTURBED AREA
- MAJOR PUBLIC ROAD
- PUBLIC ROAD
- PASTURE ROAD
- PARCEL BOUNDARY
- 443' TURBINE SETBACK FROM PROPERTY LINE
- 100' CONTOUR
- 10' CONTOUR

NOTES

1. GIS DATA OBTAINED FROM TETRATECH ON 1/7/2011. ALL DATA IS FROM THIS SOURCE UNLESS OTHERWISE NOTED.
2. ARCHAEOLOGICAL BUFFERS FROM PACIFIC LEGACY, 1/7/2011.
3. PARCELS ND PASTURE ROADS FROM CLIENT 10/18/2010.
4. ROADS DATA FROM STATE OF HAWAII.
5. CONTOURS GENERATED FROM AERIAL STUDY BY AEROMETRICS, DECEMBER 18, 2007. COMPILED AT 1:1200 SCALE WITH 2 FT CONTOURS.
6. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET

0 350 700 FEET

PROJECT: Auwahi Wind Farm
Maui, Hawaii

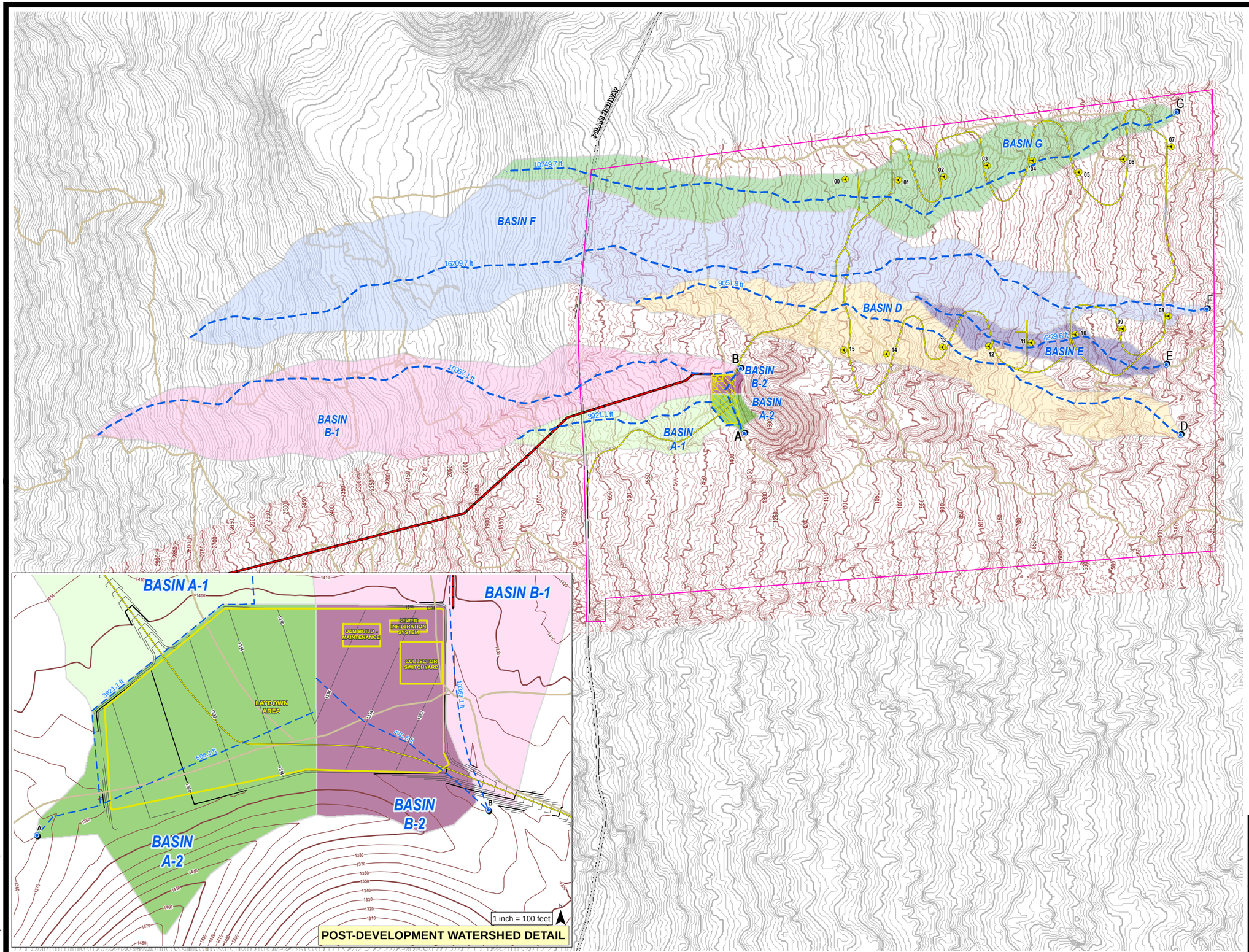
WORKING COPY

SHEET TITLE: WIND FARM SITE LAYOUT

DRAWN BY: bentonk	SCALE: AS NOTED	PROJ. NO. 06447.01	
CHECKED BY:		FILE NO. 064470123_EIS.mxd	
APPROVED BY:	DATE PRINTED: 1/14/2011	FIGURE 7	
DATE: January 2011			

RMT
744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\064470123_EIS.mxd
Printed By: bentonk on 1/14/2011, 15:33 PM



LEGEND

- DESIGN POINT
- FLOW LINE
- WIND FARM SITE
- PROPOSED WTG LOCATION
- COLLECTOR SWITCHYARD/LAYDOWN AREA, AND OPERATIONS AND MAINTENANCE BUILDING AREA
- PROPOSED SITE ACCESS ROAD
- PROPOSED GENERATOR-TIE LINE
- MAJOR ROAD
- MINOR ROAD
- PASTURE ROAD
- 50FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 10FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 50FT CONTOUR (GENERATED FROM CLIENT 10MDEM OBTAINED 10/18/2010)
- 10FT CONTOUR (GENERATED FROM CLIENT 10MDEM OBTAINED 10/18/2010)

NOTES

1. CONTOURS IN RED GENERATED FROM AERIAL STUDY BY AEROMETRICS, DECEMBER 18, 2007. COMPILED AT 1:1200 SCALE WITH 2 FT CONTOURS.
2. BLACK CONTOURS IN INSET FROM RMT CAD.
3. ROADS DATA FROM STATE OF HAWAII. PASTURE ROADS DATA FROM CLIENT.
4. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET.

0 700 1,400 FEET

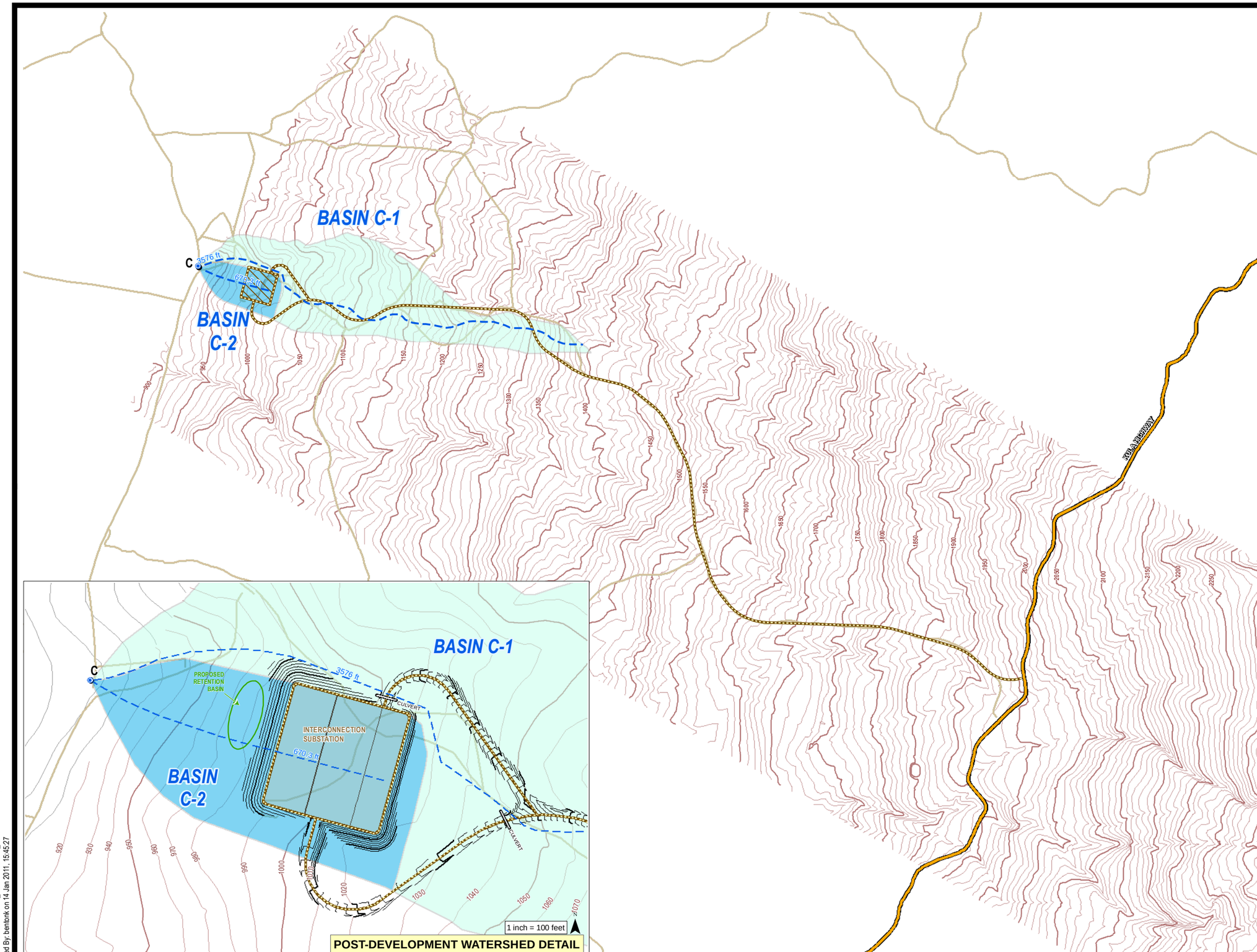
WORKING COPY

PROJECT: Auwahi Wind Farm, Maui, Hawaii			
SHEET TITLE: DEVELOPED CONDITIONS WIND FARM SITE			
DRAWN BY: BENTON K	SCALE: AS NOTED	PROJ. NO. 06447.01	
CHECKED BY:		FILE NO. 06447010121_watershedsDEV_windfarm.mxd	
APPROVED BY:	DATE PRINTED: 1/14/2011	FIGURE 8	
DATE: JANUARY 2011			

RMT

744 Heartland Trail
Madison, WI 53717-1934
P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\06447\0121_watershedsDEV_windfarm.mxd 1/14/2011 15:19:35
Printed By: bentonk on 14 Jan 2011, 15:19:39



LEGEND

- DESIGN POINT
- FLOW LINE
- PROPOSED INTERCONNECTION SUBSTATION AND ACCESS
- MAJOR ROAD
- MINOR ROAD
- PASTURE ROAD
- 50FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)
- 10FT CONTOUR (DATA FROM AEROMETRICS, SEE NOTE)

NOTES

1. CONTOURS IN RED GENERATED FROM AERIAL STUDY BY AEROMETRICS, DECEMBER 18, 2007. COMPILED AT 1:1200 SCALE WITH 2 FT CONTOURS.
2. GRAY CONTOURS IN INSET WERE GENERATED FROM THE NATIONAL ELEVATION DATASET 10MDEM.
3. BLACK CONTOURS IN INSET FROM RMT CAD.
4. ROADS DATA FROM STATE OF HAWAII. PASTURE ROADS DATA FROM CLIENT.
5. COORDINATES SYSTEM: NAD_1983_HARN_STATEPLANE_HAWAII_2_FIPS_5102_FEET.

SITE LOCATOR

N

0 400 800 FEET

WORKING COPY

PROJECT: Auwahi Wind Farm, Maui, Hawaii			
SHEET TITLE: DEVELOPED CONDITIONS INTERCONNECTION SUBSTATION			
DRAWN BY: BENTON K	SCALE:	PROJ. NO. 06447.01	
CHECKED BY:	AS NOTED	FILE NO. 064470121_watershedsDEV_SUB.mxd	
APPROVED BY:	DATE PRINTED:	FIGURE 9	
DATE: JANUARY 2011	1/14/2011		

RMT

744 Heartland Trail
Madison, WI 53717-1934

P.O. Box 8923 53708-8923
Phone: 608-831-4444
Fax: 608-831-3334

D:\06447\01\064470121_watershedsDEV_SUB.mxd 1/14/2011 15:45:23
Printed By: bentonk on 14 Jan 2011, 15:45:27

Appendix A
The Rules for the Design of Storm Drainage Facilities in the County of Maui

TITLE MC-15

DEPARTMENT OF PUBLIC WORKS AND WASTE MANAGEMENT

COUNTY OF MAUI

CHAPTER 4

RULES FOR THE DESIGN OF
STORM DRAINAGE FACILITIES
IN THE COUNTY OF MAUI

SUMMARY

1. Chapter 4, entitled "Rules For The Design Of Storm Drainage Facilities In The County of Maui", is hereby adopted to read as follows:

"TITLE MC-15
DEPARTMENT OF PUBLIC WORKS AND WASTE MANAGEMENT

SUBTITLE 01

CHAPTER 4

RULES FOR THE DESIGN OF
STORM DRAINAGE FACILITIES
IN THE COUNTY OF MAUI

GENERAL PROVISIONS

§15-04-01	Title
§15-04-02	Authority
§15-04-03	Purpose
§15-04-04	Definitions
§15-04-05	Hydrologic criteria
§15-04-06	Design standards
§15-04-07	Severability
§15-04-08	Appendix - reference tables and charts

§15-04-01 Title. The rules in this Title shall be known as the "Rules For The Design of Storm Drainage Facilities in the County of Maui". [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

§15-04-02 Authority. The rules herein are established pursuant to the provisions of Sections 46.15(13) and 46.15(14), Hawaii Revised Statutes, and Section 18.20.130A, Maui County Code. [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

§15-04-03 Purpose. These rules govern the design of storm drainage facilities in the County of Maui. [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

§15-04-04 Definitions. For the purpose of these rules, unless it is plainly evident from the context that a different meaning is intended, certain words and phrases used herein are defined as follows:

"Detention facilities" means temporarily impound runoff to control runoff rates.

"Director" means the Director of Public Works and Waste Management.

"Infiltration facilities" means facilities, such as, infiltration basins, retention basins and porous pavements, which rely on absorption of runoff.

"Injection wells" are wells that dispose runoff into the subsurface and shall be in conformance with applicable State Department of Health Underground Injection Control (UIC) Rules.

"Sumps" mean either detention facilities or infiltration facilities. [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

§15-04-05 Hydrologic criteria.

Recurrence interval.

(a) For drainage areas of 100 acres or less, Tm (recurrence interval) = 10 year based on 1 hour storm, unless otherwise specified.

(b) For drainage areas of 100 acres or less with sump, or tailwater effect, Tm (recurrence interval) = 50 year based on 1 hour storm.

(c) For the design of roadway culverts and bridges with drainage areas less than 100 acres, Tm (recurrence interval) = 50 year based on 1 hour storm.

(d) For drainage areas greater than 100 acres and all streams, the Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service) hydrograph method shall be used, Tm (recurrence interval) = 100 year based on 24 hour storm.

(e) Retention and Detention Basins: Tm (recurrence interval) = 50 year based on 1 hour storm for drainage areas 100 acres or less.

Tm (recurrence interval) = 100 year based on 24 hour storm for drainage areas more than 100 acres.

(f) When a drainage area of less than 100 acres contributes to a major stream or channel with a total drainage area greater than 100 acres, the contributory drainage system shall be designed for 10 year or 50 year storm, whichever is applicable.

Runoff Quantity.

(a) **Rational Method:** For drainage areas of 100 acres or less, the rational method along with the accompanying reference tables and charts, or latest revision thereof, shall be used. The formula Q=CIA may be used to determine quantities of flow rate, in which:

Q=flow rate in cubic feet per second;

C=runoff coefficient;

I=rainfall intensity in inches per hour for a duration equal to the time of concentration; and A=drainage area in acres.

(b) **Runoff Coefficient (C):**

(1) For Off-site Areas - The "C" value shall be determined from Table No. 1 and based on the current use of the drainage area. For distinctive composite drainage areas, a weighted value of runoff coefficient shall be used.

(2) For On-site Areas - Composite areas shall be designated and a weighted value of runoff coefficient shall be determined using the runoff coefficient from Table 1 or 2, whichever is higher. Minimum runoff coefficients for built-up areas are noted in Table 3.

(c) **Time of Concentration (Tc)**

(1) Determine overland flow time from Plate 1 generally for paved, bare soil and grassed areas.

(2) Determine flow time over small agricultural areas with well-defined divides and drainage channels from Plate 3.

(A) Use upper curve for well-forested areas representing:

$$Tc=0.0136K^{0.77}$$

(B) Use lower curve for areas with little or no cover, representing:

$$Tc=0.0078\ K^{0.77}$$

(3) To verify the time of concentration, divide the estimated longest route of runoff by the appropriate runoff velocity from Table 4.

(4) Tc for flows in uniform channels and in culverts shall be computed by length of run divided by computed velocity.

(d) **Rainfall Intensity (I)** - The design rainfall intensity of a drainage area shall be determined by the following procedure:

(1) Select the appropriate 1-hour rainfall value from Plates 4 to 9 for the design recurrence interval for each individual island.

(2) Enter Plate 2 with the 1-hour rainfall value and the required time of concentration. Obtain the design rainfall intensity in inches per hour.

Natural Resources Conservation Service (NRCS) Method, Hydrograph Analysis

(a) For drainage areas greater than 100 acres and all streams, the Natural Resources Conservation Service method shall be used.

(b) The procedure for computing the peak flows and plotting the hydrographs shall be as outlined in the NRCS, National Engineering Handbook, Section 4, Hydrology, Supplement, or latest revision thereof or Erosion and Sediment Control Guide for Hawaii, NRCS, March 1981, or latest revision thereof.

(c) The NRCS computer program TR55 or TR20 may be used in lieu of the NRCS hydrograph analysis.

Federal Emergency Management Agency (FEMA)

Federal Emergency Management Agency (FEMA) storm flows shall be the minimum storm flow in drainage basins where flows have been determined in the "Flood Insurance Study," Maui County. [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

§15-04-06 Design Standards. (a) **General Conditions:** The design and capacity of a drainage system shall be based on the following conditions:

(1) The drainage system shall dispose the design storm runoff and subsurface water without damage to street facilities, structures or ground and cause no serious interruption of normal vehicular traffic, and in a manner that will not adversely affect downstream and adjoining properties.

(2) System must have maximum reliability of operation with minimum maintenance and upkeep requirements.

(3) If applicable, system must be adaptable to future expansion.

(4) Where sump conditions exist; a safety measure such as an overflow swale shall be provided to prevent flooding of adjacent lots in the event the design capacity of the closed conduit is exceeded.

(5) In general, natural gullies, waterways, streams and tributaries shall not be replaced with a closed system except at roadway crossings. For natural drainageways with contributory areas greater than 100 acres, the engineer shall determine, dimension and designate the 100 year flooded width as a drainage reserve in the drainage report and on the final subdivision map, if applicable.

(6) Roadway culverts and bridges shall be designed to pass the design flow as determined by this design criteria. Under open channel hydraulic analysis the minimum freeboard shall be as specified in the design criteria for open channels. Multiple span road crossings (bridges) shall have minimum clear spans of 30-feet, unless otherwise permitted by the Director. Where possible, the roadway shall be designed to form a sag vertical curve with a low point at the waterway crossing with minimum grades to confine and control overflow at the crossing.

(7) In general, outlets for enclosed drains emptying into open channels shall be designed to point downstream at an angle of 45 degrees. Junctions of open channels shall be designed to flow as nearly parallel as possible.

(8) Outlet velocities of storm waters leaving culverts and channels shall not exceed existing drainage velocities when entering existing drainage ways.

(9) Subsurface drains may be installed when approved by the Director, provided no ground water is encountered or will be encountered during wet weather.

(10) In areas where existing drainage systems are inadequate, the existing system shall be upgraded to handle runoff from the new project area or a new system shall be provided to connect to an adequate outlet. When there is no existing drainage system or adequate outlet to connect to, the additional runoff generated by the development may be retained on-site in a temporary retention basin with the following design conditions:

(A) Storage volume of an infiltration basin, infiltration trench piping, or retention basin shall equal at least the total additional runoff volume for the appropriate storm intensity.

(B) Soil percolation shall not be used in satisfying required storage volumes.

(C) Fifty percent (50%) of voids within the rock envelope for subsurface drains may be used in satisfying required storage volume provided that filter fabric is installed around the subsurface pipe and at the interface of the rock envelope and soil.

(D) Sumps, detention and retention facilities will remain private.

(E) Detention or retention ponds with embankment heights equal to or in excess of 25 feet or with storage capacity equal to or in excess of 50 acre-feet shall conform to all state and federal requirements relative to dams.

(11) Flooded widths shall not be more than the following for the appropriate design storm:

(A) 8 feet for all curbed streets.

(B) No portion of the pavement shall be flooded for non-curbed streets. All storm runoff shall be confined to the roadway shoulder swale.

(12) Provide spillway or other devices that will direct overflow for design storms to an appropriate drainage channel or drainage system to assure that there will be no adverse effects on downstream or adjacent properties.

(13) Additional storm runoff from a new development shall be disposed of at an appropriate drainage outlet or drainage system so as not to create any additional adverse effects to adjacent or downstream properties.

(14) Off-site flows may be passed safely through a development provided there are no additional adverse effects resulting from the new development to adjacent and downstream properties.

(15) All new structures shall have either:

(A) The lowest floor or lowest opening be at least one foot above the crown of the nearest street or above the highest grade adjacent to the structure; or

(B) The site plan ensure that new structures are protected from local drainage problems.

(b) **Drainage system**

(1) Closed Conduits:

(A) Freeboard and Hydraulic Grade Line (HGL) unless otherwise authorize by the Director:

i. 1′ freeboard within drainage structures.

ii. HGL shall not be less than 1′ below finish ground elevation.

(B) Minimum Pipe Sizes Within County Right-of-Way:

i. 18" diameter for lateral not exceeding 50 feet in length connecting drainage structures to main line.

ii. 24" diameter for main trunk line

(C) Materials and "n" Values:

i.	Concrete Pipe	n=0.013
ii.	*High Density Polyethylene Pipe (HDPE)	n=0.013
iii.	*Corrugated Aluminum Pipe (CAP) and *Corrugated Galvanized Metal Pipe (CMP), annular (1/2 X 2 2/3 corrugation, All sizes):	
	Unpaved	n=0.024
	25% paved invert	n=0.021
	Lower 50% Paved	n=0.018
	100% Paved	n=0.013
iv.	Helical *CAP and *CSP (1/2 X 2 2/3 corrugation):	
	18"	n=0.014
	24"	n=0.017
	30"	n=0.018
	36" to 48"	n=0.020
	54" and larger	n=0.021
v.	*Spiral Rib Pipe	
	All sizes	n=0.011

*Shall be allowed only upon submittal of soil test, PH value, etc. to substantiate soil/effluent/pipe material compatibility and with written approval from the Director.

(2) Open Channels

(A) Freeboard: Freeboard shall be according to the U.S. Department of Interior Bureau of Reclamation's empirical formula,

$$\text{Freeboard in feet} = 2.000+0.025v^3\sqrt{d}$$

where v is the velocity in feet per second and d is the flow depth in feet. Freeboard shall be provided at bends from the superelevated water surface.

(B) Material, "n" values and maximum velocities:

Material	Manning n	Max. v (fps)
Concrete, trowel finish	0.013	no limitation
Concrete, form finish	0.015	no limitation
Gunite, good section	0.018	20
Gunite, wavy section	0.020	20
Grouted Rubble Paving (GRP)	0.025	20
Cement Rubble Masonry (CRM)	0.025	20
Rock, smooth, uniform	0.030	10
Rock, jagged, irregular	0.045	10
Earth, fairly uniform, grassed	0.035	5

(C) Channel rights-of-ways shall encompass the channel width and include sufficient width for maintenance.

(D) Special considerations shall be made for guard rails and fences, debris control structures, energy dissipators, etc.

(c) Drainage report: Three copies of a drainage report, when required, shall be submitted to the Land Use and Codes Administration for approval. The drainage report shall be sealed and signed by a professional civil engineer licensed to practice in the State of Hawaii and at a minimum, include the following:

(1) Hydrologic runoff computations
  (A) On-Site
    i. Existing Conditions
    ii. Developed Conditions
  (B) Off-Site
    i. Existing Conditions
    ii. Allowances for future conditions (if any).
(2) Hydraulic Analysis:
  (A) Catch Basins & Inlet Capacities.
  (B) Flooded Road Width.
  (C) Hydraulic Grade Line (HGL). The HGL shall be shown on the construction plans.
(3) Contributory drainage area maps and schematic drainage scheme.

(b) The chairperson and vice-chairperson shall have responsibilities and duties as prescribed in this chapter. [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §1.16.040 Maui County Charter

§15-04-07 Severability. If any portion of the foregoing rules or the applicability thereof to any person, property or circumstance is held invalid for any reason, such invalidity shall not affect other provisions or applications which can be given effect without the invalid provision or application, and to this end these are declared to be severable. [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

§15-04-08 Appendix. Reference charts and tables attached hereto and made a part hereof." [Eff. 11/12/95] (Auth: §§46.15(13) and (14), Hawaii Revised Statutes) (Imp: §18.20.130A, Maui County Code)

ADOPTED THIS 14th DAY OF July, 1995, by the Director of Public Works and Waste Management, County of Maui, State of Hawaii.

CHARLES JENCKS
Its Director
Department of Public Works & Waste Management
County of Maui

APPROVED AS TO FORM
AND LEGALITY:

LILLIAN B. KOLLER
Deputy Corporation Counsel
County of Maui
c:\wp51\rules\drngstnd(pk)

APPROVED this 14 day of July, 1995.

LINDA CROCKETT LINGLE
Mayor
County of Maui

CERTIFICATION

I, CHARLES JENCKS, in my capacity as Director of Public Works and Waste Management, County of Maui, do hereby certify:

1. That the foregoing is a full, true and correct copy of the Rules of the Department of Public Works and Waste Management relating to the Rules for the Design of Storm Drainage Facilities in the County of Maui.

2. That the notice of public hearing on the foregoing Rules, which notice included the substance of such Rules, was published in the Maui News on June 12 and _____, 19 95.

CHARLES JENCKS
Director, Department of Public Works and Waste Management
County of Maui

Received this 2nd day of

November, 19 95.

DARYL T. YAMAMOTO
County Clerk
County of Maui

Table 1

GUIDE FOR THE DETERMINATION OF RUNOFF COEFFICIENTS FOR BUILT-UP AREAS*

WATERSHED CHARACTERISTICS	EXTREME	HIGH	MODERATE	LOW
INFILTRATION	NEGLIGIBLE 0.20	SLOW 0.14	MEDIUM 0.07	HIGH 0.0
RELIEF	STEEP (> 25%) 0.08	HILLY (15 - 25%) 0.06	ROLLING (5 - 15%) 0.03	FLAT (0 - 5%) 0.0
VEGETAL COVER	NONE 0.07	POOR (< 10%) 0.05	GOOD (10 - 50%) 0.03	HIGH (50 - 90%) 0.0
DEVELOPMENT TYPE	INDUSTRIAL & BUSINESS 0.55	HOTEL - APARTMENT 0.45	RESIDENTIAL 0.40	AGRICULTURAL 0.15

**NOTE: The design coefficient "c" must result from a total of the values for all four watershed characteristics of the site.*

Table 2

RUNOFF COEFFICIENTS

Type of Drainage Area	Runoff Coefficient C
Business:	
Downtown areas	0.95
Neighborhood areas	0.70
Residential:	
Single-family areas	0.50
Multi-units, detached	0.60
Multi-units, attached	0.75
Suburban	0.40
Apartment dwelling areas	0.70
Industrial:	
Light areas	0.80
Heavy areas	0.90
Parks, cemeteries	0.25
Playgrounds	0.35
Railroad-yard areas	0.40
Unimproved areas	0.30
Streets:	
Asphaltic	0.95
Concrete	0.95
Brick	0.85
Drive and walks	0.85
Roofs	0.95
Lawns:	
Sandy, soil, flat, 2%	0.10
Sandy, soil, avg., 2-7%	0.15
Sandy, soil, steep, 7%	0.20
Heavy soil, flat, 2%	0.17
Heavy soil, avg., 2-7%	0.22
Heavy soil, steep, 7%	0.35

Table 3

MINIMUM RUNOFF COEFFICIENTS FOR BUILT-UP AREAS

RESIDENTIAL AREAS:	C = 0.55 to 0.70
HOTEL-APARTMENT AREAS:	C = 0.70 to 0.90
BUSINESS AREAS:	C = 0.80 to 0.90
INDUSTRIAL AREAS:	C = 0.80 to 0.90

The type of soil, the type of open space and ground cover and the slope of the ground shall be considered in arriving at reasonable and acceptable runoff coefficients.

Table 4

APPROXIMATE AVERAGE VELOCITIES OF RUNOFF FOR CALCULATING TIME OF CONCENTRATION

TYPE OF FLOW	VELOCITY IN FPS FOR SLOPES (in percent) INDICATED			
OVERLAND FLOW:	0-3%	4-7%	8-11%	12-15%
Woodlands	1.0	2.0	3.0	3.5
Pastures	1.5	3.0	4.0	4.5
Cultivated	2.0	4.0	5.0	6.0
Pavements	5.0	12.0	15.0	18.0
OPEN CHANNEL FLOW:				
Improved Channels	Determine Velocity by Manning's Formula			
Natural Channel* (not well defined)	1.0	3.0	5.0	8.0

**These values vary with the channel size and other conditions so that the ones given are the averages of a wide range. Wherever possible, more accurate determinations should be made for particular conditions by Manning's formula.*

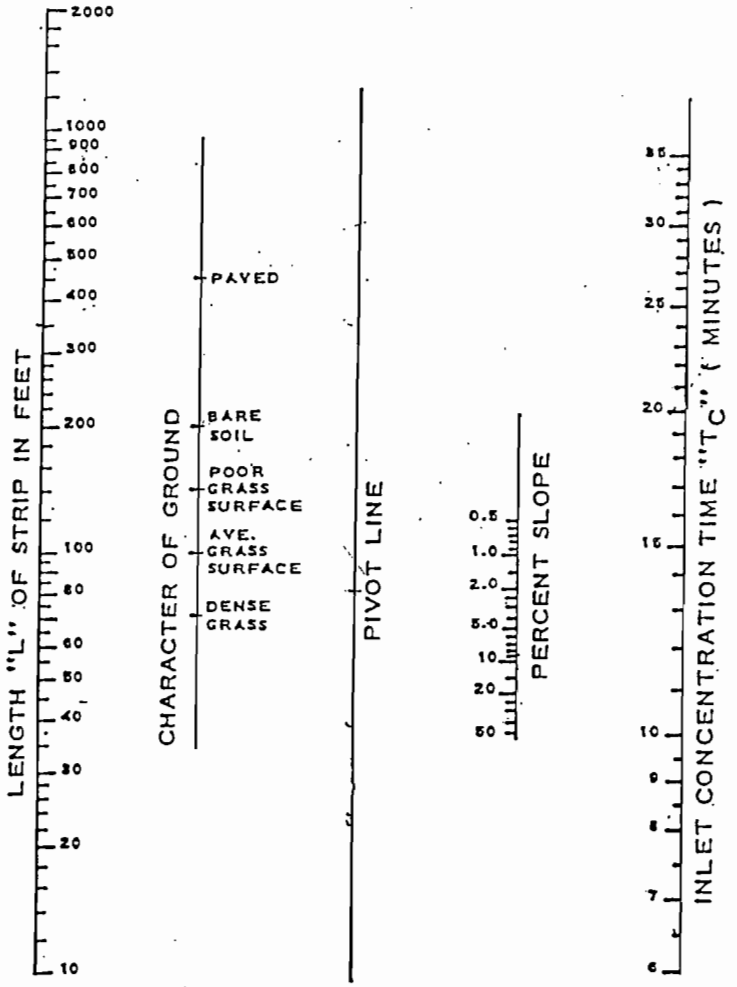
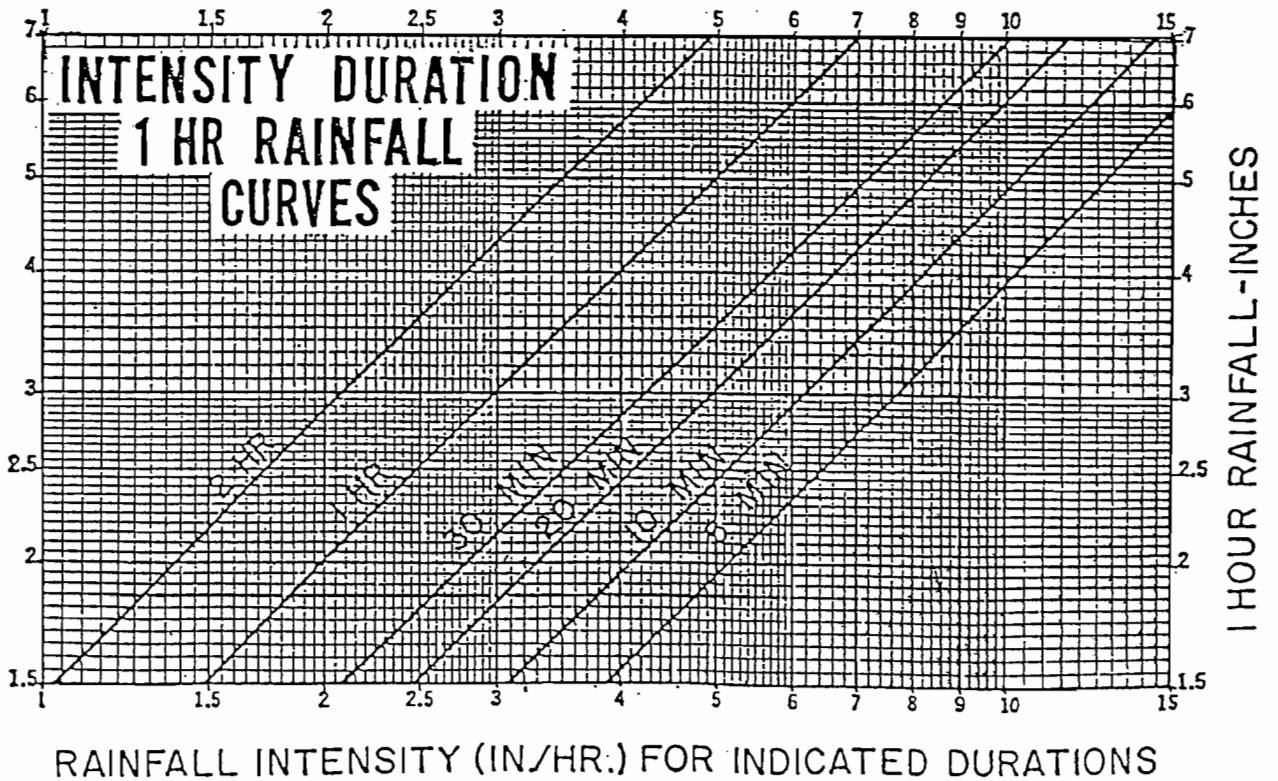
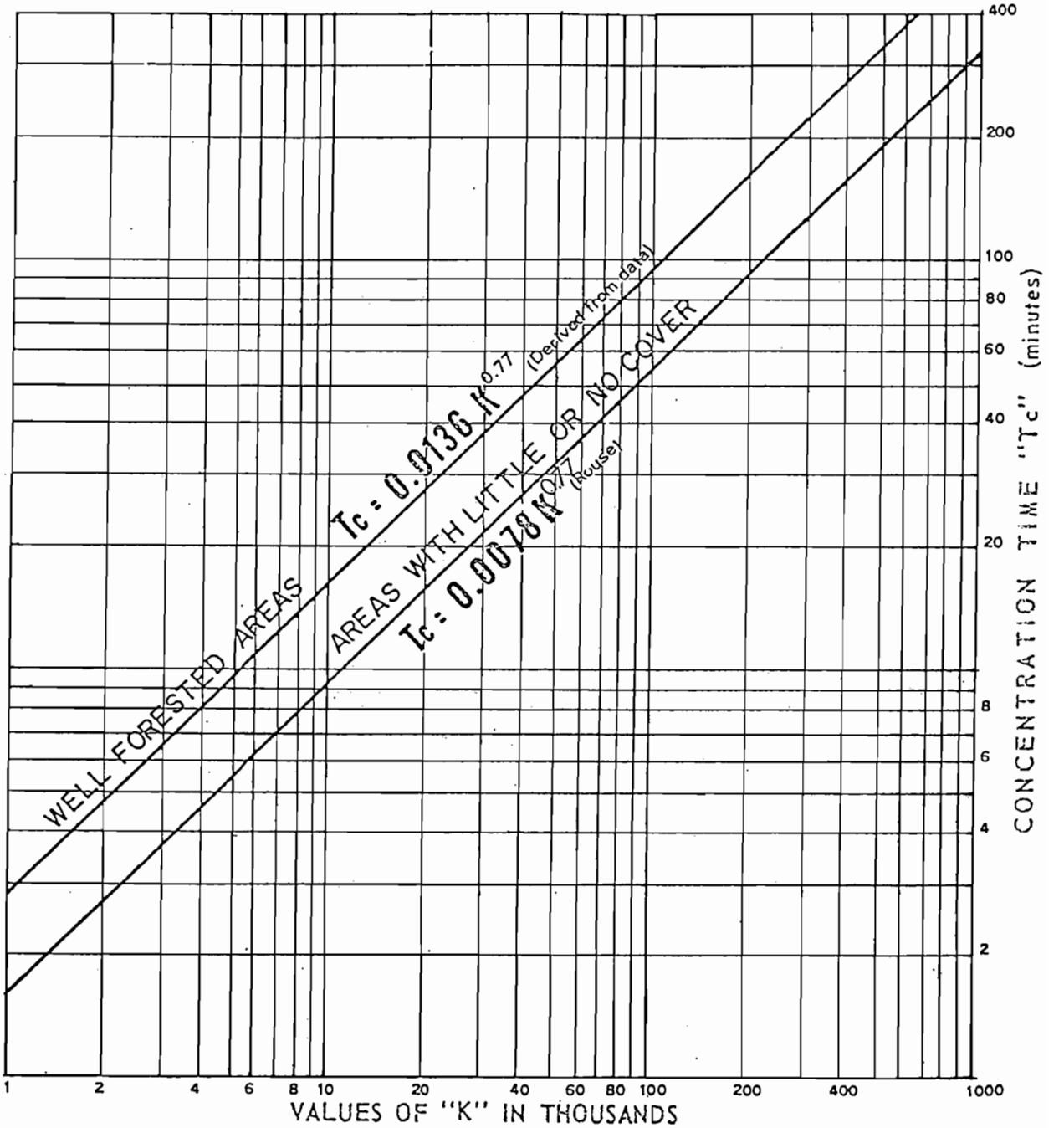


Plate 1

Overland Flow Chart

Plate 2





L = Maximum length of travel in feet
H = Difference in elevation between most remote point and outlet in feet.
S = Slope H/L

$$K = \frac{L}{\sqrt{S}} = \sqrt{\frac{L^3}{H}}$$

Use upper curve for well forested areas.
Use lower curve for areas with little or no cover.

SOURCE: CITY PLANNING COMMISSION
Graph from Hunter Rouse "Engineering Hydrauiics"

Plate 3
Time of Concentration
(OF SMALL AGRICULTURAL DRAINAGE BASIN)

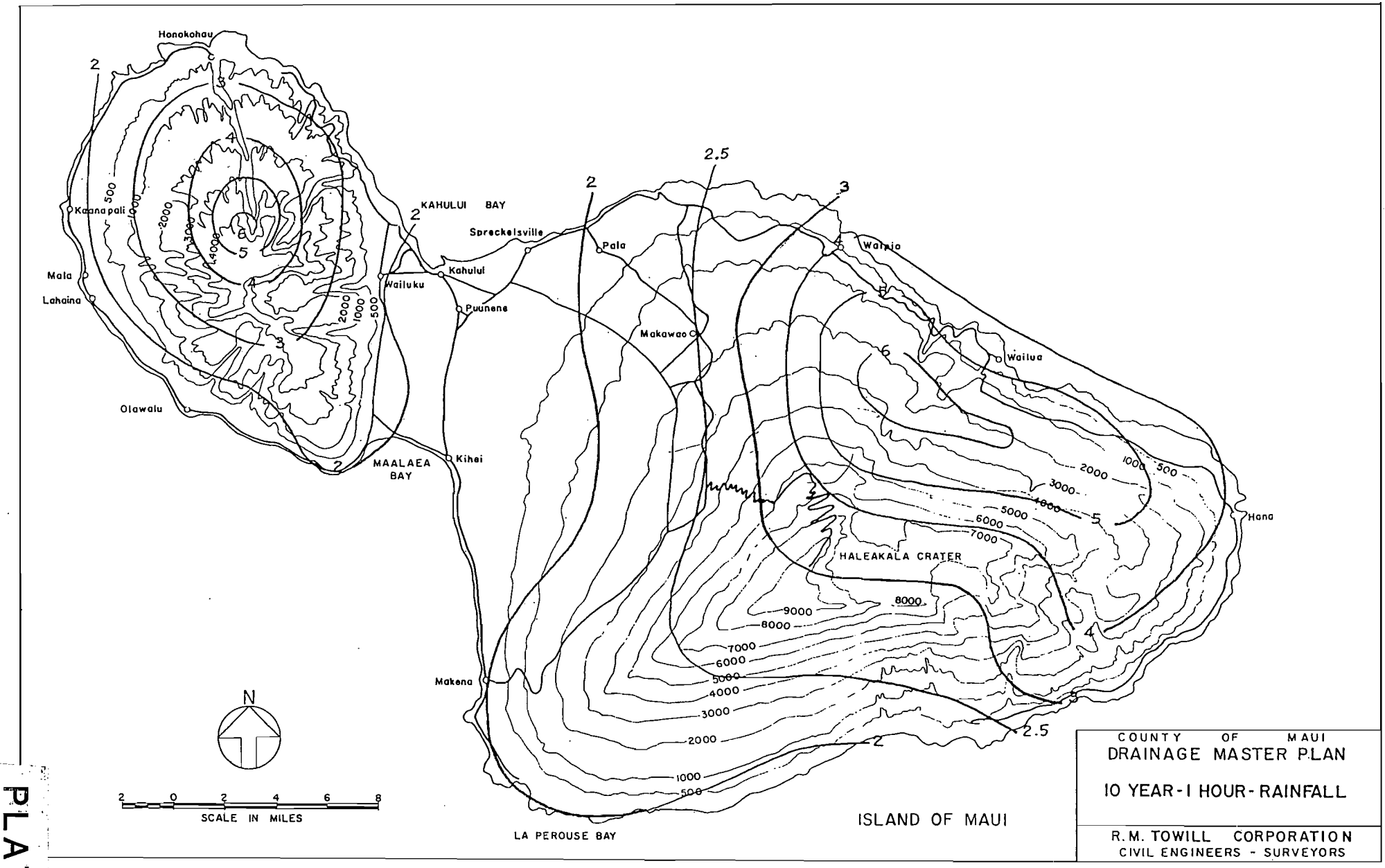
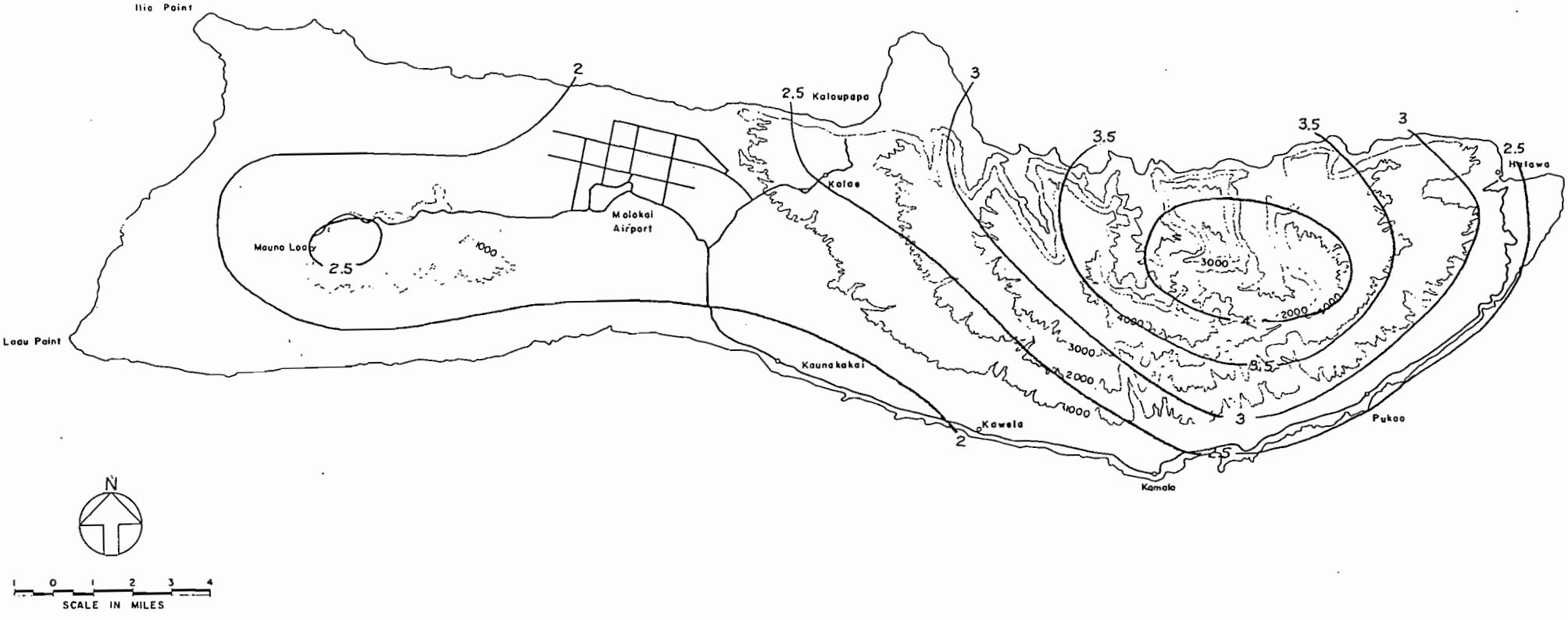

Honokohau
Kaanapali
Mala
Lahaina
Olowalu
KAHULUI BAY
Spreckelsville
Kahului
Wailuku
Puunene
Pala
Makawao
Waipio
Wailua
Hana
MAALAEA BAY
Kihei
Makena
HALEAKALA CRATER
LA PEROUSE BAY
ISLAND OF MAUI
N
SCALE IN MILES
COUNTY OF MAUI
DRAINAGE MASTER PLAN
10 YEAR-1 HOUR-RAINFALL
R.M. TOWILL CORPORATION
CIVIL ENGINEERS - SURVEYORS

PLATE 4

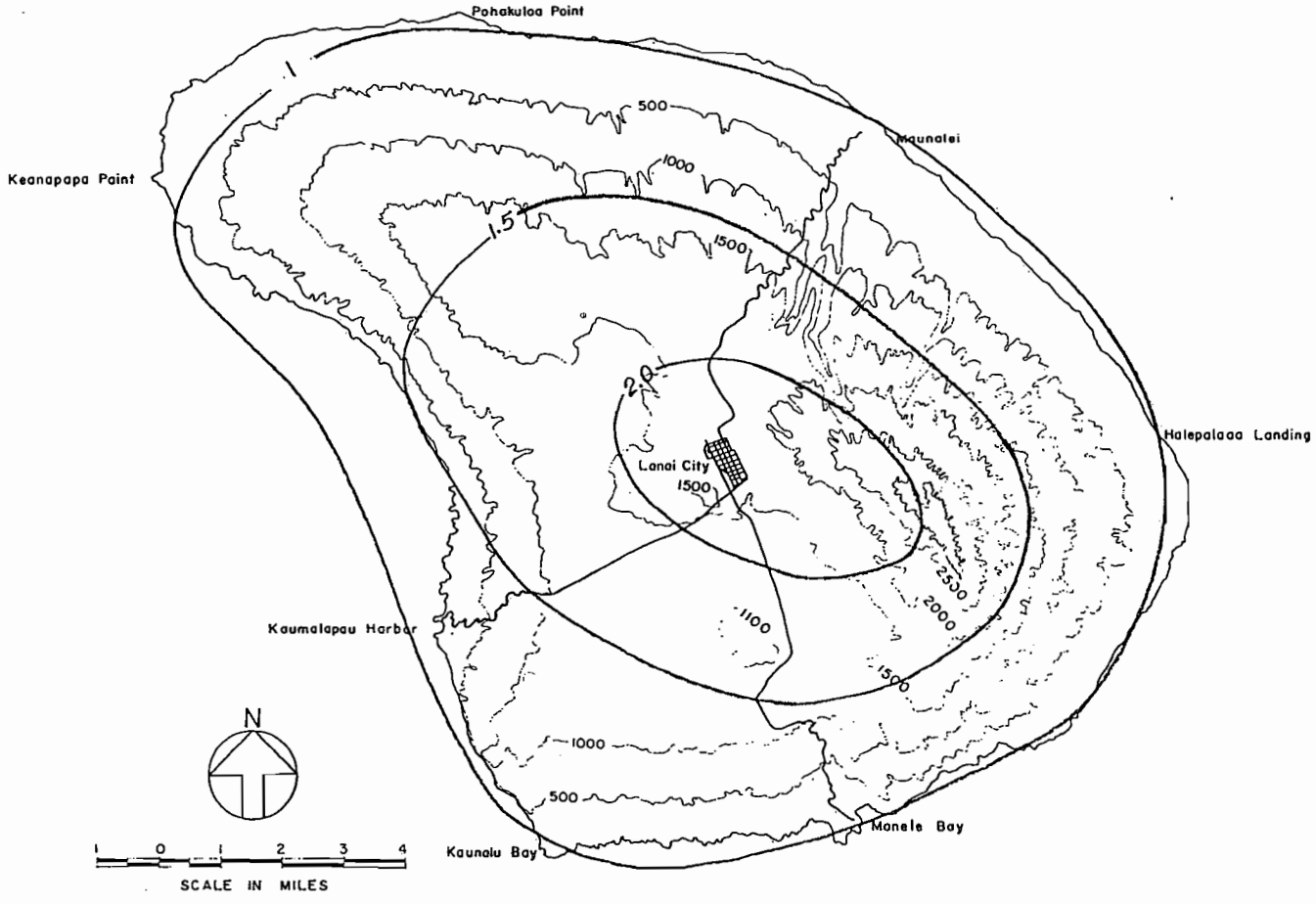


ISLAND OF MOLOKAI

COUNTY OF MAUI
DRAINAGE MASTER PLAN
10 YEAR - 1 HOUR - RAINFALL

R. M. TOWILL CORPORATION
CIVIL ENGINEERS - SURVEYORS

PLATE 5



ISLAND OF LANAI

COUNTY OF MAUI
DRAINAGE MASTER PLAN
10 YEAR - 1 HOUR - RAINFALL

R.M. TOWILL CORPORATION
CIVIL ENGINEERS - SURVEYORS

PLATE 6

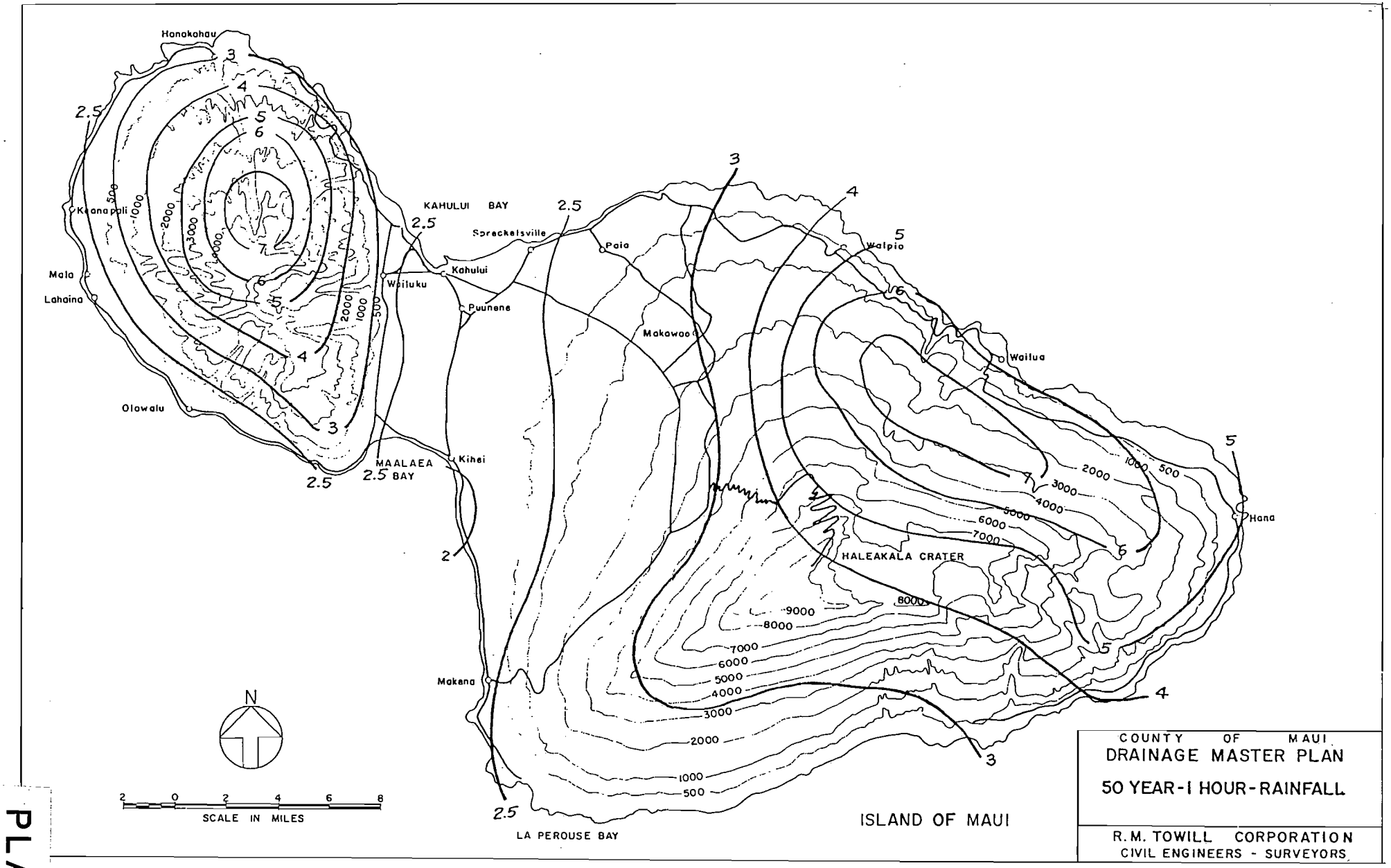
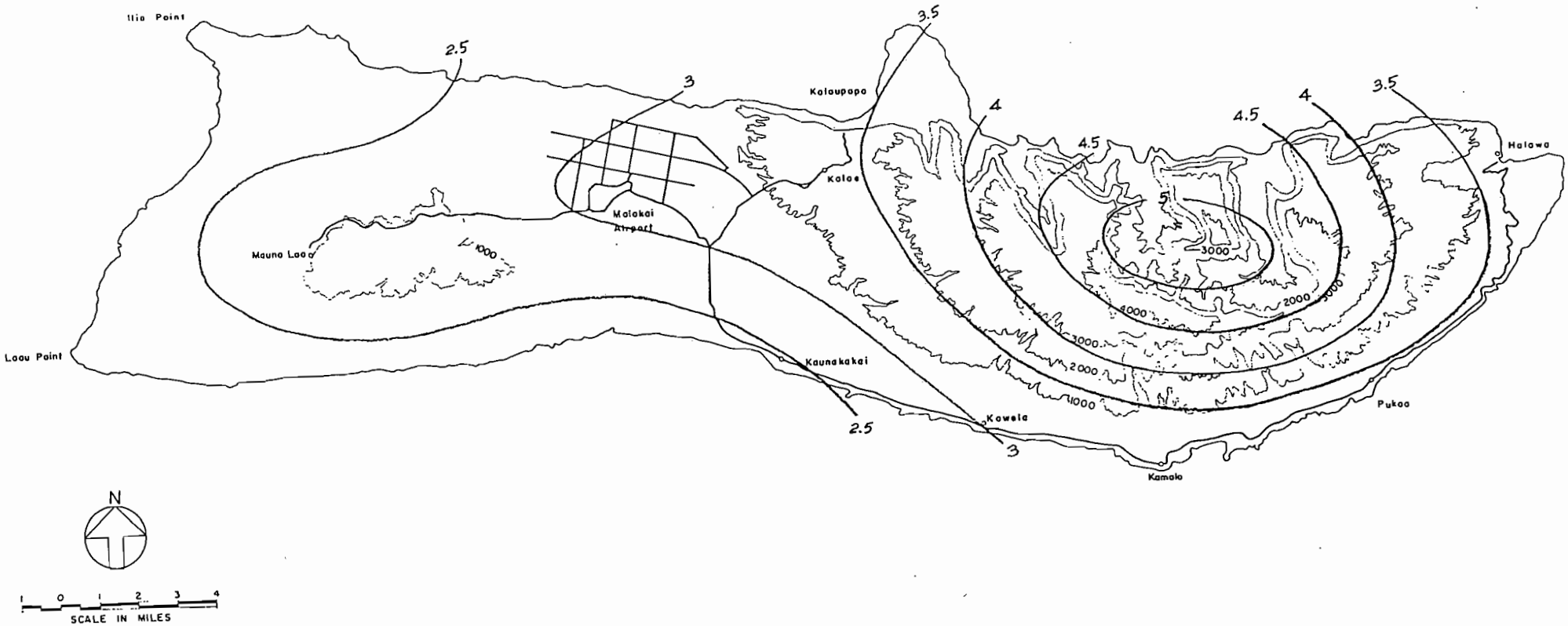

Honokohau
Kaanapali
Mala
Lahaina
Olowalu
KAHULUI BAY
Sprackelsville
Kahului
Wailuku
Puunene
Paia
Makawao
Waipio
Wailuu
Hana
MAALAEA BAY
Kihei
Makena
LA PEROUSE BAY
HALEAKALA CRATER
ISLAND OF MAUI
N
SCALE IN MILES
COUNTY OF MAUI
DRAINAGE MASTER PLAN
50 YEAR-1 HOUR-RAINFALL
R.M. TOWILL CORPORATION
CIVIL ENGINEERS - SURVEYORS

PLATE 7

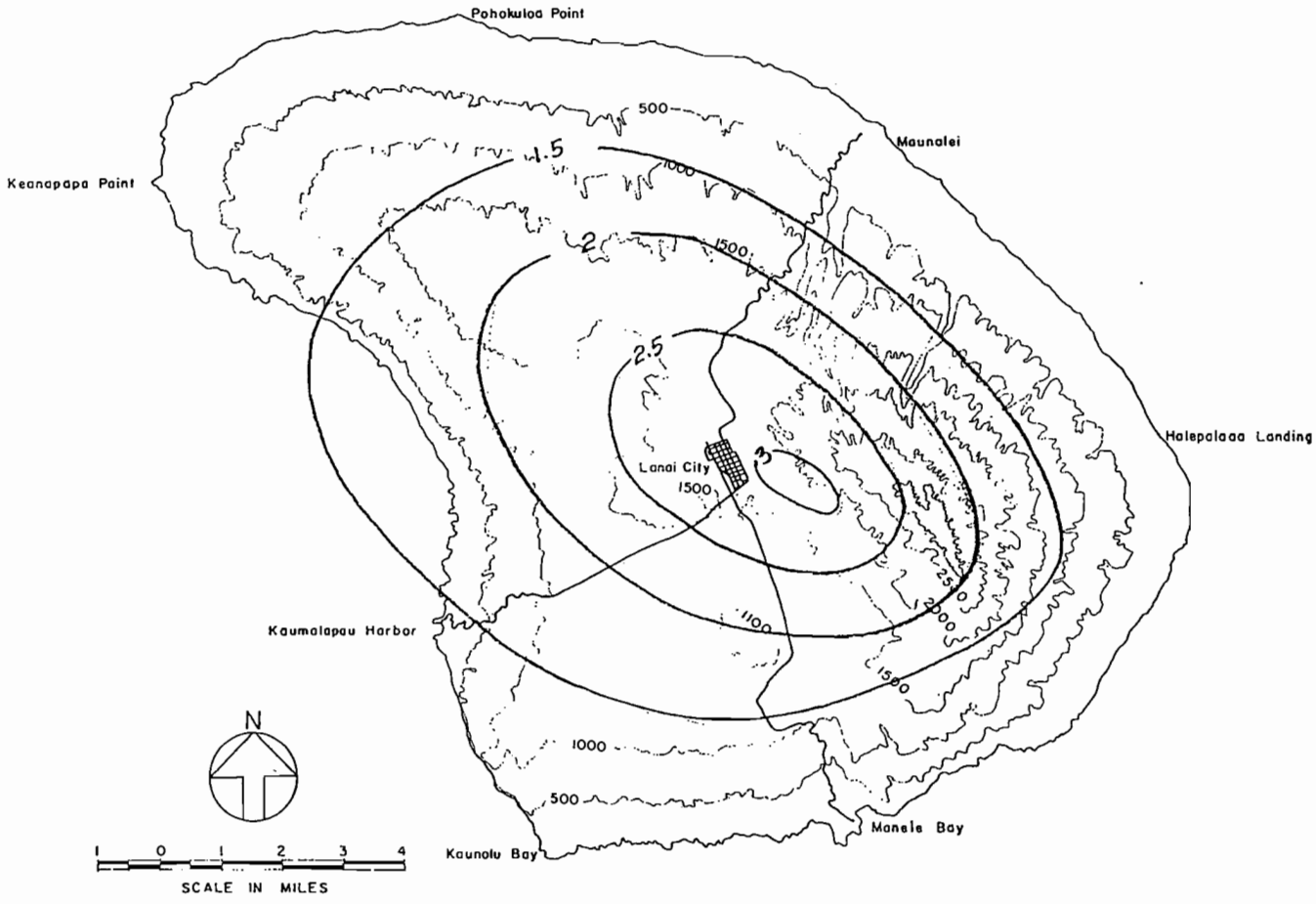


ISLAND OF MOLOKAI

COUNTY OF MAUI
DRAINAGE MASTER PLAN
50 YEAR-1 HOUR-RAINFALL

R. M. TOWILL CORPORATION
CIVIL ENGINEERS - SURVEYORS

PLATE 8



ISLAND OF LANAI

COUNTY OF MAUI
DRAINAGE MASTER PLAN
50 YEAR-1 HOUR-RAINFALL

R.M. TOWILL CORPORATION
CIVIL ENGINEERS - SURVEYORS

PLATE 9

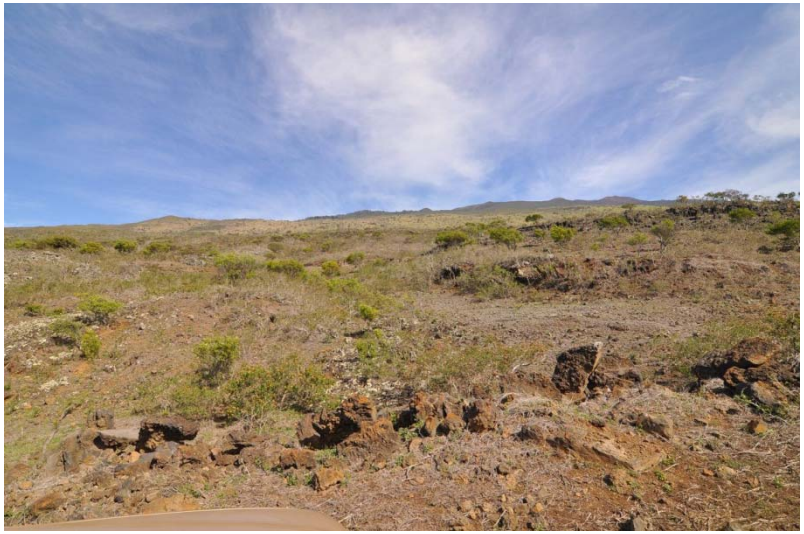
Appendix B
Photos – Typical Existing Conditions

Typical of Wind Farm Area

Typical of Wind Farm Area

Typical of Wind Farm Area

Typical of Wind Farm Area



Typical Uphill of Wind Farm

Typical Uphill of Wind Farm

Typical Uphill of Wind Farm

Typical Uphill of Wind Farm

Typical Papaka Road

Typical Papaka Road

Typical Papaka Road

Typical Papaka Road

Typical of Interconnection Sub Area

Typical of Interconnection Sub Area

Typical of Interconection Sub Area

Appendix C
HydroCAD Model Output Information

Rational Method Peak Runoff

Subcatchment A (Exist): A - Existing West Laydown

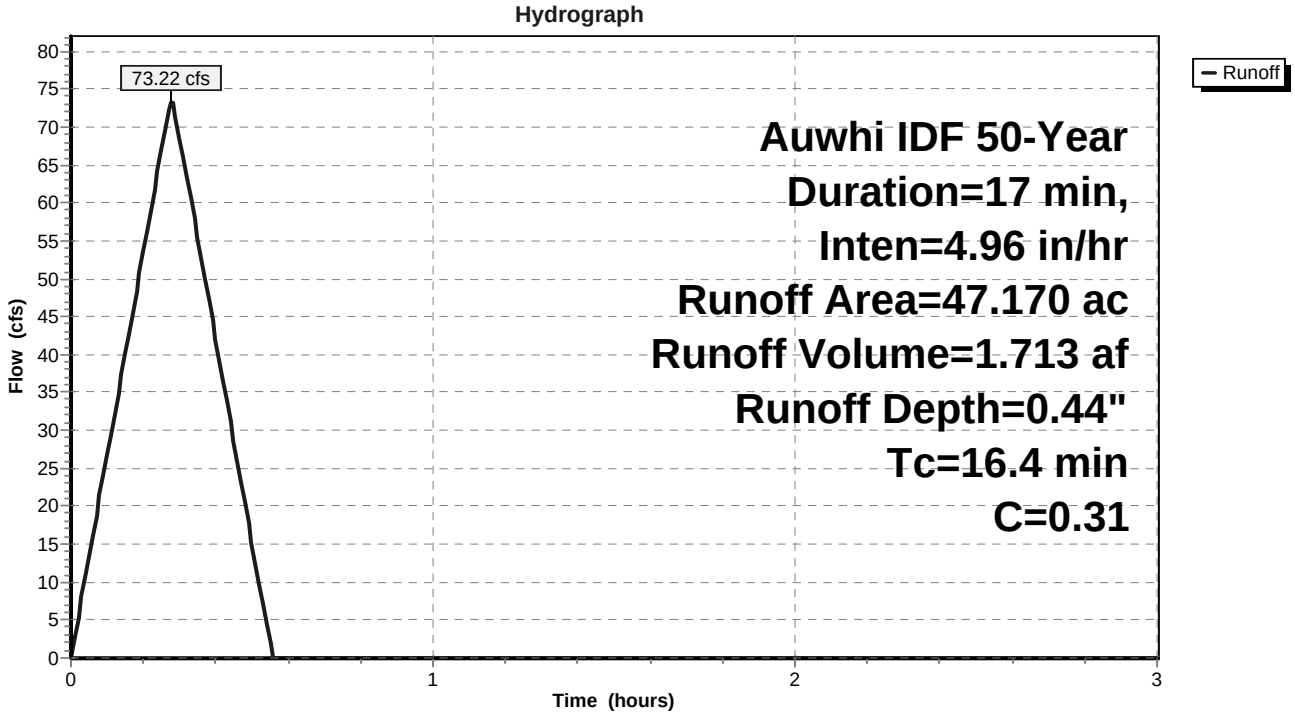
Runoff = 73.22 cfs @ 0.28 hrs, Volume= 1.713 af, Depth= 0.44"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=17 min, Inten=4.96 in/hr

Area (ac)	C	Description
47.170	0.31	
47.170	0.31	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.4					**Direct Entry,**

Subcatchment A (Exist): A - Existing West Laydown



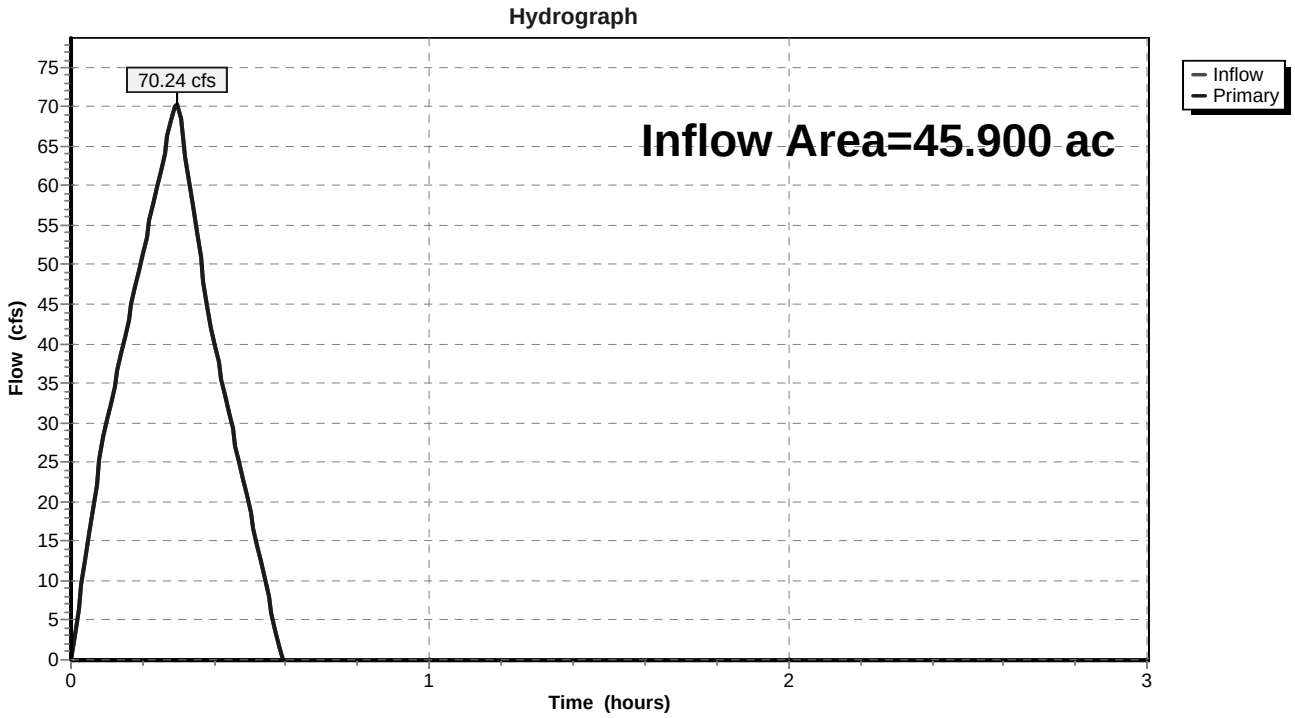
Pond A (Dev.): A - Developed West Laydown

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	45.900 ac,	Inflow Depth =	0.45"	for	50-Year event	
Inflow	=	70.24 cfs @	0.30 hrs,	Volume=	1.736 af	
Primary	=	70.24 cfs @	0.30 hrs,	Volume=	1.736 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs

Pond A (Dev.): A - Developed West Laydown



Subcatchment A-1 (Dev.): A-1 - Developed West Laydown

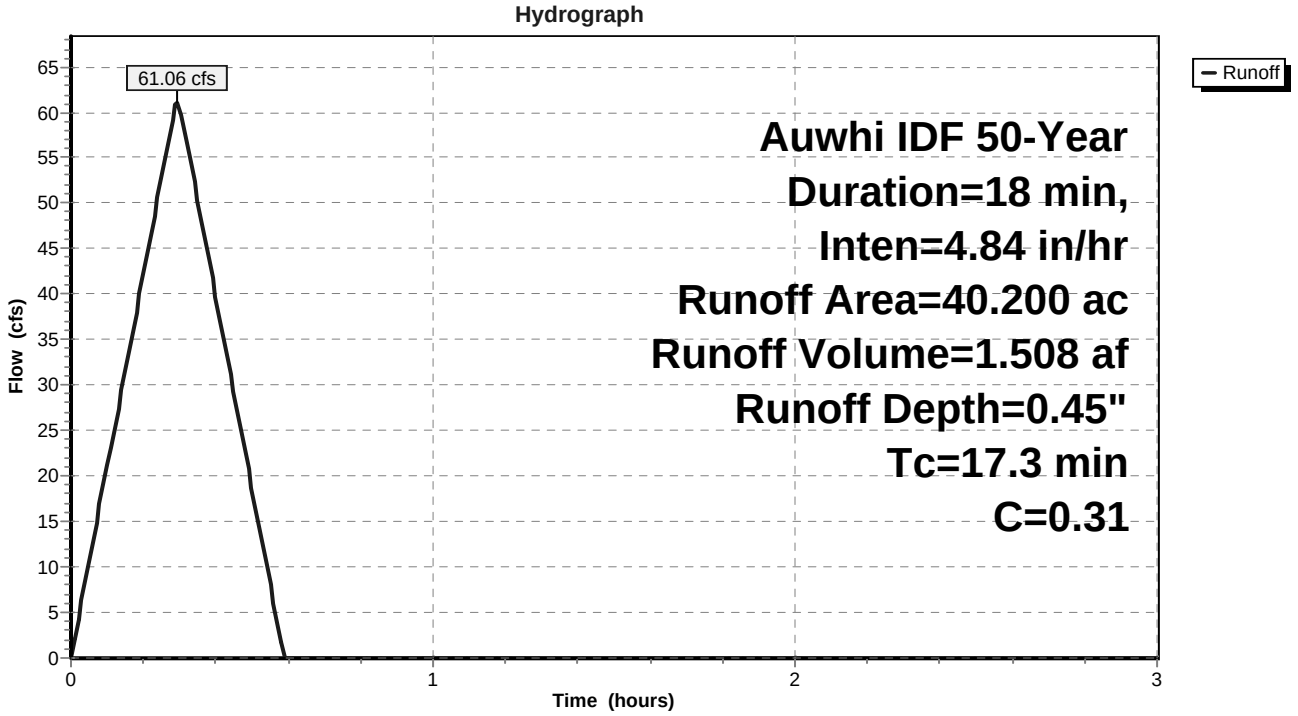
Runoff = 61.06 cfs @ 0.30 hrs, Volume= 1.508 af, Depth= 0.45"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=18 min, Inten=4.84 in/hr

Area (ac)	C	Description
40.200	0.31	
40.200	0.31	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3					**Direct Entry,**

Subcatchment A-1 (Dev.): A-1 - Developed West Laydown



Subcatchment A-2 (Dev.): A-2 - Developed West Laydown

[48] Hint: Peak<CiA due to short duration

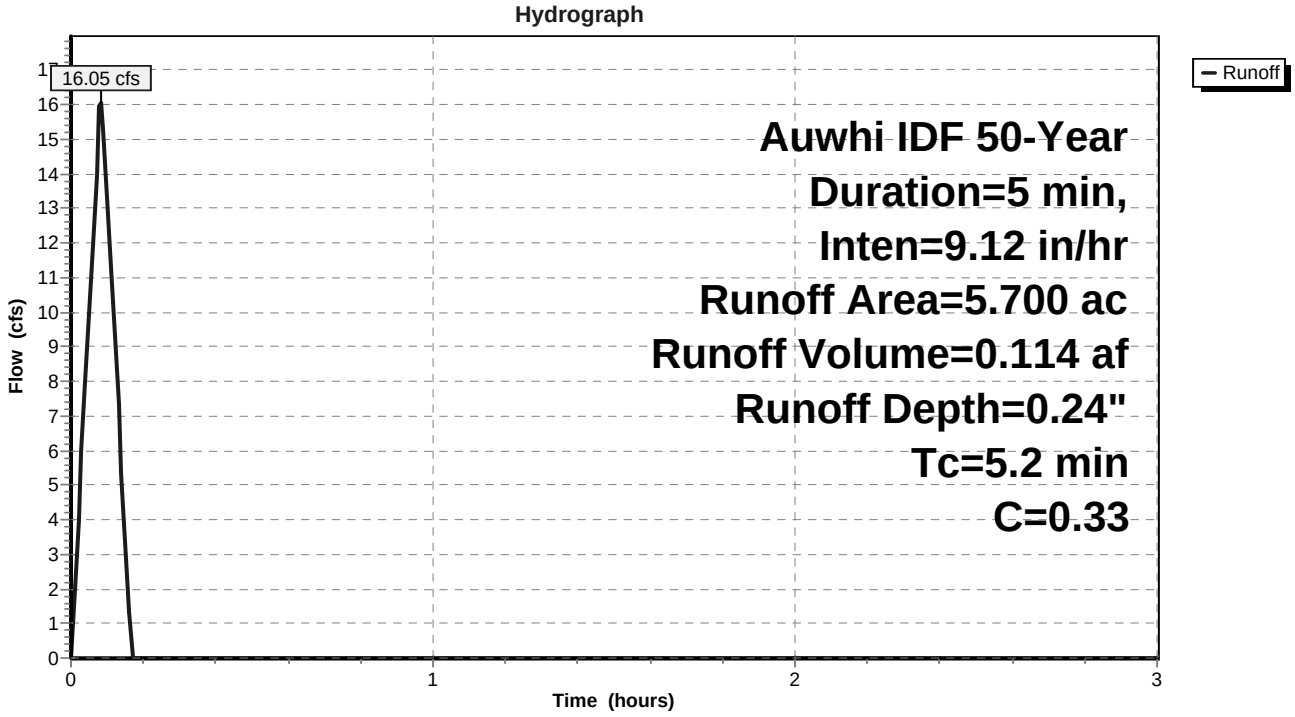
Runoff = 16.05 cfs @ 0.08 hrs, Volume= 0.114 af, Depth= 0.24"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=5 min, Inten=9.12 in/hr

Area (ac)	C	Description
5.700	0.33	
5.700	0.33	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2					**Direct Entry,**

Subcatchment A-2 (Dev.): A-2 - Developed West Laydown



Subcatchment C (Exist): C - Existing Interconnect Sub

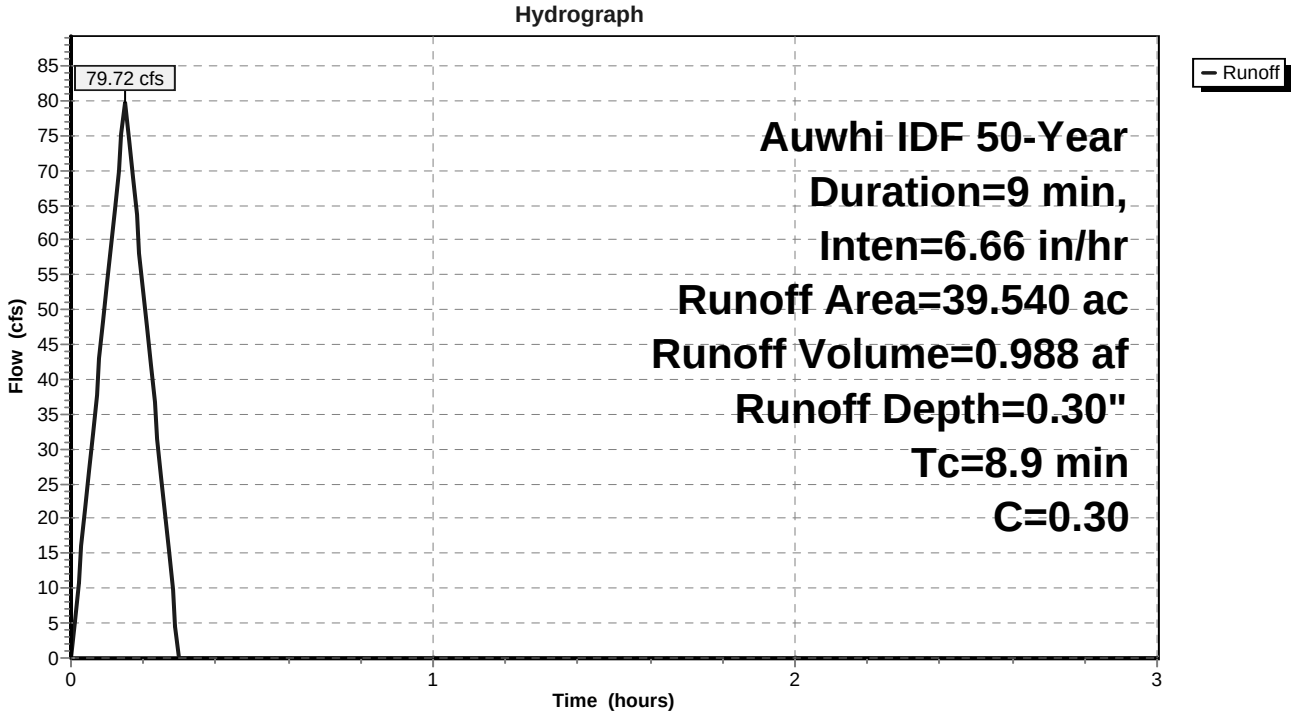
Runoff = 79.72 cfs @ 0.15 hrs, Volume= 0.988 af, Depth= 0.30"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=9 min, Inten=6.66 in/hr

Area (ac)	C	Description
39.540	0.30	
39.540	0.30	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9					**Direct Entry,**

Subcatchment C (Exist): C - Existing Interconnect Sub



Subcatchment C-2 (Exist): C-2 Existing

[70] Warning: Tc<8dt requires smaller dt

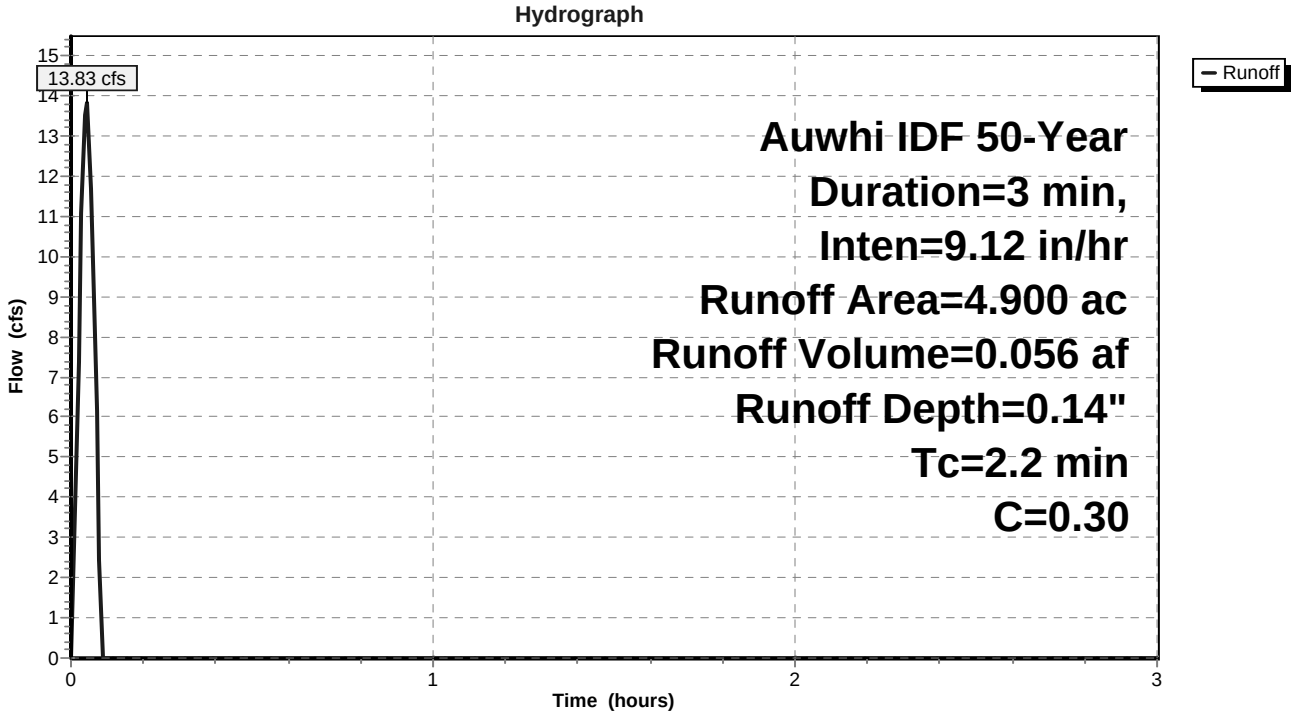
Runoff = 13.83 cfs @ 0.05 hrs, Volume= 0.056 af, Depth= 0.14"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=3 min, Inten=9.12 in/hr

Area (ac)	C	Description
4.900	0.30	
4.900	0.30	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2					**Direct Entry,**

Subcatchment C-2 (Exist): C-2 Existing



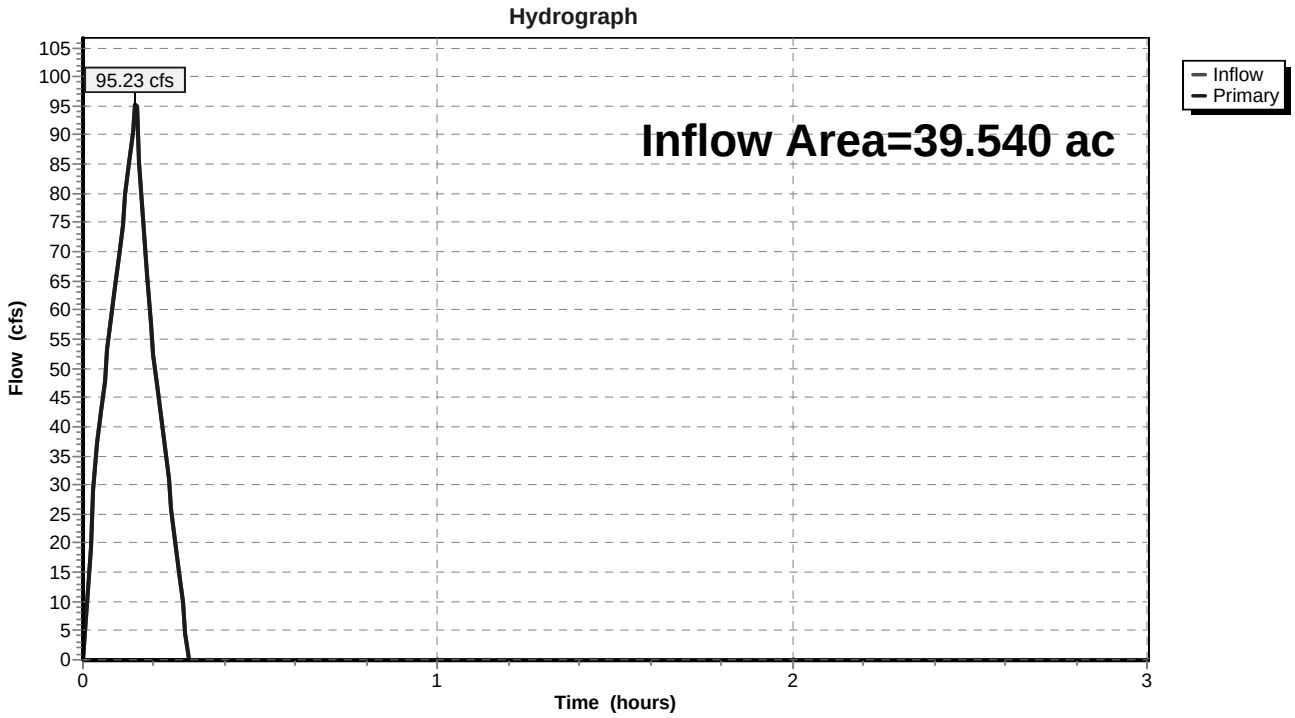
Pond C (Dev.): C - Developed Interconnect Sub

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	39.540 ac,	Inflow Depth =	0.36"	for	50-Year event
Inflow =	95.23 cfs @	0.15 hrs,	Volume=		1.178 af
Primary =	95.23 cfs @	0.15 hrs,	Volume=		1.178 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs

Pond C (Dev.): C - Developed Interconnect Sub



Subcatchment C-1 (Dev.): C-1 - Developed Interconnect Sub

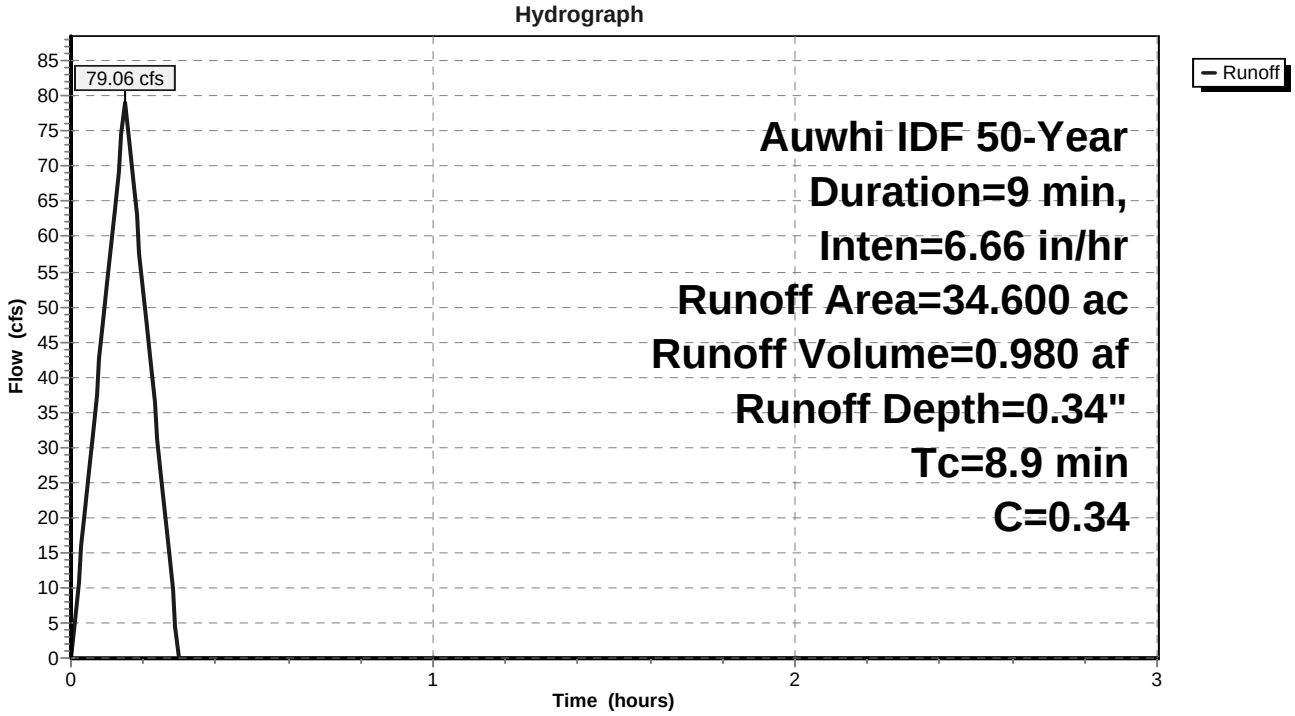
Runoff = 79.06 cfs @ 0.15 hrs, Volume= 0.980 af, Depth= 0.34"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=9 min, Inten=6.66 in/hr

Area (ac)	C	Description
34.600	0.34	
34.600	0.34	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9					**Direct Entry,**

Subcatchment C-1 (Dev.): C-1 - Developed Interconnect Sub



Subcatchment C-2 (Dev.): C-2 - Developed Interconnect Sub

[70] Warning: Tc<8dt requires smaller dt

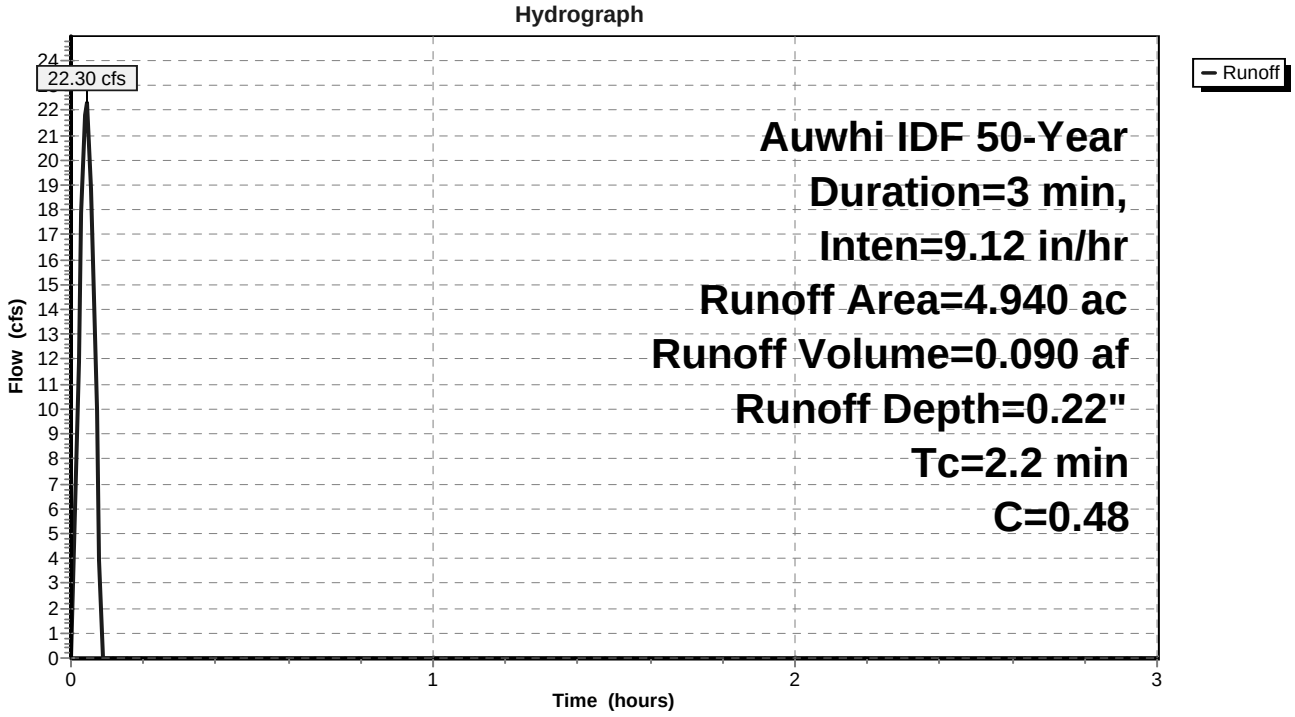
Runoff = 22.30 cfs @ 0.05 hrs, Volume= 0.090 af, Depth= 0.22"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=3 min, Inten=9.12 in/hr

Area (ac)	C	Description
4.940	0.48	
4.940	0.48	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2					**Direct Entry,**

Subcatchment C-2 (Dev.): C-2 - Developed Interconnect Sub



Subcatchment E (Exist): E - Existing Wind Farm

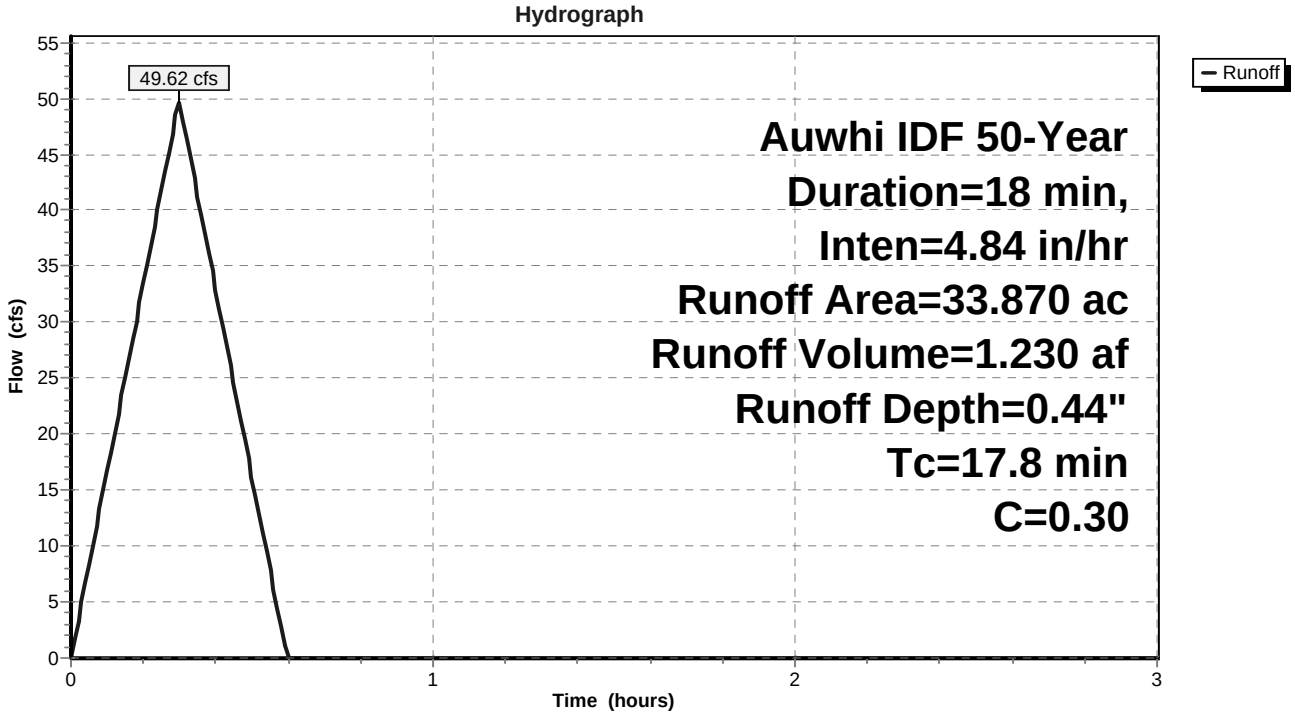
Runoff = 49.62 cfs @ 0.30 hrs, Volume= 1.230 af, Depth= 0.44"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=18 min, Inten=4.84 in/hr

Area (ac)	C	Description
33.870	0.30	
33.870	0.30	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.8					**Direct Entry,**

Subcatchment E (Exist): E - Existing Wind Farm



Subcatchment E (Dev.): E - Developed Wind Farm

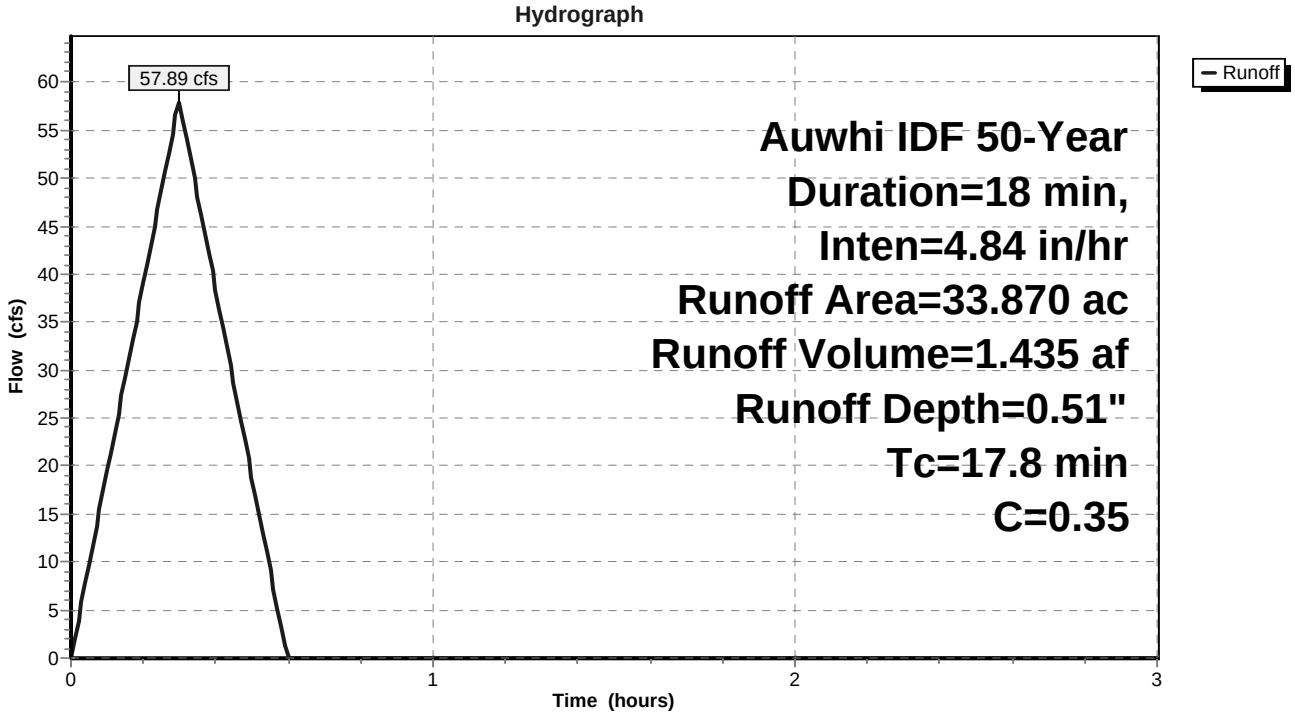
Runoff = 57.89 cfs @ 0.30 hrs, Volume= 1.435 af, Depth= 0.51"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=18 min, Inten=4.84 in/hr

Area (ac)	C	Description
33.870	0.35	
33.870	0.35	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.8					**Direct Entry,**

Subcatchment E (Dev.): E - Developed Wind Farm



Subcatchment H: H - Existing Papaka Rd

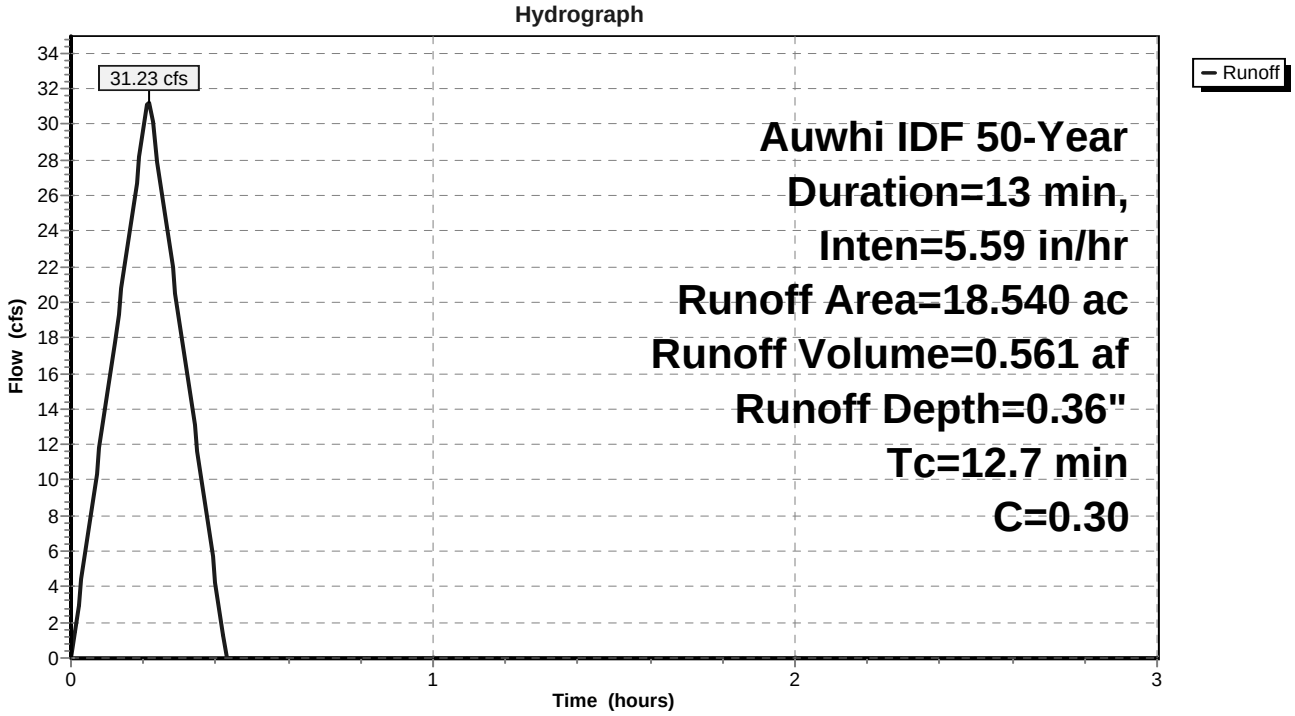
Runoff = 31.23 cfs @ 0.21 hrs, Volume= 0.561 af, Depth= 0.36"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=13 min, Inten=5.59 in/hr

Area (ac)	C	Description
18.540	0.30	
18.540	0.30	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.7					**Direct Entry,**

Subcatchment H: H - Existing Papaka Rd



Subcatchment K: K - Existing Papaka Rd

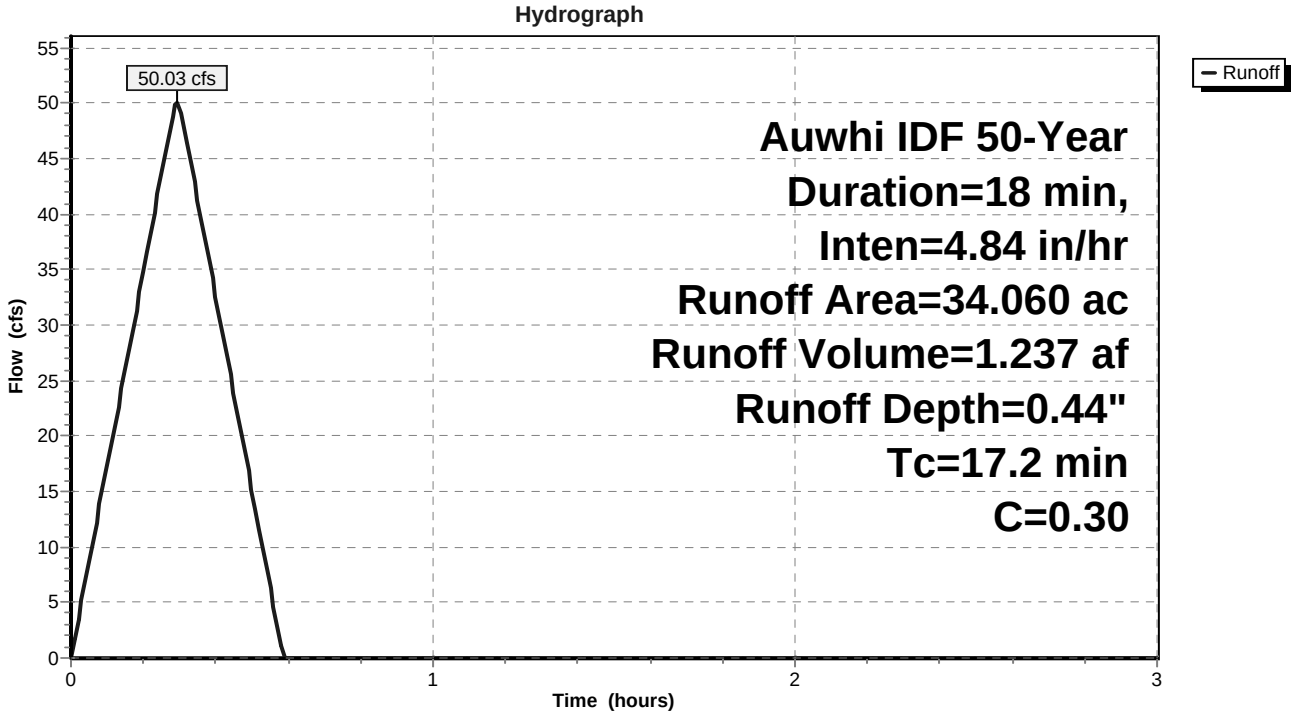
Runoff = 50.03 cfs @ 0.30 hrs, Volume= 1.237 af, Depth= 0.44"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Auwhi IDF 50-Year Duration=18 min, Inten=4.84 in/hr

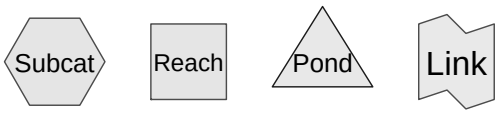
Area (ac)	C	Description
34.060	0.30	
34.060	0.30	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2					**Direct Entry,**

Subcatchment K: K - Existing Papaka Rd



NRCS Method



Drainage Diagram for Sempra HydroCAD
Prepared by {enter your company name here} 1/13/2011
HydroCAD® 8.00 s/n 004531 © 2006 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (acres)	CN	Description (subcats)
212.310	60.0	(I,J)
141.880	61.0	(D (Exist))
141.880	62.0	(D (Dev.))
3.200	63.0	(B-2 (Dev.))
151.980	64.0	(G (Exist))
151.980	65.0	(G (Dev.))
774.400	69.0	(F (Dev.),F (Exist))
465.180	73.0	(B (Exist),B-1 (Dev.))
2,042.810		

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment B (Exist): B - Existing East Laydown Runoff Area=233.580 ac Runoff Depth>7.26"
Tc=141.4 min CN=72.7 Runoff=312.60 cfs 141.301 af

Subcatchment B-1 (Dev.): B-1 - Developed East Laydown Runoff Area=231.600 ac Runoff Depth>7.29"
Tc=141.4 min CN=72.9 Runoff=311.24 cfs 140.624 af

Subcatchment B-2 (Dev.): B-2 - Developed East Laydown Runoff Area=3.200 ac Runoff Depth=5.98"
Tc=27.8 min CN=63.4 Runoff=9.03 cfs 1.595 af

Subcatchment D (Dev.): D - Developed Wind Farm Runoff Area=141.880 ac Runoff Depth>5.74"
Tc=173.7 min CN=61.7 Runoff=125.70 cfs 67.881 af

Subcatchment D (Exist): D - Existing Wind Farm Runoff Area=141.880 ac Runoff Depth>5.61"
Tc=173.7 min CN=60.8 Runoff=122.20 cfs 66.385 af

Subcatchment F (Dev.): F - Developed Wind Farm Runoff Area=387.200 ac Runoff Depth>6.69"
Tc=288.2 min CN=68.9 Runoff=304.95 cfs 215.752 af

Subcatchment F (Exist): F - Existing Wind Farm Runoff Area=387.200 ac Runoff Depth>6.66"
Tc=288.2 min CN=68.7 Runoff=303.49 cfs 214.871 af

Subcatchment G (Dev.): G - Developed Wind Farm Runoff Area=151.980 ac Runoff Depth>6.21"
Tc=203.4 min CN=65.1 Runoff=133.43 cfs 78.650 af

Subcatchment G (Exist): G - Existing Wind Farm Runoff Area=151.980 ac Runoff Depth>6.08"
Tc=203.4 min CN=64.2 Runoff=130.17 cfs 77.066 af

Subcatchment I: I - Existing Papaka Rd Runoff Area=104.210 ac Runoff Depth=5.51"
Tc=110.2 min CN=60.0 Runoff=116.95 cfs 47.807 af

Subcatchment J: J - Existing Papaka Rd Runoff Area=108.100 ac Runoff Depth=5.51"
Tc=64.8 min CN=60.0 Runoff=167.93 cfs 49.592 af

Pond B (Dev): B - Developed East Laydown Inflow=312.90 cfs 142.219 af
Primary=312.90 cfs 142.219 af

Total Runoff Area = 2,042.810 ac Runoff Volume = 1,101.524 af Average Runoff Depth = 6.47"
100.00% Pervious Area = 2,042.810 ac 0.00% Impervious Area = 0.000 ac

Subcatchment B (Exist): B - Existing East Laydown

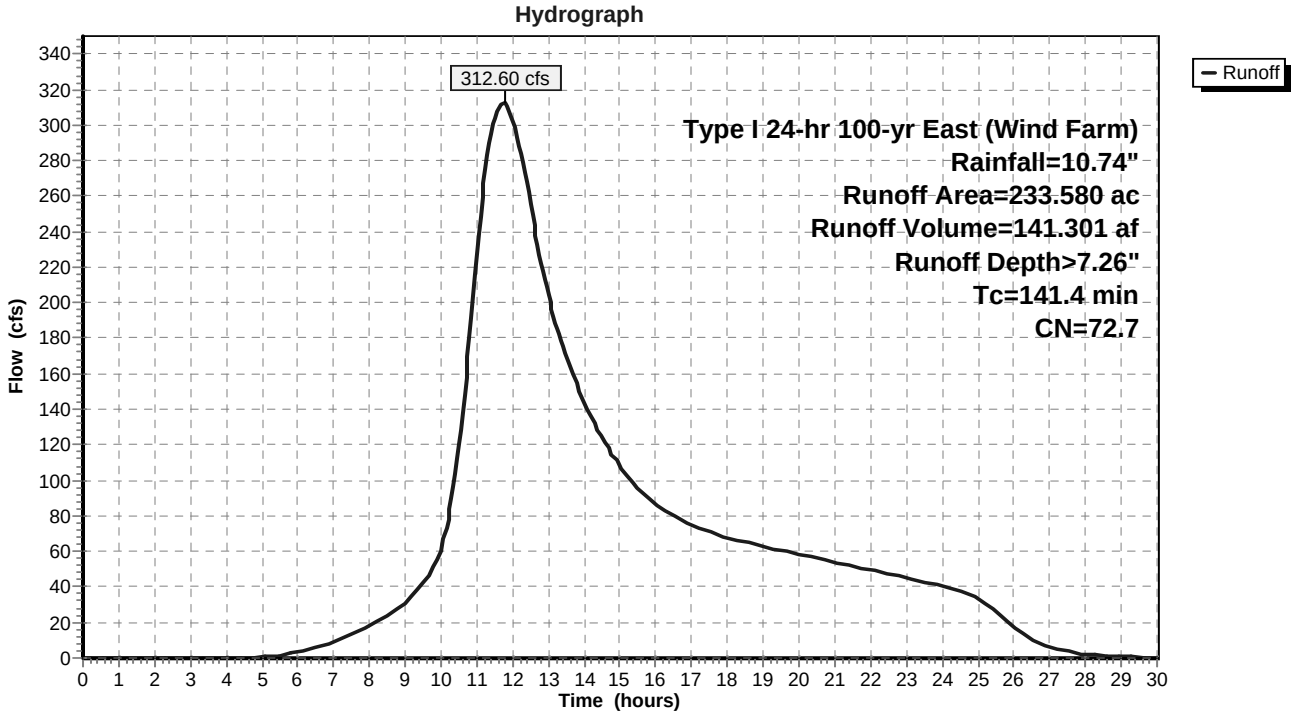
Runoff = 312.60 cfs @ 11.77 hrs, Volume= 141.301 af, Depth> 7.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
233.580	72.7	
233.580		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
141.4					**Direct Entry,**

Subcatchment B (Exist): B - Existing East Laydown



Subcatchment B-1 (Dev.): B-1 - Developed East Laydown

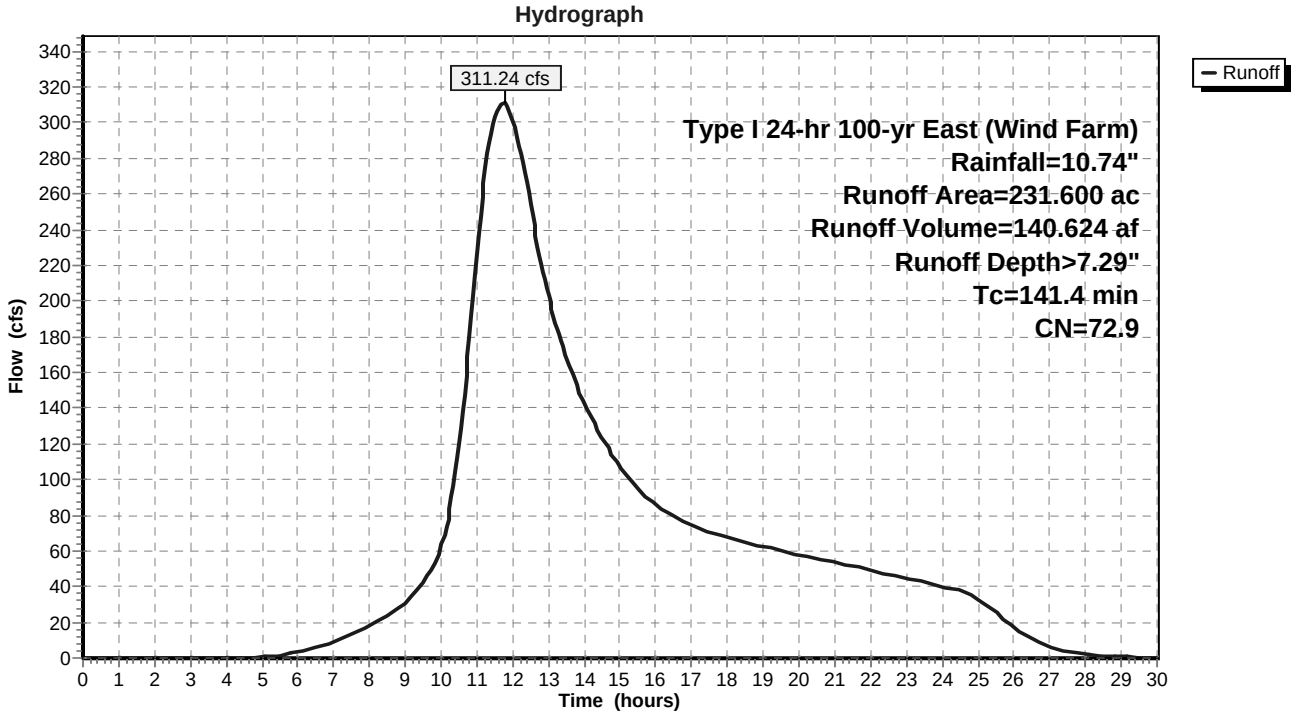
Runoff = 311.24 cfs @ 11.77 hrs, Volume= 140.624 af, Depth> 7.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
231.600	72.9	
231.600		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
141.4					**Direct Entry,**

Subcatchment B-1 (Dev.): B-1 - Developed East Laydown



Subcatchment B-2 (Dev.): B-2 - Developed East Laydown

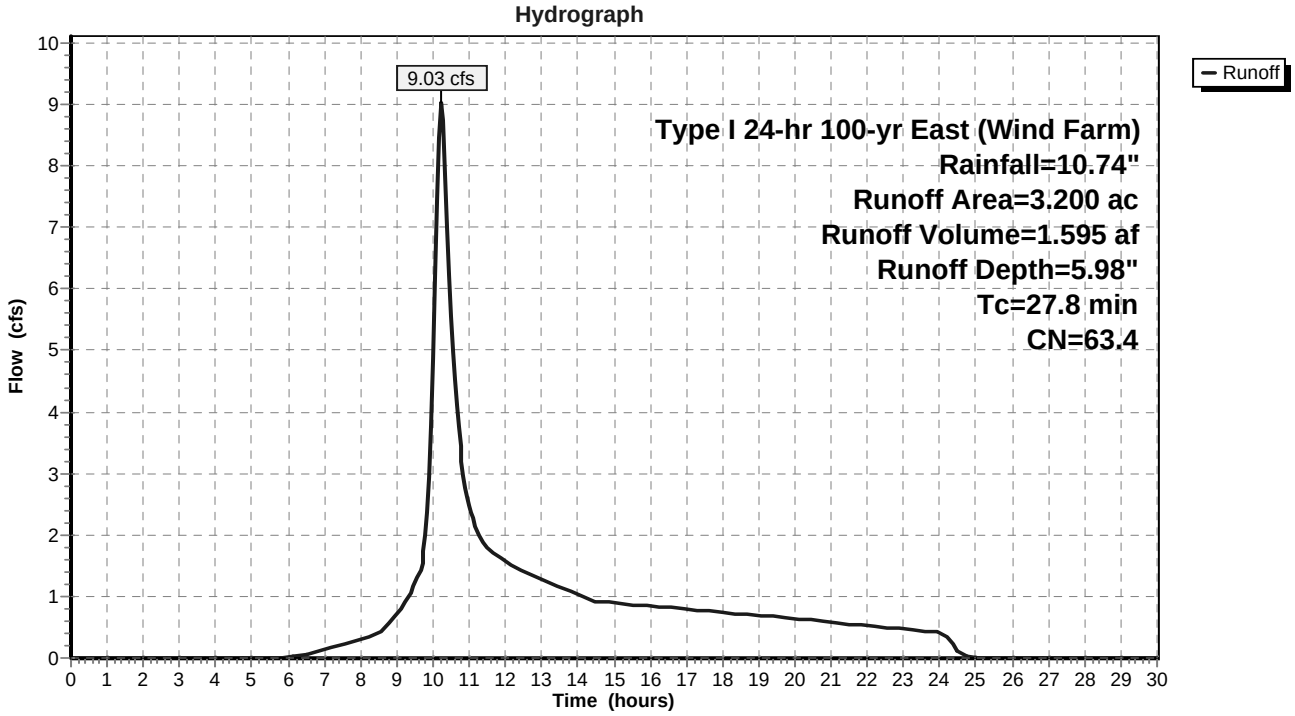
Runoff = 9.03 cfs @ 10.22 hrs, Volume= 1.595 af, Depth= 5.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
3.200	63.4	
3.200		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.8					**Direct Entry,**

Subcatchment B-2 (Dev.): B-2 - Developed East Laydown



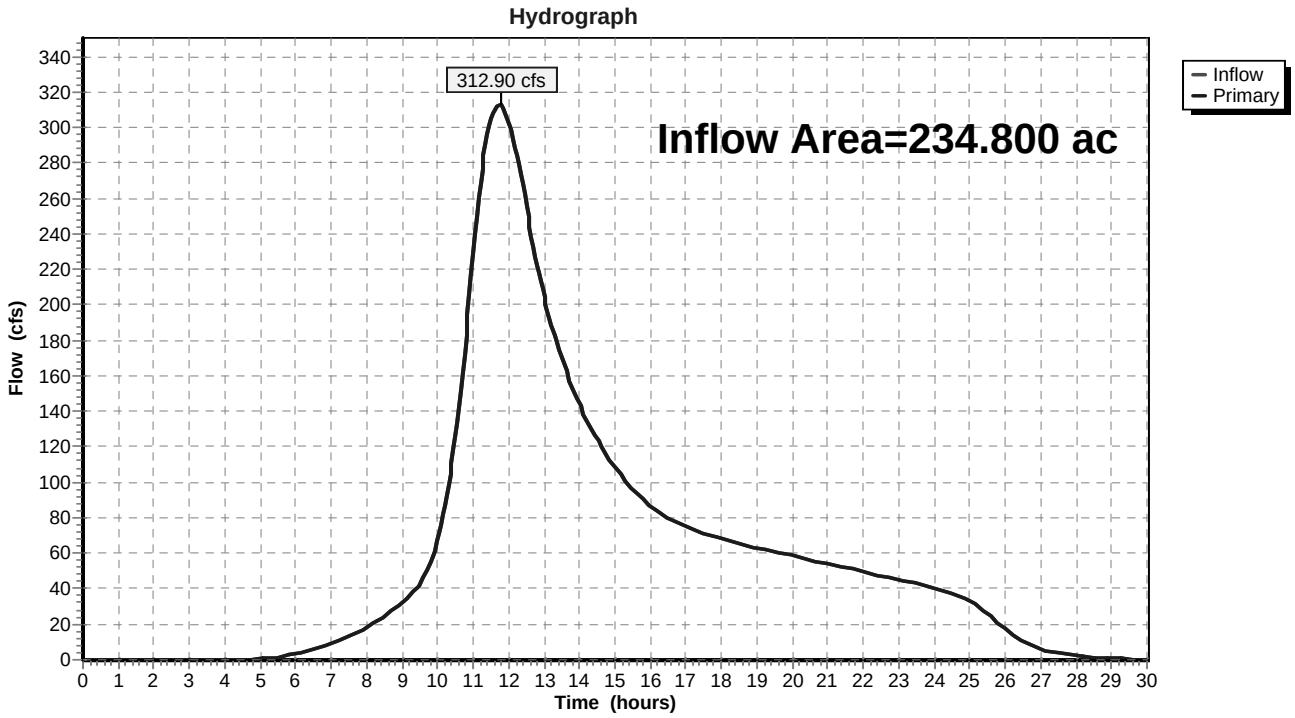
Pond B (Dev): B - Developed East Laydown

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 234.800 ac, Inflow Depth > 7.27" for 100-yr East (Wind Farm) event
Inflow = 312.90 cfs @ 11.77 hrs, Volume= 142.219 af
Primary = 312.90 cfs @ 11.77 hrs, Volume= 142.219 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Pond B (Dev): B - Developed East Laydown



Subcatchment D (Exist): D - Existing Wind Farm

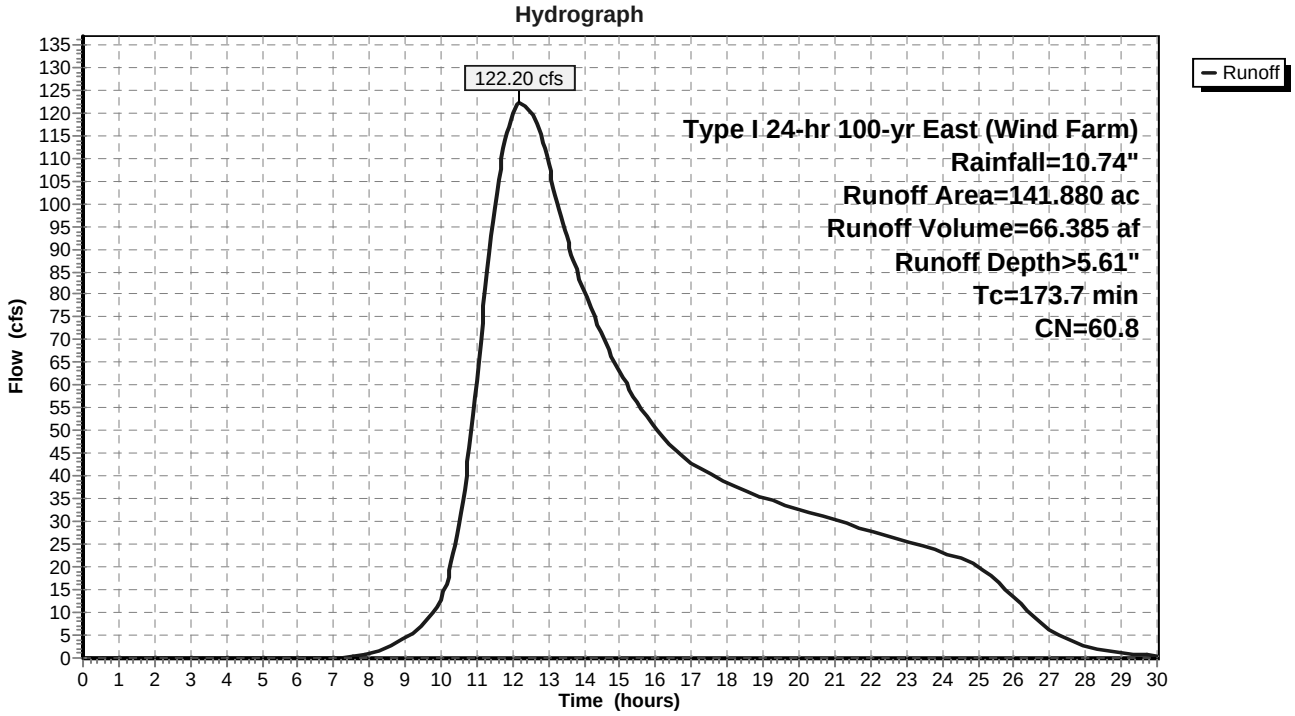
Runoff = 122.20 cfs @ 12.20 hrs, Volume= 66.385 af, Depth> 5.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
141.880	60.8	
141.880		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
173.7					**Direct Entry,**

Subcatchment D (Exist): D - Existing Wind Farm



Subcatchment D (Dev.): D - Developed Wind Farm

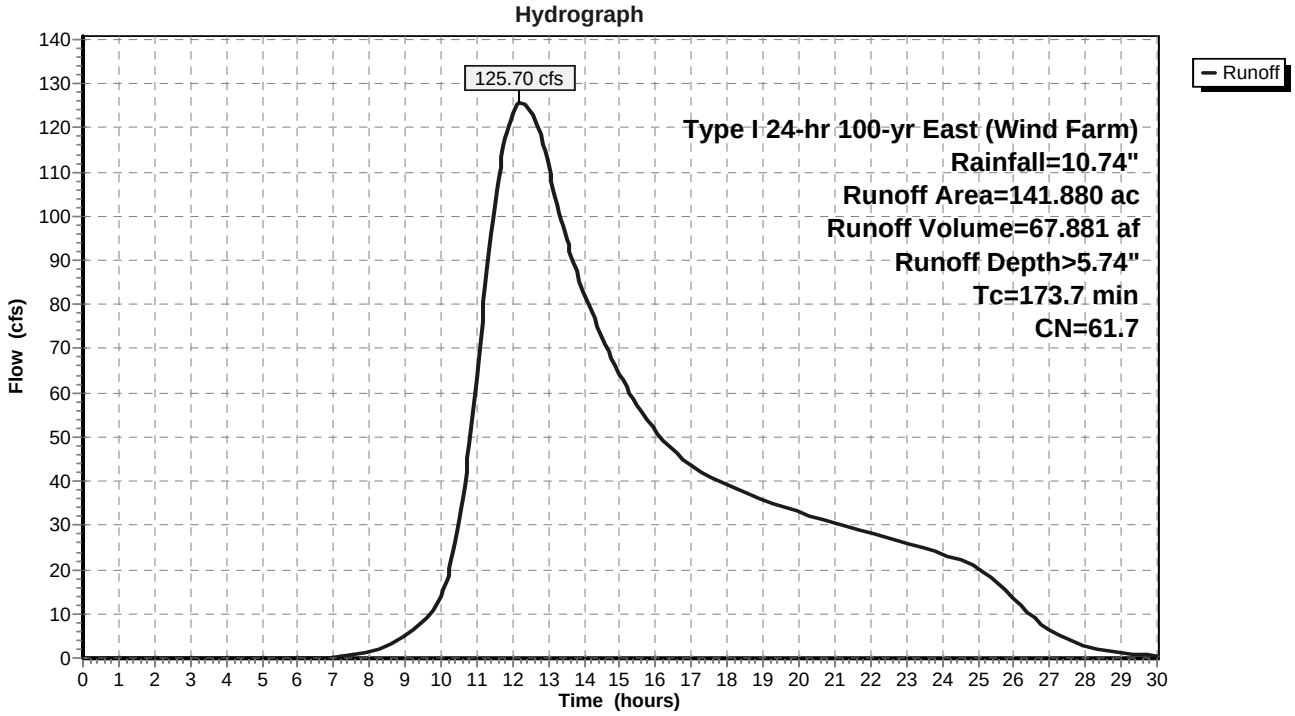
Runoff = 125.70 cfs @ 12.19 hrs, Volume= 67.881 af, Depth> 5.74"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
141.880	61.7	
141.880		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
173.7					**Direct Entry,**

Subcatchment D (Dev.): D - Developed Wind Farm



Subcatchment F (Exist): F - Existing Wind Farm

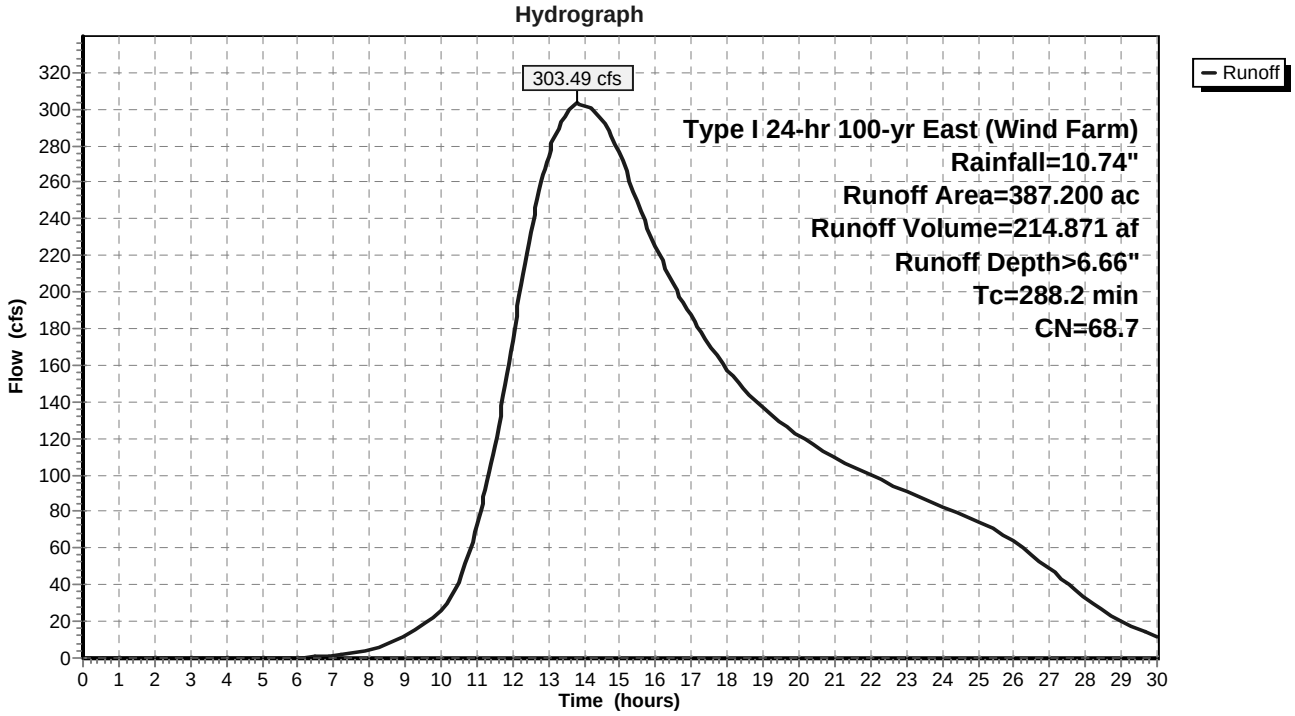
Runoff = 303.49 cfs @ 13.80 hrs, Volume= 214.871 af, Depth> 6.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
387.200	68.7	
387.200		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
288.2					**Direct Entry,**

Subcatchment F (Exist): F - Existing Wind Farm



Subcatchment F (Dev.): F - Developed Wind Farm

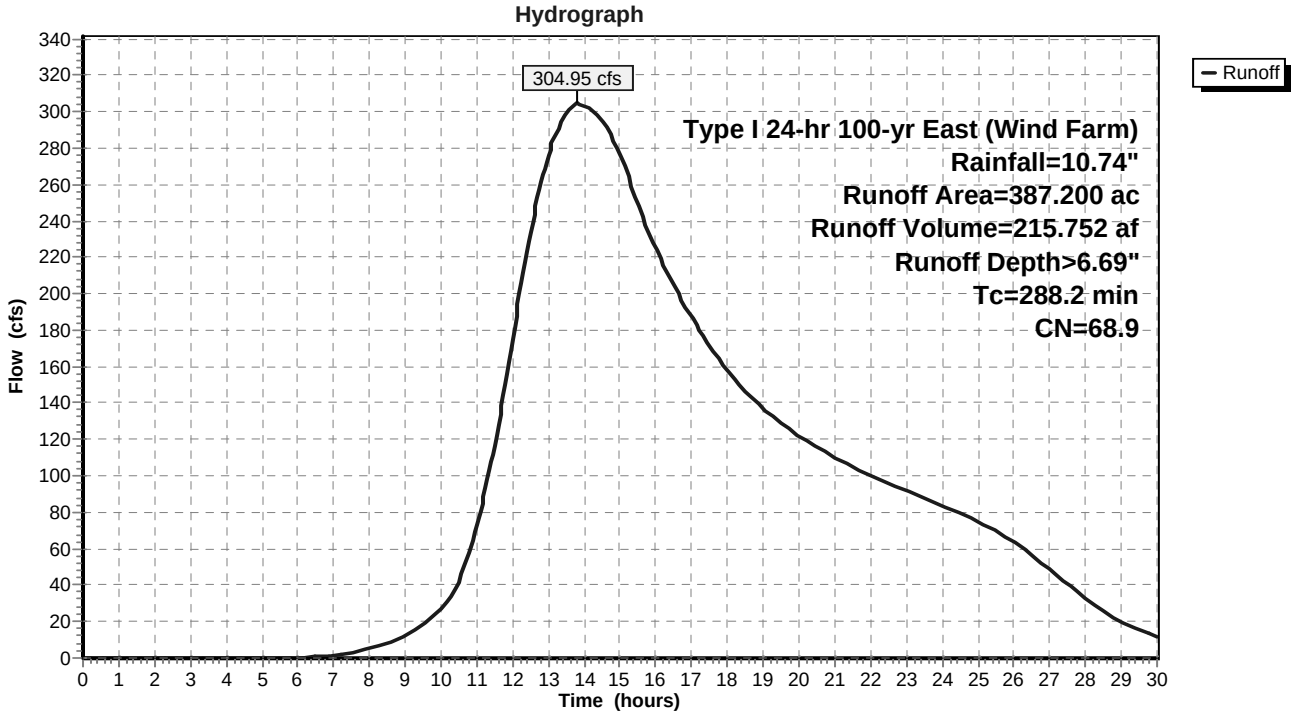
Runoff = 304.95 cfs @ 13.80 hrs, Volume= 215.752 af, Depth> 6.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
387.200	68.9	
387.200		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
288.2					**Direct Entry,**

Subcatchment F (Dev.): F - Developed Wind Farm



Subcatchment G (Exist): G - Existing Wind Farm

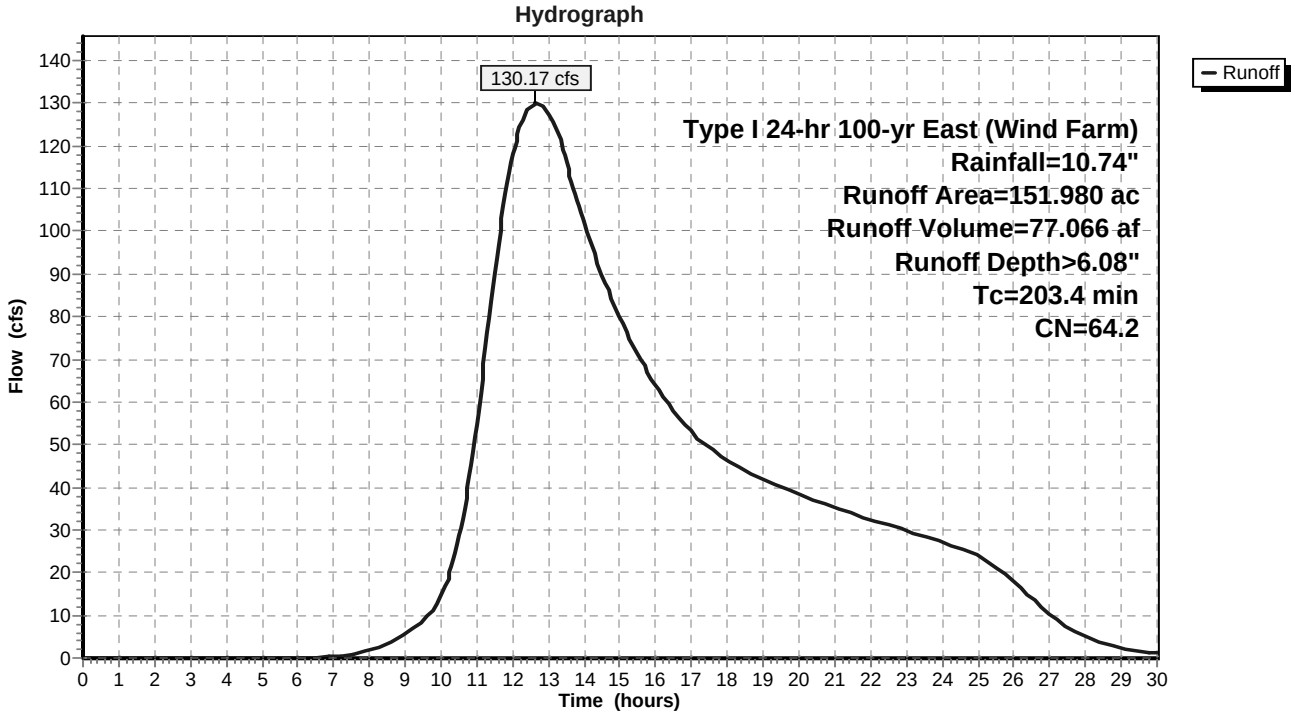
Runoff = 130.17 cfs @ 12.65 hrs, Volume= 77.066 af, Depth> 6.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
151.980	64.2	
151.980		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
203.4					**Direct Entry,**

Subcatchment G (Exist): G - Existing Wind Farm



Subcatchment G (Dev.): G - Developed Wind Farm

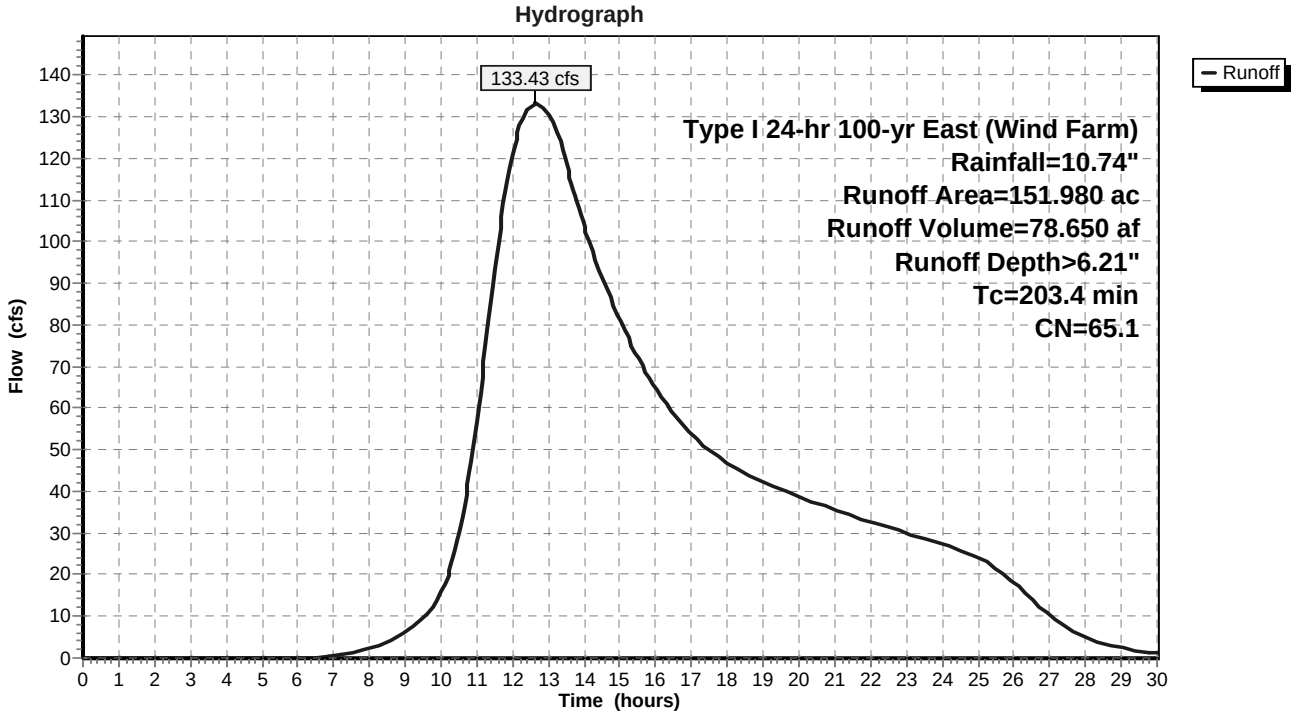
Runoff = 133.43 cfs @ 12.65 hrs, Volume= 78.650 af, Depth> 6.21"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
151.980	65.1	
151.980		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
203.4					**Direct Entry,**

Subcatchment G (Dev.): G - Developed Wind Farm



Subcatchment I: I - Existing Papaka Rd

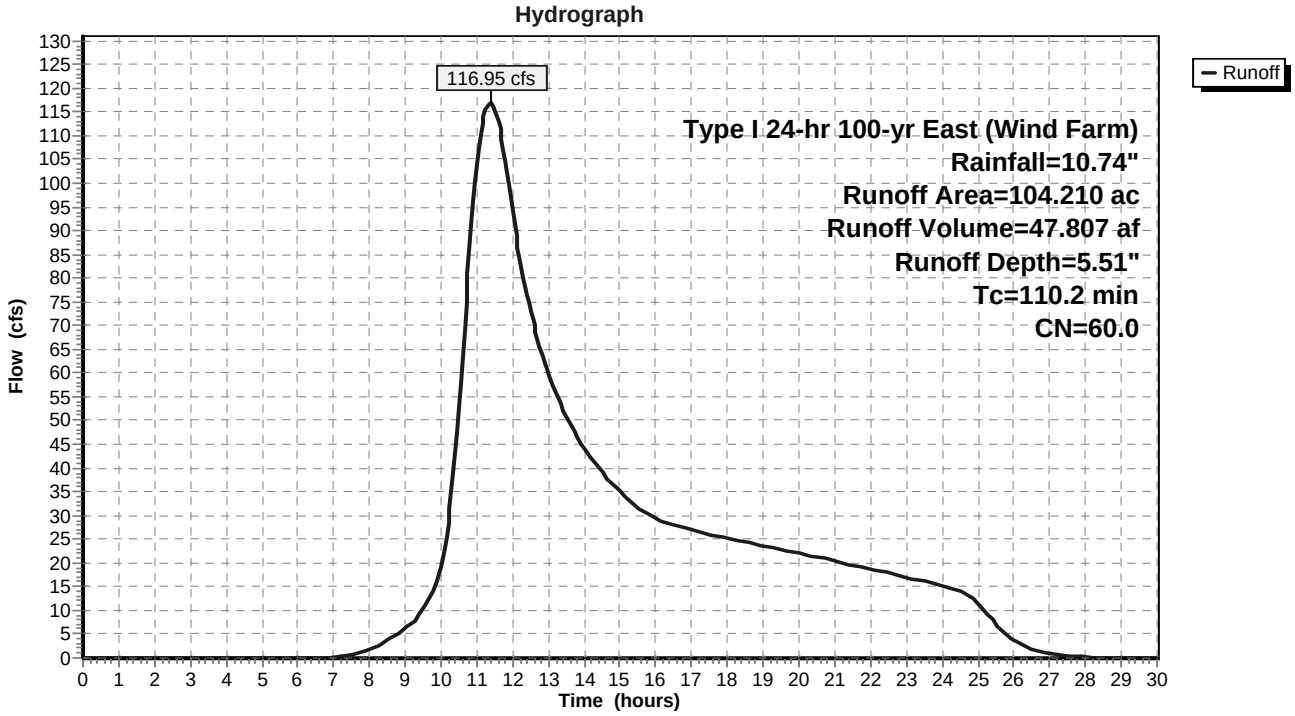
Runoff = 116.95 cfs @ 11.39 hrs, Volume= 47.807 af, Depth= 5.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
104.210	60.0	
104.210		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
110.2					**Direct Entry,**

Subcatchment I: I - Existing Papaka Rd



Subcatchment J: J - Existing Papaka Rd

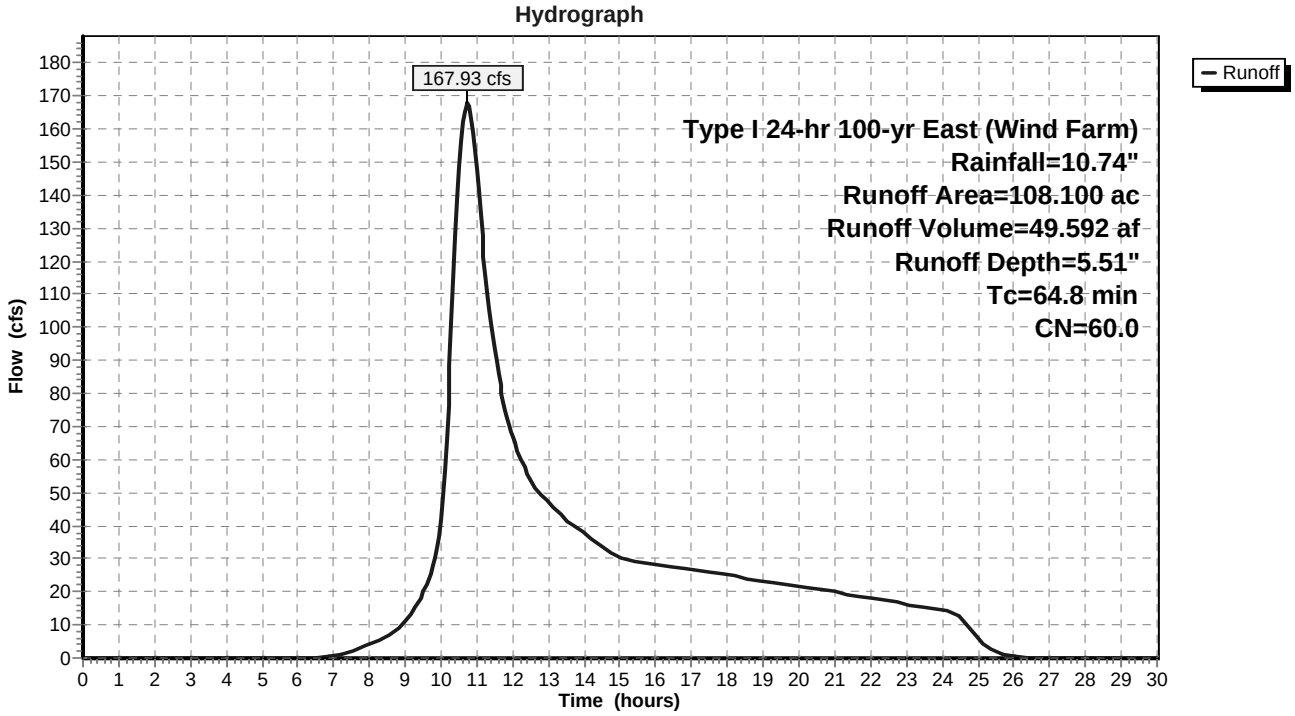
Runoff = 167.93 cfs @ 10.73 hrs, Volume= 49.592 af, Depth= 5.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100-yr East (Wind Farm) Rainfall=10.74"

Area (ac)	CN	Description
108.100	60.0	
108.100		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
64.8					**Direct Entry,**

Subcatchment J: J - Existing Papaka Rd



Appendix D
NOAA Point Precipitation Frequency Estimates

www.nws.noaa.gov

NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)

Home Site Map News Organization

Search NWS All NOAA Go

General Info
- Homepage
- Current Projects
- FAQ

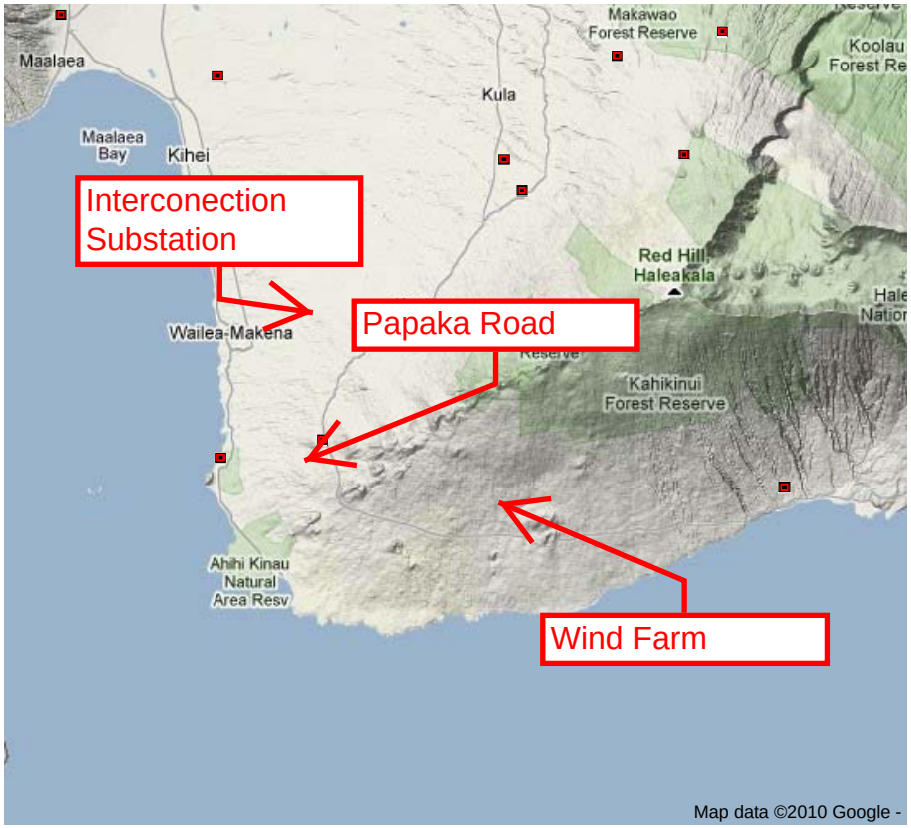
Precipitation Frequency (PF)
- PF Data Server
- PF in GIS Format
- PF Maps
- Temporal Distr.
- Time Series Data
- PFDS Perform.
- PF Documents

Probable Maximum Precipitation (PMP)
- PMP Documents
- Record Precipitation

Contact Us
- Inquiries
- List-server

Hawaiian Islands

Use "Reset Map" button to go back to previous map



Select location
Navigate map
Reset map

Legend:
Observing station

1. DATA DESCRIPTION:

Data type: Precipitation depth
Units: English
Time series type: Partial duration

2. SELECT LOCATION:

Choose one of the following options:

2.1 Select station:

a) From list:
Select observing station — Submit site

b) From map: Move mouse over station

2.2 Enter location:
Latitude (decimal degrees): lat
Longitude (decimal degrees): lon
Submit location

2.3 Click on map to select location information:
Latitude: 20.811
Longitude: -156.499
Reset

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster
Page last modified: February 4, 2010

Interconnect Substation

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Hawaiian Islands, 20.703 N, 156.395 W, 1499 feet (from DEM)

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 4, Version 2

S. Perica, D. Martin, B. Lin, T. Parzybok, D. Riley, M. Yekta, L. Hiner, L.-C. Chen, D. Brewer, F. Yan, K. Maitaria, C. Trypaluk, G. M. Bonnin
NOAA, National Weather Service, Silver Spring, Maryland, 2009

Extracted: Tue Dec 14 2010

Confidence Limits | Seasonality | Related Info | GIS Data | Maps | Docs | Return to State Map

Precipitation frequency estimates for selected durations (inches)[1]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.28	0.39	0.48	0.72	1.03	1.37	1.51	1.83	2.22	2.64	3.27	3.69	4.18	4.57	5.58	6.43	7.73	8.82
2	0.36	0.49	0.61	0.91	1.31	1.77	1.97	2.40	2.94	3.57	4.43	5.01	5.70	6.21	7.54	8.67	10.36	11.79
5	0.47	0.64	0.80	1.19	1.72	2.31	2.60	3.20	3.97	4.88	6.07	6.90	7.83	8.51	10.21	11.66	13.84	15.64
10	0.55	0.76	0.95	1.41	2.03	2.74	3.09	3.82	4.78	5.92	7.37	8.43	9.52	10.31	12.28	13.95	16.45	18.50
25	0.67	0.92	1.15	1.71	2.46	3.30	3.74	4.65	5.88	7.36	9.21	10.58	11.88	12.80	15.08	17.02	19.89	22.20
50	0.76	1.05	1.31	1.94	2.80	3.74	4.24	5.29	6.74	8.52	10.69	12.32	13.77	14.77	17.25	19.36	22.45	24.94
100	0.86	1.18	1.47	2.18	3.14	4.18	4.74	5.94	7.62	9.71	12.24	14.15	15.73	16.80	19.44	21.69	24.97	27.61
200	0.95	1.31	1.64	2.42	3.50	4.63	5.25	6.60	8.54	10.98	13.88	16.10	17.79	18.92	21.70	24.07	27.50	30.25
500	1.09	1.49	1.87	2.76	3.99	5.23	5.94	7.49	9.79	12.73	16.19	18.86	20.66	21.84	24.73	27.22	30.78	33.64
1000	1.19	1.64	2.05	3.03	4.37	5.69	6.46	8.17	10.77	14.12	18.04	21.07	22.93	24.13	27.05	29.60	33.21	36.13

[1]These precipitation frequency estimates are based on a partial duration series. ARI is the average recurrence interval. Please refer to NOAA Atlas 14 for more information.
NOTE: Formatting forces estimates near zero to appear as zero.

Upper bounds of the 90% confidence interval for selected durations (inches)[2]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.33	0.45	0.56	0.83	1.19	1.56	1.72	2.09	2.54	3.01	3.74	4.19	4.75	5.19	6.34	7.30	8.77	10.00
2	0.42	0.57	0.71	1.06	1.52	2.05	2.29	2.79	3.42	4.07	5.06	5.70	6.47	7.06	8.56	9.84	11.76	13.38
5	0.55	0.75	0.94	1.39	2.00	2.70	3.04	3.73	4.63	5.57	6.94	7.87	8.92	9.69	11.61	13.26	15.75	17.80
10	0.65	0.89	1.11	1.65	2.38	3.22	3.62	4.48	5.60	6.78	8.46	9.63	10.88	11.78	14.01	15.91	18.77	21.12
25	0.80	1.09	1.37	2.02	2.92	3.92	4.43	5.51	6.97	8.47	10.62	12.16	13.66	14.70	17.29	19.50	22.80	25.49

50	0.92	1.25	1.57	2.32	3.35	4.49	5.08	6.34	8.08	9.84	12.38	14.22	15.89	17.04	19.87	22.30	25.88	28.78
100	1.04	1.43	1.78	2.64	3.81	5.08	5.75	7.21	9.25	11.28	14.25	16.43	18.26	19.49	22.53	25.13	28.96	32.04
200	1.18	1.61	2.02	2.99	4.31	5.71	6.47	8.13	10.51	12.83	16.27	18.82	20.79	22.09	25.31	28.06	32.09	35.34
500	1.37	1.88	2.35	3.48	5.02	6.59	7.49	9.44	12.33	15.03	19.16	22.25	24.37	25.75	29.13	32.04	36.28	39.71
1000	1.53	2.10	2.63	3.90	5.62	7.31	8.30	10.50	13.81	16.81	21.54	25.07	27.28	28.68	32.13	35.13	39.47	43.01

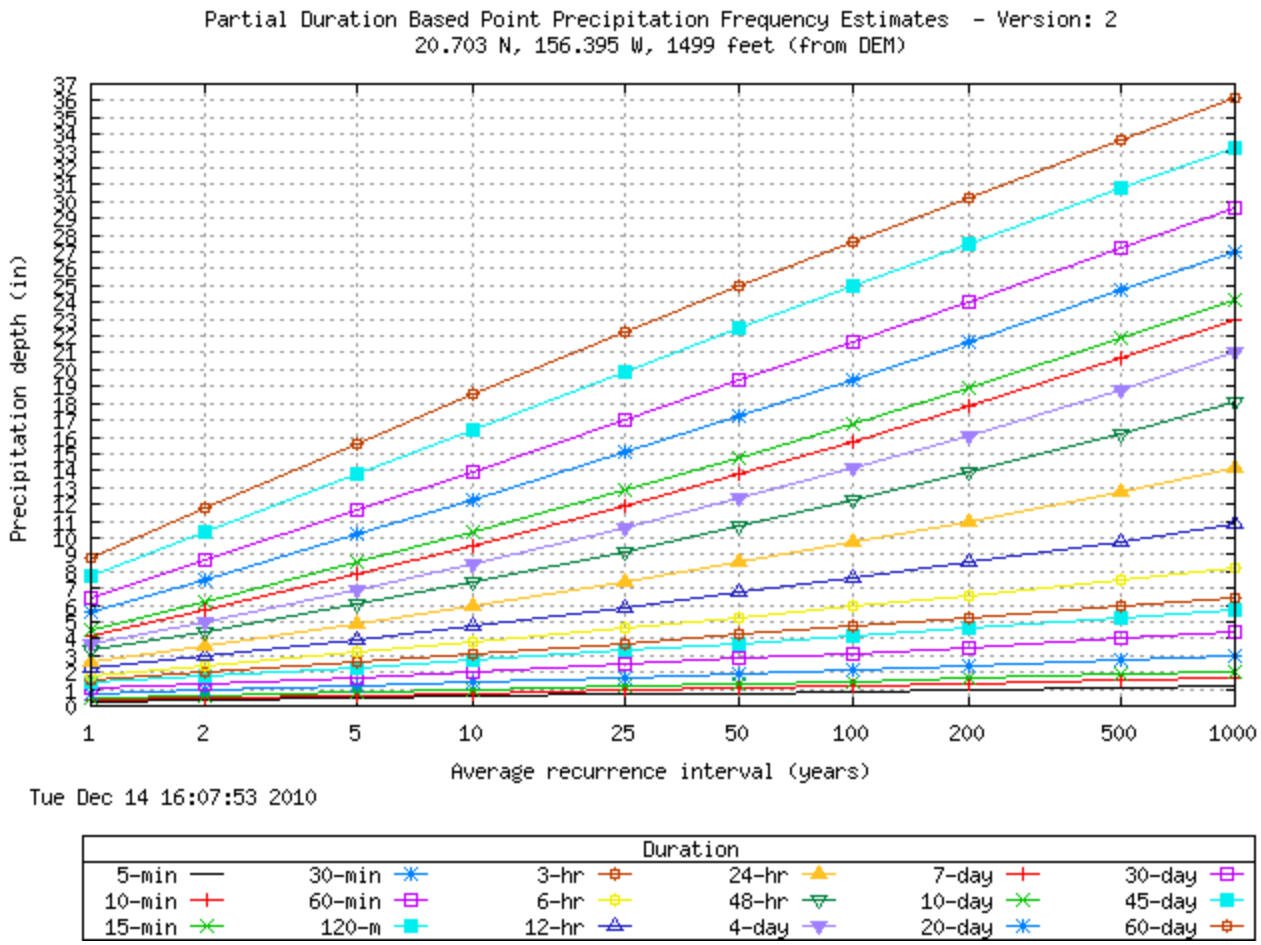
[2]Probability that precipitation frequency estimate, for a given duration and ARI, will be greater than upper bound of the 90% confidence interval is 5%.

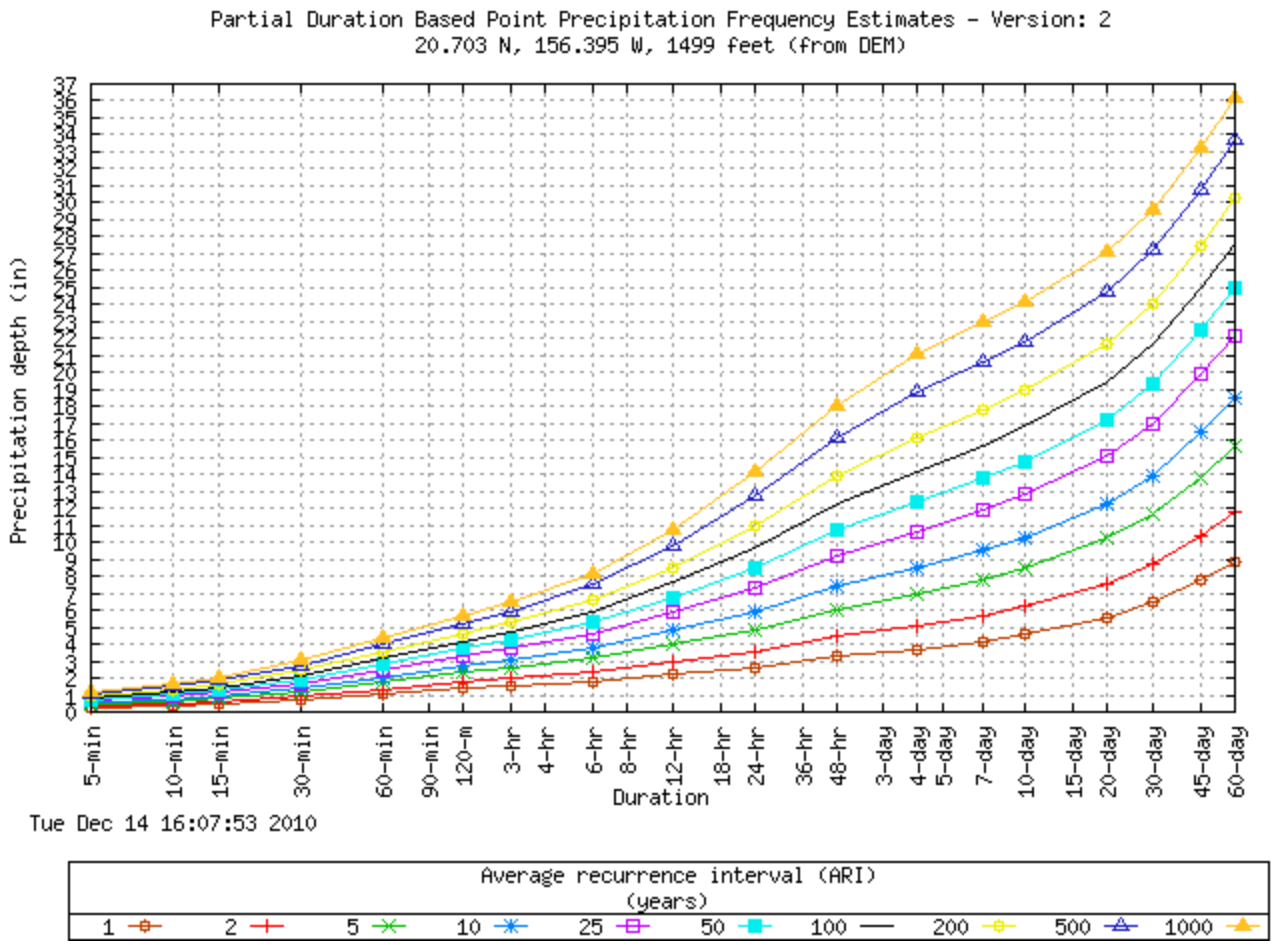
Lower bounds of the 90% confidence interval for selected durations (inches)[3]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.26	0.35	0.44	0.65	0.94	1.23	1.35	1.63	1.97	2.32	2.88	3.26	3.70	4.04	4.94	5.70	6.85	7.81
2	0.32	0.43	0.54	0.80	1.16	1.56	1.74	2.11	2.59	3.14	3.88	4.43	5.03	5.48	6.66	7.65	9.16	10.41
5	0.41	0.56	0.71	1.04	1.51	2.03	2.28	2.80	3.48	4.28	5.30	6.08	6.88	7.47	8.98	10.27	12.20	13.78
10	0.48	0.66	0.83	1.22	1.77	2.38	2.68	3.31	4.15	5.16	6.42	7.38	8.33	9.01	10.75	12.23	14.44	16.22
25	0.58	0.79	0.99	1.46	2.11	2.83	3.19	3.97	5.02	6.38	7.96	9.19	10.32	11.10	13.09	14.79	17.31	19.31
50	0.64	0.88	1.10	1.63	2.36	3.15	3.56	4.45	5.67	7.33	9.18	10.63	11.87	12.71	14.86	16.69	19.39	21.52
100	0.71	0.97	1.22	1.80	2.60	3.45	3.91	4.89	6.29	8.29	10.41	12.10	13.43	14.33	16.60	18.54	21.37	23.60
200	0.77	1.06	1.32	1.96	2.83	3.74	4.24	5.32	6.88	9.27	11.68	13.63	15.04	15.97	18.33	20.35	23.28	25.59
500	0.85	1.16	1.46	2.15	3.11	4.07	4.62	5.82	7.60	10.58	13.40	15.71	17.19	18.14	20.55	22.63	25.63	28.00
1000	0.90	1.24	1.55	2.29	3.31	4.29	4.88	6.15	8.09	11.57	14.72	17.31	18.80	19.75	22.17	24.26	27.27	29.65

[3]Probability that precipitation frequency estimate, for a given duration and ARI, will be less than lower bound of the 90% confidence interval is 5%.

Text version of tables


Partial Duration Based Point Precipitation Frequency Estimates - Version: 2
20.703 N, 156.395 W, 1499 feet (from DEM)
Precipitation depth (in)
Average recurrence interval (years)
1
2
5
10
25
50
100
200
500
1000
Tue Dec 14 16:07:53 2010
Duration
5-min
10-min
15-min
30-min
60-min
120-m
3-hr
6-hr
12-hr
24-hr
48-hr
4-day
7-day
10-day
20-day
30-day
45-day
60-day



Related Information

Maps & Aerials

Click here to see topographic maps and aerial photographs available for this location from Microsoft Research Maps

Climate Data Sources

National Climatic Data Center (NCDC) database

Locate NCDC climate stations within:

+/-30 minutes or +/-1 degree of this location. Digital ASCII data can be obtained directly from **NCDC**.

Note: Precipitation frequency results are based on analysis of precipitation data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to the matching documentation available at the PF Document page

---

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Center (Papaka Rd)

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Hawaiian Islands, 20.639 N, 156.409 W, 1466 feet (from DEM)

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 4, Version 2

S. Perica, D. Martin, B. Lin, T. Parzybok, D. Riley, M. Yekta, L. Hiner, L.-C. Chen, D. Brewer, F. Yan, K. Maitaria, C. Trypaluk, G. M. Bonnin
NOAA, National Weather Service, Silver Spring, Maryland, 2009

Extracted: Tue Dec 14 2010

Confidence Limits | Seasonality | Related Info | GIS Data | Maps | Docs | Return to State Map

Precipitation frequency estimates for selected durations (inches)[1]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.35	0.48	0.60	0.88	1.27	1.68	1.82	2.07	2.41	2.80	3.27	3.81	4.41	4.87	6.00	6.84	8.05	9.23
2	0.44	0.60	0.76	1.12	1.62	2.16	2.36	2.72	3.20	3.77	4.41	5.14	5.95	6.55	8.00	9.09	10.64	12.15
5	0.57	0.78	0.98	1.45	2.09	2.80	3.08	3.58	4.28	5.12	6.02	7.02	8.09	8.85	10.70	12.08	14.05	15.96
10	0.67	0.92	1.15	1.70	2.46	3.28	3.62	4.24	5.12	6.19	7.32	8.54	9.77	10.63	12.76	14.35	16.61	18.79
25	0.80	1.10	1.38	2.04	2.95	3.92	4.34	5.12	6.26	7.66	9.13	10.68	12.10	13.05	15.49	17.35	19.97	22.45
50	0.91	1.24	1.55	2.30	3.32	4.42	4.89	5.79	7.15	8.84	10.59	12.40	13.93	14.94	17.58	19.61	22.48	25.17
100	1.01	1.39	1.74	2.57	3.71	4.91	5.44	6.46	8.05	10.06	12.10	14.20	15.82	16.86	19.66	21.87	24.97	27.83
200	1.12	1.54	1.92	2.85	4.11	5.40	5.99	7.15	8.98	11.34	13.72	16.11	17.80	18.84	21.78	24.15	27.46	30.46
500	1.27	1.74	2.17	3.22	4.64	6.05	6.73	8.06	10.25	13.11	15.99	18.81	20.51	21.53	24.58	27.14	30.69	33.86
1000	1.38	1.89	2.37	3.51	5.06	6.55	7.28	8.76	11.24	14.52	17.81	20.97	22.64	23.61	26.69	29.39	33.11	36.36

[1]These precipitation frequency estimates are based on a partial duration series. ARI is the average recurrence interval. Please refer to NOAA Atlas 14 for more information.
NOTE: Formatting forces estimates near zero to appear as zero.

Upper bounds of the 90% confidence interval for selected durations (inches)[2]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.40	0.55	0.69	1.03	1.48	1.95	2.11	2.41	2.80	3.20	3.80	4.32	5.00	5.53	6.79	7.74	9.10	10.45
2	0.52	0.71	0.88	1.31	1.89	2.51	2.75	3.17	3.72	4.31	5.13	5.84	6.75	7.44	9.06	10.29	12.06	13.78
5	0.67	0.92	1.15	1.70	2.45	3.28	3.61	4.19	5.01	5.86	7.02	7.99	9.19	10.07	12.14	13.71	15.97	18.14
10	0.79	1.08	1.35	2.00	2.89	3.88	4.27	5.00	6.03	7.10	8.54	9.74	11.12	12.14	14.52	16.32	18.93	21.41
25	0.96	1.31	1.64	2.43	3.51	4.68	5.19	6.11	7.46	8.84	10.71	12.24	13.84	14.97	17.70	19.83	22.86	25.71

50	1.09	1.50	1.87	2.77	4.00	5.34	5.91	7.00	8.62	10.24	12.46	14.29	16.00	17.21	20.19	22.53	25.86	28.97
100	1.24	1.70	2.12	3.14	4.53	6.01	6.66	7.91	9.84	11.71	14.33	16.45	18.27	19.53	22.70	25.26	28.88	32.20
200	1.39	1.91	2.39	3.53	5.10	6.71	7.45	8.90	11.15	13.29	16.35	18.79	20.69	21.96	25.31	28.06	31.96	35.47
500	1.61	2.21	2.76	4.09	5.90	7.71	8.57	10.26	13.04	15.51	19.23	22.14	24.07	25.34	28.81	31.84	36.08	39.83
1000	1.79	2.45	3.07	4.55	6.56	8.51	9.46	11.37	14.58	17.32	21.59	24.89	26.79	28.00	31.54	34.76	39.23	43.15

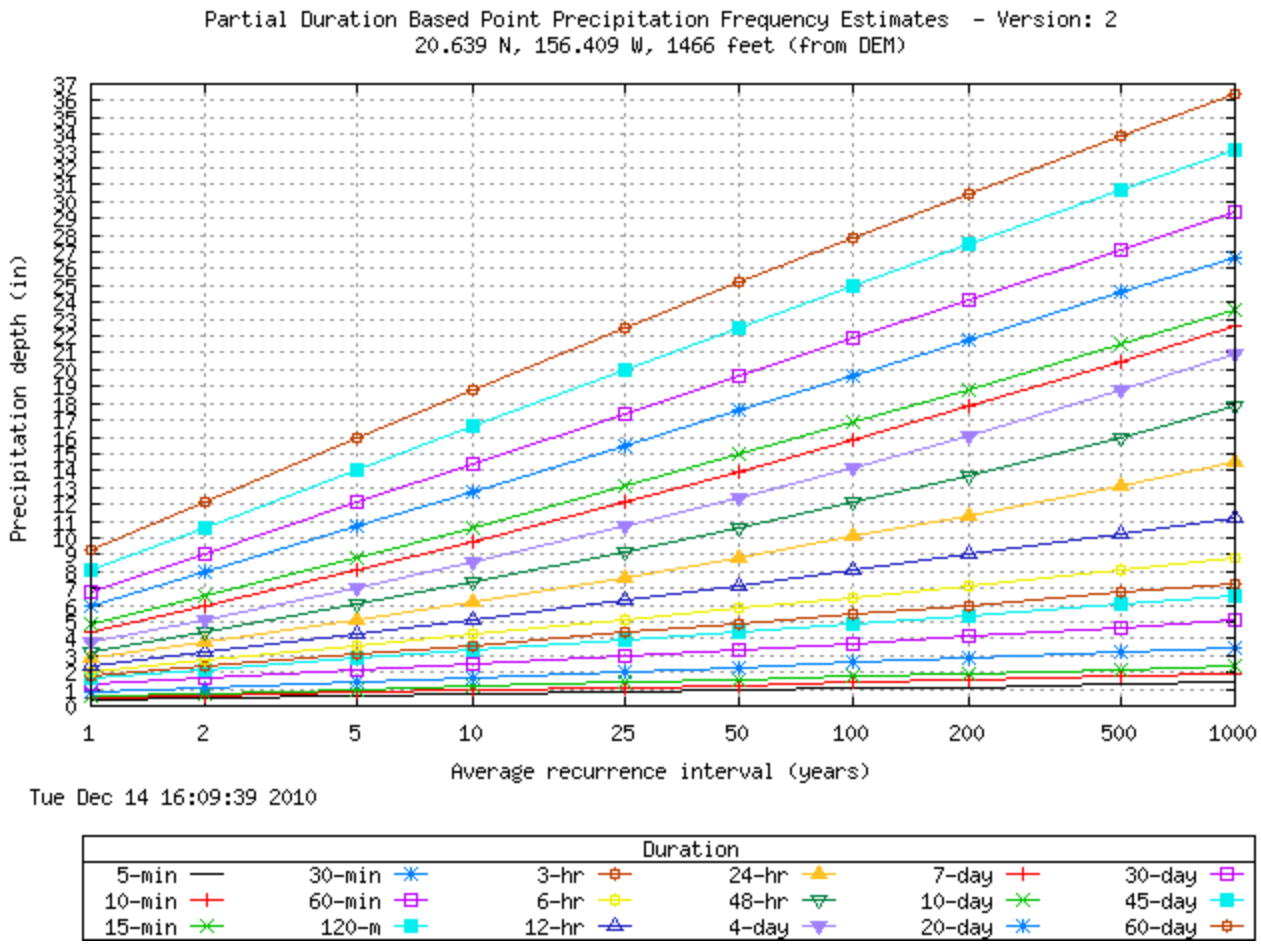
[2]Probability that precipitation frequency estimate, for a given duration and ARI, will be greater than upper bound of the 90% confidence interval is 5%.

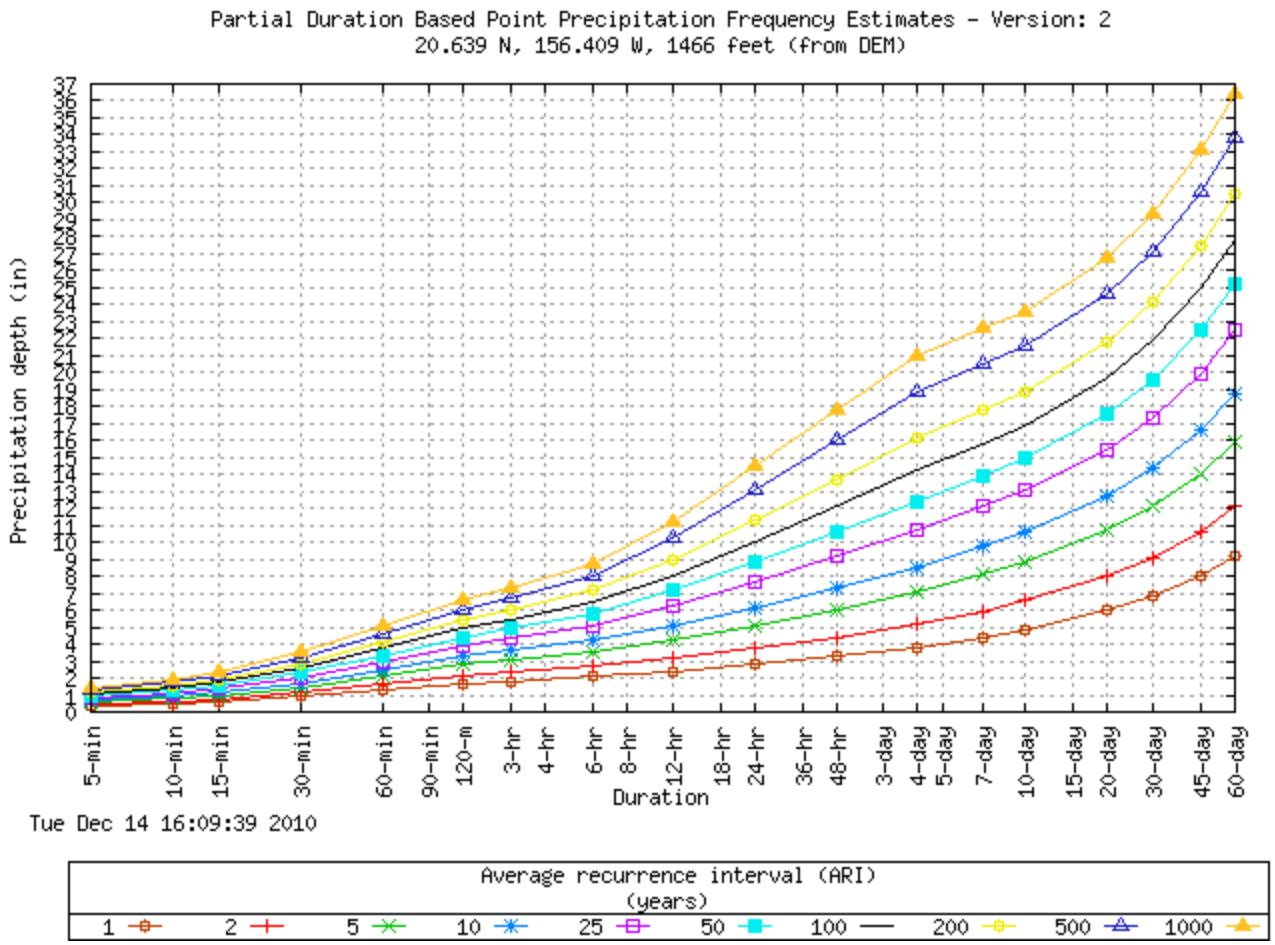
Lower bounds of the 90% confidence interval for selected durations (inches)[3]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.31	0.43	0.54	0.79	1.15	1.51	1.64	1.86	2.18	2.46	2.82	3.37	3.90	4.31	5.31	6.05	7.15	8.18
2	0.39	0.54	0.68	1.00	1.45	1.93	2.12	2.43	2.88	3.31	3.80	4.55	5.25	5.79	7.08	8.04	9.42	10.75
5	0.51	0.69	0.87	1.28	1.85	2.49	2.74	3.18	3.82	4.48	5.17	6.19	7.11	7.80	9.43	10.66	12.40	14.08
10	0.59	0.81	1.01	1.50	2.16	2.90	3.19	3.74	4.53	5.40	6.26	7.50	8.56	9.33	11.20	12.62	14.62	16.52
25	0.70	0.95	1.19	1.77	2.55	3.41	3.77	4.45	5.45	6.65	7.76	9.31	10.52	11.39	13.51	15.16	17.45	19.61
50	0.77	1.06	1.32	1.96	2.83	3.78	4.17	4.95	6.12	7.62	8.93	10.73	12.03	12.95	15.23	17.03	19.51	21.81
100	0.85	1.16	1.45	2.15	3.10	4.12	4.56	5.42	6.77	8.60	10.13	12.19	13.55	14.50	16.91	18.83	21.48	23.90
200	0.92	1.25	1.57	2.33	3.36	4.43	4.91	5.86	7.38	9.60	11.39	13.70	15.09	16.04	18.55	20.58	23.39	25.91
500	1.00	1.37	1.71	2.53	3.65	4.79	5.32	6.37	8.12	10.94	13.07	15.77	17.13	18.07	20.62	22.79	25.76	28.38
1000	1.06	1.45	1.81	2.68	3.87	5.02	5.58	6.71	8.61	11.95	14.37	17.36	18.67	19.55	22.11	24.35	27.44	30.11

[3]Probability that precipitation frequency estimate, for a given duration and ARI, will be less than lower bound of the 90% confidence interval is 5%.

Text version of tables


Partial Duration Based Point Precipitation Frequency Estimates - Version: 2
20.639 N, 156.409 W, 1466 feet (from DEM)
Precipitation depth (in)
Average recurrence interval (years)
1
2
5
10
25
50
100
200
500
1000
Tue Dec 14 16:09:39 2010
Duration
5-min
10-min
15-min
30-min
60-min
120-m
3-hr
6-hr
12-hr
24-hr
48-hr
4-day
7-day
10-day
20-day
30-day
45-day
60-day



Related Information

Maps & Aerials

Click here to see topographic maps and aerial photographs available for this location from Microsoft Research Maps

Climate Data Sources

National Climatic Data Center (NCDC) database

Locate NCDC climate stations within:

+/-30 minutes or +/-1 degree of this location. Digital ASCII data can be obtained directly from **NCDC**.

Note: Precipitation frequency results are based on analysis of precipitation data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to the matching documentation available at the PF Document page

---

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

East of Ridge (Windfarm and Laydown Area)

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Hawaiian Islands, 20.63 N, 156.331 W, 2736 feet (from DEM)

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 4, Version 2

S. Perica, D. Martin, B. Lin, T. Parzybok, D. Riley, M. Yekta, L. Hiner, L.-C. Chen, D. Brewer, F. Yan, K. Maitaria, C. Trypaluk, G. M. Bonnin
NOAA, National Weather Service, Silver Spring, Maryland, 2009

Extracted: Tue Dec 14 2010

Confidence Limits | Seasonality | Related Info | GIS Data | Maps | Docs | Return to State Map

Precipitation frequency estimates for selected durations (inches)[1]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.32	0.44	0.55	0.81	1.17	1.53	1.70	2.04	2.46	2.92	3.63	4.35	4.97	5.46	6.81	7.88	9.37	10.87
2	0.41	0.55	0.69	1.03	1.48	1.97	2.21	2.67	3.26	3.95	4.89	5.86	6.68	7.34	9.05	10.44	12.36	14.25
5	0.53	0.72	0.90	1.34	1.93	2.58	2.91	3.55	4.39	5.38	6.68	8.01	9.11	9.96	12.13	13.90	16.34	18.68
10	0.62	0.85	1.07	1.58	2.28	3.05	3.45	4.24	5.28	6.53	8.13	9.76	11.06	12.04	14.53	16.56	19.34	22.00
25	0.76	1.04	1.30	1.92	2.77	3.68	4.18	5.16	6.50	8.13	10.18	12.25	13.81	14.94	17.82	20.16	23.34	26.35
50	0.86	1.18	1.47	2.18	3.15	4.18	4.75	5.88	7.46	9.41	11.84	14.29	16.03	17.27	20.40	22.96	26.39	29.62
100	0.97	1.33	1.66	2.46	3.55	4.68	5.32	6.61	8.45	10.74	13.60	16.45	18.37	19.70	23.04	25.79	29.43	32.85
200	1.08	1.48	1.86	2.75	3.96	5.20	5.91	7.37	9.49	12.16	15.50	18.79	20.88	22.28	25.80	28.72	32.51	36.10
500	1.24	1.70	2.13	3.15	4.54	5.89	6.72	8.39	10.92	14.14	18.21	22.16	24.43	25.92	29.60	32.69	36.61	40.36
1000	1.37	1.87	2.35	3.47	5.01	6.44	7.34	9.20	12.05	15.73	20.44	24.92	27.33	28.85	32.58	35.78	39.73	43.57

[1]These precipitation frequency estimates are based on a partial duration series. ARI is the average recurrence interval. Please refer to NOAA Atlas 14 for more information.
NOTE: Formatting forces estimates near zero to appear as zero.

Upper bounds of the 90% confidence interval for selected durations (inches)[2]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.37	0.51	0.64	0.94	1.36	1.76	1.95	2.35	2.84	3.35	4.18	4.99	5.69	6.25	7.78	9.02	10.71	12.39
2	0.47	0.65	0.81	1.20	1.72	2.29	2.58	3.12	3.79	4.52	5.64	6.74	7.68	8.41	10.37	11.96	14.14	16.27
5	0.62	0.84	1.06	1.56	2.26	3.02	3.41	4.15	5.13	6.17	7.72	9.23	10.49	11.44	13.93	15.95	18.74	21.39
10	0.73	1.00	1.26	1.86	2.68	3.59	4.06	4.99	6.21	7.50	9.42	11.27	12.77	13.87	16.73	19.06	22.26	25.26
25	0.90	1.23	1.54	2.28	3.29	4.38	4.98	6.15	7.73	9.38	11.86	14.22	16.03	17.30	20.61	23.33	27.00	30.41

50	1.03	1.42	1.77	2.63	3.79	5.03	5.71	7.08	8.98	10.92	13.87	16.68	18.69	20.09	23.72	26.69	30.67	34.36
100	1.18	1.62	2.02	3.00	4.32	5.70	6.48	8.06	10.29	12.54	16.04	19.32	21.55	23.06	26.95	30.16	34.40	38.32
200	1.34	1.84	2.30	3.40	4.91	6.43	7.31	9.13	11.73	14.30	18.41	22.23	24.66	26.27	30.40	33.82	38.27	42.40
500	1.57	2.15	2.69	3.99	5.76	7.46	8.50	10.64	13.81	16.80	21.87	26.48	29.17	30.89	35.23	38.90	43.56	47.91
1000	1.77	2.42	3.03	4.49	6.48	8.32	9.47	11.89	15.54	18.86	24.78	30.06	32.93	34.70	39.15	42.96	47.71	52.18

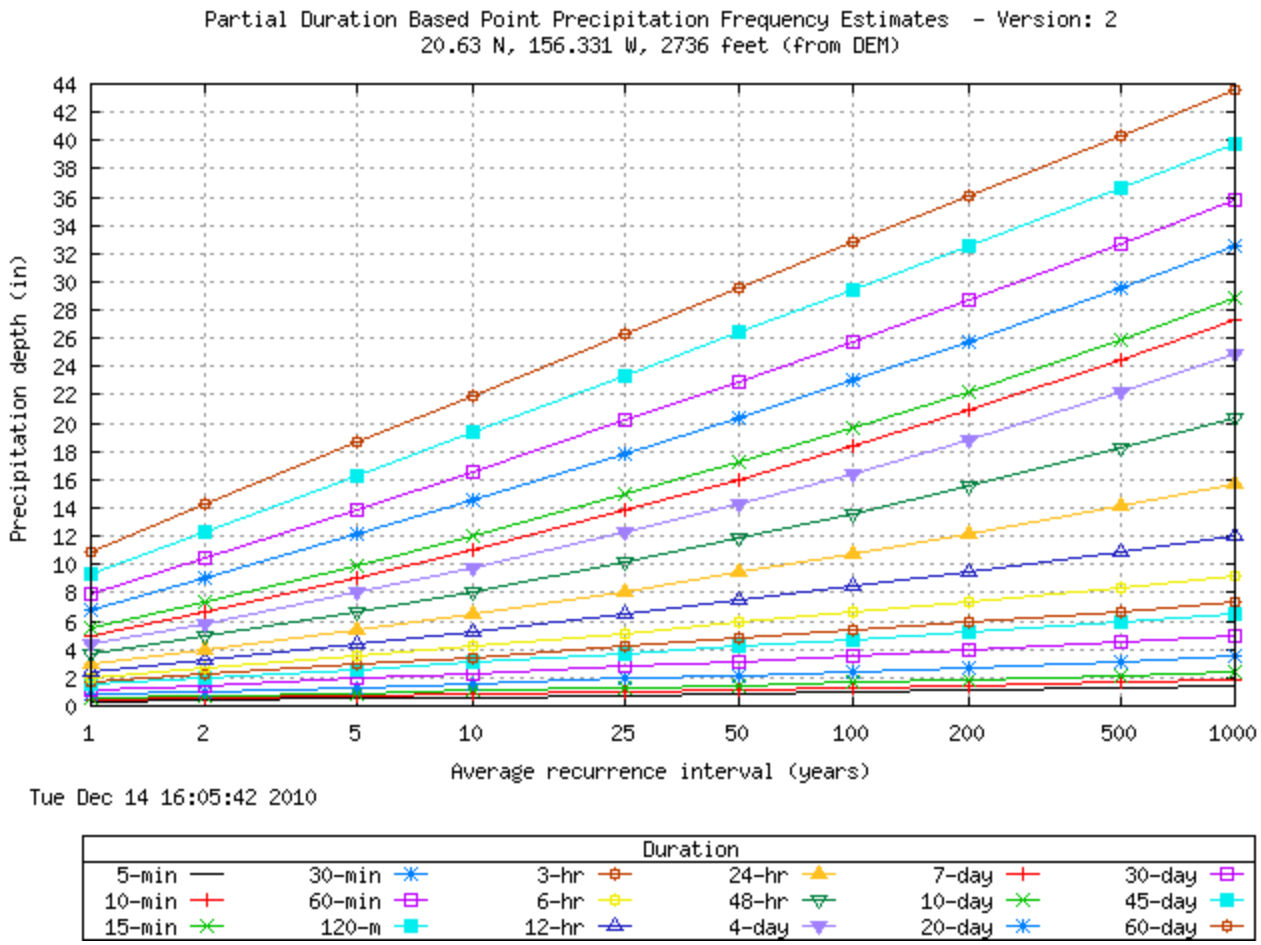
[2]Probability that precipitation frequency estimate, for a given duration and ARI, will be greater than upper bound of the 90% confidence interval is 5%.

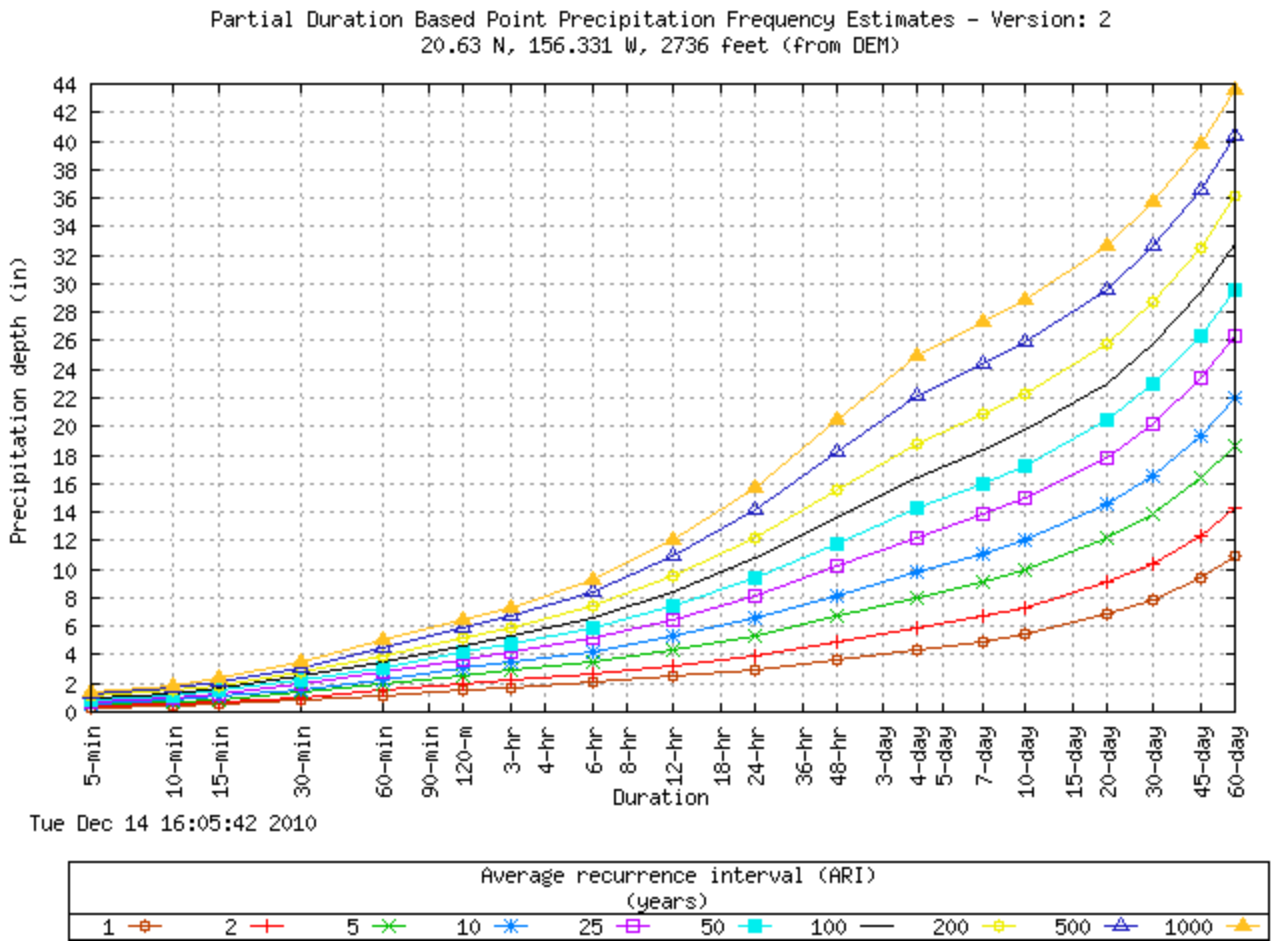
Lower bounds of the 90% confidence interval for selected durations (inches)[3]

ARI (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.29	0.39	0.49	0.73	1.05	1.37	1.51	1.82	2.19	2.56	3.15	3.80	4.34	4.78	5.96	6.91	8.22	9.53
2	0.36	0.49	0.61	0.91	1.31	1.74	1.95	2.35	2.87	3.46	4.24	5.12	5.84	6.41	7.93	9.14	10.83	12.47
5	0.46	0.63	0.79	1.17	1.69	2.26	2.55	3.11	3.85	4.70	5.78	6.97	7.93	8.67	10.58	12.12	14.26	16.29
10	0.54	0.74	0.93	1.37	1.98	2.65	2.99	3.68	4.58	5.67	6.99	8.46	9.59	10.43	12.62	14.38	16.82	19.11
25	0.65	0.88	1.10	1.64	2.36	3.14	3.56	4.40	5.54	7.00	8.68	10.52	11.88	12.85	15.36	17.37	20.14	22.71
50	0.72	0.99	1.24	1.83	2.64	3.51	3.98	4.93	6.26	8.04	10.02	12.18	13.67	14.73	17.44	19.62	22.58	25.31
100	0.80	1.09	1.36	2.02	2.91	3.85	4.37	5.43	6.94	9.09	11.39	13.88	15.51	16.64	19.51	21.83	24.93	27.79
200	0.87	1.19	1.49	2.20	3.18	4.17	4.73	5.91	7.60	10.16	12.83	15.67	17.41	18.60	21.60	24.02	27.23	30.19
500	0.95	1.31	1.64	2.42	3.49	4.55	5.17	6.47	8.41	11.60	14.78	18.13	19.99	21.23	24.31	26.84	30.11	33.15
1000	1.02	1.39	1.74	2.58	3.72	4.80	5.46	6.84	8.96	12.68	16.30	20.05	21.98	23.23	26.32	28.89	32.16	35.22

[3]Probability that precipitation frequency estimate, for a given duration and ARI, will be less than lower bound of the 90% confidence interval is 5%.

Text version of tables


Partial Duration Based Point Precipitation Frequency Estimates - Version: 2
20.63 N, 156.331 W, 2736 feet (from DEM)
Precipitation depth (in)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
1
2
5
10
25
50
100
200
500
1000
Average recurrence interval (years)
Tue Dec 14 16:05:42 2010
Duration
5-min
10-min
15-min
30-min
60-min
120-m
3-hr
6-hr
12-hr
24-hr
48-hr
4-day
7-day
10-day
20-day
30-day
45-day
60-day



Related Information

Maps & Aerials

Click here to see topographic maps and aerial photographs available for this location from Microsoft Research Maps

Climate Data Sources

National Climatic Data Center (NCDC) database

Locate NCDC climate stations within:

+/-30 minutes or +/-1 degree of this location. Digital ASCII data can be obtained directly from **NCDC**.

Note: Precipitation frequency results are based on analysis of precipitation data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to the matching documentation available at the PF Document page

---

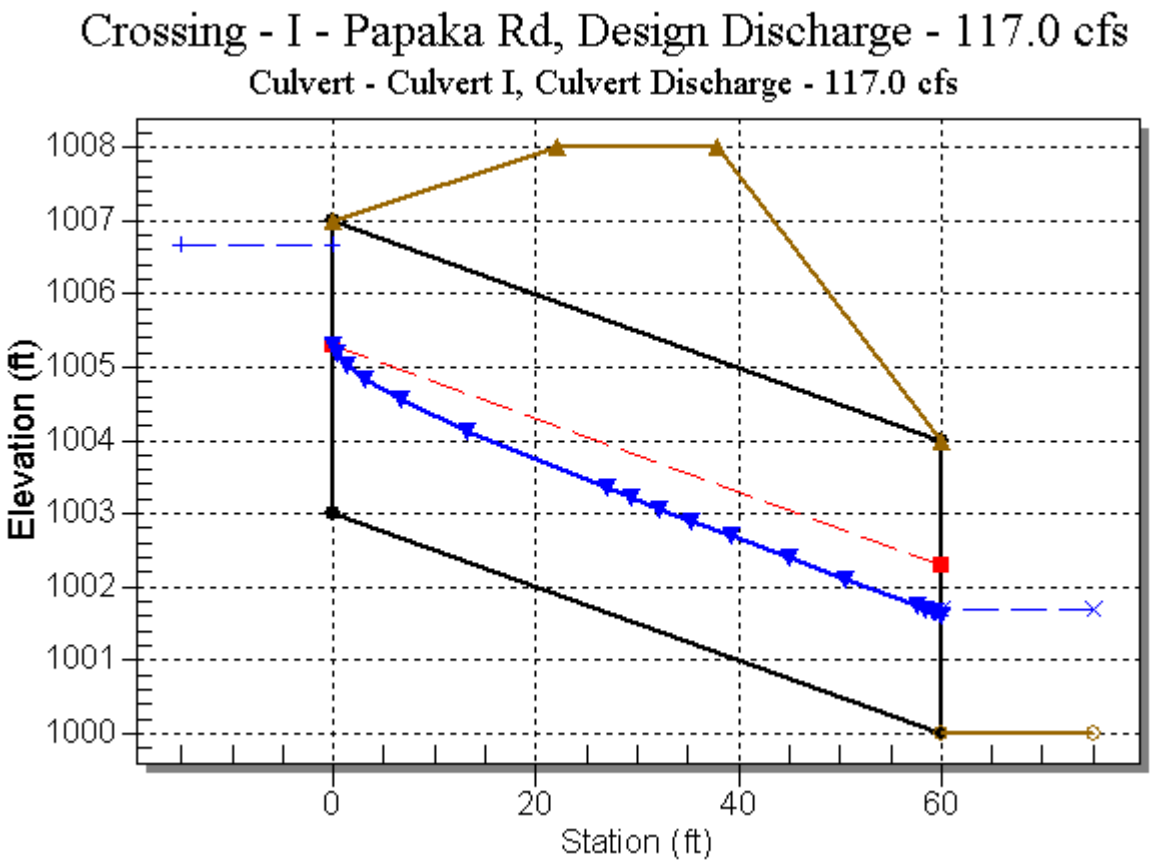
US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Appendix E
HY8 Culvert Modeling

HY-8 Culvert Analysis Report

Water Surface Profile Plot for Culvert: Culvert I



Site Data - Culvert I

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1003.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 1000.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert I

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Inlet Type: Conventional

Inlet Edge Condition: Thin Edge Projecting

Inlet Depression: None

Table 1 - Downstream Channel Rating Curve (Crossing: I - Papaka Rd)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	1000.00	0.00	0.00	0.00	0.00
20.10	1000.73	0.73	8.02	5.66	1.98
40.20	1001.03	1.03	9.67	8.00	2.06
60.30	1001.25	1.25	10.75	9.73	2.11
80.40	1001.43	1.43	11.58	11.15	2.15
100.50	1001.59	1.59	12.25	12.37	2.18
116.95	1001.70	1.70	12.75	13.25	2.20
140.70	1001.85	1.85	13.36	14.42	2.22
160.80	1001.96	1.96	13.82	15.31	2.24
180.90	1002.07	2.07	14.23	16.15	2.26
201.00	1002.17	2.17	14.63	16.91	2.27

Tailwater Channel Data - I - Papaka Rd

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 2.00 ft

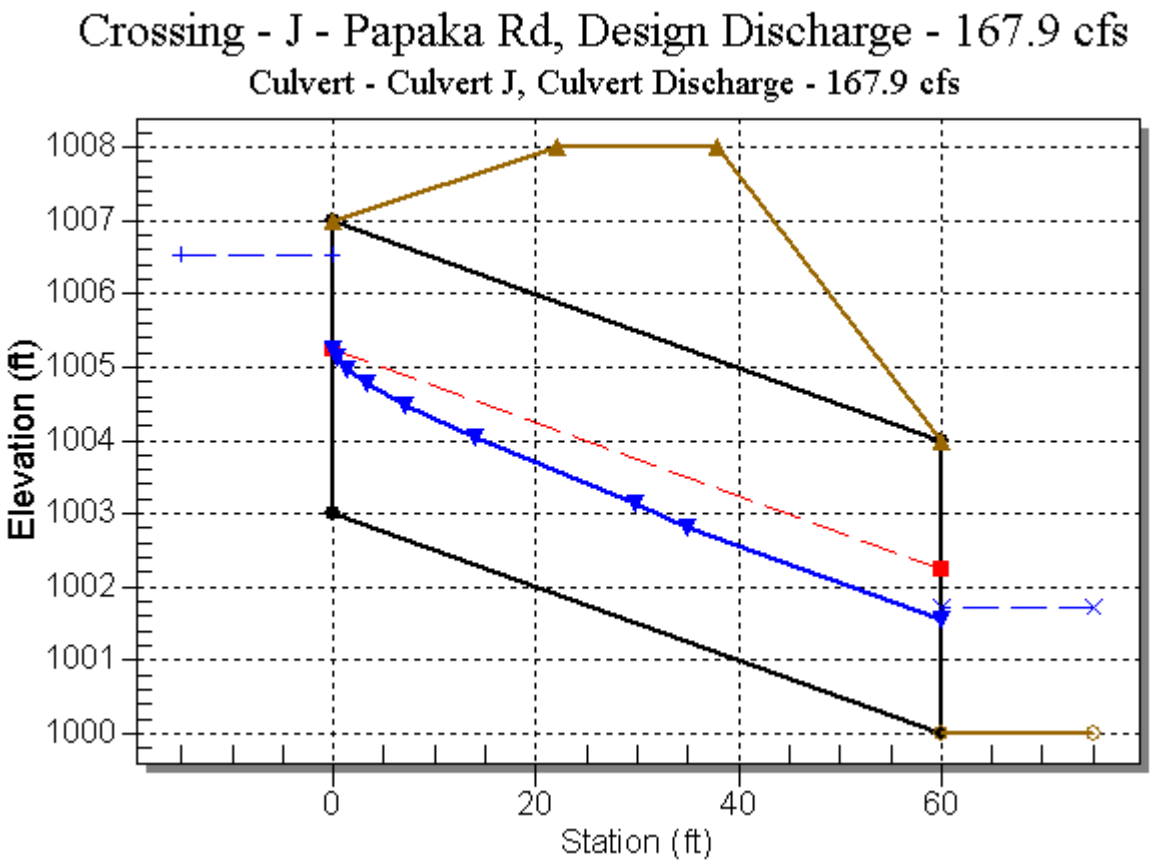
Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.1250

Channel Manning's n: 0.0400

Channel Invert Elevation: 1000.00 ft

Water Surface Profile Plot for Culvert: Culvert J



Site Data - Culvert J

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1003.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 1000.00 ft

Number of Barrels: 3

Culvert Data Summary - Culvert J

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Inlet Type: Conventional

Inlet Edge Condition: Thin Edge Projecting

Inlet Depression: None

Table 2 - Downstream Channel Rating Curve (Crossing: J - Papaka Rd)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	1000.00	0.00	0.00	0.00	0.00
28.00	1000.73	0.73	11.10	10.87	2.73
56.00	1001.03	1.03	13.38	15.37	2.85
84.00	1001.25	1.25	14.90	18.67	2.93
112.00	1001.43	1.43	16.03	21.40	2.97
140.00	1001.59	1.59	16.99	23.72	3.02
167.93	1001.73	1.73	17.80	25.78	3.05
196.00	1001.85	1.85	18.51	27.66	3.08
224.00	1001.97	1.97	19.14	29.38	3.10
252.00	1002.08	2.08	19.72	30.97	3.12
280.00	1002.18	2.18	20.25	32.46	3.14

Tailwater Channel Data - J - Papaka Rd

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 2.00 ft

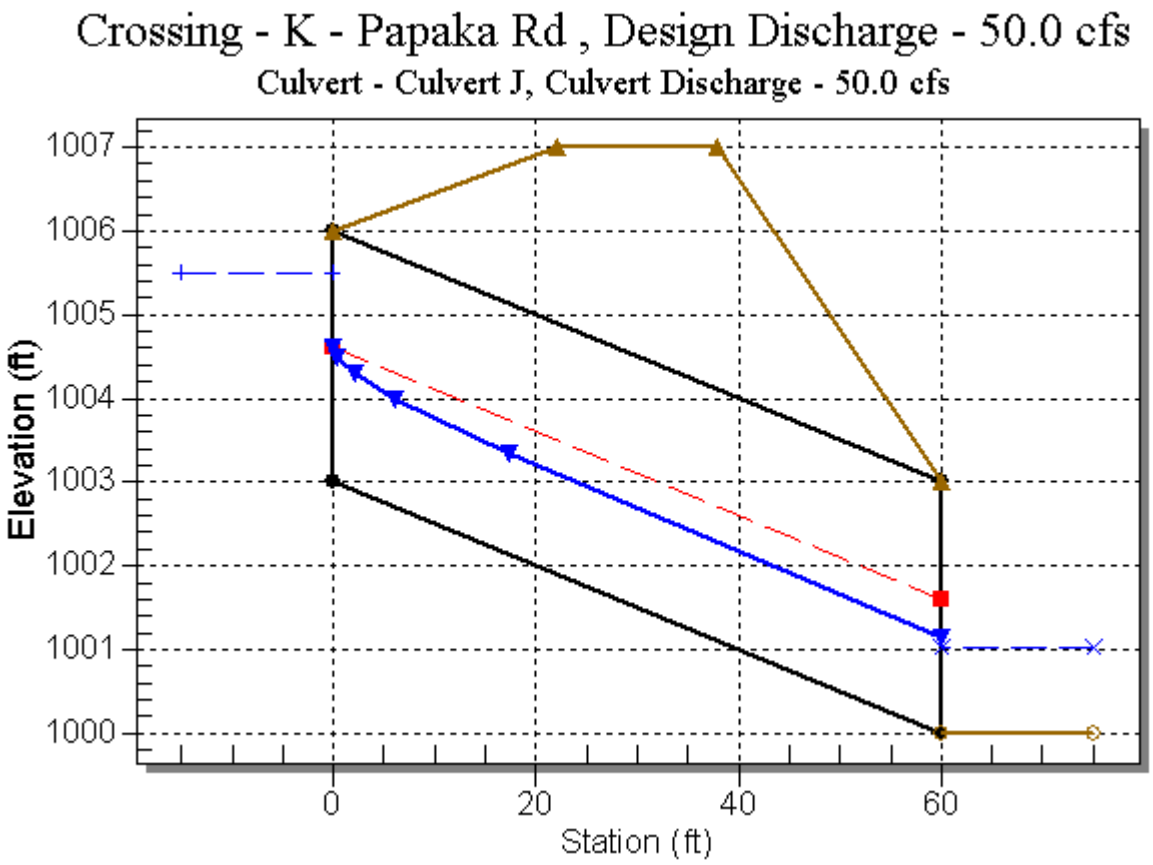
Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.2390

Channel Manning's n: 0.0400

Channel Invert Elevation: 1000.00 ft

Water Surface Profile Plot for Culvert: Culvert J



Site Data - Culvert J

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1003.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 1000.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert J

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Inlet Type: Conventional

Inlet Edge Condition: Thin Edge Projecting

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: K - Papaka Rd)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	1000.00	0.00	0.00	0.00	0.00
10.00	1000.45	0.45	7.77	5.47	2.35
20.00	1000.64	0.64	9.44	7.92	2.45
30.00	1000.79	0.79	10.57	9.73	2.51
40.00	1000.91	0.91	11.42	11.25	2.56
50.00	1001.02	1.02	12.10	12.56	2.59
50.03	1001.02	1.02	12.10	12.56	2.59
70.00	1001.20	1.20	13.22	14.78	2.64
80.00	1001.28	1.28	13.69	15.74	2.66
90.00	1001.36	1.36	14.10	16.66	2.68
100.00	1001.42	1.42	14.51	17.49	2.70

Tailwater Channel Data - K - Papaka Rd

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 2.00 ft

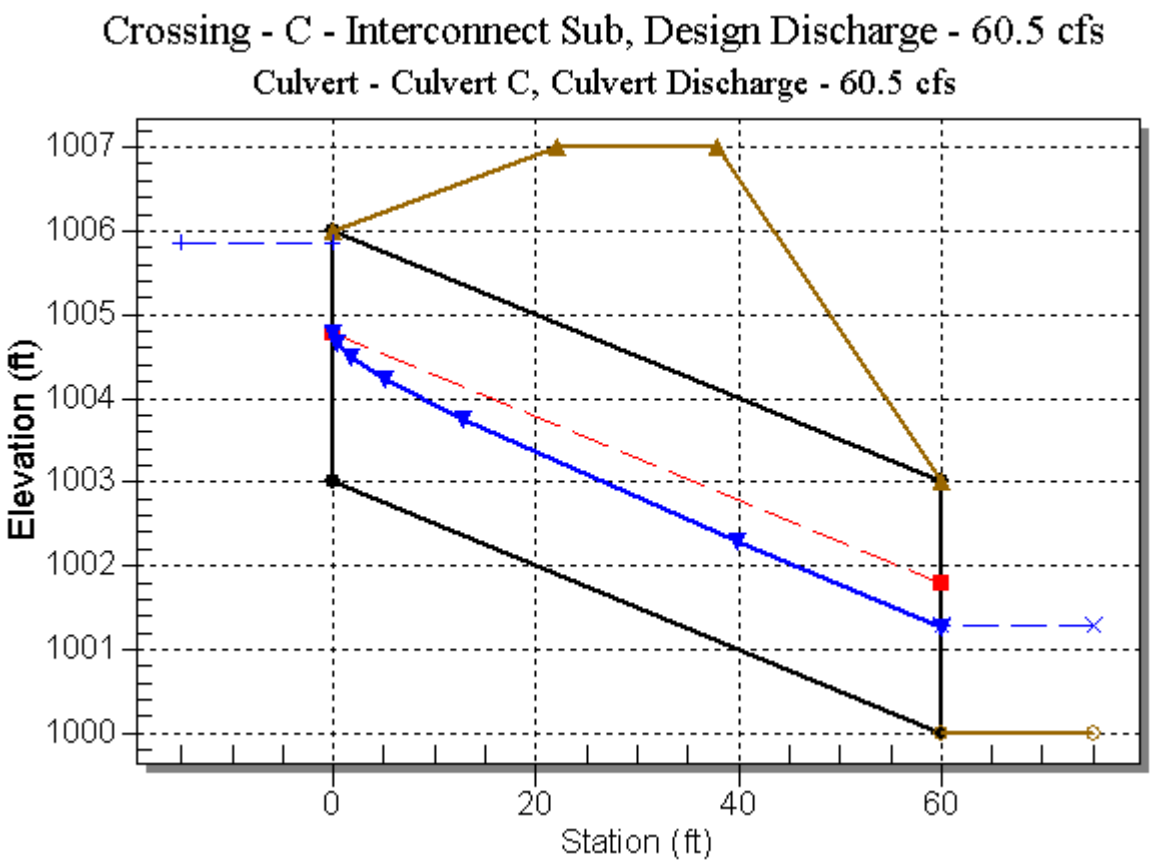
Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.1970

Channel Manning's n: 0.0400

Channel Invert Elevation: 1000.00 ft

Water Surface Profile Plot for Culvert: Culvert C



Site Data - Culvert C

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1003.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 1000.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert C

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Inlet Type: Conventional

Inlet Edge Condition: Thin Edge Projecting

Inlet Depression: None

Table 4 - Downstream Channel Rating Curve (Crossing: C - Interconnect Sub)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	1000.00	0.00	0.00	0.00	0.00
12.10	1000.58	0.58	6.65	3.96	1.80
24.20	1000.82	0.82	8.05	5.66	1.88
36.30	1001.01	1.01	8.98	6.91	1.93
48.40	1001.16	1.16	9.68	7.95	1.96
60.50	1001.29	1.29	10.25	8.85	1.99
60.54	1001.29	1.29	10.26	8.85	1.99
84.70	1001.51	1.51	11.18	10.36	2.03
96.80	1001.61	1.61	11.57	11.02	2.05
108.90	1001.69	1.69	11.94	11.62	2.06
121.00	1001.78	1.78	12.26	12.20	2.07

Tailwater Channel Data - C - Interconnect Sub

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 2.00 ft

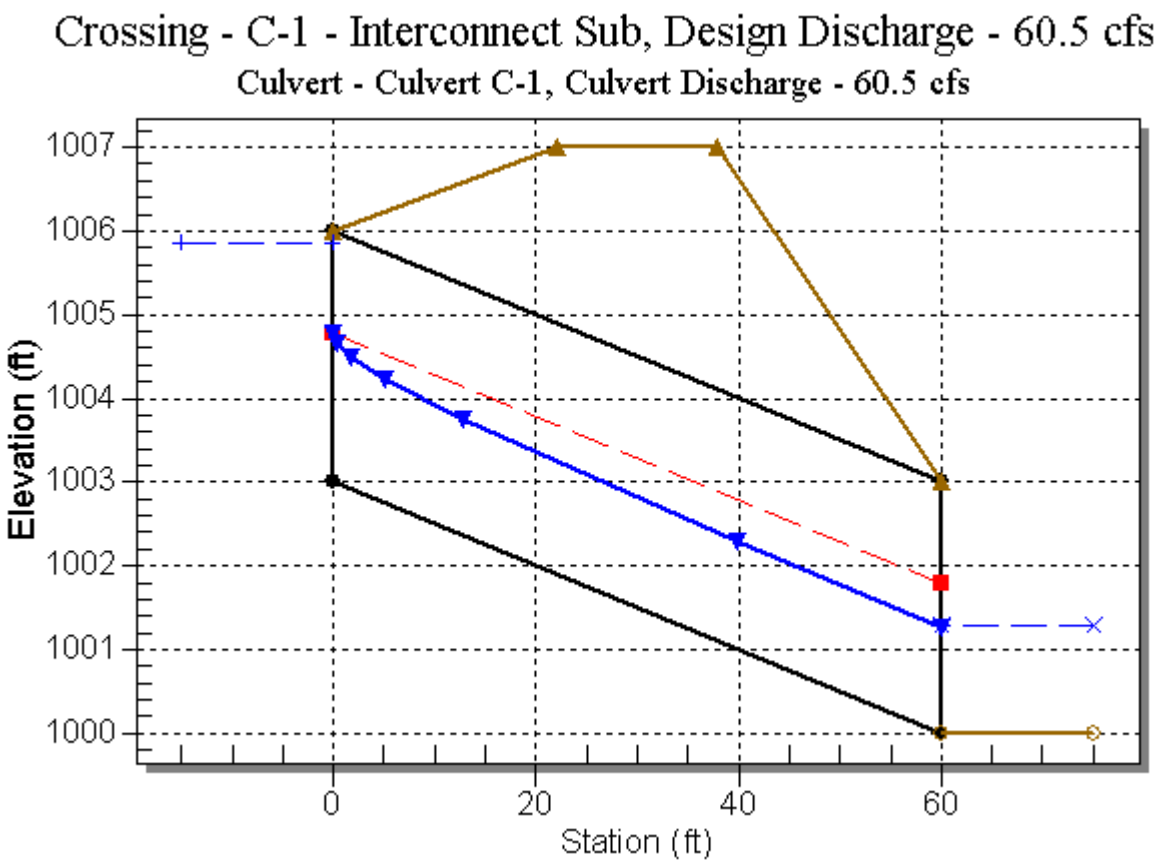
Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.1100

Channel Manning's n: 0.0400

Channel Invert Elevation: 1000.00 ft

Water Surface Profile Plot for Culvert: Culvert C-1



Site Data - Culvert C-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1003.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 1000.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert C-1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Inlet Type: Conventional

Inlet Edge Condition: Thin Edge Projecting

Inlet Depression: None

Table 5 - Downstream Channel Rating Curve (Crossing: C-1 - Interconnect Sub)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	1000.00	0.00	0.00	0.00	0.00
12.10	1000.58	0.58	6.65	3.96	1.80
24.20	1000.82	0.82	8.05	5.66	1.88
36.30	1001.01	1.01	8.98	6.91	1.93
48.40	1001.16	1.16	9.68	7.95	1.96
60.50	1001.29	1.29	10.25	8.85	1.99
60.54	1001.29	1.29	10.26	8.85	1.99
84.70	1001.51	1.51	11.18	10.36	2.03
96.80	1001.61	1.61	11.57	11.02	2.05
108.90	1001.69	1.69	11.94	11.62	2.06
121.00	1001.78	1.78	12.26	12.20	2.07

Tailwater Channel Data - C-1 - Interconnect Sub

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 2.00 ft

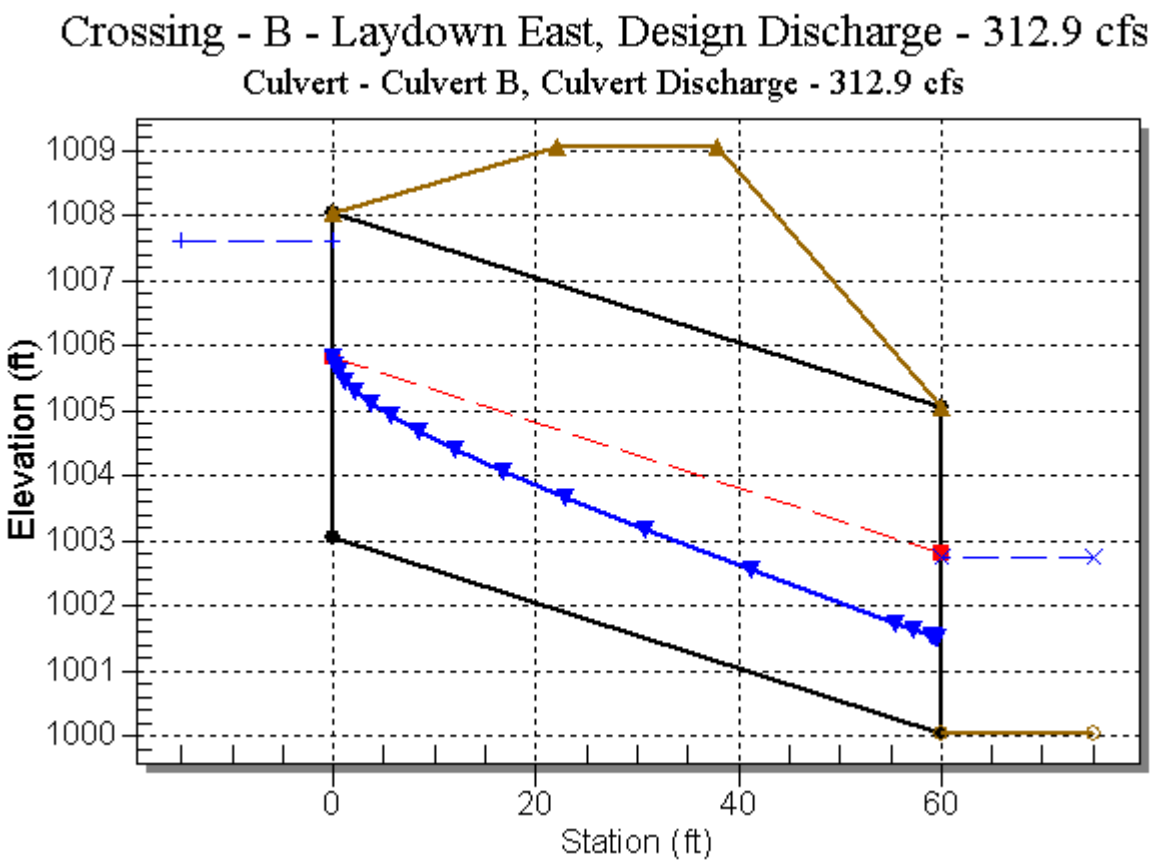
Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.1100

Channel Manning's n: 0.0400

Channel Invert Elevation: 1000.00 ft

Water Surface Profile Plot for Culvert: Culvert B



Site Data - Culvert B

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1003.00 ft

Outlet Station: 60.00 ft

Outlet Elevation: 1000.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert B

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: B - Laydown East)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	1000.00	0.00	0.00	0.00	0.00
60.00	1001.28	1.28	10.24	8.81	1.99
120.00	1001.77	1.77	12.23	12.15	2.07
180.00	1002.12	2.12	13.56	14.58	2.13
240.00	1002.41	2.41	14.58	16.56	2.16
300.00	1002.66	2.66	15.43	18.25	2.19
312.90	1002.71	2.71	15.59	18.58	2.20
420.00	1003.07	3.07	16.79	21.09	2.24
480.00	1003.25	3.25	17.36	22.32	2.25
540.00	1003.42	3.42	17.87	23.47	2.27
600.00	1003.57	3.57	18.36	24.53	2.28

Tailwater Channel Data - B - Laydown East

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 2.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.1100

Channel Manning's n: 0.0400

Channel Invert Elevation: 1000.00 ft

Hydrogeology and Water Well Development

Auwahi Wind Farm
Ulupalakua Ranch
Maui, Hawaii

Prepared for
Auwahi Wind Energy LLC
A Sempra Generation Company

Prepared by

waimea water services inc.

P.O. Box 326, Kamuela, HI 96743
Phone (808) 885-5941 Fax (808) 885-7851
e-mail waiono@wws-ius.com

July 23rd, 2011

Executive Summary

In July 2011, Waimea Water Services completed a study of the hydro-geology to determine the feasibility of developing a potable well to be located at the Auwahi Wind Farm on the Ulupalakua Ranch in Southeast Maui. The well would be used to support the 1-year construction phase of the Auwahi Wind Farm and the 20-year operation phase of the project. The Auwahi Wind Farm would require 60,000 gallons per day (gpd) during construction and 10,000 gpd during the operating phase. During the operating period, it is intended that surplus water would be made available to the Ulupalakua Ranch and Hawaiian homesteaders in Kahikinui.

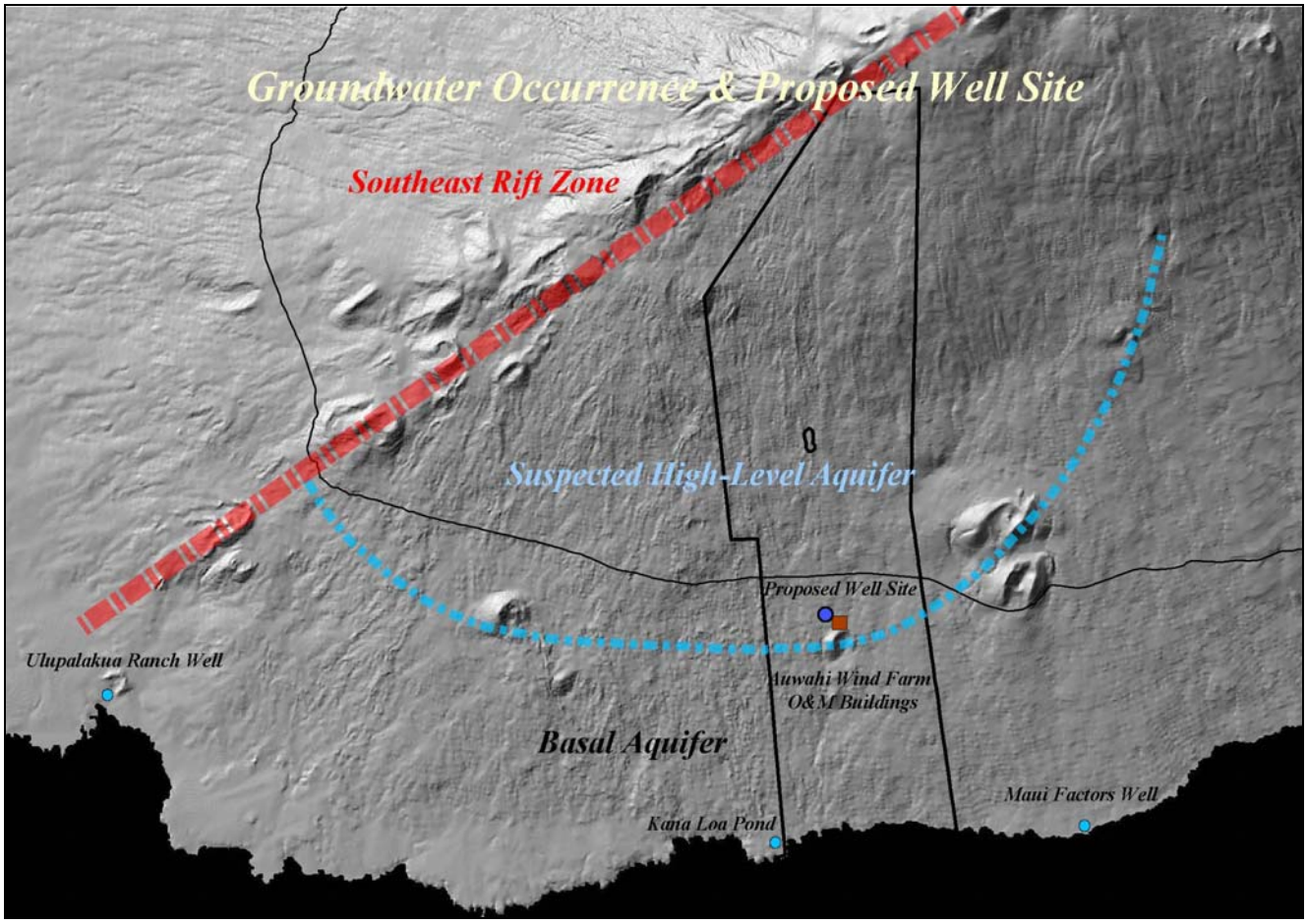
Currently, this region of Southeast Maui including the Auwahi Wind Farm is lacking ground-water development. Based on evaluation of site and hydrogeology experience throughout the Hawaii, and particularly Maui, Waimea Water Services has concluded that adequate ground-water can be developed in excess of 100,000 gpd in support of the construction and development of the Auwahi Wind Farm project. The total extent of the water resources cannot be confirmed until a well has been drilled. Waimea Water Services proposes to drill a 12" pilot bore to confirm the water quality, determine the final depth and to estimate the capacity which can be developed upon completion. Plans call for completing a 14" cased well. Should the well produce an unacceptable salinity, a desalination plant may be needed to produce potable water.

The preferred location for the well site was identified to adjacent to the Wind Farm Operation and Maintenance building, at an elevation of 1400 feet above sea level. This site was determined to be the preferred location based on the hydrology, geologic structures, proximity to auxiliary power from the future wind farm, and accessibility for exploratory drilling. The water well system is expected to cost approximately $2.4 million. Permitting and drilling would need to be completed to be able to provide water by March 2012 in order to support construction of the wind farm.

Introduction

The planned wind farm is located on the south east slope of Haleakala within the private ownership of Ulupalakua Ranch. An estimated 60,000 gpd (gallons per day) of fresh water is needed to support the construction and operations of the project. Plans call for having a capacity of at least 100,000 gpd for future needs. The neighboring Department of Hawaiian Homestead Land (DHHL) and Ulupalakua Ranch might also benefit from any surplus water supply.

No drilled wells exist within several miles of the project area and the limited supplies are either from brackish wells along the shore and from perched ground water spring located above the Ranch headquarters for stock water (Stearns and MacDonald 1946 and Takasaki 1971). More recent studies by Mink and Yuen, Inc. (1994) provided more detailed descriptions of the geology and ground-water in Kahikinui adjacent to and up slope from the Auwahi Wind Farm project.



Because there have been no recent ground-water developments south of the southeast rift zone of Haleakala, this study is devoted to updating the salinity (chlorides), total dissolved solids (as specific conductance), and temperature information from known sources at the shore. The sampling is aimed at validating previous data provided in the reports mentioned above.

New ground-water data can only be proven with well development as required for the project. The recently published Commission on Water Resource Management (CWRM) Sustainable Yield for the Lualailua sector of the Kahikinui Aquifer System (CWRM Water Resource Protection Plan 2008) is estimated at 11 mgd (million gallons daily for about 15 miles of shoreline).

Mink and Yuen estimated the ground-water flow from the basal lens at 2.8 mgd/mile assuming a hydraulic conductivity of 2000 ft/day under a head of 3 feet above sea level in 1994. As they reported, A Time Dependent Electro Magnetic survey of the DHHL Kahikinui parcel implied there might be high level ground-water on the site. Using the estimates from Mink and Yuen, the Sustainable Yield might be significantly higher than that of CWRM.

In theory, under the Gyben-Herzberg priniciple, for every 1 foot of fresh water head above sea level, there will be 40 feet of fresh water below sea level under static flow and recharge conditions. Studies in Hawaiian aquifers have shown that the highly permeable basalt lavas freely transmit tides and fluctuations of recharge. The result is very brackish water near the shore and a thickening lens with fresher water inland. Often, fresh water is only found miles inland depending on the nature of recharge. This characteristic leads to deep wells being drilled some distance from the shore.

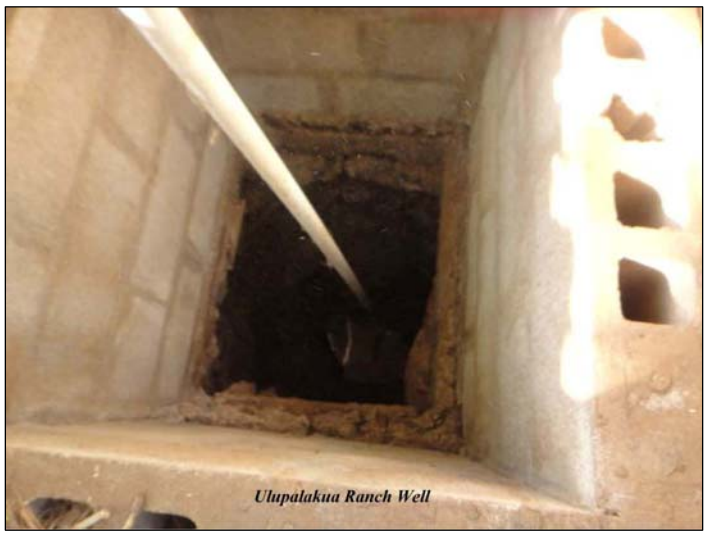
High level ground-water is commonly found in two categories, one in perched aquifer formations, which are typically thin layers of permeable cinders or clinkers lying either on dense lava flows or on soil or ash beds. These perched aquifers are very vulnerable to variations in local rainfall. The second occurrence can be extensive high-level aquifer units found within rift zones or fault compartments which in turn discharge into the basal lens. The latter storage units have been found to extend well below sea level and are not subject to salt water contamination.

Field Sampling results

The Ulupalakua Ranch Well, as described in the following table from Takasaki 1971, and a previously undocumented site were sampled and tested by WWS on July 13, 2011.

Ulupalakua Ranch Well:

Conductivity = 4.11ms/cm
Total Dissolved Solids = 2.14g/L
Temperature = 73.5 (F)
Chlorides = 2,500mg/L



Kana Loa Pond (Stagnant):

Conductivity = 17.04ms/cm
Total Dissolved Solids = 9.66g/L
Temperature = 86.1 (F)
Chlorides = 6,000mg/L

As evidenced in the July 13, 2011 results from the field sampling, although the water was brackish, both the Ulupalakua dug well and Kana Loa Pond showed significant fresh water contribution. The total chloride salt in sea water is approximately 17,000 mg/L as compared with the samples above. These results are typical for near shore wells and ponds containing discharge from the basal lens and reaffirm the existence of a significant ground-water flow system. The relatively high temperatures are the result of local stagnation.

Table 3. CHEMICAL ANALYSES OF SELECTED WATER SOURCES IN SOUTHEAST MAUI*

Source	Date	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magne-sium (Mg)	Sodium (Na)	Potas-sium (K)	Bicar-bonate (HCO_3)	Sulfate (SO4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated)	Hardness as $CaCO_3$ Ca,Mg	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°)	pH	Temp. °C at source
PERCHED WATER																		
Waiu Spring[1/]	Apr. 1941	64	0.2	10.7	7.9					120				57			7.9	
"	Mar. 1970	67		11	12	144	7.0	169	26	149	1.1	19	519	77	0	825	7.8	23
"	May 1970	64		11	12	148	6.5	170	16	160	1.0	21	523	77	0	835	7.9	23
Manawainui Spring	Mar. 1970	22		4.4	1.4	6.6	0.4	28	0	5	0.1	0.1	54	17	0	59	8.3	21.5
Waihi Spring	Mar. 1970	11		4.5	3.5	9.8	1.2	30	3.2	14	0	0.5	63	26	1	101	6.4	21.0
BASAL WATER																		
Ulupalakua Ranch Well	Mar. 1970									1210						4730		
Maui Factors Well	May 1970	25		34	101	1030	42	94	218	1760	0.2	5.3	3260	501	424	5910	8.0	18.9
Punahoa Spring[1/]	Sept. 1953									182								
"	Mar. 1970	20		9.2	10	102	5.0	46	25	160	0.1	1.8	356	64	27	651	7.2	19.5
"	May 1970	19		7.4	8.6	75	3.6	44	18	119	0.2	1.8	275	54	18	502	7.4	20
Pryor Well	May 1969									68								
STREAM WATER																		
Waiopai Pond (stagnant)	Mar. 1970	9.2		4.1	3.3	9.8	2.5	37	0	11	0.1	0.1	58	24	0		7.2	22.5
Kaupo Intake (Manuwainui Valley)	Mar. 1970	1.0		0.3	0.1	1.0	0.1	1	0	3	0	0	6	1	0	9	5.6	11.5
Kalepa Intake[1/]	Apr. 1941		0.1							10				32			6.9	

* Constituents in milligrams per liter. Analytical data by U.S. Geological Survey, except as noted.

[1/] Analytical data by State Department of Health.

(Takasaki 1971, p.24)

Water Development Potential

Demand and well location

According to the Auwahi Wind Farm development plans, the main support and service facility will be located at an elevation of about 1350 to 1400 upslope from Puu Hokukano (see map). The plan is to have a water demand available at this location of about 60,000 gpd of fresh water for the construction peak. It is assumed that this source will also supply water for potable uses.

The hydrogeology studies to date all conclude that the basal lens extends some distance inland but it is not known where the water level is high enough to support freshwater. The farther inland (or closest to recharge) a well is drilled the greater the odds of finding fresh water in the basal lens.

This report is aimed at selecting a site for drilling a well to produce fresh water yet serve the initial demand of 60,000 gpd for the project. Several sites were considered in this study with a location in the vicinity of the planned support facilities.

Regardless of what elevation the well is located, the primary demand for the water will be located at the support facility. A location just above it, at 1400' above sea level, is judged to be the best site for an initial well. It is located above the Puu Hokukano, which appears to be the result of intrusive dikes or crustal weakness caused by faults. Based on experience in similar geologic conditions in the Kona District of Hawaii there is a potential for a well to penetrate a high level ground-water compartment either within a marginal dike zone or inland of an ancient fault.

It is important to note that faults in Hawaii do not move laterally but may have vertical displacement at the time they occur. Such faults normally are the result of coastal slumping or caldera collapse. Because there is no surface evidence, other than the nearby cinder cones, the actual occurrence of the ground-water will be determined with the first deep well.

Should this initial well strike only brackish water in a basal lens, it will be necessary to desalt the well to obtain the potable water needed. The only contaminate expected is from salt water under lying the lens or from salt at the top of the lens from percolating recharge, concentrated by evapo-transpiration, which may occur on leeward slopes of the Haleakala Volcano. The primary risk of water development for the Auwahi Wind Farm is the possibility of not developing a fresh water well as salt will be the contaminant of concern.

Desalting

Typical desalting on the island of Hawaii and near Kihei on Maui consists of reverse osmosis membrane processes. Recent operating experience by Waimea Water Services has resulted in efficiencies in the 55 % to 60% range depending on the amount of silica found in the ground-waters.

With an initial water demand of 60,000 gpd, this would indicate that a well delivering about 120,000 gpd would be needed with about 60,000 gpd of brackish water available for other uses such as landscaping. Consideration should be given to storing water in tanks or open pond as a source for both the exploration drilling and to store all water produced during well testing and reject water from desalting (if required).

To meet the peak construction demand, a high voltage (2575 v) pump of about 200 horsepower to bring the water up to a 1400’ elevation. A pad mounted transformer (400 Kva 1100 -2800 multi-tap transformer will probably be needed for the well pump. An Additional 40 hp for desalting may be needed. The actual need for desalting can be determined following construction of the first well and based upon total dissolved solids and silica. The estimated cost of a desalting facility of this scale is about $250,000 not including a building.

Once the well is drilled and quality determined, it will be reasonable to consider other uses and demands for the water supply in the regions such as serving needs of the Ranch and or nearby lands.

Well size and costs

As noted above, it is estimated that a pump motor of about 200 hp is needed regardless of the water quality. A minimum size well casing will be 14” inside diameter with about 40’ of well screen. A submersible pump motor of this hp and size will have an 8” motor diameter unless it is low rpm type (1760 rpm) which might be 16” diameter motor which would require a 20” diameter well casing. Line shaft pumps can be installed but are expensive to purchase and repair at this depth.

Typical well head setup. High voltage transformer in center right

A 14" diameter well 1440' will cost about $ 1,400,000. The typical time to build this type of well in Hawaii is about 240 days. The pump and controls may cost an additional $500,000. In addition, if needed, a reverse osmosis desalting plant will cost about $250,000 with a footprint of about 8' x 30'. Surface tanks, piping and power systems will be additional depending on sizing and service. To provide water for the greater community, additional tanks, booster pumps, piping and holding ponds would be needed.

Summary of Estimated Costs

Well	
12" pilot bore and testing	$ 500,000
Ream, case (14") and test	$ 900,000
Pump (200 hp) and controls, installed	$ 500,000
Sub total	$1,900,000
Desalination (reverse osmosis)	$ 250,000
Other equipment and contingency (tanks, boosters, piping, etc)	$ 250,000
Total	$2,400,000

Final costing will be depend upon design and negotiation

Well Project Schedule

The well construction schedule is designed to provide completed well no later than April 1st 2012. Wind farm construction is planned to start during March. Well development will be designed to allow water to be pumped to storage following construction of the exploration pilot bore as a result of preliminary open bore pumping tests. Following the well reaming and casing of the well, a temporary test pump will also be installed and water can saved for construction use while the grouting is completed and a permanent pump can be installed. This procedure will need approval from the Hawaii Commission on Water Resource Management.

Permitting and drilling of the well will need to be expedited to support the start of wind farm construction during March 2012. This can be accomplished if long days and/or 24 hour shifts are permitted. A well permit application will be submitted August 1, 2011 subject to final EIS, SMA and HPD report submittals.

Task	Duration	Start	Finish
Well Permit Application	12 Weeks	8/1/2011	11/28/2011
Wind Farm FEIS Approval (Sempra)	0 Days	8/9/2011	8/9/2011
Wind Farm SMA/CUP Approval (Sempra)	0 Days	10/25/2011	10/25/2011
Well Permit issued	0 Days	10/25/2011	10/25/2011
Drill Pilot bore (12”)	8 Weeks	11/1/2011	12/30/2011
Pump Pilot Bore (water quality and yield)	7 Days	1/1/2012	1/7/2012
Initial Water Delivery	0 Days	1/7/2012	1/7/2012
Ream Bore (18" - install casing 14")	12 Weeks	1/7/2012	3/30/2012
Start of Wind Farm Construction (Roads, Substation, Wind Farm)	0 Days	3/1/2012	3/1/2012
Test Pumping (continue pumping to storage)	7 Days	4/1/2012	4/8/2012
Grout Annulus (Well construction complete)	7 Days	4/8/2012	4/15/2012

Selected References

Mink and Yuen, Inc., 1994, Preliminary Assessment of Usable Water Resources, Kahikinui, Maui, DHHL: Consultant Report Prepared for R.M. Towill Corporation Honolulu, Hawaii.

Stearns, H.T., and Macdonald, G.A., 1942, Geology and Groundwater Resources of the Island of Maui, Hawaii: Hawaii Div. Hydrography Bull. 7.

Takasaki, K.J., 1971, Preliminary Report on the Water Resources of Southeast Maui, Hawaii: Hawaii Div. Water and Land Devel. Circ. C58.

Tetra Tech EC, Inc., 2011, EIS for Auwahi Wind Farm ‘Ulupalakua Ranch Maui, Hawaii: Consultant Report prepared for Maui County Planning Commission on Behalf of Auwahi Wind Energy, LLC.

Waimea Water Services, Inc., 2004, Water Resource Review of the Kamaole Aquifer Unit (Kihei to Makena, Maui): Consultant Report prepared for Haleakala Ranch, Kaonoulu Ranch, and Ulupalakua Ranch Maui, Hawaii.

Appendix D
Biological Resources Survey

Botanical, Avian and Terrestrial Mammalian Surveys Conducted for the Auwahi Wind Farm Project, ʻUlupalakua Ranch, Island of Maui

Prepared by:

Reginald E. David
Rana Biological Consulting, Inc.
P.O. Box 1371
Kailua-Kona, Hawaiʻi 96745

&

Eric Guinther
AECOS Consultants
45-309 Akimala Place
Kāneʻohe, Hawaiʻi 96744

Prepared for:

Auwahi Wind Energy, LLC
101 Ash Street
San Diego, California 92101-3017

February 2011
Revised

Table of Contents

Table of Contents 1
Introduction 4
General Project and Site Description 4
Wind Farm Site 4
Generator Tie-Line Corridor 7
Construction Access Road 7
Methods 8
Botanical Survey Methods 8
Field Survey 8
Botanical Mapping 11
Stream and Wetland Survey Methods 12
Avian Survey Methods 12
Mammalian Survey Methods 13
Results 14
Botanical Survey 14
Wind Farm Site 14
Generator Tie-Line Corridor 24
Construction Access Road 36
Avian Survey 44
Mammalian Survey 46
Wetland and Stream Resources 48
Discussion 50
Botanical Resources 50
Pysiography 50
Vegetation Zones 51
Grasslands/pasture 53
Savanna 54
Secondary Mesic Forest 56
Native Mesic Forest 56
Dry Shrubland 60
Dryland Forest 61
Listed Plant Species 66
Stream and Wetland Resources 68
Avian Resources 68
Mammalian Resources 69
Conclusions 70
Botanical Resources 70
Avian and Mammalian Resources 71

Potential Impacts to Protected Species 71
Lānaʻi ʻiliahi 71
Hawaiian Hoary Bat 71
Hawaiian Petrel and Newell's Shearwater 71
Recommendations 71
Glossary 73
Literature Cited 74

Figures

Figure 1. Auwahi Wind Farm Map of southwest East Maui Mountains showing Project components and biologically sensitive areas 5
Figure 2. Auwahi Wind Farm site showing layout of Project components 6
Figure 3. View upslope towards Puʻu Hōkūkano showing dry condition present in July 2010. Some *koa haole* shrubs (right) manage to retain leaves and even produce fruit under the severe drought conditions 14
Figure 4. Lower part (multiple trunks) of a venerable old *naio* (*Myoporum sandwicense*) at the Auwahi wind farm site 15
Figure 5. Botanical survey map for the wind farm site between Piʻilani Highway and Puʻu Hōkūkano 19
Figure 6. Botanical survey map for the wind farm site, wind turbine pads 11 through 15 and associated roads (upper west side) 20
Figure 7. Botanical survey map for the wind farm site, wind turbine pads 00 through 03 and associated roads (upper east side) 21
Figure 8. Botanical survey map for the wind farm site, turbine pads 08 through 12 and associated access roads (lower west side). 22
Figure 9. Botanical survey map for the wind farm, wind turbine pads 03 through 07 and associated access roads (lower east side) 23
Figure 10. Botanical survey map for the upper east side generator tie-line between 3700 and 4300 feet ASL 31
Figure 11. Botanical survey map for the upper east side generator tie-line between 3200 and 3800 feet ASL 32
Figure 12. Botanical survey map for the east side generator tie-line between 2600 and 3200 feet ASL 33
Figure 13. Botanical survey map for the east side generator tie-line between 2100 and 2600 feet ASL 34
Figure 14. Botanical survey map for the east side generator tie-line between 1600 (Piʻilani Highway) and 2100 feet ASL 35
Figure 15. Botanical survey map for west end of construction access road between 100 (Alanui Road) and 350 feet ASL 41
Figure 16. Botanical survey map for western part of construction access road between 250 and 550 feet ASL 42
Figure 17. Botanical survey map for construction access road between 550 and 1100

feet ASL 43
Figure 18. Botanical survey map for construction access road between 1100 and 1750 feet ASL (Pi‘ilani Highway) 44
Figure 19. Swale of “intermittent stream” shown in Guinther (2010) seen from 250-ft elevation looking towards the outlet at the shore 49
Figure 20. Typical pasture here at around 3500 ft on the southwest rift. Note that a mesic forest covers the pu‘u (Kalanapahi cinder cone) downslope, which is not used for cattle grazing. Slope on right is Keonenelu cinder cone 53
Figure 21. Vegetation zones for the western half of the generator tie-line (in red) crossing upland pasture and lowland savanna of ‘Ulupalakua Ranch. For key see Table 6 54
Figure 22. Typical savanna: grassland with scattered trees (around 1000 ft above Wailea looking towards Kaho’olawe) 55
Figure 23. Savanna or dryland forest? The Prosopis/Cenchrus Association at lower elevations fits the definition of both vegetation types 55
Figure 24. Vegetation zones for the eastern half of the generator tie-line (in red) crossing upland savanna and scrub pasture, scrub lands of ‘Ulupalakua Ranch. For key see Table 6 57
Figure 25. Dry shrubland on the southern flank of the East Maui Volcano 61
Figure 26. Vegetation zones for the Auwahi Wind Farm SIte. Scrub vegetation predominates on lava flows of various ages, with small areas of grassland pasture and very rocky pasture in some areas. For key see Table 6. 62
Figure 27. Vegetation zones for the construction access road (Papaka Road) crossing mostly mixed *kiawe/wiliwili* forest and pasture of ‘Ulupalakua Ranch. For key see Table 6. 63
Figure 28. Wiliwili forest remnants (green areas) as mapped by Price (Altenburg, 2007) shown on a topographic map with Auwahi wind farm project elements in red 65
Figure 29. Inside a native *wiliwili* forest at the Auwahi Wind Farm site. 66

Tables

Table 1. Checklist of Plants Found on the Proposed Auwahi Wind Farm Site 16
Table 2. Checklist of Plants Found Along the Generator Tie-line Corridor, Auwahi Wind Farm 25
Table 3. Checklist of Plants Found Along the Proposed Construction Access Road, Auwahi Wind Farm 37
Table 4. Avian Species Detected on the Auwahi Wind Energy Project 45
Table 5. Mammalian Species Detected on the Auwahi Wind Farm Project 47
Table 6. Vegetation Map Key 58
Table 7. Plant Species from Auwahi Preserve, East ‘Ulupalakua Ranch 5

Introduction

Auwahi Wind Energy, LLC, a subsidiary of Sempra Generation, Inc. proposes to develop a wind energy project, called the Auwahi Wind Farm ("Project"), on ʻUlupalakua Ranch land in the southern part of the Auwahi *ahupuaʻa*, Maui Island, Hawaiʻi (Figure 1). The primary purposes of the surveys reported here are 1) to assess the botanical, avian, and mammalian resources in the Project area, and 2) to determine if any species listed as endangered, threatened, or proposed for listing under either federal or the State of Hawaiʻi endangered species programs occur within, or in the immediate vicinity of, the Project. Information regarding federal and state listed species and their status comes from the Division of Land and Natural Resources (DLNR, 1998) and the U.S. Fish & Wildlife Service (USFWS, 2005, 2010).

Initial biological surveys for the Project were undertaken for ShellWind Energy, Inc. in mid-2007 and a draft report of results and recommendations issued in early 2008. In October 2009, Sempra Energy acquired the development assets of the proposed project from Shell. Recommendations for additional surveys from the draft report were implemented beginning in May 2010, and the report presented here is a significantly revised and expanded version of the 2008 draft report. The current report reflects Sempra Energy's revised project design and footprint as detailed up through October 2010. Minor additional surveys may be needed to cover adjustments in layout of Project elements as engineering of the Project nears completion. These surveys, if needed, will insure that no listed plant species occur in impact areas not previously surveyed; and would not alter the conclusions made in this report.

Project and Site Description

The proposed project consists of three main components: a) the wind farm site, b) a transmission line corridor, and c) a construction access road. Each of these components is shown on Figure 2, and is described below.

Wind Farm Site

The wind farm site consists of approximately 1,500 acres of the Auwahi *ahupuaʻa*, and is located on ʻUlupalakua Ranch property. The northern site boundary is located along Piʻilani Highway at approximately 1,600 feet (470 meters) above sea level (ASL), and the southern boundary is located approximately 1,300 feet inland from the shore (at about 200 feet or 90 meters ASL). The site is bound to the east and west by the *ahupuaʻa* of Lualaʻilua and Kanaio, respectively. The site is currently used for cattle grazing by ʻUlupalakua Ranch, although much of the topography is rugged ʻaʻā lava flows. The majority of the site is dominated by alien scrub vegetation, although numerous stands of *wiliwili* (*Erythrina sandwicensis*) occur within this site.

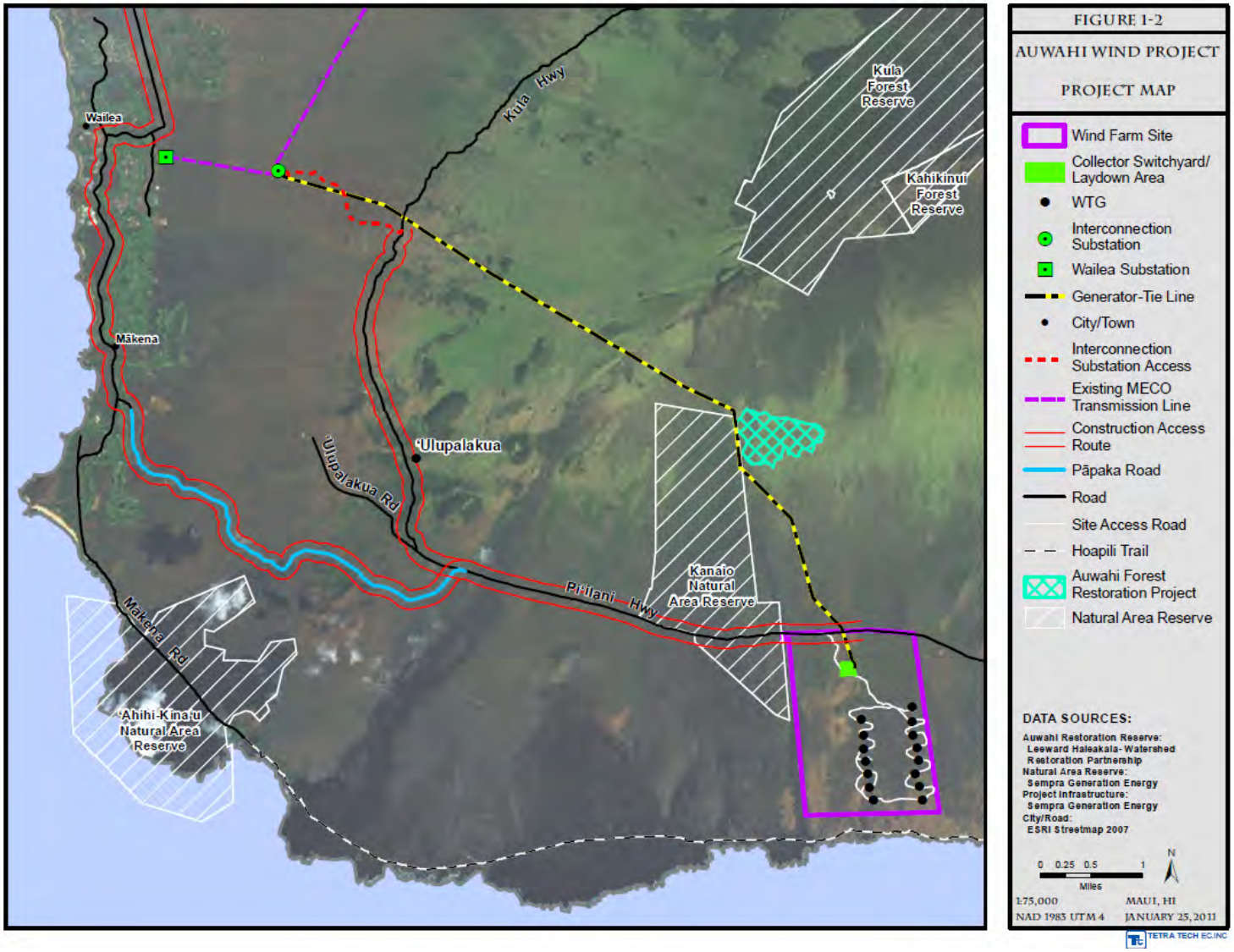


Figure 1. Auwahi Wind Farm Map of southwest East Maui Mountains showing Project components and biologically sensitive areas

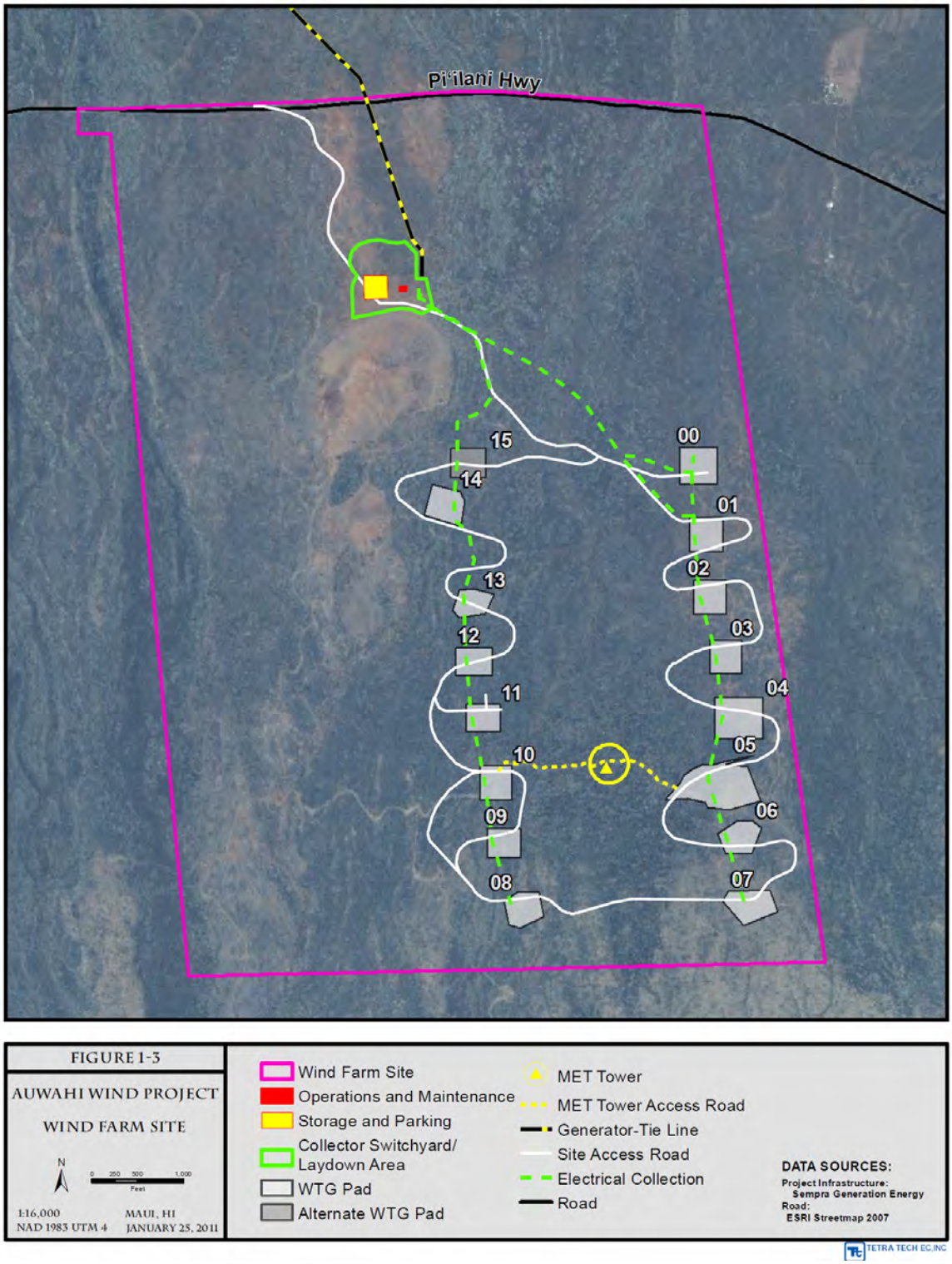


Figure 2. Auwahi Wind Farm site showing layout of Project components

Generation Tie-Line Corridor

Power generated by the wind farm will be transmitted to the Maui Electric Company (MECO) grid via an approximately nine-mile long, 34.5 kV generator tie-line. The generator tie-line will run north from the wind farm site, cross Pi‘ilani Highway and continue upslope (*mauka*) through mixed dryland scrub and pasture. West of Pu‘u ‘Ouli, at approximately 4,200 feet (1,280 meter) ASL, the generator tie-line will turn westward across the East Maui volcano, southwest rift. The environment in this location is treeless and consists of high elevation pasture dominated by Kikuyu grass (*Pennisetum clandestinum*).

The generator tie-line will cross the ridgeline of the rift zone at approximately 4,400 feet (1,340 meters) ASL and continue downslope to connect with the MECO grid at 1,000 feet (305 meters) ASL. This part of the route is entirely within pastureland of ‘Ulupalakua Ranch. The dominant grasses in this pastureland change with elevation, influenced mostly by the rainfall regime along a gradient of decreasing rainfall with decreasing elevation. The strictly grassland of the upper slopes gives way to a savanna (grassland with scattered *kiawe* trees) well below Kula Highway, at around 1,200 feet (370 meters) ASL.

Construction Access Road

The construction access road (Papaka Road) will consist of improvements to approximately 4.6 miles (7.4 kilometers) of existing pastoral and unimproved quarry access roads located between Mākena (at the intersection with Alanui Road) and Pi‘ilani Highway. The land along much of its length is currently used for cattle grazing.

Methods

Plant names follow *Hawai`i's Ferns and Fern Allies* (Palmer, 2003) for ferns, *Manual of the Flowering Plants of Hawai'i* (Wagner et al., 1990, 1999) for native and naturalized flowering plants, and *A Tropical Garden Flora* (Staples and Herbst, 2005) for ornamental plants. Avian phylogenetic order and nomenclature follow *The American Ornithologists' Union Check-list of North American Birds 7th Edition* (American Ornithologists' Union, 1998), and the 42nd through the 51st supplements to *Check-list of North American Birds* (American Ornithologists' Union, 2000; Banks et al., 2002, 2003, 2004, 2005, 2006, 2007, 2008, Chesser et al., 2009, 2010). Mammal scientific names follow *Mammals in Hawaii* (Tomich, 1986). Place names follow *Place Names of Hawaii* (Pukui et al., 1974).

Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, is included at the end of the narrative text.

Botanical Survey Methods

Field Survey

The methods used for the initial botanical surveys in 2007 involved pedestrian or wandering "transects" across the terrain in proposed Project areas, noting all plant species as they were encountered. Photographs were taken and, in some cases, specimens collected, to verify field identifications. Later surveys (2010) involved recording specific plant locations (positions) with a GPS unit within designated buffer areas established for various Project elements. On these surveys, only native plants (and tree-tobacco) were surveyed. During the 2010 surveys any species not recorded in 2007 was added to the flora listing for the area.

Plant surveys were conducted in May 2007 through October 2010 in the following areas:

- May 29, 2007 – General reconnaissance of Project locations for survey planning.
- May 30, 2007 – Survey of construction access road, Pi'ilani Highway to Mākena.
- May 31, 2007 – Survey of generator tie-line route on west mountain slope, downslope from Kula Highway all the way to MECO Wailea Substation.
- June 1, 2007 – Survey of generator tie-line route on west mountain slope, upslope from Kula Hwy. to the 4000–foot elevation.
- June 2, 2007 – Survey of generator tie-line route on south mountain slope, upslope from Pi'ilani Highway to the 4200–foot elevation.
- June 3, 2007 – Survey of wind farm site.
- June 4, 2007 – Survey of wind farm site.
- March 20, 2008 – Accompanied entomologist (S. Montgomery) on general reconnaissance of project locations and surveyed area close to upslope end of Kanaio Natural Area Reserve (NAR) around 4000-foot elevation.
- July 7, 2010 – Survey mapping (using GPS) distribution of native plants (mostly *wiliwili*) along construction access road from old quarry site at about 800-foot elevation down to Mākena.

- July 8, 2010 – Survey mapping distribution of native plants (mostly *wiliwili*) along construction access road from Piʻilani Hwy to old quarry; mapping natives along existing entrance road at wind farm site.
- July 9, 2010 – Survey mapping of native trees in the upper part of the wind farm site from proposed new entrance road to just east of Puʻu Hōkūkano.
- July 27, 2010 – Survey mapping native trees and shrubs for upper turbine pad sites and turbine access roads.
- July 28, 2010 – Survey mapping distribution of native plants (mostly *wiliwili*) and tree-tobacco on construction access road alternative behind golf course in Mākena; Mapping native trees and shrubs for generator tie-line on south mountain slope from 4200-foot elevation (above Kanaio NAR) down to 2000-foot elevation.
- July 29, 2010 – Mapping native trees and shrubs at turbine pad sites and access roads in lower half of wind farm site. Visit to possible "stream" outlet at the coast. Mapping native trees on generator tie-line routes (including alternative) immediately upslope of Piʻilani Hwy. to 2000–foot elevation.
- October 12, 2010 – Mapping native trees and shrubs in buffer for generator tie-line route between 3100 and 3900-foot elevations (proximal to Kanaio NAR).

The 2007 surveys covered the project site, generator tie-line route, and construction access road in a complete, but general manner because exact locations of project components had not been firmly established at that time. The results of the general botanical surveys were provided in an interim report with the recommendation that detailed surveys would be needed for specific areas where native plants were common. The 2010 surveys utilized GIS shape files provided by Sempra. These files—loaded into the GPS field units (Trimble GeoXT and GeoXM)—made detailed plant surveys practical by limiting survey areas to pre-defined buffers surrounding each Project component (wind turbine generator pad sites, site access roads and facilities, generator tie-line route, and construction access road improvements and alternatives). The buffers provide for small position adjustments during final design and construction. For all roads, the buffer was set at 20 meters (65 feet) to either side of the proposed centerline. For the generator tie-line, the buffer was 10 meters (33 feet) to either side of the proposed route. For wind turbine generator pad sites, the buffer was variable, but typically a rectangle 100 to 125 meters (330 to 410 feet) on a side. Mapping typically extended a short distance outside the buffer to ensure completeness, and in a few areas the terrain forced movement well outside the buffer.

Plant checklists were compiled for the different areas from field observations made primarily during the 2007 surveys, but added to with each subsequent survey in a given area. Although all species encountered are included in the flora lists, important botanical resources are those species that are (typically) rare, native species. These plants may or may not be protected by state or federal statute (such as the Endangered Species Act). Some occurrences of native species having botanical resource value in the survey area may be of unusual age, may be endemics of limited distribution, may be present in substantial numbers at the location (and generally rare elsewhere), and/or may be part of remnant populations of an otherwise degraded native plant community. Areas of mostly intact native

plant communities also have high resource value. Such botanical resources are discussed further in the text where applicable to the present survey.

In the flora listings, entries are arranged alphabetically under plant family names. Included in the lists are scientific name, common name, and status (whether native or not-native) for each species. In addition to identifying the plants present within the study site, qualitative estimates of plant abundance were made. These are coded from rare to abundant/dominant[1] in the table and apply to observations made for each survey area. In some cases, a two-level system (letter-number code) of abundance is used: the letter providing the occurrence rating of a species throughout the survey area followed by a number indicating that, where encountered, abundance tended to be greater than the occurrence rating would suggest. For example, an abundance rating of "R" indicates that a plant was encountered once to several times within a survey area. However, a rating of "R2" indicates that a plant was very infrequently encountered, but several to many individuals were present where it was encountered. Because qualitative abundance ratings are entirely dependent upon the frequency that a species is encountered during the survey (as opposed to a number representing a count within an area), the added numeral corrects for species that tend to occur in clusters or in very limited parts of the survey area. An abundant species occurs everywhere and presumably is a population with high numbers within the survey area. An R3 species may likewise have a population of many individuals, but the "R" indicates clusters that are only rarely encountered.

Although abundance information is given for each project area, it should be noted that pronounced environmental gradients exist in the areas surveyed, especially along the proposed generator tie-line route. For example, a plant might be quite common at lower elevations and entirely absent at higher elevations, or vice versa. Because the ratings are given for component areas as a whole or in large blocks, it is difficult to correct for variations in species abundance across such a broad range of conditions (elevation, moisture, soil or edaphic characteristics), making estimating and reporting relative abundances more qualitative than quantitative.

Because these surveys were conducted during dry periods, it is expected that some plant species (especially weedy annuals) may have been missed or noted in abundances much lower than would be the case in wet periods. In general, this problem does not compromise the results with respect to the native flora, which consists mostly of perennial plants (exceptions are noted in the Discussion Section) that can be located and identified under such circumstances. In any event, repeat surveys, particularly at different times of the year, would likely yield more species.

[1] Sometimes called "DACOR abundance categories" for dominant, abundant, common, occasional, and rare, we use "AA" for the very abundant and dominant (in the particular stratum) species, and insert an "uncommon" ("U") between rare and occasional categories, reserving "rare" ("R") for species encountered three times at most.

Finally, abundance values in the plant species tables were developed in 2007. Return surveys made in 2010 encountered a much changed landscape due to drought conditions having prevailed since 2007 (Dicus, 2007; CWRM, 2010). As a consequence of low rainfall over a period of several years, many of the plants recorded during the 2007 surveys were not observed in 2010. In areas such as the wind farm site, native trees stood out in stark contrast to the introduced species that had previously dominated the visual landscape, but had either disappeared or were reduced to lifeless-appearing sticks. Thus, the 2010 surveys were able to better record locations of native trees than had been the case in 2007, but semi-quantitative estimates of herbaceous species could not be made in 2010, so only minor changes have been made to the 2007 report abundance estimates. Drought conditions at elevations above Pi'ilani Highway had ameliorated somewhat between the July and October 2010 surveys.

Botanical Mapping

A series of maps combining the results of species (feature[2]) positions recorded in the field and project components were prepared using ArcView 9. These maps show all plant species positions within designated buffers and recording of features is complete only for the buffers. Some feature positions occur outside the buffer boundaries and these represent either plant finds of particular interest to the botanist, plants recorded just outside the boundaries for completeness, or plants within component alternatives that were later abandoned. In general, native trees were individually recorded, but native shrubs, being too numerous in some areas, were not. However, in a dryland forest (and the upper elevation mesic forest), the distinction between trees and shrubs is not a sharp one; consequently, species generally regarded as trees (such as *Myrsine*), whether encountered as tree or shrub-like were recorded, whereas species generally regarded as shrubs (such as *Dodonaea* and *Wikstroemia*), even where tree-like, were not recorded. Also, in cases where dense concentrations of *wiliwili* trees were encountered (defined as a copse), a copse outline was recorded rather than each individual tree, to satisfy the purpose of mapping the *wiliwili* forest in relation to a project component. The only non-native species recorded in the GPS surveys was tree tobacco (*Nicotiana glauca*; typically a shrub), for its potential as rearing habitat for the listed Blackburn's sphinx moth (*Manduca blackburni*).

General vegetation maps encompassing Project areas were developed based on field observations and Bing Map satellite images imported into ArcMap. While the vegetation maps encompass a much greater area than the Project components, the vegetation maps are based entirely on interpretation from satellite images outside of areas actually traversed during the field surveys. Vegetation maps prepared by Jacobi (1989) were imported as a shapefile (from DBEDT, 2010) and provided descriptive and boundary guidance where applicable. However, these maps covered only the area near the upper elevation portion of the generator tie-line before it crosses the southwest rift zone, and thus were of limited utility.

[2] In GIS parlance, a "feature" is any item the position of which can be recorded by a GPS unit.

Stream and Wetland Survey Methods

Given the extreme dryness of all of the lowland areas surveyed and the high infiltration rates of the rocks and soils of the more upland areas, it is not surprising that streams and wetlands are absent from this part of Maui. Between Mākena (generator tie-line below ʻUlupalakua Ranch) and Lualaʻilua Hills (east of proposed wind farm site), from the shore to the top of the mountain, only one "stream" is indicated on older USGS topographic maps (Mākena and Lualailua Hills quadrangles). This unnamed, intermittent stream lies along the western edge of the project parcel, west of the project wind turbine generator pads and roads. Selected sections of this gulch were visited and photographed in order to render an opinion as to whether the feature would be jurisdictional (a so-called "Waters of the U.S.") or not. Field observations and reference to the USFWS, "Wetland Mapper" (USFWS, 2010) were used to assess the presence of wetlands in project areas.

Avian Survey Methods

A total of eighty avian count stations were sited along linear transects running the length of the generation tie-line line corridor, the construction access road, and within the wind farm site. The count stations were placed at approximately 300-meter intervals equally spaced along these transects. Eight-minute point counts were made at each of the eighty count stations. Each station was counted once. Field observations were made with the aid of Leica 10 X 42 binoculars and by listening for vocalizations. Counts were concentrated between 07:00 a.m. and 11:00 a.m., the peak of daily bird activity. Time not spent counting was used to search the remainder of the project site for species and habitats that were not detected during count sessions.

Surveys were conducted in May 2007 through July 2010 in the following areas:

- May17, 2007 – General reconnaissance of the entire project site for survey planning.
- May 29, 2007 – General reconnaissance of project locations for survey planning.
- May 30, 2007 – Survey of construction access road, Piʻilani Highway to Mākena.
- May 31, 2007 – Survey of generator tie-line route on west mountain slope, downslope from Kula Highway to Wailea.
- June 1, 2007 – Survey of generator tie-line route on west mountain slope, upslope from Kula Hwy. to the 4000–foot elevation.
- June 2, 2007 – Survey of generator tie-line route on south mountain slope, upslope from Piʻilani Highway to the 4200–foot elevation.
- June 3, 2007 – Survey of wind farm site.
- June 4, 2007 – Survey of wind farm site.
- July 7 – 9, 2010 – On site conducting other surveys.

A separate set of ornithological radar surveys were conducted on the wind farm site by Hamer Environmental, L.P. between October 11 and 18, 2006 and May 25 and 30 2010 (Hamer Environmental 2010). Their surveys were designed to assess the impacts, if any, of the proposed project on two-listed pelagic seabird species, Hawaiian Petrel (*Pterodroma sandwichensis*), and Newell's Shearwater (*Puffinus auricularis newelli*).

Mammalian Survey Methods

With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *ʻōpeʻapeʻa* as it is known locally, all terrestrial mammals currently found on the Island of Maui are alien species. Most are ubiquitous. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal sign. A running tally was kept of all vertebrate mammalian species observed, heard or detected by other means within the project area, while we were on the property conducting avian and botanical surveys. A separate set of radar surveys were conducted on the site by Hamer Environmental, L.P. in 2006 and 2010 in which they were tasked with surveying for nocturnally flying seabirds and bats (Hamer Environmental 2010).

Results

Botanical Survey

Wind Farm Site

The results of botanical surveys at the wind farm site (flora listing) conducted between 2007 and 2010 are summarized in Table. 1. Most of the site is dry, generally stony to rocky pastureland or scrub growth on rugged lava flows (mostly *a'a* flows in this area). The majority of species recorded in Table 1 were observed only in 2007 because of drought conditions (see Figure 3) in July 2010. It is worth noting, however, that the native trees were in general good health, and so flushed with leaves that they stood out in marked contrast to the drought-devastated non-native vegetation.

The plant listing with abundance ratings provides a general sense of the flora in the survey area. The status column in Table 1 shows that the majority of species present have no particular significance from a project impacts perspective. Most are introduced (non-native) species that have become naturalized in the Hawaiian Islands. Non-native *koa haole* (*Leucaena leucocephala*) is the most abundant species overall (Figure 3).

Figure 3. View upslope towards Pu'u Hōkūkano showing dry condition present in July 2010. Some *koa haole* shrubs (right) manage to retain leaves and even produce fruit under the severe drought conditions.

Of note with respect to native botanical resources are extensive groves of *wiliwili* and very scattered *hao* (*Rauvolfia sandwicensis*) and *naio* (*Myoporum sandwicense*) trees, several of large size and therefore probably of considerable age (Figure 4). *Wiliwili* and other native trees are most abundant on the more rugged terrain characterizing the middle of the site, although *wiliwili* is not limited to these essentially non-pasture areas. One rare native plant not recorded in 2007 but found in the follow-up surveys of July 2010 is the *ʻohe makai* (*Reynoldsia sandwicensis*). Two tall specimens were encountered (the largest flushed with leaves). Unfortunately, drought conditions had become so severe that (presumably) goats or axis deer had chewed deep into the outer tissue of both plants completely girdling the trunk to a height of nearly 5 feet above the ground. By appearances, neither plant would be expected to survive this level of grazing damage.

Figure 4. Lower part (multiple trunks) of a venerable old naio (*Myoporum sandwicense*) at the Auwahi Wind Farm site.

Soil conditions on Puʻu Hōkūkano and the low-sloping ground immediately north of the *puʻu* provide much deeper soils than is the case elsewhere at the site. However, these areas are extensively grazed by cattle and feral goats and currently support only non-native herbaceous plants (for example, grasses). *Wiliwili* trees border the pastureland north of the *puʻu* (Figure 5).

Table 1. Checklist of Plants Found on the Proposed Auwahi Wind Farm Site

Species	Common name	Status	ABUNDANCE	NOTES
FLOWERING PLANTS				
DICOTYLEDONES				
AMARANTHACEAE				
Amaranthus spinosus L.	spiny amaranth	Nat.	U	
ANACARDIACEAE				
Schinus terebinthifolius Raddi	Christmas berry	Nat.	--	(4)
APIACEAE				
Petroselinum crispum (Mill.) A.W. Hill	Parsely	Nat.	R	
APOCYNACEAE				
Rauvolfia sandwicensis A. DC	*hao*	**End.**	R1	(2)
ARALIACEAE				
Reynoldsia sandwicensis A. Gray	*'ohe makai*	**End.**	R	(2)
ASCLEPIADACEAE				
Asclepias physocarpa (E. Mey.) Schlecter	balloon plant	Nat.	--	(4)
ASTERACEAE (COMPOSITAE)				
Heterotheca grandiflora Nutt.	telegraph weed	Nat.	R2	(1,3)
Parthenium hysterophorus L.	false ragweed	Nat.	R	
Tridax procumbens L.	coat buttons	Nat.	R	
Xanthium strumarium L.	*kīkānia*	Nat.	R	
Zinnia peruviana (L.) L.	*pua pihi*	Nat.	C2	(3)
BRASSICACEAE				
Lepidium cf. *virginicum* L.	---	Nat.	U	
CACTACEAE				
Opuntia ficus-indica (L.) Mill.	*pānini*	Nat.	U	(1)
CARYOPHYLLACEAE				
Petrorhagia velutina (Guss.) P. Ball & Heyw.	childing pink	Nat.	R	(2)
CHENOPODIACEAE				
Chenopodium oahuense (Mayen) Aellen	*'āheahea*	End	R	
CONVOLVULACEAE				
Ipomoea indica (J. Burm.) Merr.	*koali `awa*	**Ind.**	--	(4)
CUCURBITACEAE				
Momordica charantia L.	balsam pear	Nat.	R	
Indet.	---	---	R	(3)
EUPHORBIACEAE				
Chamaesyce hirta (L.) Millsp.	garden spurge	Nat.	R	
Ricinus communis L.	castor bean	Nat.	U	
FABACEAE				
Acacia farnesiana (L.) Willd.	*klu*	Nat.	U2	
Chamaecrista nictitans (L.) Moench	partridge pea	Nat.	U	(1)
Crotalaria pallida Aiton	smooth rattlepod	Nat.	R	

Table 1 – Continued.

Species	Common name	Status	ABUNDANCE	NOTES
Desmanthus purnambucanus (L.) Thellung	virgate mimosa	Nat.	R1	
Desmodium incanum DC	Spanish clover	Nat.	R	
Erythrina sandwicensis Degener	*wiliwili*	**End.**	C2	
Indigofera suffruticosa Mill.	indigo	Nat.	U	(1)
Leucaena leucocephala (Lam.) de Wit	*koa haole*	Nat.	A	
Neonotonia wightii (Wight & Arnott) Lackey	---	Nat.	A	
Prosopis pallia (Humb. & Bonpl. ex Willd.) Kunth	*kiawe*	Nat.	O	
Tephrosia purpurea (L.) Pers.	*‘auhuhu*	**Pol.**	R	(2)
LAMIACEAE				
Leonotis nepetifolia (L.) R.Br.	lion’s ear	Nat.	U	
Ocium sp.	---	Nat.	C3	
Salvia coccinea B. Juss. ex Murray	scarlet sage	Nat.	--	(4)
MALVACEAE				
Sida fallax Walp.	*‘ilima*	Nat.	O2	(2)
Sida rhombifolia L.	---	Nat.	R	
MYOPORACEAE				
Myoporum sandwicense A. Gray	*naio*	**Ind.**	U	(2)
NYCTAGINACEAE				
Boerhavia acutifolia (Choisy) J. W. Moore	*alena*	**Ind.**	R	
Boerhavia coccinea Mill.	false alena	Nat.	R	
PAPAVERACEAE				
Argemone glauca (Nutt. Ex Prain) Pope	*pua kala*	**End.**	R	(1)
Hunnemannia fumariifolia Sweet	Mexican tulip poppy	Nat.	--	(4)
PLANTAGINACEAE				
Plantago lanceolata L.	narrow-leaved plantain	Nat.	C	(1)
PLUMBAGINACEA				
Plumbago zeylanica L.	*‘ilie‘e*	**Ind.**	U2	(2)
PORTULACACEA				
Portulaca pilosa L.	---	Nat.	O2	
Portulaca sp “A”	---	---	R	(2)
RUBIACEAE				
Psydrax odorata (G. Forster) A.C. Sm. & S. Darwin	*alahe‘e*	**Ind.**	U	(2)
SAPINDACEAE				
Dodonaea viscosa Jacq.	*‘a‘ali‘i*	**Ind.**	U2	(1,2)
SOLANACEAE				
Nicotiana glauca R.C. Graham	tree tobacco	Nat.	R	
Solanum americanum Mill.	*pōpolo*	Nat.	--	(4)
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	Nat.	R	
STERCULARIACEAE				
Waltheria indica L.	*‘uhaloa*	**Ind.**	O	

Table 1 – Continued.

Species	Common name	Status	ABUNDANCE	NOTES
THYMELIACEAE				
Wikstroemia oahuensis (A. Gray) Rock	*ʻākia*	**End.**	U	(2)
VERBENACEAE				
Lantana camara L.	lantana	Nat.	C	
Stachytarpheta sp.	---	Nat.	R	(1,3)
	FLOWERING PLANTS			
	MONOCOTYLEDONES			
AGAVACEAE				
Furcraea foetida (L.) Haw.	Mauritius hemp	Nat.	O	(2)
POACEAE (GRAMINEAE)				
Cenchrus ciliaris L.	buffelgrass	Nat.	C	(1)
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat.	U	
Melinus repens (Willd.) Zizka	Natal redtop	Nat.	A	(1)
Urochloa maxima (Jacq.) R. Webster	Guinea grass	Nat.	U	

Table 1 Legend

Status = distributional status

End. = endemic; native to Hawaii and found naturally nowhere else.
Ind. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
Pol. = Polynesian introduction before 1778.

Abundance = occurrence ratings for plant species:

R – Rare - only one or two plant occurrences seen.
U - Uncommon - several to five plant occurrences observed.
O - Occasional - found between five and ten times; not abundant anywhere.
C - Common - considered an important part of the vegetation and observed numerous times.
A - Abundant - encountered regularly and therefore present in large numbers; may be dominant over a limited area.
AA - Abundant - abundant and dominant; defining vegetation type for the layer.

Numbers following an occurrence rating indicate clusters within the survey area. The ratings above provide an estimate of the likelihood of encountering a species within the specified survey area; numbers modify this where abundance, where encountered, tends to be greater than the occurrence rating:

1 – several plants present
2 - many plants present
3 – locally abundant

Notes:

(1) – Noted on Pu'u Hokukano (a grass-dominated cinder cone).
(2) – Found particularly and more abundant on rugged lava outcrops and flows.
(3) –.Mostly dead, dried material and/or plant lacked definitive taxonomic characters like flowers or fruit.
(4) – Seen near the site (e.g., in vicinity along Piʻilani Highway); anticipated, but not recorded at this site.

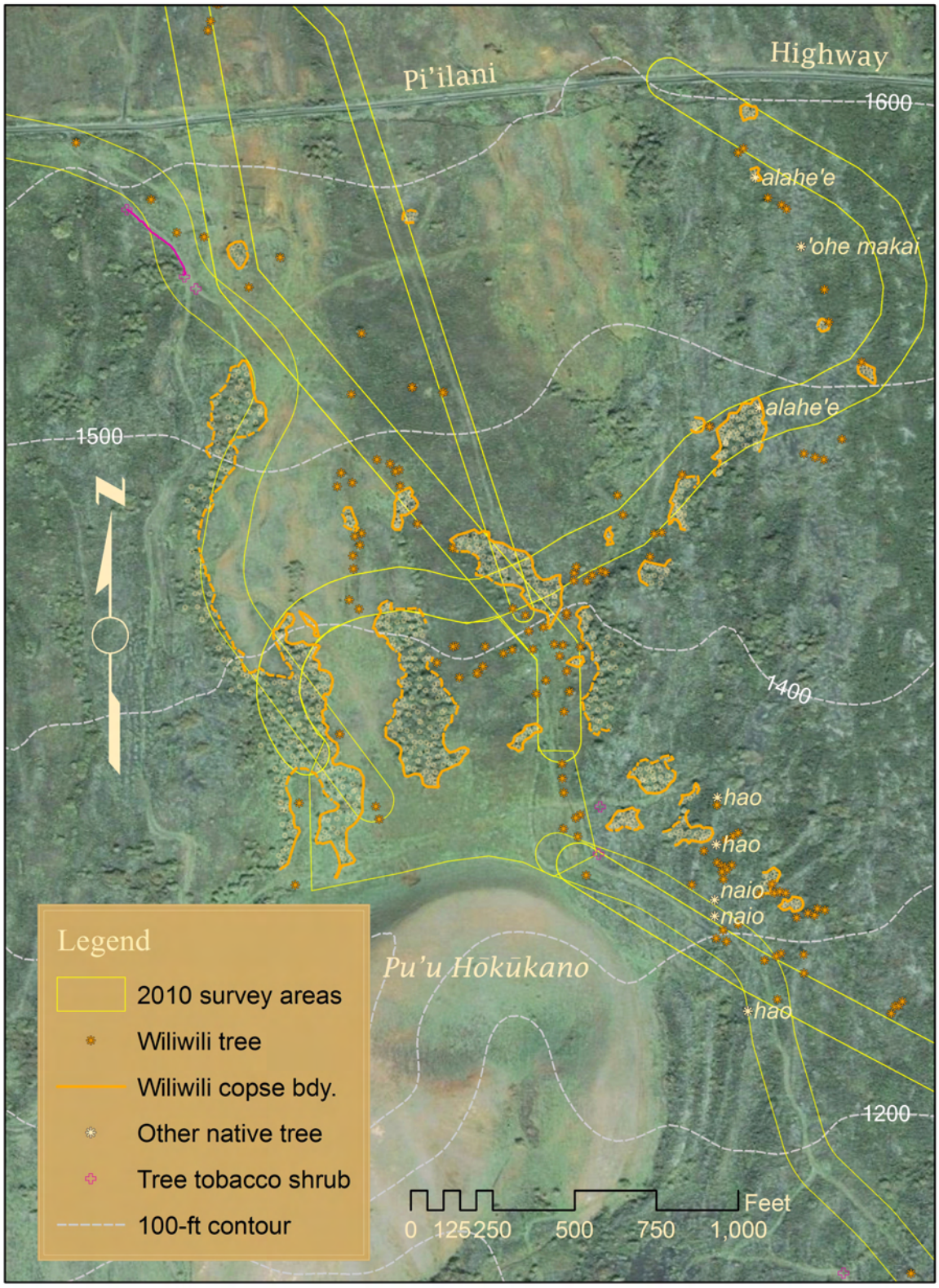


Figure 5. Botanical survey map for the wind farm site between Pi'ilani Highway and Pu'u Hōkūkano.

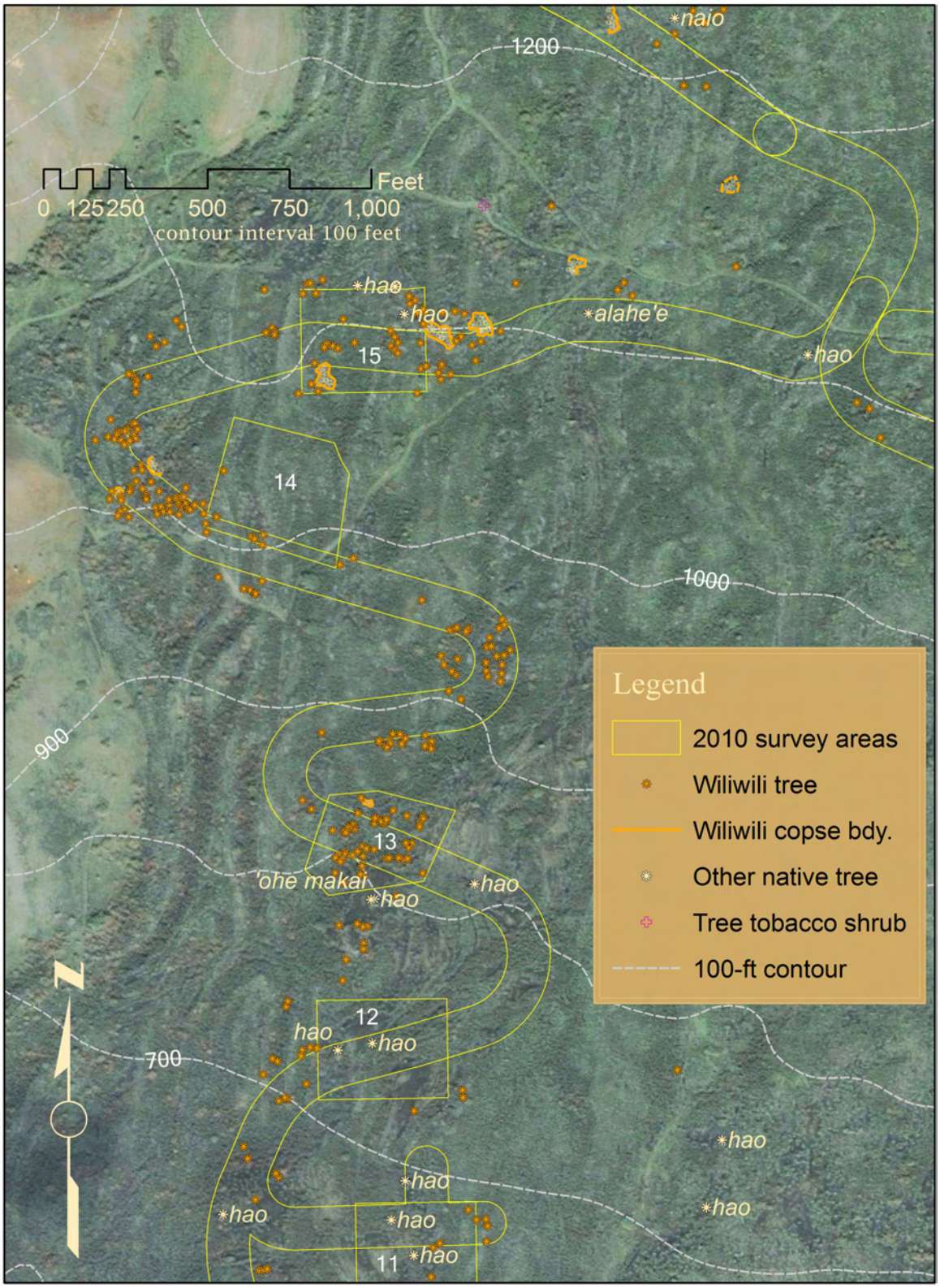


Figure 6. Botanical survey map for the wind farm site, wind turbine pads 11 through 15 and associated access roads (upper west side).

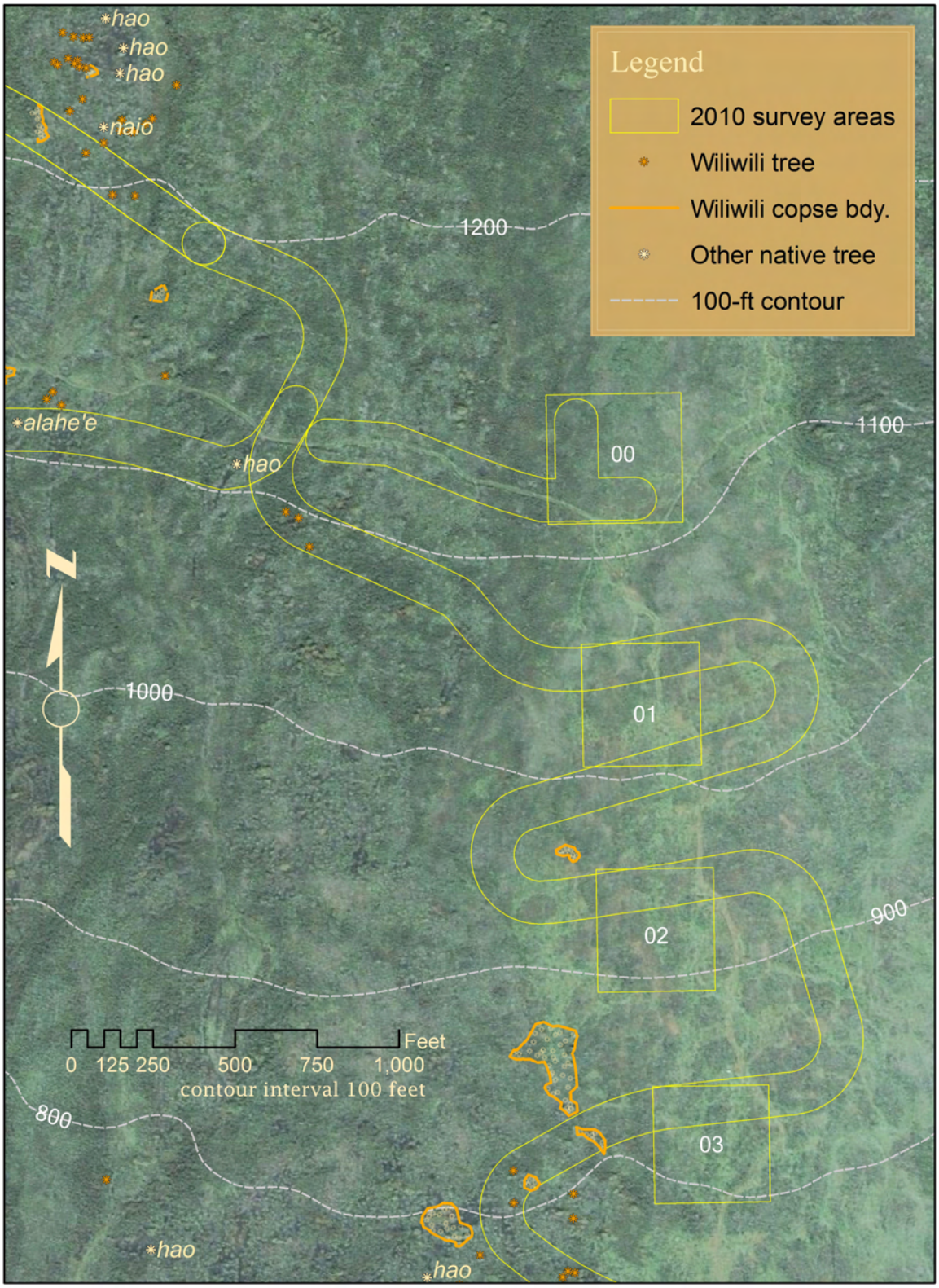


Figure 7. Botanical survey map for the wind farm site, wind turbine pads 00 through 03 and associated access roads (upper east side).

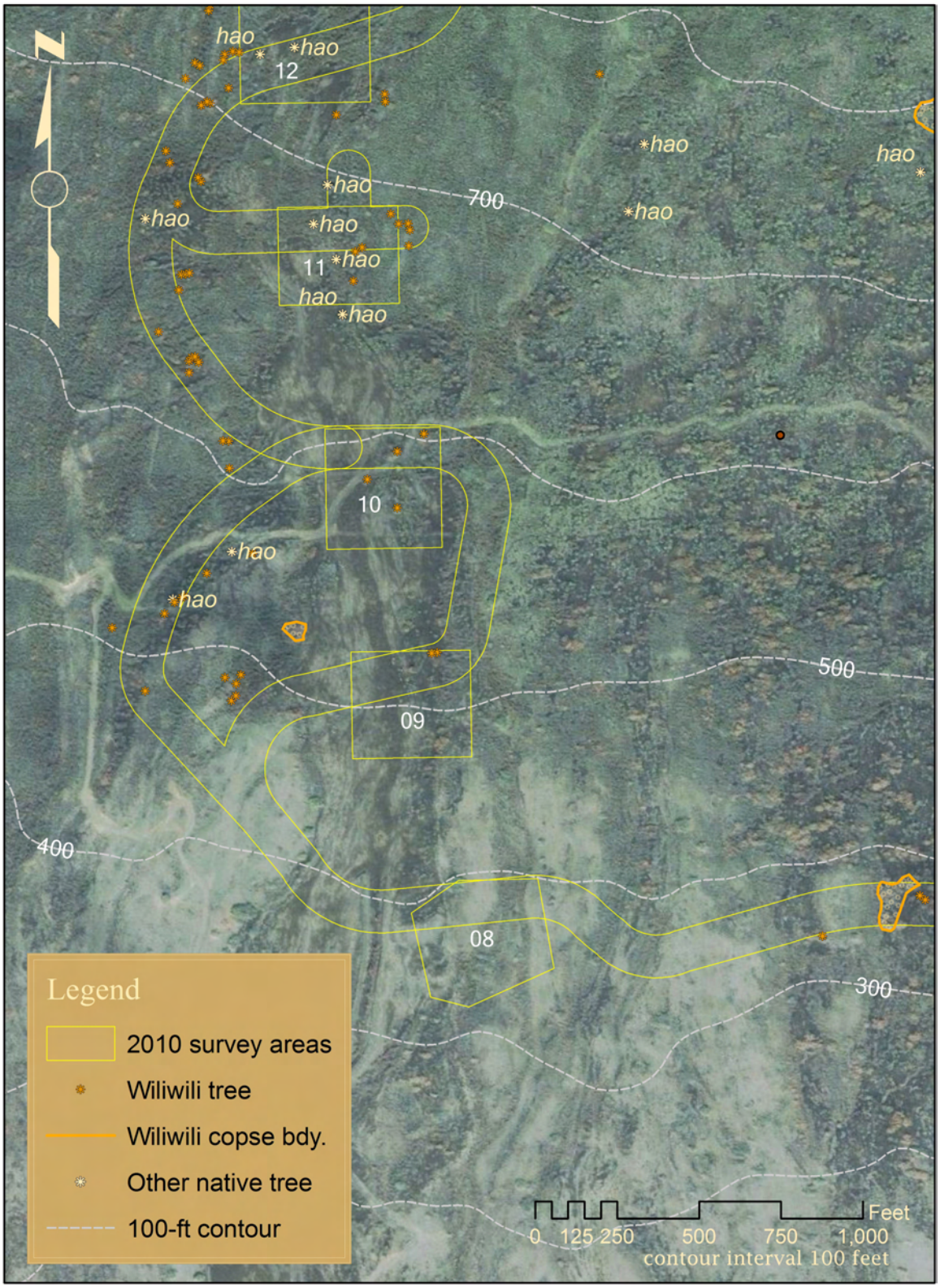


Figure 8. Botanical survey map for the wind farm site, wind turbine pads 08 through 12 and associated access roads (lower west side).

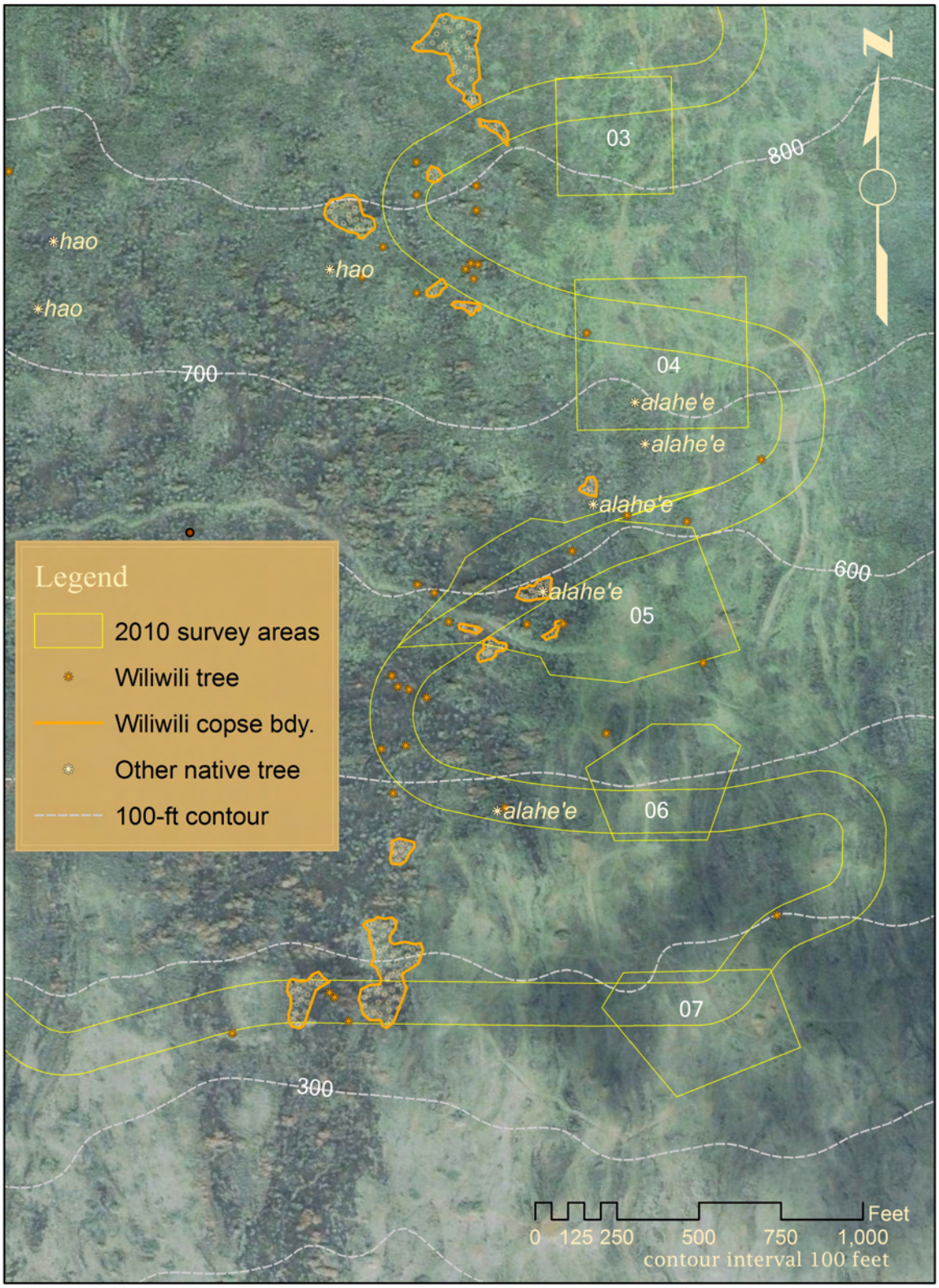


Figure 9. Botanical survey map for the wind farm site, wind turbine pads 03 through 07 and associated access roads (lower east side).

Generator Tie-line Corridor

The proposed generator tie-line route crosses dry scrubland as it climbs *mauka* from the wind farm site more or less following a ranch road that switchbacks up the slope. The vegetation in this area is mostly introduced species and subjected to grazing by cattle and feral ungulates. However, native shrubs—particularly *ʻākia* (*Wikstroemia oahuensis*) and *aʻaliʻi* (*Dodonaea viscosa*)—and native sandalwood trees or *ʻiliahialoʻe* (*Santalum ellipticum*) are common in the area (for *ʻiliahialoʻe* distribution, see Figures 12 and 13; native shrubs are too numerous to map).

Moving upslope, an increase in moisture derived largely from cloud drip results in a transition from Montane Dry Shrubland to Montane Mesic Forest (Gagne and Cuddihy, 1990)[3] and the flora becomes an important botanical resource characterized by both an abundance and high diversity of native plant species, including many uncommon species of trees. The most significant remaining mesic forest in the general Project area is found within an adjacent, State of Hawaiʻi preserve: the Kanaio Natural Area Reserve System (NARS) site, located to the west of the generator tie-line corridor. This preserve is being fenced to control ungulate browsers (east side fence is completed; north side was under construction in 2007) and facilitate restoration of the native dryland forest found within its borders. The proposed generator tie-line has been routed to avoid the Kanaio NARS parcel.

Skirting westward above the NARS, the proposed generator tie-line crosses the southern face of Puʻu ʻŌuli (an old cinder cone). The route crosses roughly 300 yards (100 meters) of scrub growth before entering grass-dominated pasture at about the 4,200-foot (1,280-meter) elevation west of Puʻu ʻŌuli. This high elevation pasture is without trees and dominated by Kikuyu grass (*Pennisetum clandestinum*). The only feature of note here is a relatively recent lava flow[4] with a sparse growth of native plants behind (northeast of) Keonehunehune (an eruption cone) where the generator tie-line crosses the southwest rift at about the 4,400-foot (1,350-meter) elevation. The length of the traverse across the lava flow would be about 100 yards (90 meters) or less.

Down from the ridgeline marking the southwest rift zone to the Wailea substation, the proposed route is located entirely within pastures owned by ʻUlupalakua Ranch. The grasses that predominate in this pastureland change with elevation, influenced mostly by the rainfall regime along a gradient of decreasing rainfall towards the coast (lower elevation). The strictly pasture (non-native grassland) of the upper slopes, gives way to a savanna (grassland with scattered trees) below Kula Highway (at about 1,200-foot [370-meter] elevation), which remains the dominant vegetation type to the MECO connection

[3] This vegetation type is referred to as a montane forest (Gagne and Cuddihy, 1990) because it is a remnant of an open-canopied forest type between 3000 feet (900 meters) and 6500 feet (2000 meters) on East Maui. However, at the elevation range we surveyed, this forest today (partly owing to ungulate grazing) is really a savanna in most places.

[4] This is a part of the historic flow of ca. 1750 (1790?) that erupted from a fissure "on the south slope of Kemehunehune, at 4200 feet". A majority of this eruption issued from Kalua o Lapa cone at an altitude of 575 feet and formed the western side of Keoneoio or La Perouse Bay (Bordner, 1995).

point at 1,000 feet (305 meters) ASL[5]. The only tree species in this savanna is *kiawe*, which shows a steady increase in density from 1,200 down to 400 feet (370 to 120 meters) ASL. Although some areas of native lowland vegetation are known from the general area (Altenberg, 2007), these populations appear limited to rugged ground not subjected to the long history of cattle grazing characterizing the generator tie-line corridor.

Table 2 is a listing of plants observed within the generator tie-line corridor and, where surveyed on the leeward mountain slope in 2010, associated buffer areas. The relative abundance columns divide this route into three segments: 1) "E1", the leeward slope from Pi'ilani Hwy to approximately 2,800 feet (850 meters) ASL, 2) "E2", the leeward slope from 2,800 to 4,500 feet (1400 meters) ASL at the ridgeline (E2), and 3) "W", the windward slope from the ridgeline, across Kula Highway at about 1,900 feet (580 meters) ASL and downslope to the Wailea substation at about 400 feet (120 meters) ASL (Figure 2).

Table 2. Checklist of Plants Found Along the Proposed Generator Tie-Line Route and Vicinity, Auwahi Wind Farm Project.

Species	Common name	Status	ABUNDANCE			
			E1	E2	W	NOTES
FERNS & FERN ALLIES						
ANTHYRIACEAE						
Cystopteris douglasii Hook.	---	**End**	--	R	--	(2)
BLECHNACEAE						
Blechnum appendiculatum Willd.	---	Nat	--	--	R3	
Sadleria sp.	*`ama`u*	**End**	--	U	--	(2)
GLEICHENIACEAE						
Dicranopteris linearis (Burm. f.) Underw.	*uluhe*	**Ind**	--	R	U	(2)
GRAMMITIDACEAE						
Adenophorus tripinnatifidus Gaud.	---	**End**	--	--	R	
LINDSAEACEAE						
Sphenomerus chinensis (L.) Maxon	*pala`a*	**Ind**	--	--	R	
NEPHROLEPIDACEAE						
Nephrolepis multiflora (Roxburgh) Jarrett ex Morton	common sword fern	Nat	R	--	R1	
PTERIDACEAE						
Adiantum hispidulum Sw.	rough maidenhair	Nat	--	--	R3	
Pellaea ternifolia (Cav.) Link	*kalamoho lau li'i*	**Ind**	U	--	--	
Pteris cretica L.	cretan brake	**Ind**	--	U	R	
PSILOTACEAE						
Psilotum nudum Sw.	*moa*	**Ind**	--	--	R2	

[5] The end of the 2007 reconnaissance survey; the actual connection to an existing MECO service line would be at the 1000-foot (300-meter) elevation (see Figure 1).

Table 2 continued

Species	Common name	Status	ABUNDANCE			
			E1	E2	W	NOTES
THELYPTERIDACEAE						
Christella sp.	wood fern	Nat	--	--	R	
FLOWERING PLANTS						
DICOTYLEDONES						
AMARANTHACEAE						
Amaranthus spinosus L.	spiny amaranth	Nat.	C	--	U	
Charpentiera obovata Gaud.	*pāpala*	**End.**	--	R	--	
ANACARDIACEAE						
Schinus terebinthifolius Raddi	Christmas berry	Nat.	C	--	O	
APIACEAE						
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery	Nat.	--	--	R	
APOCYNACEAE						
Ochrosia haleakalae St. John.	*hole'i*	**End.**	--	R	--	(5)
ARALIACEAE						
Tetraplasandra cf. *oahuensis* (A. Gray) Harms	*'ohe*	Nat.	--	--	R	(4)
ASCLEPIADACEAE						
Asclepias physocarpa (E. Mey.) Schlecter	balloon plant	Nat.	--	U	--	(3)
ASTERACEAE (COMPOSITAE)						
Ageratina riparia (Regel) R. King & H. Robinson	*hāmākua*	Nat.	--	--	R	
Bidens cf. *alba* (L.) DC	beggar's-tick	Nat.	R	--	R	(4)
Centaurea melitensis L.	star thistle	Nat.	--	--	R	(4)
Chromolaena odorata (L.) King & Rob.	Siam weed	Nat.	--	U	R	(3)
Cirsium vulgare (Savi) Ten.	Bull thistle	Nat.	--	R	U	
Conyza bonariensis (L.) Cronq.	Hairy horseweed	Nat.	--	R	O	
Cyanthillium cinereum (L.) H. Rob	little ironweed	Nat.	--	--	R	(4)
Emilia fosbergii Nicolson	Flora's paintbrush	Nat.	--	--	U	
Erigeron karvinskianus DC	daisy fleabane	Nat.	--	U2	R	(3)
Hypochoeris radicata L.	hairy cat's ear	Nat.	R	R	U	
Parthenium hysterophorus L.	false ragweed	Nat.	R	--	R	
Senecio madagascariensis Poir.	---	Nat.	U	O	O	(3)
Sigesbeckia orientalis L.	sm. Yel. Crown-beard	Nat.	--	--	R	
Sonchus oleraceus L.	sow thistle	Nat.	R	U	U	(3)
Taraxacum officinale W.W. Weber ex Wigg.	Common dandelion	Nat.	--	--	R	
Tridax procumbens L.	coat buttons	Nat.	R	--	--	
Verbesina encelioides (Cav.) Benth. & Hook.	Golden crown-beard	Nat.	R	--	U3	
Xanthium strumarium L.	*kikiāna*	Nat.	U	--	R	
BIGNONIACEAE						
Jacaranda mimosifolia D. Don	green ebony	Nat.	--	--	U	
BRASSICACEAE						
Lepidium virginicum L.	---	Nat.	R	--	R	(4)

Table 2 continued

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
Sisymbrium officinale (L.) Scop.	Hedge mustard	Nat.	O	R	R	(4)
CACTACEAE						
Opuntia ficus-indica (L.) Mill.	*Pänini*	Nat.	R	--	R	
CARYOPHYLLACEAE						
Petrorhagia velutina (Guss.) P. Ball & Heyw.	Childing pink	Nat.	--	U1	R	
CHENOPODIACEAE						
Chenopodium carinatum R. Br.	---	Nat.	U	--	U	
Chenopodium oahuense (Meyen) Aellen	*ʻāheahea*	**End.**	--	R	--	
Chenopodium sp.	---	Nat.	O2	--	U	(4)
CONVOLVULACEAE						
Ipomoea indica (J. Burm.) Merr.	*koali `awa*	**Ind.**	R	--	--	
CRASSULACEAE						
Kalanchoë pinnata (Lam.) Pers.	air plant	Nat.	--	--	U1	
EBENACEAE						
Diospyros sandwicensis (A. DC) Fosb.	*lama*	Nat.	--	R	--	(4)
EPACRIDACEAE						
Styphelia tameiameiae (Cham. & Schlechtend.) F. v. Muell.	*pūkiawe*	**Ind.**	U	O	--	(1)
EUPHORBIACEAE						
Chamaesyce hirta (L.) Misllsp.	garden spurge	Nat.	--	--	R	
Chamaesyce hirta (L.) Misllsp.	garden spurge	Nat.	--	--	R	
FABACEAE						
Acacia mearnsii De Willd.	black wattle	Nat.	--	U2	O3	
Chamaecrista nictitans (L.) Moench	partridge pea	Nat.	O	--	U	
Crotalaria sp.	rattlepod	Nat.	R	--	R2	(4)
Desmodium incanum DC	Spanish clover	Nat.	--	--	A	
Erythrina sandwicensis Degener	*wiliwili*	**End.**	U2	--	--	
Indigofera suffruticosa Mill.	indigo	Nat.	O	--	R	
Leucaena leucocephala (Lam.) de Wit	*koa haole*	Nat.	AA	--	O	
Macroptilium atrropurpureum (DC) Urb.	---	Nat.	--	--	R	
Macroptilium lathyroides (L.) Urb.	cow pea	Nat.	--	--	R	
Melilotus alba Medik.	white sweet clover	Nat.	--	U	C	
Neonotonia wightii (Wight & Arnott) Lackey	---	Nat.	A	--	A	
Senna occidentalis (L.) Link	coffee senna	Nat.	--	R	--	
Sophora chrysophylla (Salisb.) Seem.	*māmane*	**End.**	--	U	--	
Trifolium sp.	clover	Nat.	--	--	R	(4)
GERANIACEAE						
Geranium homeanum Turcz.	---	Nat.	--	U	R	
LAMIACEAE						
Leonotis nepetifolia (L.) R.Br.	lion's ear	Nat.	R	R	--	
Salvia coccinea B. Juss. Ex Murray	scarlet sage	Nat.	R	U	--	
Stachys arvensis L.	staggerweed	Nat.	--	--	R	
LYTHRACEAE						

Table 2 continued

Species	Common name	Status	ABUNDANCE			
			E1	E2	W	NOTES
Lythrum maritimum Kunth	*pūkāmole*	**Ind.**	--	--	R	
MALVACEAE						
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	Nat.	U	O	U	
Malva parviflora L.	cheese weed	Nat.	R	--	R	
Malvastrum coromendalianum	false mallow	Nat.	U	--	O	
Sida fallax Walp.	*‘ilima*	**Ind.**	--	--	O	
Sida rhombifolia L.	Cuba jute	Nat.	R	--	R	
Sida spinosa L.	prickly sida	Nat.	--	--	U	
MELIACEAE						
Melia azedarach L.	Chinaberry	Nat.	--	--	U	
MENISPERMACEAE						
Cocculus trilobus (Thunb.) DC	*huehue*	**Ind.**	R	--	R	
MYRTACEAE						
Eucalyptus citriodoira Hook.	lemon-scented gum	Nat.	--	--	R1	
Eucalyptus robusta Sm.	swamp mahogony	Nat.	--	--	U3	
Metrosideros polymorpha Gaud.	*`ōhi`a*	**End.**	--	O	R	
Psidium guajava L.	common guava	Nat.	--	--	U	
OLEACEAE						
Nestegis sandwicensis (A. Gray) Deg., I. Deg, & L. Johnson	*olopua*	**End.**	--	O	--	
OXALIDACEAE						
Oxalis corniculata L.	*‘ihi‘ai*, wood sorrel	**Pol.**	--	U	U	
PAPAVERACEAE						
Argemone glauca (Nutt. Ex Prain) Pope.	*pua kala*	**End.**	R	--	--	
Bocconia frutescens L.	tree poppy	Nat.	O	U	U	
PASSIFORACEAE						
Passiflora mollissima (Kunth) L.H. Bailey	banana *poka*	Nat.	--	U	R	
PLANTAGINACEAE						
Plantago lanceolata L.	narrow-leaved plantain	Nat.	A	--	O2	
PLUMBAGINACEA						
Plumbago zeylanica L.	*‘ilie‘e*	**Ind.**	R	--	R	
PORTULACACEA						
Portulaca oleracea	pigweed	Nat.	R	--	U	
Portulaca pilosa L.	---	Nat.	--	--	R1	
Portulaca sp “A”	---	---	U1	--	U	
PRIMULACEAE						
Anagalis arvensis L.	scarlet pimpernel	Nat.	--	R	R	
PROTEACEAE						
Grevillea robusta A. Cunn. Ex R. Br.	silk oak	Nat.	--	--	R	
ROSACEAE						
Osteomeles anthyllidifolia (Sm.) Lindl.	*‘ūlei*	**Ind.**	--	U	--	
Rubus argutus Link	blackberry	Nat.	--	U	U2	(2)

Table 2 continued

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
RUBIACEAE						
Sherardia arvensis L.	field madder	Nat.	--	R	R	
SANTALACEAE						
Santalum ellipticum	*ʻiliahi*	**End.**	R	--	--	(4)
Santalum freycinetianum var. lanaiense Rock	*ʻiliahi*	**End.**	--	R	--	<E>
SAPINDACEAE						
Alectryon macrococcus Radlk.	*māhoe*	**End.**	--	R	--	<E>
Dodonaea viscosa Jacq.	*ʻaʻaliʻi*	**Ind.**	O	AA	R	(1)
SAPOTACEAE						
Pouteria sandwicensis (A. Gray) Baehna & Degener.	*ʻālaʻa*	**End.**	--	U	R	(1)
SOLANACEAE						
Datura stramonium L.	jimson weed	Nat.	R	--	R	
Nicotiana glauca R.C. Graham	tree tobacco	Nat.	R	--	--	
Nothocestrum latifolium A. Gray	*ʻaiea*	End	--	R	--	(5)
Solanum americanum Mill.	*pōpolo*	Nat.	--	--	R	
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	Nat.	U	--	R	
Solanum torvum Sw.	---	Nat.	--	--	U	
STERCULARIACEAE						
Waltheria indica L.	*ʻuhaloa*	**Ind.**	C	--	U	
THYMELIACEAE						
Wikstroemia oahuensis (A. Gray) Rock	*ʻākia*	**End.**	U	--	--	
TILIACEAE						
Triumfetta semitriloba Jacq.	Sacramento burr	Nat.	--	--	U2	
URTICACEAE						
Pipturus albidus (Hook. & Arnott.) A. Gray	*māmaki*	**End.**	--	R	--	(2)
VERBENACEAE						
Lantana camara L.	lantana	Nat.	A	O	O	
Verbena litoralis Kunth	*owi*	Nat.	U	--	U	
FLOWERING PLANTS						
MONOCOTYLEDONES						
AGAVACEAE						
Pleomele auwahiensis St. John	*hala pepe*	**End.**	--	O	--	
COMMELINACEAE						
Commelina diffusa N. L. Burm	*honohono*	Nat.	--	--	R	
CYPERACEAE						
Cyperus gracilis R. Br.	McCoy grass	Nat.	O2	--	O3	
Kylinga brevifolia Rottb.	*kili`o`opu*	Nat.	U2	--	U	
POACEAE (GRAMINEAE)						
Axonopus fissifolius (Raddi) Kuhlm.	nrw-lvd. carpet grass	Nat.	--	--	O	
Anthoxanthum odoratum L.	sweet vernalgrass	Nat.	--	U	A	(2)
Cenchrus ciliaris	buffelgrass	Nat.	A	--	--	
Chloris barbata (L.) Sw.	swollen finger grass	Nat.	--	--	U2	
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat.	--	--	U	
Dichanthium sp.	---	Nat.	A	--	C3	

Table 2 continued

Species	Common name	Status	ABUNDANCE			
			E1	E2	W	NOTES
Digitaria insularis (L.) Mez ex Ekman	sourgrass	Nat.	--	--	U1	
Eleusine indica (L.) Gaertn.	wire grass	Nat.	O	--	--	
Eragrostis pectinacea		Nat.	--	--	U	
Holcus lanatus L.	common velvet grass	Nat.	--	R	--	
Melinus minutiflora P. Beauv.	molasses grass	Nat.	--	--	R	
Melinus repens (Willd.) Zizka	Natal redtop	Nat.	C	--	U2	
Paspalum cf. *dilatatum* Poir	Dallis grass	Nat.	--	--	O	
Pennisetum clandestinum Chiov.	Kikuyu grass	Nat.	C	AA	AA	
Polypogon sp.	hare's foot	Nat.	--	--	U	
Sporobolis indicus (L.) R. Br.	West Indian dropseed	Nat.	--	O	O	
Urochloa maxima	Guinea grass	Nat.	--	--	C	
Vulpia bromoides (L.) S.F. Gray	brome fescue	Nat.	--	U	--	
indet. large bunch grass	--	---	--	--	O3	(4)

Table 2 Legend:

Status = distributional status

End. = endemic; native to Hawaii and found naturally nowhere else.
Ind. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
Pol. = Polynesian introduction before 1778.

Abundance = occurrence ratings for plants:

R – Rare - only one or two plants seen.
U - Uncommon - several to five plants observed.
O - Occasional - found between five and ten times; not abundant anywhere
C - Common - considered an important part of the vegetation and observed numerous times.
A - Abundant - encountered regularly and therefore present in large numbers; may be dominant over a limited area.
AA - Abundant - abundant and dominant; defining vegetation type for the layer.

Numbers following an occurrence rating indicate clusters within the survey area. The ratings above provide an estimate of the likelihood of encountering a species within the specified survey area; numbers modify this where abundance, where encountered, tends to be greater than the occurrence rating:
1 – several plants present
2 - many plants present
3 – locally abundant

AREA: E1 – Leeward slope, below 2800 ft (850 m).
E2 – Leeward slope, above 2800 ft (850 m).
W – Windward slope.

Notes:

(1) – Especially part of shrub-scrub above 4000 ft (1200 m) for column E2.
(2) – On ca. 1790 lava flow at 4400 ft (1340 m) for column E2 .
(3) – Found mostly along roads above 4000 ft (1200 m); ruderal for column E2.
(4) – Material observed lacked definitive taxonomic characters (dried out in some cases).
(5) – Described by USFWS (2010) as a candidate for listing under the ESA.
<E> - A species listed as endangered (USFWS, 2010)

Figures 10 through 13, following, give mapping results for native trees along the portion of the generator tie-line surveyed in 2010. In these figures, bright yellow lines show buffer areas (essentially survey limits) for the generator tie-line. However, some native plants of potential interest were recorded outside of the buffer limits: either because these were on an eventually abandoned alternate route or, in a few cases, where encountered walking to the survey areas. Only a few of the native plant features are labeled due to crowding.

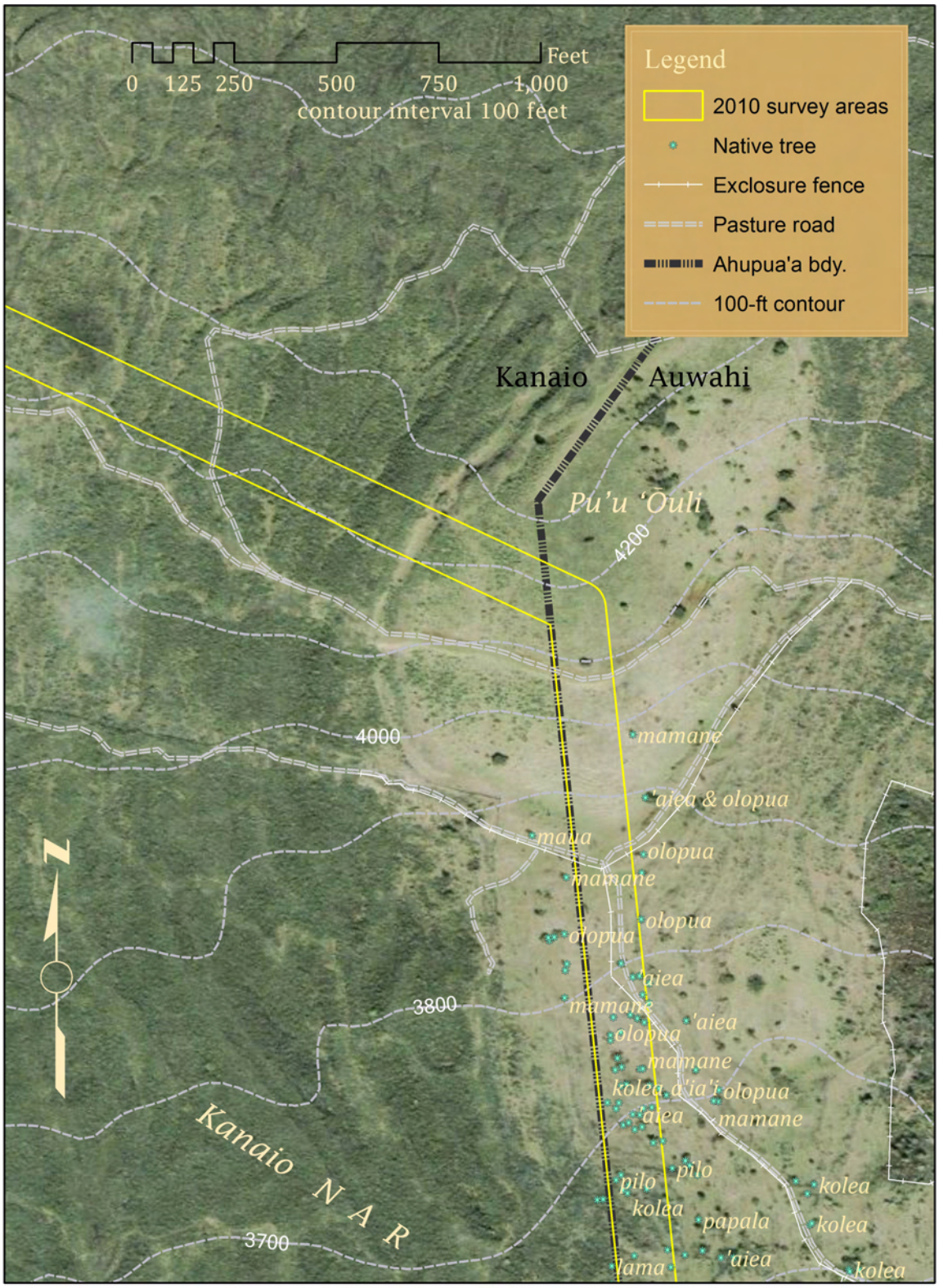


Figure 10. Botanical survey map for the upper east side generator tie-line between 3700 and 4300 feet ASL.

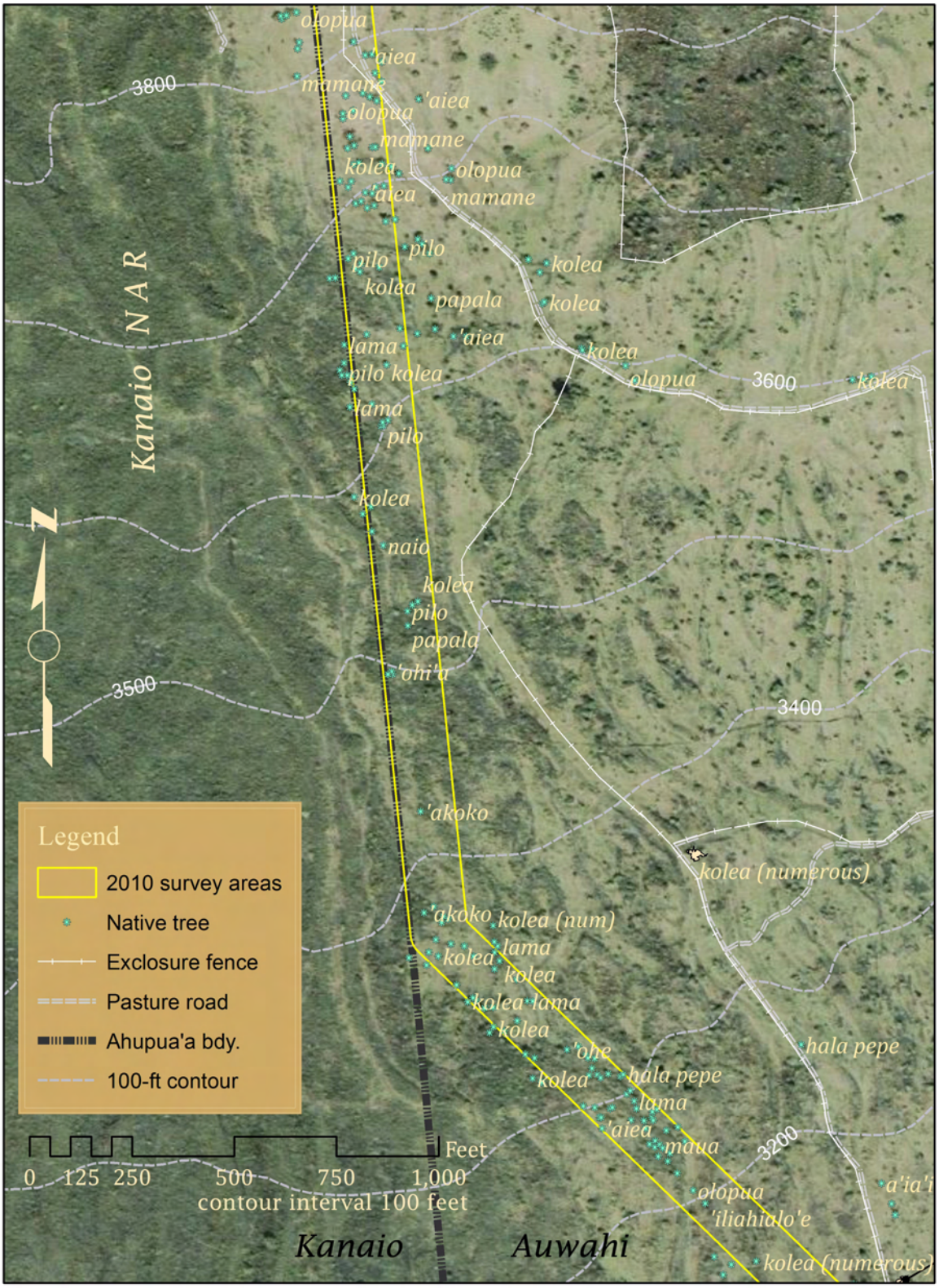


Figure 11. Botanical survey map for the upper east side generator tie-line between 3200 and 3800 feet ASL.

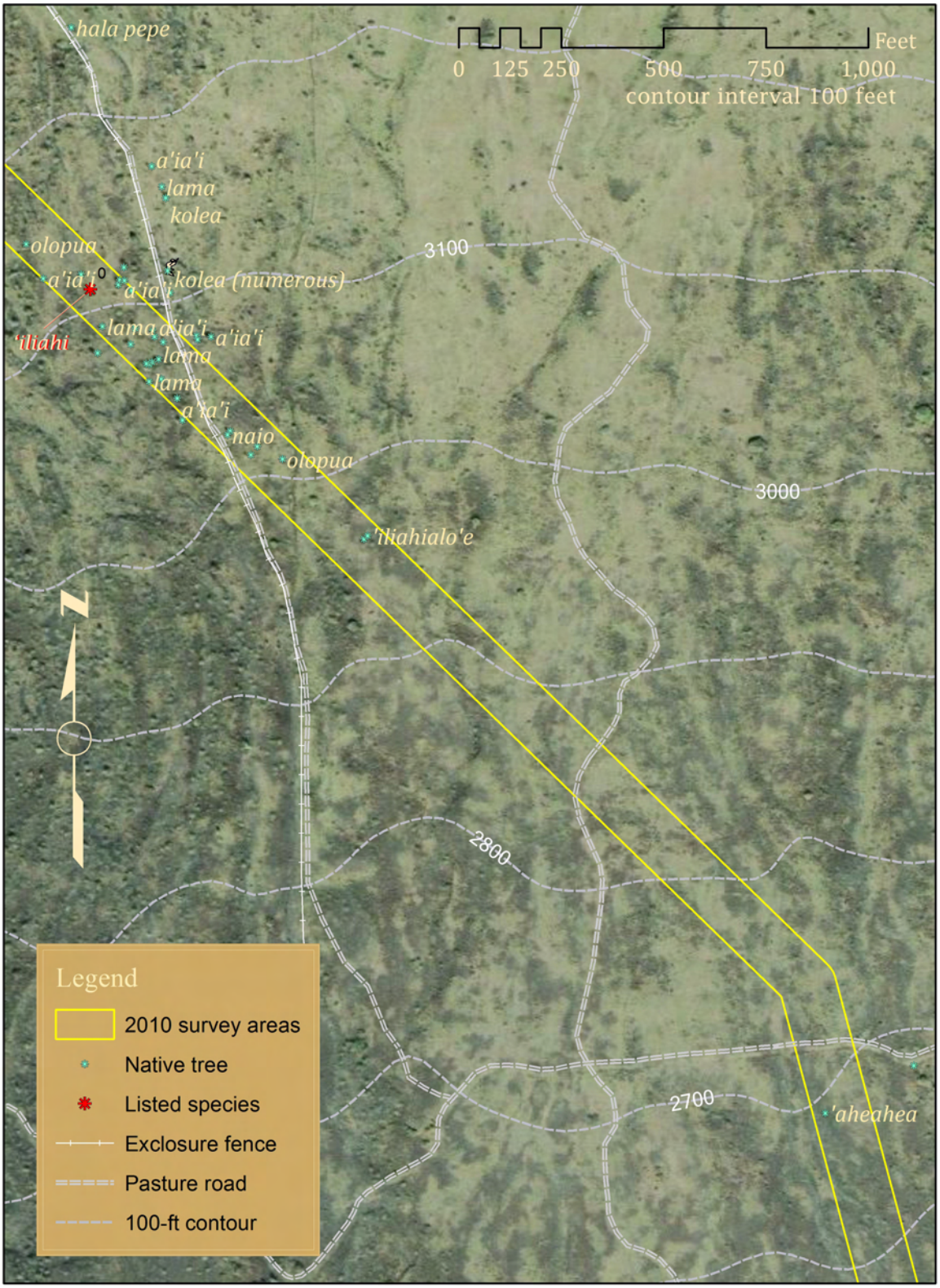


Figure 12. Botanical survey map for the east side generator tie-line between 2100 and 2600 feet ASL.

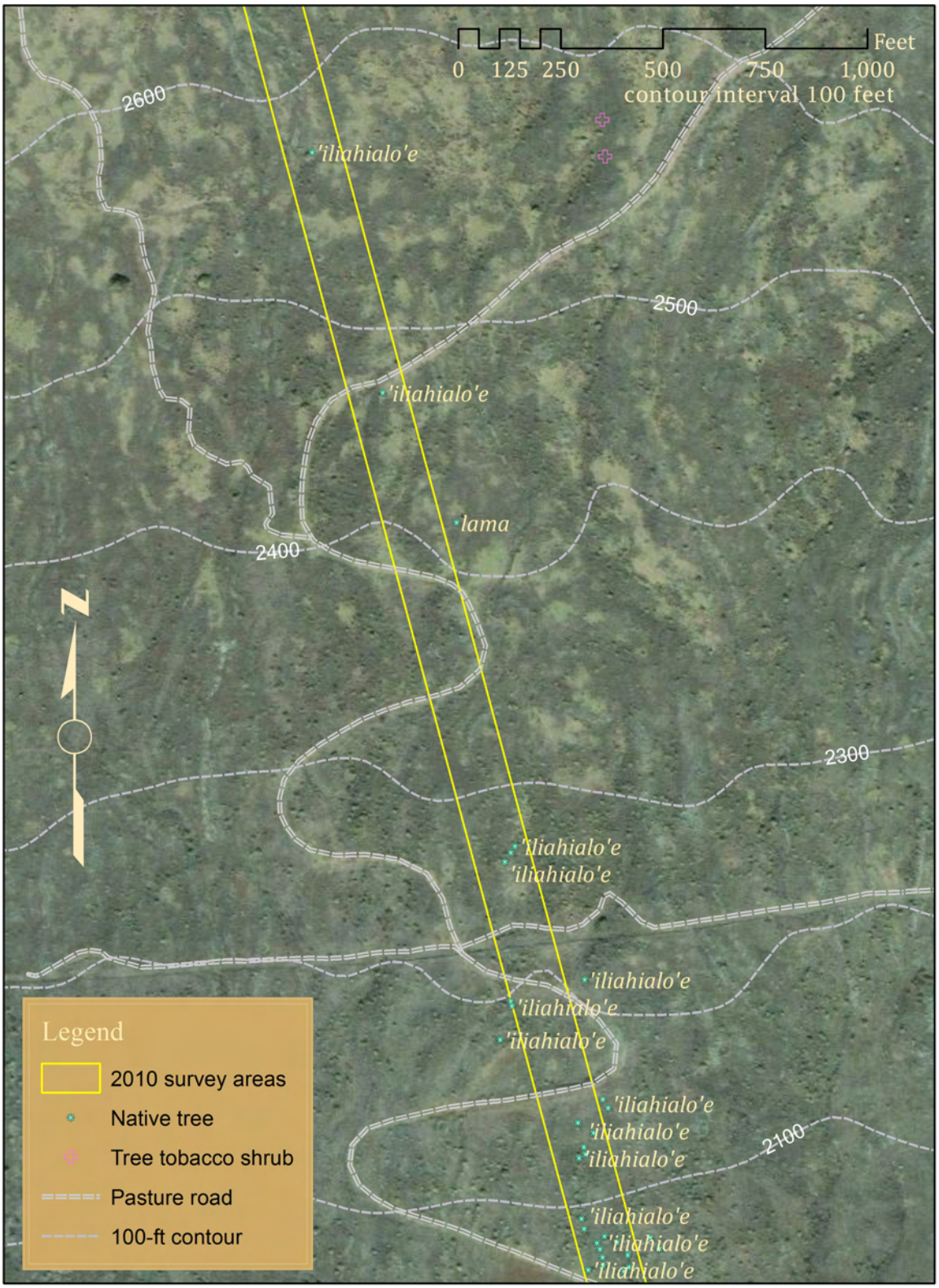


Figure 13. Botanical survey map for the east side generator tie-line between 2100 and 2600 feet ASL.

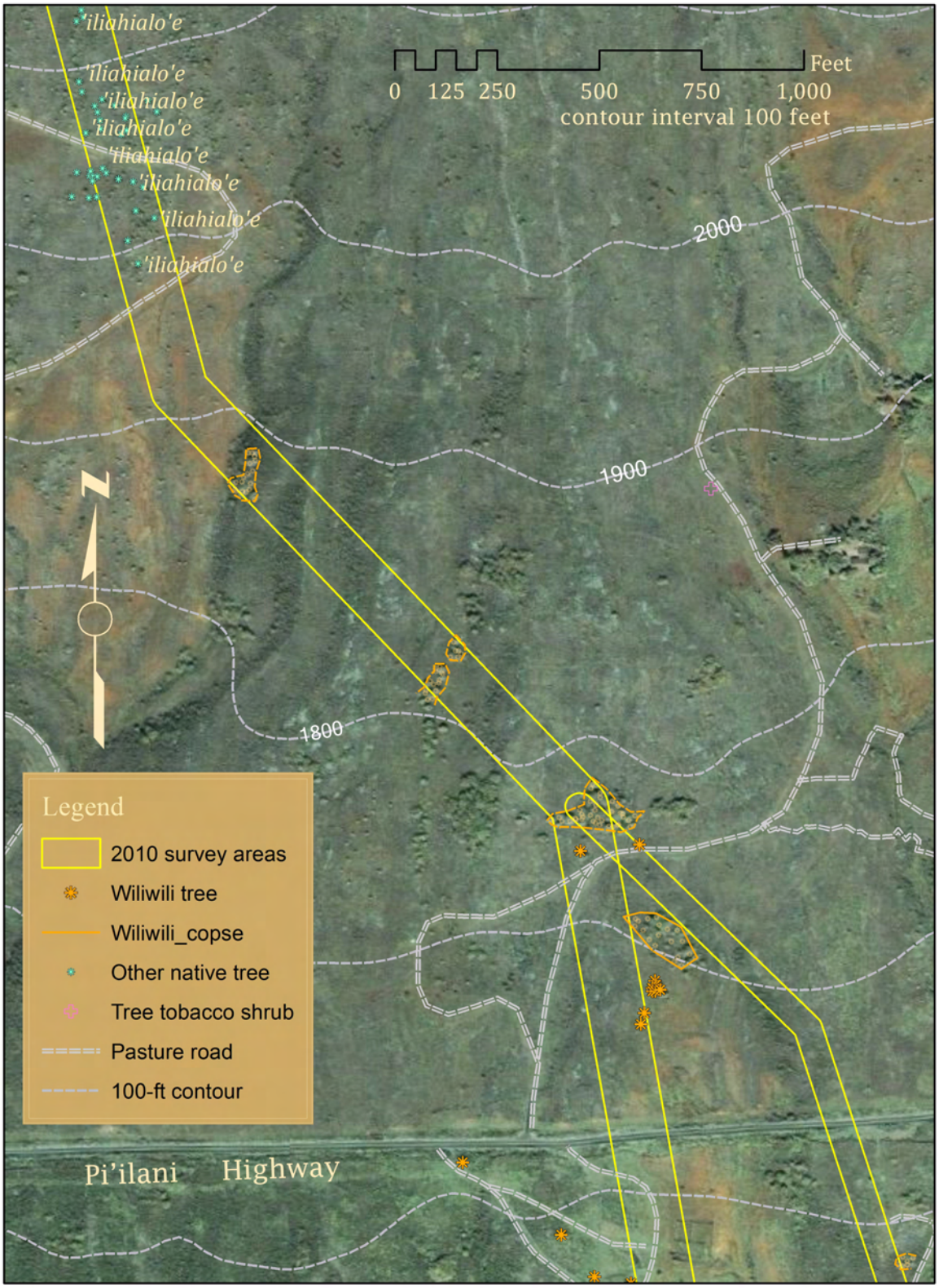


Figure 14. Botanical survey map for the east side generator tie-line between 1600 (Pi'ilani Highway) and 2100 feet ASL.

Construction Access Road

The results of botanical surveys for the construction access road, conducted in 2007 and 2010, are summarized in Table 3. The proposed construction access road covers 4.6 miles (7.2 kilometers) from Wailea Alanui Road to Piʻilani Highway, with a change in elevation of approximately 1,500 feet (460 meters). The vegetation changes considerably over the course of the roadway.

The existing road is "paved" (although in poor condition) for much of the way between Mākena and a small quarry located on the southwestern slope of an unnamed cinder cone immediately west of Puʻu Naio. Upslope from this quarry to Piʻilani Highway the condition of the ranch roads is somewhat variable: between tracks through rocky pasture and graded and graveled, 4-wheel drive roads. From just upslope of the *puʻu*, two routes were surveyed in 2007: one that wound upslope to Papaka Road (western alternative) to join Piʻilani Hwy, and a second that went eastward and up across the slope (eastern alternative) to join Piʻilani Highway about 1,000 feet (305 meters) east of Papaka Road. The two alternatives pass through distinctly different environments. The western alternative cuts through a more mesic environment of mixed pasture and open-canopied forest with non-native trees of mostly Chinaberry (*Melia azedarach*), silk oak (*Grevillea robusta*), and *kukui* (*Aleurites moluccana*). The terrain includes relatively recent cinder and spatter cones and lava that are part of the volcanics responsible for the narrow, rugged habitat along the west side of the Puʻu Naio cones. The eastern alternative cuts diagonally across a slope of increasing dryness, primarily stony pastureland, but also including extensive shrub/scrub vegetation. *Koa haole* (*Leucaena leucocephala*), indigo (*Indigofera suffruticosa*), *ʻākia* (*Wikstroemia oahuensis*), *ʻaʻaliʻi* (*Dodonaea viscosa*), glycine vine (*Neonotonia wightii*), air plant (*Kalanchoë pinnata*), and *ʻuhaloa* (*Waltheria indica*) are common to abundant species in this area.

Downslope and west from the quarry area along Papaka Road, the vegetation changes gradually to a *kiawe*/buffelgrass (*Prosopis/Cenchrus*) association, which is the dominant vegetation type near the coast. However, across much of this area the *kiawe*/buffelgrass community occurs mixed with extensive stands of native *wiliwili* tree. Typically associated with the *wiliwili* as understory are native *ʻilima* (*Sida fallax*), *ʻuhaloa*, and non-native Natal redtop (*Melinus repens*) on the more rocky ground where remnant *wiliwili* forest (Figures 15 and 16) tends to predominate. Although *wiliwili* trees become uncommon below 200 feet (60 meters) ASL, scattered trees occur all the way to the coast near Puʻu Olaʻi.

Besides the extensive areas of *wiliwili*, the most botanically interesting area on the proposed route for the construction access road is the relatively recent lava flow that passes along the west side of the Puʻu Naio cinder cones. The age of the flow relative to the surrounding area makes it stand out as both geologically and floristically distinct. Plants observed on this flow west of the cinder cones are indicated in Table 3 by Note "(1)". These plants are not all native, though a significant proportion (some 7 species), are. Further, on the rugged lava, native species are relatively more common in comparison with non-native species. However, vegetative growth on the lava flow is sparse. With the exception of *maiapilo* (*Capparis sandwichiana*), the natives are commonly occurring species in the

Islands. Despite the severe dry conditions in 2010, several species were conspicuous by their general good health: *kiawe*, *wiliwili*, tree tobacco, and *maiapilo*.

Table 3. Checklist of Plants Found Along the Proposed Construction Access Road, Auwahi Wind Farm Site

Species	Common name	Status	ABUNDANCE E1	ABUNDANCE E2	NOTES
FERNS & FERN ALLIES					
NEPHROLEPIDACEAE					
Nephrolepis multiflora (Roxburgh) Jarrett ex Morton	common sword fern	Nat	--	O	(1)
PSILOTACEAE					
Psilotum nudum Sw.	*moa*	**Ind**	--	R	(1)
PTERIDACEAE					
Pellaea ternifolia (Cav.) Link	*kalamoho lau li'i*	**Ind**	--	U	(1)
FLOWERING PLANTS DICOTYLEDONES					
AMARANTHACEAE					
Amaranthus spinosus L.	spiny amaranth	Nat.	U	O2	
ANACARDIACEAE					
Mangifera indica L.	mango	Nat.	--	U	
Schinus terebinthifolius Raddi	Christmas berry	Nat.	--	O	
ASCLEPIADACEAE					
Asclepias physocarpa (E. Mey.) Schlecter	balloon plant	Nat.	--	O	
ASTERACEAE (COMPOSITAE)					
Ageratum conyzoides L.	*maile hohono*	Nat.	--	R1	
Bidens cf. *alba* (L.) DC	beggar's-tick	Nat.	--	R	(2)
Chromolaena odorata (L.) King & Rob.	Siam weed	Nat.	--	U2	(1)
Cirsium vulgare (Savi) Ten.	bull thistle	Nat.	--	R	
Conyza bonariensis (L.) Cronq.	hairy horseweed	Nat.	--	R	
Cyanthillium cinereum L.	little ironweed	Nat.	R	--	
Emilia fosbergii Nicolson	Flora's paintbrush	Nat.	--	U	
Parthenium hysterophorus L.	false ragweed	Nat.	O	O	
Pluchea carolinensis (Jacq.) G. Don	sourbush	Nat.	U	--	
Pluchea indica (L.) Less.	Indian sourbush	Nat.	U	R	
Pluchea x *fosbergii* Cooperr. & Galang	hybrid pluchea	Nat.	R	--	
Senecio madagascariensis Poir.	---	Nat.	--	R	(1)
Tridax procumbens L.	coat buttons	Nat.	--	O	
Verbesina encellioides (Cav.) Benth. & Hook.	golden crown-beard	Nat.	U2	R	
Xanthium strumarium L.	*kikiāna*	Nat.	R	--	
BIGNONIACEAE					
Heliotropium curassavicum L	---	Nat.	R	--	
BORAGINACEAE					
Jacaranda mimosifolia D. Don	green ebony	Nat.	--	R	
BRASSICACEAE					
Sisymbrium officinale (L.) Scop.	hedge mustard	Nat.	--	R	

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	ABUNDANCE E2	NOTES
CACTACEAE					
Opuntia ficus-indica (L.) Mill.	*pānini*	Nat.	R	U	
CAPPARACEAE					
Capparis sandwichiana DC	*maiapilo*	**End.**	--	R	(1)
CARYOPHYLLACEAE					
Petrorhagia velutina (Guss.) P. Ball & Heyw.	childing pink	Nat.	--	R	
CHENOPODIACEAE					
Chenopodium carinatum R. Br.	---	Nat.	R	U2	
CONVOLVULACEAE					
Merremia aegyptia (L.) Urb	hairy merremia	Nat.	--	R	(2)
Ipomoea indica (J. Burm.) Merr.	*koali ‘awa*	**Ind.**	R	R	
CRASSULACEAE					
Kalanchoë pinnata (Lam.) Pers.	air plant	Nat.	--	O3	
Kalanchoë tubiflora (Harv.) Raym.-Hamet	chandelier plant	Nat.	--	R	(1)
CUCURBITACEAE					
Momordica charantia L.	balsam pear	Nat.	R	--	
EUPHORBIACEAE					
Aleurites moluccana (L.) Wild.	*kukui*	**Pol.**	--	O2	
Chamaesyce hirta (L.) Millsp.	garden spurge	Nat.	U	--	
Ricinus communis L.	castor bean	Nat.	U	U	
FABACEAE					
Acacia farnesiana	*klu*	Nat.	U	U	
FABACEAE					
Chamaecrista nictitans (L.) Moench	partridge pea	Nat.	--	O	
Crotalaria pallida Aiton	smooth rattlepod	Nat.	U	R	
Desmanthus purnambucanus (L.) Thellung	virgate mimosa	Nat.	U	--	
Desmodium incanum DC	Spanish clover	Nat.	--	R	
Erythrina sandwicensis Degener	*wiliwili*	**End.**	O2	O2	(1)
Indigofera suffruticosa Mill.	Indigo	Nat.	C	C	
Leucaena leucocephala	koa haole	Nat.	AA	A	
Neonotonia wightii (Wight & Arnott) Lackey	---	Nat.	C	AA	
Prosopis pallida (Humb. & Bonpl. Ex Willd.) Kunth	*kiawe*	Nat.	AA	--	
Senna occidentalis (L.) Link	coffee senna	Nat.	O	O	
LAMIACEAE					
Hyptis pectinata (L.) Poir.	Comb hyptis	Nat.	--	U	
Leonotis nepetifolia (L.) R.Br.	lion’s ear	Nat.	U	O	
Ocium sp.	---	Nat.	C3	--	(2)
Plectranthus parviflorus Willd.	*‘ala ‘ala wai nui wahine*	**Ind.**	--	R	(1)
Salvia coccinea B. Juss. Ex Murray	scarlet sage	Nat.	U	U2	
MALVACEAE					
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	Nat.	O2	O	
Malvastrum coromendalianum	false mallow	Nat.	R	O	
Sida fallax	*‘ilima*	**Ind.**	O2	O2	

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	ABUNDANCE E2	NOTES
Sida spinosa L.	prickly sida	Nat.	O	R	
Sidastrum micranthum (St. Hil.) Fryx.	---	Nat.	--	R	(2)
MELIACEAE					
Melia azedarach L.	Chinaberry	Nat.	--	O3	
MENISPERMACEAE					
Cocculus trilobus (Thunb.) DC	*huehue*	**Ind.**	--	U2	(1)
MORACEAE					
Broussonetia papyrifera (L.) Venten.	*Wauke*	**Pol.**	--	R	
NYCTAGINACEAE					
Boerhavia coccinea Mill.	false alena	Nat.	--	U	
Mirabilis jalapa L.	marvel of Peru	Nat.	--	U	
PAPAVERACEAE					
Argemone glauca (Nutt. Ex Prain) Pope.	*Pua kala*	**End.**	--	R1	
Bocconia frutescens L.	tree poppy	Nat.	--	O	
PIPERACEAE					
Peperomia cf. *leptostachya* Hook. & Arnott	---	**Ind.**	--	R3	(1)
PLUMBAGINACEA					
Plumbago zeylanica L.	*‘ilie‘e*	**Ind.**	--	R	
PORTULACACEA					
Portulaca oleracea L.	pig weed	Nat.	--	R	
Portulaca pilosa L.	---	Nat.	U2	U	
Portulaca sp. “A”	---	---	--	U2	(1)
PROTEACEAE					
Grevillea robusta A. Cunn. Ex R. Br.	silk oak	Nat.	--	U	(1)
SAPINDACEAE					
Dodonaea viscose Jacq.	*‘a‘ali‘i*	**Ind.**	--	O	(1)
SAPOTACEAE					
Nesoluma polynesicum (Hillebr.) Baill.	*keahi*	**Pol.**	--	R	
SOLANACEAE					
Datura stramonium L.	jimson weed	Nat.	--	R	
Nicotiana glauca R.C. Graham	tree tobacco	Nat.	U	O	
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	Nat.	--	U	
Solanum seaforthianum Andr.	---	Nat.	R	--	
STERCULARIACEAE					
Waltheria indica L.	*‘uhaloa*	**Ind.**	O	A	
THYMELIACEAE					
Wikstroemia oahuensis (A. Gray) Rock	*‘ākia*	**End.**	--	O2	
TILIACEAE					
Triumfetta semitriloba Jacq.	Sacramento burr	Nat.	--	U	
VERBENACEAE					
Lantana camara L.	lantana	Nat.	--	O	(1)
Stachytarpheta australis Moldenke	---	Nat.	R	C	
Stachytarpheta cf. *jamaicense* (L.) Vahl	Jamaican vervain	Nat.	--	R	(2)
Stachytarpheta cayennensis (Rich.) Vahl	---	Nat.	--	U	(1)

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	ABUNDANCE E2	NOTES
	FLOWERING PLANTS				
	MONOCOTYLEDONES				
AGAVACEAE					
Furcraea foetida (L.) Haw.	Mauritius hemp	Nat.	U2	--	
CYPERACEAE					
Cyperus gracilis R. Br.	McCoy grass	Nat.	--	O	
POACEAE (GRAMINEAE)					
Cenchrus ciliaris L.	buffelgrass	Nat.	AA	--	
Dichanthium sp.	---	Nat.	U	O2	
Digitaria insularis (L.) Mez. ex Ekman	sourgrass	Nat.	A	C	
Eleusine indica (L.) Gaertn.	wire grass	Nat.	--	R	
Eragrostis amabilis	love grass	Nat.	--	U	
Chloris barabata (L.) Sw.	swollen fingergrass	Nat.	--	O	
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat.	--	U	
Melinus minutiflora P. Beauv.	molasses grass	Nat.	--	U	(1)
Melinus repens (Willd.) Zizka	Natal redtop	Nat.	O	C	(1)
Sporobolis indicus (L.) R. Br.	West Indian dropseed	Nat.	--	R	
Sporobolus sp.		Nat.	--	O	
Urochloa maxima (Jacq.) R. Webster	Guinea grass	Nat.	AA	A	

Table 3: Legend

Status = distributional status

End. = endemic; native to Hawaii and found naturally nowhere else.
Ind. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
Pol. = Polynesian introduction before 1778.

Abundance = occurrence ratings for plants:

R – Rare - only one or two plants seen.
U - Uncommon - several to five plants observed.
O - Occasional - found between five and ten times; not abundant anywhere
C - Common - considered an important part of the vegetation and observed numerous times.
A - Abundant - encountered regularly and therefore present in large numbers; may be dominant over a limited area.
AA - Abundant - abundant and dominant; defining vegetation type for the layer.
Numbers following an occurrence rating indicate clusters within the survey area. The ratings above provide an estimate of the likelihood of encountering a species within the specified survey area; numbers modify this where abundance, where encountered, tends to be greater than the occurrence rating:
1 – several plants present
2 - many plants present
3 – locally abundant

Area: E1 – Leeward slope, below 1000 ft (300 m).
E2 – Leeward slope, above 1000 ft (300 m).

Notes:

(1) – Found particularly and more abundant on rugged lava outcrops and flows.
(2) – Plant material observed lacked definitive taxonomic characters (dried out in some cases).
(3) – Described by USFWS (2010) as a "species of concern."

The results of mapping native trees along the construction access road are expressed in Figures 15 through 18. For this set of maps, besides *wiliwili*, the only natives recorded were *maiapilo* and a single *alahe'e* shrub. Areas of dense *wiliwili* (copses), within which individual trees were not recorded (only a light orange fill appears on the maps), are outlined in orange: solid lines where recorded in the field; dashed lines where interpreted from a satellite image.

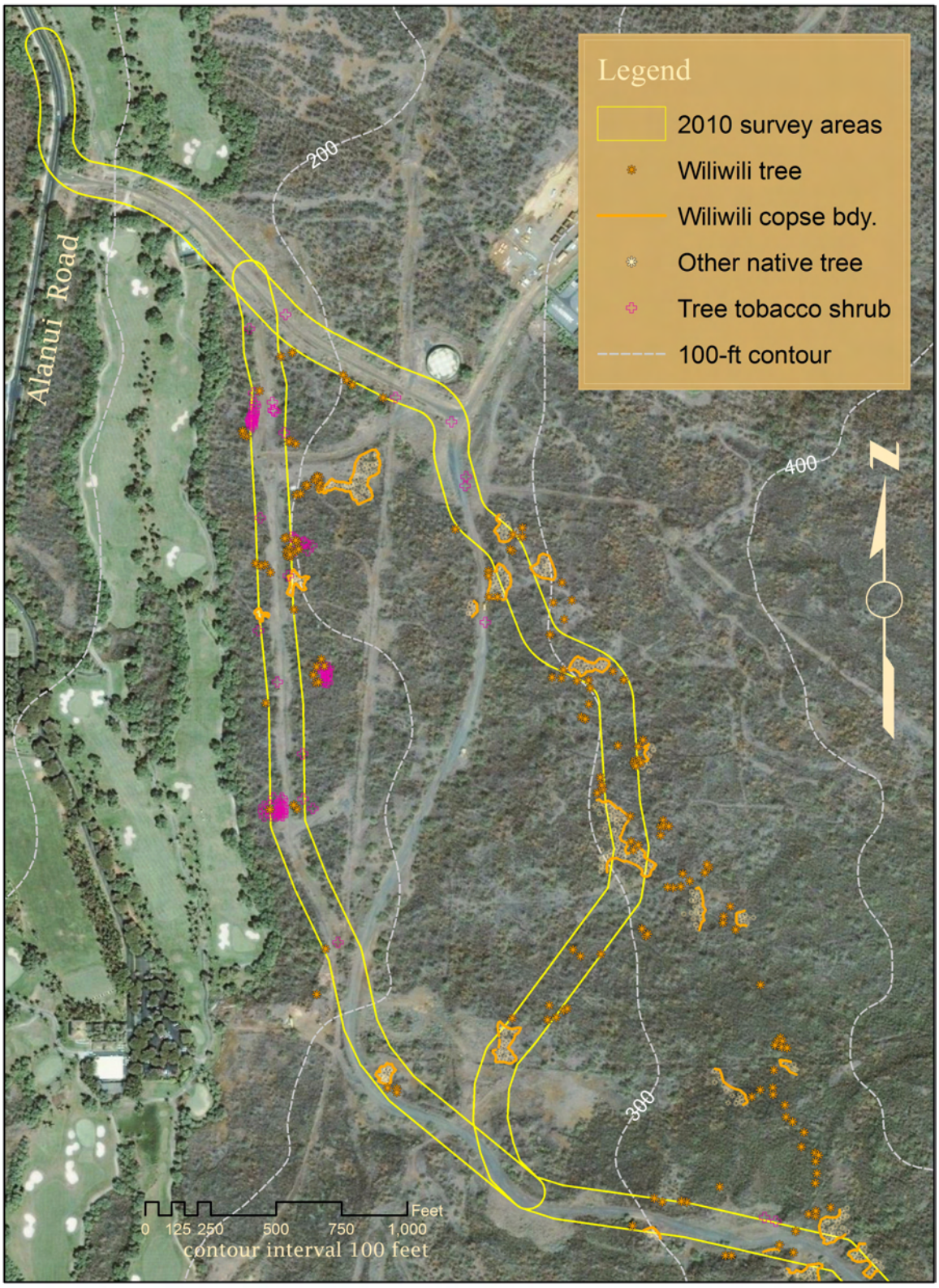


Figure 15. Botanical survey map for west end of construction access road between 100 (Alanui Road) and 350 feet ASL.

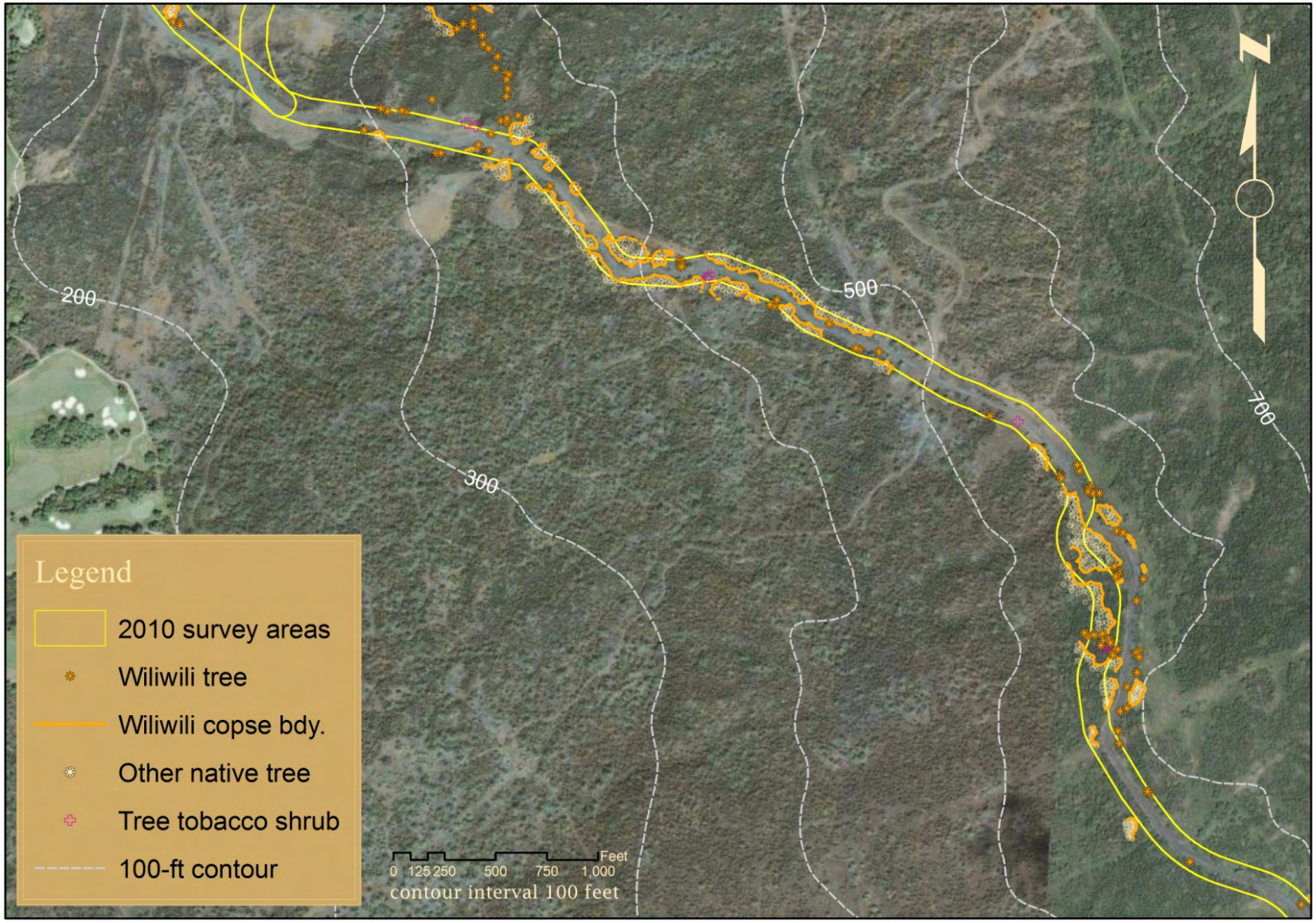


Figure 16. Botanical survey map for western part of construction access road between 250 and 550 feet ASL.

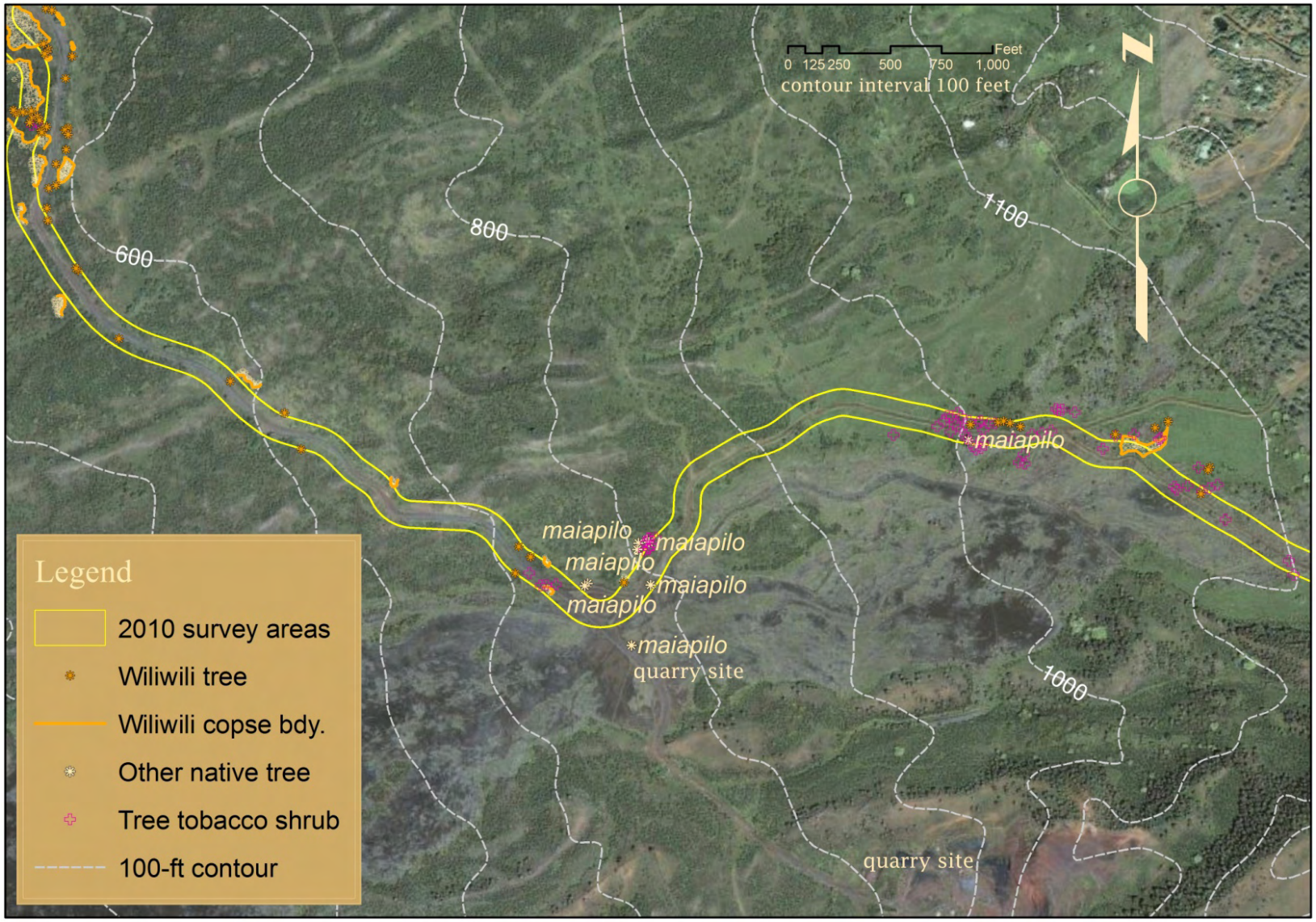


Figure 17. Botanical survey map for construction access road between 550 and 1100 feet ASL.

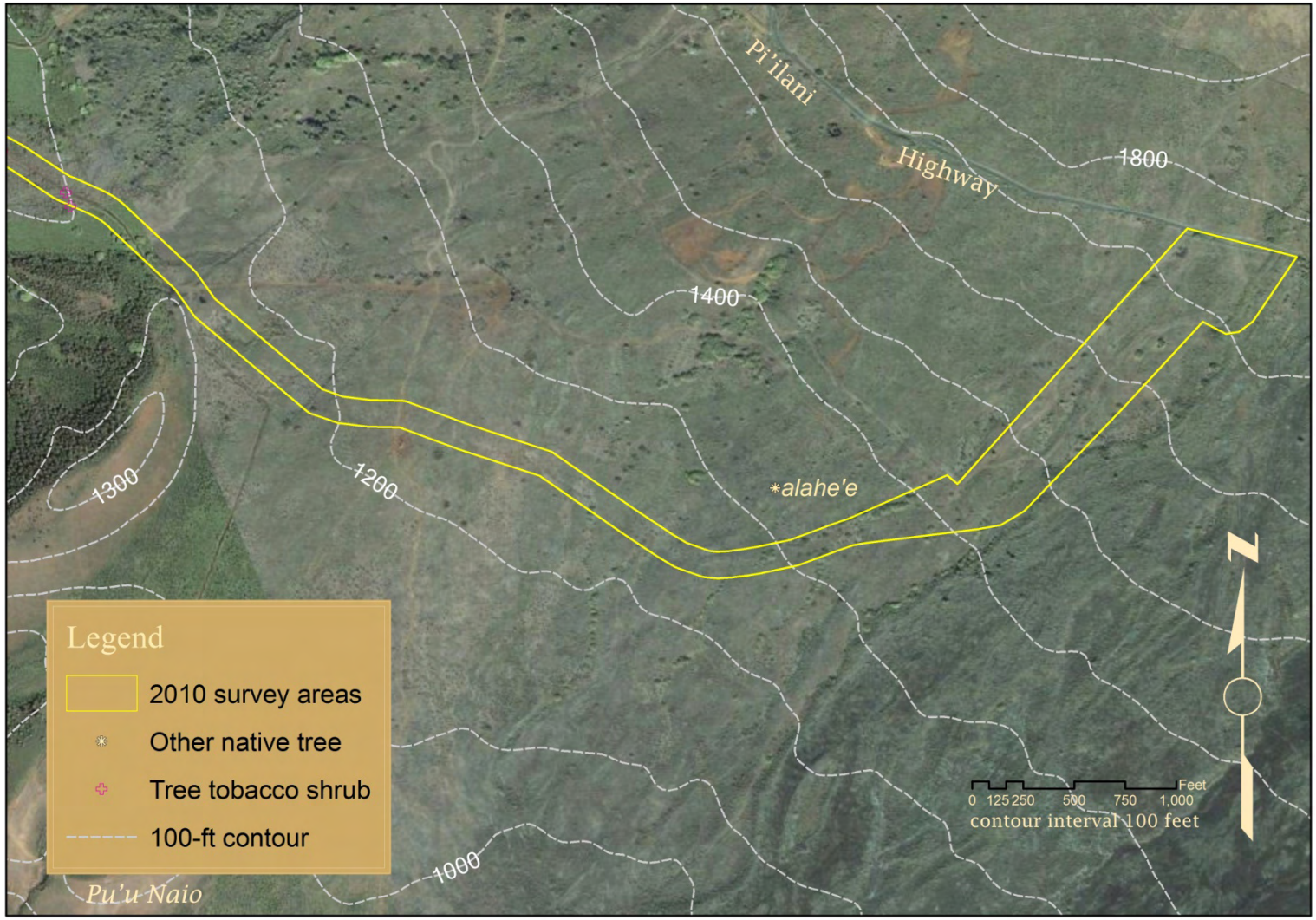


Figure 18. Botanical survey map for east end of construction access road between 1100 and 1750 feet ASL (Pi'ilani Higway).

Avian Survey

A total of 2,156 individual birds of 23 different species, representing 15 separate families, were recorded during station counts (Table 4). An additional two species, representing one additional family were recorded as incidental observations while transiting the site between count stations (Table 4). One of the species detected, Short-eared Owl (*Asio flammeus sandwichensis*), is a Hawaiian endemic subspecies. All other species detected are considered to be alien to the Hawaiian Islands. No species currently listed as endangered, threatened or proposed for listing under either the federal or State of Hawai'i endangered species statutes was recorded during the course of this survey.

Avian diversity and densities were relatively low, though in keeping with the habitat present on the site. An average of 27 individual birds were recorded per station count. Four species (17%), House Finch (*Carpodacus mexicanus*), Japanese White-eye (*Zosterops japonicus*), Black Francolin (*Francolinus francolinus*), and Sky Lark (*Alauda arvensis*), accounted for 49% of the total number of birds recorded during station counts. The most common avian species recorded was House Finch, which accounted for slightly less than 15% of the total number of individual birds recorded.

Table 4 Avian Species Detected, Auwahi Wind Farm Project.

Common Name	Scientific Name	ST	RA
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Chukar	*Alectoris chukar*	A	**I-5**
Gray Francolin	*Francolinus pondicerianus*	A	1.60
Black Francolin	*Francolinus francolinus*	A	2.86
Japanese Quail	*Coturnix japonica*	A	0.04
Red Junglefowl	*Gallus gallus*	A	0.10
Ring-necked Pheasant	*Phasianus colchicus*	A	0.74
Common Peafowl	*Pavo cristatus*	A	0.56
	ODONTOPHORIDAE - New World Quail		
California Quail	*Callipepla californica*	A	0.20
	CICONIIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	0.84
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	0.30
Zebra Dove	*Geopelia striata*	A	1.45
Mourning Dove	*Zenaida macroura*	A	0.13

Table 4 - Continued

Common Name	***Scientific Name***	**ST**	**RA**
	STRIGIFORMES		
	TYTONIDAE - Barn Owls		
Barn Owl	*Tyto alba*	A	**I-27**
	STRIGIDAE - Typical Owls		
Short-eared Owl	*Asio flammeus sandwichensis*	IB	0.05
	PASSERIFORMES		
	ALAUDIDAE - Larks		
Sky Lark	*Alauda arvensis*	A	2.51
	SYLVIIDAE - Old World Warblers & Gnatcatchers		
	Sylviinae - Old World Warblers		
Japanese Bush-Warbler	*Cettia diphone*	A	0.56
	ZOSTEROPIDAE - White-eyes		
Japanese White-eye	*Zosterops japonicus*	A	3.59
	MIMIDAE - Mockingbirds & Thrashers		
Northern Mockingbird	*Mimus polyglottos*	A	1.15
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	2.49
	EMBERIZIDAE - Emberizids		
Red-crested Cardinal	*Paroaria coronata*	A	0.10
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	1.15
	FRINGILLIDAE - Fringilline and Carduline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	4.24
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
African Silverbill	*Lonchura cantans*	A	1.40
Nutmeg Mannikin	*Lonchura punctulata*	A	0.93
Java Sparrow	*Padda oryzivora*	A	0.01

Key To Table 4

ST	Status
A	Alien Species
IB	Indigenous Resident Breeding Species
RA	Relative Abundance: Number of birds detected divided by the number of count stations (80)
I	Incidental Observation – Species seen while transiting the site, followed by the number of individuals seen

Mammalian Survey

Eleven mammalian species were detected during the course of this survey. Their status in Hawai‘i, relative abundance observed and detection type are displayed in Table 5. All 11 species recorded are alien to the Hawaiian Islands. We saw large numbers of cattle (*Bos taurus*), horses (*Equus c. caballus*), Axis deer (*Axis axis*), and goats (*Capra h. hircus*). We saw fairly small

numbers of pigs (*Sus s. scrofa*), small Indian mongooses (*Herpestes a. auropunctatus*), dogs (*Canis f. familiaris*), and cats (*Felis catus*). We also recorded one roof rat (*Rattus r. rattus*) and one European house mouse (*Mus musculus domesticus*). We did not see any elk (*Cervus elaphus*), although we did encounter sign of this species along the Wailea side of the transmission line corridor. Hawai‘i‘s sole endemic terrestrial mammalian species, the endangered Hawaiian hoary bat, was not detected during the course of this survey.

Table 5 Mammalian Species Detected, Auwahi Wind Farm Project.

Common Name	Scientific Name	ST	AB	DT
	RODENTIA - GNAWERS			
	MURIDAE - Old World Rats & Mice			
Roof rat	*Rattus r. rattus*	A	R	V
European house mouse	*Mus musculus domesticus*	A	R	V
	CARNIVORA – FLESH EATERS			
	CANIDAE – Wolves, Jackals & Allies			
Domestic dog	*Canis f. familiaris*	A	U	V, SC, SI
	VIVERRIDAE – Civets & Allies			
Small Indian mongoose	*Herpestes a. auropunctatus*	A	U	V, SC, SI
	FELIDAE- Cats			
House cat	*Felis catus*	A	U	V, SC, SI
	PERISSODACTYLA – ODD-TOED UNGULATES			
	EQUIDAE – Horses, Asses & Zebras			
Domestic horse	*Equus c. caballus*	A	A	V, SC, SI
	ATRIODACTYLA – EVEN-TOED UNGULATES			
	SUICIDAE – Old World Swine			
Pig	*Sus s. scrofa*	A	U	V, SC, SI
	CERVIDAE – Antlered Ruminants			
Axis deer	*Axis axis*	A	A	V, SC, SI
Elk (Red Deer)	*Cervus elaphus*	A	?	SI
	BOVIDAE- Hollow-horned Ruminants			
Domestic cattle	*Bos taurus*	A	A	V, SC, SI
Feral goat	*Capra h. hircus*	A	A	V, SC, SI

Table 5 – continued ……

Key To Table 5

ST	Status
A	Alien Species
DT	Detection Type
R	Rare – one animal during all time spent on the project site
U	Common – 1-5 animals detected each day
A	Abundant – 25-150 animals detected on a daily basis
V	Visual – one or more individuals were seen
SC	Scat – Scat of this species was encountered
SI	Sign – Sign, tracks, bark rubbing, wallows, dust bath depressions etc. of this species encountered

Wetland and Stream Resources

Occurrences of surface water in all areas potentially impacted by the Project are limited to manmade ranch watering structures and infrequent surface flows occurring during heavy rains. Even where the climate is generally wetter upslope—at and above the highest point reached by the generator tie-line—atmospheric moisture is delivered as cloud drip and does not generate surface water flows. The one "stream" indicated on older maps lies along the far western edge of the Project parcel. A brief assessment (Guinther, 2010) of this feature was prepared for the record and presentation to the U.S. Army Corps of Engineers (USACE); the lower end of the "stream" was visited a short time later in June 2010. The following description is taken from the assessment report:

> Owing to the relatively recent lava flows and generally dry climate that characterize the southwest rift zone of East Maui Mountain below 4000 ft (1220 m), flowing streams, natural ponds, and wetlands are absent, with but a very few exceptions. These exceptions are all located close to the coastline where either tidal flooding occurs or the basal water table is exposed by depressions in the ground surface (fish ponds and anchialine features). Inland and upslope, above a few meters elevation, and therefore in all of the areas potentially impacted by the Auwahi Windfarm Project (including the windfarm site, construction access roads, and electrical transmission lines), occurrences of surface water are limited to manmade ranch watering structures and infrequent surface flows occurring during heavy rains. Even where the climate is somewhat wetter far upslope—at and above the highest point reached by the [generator tie-line]—atmospheric moisture is delivered as cloud drip and does not generate surface water flows.
>
> The land in the project area shows some weathering, with evidence of surface flow within swales that extend to the coast. The USGS topographic map (Makena Quadrangle) shows only a single intermittent stream in the area. This unnamed "stream" is indicated as arising around the 3200-ft (975-m) elevation and descending to the coast east of Kanaloa. The feature appears to be following along the eastern edge of the lava flow dated 3000 to 5000 years before present (BP) on the much older surface of the mountain dated at between 13,000 and 50,000 years BP (Sherrod, et al., 2007). On May 17, 2010, this "stream" was visited in the area where it crosses Pi'ilani Highway, but which of several swales in this area was the stream could not be determined. The most likely swale (lowest apparent dip in the road) was photographed…[see cited report]

This feature is located on 'Ulupalakui Ranch land, but in an area where no Project components will be located. Like all of the gullies and swales on the Project area, this one carries water only during exceptional storms, with flow ceasing soon after the rainfall quits. While it is possible that rain storms of sufficient strength occur at least once each year, it is also the case that owing to drought cycles, flow in these tributaries may be absent for several years running. This feature could be defined as a non-navigable tributary that is not relatively permanent, and thus requiring a determination that a significant nexus with a traditional navigable water exists (Grumbles & Woodley, 2008); or it and all other swales on the property are erosional features characterized by low volume, infrequent, or short duration flow and not jurisdictional.

To further confirm that this specific feature carries flowing water to the ocean only very infrequently (less often than annually), and is not jurisdictional, the mouth at the shore was visited in July 2010. Here, geophysical processes are clearly dominated by wave energies and a stream outlet is barely perceptible. No standing water or evidence of wetness was observed. The gulch can be traced upslope from the mouth (Figure 19), but evidence of water flow occurs in very scattered locations.

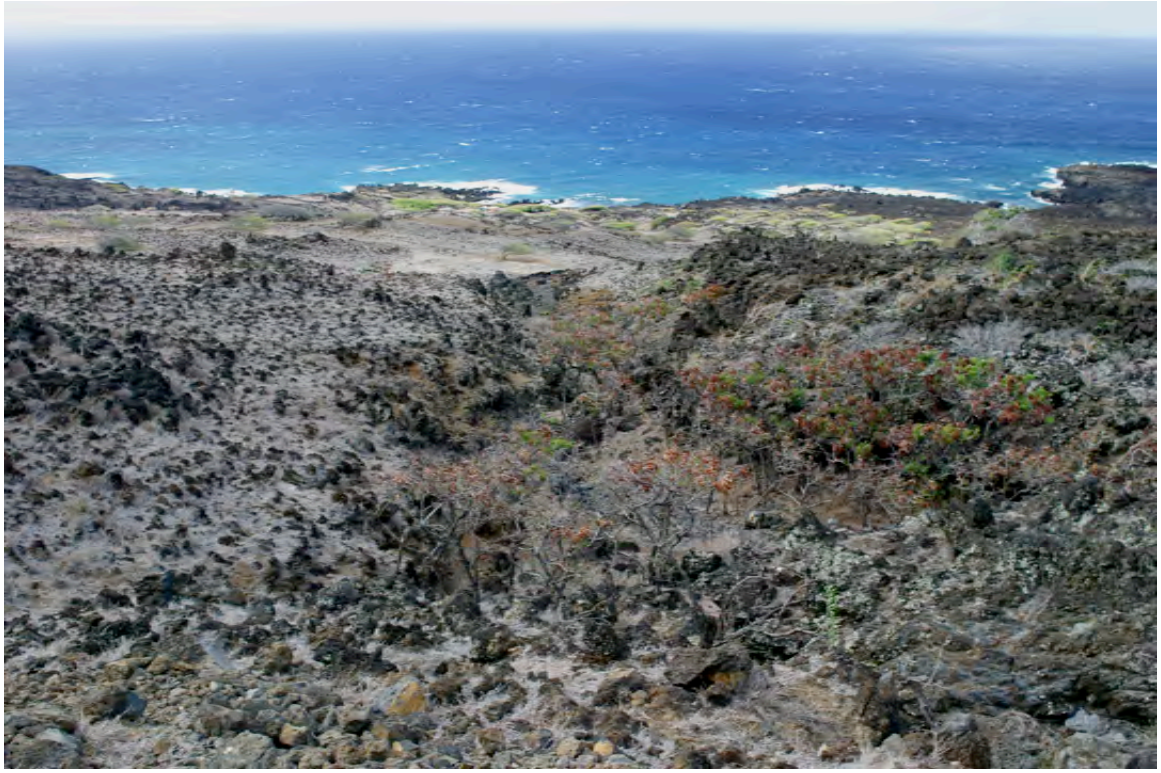


Figure 19. Swale of "intermittent stream" shown in Guinther (2010) seen from 250-ft elevation looking towards the outlet at the shore.

Discussion

Botanical Resources

The botanical resources of the southwestern end of East Maui are controlled by the local geology and physiography, and of course, land use patterns. A broad range of conditions with respect to temperature, wind, rainfall, and soil occur within the areas of potential impact from the proposed Auwahi Wind Farm, associated generator tie-line, and proposed construction access roadway improvements. These environmental factors interact with each other in complex ways to produce a range of habitat types that support more or less distinctive plant associations. It is beyond the scope of this report to explore in any detail these relationships, but to achieve an understanding of the floristic observations, it is necessary to attempt to relate these environmental factors to vegetation distribution, especially the occurrence of native vs. non-native plants, and sensitive vs. non-sensitive plant communities. The proposed wind farm covers a much smaller range of conditions as compared to the proposed generator tie-line corridor that covers the full range of elevation (and therefore rainfall) found within the Project area.

General vegetation maps for each of the project areas are presented as Figures 21, 24, 26, and 27, and are discussed in the text that follows describing vegetation types in the Project area. The purpose of this discussion is to provide the reader with a sense of the nature of the environments in which Project elements will be constructed. In this part of Maui, some (indeed most) vegetation types harbor few or only rare occurrences of native plants; others support many, or at least a diversity of natives. In a few types, native plants reach dominance. Given this variety of conditions with respect to botanical resources, it is not possible to summarize impacts as either unacceptable or minimal. In some vegetation types, considerable care will be required to minimize adverse impacts, particularly during the construction phase.

Physiography

The project area extends from just above sea level to an elevation of around 4,000 feet (1,200 meters) on the slope of the East Maui Volcano (called Haleakalā in some sources, although this name applies to the central crater-like valley of the mountain). The project area lies close to (and the generator tie-line and roadway corridors both straddle) the southwest rift of the volcano. Rift zones are areas where flank eruptions were concentrated in the distant past. The three rift zones of the East Maui Volcano contributed to the three-cornered shape of the mountain, which built outward especially along these axes. The southwest rift zone in particular is marked by a relatively narrow band of eruption cones from which the Kula Series lavas issued, this rift zone "extending southwestward… from the summit, forming a nearly straight line across the mountain" (Macdonald, Abbott, and Peterson, 1983).

The eruptive activity that gave rise to this part of Maui is significant to the extant flora in one respect: the more recent lava flows are distinct in having poorly developed soils, complex rocky outcrops, and flows little modified by time, and therefore provide a poor physiographic setting for agricultural uses. As a consequence, the older exposed surfaces

have deeper soils and, in this part of Maui, have been extensively developed as pastureland by ʻUlupalakua Ranch and others.

Two other factors are important: elevation and position relative to the rain shadow effect that results in the very dry southern slopes of the East Maui Volcano. Elevation affects temperature, but more important to flora in the project areas, is the effect of elevation on rainfall. This part of Maui has two rainfall gradients: elevation and shadow effect. Average rainfall received (Taliaferro, 1959) increases in the upslope direction from the coastline (~10 in/yr or 250 mm/yr at Kīhei, but ~40 in/yr or 1000 mm/yr at Kula) reaching a peak value at around 5,000 feet (1,500 meters) of elevation. This gradient is weaker on the south flank, with annual rainfall amounts of around 20 inches (500 mm) at the coast and not much over 30 inches (800 mm) all the way up the mountain, decreasing above 4,000 feet (1,200 meters) to 20 in/yr along the southern crest of Haleakalā. The median annual rainfall differences may not seem great (after all, the north or windward face of the mountain receives around 100 in/yr or 2500 mm/yr), but are particularly influential on plant life during the driest months (May through September) when little or no rainfall occurs in the lowlands below either flank of the mountain, while an orographic effect (air forced to give up moisture as it rises upon encountering the mountain) brings some rainfall to the higher elevations of the ʻUlupalakua ranchlands facing to the northwest. Thus, the orographic or elevational influence on rainfall predominates on the northwest flank of the rift zone, while the shadow effect predominates on the southeast flank of the rift zone. The climate along the Kula Highway (between 2,000 and 3,000 feet or 600 to 1000 meters) is decidedly mesic upslope from the highway on the Kīhei (western) slope, and increasingly drier downslope. On the entire southern face of the mountain above and below Piʻilani Highway, only a kilometer or less from the rift zone, the climate is dry.

Vegetation Zones

The physical factors discussed above strongly influence the nature of the vegetation found in the project area. In broad terms, we can identify the following types of vegetation within the project area: dry shrubland, grassland (includes pasture), and savanna (grassland with scattered trees). Some areas of mesic forest and dryland forest are present, although most of the mesic forest occurs along the rift zone ridgeline in areas not included in the survey. Dryland forest occurs as a remnant vegetation type on the southern flank of the mountain between about 1000 and 4000 feet ASL. The pattern of these vegetation types on the landscape is influenced by land use practices: extensive pastures at higher elevation are maintained as grasslands by the presence of cattle and the efforts of the ranch to minimize tree and shrub growth. Dry scrub and savanna lands are also utilized for pasturing cattle, but these occur in the driest areas and support lower densities of ungulates. It was apparent during our surveys that native plant species were well represented in the more rugged terrain representing the most recent lava flows. This conclusion seems to have been reached by nearly every botanist that has visited this part of Maui in the last half century or longer. Bordner (1995), an archaeologist, expressed it thus:

> *"…. Since Rock's (1913) survey of indigenous trees and shrubs, it has been acknowledged that Aʻuahi contains one of the highest proportions of indigenous dryland forest left in the Hawaiian Islands (Lamb 1981). The survival of such a large number appears mainly to reflect the recent*

dates of the lava flows, which must have been so destructive of the very forest they now preserve. Small kipuka, isolated in fields of bare lava, are thus protected from much of the wanton grazing by goats and cattle which destroyed the former expanse of dry forest."

The conclusion that the preserved dryland forest is limited to, or even significantly occupies, *kīpuka* of any size is unlikely to be the case. It is the ruggedness of specific lava flows, directly a property of their youthful age relative to surrounding flows (including *kīpuka*) that confers protection, certainly from grazing cattle, but also from non-native plants less able to establish on the thin or non-existent soils of these recent flows located in a dry climate. Key as well to explaining the thinning and gradual disappearance of the native dryland forest in this area is the predominance of non-native Kikuyu (*Pennisetum cladestinum*) as the abundant pasture grass above about 2200 feet (670 meters) ASL. The "…smothering, thick, dense growth [of Kikuyu] prevents virtually any new [native] seedling establishment" (Wagner, Herbst, and Sohmer, 1990, p. 1579).

Table 6. Vegetation Map Key

Map Unit	Description	Coding*
DD	Developed or disturbed areas; farmland, house lots, golf courses, etc.	not applicable
Fk	*Kiawe* forest and *kiawe* coastal strand.	D: xt(xg)
Fkw	*Kiawe*, *koa haole*, and *wiliwili* mixed forest.	D: xt/nt(xg)
Fo2	Secondary forest; non-native.	M: xt(xg)
GP	Grassland; pasture.	D: xg
GPj	Savanna; pasture with scattered trees and shrubs, roughly corresponding to Jacobi (1989) mapping unit.	D: (xg,ns-xs)nt
GPr	Grassland with shrubs and herbs; very rocky pasture.	D: xg, ns-xs
R	Restoration area (active)	D: (ns)nt
Sc	Shrub/scrub vegetation	D: nx-xs
ScL	Scrub vegetation; dry shrubland usually on recent lava flows.	D: nx-xs
ScP	Scrub vegetation and grassland; pasture.	D: xs-ns(xg)
SvF	Savanna; forest with <25% canopy roughly corresponding to Jacobi (1989) mapping unit	D: nt (ns, xg/xs)
SvL	Lowland (*kiawe*/buffelgrass) savanna.	D: xt(xs)
SvU	Open canopy forest/savanna of upland trees.	M:(xg/xs)xt

Coding — Adapted from Jacobi (1989): D: = dry zone, M: = mesic zone; n = native, x = non-native; g = grass, s = shrub, t = tree; (…) = understory, t( ) = trees ≥ 25% cover, ( )t = trees < 25% cover.

Table 6 (above) is a key to the codes used in the vegetation maps presented in this discussion section. Note that areas of significant disturbance and/or development are

mapped as ***DD*** where the vegetation is either absent or ornamental and maintained. Examples are urban areas, golf courses, and crop lands. The vegetation types mapped in Figures 21, 24, 26, and 27). These figures are discussed within the context of broader vegetation types (e.g., grassland, scrub, savanna) that predominate in the area of the project sites as shown on each map. A column of codes for each map unit type in the table and maps—adapted from the vegetation scheme presented by Jacobi (1989)—is useful for relating information on some characteristics (native vs. non-native, dry vs. mesic, shrub vs. tree, etc.) of the vegetation present. As an example, the coding for the Auwahi restoration areas (map unit "R") is "D: (ns)nt"; to be interpreted as "dry zone native savanna (tree canopy less than 25%) with native shrub understory."

Grassland/pasture

The proposed project occurs almost entirely on land that is utilized to a greater or lesser degree by 'Ulupalakua Ranch for cattle grazing. A majority of the area is pasture, or grassland maintained for agricultural pasturing (see Figure 20; ***GP*** on vegetation maps such as Figure 21; ***GPr*** as very rocky pasture in drier areas). These pastures support non-native grasses. Grazing of cattle is not limited to this just vegetation type and climatic and edaphic (soil) factors determine the appropriate extent of pasturing supportable in any given area. Areas of mostly grassland occur along the generator tie-line route from near where the line crosses the southwest rift down the west face of the mountain to around 1,000 feet (300 meters) ASL in the direction of Wailea. Below about 1000 feet (300 meters), the open grassland transitions to a grass/tree savanna (see Savanna below).

Figure 20. Typical pasture, here at around 3500 feet on the southwest rift. Note that a mesic forest covers the pu'u (Kalanapahi cinder cone) downslope, which is Not used for cattle grazing. Slope on right is Keonenelu cinder cone.

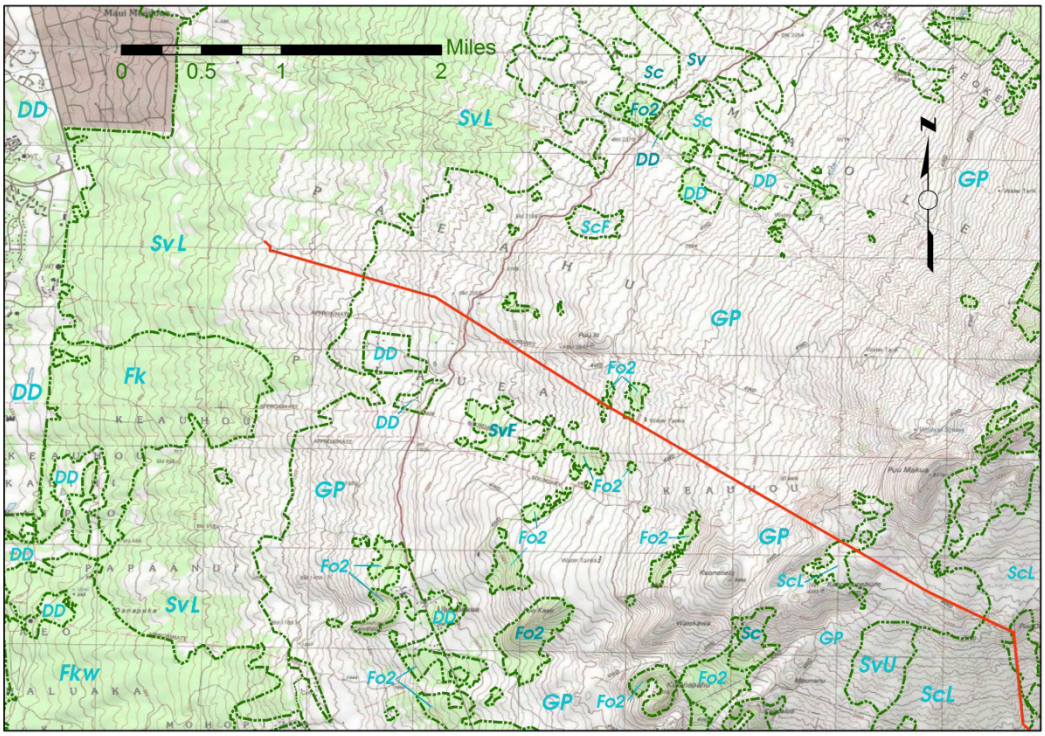


Figure 21. Vegetation zones for the western half of the generator tie-line (in red) crossing upland pasture and lowland savanna of 'Ulupalakua Ranch. For key see Table 6.

Savanna

Savanna is a vegetation type characterized by both grass and trees. Typically, a savanna has the appearance of a grassland with a varying density of tree species, but these are not so dense as to form a closed canopy shading out the understory grasses. Figure 22 shows a savanna in the project area consisting of pasture grasses and *kiawe* trees (***SvL*** in vegetation maps). This vegetation type is crossed by the proposed generator tie- line, downslope of where the line passes over the ridge of the Southwest Rift Zone and continues across pastureland above and below Kula Highway (State Rte. 31; here at about 2,000 feet or 600 meters). Savanna appears around the 1,200-foot (360-meter) elevation, with the density of *kiawe* trees increasing steadily in the downslope direction. It is not easily determined at which point savanna here becomes a dryland forest—by most definitions, "savanna" is characterized by "scattered trees," some definitions including concepts such as an open canopy and an unbroken herbaceous layer (Wikipedia, 2007). In the normally dry conditions on the lower slope of the mountain, *kiawe* trees do not create deep enough shade so the understory remains mostly dense grass with only scattered shrubs all of the way to the Wailea substation. It is arguable whether, in this area, a dryland forest is present, since the canopy remains sufficiently open to support a dense growth of grass beneath (see Figure 7). *Kiawe* forest (***Fk***) is mapped on the general vegetation map southwest of the generator tie- line. This forest type merges into a mixed *kiawe* and *wiliwili* forest (***Fkw***) further south towards the construction access road.

Figure 22. Typical savanna: grassland with scattered trees.
(Around 1000 ft above Wailea looking towards Kaho'olawe).

Figure 23. Savanna or dryland forest? The Prosopis/Cenchrus Association at lower elevations fits the definition of both vegetation types.

Secondary Mesic Forest

The term mesic describes moisture conditions between dry and wet; typically there is a dry season, but the moisture deficit is not prolonged (Gagne and Cuddihy, 1990). Upland areas that are mesic in character support forested slopes. On the west slope, in the vicinity of the generator tie-line (Figure 21), these are secondary forest copses (***Fo2***) representing, in most cases, old plantings of eucalyptus or gum trees. Mesic forest occupies scattered areas along the rift zone in the ʻUlupalakua area, especially near the upper end of the construction access road (west alternative) and in a few scattered locations mostly adjacent to the generator tie-line at its higher elevation. A few cases of very open canopy growth associated with these plantings is mapped as savanna (***SvF***). It is likely the case that in the absence of cattle grazing and active promotion of pasture development, much of the ʻUlupalakua Ranch land *mauka* of Kula Highway would be a mesic forest. The mesic forest in the areas surveyed are mostly dominated by non-native trees, but remnants of native mesic forest (dominated by *ʻōhiʻa*) occur in the area on relatively recent lava flows and as described following.

Native Mesic Forest

In the Project area of the upper generator tie-line on the south mountain slope, the vegetation is transitional between xeric (dry) and mesic (moisture from cloud drip becomes significant here)[6]. Further, the vegetation is a complex mixture of pasture (grassland), shrubland, and open forest or savanna, and cannot be mapped as a single type or map unit. The native vegetation occurs mostly in the **ScL**, **GPj and SvF** units mapped in Figure 24. The botanical significance of this area lies in the Montane Mesic Forest, here a remnant of a once more extensive *Olopua* (*Nestegis*) Montane Forest (Gagne and Cuddihy, 1990). These authors note that this forest type is "extremely rich in native tree species, especially in the Auwahi and Kanaio Districts on East Maui, where *olopua* may lose dominance and the community can be considered a montane Diverse Mesic Forest with no clearly dominant species."

This native "forest" type at Auwahi is protected by the Kanaio NAR, an area of high diversity of native plant species and considered one of the most intact "dryland" forest areas in the state (Wagner et al., 1990). In botanical references, Auwahi currently refers to a 5,400-acre stand of diverse forest at 3,000-5,000 feet (900-1500 meters) elevation surrounded by less diverse forest and shrubland on relatively recent lava flows. Auwahi contains high native tree diversity with 50 dryland species, many with extremely hard, durable, and heavy wood (Medeiros, Davenport, and Chimera, undated). A website (HEAR, 2007) provides the following history: "The area was first explored botanically in the early 20th century by Joseph Rock of the University of Hawai'i and Charles Forbes of Bishop Museum. In his seminal book, *Indigenous Trees of the Hawaiian Islands* (1913), Rock praised the area for its

[6] The difficulty of assigning mesic vs. xeric here is illustrated by the fact that Gagne and Cuddihy (1990, p. 99) classified the area as mesic, whereas Jacobi (1989) mapped it as "D" or dry (xeric), and many others describe the vegetation as a "native dryland forest." Since 2009-2010 was an uncommonly dry period for this part of Maui, we cannot reasonably support an opinion from experience either way. Xeric conditions very likely prevail on this slope below 3000 feet (900 meters) ASL, which encompasses the vast majority of Kanaio NAR.

botanical diversity calling it one of the richest districts in the State. Upon his return to the area some 20 years later in 1939, Rock is said to have wept over the dramatic deterioration during his absence".

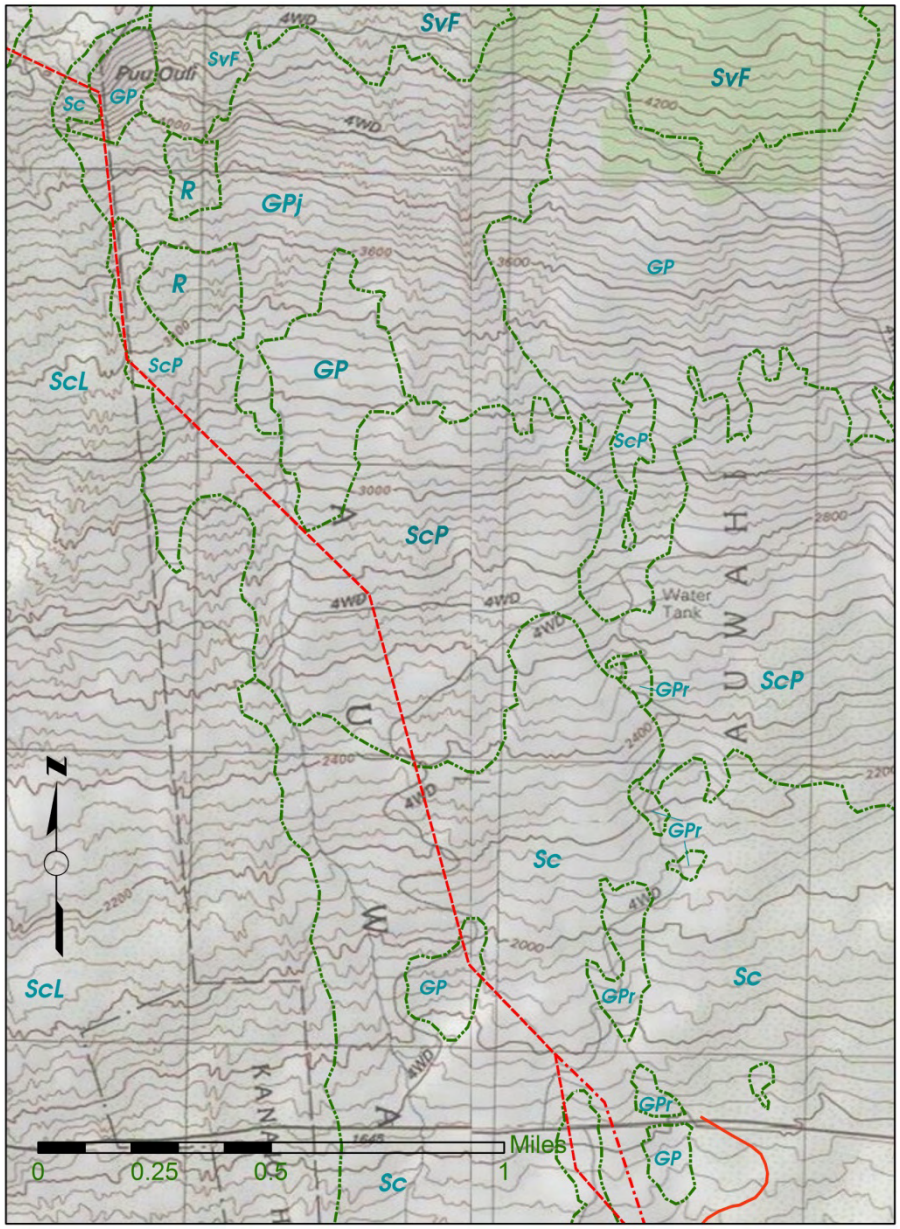


Figure 23. Vegetation zones for the eastern half of the generator tie-line (in red) crossing upland savanna and scrub pasture, scrub lands of 'Ulupalakua Ranch. For key see Table 6.

The following is from the HEAR website:

> *The first attempts at conservation at Auwahi were made in the late 1960's, when retired Territorial Forester Collin Lennox and The Nature Conservancy constructed a large exclosure[7] in an abortive restoration effort which unfortunately coincided with the invasion of the area by Kikuyu grass. USGS scientists (with National Park Service until 1993) began exploratory work, with the permission (and blessing) of the landowner, 'Ulupalakua Ranch, 19 years ago. A status report based on extensive field exploration in the early 1980s (Medeiros et al., 1986) called attention to continued deterioration of native vegetation on leeward Haleakalā and identified the Auwahi area as a prime area worthy of concerted conservation efforts.*

Table 7 is an "incomplete" list of plant species from the Auwahi "Reserve", East 'Ulupalakua Ranch (from the HEAR website)[8]. Federally listed species (USFWS, 2005) are indicated as either "threatened" (T) or "endangered" (E) in the final column. Non-native species have an asterisk (*) following the species name.

Table 7. Plant species from the Auwahi Reserve, East 'Ulupalakua Ranch

Scientific Name	***Common Name***	***Family***	***ST***
Alectryon macrococcus var. *auwahiensis*	*Mahoe*	Sapindaceae	E
Alphitonia ponderosa	*Kauila*	Rhamnaceae	
Alyxia oliviformis	*Maile*	Apocynaceae	
*Anagallis arvensis**	Scarlet pimpernel	Primulaceae	
*Anthoxanthum odoratum**	Sweet vernalgrass	Poaceae	
Argemone glauca	*Pua kala*	Papaveraceae	
*Asclepias physocarpa**	Balloon plant	Asclepiadaceae	
Asplenium adiantumnigrum	*Iwaiwa*	Aspleniaceae	
Bidens micrantha subsp. *kalealaha*	*Kookoolau*	Asteraceae	E
*Bidens pilosa**	Spanish needle	Asteraceae	
*Bocconia frutescens**	Tree poppy	Papaveraceae	
Carex wahuensis	Carex	Cyperaceae	
*Cerastium fontanum**	Common mouse-ear chickweed	Caryophyllaceae	
Chamaesyce celastroides var. *lorifolia*	*Akoko*	Euphorbiaceae	
Charpentiera obovata	*Papala*	Amaranthaceae	
Cheirodendron trigynum	*Olapa*	Araliaceae	
Cirsium vulgare *	Bull thistle	Asteraceae	
Claoxylon sandwicense	*Poola*	Euphorbiaceae	
Cocculus orbiculatus	*Huehue*	Menispermaceae	

[7] An "exclosure is a fencing intended to keep animals (typically grazing ungulates) out.
[8] The "Auwahi Reserve" is a project of the Auwahi Restoration Group, a coalition of private and public agencies spearheaded by the U.S. Geological Survey and 'Ulupalakua Ranch. It is located east of the generator tie-line corridor near the 4000-ft (1220-m) elevation.

Table 7 (continued)

Scientific Name	***Common Name***	***Family***	***ST***
Coprosma foliosa	*Pilo*	Rubiaceae	
Cyrtomium caryotideum	*Kaapeape*	Dryopteridaceae	
Diospyros sandwicensis	*Lama*	Ebonaceae	
Dodonaea viscosa	*Aalii*	Sapindaceae	
*Euphorbia peplus**	Petty spurge	Euphorbiaceae	
*Geranium homeanum**	Cranesbill	Geraniaceae	
*Holcus lanatus**	Yorkshire fog	Poaceae	
Korthalsella complanata	*Hulumoa*	Viscaceae	
*Kyllinga brevifolia**	Kyllinga	Cyperaceae	
*Lantana camara**	Lantana	Verbenaceae	
Lepisorus thunbergianus	*Pakahakaha*	Polypodiaceae	
Mariscus hillebrandii subsp. *hillebrandii*	*Mariscus*	Cyperaceae	
Melicope adscendens	Melicope	Rutaceae	E
*Melinis minutiflora**	Molasses grass	Poaceae	
*Melinis repens**	Natal red top	Poaceae	
Metrosideros polymorpha	*Ohia*	Myrtaceae	
Microlepia strigosa	*Palapalai*	Dennstaedtiaceae) (v. mauiensais	
Myoporum sandwicense	*Naio*	Myoporaceae	
Myrsine lanaiensis	*Kolea*	Myrsinaceae	
Myrsine lessertiana	*Kolea lau nui*	Myrsinaceae	
Nephrolepis sp.	Sword fern	Nephrolepidaceae	
Nestegis sandwicensis	*Olopua*	Oleaceae	
Nothocestrum latifolium	*Aiea*	Solanaceae	
Ochrosia haleakalae	*Holei*	Apocynaceae	
Osteomeles anthyllidifolia	*Ulei*	Rosaceae	
*Oxalis corniculata**	Yellow wood sorrel	Oxalidaceae	
Panicum nephelophilum	*Konakona*	Poaceae	
Panicum tenuifolium	Mountain pili	Poaceae	
*Passiflora subpeltata**	White passion flower	Passifloraceae	
Pellaea ternifolia	*Kalamoho*	Pteridaceae	
*Pennisetum clandestinum**	Kikuyu grass	Poaceae	
*Physalis peruviana**	Cape gooseberry	Solanaceae	
Pipturus albidus	*Mamaki*	Urticaceae	
Pleomele auwahiensis	*Halapepe*	Agavaceae	E
*Poa pratensis**	Kentucky bluegrass	Poaceae	
Pouteria sandwicensis	*Alaa*	Sapotaceae	
Psilotum nudum	*Moa*	Psilotaceae	
Pteridium aquilinum subsp. *decompositum*	Bracken fern	Hypolepidaceae	
Pteris cretica	Cretan brake	Pteridaceae	
*Rubus argutus**	Blackberry	Rosaceae	
Santalum ellipticum	*Iliahialoe*	Santalaceae	
Santalum freycinetianum var. *lanaiense*	*Iliahi*	Santalaceae	E
*Schinus terebinthifolius**	Brazilian pepper tree	Anacardiaceae	

Table 7 (continued)

Scientific Name	*Common Name*	*Family*	*ST*
*Sherardia arvensis**	Field madder	Rubiaceae	
Sicyos pachycarpus	Sicyos	Cucurbitaceae	
*Solanum americanum**	Glossy nightshade	Solanaceae	
*Solanum linnaeanum**	Apple of sodom	Solanaceae	
*Sonchus oleraceus**	Sow thistle	Asteraceae	
Sophora chrysophylla	*Mamane*	Fabaceae	
*Sporobolus indicus**	Smutgrass	Poaceae	
Streblus pendulinus	*Aiai*	Moraceae	
Styphelia tameiameiae	*Pukiawe*	Epacridaceae	
Tetraplasandra oahuensis	*Ohe mauka*	Araliaceae	
*Verbena litoralis**	Vervain	Verbenaceae	
Vicia sativa subsp. *nigra**	Common vetch	Fabaceae	
*Vulpia bromoides**	Brome fescue	Poaceae	
Xylosma hawaiiense	*Maua*	Flacourtiaceae	

Dry Shrubland

Dry shrubland (Figures 3, 25 and 26) occupies a majority of the southern flank of East Maui Volcano, and is thus the dominant vegetation type at the wind farm site as well as the generator tie-line route upslope from the wind farm site to the vicinity of the southwest rift zone (although above about 3000 feet, the area becomes more mesic in charascter). Dry shrubland also occurs along the construction access road. Shrubland is generally characterized by the dominance of shrubs, or low-growing woody plants. This vegetation type is mapped as ***Sc***. However, the shrubs may be dense and comprise the dominant vegetation, or they may be more scattered, with pockets of grassland or barren, rocky ground present or even prominent. In the latter case, typified on recent lava flows, coding is ***ScL***. In some area, rocky outcrops are mixed with areas of accumulated soil, resulting in a mixture of grasses and shrubs (mapped as ***ScP***) utilized as pasture. Shrubland typically develops where conditions (poor soil, low moisture, high salinity, etc.) are simply too harsh for trees to grow. Plant species that grow into trees in more hospitable locations may be present as low, scrubby growth in dry shrublands.

Dry shrubland or scrub (**Sc**) is the dominant vegetation type on the Auwahi wind farm site. Whereas native shrubs (such as *a'ali'i*) are not absent from the site flora, they are far less common than in Kanaio (to the west) or upslope of Pi'ilani Highway. At the wind farm site, *koa haole* (*Leucaena leucocephala*) is the overwhelming dominant species in this vegetation type (Figure 3). This species was reduced by drought conditions (in 2009-10) to scrubby, leafless trunks damaged by ungulate gnawing, although appears poised to recover quickly once rainfall returns to the area. An abundance of axis dear and goats ensure that seedlings of the widely scattered native plants have little chance of taking advantage of any drought-induced set-back to the non-native vegetation.

Figure 25. Dry shrubland on the southern flank of the East Maui Volcano.

Dryland Forest

Dryland forest is present near the coast in the Kīhei/Wailea area where the *kiawe* growth of the savanna gains a closed canopy . This *Kiawe* (*Prosopis*) Forest (Gagne and Cuddihy, 1990; see Figure 23, above) is considered a coastal dry forest type and mapped as ***Fk***. This forest occupies much of the undeveloped lowlands around Mākena and southward to the Kīnaʻu Peninsula, and is the forest encountered along the low elevation portion of the project construction access road and well downslope from the proposed generator tie-line route (west end). The forest has a closed to partially open canopy of *kiawe* trees with a dense growth of buffelgrass (*Cenchrus ciliaris*) covering the ground (by some definitions, this is not a forest, but a savanna. Nearly all of the components of this association are non-native, except for *ʻilima* which can be locally abundant. Various shrubs may be present in low densities. The forest in the surveyed areas thins with increasing elevation, eventually becoming a savanna (Figure 22, above) not far upslope of Wailea. This transition occurs perhaps somewhere below 800 feet (200 meters) ASL west of the proposed generator tie-line route (see description of savanna, above), although extends much further upslope along the proposed construction access road where a mixed forest type (*kiawe/wiliwili/koa haole*; ***Fkw***) occurs (Figure 27). *Wiliwili* is also abundant in the wind farm area as scattered remnant forest pockets separated (typically) by extensive shrub vegetation (shrubland; ***Scw***).

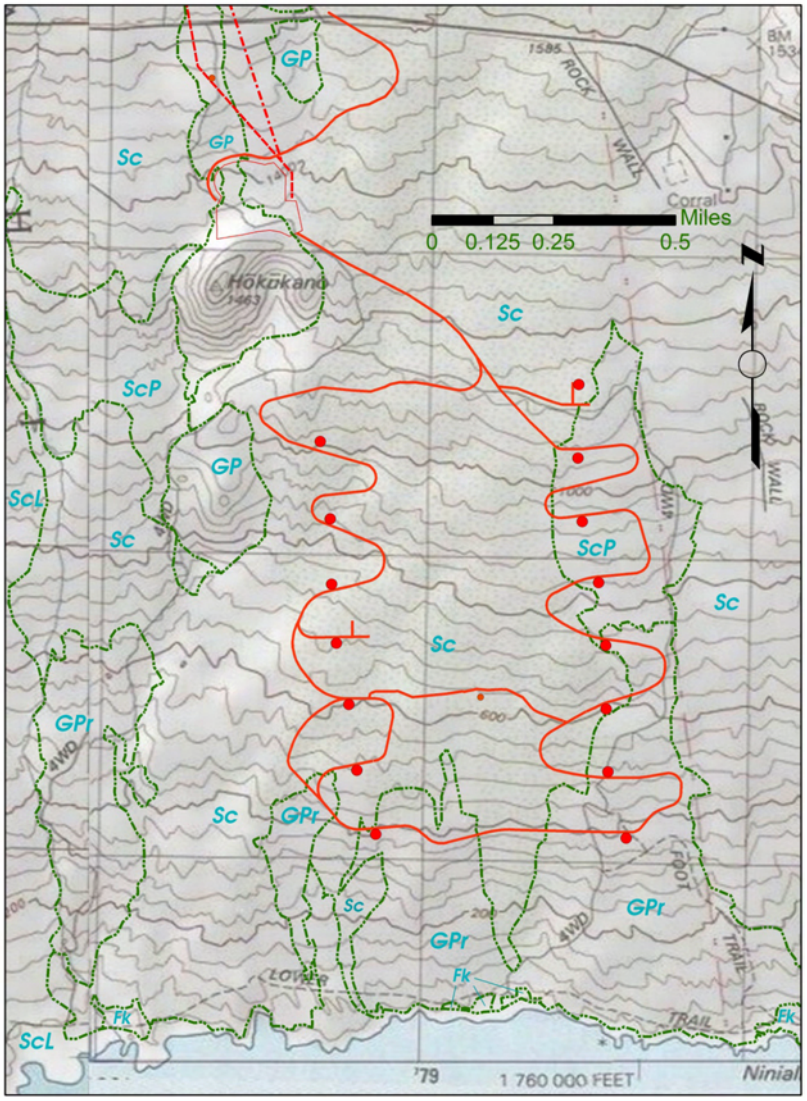


Figure 26. Vegetation zones for the Auwahi Wind Farm site. Scrub vegetation predominates on lava flows of various ages, with small areas of grassland pasture and very rocky pasture present in some areas. For key see Table 6.

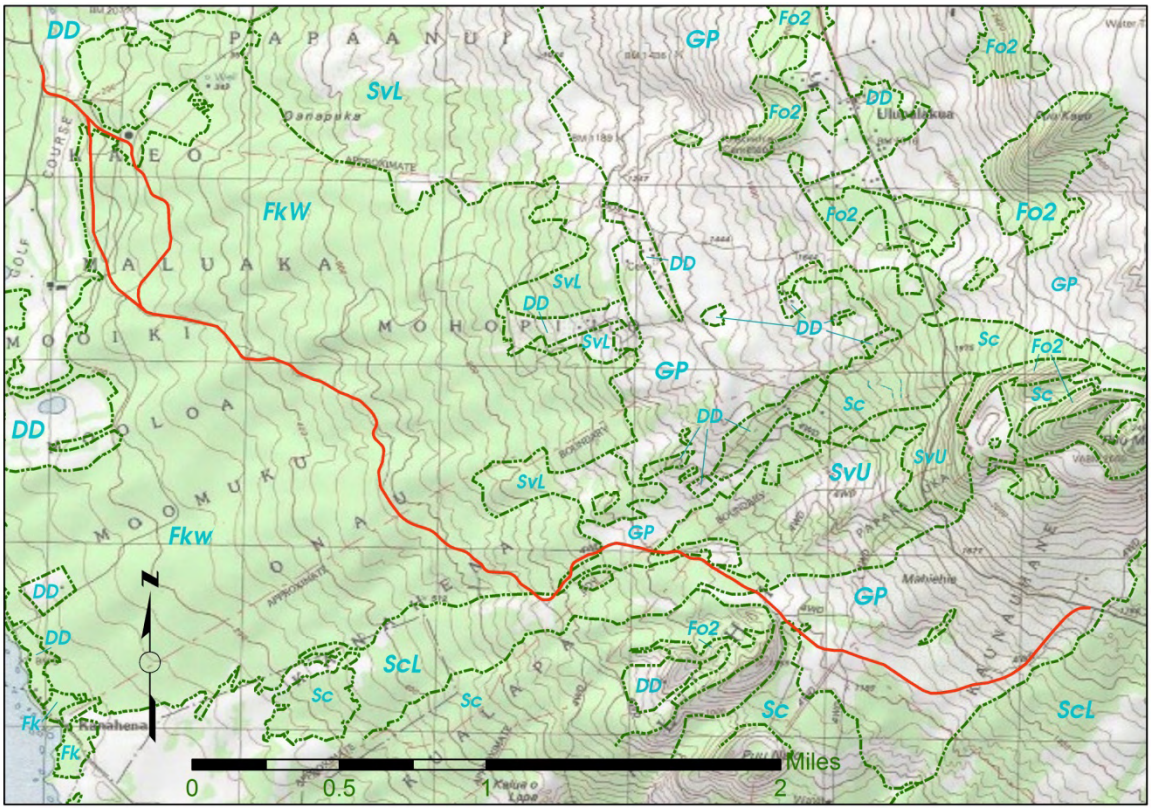


Figure 27. Vegetation zones for the construction access road (Papaka Road; in red) crossing mostly mixed kiawe/wiliwili forest and pasture of 'Ulupalakua Ranch. For key see Table 6.

Wiliwili (Erythrina) Forest is a vegetation type recognized by Gagne and Cuddihy (1990). The *wiliwili* is a summer deciduous tree and a Hawai'i endemic. This plant community type occurs on all the main islands, and is usually characterized by an understory of mixed native shrubs. This forest type is extensively degraded in most places where it occurs naturally on leeward slopes in the rain-shadow belt between about 1,000 and 5,000 feet (300 to 1,500 meters) in elevation (Gagne and Cuddihy, 1990). The prehistoric (pre-settlement) range of this dryland forest ecosystem on Maui covered vast areas of the lowland on West Maui, most of the Maui isthmus, and the west and south slopes of East Maui volcano to an elevation of around 5,000 ft (1,500 m).

The distribution of *wiliwili* forest ecosystem on East Maui in the general project vicinity is shown in Figure 28 (modified from Altenberg, 2007). The largest forest remnant recognized by Altenberg in this area is the "Kanaio" remnant. Next in size order are "Wailea 670," "La Perouse," and "Mākena." Only "Wailea 670" is entered by a project feature: the proposed construction access road near its western end. The large Kanaio remnant shown in Figure 26 lies roughly between the cinder cones, Pimoe and Hōkūkano, or within the western part of the Project site. Altenberg (2007, p. 5) points out: "the reason for the survival of *wiliwili* forest in the habitats that are left are believed to be due to their relative unsuitability for these causes: [fire, cattle grazing, buffelgrass, and kiawe]. The remnants are all on recent

ʻaʻā lava flows whose soil cover is so sparse that it (1) produces an open canopy less able to propagate the fires that swept through many of these areas, (2) does not become choked with buffelgrass, and (3) is a rugged substrate discouraging to cattle." We recognized a similar theme for all of the vegetation in the Project impact areas: significant native vegetation growth is mostly on recent lava flows. For example, the Kanaio lava flow, through the Kanaio NAR, occurred only some 4070 years ago (Bergmanis, et al., 2000).

The remnant forest areas shown in Figure 28 are reportedly from a map by J. Price, and are described as "'areas of extent' rather than 'areas of occupancy'…in other words, the [green shapes] are meant to enclose scattered individuals in each of the populations rather than depicting contiguous forest filling each [shape area]." This description seems odd, since the actual distribution of *wiliwili* forest in this area is that of isolated trees and copses of crowded growth (Figure 28) and, we would suggest, far more extensive than shown, if one is attempting to enclose the distribution of the species on these slopes. This contention is validated by the *wiliwili* distribution surveys in relation to project elements that we made in 2010 (see Figures 16 and 17). On the other hand, the authors are familiar with the small forest remnant shown by Price behind (east and northeast of) Puʻu Olaʻi at the coast labeled "Makena." A few *wiliwili* trees occur in this area, but more than half of the mapped area is dunes, wetland, golf course, houses, and kiawe forest. Thus, we might suggest that the scattered remnants of *wiliwili* along the proposed construction access road (and there are many) could be as significant as the areas mapped by Price (Altenberg, 2007) given that no density definition is provided or perhaps even implied by the latter. Our results would indicate, at least, that *wiliwil*i is far more common in this area than indicated by the Price map.

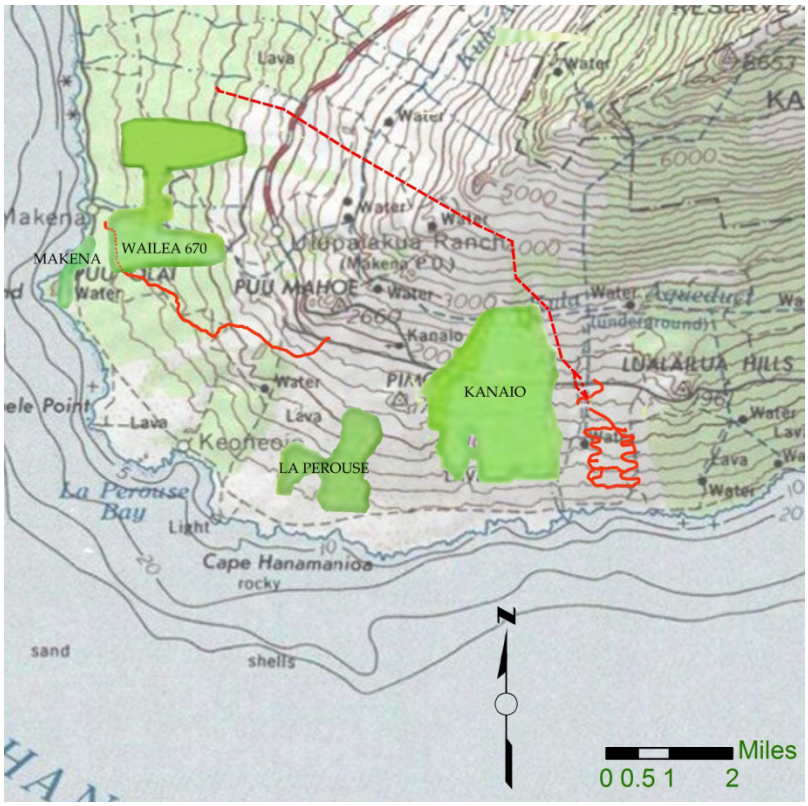


Figure 28. Wiliwili forest remnants (green areas) as mapped by Price (Altenburg, 2007) shown on a topographic map with Auwahi wind farm project elements in red.

Since 2005, an introduced insect (the Erythrina gall wasp, *Quadrastichus erythrinae*) has preyed exclusively on several *Erythrina* species in Hawai‘i, killing most of the widespread ornamental species (*E. variagatis*, but not *E. crista-galli*) and agricultural windbreak species (*E. variegata* “Tropical Coral”), while severely damaging the native *wiliwili*. However, it appears that *E. sandwicensis* may not be as susceptible to the gall wasp as originally thought. The wasp appears to do most of its damage in the dry months, when *wiliwili* are without leaves. We noted that damage to *wiliwili* trees in the ‘Ulupalakua Ranch lands appeared to be rather mild, and the trees were seen to be producing seeds, something that did not occur in 2006 (Art Medeiros, 2007). *Wiliwili* trees are abundant along the proposed construction access road, first appearing mixed in the lowland *kiawe* forest around the 200-foot (60-meter) contour and becoming increasingly numerous along the road as it climbs towards the quarry area at 800 feet (260 meters) west of Pu‘u Naio. This forest area is generally degraded, although the *wiliwili* sometimes form dense copses with an understory of *‘ilima* shrubs (Figure 29).

Although *wiliwili* is not a listed species and thus is not afforded legal protection, it represents an important component (so-called “keystone species”) of the native dry forest, now considered by some to be the most endangered ecosystem in the Hawaiian Islands with less than 10% remaining statewide (HIARNG, 1999; Noss, LaRoe, and Scott, 2001). Our survey provides a detailed distribution of *wiliwili* along the construction road route (within

the designated buffer). Although the impression from the maps (Figures 15 through 17) is one of numerous *wiliwili* in the path of the construction road, the width of the buffer (130 feet) was selected to provide leeway in designing roadway improvements and does not represent an area of actual impact. All of these *wilwili* trees are not threatened because road improvements will largely be within the footprint of the existing Papaka Road. Although this same reasoning applies with respect to the impact on *wiliwili* at the Auwahi Wind Farm site (Figures 5 through 9), proposed access roads follow existing ranch roads in only limited cases.

Figure 29. Inside a native *wiliwili* forest at the Auwahi Wind Farm site.

Listed Plant Species and Critical Habitat

The list of plants found in the Kanaio NAR and Auwahi Reserve (Table 7) represents recently documented occurrences of four of 70 listed (ESA) species historically found on the islands of Maui and nearby Kahoolawe (treated as a unit; USFWS, 2003a). The discussion here considers which of these 70 species might be in the general Project area and which have been documented or reported from the general Project area. Only one specimen of a listed plant was recorded in the areas surveyed (buffers) in 2010.

Both the Project area (wind farm and portion of generator tie-line) were part of "Maui H," an area of 34,843 ac (14,101 ha) of proposed critical habitat encompassing much of the western end of the south-facing slope of East Maui Mountain above about 900 ft (275 m). In a final determination (USFWS, 2003a), 'Ulupalakua and Haleakala Ranch lands were

excluded from "Maui H". Units 09 and 13 in the final rule are east and west of the Project, respectively. Unit 13 is close to the proposed project; Unit 09 is not and therefore not discussed further.

Critical Habitat Maui Unit 13 encloses areas of designated critical habitat for 10 plant species: *Alectryon micrococcus*, *Bonamia menziesii*, *Cenchrus agrimonioides*, *Colubrina oppositifolia*, *Flueggea neowawraea*, *Melicope adscendens*, *M. knudsenii*, *M. mucronulata*, *Sesbania tomentosa*, and *Spermolepis hawaiiensis*. The unit is roughly in the form of a right triangle, with its base along the 900-foot (275-meter) contour, the vertical leg rising along the mountain slope to Pu'u Ouli at about 4000 feet (1,200 meters) ASL, and the hypotenuse through Kanaio. The eastern boundary of this area is the parcel boundary as shown in Figure 1[9]. Thus, the designated area includes, at its upper end, the Kanaio NAR site and is west of the proposed wind farm site and generator tie-line route. USFWS provides boundary points for subareas within Unit 13, but not the unit itself (USFWS, 2003a). However, from the maps provided at the critical habitat web data site (USFWS, 2011) and using the boundary points for *M. mucronulata* published by USFWS (2003a), the top of Unit 13 (the highest and northernmost two points) runs west from the Kanaio-Auwahi boundary at the 4000-foot elevation to almost the 4100-foot elevation[10], possibly corresponding with the upper boundary of the Kanaio NAR in this location. Therefore it is the case that the generator tie-line route, as shown in Figure 10, is always either east of or upslope of the unit. Unit 13 is also critical habitat for Blackburn's sphinx moth (USFWS, 2003b).

Seven of the plants with designated habitat areas in Unit 13 are shrubs or trees known from the dry to mesic native forest at higher elevations (i.e., Auwahi and Kanaio). The trees, *Colubrina oppositifolia* and *Flueggea neowawraea*, are presently not known to occur in Unit 13. Of the three species of *Melicope* (=*Pelea*), only a single individual of *M. adscendens*, a sprawling shrub, is known from Unit 13. Thirteen individuals of the small shrub, *'ohai* or *Sesbania tomentosa*, are known from Unit 13 on Pimoe and Pohakea cinder cones (at around 1200 feet [370 meters] elevation, west of the Auwahi Wind Farm site).

Cenchrus agrimonioides is a grass found on dry, rocky slopes. It is a moderately large, coarse grass, distinctive in form, and would be recognizable in the dry season if not heavily grazed by ungulates. Two of the listed species might not be observed if surveyed for during an extended dry period. *Bonamia menziesii* is a liana (a perennial, woody vine) found in dry to mesic forests. A few plants are known from the Kanaio NAR, but this plant could occur in the lowland dry *wiliwili* forest. *Spermolepis hawaiiensis* is an annual herb that would be difficult to observe in the dry season or during drought conditions, but has a known population of about 100 individuals in the Kanaio NAR, lowland dry shrubland (USFWS, 2003a).

[9] Being also the traditional boundary between the moku of Honoa'ula and moku of Kahikinui, and the boundary between the *ahupua'a* of Kanaio and "A'uahi" (Bordner, 1995) shown in Figures 10 and 11.

[10] This upper boundary would be located roughly midway between the ranch road at the base of Pu'u Ouli and the ranch road near the top of Pu'u Ouli.

Two listed species recorded from the Auwahi Reserve (Table 7), *Bidens micrantha* ssp. *kalealaha* and *Santalum freycinetianum* var. *lanaiense,* do not have designated critical habitat areas in Unit 13. *B. micrantha* is a perennial herb and has a critical habitat area within Unit 09, where a very few plants still exist. Unit 09 is located well east of both the generator tie-line route and the Auwahi Reserve. The rare variety of sandlewood known as the *Lānaʻi ʻiliahi* (*S. freycinetianum* var. *lanaiense*) has no critical habitat designated and recovery efforts are focused on the Lānaʻi Island population (USFWS, 2009). Several hundred individuals of this listed variety are known from Auwahi (Medeiros, Davenport, and Chimera, undated). A single shrub-like individual was recorded within the generator tie-line buffer at a little above 3,100 feet (945 meters) ASL (see Figure 12 for location).

Stream and Wetland Resources

Although final determination rests with the local District Engineer, in our judgment, no aquatic features within the definitions of wetlands and streams subject to USACE jurisdiction are present on the project property or vicinity, and thus none would be impacted by the proposed project. USFWS (2010b) maps show no wetlands within or close to project areas.

Avian Resources

The findings of the avian survey are consistent with the habitat present within the three component parts of the proposed project. A total of 23 avian species were recorded during station counts (Table 4). Two additional species, Chukar (*Alectoris chukar*), and Barn Owl (*Tyto alba*) were recorded as incidental observations. We were a little surprised at the number of Barn Owls we saw; we recorded 27 sightings over the course of nine evenings. All but one of the species detected, Short-eared Owl, are considered to be alien to the Hawaiian Islands. No species currently listed as endangered, threatened or proposed for listing under either federal or State of Hawaii endangered species statutes was recorded during the course of this survey.

No indigenous migratory species were recorded during the course of this survey, which is not surprising since the surveys were conducted in June, a time of year when almost all of the regularly occurring indigenous migratory shorebird species normally encountered in Hawaiʻi are not present. It is likely that several migratory shorebird species are present on the site between late July and late April each year. The most likely species to be expected are Pacific Golden-Plover (*Pluvialis fulva*), Ruddy Turnstone (*Arenaria interpres*), and Wandering Tattler (*Tringa incana*). All of these species are commonly encountered in Hawaiʻi during the fall and winter months – they all nest in the high Arctic during the late spring and summer months, returning to their wintering grounds in Hawaiʻi, Japan, Okinawa, Polynesia, Micronesia, Melanesia, New Zealand, Australia, Indonesia, Philippines, southern China, southeast Asia, Bangladesh, Nepal, India, Sri Lanka, Pakistan, Iran, Bahrain, and northeast and southern Africa (Johnson and Conners 1996). Wintering birds usually leave Hawaiʻi for their trip back to the Arctic in late April or the very early part of May, and

return to their wintering grounds in late July. Some individuals overwinter in Hawai'i, and thus are present all year.

It was beyond the scope of these surveys to conduct nocturnal surveys for two listed pelagic seabird species known to occur on Maui. The two species in question are the endangered Hawaiian Petrel, and the threatened endemic sub-species of the Newell's Shearwater, both of which likely over-fly the project area between April and the end of November each year.

Mammalian Resources

The findings of the mammalian survey are consistent with the habitats present within the three component parts of the Project. As previously mentioned, we detected 11 mammalian species during the course of these surveys. Although we did not encounter any Hawaiian hoary bats, Hawaiian hoary bats have been seen within the general area in low numbers over the years (Erdman, 2007), and would be expected to use resources within the Project site on a seasonal basis. However, considering the xeric conditions, relatively little use of the wind farm site by this species would be anticipated.

We saw one roof rat and one European house mouse within the study area. It is to be expected that the other two established rodent species present on the Island of Maui, Norway rat (Rattus norvegicus) and Polynesian rat (Rattus exulans hawaiiensis), use resources within the Project area on a seasonal basis. All of these introduced rodents are deleterious to remaining native ecosystems and the native floral and faunal species that are dependent on them for their survival.

As expected on an active cattle ranch, we encountered large numbers of cows, lesser numbers of horses, and several dogs, including two pit bulls that were seen harassing cattle on the wind farm site. We also encountered large numbers of axis deer and several large herds of goats, including one herd of over 150 animals. Habitats on the wind farm site and the land immediately mauka of Pi'ilani Highway clearly show the effects of the large number of both domestic and feral ungulates present within this extremely xeric setting.

Conclusions

Botanical Resources

The lands proposed for development of the Auwahi Wind Farm are floristically degraded grass and shrublands utilized as pasture for cattle, yet still harboring scattered remnants of the native forest and shrublands that occupied the area a little more than a century ago. It is evident that much of the preservation of the native flora is the result of the complex geology, and the presence of relatively recent volcanic activity that has occurred along the southwest rift zone of East Maui Mountain. In places at higher elevations crossed by the proposed generator tie-line, the remnant mesic forest is invaded by alien plants, but reasonably intact, supporting a high diversity of indigenous and endemic species found in few other places in the Islands.

Adherence to improving existing roads, to the extent possible, will minimize impacts to botanical resources. New roads will need to be put in to reach the wind turbines distributed across the Wind Farm site. With the exception of the many copses of wiliwili, which should be avoided to the extent possible, other natives on the site are few, being very scattered remnants of a native ecosystem that no longer exists at this location. No listed plant species are known from the Auwahi Wind Farm site.

The proposed improvements to the existing Pua Pala (or Papaka) Road between Wailea and Piʻilani Highway (construction access road) will have no impact on protected species, as none was observed, nor are any known, from the route. However, three species of interest occur in this area: wiliwili, maiapilo, and tree tobacco.

With respect to the generator tie-line route, one listed species of plant (Santalum freycinetianum var. lanaiense) was observed within the buffer area. Although a detailed survey of the pasture and savanna on the western slope of East Maui Mountain was not undertaken in 2010, the 2007 survey revealed this area to have no potential for harboring listed plant species and only a small area on a recent lava flow (actually on the rift zone) around 4,100 feet (1250 meters) ASL where native plants were even recorded.

The same conclusion with respect to listed species applies to the proposed generator tie-line route between the Auwahi Wind Farm site and about the 3000-foot (900-meter) elevation on the south slope of the mountain. However between 3000 feet (900 meters) and 4000 feet (1200 meters) ASL the route passes through remnant native montane forest and shrubland known to support several listed species of plants (see Table 7). The mapping of individual native trees within this area (Figures 10 and 11) will allow placement of generator tie-line poles and grading of access roads to avoid both listed species and native trees that are important components of the montane "forest" ecosystem. Several ranch access roads already occur in the area, minimizing the need for substantial grading of additional roads.

Avian and Mammalian Resources

Faunal resources detected during the course of these surveys were predominately alien or non-native. These findings were to be expected given the habitat present in the majority of the three main component parts of the Project. We observed only one native avian species, and no bats.

Potential Impacts to Protected Species

Lānaʻi ʻiliahi

As noted above, only a single individual of a listed plant species (in this case a subspecies of sandalwood, *S. freycinetianum* var. *lanaiense*) was recorded from within the buffers established for the 2010 survey. The single, *Lānaʻi ʻiliahi* was recorded from the generator tie-line route (see Figure 12) and the subspecies is known from the area (Mederios et al., undated). An impact on this plant can be avoided by not placing either an access road or a support pole in the vicinity of the plant. However, in view of the fact that security from ungulate browsers could be compromised by proposed changes in the Kanaio NARS fence location, it is recommended that a separate exclosure be built around the plant.

Hawaiian Hoary Bat

As previously discussed, it is likely that Hawaiian hoary bats occasionally use resources in the general Project area on a seasonal basis. What impacts a wind generation facility would have on this listed species are not known. Within the continental U. S., hoary bats (*Lasiurus cinereus*), a sister species of the native bat, have been recorded being taken by wind turbines (Arnett et al., 2008).

Hawaiian Petrel and Newell's Shearwater

Wind turbines have the potential to take Hawaiian Petrels and Newell's Shearwaters; one Hawaiian Petrel has been taken by another wind farm on Maui in 2007 (William Standley, USFWS personal communication, 2007). It is beyond the scope of these surveys to address the potential threat that the proposed Project poses to either of these listed pelagic seabird species.

Recommendations

- Due to the potential for Hawaiian Petrels, or possibly Newell's Shearwaters, within the general Project area, if exterior lighting is installed in conjunction with the Project, it is recommended that lights be shielded to reduce the potential for interactions of nocturnally flying birds (Reed et al., 1985; Telfer et al., 1987).
- While no known listed species were identified on the Auwahi Wind Farm site, a number of large native trees (including *wiliwili* forest remnants) exist. These areas should be avoided to the extent possible.
- Plant species mapping for the segment of the generator tie-line route passing through the native mesic forest and/or shrubland below Puʻu Oʻuli should be consulted to minimize or avoid impacts to rare native plant species. At least one

individual of a listed species (a subspecies of *'iliahi*) was recorded in the area and must be suitably protected from generator tie-line construction impacts; a separate ungulate exclosure fence should be constructed around this sandalwood individual.

- Replanting of selected native plant species characteristic of the Auwahi/Kanaio area is highly recommended for locations where replanting may be required to mitigate impacts or for landscaping at the wind farm site. The lowland (windfarm site) species—notably *'a'ali'i* (*Dodonaea viscosa*), *naio* (*Myoporum sandwicense*), *'iliah*i (*Santalum ellipticum*), *alahe'e* (*Psydrax odorata*), and *wiliwili* (*Erythrina sandwicensis*)—are easily grown from seed or obtained from local nurseries and adapt well to landscape use. Once established, these plantings should require no or minimal watering. Native plant nurseries on Maui could also supply *hao* (*Rauvolfia sandwicensis*), *'ohe makai* (*Reynoldsia sandwice*nsis), and *'akia* (*Wikstroemia oahuense*), providing additional interest and support for a variety of native trees, but these species are not widely used in landscaping. There are many herbaceous natives that do well in xerophytic situations that could be used to complement the landscaping at the site.

Glossary

ʻAʻā– Clinker lava formed by slow moving lava flows
Ahupuaʻa – Traditional Hawaiian land division, usually extending from the uplands to the sea.
Alien – Introduced to Hawaiʻi by humans.
Crepuscular – Twilight hours.
Edaphic – Produced by, or influenced by the soil
Endangered – Listed and protected under the Endangered Species Act of 1973, as amended as an endangered species.
Endemic – Native and unique to the Hawaiian Islands
Incidental observation – A species not counted during station counts, but seen within the project area.
Indigenous – Native to the Hawaiian Islands, but also found elsewhere naturally.
Kīpuka – An oasis in a lava flow usually containing vegetation, often a refugia for native species
Mauka – Upslope, towards the mountains.
Makai – Down-slope, towards the ocean.
Mesic - Neither very wet nor very dry with respect to the needs of the plant life.
Naturalized – An alien organism that has become established in an area that it is not native to over time, without further human assisted releases or plantings.
Nocturnal – Night-time, after dark.
Orographic – In this case the effects of mountains in forcing moist air to rise
Pelagic – An animal that spends its life at sea – in this case seabirds that only return to land to nest and rear their young.
Physiographic – Physical geography
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles.
Threatened – Listed and protected under the ESA as a threatened species.
Volant – Flying, capable of flight, as in flying insect.

DLNR – Hawaii State Department of Land & Natural Resources.
DOFAW – Division of Forestry and Wildlife
ESA – Federal Endangered Species Act of 1973, as amended.
GPS – Global Positioning System
MECO – Maui Electric Company
NARS – State of Hawaii, Natural Area Reserves System
USFWS – United States Fish & Wildlife Service.

Literature Cited

Altenberg. L. 2007. Remnant wiliwili forest habitat at Wailea 670, Maui, Hawaiʻi. Special report, Maui Ecosystems at Risk. 18 http://www.santafe.edu/~altenber/DISTRIB/Wailea670.v1.pdf last visited, September 5, 2007

American Ornithologist's Union. 1998. *Check-list of North American Birds*. 7th edition. AOU. Washington D.C. 829pp.

_____. 2000. Forty-second supplement to the American Ornithologist's Union *Check-list of North American Birds*. Auk 117:847-858.

Arnett E. B, Brown K, Erickson WP, et al. 2008. Patterns of fatality of bats at wind energy facilities in North America. J Wildlife Management 72: 61-78.

Banks, R. C., C. Cicero, J. L. Dunn, A. W. Kratter, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, and D. F. Stotz. 2002. Forty-third supplement to the American Ornithologist's Union *Check-list of North American Birds*. Auk 119:897-906.

_____. 2003 Forty-fourth supplement to the American Ornithologist's Union *Check-list of North American Birds*. Auk 120:923-931.

_____. 2004 Forty-fifth supplement to the American Ornithologist's Union *Check-list of North American Birds*. Auk 121:985-995.

_____. 2005 Forty-sixth supplement to the American Ornithologist's Union *Check-list of North American Birds*. Auk 122:1031-1031.

_____. 2006 Forty-seventh supplement to the American Ornithologist's Union *Check-list of North American Birds*. Auk 123:926-936.

Banks, R. C., C. R. Terry Chesser, C. Cicero, J. L. Dunn, A. W. Kratter, I. J. Lovette, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, and D. F. Stotz. 2007 Forty-eighth supplement to the American Ornithologist Union *Check-list of North American Birds*. Auk 124:1109-1115.

Banks, R. C., C. R. Terry Chesser, C. Cicero, J. L. Dunn, A. W. Kratter, I. J. Lovette, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, and D. F. Stotz, and K. Winker. 2008 Forty- ninth supplement to the American Ornithologist Union *Check-list of North American Birds*. Auk 125:758-768.

Chesser, R. T., R. C. Banks, F. K. Barker, C. Cicero, J. L. Dunn, A. W. Kratter, I. J. Lovette, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, and D. F. Stotz, and K. Winker. 2009. Fiftieth supplement to the American Ornithologist Union *Check-list of North American Birds*. Auk 126:1-10.

_____. 2010. Fifty-first supplement to the American Ornithologist Union *Check-list of North American Birds*. Auk 127:726-744.

Commission on Water Resource Management (CWRM). 2010. Hawaii Drought Monitor. Available online at http://hawaii.gov/dlnr/drought/; last visited September 28, 2010.

Bergmanis, et al. 2000. Rejuvinated volcanism along the southwest rift zone, East Maui, Hawaiʻi. Bull. Volcanol., 62: 239-255.

Bordner, R. 1995. Contested images of place in a multiucultural context: the ahupuaʻa of Kanaio and Aʻuahi, Maui. Ph.D. dissertation, Dept. of Geography, Univ. of Hawaii. Available at: SocialResearch Systems. http://www.socialresearchsystems.com/files/KanaioDissv1.pdf

Department of Business, Economic Development & Tourism. (DBEDT). 2010. Hawaii Statewide GIS Program. Online at: http://www.state.hi.us/dbedt/gis/

Department of Land and Natural Resources. (DLNR). 1998. Indigenous Wildlife, Endangered and Threatened Wildlife and Plants, and Introduced Wild Birds. Department of Land and Natural Resources. State of Hawaii. Administrative Rule §13-134-1 through §13-134-10, dated March 02, 1998.

Dicus, H. 2007. Drought hits Maui, worsens on Big Island. *Pacific Business News*, Wednesday, June 13, 2007.Online at :http://pacific.bizjournals.com/pacific/stories/2007/06/11/daily23.html.

Erdman, S.P. 2007. Personal communication with Reginald David over the historical presence of wildlife on Ulupalakua Ranch.

Federal Register. 2003. Department of the Interior, Fish and Wildlife Service, 50 CFR 17. Endangered and Threatened Wildlife and Plants: Designation of Critical Habitat for the Blackburn's Sphinx Moth; Final Rule. Federal Register, 68 No. 111 (Tuesday, June 10, 2003): 34710-34766.

_____. 2005. Department of the Interior, Fish and Wildlife Service, 50 CFR 17. Endangered and Threatened Wildlife and Plants. Review of Species That Are Candidates or Proposed for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petition; Annual Description of Progress on Listing Actions. Federal Register, 70 No. 90 (Wednesday, May 11, 2005): 24870-24934.

Gagne, W. C., and L. W. Cuddihy 1990. Classification of Hawaiian Plant Communities. In: Wagner, W.L., D.R Herbst, and S.H. Sohmer. 1990. *Manual of the Flowering Plants of Hawaiʻi*. University of Hawaii Press, Honolulu, Hawaii 1854 pp.

Grumbles, B. H., and J. P. Woodley, Jr. 2008. Clean Water Act jurisdiction following the U. S. Supreme Court's decision in *Rapanos v. United States* & *Carabell v. United States*. Issued by USEPA & USACOE. 13 pp.

Guinther, Eric. 2010. Auwahi Windfarm Project, Jurisdictional Waters Considerations. AECOS Consultants letter report dated May 20, 2010. 3 pp.

Hamer Environmental. 2010. Endangered bird and bat surveys conducted at the south Auwahi wind resource area, Maui, Hawaiʻi. Prepared for Sempra Generation, San Diego, CA. Prepared by Hamer Environmental, L.P. Mount Vernon, WA.

Hawaii Army National Guard (HIARNG). 1999. Secretary of defense Environmental Security Awards, Hawaii Army National Guard, Natural Resources Conservation.

Hawaii Ecosystems at Risk project (HEAR). 2007. Natural Areas of Hawaii, Auwahi. (URL: http://www.hear.org/naturalareas/auwahi/index.html(last visited on September 5, 2007)

HEAR Website. undated. Natural Areas of Hawaii. Auwahi. http://www.hear.org/naturalareas/auwahi/

Johnson, O. W. and P. G. Connors. 1996. Pacific Golden-Plover (*Pluvialis fulva*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/202

Lamb, Samuel. 1981. Native Trees and Shrubs of the Hawaiian Islands. Sunstone Press, SantaFe.

Medeiros, A. 2007. Quoted in "Hope for Wiliwili Trees Infested with Gall Wasp. Environment Hawai`i, 18(3): 6-7.

_____, C. F. Davenport, and C. G. Chimera. Undated. Auwahi: Ethnobotany of a Hawaiian dryland forest. U.S. Geol. Survey, Biol. Resources Div., Haleakala Field Sta., Makawao, HI. 49 pp.

_____. L. L. Loope, and C. G. Chimerea. 1993. Kanaio Natural Area Reserve, biological inventory and management recommendations. Natural Area Reserve System, State of Hawaii.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 2001. Endangered ecosystems of the United States: A preliminary assessment of loss and degradation.

Palmer, D. D. 2003. *Hawai`i's ferns and fern allies*. University of Hawaii Press, Honolulu. 324 pp.

Pukui , M. K., S. H. Elbert, and E. T. Mookini. 1976. *Place Names of Hawaii*. University of Hawaii Press. Honolulu, Hawai'i. 289 pp.

Reed, J. R., J. L Sincock, and J. P. Hailman 1985. Light Attraction in Endangered Procellariform Birds: Reduction by Shielding Upward Radiation. Auk 102: 377-383.

Resnick, J. M. 1977. A history of vegetation change: man and the vegetation at Honua'ula, Maui, 1786 to present. MA Thesis, Univ. of Hawaii, Dept. of Geography.

Rock, Joseph. 1913. *The Indigenous Trees of the Hawaiian Islands*. Honolulu.

Sherrod, D. R., J. M. Sinton, S. E. Watkins, and K. M. Brunt. 2007. Geologic map of the State of Hawai'i, Sheet 7—Island of Maui. U.S. Geological Survey, Open-File Report 2007-1089. Sheet 7 of 8. Available at URL: http://pubs.usgs.gov/of/2007/1089/Maui_ 2007.pdf; Last viewed May 11, 2010.

Staples, G. W. and D. R. Herbst. 2005. *A Tropical Garden Flora. Plants Cultivated in the Hawaiian Islands and other Tropical Places.* Bishop Museum, Honolulu. 908 pp.

Telfer, T. C. , J. L. Sincock, G. V. Byrd, and J. R. Reed. 1987. Attraction of Hawaiian seabirds to lights: Conservation efforts and effects of moon phase. Wildlife Society Bulletin 15:406-413.

Tomich, P.Q. 1986. *Mammals in Hawaii*. Bishop Museum Press. Honolulu, Hawaii. 37 pp.

U.S. Fish & Wildlife Service (USFWS). 2003a. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for 60 Plant Species from the Islands of Maui and Kahoolawe, HI. Final Rule. 50 CFR Part 17 (*Federal Register* 68(93): 25933-25982; May 14, 2003).

_____. 2003b. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for 60 Plant Species from the Islands of Maui and Kahoolawe, HI. Final Rule. 50 CFR Part 17 (*Federal Register* 68(93): 25933-25982; May 14, 2003).

_____. 2005a. Department of the Interior, Fish and Wildlife Service, 50 CFR 17. Endangered and Threatened Wildlife and Plants. Review of Species That Are Candidates or Proposed for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petition; Annual Description of Progress on Listing Actions. *Federal Register*, 70 No. 90 (Wednesday, May 11, 2005): 24870-24934.

_____. 2005b. Endangered and Threatened Wildlife and Plants. 50CFR 17:11 and 17:12 (Tuesday, November 1, 2005).

_____. 2010a. USFWS Threatened and Endangered Species System (TESS). http://ecos.fws.gov/tess_public/StartTESS.do

_____. 2010b. USFWS Wetland Mapper.http://www.fws.gov/wetlands/Data/Mapper.html

_____. 2011. Critical Habitat Portal. http://criticalhabitat.fws.gov

Wagner, W.L., D.R Herbst, and S.H. Sohmer. 1990. *Manual of the Flowering Plants of Hawai'i*. University of Hawaii Press, Honolulu, Hawaii 1854 pp.

Wagner, W.L. and D.R. Herbst. 1999. *Supplement to the Manual of the flowering plants of Hawai'i*, pp. 1855-1918. *In:* Wagner, W.L., D.R. Herbst, and S.H. Sohmer, Manual of the flowering plants of Hawai'i. Revised edition. 2 vols. University of Hawaii Press and Bishop Museum Press, Honolulu.

Wikipedia. 2007. Savanna. http://en.wikipedia.org/wiki/Savanna; last visited Oct. 16, 2007).

Appendix E-1
Final Archaeological Inventory Report

Pacific Legacy

Historic Preservation

FINAL

Archaeological Inventory Survey for the Proposed Auwahi Wind Farm Ahupua‘a of Auwahi, District of Kahikinui, Island of Maui, Hawai‘i [TMK (2) 1-9-001:006]

Pacific Legacy: Exploring the past, informing the present, enriching the future.

CULTURAL RESOURCES CONSULTANTS

Hawai‘i Offices:
Kailua, O‘ahu
Hilo, Hawai‘i

California Offices:
Arnold
Berkeley
El Dorado Hills
Quartz Hill

This page intentionally left blank.

FINAL

Archaeological Inventory Survey for the Proposed Auwahi Wind Farm Ahupuaʻa of Auwahi, District of Kahikinui, Island of Maui, Hawaiʻi

[TMK (2) 1-9-001:006]

Prepared by:
William A. Shapiro, M.A.
Paul L. Cleghorn, Ph.D.
Patrick V. Kirch, Ph.D.
Lisa Holm, Ph.D.
Elizabeth L. Kahahane, B.A.
and
Kimberly M. Mooney, B.A.

Pacific Legacy, Inc.
30 Aulike Street, Suite 301
Kailua, HI 96734

Prepared for:
Auwahi Wind Farm, LLC
101 Ash Street
San Diego, CA 92101-3017

June 2011

ACKNOWLEDGEMENTS

Pacific Legacy sincerely acknowledges all those who contributed to the successful completion of the archaeological inventory survey for the proposed Auwahi Wind Farm Project. Sempra Generation, Inc. provided guidance throughout the project; in particular, Joan Heredia, Mitch Dmohowski, Dan Hyatt, and Thomas Jennings made major efforts to avoid as many resources as possible during project design and component changes.

We are grateful for the assistance and support of the ʻUlupalakua Ranch personnel without whose help the fieldwork could not have been accomplished. Sumner Erdman offered invaluable insights into the previous land uses of the ranch, assisted in interpreting the archaeological features, and participated in the field tours of the identified resources. The ranch staff gave logistical support and assistance during the entire project with special thanks going to Diana, Ann, Kaimi, and Jimmy.

The 2007 and 2010 work, field crews worked long hard days often under difficult field conditions. We want to thank all of those who participated. In 2007, the crew included Lisa Holm, Kari Jones, Solomon Kailihiwa, James McIntosh, Sidsel Millerstrom, Jeff Putzi, and Tanya Souza. In 2010, the crew consisted of William Shapiro, Chris Azevedo, Katherine Chao, Patrick Day, Caleb Fechner, Lisa Holm, Elizabeth Kahahane, James McIntosh, Kimberly Mooney, Kelene Pfennig, Mary Schmidt, Tara Seaver, Jet Stoner, Dan Trout, and Reid Yamasato. Special thanks go to Lisa Shapiro and Patty Elison for volunteering during the fieldwork. GIS efforts were capably performed by Elizabeth Kahahane and laboratory analyses were overseen and written by Kimberly Mooney – all of these efforts contributed significantly to the report presented here. Paul Cleghorn and John Holson were the co-principal investigators for the project and provided guidance throughout both phases of fieldwork and reporting. Lisa Holm was the field director in 2007 and William Shapiro was field director in 2010. Visitors to the project area who provided research insights and comments included Thomas Jackson, Jenny Kahn, Morgan Davis, and Charley Maxwell. Finally, we need to thank Pat Kirch whose collaboration on this report and sharing of his perspectives on the settlement at Auwahi and Kahikinui made this, not only a more pleasant project to work on, but an important contribution to Hawaiian archaeology.

ABSTRACT

This report presents a summary of the results of an archaeological inventory survey conducted at the proposed Auwahi Wind Farm located on ʻUlupalakua Ranch Lands in the *ahupuaʻa* of Auwahi, Kahikinui District, Island of Maui. The Auwahi Wind Farm project consists of several components: a 282 acre wind farm; a 5 mile long construction access road, and 9 miles of generator-tie line terminating at a proposed new Interconnection substation. The archaeological inventory survey was conducted in two phases. In 2007, the 1,450 acre wind farm parcel, Generator-Tie Line, and access road routes underwent a 100 percent pedestrian survey. Using data provided by this survey, engineers designed wind farm facilities to avoid as many of the archaeological resources as possible and especially avoiding those that were thought to be most sensitive (i.e., ceremonial/religious structures and possible human burials). In 2010, a detailed recording and testing phase was conducted on those archaeological resources that were within the area of potential effect (APE). A total of 238 archaeological sites composed of 1,881 features were recorded in detail, with their locations accurately recorded using GPS technology. Because of design changes during the course of fieldwork, some of the sites recorded in detail are no longer located within the APE. The total number of sites and features in the current APE are 170 sites and 995 features. Test excavations were conducted in 37 features with the goal of obtaining dateable material to establish chronological parameters for the archaeological resources in the area. The APE was changed partially to avoid sites containing human bone, ceremonial sites, or sites that were thought to contain human burials. Every effort has been made to avoid these sensitive sites.

The results of the archaeological inventory survey at Auwahi have added significantly to our knowledge about the prehistory of the *moku* of Kahikinui. The pattern of settlement in this area has been well documented; innovative traditional Hawaiian agricultural techniques have been discovered and described; and numerous radiocarbon dates have added to our understanding of settlement in leeward Maui. The results of our work are well described in the Summary and Discussion Section of this report.

The significance of the archaeological resources at Auwahi have been assessed and recommendations have been made to mitigate the adverse effects of the planned wind farm development.

TABLE OF CONTENTS

1.0 INTRODUCTION **1**

1.1 Project Description 2
1.2 Regulatory Context and SHPD Consultation 6
1.3 Anticipated Settlement Patterns 7
1.4 Pacific Legacy Staff 7
1.5 Environmental Setting 8
1.6 Description of Soils 12
1.6.1 Wind Farm 12
1.6.2 Pāpaka Road 13
1.6.3 Generator-Tie Line 14
1.6.4 Interconnection Substation and Access Road 16

2.0 METHODS **18**

2.1 2007 Pedestrian Survey 18
2.1.1 Wind Farm 18
2.1.2 Generator-Tie Line Corridor Survey 18
2.1.3 Pāpaka Road Survey 18
2.1.4 2007 Survey Constraints 19
2.2 2010 Detailed Recording and Testing 19
2.3 Terminology Used in Recording Resources 20
2.4 Primary Feature Types 21
2.5 Feature Function 22

3.0 BACKGROUND **23**

3.1 Historical Background 23
3.2 Previous Archaeological Research in Kahikinui 28

4.0 2007 PEDESTRIAN SURVEY RESULTS **32**

4.1 Wind Farm 32
4.2 Generator-Tie Line Corridor 35
4.3 Pāpaka Road Corridor 39

5.0 2010 DETAILED RECORDING AND TESTING RESULTS **42**

5.1 Summary of Resources Recorded 42
5.1.1 Ceremonial/Religious Resources 68
5.1.2 Burials 71
5.1.3 Possible Burials 72
5.1.4 Traditional Habitation Features 80
5.1.5 Traditional Agriculture 80
5.1.6 Transportation Features 83
5.1.7 Historic Features 83

5.2 Test Excavations 85
5.3 Wind Farm Tested Sites 86
5.3.1 Site 50-50-15-6832 86
5.3.2 Site 50-50-15-6833 89
5.3.3 Site 50-50-15-6838 91
5.3.4 Site 50-50-15-6839 93
5.3.5 Site 50-50-15-6845 94
5.3.6 Site 50-50-15-6848 95
5.3.7 Site 50-50-15-6851 108
5.3.8 Site 50-50-15-6852 110
5.3.9 Site 50-50-15-6853 115
5.3.10 Site 50-50-15-6854 115
5.3.11 Site 50-50-15-6855 118
5.3.12 Site 50-50-15-6857 120
5.3.13 Site 50-50-15-6860 121
5.3.14 Site 50-50-15-6861 124
5.3.15 Site 50-50-15-6864 125
5.3.16 Site 50-50-15-6951 134
5.4 Generator-Tie Line Tested Sites 138
5.4.1 Site 50-50-15-6819 138
5.4.2 Site 50-50-14-6865 139
5.4.3 Site 50-50-15-6871 143
5.5 Pāpaka Road Tested Sites 147
5.5.1 Site 50-50-14-6931 147
5.5.2 Site 50-50-14-6939 151
5.5.3 Site 50-50-14-6940 157
5.5.4 Site 50-50-14-6943 160

6.0 RESULTS OF LABORATORY ANALYSES 166

6.1 Artifact and Manuport Analyses 166
6.2 Midden Analysis 215
6.3 Radiocarbon Dating 229

7.0 SIGNIFICANCE ASSESSMENTS ..... ERROR! BOOKMARK NOT DEFINED.

8.0 RECOMMENDED TREATMENTS 242

8.1 "The Archaeology of Hydrology" 242
8.2 Development of the Formal Field System in "Gobi Desert" 244
8.3 Settlement Chronology in Auwahi—Is it Earlier than Elsewhere in Kahikinui? 245
8.4 Household Organization and Structure 246
8.5 Post-Contact Transformations to Hawaiian Rural Society 247
8.6 Impact of Hawaiian Land Use on Dryland Forest Environment 249
8.7 Human Burials 250

9.0 SUMMARY AND DISCUSSION 266

9.1 Site Avoidance 268
9.2 Auwahi in a Regional Kahikinui Perspective 268

9.3 Auwahi and the Ahupua‘a of Kahikinui 269
9.4 Chronology of Occupation and Land Use in Auwahi 272
9.5 Settlement Patterns, Population Density and Distribution 277
9.6 Agricultural Systems and Water Control 283
9.7 The Ritual Landscape 286

10.0 BIBLIOGRAPHY 289

APPENDICES (SEE ENCLOSED CD) 296

APPENDIX A. 2007 Site Data
APPENDIX B. Site Attribute Table
APPENDIX C. 2010 Site Records
APPENDIX D. Artifact and Manuport Catalogue
APPENDIX E. Test Excavation Quantitative Tables
APPENDIX F. Radiocarbon Data Sheets

LIST OF FIGURES

Figure 1. Auwahi Wind Farm vicinity map (courtesy of Tetra Tech). 3
Figure 2. Auwahi Wind Farm Project components (courtesy of Tetra Tech). 4
Figure 3. Auwahi Wind Farm Plan map (courtesy of Tetra Tech). 5
Figure 4. Major geological flows of the Auwahi area (map by P. V. Kirch based on data from Sherrod et al. 2007). 10
Figure 5. Soil types within project area (aerial background courtesy of ESRI). 17
Figure 6. Wind Farm cultural resources found in 2007. 33
Figure 7. Functional classes of cultural resources in the Wind Farm (2007). 34
Figure 8. Generator-Tie Line Corridor cultural resources found in 2007. 37
Figure 9. Functional classes of resources along the Generator-Tie Line Corridor found in 2007. 38
Figure 10. Upper 2.6 mile portion of Pāpaka Road Corridor cultural resources found in 2007. .. 40
Figure 11. Functional classes of cultural resources along Upper 2.6 mile portion of Pāpaka Road Corridor (2007). 41
Figure 12. Site location map of northern portion of Wind Farm. 50
Figure 13. Site location map of central portion of Wind Farm. 51
Figure 14. Site location map of southern portion of Wind Farm. 52
Figure 15. Site location map of Interconnection Substation and NW End of Generator-Tie Line. 53
Figure 16. Site location map of Substation Access Road and Transmission Line near Kula Highway. 54
Figure 17. Site location map of Generator-Tie Line section between Figures 17 and 19. 55
Figure 18. Site location map of Generator-Tie Line section between Figures 18 and 20. 56
Figure 19. Site location map of Generator-Tie Line section between Figures 19 and 21. 57
Figure 20. Site location map of Generator-Tie Line section between Figures 20 and 22. 58
Figure 21. Site location map of Generator-Tie Line section between Figures 21 and 23. 59
Figure 22. Site location map of southeastern end of Generator-Tie Line. 60
Figure 23. Site locations along Pi‘ilani Highway. 61
Figure 24. Site location map of northwestern end of Pāpaka Road. 62
Figure 25. Site location map of Pāpaka Road between figures 24 and 26. 63
Figure 26. Site location map of Pāpaka Road between Figures 25 and 27. 64
Figure 27. Site location map of Pāpaka Road between Figures 26 and 28. 65
Figure 28. Site location map of Pāpaka Road between Figures 27 and 29. 66
Figure 29. Site location map of eastern end of Pāpaka Road. 67
Figure 30. View of notched *heiau* at Site 50-50-15-6908 Feature A. 69
Figure 31. Distribution of “notched” *heiau*. 70
Figure 32. Distribution of burial features within the Wind Farm. 75
Figure 33. Relationship of access roads to possible burial sites, upper section of Access Road leading from Pi‘ilani Highway to Laydown Area. 76
Figure 34. Relationship of access roads to possible burial sites, lower section of Access Road leading from Pi‘ilani Highway to Laydown Area. 77
Figure 35. Relationship of access roads to possible burial sites: Laydown Area to Pad 00. 78
Figure 36. Relationship of Access Roads to possible burial sites: lower portion of Wind Farm. . 79

Figure 37. Overview of high-status habitation Feature at Site 50-50-15-6824. 81
Figure 38. Stone-lined fire hearth at Site 50-50-15-6824. 81
Figure 39. Site 50-50-15-6910 site map. 82
Figure 40. *Pāhoehoe* slab lined trail at Site 50-50-15-6815 leading to lava tube. 83
Figure 41. Standing wooden structure (Site 50-50-14-7024 Feature A) at the Goodness Ranch Complex. 84
Figure 42. Cistern (Site 50-50-14-7024 Feature B) at the Goodness Ranch Complex. 84
Figure 43. View northeast of Site 50-50-15-6832, TU-1 at bedrock. 87
Figure 44. Stratigraphic profile of Site 50-50-15-6832, TU-1. 88
Figure 45. View north of Site 50-50-15-6832, TU-2 prior to excavation. 88
Figure 46. View northwest of Site 50-50-15-6833, Feature A, TU-1 surface prior to excavation... 90
Figure 47. View of west wall profile of TU-1 at Site 50-50-15-6833, Feature A showing bedrock at base of excavation. 90
Figure 48. View east of TU-1 prior to excavation at Site 50-50-15-6838, Feature G. 92
Figure 49. Close up of TU-1 at Site 50-50-15-6838 showing bedrock and ash deposit at 10-20 cm bs level which was terminated due to discovery of deciduous human tooth. 92
Figure 50. View east of TU-1 at Site 50-50-15-6839 Feature B at start of excavation. 94
Figure 51. View northwest of TU-1 prior to excavation at Site 50-50-15-6845. 95
Figure 52. Plan view of Site 50-50-15-6848. 97
Figure 53. Overview east of Feature A, showing wind break, cleared activity area and TU-1 location prior to excavation. 98
Figure 54. South wall of TU-1 showing the sterile cinder deposit below the cultural layers. 99
Figure 55. Stratigraphic profile of TU-1 of Site 50-50-15-6848. 100
Figure 56. Overview of Feature L at Site 50-50-15-6848 showing excavation of TU-2. 102
Figure 57. View south of TU-2 at base of excavation. 102
Figure 58. Crew member in center of Feature E, at TU-3 location within Site 50-50-15-6848. 103
Figure 59. TU-3 showing base of excavation and rock fill from terrace in profile. 103
Figure 60. Overview of TU-4 excavation in center of Feature I at Site 50-50-15-6848. 105
Figure 61. TU-4, Feature I at base of excavation. 105
Figure 62. Overview of Feature J, with screen on lower terrace and photo board at TU-5. 106
Figure 63. View of TU-5 at terrace Feature J at base of excavation. 106
Figure 64. View southeast of Feature K, C-shaped wall with TU-6 location. 107
Figure 65. View southeast of base of excavation at TU-6, Feature K. 107
Figure 66. Overview south of enclosure Feature B at Site 50-50-15-6851. 108
Figure 67. Site 50-50-15-6851 TU-1 stratigraphic profile. 109
Figure 68. Site 50-50-15-6851 TU-1 showing bedrock at base of excavation. 110
Figure 69. Overview of Feature A, enclosure at Site 50-50-15-6852 prior to excavation. 111
Figure 70. View of TU-1 within Feature A at 50-50-15-6852 at base of excavation. 111
Figure 71. Overview of U-shaped wall, Feature I at Site 50-50-15-6852. 113
Figure 72. Site 50-50-15-6852, Feature I stratigraphic profile. 114
Figure 73. View of hearth (left of scale) in TU-2 at Feature I, Site 50-50-15-6852. 114
Figure 74. Overview southwest of Feature A, enclosure at Site 50-50-15-6853. 116
Figure 75. View northeast of TU-1 at bedrock within Feature A at Site 50-50-15-6853. 116
Figure 76. Overview northeast of C-shaped wall, Feature C at Site 50-50-15-6854. 117
Figure 77. View east of TU-1, Feature C at Site 50-50-15-6854 at base of excavation. 117

Figure 78. Overview of Feature A at Site 50-50-15-6855. 118
Figure 79. North wall of TU-1 showing base of excavation against C-shaped wall. 119
Figure 80. TU-1 West wall stratigraphic profile. 119
Figure 81. View east of terrace and wall of Site 50-50-15-6857 Feature A. 120
Figure 82. View east of TU-1 at Site 50-50-15-6857 Feature A. 121
Figure 83. Overview of Feature B at Site 50-50-15-6860, upper terrace flat to right of *wiliwili* tree and lower terrace flat at meter stick. 122
Figure 84. View of TU-1 at base of excavation. 122
Figure 85. Stratigraphic profile of TU-1 at Site 50-50-15-6860, Feature B. 123
Figure 86. Overview of Feature A at Site 50-50-15-6861 showing location of test unit prior to excavation. 124
Figure 87. View north of TU-1 at Site 50-50-15-6861 Feature A at base of excavation. 125
Figure 88. Plan view of Site 50-50-15-6864. 126
Figure 89. View south of Feature E at Site 50-50-15-6864. 127
Figure 90. Close up of branch coral at Site 50-50-15-6864 Feature E. 127
Figure 91. TU-1 at base of excavation within Feature E at Site 50-50-15-6864. 128
Figure 92. Overview east of terrace and windbreak at Site 50-50-15-6864 Feature C. 129
Figure 93. TU-2 east wall profile at Site 50-50-15-6864 Feature C. 130
Figure 94. Stratigraphic profile of TU-2 at Site 50-50-15-6864 Feature C. 130
Figure 95. Overview of Site 50-50-15-6864 Feature A showing location of TU-3 prior to excavation. 131
Figure 96. TU-3 at Site 50-50-15-6864 Feature A showing bedrock at base of excavation. 131
Figure 97. Overview of terrace Feature I at Site 50-50-15-6864. 132
Figure 98. View of Site 50-50-15-6864, Feature I, TU-4 at terrace prior to excavation. 133
Figure 99. View of Site 50-50-15-6864, Feature I, TU-4 at base of excavation showing exposed half of hearth. 133
Figure 100. TU-5 at Site 50-50-15-6864 at base of excavation. 134
Figure 101. Plan view of Site 50-50-15-6951. 135
Figure 102. Overview of Feature C at Site 50-50-15-6951. 137
Figure 103. Feature C at Site 50-50-15-6951 showing TU-1 at base of excavation. 137
Figure 104. Overview northeast of Feature C mound at Site 50-50-15-6819 prior to testing. 138
Figure 105. Site 50-50-15-6819 Feature C mound after mound dismantling prior to excavation of underlying soil. 139
Figure 106. Overview northeast of Site 50-50-14-6865 Feature B. 140
Figure 107. View east of TU-1 at Site 50-50-14-6865 Feature B at base of excavation. 140
Figure 108. Overview east of Feature C at Site 50-50-14-6865. 141
Figure 109. View southeast of TU-2 at Site 50-50-14-6865 Feature C showing base of excavation. 142
Figure 110. East wall profile of TU-2, Site 50-50-14-6865 Feature C. 142
Figure 111. Plan view of Site 50-50-15-6871. 144
Figure 112. Overview of Feature B at Site 50-50-15-6871 with crew member in U-shape. 145
Figure 113. View northwest of TU-1 at Site 50-50-15-6871 Feature B with Feature C (rock filled terrace) in background. 145
Figure 114. East wall profile of TU-1, Feature B at Site 50-50-15-6871 showing ash deposit. 146
Figure 115. East wall stratigraphic profile of TU-1, Site 50-50-15-6871 Feature B. 146

Figure 116. Plan view of Site 50-50-14-6931 148
Figure 117. Overview of TU-1 location at Site 50-50-14-6931 Feature D (note waterworn stones). 149
Figure 118. View of surface artifacts on Feature D at Site 50-50-14-6931. 149
Figure 119. Site 50-50-14-6931 Feature D, TU-1 West wall at base of excavation. 150
Figure 120. Site 50-50-14-6931 Feature D, TU-1 stratigraphic profile. 150
Figure 121. Plan view of Site 50-50-14-6939 152
Figure 122. Plan view of Site 50-50-14-6939, Feature A. 153
Figure 123. Overview of Feature A at Site 50-50-14-6939 prior to excavation of TU-1. 154
Figure 124. View north of TU-1 at base of excavation within Feature A at Site 50-50-14-6939 154
Figure 125. View northeast of terrace, Feature C at Site 50-50-14-6939. 155
Figure 126. View west of TU-2 at Site 50-50-14-6939 Feature C at base of excavation. 156
Figure 127. Site 50-50-14-6939 Feature C, stratigraphic profile of TU-2. 156
Figure 128. Plan view of Site 50-50-14-6940 158
Figure 129. Overview of terrace with wall, Feature H at Site 50-50-14-6940. 159
Figure 130. Site 50-50-14-6940 Feature H, TU-1 (board mislabeled), showing west wall profile with ash deposit. 159
Figure 131. View west of mound Feature B at Site 50-50-14-6943 prior to testing 160
Figure 132. View of Site 50-50-14-6943 Feature B during testing showing mound cross section and sterile soil. 161
Figure 133. Overview north of TU-1 trench at Site 50-50-14-6943 through eastern portion of mound 161
Figure 134. Overview Site 50-50-14-6956 (enclosure) 163
Figure 135. Plan view map of Site 50-50-14-6956 164
Figure 136. TU-1 at Site 50-50-14-6956 showing unit against interior north wall. 165
Figure 137. Pie chart depicting artifact frequency by general category. 168
Figure 138. Pie chart depicting manuport frequency by general category. 168
Figure 139. Chart depicting distribution of artifacts collected from Wind Farm sites test excavations. 174
Figure 140. Chart depicting distribution of manuports collected from Wind Farm sites test excavations. 174
Figure 141. Distribution of Artifacts Collected from Generator-Tie Line Test Excavations 176
Figure 142. Pāpaka sites distribution of artifacts collected from test excavations. 180
Figure 143. Pie chart of Wind Farm surface collection artifact frequencies. 184
Figure 144. Pie chart of Generator-Tie Line surface collection artifact frequencies. 184
Figure 145. Basalt adze preform fragment from Site 50-50-15-6984 Feature C. 186
Figure 146. Basalt core from Site 50-50-15-6848 Feature J. 186
Figure 147. Cryptocrystalline core from Site 50-50-14-6931 Feature D. 189
Figure 148. Cryptocrystalline core from Site 50-50-14-6931 Feature D. 189
Figure 149. Small polished basalt adze from Site 50-50-14-7020 Feature E. 191
Figure 150. Large polished basalt adze from Site 50-50-14-7020 Feature D. 192
Figure 151. Small polished basalt adze from Site 50-50-14-7022 Feature B. 192
Figure 152. Polished basalt adze from Site 50-50-15-6906 Feature II. 193
Figure 153. Basalt adze fragment, tang portion from Site 50-50-14-6881 Feature C. 194
Figure 154. Basalt awl collected from Site 50-50-14-6939 Feature C. 195

Figure 155. Basalt awl collected from Site 50-50-15-6951 Feature A. 195
Figure 156. Basalt hammerstone, discoidal, collected from Site 50-50-15-7030. 197
Figure 157. Basalt hammerstone, spherical, collected from Site 50-50-15-6952. 197
Figure 158. Basalt pestle (*pōhaku ku'i*), double-ended, from Site 50-50-15-6906 Feature YY. 198
Figure 159. Coral abraders from Site 50-50-15-6906, Features P and T, respectively. 200
Figure 160. Coral abrader from Site 50-50-15-6821 Feature A. 200
Figure 161. Granite *poi* pounder from Site 50-50-15-6911 Feature C. 201
Figure 162. Basalt coffee bean sinker (*pōhaku lūhe'e*) from Site 50-50-15-6910 Feature I. 203
Figure 163. Cowrie shell lure (*lūhe'e*), shell portion from Site 50-50-15-6906 Feature II. 203
Figure 164. Granite coffee bean sinker (*pōhaku lūhe'e*) from Site 50-50-15-6840 Feature C. 204
Figure 165. Basalt game stone, discoidal (*'ulu maika*), from Site 50-50-15-6906 Feature W. 205
Figure 166. Basalt game stone, discoidal (*'ulu maika*), from Site 50-50-14-7022 Feature E. 206
Figure 167. Echinoid spine bead preform from Site 50-50-15-6833 Feature A. 207
Figure 168. Glass bead, clear, faceted from Site 50-50-15-6919 Feature E. 208
Figure 169. Glass soda bottle, Maui Soda Works, clear, from isolated location. 210
Figure 170. Glass utility bottle, aqua, from Site 50-50-15-6911 Feature C. 210
Figure 171. Clothing iron, 6 lb, from Site 50-50-15-6988 Feature E. 211
Figure 172. Iron curb bit collected from Site 50-50-15-6906 Feature DD. 212
Figure 173. Iron flensing tool, tip portion, found in Site 50-50-15-6906 Feature HHH. 213
Figure 174. Distribution of midden by type throughout the Auwahi Wind Farm APE. 215
Figure 175. Wind Farm sites midden frequencies by general taxon. 219
Figure 176. Wind Farm Sites frequencies of species representing at least 1% of the midden assemblage totals. 219
Figure 177. Generator-Tie Line sites midden frequencies by general taxon. 223
Figure 178. Generator-Tie Line Sites midden species representing at least 1% of the area total. 223
Figure 179. Distribution of Pāpaka Road Sites Midden. 226
Figure 180. Pāpaka Road Sites frequencies of species representing at least 1% of the midden assemblage totals. 227
Figure 181. Map of Kahikinui District showing the various place names which are believed to represent individual *ahupua'a*, or in some cases possibly *'ili*, land units. (Map by U. S. Geological Survey, 1942.) 271
Figure 182. Histogram plot of 162 radiocarbon dates from Kahikinui archaeological sites (excluding Auwahi). Dates have been plotted based on their highest probability intercepts. The trendline is a 2-period moving average. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 274
Figure 183. Oxcal generated chart of the 14 dates from Auwahi by this project. The black histograms for each date are probability distributions indicating the likelihood that the radiocarbon age corresponds to a particular calendar year. As can be seen, "dates" have multiple probability intercepts. 275
Figure 184. Histogram plot of 14 radiocarbon dates from Auwahi archaeological sites. Dates have been plotted based on their highest probability intercepts. The trend line is a 2-period moving average. 276
Figure 185. The temporal distribution by 100-year age intervals of radiocarbon dates from five *ahupua'a* of Kahikinui (Auwahi, Kīpapa, Nakaohu, Mahamenui, and Mahawainui from left

to right). 277
Figure 186. Simplified geologic map of the Kahikinui District showing the distribution of substrates according to age categories (from Kirch et al. 2004). The older Kula Volcanic Series is shown in blue. The orange colored areas are of very young lava flows not amenable to cultivation. Areas shaded green and yellow have substrates with ages best suited to intensive cultivation. 279
Figure 187. Major zones of archaeological survey in Kahikinui District. (Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 280
Figure 188. Spatial distribution of archaeological features in Kīpapa-Nakaohu, Mahamenui, and Manawainui. Inset charts show the frequency of feature categories by elevation. Rainfall increases as function of elevation. Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley. 281
Figure 189. Kahikinui rainfall as a function of elevation. 282
Figure 190. A medium sized natural swale in the *ʻaʻā* lava topography of Auwahi, below Puʻu Hōkū Kano. This swale has a level soil surface and artificially constructed walls around its perimeter. It is typical of swales throughout Kahikinui used for intensive cultivation. (Photo by P. V. Kirch, 2007.) 284
Figure 191. Map of a portion of the Kaupō Field System, based on aerial photo analysis of field embankment and wall patterns. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 285
Figure 192. Map of the Kīpapa-Nakaohu to Manawainui section of Kahikinui District, with archaeological sites (individual dots) and the distribution of mapped *heiau* (red dots). (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 288

LIST OF TABLES

Table 1. Wind Farm Cultural Resources (N=553) 32
Table 2. Functional Classes of Cultural Resources Recorded Within the Wind Farm (N=553) 35
Table 3. Proposed Generator-Tie Line Corridor Cultural Resources (N=29) 36
Table 4. Functional Classes of Cultural Resources Recorded Along the Proposed Generator-Tie Line Corridor (N=29) 36
Table 5.Cultural Resources Recorded Along the Pāpaka Road Corridor (N=21) 39
Table 6. Functional Classes of Cultural Resources Recorded Along the Pāpaka Road Corridor 39
Table 7. Comprehensive Site and Feature List 43
Table 8. Wind Farm Test Excavations 85
Table 9. Generator-Tie Line Corridor Test Excavations 86
Table 10. Pāpaka Road Test Excavations 86
Table 11. Test Excavated Sites (n=24) 166
Table 12. Test Excavations — Artifact and Manuport Table for Wind Farm Sites 173
Table 13. Artifact and Manuport Table for Transmission Sites Test Excavations 176
Table 14. Artifact and Manuport Table for Pāpaka Road Test Excavations 179
Table 15. Surface Collections — Artifact and Manuport Table by Site 181
Table 16. Wind Farm Sites Surface Collection Table 183
Table 17. Wind Farm Test Excavations Midden Summary by Feature 220
Table 18. Controlled Excavations Midden Table for Wind Farm Sites 221
Table 19. Generator-Tie Line Test Excavations Midden Summary by Feature 223
Table 20. Controlled Excavations Midden Table for Generator-Tie Line Sites 224
Table 21. Pāpaka Road Test Excavations Midden Summary 227
Table 22. Controlled Excavations Midden Table for Pāpaka Sites 228
Table 23. Radiocarbon Dating Results 232
Table 24. Significance Assessments of Sites 236
Table 25. Recommended Treatments to Features within the APE 250

Frontispiece: Puʻu Hōkū Kano in project area.

1.0 INTRODUCTION

Auwahi Wind Farm, LLC proposes to develop a wind energy project, called the Auwahi Wind Farm, in the southern half of the Auwahi Ahupuaʻa of Maui Island, Hawaiʻi, which is currently a holding of ʻUlupalakua Ranch [TMK (2) 1-9-001:006]. Under contract to Auwahi Wind Farm, LLC, Pacific Legacy conducted an archaeological inventory survey of the proposed wind farm, as well as a proposed Generator-Tie Line and electrical substation, and a construction access road (Figures 1, 2, and 3). The survey was conducted to facilitate an Environmental Impact Statement for the project that is being prepared by Tetra Tech, Inc. The Department of Land and Natural Resources State Historic Preservation Division (SHPD) requires that an archaeological inventory survey be conducted to evaluate the significance of prehistoric, historic, and burial sites within the proposed project area (HRS 6E-42 and Hawaiʻi Administrative Rules 13-276-5 and 13-284-5).

The archaeological inventory survey was conducted in two phases as proposed in an archaeological inventory survey plan prepared by Pacific Legacy in 2007 and submitted to the State Historic Preservation Division (Pacific Legacy 2007). During the two phases, work consisted of a large scale pedestrian survey, followed by an intensive recording and testing phase.

This two-phase approach was developed through consultations with the State Historic Preservation Division (SHPD). Representatives of CH2M Hill, Shell WindEnergy (the previous planner and developer respectively), and Pacific Legacy met with the SHPD Maui Lead Archaeologist on 13 February 2007 to introduce the project and to discuss with SHPD plans for the archaeological inventory survey. Pacific Legacy proposed to conduct the archaeological investigations in two phases. The first phase would be to conduct a survey of a larger study area based on Shell WindEnergy's conceptual design at the time. This would be completed first. The information gathered during the initial survey would be incorporated into the project design, as avoidance of resources was the preferred outcome. The second phase, consisting of two tasks (detailed recording and evaluation) would be completed after the locations of specific project components could be determined (e.g., roads, turbine pads, and staging areas). Therefore, not all resources within the project area would be subject to further study. Only those resources found to be within the area of potential impact (APE) would be subject to detailed recording and evaluation. In accordance with this proposal, it was agreed that the first phase of the study could begin. SHPD requested a written plan for the conduct of the archaeological study, which was submitted on 11 April 2007.

The first phase, conducted in 2007, was an extensive pedestrian survey of the wind farm consisting of approximately 1,450 acres, approximately 9 miles of Generator-Tie Line, and approximately 5 miles of existing roadway for construction access. The purpose of this pedestrian survey was twofold: (1) identify cultural resources in a proactive manner to aid in the design and placement of wind farm components (including roadways, Generator-Tie Lines, turbine pads, and staging areas) to avoid important cultural resources; and (2) to provide a

broad context to evaluate the sites and features to be impacted by construction of the wind farm. At the conclusion of the pedestrian survey phase, engineers used the data generated to design the wind farm components (including roadways, Generator-Tie Lines, turbine pads, and staging areas) to avoid important cultural resources.

The second phase of archaeological investigations took place in 2010, after the project layout was determined. This phase consisted of detailed recording (GPS coordinates, mapping, photographing, and written descriptions) of all sites and features to be impacted by the construction of the wind farm components, and test excavations of selected features. During the course of fieldwork several significant ceremonial and burial sites were encountered in the APE. Consultations with design engineers were immediately held and design changes were made so that these sensitive sites would be avoided by construction activities.

1.1 PROJECT DESCRIPTION

The project area is located on undeveloped land on the south coast of East Maui. It is located south of the Pi‘ilani Highway within approximately 1,450 acres; the actual wind farm consisting of 15 – 16 turbine pads and associated access roads and staging area covers ca. 282 acres. The general project location and the various component parts are depicted in Figures 1 - 3. The proposed wind energy development project would provide 21megawatts (MW) of clean, renewable energy to Maui Island. In addition to the wind turbines pads, access roads will have to be constructed. The access roads would be approximately 10.4 m (38 feet) wide, including shoulders. Other planned components within the project area include a construction staging area and an on-site substation.

In addition to the wind farm, Auwahi Wind Farm, LLC proposes to construct a ca. 9 mile long Generator-Tie Line and substation to link the energy generated by the Auwahi Wind Farm with the Maui Electric Company electrical grid (Figure 2). Auwahi Wind Farm, LLC also proposes to improve the existing ca. 5 mile long ‘Ulupalakua Ranch Pāpaka Road to be used to transport construction materials from the coast up to the wind farm site. In summary, the area of potential effect (APE) for the project is:

- an improved series of ranch roads collectively referred to as Pāpaka Road that extends for 4.7 miles and measures 20 m on either side of the centerline;
- 16 1.5 acre turbine pads;
- access road corridors connecting the turbine pads that measure 20 m on either side of centerline (the actual roads will be 10.4 m wide within these 40 m wide corridors to provide flexibility in final design that will allow avoidance of features);
- a 30 m wide Generator-Tie Line corridor that extends for 9 miles north and west from the wind farm to a proposed Interconnection substation;
- a 2.0 acre Interconnection substation at the NW terminus of the Generator-Tie Line; and
- 10 m on each side of Pi‘ilani Highway between the intersection with Pāpaka Road and the Wind Farm (c. 3.7 miles) in order to eliminate various dips in the roadway so that the project components could be transported.

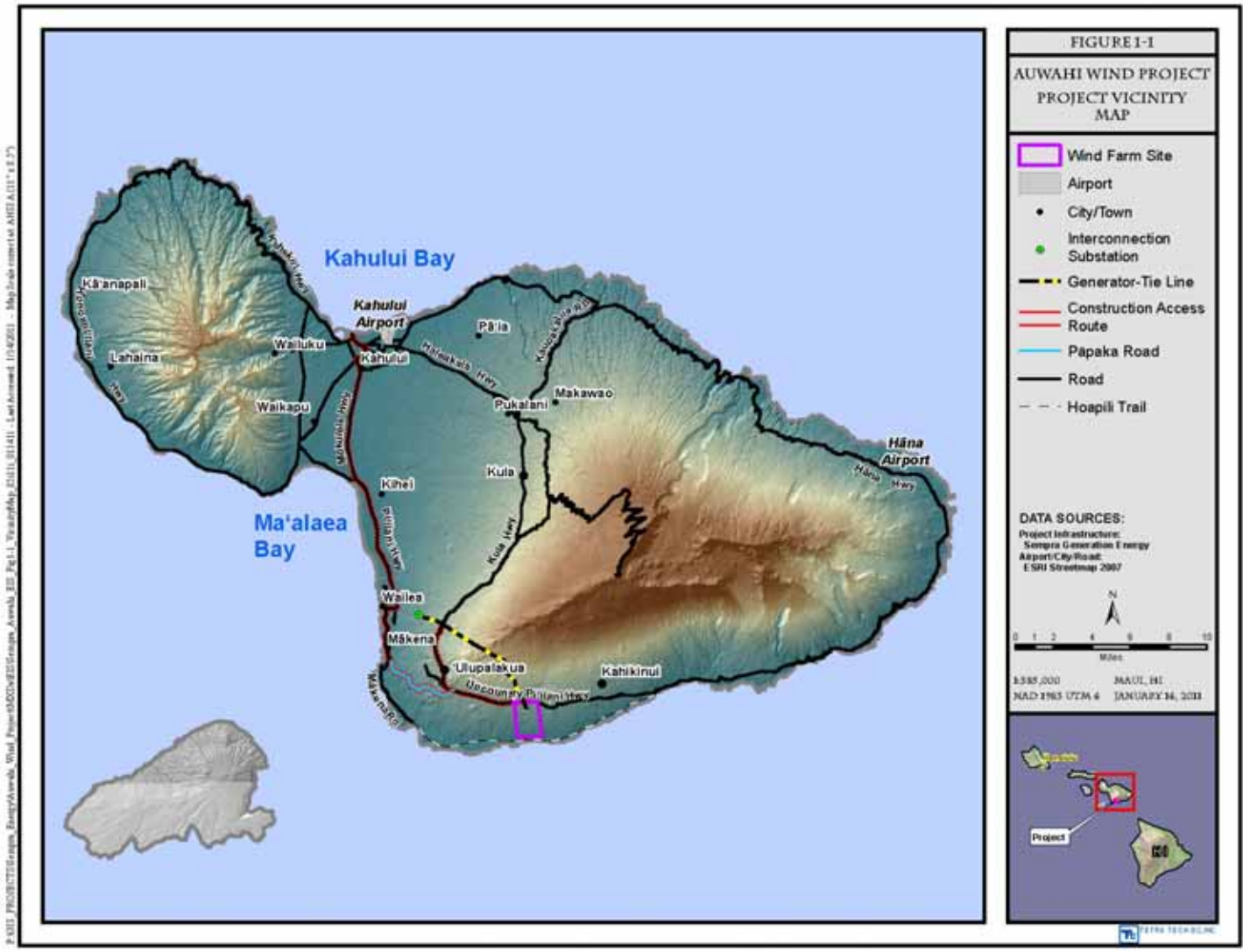


Figure 1. Auwahi Wind Farm vicinity map (courtesy of Tetra Tech).

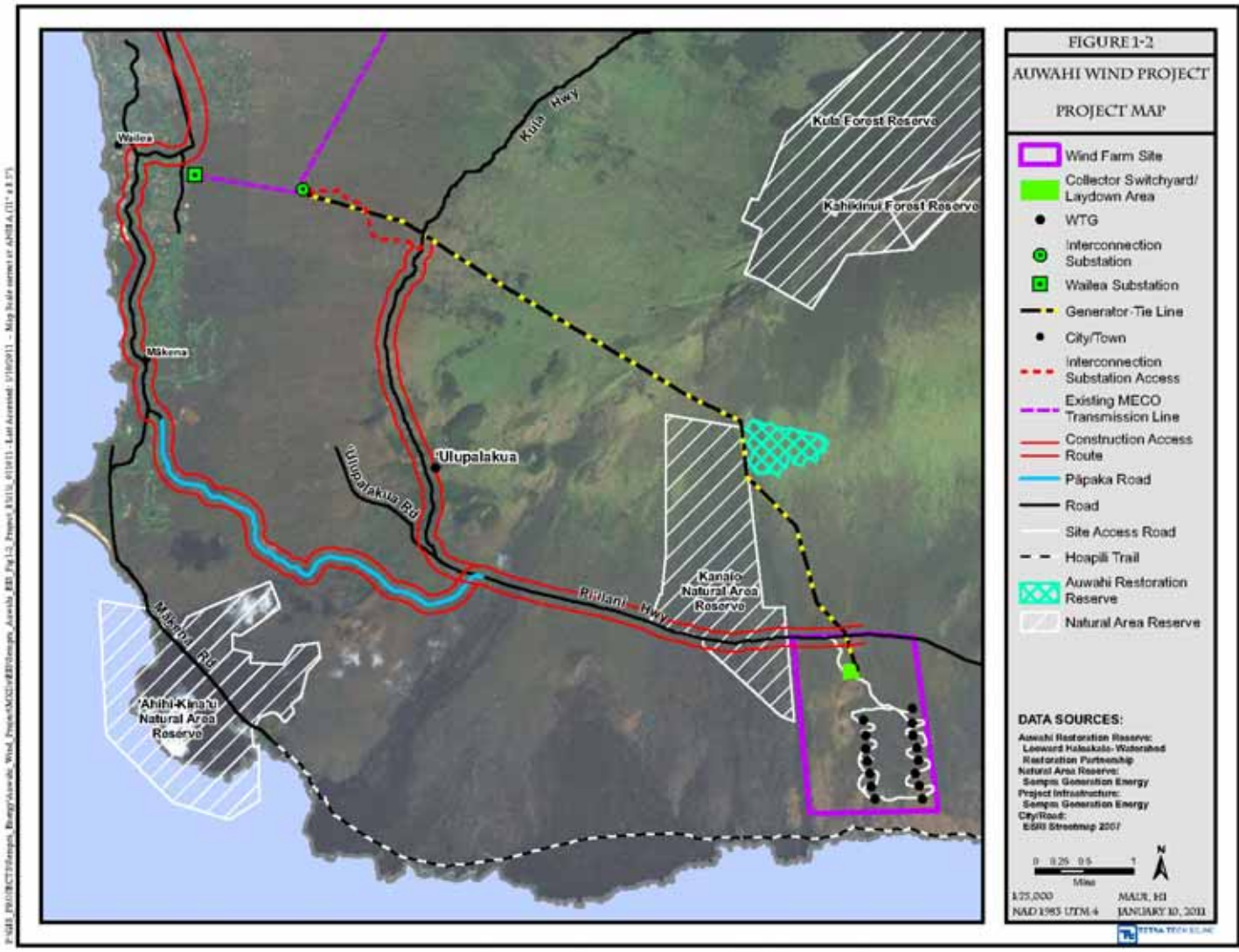


Figure 2. Auwahi Wind Farm Project components (courtesy of Tetra Tech).

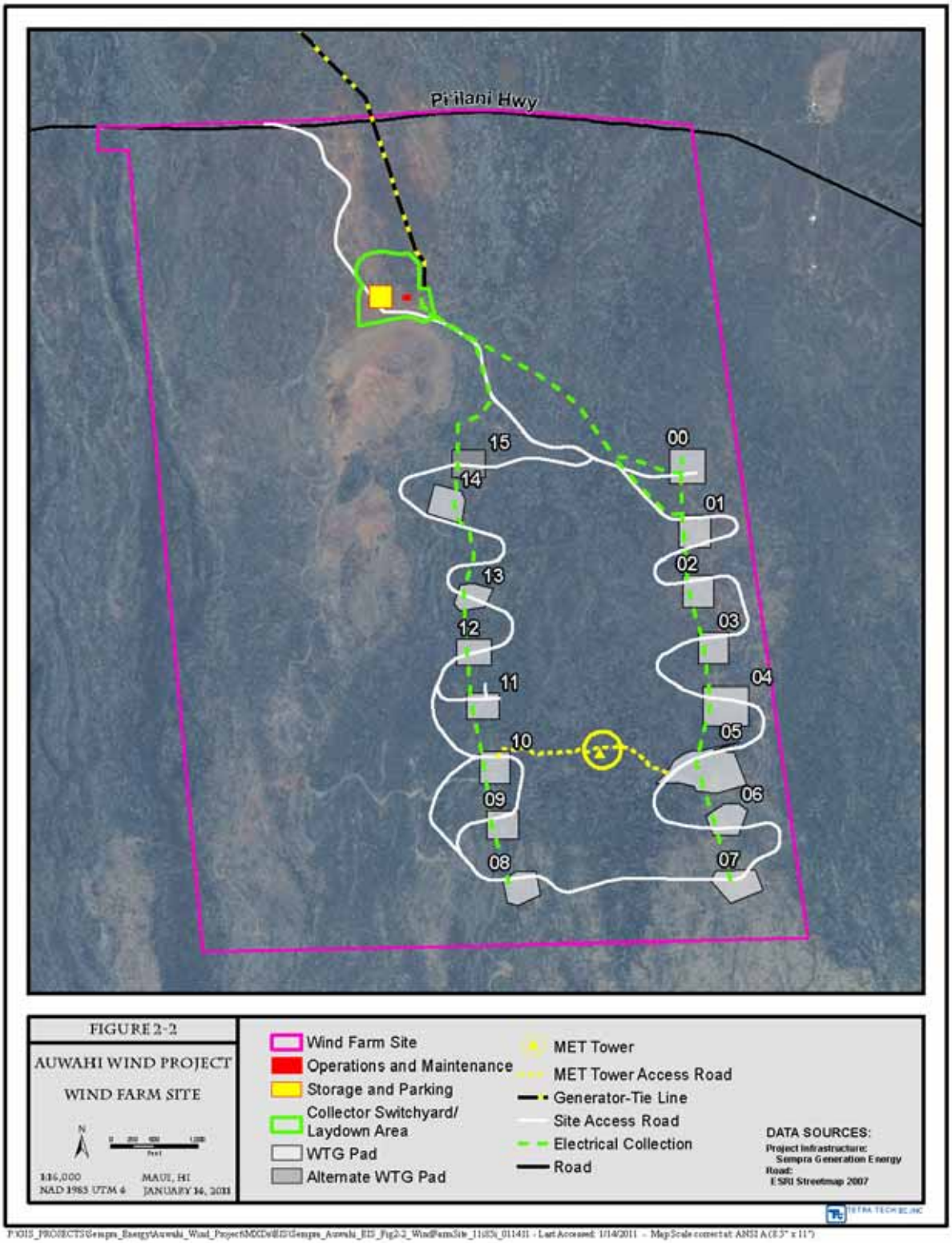


Figure 3. Auwahi Wind Farm Plan map (courtesy of Tetra Tech).

1.2 REGULATORY CONTEXT AND SHPD CONSULTATION

Hawai‘i Administrative Rules state that an archaeological inventory survey shall:

(1) Determine if archaeological historic properties are present in the project area and, if so, identify all such historic properties.

(2) Gather sufficient information to evaluate each historic property's significance in accordance with the significance criteria listed in subsection 13-275-6(b). (HAR §13-276-3)

Data gathering for the identification of properties entails field investigations, which consist of pedestrian surveys, evaluations, and test excavations. The Hawai‘i Administrative Rules present the following guidelines:

> (a) Portions of the project area that have no adequate inventory survey reports prepared for them shall undergo archaeological inventory survey to determine whether archaeological historic properties are present and, if so, to present their description, interpretation, and location. The entire surface of the project area shall be visually inspected, and any proposed deviations from this level of inspection shall be approved by SHPD prior to implementation.
>
> (b) The presence or absence of subsurface sites shall be evaluated for areas which have no visible historic properties. This evaluation shall include findings of test excavations, if deemed necessary by the department, or a conclusion, with supportive documentation, that historic properties are not anticipated to be present.
>
> (c) Test excavations shall be undertaken on historic properties, or features of properties, that have several possible alternative functions based on surface examination to provide additional information that might help to resolve the question of property or feature function. Recordation of such excavations and any necessary laboratory analysis of recovered materials shall be undertaken as part of the archaeological inventory survey. If human skeletal remains are found, they shall not be disturbed, excavations shall be backfilled, and SHPD notified as soon as possible. Archaeological historic properties, or features of properties, that are highly probable to be burials based on surface examination shall not undergo test excavation without authorization from the department (HAR §13-276-4).

Prior to the initiation of the first phase of fieldwork, Pacific Legacy consulted with the SHPD Lead Maui Archaeologist (see Section 1.0 above). During the course of the second phase of fieldwork, Pacific Legacy personnel sponsored a field visit with the SHPD Maui Lead Archaeologist. In addition, two presentations were made to the Maui/Lāna‘i Island Burial Council to discuss the project and to report on the findings of human remains.

1.3 ANTICIPATED SETTLEMENT PATTERNS

Holm (2006) has discussed site types in eastern Kahikinui in terms of 1) un-mortared stone features related to agricultural production or animal husbandry, 2) stone structures identified as permanent or temporary residences, 3) structures connected with ritual or religious activities, and, 4) special purpose features such as rockshelters, petroglyphs, trails and roads. Previous archaeological studies within the Kahikinui District suggested that these types of sites would be distributed throughout Auwahi in a pattern similar to that found in other *ahupuaʻa*. Elsewhere in the Kahikinui District, Kirch (1997) and Holm (2006) found that sites tend to cluster along the immediate coast and in the mid- to upper-elevation ranges between ca.250-800 m (820-2625 feet) above sea level (asl). While a survey conducted by the SHPD for the Department of Hawaiian Homelands revealed that settlement reached an elevation of ca.1200 m (4,000 feet) asl, few sites were found above ca.975 m (3,200 feet) asl. A high density of sites along the coast to approximately ca. 75 m (250 feet) asl is expected, with a lower density of sites in the elevation range of ca. 75-175 m (250 feet to 575 feet) asl. A high density of sites was again anticipated between ca. 175-800 m (575 feet to 2600 feet) asl, with site density tapering off above ca. 600 m (1975 feet) asl (the approximate forest line). The proposed project area is located within the high density zone and we therefore anticipated that approximately 250 resources would be recorded.

1.4 PACIFIC LEGACY STAFF

The co-Principal Investigators for both phases of this project were Paul L. Cleghorn, Ph.D. and John Holson, M.A. from Pacific Legacy. The Consultant for both phases was Patrick V. Kirch, Ph.D. from the University of California at Berkeley. Paul Cleghorn conducted numerous site visits during the course of the field work. Patrick Kirch and John Holson were on-site for three one-week sessions during field work giving assistance providing input on the recording and interpretation of resources.

The 2007 pedestrian survey crew consisted of Project Supervisor Lisa Holm, Ph.D.; Kari Jones, M.A.; Solomon Kailihiwa, B.A.; Sidsel Millerstrom, Ph.D.; Jeff Putzi, B.A.; and Tanya Souza, B.A. The survey of the access road was conducted on a separate occasion by Solomon Kailihiwa, B.A. and James McIntosh, B.A.

The 2010 detailed recording and testing phase crew consisted of Project Supervisor William Shapiro, M.A.; Chris Azevedo, B.A.; Katherine Chao, B.A.; Patrick Day; Patty Elison, B.A.; Caleb Fechner, B.A.; Lisa Holm, Ph.D.; Elizabeth Kahahane, B.A.; James McIntosh, B.A.; Kim Mooney, B.A.; Kelene Pfennig, B.A.; Mary Schmidt, B.A.; Tara Seaver, B.A.; Lisa Shapiro, M.A.; Jet Stoner, B.A.; Dan Trout, B.A.; and Reid Yamasato, B.A.

1.5 ENVIRONMENTAL SETTING[1]

Kahikinui District lies astride the southwestern flanks of East Maui, surmounted by the magnificent 3,055 m (10,023 feet) high summit of Haleakalā. In Hawaiian tradition, the great culture hero Maui climbed to the peak of Haleakalā to snare the sun and slow its path across the heavens, so that people could grow their crops (Beckwith 1970:226 *passim*). Because Haleakalā creates a rain shadow effect, the leeward lands of Kahikinui are quite arid. They typify what the Hawaiian scholar David Malo called the "dry lands," the *ʻāina maloʻo* (Malo 1951:204). In such areas the sweet potato was the principal crop of the Hawaiian inhabitants, although dryland taro might also have been grown in the higher elevations. In Malo's words, farming such an *ʻāina maloʻo* "was a laborious occupation and called for great patience, being attended with many drawbacks" (1951:204).

The steep southern slope of Haleakalā consists of two major volcanic series, the older Kula Volcanic Series and the younger Hāna Volcanic Series (Stearns and Macdonald 1942). The Hāna Volcanic Series consists largely of undissected lava flows derived from the southwest rift of Haleakalā, dotted in a few places with pyroclastic vents such as the Puʻu Hōkū Kano cinder cone complex in Auwahi, and the Lualaʻilua cinder cones to the east (Stearns and Macdonald 1942; Macdonald and Abbott 1970:318-36). The Hāna lavas are made up of alkalic olivine basalts, basaltic hawaiites, and ankaramites. The young age of the Hāna lavas is indicated by their lack of weathering, especially the absence of any deep stream dissection. The *ahupuaʻa* of Auwahi is covered entirely in these young Hāna lava flows.

Since it is geologically youthful, the landscape of western Kahikinui including Auwahi has hardly been modified by erosion. The slopes are traversed only by intermittent, shallow stream channels ranging from 2-8 m (7-26 feet) in width; scoured and smoothed channel floors and small quantities of waterworn gravel indicate flowing water at times of heavy rains. In our experience, most channel erosion occurs during occasional *Kona* storms, which can result in several inches of rain falling within less than 24 hours. None of the small water channels flow regularly today, but it is possible that there was more frequent discharge in pre-Contact times when the forest line was significantly lower (and the water table higher as a result of dew drip precipitation), prior to the late nineteenth and twentieth-century depredations of cattle and goats. Stock et al. (2003) present evidence that greater levels of fog-drip precipitation on the higher elevation slopes of Kahikinui in pre-Contact times may have fed perched springs and other water sources. Such springs and intermittent watercourses would have provided the main sources of surface water to the pre-Contact Hawaiian population of Kahikinui.

In the eastern portion of Kahikinui *moku*, slightly more deeply incised stream channels are found. However, since these reflect the older Kula Volcanic Series landscape which has had a longer time for water erosion to occur, they do not necessarily indicate a greater amount of surface water flow relative to the western part of the *moku*. East of the Kīpapa-Nakaohu survey area, for example, is Kepuni Gulch, where the U. S. Geological Survey maintained a gauging

[1] This section incorporates some material previously published in Kirch (1997).

station; from May 1963 to September 1965, the Kepuni stream had measurable discharge on only four days (U.S.G.S. 1971:363).

Within the Auwahi area proposed for wind farm development, where the majority of archaeological survey work was conducted, the geological substrate is dominated by a few major lava flows of the Hāna Volcanic Series, as depicted in Figure 4. The Puʻu Hōkū Kano cinder cone complex visually dominates the landscape, with its orange-red colored slopes. This cinder cone, the result of a late flank eruption, dates to between 30,000-50,000 years (30-50 kyr) old.

To the east of Puʻu Hōkū Kano is a large massive flow of aphyric basalt, designated by Sherrod et al. (2007) as the "Chiefly Homes" flow; this dates to between 10-30 kyr. Further east, and straddling the Auwahi-Lualaʻilua boundary is the Kipapa-2 ankaramite flow, also between 10-30 kyr in age. *Mauka* of Puʻu Hōkū Kano and slightly to the east is the Auwahi ankaramite flow, much younger in age, only 3-5 kyr. This flow is covered with a high density of archaeological features. Immediately *mauka* of the cinder cone is a deposition basin (colloquially referred to by the field team as the "Gobi Desert") filled with in-washed sediments. This basin was evidently a major agricultural zone for the pre-Contact and early post-Contact Hawaiian population of Auwahi. Remnants of a formal agricultural field system were identified by the field team on the upper slopes of this basin. Finally, on the western side of Puʻu Hōkū Kano is the large Kealakapu Basanite flow, between 10-30 kyr in age.

The relatively young age (in a geological sense) of the lava flows in the Auwahi area is important in terms of the way in which this landscape was utilized by the Hawaiian population for subsistence farming. As Vitousek et al. (2004) have shown for Hawaiian landscapes in general, and Kirch et al. (2004) demonstrated specifically for the Kahikinui region, the ability of substrates to support intensive dryland farming was dependent primarily on the interaction between substrate age and rainfall. Substrates that are only a few thousand years old generally lack soil development, while those that are several hundred thousand years old often have significant depletion of nutrients through leaching (especially if rainfall is high). Most of the lava flows in the Auwahi area are between 10,000-30,000 years old, which is old enough for them to have developed a workable soil horizon on top of the lava base, but not too old for nutrients to be depleted. In short, given adequate rainfall, the Auwahi soils were probably quite fertile and productive for Hawaiian subsistence crops such as sweet potato.

The rainfall gradient between the Haleakalā summit and the coast is steep. Rainfall in the archaeological survey area of Auwahi (*makai* of the Piʻilani highway), is estimated to be between 750 and 500 mm annually, with the lower elevations receiving less rain. The majority of this rainfall comes during the periodic *kona* storms in the winter months. From the viewpoint of traditional Hawaiian cultivators, annual rainfall in the range of 750-500 mm would have been minimally adequate for growing an annual crop of sweet potato. However, this would presumably have been too marginal for dryland taro, which would have to be planted at a higher elevation to receive adequate rainfall.

The upland portions of Kahikinui and particularly Auwahi still support the remnants of a once-remarkable dryland forest, with a diversity of endemic trees and shrubs, including *hala pepe*

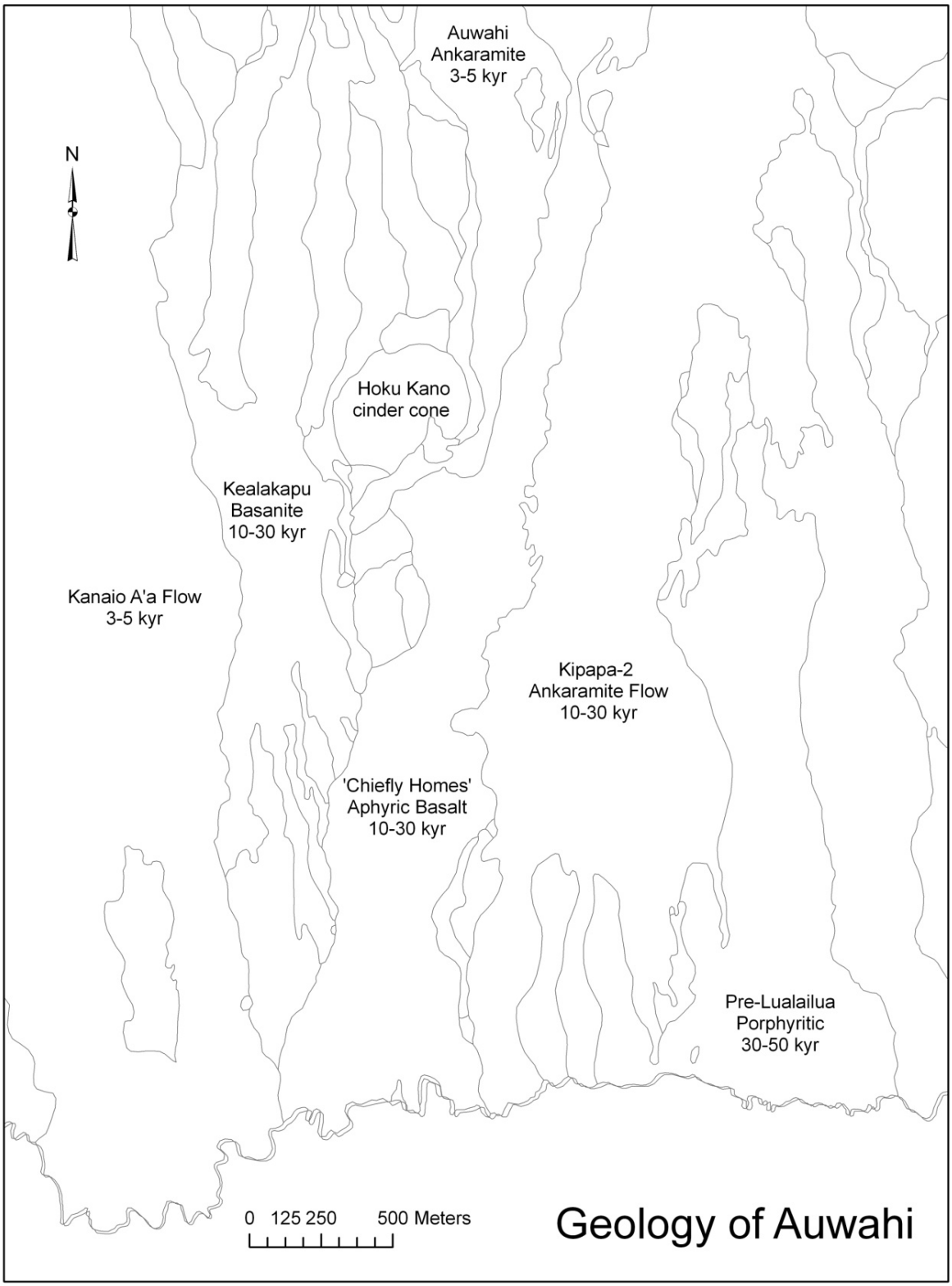


Figure 4. Major geological flows of the Auwahi area (map by P. V. Kirch based on data from Sherrod et al. 2007).

(*Pleomele auwahiensis*), *alahe'e* (*Canthium odoratum*), *hao* (*Rauvolfia sandwicensis*), *'ākia* (*Wikstroemia monticola*), *olopua* (*Nestegis sandwicensis*), *'ūlei* (*Osteomeles anthyllidifolia*), *'ōhi'a lehua* (*Metrosideros polymorpha*), and others. This endemic forest has been sadly degraded through the effects of feral pigs, goats, and especially cattle (Medeiros, Loope, and Holt 1986). In Auwahi, the area of archaeological survey is today dominated by a mix of exotic and invasive species, including lantana (*Lantana camara*), and *koa haole* (*Leucaena glauca*). However, significant numbers of native species such as *wiliwili* (*Erythrina sandwicensis*), *naio* (*Myoporum sandwicense*), and *'a'ali'i* (*Dodonea eriocarpa*) also persist. The lower elevations and coastal region are more barren, although scattered *wiliwili* and *'a'ali'i* grow to within a few hundred m of the coast.

The coastal resources available to the pre-Contact and early historic inhabitants of Kahikinui were more restricted than in other parts of Maui. The coastline is dominated by sea cliffs ranging from a few meters to 30-50 m (98-164 feet) high, making access difficult except in scattered locations where there are small bays with cobble or gravel beaches. Not surprisingly, such bays are marked by concentrations of archaeological sites, indicating that Native Hawaiians focused their coastal activities around them. There is no fringing reef along the Kahikinui coastline. The 'Alenuihāhā Channel between Maui and Hawai'i is noted for its strong currents and rough seas, which make fishing from small canoes hazardous. Surge-zone mollusks such as the prized *'opihi* (*Cellana exarata*), small cowries or *leho* (*Cypraea caputserpentis*), nerites or *pipipi* (*Nerita picea*), drupes or *pūpū-'awa* (*Drupa ricinus*), and sea urchins or *wana* (*Centrechinus paucispinus*); and *hā'uke'uke (Podophora atrata*) can be gathered from the sea cliffs and lava rock benches, and octopus (*he'e*) inhabit the shallower waters immediately offshore. Cowry-shell lures and "coffee-bean" type sinkers of the *lūhe'e* fishing gear have been commonly found on the surface of Kahikinui archaeological sites.

In an *'āina malo'o* such as Kahikinui, the Native Hawaiian population had to develop special methods and techniques for creating a viable subsistence economy. In wetter regions, Hawaiian agriculture depended first and foremost upon cultivation of the taro or *kalo* (*Colocasia esculenta*), both in irrigated pondfields (*lo'i*) and in non-irrigated (rain-fed) plots. In Kahikinui, however, the main crop was the *'uala* or sweet potato (*Ipomoea batatas*), among other reasons because it required far less rainfall, was more tolerant of periodic droughts, and produced high yields. Edward S. C. Handy, who made a study of traditional Hawaiian agricultural practices as they survived into the 1930s, called the region from Kaupō "through Kahikinui, Honua'ula, and Kula . . . the greatest continuous dry planting area [for sweet potatoes] in the Hawaiian Islands" (1940:161). Taro was not unknown in Kahikinui, however, and Handy also reported:

> I am told by an old informant, born at Kanaio in the next moku, that the Hawaiians formerly living along the coast of Kahikinui had their plantations of dry taro and other edibles inland in the forest zone, where the forest along the southern wall of Haleakala came much lower and where rainfall was more plentiful than it is today (1940:113).

Thus it is likely that there was some vertical zonation of agriculture according to elevation, with sweet potatoes dominant in the mid-elevation range, and taro becoming more plentiful at the higher elevations and forest margins.

The dearth of *kuleana* land claims from Kahikinui during the Mahele unfortunately deprives us of direct information on crops that were being cultivated at this time, such as are available for other regions. However, a few claims do exist for the adjacent district of Honua‘ula (which has a similar climate and soil regime to Kahikinui). These claims, made by the *maka‘āinana* of Honua‘ula before the Lands Commission, speak of gardens (*māla*) often situated within *moku mau‘u* (literally, “islands of grassland”), the latter presumably being patches of deeper soil. Aside from sweet potatoes, these claimants mentioned sugar cane, dryland taro, and Irish potatoes (which had been introduced after Contact) as crops being grown on their lands in 1947-48 (see L.C.A. 2405, 3676, 5331, 5455 and others, Native Register and Testimony, Archives of Hawai‘i).

1.6 DESCRIPTION OF SOILS

The various portions of the project area are extremely rocky. Below are descriptions of the soils in each of the portions of the project based on the comprehensive Statewide soil studies conducted in the mid 1900s (Foote et al. 1972). Figure 5 shows the distribution of the project area soils.

1.6.1 Wind Farm

Soils within the Wind Farm area are comprised of Cinder Land, Oanapuka Series (Oanapuka extremely stony silt loam, 7 to 25 percent slopes), and Very Stony Land.

Cinder Land (rCI)

> Cinder Land consists of areas of bedded magmatic ejecta associated with cinder cones. It is a mixture of cinders, pumice, and ash. These materials are black, red, yellow, brown, or variegated in color. They have jagged edges and a glassy appearance and show little or no evidence of soil development… (Foote et al. 1972: 29).

Oanapuka Series

> This series consists of well-drained, very stony soils . . . These soils developed in volcanic ash and material derived from cinders. They are moderately sloping to moderately steep (Foote et al. 1972: 101).
>
> **Oanapuka extremely stony silt loam, 7 to 25 percent slopes (OAD)** - This soil is similar to Oanapuka very stony silt loam, 7 to 25 percent slopes, except that stones cover 3 to 15 percent of the surface area. Included in mapping were small areas of rock outcrop… (Foote et al. 1972: 101).

Very Stony Land (rVS)

> This land type consists of areas where 50 to 90 percent of the surface is covered with stones and boulders . . . The slope ranges from 7 to 30 percent…On Maui this land type consists of young Aa lava that has a thin covering of volcanic ash that locally extends deep into cracks and depressions (Foote et al. 1972: 124).

1.6.2 Pāpaka Road

Soils within the Pāpaka Road corridor consist of the Io Series (Io silt loam, 7 to 25 percent slopes), Kula Series, Lava Flows – Aa, Makena Series (Makena loam, stony complex, 3 to 15 percent slopes), Oanapuka Series (Oanapuka stony silt loam, 7 to 25 percent slopes) and Very Stony land.

Io Series

> This series consists of well-drained soils. . . These soils developed in volcanic ash and material weathered from cinders. They are moderately sloping to moderately steep (Foote et al. 1972: 47).
>
> **Io silt loam, 7 to 25 percent slopes (ISD) –** This soil is on smooth, low mountain slopes. Included in mapping were small areas of Kula and Oanapuka soils. Also included were small, cobbly areas and small, steep areas near cinder (Foote et al. 1972: 47).

Kula Series

> This series consists of well-drained soils . . . These soils developed in volcanic ash. They are gently sloping to steep (Foote et al. 1972: 76).
>
> **Kula very rocky loam, 12 to 40 percent slopes (KxbE) –** This soil has a profile like that of Kula cobbly loam, 12 to 20 percent slopes, except that rock outcrops cover 10 to 25 percent of the surface. Runoff is medium, and the erosion is moderate (Foote et al. 1972: 77).

Lava Flows, Aa (rLW)

> Lava Flows, Aa consists of areas of geologically recent lava flows . . . The flows are a mass of clinker, hard, glassy, sharp pieces of lava on rough to undulating topography. The areas are difficult to traverse (Foote et al. 1972: 80).

Makena Series

> This series consists of well-drained soils . . . These soils developed in volcanic ash. They are gently to moderately sloping. Elevations range from nearly sea level to 500 feet. The annual rainfall amounts to 10 to 20 inches. Most of it occurs in winter. The mean annual soil temperature is 75° F. Makena soils are geographically associated with Keawakapu and Oanapuka soils….These soils are used for pasture and wildlife habitat. The natural vegetation consists of bristly foxtail, feather fingergrass, *ilima*, and *kiawe* (Foote et al. 1972: 91).
>
> **Makena loam, stony complex, 3 to 15 percent slopes (MXC) –** This complex is on the lower leeward slopes of Haleakala, between Makena and Kamaole. It consists of Makena loamand Stony land. Stony land occurs on low ridges and makes up 30 to 60 percent of the complex. Makena loam occurs as gently sloping areas between the low ridges of Stony land. . . Included in mapping were small areas of Keawakapu and Oanapuka soils. Also included were areas where outcrops of Aa lava cover as much as 15 percent of the surface. . . On the

Makena part of the complex, permeability is moderately rapid, runoff is slow to medium, and the erosion hazard is slight to moderate…On the Stony land part, permeability is very rapid and there is no erosion hazard (Foote et al. 1972: 91).

Oanapuka Series

This series consists of well-drained, very stony soils on low uplands on the island of Maui. These soils developed in volcanic ash and material derived from cinders. They are moderately sloping to moderately steep (Foote et al. 1972: 101).

Oanapuka extremely stony silt loam, 7 to 25 percent slopes (OED) - This soil is similar to Oanapuka very stony silt loam, 7 to 25 percent slopes, except that stones cover 3 to 15 percent of the surface area. Included in mapping were small areas of rock outcrop…This soil is used for pasture and wildlife habitat (Foote et al. 1972: 101).

Very Stony Land (rVS)

This land type consists of areas where 50 to 90 percent of the surface is covered with stones and boulders. . . The slope ranges from 7 to 30 percent. . . On Maui this land type consists of young Aa lava that has a thin covering of volcanic ash that locally extends deep into cracks and depressions (Foote et al. 1972: 124).

1.6.3 Generator-Tie Line

Soils within the Generator-Tie Line corridor consist of Io Series (Io silt loam, 7 to 25 percent slopes), Kamaole Series (Kamaole very stony silt loam, 3 to 15 percent slopes), Kula Series (Kula loam, 12 to 20 percent slopes, Kula very rocky loam, 12 to 40 percent slopes), Lava Flows - Aa, Ulupalakua Series (Ulupalakua silt loam, 7 to 25 percent slopes), Uma Series (Uma loamy coarse sand, 15 to 40 percent slopes, Uma loamy coarse sand, 40 to 70 percent slopes, and Uma rocky loamy coarse sand, 7 to 25 percent slopes), Very Stony land.

Io Series

This series consists of well-drained soils . . . These soils developed in volcanic ash and material weathered from cinders. They are moderately sloping to moderately steep (Foote et al. 1972: 47).

Io silt loam, 7 to 25 percent slopes (ISD) – This soil is on smooth, low mountain slopes. Included in mapping were small areas of Kula and Oanapuka soils. Also included were small, cobbly areas and small, steep areas near cinder…Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate (Foote et al. 1972: 47).

Kamaole Series

This series consists of well-drained soils on uplands on the island of Maui. These soils developed in volcanic ash. They are gently to moderately sloping (Foote et al. 1972: 59).

Kamaole very stony silt loam, 3 to 15 percent slopes (KGKC) – This soil is on uplands. Included in mapping were small areas of Keawakapu and Kula soils. Also included were small areas where slopes have been removed. Outcrops of Aa lava are common…Permeability is moderate. Runoff is slow to medium, and the erosion hazard is slight to moderate (Foote et al. 1972: 59).

Kula Series

This series consists of well-drained soils . . . These soils developed in volcanic ash. They are gently sloping to steep (Foote et al. 1972: 76).

Kula loam, 12 to 20 percent slopes (KxD) – This soil has a profile like that of Kula cobbly loam, 12 to 20 percent slopes, except that it is nearly free of cobblestones. Included in mapping were small, stony areas and a few rock outcrops, mainly on knolls and the sides of gulches (Foote et al. 1972: 77).

Kula very rocky loam, 12 to 40 percent slopes (KxbE) – This soil has a profile like that of Kula cobbly loam, 12 to 20 percent slopes, except that rock outcrops cover 10 to 25 percent of the surface. Runoff is medium, and the erosion is moderate (Foote et al. 1972: 77).

Lava Flows, Aa (rLW)

Lava Flows, Aa consists of areas of geologically recent lava flows . . . The flows are a mass of clinker, hard, glassy, sharp pieces of lava on rough to undulating topography. The areas are difficult to traverse (Foote et al. 1972: 80).

Ulupalakua Series

This series consists of well-drained soils on intermediate mountain slopes . . . These soils developed in volcanic ash and material weathered from cinders. They are moderately sloping to moderately steep (Foote et al. 1972: 122).

Ulupalakua silt loam, 7 to 25 percent slopes (ULD) – This soil is on smooth intermediate mountain slopes. Included in mapping were small areas of Io and Kaipoioi soils. Also included were small, very steep areas...Permeability is moderately rapid. Runoff is slow, and the erosion hazard is slight (Foote et al. 1972: 122).

Uma Series

This series consists of excessively drained, sandy soils on intermediate mountain slopes. . . These soils developed in volcanic ash and material weathered from cinders. They are on moderately sloping to very steep intermediate mountain slopes (Foote et al. 1972: 122-123).

Uma loamy coarse sand, 15 to 40 percent slopes (UME) – This soil is on smooth, intermediate mountain slopes. Included in mapping were small areas of Puu Pa and Ulupalakua soils. Also included were a few cinder cones and small areas of

rock outcrop. . . Permeability is very rapid. Runoff is slow, and the erosion hazard is slight to moderate (Foote et al. 1972: 123).

Uma loamy coarse sand, 40 to 70 percent slopes (UMF) – This soil is similar to Uma loamy coarse sand, 15 to 40 percent slopes, except for the slope. The erosion hazard is severe. Included in mapping were small areas of rock outcrop and cinder cones (Foote et al. 1972: 123).

Uma rocky loamy coarse sand, 7 to 25 percent slopes (URD) – This soil is similar to Uma loamy coarse sand, 15 to 40 percent slopes, except that rock outcrops cover 5 to 10 percent of the surface. Runoff is medium, and the erosion hazard is moderate. Included in mapping were small areas where there are few too many stones on the surface and in the profile (Foote et al. 1972: 123).

Very Stony Land (rVS)

This land type consists of areas where 50 to 90 percent of the surface is covered with stones and boulders. . . The slope ranges from 7 to 30 percent. . . On Maui this land type consists of young Aa lava that has a thin covering of volcanic ash that locally extends deep into cracks and depressions (Foote et al. 1972: 124).

1.6.4 Interconnection Substation and Access Road

Soils found in the Interconnection substation and associated access road consist of Io silt loam, 7-25 percent slope; Kula loam; and Kamaole very stony silt loam, 3-15 percent slopes. These have been described in Section 1.6.3 above.

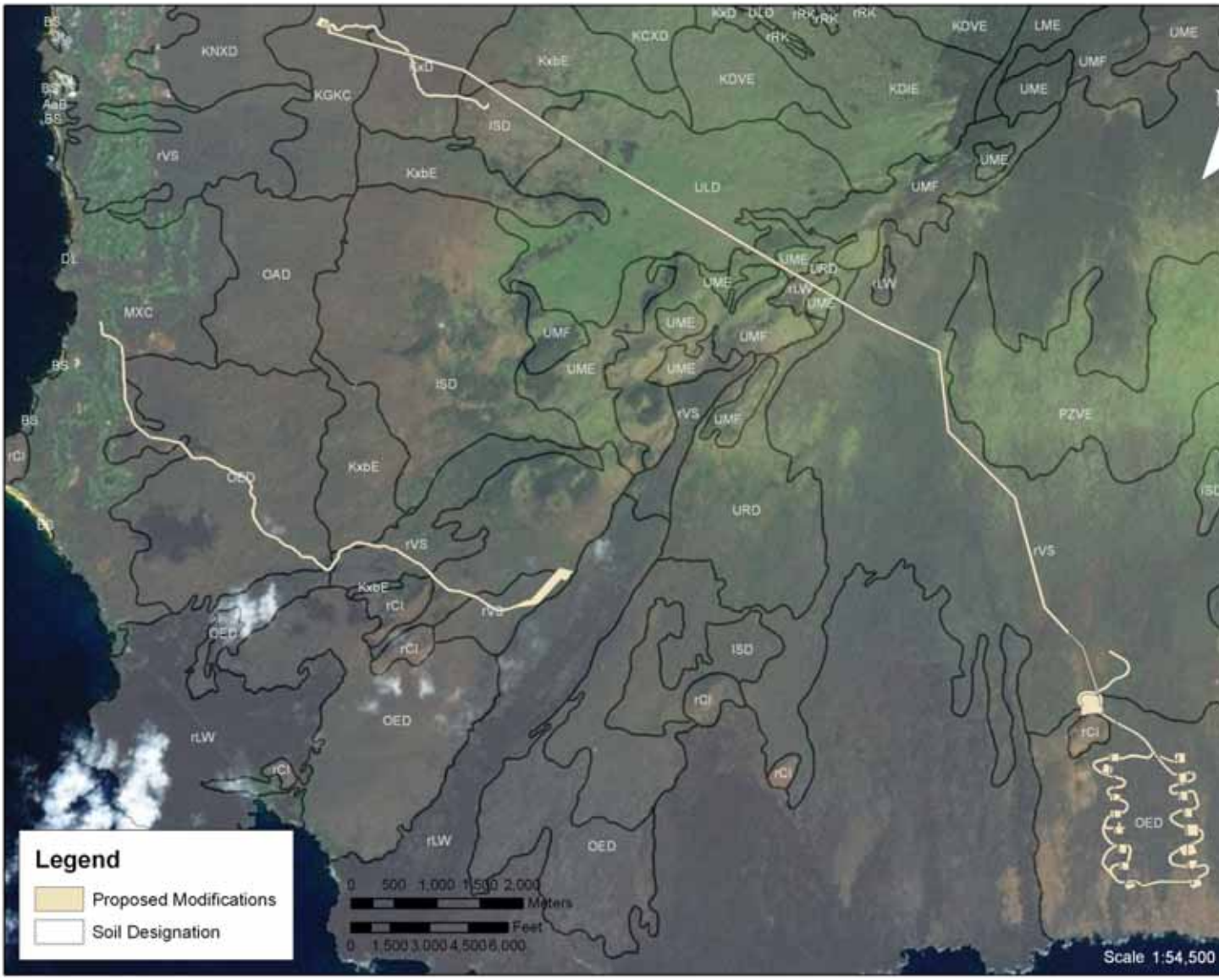


Figure 5. Soil types within project area (aerial background courtesy of ESRI).

2.0 METHODS

2.1 2007 PEDESTRIAN SURVEY

2.1.1 Wind Farm

The pedestrian survey was conducted by a five-person crew between 7 May 2007 and 3 June 2007. The study area, comprising approximately 1,450 acres, was defined by GIS shape files provided by CH2M Hill. During the initial pedestrian survey, 20 m linear transect intervals were used between surveyors as they traversed the landscape from east to west. Due to constraints of topography, vegetation, and visibility, however, the interval between crew members was changed to ca. 40 m with surveyors zigzagging to achieve a 20 meter interval.

All cultural resources encountered were recorded on a standardized form developed for this project that was modified from forms used elsewhere in Kahikinui by Patrick Kirch and Lisa Holm. The forms contained coded attribute information for each resource detailing its type, structural form, probable function, and wall construction. The presence or absence of paving, formal entryways, hearths, pits, upright stones, coral, artifacts, midden, and lithics was also noted, as was the resource's state of preservation, topographic setting, and physical dimensions. Locational information was recorded for each resource with handheld GPS (Garmin 60CSx and Trimble Geo-XT) receivers. Digital photographs were taken of many of the more prominent resources, and brief verbal descriptions of each were recorded.

2.1.2 Generator-Tie Line Corridor Survey

Part of the project includes the construction of a 14.5 kilometer (9 miles) long Generator-Tie Line within a 30 meter (100 feet) corridor. This Generator-Tie Line will originate at the wind farm in Auwahi and extended northwestward to its terminus in Wailea where it will connect with existing Maui Electric Company infrastructure. A pedestrian survey along the Generator-Tie Line corridor was conducted on 21-22 May 2007 by two two-person crews; a fifth individual was stationed in a project vehicle to ensure personnel safety and to maintain intermittent contact with both teams. Both crews began the survey at the apex of the proposed Generator-Tie Line (an elevation of ca. 4,500 feet) and proceeded in opposite directions; one crew terminated their survey at the Piʻilani Highway immediately above the wind farm, while the other completed their survey at Highway 37 in Kula. On 22 May 2007, both teams surveyed disparate portions of the Generator-Tie Line corridor between Highway 37 and its northwestern endpoint. A survey interval of no more than 30 m was used along the full length of the Generator-Tie Line corridor, with surveyors zigzagging between the boundary and centerline to achieve full coverage.

2.1.3 Pāpaka Road Survey

Pāpaka Road was surveyed by two archeologists on 28-30 January 2008. The road extends for approximately 4.8 miles from Mākena gate (near 5145 Wailea Alanui Drive) up to Piʻilani Highway just east of the ʻUlupalakua Ranch Headquarters. Proposed widening of the road was to be limited to the upper ca. 2.1 miles; the lower 2.5 miles were deemed wide enough to accommodate the anticipated traffic and was not designed to be widened. The pedestrian

survey was limited to the upper 2.1 mile segment. A corridor measuring approximately 30 to 40 m (98 to 131 feet) wide was surveyed by a two member team, focusing on each side of the existing roadway.

2.1.4 2007 Survey Constraints

The survey area was characterized by moderate to steep slopes covered by a mix of native and introduced grasses, shrubs, and trees. A number of areas were dominated by dense stands of *koa haole* and *wiliwili*, which frequently hampered the pedestrian survey. Exotic grasses and shrubs such as kikuyu, glycine, and lantana also obscured the ground surface in many areas, impacting resource visibility and hence discovery. Vegetation clearance during this phase of recording was not attempted, and it is likely that a number of features such as lava tubes, stone mounds, and low earth-filled terraces remain obscured that might otherwise be visible under more optimal conditions. In a recent study, Holm and Kirch (2007) found a direct correlation between the effectiveness of pedestrian surveys and (1) the height of archaeological features above the earth's surface and (2) the type/density of the surrounding vegetation. The most intensive pedestrian surveys may fail to uncover low or minimally extrusive features, while dense vegetation may obscure even more substantial resources. It was therefore assumed that a certain percentage of resources within Auwahi remain undiscovered, which highlighted the need for further investigation and more intensive recording within the project's APE.

2.2 2010 Detailed Recording and Testing

The detailed recording and site testing phase occurred from 12 April 2010 through 3 September 2010 with a field crew varying in size from five to ten archaeologists. The field methods for the detailed recording and site testing phase initially consisted of relocating the previously identified resources from the 2007 inventory survey located within the APE for the proposed Auwahi Wind Farm project components (see Section 1.1 for a definition of the APE).

The APE included 120 sites within the wind farm where the turbine pads and access roads are proposed, 66 sites along the Pāpaka Road route which will be used for construction access, and 48 sites along the proposed Generator-Tie Line route and the Interconnection substation and four sites along Piʻilani Highway where proposed adjustments are needed for access. Relocation of the sites was facilitated through the use of Trimble Explorer GPS units and the previously collected GPS data from the 2007 inventory survey. Relocated sites were marked with pink flagging with their temporary site number designations written on the flagging in permanent marker to facilitate future recording.

After all the sites were relocated, the field crews then began hand clearing the vegetation from the site areas so that each of the individual features could be more thoroughly examined and recorded. Site clearing was accomplished with the use of hand tools (machetes and pruning clippers). Once the site areas and individual feature components were cleared of vegetation, the detailed recording of the sites could commence.

Detailed recording included the gathering of data sufficient to complete Archaeological Site and Feature Record Forms. Data collection included observations on the nature of each feature and

site area which included interpretations as to their function. This information is necessary for the significance evaluation of the various features. Sub-meter accuracy GPS data was obtained for each individual feature at all the sites within the APE. This allowed for the precise location of each feature in the event that project design changes were necessary and as a result significant features could be avoided as much as possible. GPS readings were also collected for each site datum, as well as for diagnostic and collected artifacts, and subsequent test excavation units. Site maps were prepared using tape and compass and/or the collected GPS reference data. Representative detailed feature maps were also prepared using tape and compass or plan table and stadia rod. Digital photographs were taken for each of the individual features, artifacts and site areas.

Following the detailed recording, a representative sample of the resources within various project component areas were subjected to test unit excavations. Test excavation units typically measured 1x1 meter in size and were excavated by 10 cm arbitrary levels within each of the observed stratigraphic layers. Excavated soils were processed through 1/8-inch mesh screens and recovered constituents were sorted and bagged by level. Special emphasis was placed on trying to recover radiocarbon samples for dating purposes. Excavation level records were filled out for the various levels of each unit and were supplemented by digital photographs and sidewall profile data and illustrations. Bag logs were used to inventory the collected materials from the excavation recovery and collected surface artifacts at the sites prior to transport to the Pacific Legacy lab facility in Kailua, Hawai‘i. All units were backfilled at the end of excavation and unit locations were added to the previously prepared site and feature maps. Updates to the site records were prepared documenting the excavations that occurred to the sites which were tested.

Additional archaeological inventory survey was required in certain areas as a result of project design changes. During the supplemental survey, crew members were spaced at transect intervals varying from 10 to 15 m wide to provide complete survey coverage within the new APE. New survey area APE boundaries were based on the information and maps provided by Auwahi Wind Farm, LLC engineers and were supplemented with Trimble GPS shape files for the new project component changes. This insured that the new APE areas were completely inventoried for cultural resources. When newly identified resources were discovered, they were flagged, cleared and recorded following the methods which were described above.

2.3 TERMINOLOGY USED IN RECORDING RESOURCES

Archaeological resources are commonly referred to as “sites” in Hawaiian archaeological surveys. The term “site” is non-standardized and therefore problematic. Some investigators use this term to refer to single architectural elements, while others lump multiple architectural features into a single “site.” We avoided the use of this term by using the concept of the *archaeological feature* as our basic unit of recording. An archaeological feature is a spatially discrete unit, made up of two or more *single architectural components* such as pavements or free-standing walls. Examples of features include stone-walled enclosures, C-shaped stacked stone structures, and stone-faced terraces. When one or more features are contiguous, as in a multi-

chambered structure, we call this a *compound structure*. Such compound structures are relatively rare in Hawaiian landscapes, and most typically consist either of religious structures (*heiau)* or chiefly (*ali'i*) residences. Frequently, a number of individual features and compound structures may be found spatially clustered together; these clustered features are usually assumed to be temporally and/or functionally related, and hence such groupings are referred to as *feature complexes or sites*. Feature complexes are often comprised of structures that functioned as extended-family residences (*kauhale*), or as agricultural areas encompassing planting mounds, terraces, and/or field system boundary walls. Functionally disparate features are also sometimes found clustered together, as in the case of a residential complex with an associated family shrine or temple and household garden area.

Single architectural components, features, compound structures, and feature complexes (sites) were numbered sequentially as they were encountered in the course of pedestrian survey. The prefix AWF was used to refer to the "Auwahi Wind Farm" project; features were numbered in the order they were encountered and logged into our recording system. Individual ("stand alone") features received a single number, as did clusters of features when these clearly formed a feature complex.

2.4 PRIMARY FEATURE TYPES

Features were assigned a "basic feature type" according to a classification developed over more than a decade of field research in the Kahikinui region of southeast Maui by members of the Oceanic Archaeology Laboratory at the University of California, Berkeley. In the case of feature complexes, more than one basic feature type may be recorded for the complex. The most common feature types occurring in the Auwahi study area are found below.

Stone mound: a heap or mound of artificially placed stones, often size-sorted, and typically ranging between 0.5-2.0 m in diameter. The functions of such mounds are difficult to determine based on surface survey alone, but many of these could potentially indicate human burials.

Free-Standing Wall: a stacked or core-filled wall not otherwise part of a structure, often running for some distance over the landscape. Many such walls were constructed during the cattle-ranching period beginning in the later 1800s.

Terrace: A level surface, usually rectangular in plan view, constructed on sloping terrain with retaining walls on the front and sides. Terraces may be either stone-filled or earth–filled and their functions were variable, encompassing agricultural, residential, and ritual activities.

Platform: A level surface, usually square or rectangular in plan view, constructed with four free-standing retaining walls and filled with cobble or pebble-sized stones. Typically, platforms were used as formal burials or occasionally as boundary or territorial markers.

Shelter: This is perhaps the most prevalent feature category, encompassing considerable variation in architectural style. Shelters have constructed stone walls (either stacked or core-filled) defining at least one side, but are typically less formal in plan view than enclosures (see below). In Auwahi as elsewhere in Kahikinui, common types of shelters include C-shapes, L-shapes, and linear shelters (usually adjoining a terrace). Their functions are most commonly residential, and several shelters are often found together making up a residential or feature complex.

Enclosure: These structures are defined by enclosing walls on at least three and usually four sides; they may or may not incorporate a formal entryway ("doorway"). Their plan views include rectangular, square, circular, and U-shaped varieties. Most often, such features are of residential function, although they can include agricultural and ritual functions as well.

2.5 FEATURE FUNCTION

As features and complexes were recorded, they were assigned a "probable function" corresponding to one or more of the following categories: (0) not determined, (1) residential/habitation, (2) agricultural, (3) ritual/ceremonial, (4) burial, (5) boundary marker/land division, and (6) special purpose/other. The assignment of a feature to a particular functional class was based upon accumulated knowledge of the archaeology of the Kahikinui, predicated on the results of long-term excavation projects undertaken by the Oceanic Archaeology Laboratory (Kirch 1997, Coil 2004, Holm 2006) and by the State Historic Preservation Division (SHPD) (Dixon 2000). It is important to stress that this is not a definitive statement about a feature's actual past function, and these preliminary assessments are subject to revision based on additional information. When appropriate, one or more functional attributes were assigned to a feature or complex.

3.0 BACKGROUND

3.1 HISTORICAL BACKGROUND[2]

The place name *Kahikinui* has considerable significance in Polynesian and Hawaiian traditions. Literally, Kahikinui translates as "Great Tahiti" (Pukui, Elbert, and Mookini 1974:64). The name was most likely first applied in ancient times in commemoration of Tahiti Nui, perhaps by one of the famous Polynesian navigators who made the long voyage between the Society Islands and Hawaiʻi. Like the island of Tahiti, Maui is also a double-volcano, and both islands have a low isthmus connecting smaller and larger mountain masses. On Tahiti, these two volcanic masses are named Tahiti Nui and Tahiti Iti. One of the original voyagers to Hawaiʻi, perhaps sailing through the channel known as Ke Ala i Kahiki ("the road to Tahiti"), probably recognized the striking topographic similarity between Maui and the homeland Tahiti. It is probable that the name Kahikinui thus originally applied to the entire eastern half of Maui. Generations later, after the ruling chiefs had imposed their territorial land system, Kahikinui came to refer more narrowly to the specific *moku* or district facing towards the south: the ancient voyaging route from Kahiki.

The great nineteenth-century Hawaiian scholar Samuel Mānaiakalani Kamakau wrote the following text about the "Coming of the Gods," which is to say the arrival of the first ancestors of the Hawaiian people:

> According to the *moʻolelo* of Kāne and Kanaloa, they were perhaps the first who kept gods (*ʻo laua paha nā kahu akua mua*) to come to *Hawaiʻi nei*, and because of their *mana* they were called gods. Kahoʻolawe was first named Kanaloa for his having first come there by way of Ke-ala-i-kahiki. From Kahoʻolawe the two went to Kahikinui, Maui, where they opened up the fishpond of Kanaloa at Lua-laʻi-lua, and from them came the water of Kou at Kaupō (Kamakau 1991:112).

Another traditional reference to Kahikinui appears to the famous *moʻolelo* or tradition of the voyaging chief Laʻamaikahiki. Laʻamaikahiki was a son of the famous Moʻikeha, who had sailed from Hawaiʻi to Tahiti and dwelled in the land of Moaulanuiākea, where Laʻamaikahiki was born. After Moʻikeha had returned to Hawaiʻi and was living on Kauaʻi, he sent his son Kila to fetch Laʻamaikahiki. After spending some time with his father Moʻikeha, Laʻamaikahiki decided to return to Tahiti, but first spent some time in Kahikinui on Maui. Fornander gives the following brief information:

> Laamaikahiki lived in Kauai for a time, when he moved over to Kahikinui in Maui. This place was named in honor of Laamaikahiki. As the place was too windy, Laamaikahiki left it and sailed for the west coast of the island of Kahoolawe, where he lived until he finally left for Tahiti. It is said that because Laamaikahiki lived on Kahoolawe, and set sail form that island, was the reason why the ocean to the west of Kahoolawe is called "the road to Tahiti." (Fornander 1916:128).

[2] This section incorporates some material previously published in Kirch (1997).

Aside from these accounts, however, Kahikinui is virtually ignored in the Hawaiian pre-Contact traditions, and the *moku* seems to have largely been a *kua'āina* or "back country" land shunned by the ruling chiefs. Maui king Kekaulike made the adjacent *moku* of Kaupō his primary residence in the 1700s, building several major heiau there (Kamakau 1961:66). However, Kaupō, which supported a substantial dryland field system, is considerably more fertile than Kahikinui.

The written documentary sources of the post-Contact era are also scanty compared with other parts of the island. The first European explorer to sail along the southeast Maui coast was Jean-François de Galaup de la Pérouse, in command of the French frigates *Boussole* and *Astrolabe.* On May 28, 1786, La Pérouse's ships sighted the snow-covered summits of Hawai'i Island and soon after, that of Haleakalā. La Pérouse wrote that "the island of Maui looked delightful," and he directed his ships to coast it one league offshore. His sea-weary crew was enthralled with "waterfalls tumbling down the mountainside into the sea," as they passed Kīpahulu and Kaupō (Dunmore, ed., 1994:80). But this idyllic landscape was soon replaced as "the mountains receded towards the interior of the island."

> We saw no more waterfalls, the trees were fairly sparsely planted along the plain, and the villages, consisting only of 10 or 12 huts, were quite distant from each other. Every moment made us regret the country which we were leaving behind, and we only found shelter when we were faced with a frightful shore, where the lava had once run down as waterfalls do today in the other part of the island (Dunmore, ed. 1994:82).

La Pérouse dropped anchor off the small fishing village of Keone'ō'io, in Honua'ula District. He went ashore the next day, giving us one of the first accounts of traditional Hawaiian houses on Maui. Along the Kahikinui shoreline, however, the French explorer reported only small "villages" of 10-12 huts along the shore. This absence of settlement is at odds with archaeological evidence for a fairly large and dense population in Kahikinui in pre-Contact times. However, this population was largely concentrated in an upland zone above about 300 m (984 feet) elevation. The immediate coastal strip may have been used only intermittently for fishing and shellfish gathering. It is possible that La Pérouse observed only the intermittently-utilized coastal residences (mistaking these for "villages") of a population that resided primarily in the uplands, where their main gardens and temples were located.

The population of Kahikinui at the time of European contact must be estimated based on archaeological evidence (Kirch 2007). As throughout the archipelago, the introduction of Western diseases—for which the Native Hawaiians had little or no resistance—led to massive depopulation. In addition, there was out-migration from marginal *moku* such as Kahikinui to areas such as Lāhainā. Early missionary census figures from the period 1831-36 portray a small population in relation to other parts of Maui. In the 1831-32 census of Maui, Kahikinui District was reported to have 517 occupants out of an island-wide total of 35,062 (Schmitt 1973:18, Appendix A). By 1836 this population had declined to 447 out of a total of 24,195 (1973:36, Appendix C). While it is possible that the Protestant missionaries who undertook these censuses may have underestimated the largely Catholic population of Kahikinui, they nonetheless had the overt support of the local Government authorities, such as *konohiki*, and therefore such underestimation is unlikely. Coulter, who made an extensive study of the 1853 Government census and its geographic distribution, observed that "the districts of Kaupō and Kahikinui,

dissected uplands of little rainfall on the lee side of Mount Haleakalā, were almost uninhabited" by that time (1931:23). His map (1931, fig. 8) indicates a population of no more than 50 persons.

Kahikinui has always been something of a hinterland, a *kua'āina*, not only environmentally but culturally. Not surprisingly, Kahikinui was a major refuge for Native Hawaiians who had adopted the Catholic faith in the first half of the nineteenth century, a time when the official (and exclusively legal) religion of the islands was the Congregational Protestant denomination introduced by the missionaries of the American Board of Commissioners for Foreign Missions. High chiefess Ka'ahumanu, *Kuhina Nui* ("Regent") of the Kingdom during the reign of Kamehameha II and the early part of reign of Kamehameha III, adopted this new religion following the famous *'ai noa* of 1819 after the death of Kamehameha I. She appointed Hiram Bingham as a new kind of *Kahuna Nui* or "high priest" (Sahlins 1992:67-68). Successive attempts by French Catholics to establish a mission in the islands between 1826 and 1840 were met by varied forms of hostility and outright aggression, to which the French responded at times with gunboat diplomacy (Kuykendall 1938:137-47).

Precisely when the Native Hawaiian population of Kahikinui was converted to the Catholic faith seems not to be recorded (the first "official" mission on Maui dates to 1846). A thatched church (*hale pili*) was constructed at the site of the present St. Ynez Church ruin in Nakaohu sometime during the late 1830s (Ashdown 1973:6). The leader of the Kahikinui Catholics was Helio Kaiwiloa (sometimes recorded as Koa'eloa [e.g., Anon. 1963]), known also as the "Apostle of Maui" (Bartholomew 1994:19). According to Ashdown (1973:6), the first church was burned by local authorities, only to be quickly reconstructed. Helio Kaiwiloa and another fervent Catholic of Kahikinui, Simeon Kaoao, gained notoriety in 1843 with the infamous *pa'a kaula* ("tying with ropes") incident. As recounted by Bartholomew,

> . . . the Protestant mission at Hāna notified the police that a small group of defiant Catholic women were congregating for prayer at Kahikinui. The police dutifully arrested them, tied them to each other with sennit, and marched them eastwards toward Wailuku, 90 miles away. As word was passed along the route, other converts asked to be tethered to their fellow believers and joined the procession along Hana's coast, dressed in their lei-bedecked Sunday best. By the time they reached Wailuku a month later, their numbers had risen to over 100. The judge, seeing the futility of prosecuting such a large group, dismissed the charges (1994:19).

After a legitimate Catholic mission had been established in the islands in 1846, the Kahikinui congregation practiced its faith openly. The diary of Father Modest Favens (also known as Pekelo) records that on May 1, 1846 he arrived "in early morning at Kahikinui by trail along the seashore. Mass and prayers. Examination of catechumens . . . baptize 15 children on the spot" (Schoofs 1978:265). In July of that year Father Favens also reported that Kahikinui had "a nice little chapel [St. Ynez] flanked by a cottage for the priest" (1978:278). Schoofs continues:

> Legend has it that catechist Helio Kaiwiloa was responsible for having the people of Kahikinui erect these buildings. Kahikinui was not a 'regular' village where people lived close together. Its *pili*-grass cottages were spread out far and wide under trees and shrubs. Nevertheless at one time Kahikinui, which was the birthplace of catechist Simeon Kaoao, who donated part of his property to build a school, was a devout community. It is

> here that Simon came back to die in December, 1846, after guiding Father Favens through the district (1978:278).

A major event that took place sometime during the 1830s-40s was the construction of the "Hoapili Trail", the coastal route that runs through Honua‘ula and Kahikinui and on to Kaupō. The curbstone-lined trail, about 2 m wide and with well-constructed causeways where it crosses depressions in the lava or small stream channels, was constructed by Native Hawaiians who had been sentenced for violating the laws against theft, adultery, drinking, and so forth, first issued as edicts by Governor Hoapili around 1826, and later codified in the penal code adopted by King Kamehameha III in 1835 (Kuykendall 1938:136, 163). Such offenders provided the principal labor source for road building both on Maui and Hawai‘i Islands (Apple 1965:45). The missionary Henry T. Cheever traveled along the Hoapili Trail in the late 1840s, and described it as follows:

> Yet it is a way not devoid for interest and novelty, especially that part of it which runs from Honuaula to Kahikinui and Kaupo; for it is a road built by the convicts of adultery, some years ago, when the laws relating to that and other crimes were first enacted, under the administration of the celebrated chief Hoapili, in whom was the first example of a Christian marriage.
>
> It is altogether the noblest and best Hawaiian work of internal improvement I have anywhere seen. It is carried directly over a large verdureless tract, inundated and heaved up by an eruption from the giant crater of Hale-a-ka-la; and when it is considered that it was made by convicts, without sledge-hammers, or crowbars, or any other instrument but the human hands, holding a stone, and the Hawaiian Oo, it is worthy of great admiration (Cheever 1851:105).

No series of events could have had more sweeping consequences for the Native Hawaiian people than those culminating in the Mahele of 1848-52. This series of government acts imposed upon the islands a Western, allodial system of land tenure, resulting in the end of the old chiefly regime (Kirch and Sahlins 1992; Kame‘eleihiwa 1992). That Kahikinui itself was a *moku*, and not simply an *ahupua‘a* as some have incorrectly stated, is made clear in the *Indices of Awards* (1929:13), where "Ka Moku" of Kahikinui is included in the listing of Government Lands. Prior to the Mahele, the greater part of the district of Kahikinui was the personal estate of Prince Lot Kamehameha, later to become King Kamehameha V. The *Indices of Awards* further notes that:

> . . . by action of the Privy Council on Aug. 29, 1850, as recorded on page 423 of Vol. 3 of Privy Council Records, a Resolution was passed for his [Lot's] relief as follows: "Resolved that in consideration of the relinquishment of 'Kahikinui' on East Maui, by Lot Kamehameha to the Government in former division of lands, the Minister of the Interior is hereby authorized to grant Royal Patents to Lot for his lands, said to be eighteen in number, without further division or commutation" (Commissioner of Public Lands 1929:7-8).

Thus, by giving over the greater part of Kahikinui *moku* to the Hawaiian Government for its purposes, Lot Kamehameha retained clear title to his other *ahupua‘a* holdings throughout the Kingdom.

The westernmost *ahupua'a* of Kahikinui, Auwahi, although part of the larger *moku* was not included among the lands deeded by Lot Kamehameha to the Government during the Mahele. Rather, this *ahupua'a* was awarded to Princess Ruta (Ruth) Ke'elikolani (L.C.A. 7716, Royal Patent 7791), half-sister of Lot Kamehameha, and great grand-daughter of Kamehameha I. Later, Auwahi would become part of the holdings of 'Ulupalakua Ranch. Princess Ruth may have considered Auwahi to be more valuable land than the eastern part of Kahikinui given to her half-brother Lot. There is some evidence to suggest that Auwahi had a large and dense inland population. The coastal settlement at Makee (also known as "Ranch Beach") contains the largest house sites in the entire Kahikinui District, and was probably the chiefly center for the entire moku. It is likely that Ruth's *konohiki* resided at Makee during the mid-20th century. Two historic grave sites on the lava ridge overlooking the Makee settlement, both incorporating coral-lime mortar, may be burials of individuals who resided at Makee during Ruth's tenure.

Virtually no commoners or *maka'āinana* of Kahikinui received lands during the Mahele. Aside from the granting of the several *ahupua'a* to Lot Kamehameha and Ruta Ke'elikolani (see above), only a single *maka'āinana* submitted a claim to the Lands Commission. This was Makaole of Lula'ilua *ahupua'a*, who submitted his claim for two house sites, and various garden plots, as well as salt-collecting areas on the coast (Commissioner of Public Lands 1929, L.C.A. 5404; Native Register 6:286, Foreign Testimony 8:227, Native Testimony 5:360, Archives of Hawai'i). Why it was that others did not submit claims is not known. Possibly their status as Catholics could have mitigated against them in the eyes of staunch Protestant members of the Lands Commission such as David Malo.

Lot Kamehameha's transfer of Kahikinui to the Kingdom had an unintended consequence. Since the entire *moku* was now Government land, there was no reason for dispute over the boundaries of its individual *ahupua'a* subdivisions. Thus, when the Boundary Commission later carried out its important task of taking testimony from local residents regarding the specific divisions between *ahupua'a* throughout the Kingdom, they simply passed over Kahikinui. This left a gap in our knowledge of the cultural landscape of Kahikinui. Today, we know only that there were eight named subdivisions within Kahikinui, but it is not certain that all of these had the status of *ahupua'a*. Some may have been smaller *'ili* segments of *ahupua'a*. From west to east, these named land units are: Auwahi, Lula'ilua, Alena, Kīpapa, Nakaohu, Nakaaha, Mahamenui, and Manawainui. Most maps indicate that the eastern boundary of Kahikinui was Wai'ōpai Gulch, with the land of Nakula lying in Kaupō (e.g., Hawai'i Territory survey, 1929, 1" = 5000').

A physician, Dr. James Rae, provides a rare account of a trip through Kahikinui District in 1853 (Rae, Ms.). Leaving Kaupō, Dr. Rae "came on about seven miles to the house of Makaole," at Lula'ilua Hills. He ate a meal of sweet potatoes with Makaole's family, and described several groups of travelers passing by, including a woman carrying two turkeys and a pig, and another with a load of watermelons. Rae observed that "here and there are patches suited to the sweet potato and Kalo." His description of Makaole's house provides a glimpse of household life at mid-century:

> Makaole's house very comfortable, about 20 by 28 [feet]. The family were all seated under a tree on a spot where the stones had been cleared away and the space covered

> with dry grass. In a corner of the sort of wall thus formed a fireplace and hanging on the tree, their calabashes. They were just removing the pot from the fire containing a fowl in fragments and asked me to partake which I did with sweet potatoes. . . . There was a small square spot within the entrance covered with coarse mat. The rest well matted. The third of the house which I slept raised a little by the mats. I counted ten besides the upper fine one 8 x17. The woman made a calico curtain, purple and pink, thrown down at night. Strings stretched across with great abundance of Kapas. They covered me with two, a blanket & many articles of clothing in good order & ditto quality (Rae, Ms.).

The small Native Hawaiian population resident in Kahikinui declined rapidly after the Mahele; St. Ynez Church itself was evidently abandoned sometime in the 1860s. Cattle ranching began in Kahikinui in the early 1870s. A Portuguese rancher by the name of Pico (sometimes indicated as "Paiko") obtained a lease from the Hawaiian Government, and was running cattle in Kahikinui in the 1870s and 80s. As a boy, E. D. Baldwin visited Pico's ranch house in Kahikinui while assisting with the Government survey. In October of 1881, Baldwin recounts "packing all of our drinking water from Paiko's tanks", and visiting "Paiko's wind-mill . . . located below Lualaʻilua Hills, about a mile back from the sea" (Baldwin, Ms.). By the turn of the century a small independent Kahikinui Ranch was operating out of Kahikinui House, which still stands northeast of St. Ynez Church. According to Mr. Pardee Erdman of ʻUlupalakua Ranch (pers. comm., June 7, 1996), Kahikinui House was constructed by two Portuguese ranchers, Enos and Feirrera, who hauled the timber up from Nuʻu Landing. Erdman said that the house was meant to be constructed in Mahamenui, where Enos and Feirrera had a 118-acre exclusion (indicated on Territorial tax map dated May 1934 as "Grant 2824," Zone 1, Section 9, Plat 2), but was built in Nakaohu instead. Enos and Feirrera reportedly sold Kahikinui Ranch to Dr. James Raymond who reacquired ʻUlupalakua Ranch (Raymond married Phoebe K. Dowsett, widow of Charles Makee and daughter-in-law of Captain James Makee [founder of ʻUlupalakua Ranch], in 1898).

Following the overthrow of the Hawaiian Kingdom in 1893 and annexation of the islands by the United States in 1900, considerable interest arose in the idea of making rural lands available for resettlement by Native Hawaiians. Prince Jonah Kūhiō Kalanianaʻole was the main impetus behind the Hawaiian Homes Commission Act of 1920 (Daws 1968:297-98) through which certain tracts of former Government lands (then become Territorial lands) were to be turned over for the benefit of Native Hawaiians. Kahikinui (excepting the *ahupuaʻa* of Auwahi and Manawainui) was among these newly-designated Hawaiian Home Lands. Rather than being immediately resettled, however, Kahikinui continued to be leased for cattle ranching, primarily to ʻUlupalakua Ranch and later to several other Maui ranchers.

3.2 PREVIOUS ARCHAEOLOGICAL RESEARCH IN KAHIKINUI

The first comprehensive efforts to record archaeological sites throughout the Hawaiian Islands began in the 1920s and 30s, under the auspices of the Bernice P. Bishop Museum in conjunction with Yale University (Hiroa 1945). In 1929, Winslow Walker, a Yale University-Bishop Museum Fellow, was assigned the task of surveying the archaeological sites of Maui Island (Hiroa 1945:57; Walker 1931). Walker followed the precedent set by Kenneth Emory, Wendell Bennett, Gilbert McAllister, and others of focusing primarily on the largest monumental stone

constructions, principally *heiau*. With limited time and resources to cover an entire unmapped island, Walker inquired of Native Hawaiian informants regarding the ruins of known *heiau*. In Kahikinui, he was guided to a number of temple ruins, mapping some with compass-and-tape. Within Auwahi specifically, Walker recorded only a single *heiau* (Site 187) at Makee. Walker's manuscript was never published, but remains on file in the Bishop Museum Archives. Sterling (1998) incorporated much of Walker's information into her overview of Maui sites.

Beginning in 1950, archaeology in Hawaiʻi entered a new phase under the impetus of Kenneth P. Emory of the Bishop Museum. Emory, joined by colleagues Yosihiko Sinoto and William J. Bonk, commenced a program of stratigraphic excavations through the archipelago. However, only a single site in southeast Maui was investigated during this period, a small cave in Mahamenui, tested by Emory in 1961. Emory did not write a report on this excavation, but based on his field notes Chapman and Kirch (1979:19) summarized his findings.

In the 1960s, the settlement pattern approach was introduced to Polynesian and Hawaiian archaeology, largely through the efforts of Roger C. Green. Through a settlement pattern approach, a more complete understanding of the past could be achieved, both in terms of how people adapted to and used their natural environment, and how they spatially organized their daily lives with distinctive social and cultural patterns. In 1966, Peter S. Chapman, a graduate student at Stanford University and affiliate of the Bishop Museum, set out to apply a settlement pattern study in Kahikinui District. Chapman focused on the two *ahupuaʻa* of Kīpapa and Nakaohu in central Kahikinui. Although Chapman's team fell short of achieving his initial goal of 100 percent coverage of both *ahupuaʻa*, a large part of the *mauka* region was mapped, as well as the entire coastal strip. A total of 544 sites were recorded and mapped. A preliminary "settlement pattern map" of these was compiled by William Kikuchi, based on detailed plane-table-and-alidade survey maps by P. V. Kirch and W. Kikuchi. Tragically, Chapman fell ill not long after the 1966-67 fieldwork was completed, and was unable to work up his results.

During the 1970s and 80s, Kahikinui was ignored or bypassed by archaeologists, even though the pace of archaeological research accelerated greatly in Hawaiʻi during this time. In the mid 1990s, several serendipitous events led to a resurgence of interest in the archaeology of Kahikinui. A major factor was the grass-roots organizing of Ka ʻOhana o Kahikinui, which advocated for the return of that part of the vast *moku* controlled by the Department of Hawaiian Home Lands to Native Hawaiian control. As the Department of Hawaiian Home Lands began to plan for the possibility of facilitating resettlement in the region, it entered into discussions with the State Historic Preservation Division regarding archaeological sites. An aerial reconnaissance survey of portions of the upland zone was carried out by Cultural Surveys, Hawaiʻi in 1994 (Hammatt and Folk 1994). Their survey, although extremely limited in new data presented, reinforced the earlier findings of the 1966 Chapman survey that archaeological remains were abundant in certain parts of this zone. At about the same time, a narrow corridor paralleling Highway 31 was surveyed by Conrad Erkelens of International Archaeological Research Inc. (1995), for a possible geothermal powerline through Kahikinui. Erkelen's survey likewise indicated a high density of archaeological features.

In 1995, P. V. Kirch began to explore the possibility of reactivating and extending the 1966 Chapman settlement pattern survey. Kirch had been a member of the 1966 Bishop Museum survey team, and had been given copies of Chapman's notes and maps by Chapman's widow. In 1995, Kirch returned to Kīpapa-Nakaohu with his students from the University of California, Berkeley, in order to re-check and evaluate the quality of the 1966 data. As a result, an additional 462 archaeological sites were added to the database for these two *ahupua'a* (Kirch and Van Gilder 1996). Kirch subsequently applied for research support from the U. S. National Science Foundation, which funded two successive grants that allowed Kirch to continue his field investigations in the Kahikinui region from 1996 through 2000. One outcome of this phase of research was the investigation of several household complexes, reported in the doctoral dissertation of Van Gilder (2005).

At roughly the same time, the Department of Hawaiian Home Lands contracted with the State Historic Preservation Division to survey and study sites that might be affected by the Department's plans to open up parts of the Kahikinui uplands to resettlement by Native Hawaiians. This program was under the direction of Boyd Dixon. Dixon's team intensively surveyed a large area in the upper elevation zones of Kīpapa, Nakaohu, and Nakaaha *ahupua'a*. Dixon's group also carried out test excavations in a large number of these sites, providing significant information on the age and function of these features. The comprehensive results of this research into the upland regions of the Kīpapa-Nakaohu area within central Kahikinui were reported by Dixon et al. (2000).

A third archaeological team also began work in the Kahikinui district in the late 1990s, under the direction of Michael Kolb of Northern Illinois University (NIU). Kolb had a long-term interest in the *heiau* of Maui Island, the topic of his doctoral dissertation at UCLA. With grant support from the National Science Foundation, Kolb in 1996 began a three year study of the *heiau* of Kahikinui. A full report of his investigations has not yet been completed. However, a preliminary summary of his Kahikinui heiau study was published (Kolb and Radewagen 1997). Kolb also published a list of his radiocarbon dates from Kahikinui and other Maui heiau (Kolb 1992).

The U. C. Berkeley, State of Hawai'i Historic Preservation, and NIU (Kolb) teams all worked in fairly close collaboration during the period between 1995-1999, sharing research methods and results. Kirch (1997) edited a volume of preliminary reports on these coordinated research endeavors, intended primarily to disseminate results to a general public audience.

In 2001, the U. C. Berkeley archaeology team under the direction of Kirch initiated a new phase of investigations supported by the National Science Foundation's program of Biocomplexity in the Environment. This program is explicitly multi-disciplinary, and engaged ecologists, soil scientists, demographic modelers, paleobotanists, and others to join with archaeologists in enhancing understanding of how pre-Contact Hawaiians had adapted to the constraints of leeward dryland regions in the islands. The two major study areas for this project were Kahikinui and Kohala on the island of Hawai'i. With funding from this program, Kirch expanded his team's investigations of Kahikinui into the areas of Mahemenui and Manawainui. Major contributions from this project include studies of the relationship between substrate age

and indigenous Hawaiian land use (Kirch et al. 2004; Vitousek et al. 2004), and the impact of intensive farming on soil nutrient status (Hartshorn et al. 2006; Kirch et al. 2005). Two doctoral dissertations at U. C. Berkeley, by Coil (2004) and Holm (2006), also report results partly supported by the NSF Biocomplexity in the Environment program.

The U. C. Berkeley research team under the direction of Kirch has continued its investigation of the archaeology of Kahikinui and southeast Maui continuously since 1995. Topics investigated by this team have included the distribution, orientations, and chronology of *heiau* (Kirch 2004; Kirch and Sharp 2005), agriculture and subsistence in this leeward region (Coil and Kirch 2005; Kirch et al. 2005), the paleodemography or population history of the region (Kirch 2007), fishing and marine exploitation (Jones and Kirch 2007), petroglyphs (Millerstrom and Kirch 2005), and methodological problems of site visibility and discovery (Holm and Kirch 2007).

4.0 2007 PEDESTRIAN SURVEY RESULTS

4.1 WIND FARM

Between 7 May 2007 and 3 June 2007 a pedestrian survey of the Auwahi Wind Farm parcel was conducted resulting in the discovery of 553 cultural resources (Tables 1 and 2; Figures 6 and 7). It was noted in Section 2.3 that the basic unit of recording during the surface survey was the *archaeological feature*: spatially and functionally discrete units composed of two or more single architectural components such as pavements or free-standing walls. Some of the most common feature types include shelters, enclosures or stone-filled terraces. Such features made up the majority of the resources discovered in the Auwahi Wind Farm parcel, representing 57% of the total number of resources recorded (Table 1). Site complexes, or spatially clustered and/or functionally related resources, made up 24% of the total; single components such as walls and isolated mounds made up 14%; and compound structures such as *heiau* or extended habitation structures comprised the remaining 5%.

Table 1. Wind Farm Cultural Resources (N=553)

Architecture Code	No.	Percent
Single architectural component	77	13.9%
Feature	315	57.0%
Compound structure	27	4.9%
Site complex	134	24.2%
Total Recorded:	*553*	*100.0%*

Based upon previous research and test excavation conducted throughout central and eastern Kahikinui, the probable function of many of these resources could be inferred given their morphology, size, position in the landscape, and relation to other features. By examining those variables, 43% of the resources recorded in the Auwahi Wind Farm parcel could be interpreted as permanent or temporary residential features (Table 2; Figure 7). Typically, such features are found to cluster in residential complexes (*kauhale*), with each feature serving as a spatially and functionally distinct unit analogous to a "room" within a modern western dwelling (Holm 2006; Kirch 1997).

Agricultural features and complexes, which were found to comprise approximately 12% of all resources recorded, were less abundant than anticipated. Extensive systems of terraces and agricultural boundary walls (*kuaiwi*) associated with prehistoric dryland planting have been noted elsewhere in Kahikinui (Holm 2006), though few of these were observed in Auwahi. This pattern may in part have been due to survey constraints; most agricultural features are unobtrusive and easily obscured by dense vegetation or disturbed by cattle and other surface disturbances. It is also possible that agricultural practices in pre-Contact Auwahi centered on "invisible agriculture" (agricultural practices that left few or no surface remains) in soil-filled swales that required little formal construction or land alteration.

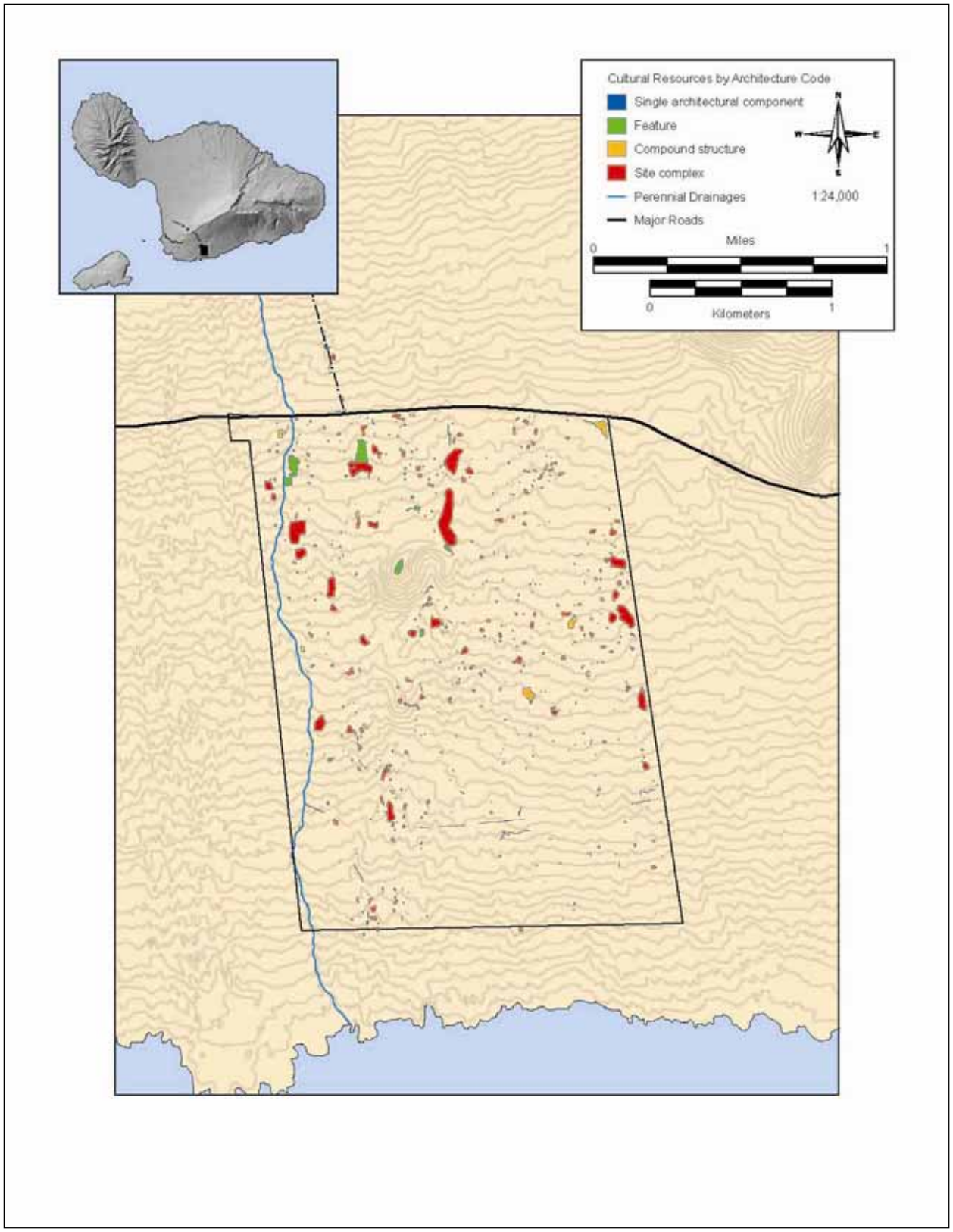


Figure 6. Wind Farm cultural resources found in 2007.

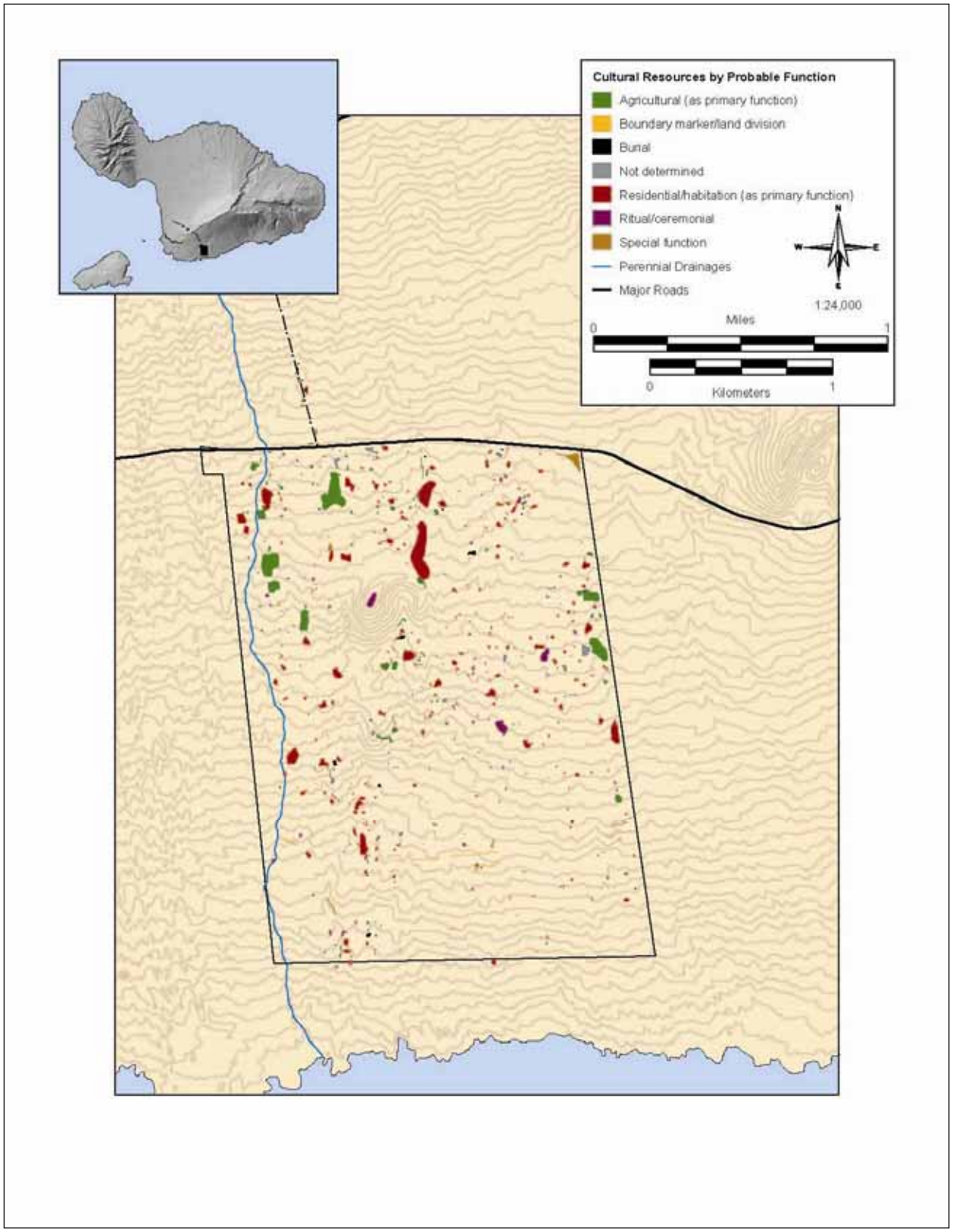


Figure 7. Functional classes of cultural resources in the Wind Farm (2007).

Table 2. Functional Classes of Cultural Resources Recorded Within the Wind Farm (N=553)

Functional Class	No.	Percent
Agricultural	66	11.9%
Agricultural; Boundary marker/land division	1	0.2%
Agricultural; Special function	1	0.2%
Boundary marker/land division	5	0.9%
Burial	20	3.6%
Not determined	153	27.7%
Residential/habitation	236	42.7%
Residential/habitation; Agricultural	20	3.6%
Residential/habitation; Agricultural; Burial	1	0.2%
Residential/habitation; Agricultural; Ritual/ceremonial	1	0.2%
Residential/habitation; Burial	3	0.5%
Residential/habitation; Ritual/ceremonial	5	0.9%
Residential/habitation; Ritual/ceremonial; Burial	1	0.2%
Ritual/ceremonial	25	4.5%
Special function	15	2.7%
Total Recorded:	*553*	*100.0%*

In addition to residential and agricultural resources, a number of ritual/ceremonial resources were also recorded such as Native Hawaiian temples (*heiau*), shrines, and even isolated upright stones (*pōhaku o Kāne*). Features presumed to be burials and special-purpose features such as trails, lava tubes, and petroglyphs were also recorded, though these comprised only a small proportion of the total number of resources recorded.

4.2 GENERATOR-TIE LINE CORRIDOR

On 21-22 May 2007 a pedestrian survey of the proposed Generator-Tie Line corridor resulted in the discovery of 29 resources, all of which were presumed to lie within areas of potential ground disturbance associated with the project (Tables 3 and 4; Figures 8 and 9). The majority of these resources consisted of features (Table 3), however a number of single architectural components and site complexes were also recorded. Of those resources that could be associated with a probable function, the majority (21%) again comprised habitation or residential features (Table 4).

Table 3. Proposed Generator-Tie Line Corridor Cultural Resources (N=29)

Architecture Code	No.	Percent
Single architectural component	10	34.5%
Feature	14	48.3%
Compound structure	0	0%
Site complex	5	17.2%
Total Recorded:	*29*	*100.0%*

Agricultural features and complexes were found to be somewhat more numerous (10%) along the Generator-Tie Line corridor than within the wind farm, though ritual/ceremonial, burial, and special function features were found to be more consistent. Only one cultural resource was recorded at an elevation greater than 1340 m (4400 feet) above sea level, which was consistent with findings from elsewhere in Kahikinui. All other resources along the proposed Generator-Tie Line corridor were noted below an elevation of 975 m (3200 feet), which likely corresponded to the pre-Contact forest zone and the upper limits of settlement distribution.

Table 4. Functional Classes of Cultural Resources Recorded Along the Proposed Generator-Tie Line Corridor (N=29)

Functional Class	No.	Percent
Agricultural	3	10.3%
Agricultural; Boundary marker/land division	1	3.5%
Boundary marker/land division	3	10.3%
Burial	2	6.9%
Not determined	11	37.9%
Residential/habitation	6	20.7%
Residential/habitation; Agricultural	1	3.5%
Special function	2	6.9%
Total Recorded:	*29*	*100.0%*

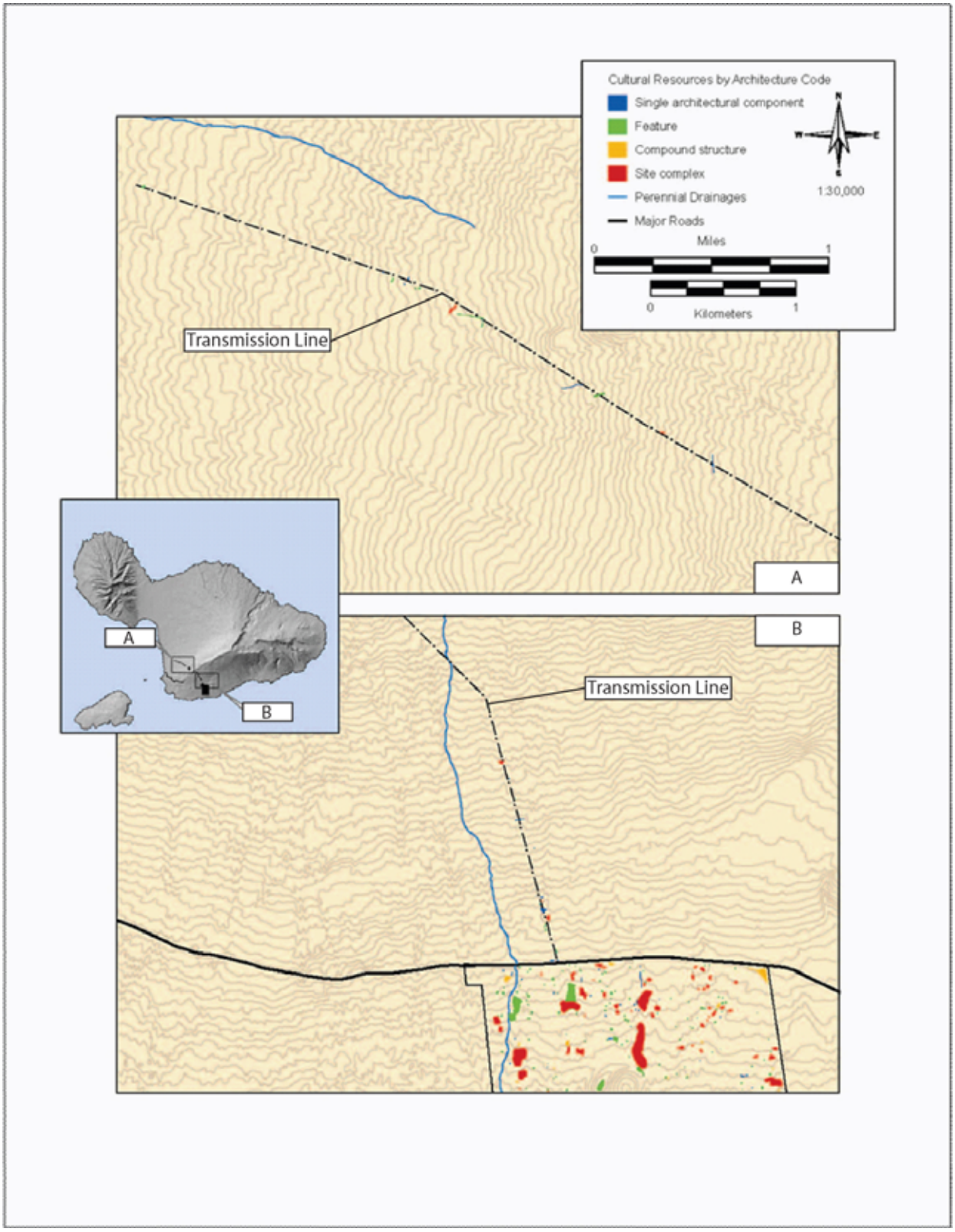


Figure 8. Generator-Tie Line Corridor cultural resources found in 2007.

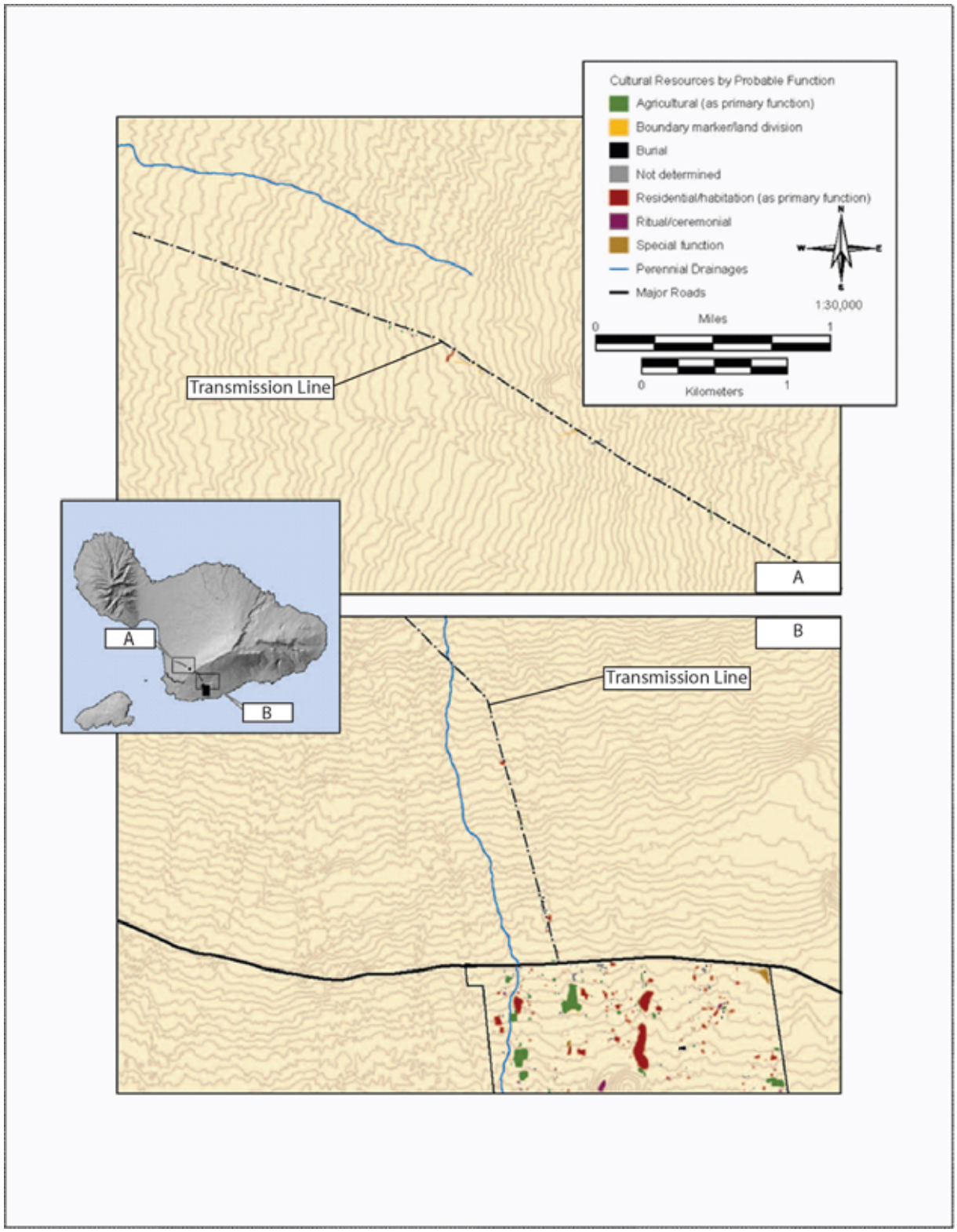


Figure 9. Functional classes of resources along the Generator-Tie Line Corridor found in 2007.

4.3 PĀPAKA ROAD CORRIDOR

The pedestrian survey of the Pāpaka Road corridor resulted in the discovery of 21 resources along either side of the existing road. These resources are presumed to be located within the areas to be affected by the widening of the upper 2.1 miles of this roadway (Tables 5 and 6; Figures 10 and 11). The majority of these resources consisted of single architectural components such as free-standing walls.

Table 5.Cultural Resources Recorded Along the Pāpaka Road Corridor (N=21)

Architecture Code	No.	Percent
Single architectural component	14	66.7%
Feature	4	19.1%
Compound structure	2	9.5%
Site complex	1	4.8%
Total Recorded:	*21*	*100.0*

Table 6. Functional Classes of Cultural Resources Recorded Along the Pāpaka Road Corridor

Functional Class	No.	Percent
Agricultural	5	23.8%
Not determined	3	14.3%
Residential/habitation	3	14.3%
Special function	10	47.6%
Total Recorded:	*21*	*100.0%*

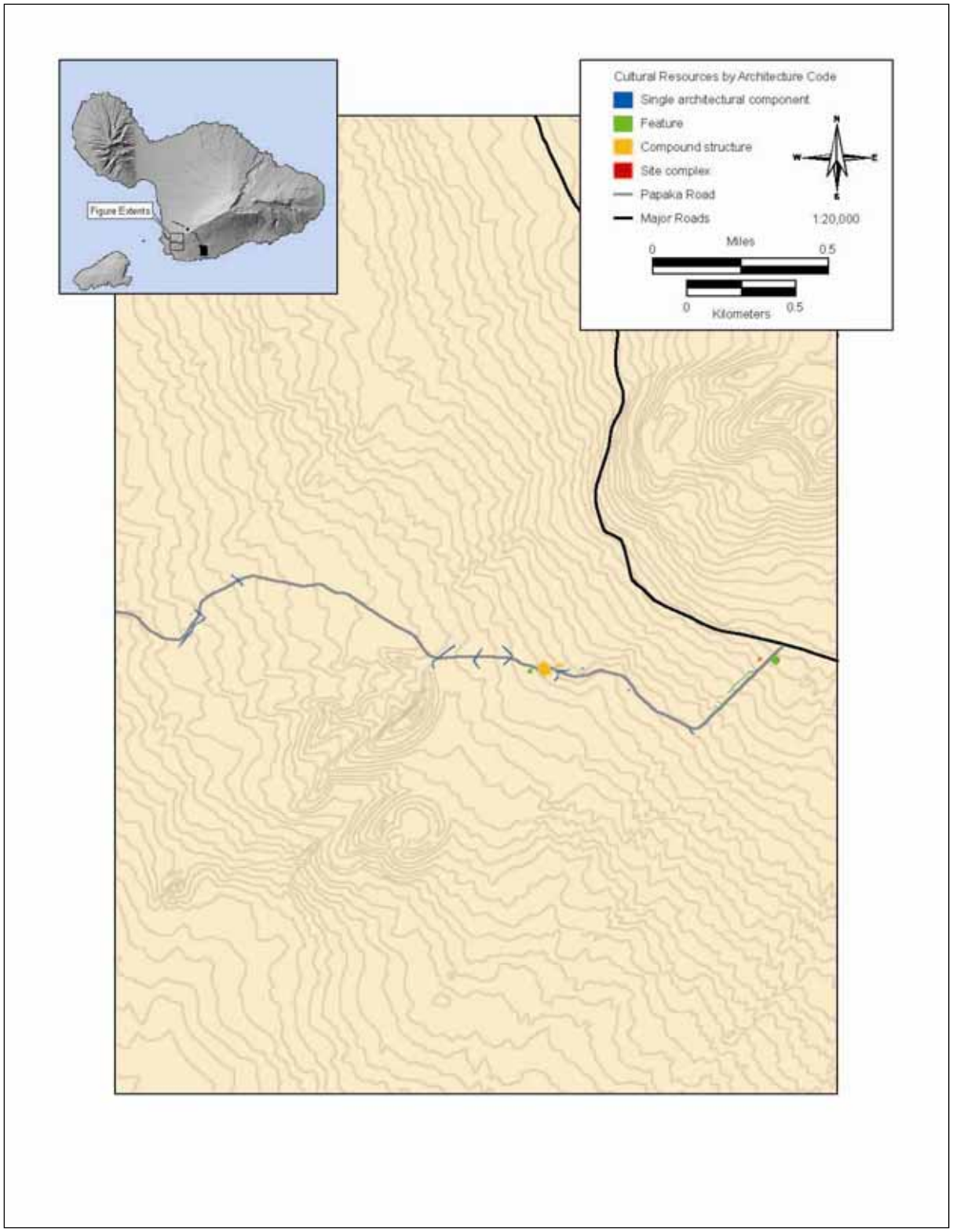


Figure 10. Upper 2.6 mile portion of Pāpaka Road Corridor cultural resources found in 2007.

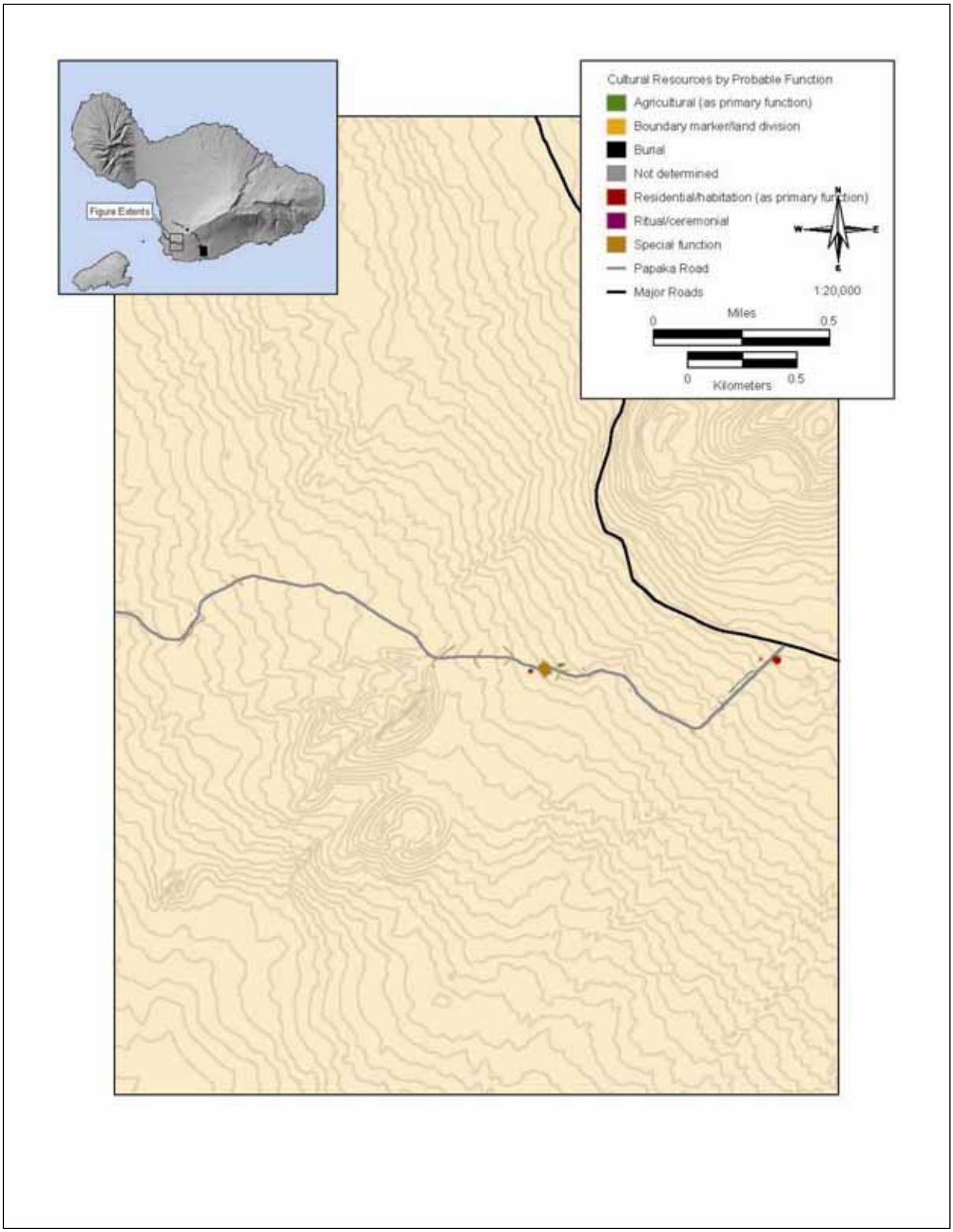


Figure 11. Functional classes of cultural resources along Upper 2.6 mile portion of Pāpaka Road Corridor (2007).

5.0 2010 DETAILED RECORDING AND TESTING RESULTS

Due to the extreme drought conditions on Maui in 2010, visibility was excellent and far superior to that which was available during the initial pedestrian inventory survey in 2007. As a result, additional features were identified in most of the original site areas often doubling or tripling the total feature counts which were observed during the 2007 pedestrian survey. Site boundaries were expanded to incorporate the additional features when in close proximity to the originally recorded area. This would occasionally result in two or more previously identified sites merging into one resource area. When this occurred the newly combined site area was given all of the previous temporary site number designations so that tracking of the resources would be consistent (i.e., previously recorded Sites AWF-190 and AWF-310 were merged into a single Site AWF-190/310).

In addition, when accessing the site areas occasionally newly identified features and sites were encountered which had not been previously identified due to the dense vegetation and poorer visibility in 2007. These newly identified sites were given temporary site designations with a 2010 prefix and letter designation to distinguish them from the sites identified during the 2007 pedestrian survey (i.e., Site AWF-2010 A). Modifications to the APE were implemented during the fieldwork to avoid some of the newly identified sensitive site areas and to accommodate engineering design changes. This resulted in some of the originally recorded and tested sites and features that were initially within the APE being eliminated from the final APE.

5.1 SUMMARY OF RESOURCES RECORDED

A total of 238 sites were recorded during the 2010 fieldwork for the Auwahi Wind Farm project. Some of these represent individual features while others consist of feature complexes (related features in proximity to each other or on the same landform). Of these, portions of 170 sites composed of more than 995 individual features, are located within or immediately adjacent to the APE.

The features within the site areas represent a variety of resource types which can be grouped by functional category. These include:

Agricultural
Animal Husbandry
Burial
Ceremonial
Habitation
Ranching
Transportation

Each of these functional categories is summarized below; a tabulation of all of these resources is presented in Table 7; with their locations shown in Figures 12-29. Appendix B presents a comprehensive data table for all attributes recorded and Appendix C presents individual site and feature forms for these resources. It must be noted that many of the larger site complexes can have features reflecting more than one function (e.g., Site XX contains habitation, agricultural, and ceremonial features); however it is useful to summarize the recorded features by functional category. In Table 7, sites listed as "in" have some (but not necessarily all) features located within the APE; those sites listed as "out" have no features within the APE.

Table 7. Comprehensive Site and Feature List

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Wind Farm	**6813**	**037/038/040/041**	14	Complex	Agriculture / Burial / Habitation / Uncertain	**Out**
	6814	**042**	1	Lava Tube	Habitation	**Out**
	6815	**045**	2	Complex	Ceremonial / Habitation / Transportation	**In**
	6816	**067/068**	19	Complex	Agriculture / Habitation / Uncertain	**In**
	6817	**069**	1	C-Shaped Wall	Habitation	**In**
	6818	**070**	1	Wall	Ranching	**In**
	6820	**089**	7	Complex	Agriculture / Habitation / Uncertain	**In**
	6821	**091/092/093**	8	Complex	Agriculture / Habitation / Transportation / Uncertain	**In**
	6822	**095**	2	Complex	Agriculture / Uncertain	**In**
	6823	**096**	4	Complex	Agriculture / Habitation	**In**
	6824	**098**	14	Complex	Agriculture / Animal Husbandry / Habitation / Uncertain	**Out**
	6825	**100**	2	Complex	Ceremonial / Habitation / Uncertain	**Out**
	6826	**102**	5	Complex	Agriculture / Transportation / Uncertain	**Out**
	6827	**106/108**	38	Complex	Agriculture / Burial / Habitation / Uncertain	**In**
	6828	**107**	1	Wall	Agriculture / Ranching	**In**
	6829	**109**	2	Complex	Habitation	**In**
	6830	**129**	2	Complex	Agriculture / Habitation	**In**
	6831	**133**	1	Stone Mound	Uncertain	**Out**
	6832	**141**	2	Complex	Agriculture	**In**
	6833	**142**	3	Complex	Agriculture / Habitation / Uncertain	**In**
	6834	**143**	4	Complex	Agriculture / Habitation	**In**
	6835	**145**	1	Lava Tube	Burial / Uncertain	**Out**
	6836	**155**	3	Complex	Agriculture / Habitation	**In**
	6837	**166**	1	Wall	Uncertain	**In**
	6838	**167/557**	17	Complex	Agriculture / Burial / Habitation / Uncertain	**In**
	6839	**168**	4	Complex	Agriculture	**Out**
	6840	**176**	21	Complex	Agriculture / Animal Husbandry / Ceremonial / Habitation / Uncertain	**Out**
	6841	**180/546**	8	Complex	Agriculture / Habitation	**In**

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Wind Farm	6842	181	4	Complex	Agriculture / Habitation	In
	6843	182/184	14	Complex	Ceremonial / Habitation / Uncertain	In
	6844	183/185	5	Complex	Habitation / Uncertain	Out
	6845	186	1	C-Shaped Wall	Habitation	In
	6846	187	1	Terrace	Habitation	Out
	6847	188	1	Enclosure	Habitation	Out
	6848	190/310	18	Complex	Habitation / Uncertain	In
	6849	194	1	Terrace	Ceremonial	Out
	6850	195	27	Complex	Agriculture / Ceremonial / Habitation / Uncertain	Out
	6851	197	4	Complex	Habitation	Out
	6852	198/199	11	Complex	Agriculture / Habitation / Uncertain	Out
	6853	200	6	Complex	Agriculture / Habitation	Out
	6854	202	12	Complex	Agriculture / Habitation / Uncertain	Out
	6855	204	5	Complex	Agriculture / Habitation	Out
	6856	207	1	L-Shaped Wall	Habitation	Out
	6857	208	11	Complex	Agriculture / Habitation / Uncertain	In
	6858	209	3	Complex	Agriculture / Habitation	Out
	6859	211	3	Complex	Agriculture / Habitation	Out
	6860	212	3	Complex	Agriculture / Uncertain	In
	6861	213	4	Complex	Agriculture / Uncertain	In
	6862	214	28	Complex	Agriculture / Habitation / Uncertain	In
	6863	215	16	Complex	Agriculture / Animal Husbandry / Habitation / Transportation / Uncertain	In
	6864	216	15	Complex	Ceremonial / Habitation / Uncertain	In
	6886	297	3	Complex	Habitation	Out
	6887	305	4	Complex	Habitation / Uncertain	In
	6888	306	1	U-Shaped Wall	Habitation	In
	6889	307	6	Complex	Agriculture / Habitation / Uncertain	In
	6890	308	8	Complex	Burial / Habitation / Uncertain	Out
	6891	309	8	Complex	Agriculture / Transportation	In
	6892	322	15	Complex	Agriculture / Habitation	In
	6893	323	2	Complex	Agriculture	In
	6894	324	4	Complex	Burial / Habitation / Uncertain	In
	6895	326	40	Complex	Agriculture / Habitation	In
	6896	329	50	Complex	Agriculture / Habitation	In
	6897	331	33	Complex	Agriculture / Habitation	In
	6898	332	16	Complex	Agriculture / Uncertain	In
	6899	335	10	Complex	Agriculture / Habitation / Uncertain	In
	6900	346	1	C-Shaped Wall	Habitation	Out
	6901	349	1	C-Shaped Wall	Habitation	In
	6902	351	4	Complex	Agriculture / Habitation	Out
	6903	353	4	Complex	Habitation / Uncertain	In

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Wind Farm	**6904**	**354**	5	Complex	Agriculture / Burial / Uncertain	**In**
	6905	**356/361**	3	Complex	Habitation	**Out**
	6906	**359/488**	135	Complex	Agriculture / Ceremonial / Habitation / Uncertain	**In**
	6907	**367**	9	Complex	Agriculture / Habitation / Uncertain	**Out**
	6908	**391**	7	Complex	Agriculture / Ceremonial / Habitation / Uncertain	**Out**
	6909	**395-398**	26	Complex	Agriculture / Burial / Habitation / Uncertain	**In**
	6910	**423 thru 430**	67	Complex	Agriculture / Habitation / Uncertain	**In**
	6911	**440**	10	Complex	Habitation	**Out**
	6912	**441**	11	Complex	Agriculture / Burial / Uncertain	**Out**
	6913	**442**	9	Complex	Agriculture / Habitation / Uncertain	**Out**
	6914	**443**	1	Wall	Agriculture	**Out**
	6915	**445**	2	Complex	Uncertain	**Out**
	6916	**468**	11	Complex	Agriculture / Habitation / Uncertain	**Out**
	6917	**480/481**	10	Complex	Agriculture / Habitation	**In**
	6918	**489/491**	5	Complex	Habitation / Uncertain	**In**
	6919	**495**	8	Complex	Agriculture / Habitation / Uncertain	**In**
	6920	**499**	1	Wall	Habitation	**In**
	6921	**501**	3	Complex	Agriculture / Burial / Uncertain	**In**
	6922	**502**	2	Complex	Burial	**In**
	6923	**503**	6	Complex	Agriculture / Burial / Habitation / Uncertain	**In**
	6924	**544**	11	Complex	Agriculture / Habitation / Uncertain	**In**
	6925	**559**	50	Complex	Agriculture / Habitation / Uncertain	**In**
	6926	**560**	4	Complex	Agriculture	**Out**
	6927	**564**	1	U-Shaped Wall	Habitation	**Out**
	6928	**582**	1	C-Shaped Wall	Agriculture	**Out**
	6929	**583**	2	Complex	Habitation / Uncertain	**In**
	6930	**584**	42	Complex	Agriculture / Uncertain	**In**
	6951	**2010 A**	8	Complex	Burial / Habitation / Uncertain	**Out**
	6952	**2010 B**	1	Overhang Shelter	Habitation	**In**
	6953	**2010 C**	7	Complex	Burial	**In**
	6954	**2010 D**	16	Complex	Burial	**Out**
	6955	**2010 E**	16	Terrace	Agriculture	**Out**
	6989	**2010 LL**	3	Complex	Agriculture / Uncertain	**In**
	6990	**2010 MM**	2	Complex	Habitation / Uncertain	**Out**
	7026	**2010 WWW**	7	Complex	Agriculture / Habitation / Uncertain	**In**
	7027	**2010 AAAA**	4	Complex	Agriculture	**In**
	7028	**2010 BBBB**	3	Complex	Agriculture	**In**
	7029	**2010 CCCC**	3	Complex	Agriculture / Uncertain	**In**
	7030	**2010 DDDD**	2	Complex	Uncertain	**In**
	7031	**2010 EEEE**	1	Modified Outcrop	Agriculture	**In**
	7032	**2010 FFFF**	1	Wall	Uncertain	**In**

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Wind Farm	7033	2010 GGGG	1	Terrace	Agriculture	In
	7034	2010 HHHH	2	Complex	Agriculture	Out
	7035	2010 IIII	5	Complex	Agriculture / Burial	In
	7036	2010 JJJJ	2	Complex	Agriculture	In
	7037	2010 KKKK	2	Complex	Agriculture	In
	7038	2010 LLLL	4	Complex	Agriculture	In
	7039	2010 MMMM	1	Platform	Uncertain	In
	7040	2010 NNNN	1	Stone Mound	Agriculture	In
	7041	2010 OOOO	4	Complex	Agriculture / Burial / Habitation	In
	7042	2010 PPPP	6	Complex	Habitation / Uncertain	In
	Total Features in Project Area:		**1,136**		**Total Sites in Project Area:**	**120**
Pāpaka Road	6931	585	8	Complex	Ceremonial / Habitation / Ranching	Out
	6932	586	13	Complex	Agriculture	Out
	6933	587	2	Complex	Agriculture / Animal Husbandry / Habitation / Uncertain	Out
	6934	588	7	Complex	Agriculture / Uncertain	Out
	6935	589	1	Enclosure	Ranching	Out
	6936	590/596	50	Complex	Agriculture / Burial / Habitation / Ranching / Uncertain	Out
	6937	591	2	Complex	Agriculture	In
	6938	592	17	Complex	Agriculture / Habitation / Ranching / Uncertain	In
	6939	593	4	Complex	Agriculture / Habitation / Uncertain	In
	6940	594	9	Complex	Agriculture / Habitation	In
	6941	595	3	Complex	Agriculture / Habitation	In
	6942	597	1	Wall	Ranching	In
	6943	598	3	Complex	Ranching / Uncertain	Out
	6944	599	1	Wall	Ranching	Out
	6945	600	1	Wall	Uncertain	Out
	6946	601	1	Wall	Ranching	In
	6947	602	1	Wall	Uncertain	Out
	6948	603	1	Wall	Uncertain	In
	6949	604	1	Wall	Ranching	In
	6950	605	1	Wall	Ranching	In
	6956	2010 F	1	Enclosure	Ranching	In
	6957	2010 G	4	Complex	Uncertain	In
	6958	2010 H	1	Wall	Ranching	In
	6959	2010 I	2	Complex	Ranching / Uncertain	In
	6960	2010 J	1	Wall	Ranching	In
	6961	2010 K	1	Wall	Ranching	In
	6962	2010 L	2	Complex	Agriculture	In
	6963	2010 M	1	Wall	Ranching	In
	6964	2010 N	1	Enclosure	Habitation	Out
	6965	2010 O	1	Wall	Ranching	In

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Pāpaka Road	6966	2010 P	1	Cast Iron Tank	Ranching	In
	6967	2010 Q	2	Complex	Agriculture / Ranching	In
	6968	2010 R	3	Complex	Agriculture	In
	6969	2010 S	1	Wall	Ranching	In
	6970	2010 T	1	Wall	Ranching	In
	6971	2010 U	1	Wall	Uncertain	In
	6972	2010 V	2	Complex	Habitation	In
	6973	2010 W	1	Enclosure	Habitation	Out
	6974	2010 X	1	Wall	Habitation	In
	6975	2010 Y	3	Complex	Ranching / Uncertain	In
	6976	2010 Z	3	Complex	Habitation / Uncertain	In
	6977	2010 AA	1	Wall	Ranching	In
	6978	2010 BB	1	Wall	Ranching	In
	6980	2010 CC Pāpaka	1	Wall	Ranching	In
	6996	2010 SS	2	Complex	Agriculture	In
	7014	2010 KKK	28	Complex	Agriculture	In
	7015	2010 LLL	12	Complex	Agriculture	In
	7016	2010 MMM	102	Complex	Agriculture / Habitation / Uncertain	In
	7017	2010 NNN	20	Complex	Agriculture / Ceremonial / Habitation / Uncertain	In
	7018	2010 OOO	1	Wall	Ranching	In
	7019	2010 PPP	84	Complex	Agriculture / Habitation / Uncertain	In
	7020	2010 QQQ	30	Complex	Agriculture / Habitation	In
	7021	2010 RRR	4	Complex	Agriculture	In
	7022	2010 SSS	26	Complex	Agriculture / Habitation / Uncertain	In
	7023	2010 TTT	1	Barbed Wire Fence	Ranching	In
	7024	2010 UUU	5	Complex	Agriculture / Habitation / Ranching	In
	7025	2010 VVV	2	Complex	Agriculture / Uncertain	In
	7043	Mākena 1	2	Complex	Habitation	Out
	7044	Mākena 2	1	Terrace	Uncertain	In
	7045	Mākena 3	4	Complex	Agriculture / Habitation / Uncertain	In
	7046	Mākena 4	1	Enclosure	Uncertain	In
	7047	Mākena 5	1	Wall	Ranching	in
	7048	Mākena 6	1	Modified Outcrop	Uncertain	In
	7049	Mākena 7	2	Complex	Habitation	In
	7050	Mākena 8	2	Complex	Habitation	In
	Total Features in Project Area:		503		Total Sites in Project Area:	66
Gen-Tie Line	6819	071/252/253	16	Complex	Burial / Uncertain	Out
	6865	247	9	Complex	Agriculture / Uncertain	In
	6866	249	4	Complex	Agriculture / Habitation	In
	6867	250	1	Wall	Ranching	In
	6868	251	1	Wall	Agriculture	Out
	6869	254	3	Complex	Habitation	Out

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Gen-Tie Line	**6870**	**255**	4	Complex	Agriculture	**Out**
	6871	**256**	7	Complex	Agriculture / Habitation	**Out**
	6872	**258/259**	5	Complex	Agriculture / Habitation / Ranching / Uncertain	**Out**
	6873	**260/261**	5	Complex	Habitation / Uncertain	**Out**
	6874	**262/263**	1	Wall	Ranching	**In**
	6875	**264**	1	Lava Tube	Habitation	**Out**
	6876	**265**	1	Wall	Ranching	**In**
	6877	**266**	7	Complex	Agriculture / Ranching	**In**
	6878	**267**	3	Complex	Agriculture	**In**
	6879	**268**	1	Wall	Ranching	**In**
	6880	**269**	3	Complex	Ranching	**In**
	6881	**270/271**	8	Complex	Agriculture / Ranching / Uncertain	**In**
	6882	**273/362**	5	Complex	Agriculture / Ranching	**In**
	6883	**274/275**	2	Complex	Agriculture / Uncertain	**Out**
	6884	**276**	1	Stone Mound	Agriculture / Ranching	**Out**
	6885	**277**	1	Stone Mound	Agriculture	**Out**
	6976	**2010 CC Gen-Tie Line**	21	Complex	Agriculture / Habitation	**In**
	6981	**2010 DD**	1	Wall	Uncertain	**In**
	6982	**2010 EE**	1	Wall	Uncertain	**In**
	6983	**2010 FF**	11	Complex	Agriculture / Uncertain	**In**
	6984	**2010 GG**	8	Complex	Agriculture / Habitation	**In**
	6985	**2010 HH**	13	Complex	Agriculture / Burial / Uncertain	**In**
	6986	**2010 II**	1	Wall	Uncertain	**In**
	6987	**2010 JJ**	7	Complex	Agriculture / Habitation / Uncertain	**In**
	6988	**2010 KK**	12	Complex	Agriculture / Habitation / Uncertain	**In**
	6995	**2010 RR**	7	Complex	Agriculture	**In**
	6997	**2010 TT**	1	Modified Outcrop	Agriculture	**In**
	6998	**2010 UU**	1	Modified Outcrop	Uncertain	**In**
	6999	**2010 VV**	2	Complex	Agriculture	**In**
	7000	**2010 WW**	1	Wall	Agriculture	**In**
	7001	**2010 XX**	1	Stone Mound	Agriculture	**In**
	7002	**2010 YY**	1	Stone Mound	Agriculture	**In**
	7003	**2010 ZZ**	1	Stone Mound	Agriculture	**In**
	7004	**2010 AAA**	14	Complex	Agriculture	**In**
	7005	**2010 BBB**	2	Terrace	Agriculture	**In**
	7006	**2010 CCC**	1	Stone Mound	Agriculture	**In**
	7007	**2010 DDD**	1	Cleared Area	Agriculture	**In**
	7008	**2010 EEE**	6	Stone Mound	Agriculture	**In**
	7009	**2010 FFF**	3	Complex	Agriculture	**In**
	7010	**2010 GGG**	2	Complex	Agriculture	**In**

Project Area	SIPH No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Feature	Site / Feature Type	Possible Function	In/Out of APE
Gen-Tie Line	**7011**	**2010 HHH**	2	Complex	Ranching	**In**
	7012	**2010 III**	3	Complex	Agriculture	**In**
	7013	**2010 JJJ**	1	Platform	Ranching	**In**
	Total Features in Project Area:		**206**		**Total Sites in Project Area:**	**48**
Pi'ilani Hwy	**6991**	**2010 NN**	1	Wall	Ranching	**In**
	6992	**2010 OO**	7	Complex	Agriculture / Burial / Ranching / Uncertain	**In**
	6993	**2010 PP**	26	Complex	Agriculture / Burial / Uncertain	**Out**
	6994	**2010 QQ**	2	Complex	Agriculture / Ranching	**In**
	Total Features in Project Area:		**36**		**Total Sites in Project Area:**	**4**

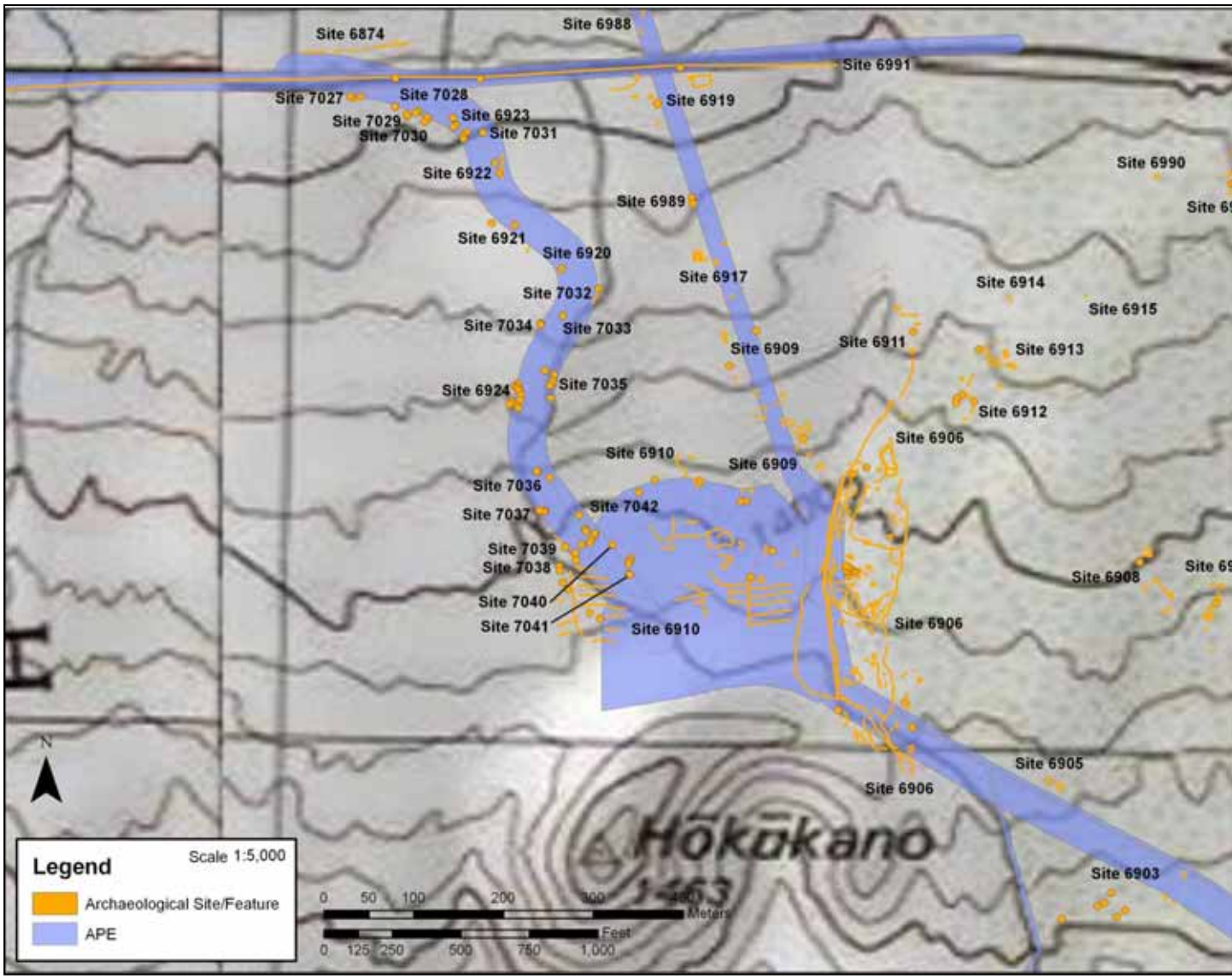


Figure 12. Site location map of northern portion of Wind Farm.

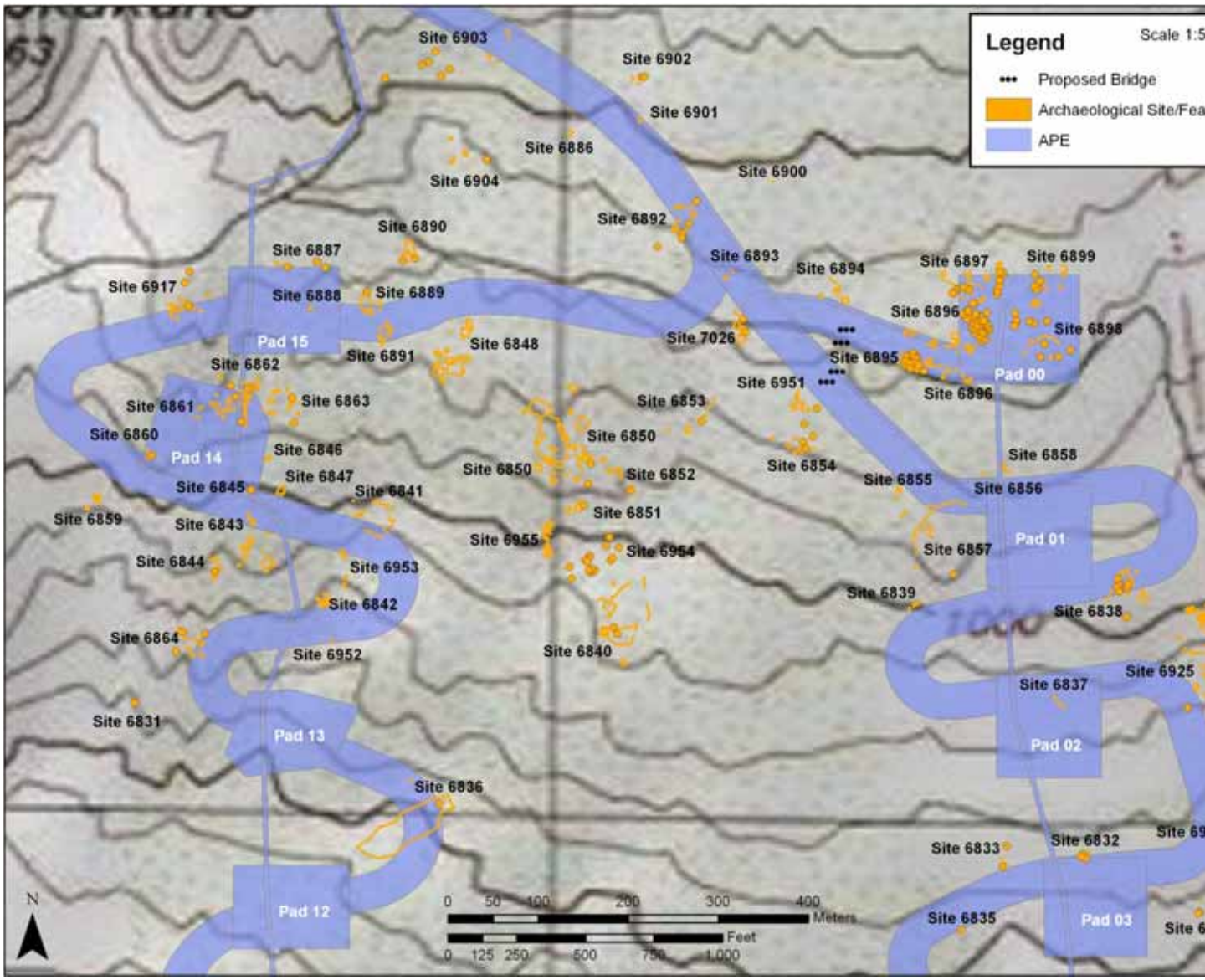


Figure 13. Site location map of central portion of Wind Farm.

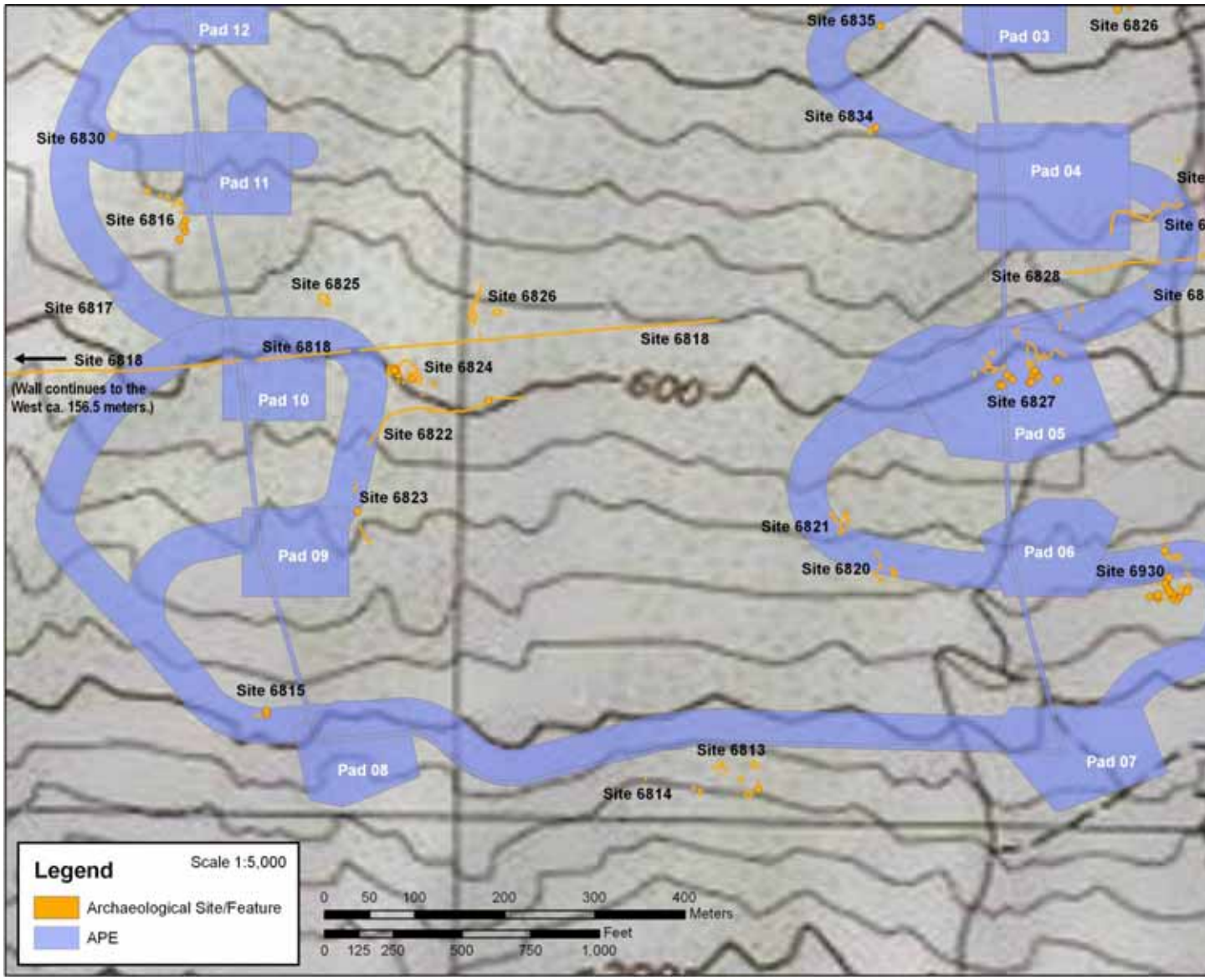


Figure 14. Site location map of southern portion of Wind Farm.

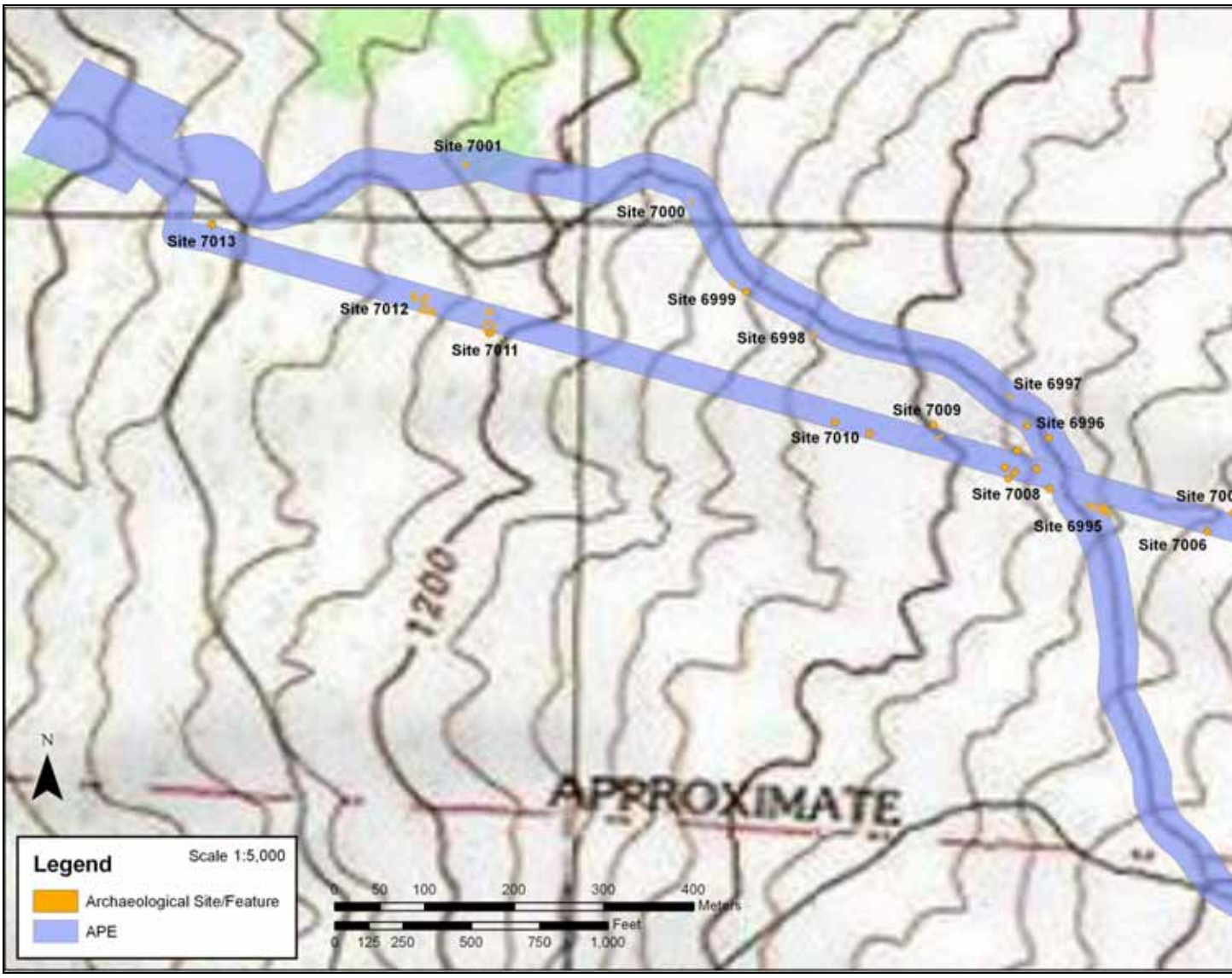


Figure 15. Site location map of Interconnection Substation and NW End of Generator-Tie Line.

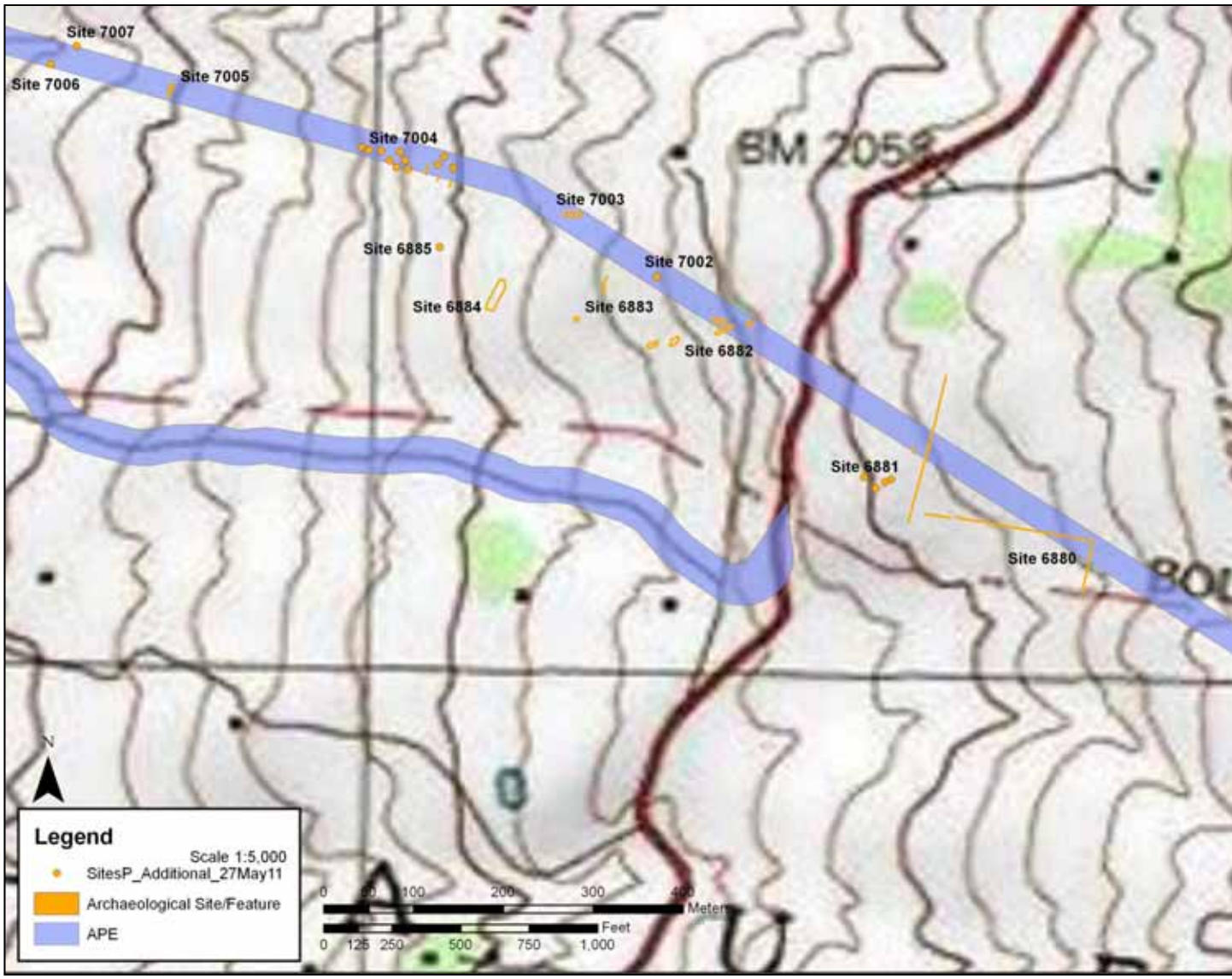


Figure 16. Site location map of Substation Access Road and Transmission Line near Kula Highway.

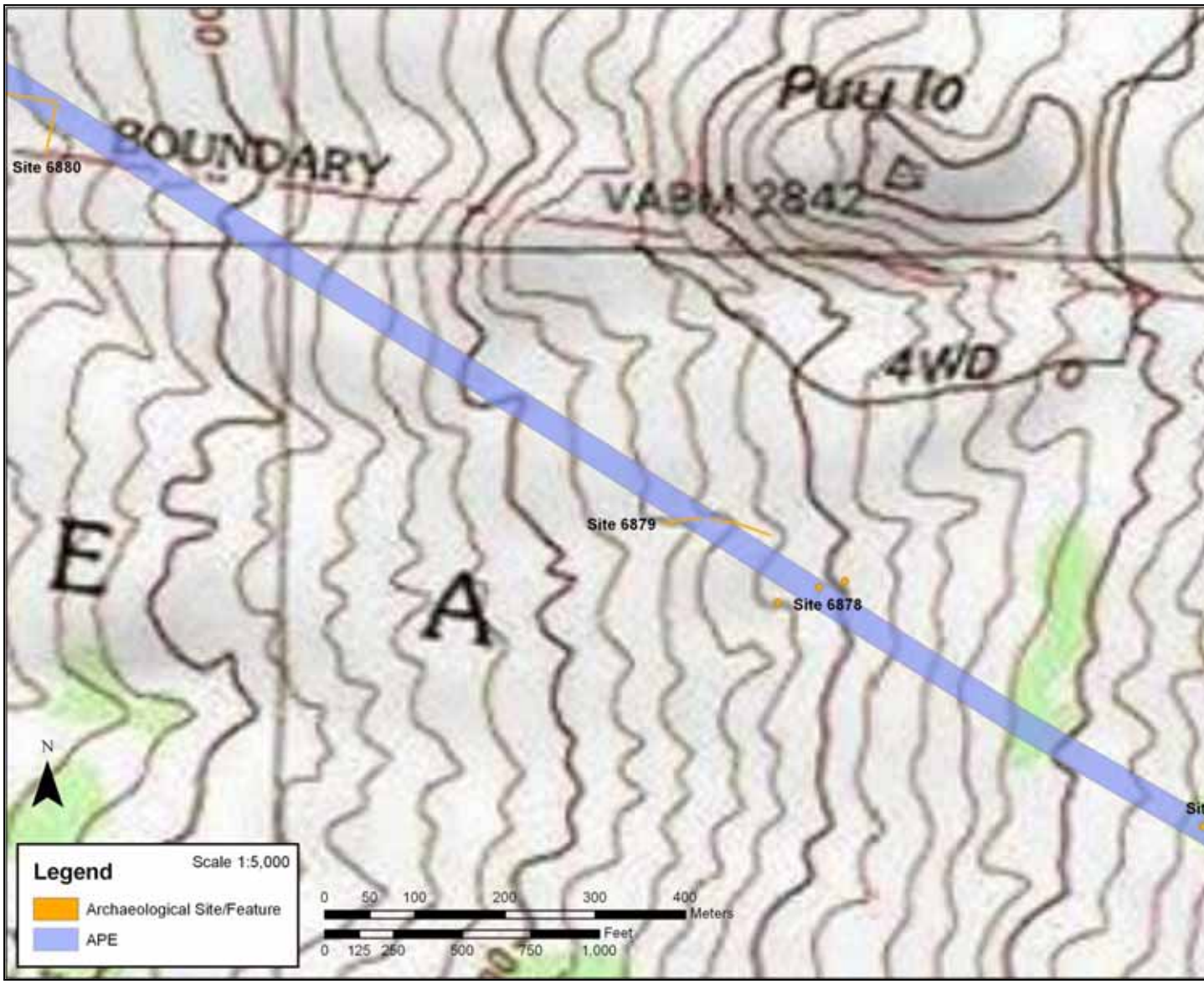


Figure 17. Site location map of Generator-Tie Line section between Figures 17 and 19.

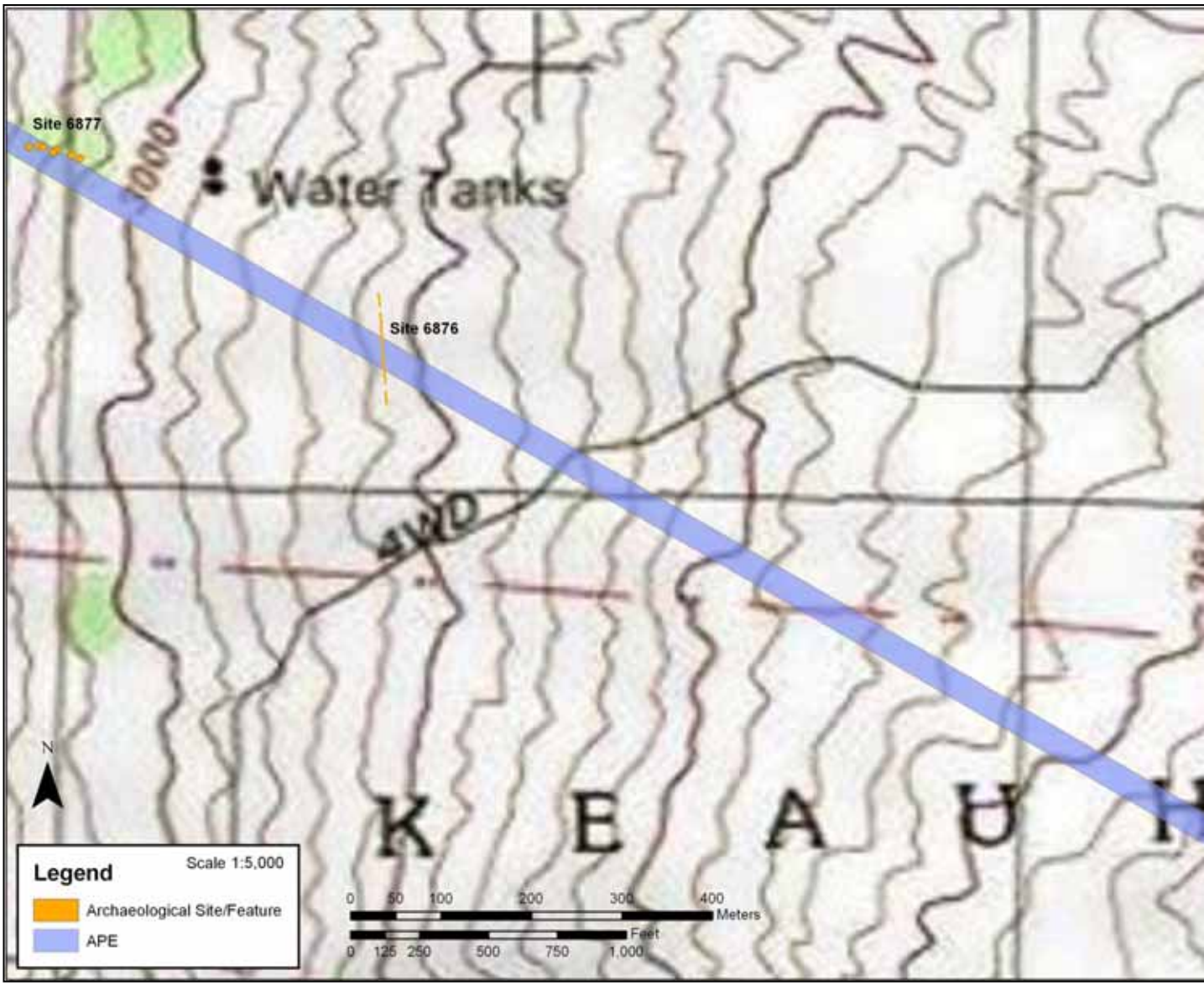


Figure 18. Site location map of Generator-Tie Line section between Figures 18 and 20.

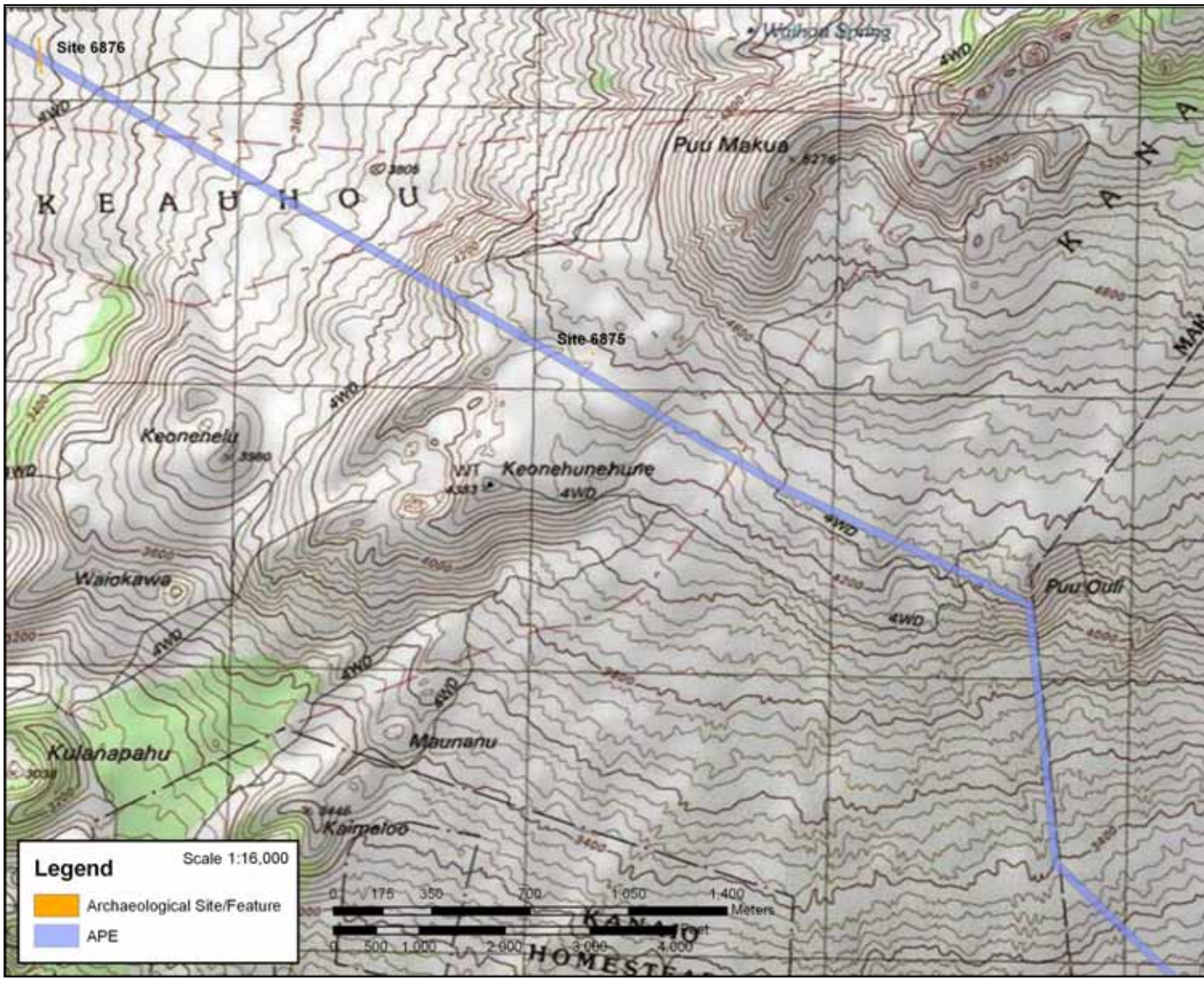


Figure 19. Site location map of Generator-Tie Line section between Figures 19 and 21.

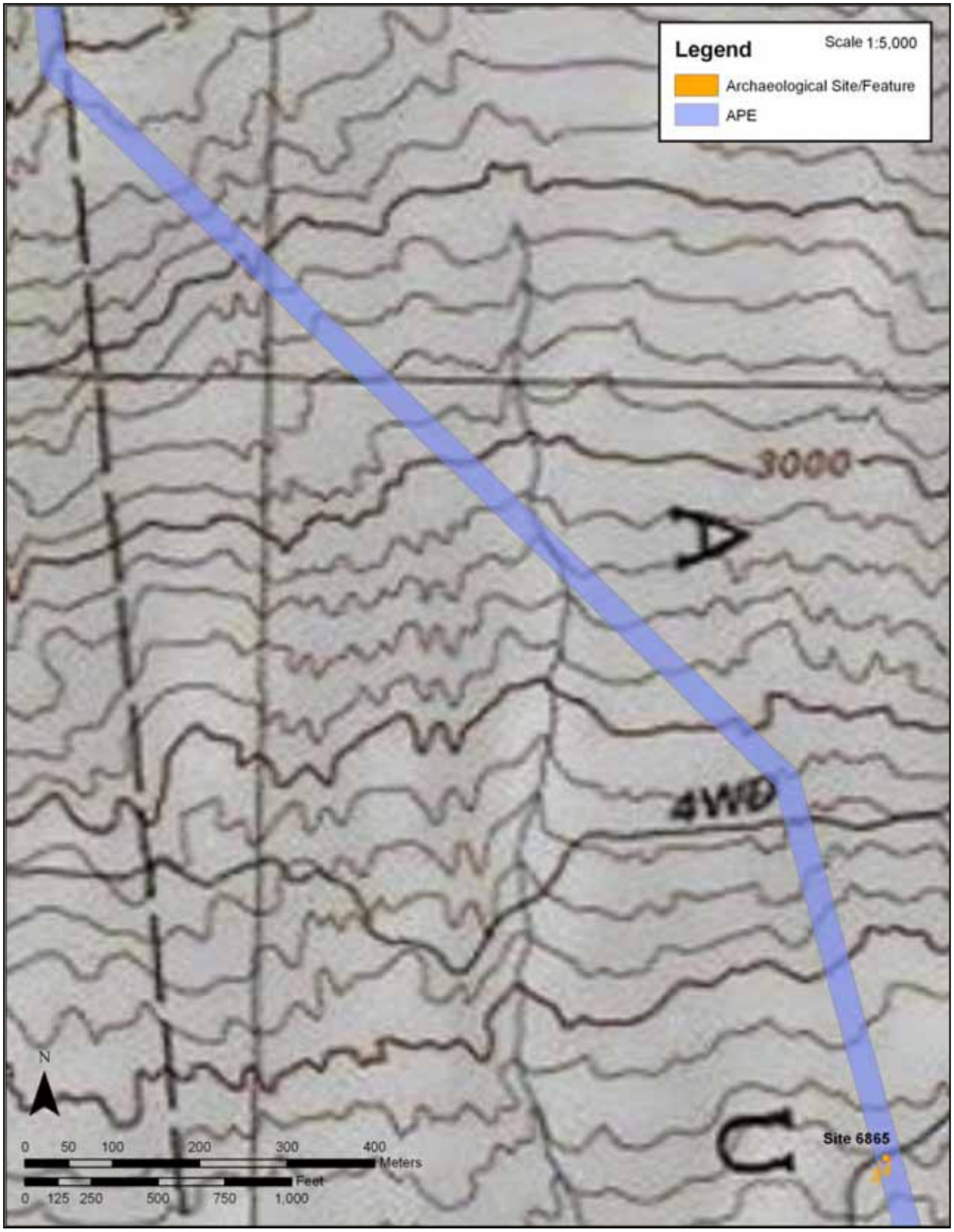


Figure 20. Site location map of Generator-Tie Line section between Figures 20 and 22.

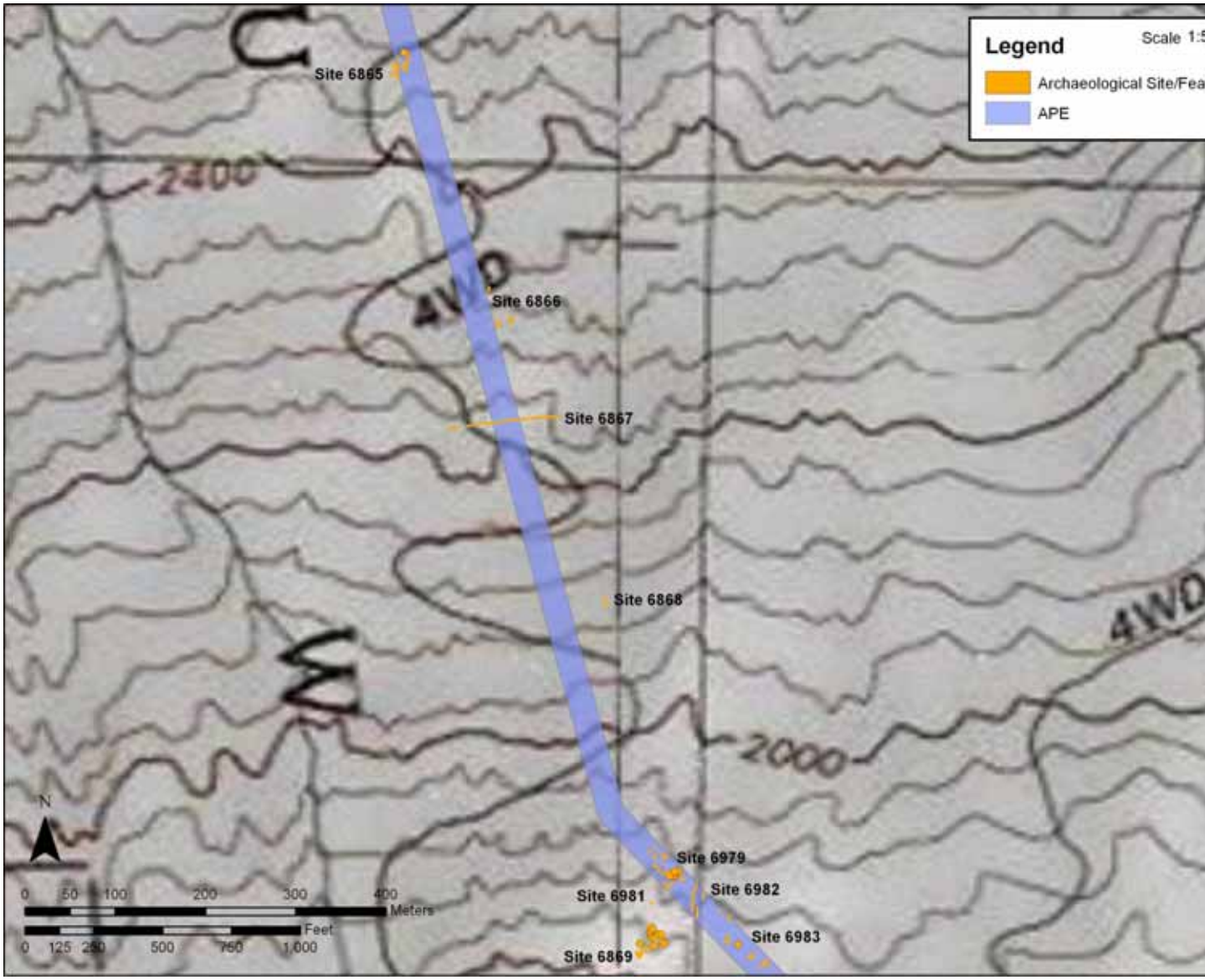


Figure 21. Site location map of Generator-Tie Line section between Figures 21 and 23.

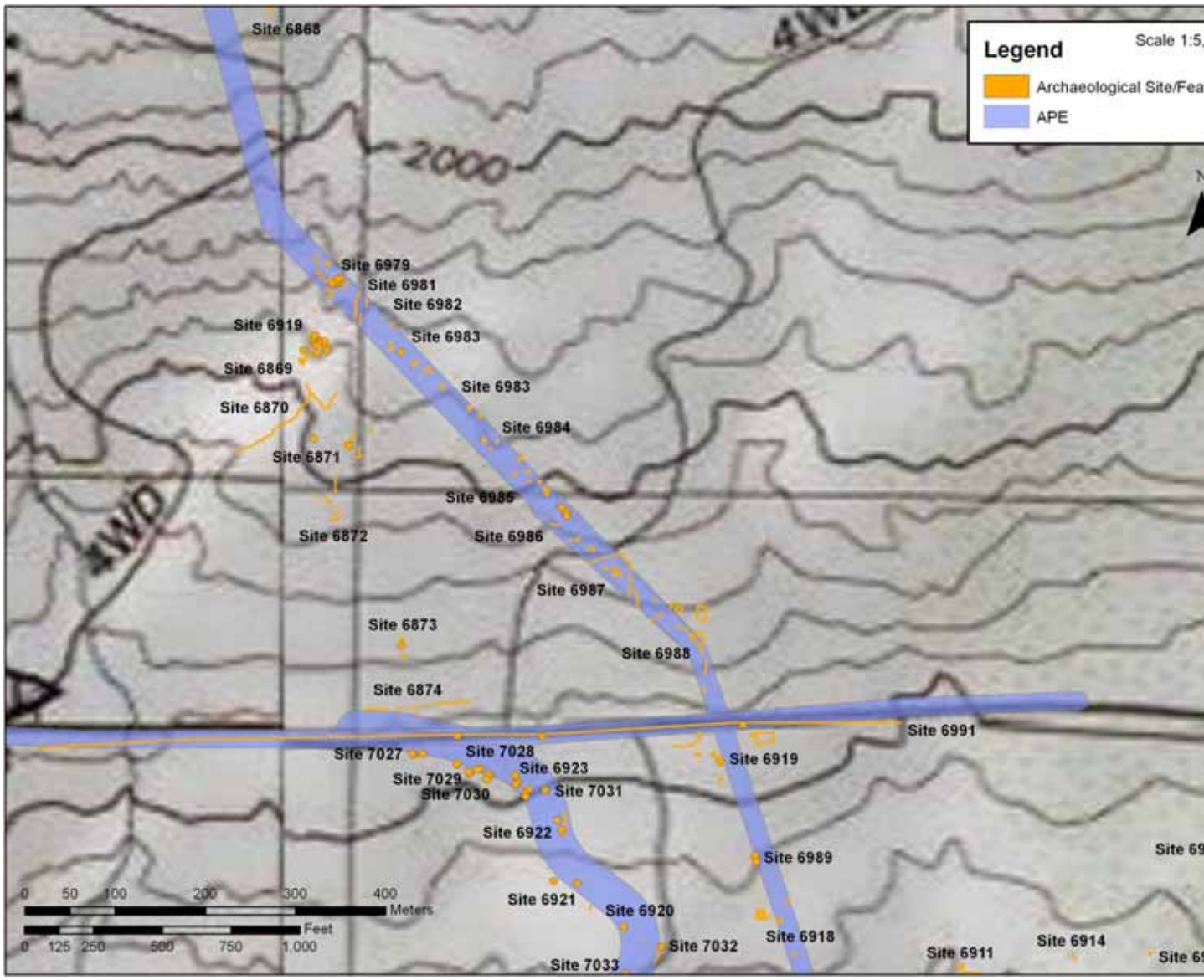


Figure 22. Site location map of southeastern end of Generator-Tie Line.

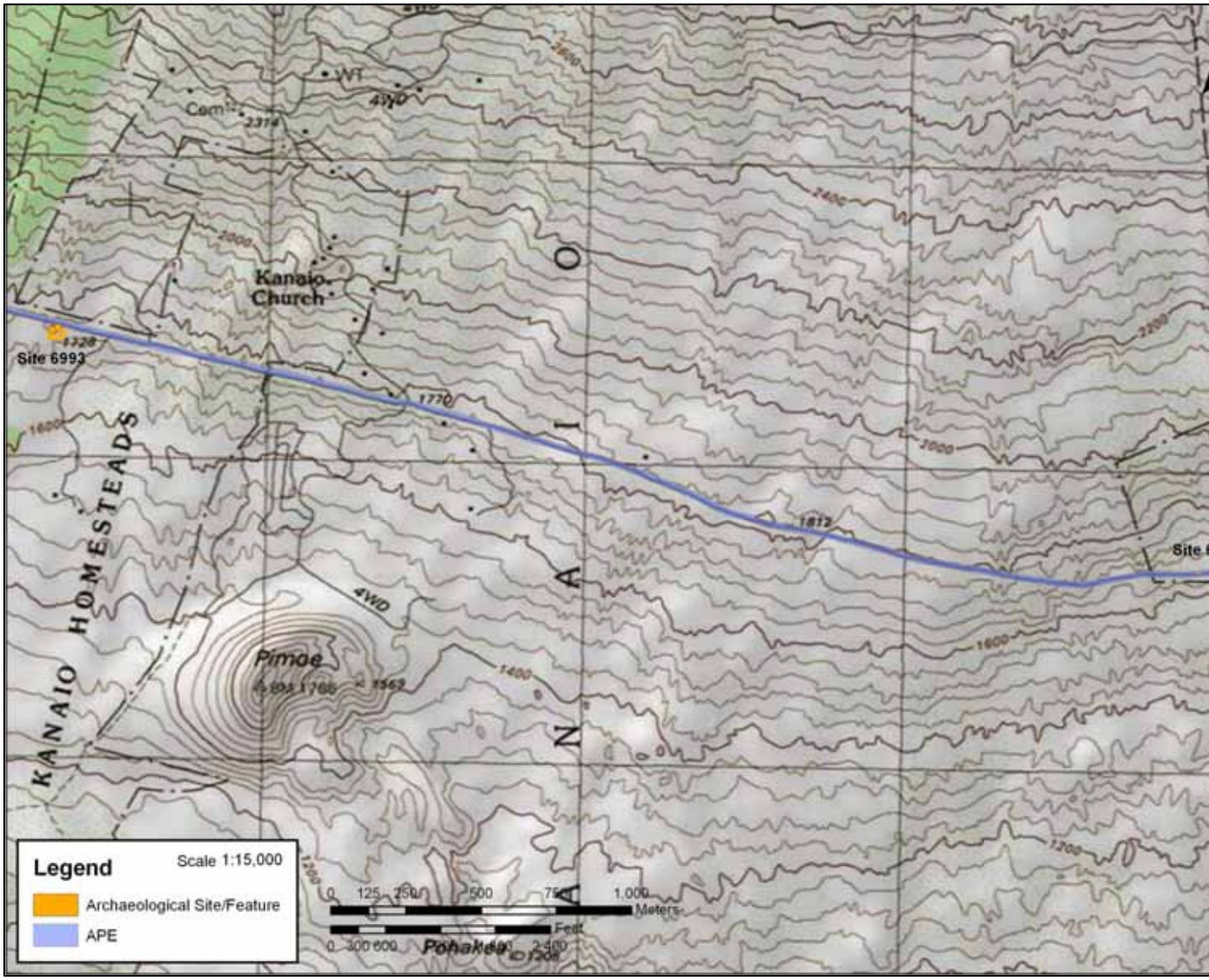


Figure 23. Site locations along Pi‘ilani Highway.

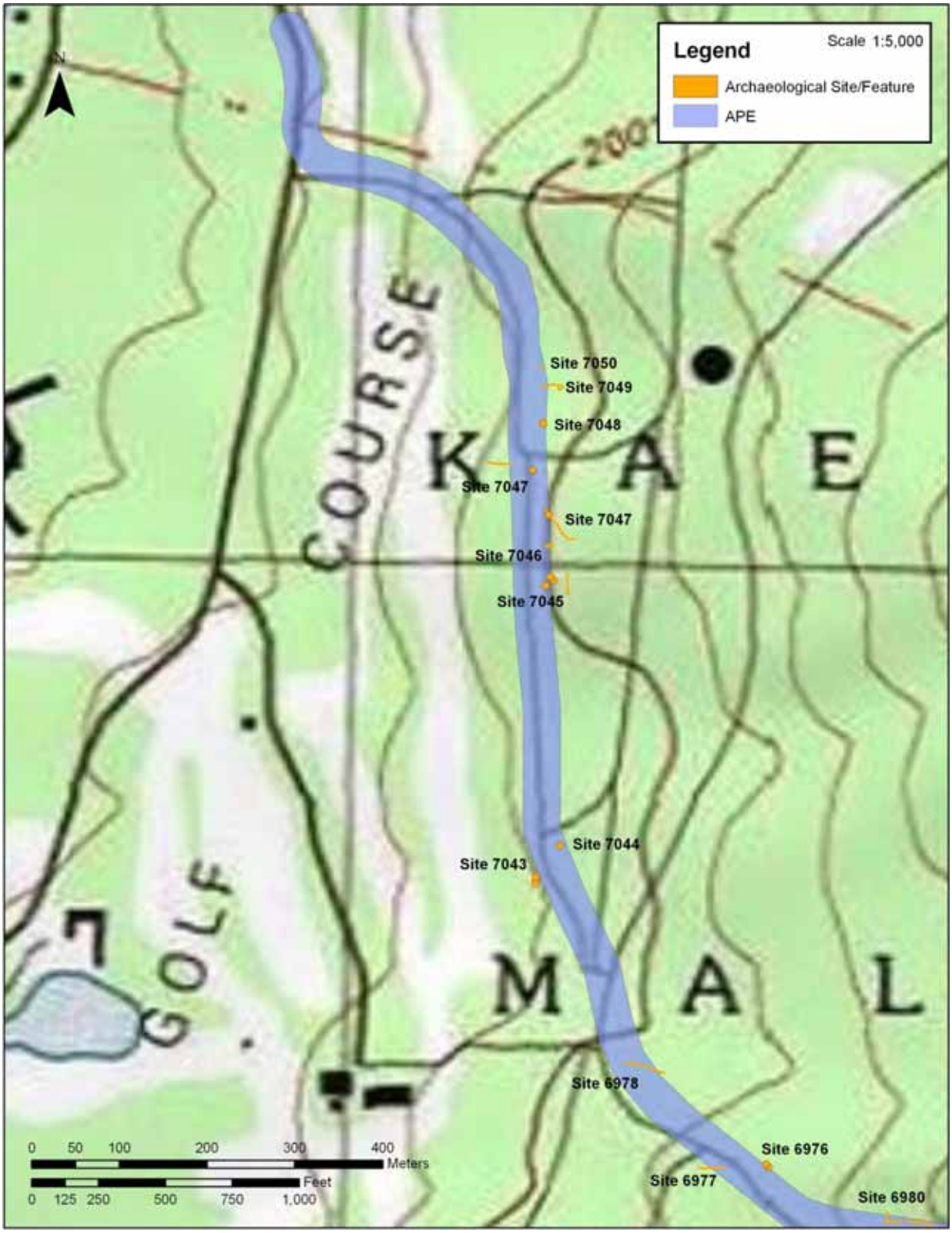


Figure 24. Site location map of northwestern end of Pāpaka Road.

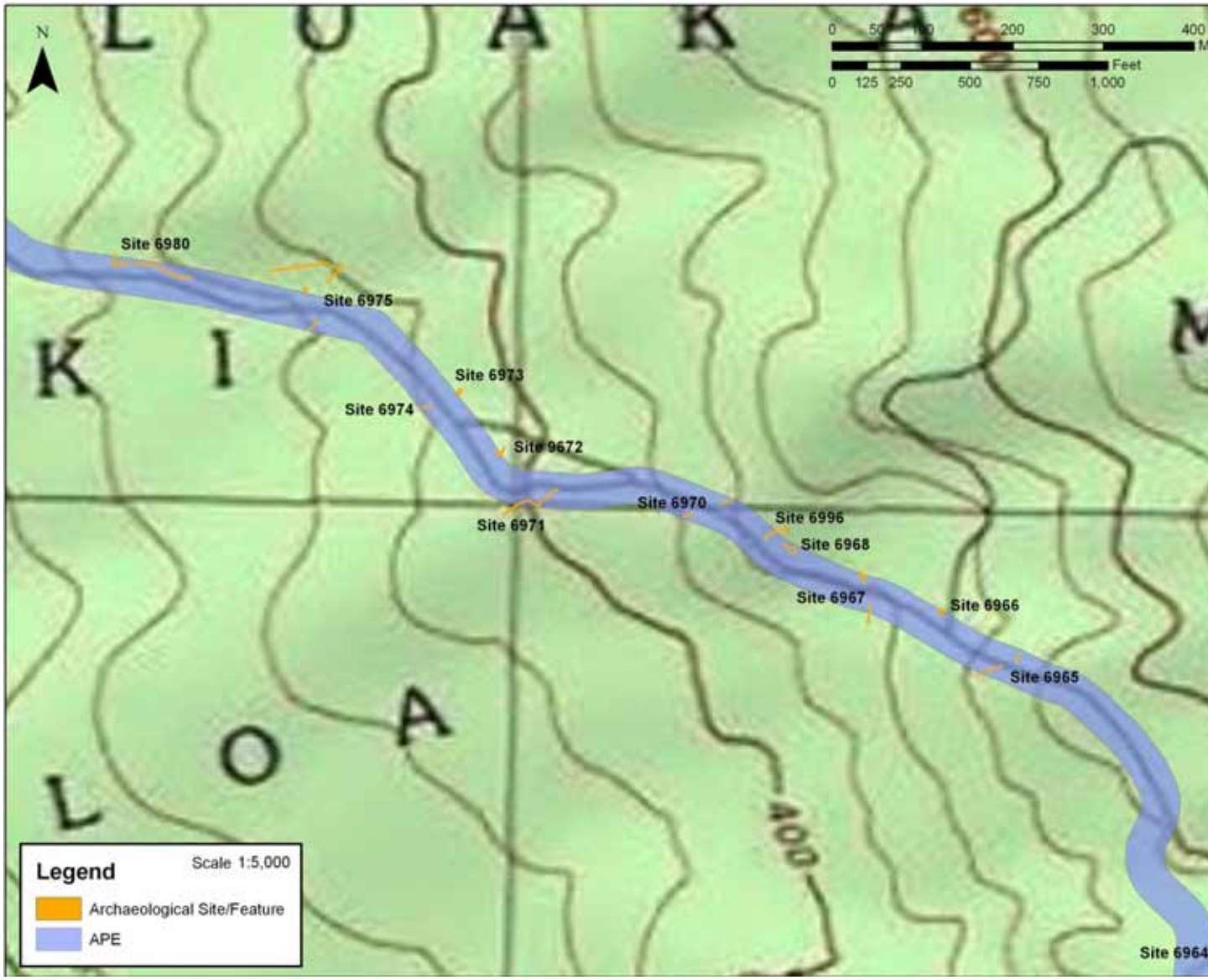


Figure 25. Site location map of Pāpaka Road between figures 24 and 26.

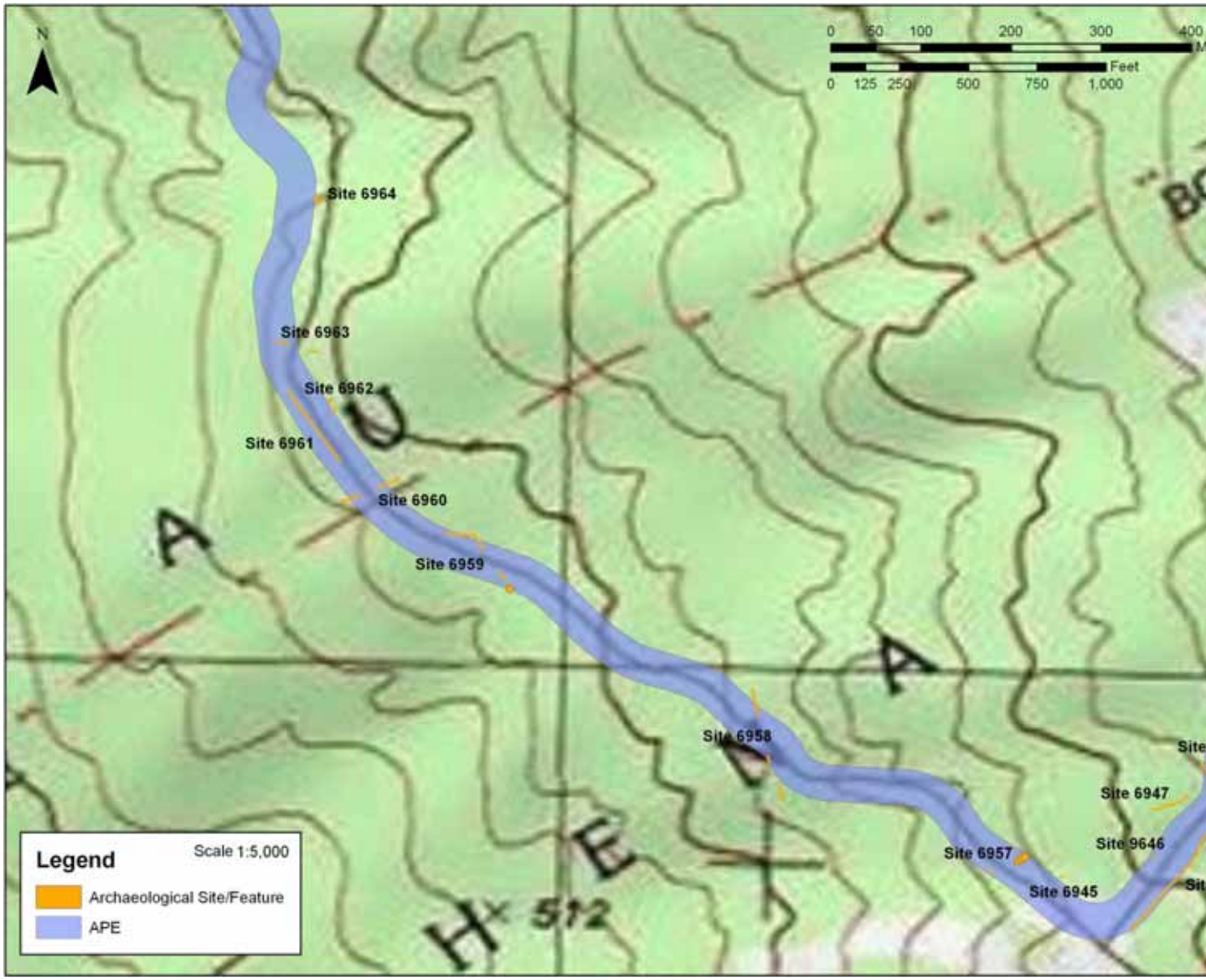


Figure 26. Site location map of Pāpaka Road between Figures 25 and 27.

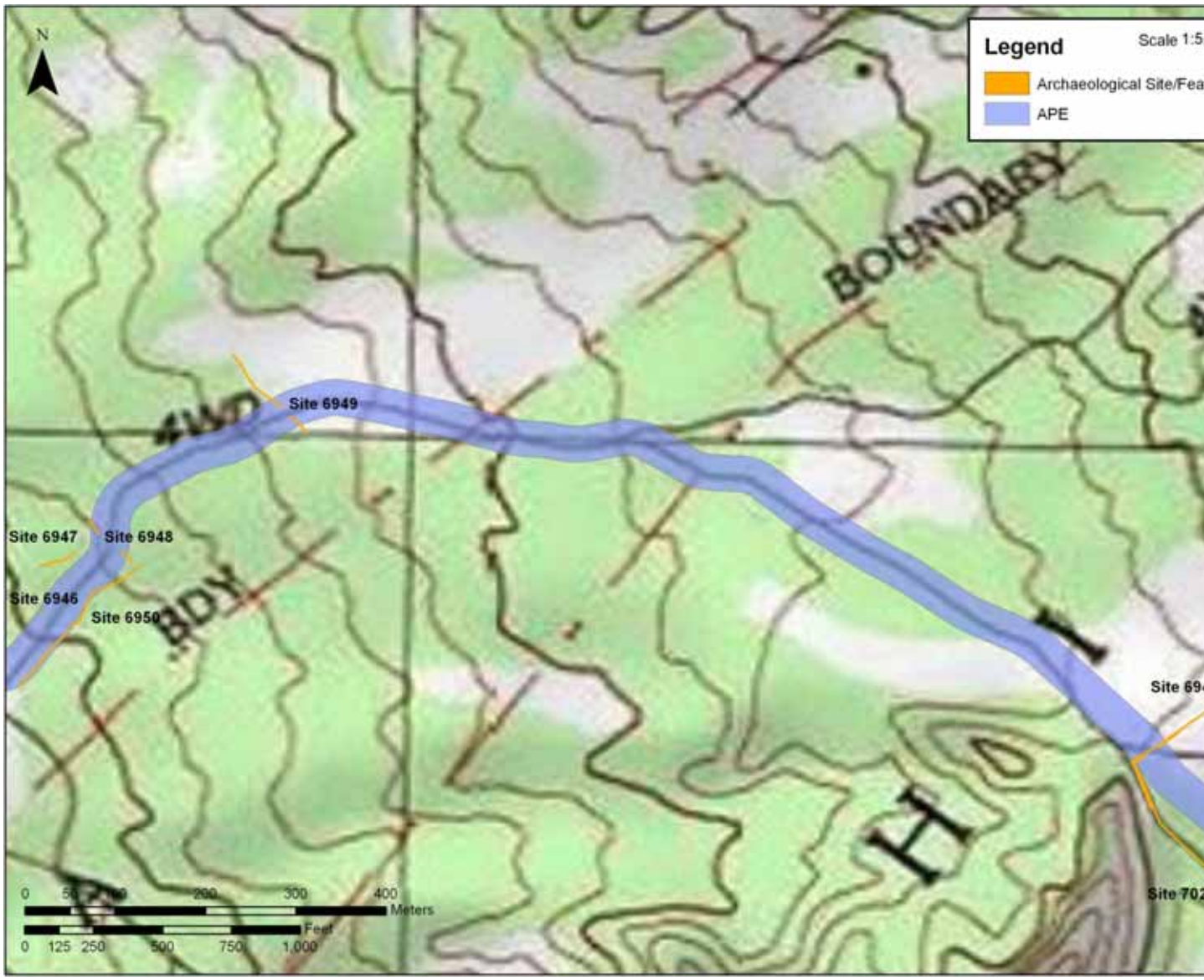


Figure 27. Site location map of Pāpaka Road between Figures 26 and 28.

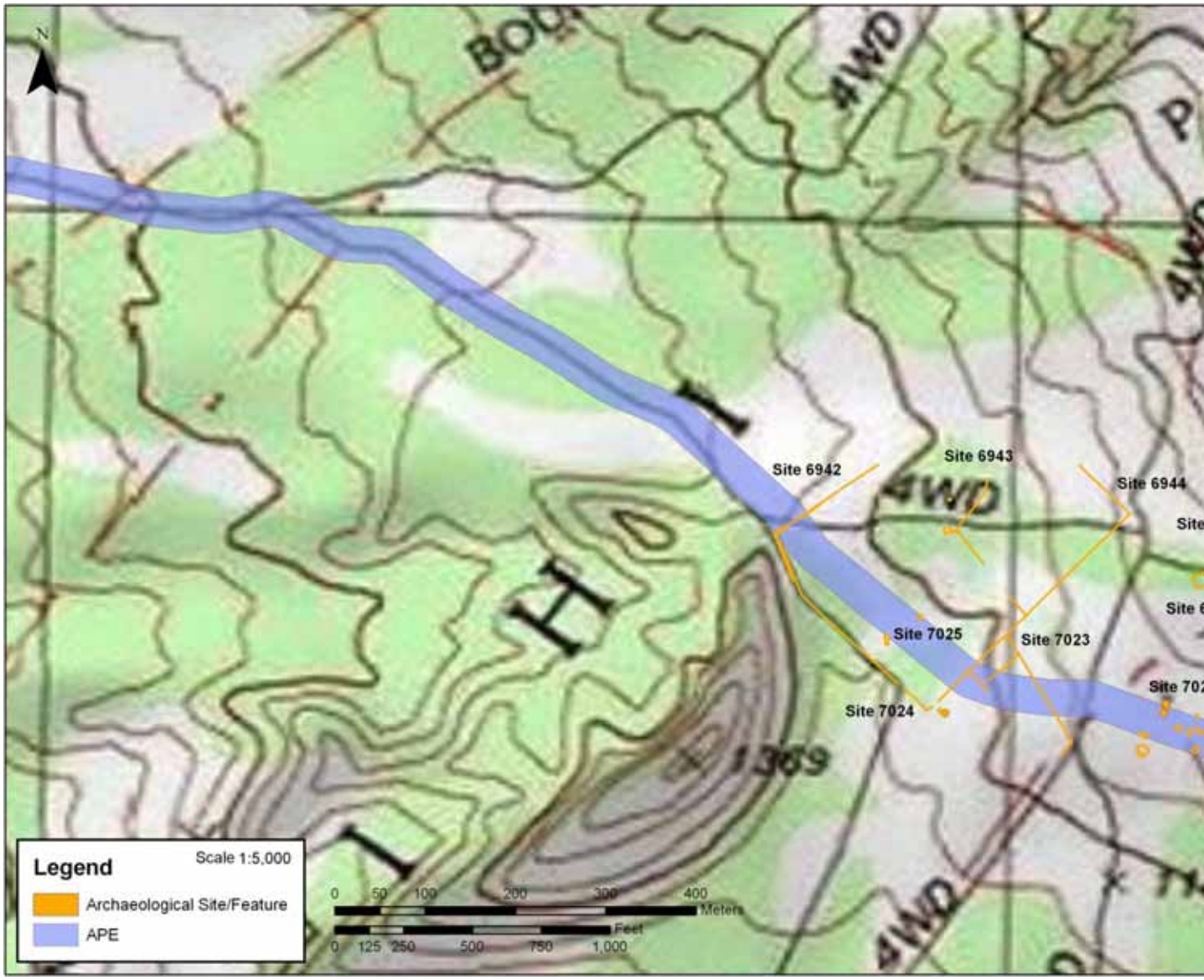


Figure 28. Site location map of Pāpaka Road between Figures 27 and 29.

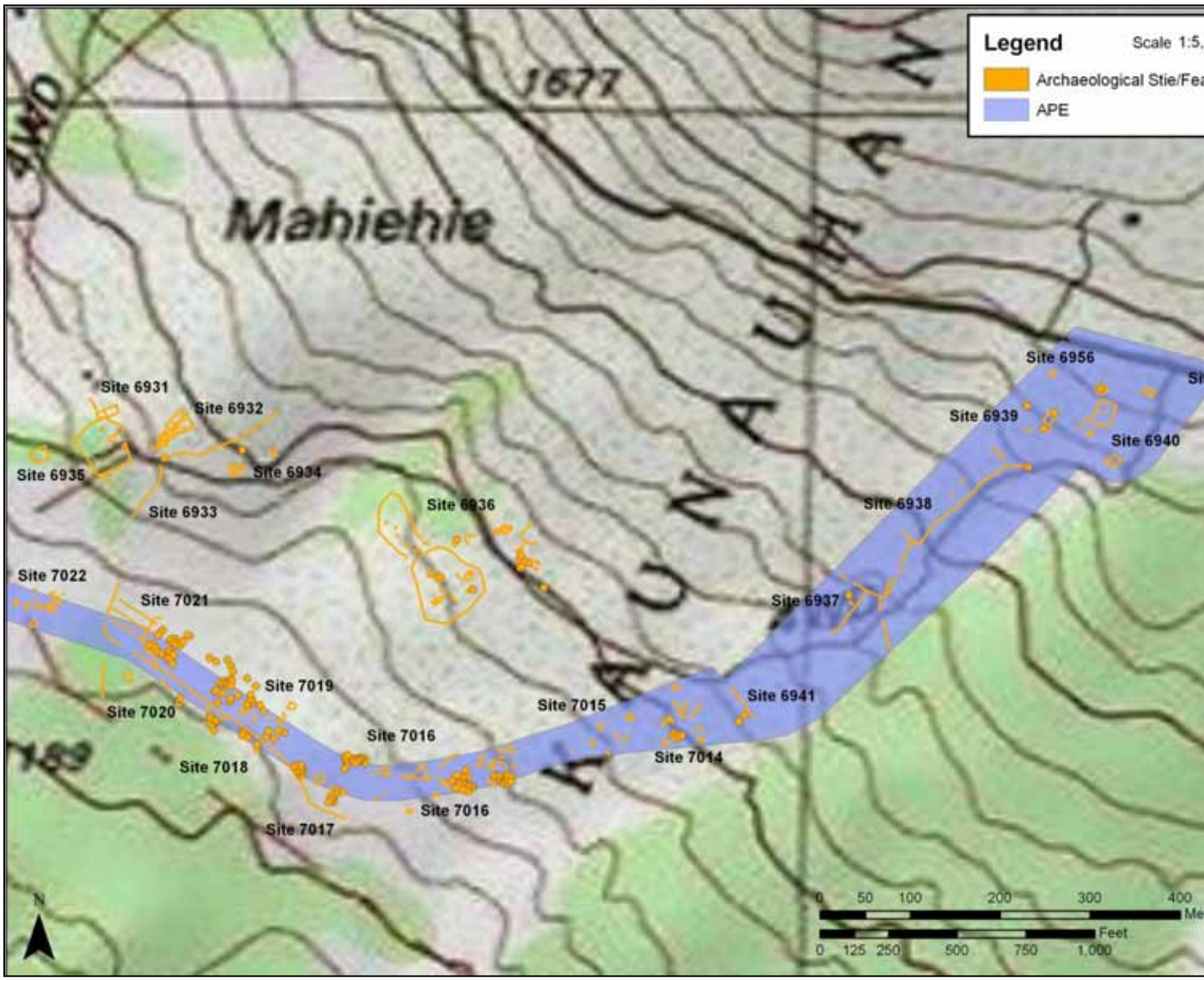


Figure 29. Site location map of eastern end of Pāpaka Road.

5.1.1 Ceremonial/Religious Resources

Pre-Contact ceremonial/religious features are represented by five "notched" *heiau*. The term "notched" *heiau* is used by archaeologist to refer to a distinctive form of ceremonial structure that is a dominant form on the island of Maui, with only few examples of this form on other islands. This descriptive term reflects that this form of structure is generally a rectangular enclosure with one corner missing so that in plan view there appears to be a notch in one of the enclosure corners; another way to describe this feature is as a six-sided enclosure. These *heiau* are generally fairly small rectangular enclosures, roughly 10 by 10 m with walls substantially thicker with a higher level of effort afforded in their construction as compared to typical habitation enclosures (Figure 30). These ceremonial/religious sites appear to be associated with the agricultural pursuits that dominate this portion of Auwahi. As such they may have been dedicated to either Kāne or Lono.

Four of the five "notched" *heiau* are located outside of the APE (Figure 31). The only "notched" *heiau* within the APE is Site 50-50-15-6906 Feature II. This site has been extensively disturbed by cattle and a ranch road that was inadvertently bulldozed through a portion of the site. This site is in poor condition. A better example of a "notched" *heiau* outside the APE is Site 50-50-15-6908 Feature A shown in Figure 30.

In addition to these formal ceremonial/religious structures, numbers of possible shrines were recorded, usually associated with habitation structures. These shrines were often indicated by the presence of large elongated water worn boulders that are now fallen, but were probably upright in the past. Often associated with these water worn stones are large pieces of branch coral that were probably left as offerings. Generally these branch corals were harvested live, as they do not exhibit any water worn surfaces that would have resulted from tumbling in the ocean waves. Examples of features with ceremonial /religious components include Feature B at Site 50-50-15-6843 a large structure with several elongated waterworn stones and Feature E at Site 50-50-15-6864 a rough C-shaped structure with a rock filled interior which is slightly depressed and containing large branch coral head offerings.

Figure 30. View of notched *heiau* at Site 50-50-15-6908 Feature A.

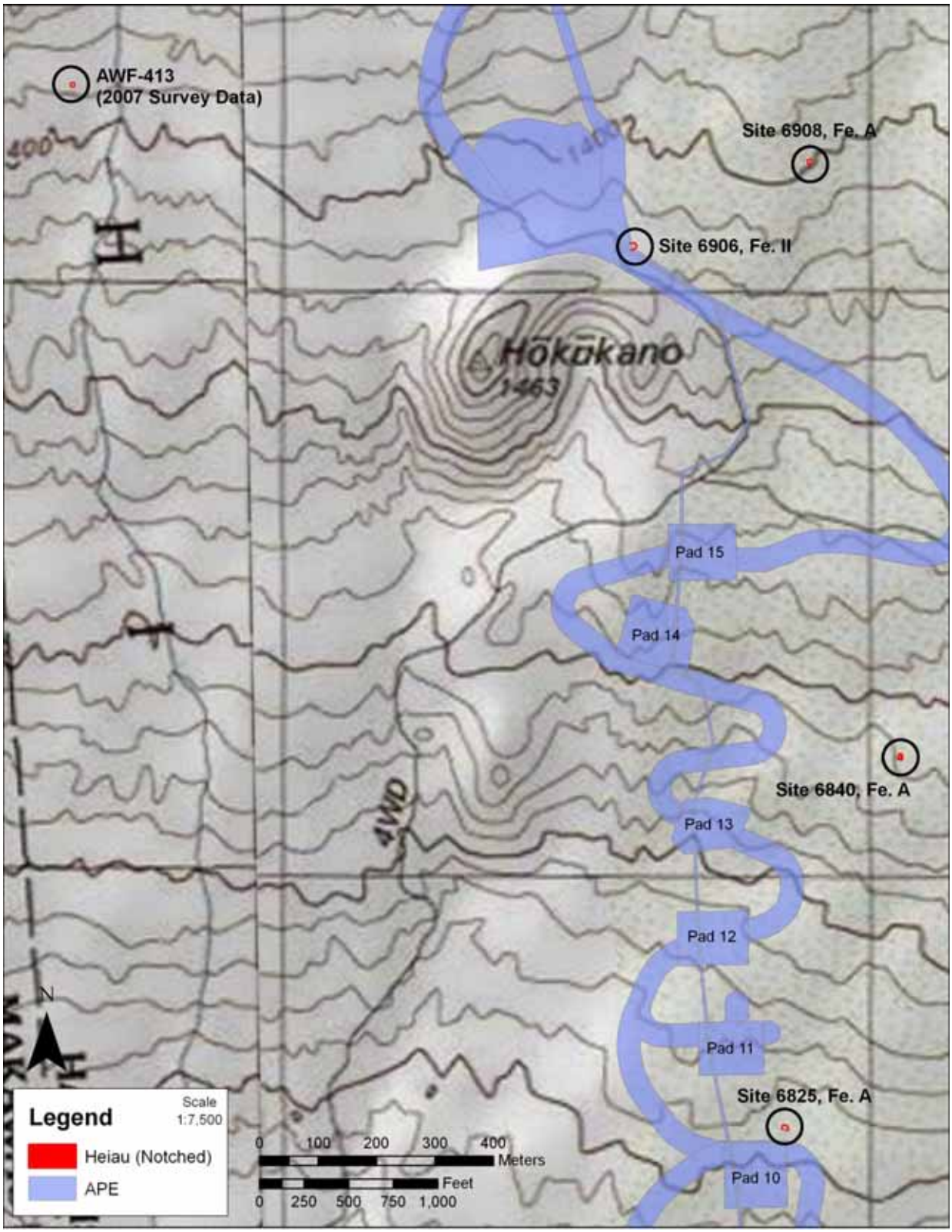


Figure 31. Distribution of "notched" *heiau*.

5.1.2 Burials

Four features containing human remains were located and recorded (Figure 32). Three of the features are lava tubes and one is an open air shelter. Two of the lava tubes contain scattered skeletal elements from disturbed burials, while the third tube contains a single adult tooth with no other associated skeletal elements. The open air shelter contains a single deciduous tooth.

Identical protocol was followed for each discovery. Once remains were encountered and their human nature was confirmed, all work at the feature ceased and archaeological personnel left the site/feature. SHPD cultural staff was immediately notified by telephone with a back up email that described the circumstances of the find. Principal Investigator Paul Cleghorn appeared before the Maui/Lānaʻi Island Burial Council to describe the circumstances surrounding the finds. No further work at these sites has taken place.

Each of these finds is described below.

Site 50-50-15-6894, Feature A

Feature A of Site 6894 is a large lava tube that contains a cultural deposit with ʻ*opihi*, *nerita*, *kukui* endocarp, rock walls, stacked rock work and terracing, charcoal fragments and a torch remnant. A charcoal sample was collected during the recording. Numerous goat, bird and rodent bones were present within the lava tube as well. As the inspection and recording of the lava tube chambers proceeded, two areas containing human bone were identified deep within the tube (30+ m [98+ feet] from the entrance). On the floor of the tube were scattered animal bone fragments and five human hand phalanges (one proximal and four medial). A few meters away on a shelf above the floor were scattered human elements, including a rib fragment, a vertebrae fragment, four metatarsals, medial and distal toe phalanges, and two teeth - which appeared to be a worn incisor and a molar. It appears that these remains, while disturbed, are in their original locations. Once the human bone was identified, all work within the lava tube was halted.

Site 50-50-15-6838, Feature B

Feature B of Site 6838 is a lava tube. During the recording of this feature human bone fragments were identified on the surface within the interior of the lava tube. Human elements identified included a lumbar and thorasic vertebrae, a rib fragment, an incisor and a medial hand phalanx. While the skeletal remains have been disturbed, they appear to be in their original burial location. Midden and cultural constituents were also present in the lava tube including ʻ*opihi*, cowry, *pipipi*, *kukui* endocarp, and coral and water worn pebbles and cobbles. Once the presence of human bone was confirmed, all archaeological work and exploration of the lava tube feature was halted.

Site 50-50-15-6838, Feature G

Feature G of Site 6838 is a windbreak wall and cleared area. On the surface there are basalt cores and flakes, and scattered marine shell midden. A 1.0 x 1.0 m (3 x 3 feet) test unit was being excavated in the lee and adjacent to the windbreak wall when a deciduous human incisor was found while screening the soil. The tooth was from ca. 15 - 20 cm (6-8 inches) below surface. Upon this discovery all work in the test unit terminated and the unit was back filled with the tooth placed in the approximate location of where it was found and buried.

Site 50-50-15-6951, Feature A
Feature A of Site 6951 is a lava tube. A single human incisor was located at 14.5 m (48 feet) from the tube entrance. The crew was in the process of collecting surface artifacts and charcoal samples when the incisor was discovered. It was located in an area of exposed surface bedrock with sparsely scattered bone fragments in the vicinity (including fish and some burnt unidentifiable small mammal). The team had already collected some of the surface material (including shark teeth, dog tooth, basalt awl, coral abrader, etc.) and surface charcoal samples from within the tube for further analysis. A cultural deposit appears to be located within portions of the tube as suggested by the surface constituents and artifacts. Once the human incisor was identified, all work within the lava tube feature was halted.

5.1.3 Possible Burials
In addition to the above features with confirmed human remains, 15 features contain stone mounds that appear to be possible burial markers (Figures 33-36). These sites currently plot within the APE, with the exception of Site 6954. However, given that the actual roadways will measure approximately 10.4 m (34 feet) wide within the 40 m (131 feet) wide APE, we have engineering assurances that these clusters of possible burial mounds can be avoided during construction and thus not be impacted. The avoidance of these features has been addressed in the Burial Treatment Plan for the project.

Site 50-50-15-6827
This site contains 12 mounds that may be burial monuments containing human remains. These features are in the vicinity of Pad 05. No test excavations were conducted in these features and for the present we are assuming that they are burial sites and are being treated accordingly.

Site 50-50-15-6909, Feature N
Feature N of Site 6909 is a stone mound constructed of subangular basalt boulders and cobbles with a roughly stacked perimeter and filled in with loose boulders and cobbles. The stacking is two to three courses on bedrock. It measures 1.1 x 1.7 m.

Site 50-50-15-6921, Feature B
This feature is a roughly circular and flat topped stone platform, measuring 3.0 x 3.0 x 0.2 m high. Basalt boulders and large cobbles ring the perimeter of the platform, with the interior filled with cobbles and pebbles.

Site 50-50-15-6922, Feature B
Feature B of Site 6922 is a roughly rectangular terrace, with three sides bounded with basalt boulders, the forth side grades into the natural slope. The interior of the terrace is filled with angular basalt pebbles. The feature measures 1.5 x 1.1 x 0.3 m high.

Site 50-50-15-6923, Feature C
Feature C of Site 6923 is a low stone mound constructed of piled basalt cobbles and small boulders. It measures 3.2 x 2.6 x 0.4 m high.

Site 50-50-15-6930
This site is located along the access road between Pads 06 and 07. It contains 19 mounds and

two modified outcrops where crevices have been filled with stones. While no archaeological excavations have been undertaken in any of these features, we are assuming that these features are burial sites and are being treated accordingly.

Site 50-50-15-6953
This site is located along the access road between Pads 13 and 14. It consists of seven stone mounds. Four of these mounds are outside of the APE and three are within the APE, but are far removed from the planned route of the road. No archaeological excavations were undertaken and we are assuming that these are burial features.

Site 50-50-15-6954
This is a complex of 16 stone mounds. The complex was located in the originally planned lay down area that has been relocated to avoid these possible burial features. No excavations have taken place and they are far removed from any construction activity.

Site 50-50-15-6985, Feature G
Feature G of Site 6985 consists of at least three clearing mounds and a modified bedrock outcrop. The modified outcrop is irregularly shaped; Mound 1 is irregularly shaped; Mound 2 is roughly circular; Mound 3 is irregularly shaped and built into the slope. The modified outcrop measures 2.8 x 2.2 x 1 m high on the west side and 0.55 meters high on the east. Mound 1 measures 2.7 x 2.4 x 0.75 m high at most. Mound 2 measures 2.3 m in diameter and 0.6 m high at most. Mound 3 measures 2.7 x 2.5 x 0.95 m high on the south side. A large piece of branch coral, measuring 12 cm by 15 cm, was observed 6 m east of Mound 2 indicating the feature may have functioned as a burial.

Site 50-50-14-6992, Feature D
Feature D of Site 6992 consists of three linear mounds constructed of subangular basalt cobbles closely piled in a linear shape. Mound 1 measures 12.9 x 1.7 x 0.2 m. Mound 2 measures 8.5 x 2.1 x 0.35 m and several small boulder sized slabs have been inset upright along the southern length; these slabs may indicate a burial location. Mound 3 measures 4 x 1.4 x 0.25 m. Mound 2 may have functioned as a burial. The function of Mounds 1 and 3 is uncertain.

Site 50-50-15-7035, Feature B
Feature B of Site 7035 is a roughly square mound constructed of piled boulders and large cobbles. It measures 1.8 x 1.7 x 0.7 m high.

Site 50-50-15-7035, Feature C
Feature C is an irregular shaped mound constructed of boulders and cobbles. It measures 2.0 by 1.5 x 0.2 m high.

Site 50-50-15-7035, Feature D
Feature D is an irregular shaped mound constructed of piled cobbles and boulders; four set stones mark the downslope side of the feature. It measured 2.0 x 1.4 x 0.6 m high on the downslope side; the upslope side grades into the natural slope.

Site 50-50-15-7035, Feature E
This feature is a small irregular shaped mound constructed of piled large and small cobbles. It measures 1.5 x 1.2 x 0.4 m high.

Site 50-50-15-7041
Site 7041 is a single stone mound that is roughly rectangular in shape and constructed of piled subangular cobbles and boulders. Boulders mark most of the perimeter of the mound with small cobbles filling the interior of the feature. It measures 1.5 x 0.8 x 0.3 m high.

All of the confirmed burial sites and the possible burial sites will be preserved in place. The specifics on how these preservation measures will be accomplished are provided in a burial treatment plan that has been submitted to the State Historic Preservation Division for review prior to being presented to the Maui/Lānaʻi Island Burial Council.

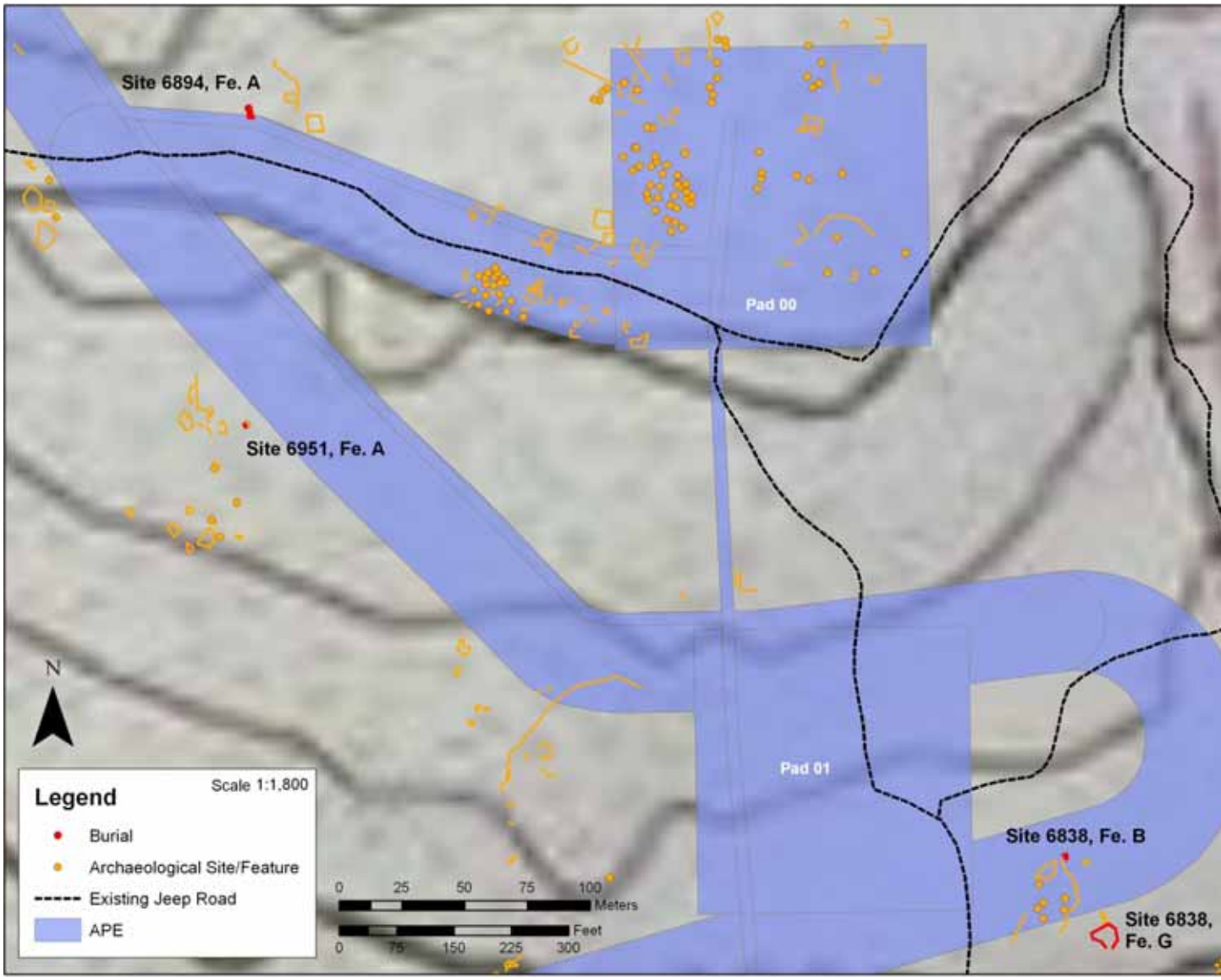


Figure 32. Distribution of burial features within the Wind Farm.

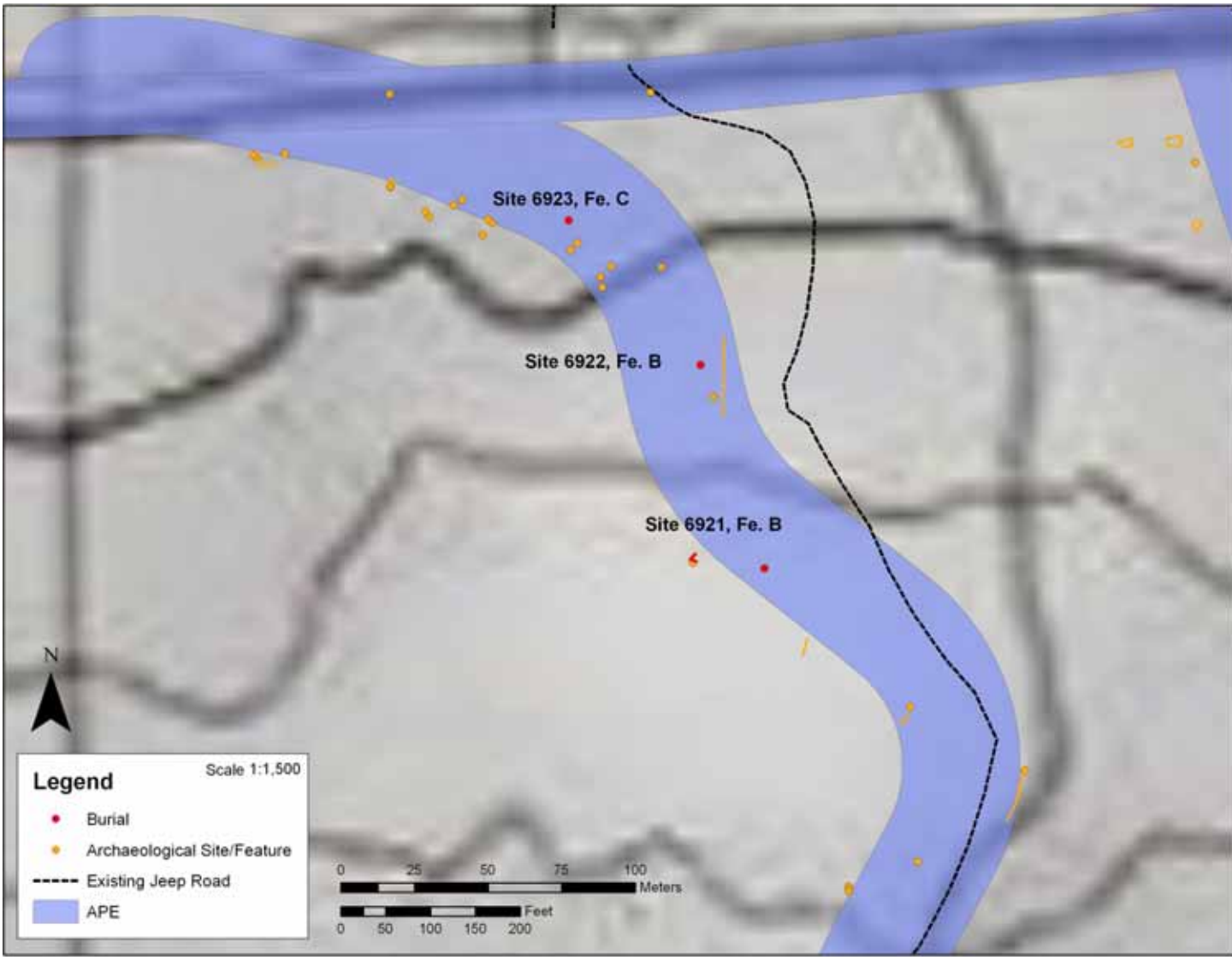


Figure 33. Relationship of access roads to possible burial sites, upper section of Access Road leading from Pi‘ilani Highway to Laydown Area.

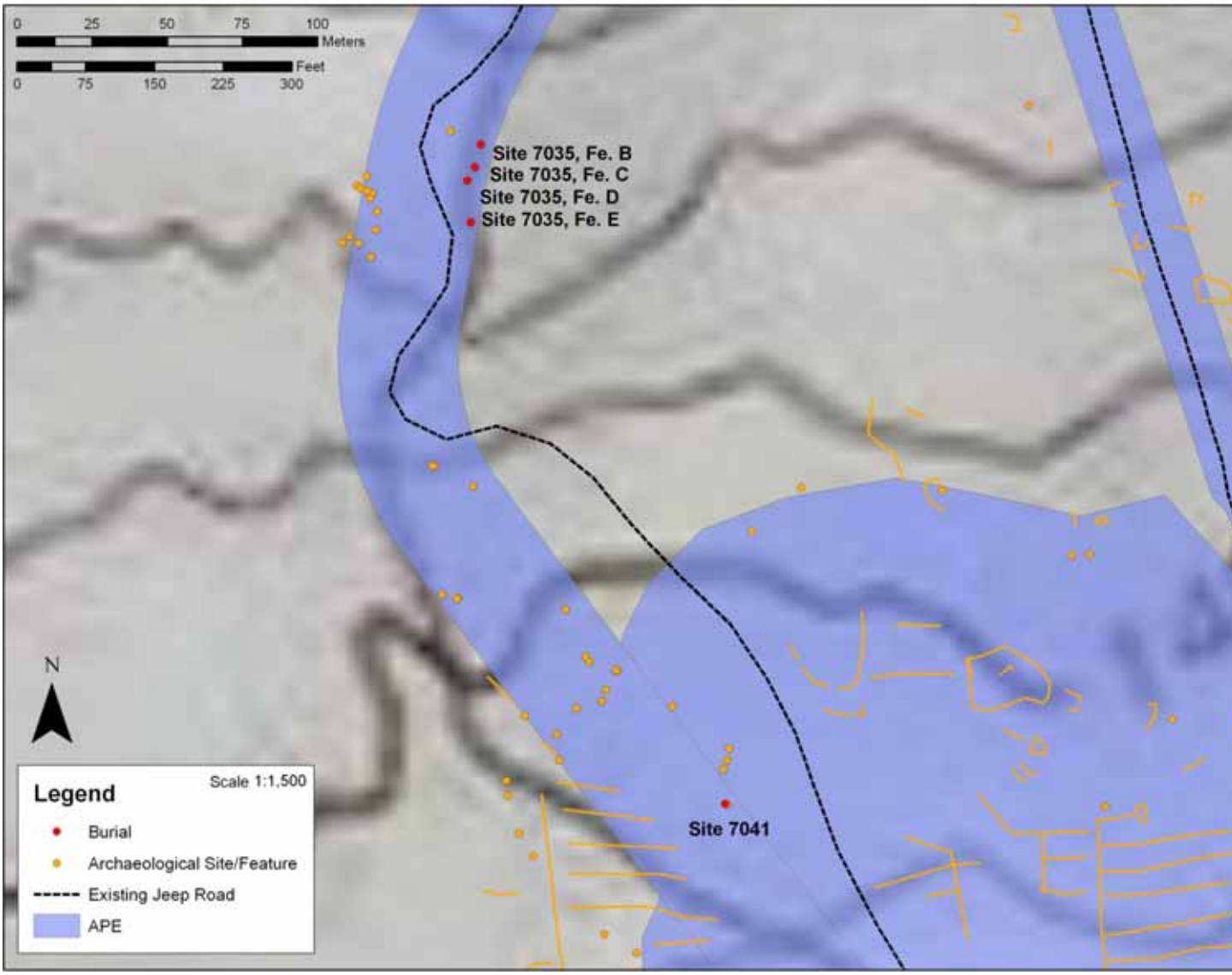


Figure 34. Relationship of access roads to possible burial sites, lower section of Access Road leading from Pi
Laydown Area.

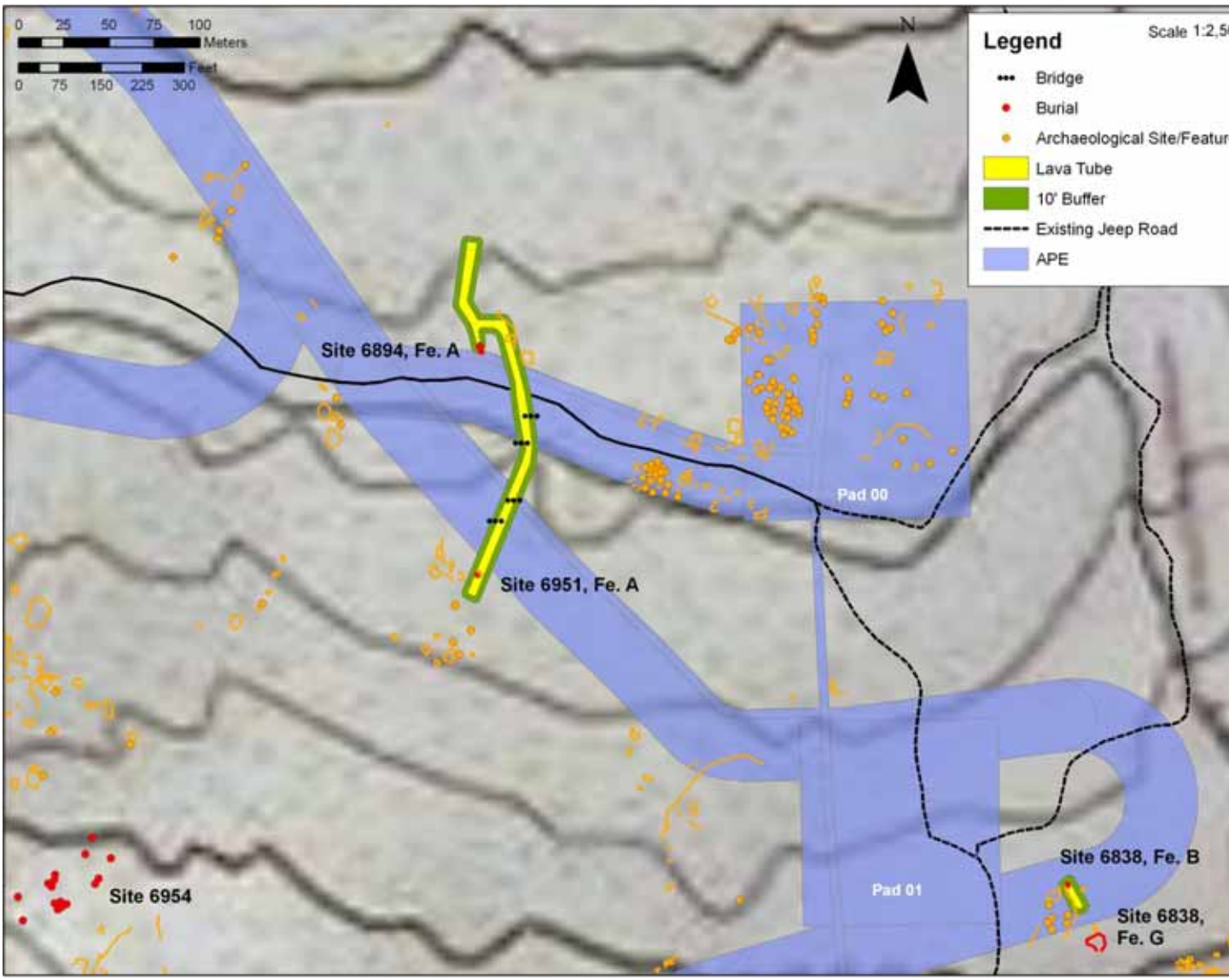


Figure 35. Relationship of access roads to possible burial sites: Laydown Area to Pad 00.

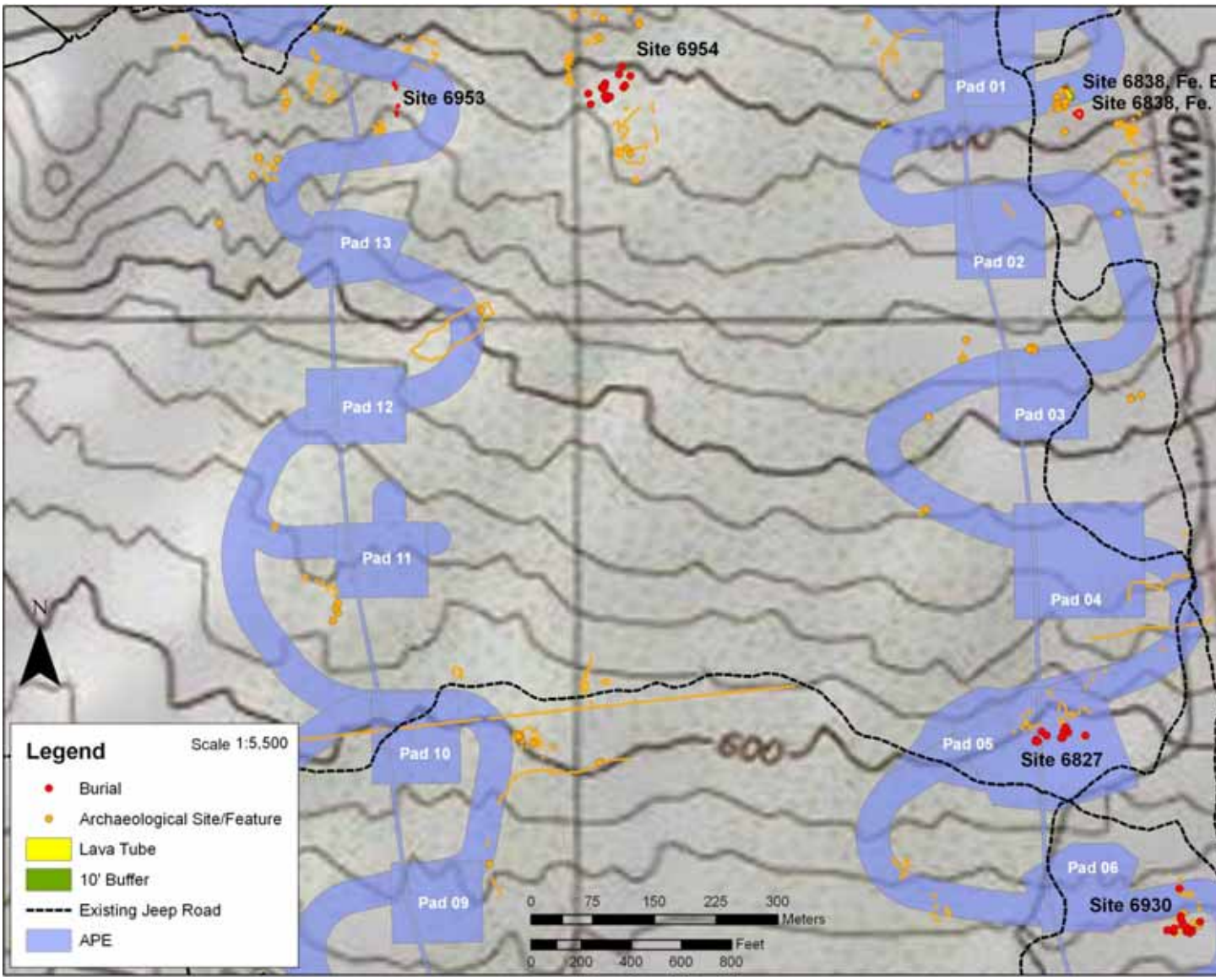


Figure 36. Relationship of Access Roads to possible burial sites: lower portion of Wind Farm.

5.1.4 Traditional Habitation Features

Traditional habitation features are represented by enclosures, platforms, terraces, rock walls (including C-shape, L-shape and U-shape structures), rock alignments, modified outcrops and overhangs, lava tubes and cleared activity areas. The low walled C-, L-, and U-shaped structures as well as the overhangs and lava tubes appear to have been used as temporary shelters as they are quite small, involve a minimum of effort to construct, and generally lack artifacts, midden or internal features.

Permanent habitation structures are the much more substantial enclosures, platforms, and terraces. These typically have shell midden scatters, as well as basalt debitage from stone tool manufacture and *porites* coral fragments from making abraders. They also sometimes have portable artifacts on the surface. Several of the habitation features have rock slab-lined hearth features.

Some of the more substantial habitation structures appear to have been the residences for families of relatively high status. These are distinguished by thicker and more massive wall construction, relatively larger surface areas, and distinct use areas within the structures such as slab paved floor areas, terraces, platforms, or divided interior spaces. Some of these structures also contain evidence for recreational activity such as *ʻulu maika* stones, *papamū* boards and petroglyphs. Two large habitation enclosure features at different site areas (Sites 50-50-15-6824 Feature A and 50-50-15-6847) each contain a slab lined hearth feature, a *pāhoehoe* slab paved floor area, a rock concentration or low platform area with large water worn cobbles and/or branch coral suggestive of a shrine or area for offerings (Figures 37 and 38). These may represent *hale mua* or men's houses.

5.1.5 Traditional Agriculture

Due to the current drought and resulting enhanced visibility, numerous agricultural features were recognized in the project area that were previously unidentified. Among the most interesting discoveries is evidence for the extensive use and re-use of available water to irrigate traditional agricultural field systems and planting areas. Water during flash flood and rainfall events appear to have been deliberately slowed down and captured for use in a field system and then channeled and reused again. At least six sites (6841, 6840, 6955, 6925, 6906 and 6910) contain the remnants of extensive agricultural field systems. These include enhanced drainages, ditches, evenly spaced and stepped agricultural terraces, rock clearing mounds, planting circles, modified outcrops and cleared areas. Perhaps the best example of a field system in the project are is Site 6910 with remnants of evenly spaced terraces on the margins of a large flat whose central portion has been disturbed by cattle grazing activity (Figure 39).

Figure 37. Overview of high-status habitation Feature at Site 50-50-15-6824.

Figure 38. Stone-lined fire hearth at Site 50-50-15-6824.

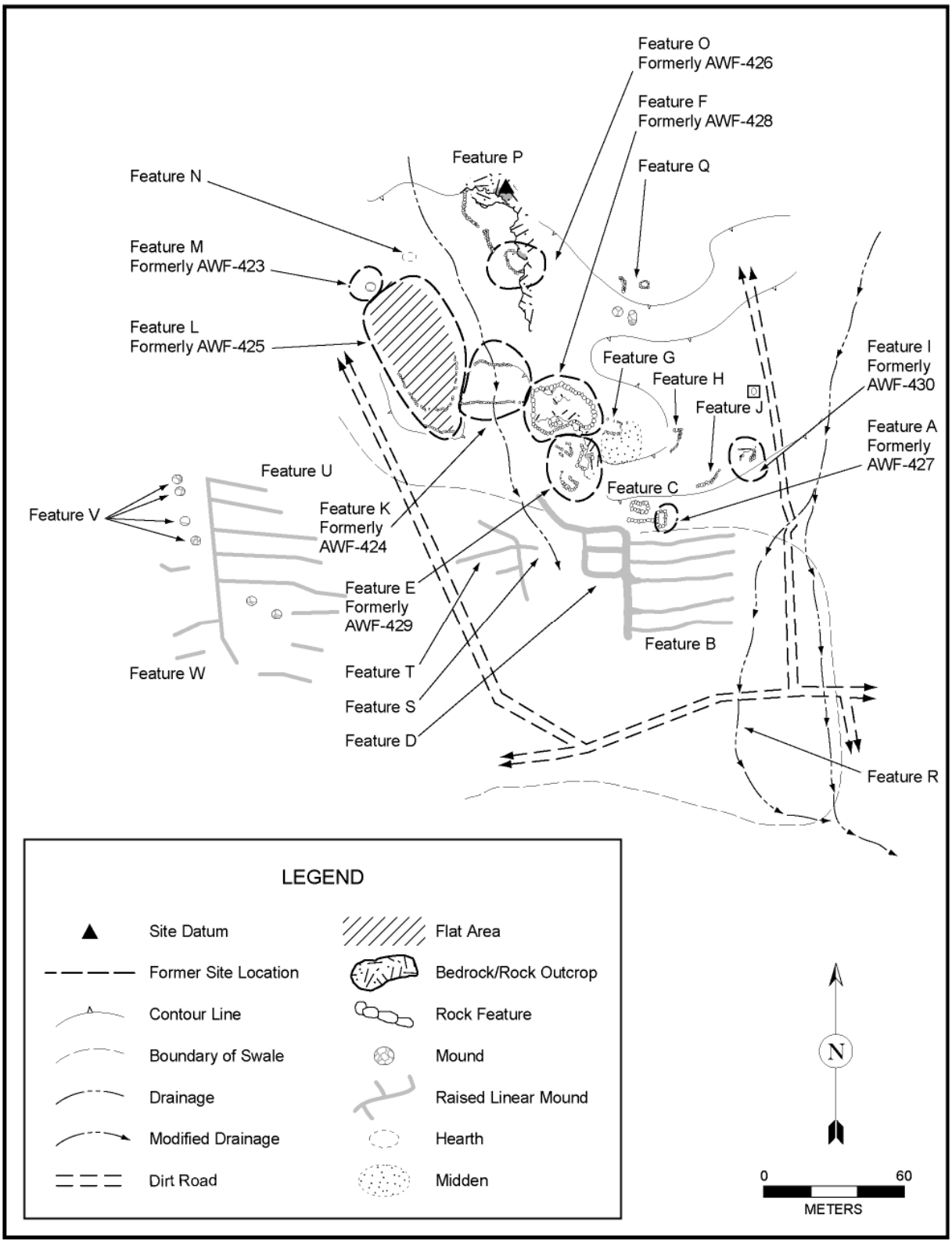


Figure 39. Site 50-50-15-6910 site map.

5.1.6 Transportation Features

Two *pāhoehoe* slab stepping-stone trail sections represent the transportation features identified in the project area (Sites 50-50-15-6815 Feature A and 50-50-15-6826 Feature B). Both are short trail segments within *ʻaʻā* lava flows and lead to other feature areas (Figure 40).

Figure 40. *Pāhoehoe* slab lined trail at Site 50-50-15-6815 leading to lava tube.

5.1.7 Historic Features

Numerous historic features were found in the APE. The most common historic features consisted of cattle wall associated with ranching activities. Other historic features included stone walled enclosures, standing wooden structures, concrete cisterns, and stone and mortar platforms that supported water tanks (Figures 41 and 42).

In addition to these modern historic features, several of the traditional features showed evidence of use or re-use during the contact and early historic periods as evidenced by historic artifacts such as ceramics, glass, trade beads, metal can fragments, barrel hoops, and domestic artifacts such as a cast iron clothing iron and a metal flensing tool used for de-blubbering whales which was re-used as a digging stick (see Section 6.1 artifact analysis).

Figure 41. Standing wooden structure (Site 50-50-14-7024 Feature A) at the Goodness Ranch Complex.

Figure 42. Cistern (Site 50-50-14-7024 Feature B) at the Goodness Ranch Complex.

5.2 TEST EXCAVATIONS

Twenty four sites were excavated during the 2010 fieldwork with a total of 37 test units (TUs) being conducted within 37 different feature areas. Of these sites, 16 are located in the wind farm (27 features excavated), three along the Generator-Tie Line corridor (four features excavated), and five along the Pāpaka Road corridor (six features excavated) (Tables 8-10). Due to revisions in the project design, only 12 of the 24 sites remain in the APE for the project.

TUs typically measured 1 x 1 m in size and all deposits were screened through ⅛-inch mesh. On three occasions unit sizes were increased in order to extend up against a wall or when dismantling sections of a mound to provide a better cross section profile. Upon completion of the excavations, all units were backfilled. Below is a list of the excavation units by project area, site, feature and unit designation (Tables 8-10). This is followed by a brief description of the tested site features and the excavations conducted. For additional details on the sites and feature descriptions see Appendix C.

Table 8. Wind Farm Test Excavations

SITE	FEATURE	UNIT
AWF-141*	Feature A – U-shaped wall	TU-1
AWF-141*	Feature B – C-shaped wall	TU-2
AWF-142*	Feature A – enclosure	TU-1
AWF-167/557*	Feature G – wall with cleared area	TU-1
AWF-168	Feature B – terrace with windbreak	TU-1
AWF-186*	C-shaped wall	TU-1
AWF-190/310*	Feature A – cleared area with windbreak	TU-1
AWF-190/310*	Feature L –terrace (soil filled)	TU-2
AWF-190/310*	Feature E –terrace (stone filled)	TU-3
AWF-190/310*	Feature I – terrace	TU-4
AWF-190/310*	Feature J – terrace (stone filled)	TU-5
AWF-190/310*	Feature K – C-shaped wall	TU-6
AWF-197	Feature B – enclosure	TU-1
AWF-198/199	Feature A – enclosure	TU-1
AWF-198/199	Feature I – U-shaped wall	TU-2
AWF-200	Feature A – enclosure	TU-1
AWF-202	Feature C – C-shaped wall	TU-1
AWF-204	Feature A – C-shaped wall	TU-1
AWF-208	Feature A – terrace	TU-1
AWF-212*	Feature B – terrace	TU-1
AWF-213*	Feature A – terrace	TU-1
AWF-216*	Feature E – C–shaped wall with coral	TU-1
AWF-216*	Feature C – terrace with overhang	TU-2
AWF-216*	Feature A – terrace with windbreak	TU-3
AWF-216*	Feature I – terrace with surface hearth	TU-4
AWF-216*	Flat below Feature I	TU-5
AWF-2010 A	Feature C – cleared area with wall	TU-1
Key:		
*	**Sites located in the current APE**	

Table 9. Generator-Tie Line Corridor Test Excavations

SITE	FEATURE	UNIT
AWF-071/252/253	Feature C – stone mound; south half	TU-1
AWF-247*	Feature B - terrace next to wall Feature A	TU-1
AWF-247*	Feature C – terrace and alignment	TU-2
AWF-256	Feature B – U-shaped wall	TU-1
Key:		
*	**Sites located in the current APE**	

Table 10. Pāpaka Road Test Excavations

SITE	FEATURE	UNIT
AWF-585	Feature D – midden area with historic artifacts	TU-1
AWF-593*	Feature A – enclosure	TU-1
AWF-593*	Feature C – terrace	TU-2
AWF-594*	Feature H – terrace	TU-1
AWF-598	Feature B – mound; east half	TU-1
AWF-2010 F*	Enclosure	TU-1
Key:		
*	**Sites located in the current APE**	

5.3 WIND FARM TESTED SITES

5.3.1 Site 50-50-15-6832

Site 6832 is a large U-shaped enclosure (Feature A) with a smaller C-shaped wall that extends off of the U-shape. The U-shape opens to the south and the south end of its western wall incorporates the C-shape. The features are constructed on natural bedrock outcroppings with the walls consisting of stacked and piles of boulders and cobbles. The north wall is only two courses (30 cm) high, and it appears that the walls were originally taller as there is over 3 m of scattered tumble adjacent to the wall remnants. Up-ended *pāhoehoe* slabs are also incorporated into the rock walls. The U-shape interior measures 4.8 m long N-S by 1. 6 m wide. The C-shape entrance is 2 m wide with an interior space of 1 m in length. No artifacts or cultural constituents were observed in the interior or the vicinity of the features.

Two test excavation units (each measuring 1x1 meter) were excavated at the site. TU-1 was located in the U-shape interior along the east wall (Figure 43). It was excavated to bedrock with a depth ranging from 12 to 25 cm below surface. Three stratigraphic layers were uncovered (Figure 44):

I	0 – 2/3 cm bs	Dark yellowish brown (10 YR 3/6) silty loam; structureless; nonsticky, non plastic; abrupt smooth boundary; top soil with abundant organic material.
II	3 – 7/14 cm bs	Very dark brown (10 YR 2/2) silty clay loam; fine granular; slightly sticky, slightly plastic; abrupt smooth boundary; cultural layer with sparse amount of midden and charcoal.
III	7/14 – 7/23 cm bs	Dark brown (10 YR 3/3) silty clay loam; fine granular; slightly sticky, slightly plastic; sterile.

Sparse amounts of cultural material were recovered including coral, marine shell and charcoal. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample from 22 cm bs was collected and submitted for radiocarbon analysis which yielded a date which indicates that this feature was probably utilized between the mid AD 1400s and the mid AD 1600s.

Figure 43. View northeast of Site 50-50-15-6832, TU-1 at bedrock.

TU-2 was excavated within the C-shape interior which required the removal of wall tumble. The unit was excavated to bedrock at a maximum depth of 55 cm bs with no cultural material being recovered (Figure 45). The stratigraphy in TU-2 was similar to that described for TU-1 with three layers represented. Layer I consisted of a thin topsoil of silty loam with organics which was followed by a Layer II a dark brown silty clay loam which contained the cultural constituents if present. Layer III consisted of a lighter brown or dark yellowish brown silty clay loam which represented the sterile layer just above the lava bedrock. These stratigraphic layers were typical of all 37 of the excavation units with minor variations, usually in the form of ash pockets, occasional hearth features and slight variations in soil color.

The features at Site 6832 appear to represent habitation areas likely associated with agricultural pursuits based on the spatial association with nearby agricultural features and the relative lack of cultural material.

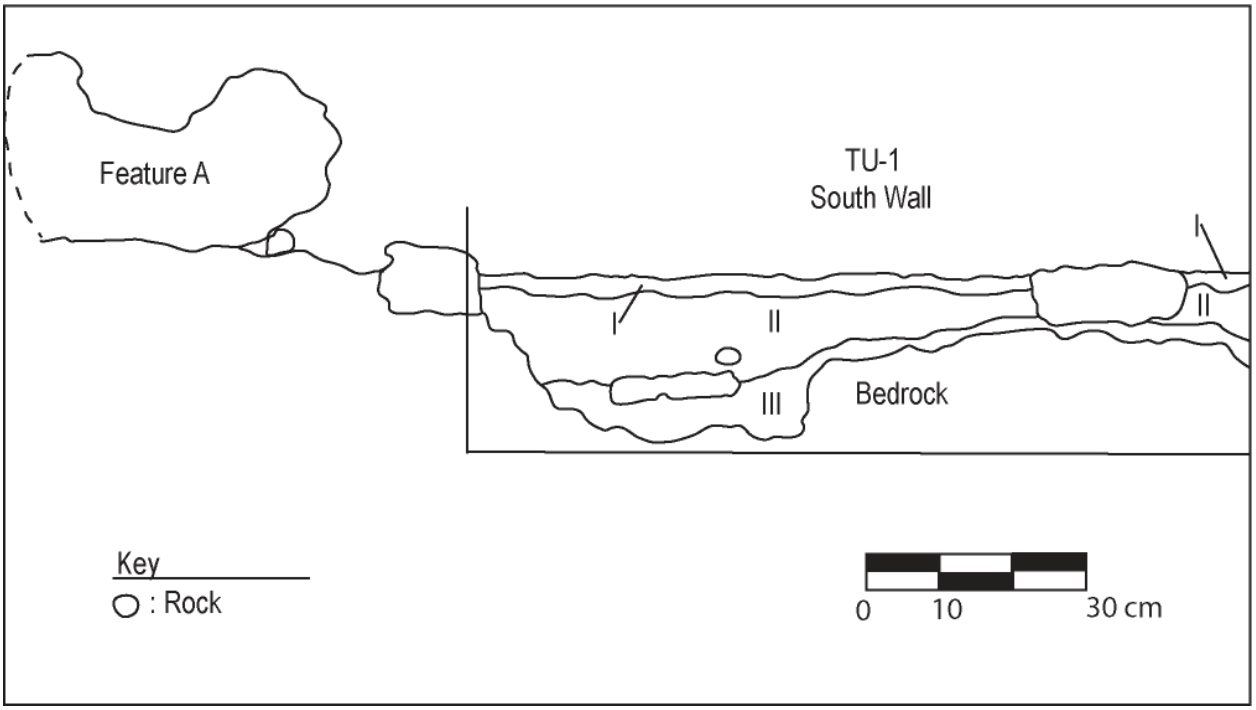


Figure 44. Stratigraphic profile of Site 50-50-15-6832, TU-1.

Figure 45. View north of Site 50-50-15-6832, TU-2 prior to excavation.

5.3.2 Site 50-50-15-6833

Site 6833 is a complex consisting of three features; Feature A is a rectangular enclosure, Feature B is a C-shaped wall, and Feature C is a rock mound. The enclosure measures 5.1 m north-south by 3.6 m east-west with the walls constructed of basalt boulders and cobbles with core filling. The enclosure walls are 2-3 courses high (35 cm) and are 80-90 cm wide with rock tumble from the walls located in the enclosure interior and with the southwest and northeast corners being partially collapsed.

A single test unit was excavated against the north wall of the Feature A enclosure (Figure 46). The unit measured 1 x 1 meter in size and was excavated to bedrock with the deepest point in the unit being 49 cm below surface (Figure 47). Three stratigraphic layers were present:

I	0 – 5 cm bs	Very dark brown (7.5 YR 2.5/3) silt; single grain; slightly sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material.
II	5 - 26 cm bs	Dark brown (10 YR 3/3) silty loam; single grain; slightly sticky, slightly plastic; gradual smooth boundary; cultural layer with sparse amount of midden and charcoal.
III	26 - 49 cm bs	Dark yellowish brown (10YR 3/6) silty loam; granular; slightly sticky, slightly plastic; sterile.

Layer I represents a silty duff layer which is present on the surface and extends for 5 cm. Layer II is a dark brown silty loam which contained most of the cultural constituents and is approximately 21 cm thick. Layer III is a dark yellowish brown silty loam which contained only a single piece of shell midden and a sea urchin spin. Layer III extended to bedrock and averaged only 6-7 cm deep but pockets of this layer extended into the cracks of bedrock giving the layer a maximum thickness of 24 cm. The cultural deposit revealed sparse amounts of shell midden, basalt flakes, a piece of worked echinoid spine, an *ʻiliʻili* pebble, and charcoal flecking which was too small to collect. For details on the recovered materials see Section 6: Results of Laboratory Analysis.

Site 6833 likely represents habitation features and activity areas associated with nearby agricultural pursuits.

Figure 46. View northwest of Site 50-50-15-6833, Feature A, TU-1 surface prior to excavation.

Figure 47. View of west wall profile of TU-1 at Site 50-50-15-6833, Feature A showing bedrock at base of excavation.

5.3.3 Site 50-50-15-6838

Site 6838 is a complex comprised of ten features. Feature A is a natural bedrock platform with a stone alignment and piling; Feature B is a small lava tube which contains human remains; Feature C is a series of six agricultural clearing mounds; Feature D is a stone wall; Feature E is a rock alignment; Feature F is a rock cairn; Feature G is a small wall segment with an adjacent cleared flat; Feature H is rough U-shaped wall; Feature I is a rough C-shape; and Feature I is a modified lava blister.

Once human bone was identified during the recording of the lava tube (Feature B), all work in the feature area was terminated and the appropriate personnel were informed of the discovery. A subsequent investigation took place at the request of the Project's cultural advisor (Charles Maxwell) to determine if the remains were in an in situ or re-deposited context. Without removing or disturbing the remains, soil was lightly brushed off to expose the bone which revealed that they were partially articulated and within an in situ context. No further work was conducted within the lava tube and this feature will be avoided during project implementation.

A test excavation unit was excavated at Feature G adjacent to the rock wall (Figure 48). The unit was terminated at approximately 15 cm below surface due to the discovery of a single deciduous human tooth. Basalt flakes, shell midden, fish and mammal bone, charcoal flecking and pockets of ash were observed in the unit prior to the termination. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample collected from the unit at 6 cm bs was submitted for radiocarbon dating and most likely dates from between the mid AD 1500s and AD 1800 (see Section 6.3: Radiocarbon Dating). Bedrock was starting to be exposed in portions of the unit at that depth, and it is likely that the unit would not have extended much deeper before encountering solid bedrock (Figure 49).

A large agricultural complex (Site 50-50-15-6925) is located below and southeast of Site 6838. Site 6838 appears to represent a habitation and activity area associated with agricultural pursuits as well as having a religious /burial component.

Figure 48. View east of TU-1 prior to excavation at Site 50-50-15-6838, Feature G.

Figure 49. Close up of TU-1 at Site 50-50-15-6838 showing bedrock and ash deposit at 10-20 cm bs level which was terminated due to discovery of deciduous human tooth.

5.3.4 Site 50-50-15-6839

This site complex consists of two features. Feature A is an irregular oval terrace measuring roughly 1.3 m east-west by 2.6 m north-south with a built up eastern wall which incorporates natural bedrock and measures approximately 3 m long and 0.5 m high. Feature B is a round terrace against a C-shaped windbreak wall with a possible cupboard. Feature B terrace measures approximately 2 m in diameter with the C-shaped wall located along its northeast side which is 1.1 m high (four courses).

A test unit was excavated adjacent to the interior edge of the Feature B wall within the terrace flat (Figure 50). The unit was excavated to bedrock with a maximum depth of 42 cm bs. Minor amounts of marine shell midden, basalt flakes, *porites* coral and charcoal flecking were observed. For details on the recovered materials see Section 6: Results of Laboratory Analysis. An ash lens was present in the northwest corner and extended from 19 to 31 cm bs and another ash lens appeared in the southwest quadrant of the unit at 24 to 37cm bs and both likely represent hearth cleaning deposits. Three stratigraphic layers were represented.

I	0 – 3 cm bs	Dark brown (7.5 YR 3/2) silty loam; single grain; non-sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material.
II	3 - 33 cm bs	Dark brown (10 YR 3/3) silty loam; single grain; non-sticky, non-plastic; abrupt smooth boundary; cultural layer with sparse amount of midden and charcoal.
lens	33 - 46 cm bs	Dark gray (10YR 4/1) silt; single gain; non-sticky, non-plastic; abrupt smooth boundary; ash deposit within Layer II.
III	46 - 54 cm bs	Dark yellowish brown (10YR 4/6) silty clay; granular; slightly sticky, slightly plastic; sterile.

Site 6839 appears to represent habitation and activity areas associated with nearby agricultural activity.

Figure 50. View east of TU-1 at Site 50-50-15-6839 Feature B at start of excavation.

5.3.5 Site 50-50-15-6845

Site 6845 is a C-shaped wall which opens to the southwest. The wall incorporates a natural bedrock outcropping with a total diameter of 3.7 m north-south by 2.9 m east-west. The wall is constructed of stacked boulders and cobbles with a maximum height of 70 cm (two to three courses). It is located just west of Site 50-50-15-6847 and just north of Site 50-50-15-6843 both of which contain high status residences and structures with ceremonial/religious components.

A test unit was excavated in the interior flat formed by the C-shape wall (Figure 51). The unit was excavated to bedrock with a maximum depth of 73 cm bs. No cultural material was recovered during the screening, however charcoal flecking was observed but was too small for collection. Two stratigraphic layers were observed. Layer I consists of a dark brown very fine loam which extended from the surface to a depth of 15 to 20 cm. Layer II consists of a dark yellowish brown very fine sandy loam and was 53 to 58 cm thick with bedrock underneath.

Site 6845 appears to represent a temporary shelter feature with very limited use.

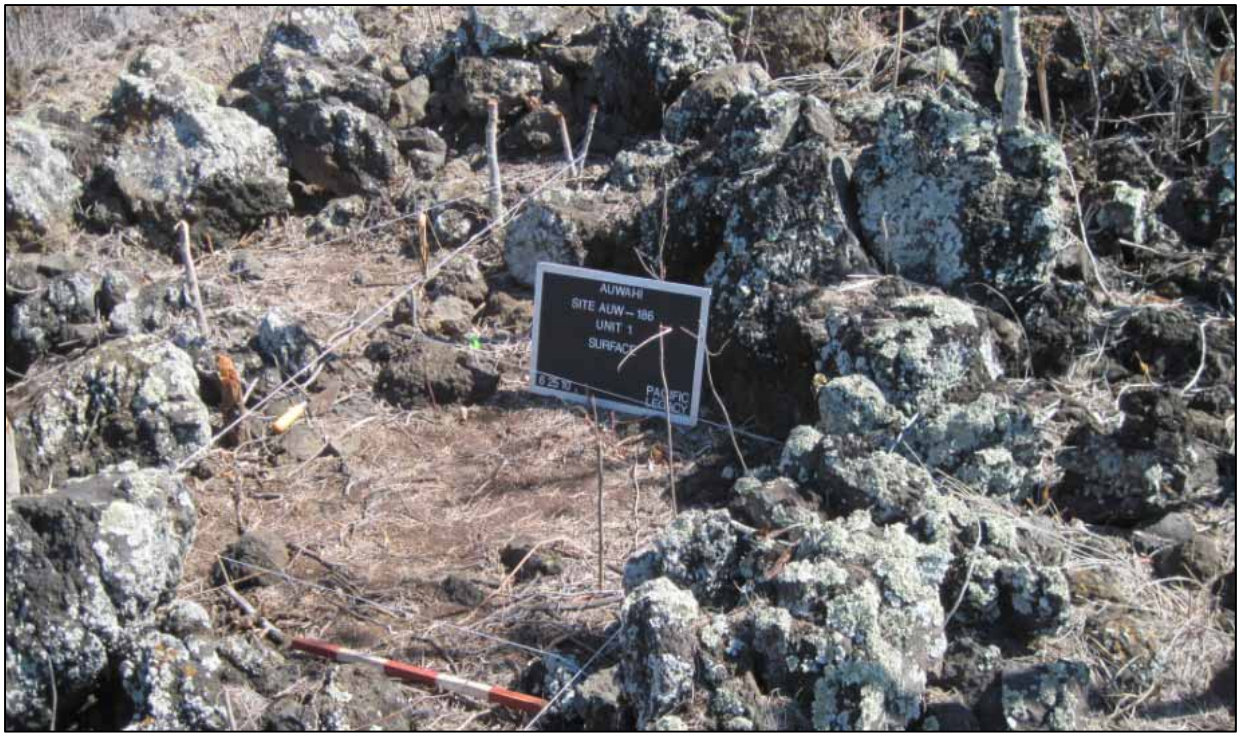


Figure 51. View northwest of TU-1 prior to excavation at Site 50-50-15-6845.

5.3.6 Site 50-50-15-6848

Site 6848 is a large complex measuring 75 m north-south by 45 m east-west containing 16 individual features including three natural windbreak with habitation flats, two U-shaped walled structures, three stone filled terrace, two cleared flat activity areas, three C-shaped walls, a soil filled terrace, a walled structure with separate cleared areas, and a wall segment with adjacent terrace (Figure 52).

Site 6848 is one of the more impressive site complexes within the Auwahi Wind Farm project area. The site functions include habitation (including high status residences), shelter, work activity areas including evidence for stone tool manufacture, and possible storage facilities. Six of the features were test excavated and are discussed below. Information on the remaining features is provided in the detailed site record included in Appendix C.

Test Unit 1 was excavated within Feature A, a cleared area adjacent to a natural windbreak lava escarpment (Figure 53). The windbreak is approximately 5 m long and varies for 0.8 to 1.85 m high. The cleared flat adjacent to the windbreak measures 4 m north-south by 2 m east west and is defined on it north and west sides by rock alignments and on its south side by the retaining wall of the Feature L terrace. The test unit was located in the center of the cleared flat and excavated to a maximum depth of 110 cm bs (Figure 54). Five stratigraphic layers were identified during the excavations (Figure 55).

I	0 – 21 cm bs	Dark brown (7.5 YR 3/2) silty loam; single grain; non-sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material with some cultural material.
II	21 - 33 cm bs	Dark yellowish brown (10 YR 3/2) silty loam; single grain; slightly sticky, slightly plastic; abrupt smooth boundary; cultural material present with charcoal and ash at the bottom of the layer.
III	33 - 45 cm bs	Brown (10YR 4/3) silty loam; single gain; slightly sticky, non-plastic; abrupt smooth boundary; cultural material, charcoal, and ash present at the top of the layer.
IV	45 - 107 cm bs	Grayish brown (10YR 4/6) cobbles; non-sticky, non-plastic; sterile.
V	107 – 123 cm bs	Yellowish brown (10 YR 5/4) sandy clay; structureless; slightly sticky, slightly plastic; sterile.

A charcoal sample was radiocarbon dated from Layer III at 28 cm bs and most likely dates from between the mid AD 1500s and AD 1800. Materials recovered included marine shell, basalt and volcanic glass flakes, *ʻiliʻili*, coral and faunal bone which were confined to the upper 31 cm of the deposit. For details on the recovered materials see Section 6: Results of Laboratory Analysis.

The feature probably represents a habitation shelter and activity area.

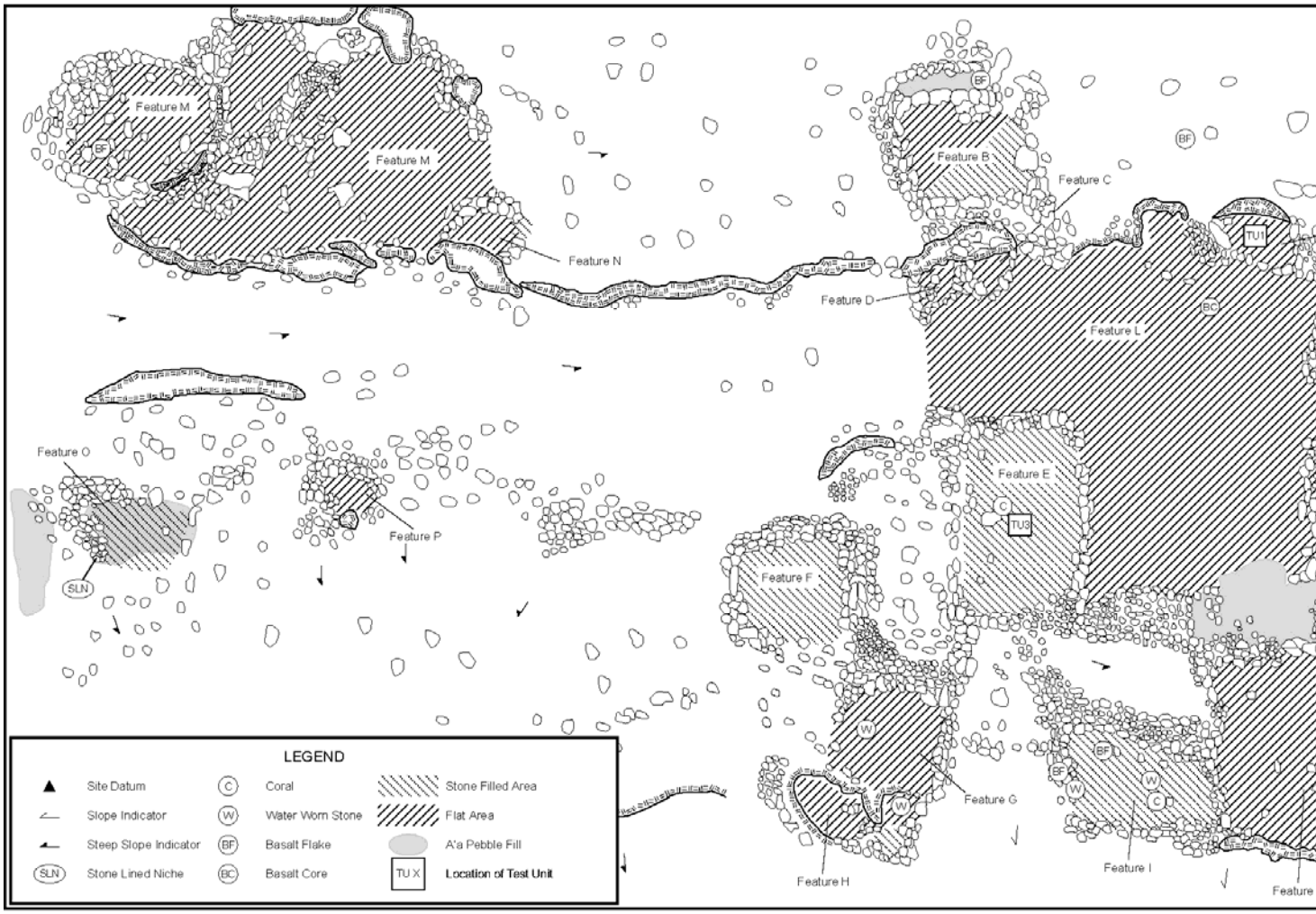


Figure 52. Plan view of Site 50-50-15-6848.

Figure 53. Overview east of Feature A, showing wind break, cleared activity area and TU-1 location prior to excavation.

Figure 54. South wall of TU-1 showing the sterile cinder deposit below the cultural layers.

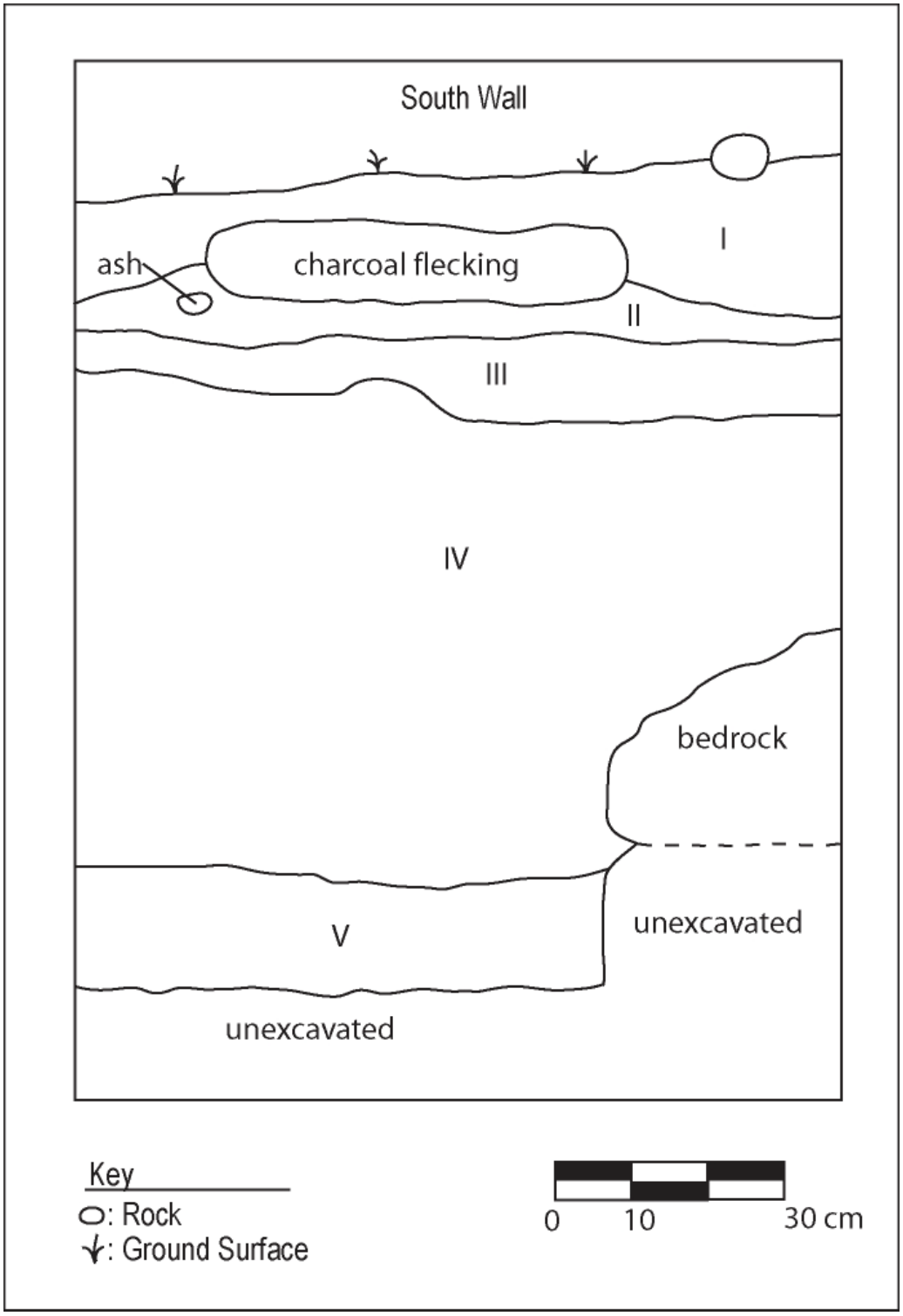


Figure 55. Stratigraphic profile of TU-1 of Site 50-50-15-6848.

TU- 2 was excavated within the large earth filled terrace, Feature L (Figure 56). The terrace measures approximately 20 m north-south by 19 m east-west with a rock core filled retaining wall along its southern edge. The wall measures 22.5 m east-west and averages 1.25 m wide with a gap of 3 m in the center which may have functioned as an entry way. The unit was excavated to a maximum depth of 80 cm bs with only one stratigraphic layer being represented, a very rocky silt which was dark brown to dark yellowish-brown in color (Figure 57). The only cultural constituents were charcoal flecking and a few pieces of volcanic glass recovered from the upper levels. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Feature L appears to represent a flat activity area or courtyard located between adjacent habitation features, upon which other features (i.e., Features C, D, and E) were constructed.

TU-3 was located in the center of Feature E, a prominent rock filled terrace with a flat paved surface (Figure 58). The terrace is only elevated above the ground surface on its east and south sides being flush with the surrounding terrain to the north and west. It is located adjacent and northwest of the Feature L terrace and appears to have been constructed upon a lava flow. Feature E measures 10 m east-west by 5.5 m north-south with an average height of 0.4 m above Feature L.

TU-3 was excavated to a maximum depth of 92 cm bs. The matrix was comprised of stone fill from the terrace with minor amounts of soil (Figure 59). The soil was a silty clay loam which was very dark brown to dark yellowish brown in color. Minor charcoal flecking was occasionally present and a single piece of clear quartz or chalcedony like material was recovered at 58-60 cm bs. The piece has natural cortex and did not appear to be modified. For details on the recovered materials see Section 6: Results of Laboratory Analysis

The Feature E terrace likely represents a foundation for a habitation structure possibly for a high status individual due to its substantial construction. The lack of ceremonial or religious constituents (i.e., upright stones and offerings) also suggests a habitation function rather than a ceremonial function for this feature.

Figure 56. Overview of Feature L at Site 50-50-15-6848 showing excavation of TU-2.

Figure 57. View south of TU-2 at base of excavation.

Figure 58. Crew member in center of Feature E, at TU-3 location within Site 50-50-15-6848.

Figure 59. TU-3 showing base of excavation and rock fill from terrace in profile.

TU-4 was located within Feature I, a walled terrace with a paved surface (Figure 60). The terrace measures 7 m north-south by 5.6 m east-west. Core-filled rock walls define its boundaries and separate it from adjacent terrace features. The walls vary from approximately 0.5 to 1.0 m wide and 0.3 to 0.7 m high (two to five courses). Tumble from portions of the walls are located on the edges of the terrace flat, but a paving of *'ili'ili* pebbles with scattered cultural constituents (basalt flakes and cores, shell midden, and porites coral) was present on the feature surface. TU-4 was excavated to a maximum depth of 52 cm bs with bedrock starting to appear at 20 cm bs (Figure 61). Three stratigraphic layers were present in the unit.

I	0 – 5 cm bs	*'ili'ili* pavement.
II	5 – 19 cm bs	Very dark brown (10 YR 2/2) silt loam; granular; non-sticky, non-plastic; clear smooth boundary; cultural material present.
II	19 – 22 cm bs	Dark brown (10 YR 3/2) silt; structureless; non-sticky, non-plastic; contains sparse cultural material that may have filter down form Layer II.

Layer I represents the *'ili'ili* surface which extended to a depth of 5 cm. Below this was Layer II, a very dark brown loamy silt with charcoal staining and cultural constituents (volcanic glass, basalt flakes, shell midden, *porites* coral, faunal bone and water worn pebbles) which was 10 to 14 cm thick. Layer III consisted of a dark brown silt above the bedrock and contained a few cultural constituents which may have filtered down from Layer II. For details on the recovered materials see Section 6: Results of Laboratory Analysis.

Feature I appears to represent a habitation and activity area which includes stone tool manufacture based on the presence of basalt cores and flakes.

TU-5 was excavated in Feature J, a stone filled terrace with an upper and lower section which is adjacent and south of Feature I. The upper terrace of Feature J measures 8.5 m (north-south) by 11 m (east-west) with a height of 0.5 to 0.8 m above the ground surface at its makai end. The lower terrace section measures 5 m (north–south) by 3.5 m (east-west) and is 1.4 m below the upper terrace to the west. A rough C-shaped alignment of medium basalt slabs is located in the southeast portion of the upper terrace forming a space 3 m wide and 1 m deep. Materials present on the surface of the upper terrace include several basalt cores and flakes with the terrace surface being paved with clinker cobbles and pebbles. TU-5 was placed in the upper terrace in the vicinity of the basalt cores (Figure 62).

TU-5 was excavated to bedrock with a maximum depth of 36 cm bs. Two stratigraphic layers were present. Layer I consisted of 80% pebbles and cobbles with a dense layer of this rock near the surface forming a level floor (Figure 63). The soil in Layer I consisted of a very dark brown sandy loam which extended from the surface to a maximum depth of 30 cm bs and contained the cultural materials (charcoal flecking, *porites* coral, *kukui* nut shell and volcanic glass). For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer II was confined to the western portion of the unit and consisted of a sterile, dark brown silty loam directly above bedrock which was only 6 cm thick.

Feature J appears to represent a habitation/activity area.

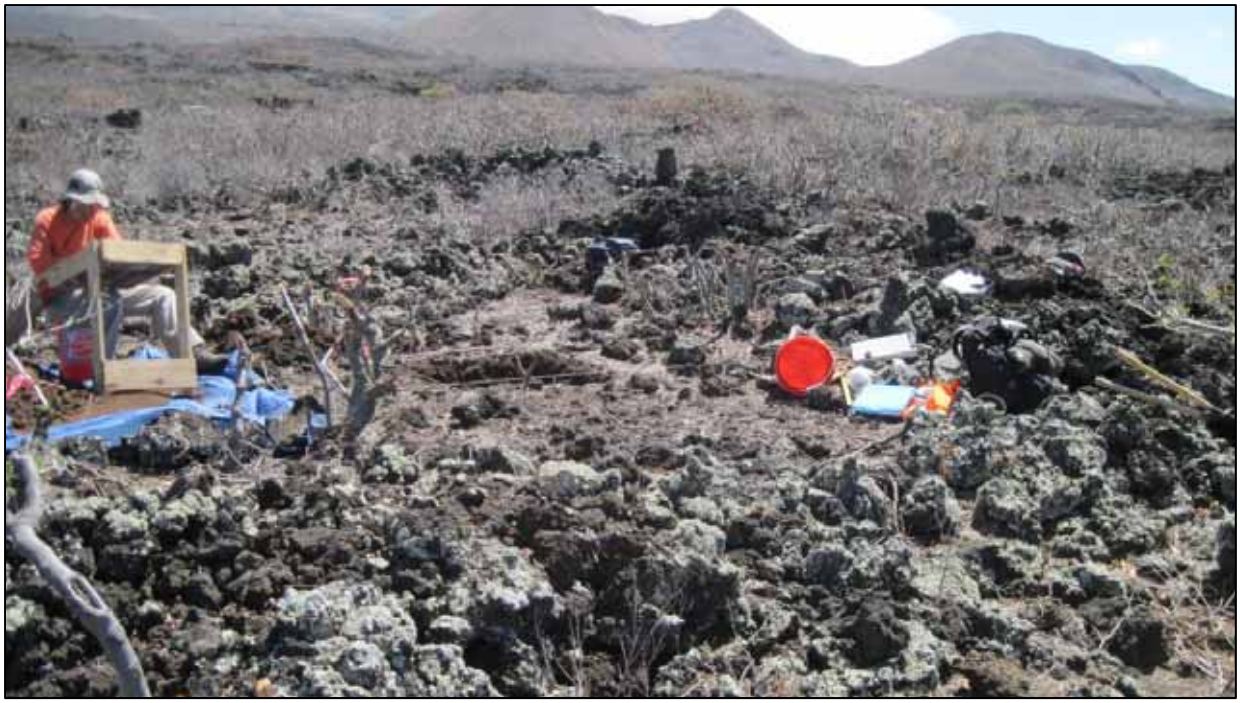


Figure 60. Overview of TU-4 excavation in center of Feature I at Site 50-50-15-6848.

Figure 61. TU-4, Feature I at base of excavation.

Figure 62. Overview of Feature J, with screen on lower terrace and photo board at TU-5.

Figure 63. View of TU-5 at terrace Feature J at base of excavation.

TU-6 was excavated within Feature K, a C-shaped wall adjacent and south of Feature J. The C-shape wall is constructed of loosely stacked cobbles and boulders, measuring 6 m long and averaging 0.75 m wide and 0.4 m high (Figure 64). The interior space measures approximately 4 m long by 3.8 m deep with a rough paved of clinker cobbles and pebbles. The interior space also has a fair amount of tumble from the wall. TU-6 was excavated to bedrock with a maximum depth of 70 cm bs with no cultural material being recovered (Figure 65).

The feature likely represents a shelter or activity area.

Figure 64. View southeast of Feature K, C-shaped wall with TU-6 location.

Figure 65. View southeast of base of excavation at TU-6, Feature K.

5.3.7 Site 50-50-15-6851

Site 6851 is a large rectangular enclosure (Feature B), an adjacent terrace (Feature A) on its *mauka* (north) side, and a small rock overhang and terrace (Feature C) to the west of the enclosure overlooking a drainage. The site is located on the slope of a ridge directly below Site 50-50-15-6852 and above the large complex Site 50-50-15-6840. The enclosure at 6851 measures approximately 7.9 m north-south by 7.4 m east-west with well defined walls, with the north and east walls being the tallest at 1.2 m (five to six courses) and the west and southern walls averaging 0.75 m high (two to three courses). An alignment of boulders extends north-south through the interior space of the enclosure dividing it into two distinct areas (Figure 66). The eastern portion is further subdivided by a low east-west alignment of boulders and cobbles, forming two rough compartments within the eastern room.

Figure 66. Overview south of enclosure Feature B at Site 50-50-15-6851.

TU-1 was excavated within the Feature B enclosure against its eastern wall. The unit was excavated to bedrock with a maximum depth of 69 cm bs (Figures 67 and 68). Three stratigraphic layers were identified.

I	0 – 2 cm bs	Very dark grayish brown (10 YR 3/2) silty loam; single grain; non-sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material
II	2 – 23 cm bs	Very dark grayish brown (10 YR 2/2) silt loam; granular; non-sticky, non-plastic; clear smooth boundary; cultural material present.
II	23+ cm bs	Dark yellowish brown (10 YR 3/6) silt; structureless; non-sticky, non-plastic; sterile.

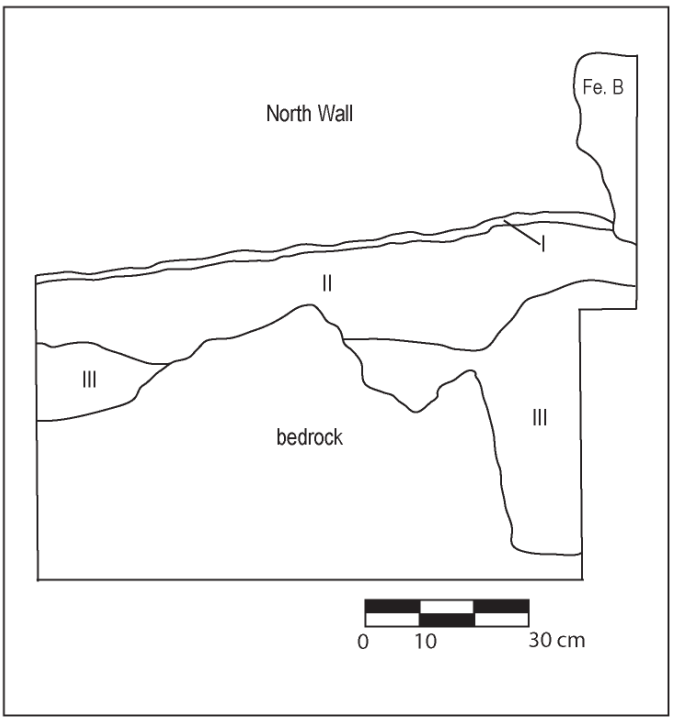


Figure 67. Site 50-50-15-6851 TU-1 stratigraphic profile.

Cultural materials recovered include basalt flakes, marine shell, fish bone, sea urchin and waterworn branch coral. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample was collected at 20 cm bs from charcoal stained soil in the southwest quadrant of the unit, which yielded a date likely ranging from the mid AD1400s to the mid –AD 1600s.

Site 6851, Feature B probably represents a semi-permanent or permanent habitation structure, possibly of a high status individual based on the size and construction complexity of the feature.

Figure 68. Site 50-50-15-6851 TU-1 showing bedrock at base of excavation.

5.3.8 Site 50-50-15-6852

This complex consists of nine features including an enclosure, U-shaped walls, terraces, modified outcrops and stone mounds. It is located on a ridgeline adjacent and west of a prominent stream channel. It is undoubtedly related to the nearby Site Complex 50-50-15-6850 to the west which includes 24 agricultural and habitation features. Two features at Site 6852 were test excavated; TU-1 was excavated with Feature A, a rectangular enclosure, and TU-2 was excavated in Feature I, a U-shaped wall.

The Feature A enclosure has an exterior dimension (including the wall tumble) of 7.3 m north-south by 6.7 m east-west with wall height varying from 0.4 to 1.1 m high. The enclosure's interior dimension measures 2.4 m north-south by 3.4 m east-west (Figure 69). The interior floor contains *'ili'ili* pebbles of basalt as well as water worn coral. A piece of branch coral is incorporated into the wall construction near the northwest corner of the structure and a basalt core was observed adjacent and south of the structure. TU-1 was excavated along the north interior wall (Figure 70). Cobble tumble was first cleared and then the unit was excavated to a depth of 56 cm bs at which point decomposing bedrock was encountered. Three stratigaraphic layers were identified during the excavation.

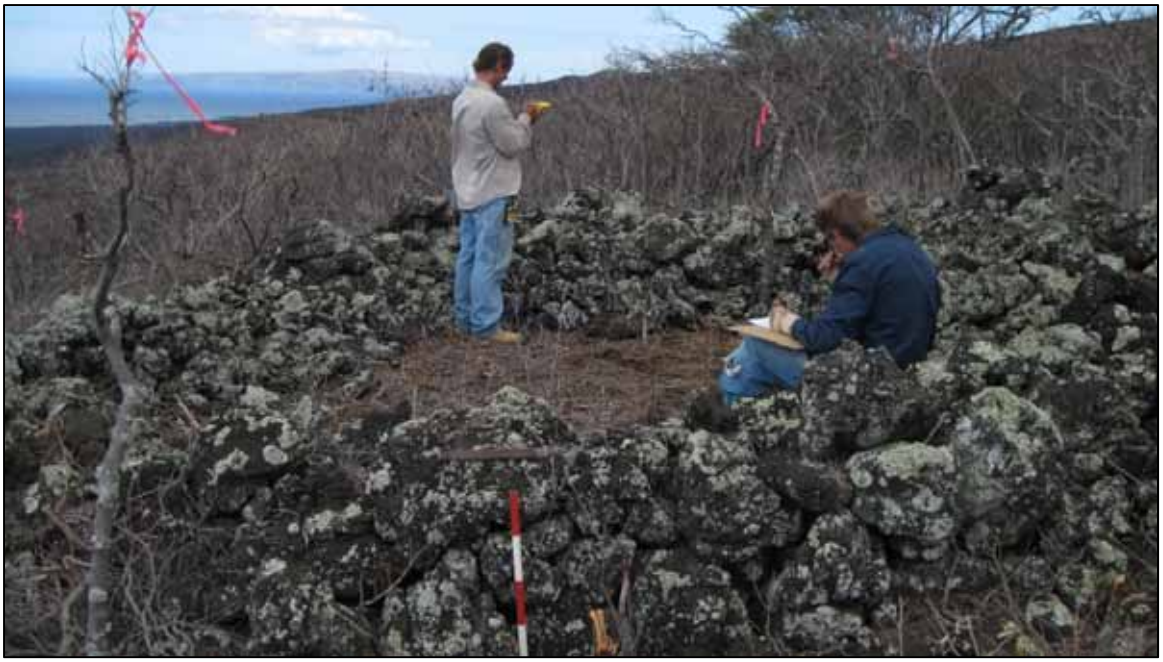


Figure 69. Overview of Feature A, enclosure at Site 50-50-15-6852 prior to excavation.

Figure 70. View of TU-1 within Feature A at 50-50-15-6852 at base of excavation.

I	0 – 3 cm bs	Very dark grayish brown (10 YR 3/2) silt; single grain; slightly sticky, slightly plastic; abrupt smooth boundary; top soil with abundant organic material.
II	3 – 16 cm bs	Very dark yellowish brown (10 YR 3/4) silty clay; granular; slightly sticky, slightly plastic; clear smooth boundary; cultural material present.
II	16 - 56 cm bs	Dark yellowish brown (10 YR 4/4) silty clay; structureless; sticky, plastic; sterile.

Minimal cultural material was recovered including ‘*ili*‘*ili* pebbles, a few marine shell midden fragments and several pieces of branch coral. For details on the recovered materials see Section 6: Results of Laboratory Analysis.

Feature A is interpreted as a habitation enclosure with a possible ceremonial component based on the presence of branch coral.

Feature I at Site 6852 is a U-shaped core-filled wall which measures approximately 1 m high (four courses) by 1.3 m wide. The interior spaced formed by the wall measures approximately 3.8 m north-south by 2.4 m east-west (Figure 71). TU-2 was excavated against the eastern wall section of Feature I to a depth of 54 cm bs. Three stratigraphic layers were observed during the excavation (Figure 72).

I	0 – 4 cm bs	Very dark grayish brown (7.5 YR 3/2) silt loam; granular; slightly sticky, slightly plastic; abrupt smooth boundary; top soil with abundant organic material.
II	4 – 12 cm bs	Dark brown (10 YR 3/3) silt; granular; non-sticky, non-plastic; abrupt smooth boundary; cultural material present.
Hearth	10 – 22 cm bs	Black (10 YR 2/1) silt; granular; non-plastic; abrupt smooth boundary; cultural material including abundant charcoal present.
II	12 - 47 cm bs	Dark yellowish brown (10 YR 3/6) silt; granular; non-sticky, non-plastic; sterile.

The hearth extended from 10 to 22 cm bs, from the base of Layer II into the sterile strata Layer III. The hearth had a vertical slab along its east side but consisted mostly of lined cobbles with an interior containing high quantities of ash and charcoal surrounded by fire effected oxidized soil which was orange in color (Figure 73). Minor amounts of burnt shell midden and bone were also recovered from the hearth. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Ash and charcoal samples were also collected from the hearth. Two charcoal samples were submitted from TU-2, the radiocarbon dating results indicate that this feature was occupied sometime between AD 1540 and 1800 (see carbon analysis section).

Feature I is interpreted as a habitation feature.

Figure 71. Overview of U-shaped wall, Feature I at Site 50-50-15-6852.

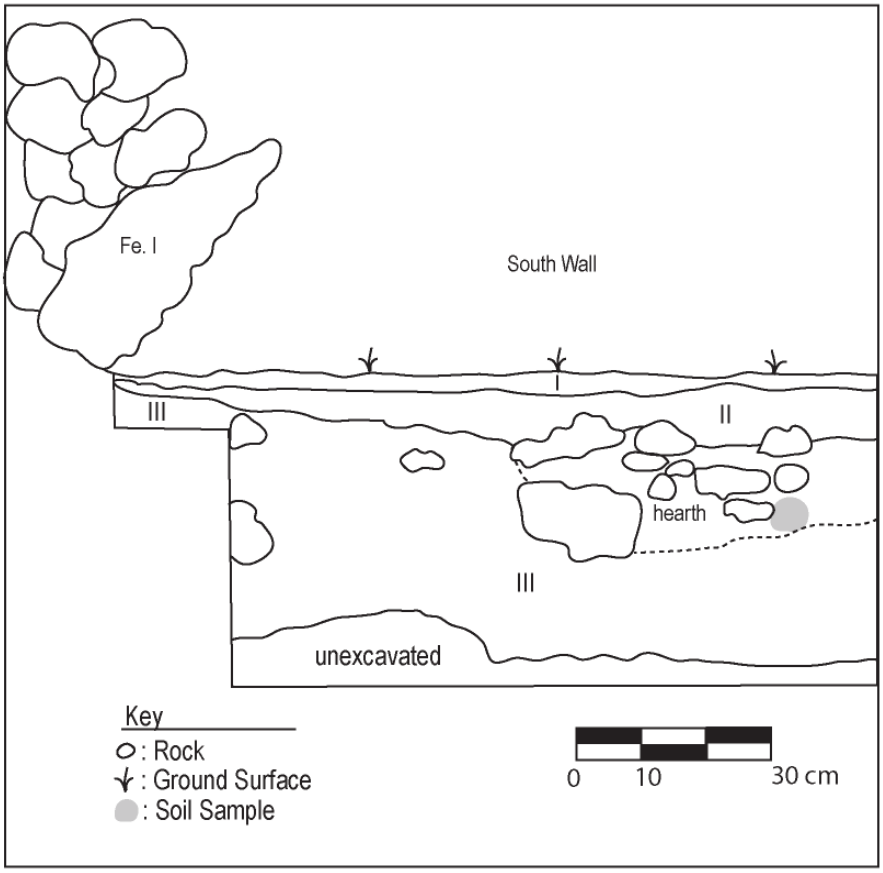


Figure 72. Site 50-50-15-6852, Feature I stratigraphic profile.

Figure 73. View of hearth (left of scale) in TU-2 at Feature I, Site 50-50-15-6852.

5.3.9 Site 50-50-15-6853

This site complex consists of six features: a square enclosure, a terrace, a C-shaped wall, a terrace with cleared flat, a stacked windbreak, and a U-shaped wall. Feature A is a square enclosure which measures 5.9 m east-west by 5.1 m north-south with wall heights ranging from 0.7 to 0.9 m (Figure 74). A test unit was excavated along the southeast wall of Feature A. The unit was excavated to bedrock at a depth of 40 cm bs with three stratigraphic layers present. Layer I was a surface organic layer which was not a consistent across the unit being present in patches and extending for a maximum of 5 cm bs. Layer II was the cultural layer, a dark brown fine silt which extended from the surface to a maximum depth of 36 cm bs with bedrock below. Layer III was a small pocket of dark yellowish brown silt at the deepest portion of the unit just above bedrock (Figure 75). Materials recovered during the excavation of TU-1 include shell midden, *porites* coral, basalt flakes and charcoal samples. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample recovered from the screen at 20-30 cm bs was submitted for radiocarbon analysis and yielded a date most likely from between the mid 1600s and 1800.

Feature A represents a habitation feature likely associated with nearby agricultural pursuits.

5.3.10 Site 50-50-15-6854

This complex consists of nine features including a cleared flat with stacked wall and cupboard, a terrace with windbreak, two C-shaped walls, a wall, a modified depression, two rough terraces, and a small lava tube. A test unit was excavated within Feature C, a rough C-shaped wall. The wall is 0.6 to 1.0 m high (three to five courses), incorporates flat *pāhoehoe* slabs which have been set on their ends, and opens to the south. The feature forms an interior flat space which measures 2.0 m wide and 1.8 m deep (Figure 76). TU-1 was located within the C-shape interior against the wall. The unit was excavated to bedrock with a maximum depth of 26 cm bs. Two stratigraphic levels were present. Layer I was a black silty loam with numerous surface organics extending from surface to 4 cm bs. Layer II was the cultural layer consisting of a very dark brown silty clay loam extending for 4 to 26 cm bs (Figure 77). Materials recovered include shell midden, sea urchin spine fragments, *ʻiliʻili* pebbles and charcoal fragments**.** For details on the recovered materials see Section 6: Results of Laboratory Analysis. An in situ charcoal sample from 11 cm bs was submitted for radiocarbon analysis and likely dates from between the mid AD 1600s and AD 1800.

The feature appears to have a habitation function with possibly a ceremonial component based on the presence of branch coral.

Figure 74. Overview southwest of Feature A, enclosure at Site 50-50-15-6853.

Figure 75. View northeast of TU-1 at bedrock within Feature A at Site 50-50-15-6853.

Figure 76. Overview northeast of C-shaped wall, Feature C at Site 50-50-15-6854.

Figure 77. View east of TU-1, Feature C at Site 50-50-15-6854 at base of excavation.

5.3.11 Site 50-50-15-6855

Site 6855 is a complex which includes two C-shaped walls, an L-shaped wall, and stone mounds. Feature A is a C-shaped wall that opens to the west with a wall extending from the C-shape to the northwest. The wall is constructed of well stacked and faced basalt boulders which incorporates several *pāhoehoe* slabs set on their ends with a maximum height of approximately 1.2 m (three to five courses) (Figure 78). TU-1 was excavated against the northeast wall of the C-shape which extended to a maximum depth of 45 cm bs at bedrock (Figure 79). Three stratigraphic layers were identified (Figure 80).

I	0 – 4 cm bs	Very dark gray (7.5 YR 3/1) silt loam; granular; slightly sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material.
II	4 – 22 cm bs	Very dark grayish brown (10 YR 3/2) silt loam; granular; slightly sticky, slightly plastic; abrupt smooth boundary; cultural material present.
II	22 - 45 cm bs	Dark yellowish brown (10 YR 3/6) silt loam; granular; slightly sticky, slightly plastic; sterile.

Layer II was the cultural layer consisting of a very dark grayish brown silty loam which was approximately 18 cm thick. Materials recovered included a basalt flake, coral fragments and charcoal. For details on the recovered materials see Section 6: Results of Laboratory Analysis. An in situ charcoal sample from 14 cm bs was submitted for radiocarbon analysis and likely dates from between the mid AD 1500s and AD 1800.

Feature A at Site 6855 represents a temporary habitation feature or shelter, likely associated with the nearby agricultural activity.

Figure 78. Overview of Feature A at Site 50-50-15-6855.

Figure 79. North wall of TU-1 showing base of excavation against C-shaped wall.

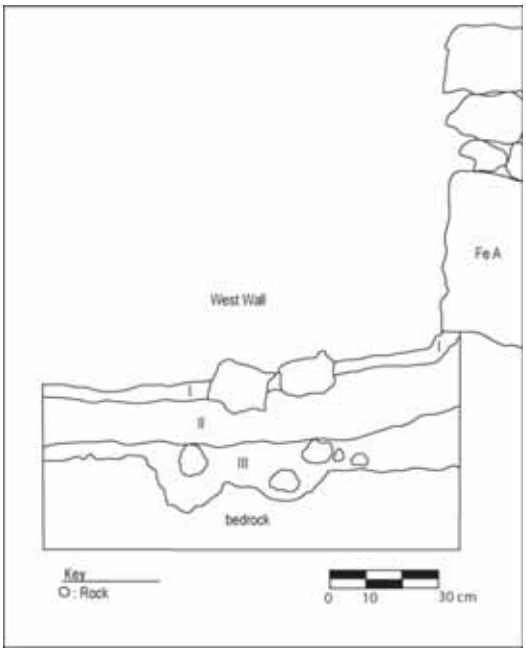


Figure 80. TU-1 West wall stratigraphic profile.

5.3.12 Site 50-50-15-6857

Site 6857 is a complex of ten features reflecting habitation and agricultural activity including terraces, boulder alignments, C-shapes and stone mounds. Feature A is a terrace with a built up edge on its south side and a free standing wall on the north and east. The built up southern edge appears to have tumbled and once consisted of a single course of boulders placed in an alignment on top of natural bedrock. The southern side measures 4.5 m long east-west. The north and east wall is loosely stacked and measures 0.7 to 1.2 m high (four to five courses) (Figure 81). The terrace flat measures approximately 5 m long east-west by 4 m north-south. A test unit was excavated within the Feature A terrace adjacent to the eastern wall (Figure 82). Two stratigraphic layers were observed in the unit which was excavated to a maximum depth of 70 cm bs. Layer I was the cultural layer which consisted of a dark brown silt and extended from surface to approximately 20 cm bs. Materials recovered included shell midden, volcanic glass, basalt flakes and core, *ʻiliʻili* pebbles, ash pockets and charcoal flecking. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer II was a sterile dark yellowish brown silt which extended from 20 to 70+ cm bs. The unit was not excavated completely to bedrock, but no cultural material was recovered in the 50 cm deposit excavated within Layer II.

Feature A appears to represent a habitation feature.

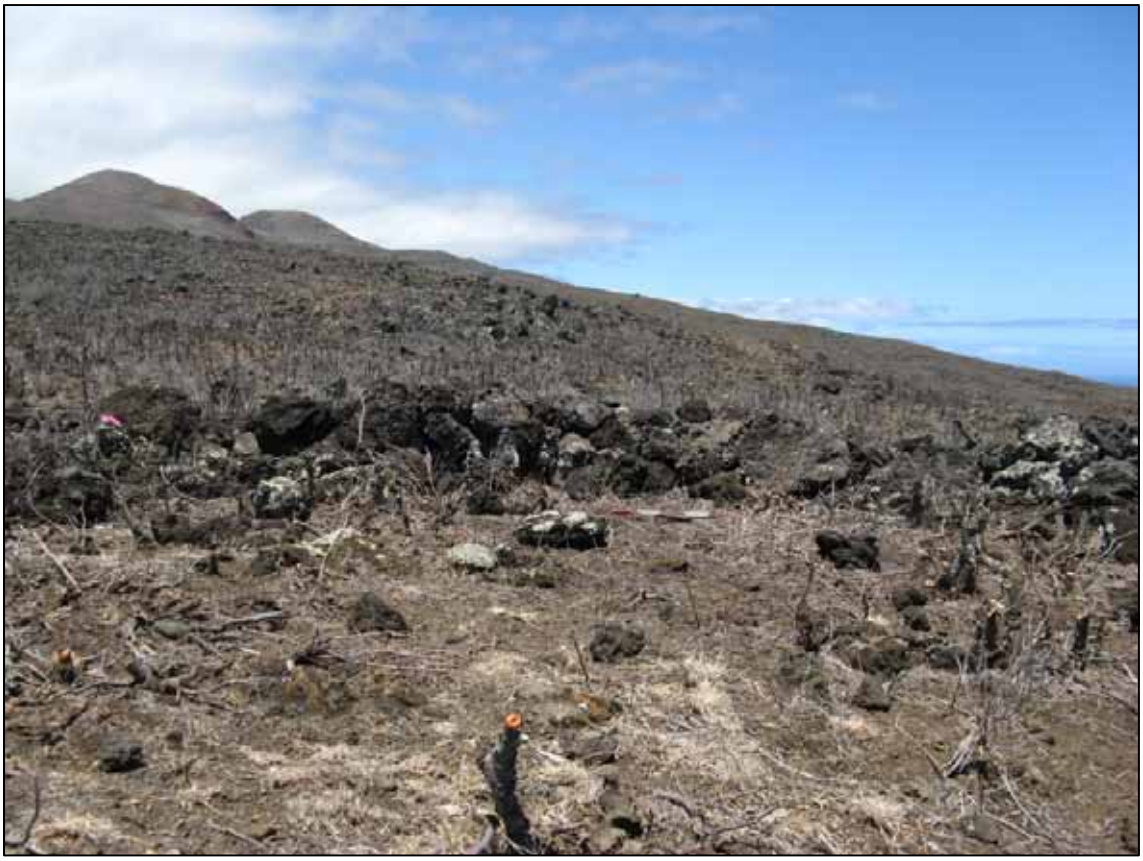


Figure 81. View east of terrace and wall of Site 50-50-15-6857 Feature A.

Figure 82. View east of TU-1 at Site 50-50-15-6857 Feature A.

5.3.13 Site 50-50-15-6860

This site consists of a series of terraces which represent habitation and agricultural features. Feature A is a series of cascading terraces which appear to be related to agricultural plantings and possible erosion control. Feature B consists of an upper and lower terrace flat (Figure 83). The upper flat of Feature B is less damaged from erosion and measures approximately 5.5 m east-west by 1.2 m. The lower terrace flat measures approximately 4.7 m east-west by 3.6 m north-south. A coral abrader was recovered from the lower flat of Feature B. A test unit was excavated within the upper flat of Feature B and excavated to a maximum depth of 115 cm bs (Figure 84). Three stratigraphic layers were identified during the excavation (Figure 85).

Layer I consists of a very dark brown silty loam which extended from surface to approximately 35 cm bs. Layer II is represented by a dark brown silty clay loam which extended from approximately 35 to 70 cm bs. Both Layers I and II contained cultural constituents including coral, *'ili'ili*, Section 6: Results of Laboratory Analysis the Lab Analysis section. A charcoal sample collected at 20 cm bs was submitted for radiocarbon analysis and yielded a result most likely dating from between the mid AD 1500s and AD 1800. Layer III is represented by a dark yellowish brown silty clay loam which extended from approximately 70 to 115+ cm bs. At 115 cm bs bedrock was not covering the entire unit floor, but over 40 cm of sterile deposit was excavated before terminating the unit.

Feature B appears to represent a habitation terrace associated with the nearby agricultural terrace features.

Figure 83. Overview of Feature B at Site 50-50-15-6860, upper terrace flat to right of *wiliwili* tree and lower terrace flat at meter stick.

Figure 84. View of TU-1 at base of excavation.

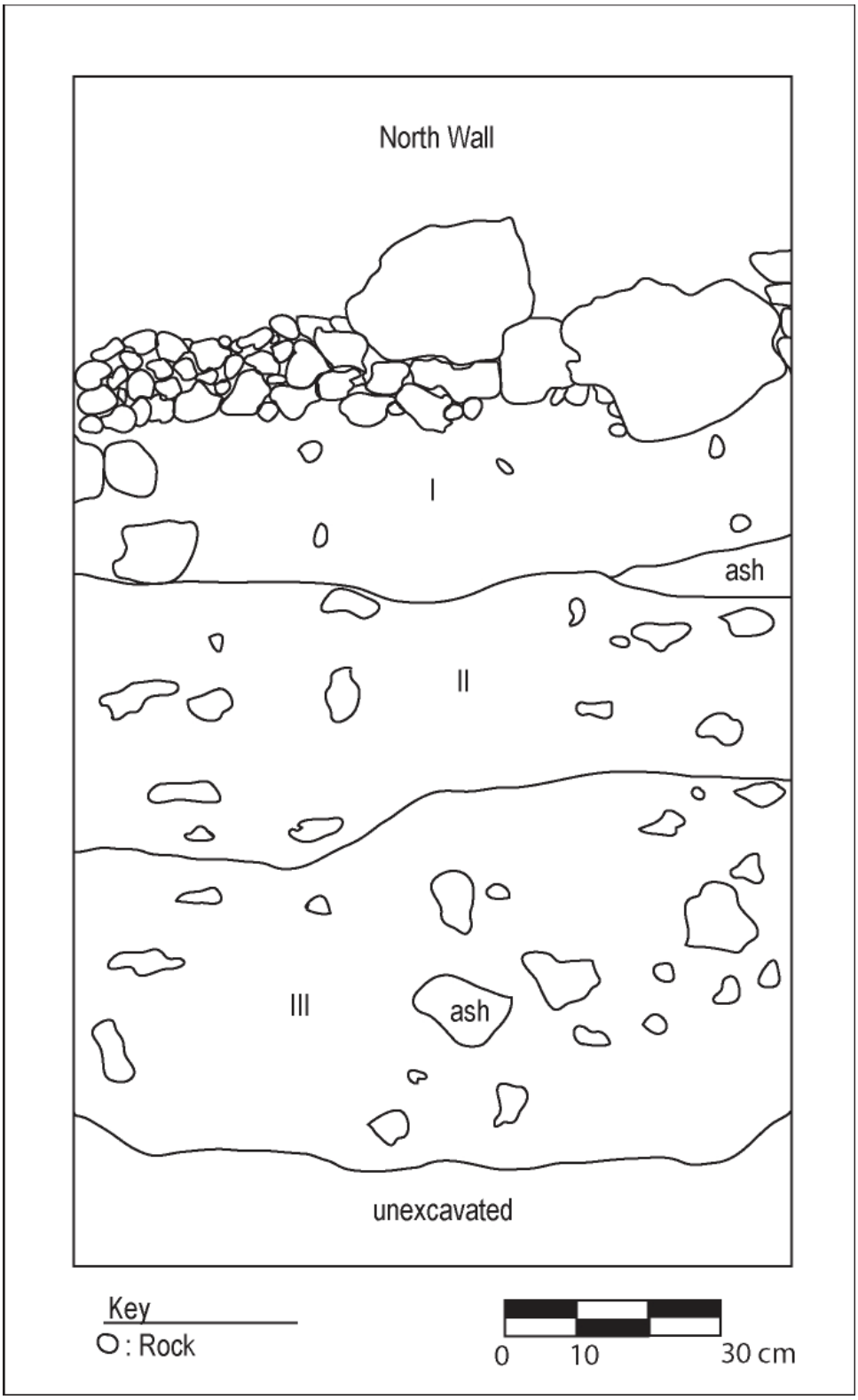


Figure 85. Stratigraphic profile of TU-1 at Site 50-50-15-6860, Feature B.

5.3.14 Site 50-50-15-6861

This site consists of a complex of four features; three terraces and an L-shaped wall. It is undoubtedly associated with the habitation and agricultural complex Site 50-50-15-6862 which is adjacent, down slope and east of Site 6861. Feature A consists of a terrace which is built up on its south, east and west edges. Boulders and cobbles have been stacked on exposed bedrock creating a retaining wall for the terrace flat which is 0.5 to 1.1 m (five courses) high and 8.5 m long. The terrace flat measures approximately 9 m east west by 2.5 m north-south (Figure 86). A basalt core and a basalt chopping tool were located on the terrace surface.

TU-1 was excavated within the Feature A terrace flat to a maximum depth of 80 cm bs. Two stratigraphic layers were identified. Layer I is a very dark brown silt which was the cultural layer extending from surface to approximately 20 cm bs. Layer II is a dark yellowish brown silt which extended from 20 to 80+ cm bs. The cultural constituents were primarily located in the upper 25 cm of the deposit, with cultural materials extending into the upper portion of Layer II but no materials being recovered below 40 cm bs. Materials recovered included shell midden, basalt flakes, a basalt core, and faunal bone. Charcoal staining was present but no ash was identified. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Bedrock was not encountered throughout the bottom of the unit, but three sterile levels were excavated prior to terminating the excavation (Figure 87).

Feature A appears to be a habitation terrace associated with agricultural pursuits in the immediate vicinity.

Figure 86. Overview of Feature A at Site 50-50-15-6861 showing location of test unit prior to excavation.

Figure 87. View north of TU-1 at Site 50-50-15-6861 Feature A at base of excavation.

5.3.15 Site 50-50-15-6864

This extensive complex consists of eleven features reflecting habitation, agricultural and ceremonial/religious activity. It is located on a ridgeline with an adjacent swale that empties into a larger draw. Among the features identified are: a double terrace with a natural windbreak, a soil filled terrace, two rock filled terraces, a C-shaped depression with large pieces of branch coral, a cupboard or *puka*, two adjoining terraces, a terraced flat with slab lined hearth, a rock wall, and a modified depression or *puka* with a cache of elongated coral pieces (Figure 88). For details on site features, see site records in Appendix C.

Five test units were excavated at various features within the site. TU-1 was excavated in the central and eastern portions of the interior floor space of Feature E. Feature E is a rough C-shaped structure incorporating a natural lava windbreak with a rock filled interior which is slightly depressed. The wall heights vary from 0.75 to 1.1 m (two to four courses). The western side of the structure is the lowest and likely would have been the entrance, although tumble from the walls and the rocky floor interior gives the feature a more circular plan view (Figure 89). Slightly buried within the floor of Feature E were two large branch coral heads (Figure 90). TU-1 was excavated thru the rock floor where additional pieces of branch coral were identified under the tumble. The unit was expanded to measure 1 m north-south by 1.7 m east-west so that the unit would butt up against the eastern wall of the structure. TU-1 was excavated to a maximum depth of 74 cm bs (Figure 91). Excavation proceeded through a 37 cm thick rock fill layer that contained numerous branch coral fragments. Two layers were uncovered below the rock fill. Layer I was a very dark grayish brown silty loam. This layer extended from approximately 37 to 57 cm bs and contained faunal bone, marine shell and waterworn pebbles.

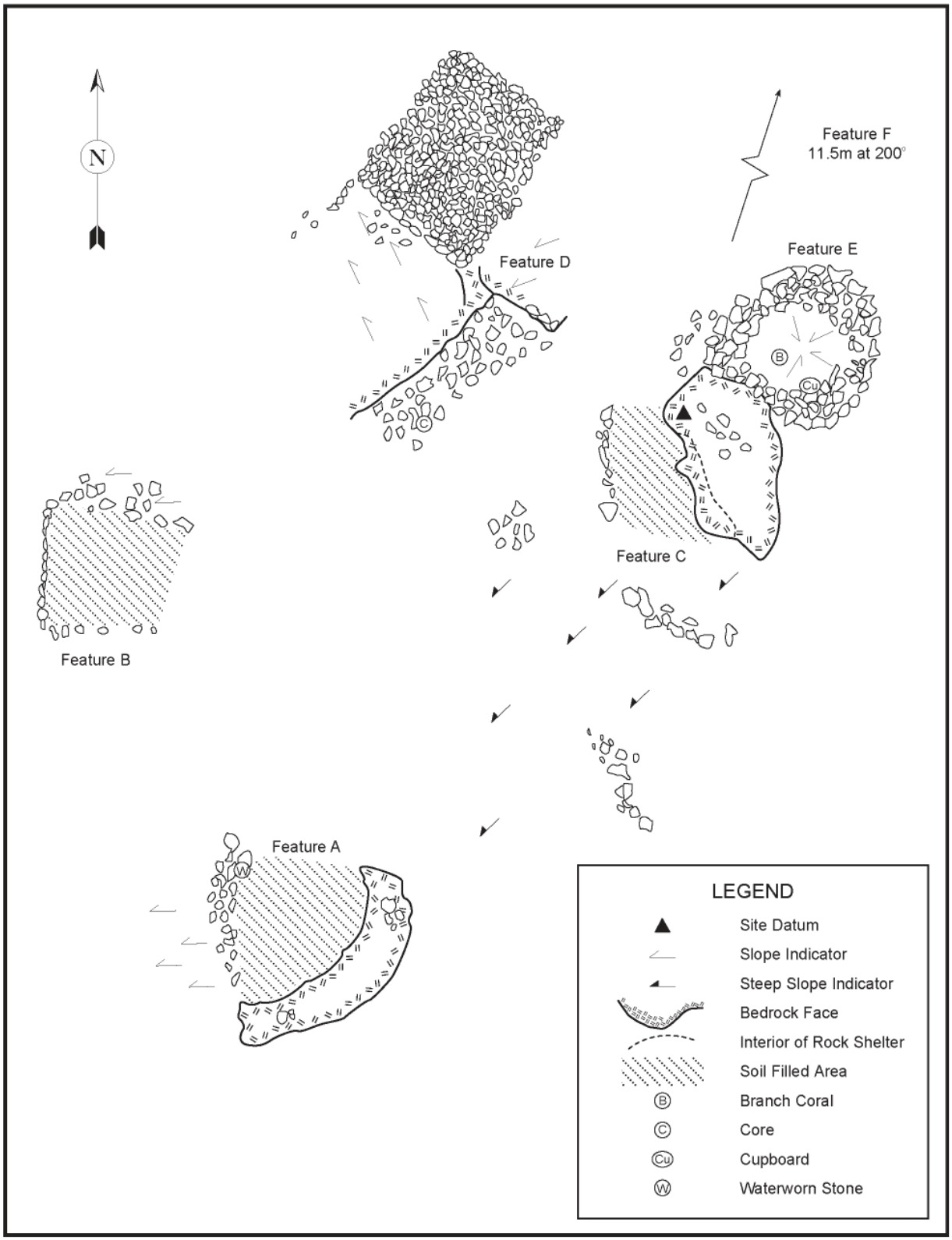


Figure 88. Plan view of Site 50-50-15-6864.

For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer II consisted of sterile, dark yellowish brown silty loam which extended from 57 to 73 cm bs. Feature E appears to represent a shrine rather than a habitation feature based on the amount of branch coral offerings and fish bone.

Figure 89. View south of Feature E at Site 50-50-15-6864.

Figure 90. Close up of branch coral at Site 50-50-15-6864 Feature E.

Figure 91. TU-1 at base of excavation within Feature E at Site 50-50-15-6864.

TU-2 was excavated within Feature C, a terrace with a natural windbreak (Figure 92). The terrace measures approximately 3 m north-south by 1.5 m east-west with a built up retaining wall on the west side which is 0.4 m high (2 courses). On the east side of the feature is a natural lava escarpment which forms a windbreak 2.5 m long by 0.9 m high. TU-1 was excavated to a maximum depth of 60 cm bs with three stratigraphic layers present.

I	0 – 18 cm bs	Very dark grayish brown (10 YR 3/2) silt loam; granular; slightly sticky, non-plastic; clear smooth boundary; top soil with abundant organic material and some cultural material.
II	18 – 44 cm bs	Very dark gray (10 YR 3/1) silt loam; granular; slightly sticky, slightly plastic; abrupt smooth boundary; cultural material present.
II	44 – 60 cm bs	Yellowish brown (10 YR 5/4 silt loam; granular; slightly sticky, slightly plastic; sterile.

Cultural constituents recovered in Layers I and II include marine shell midden, coral, mammal and fish bone, basalt flakes, *ʻiliʻili*, ash pockets and charcoal. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample from Layer II at a depth of 24 cm bs was submitted for radiocarbon analysis and yielded a result most likely dating from between the mid AD 1500s and AD 1800. Layer III was a sterile, yellowish brown silty loam beneath Layer II and extending to bedrock with at maximum depth of 60 cm bs (Figures 93 and 94).

Feature C, likely represents a habitation feature.

Figure 92. Overview east of terrace and windbreak at Site 50-50-15-6864 Feature C.

Figure 93. TU-2 east wall profile at Site 50-50-15-6864 Feature C.

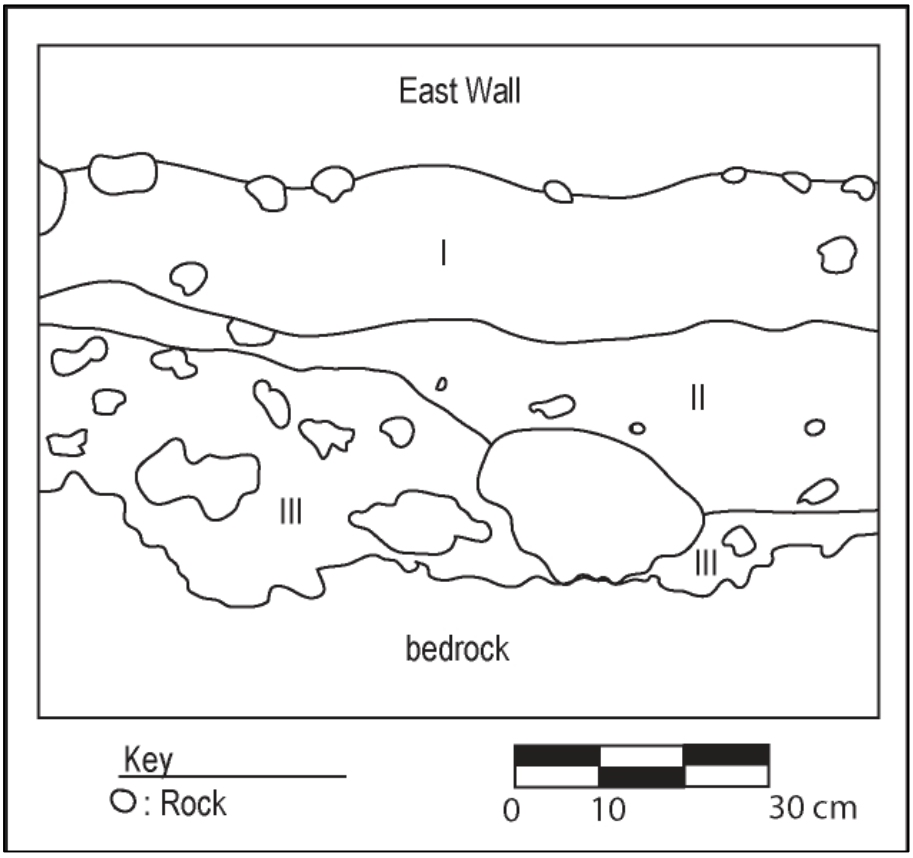


Figure 94. Stratigraphic profile of TU-2 at Site 50-50-15-6864 Feature C.

Test Unit 3 at Site 50-50-15-6864 was excavated in Feature A, a terrace with a natural windbreak. The terrace flat measures 4.2 m north-south by 2.7 m east-west with a retaining wall on the west side and a natural lava escarpment forming a windbreak to the east and south (Figure 95). TU-3 was excavated to a depth of 60 cm bs with two stratigraphic layers represented. Layer I extended from surface to approximately 30 cm bs and consisted of a brown silt with cultural constituents including shell midden and basalt flakes. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer II consisted of a sterile yellow brown silt which extended from about 30 to 60+ cm bs, at which point most of the unit was covered in bedrock (Figure 96).

Feature A is interpreted as a habitation structure.

Figure 95. Overview of Site 50-50-15-6864 Feature A showing location of TU-3 prior to excavation.

Figure 96. TU-3 at Site 50-50-15-6864 Feature A showing bedrock at base of excavation.

TU-4 was excavated within a rectangular terrace, Feature I at Site 50-50-15-6864. Feature I measures 5.4 m north-south by 7.0 m east west with a wall (Feature J) forming its north boundary (Figure 97). Alignments of rock form its western, southern and eastern edges. On the south side of the feature are two parallel alignments of cobbles and boulders creating a step onto the terrace feature. A slab lined rectangular hearth is located in the center of the feature, and TU-4 was positioned so that it bisected the hearth feature (Figure 98). Materials from inside the hearth were screened separately from soil outside the hearth. TU-4 was excavated to a maximum depth of 37 cm bs at which point bedrock was exposed. Within the hearth was a silty grayish brown ash deposit that lacked charcoal, but from which a faunal bone fragment was recovered at 13-23 cm bs. Ash samples were also collected. The hearth was constructed by placing vertical *pāhoehoe* slabs on bedrock which were supported by basalt cobbles (Figure 99). Outside of the hearth, two stratigraphic layers were observed. Layer I is a dark brown silt from which minor amounts of shell midden and basalt flakes were recovered which extended from surface to 15 cm bs. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer II was a sterile, brown sandy silt which extended from 15 to 37 cm bs at which point bedrock was encountered.

Feature I appears to represent a habitation structure.

Figure 97. Overview of terrace Feature I at Site 50-50-15-6864.

Figure 98. View of Site 50-50-15-6864, Feature I, TU-4 at terrace prior to excavation.

Figure 99. View of Site 50-50-15-6864, Feature I, TU-4 at base of excavation showing exposed half of hearth.

South, adjacent and slightly below Feature I is a level flat area which may have functioned as a lanai or activity area. TU-5 was excavated in this flat adjacent to the southern edge of Feature I and reached a maximum depth of 73 cm bs at bedrock. Three stratigraphic layers were identified. Layer I extended from surface to approximately 18 cm bs and consisted of a very dark grayish brown silty loam which contained charcoal flecking and a single piece of marine shell midden. Layer II was a sterile dark yellowish brown silty clay loam extending from approximately 18 to 40 cm bs. Layer III was a sterile yellowish brown silty loam and extended from approximately 40 to 73 cm bs (Figure 100).

Figure 100. TU-5 at Site 50-50-15-6864 at base of excavation.

5.3.16 Site 50-50-15-6951

This site complex consists of eight features including a lava tube (with midden, artifacts and a human tooth), a C-shaped wall, a wall with cleared flat, two terraces, a rock alignment, a U-shaped enclosure, and two stone mounds. These features represent habitation, shelter and possible agricultural or burial functions (Figure 101).

The lava tube (Feature A) extends for over 32 m at which point it splits into two chambers. Due to the rich deposit near the entrance, a test unit was initially planned at the feature. The tube contains several surface artifacts and constituents including basalt cores, basalt flakes, basalt hammerstones, a basalt awl, coral abraders, two sharks teeth, a dogs tooth, bird bone,

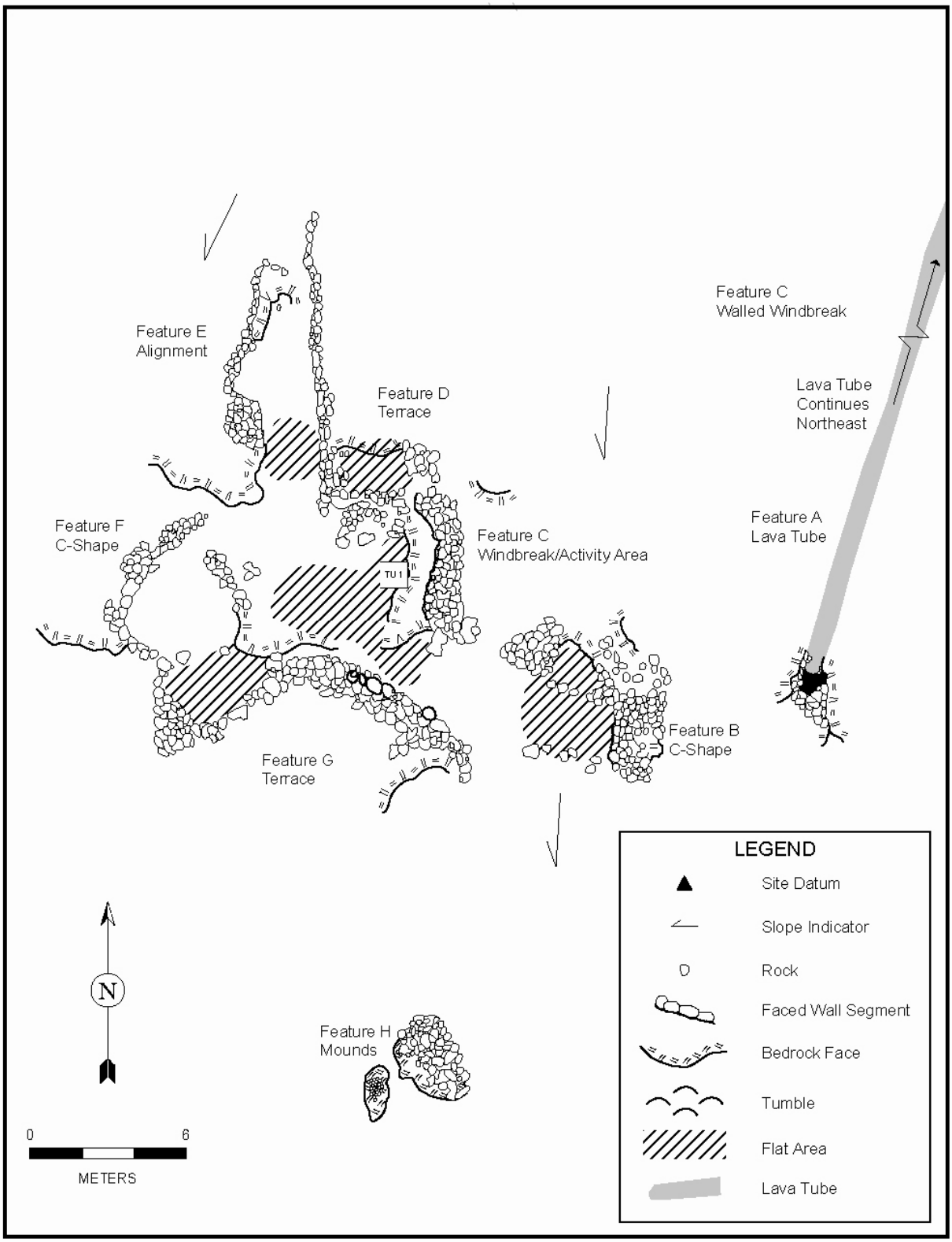


Figure 101. Plan view of Site 50-50-15-6951.

faunal bone, *kukui* nut, shell midden (cowrie and ʻ*opihi*), as well as an adult human incisor. Once the human bone was identified, all work in the feature was terminated and the appropriate personnel were informed of the discovery.

Feature C is a flat with an adjacent wall which serves as a windbreak (Figure 102). The wall is constructed on a natural outcrop of basalt with stacked boulders and cobbles forming a windbreak for the adjacent flat to the west. The wall is approximately 5 m long north-south and reaches a height of 1.6 m (three courses). The adjacent flat measures approximately 4 m north-south by 5 m east-west. TU-1 was excavated in the flat which had a piece of marine shell midden and a waterworn piece of branch coral on the surface. The unit was excavated to a maximum depth of 32 cm bs at which point bedrock was encountered (Figure 103). Three stratigraphic layers were present in the unit all of which yielded cultural material.

I	0 – 2 cm bs	Dark brown (7.5 YR 3/2) silt; granular; slightly sticky, non-plastic; clear smooth boundary; top soil with abundant organic material and some cultural material.
II	3 – 12 cm bs	Very dark brown (7.5 YR 2.5/2) silt loam; granular; slightly sticky, non-plastic; clear smooth boundary; cultural material present.
II	13 – 32 cm bs	Reddish brown (5 YR 3/3 silty clay; granular; slightly sticky, non-plastic; contains cultural material.

Layer I contained the majority of the cultural materials recovered including waterworn *porites* coral, ʻ*ili*ʻ*ili* pebbles, basalt flakes, shell midden, faunal bone, *kukui* nut, a *puka* shell bead, and an in situ charcoal sample. The charcoal sample was recovered from the top of Layer II and was submitted for radiocarbon analysis yielding a result most likely dating from between the mid AD 1600s and AD 1800. Layer III was a dark reddish brown silty clay extending from 12 to 32 cm bs at its deepest point. Materials recovered from Layer III include marine shell midden, *porites* coral and a basalt flake. For details on the recovered materials see Section 6: Results of Laboratory Analysis.

Feature C is interpreted as a shelter/activity area.

Figure 102. Overview of Feature C at Site 50-50-15-6951.

Figure 103. Feature C at Site 50-50-15-6951 showing TU-1 at base of excavation.

5.4 GENERATOR-TIE LINE TESTED SITES

5.4.1 Site 50-50-15-6819

This site complex consists of a terrace and 15 mounds located on a north-south trending ridgeline with a ravine to the west. The mounds are scattered along the ridge with some being more formally constructed than others and likely representing agricultural or possible burial features. For details on the various features descriptions see the site record in Appendix C. Feature C is the northernmost mound, being circular in plan view and constructed of piled boulders and cobbles on bedrock (Figure 104). It measures 3.2 m north-south by 2.4 m east-west with a maximum height of 1.1 m. The Feature C mound was subjected to test excavations in an attempt to determine its function. The southern half of the mound was first dismantled and then the soil beneath this portion of the feature was excavated (Figure 105). Two soil layers were identified underneath the mound construction and above the bedrock with no cultural materials being identified. Layer I consisted of a dark brown silty loam extending from 76-106 cm below the mound surface. Layer II consisted of a yellowish brown silty clay loam extending from 106-165 cm below the mound surface with bedrock below.

Feature C appears to represent an agricultural clearing mound.

Figure 104. Overview northeast of Feature C mound at Site 50-50-15-6819 prior to testing.

Figure 105. Site 50-50-15-6819 Feature C mound after mound dismantling prior to excavation of underlying soil.

5.4.2 Site 50-50-14-6865

This site complex consists of nine features including a wall remnant, a walled terrace, a stone alignment with flat terrace, a stone filled terrace, four terraces, and a modified lava blister. For details on the various features descriptions see the site record in Appendix C. Feature B, a walled terrace, and Feature C, a stone alignment with terrace, were both test excavated. Feature B is a walled terrace with the terrace flat measuring approximately 3.7 m north-south by 3.2 m east-west (Figure 106). Wall remnants (part of Feature A) border the north and east sides of the terrace flat. TU-1 was excavated in the terrace flat along the edge of the wall remnant to a maximum depth of 75 cm bs with no cultural material being recovered (Figure 107). Three sterile stratigraphic layers were uncovered. Layer I is a very dark brown silty loam with organics extending from surface to about 2 cm bs. Layer II is a very dark brown silty clay loam which was sterile and extended from 2 to 45 cm bs. Layer III is a dark yellowish brown silty clay loam extending from 45 to 75 cm bs which was also sterile and rested on top of the bedrock.

Feature B likely represents an agricultural terrace.

Figure 106. Overview northeast of Site 50-50-14-6865 Feature B.

Figure 107. View east of TU-1 at Site 50-50-14-6865 Feature B at base of excavation.

TU-2 was excavated in the center of the terrace floor at Feature C. The Feature C terrace measures approximately 2.3 m east-west by 2.8 m north-south with a circular stone alignment on the east side of the terrace flat which extends for 3.5 m (Figure 108). On the surface of TU-2 were eight waterworn *porites* coral fragments, a basalt flake and a piece of marine shell midden. TU-2 was excavated to a maximum depth of 39 cm bs at which point bedrock covered the unit floor (Figure 109). Three stratigraphic layers were present during the excavation of TU-2.

I	0 - 5 cm bs	Very dark brown (7.5 YR 2/2) silt loam; granular; non-sticky, non-plastic; clear smooth boundary; top soil with abundant organic material with some cultural material.
II	5 - 30 cm bs	Dark brown (10 YR 3/3) silt loam; granular; non-sticky, non-plastic; clear smooth boundary; cultural material present with ash lens.
ash	10 cm thick	Grayish brown (10 YR 5/2) silt; single grain; non-sticky, non-plastic; abrupt smooth boundary; probably the result of hearth cleaning as no discernable hearth evident and no charcoal.
III	30 - 39 cm bs	Dark yellowish brown (10 YR 3/4) silt loam; granular; non-sticky, non-plastic; sterile.

Layer I was the surface organic layer that contained marine shell midden and basalt flakes. Layer II contained cultural material in the upper 10 cm of this layer including marine shell midden, basalt flakes, water worn basalt pebbles and coral fragments (both *porites* and branch coral). For details on the recovered materials see Section 6: Results of Laboratory Analysis. An ash pocket was also present in this layer which was 10 cm thick and likely represented a hearth cleaning episode as there were no rock alignments or large amounts of charcoal present. Layer III was confined to the deeper pockets between bedrock and consisted of a sterile, dark yellowish brown silty loam (Figure 110).

Feature C appears to represent a habitation or activity area associated with the nearby agricultural features.

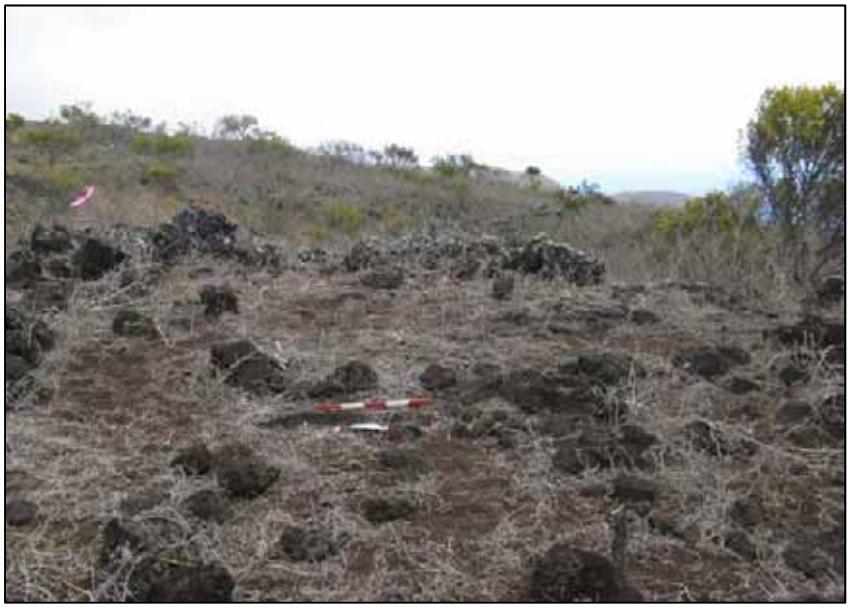


Figure 108. Overview east of Feature C at Site 50-50-14-6865.

Figure 109. View southeast of TU-2 at Site 50-50-14-6865 Feature C showing base of excavation.

Figure 110. East wall profile of TU-2, Site 50-50-14-6865 Feature C.

5.4.3 Site 50-50-15-6871

This impressive complex contains seven features including a stone faced wall, a U-shaped wall, a walled terrace with depression, three terraces and a stone mound (Figure 111). For details on the various features descriptions see the site record in Appendix C. Feature B is a U-shaped wall which connects to Feature C to the west, a rock filled and walled terrace with a depression. These two features likely represent a high status habitation structure or possibly a heiau (Figure 112). The walls of Feature B are thick and impressive being constructed of stacked boulders and cobbles with core filled pebbles. The north wall is in the best condition being 7.6 m long east-west by 1.9 m thick and 0.75 m high (four to five courses). The interior space of the U-shape measures approximately 5 m east-west by 5 m north-south, is soil filled and contains tumble from the surrounding walls. The north and west walls of the U-shape form the east wall of the Feature C rock filled terrace. Feature C is square in plan view measuring 3.6 m east-west by 3.8 m north-south. The interior of Feature C is stone filled and is slightly depressed in the southwest corner.

TU-1 was excavated in the center of the U-shape interior at Feature B (Figure 113). The unit was excavated to a depth of 60 cm bs with three stratigraphic layers identified (Figures 114 and 115).

I	0 – 20 cm bs	Very dark brown (7.5 YR 2.5/2) silt loam; granular; non-sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material with some cultural material.
II	20 - 50 cm bs	Dark yellowish brown (10 YR 4/4) silt loam; granular; non-sticky, non-plastic; clear smooth boundary; cultural material present.
III	50 - 60 cm bs	Dark yellowish brown (10 YR 3/6) silt loam; granular; non-sticky, non-plastic; sterile.

Layer I contained cultural materials including shell midden, basalt flakes, coral fragments and charcoal. A pocket of Layer I mixed with ash extended through Layers II and III to a depth of 60 cm bs (Figures 114 and 115). Layer II contained lesser amounts of cultural material. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample from the top of Layer II at a depth of 25 cm bs was submitted for radiocarbon analysis and yielded a result indicating that this feature was utilized from between the mid AD 1600s and AD 1800. Layer III is a sterile dark yellowish brown silty loam extending from 50 to 60+ cm bs.

Feature B likely represents a habitation feature, possible of a high status individual based on its level of construction and nearby feature association.

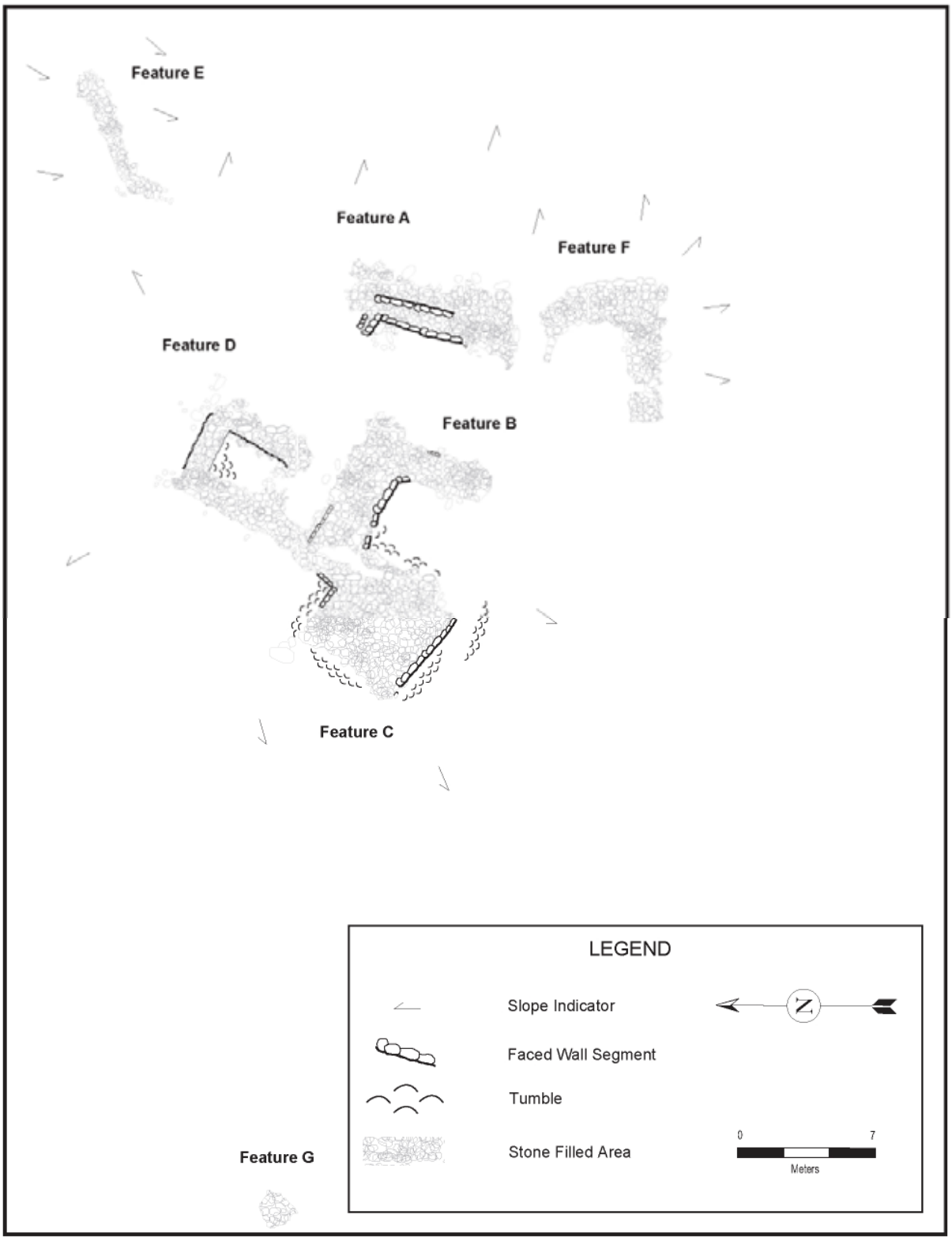


Figure 111. Plan view of Site 50-50-15-6871.

Figure 112. Overview of Feature B at Site 50-50-15-6871 with crew member in U-shape.

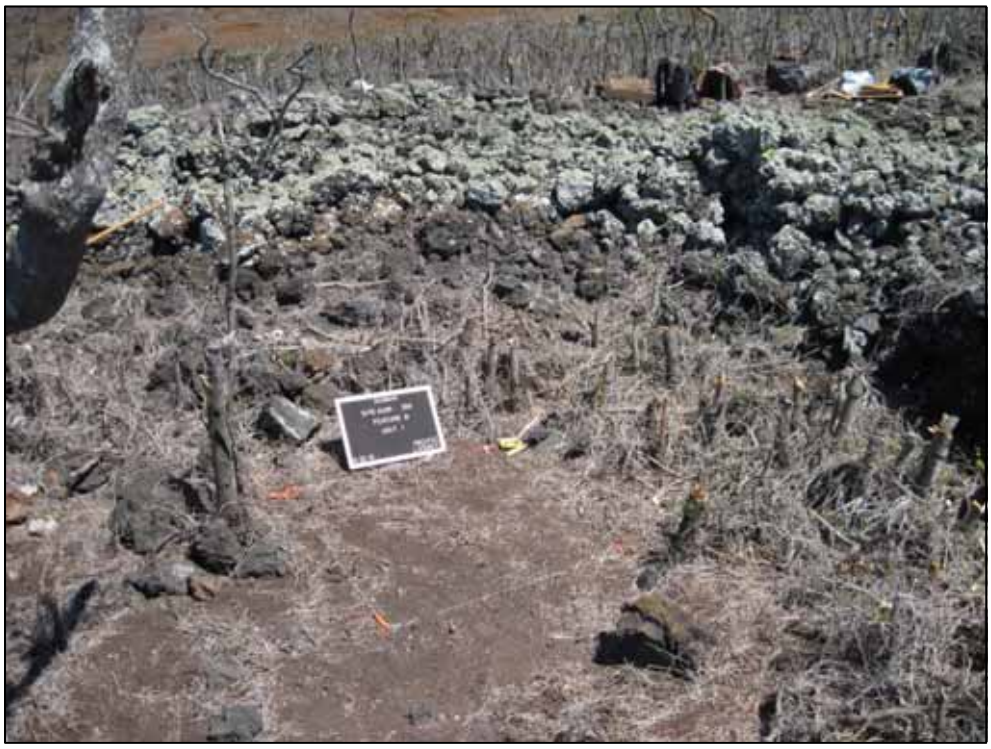


Figure 113. View northwest of TU-1 at Site 50-50-15-6871 Feature B with Feature C (rock filled terrace) in background.

Figure 114. East wall profile of TU-1, Feature B at Site 50-50-15-6871 showing ash deposit.

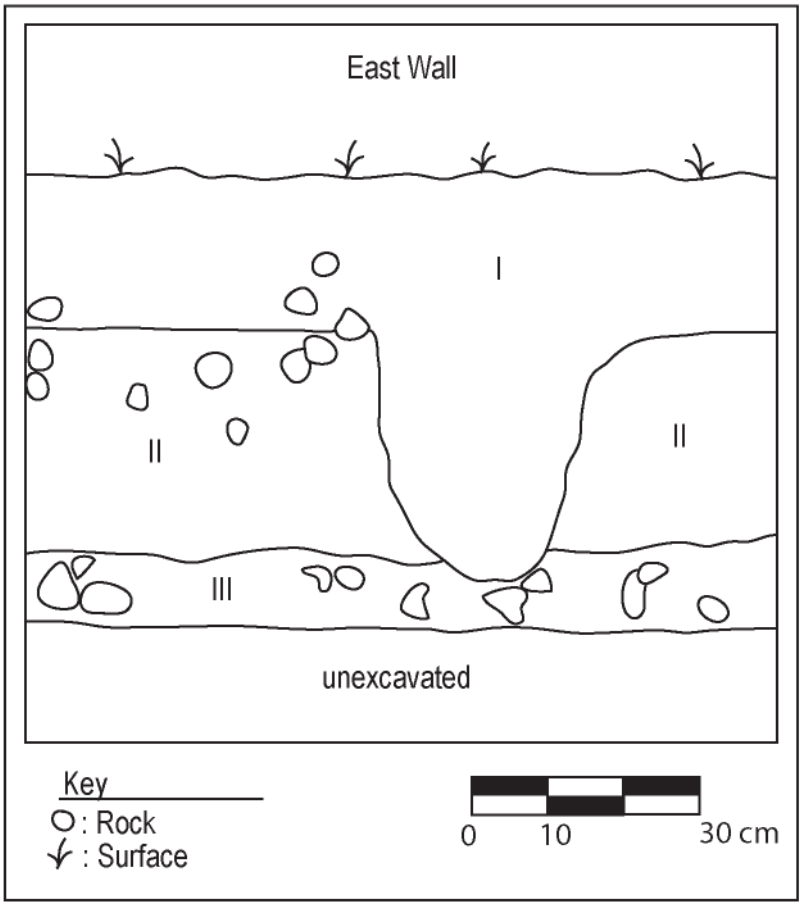


Figure 115. East wall stratigraphic profile of TU-1, Site 50-50-15-6871 Feature B.

5.5 PĀPAKA ROAD TESTED SITES

5.5.1 Site 50-50-14-6931

This site complex consists of six features reflecting traditional use and historic ranching activity. The complex is enclosed by a large historic wall (Feature A) likely for keeping cattle outside the site area. Other features include concrete circular cisterns, earthen mounds with traditional and historic artifacts, a rock enclosure and a lava tube (Figure 116). For details on the various features descriptions see the site record in Appendix C. A test unit was excavated within Feature D, two disturbed and adjacent earthen mounds each about 70 to 80 cm high which cover an area approximately 10 m north-south by 9 m east-west (Figure 117). On the surface of the feature are several artifacts including large water worn stones (possible former upright stones), shell midden and a variety of historic artifacts (including Chinese porcelain with the Bamboo or Three Circles and Dragonfly design pattern, porcelain with blue on white stencil transfer designs, earthenware, solarized glass, and contemporary trash) (Figures 118). The feature likely represents the remnant of a traditional feature which may have been dismantled so that the available stones could be used for the historic wall enclosure.

TU-1 at Feature D was excavated to a maximum depth of 80 cm bs at which point bedrock covered the unit floor. Three stratigraphic layers were observed during the excavation. Layer I is a dark brown silty loam with cultural material (shell midden, *kukui* nut, charcoal, historics) which extends from surface to approximately 25 cm bs. A charcoal sample from Layer I was submitted for radiocarbon analysis, the results suggest an overall occupation period then may have extended from the mid 16th century to the mid 20th century. Layer II is a dark yellowish brown silty loam with decreasing cultural material with depth (basalt flakes, *kukui* nut, faunal bone, historics) extending from approximately 25 to 53 cm bs. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer III is a sterile, dark brown silt above bedrock which extends from 53 to 83 cm bs (Figures 119 and 120).

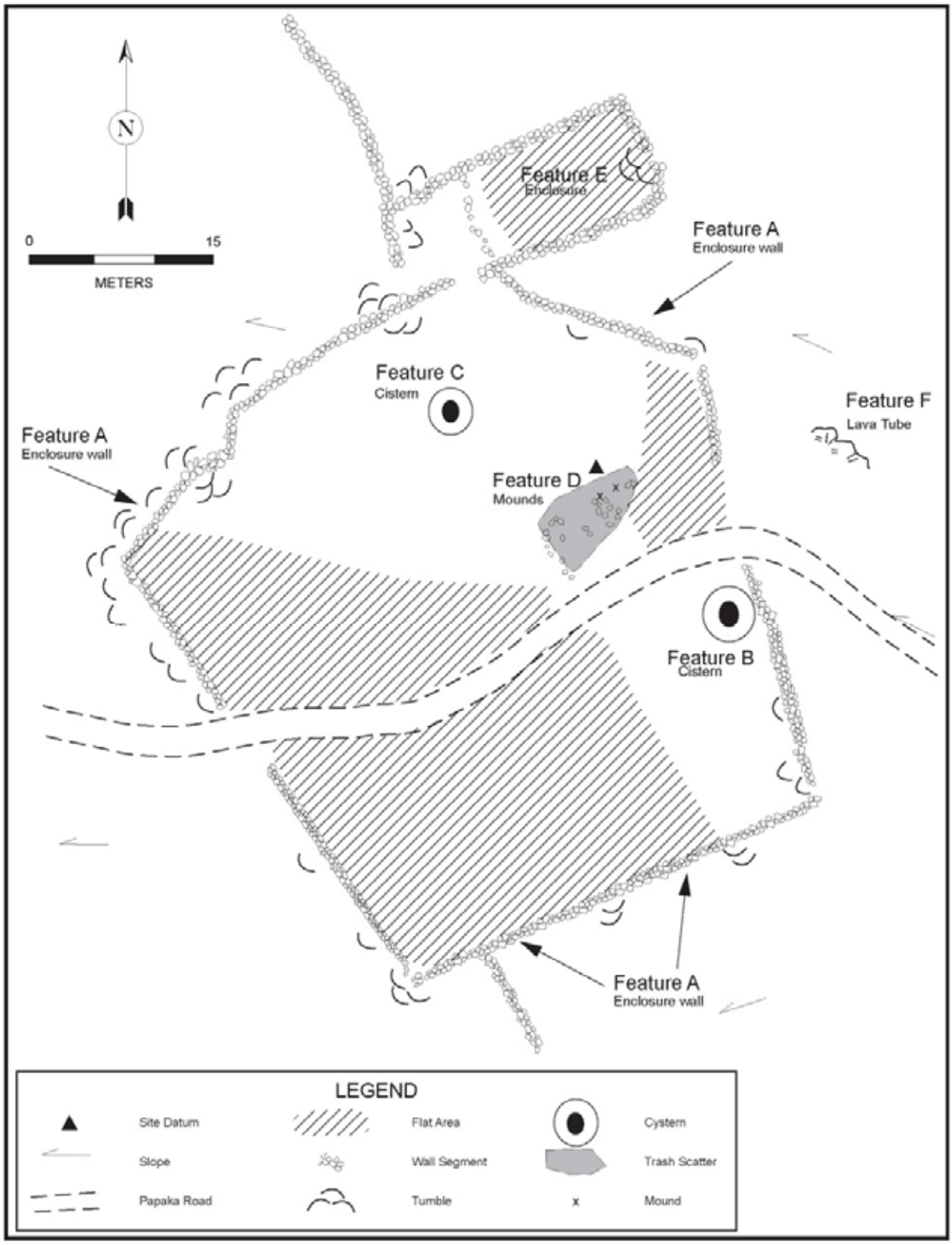


Figure 116. Plan view of Site 50-50-14-6931.

Figure 117. Overview of TU-1 location at Site 50-50-14-6931 Feature D (note waterworn stones).

Figure 118. View of surface artifacts on Feature D at Site 50-50-14-6931.

Figure 119. Site 50-50-14-6931 Feature D, TU-1 West wall at base of excavation.

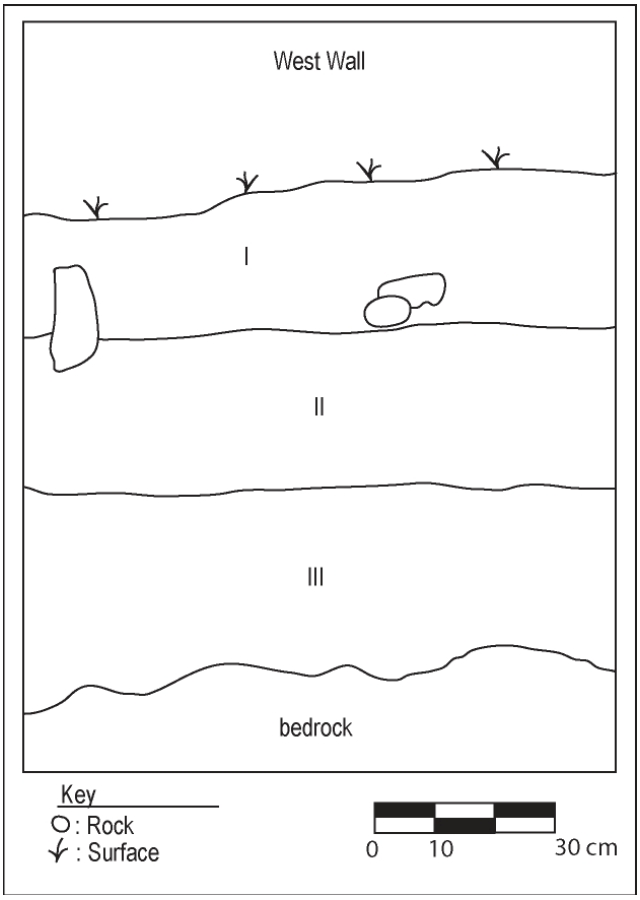


Figure 120. Site 50-50-14-6931 Feature D, TU-1 stratigraphic profile.

5.5.2 Site 50-50-14-6939

This complex consists of four features including a large rock walled enclosure and three terraces (Figure 121). Two test units were excavated at the site, one within the stone enclosure Feature A and one within terrace Feature C. For details on the various features descriptions see the site record in Appendix C.

The Feature A enclosure is roughly rectangular in plan view with an interior space measuring approximately 15 m north-south by 8 m east-west (Figure 122). A *pāhoehoe* lava escarpment is located on the mauka (northeast) side of the feature with a small overhang shelter measuring 5 m east-west by 1.7 m deep (north-south) and 1.0 m high. The enclosure walls are partially faced with maximum heights of 1.5 m, with the eastern and western walls being in the best condition. The southern wall appears to have been disassembled and possibly rebuilt in historic times as it is not a well constructed and is much smaller in size as compared to the other wall segments. On the surface of the enclosure were scattered basalt flakes, waterworn cobbles and pebbles, a basalt hammerstone fragment, coral fragments and marine shell midden. TU-1 was excavated in the center of the feature interior with an *ʻiliʻili* pebble, porites coral fragment and a piece of marine shell midden on the unit surface (Figure 123). Three stratigraphic layers were observed during the excavation which extended to bedrock at a maximum depth of 49 cm bs (Figure 124).

I	0 – 20 cm bs	Very dark brown (7.5 YR 2.5/2) silt loam; granular; non-sticky, non-plastic; clear wavy boundary; top soil with abundant organic material.
II	20 - 27 cm bs	Dark brown (10 YR 3/3) silt loam; granular; non-sticky, non-plastic; abrupt wavy boundary; cultural material present.
III	27 - 50 cm bs	Dark yellowish brown (10 YR 3/6) silt loam; granular; non-sticky, non-plastic; sterile.

Layer I contains most of the cultural constituents recovered, including drilled marine shell, shell midden, volcanic glass, faunal bone, *porites* coral fragments, basalt flakes and a basalt core. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer II also contained cultural constituents. Layer III is a sterile dark yellowish brown silty loam extending from 27 to 50+ cm bs.

The Feature A enclosure appears to be a habitation feature which may have been reused in historic times.

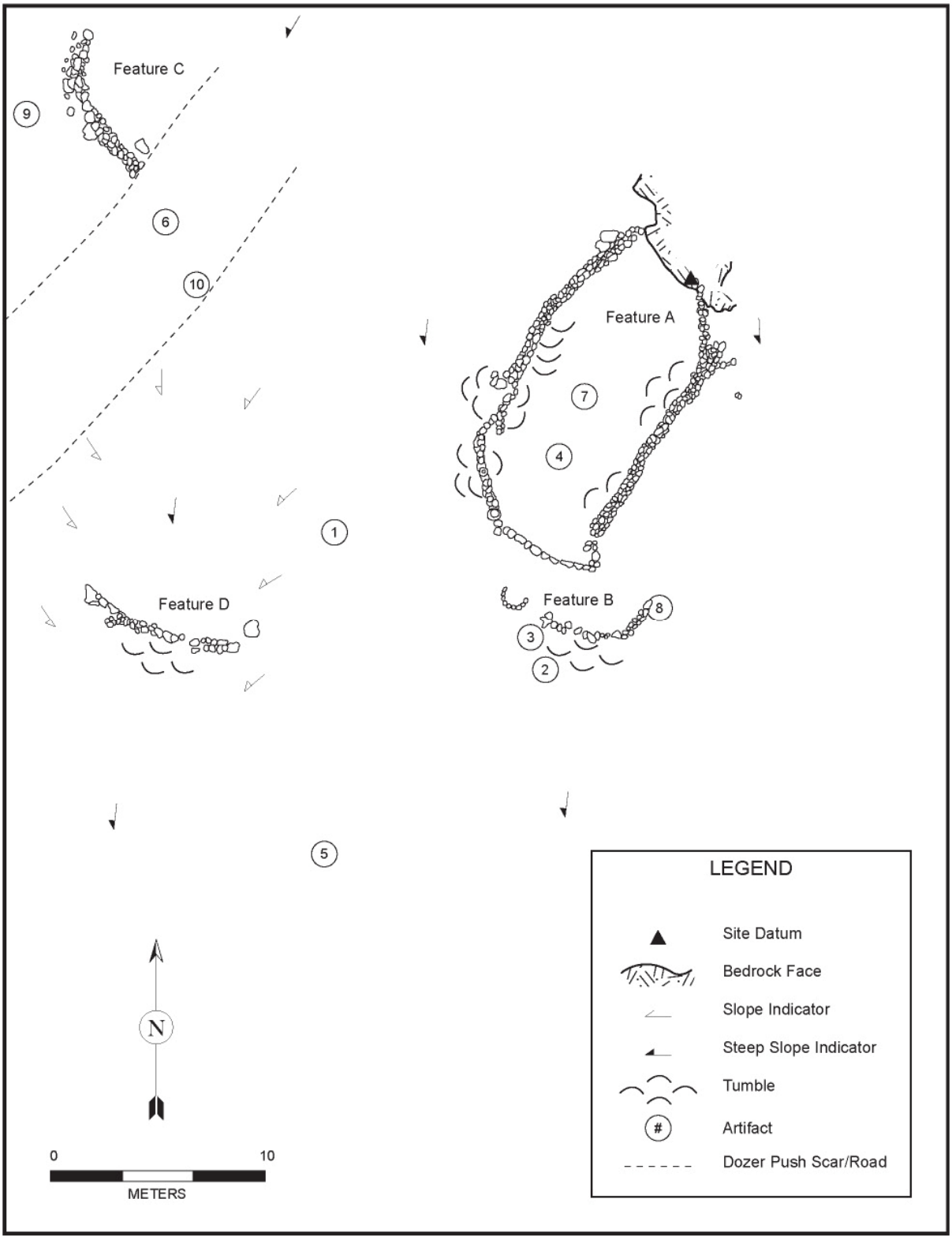


Figure 121. Plan view of Site 50-50-14-6939.

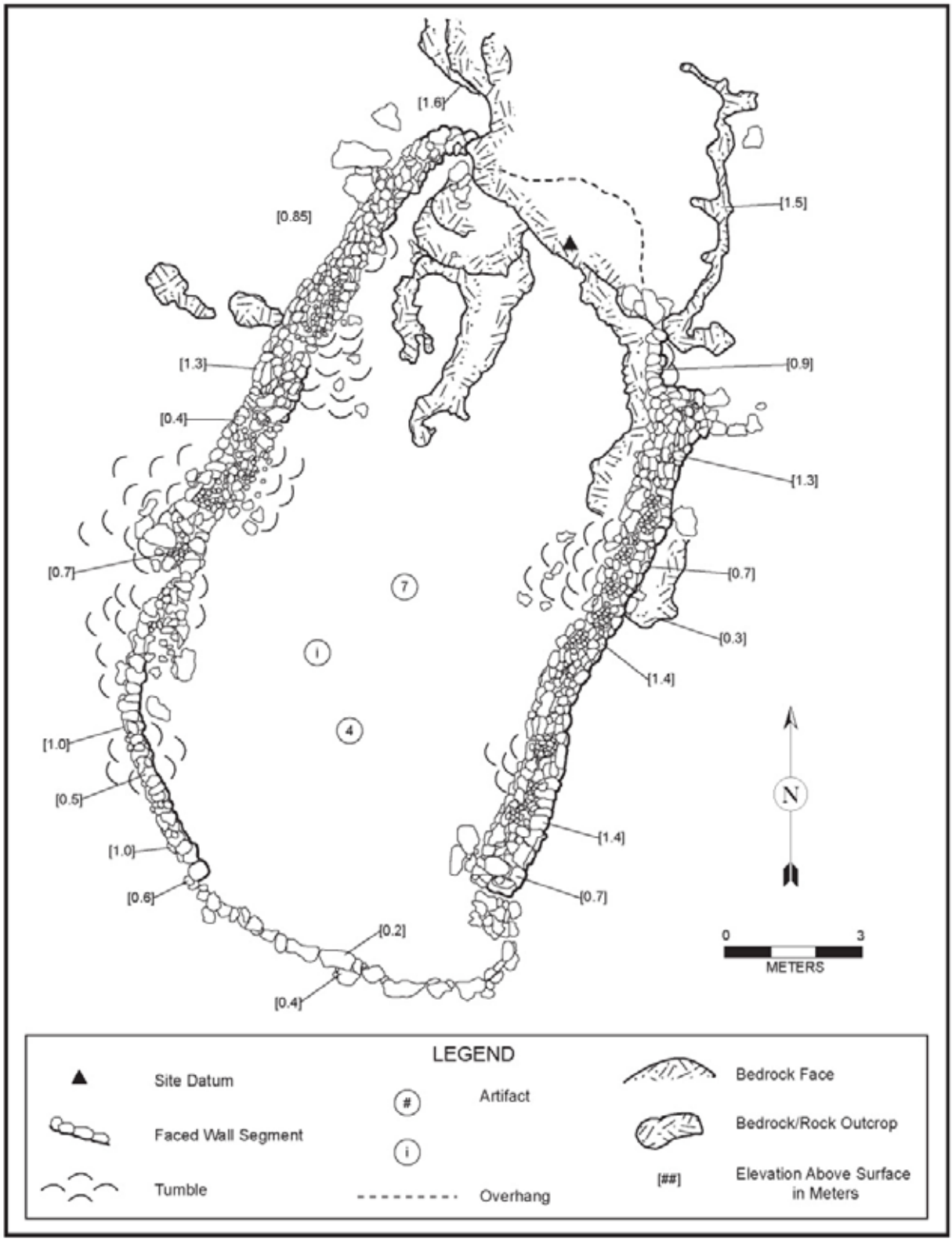


Figure 122. Plan view of Site 50-50-14-6939, Feature A.

Figure 123. Overview of Feature A at Site 50-50-14-6939 prior to excavation of TU-1.

Figure 124. View north of TU-1 at base of excavation within Feature A at Site 50-50-14-6939.

The Feature C terrace is constructed of stacked boulders on its downslope (southwest) side measuring 75-90 cm high (two to three courses) (Figure 125). The terrace flat is soil filled measuring approximately 7 m in length by 4 m wide. No cultural material was present on the terrace although a broken waterworn cobble and a coral fragment are located within a few meters of the feature. TU-2 was excavated in the center of the terrace flat down to bedrock with a maximum depth of 42 cm bs. Three stratigraphic layers were identified during the testing (Figures 126 and 127).

I	0 – 4 cm bs	Dark brown (7.5 YR 3/2) silt loam; granular; non-sticky, non-plastic; abrupt smooth boundary; top soil with abundant organic material.
II	4 - 20 cm bs	Dark brown (7.5 YR 3/3) silty clay loam; granular; slightly sticky, slightly plastic; clear smooth boundary; cultural material present.
III	20 - 42 cm bs	Dark yellowish brown (7.5 YR 4/4) silty clay loam; granular; slightly sticky, slightly plastic; sterile.

Layer II was the cultural layer at this site and contained basalt flakes, *kukui* nut fragments, *porites* coral fragments, marine shell midden, ash and charcoal. For details on the recovered materials see Section 6: Results of Laboratory Analysis. A charcoal sample taken from the base of Layer II at 27 cm bs was submitted for radiocarbon analysis. The results indicate that this site was probably utilized between the mid AD 1500s and AD 1800. Layer III is a sterile dark yellowish brown silty clay loam extending from 20 to 42+ cm bs.

The Feature C terrace appears to reflect temporary habitation associated with agricultural activity.

Figure 125. View northeast of terrace, Feature C at Site 50-50-14-6939.

Figure 126. View west of TU-2 at Site 50-50-14-6939 Feature C at base of excavation.

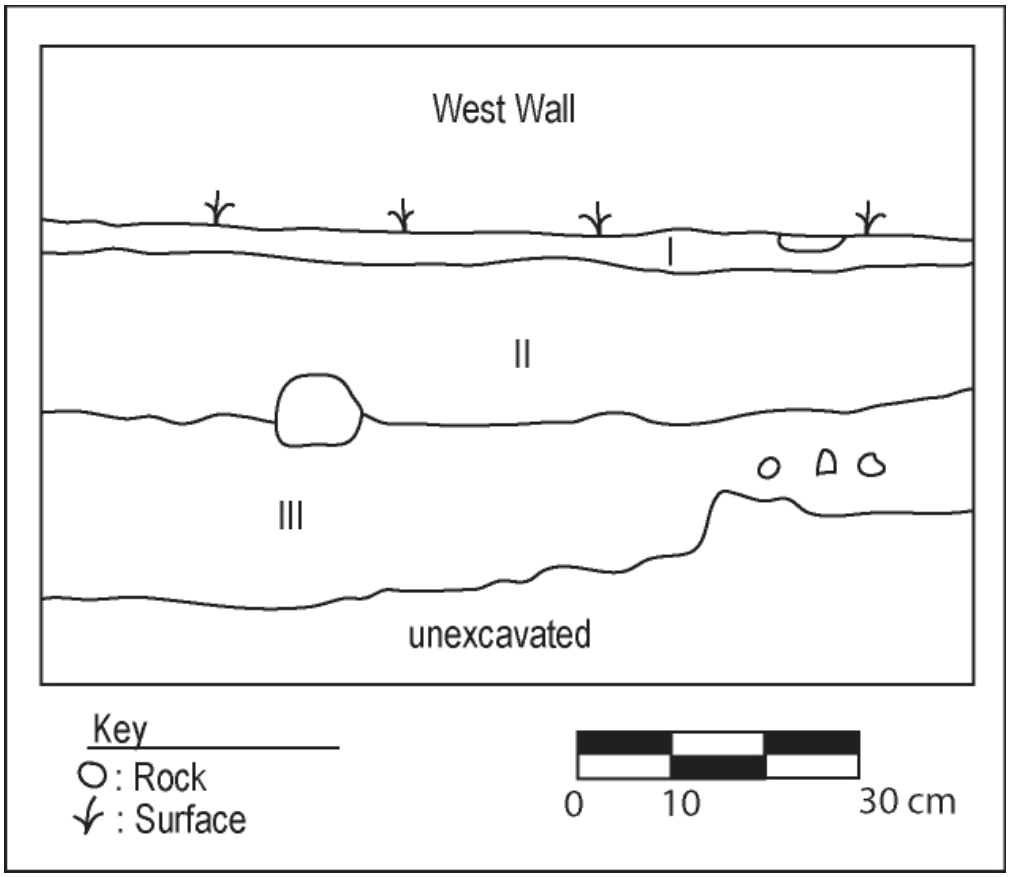


Figure 127. Site 50-50-14-6939 Feature C, stratigraphic profile of TU-2.

5.5.3 Site 50-50-14-6940

This complex is comprised of eight features reflecting habitation and agricultural activity (Figure 128). Features include a large rock walled enclosure, a double enclosure, a small enclosure, three terraces, a terrace with a platform, and a terrace with adjacent wall. For details on the various features descriptions see the site record in Appendix C. A test unit was excavated within Feature H, a terrace with adjacent wall segment (Figure 129). The Feature H terrace flat is soil filled and measures approximately 12 m east-west by 7 m north-south. The face of the terrace is in poor condition and appears to have been impacted by cattle grazing. A rock wall borders the mauka (north side of the feature) and extends east-west for approximately 12.5 m and has a maximum height of approximately 1 m (six courses).

TU-1 was excavated in the center of the terrace flat and extended to bedrock at 65 cm bs, with pockets of sterile soil extending between bedrock to a maximum depth of 91 cm bs. Four stratigraphic layers were identified during the excavation. Layer I is a very dark grayish brown silty loam with surface organics and cultural material (shell midden, *porites* coral fragments and basalt flakes) extending from surface to approximately 20 cm bs. Layer II is a dark yellowish brown silty loam which also contained cultural material (shell midden, basalt flakes, volcanic glass and fish bone) extending from approximately 20 to 40 cm bs. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer III was a dark brown silty clay loam which extended from approximately 40 to 55 cm bs. An ash pocket in the northwest corner of the unit extended from the base of Layer II through Layer III to the top of Layer IV (Figure 130). Layer III had fewer cultural constituents with depth and the materials present may have been recovered from the intrusive ash deposit. Layer IV was a sterile, dark yellowish brown silty clay loam extending from 55 to 65 cm bs with pockets between bedrock going to approximately 90 cm bs. The Feature H terrace represents a habitation feature.

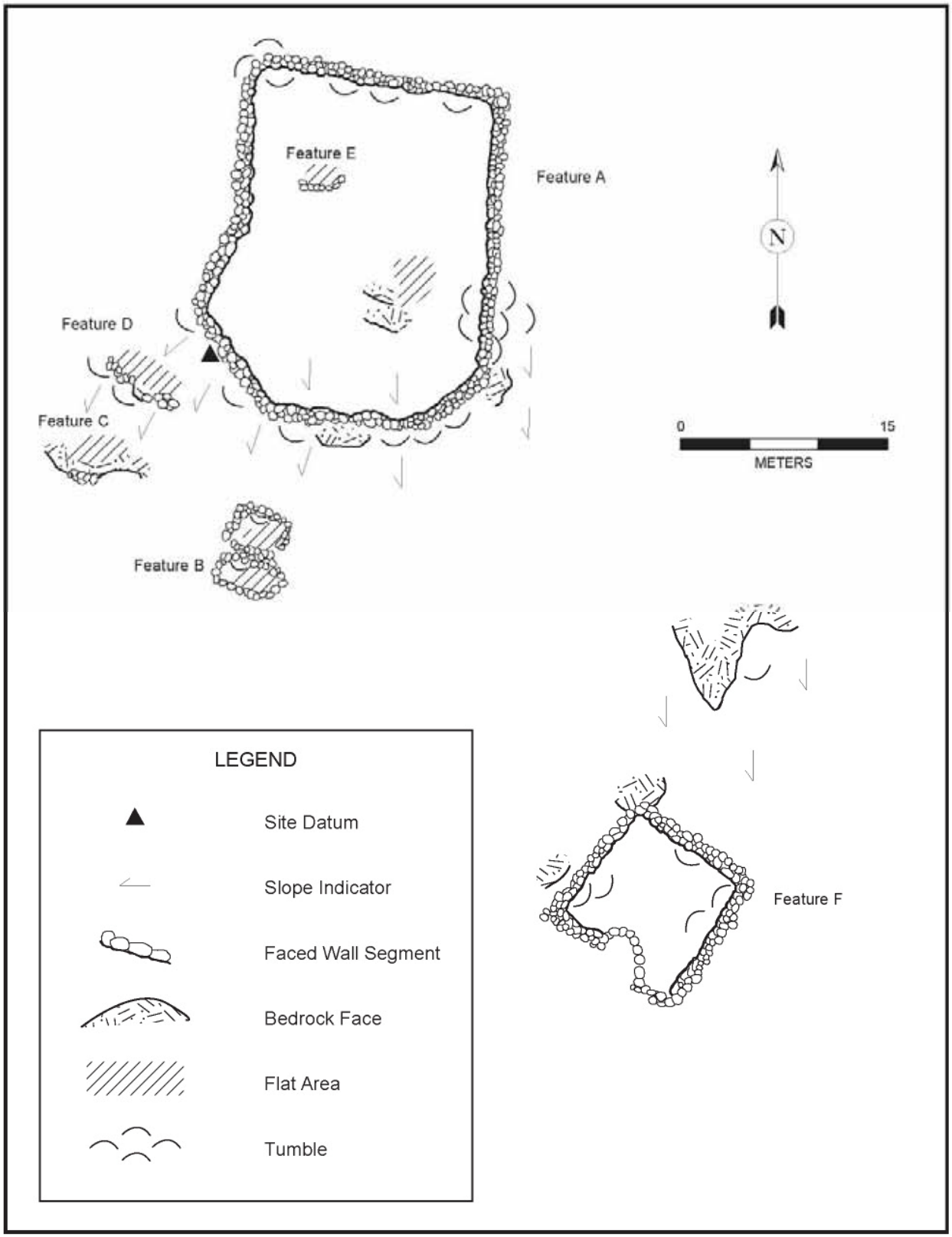


Figure 128. Plan view of Site 50-50-14-6940.

Figure 129. Overview of terrace with wall, Feature H at Site 50-50-14-6940.

Figure 130. Site 50-50-14-6940 Feature H, TU-1 (board mislabeled), showing west wall profile with ash deposit.

5.5.4 Site 50-50-14-6943

This complex consists of three features; a cattle wall, a faced mound, and a large cobble mound with historic artifacts including cast iron stove fragments. For details on the various features descriptions see the site record in Appendix C.

Feature B, the faced mound, was subjected to testing to help determine its function, as it was more formally constructed than the typical agricultural clearing mounds observed in the project area. Feature B is constructed of stacked boulders and cobbles with facing on its north and south sides. It measures approximately 4.0 m long northeast-southwest by 2.5 m wide northwest-southeast and has a maximum height of 0.9 m (Figure 131). The feature is located in flat terrain which is void of rock and has been used for agriculture and cattle grazing. The eastern portion of the mound (measuring 2.7 m north-south by 1.2 m) was dismantled and then a test unit was excavated under the dismantled portion. TU-1 measured 2.1 m north-south by 0.75 m east-west and was situated to provide a complete cross section through the dismantled portion of the mound (Figure 132). During the systematic dismantling, two *kukui* nut shell fragments were recovered at 50-60 cm from the top of mound. A waterworn pebble was recovered at 70 cm from the top of the mound and a cowrie shell fragment was recovered at 110 cm below the top of the mound within the soil layer. TU-1 was excavated below the base of the mound for 40 cm with only one stratigraphic layer being represented. The soil consists of a yellowish brown silty loam with only the pebble and cowrie fragment being recovered (Figure 133). For details on the recovered materials see Section 6: Results of Laboratory Analysis. No materials were recovered from the bottom 30 cm of the soil layer.

Feature B appears to represent an agricultural clearing mound.

Figure 131. View west of mound Feature B at Site 50-50-14-6943 prior to testing.

Figure 132. View of Site 50-50-14-6943 Feature B during testing showing mound cross section and sterile soil.

Figure 133. Overview north of TU-1 trench at Site 50-50-14-6943 through eastern portion of mound.

Site 50-50-14-6956

This site consists of a large rectangular enclosure. The walls of the enclosure are unusually massive compared to the typical enclosure encountered in the project area (Figures 134 and 135). The enclosure measures approximately 10 m northeast to southwest by 8 m northwest to southeast. The walls are faced on both the interior and exterior sides and vary from 1.5 to 2.5 m wide with core filling in the wall interior. The tops of the walls are very flat and vary in height from 0.6 to 1.25 m high (three to nine courses). Large trees are growing in the interior of the enclosure some of which have fallen and toppled sections of the wall. For details of the feature description see the site record in Appendix C. TU-1 was excavated within the interior of the enclosure against its northeast (*mauka*) wall. TU-1 was excavated to a maximum depth of 95 cm bs with three stratigraphic layers observed (Figure 136).

I	0 - 30 cm bs	Dark brown (10 YR 2/7) loam; granular; slightly sticky, slightly plastic; abrupt smooth boundary; top soil with abundant organic material.
II	30 - 75 cm bs	Dark brown (10 YR 3/3) silt; granular; non-sticky, non-plastic; clear smooth boundary; sparse cultural material present.
III	75 - 95 cm bs	Dark yellowish brown (10 YR 3/6) sandy loam; granular; slightly sticky, slightly plastic; sterile.

Layer I consists of a very dark brown loam with surface organics which extended from surface to 10 to 30 cm bs being deepest against the rock wall. The wall extended below surface for 15 cm. Some charcoal, ash and a burnt faunal bone fragment were present in this layer along with contemporary material (tin foil and plastic fragments). Layer II consisted of a dark brown silt. Minor amounts of cultural material were recovered from this layer including shell midden, basalt flakes, a faunal bone fragment, *porites* coral fragment and waterworn basalt pebbles. For details on the recovered materials see Section 6: Results of Laboratory Analysis. Layer III is a sterile dark yellowish brown sandy loam extending from 75 to 95+ cm bs.

The function of this large enclosure is uncertain. The sparse amounts of recovered material and the massively thick walls are not typical of the other habitation enclosures in the area. It may have been constructed during the historic period and further work is needed to interpret this feature.

Figure 134. Overview Site 50-50-14-6956 (enclosure).

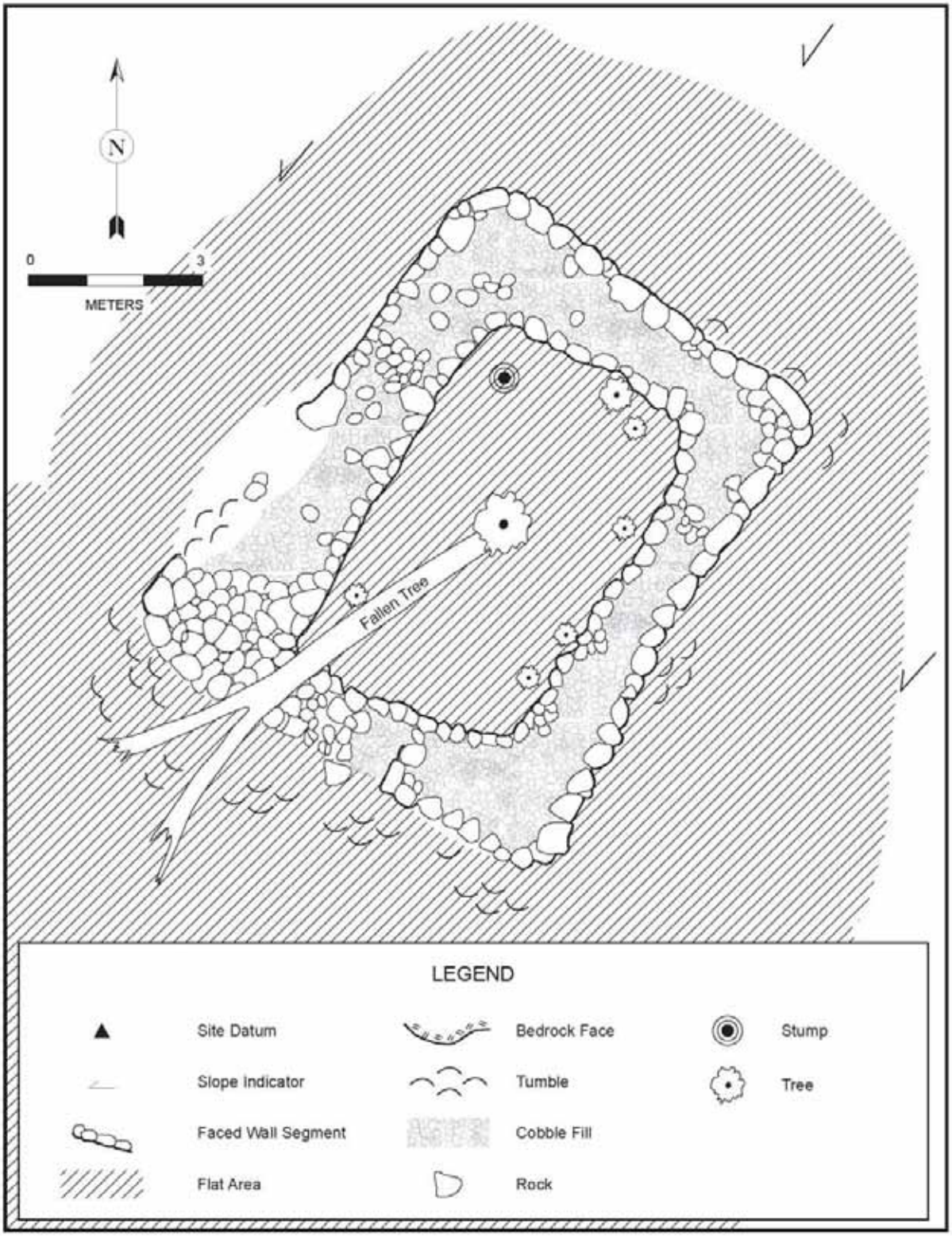


Figure 135. Plan view map of Site 50-50-14-6956.

Figure 136. TU-1 at Site 50-50-14-6956 showing unit against interior north wall.

6.0 RESULTS OF LABORATORY ANALYSES

The cultural material recovered from the surface collections and test excavations are analyzed below. They are grouped by Wind Farm, Generator-Tie Line, and Pāpaka Road areas, respectively. The cultural material collection is comprised of 408 artifacts, 331 manuports, 658.1 grams of midden, 32 datable charcoal samples, and six hearth/ash samples.

6.1 ARTIFACT AND MANUPORT ANALYSES

The complete Auwahi Wind Farm artifact assemblage, from both controlled excavations and surface collections, totals 739 individual artifacts and manuports, which are comprised of 256 lithic artifacts (i.e., cores, preforms, flakes, and debitage), 51 stone and coral tools, five fishing implements, two recreational artifacts, five miscellaneous artifacts, and 89 historic household and agricultural artifacts, as well as 331 manuports. Manuports consisted of unworked coral (n=242), waterworn basalt pebbles, or *ʻiliʻili* (n=57), unworked pumice (n=9), unidentified black faceted crystals (n=7), and branch coral (n=1), as well as unidentified marine mammal bone fragments (n=12), dog premolar (n=1), and shark teeth (n=2) that were not found in a midden context (Tables 12-14; Figures 137-142).

6.1.1 Controlled Test Excavations

A variety of cultural materials, including midden, charcoal for dating and wood identification, traditional and historic artifacts, and manuports were collected from test excavations carried out in Wind Farm, Generator-Tie Line, and Pāpaka sites. Twenty four sites were test excavated with a total of 37 excavation units. Of these sites, 16 are located in the wind farm (27 features excavated), three along the Generator-Tie Line route (four features excavated), and five along Pāpaka Road (six features excavated) (Table 11).

Table 11. Test Excavated Sites (n=24)

Wind Farm (n=16) SIHP No. (50-50-xx-xxxx)		Generator-Tie Line (n=3) SIHP No. (50-50-xx-xxxx)	Pāpaka Road (n=5) SIHP No. (50-50-xx-xxxx)
6832	6853	6819	6931
6833	6854	6865	6939
6838	6855	6871	6940
6839	6857		6943
6845	6860		6956
6848	6861		
6851	6864		
6852	6951		

Controlled test excavation units typically measured 1x1 m in size and were excavated by 10 cm arbitrary levels within each of the observed stratigraphic layers. Excavated soils were processed through 1/8-inch mesh screens and recovered materials were sorted and bagged by level. However, given the simplicity of the stratigraphy of the sites excavated and the short

time span represented by the cultural deposits, all cultural material was analyzed by stratigraphic layer, with all levels within that layer combined.

A total of 365 portable artifacts, 315 manuports, and 658.1 grams of midden were collected during test excavations (Tables 12-14 and 15-17). The majority of artifacts from test excavations were collected from Wind Farm sites (n=191), which is where the majority of test units were performed, followed by Pāpaka Road sites (n=156), and Generator-Tie Line sites (n=18) (Tables 12-14). For the same reason, Wind Farm sites dominate the manuport assemblage (i.e., unmodified materials transported to archaeological sites by human agency; n=255), followed by Generator-Tie Line sites (n=37), and Pāpaka Road sites (n=16). Traditionally manufactured implements, objects, or by-products of traditional artifact manufacture, including an array of lithics and tools made of Hawaiian and post-Contact imported materials, represent over 87% of the entire collection. However, a significant amount of historic household and agriculture related artifacts were also collected from test units, primarily from Pāpaka Road. Detailed tables and collection catalogues for each test unit that contained cultural materials can be found in Appendix C.

Controlled test excavations yielded a diverse assemblage of lithics, tools, historic artifacts, miscellaneous artifacts, and manuports (Figures 137 and 138). Lithics, which represent over 67% of the complete test excavation artifact assemblage, consist of basalt cores (n=7), basalt flakes (n=134), basalt flakes with polish (n=3), basalt flake with retouch (n=1), basalt shatter (n=19), cryptocrystalline cores (n=3), cryptocrystalline flake (n=1), cryptocrystalline shatter (n=1), volcanic glass cores (n=4), spent volcanic glass cores (n=2), volcanic glass flakes (n=6), volcanic glass flake fragments (n=6), and volcanic glass shatter (n=3). Tools make up approximately 8.2% of the test unit assemblage. This group includes basalt awls (n=2), basalt flake tools (n=13), fragmentary basalt flake tools (n=8), cryptocrystalline flake tools (n=2), volcanic glass flake tools (n=2), coral abraders (n=2), and coral abrader fragment (n=1). Roughly 22.7% of the assemblage is comprised of historic artifacts, including a wide variety of glass, ceramic, and metal artifacts – nearly all collected from Pāpaka Road sites. Miscellaneous artifacts collected from controlled excavations represent only 1.3% of the assemblage and include an echinoid spine bead preform (n=1), modified basalt (n=1), modified burnt bone fragment (n=1), and cone shell beads (n=2). Manuports collected from controlled excavations consist of unworked coral (n=242), waterworn basalt pebbles or *ʻiliʻili*, (n=57), and unworked pumice (n=9).

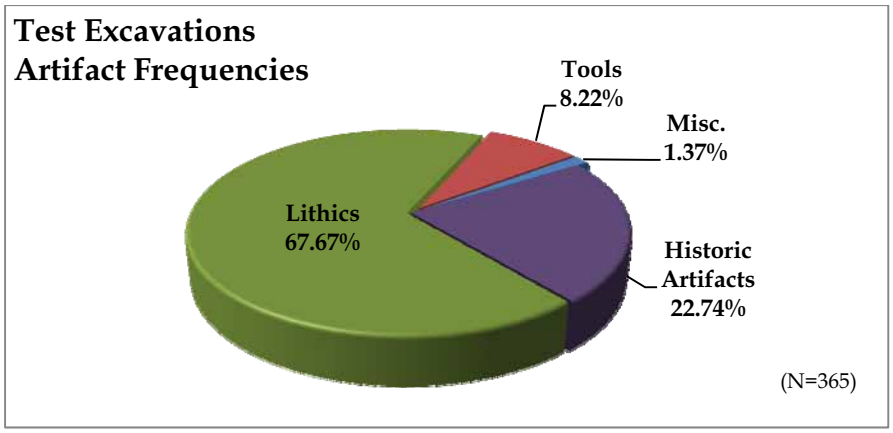


Figure 137. Pie chart depicting artifact frequency by general category.

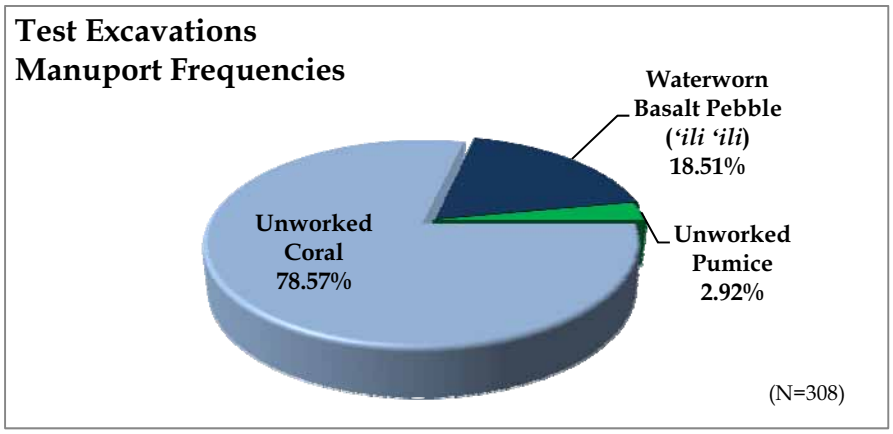


Figure 138. Pie chart depicting manuport frequency by general category.

6.1.1.1 Wind Farm Test Excavations. A total of 446 cultural resources were collected from Wind Farm sites, comprised of 191 artifacts and 255 manuports (Table 12). The Wind Farm test unit assemblage is dominated by manuports (n=255; 57.2%; Figures 139 and 140), including unworked coral (n=192; 43.0%), waterworn basalt pebbles or *ʻiliʻili* (n=54; 12.1%), and unworked pumice (n=9; 2.0%). Lithics represent the most frequently collected artifact type (n=180; 40.4%), which is largely made up of basalt flakes (n=92; 20.6%), followed by basalt flake fragments (n=51; 11.4%), basalt shatter (n=18; 4.0%), volcanic glass flakes (n=5; 1.1%), volcanic glass flake fragments (n=5; 1.1%), basalt cores (n=3; 0.7%), spent volcanic glass cores (n=2; 0.4%), volcanic glass shatter (n=2; 0.4%), basalt flake with retouch (n=1; 0.2%), and a cryptocrystalline core (n=1; 0.2%). Tools trail in frequency (n=6), representing only 1.3% of the Wind Farm assemblage. Tools are comprised of fragmentary flake tools (n=2; 0.4%), basalt awl (n=1; 0.2%), basalt flake tool (n=1; 0.2%), coral abrader (n=1; 0.2%), and fragmentary coral abrader (n=1; 0.2%). Other artifacts include an Echinoid spine bead preform (n=1; 0.2%) (Figure 167), cone shell bead (n=1; 0.2%), modified piece of basalt (n=1; 0.2%), modified burnt bone fragment (n=1; 0.2%), and a chunk of plaster/mortar conglomerate (n=1; 0.2%).

Complete artifact/manuport tables with stratigraphic data and catalogues for each tested Wind Farm site are located in Appendix C.

As previously mentioned, the majority of test units were performed in Wind Farm sites with 24 units containing cultural materials (Table 12), which explains the relatively high frequency of artifacts in this portion of the project area. The Wind Farm test excavation (concentrating on artifacts and manuports) are briefly summarized by site below.

Site 50-50-15-6832, Feature A (U-shaped wall). This feature contained two pieces of unworked coral, all coming from Layer II.

Site 50-50-15-6833, Feature A (C-shaped wall). A basalt flake, echinoid spine bead preform, three pieces of unworked coral, and a single *'ili'ili* were collected from this C-shaped enclosure. Layer I bore the single basalt flake. Layer II bore the echinoid spine bead preform, unworked coral, and *'ili'ili.*

Site 50-50-15-6838, Feature G (wall). This wall also bore 15 lithic artifacts (7.9% of total Wind Farm artifacts), including basalt flakes (n=7), basalt flake fragments (n=5), and basalt shatter (n=3). All artifacts were collected from Layer I.

Site 50-50-15-6839, Feature B (terrace with windbreak). Two basalt flakes and a single piece of unworked coral were collected from this site. Layer I contained one basalt flake. Layer II contained a basalt flake and a piece of unworked coral.

Site 50-50-15-6848 (habitation complex). This site had the highest total of Wind Farm excavations artifacts (n=43; 22.5%), most of which were lithics, obtained from five individual test excavations with units in Features A, E, I, J, and L.

- **Feature A (cleared area with windbreak)**. This feature yielded basalt flakes (n=7), basalt flake fragments (n=8), fragmentary basalt flake fragment (n=1), volcanic glass flake (n=1), volcanic glass shatter (n=1), and one *'ili'ili.* Layer I contained the bulk of artifacts (n=15), which included basalt flakes (n=6), basalt flake fragments (n=8), and volcanic glass shatter (n=1). Layer II/III contained a basalt flake, a volcanic glass flake, and an *'ili'ili.*
- **Feature E (terrace, stone filled).** A single cryptocrystalline core was found in Layer I (ca. 0-15 cmbs).
- **Feature I (terrace).** This feature contained basalt flakes (n=5), basalt flake fragments (n=5), basalt shatter (n=5), and volcanic glass flake fragments (n=3), and modified basalt (n=1). The surface of the test unit bore a piece of modified basalt. Layer I contained only basalt shatter (n=2) and unworked coral (n=1). Layer II contained the bulk of the artifacts (n=14), comprised of basalt flakes (n=4), basalt flake fragments (n=4), basalt shatter (n=3), volcanic glass flake fragments (n=3), *'ili'ili* (n=2), and unworked coral (n=11). Layer III contained only a basalt flake and flake fragment.
- **Feature J (terrace, stone filled).** The terrace bore a single basalt core and volcanic glass flake fragment as well as a coral abrader and one piece of unworked coral. The wall fall contained a single coral abrader and the surface bore a single basalt core. Layer I contained a volcanic glass flake

fragment and a piece of unworked coral.

- **Feature L (terrace, soil filled).** This feature contained one volcanic glass flake fragment and shatter, all from Layer I.

Site 50-50-15-6851, Feature B (enclosure). This feature contained 6.3% of total Wind Farm artifact assemblage, including basalt flakes (n=10), basalt shatter (n=1), basalt flake with retouch (n=1), as well as unworked coral (n=3). All cultural materials were collected from Layer II.

Site 50-50-15-6852 (complex). This site was tested in Features A and I, bearing a total of two artifacts and 48 manuports.

- **Feature A (enclosure).** This enclosure contained a basalt awl (n=1), unworked coral (n=13), and *'ili'ili* (n=16). Layer I bore the basalt awl as wells as three pieces of unworked coral and three *'ili'ili.* Layer II contained a significant amount of manuports, including ten pieces of unworked coral and 13 *'ili'ili.*
- **Feature I (U-shaped wall).** A single basalt flake, unworked coral (n=10), and *'ili'ili* (n=9) were collected from this feature. The surface bore a basalt flake and one piece of unworked coral. Layer II contained unworked coral (n=9) and *'ili'ili* (n=9).

Site 50-50-15-6853, Feature A (enclosure). One basalt flake, a basalt flake fragment, and a piece of unworked coral were collected from this feature. Layer I contained the unworked coral and Layer II contained the two lithic artifacts.

Site 50-50-15-6854, Feature C (C-shaped wall). This feature contained a single *'ili'ili* that was collected from Layer II.

Site 50-50-15-6855, Feature A (C-shaped wall). A single basalt flake fragment and nine unworked coral pieces were collected from this feature. Layer I bore two unworked coral pieces. Layer II contained the basalt flake fragment and six pieces of unworked coral. Layer III contained a single piece of unworked coral.

Site 50-50-15-6857, Feature A (habitation terrace). This terrace feature contained 16 artifacts (8.4% of total Wind Farm artifacts) and yielded a wide variety of lithics (n=15), including basalt flakes (n=5), basalt flake fragments (n=2), basalt core (n=1), basalt shatter (n=1), volcanic glass flakes (n=4), and spent volcanic glass cores (n=2). This feature also contained a chunk of plaster/mortar conglomerate and four *'ili'ili.* Layer I contained the greater part of the collection from this feature, including all lithic artifacts but one (n=14), one plaster and mortar conglomerate, and four *'ili'ili.* Layer II contained a single basalt flake fragment.

Site 50-50-15-6860, Feature B (terrace). A single fragmentary coral abrader, *'ili'ili* (n=16), and unworked coral (n=11) were collected from this terrace. Layer I contained nine *'ili'ili* and eight unworked coral. Layer II bore the fragmentary coral abrader as well as *'ili'ili* (n=7) and unworked coral pieces (n=3).

Site 50-50-15-6861, Feature A (habitation terrace). This terrace contained the highest density of artifacts from a single test unit in the Wind Farm area (n=40; 20.9% of total Wind Farm artifacts), with an assemblage comprised solely of lithics, including basalt flakes (n=22), basalt flake fragments (n=11), basalt shatter (n=6), and one basalt core. Layer I bore a basalt core (n=1), basalt flakes (n=19), basalt flake fragments (n=11), and basalt shatter (n=6). Layer II contained three basalt flakes.

Site 50-50-15-6864 (habitation/ceremonial complex). A total of 41 artifacts (21.5%of total Wind Farm artifacts) and 134 manuports (52.5% of total Wind Farm manuports) were collected from this complex, which came from four test units placed in Features A, C, E, and I.

- **Feature A (habitation terrace).** This feature yielded mainly basalt flakes (n=21) and basalt flake fragments (n=14), but also contained a fragmentary basalt flake tool, and modified burnt bone fragment – all collected from Layer I.
- **Feature C (terrace with overhang).** One basalt flake, an unworked coral, and an *'ili'ili* was collected from this feature. Layer I contained all artifacts and manuports for the test unit.
- **Feature E (habitation C-shaped wall/ windbreak)**. The test unit contained no artifacts, but contained a significant amount of unworked coral (n=130) and minor amounts of *'ili'ili* (n=2). All artifacts and manuports were collected in the rock fill.
- **Feature I (terrace with surface hearth)**. This feature yielded only three basalt flakes, all collected from Layer I.

Site 50-50-15-6951, Feature C (cleared area with windbreak). A total of 14 artifacts (7.3% of total Wind Farm artifacts), which included a fair amount of lithics (n=12), including basalt flakes (n=6), basalt flake fragments (n=4), basalt shatter (n=2), and basalt flake tool (n=1) were collected from the cleared flat. This feature also contained a single human incisor, a cone shell bead, four pieces of unworked coral, and a single *'ili'ili.* Layer I yielded a basalt flake tool and a piece of unworked coral. Layer II contained the bulk of this feature's artifact/manuports assemblage, including basalt flakes (n=5), basalt flake fragments (n=4), basalt shatter (n=2), cone shell bead (n=1), as well as unworked coral (n=2) and *'ili'ili* (n=1). Layer III bore a basalt flake and a piece of unworked coral.

Test excavated sites bear artifact and manuport assemblages suggestive of what activities were taking place and how they might differ between individual features within the site. The majority of tested Wind Farm sites have significant amounts of basalt, volcanic glass and/or cryptocrystalline, in the form of flakes, debitage, and tools. Lithic artifacts are found to be either products or by-products of stone tool manufacture, repair, and/or use. Tools from the Wind Farm test excavations assemblage appear to have been used for a variety of activities, such as manufacture and/or repair of stone tools, manufacture of wood, gourd, or bone artifacts, finishing of bone, gourd, or wood artifacts, and butchery.

While the majority of artifacts were made of stone, artifacts made of coral, shell, bone, and historic plaster/mortar were found as well. Site 6833, Feature A (enclosure) contained an echinoid spine bead preform (Figure 167). Site 6848, Feature J (stone filled terrace) produced a single coral abrader. A fragmentary coral abrader was collected from 6860, Feature B. Additionally, a modified burnt bone fragment and single cone shell bead were collected from Sites 6864 and 6951, respectively. The only historic artifact, a chunk of plaster and mortar conglomerate, was collected from Site 6857, Feature A (habitation terrace).

Several Wind Farm sites yielded significant amounts of manuports. Unworked coral, in various states of wear and fragmentation, is the most common type of manuport (n=192), followed by waterworn basalt pebbles, or *'ili'ili* (n=54), and unworked pumice (n=9) (Table 12; Figure 140). Site 6864, Feature E (habitation C-shape/windbreak) contained the highest amount of unworked coral (n=130). Site 6852 followed in unworked coral frequency (n=23), with Feature A (enclosure) containing 13 pieces and Feature I (U-shaped enclosure) containing ten pieces. Feature I of Site 6848 (walled terrace) contained 12 pieces. Feature B of Site 6860 (terrace) yielded 11 pieces. The sites with the greatest amount of waterworn basalt pebbles (*'ili'ili*) were Sites 6851, Feature B (enclosure), and 6860, Feature B (terrace), both containing 16 individual (*'ili'ili*). Site 6855, Feature A (C-shape) produced nine (*'ili'ili*). Only found in Site 6852, Feature I (U-shaped enclosure), unworked pumice was the least common manuport (n=9).

Table 12. Test Excavations — Artifact and Manuport Table for Wind Farm Sites

SIHP No. (50-50-xx-xxxx)	6832 A	6833 A	6838 G	6839 B	6848 A	6848 E	6848 I	6848 J	6848 L	6851 B	6852 A	6852 I	6853 A	6854 C	6855 A	6857 A	6860 B	6861 A	6864 A	6864 C
Artifacts																				
Lithics	**0**	**1**	**15**	**2**	**17**	**1**	**18**	**2**	**2**	**12**	**0**	**1**	**2**	**0**	**1**	**15**	**0**	**40**	**35**	**1**
Basalt Core								1								1		1		
Basalt Flake		1	7	2	7		5			10		1	1			5		22	21	
Basalt Flake Fragment			5		8		5						1		1	2		11	14	
Basalt Flake w/Retouch										1										
Basalt Shatter			3				5			1						1		6		
Cryptorystalline Core						1														
Volcanic Glass Core, spent																2				
Volcanic Glass Flake					1											4				
Volcanic Glass Flake Fragment							3	1	1											
Volcanic Glass Shatter					1				1											
Tools	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**
Basalt Awl											1									
Basalt Flake Tool																				
Basalt Flake Tool, fragmentary					1														1	
Coral Abrader								1												
Coral Abrader, fragmentary																	1			
Miscellaneous	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
Echinoid Spine Bead Preform		1																		
Modified Basalt							1													
Modified Burnt Bone																			1	
Shell Bead, Conus sp.																				
Historics	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
Plaster/Mortar Conglamorate																1				
Artifacts Totals	**0**	**2**	**15**	**2**	**18**	**1**	**19**	**3**	**2**	**12**	**1**	**1**	**2**	**0**	**1**	**16**	**1**	**40**	**37**	**1**
Manuports																				
Unworked Coral	2	3		1			12	1		3	13	10	1				11			
Waterworn Basalt Pebble (*`ili`ili*)		1			1		2				16			1	9	4	16			
Unworked Pumice												9								
Manuports Totals	**2**	**4**	**0**	**1**	**1**	**0**	**14**	**1**	**0**	**3**	**29**	**19**	**1**	**1**	**9**	**4**	**27**	**0**	**0**	**2**
Totals	**2**	**6**	**15**	**3**	**19**	**1**	**33**	**4**	**2**	**15**	**30**	**20**	**3**	**1**	**10**	**20**	**28**	**40**	**37**	**3**

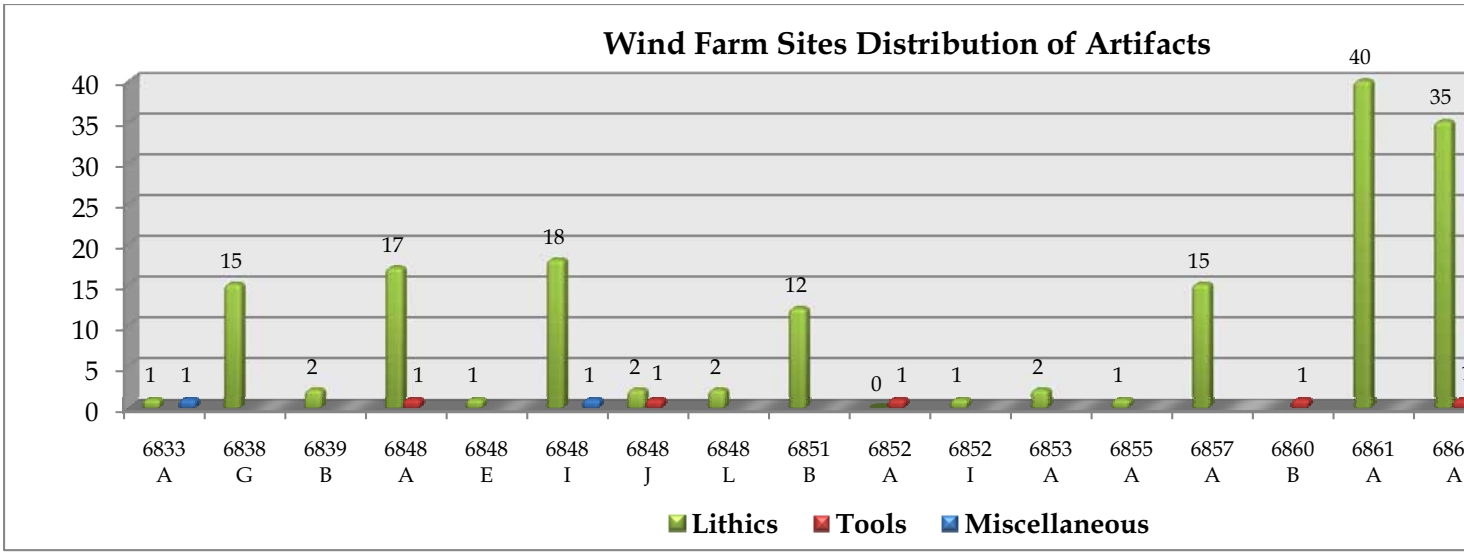


Figure 139. Chart depicting distribution of artifacts collected from Wind Farm sites test excavations.

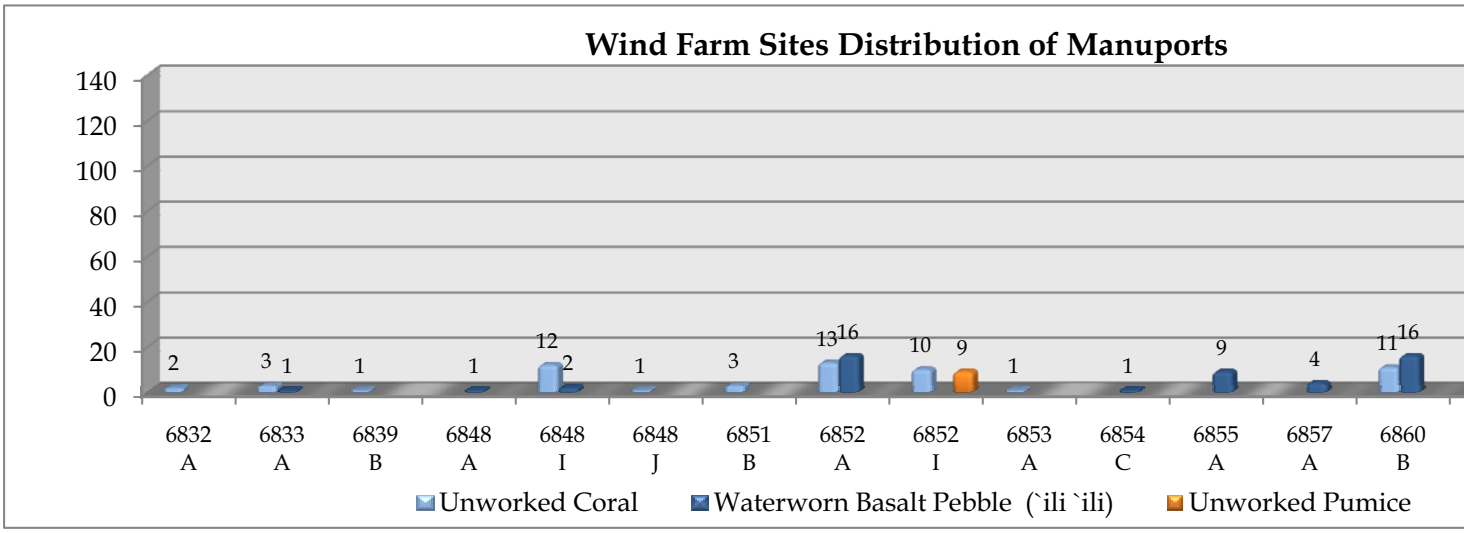


Figure 140. Chart depicting distribution of manuports collected from Wind Farm sites test excavations.

6.1.1.2 Generator-Tie Line Test Excavations. Two test units from Sites 50-50-14-6865 (agricultural complex) and 50-50-15-6871 (habitation complex) along the Generator-Tie Line Corridor contained a total of 18 artifacts and 37 manuports (Table 13; Figure 141). The most common cultural material collected was unworked coral (n=37; 67.3%). Site 6865, Feature C bore 27 pieces of unworked coral and 6871, Feature B yielded ten pieces. The artifact assemblage consisted primarily of lithics (n=12; 25.5%), with Site 6865- C producing basalt flakes (n=7) and 6871-B yielding basalt flakes (n=5), basalt flake with polish (n=1), and volcanic glass flake (n=1). Tools collected from the Generator-Tie Line sites represented only 7.3% (n=6) of the artifact assemblage, largely coming from Site 6871-B (n=5). While Site 6865-C yielded only a single coral abrader, Site 6871-C contained volcanic glass flake tools (n=2), a basalt flake tool (n=1), and coral abrader (n=1). Generator-Tie Line test excavations, with a focus on artifacts and manuports, are briefly summarized by site below.

Site 50-50-14-6865, Feature C (terrace and alignment). This feature contained 61.8% of the artifact/manuport assemblage, representing 38.9% of total artifacts and 73% of manuports collected from the Generator-Tie Line Corridor. The test unit surface yielded a basalt flake and eleven unworked coral pieces. Layer I contained a single basalt flake. Layer II bore the majority of artifacts and manuports, including basalt flakes (n=5), coral abrader (n=1), and unworked coral (n=16).

Site 50-50-15-6871, Feature B (U-shaped enclosure). This U-shaped enclosure yielded 32.8% of the artifact/manuport assemblage, but contained 61.1% of artifacts and 27% of manuports collected from the Generator-Tie Line Corridor. Layer I contained the majority of artifacts and manuports, including basalt flakes (n=5), basalt flake with polish (n=1), basalt flake tool (n=1), volcanic glass flake (n=1), volcanic glass flake tool (n=2), and unworked coral (n=8). Layer II bore a volcanic glass flake and two pieces of unworked coral.

The Generator-Tie Line artifact assemblage contained only artifacts of traditional manufacture made of local materials. The assemblage suggests that stone tool manufacture, repair, and use were common at these sites. The most common stone used was basalt (n=14) followed by volcanic glass (n=3). Coral, in various states of wear and fragmentation, appeared to have been transported to the sites (n=37), but less frequently used as a tool such as an abrader (n=1).

Table 13. Artifact and Manuport Table for Transmission Sites Test Excavations

SIHP No. (50-50-xx-xxxx)	6865, Fe. C	6871, Fe. B	Total	%
Artifacts				
Lithics	7	7	**14**	**25.5%**
Basalt Flake	7	5	**12**	**21.8%**
Basalt Flake w/Polish		1	**1**	**1.8%**
Volcanic Glass Flake		1	**1**	**1.8%**
Tools	1	3	**4**	**7.3%**
Basalt Flake Tool		1	**1**	**1.8%**
Volcanic Glass Flake Tool		2	**2**	**3.6%**
Coral Abrader	1		**1**	**1.8%**
Artifacts Totals	8	10	**18**	**32.7%**
Manuports				
Unworked Coral	27	10	**37**	**67.3%**
Manuports Totals	27	10	**37**	**67.3%**
Totals	**35**	**20**	**55**	**100%**

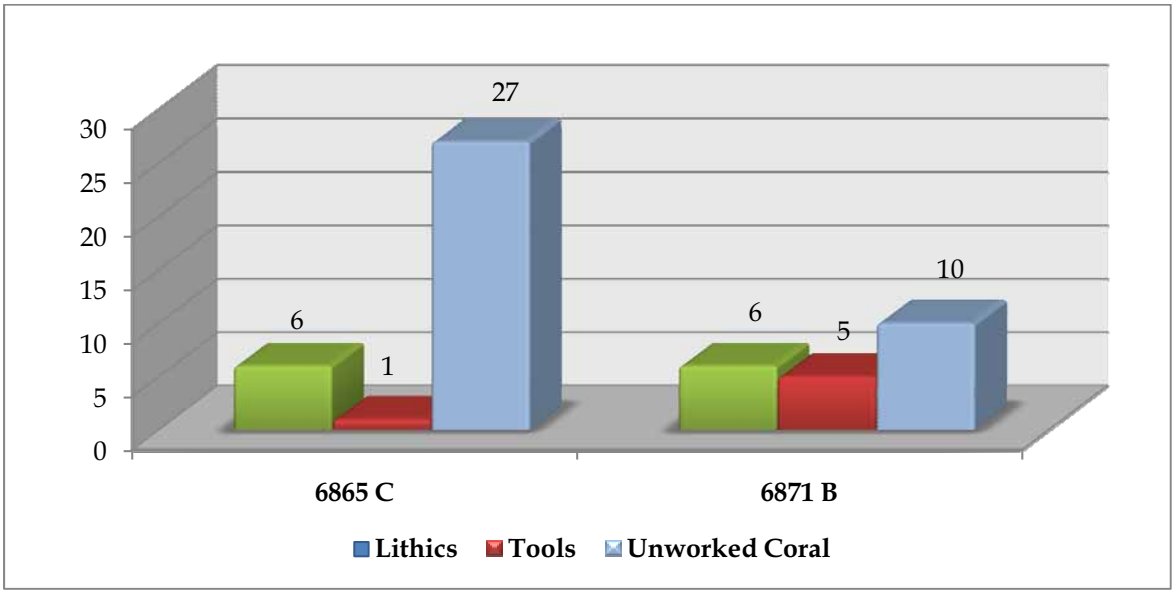


Figure 141. Distribution of Artifacts Collected from Generator-Tie Line Test Excavations.

6.1.1.3 Pāpaka Road Test Excavations. Five features in four sites were test excavated in the Pāpaka Road corridor, yielding a total of 156 artifacts and 23 manuports (Table 14; Figure 142). The most common artifact types in Pāpaka Road corridor were historic household and hardware artifacts (n=82; 45.8%), collected predominantly from Site 50-50-14-6931, Feature D (midden area with historic artifacts), which bore 81 of the 82 historic artifacts. The historic artifact assemblage is comprised of square metal nail fragments (n=32; 17.9%), glass bottle fragments of various colors (n=17; 9.5%), glass pane fragments of various colors (n=15; 8.9%), nondescript clear glass fragments (n=6; 3.4%), porcelain vessel sherds (n=5; 2.8%), various nondescript metal fragments (n=4; 2.2%), metal slotted flat head screw(n=1; 0.6%), and a

stoneware bottle sherd (n=1; 0.6%). Following in frequency were lithics (n=53; 29.6%), which were found in all but one Pāpaka Road site (Site 50-50-14-6943-A). Lithics were primarily basalt flakes (n=30; 16.8%), basalt flake fragments (n=6; 3.4%), basalt cores (n=4; 2.2%), and volcanic glass cores (n=4; 2.2%). Less frequently found were basalt flakes with polish (n=2; 1.1%) and cryptocrystalline cores (n=2; 1.1%). Minor amounts of basalt, cryptocrystalline, and volcanic glass debitage were also collected, each type representing less than 1% of the assemblage. A total of 20 tools, dominated by basalt flake tools (n=11), but also including volcanic glass flake tools (n=6), cryptocrystalline flake tools (n=2), and a single basalt awl were collected. Additionally, a single cone shell bead was collected. Manuports represented only 12.8% of the assemblage, consisting of unworked coral (n=13), unidentified minerals (black faceted crystals; n=7), and waterworn basalt pebble (*ʻiliʻili;* n=3). Pāpaka Road test excavations, focusing on artifacts and manuports, are briefly summarized by site below.

Site 50-50-14-6931, Feature D (midden area with historic artifacts). This feature contained 50.8% (n=91) of the entire Pāpaka Road excavations assemblage and 98.8% (n=81) of the entire historic artifact assemblage. However, it only contained 13.2% (n=7) of the lithics and 10% (n=2) of the tools assemblage as well as 33.3% (n=1) of *ʻiliʻili* collected. The surface of the test unit yielded a variety of historic bottle glass (n=10), pane glass (n=1), porcelain sherds (n=4), and a stoneware bottle fragment (n=1). Layer I (0-43 cmbs) contained cryptocrystalline cores (n=2), nondescript clear glass fragments (n=5), various glass bottle fragments (n=4), various glass pane fragments (n=6), square nail fragments (n=13), metal screw (n=1), various unidentified metal fragments (n=2), and an *ʻiliʻili* (n=1). Layer II bore the greater part of artifacts, including those of traditional manufacture, such as basalt flakes (n=3), cryptocrystalline flake (n=1), cryptocrystalline shatter (n=1), cryptocrystalline flake tools (n=2). Also collected from Layer II was the greatest amount of historic artifacts, including a nondescript clear glass fragment (n=1), aqua glass bottle fragments (n=2), cobalt glass bottle fragment (n=1), teal glass pane fragments (n=3), clear glass pane fragments (n=5), various unidentified metal fragments (n=3), square nail fragments (n=19), and a porcelain sherd fragment (n=1).

Site 50-50-14-6939 (agricultural and habitation complex). This complex was tested in two features, A and C, which yielded a total of 39 artifacts and manuports, representing 22.8% of Pāpaka Road collections.

- **Feature A (enclosure)** represented 14% (n=24) of the entire Pāpaka Road assemblage, comprised of lithics (n=11; 20.8%) and of tools (n=6; 30%) collected. It also contained 38.5% (n=5) of unworked coral and 33.3% (n=1) of *ʻiliʻili* collected from Pāpaka Road. Layer I contained the majority of artifacts and manuports, including a basalt core (n=1), basalt flakes (n=4), volcanic glass core (n=1), volcanic glass shatter (n=1), volcanic glass flake tools (n=5), cone shell bead (n=1), unworked coral (n=3), and *ʻiliʻili* (n=1). Layer II bore a basalt flake (n=1), basalt flake fragment (n=2), volcanic glass core (n=1), a volcanic glass flake tool (n=1), unworked coral (n=1), and an *ʻiliʻili* (n=1).
- **Feature C (terrace)** of the same site contained only 8.7% (n=15) of the artifact and manuport totals for Pāpaka Road, which was comprised of lithics (n=6; 11.3%), tools (n=3; 15.2%), and unworked coral (n=6; 42.2%). All collections were from Layer II.

Site 50-50-14-6940, Feature H (terrace). This terrace contained 20.1% (n=36) of the artifact/manuport assemblage, which represented 52.8% (n=28) of lithics collected and 40% (n=8) of tools collected. Layer I contained the majority of artifacts collected, including basalt cores (n=2), basalt flakes (n=12), basalt flake fragments (n=2), basalt flakes with polish (n=2), basalt flake tools (n=8), and volcanic glass cores (n=2). Layer II bore basalt flakes (n=7) and a volcanic glass flake fragment (n=1).

Site 50-50-14-6943, Feature B (mound, east half). The collections from this mound represented a mere 1.1% (n=2) of the entire Pāpaka Road assemblage, comprised solely of manuports, including 7.7% (n=1) of the unworked coral and 33.3% (n=1) of *ʻiliʻili* collected. Both unworked coral and *ʻiliʻili* were collected from the rock fill.

Site 50-50-14-6956 (large enclosure). This large enclosure contained 6.1% (n=11) of the artifact/manuport assemblage, representing 1.9% (n=1) of lithics, 5% (n=1) of tools, 1.2% (n=1) of historic artifacts, 100% of unidentified black faceted minerals (n=7), and 7.7% (n=1) of unworked coral collected. Layer I contained a single piece of unworked coral. Layer II contained the unidentified black faceted minerals, a basalt core, basalt flake tool, and a clear glass pane fragment.

Test excavated sites bore artifact and manuport assemblages suggestive of what activities were taking place within the sites and provide some information on site chronologies. Site 50-50-14-6931, Feature D, a midden and historic artifact scatter, contained a substantial amount of historic artifacts (Figure 142), which were collected from Layer I to nearly the base of Layer II. Yet, the feature contained a fair amount of traditional artifacts, including a variety of lithics and tools made of local and historic imported materials in Layers I and II. Thus, the inhabitants of the site had access to historic imported goods from the initial to final use of the site, but made use of local and imported materials as traditional tools to facilitate daily tasks. Site 50-50-14-6939, an agricultural/habitation complex, was test excavated in Features A (enclosure) and C (terrace), which produced only traditional artifacts, including a variety of lithics, stone tools, along with a single cone shell bead. A substantial amount of unworked coral (n=11) was collected from Site 6939, Features A and C, also indicative of traditional practices. Therefore, this site appears to be pre-Contact or early Contact period. In addition, the test excavation in Feature H (terrace) of Site 6940, an agricultural/habitation complex, contained the greatest amount of traditional lithic artifacts (n=28) and tools (n=8), which were either flake tools or unmodified flakes. No historic artifacts were collected from Site 6940. Hence, this site was also likely pre-Contact or early Contact. Site 6956, a large enclosure possibly used for animal husbandry, contained mostly pre-Contact cultural material, including basalt lithics and tools as well as unworked coral. A single historic artifact, consisting of a single clear glass pane fragment, was collected from the middle of Layer II (35-45 cm bs). Thus traditional activities, such as basalt tool manufacture and use, were occurring into the historic era.

Table 14. Artifact and Manuport Table for Pāpaka Road Test Excavations

Site AWF -	6931 D	6939 A	6939 C	6940 H	6943 B	6956 F	Total	%
Artifacts								
Lithics	**7**	**11**	**6**	**28**	**0**	**1**	**53**	**29.6%**
Basalt Core		1		2		1	**4**	**2.2%**
Basalt Flake	3	5	3	19			**30**	**16.8%**
Basalt Flake Fragment		2	2	2			**6**	**3.4%**
Basalt Flake w/ polish				2			**2**	**1.1%**
Basalt Shatter			1				**1**	**0.6%**
Cryptocrystalline Core	2						**2**	**1.1%**
Cryptocrystalline Flake	1						**1**	**0.6%**
Cryptocrystalline Shatter	1						**1**	**0.6%**
Volcanic Glass Core		2		2			**4**	**2.2%**
Volcanic Glass Flake Fragment				1			**1**	**0.6%**
Volcanic Glass Shatter		1					**1**	**0.6%**
Tools	**2**	**6**	**3**	**8**	**0**	**1**	**20**	**11.2%**
Basalt Awl			1				**1**	**0.6%**
Basalt Flake Tool			2	8		1	**11**	**6.1%**
Crypto Crystalline Flake Tool	2						**2**	**1.1%**
Volcanic Glass Flake Tool		6					**6**	**3.4%**
Miscellaneous	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0.6%**
Shell Bead, Conus sp.		1					**1**	**0.6%**
Historic Artifacts	**81**	**0**	**0**	**0**	**0**	**1**	**82**	**45.8%**
Glass Fragment, clear	6						**6**	**3.4%**
Glass Bottle Fragment, amethyst	3						**3**	**1.7%**
Glass Bottle Fragment, aqua	4						**4**	**2.2%**
Glass Bottle Fragment, aqua-blue	2						**2**	**1.1%**
Glass Bottle Fragment, aqua-green	3						**3**	**1.7%**
Glass Bottle Fragment, brown	1						**1**	**0.6%**
Glass Bottle Fragment, clear	1						**1**	**0.6%**
Glass Bottle Fragment, cobalt	1						**1**	**0.6%**
Glass Bottle Fragments, olive	2						**2**	**1.1%**
Glass Pane Fragment, aqua	6						**6**	**3.4%**
Glass Pane Fragment, teal	3						**3**	**1.7%**
Glass Pane Fragment, clear	6					1	**7**	**3.9%**
Metal Fragment, flat/sheet	1						**1**	**0.6%**
Metal Fragment, unidentified	2						**2**	**1.1%**
Metal Nail Fragment, square	32						**32**	**17.9%**
Metal Screw, slotted flat head	1						**1**	**0.6%**
Metal Shank Fragment	1						**1**	**0.6%**
Porcelain Sherd, Celadon	1						**1**	**0.6%**
Porcelain Vessel Sherds, Asian	2						**2**	**1.1%**
Porcelain Vessel Sherds, Celadon	2						**2**	**1.1%**
Stoneware Bottle Fragment	1						**1**	**0.6%**
Artifacts Totals	**90**	**18**	**9**	**36**	**0**	**3**	**156**	**87.2%**
Manuports								
Unworked Coral		5	6		1	1	**13**	**7.3%**
Waterworn Basalt Pebble (*ʻiliʻili*)	1	1			1		**3**	**1.7%**
Unidentified Mineral, black faceted crystals						7	**7**	**3.9%**
Manuports Totals	1	6	6	0	2	8	**23**	**12.8%**
Totals	**91**	**24**	**15**	**36**	**2**	**11**	**179**	**100%**

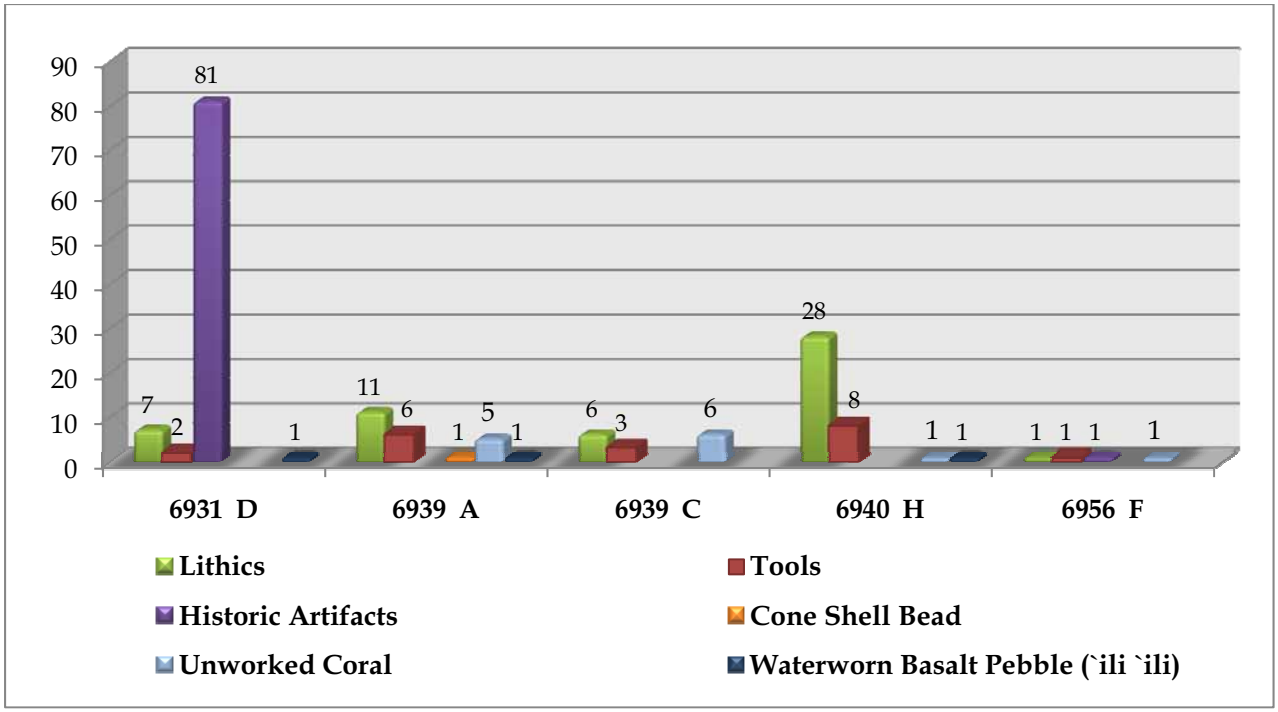


Figure 142. Pāpaka sites distribution of artifacts collected from test excavations.

6.1.2 Surface Collections

A total of 43 artifacts (72.9% of total surface collections) and 16 manuports (27.1% of total surface collections) were obtained from the surface of sites from Wind Farm Site, the Generator-Tie Line Corridor, and the Pāpaka Road Corridor (Table 15). These artifacts and manuports have been separated from the controlled test excavation collections as they lack detailed provenience information and, thus, add little to the interpretation of archaeological sites. The majority of surface collections are from Wind Farm sites (36 artifacts and 16 manuports), followed by artifacts from Generator-Tie Line Corridor (n=5), and Pāpaka Road Corridor sites (n=2). Detailed tables and catalogues of surface collections can be found in Appendix D.

Surface collections from Wind Farm, Generator-Tie Line, and Pāpaka areas consist primarily of traditional tools manufactured out of local Hawaiian materials and exotic materials likely brought in raw form to the islands as ballast in the historic era. Tools, comprising 35.6% of the total surface assemblage, include several polished basalt adzes, or *ko'i,*(n=4), basalt adze tang (n=1), basalt awls (n=2), discoidal basalt hammerstone (n=2), spherical basalt hammerstone (n=1), waterworn basalt hammerstone (n=1), double-ended basalt pestle, or *pōhaku ku'i,* (n=1), the base/body portion of a granite poi pounder, or *pōhaku ku'i poi*, (n=1), coral abraders (n=5), fragmentary coral abrader (n=1), coral abrader fragment (n=1), and a fragmentary *pāhoehoe* grinding slab. Lithic artifacts, which represent about 15% of the surface collections, include a basalt adze preform (n=1), basalt adze preform fragment (n=1), basalt cores (n=2), basalt flakes (n=4), and basalt flake with polish (n=1). Several fishing implements, representing 8.5% of the surface collections, were also collected, consisting of a basalt coffee bean sinker (n=1), granite coffee bean sinker (n=1), finished (n=2) and unfinished (n=1) cowrie shells modified for use as octopus lures, or *lūhe'e*.

Table 15. Surface Collections — Artifact and Manuport Table by Site

SIHP No. (50-50-xx-xxxx)-	Field No. (AWF-xxx)	Artifact	Quantity	Totals
Wind Farm Sites				
6821	091/092/093	Coral Abrader	1	**1**
6840 C	176	Basalt Core	2	**4**
		Basalt Awl	1	
		Granite Coffee Bean Sinker (*pōhaku lūhe'e*)	1	
6840 D	176	Basalt Flake	4	**4**
6840 K	176	Basalt Hammerstone, discoidal	1	**1**
6841	180/546	Basalt Flake w/polish	1	**2**
		Basalt Waterworn Hammerstone	1	
6864	216	Cowrie Shell Lure, shell portion (*lūhe'e*)	1	**14**
		Bone Fragments, unidentified marine mammal	12	
		Branch Coral Fragment	1	
6881 C	270/271	Basalt Adze (*ko'i*) Fragment, tang portion	1	**1**
6906	359/488	Basalt Adze (*ko'i*), polished	1	**9**
		Basalt Pestle (*pōhaku ku'i*), double-ended	1	
		Pāhoehoe Grinding Slab, fragmentary	1	
		Coral Abrader	2	
		Cowrie Shell Lure (*lūhe'e*), unfinished, shell portion	1	
		Basalt Game Stone (*'ulu maika*), discoidal	1	
		Iron Curb Bit (horse tack)	1	
		Iron Flensing Tool (whale butchering), tip portion	1	
6909	395/398	Coral Abrader	1	**1**
6910	423 thru 430	Coral Abrader, fragmentary	1	**3**
		Coral Abrader Fragment	1	
		Basalt Coffee Bean Sinker (*pōhaku lūhe'e*)	1	
6911 C	440	Granite Poi Pounder (*pōhaku ku'i poi*), fragmentary	1	**2**
		Glass Utility Bottle, aqua	1	
6919	495	Glass Bead, faceted, clear	1	**1**
6925	559	Cowrie Shell Lure (*lūhe'e*), shell portion	1	**1**
6951	2010 A	Basalt Awl	1	**5**
		Coral Abrader	1	
		Dog Tooth, premolar	1	
		Shark Tooth, *Triaenodon obesus*	2	
6952	2010 B	Basalt Hammerstone, spherical	1	**1**
6953	2010 C	Basalt Adze Preform	1	**1**
7030	2010 DDDD	Basalt Hammerstone, discoidal	1	**1**
Generator-Tie Line Sites				
7033	2010 GG	Basalt Adze (*ko'i*) Preform Fragment	1	**1**
6988	2010 KK	Iron, clothing, 6 lb.	1	**1**
7022	2010 SSS	Basalt Adze (*ko'i*), polished	1	
		Basalt Game Stone (*'ulu maika*), discoidal	1	**2**
Isolate Find	Isolate Find	Glass Bottle, clear, soda	1	**1**
Pāpaka Road Sites				
7020	2010 QQQ	Basalt Adze (*ko'i*), polished	2	**2**
Surface Finds Total				**59**

6.1.2.1 Wind Farm Sites Surface Collections. The majority of surface collections come from the Wind Farm portion of the projected Auwahi Wind Farm APE (n=52; 88.1%; Table 16). The Wind Farm surface collection is primarily tools (n=18; 34.6%; Figure 143), comprised of a polished basalt adze (n=1), basalt adze tang (n=1), basalt awls (n=2), basalt discoidal hammerstone (n=2), basalt spherical hammerstone (n=1), waterworn basalt hammerstone (n=1), double-ended basalt pestle (n=1), fragmentary granite poi pounder (base/body portion; n=1), coral abraders (n=5), fragmentary coral abrader (n=1), coral abrader fragment (n=1), and fragmentary *pāhoehoe* grinding slab (n=1). Following in frequency were lithics (n=8; 15.4%), including a basalt adze preform (n=1), basalt cores (n=2), basalt flakes (n=4), and basalt flake with polish (n=1). Fishing gear (n=5), only found in Wind Farm sites, represented only 9.6% of Wind Farm surface collections and was comprised of 1 basalt and 1 granite coffee bean sinkers, two modified cowrie shells intended for use as octopus lures (*lūheʻe*). A number of manuports were collected from two Wind Farm sites, 6864 and 6952, which consisted of branch coral (n=1), unidentified marine mammal bone fragments (n=12), dog premolar (n=1), and shark teeth (n=2). Although these items are faunal remains they were grouped in with manuports rather than midden, because of the context in which they were found (see Section 5).

Sites 6840 and 6906 contained the highest frequencies of surface artifacts, both yielding nine artifacts apiece (Table 16). Site 6840, Features C, D, and K are features in a habitation, agricultural, and ceremonial complex, bearing mostly lithics, including basalt cores (n=2) and basalt flakes (n=4) as well as tools such as a basalt awl (n=1) and basalt discoidal hammerstone (n=1). Site 6906 contained mostly traditional tools, including a polished basalt adze (n=1), double-ended basalt pestle (n=1), coral abraders (n=2), and *pāhoehoe* slab grinding stone (n=1). This site also contained other traditional items, including a cowrie shell modified for use as an octopus lure and a basalt *ʻulu maika.* Historic artifacts from this site included an iron curb bit and iron flensing tool tip, originally used by whalers to de-flesh whales, but likely reused as a farming implement. In these cases, surface collections, to some degree, shed some insight on site function. However, most other sites contained artifacts that were collected because they were good examples of the artifact type or unique examples of an artifact type.

Table 16. Wind Farm Sites Surface Collection Table

SHIP No. (50-50-xx-xxxx)	6821	6840 C, D, K	6841	6864	6881 C	6906	6909	6910	6911 C	6919	6925 II	6951	6952	6
Artifacts														
Lithics	**0**	**6**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Basalt Adze Preform														
Basalt Core		2												
Basalt Flake		4												
Basalt Flake w/Polish			1											
Tools	**1**	**2**	**1**	**0**	**1**	**5**	**1**	**2**	**1**	**0**	**0**	**2**	**1**	
Basalt Adze (*koi*) Fragment, tang portion					1									
Basalt Adze (*koi*), polished						1								
Basalt Awl		1										1		
Basalt Hammerstone, discoidal		1												
Basalt Hammerstone, spherical													1	
Basalt Waterworn Hammerstone			1											
Basalt Pestle (*Pohaku ku'i*), double-ended						1								
Granite Poi Pounder (*Pōhaku ku'i poi*), fragmentary									1					
Coral Abrader	1					2	1					1		
Coral Abrader, fragmentary								1						
Coral Abrader Fragment								1						
Pāhoehoe Grinding Slab, fragmentary						1								
Fishing Gear	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	
Basalt Coffee Bean Sinker (*Pohaku luhe'e*)								1						
Granite Coffee Bean Sinker (*Pohaku luhe'e*)		1												
Cowrie Shell Lure (*luhe'e*), shell portion				1							1			
Cowrie Shell Lure (*luhe'e*), unfinished, shell portion						1								
Recreational	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Basalt Game Stone, discoidal (*Ulu Maika)*						1								
Historic Artifacts	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	
Glass Bead, faceted, clear										1				
Glass Utility Bottle, aqua									1					
Iron Curb Bit						1								
Iron Flensing Tool, tip portion						1								
Artifacts Totals	**1**	**9**	**2**	**1**	**1**	**9**	**1**	**3**	**2**	**1**	**1**	**2**	**1**	
Manuports														
Branch Coral Fragment				1										
Bone Fragments, unid. marine mammal				12										
Dog Tooth, *C. lupus familiaris*, premolar												1		
Shark Tooth, *Triaenodon obesus*												2		
Manuports Totals	**0**	**0**	**0**	**13**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	
Totals	**1**	**9**	**2**	**14**	**1**	**9**	**1**	**3**	**2**	**1**	**1**	**5**	**1**	

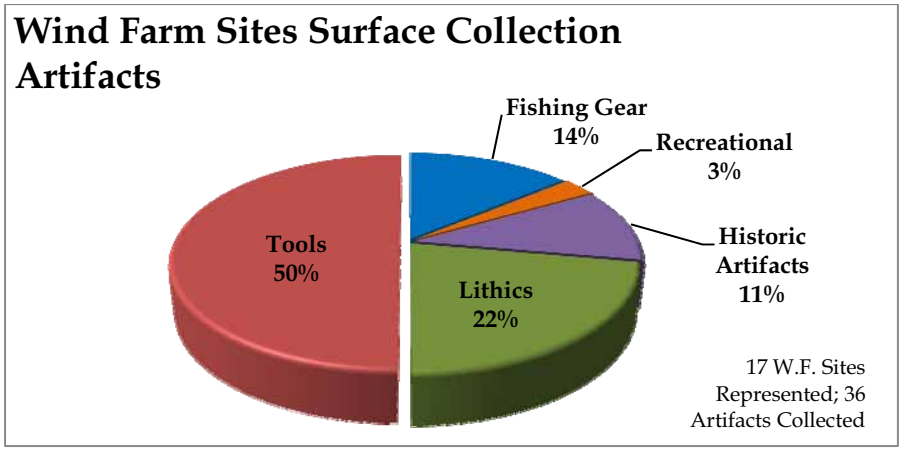


Figure 143. Pie chart of Wind Farm surface collection artifact frequencies.

6.1.2.2 Generator-Tie Line Corridor Surface Collections. A total of five artifacts were collected from three sites and one isolated location within the Generator-Tie Line Corridor (Table1 5). Three, comprising 60% of the Generator-Tie Line surface collection assemblage, are traditional, including a basalt adze preform fragment (Figure 144), a complete polished basalt adze (Figure 151), and a basalt ʻ*ulu maika* (Figure 166). Two historic artifacts were collected, including a 6 lb. clothing iron (Figure 171) and a clear glass soda bottle (Figure 169), making up 40% of the assemblage (Figure 144).

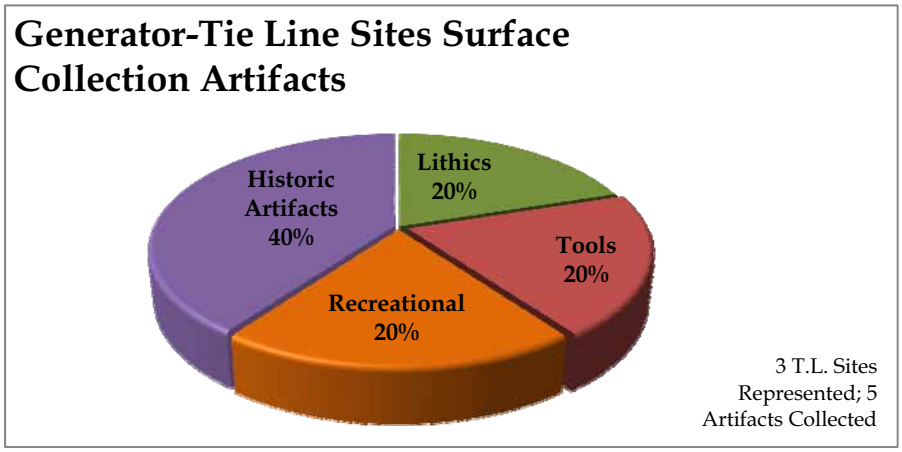


Figure 144. Pie chart of Generator-Tie Line surface collection artifact frequencies.

6.1.2.3 Pāpaka Road Corridor Surface Collections. Only two artifacts were collected from the Pāpaka Road Corridor during surface collections, both of which were collected from Site 50-50-14-7020 (Table 15). The artifacts collected consisted of one small polished basalt adze (Figure 149) and one large polished basalt adze (Figure 150).

6.1.3 Artifact Descriptions

A great variety of artifacts were collected from the proposed Auwahi Wind Farm APE, covering a diversity of form, function, period of manufacture, and material of manufacture. Detailed information regarding artifact and manuport provenience and statistical breakdown by site can be found in Appendix D. Following are general descriptions by artifact type.

6.1.3.1 Lithics. A total of 256 lithic artifacts were collected during test excavations and surface collections in the Auwahi Wind Farm (Tables 12-16). Basalt was the most common material used for lithic artifacts. A total of 230 basalt lithics were collected, including cores (n=9), adze preform (n=1), adze preform fragment (n=1), flakes (n=138), flake fragments (n=57), flakes with polish (n=4), flake with retouch (n=1), and shatter (n=19) were collected from test units and during surface collections. Generally speaking, the basalt material in the lithic assemblage varies slightly in color, texture, and density. Colors vary from gray to dark gray. In terms of texture, the basalt varies from fine to medium grain, with a few rough grain basalt lithics. The density of basalt also ranges from dense basalt to semi-vesicular. Volcanic glass lithics follow in frequency (n=22) and found only in test excavations, with the majority being collected from Wind Farm sites (n=14), followed by Pāpaka Road (n=6), and Generator-Tie Line (n=2). The volcanic glass is vitreous and ranges in color from dark gray to black. Volcanic glass artifacts include, cores (n=4), spent cores (n=2), flakes (n=6), flake fragments (n=6), and shatter (n=3). Cryptocrystalline lithics were also found, predominantly in Pāpaka Road test excavations (n=4), consisting of cores (n=2), flakes (n=1), and shatter (n=1). A single cryptocrystalline core was found in the Wind Farm area. Cryptocrystalline materials range from vitreous to waxy in luster, translucent to semi-translucent in clarity, and range in color from tan to honey colored.

Basalt Adze Preform. One basalt adze preform was found during Wind Farm area surface collections. This adze preform is rectangular in plan, rectangular wedge in cross-section and appears to be in the early reduction phase. Flake scaring is visible on all sides with cortex covering most of one surface. This preform was possibly abandoned due to manufacturing or material defect. Its material is a medium to fine grain, dense gray basalt and measures 66.5 mm in length, 40 mm in width, 20.5 mm in thickness, and weighs 77.7 grams.

Basalt Adze Preform Fragment. One basalt adze preform fragment was found during surface collections at the Generator-Tie Line portion of Auwahi Wind Farm APE. This preform fragment is roughly rectangular in cross-section and represents the bevel and a portion of the blade (broken laterally mid-blade). There is no evidence of wear, grinding, or polish and is likely an unfinished adze that broke during its manufacture. The material is fine to medium grained, dense, dark gray basalt. It measures 90 mm in length, 64 mm in width, 24 mm in thickness, and weighs 107.5 grams (Figure 145).

Basalt Cores. Nine basalt cores were found in the Wind Farm and Pāpaka Road sites, which varied in stage of use, technique of flake removal, and material quality. Most cores display multiple multidirectional flake scars on multiple surfaces, with a wide diversity of flake scar size (Figure 146). Five out of nine basalt cores exhibit cortex on at least one surface, which suggest the core is in an early phase of usage. Material ranged from medium to fine grain, dense to semi-vesicular, and gray to dark gray basalt. Core

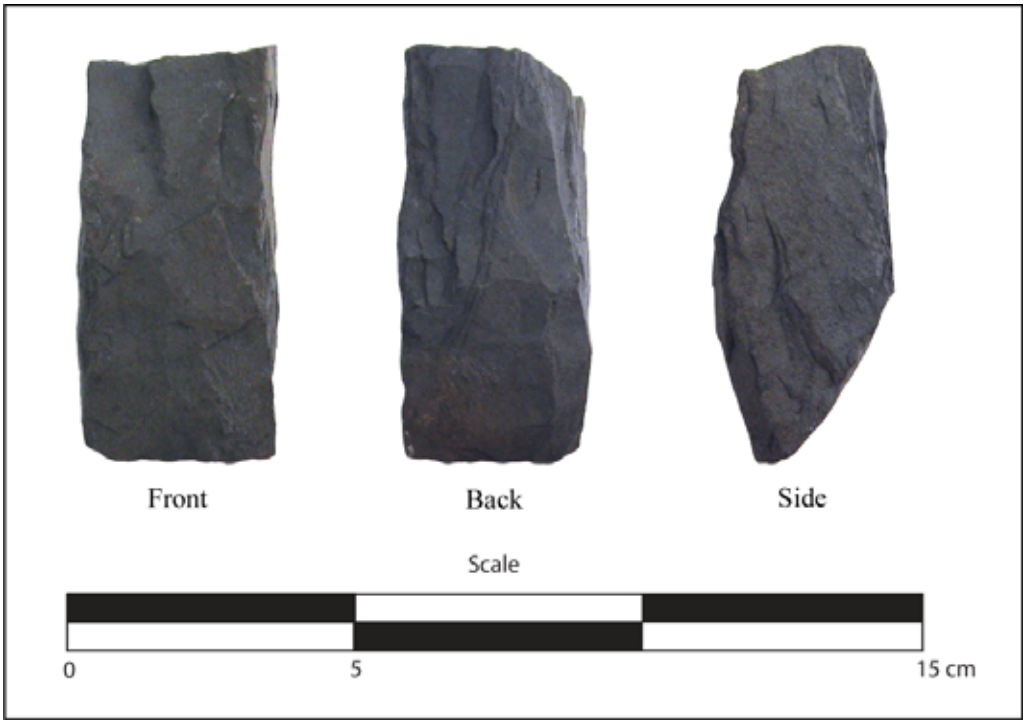


Figure 145. Basalt adze preform fragment from Site 50-50-15-6984 Feature C.

Figure 146. Basalt core from Site 50-50-15-6848 Feature J.

sizes ranged from 33.5 – 140 mm in length, 26 – 130 mm in width, 18 – 90 mm in thickness, and 13.4 grams to 1759.5 grams in weight. Basalt cores in Wind Farm sites are significantly larger than those collected from Pāpaka Road, while no basalt cores were collected from Generator-Tie Line sites.

Basalt Flakes. Basalt flakes were found in abundance throughout the Auwahi Wind Farm APE (n=138). Flakes were considered complete when they exhibited all of the attributes of a flake (i.e., platform, bulb, and margins). These ubiquitous artifacts represent various stages of tool manufacture, a variety of tools being manufactured, as well as an assortment of basalt types used. For example, 69 basalt flakes do not have visible cortex and 44 have at least one flake scar on the dorsal surface, which indicates that at least 50% of the basalt flake assemblage are not initial flakes and 32.1% of basalt flakes represent a later phase of manufacture or repair of flaked basalt tools. The majority of basalt flakes are made of fine to medium grained, gray to dark gray, and dense material. Basalt flake sizes range from 4.5 – 85 mm in length, 3 – 97 mm in width, 1 – 28 mm in thickness, and 0.1 grams to 178.4 grams in weight. Basalt Flakes found in Wind Farm sites tend to be smaller than those collected from Pāpaka Road, while Generator-Tie Line basalt flakes are average in size.

Basalt Flake Fragments. Basalt flake fragments were found only in tested Wind Farm and Pāpaka Road sites (n=57). Basalt flake fragments are similar in material and some flake attributes as basalt flakes, however, they were separated from that category when flake attributes, such as platform and bulb of percussion were present, but distal and/or lateral margins were broken off. Basalt flake fragment sizes range from 4 – 42 mm in length, 4 – 33.3 mm in width, 1 – 15.5 mm in thickness, and 0.1 grams to 8.6 grams in weight. Pāpaka Road basalt flake fragments tend to be larger than those collected from Wind Farm sites.

Basalt Flakes with Polish. A total of four basalt flakes with polish were collected from Wind Farm, Generator-Tie Line, and Pāpaka Road sites. Basalt Flakes with polish tend to be of a fine grain, dense, dark gray material. Most of these flakes are likely from basalt adze repair or use. Basalt flakes with polish range in size from 13.5 – 57 mm in length, 15 – 44 mm in width, 3 – 14 mm in thickness, and 1.1 grams to 44.8 grams in weight. The largest flake is a surface collection from a Wind Farm site.

Basalt Flake with Retouch. A single basalt flake was found with defined retouch, which was found in a Wind Farm site. This flake is large with multiple multidirectional scalar flake scars on both side edges with some possible usewear on edge (slight abrasion) as well as possible edge damage. The material is a medium grain, semi-vesicular, dark brownish gray basalt with some crystalline inclusions. It measures 54 mm in length, 70 mm in width, 20 mm in thickness, and 86.8 grams in weight.

Basalt Shatter. Basalt shatter was found primarily in Wind Farm sites and one piece in Pāpaka Road (n=19). These artifacts lack flake attributes, such as platform and bulb of percussion, but appear blocky or angular with some trace evidence of flake attributes, such as concentric rings. These artifacts were found in varying sizes and conditions.

The material is generally medium grain, with some medium to fine and medium to rough grain, dark gray basalt.

Cryptocrystalline Cores. A total of three cryptocrystalline cores were collected during test excavations, one from the Wind Farm area and two from Pāpaka Road. There are some variations in material, but all specimens are non-native and likely came as ballast. Colors range from yellow/honey to tan. Clarity ranges from translucent to semi-translucent, with one core exhibiting cream colored mineral inclusions – all are possibly chalcedony or chert. One specimen is transparent, vitreous, yellowish white quartz with numerous multidirectional conchoidial fractures/flake scars and some dark cortex present. A different core appears to be tan, waxy, semi-translucent flake with cream colored inclusions, which has been utilized as a core with multiple multidirectional flake scars on ventral and dorsal surfaces. Another is a honey colored, semi-translucent, waxy, nodule utilized as a core with several multidirectional flake scars with many non-conchoidial microfractures and chips all over its surface from poor cleavage. In general, flake scars are small. Cryptocrystalline cores ranged in size from 10 - 25 mm in length, 6.5 – 26 mm in width, 5 – 12.5 mm in thickness, and 0.3 grams to 5.8 grams in weight (Figures 147 and 148).

Cryptocrystalline Flakes. One cryptocrystalline flake was found in the tested Pāpaka Road section of the Auwahi Wind Farm APE. The material appears to be a grayish tan, semi-translucent, and waxy chalcedony or chert — a non-native material that likely came as ballast. This flake measures 10 mm in length, 7 mm in width, 0.75 mm in thickness, and 0.1 grams in weight. No usewear or retouch were visible.

Cryptocrystalline Shatter. One piece of cryptocrystalline shatter was also found in the tested Pāpaka Road section of the Auwahi Wind Farm APE. This shatter is an irregular chunk of cryptocrystalline material with some remnants of conchoidial fracturing, weighing 0.3 grams. The material is grayish tan, semi-translucent, and waxy chert or chalcedony that likely came as ballast.

Volcanic Glass Cores and Spent Cores. A total of four volcanic glass cores were collected from test units in Pāpaka Road sites. Generally, the material is black and vitreous with some cortex visible. These cores exhibit multiple multidirectional flake scars on multiple surfaces. Volcanic glass cores ranged in size from 10 - 22 mm in length, 8 – 15 mm in width, 6 - 11.5 mm in thickness, and 0.8 grams to 6.2 grams in weight. Two spent volcanic glass cores were collected from the Wind Farm section. The material is black to dark gray, semi-vitreous to vitreous. A single core remnant exhibits minor amounts of cortex. These cores exhibit multiple multidirectional flake scars on multiple surfaces, but are too small to provide additional flaking material. The spent volcanic glass cores range in size from 12 - 15 mm in length, 10 – 13 mm in width, 9 - 10 mm in thickness, and 0.3 grams to 1.7 grams in weight.

Figure 147. Cryptocrystalline core from Site 50-50-14-6931 Feature D.

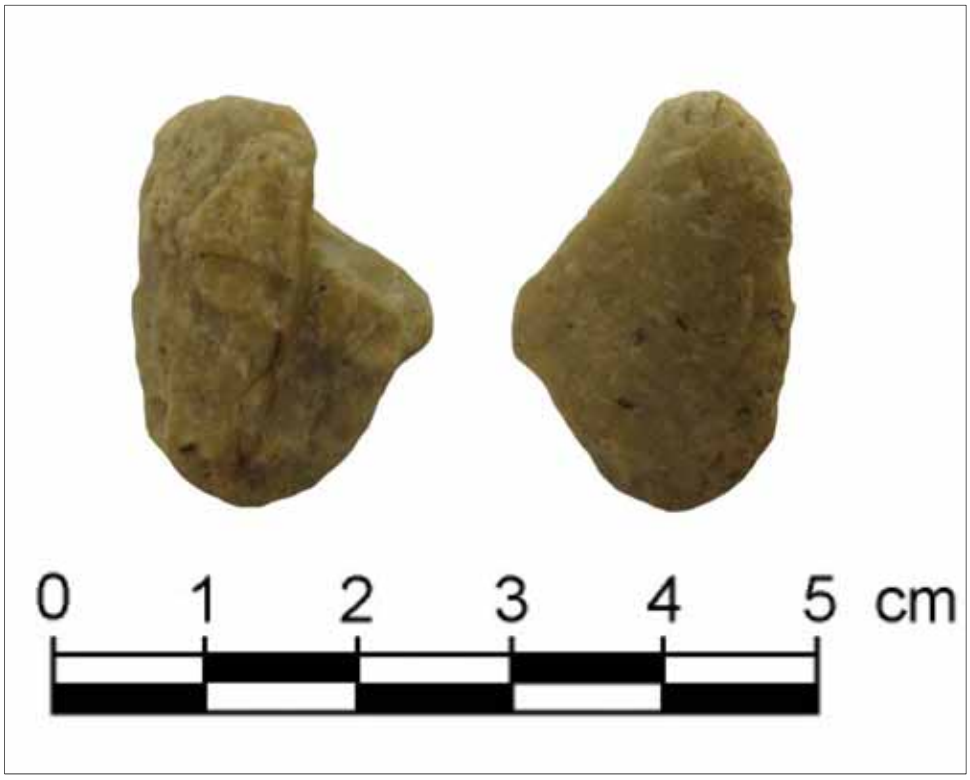


Figure 148. Cryptocrystalline core from Site 50-50-14-6931 Feature D.

Volcanic Glass Flakes. A total of six volcanic glass flakes were collected from test units in the Wind Farm (n=5) and Generator-Tie Line (n=1) portions of the Auwahi Wind Farm APE. Most material was vitreous and black, although two flakes were semi-vitreous. One specimen exhibited a cortex or heavy patina on its dorsal surface. Generally, the flakes display multiple flake scars on the dorsal surface, one having possible polish on one lateral edge. Volcanic glass flakes range in size from 6 – 21.5 mm in length, 7 – 25 mm in width, 1.5 - 8 mm in thickness, and 0.1 grams to 3.5 grams in weight. No usewear or retouch was evident in the assemblage.

Volcanic Glass Flake Fragments. A total of six volcanic glass flake fragments were collected from test units in the Wind Farm area and Pāpaka Road corridor. Material for these flake fragments is typically semi-vitreous, ranging from dark gray to black, with all but one specimen retaining some cortex or heavy patina on dorsal surface or platform. Volcanic glass flake fragments range in size from 3 – 10 mm in length, 5 – 6 mm in width, 1.5 - 3 mm in thickness, and all were approximately 0.1 grams in weight.

Volcanic Glass Shatter. Three pieces of volcanic glass shatter were collected from test units in the Wind Farm area and Pāpaka Road corridor. Generally, shatter lacks most attributes of a flake and tends to be blocky and angular. The material tends to vary from dark gray to black, semi-vitreous to vitreous, with some cortex visible. Volcanic glass shatter range from 0.2 grams to 1.4 grams in weight.

6.1.3.2 Tools. Traditional tools made up only 4.5% (n=30) of the controlled excavations. Yet, 35.6% (n=21) of the surface collections were tools, with a total of 51 collected and the most common find in Wind Farm surface collections (n=18). In test excavations, traditional tools were most numerous in Pāpaka Road sites (n=20). The most common tool is the basalt flake tool (n=13), followed by coral abraders (n=7), basalt awls (n=4), and polished basalt adzes (n=4). Other tool types include fragmentary basalt flake tools (n=2), cryptocrystalline flake tools (n=2), volcanic glass flake tools (n=2), fragmentary coral abraders (n=2), discoidal basalt hammerstone (n=2), spherical basalt hammerstone (n=1), basalt waterworn hammerstone (n=1), basalt adze fragment (n=1), double-ended basalt pestle (n=1), fragmentary granite poi pounder (n=1), fragmentary *pāhoehoe* grinding slab (n=1), and a coral abrader fragment (n=1).

Basalt Adze, polished (*ko'i*). Four complete polished basalt adzes were collected from the surfaces in the Wind Farm, Generator-Tie Line Corridor, and Pāpaka Road Corridor sections of the Auwahi Wind Farm APE. These polished basalt adzes represent a diverse array of size, robusticity, wear, and degree of finishing as well as likely function. The smallest adze, collected from Pāpaka Road is a small, slightly tanged adze that is rectangular in plan and cross-section, though width is greatest at the corners of the blade edge. Its shoulder is very slight and its front, sides, poll, and back are well-ground and polished. The blade is beveled with a rounded chin and its back face, above the chin exhibits one prominent flake scar. Several smaller flake scars are visible along the bevel and lateral edges. This small adze is manufactured out of fine grained, dense, dark gray basalt and measures 53 mm in length, 27.5 mm in width, 12.5 mm in thickness, and weighs 39.4 grams (Figure 149). The other adze collected from Pāpaka Road is a large, robust adze that is quadrilateral in plan and cross-section, though width is greatest at

the center of the bevel. All surfaces are slightly convex transversely and its shoulder is very slight. The front, sides, and back are moderately ground and polished, although the back face of poll is not ground or polished. The blade is beveled with a rounded chin. This adze is made of fine grained, dense, dark gray basalt and measures 90 mm in length, 64 mm in width, 24 mm in thickness, and weighs 107.5 grams (Figure 150). The single adze collected from the Generator-Tie Line Corridor can be described as a small tanged adze that is rectangular in plan and cross-section, though width is greatest at the corners of the blade edge. Its shoulder is very slight and has well-ground and polished front, sides, and back, yet the back face of poll is not ground or polished. Its blade is beveled with a rounded chin with two prominent opposing flake scars exhibited on its back face, above the chin. Several smaller flake scars are visible along the bevel and lateral edges. This adze is manufactured out of fine grained, dense, dark gray basalt and measures 91 mm in length, 40 mm in width, 20 mm in thickness, and weighs 147 grams (Figure 151). The largest adze was collected from the Wind Farm area. It is a large, robust quadrangular adze with a trapezoidal cross-section and roughly parallel sided. The blade, bevel, and raised surfaces of sides are ground and polished, although the tang has no polish. Its blade length relative to the length of the tang appears shorter than the typical adze of this size, which suggests that it was originally longer and had been reworked after its original manufacture. Two flake scars are observed on bevel edge (left), possibly from usage. Further, irregular striations (meandering and multidirectional) appear on most surfaces, which may be usewear or trampling from cattle, as the adze was found on the ground surface in pasture lands. The material of manufacture is fine grained, dense, dark gray basalt and measures 238 mm in length, 46.5 mm in width, 50 mm in thickness, and weighs 1092.5 grams (Figure 152).

Figure 149. Small polished basalt adze from Site 50-50-14-7020 Feature E.

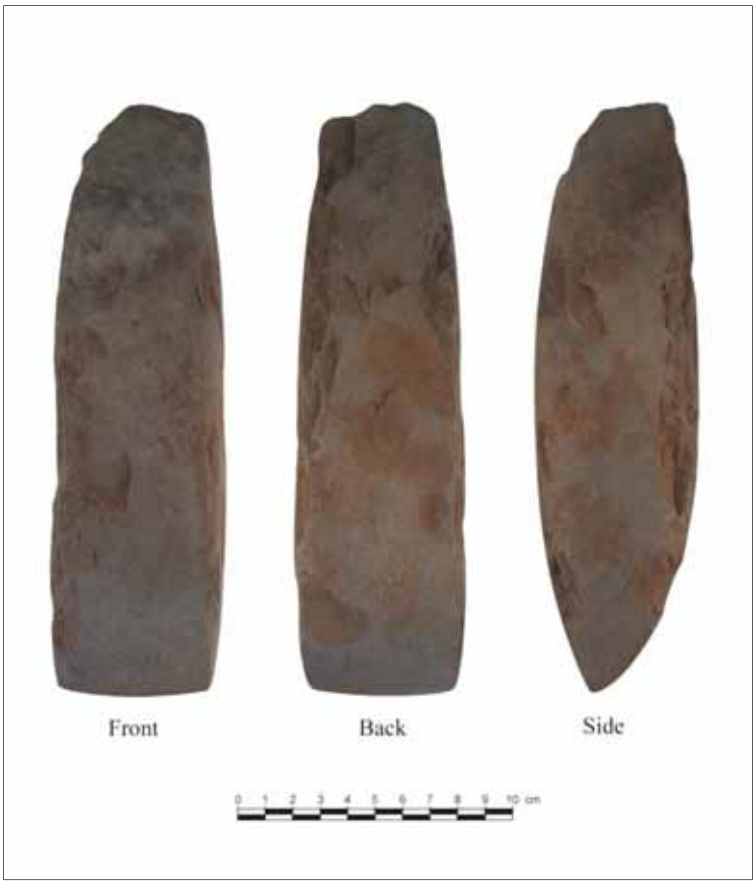


Figure 150. Large polished basalt adze from Site 50-50-14-7020 Feature D.

Figure 151. Small polished basalt adze from Site 50-50-14-7022 Feature B.

Figure 152. Polished basalt adze from Site 50-50-15-6906 Feature II.

Basalt Adze Fragment, Tang. One tang portion of a basalt adze was collected from the Wind Farm area surface. This tang fragment is rectangular in plan and cross-section. It has some polished surfaces on three sides, but has predominant polishing on the base of the specimen. It is fine to medium grained, dark gray basalt and measures 75 mm in length, 41 mm in width, 41 mm in thickness, and weighs 233.4 grams (Figure 153).

Figure 153. Basalt adze fragment, tang portion from Site 50-50-14-6881 Feature C.

Basalt Awls. Four basalt awls were found during surface collections and test excavations carried out in Wind Farm and Pāpaka Road corridor sections of the Auwahi Wind Farm APE. The two basalt awls collected during controlled excavations appear to be utilized flakes. One specimen exhibits scalar retouch on its lateral and margins to taper flake to a point, which is blunted from use. Its material is fine to medium grain, dark gray basalt (Figure 154). The other test collection awl was a triangular shaped flake with a long tapered point on one side that has a blunted tip and some use-wear on edges. Surface collection basalt awls were much more robust and showed more evidence of reduction to create shape. One of these specimens displayed multiple flake scars on the proximal end, creating a tapered form with short narrow point at one end. Some usewear is visible on distal end. The second surface collection awl is a robust basalt core tool reduced by flaking to a rough triangular, multi-sided awl. This awl is somewhat rectangular in cross-section with remnants of rough polish with grinding striations are visible on two sides adjacent to a large flake scar that may have rendered the original tool, likely an adze, useless. Some usewear is visible on and around point of distal end (Figure 155). Basalt awls range in size from 30 – 94 mm in length, 16.5 – 61 mm in width, 6 - 33 mm in thickness, and 1.7 grams to 181.1 grams in weight.

Basalt Flake Tools. The most common tool was the basalt flake tool (n=14), which were found only in test excavations performed in the Wind Farm (n=2), Generator-Tie Line (n=1), and Pāpaka Road (n=11) sections of the Auwahi Wind Farm APE. Basalt flake tools are basalt flakes that exhibit usewear on one or more surfaces. The majority of basalt flake tools appeared to be cutting tools, although some of the specimens appeared multi-purposed (i.e. piercing or grinding). Basalt flake tools also came in various

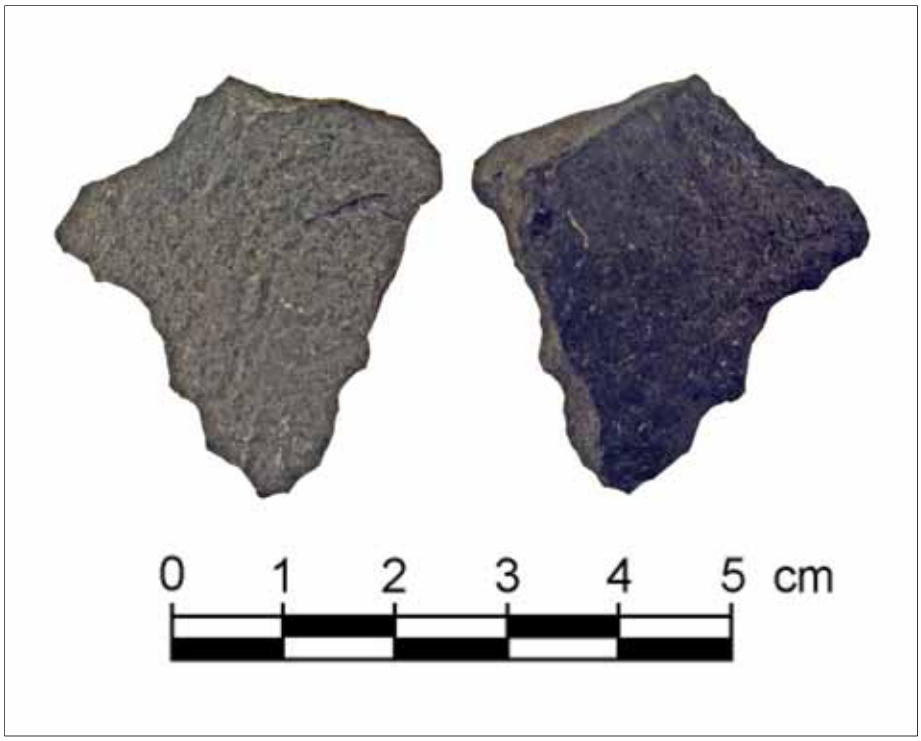


Figure 154. Basalt awl collected from Site 50-50-14-6939 Feature C.

Figure 155. Basalt awl collected from Site 50-50-15-6951 Feature A.

shapes, sizes, usages, conditions, and materials. Basalt flake tools range in size from 11 – 45.5 mm in length, 6.5 – 40 mm in width, 2 - 11 mm in thickness, and 0.1 grams to 15.2 grams in weight.

Basalt Flake Tools, fragmentary. Fragmentary basalt flake tools (n=2) were found only in test excavations performed in Wind Farm sites. Basalt flake fragment tools are basalt flake fragments that exhibit usewear on one or more surface, though the breakage may have occurred before or after the use of the tool. Both tools display wear on the distal end and are made of medium grain gray basalt with no cortex. Fragmentary basalt flake tools range in size from 13 – 37 mm in length, 22 – 33 mm in width, 4 - 6 mm in thickness, and 3 grams to 4.3 grams in weight.

Basalt Hammerstone, discoidal. Two basalt discoidal hammerstones were collected from the surface of the Wind Farm area. The smaller of the two could is a discoidal shaped hammerstone made of vesicular basalt with rounded sides and no definite edge demarcation. The sides and edges appear pecked and battered from use. One small (ca. 13 mm in diameter), shallow depression (ca. 2-3 mm deep) can be felt in the center of one side face but is hardly visible, which was likely pecked to increase control while hammering. The hammerstone is relatively thick laterally and measures 65.5 mm in length, 65 mm in width, 50 mm in thickness, and weighs 200.9 grams (Figure 156). The larger of the two hammerstones is a discoidal hammerstone with one concave and one convex side. Its sides and edges are rounded with no definite edge demarcation and appears to have been pecked to create disc shape, but also displays roughly battered areas. This hammerstone exhibits a small, irregular shaped shallow depression (ca. 11 mm diam x 2-3 mm deep) on its concave side surface for added control as well. The material is vesicular basalt with some small crystalline inclusions, dark gray on one side, lighter gray on other side and measures 71 mm in length, 69 mm in width, 37 mm in thickness, and weighs 207.8 grams.

Basalt Hammerstone, spherical. One basalt spherical hammerstone was collected from the Wind Farm area surface. This hammerstone has been totally rounded, apparently the result of pecking and battering, likely as a bi-product of manufacturing other stone tools. Some minor chips and depressions on can be seen on random areas of its surface. Its surface does not appear to be ground or polished. There is a possibility that it could be a game stone (*no'a*), which is used in the game *pūhenehene*. However, the *no'a* are typically ground and polished. The material of manufacture is medium to fine grain, dense gray basalt. The basalt spherical hammerstone measures 67 mm in length, 66 mm in width, 65 mm in thickness, and weighs 420.7 grams (Figure 157).

Basalt Waterworn Hammerstone. One basalt waterworn hammerstone was collected from the Wind Farm area during surface collections. This artifact is a circular, disc shaped waterworn cobble with battering on several edges and a scar where a chunk of material has been broken off, presumably during use. The material is light gray, medium grain and density basalt. It measures 117 mm in length, 115 mm in width, 43 mm in thickness, and weighs 939.0 grams.

Figure 156. Basalt hammerstone, discoidal, collected from Site 50-50-15-7030.

Figure 157. Basalt hammerstone, spherical, collected from Site 50-50-15-6952.

Basalt Pestle (*pōhaku ku'i*), double-ended. One double-ended basalt pestle was collected from the Wind Farm area surface. This artifact is an oval/loaf style pestle that tapers in plan, but is oval in cross-section. The pestle's proximal and distal ends are worn nearly flat and battered. Some polishing is visible on one wide surface of body. It is manufactured out of medium grained semi-vesicular, gray basalt and may have been used for dye making. This double-ended pestle measures 135 mm in length, 71 mm in width, 53 mm in thickness, and weighs 841.1 grams (Figure 158).

Figure 158. Basalt pestle (*pōhaku ku'i*), double-ended, from Site 50-50-15-6906 Feature YY.

Cryptocrystalline Flake Tools. Two cryptocrystalline flake tools were collected from tested Pāpaka Road sites in the Auwahi Wind Farm APE. These artifacts are cryptocrystalline flakes that have been utilized as cutting tools with some retouch, microflaking, and usewear on lateral and/or distal edges. The material of manufacture varies from tan to gray colored, are both semi-translucent, waxy, and possibly

chalcedony or chert. One specimen has with cream colored inclusions and the other specimen has non-conchoidial microfractures all over its surface from poor cleavage. Both are imported materials, likely brought to Hawai‘i as ballast. These flake tools vary in shape and range in size from 20 – 23 mm in length, 14 – 16 mm in width 4.5 - 18.5 mm in thickness, and 1.7 grams to 3 grams in weight.

Coral Abraders. A total of seven coral abraders were collected from the surface and test units of the Wind Farm (n=6) and Generator-Tie Line (n=1) areas. Coral abraders were found in a variety of shapes, sizes, abrading facets, and conditions. Shapes of abraders in plan view included ovoid, semi-circular, rectangular, rectilinear, and trapezoidal. Abraders in cross-section were triangular wedges, rectangular, ovoid, and plano-convex in shape (Figure 159 and 160). Abrading facets were also found in a variety of abrasiveness, orientations, and varied in number of individual facets per abrader (from one to six faces). Coral abraders range in size from 20 – 90 mm in length, 13 – 64 mm in width 5 - 24 mm in thickness, and 0.7 grams to 107.5 grams in weight.

Coral Abraders, fragmentary. Two fragmentary coral abraders were collected from the Wind Farm area, one in a test excavation and one during surface collections. Coral abraders are considered fragmentary when they are fractured, but more than 50% of the original abrader is present. The smaller fragmentary abrader has been fractured into two halves longitudinally near its center, with both halves collected. It is relatively thin and somewhat triangular in plan view with one edge abraded into a lateral ridge. It may have been pecked into shape or has been battered on several edges. The larger of the two is likely a fragment of a discoidal or coit shaped abrader. This fragmentary abrader is now roughly semi-circular in plan and somewhat plano-convex in cross-section. It appears unifacial with a relatively smooth flat abrading surface. The sides and rounded dorsal surface may have been shaped and smoothed. Fragmentary coral abraders ranged in size from 84 – 86 mm in length, 43 – 53 mm in width 22.5 - 31 mm in thickness, and 57.4 grams to 89.6 grams in weight.

Coral Abrader Fragment. One coral abrader fragment was collected during the surface collections in the Wind Farm area. A coral abrader fragment represents less than 50% of the original coral abrader. This abrader fragment is roughly trapezoidal in plan (was likely tapered prior to fracturing on its proximal and distal ends) and ovate/lenticular in cross-section, with one side protruding further than the other. It is bifacially beveled on one side and the opposite lateral edge is more rounded with both rounded faces having varying degrees of smoothing and wear. The specimen measures 62 mm in length, 45 mm in width, 21 mm in thickness, and weighs 39.6 grams.

Granite *Poi* Pounder (*pōhaku ku‘i poi*), fragmentary. A single fragmentary granite *poi* pounder was collected from the Wind Farm surface. This artifact is the base and body portion of a historic era *poi* pounder (*pōhaku ku‘i poi*), likely a common knobbed form. The neck and knob are missing. Its base is flared with a somewhat rounded edge and a convex undersurface with a relatively flat and battered center. The edges of base are battered and chipped as well. The pounder’s body/sides appears ground smooth with

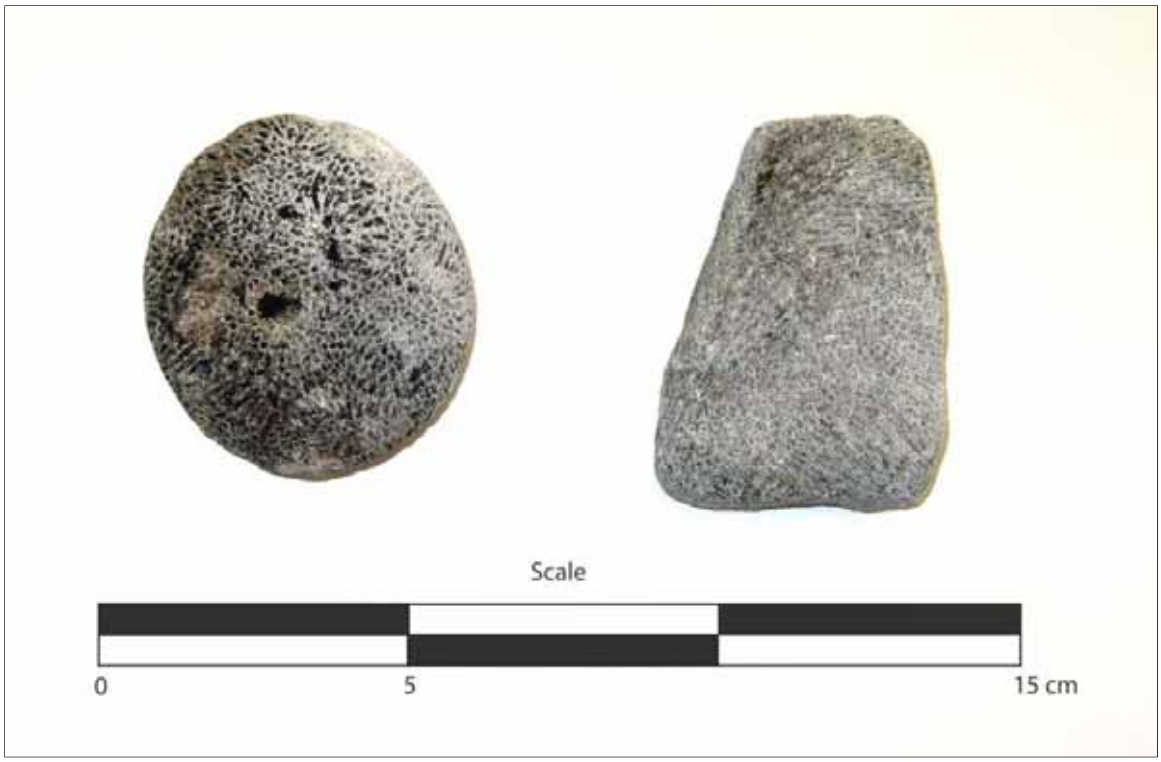


Figure 159. Coral abraders from Site 50-50-15-6906, Features P and T, respectively.

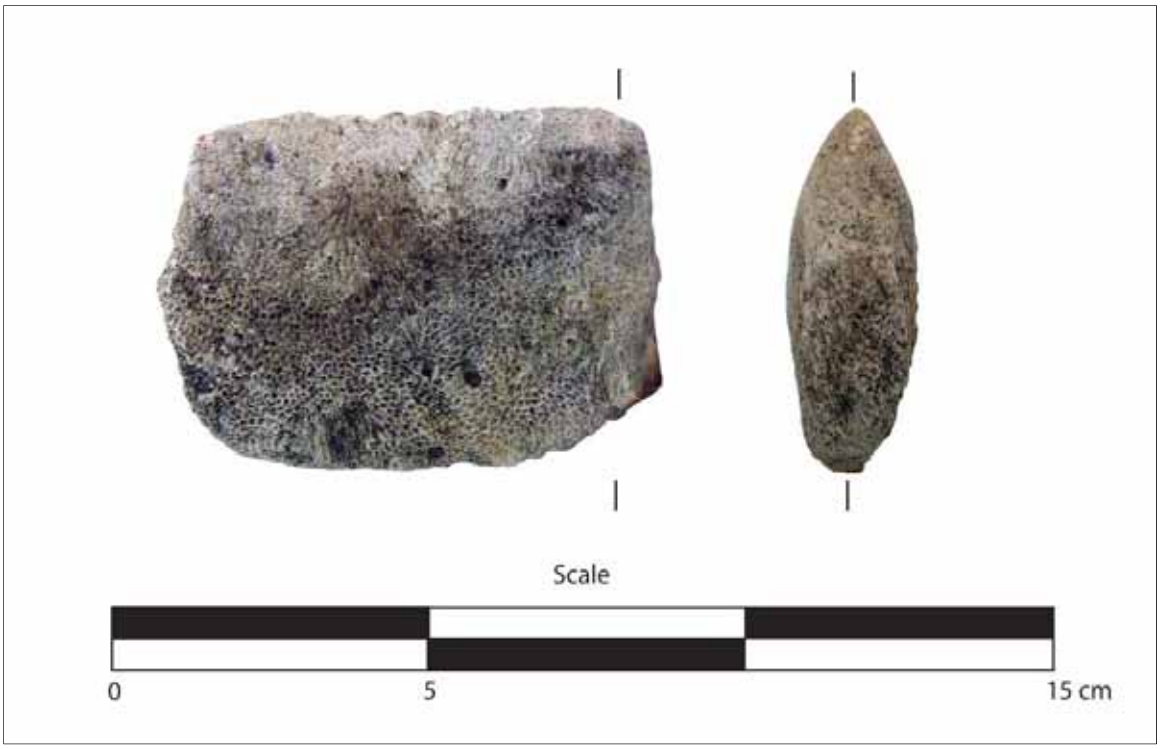


Figure 160. Coral abrader from Site 50-50-15-6821 Feature A.

as small, ephemeral section that is worn very smooth, possibly from use. The material is medium to fine grained, gray speckled granite (visible quartz and feldspar crystals), which is not a local material that likely came as ballast in the historic era and formed into a *poi* pounder using traditional methods. This specimen measures 110.5 mm in length, 112 mm in width, 103 mm in thickness, and weighs 1571.5 grams (Figure 161).

Figure 161. Granite *poi* pounder from Site 50-50-15-6911 Feature C.

***Pāhoehoe* Grinding Slab, fragmentary**. One fragmentary *pāhoehoe* grinding slab was collected in the Wind Farm area during surface collections. This artifact is a portion of a *pāhoehoe* slab that has been utilized as a grinding stone. The collected portion has been fragmented into two pieces with the fracture going through the grinding surface. The slab is unifacial with a very shallow (≤ 3mm deep), smooth, rusty-colored grinding

surface that centers in one corner of the slab, but likely extended further onto a missing portion of the grinding slab. The grinding slab fragment is irregular (polygon) in plan and somewhat rectangular in cross-section with unmodified dorsal surface and sides. The material is dark brownish gray vesicular basalt, with small evenly spaced vesicles and a smooth ventral surface. The artifact measures (reassembled at break) 177.5 mm in length, 162 mm in width, 50 mm in thickness, and weighs 1718.1 grams.

Volcanic Glass Flake Tools. Two volcanic glass flake tools were collected from the Generator-Tie Line section of the APE. These artifacts are volcanic glass flakes that exhibit usewear on one or more surface. The smaller of the two can appears to be a scraper and/or cutting tool with some polish, microflake scars, and striations on one lateral edge as well as a ground facet on ventral and dorsal sides, creating a ridge or beveled edge. The larger of the two appears to be a cutting tool with some polish on distal edge, but is mostly cortex on its dorsal surface. Both flake tools are made of black, vitreous material. These flake tools ranged in size from 7 – 10 mm in length, 14 – 32 mm in width 4 - 6 mm in thickness, and 0.5 grams to 2.0 grams in weight.

6.1.3.3 Fishing Gear. Traditional fishing gear represented only 8.5% (n=5) of the surface collections and were only found in the Wind Farm portion of the Auwahi Wind Farm APE. Two coffee bean sinkers were collected, one made of basalt and one of granite. Three cowrie shells were found that had modifications for use as shell portions of octopus lures, two finished and one unfinished.

Basalt Coffee Bean Sinker (*pōhaku lūheʻe*). A single basalt coffee bean sinker was collected from the Wind Farm area while surface collections were performed. This artifact is oval in plan view and roughly plano-convex in cross-section with a rough groove pecked around the center longitudinally. The material of manufacture is reddish brown, vesicular basalt. The sinker measures 78 mm in length, 50 mm in width, 34 mm in thickness, and weighs 189.5 grams (Figure 162).

Cowrie Shell Lure (*lūheʻe*), shell portion. Two cowrie shells were collected that exhibited modifications for use as the shell portion of an octopus lure (*lūheʻe*). Generally, the specimens were nearly complete *Cypraea mauritiana* shells modified to serve as part of an octopus lure. The anterior and posterior appear to have been pecked and ground to create a holes with some degrees of difference in shape, hole diameter, and condition. The columellar (ventral) lip has also been partially chipped away to remove meat. The enamel of these specimens has been worn off likely due to elemental exposure and one had a cracked crown. The cowries ranged in size from 82 – 95.5 mm in length, 63 – 68.5 mm in width 43 - 50 mm in thickness, and 108.3 grams to 141.5 grams in weight (Figure 163).

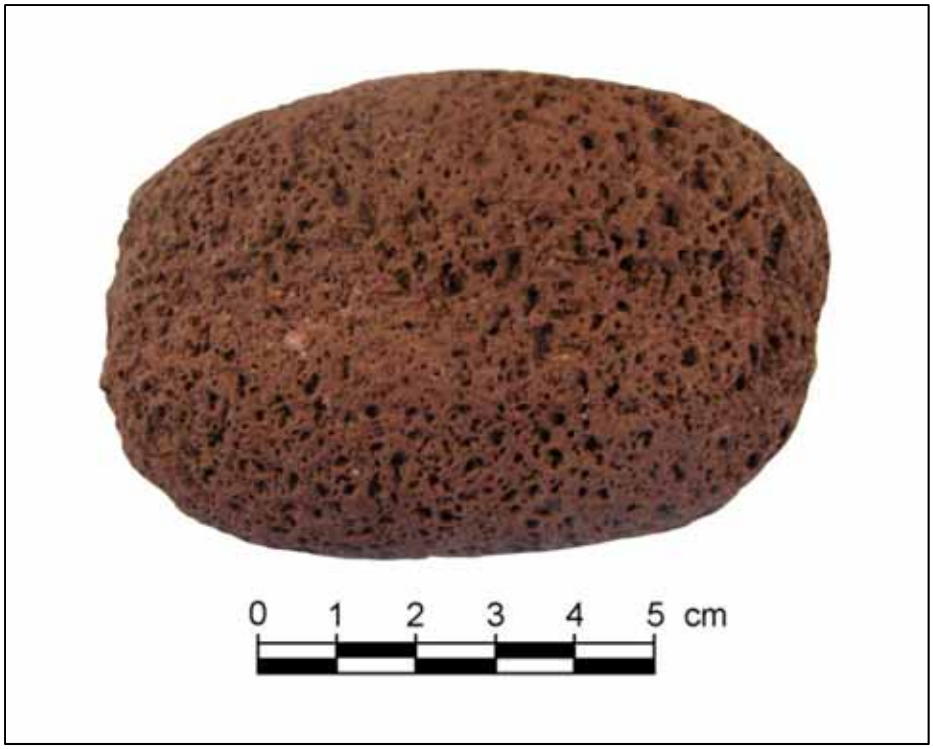


Figure 162. Basalt coffee bean sinker (*pōhaku lūheʻe*) from Site 50-50-15-6910 Feature I.

Figure 163. Cowrie shell lure (*lūheʻe*), shell portion from Site 50-50-15-6906 Feature II.

Cowrie Shell Lure (*lūheʻe*), shell portion, unfinished. One unfinished cowrie shell portion of an octopus lure (*lūheʻe*). This artifact is a mostly complete *Cypraea mauritiana* shell that was intended for an octopus lure. The posterior has a pecked hole, but is expanded/fractured beyond its original shape, likely during manufacture. The anterior is not modified, thus the artifact is unfinished. The columellar (ventral) lip has also been partially removed by chipping and some enamel has been worn off due to elemental exposure. This specimen measures 93 mm in length, 71 mm in width, 50 mm in thickness, and weighs 144.8 grams.

Figure 164. Granite coffee bean sinker (*pōhaku lūheʻe*) from Site 50-50-15-6840 Feature C.

Granite Coffee Bean Sinker (*pōhaku lūheʻe*). A single granite coffee bean sinker was collected from the Wind Farm area while surface collections were performed. This artifact is ovoid in plan and plano-convex in cross-section with a linear pecked groove running longitudinally down the center, creating the classic coffee bean form of sinker. The material of manufacture is medium to fine grained, gray speckled granite (visible quartz and feldspar crystals), which is not local and likely came as ballast in the historic era and formed into a coffee bean sinker using traditional methods. This specimen measures 82 mm in length, 63 mm in width, 45 mm in thickness, and weighs 372.0 grams (Figure 164).

6.1.3.4 Recreational Artifacts. Two recreational artifacts were collected from Generator-Tie Line and Wind Farm sections of the Auwahi Wind Farm APE during surface collections. Both artifacts were basalt game stones, or ʻ*ulu maika,* which represent 3.4% of surface collections.

Basalt Game Stone, discoidal (ʻ*ulu maika*). Two basalt game stones were collected from the Wind Farm and Generator-Tie Line areas during surface collections. The two specimens varied in material, morphology, size, and condition. The smaller of the two is a finely ground discoid fashioned out of a single basalt stone that represents two different lava flows, with the interface of the two flows roughly bisecting the ʻ*ulu maika* laterally. As one basalt type is relatively dense and the opposite is more vesicular, the shape has been modified to where the vesicular side bulges further out than dense side to make up for the weight differential. Thus, it appears unbalanced, but rolls straight (as tested on a carpeted surface in the archaeological laboratory). Both basalts of the specimen are gray, but the more dense basalt is several shades lighter than the vesicular and there is some mild polishing on the vesicular side (Figure 165). The larger of the two ʻ*ulu maika* is a finely ground basalt discoidal, also intended for rolling on its side. The edge is roughened by usage while side surfaces are smooth with one large flake scar on its side/edge, several small flake scars on edge, and several striations on sides, which may be a result of trampling by cattle. Regardless of condition, this ʻ*ulu maika* rolls straight. The material of manufacture is uniform, fine to medium grained, dense, dark gray basalt (Figure 166). Basalt Game Stones ranged in size from 67 – 78 mm in length, 67 – 78 mm in width 37.5 - 42 mm in thickness, and 260.6 grams to 442.5 grams in weight.

Figure 165. Basalt game stone, discoidal (ʻ*ulu maika*), from Site 50-50-15-6906 Feature W.

Figure 166. Basalt game stone, discoidal (*ʻulu maika*), from Site 50-50-14-7022 Feature E.

6.1.3.4 Miscellaneous Artifacts. A total of five artifacts grouped under the miscellaneous category were collected from test excavations in Wind Farm and Pāpaka Road portions of the Auwahi Wind Farm APE. This assemblage, representing only 0.7% of the test excavation assemblage, is comprised of an echinoid spine bead preform, a piece of modified basalt, a modified burn bone fragment, and two cone shell beads.

Echinoid Spine Bead Preform. A single echinoid spine bead preform was collected from the Wind Farm area. This artifact is a thin disk made of a *Heterocentrotus mammillatus* spine that has been drilled in center from both front and back faces. The center drilled depressions have not passed all the way through and are conical in cross-section. This specimen measures 10 mm in length, 10 mm in width, 4 mm in thickness, and weighs 0.7 grams (Figure 167).

Modified Basalt. One article of modified basalt was collected from a test unit in the Wind Farm area. It is a completely waterworn basalt flake, possibly a natural flake, which exhibits some modification. Although all edges and surfaces appear to have been worn smooth by wave action tumbling previous to use, two edges appear to have more recent wear in the form of small striations, both perpendicular and parallel to the edges. As the sides are not sharp, the function is undetermined, but may have been used as a smoothing, burnishing, or polishing implement. The material is medium gray, fine grain, dense basalt. It measures 10 mm in length, 10 mm in width, 4 mm in thickness, and weighs 0.7 grams.

Modified Burnt Bone. A single piece of modified burnt bone was collected from a test unit in the Wind Farm area. This artifact has one curved edge and one flat edge with modified edges that appear cut and/or abraded. It is possible that the specimen was a fish hook preform fragment that had been burnt before or after modification. The bone fragment is likely bird (Aves sp.) due to its gracile and solid wall structure as well as waxy cortical surface. This specimen measures 7 mm in length, 6.5 mm in width, 1 mm in thickness, and weighs 0.1 grams.

Shell Beads, Conus sp. Two cone shell beads were collected from test excavations in Wind Farm and Pāpaka Road portions of the APE. Both were fashioned from the apical whorl sections of small unidentified cone shells. Additionally they were drilled in the center of the apical whorl, with some variance in hole size, ranging from 1 - 2.5 mm in diameter. They both are extremely worn from the elements and, thus, beyond identifying by species. The beads ranged in size from 7.5 – 8 mm in diameter, 4 – 4.5 mm in thickness, and 0.2 grams to 0.3 grams in weight.

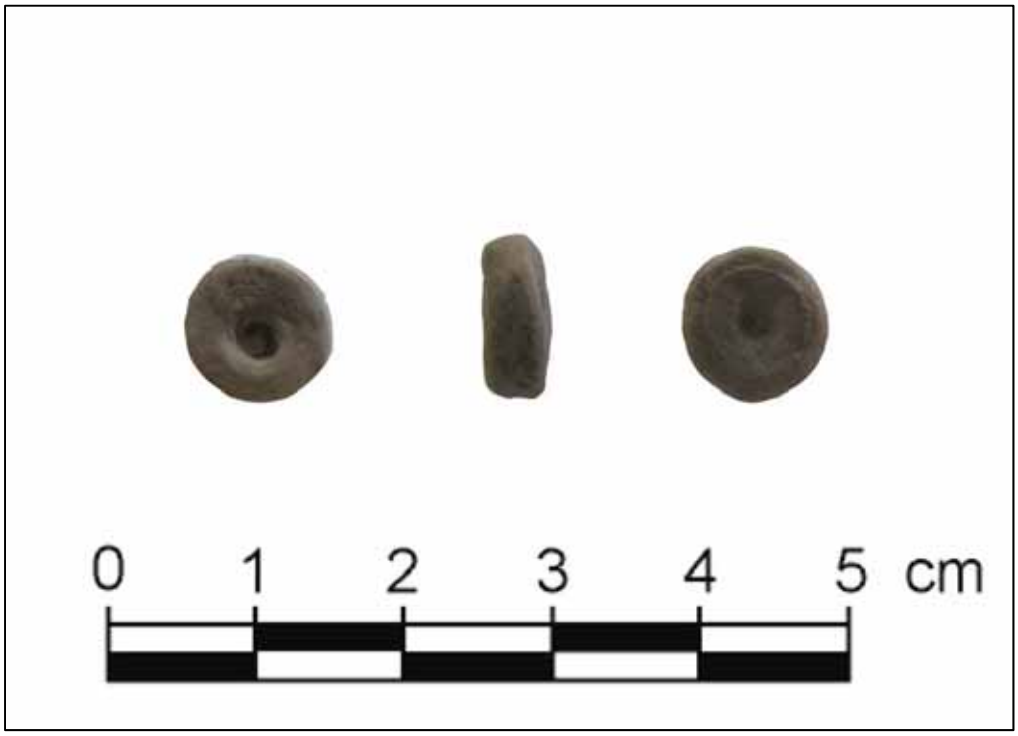


Figure 167. Echinoid spine bead preform from Site 50-50-15-6833 Feature A.

6.1.3.5 Historic Artifacts. A total of 89 historic artifacts were collected from test excavations and surface collections within the Wind Farm, Generator-Tie Line, and Pāpaka Road portions of the Auwahi Wind Farm APE. These artifacts represent a variety of materials, origins, periods, and activities. Among historic artifacts are various colored glass bottle fragments (n=17), various colored flat/pane glass fragments (n=16), nondescript glass fragments (n=6), clear glass bead (n=1), clear glass Maui Soda Works bottle (n=1), aqua glass utility bottle (n=1), various square

nail fragments (n=32); unidentified metal fragments (n=4), iron clothes iron (n=1), iron curb bit (n=1), iron flensing tool tip (n=1), metal screw (n=1), plaster/mortar chunk (n=1), various porcelain vessel sherds (n=5), and stoneware bottle fragment (n=1). Artifacts from this assemblage represent 12.3% of the total test unit collection and 10.2% of the surface collections.

Glass Bead, clear, faceted. A single clear glass faceted bead was collected from the surface of Wind Farm area. This artifact is an individual historic Western style bead, possibly a trade bead. The bead is octagonal in plan and cross-section. It is manufactured out of clear glass with crude faceting on sides, rounding out bead and adding the element of design. There are several irregularities about this artifact, including irregular faceting, and top and bottom appear to be cut or shaped at slight angle. These irregularities suggest that it was handmade. The surface exhibits an iridescent patina and some chipped edge damage. This artifact probably dates from late 1800 to early 1900. The artifact measures 4 mm in length, 6 mm in width, 6 mm in thickness, and weighs 0.2 grams (Figure 168).

Figure 168. Glass bead, clear, faceted from Site 50-50-15-6919 Feature E.

Glass Bottle Fragments, various colors. A total of 17 fragments of various colored bottle glass were collected from the Pāpaka Road Corridor. In collection and quantification tables, these fragments are divided by color. Aqua bottle glass is the most common (n=4), followed by aqua-green (n=3), amethyst (n=3), aqua blue (n=2), olive (n=2), clear (n=1), cobalt (n=1), and brown (n=1). These fragments ranged in size, shape, and bottle type. Judging by color, patina, and glass quality, the majority of the glass fragments were likely late 1800 to early 1900. The origin of the glass bottles is likely American (pre-Hawai‘i statehood) and/or European.

Glass Fragments, clear. Six clear glass fragments were collected from test units in the Pāpaka Road area. These artifacts are non-descript and too small to determine the origin. Two of the fragments have slight amethyst hue, probably UV induced. A total of 1.5 grams were collected.

Glass Pane Fragments, various colors. A total of 16 fragments of various colored pane, or flat glass were collected from the Pāpaka Road Corridor. In collection and quantification tables, these fragments were divided by color. Clear pane glass was the most common (n=7), followed by aqua (n=6), and teal (n=1). These fragments ranged in size, shape, thickness, and patina. Clear glass fragments tended to have a thick iridescent patina. The teal glass could be from a decorative window, or stained glass window. However, the glass is relatively thin and very smooth, which is not consistent with stained glass. Therefore, the teal glass likely came from an ornamental object, such as a glass box or flat sided vessel. Based on glass quality and patina the majority of glass pane fragments were likely from early to mid-1900.

Glass Soda Bottle, Maui Soda Works, clear. One intact Maui Soda Works bottle was collected from an isolated area outside of the APE near the Generator-Tie Line. This bottle can be described as a clear glass bottle with an embossed body (front) that reads: "MAUI, SODA WORKS" (arched and opposing) and has two symbols, both boxes with a "P" and "C" stamped inside, followed by the number "5" above base. The back of the body reads: "NET CONTENTS, 9 FLUID OUNCES" (in two straight rows). The base is embossed with a large letter "M". The bottle has a crown cap finish with a side mold seam that goes to the highest vertical point of the finish and onto the finishes top surface (rim) and a suction scar on base. Hence, the manufacture of the bottle is post 1912. The bottle has considerable wear, including UV-induced amethyst hue, iridescent patina and slight hydration rind. This artifact measures 203 mm in length, 63 mm in width, 63 mm in thickness, and weighs 426.7 grams (Figure 169).

Glass Utility Bottle, aqua. A single aqua glass utility bottle was collected in the Wind Farm area during surface collections. This artifact is a square bodied bottle, specifically a French square style due to the beveled corners, with a wide patent finish. The bottle is not embossed, yet it displays many bubbles in glass, pontil mark on base, tooled finish and neck, and the side mold seam ends well below the lip/finish. Therefore, its manufacture is likely mid- to late-1800s. Although its morphology is somewhat generic, it was likely a polish bottle or saddle bag vial. This bottle measures 121 mm in length, 41 mm in width, 41 mm in thickness, and weighs 146.0 grams (Figure 170).

Clothing Iron, 6 lb. One clothing iron, also known as a flatiron or press, was collected from the Generator-Tie Line corridor during surface collections. This artifact is a solid core clothing iron, embossed with the number "6" on its top surface. It is triangular in plan with rounded lateral edges and straight bottom edge. The base is molded decoratively and its solid iron handle shaft is ribbed with bulbous ends. The handle has been fractured, yet both pieces remain in place, albeit loosely. All surfaces exhibit oxidization, but the rust appears surficial. It was likely manufactured in England or the American mainland and its style dates from mid-1800 to early 1900. The iron

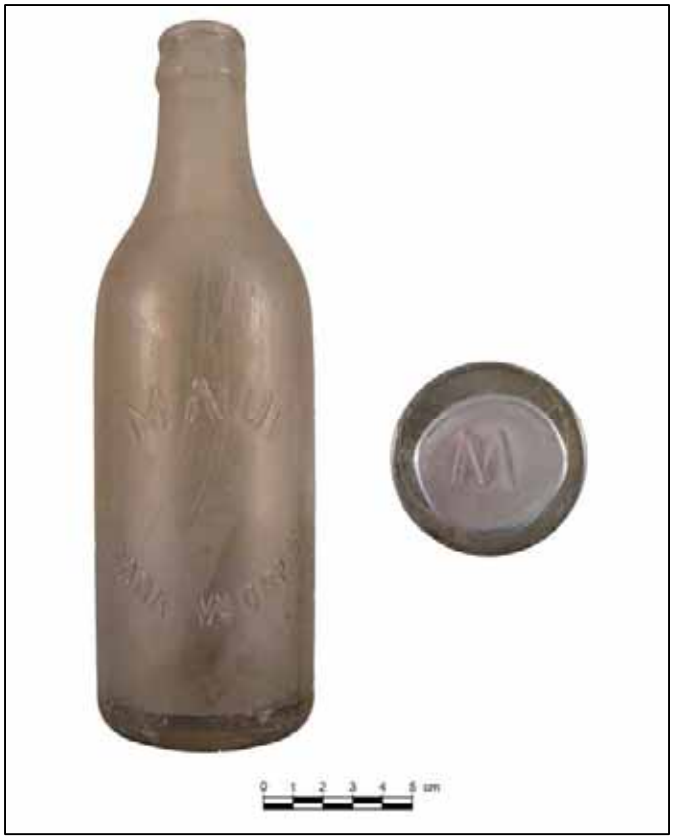


Figure 169. Glass soda bottle, Maui Soda Works, clear, from isolated location.

Figure 170. Glass utility bottle, aqua, from Site 50-50-15-6911 Feature C.

measures 150 mm in length, 108 mm in width, 132 mm in thickness, and weighs 2285.5 grams, which converts to roughly 6 lbs., hence the number "6" embossed on top surface (Figure 171).

Iron Curb Bit. A single iron curb bit was collected from the Wind Farm portion of the APE. This artifact is a near complete curb bit with rounded shank hobble. The shank/lever arm is curved and its mouth piece has a deep, squared port. There are two snaffle or headstall rings, which are independent (loose) and of crude manufacture. It has a short cheek or shank length and the rein rings double as a bolt to secure the shank hobble to the lever arm, with one rein ring broken off above the bolt portion. One lip strap ring remains and is made of a crude solid core wire bent into a rough oval ring (possibly broken and reshaped). All surfaces exhibit oxidization, but the rust appears surficial. This artifact is probably of American manufacture and dates to the late historic period. The entire curb bit assembly measures 154 mm in length, 144 mm in width, 47 mm in thickness, and weighs 346.7 grams (Figure 172).

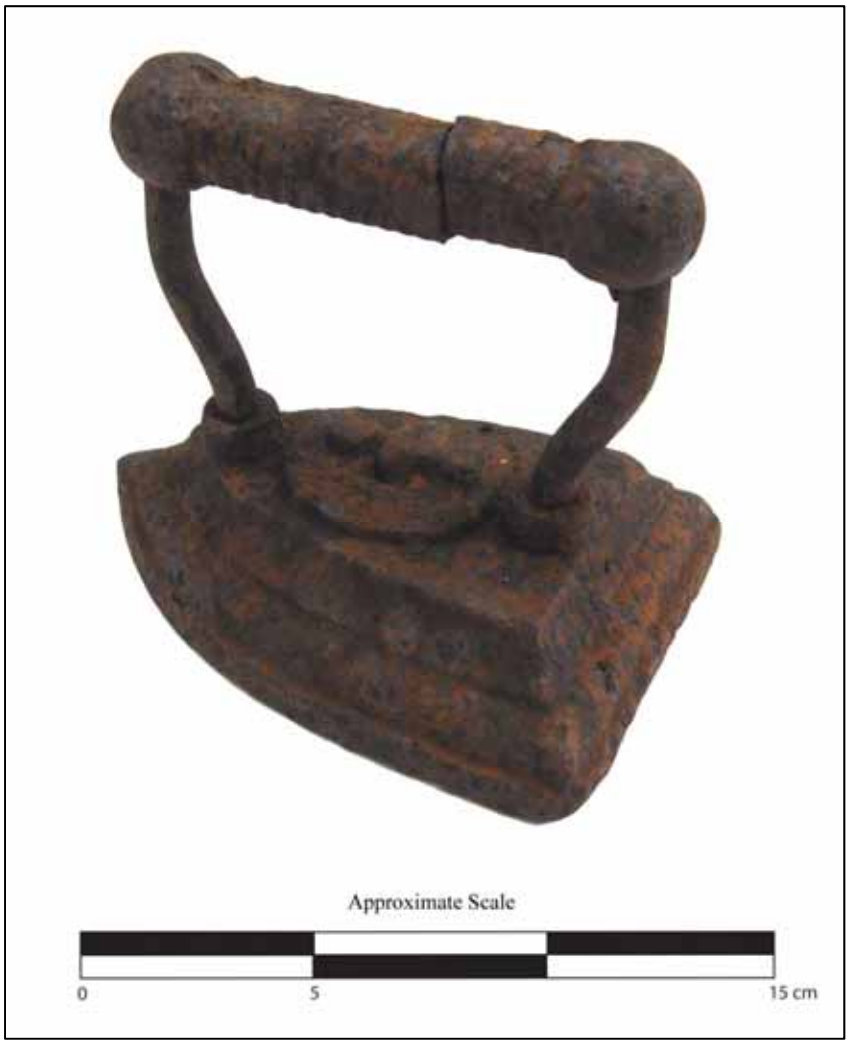


Figure 171. Clothing iron, 6 lb, from Site 50-50-15-6988 Feature E.

Figure 172. Iron curb bit collected from Site 50-50-15-6906 Feature DD.

Iron Flensing Tool, tip portion. The tip of an iron flensing tool was found during surface collections performed in the Wind Farm portion of the APE. This artifact is the iron tip of a flensing tool used in historic times to cut and/or remove the blubber and flesh of a whale. The blade portion is flat and somewhat trapezoidal in plan view with rounded sides and a wide distal end. The mounting portion is tapered and cylindrical (with greater width on the proximal end) and has one pinhole to secure it to a wooden stake (missing). The mounting end is also roughly finished where the rim shape is irregular and the seam is overlapped, both rim and seam have irregular edges, suggesting that it was hand wrought. Several chips and dents are observed along the lateral edge of cutting end and on the shaft. The entire tool surface is badly oxidized with one face of the cutting end exhibiting a flared section, possibly caused by sub-surface oxidation. The cutting edge is blunted and worn to a slight bias which suggests a secondary function, possibly as a farming implement (i.e. the tip to a digging stick, or ʻōʻō). The manufacture origin is likely North American or European and dates from early to mid-1800. The flensing tool measures 327 mm in length, 95 mm in width, 40 mm in thickness, and weighs 829.5 grams (Figure 173).

Figure 173. Iron flensing tool, tip portion, found in Site 50-50-15-6906 Feature HHH.

Metal Fragments, unidentified (all types). A total of four fragments of various shaped rusted metal were collected from test excavations in the Pāpaka Road Corridor. In collection and quantification tables, these fragments are divided into flat/sheet, shank, and unidentified types. Unidentified is the most common (n=2), followed by flat/sheet (n=1), and shank (n=1). These fragments range in size, shape, and oxidation. Based on level of oxidation, the greater part of unidentified metal fragments are likely early to mid-1900, but may be older.

Metal Screw, slotted flat head. One slotted flat head screw was collected from Pāpaka Road Corridor test excavations. The screw is a round, slotted flat-head type with threads that extend from its tip to 3/4 of its shank. Due to advanced oxidation, this artifact is likely late historic. The screw measures 15.5 mm in length, 4 mm in shank diameter, and weighs 0.4 grams.

Metal Nail Fragments, square. A total of 32 metal nail fragments were collected from test units in the Pāpaka Road corridor. These nail fragments all appeared to be hand wrought as they exhibited tapering on all four sides and blocky, irregular square/rectangular heads. All nail fragments were warped and splintered from advanced oxidation. Size, nail portion, and condition varied greatly in the assemblage,

but generally ranged in size from 5 – 38 mm in length, 3 – 8.5 mm in width, and 0.2 grams to 2.5 grams in weight.

Plaster and Mortar Conglomerate. A single chunk of plaster and mortar conglomerate was collected from a test unit in the Wind Farm area. This specimen is an irregular shaped chunk made of mostly plaster with a thin layer of sandy limestone mortar, likely a structural remnant. It is very worn, possibly by wind and rain. The artifact could be made of local materials (coral limestone and sand), and was probably made from late 1800 to early 1900. It measures 15 mm in length, 13 mm in width, 10 mm in thickness, and weighs 1.7 grams.

Porcelain Sherds, Celadon (all types). A total of three sherds of celadon porcelain, vessel and unidentified form, were collected from a test unit in the Pāpaka Road Corridor. In collection and quantification tables, these fragments were divided by unidentified sherd and vessel sherds. The term "celadon" is generally used for pottery displaying a pale jade-green glaze. Two vessel sherds and one unidentified shard were collected. All sherds ranged in size, shape, thickness, and color. The vessel types were likely from the same bowl or cup, which appeared to be a hollow footed bowl type vessel. The paste is white with greenish blue-gray tint and fine to medium grain. The surface treatment is gray green with a bluish tint. The surface has hand painted watered-down blue detail in a floral design and some concentric rings circling interior and exterior of vessel. The unidentified sherd material paste is white with greenish blue-gray tint and fine to medium grain. The surface treatment is gray green with a bluish tint and has a watered-down blue hand painted detail in an undetermined design. This sherd is possibly related to the vessel sherds although they were collected the surface and this sherd is from Layer II. Based on style and condition the sherds are possibly of Chinese, or Japanese manufacture from the late historic period.

Porcelain Vessel Sherds, unidentified Asian. Two Asian style vessel sherds were collected from the Pāpaka Road Corridor. These sherds are bowl or cup fragments made of a white paste with blue tint. These sherds appear to be from the same hollow footed vessel. The surface treatment of the sherds is hand painted dark blue detail on clear glaze with a floral design and stippling for background as well as dashed lines in concentric rings on exterior foot of vessel. The interior lip of the vessel has a repeating filigree or lace design. These artifacts are possibly of Chinese, Japanese, or Korean manufacture from the late historic period as well.

Stoneware Bottle Fragment. A single stoneware bottle fragment was collected during test excavating in Pāpaka Road Corridor. This artifact is a base fragment, likely from a round bodied alcoholic beverage (whiskey) bottle. The stoneware is light tan clay with little to no temper and has white/cream glaze on sides and interior. The base is unglazed and has no diagnostic markings. The origin is undetermined and likely dates from mid- to late-1800s.

6.2 MIDDEN ANALYSIS

Midden, which is typically the result of human consumption or domestic refuse in the form of unmodified shell, bone, or macrobotanical remains, was also a major component of cultural materials collected from test excavations. A total of 658.7 grams of midden was collected from the Wind Farm, Generator-Tie Line, and Pāpaka Road portions of the Auwahi Wind Farm project. The majority of midden was collected from the Wind Farm area (496.6 g; 75.5%), followed by Pāpaka Road Corridor (123 g; 18.7%) and Generator-Tie Line Corridor (38.5 g; 5.9%) (Figure 174). The most frequent midden type is marine shell, comprising 83.5% (549.4 g) of the midden assemblage, followed by bone (62.5 g; 9.5%), and flora, which was completely represented by *A. moluccana* or *kukui* (44.0 g; 6.7%). In terms of condition, midden was typically fragmented and poorly preserved, particularly in the case of marine shell, and thus, difficult to identify to the species level. Marine shell midden appeared to be heavily deteriorated either by weathering or post-depositional chemical erosion. Individual site and feature midden tables can be found in Appendix D.

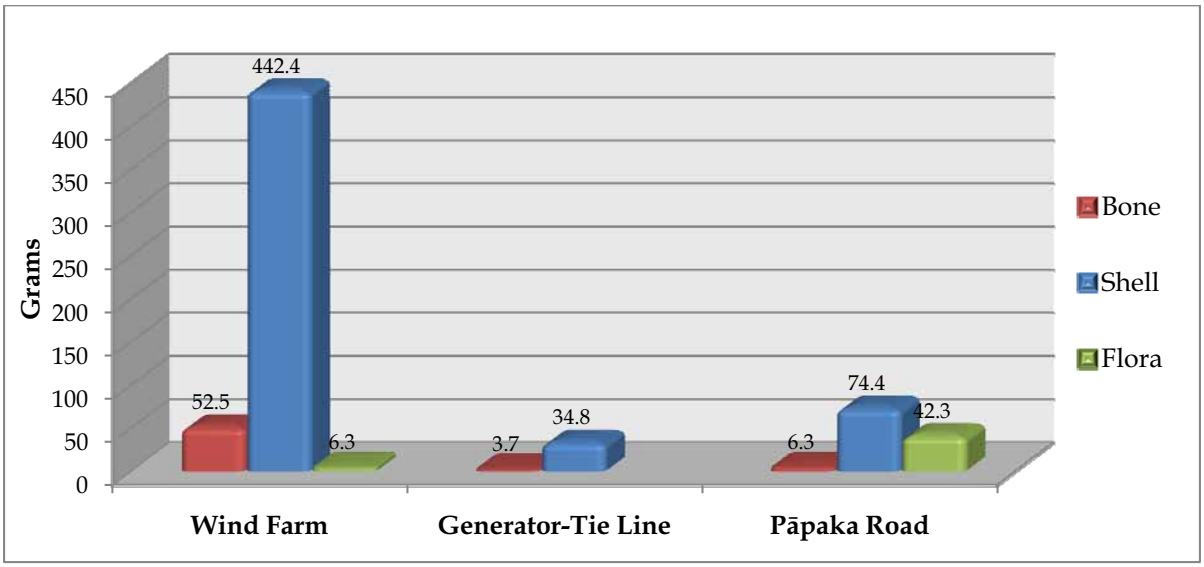


Figure 174. Distribution of midden by type throughout the Auwahi Wind Farm APE.

6.2.1 Wind Farm Test Excavations

A total of 496.6 grams of midden was collected from 27 features in the Wind Farm area (Tables 17 and 18). This midden assemblage is predominantly comprised of marine shell (442.4 g; 89.1%), which includes a variety of bivalves (11.4 g; 2.3%), echinoids (10.7 g; 2.15%), gastropods (351.1 g; 70.7%), and unidentified shell (69.2 g; 13.93%)(Figures 175 and 176). Non-human bone is also a significant component of Wind Farm midden (52.5 g; 16.3%), and includes a variety of mammal (23.9 g; 4.81%), Aves spp. or bird (0.1 g; 0.02%), and Osteichthyes spp. or bony fish (28.5; 5.74%). A minor amount of *kukui* was collected from this area (1.7 g; 0.34%). Yielding the greatest total midden in the Wind Farm area (24.6%) was Site 50-50-15-6848, Feature A, which is described as a cleared flat with windbreak, with 121.3g. Other sites with significant midden weights were Site 50-50-15-6833, Feature A (enclosure; 66.4 g; 13.5%), -202, Feature C (C-shape; 47 g; 9.5%),-216, Feature E (C-shape with coral; 35.4 g; 7.2%), and -216, Feature C (terrace with overhang; 33.3 g; 6.8%).

The results of the analyses of midden by test unit are presented in Tables 17and 18 and are briefly summarized below.

Site 50-50-15-6832, Feature A (U-shaped enclosure). This feature yielded a mere 0.1 gram of midden, consisting of Cypraeidae sp. (0.1 g; 100%), which was found in Layer II.

Site 50-50-15-6833, Feature B (enclosure). A total of 66.4 grams of midden was collected from this feature, accounting for 13.4% of the total Wind Farm midden assemblage. All midden collected from this enclosure is marine shell, dominated by Cypraeidae spp. (32.8 g; 49.4%), with significant amounts of Thaididae spp. (12.2 g; 18.37%), Tellinidae spp. (10.5 g;15.81%), and Patellidae spp. (2.7 g; 4.07%). Other species in the assemblage are Echinoidea spp. (1.4 g), Conidae spp. (0.5 g), and Neritidae spp. (0.3 g). Layer I contained 7.6 grams of midden. Layer II contained the greater part of the assemblage, with 58.6 grams of midden. Layer III contained only 0.2 gram.

Site 50-50-15-6838, Feature G (wall with cleared flat). This feature contained a total of 30.2 grams of midden, which consisted of 6.9 grams (22.85%) of bone and 23.3 grams (77.15%) of marine shell. The bone assemblage is comprised of unidentified fish bone (5.8 g; 19.21%) and unidentified small mammal (1.1 g; 3.64%). Marine shell was predominantly Cypraeidae spp. (10.8 g; 35.76%), followed by Thaididae spp. (4.2 g; 13.91%), Conidae spp. (3 g; 9.93%), Patellidae spp. (1.8 g; 5.96%), and Neritidae spp. (0.4 g; 1.32%). All midden was collected from Layer I, although 11.3% (3.4 g) of this assemblage came from a hearth within Layer I (Sub-Feature 1).

Site 50-50-15-6839, Feature B (terrace with windbreak). A total of 4.9 grams of midden was collected from this feature, with Cypraeidae spp. (3.9 g; 79.59%) leading in weight with a slight amount of Thaididae spp. (0.1 g; 2.04%) and the rest comprised of unidentified shell. Layer I contained 0.7 gram and Layer II contained the bulk of the total feature midden with 4.2 grams.

Site 50-50-15-6848 (habitation complex). This site was tested in Features A, E, I, J, K, and L. However, only Features A, I, and J contained midden. A total of 125.1 grams of midden was collected from the three features.

- **Feature A (cleared flat with windbreak).** This feature contained the most midden per unit in the Wind Farm area (121.3 g; 24.5%). This assemblage is dominated by marine shell (116.4 g; 95.96%), but also contained bone (4.9 g; 4.04%). The majority of shell was gastropods, with Cypraeidae spp. (46.7g; 38.5 %) in the lead, trailed by Neritidae spp. (21.3 g; 17.56%), Conidae spp. (16.9 g; 13.93%), Thaididae spp. (14.3 g; 11.79%), Patellidae spp. (5.9 g; 4.86%), and minor amounts of Trochidae and Columbellidae species. Bone was primarily unidentified medium mammal (4.8 g; 3.96%), with 1.7 grams of burnt mammal bone as part of that assemblage. The wall fall of that feature contained 10.1 grams of shell. Layer I contained the bulk of the feature's midden (77.9 g). Layer II/III contained 33.3 grams of midden.
- **Feature I (walled terrace).** A total of 3.3 grams was collected from this feature, consisting of 0.1 gram of bone (3.03%) and 3.2 grams of shell (96.97%). Bone was comprised of unidentified fish. Marine shell was primarily Cypraeidae spp. (1.6 g;

48.48%), with some Neritidae spp. (0.4 g; 12.12%), Thaididae spp. (0.4 g; 12.12%), and Patellidae spp. (0.3 g; 9.09%). Layer II contained 1.4 grams and Layer III contained 1.9 grams of midden.

- **Feature J (stone filled terrace).** This feature contained a total of 0.5 gram of kukui nut shells, all collected from Layer I.

Site 50-50-15-6851, Feature B (enclosure). A total of 14.2 grams of midden was found in this feature, comprised of unidentified fish bone (0.6 g; 4.23%), Conidae spp. (12.5 g; 88.03%), Cypraeidae spp. (0.9 g; 6.34%), Echinoidea spp. (0.1 g; 0.7%), and unidentified shell (0.1 g; 0.7%). All midden was collected from Layer II.

Site 50-50-15-6852 (Habitation/Agricultural Complex). This site contained a total of 26.8 grams of midden, collected from Features A and I.

- **Feature A (enclosure).** This feature yielded only 2.2 grams of Cypraeidae spp., which was collected from Layer II.
- **Feature I (U-shaped enclosure).** The U-shaped enclosure contained a total of 24.6 grams of midden. The midden consists of 3.6 grams (14.63%) of unidentified medium mammal bone as well as 21 grams of marine shell (85.37%). Marine shell was primarily Cypraeidae spp. (10.6 g; 43.09%), with amounts of Thaididae spp. (3.3 g; 13.41%), Neritidae spp. (2.8 g; 11.38%), and Patellidae spp. (2.8 g; 11.38%). All mammal bone was collected from the surface. Marine shell was collected from Layer I (6.7 g) and Layer II (14.3 g).

Site 50-50-15-6853, Feature A (enclosure). This feature contained 22.8 grams of midden total. Cypraeidae species represented 61.84% (14.1 g) of the assemblage, followed by Neritidae spp. (0.6 g; 2.63%), Thaididae spp. (0.4 g; 1.75%), and Echinoidea spp. (0.1 g; 0.44%). Layer II contained the entire midden assemblage.

Site 50-50-15-6854, Feature C (C-shape). A total of 47.0 grams of midden was collected from this C-shape, which included 23.1 grams of Cypraeidae spp. (49.15%), followed by Neritidae spp. (3.5 g; 7.45%), Conidae spp. (3 g; 6.38%), Thaididae spp. (2.6 g; 5.53%), and Echinoidea spp. (0.5 g; 1.06%), and Patellidae sp. (0.3 g; 0.64%). All midden was collected from Layer II.

Site 50-50-15-6857, Feature A (terrace). This feature contained a total of 33.3 grams of midden, which was comprised primarily of Cypraeidae spp. (13.1 g; 39.34%), but also contained Conidae spp. (1 g; 3.0%) and minor amounts of Thaididae spp. (0.3 g; 0.9%), Echinoidea spp. (0.3 g; 0.9%), Patellidae sp. (0.3 g; 0.9%), and Neritidae sp. (0.2 g; 0.6%). The majority of midden was collected from Layer I (32.1 g), which also included the midden of Subfeature 1, comprised of only 0.8 gram of Cypraeidae species.

Site 50-50-15-6860, Feature B (terrace). A total of 19.3 grams of midden was collected from the terrace. Midden was comprised of Cypraeidae spp. (5.1 g: 26.42%), Patellidae spp. (4.4 g; 22.8%), Thaididae spp. (1.3 g; 6.74%), and unidentified shell. The bulk of midden (16.4 g) came from Layer I and 2.9 grams was collected from Layer I.

Site 50-50-15-6861, Feature A (terrace). This terrace yielded 9 grams of midden, which consisted of marine shell (8.9 g; 98.89%) and bone (0.1 g; 1.11%). Shell was comprised primarily of Cypraeidae spp. (5 g; 55.56%), Columbellidae spp. (0.8 g; 8.89%), Thaididae spp. (1.4 g; 15.56%), Patellidae spp. (0.2 g; 2.22%), and unidentified shell. Layer I yielded the majority of midden with 8.1 grams of midden as opposed to Layer II, which contained only 0.9 gram of midden.

Site 50-50-15-6864 (Habitation/Ceremonial Complex). This site yielded a total of 88.0 grams of midden, which was mostly found in Features C and E, although Features A, I, and a test unit down slope of Feature I that also bore midden.

- **Feature A (Terrace with natural windbreak)**. This feature contained a total of 10.2 grams of midden, which included Cypraeidae spp. (6.3 g: 61.76%), Conidae spp. (1.5 g; 14.71%), Patellidae spp. (1.3 g; 12.75%), Neritidae spp. (0.6 g; 5.88%), and Thaididae spp. (0.4 g; 3.92%). All midden was collected from Layer I.
- **Feature C (terrace with overhang).** A total of 42.8 grams of midden was collected from this feature. The midden consists of 42 grams of marine shell, including high concentrations of Cymatiidae spp. (29.4 g; 68.9%), followed by Cypraeidae spp. (5 g; 11.68%), Conidae spp. (1.5 g; 2.34%), Thaididae spp. (1.6 g; 3.74%), and Patellidae spp. (1.3 g; 12.75%). Layer I contained 16.3 grams of midden, consisting primarily of Cymatiidae spp. (12.1 g), followed by various other gastropods (3.3 g) and some *Echinothrix* spp. (0.9 g). Layer II led in midden weight, with 26.1 grams of midden, which contained all of the bone (0.6 g mammal; 0.2 g fish) and a significant portion of marine shell (25.3 g), again led by Cymatiidae spp. (17.3 g) with significant levels of Cypraeidae spp. (3.3 g), Thaididae spp. (1.2 g), and Echinoidea spp. (3.5 g). Layer III contained a mere 0.4 gram of midden, which were all Echinoidea spp.
- **Feature E (C–shape with coral).** This feature contained a total of 35.4 grams of midden, which consisted of mostly bone (35.3 g; 99.72%). Bone midden was predominantly fish bone of various species (21.6 g; 61.02%), followed by mammal bone (13.6 g; 38.42%), and bird (0.1 g; 0.28%). Bone was largely made up of Scaridae spp. (11.3 g; 31.92%), followed by pig, or *Sus scrofa* (8.2 g; 23.16%), unidentified fish (5.6 g; 15.82%), unidentified medium mammal (5.3 g; 14.97%), Scorpaenidae spp. (4.7 g; 13.28%), and minor amounts of bird, unidentified fish, and shell. All midden was collected from the rock fill.
- **Feature I (terrace with surface hearth).** A mere 0.2 gram of midden was collected from this feature. This assemblage consisted of 0.1 gram of fish bone (Scombridae sp.) and 0.1 grams of unidentified shell. The shell was collected from Layer I and the Scombridae sp. (tuna) bone was collected from Layer II.
- **Test Unit 5 (no feature).** This test unit yielded a total of 0.4 gram of midden, which was all Thaididae sp. collected from Layer I.

Site 50-50-15-6951, Feature C (cleared flat with windbreak wall). A total of 8.5 grams of midden was collected from this feature. The majority of midden in this assemblage is shell (7.2 g; 84.71%), which includes Patellidae spp. (0.4 g; 24.71%), Thaididae spp. (1.7 g; 20%), Cypraeidae spp. (1.4 g; 16.47%), Neritidae spp. (0.7 g; 8.24%), Conidae spp. (0.5 g; 5.88%), and unidentified shell. Layer I contained 2 grams of marine shell. Layer II contained 5.8 grams of midden. Layer III contained only 0.7 gram of midden.

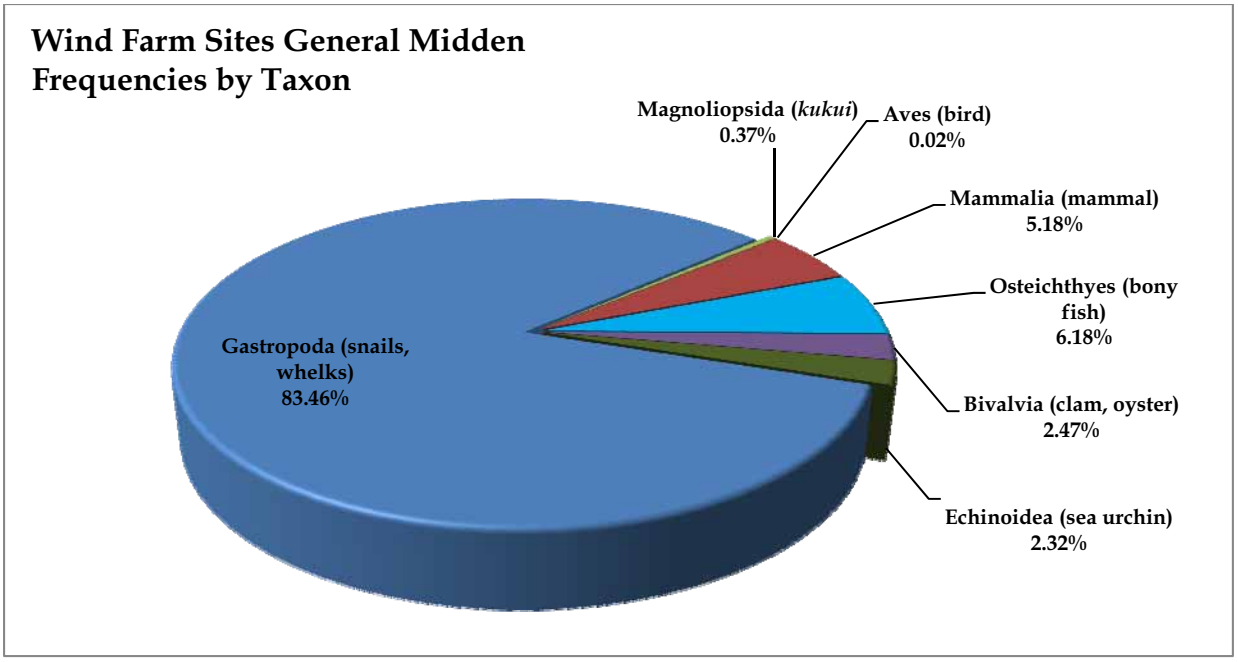


Figure 175. Wind Farm sites midden frequencies by general taxon.

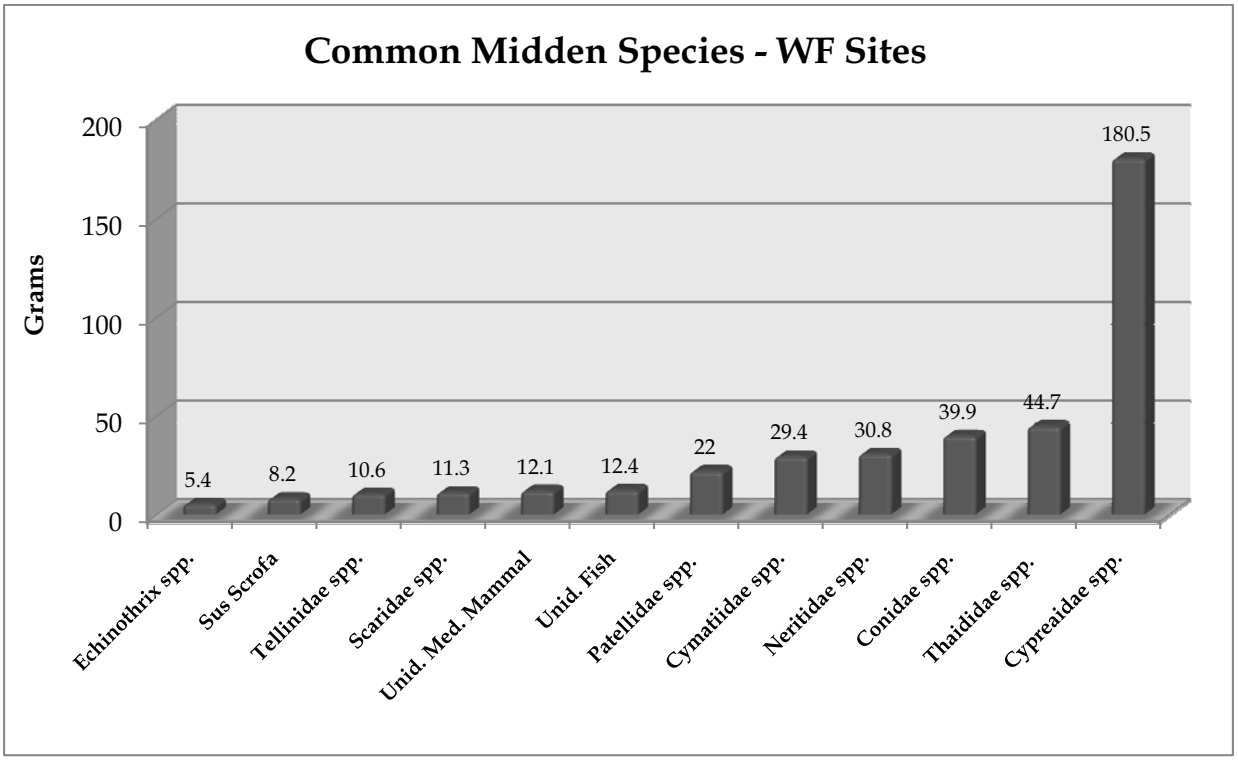


Figure 176. Wind Farm Sites frequencies of species representing at least 1% of the midden assemblage totals.

Table 17. Wind Farm Test Excavations Midden Summary by Feature

SIHP No. (50-50-xx-xxxx)	Field No. AWF-	Site Type	Feature	Feature Description	Midden wt. (g)	Midden Frequency by General Type
6832	141	Habitation Complex	A	U-shaped enclosure	0.1	Marine shell 100%
			B	C-shaped enclosure	0	None
6833	142	Agricultural/ Habitation Complex	A	Enclosure	66.4	Marine shell 100%
6838	167/557	Agricultural/Burial Complex	G	Wall with cleared flat	30.2	Bone 22.85%, Marine shell 77.2%
6839	168	Agricultural/ Habitation Complex	B	Terrace with windbreak	4.9	Marine shell 100%
6845	186	C-shape	-	None	0	None
6848	190/310	Habitation Complex	A	Cleared flat with windbreak	121.3	Bone 4.04%, Marine shell 95.96%
			L	Soil filled terrace	0	None
			E	Stone filled terrace	0	None
			I	Walled terrace	3.3	Bone 3.03%, Marine shell 96.7%
			J	Stone filled terrace	0.5	Kukui 100%
			K	C-shape	0	None
6851	197	Habitation Complex	B	Enclosure	14.2	Bone 4.23%, Marine shell 95.8%
6852	198/199	Agricultural/ Habitation Complex	A	Enclosure	2.2	Marine shell 100%
			I	U shaped enclosure	24.6	Bone 14.63%, Marine shell 85.37%
6853	200	Agricultural/ Habitation Complex	A	Enclosure	22.8	Marine shell 100%
6854	202	Habitation/ Ceremonial Complex	C	C-shape	47.0	Marine shell 100%
6855	204	Habitation Complex	A	C-shape	0	None
6857	208	Agricultural/Habitation Complex	A	Terrace	33.3	Marine shell 100%
6860	212	Agricultural Complex	B	Terrace	19.3	Marine shell 100%
6861	213	Habitation Complex	A	Terrace	9.0	Bone 1.11%, Marine shell 98.9%
6864	216	Habitation/ Ceremonial Complex	E	C–shape with coral	35.4	Bone 99.72% (mammal 38.42%, fish 61.02%), Marine shell 0.2%
			C	Terrace with overhang	42.8	Bone 1.87%, Marine shell 98.13%
			A	Terrace with natural windbreak	10.2	Marine shell 100%
			I	Terrace with surface hearth	0.2	Marine shell 50%, bone 50%
			-	Flat below Feature I	0.4	Marine shell 100%
6951	2010 A	Habitation / Agricultural/Burial Complex	C	Cleared flat with windbreak wall	8.5	Bone 1.18%, Marine shell 84.71%, Kukui 14.12%

Table 18. Controlled Excavations Midden Table for Wind Farm Sites

SIHP No. (50-50-xx-xxxx)	6832 A		6833 A		6838G		6839 B		6848 A		6848 I		6848 J		6851 B		6852 A		6852 I		6853 A		6854 C		6857		6860 B		6861 A		6864		6864 A		686
Bone	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.
Aves																																			
Unidentified Bird																																			
Mammalia																																			
C. lupus familiaris																																			0.6
Rattus exulans																																			
Sus Scrofa																																			
Unid. Med. Mammal									3.1	2.6%									3.6	14.6%									0.1	1.1%					
Unid. Med. Mammal, burnt									1.7	1.4%																									
Unid. Small Mammal					1.1	3.6%																													
Osteichtheyes																																			
Scaridae spp.																																			
Scombridae spp.																																			
Scorpaenidae spp.																																			
Unid. Fish					5.8	19.2%			0.1	0.1%	0.1	3.0%			0.6	4.2%																			0.2
Bone Totals	0.0	0%	0.0	0%	6.9	22.8%	0.0	0%	4.9	4.1%	0.1	3%	0.0	0%	0.6	4%	0.0	0%	3.6	15%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.1	1%	0.0	0%	0.0	0%	0.8
Shell	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.
Bivalvia																																			
Lucinidae spp.									0.8	0.6%																									
Tellinidae spp.			11	15.8%					0.1	0.1%																									
Echinoidea																																			
C. atratus			0.2	0.3%					0.6	0.5%																									
H. mammillatus									0.3	0.2%													0.5	1.1%											0.6
Echinothrix spp.					0.5	1.7%			0.7	0.6%																									4.2
Unid. Echinoidea			1.2	1.8%	0.4	1.3%					0.2	6.1%			0.1	0.7%			0.7	2.8%	0.1	0.4%			0.3	0.9%							0.1	1.0%	
Gastropoda																																			
Columbellidae spp.									0.2	0.2%																			0.8	8.9%					
Conidae spp.			0.5	0.8%	3	10.0%			16.9	13.9%					12.5	88.0%							3.0	6.4%	1.0	3.0%							1.5	14.7%	1.0
Cymatiidae spp.																																			29
Cypreaidae spp.	0.1	100%	32.8	49.4%	11	35.8%	3.9	79.6%	46.7	38.5%	1.6	48.5%			0.9	6.3%	2.2	100%	10.6	43.1%	14.1	61.8%	23.1	49.1%	13.1	39.3%	5.1	26.4%	5.0	55.6%			6.3	61.8%	5.0
Neritidae spp.			0.3	0.5%	0.4	1.3%			21	17.6%	0.4	12.1%							2.8	11.4%	0.6	2.6%	3.5	7.4%	0.2	0.6%							0.6	5.9%	
Patellidae spp.			2.7	4.1%	1.8	5.9%			5.9	4.9%	0.3	9.1%							2.8	11.4%			0.3	0.6%			4.4	22.8%	0.2	2.2%			1.3	12.7%	0.2
Thaididae spp.			12	18.4%	4.2	13.9%	0.1	2.0%	14	11.8%	0.4	12.1%							3.3	13.4%	0.4	1.8%	2.6	5.5%	0.3	0.9%	1.3	6.7%	1.4	15.6%	0.4	100%	0.4	3.9%	1.6
Trochidae spp.									0.6	0.5%																									
Unidentified shell			6	9.0%	2.2	7.3%	0.9	18.4%	8	6.6%	0.3	9.1%			0.1	0.7%			0.8	3.3%	7.6	33.3%	14	29.8%	18	55.3%	8.5	44.0%	1.5	16.7%					
Shell Totals	0.1	100%	66.4	100%	23.3	77%	4.9	100%	116.4	95.9%	3.2	97%	0.0	0%	13.6	96%	2.2	100%	21.0	85%	22.8	100%	47.0	100%	33.3	100%	19.3	100%	8.9	99%	0.4	100%	10.2	100%	42.0
Flora	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.	site %	Wt.
Magnoliopsida																																			
A. moluccana (kukui)													0.5	100%																					
Flora Totals	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.5	100%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0
Site Totals/Overall Midden %	0.1	0.02%	66.4	13.4%	30.2	6.1%	4.9	1.0%	121.3	24.4%	3.3	0.7%	0.5	0.1%	14.2	2.9%	2.2	0.4%	24.6	5.0%	22.8	4.6%	47.0	9.5%	33.3	6.7%	19.3	3.9%	9.0	1.8%	0.4	0.1%	10.2	2.1%	42.8

6.2.2 Generator-Tie Line Test Excavations

A total of 38.5 grams of midden was collected from two features in the Generator-Tie Line Corridor (Table 19 and 20). This midden assemblage is predominantly marine shell (34.8 g; 90.4%), bone was collected from this area, yet only represented 9.6% (3.7 g) of the Generator-Tie Line assemblage (Figure 177). Shell is dominated by gastropods again, primarily Cypraeidae spp. (11.7 g; 30.39%), Conidae spp. (10.8 g; 28.05%), and Patellidae spp. (5.1 g; 13.25%) (Figure 40). Bone is dominated by fish bone, particularly Scaridae spp. or parrot fish (3 g; 7.79%). Site 50-50-15-6871, Feature B (U-shaped enclosure) leads the assemblage in weight, representing 87.5% of the total midden collected.

The results of the analyses of midden by excavated test unit are presented in Tables 19 and 20 and are briefly summarized below.

Site 50-50-14-6865, Feature C (terrace and alignment). This feature contained a total of 4.8 grams of midden, which was primarily Cypraeidae spp. (3.9 g; 81.25%), followed by Thaididae spp. (0.6 g; 12.5%), Nuclidae sp. (0.2 g; 4.17%), and Patellidae sp. (0.1 g; 2.08%). Layer I yielded only 0.5 grams of Cypraeidae spp. Layer II contained the majority of midden with 4.3 grams, which was comprised largely of Cypraeidae spp. (3.9 g), followed by Thaididae spp. (0.6 g), Nuclidae sp. (0.2 g), and only 0.1 grams of Patellidae sp.

Site 50-50-15-6871, Feature B (U-shaped enclosure). A significantly larger amount of midden was collected from this feature, including bone (3.7 g; 10.98%) and marine shell (30.0 g; 89.02%) midden. The majority of bone was fish (3.6 g), which was primarily Scaridae spp. (3 g) with 0.6 grams of unidentified Osteichthyes spp. (fish). A mere 0.1 gram of *C. lupus familiaris* (dog) bone was collected. Layer I contained the highest frequency of midden, including 3.6 grams of fish bone and 28.8 grams of shell, which was dominated by Conidae spp. (10.8 g), followed by Cypraeidae spp. (7.8 g), Patellidae spp. (5.0 g), Thaididae spp. (2.9 g), unidentified Echinoidea spp. (1.1 g), *H. mammillattus* (0.4 g), and Neritidae sp. (0.3 g). Layer II yielded a total of 1.1 grams of midden, which included *Echinothrix* sp. (0.4 g), Neritidae sp. (0.3 g), and Echinoidea spp. (0.2 g). Layer III contained a mere 0.2 grams of midden, which consisted of 0.1 grams of *C. lupus familiaris* and unidentified Echinoidea (0.1 g).

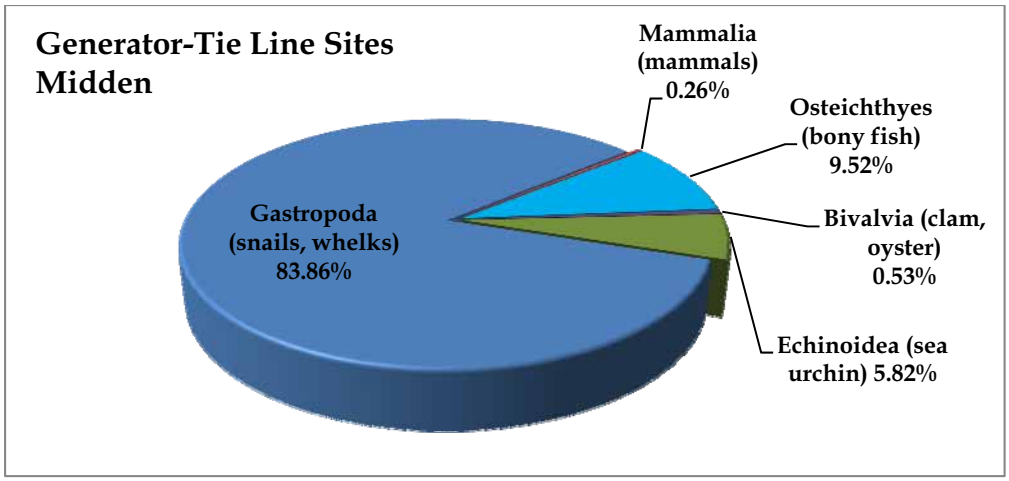


Figure 177. Generator-Tie Line sites midden frequencies by general taxon.

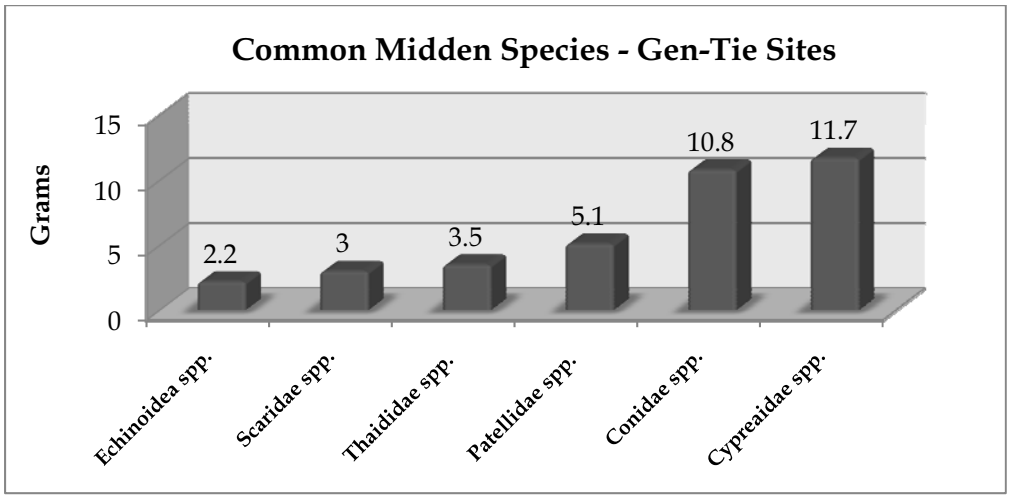


Figure 178. Generator-Tie Line Sites midden species representing at least 1% of the area total.

Table 19. Generator-Tie Line Test Excavations Midden Summary by Feature

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Site Type	Feature	Feature Type	Midden wt. (g)	Midden Frequency by General Type
6819	071/252/253	Agricultural Complex	C	Mound, south half	0	None
6865	247	Habitation/Agricultural Complex	B	Terrace	0	None
			C	Terrace and alignment	4.8	Shell 100%
6871	256	Habitation Complex	B	U shaped enclosure	33.7	Bone 10.98%, Shell 89.02%

Table 20. Controlled Excavations Midden Table for Generator-Tie Line Sites

SIHP No. (50-50-xx-xxxx)	6865 C		6871 B		Midden Totals	
Bone	Wt. (g)	site %	Wt. (g)	site %	Total	%
Mammal					**0.1**	**0.26%**
Canis lupus familiaris			0.1	0.3%	**0.1**	**0.26%**
Osteichthyes					**3.6**	**9.35%**
Scaridae spp.			3	8.9%	**3.0**	**7.79%**
Unidentified Fish			0.6	1.8%	**0.6**	**1.56%**
Bone Totals	**0.0**	**0.0%**	**3.7**	**11.0%**	**3.7**	**9.6%**
Marine Shell	Wt. (g)	site %	Wt. (g)	site %	**Wt. (g)**	**%**
Bivalvia					**0.2**	**0.52%**
Nuclidae spp.	0.2	4.2%			**0.2**	**0.52%**
Echinoidea					**2.2**	**5.71%**
Heterocentrotus mammillatus			0.4	1.2%	**0.4**	**1.04%**
Echinothrix spp.			0.4	1.2%	**0.4**	**1.04%**
Unid. Echinoidea			1.4	4.2%	**1.4**	**3.64%**
Gastropoda					**31.7**	**82.34%**
Conidae spp.			10.8	32.0%	**10.8**	**28.05%**
Cypreaidae spp.	3.9	81.3%	7.8	23.1%	**11.7**	**30.39%**
Neritidae spp.			0.6	1.8%	**0.6**	**1.56%**
Patellidae spp.	0.1	2.1%	5	14.8%	**5.1**	**13.25%**
Thaididae spp.	0.6	12.5%	2.9	8.6%	**3.5**	**9.09%**
Unidentified shell			0.7	2%	**0.7**	**1.82%**
Shell Totals	**4.8**	**100.0%**	**30.0**	**89.0%**	**34.8**	**90.4%**
Site Totals/Overall Midden %	**4.8**	**12.5%**	**33.7**	**87.5%**	**38.5**	**100.0%**

6.2.3 Pāpaka Road Test Excavations

A total of 123.0 grams of midden was collected from six features in the Pāpaka Road area (Tables 21 and 22). The midden assemblage is dominated again by marine shell (74.4 g; 60.5%), followed by Magnoliopsida, specifically *kukui* nut and shells (42.3 g; 34.4%), and bone (6.3 g; 5.1%)(Figure 179). Marine shell is predominantly Gastropoda (57g; 46.34%), with Cypraeidae spp. (35.1 g; 28.54%) leading in weight, followed by Patellidae spp. (9.8 g; 7.97%), Neritidae spp. (4.4 g; 3.58%), Thaididae spp. (4.2 g; 3.41%), Conidae spp. (3.1 g; 2.52%), and Columbellidae spp. (0.4 g; 0.33%) (Figure 180). Bivalves are also a significant portion of the midden assemblage (12.9 g; 10.49%), essentially consisting of Pteriidae spp. (12.7 g; 10.33%) with a mere 0.2 grams of Isognomonidae sp. (0.16%). Echinoidea spp. are also in the assemblage (2.9 g; 2.36%), which includes *Echinothrix* spp. (0.6 g; 0.49%), *Heterocentrotus mammillatus* (0.4; 0.33%), and *Colobocentrotus atratus* (0.3 g; 0.24%). The assemblage contains a significant amount of *kukui* (42.3 g; 34.39%), which is comprised largely of shell fragments (35.9 g; 29.19%) and a minor amount of intact nut and shell (6.4 g; 5.2%). The bone assemblage (6.3 g; 5.1%) is dominated by mammal bone, which includes unidentified medium mammal (2.8 g; 2.28%), *Sus scrofa* (2.7 g; 2.2%), unidentified small mammal (0.4 g; 0.33%), and *Rattus exulans* (0.1 g; 0.08%). Feature D of Site 50-50-14-6931 (midden/historic artifact scatter) contained the greatest amount of midden (53.1 g; 43.2%), which was largely *kukui* shell (29.9 g; 56.3%) and intact *kukui* nut and shell (6.4 g; 12.1%). Site 50-50-14-6940, Feature H (terrace) followed closely in total midden weight (37.9 g; 30.8%), but led in species diversity with shell and bone.

The results of the analyses of midden by excavated test unit are presented in Tables 21 and 22 and are briefly summarized below.

Site 50-50-14-6931, Feature D (midden/historic artifact scatter). This feature yielded a total of 53.1 grams of midden, representing 43.2% of the total Pāpaka Road area assemblage. The bulk of this feature's midden is kukui (36.3 g; 68.4%), which is predominantly shell fragments (29.9 g; 56.3%) with 6.4 grams of whole nut in shell (12.1%). Marine shell represents only 26.6% of the midden assemblage and is dominated by pearl oysters, or Pteriidae spp. (12.7 g; 23.9%), with trace amounts of Patellidae spp. (0.3 g; 0.6%) and Thaididae spp. (0.3 g; 0.6%). A total of 2.7 grams (5.1%) of *Sus scrofa* (pig) was also collected. The surface of this test unit yielded the majority midden collected (26.3 g) that was almost equally *kukui* shell (12.8g) and Pteriidae spp. (12.7g) as well as some unidentified shell (0.8 g). Layer I contained 23.9 grams of midden, which was predominantly *kukui* shell (17.1g), followed by whole *kukui* nut in shell (6.4 g), and trace amounts of Thaididae sp. (0.3 g) and Patellidae sp. (0.1 g). Layer II contained only 2.9 grams of midden, which was predominantly *Sus scrofa* (2.7 g) with a few Patellidae sp. (0.2 g).

Site 50-50-14-6939, Feature A (enclosure). The enclosure yielded a total of 9.9 grams of midden, dominated by Cypraeidae spp. (4.2 g; 42.4%), followed by Patellidae spp. (3.1 g; 31.3%), Neritidae spp. (1.1 g; 11.1%), Thaididae spp. (0.8 g; 8.1%), unidentified medium mammal (0.2 g; 2.0%), Columbellidae spp. (0.2 g; 2.0%), unidentified Echinoidea sp. (0.2 g; 2.0%), and *Rattus exulans* (0.1 g; 1.0%). Layer I contained the highest frequency of midden (8.2 g), with Cypraeidae spp. (3.1 g) and Patellidae spp. (3.1 g) leading in weight, followed by Neritidae spp. (0.9 g), Thaididae spp. (0.5 g), Columbellidae spp. (0.2 g), and unidentified medium mammal (0.2 g). Layer II trailed in weight with 1.7 grams of midden, which was comprised of Cypraeidae spp. (1.1 g), followed by Thaididae sp. (0.3 g), Neritidae sp. (0.2 g), and *Rattus exulans* (0.1 g).

Site 50-50-14-6939, Feature C (terrace). This terrace yielded only 3.7 grams of midden, which was dominated by *kukui* shell (3.6 g; 97.3%), with a mere 0.1 grams of Cypraeidae sp. (2.7%). All midden was collected from Layer II.

Site 50-50-14-6940, Feature H (terrace). A total of 37.9 grams of midden was collected from this feature, including 34.9 grams of marine shell and 3 grams of bone. The shell assemblage is predominantly Gastropoda spp. (31.2 g; 82.3%), principally Cypraeidae spp. (17.5 g; 46.2%), followed by Patellidae spp. (6.4 g; 16.9%), Conidae spp. (3.1 g; 8.2%), Neritidae spp. (2.9 g; 7.7%), Thaididae spp. (1.1 g; 2.9%), and Columbellidae spp. (0.2 g; 0.5%). Echinoidea, or sea urchin, was also a significant portion of the shell assemblage, which was comprised of unidentified Echinoidea spp. (1.4 g; 3.7%), followed by *Echinothrix* spp. (0.6 g; 1.6%), *Heterocentrotus mammillatus* (0.4 g; 1.1%) and *Colobocentrotus atratus* (0.3 g; 0.8%). Bone was comprised mainly of unidentified medium mammal (2.6 g; 6.9%), with identifiable fish species, such as Lutjanidae sp. (0.2 g; 0.5%). Layer I lead in midden weight (19.8 g), with a significant portion of the Gastropoda weight (19.2 g), which was primarily Cypraeidae spp. (15.6 g), followed by

Patellidae spp. (3.3 g), and Conidae sp. (0.3 g). Layer II contained a total of 18.1 grams of midden, which was led by Patellidae spp. (3.1 g) in weight, followed closely by Neritidae spp. (2.9 g), Conidae spp. (2.8 g), Echinoidea spp. (2.7 g), unidentified medium mammal (2.6 g), Cypraeidae sp. (1.9 g), Thaididae spp. (1.1 g), Columbellidae sp. (0.2 g), Lutjanidae sp. (0.2 g), and Isognomonidae sp. (0.2 g).

Site 50-50-14-6943, Feature B (mound, east half). This feature yielded a total of 14.1 grams of midden, which was dominated by Cypraeidae spp. (11.3 g; 80.1%), with a significant amount of *kukui* shell (2.4 g; 17.0%) and some Neritidae sp. (0.4 g; 2.8%). All midden was collected from Layer I.

Site 50-50-14-6956 (large enclosure). This enclosure contained a total of 4.3 grams of midden, which was mainly marine shell (4 g; 81.6%), followed by unidentified small mammal (0.3 g; 6.1%). Only the small mammal was collected from Layer I. Layer II contained the bulk of this feature's midden, with equal portions of Cypraeidae sp. (2.0 g) and Thaididae sp. (2.0 g), followed by 0.3 grams of unidentified small mammal.

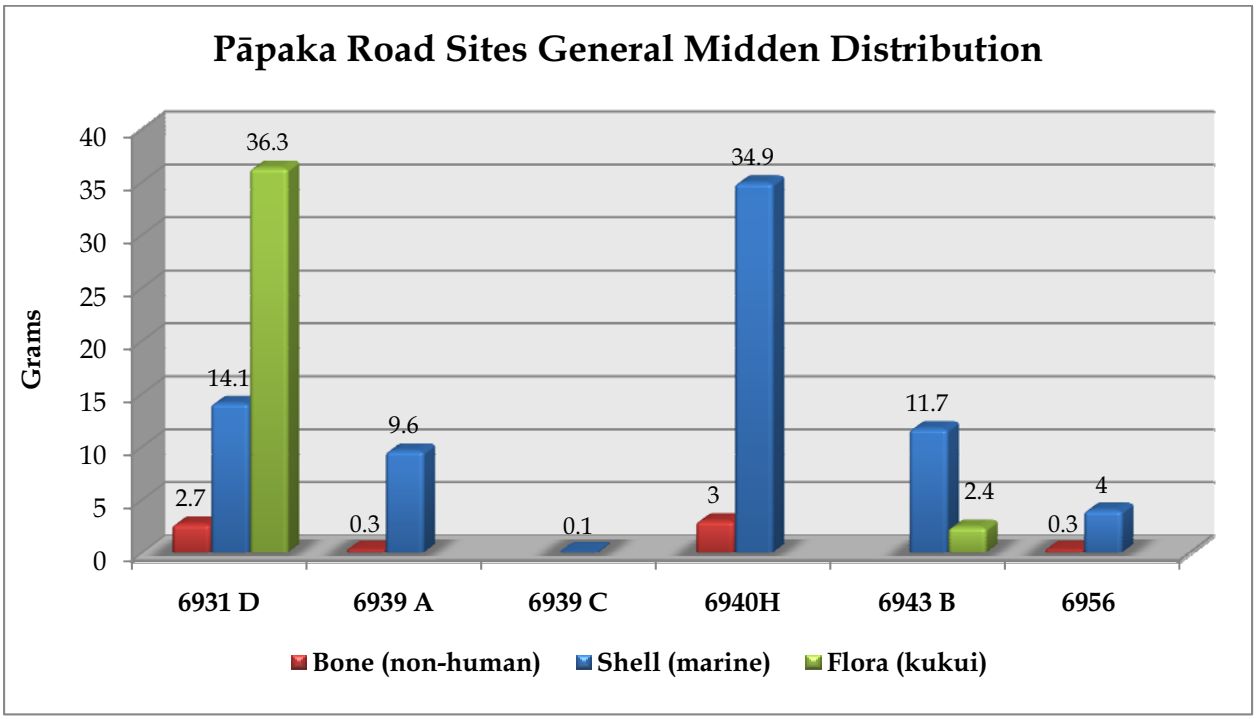


Figure 179. Distribution of Pāpaka Road Sites Midden.

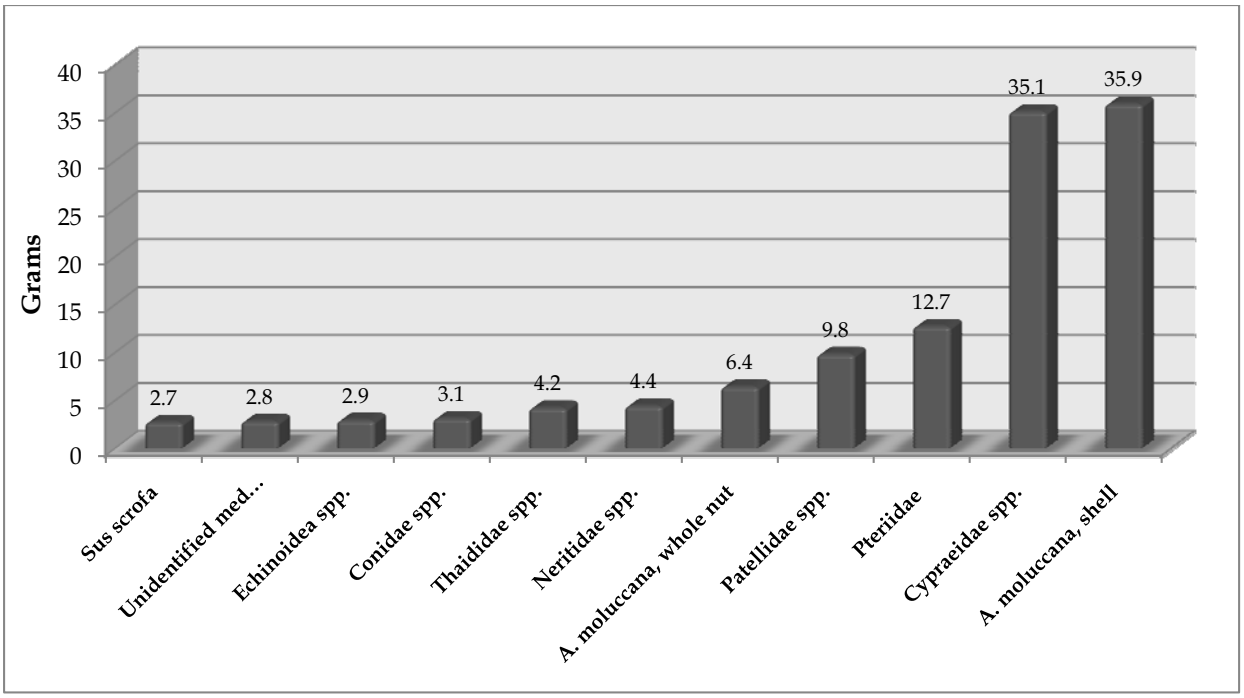


Figure 180. Pāpaka Road Sites frequencies of species representing at least 1% of the midden assemblage totals.

Table 21. Pāpaka Road Test Excavations Midden Summary

SIHP No. (50-50-xx-xxxx)	Field No. (AWF-xxx)	Site Type	Feature	Feature Type	Midden wt. (g)	Midden Frequency by General Type
6931	585	Habitation / Ranching Complex	D	midden / historic artifact scatter	53.1	Kukui 68.4%; Shell 26.6%; Bone 5.1%
6939	593	Habitation Complex	A	enclosure	9.9	Shell 97.0%; Bone 3.0%
6939	593	Habitation Complex	C	terrace	3.7	Kukui 97.3%; Shell 2.7%
6940	594	Habitation / Agricultural Complex	H	terrace	37.9	Shell 92.1%; Bone 7.9%
6943	598	Ranching Complex	B	Mound, east half	14.1	Shell 83.0%; Kukui 17.0%
6956	2010F	Large Enclosure	-	No features	4.3	Shell 81.6%; Bone 6.1%

Table 22. Controlled Excavations Midden Table for Pāpaka Sites

SIHP No. (50-50-xx-xxxx)	6931 D		6939 A		6939 C		6940 H		6943 B		6956		Midden Table	
Bone	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Total	%
Mammal													**6.0**	**4.88%**
Rattus exulans			0.1	1.0%									**0.1**	**0.08%**
Sus scrofa	2.7	5.1%											**2.7**	**2.20%**
Unidentified med. mammal			0.2	2.0%			2.6	6.9%					**2.8**	**2.28%**
Unidentified small mammal							0.1	0.3%			0.3	6.1%	**0.4**	**0.33%**
Osteichtheyes													**0.3**	**0.24%**
Lutjanidae spp.							0.2	0.5%					**0.2**	**0.16%**
Scaridae spp.													**0.0**	**0.00%**
Unidentified Fish							0.1	0.3%					**0.1**	**0.08%**
Bone Totals	**2.7**	**5.1%**	**0.3**	**3.0%**	**0.0**	**0.0%**	**3.0**	**7.9%**	**0.0**	**0.0%**	**0.3**	**6.1%**	**6.3**	**5.1%**
Marine Shell	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Total	%
Bivalvia													**12.9**	**10.49%**
Isognomonidae spp.							0.2	0.5%					**0.2**	**0.16%**
Pteriidae spp.	12.7	23.9%											**12.7**	**10.33%**
Echinoidea													**2.9**	**2.36%**
Colobocentrotus atratus							0.3	0.8%					**0.3**	**0.24%**
Heterocentrotus mammillatus							0.4	1.1%					**0.4**	**0.33%**
Echinothrix spp.							0.6	1.6%					**0.6**	**0.49%**
Unidentified Echinoidea			0.2	2.0%			1.4	3.7%					**1.6**	**1.30%**
Gastropoda													**57.0**	**46.34%**
Columbellidae spp.			0.2	2.0%			0.2	0.5%					**0.4**	**0.33%**
Conidae spp.							3.1	8.2%					**3.1**	**2.52%**
Cypreaidae spp.			4.2	42.4%	0.10	2.7%	17.5	46.2%	11.3	80.1%	2.0	40.8%	**35.1**	**28.54%**
Neritidae spp.			1.1	11.1%			2.9	7.7%	0.4	2.8%			**4.4**	**3.58%**
Patellidae spp.	0.3	0.6%	3.1	31.3%			6.4	16.9%					**9.8**	**7.97%**
Thaididae spp.	0.3	0.6%	0.8	8.1%			1.1	2.9%			2	40.8%	**4.2**	**3.41%**
Unidentified shell	0.8	1.5%					0.8	2.1%					**1.6**	**1.30%**
Shell Totals	**14.1**	**26.6%**	**9.6**	**97.0%**	**0.1**	**2.7%**	**34.9**	**92.1%**	**11.7**	**83.0%**	**4.0**	**81.6%**	**74.4**	**60.5%**
Flora	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Wt. (g)	site %	Total	%
Magnoliopsida													**42.3**	**34.39%**
Aleurites moluccana (*kukui*)	29.9	56.3%			3.6	97.3%			2.4	17.0%			**35.9**	**29.19%**
A. moluccana, whole nut	6.4	12.1%											**6.4**	**5.20%**
Flora Totals	**36.3**	**68.4%**	**0.0**	**0.0%**	**3.6**	**97.3%**	**0.0**	**0.0%**	**2.4**	**17.0%**	**0.0**	**0.0%**	**42.3**	**34.4%**
Site Totals/Overall Midden %	**53.1**	**43.2%**	**9.9**	**8.0%**	**3.7**	**3.0%**	**37.9**	**30.8%**	**14.1**	**11.5%**	**4.3**	**3.5%**	**123.0**	**100.0%**

6.3 RADIOCARBON DATING

Sixteen carbon samples were collected from 15 sites investigated in the Auwahi Wind Farm. Thirteen of the samples were from the Wind Farm, two were from Pāpaka Road and one was from the Generator-Tie Line Corridor *mauka* Pi‘ilani Highway. The samples dated are from the following proveniences:

Site 50-50-15-6832, Feature A
Site 50-50-15-6838, Feature G
Site 50-50-15-6848, Feature A
Site 50-50-15-6851, Feature B
Site 50-50-15-6852, Feature I (N=2)
Site 50-50-15-6853, Feature A
Site 50-50-15-6854, Feature C
Site 50-50-15-6855, Feature A
Site 50-50-15-6860, Feature B
Site 50-50-15-6864, Feature C
Site 50-50-15-6871, Feature B (Generator-Tie Line Corridor)
Site 50-50-15-6894, Feature A
Site 50-50-14-6931, Feature D (Pāpaka Road Corridor)
Site 50-50-14-6939, Feature C (Pāpaka Road Corridor)
Site 50-50-15-6951, Feature C

Prior to submitting the 16 carbon samples for radiometric analyses, they were submitted to the Wood Identification Laboratory at the International Archaeological Research Institute, Inc. for charcoal identification. The goal was to factor out possible long lived species thus controlling for the "old wood effect." All of the samples from the test excavations were composed of short lived species.

Carbon samples were sent to Beta Analytic Radiocarbon Dating Laboratory for dating. The carbon samples were quite small so that accelerator mass spectrometry (AMS) radiocarbon dating was necessary for all 21 samples. AMS dating at Beta Analytic includes $^{13}C/^{12}C$ analysis, so all samples were adjusted based on the $^{13}C/^{12}C$ ratio.

The pretreatment for the AMS dating charred material samples consisted of acid/alkali/acid washes where the sample was first gently crushed and dispersed in deionized water. It was then given hot acid washes to eliminate carbonates, then alkali washes to remove secondary organic acids, then a final acid rinse to neutralize the solution prior to drying. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated.

The results of the radiocarbon dating are summarized in Table 23; Appendix F presents the data sheets.

Site 50-50-15-6832, Feature A
The single sample of a charred native shrub (*Chamaesyce* (sp) *Akoko)* from Site 6832, Feature A provided a pooled age range at two standard deviations of AD 1430 – 1630. This site may have been settled as early at the mid 15th century and was probably occupied to the mid 1600s, thus making it possibly one of the earliest sites utilized within the project area.

Site 50-50-15-6838, Feature G
The single sample of a charred native shrub (*Chamaesyce* (sp) *Akoko)* from Site 6838, Feature G provided a pooled age range at two standard deviations of AD 1520 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-15-6848, Feature A
The single sample of a charred native shrub (cf. *Myoporum sandwicensis, Naio)* from Site 6848, Feature A provided a pooled age range at two standard deviations of AD 1500 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the early AD 1500s and AD 1800.

Site 50-50-15-6851, Feature B
The single sample of a charred native shrub (*Nototrichium sandwicense, Kulu'i.)* from Site 6851, Feature B provided a pooled age range at two standard deviations of AD 1430 – 1630. This site may have been settled as early at the mid 15th century and was probably occupied to the mid 1600s, thus making it possibly one of the earliest sites utilized within the project area.

Site 50-50-15-6852, Feature I
Two samples (Beta287012 and 287013) of charred native shrubs (*Chamaesyce* (sp) *Akoko* and *Dodonaea viscose 'A'ali'i* respectively*)* were submitted to date Site 6852, Feature I. Beta 287012 yielded a pooled two sigma age range of AD 1540 – 1950; Beta 287013 produced an age range of AD 1660 to 1960. No historic artifacts were found on the surface or recovered from the excavations, it is reasonable to assume that this feature was not used beyond 1800 suggesting that this site was used between AD 1540 and 1800.

Site 50-50-15-6853, Feature A
The single sample of a charred native shrub (*Chamaesyce* (sp) *Akoko)* from Site 6853, Feature A provided a pooled age range at two standard deviations of AD 1650 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1600s and AD 1800.

Site 50-50-15-6854, Feature C
The single sample of a charred native shrub (cf. *Myoporum sandwicensis, Naio)* from Site 6854, Feature C provided a pooled age range at two standard deviations of AD 1520 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-15-6855, Feature A
The single sample of a charred native shrub (*Chamaesyce* (sp) *Akoko)* from Site 6855, Feature A provided a pooled age range at two standard deviations of AD 1530 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-15-6860, Feature B
The single sample of a charred native shrub (*Chamaesyce* (sp) *Akoko)* from Site 6860, Feature B provided a pooled age range at two standard deviations of AD 1530 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-15-6864, Feature C
The single sample of a charred native shrub (*Dodonaea viscose ʻAʻaliʻi)* from Site 6864, Feature C provided a pooled age range at two standard deviations of AD 1520 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-15-6871
The single sample of a charred native shrub (*Perrottetia sandwicensis, Olomea)* from Site 6871 provided a pooled age range at two standard deviations of AD 1640 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1600s and AD 1800.

Site 50-50-15-6894, Feature A
The single sample of a charred native shrub (*Dodonaea viscose ʻAʻaliʻi)* from Site 6894, Feature A provided a pooled age range at two standard deviations of AD 1530 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-14-6931, Feature D
The single sample of a charred native shrub (*Chenopodium oahuensisi, ʻAheahea)* from Site 6931, Feature D provided a pooled age range at two standard deviations of AD 1540 – 1950. Numerous historic artifacts were recovered from the excavations, including, bottle glass, flat window glass, ceramics, metal nails, and a machined screw. These artifacts indicate that this

site was occupied into the historic period, possibly as recently as the mid 20th century. The overall occupation period then may have extended from the mid 16th century to the mid 20th century.

Site 50-50-14-6939, Feature C

The single sample of a charred native shrub (*Dodonaea viscose 'A'ali'i)* from Site 6939, Feature C provided a pooled age range at two standard deviations of AD 1520 – 1950. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1500s and AD 1800.

Site 50-50-15-6951, Feature C

The single sample of a charred native shrub (cf. *Myoporum sandwicensis, Naio)* from Site 6951, Feature C provided a pooled age range at two standard deviations of AD 1660 – 1960. Because of the lack of historical material associated with this site, it is reasonable to think that it was utilized between the mid AD 1600s and AD 1800.

Summary

Two sites have initial dates extending back to the 15th century and probably represent the initial exploration and possible use of this area. The majority of the sites (N=10) date between the 16th and 18th centuries, with three sites dating to the 17th and 18th centuries. Most of the age ranges extend into the modern era, but do not appear to actually have been used in historic times. The exception to this is Site 3931, Feature D along the Pāpaka Road corridor, which contained abundant historic materials and thus probably dated into the historic era. For the most part, it appears that Auwahi was initially explored in the 1400s and then intensively used from the mid 1500s up until about 1800. Most of Auwahi appears to have been abandoned by 1800.

Table 23. Radiocarbon Dating Results

Sample No.	SIHP No. (50-50-xx-xxxx) & Provenience	Field Site & Bag No.	Material	$^{13}C/^{12}C$ Ratio	^{13}C Conventional Age B.P.	Calibrated Age[1] (one sigma)	Calibrated Age[2] (two sigma)
Beta 287009	Site 6931, Feat. D TU 1; I/2 20 cm bd	. AWF-585, Feat. D; Bag 007	Charred material *Chenopodium oahuensisi 'Aheahea* `	-26.2 o/oo	230 ± 40	AD 1650 – 1670 AD 1780 – 1800 AD 1930 – 1950	AD 1540 – 1540 AD 1630 – 1680 AD 1740 – 1810 AD 1930 - 1950
Beta 287010	Site 6851, Feat. B TU 1; II/2 22 cm bs	AWF-197, Feat. B Bag 055	Charred material *Nototrichium sandwicense Kulu'i.*	-24.5 o/oo	400 ± 40	AD 1440 – 1490	AD 1430 – 1530 AD 1560 - 1630

Sample No.	SIHP No. (50-50-xx-xxxx) & Provenience	Field Site & Bag No.	Material	$^{13}C/^{12}C$ Ratio	^{13}C Conventional Age B.P.	Calibrated Age[1] (one sigma)	Calibrated Age[2] (two sigma)
Beta 287011	Site 6870, Feat. B TU 1; I 25 cm bs	AWF-256, Feat. B Bag 065	Charred material *Perrottetia sandwicensis Olomea*	-10.62 o/oo	200 ± 40	AD 1660 – 1680 AD 1740 – 1800 AD 1940 – 1950	AD 1640 – 1700 AD 1720 – 1820 AD 1920 – 1950
Beta 287012	Site 6852, Feat. I TU 2; II 34 cm bd	AWF-198/199; Feat. I Bag 086	Charred material *Chamaesyce* (sp) *Akoko`*	-11.0 o/oo	230 ± 40	AD 1650 – 1670 AD 1780 – 1800 AD 1950 – 1950	AD 1540 – 1540 AD 1630 – 1680 AD 1740 – 1810 AD 1930 – 1950
Beta 287013	Site 6852, Feat. I TU 2; II/4 Hearth 46-53 cm bd	AWF-198/199; Feat. I Bag 093	Charred material *Dodonaea viscose 'A'ali'*	-26.2 o/oo	150 ± 40	AD 1670 – 1700 AD 1720 – 1780 AD 1800 – 1820 AD 1840 – 1880 AD 1920 – 1950 AD 1950 – 1950	AD 1660 – 1960
Beta 287014	Site 6853, Feat. A TU 1; II/4 20-30cm bd	AWF-200, Feat. A Bag 108	Charred material *Chamaesyce* (sp) *Akoko `*	-23.1 o/oo	190 ± 40	AD 1660 – 1680 AD 1740 – 1810 AD 1930 – 1950	AD 1650 – 1700 AD 1720 – 1820 AD 1840 – 1880 AD 1920 – 1950
Beta 287015	Site 6854, Feat. C TU 1; II 11 cm bs	AWF-202; Feat. C Bag 112	Charred material cf. *Myoporum sandwicensis Naio`*	-24.8 o/oo	260 ± 40	AD 1640 – 1660	AD 1520 – 1590 AD 1620 – 1670 AD 1770 – 1800 AD 1940 – 1950
Beta 287016	Site 6951, Feat. C TU 1; II 0-12 cm bs	AWF-2010 A; Feat. C Bag 119	Charred material cf. *Myoporum sandwicensis Naio``*	-24.4 o/oo	150 ± 40	AD 1670 – 1700 AD 1720 – 1780 AD 1800 – 1820 AD 1840 – 1880 AD 1920 – 1950 AD 1950 – 1950	AD 1660 – 1960
Beta 287017	Site 6855, Feat. A TU 1; II 14 cm bs	AWF-204, Feat. A Bag 143	Charred material *Chamaesyce* (sp) *Akoko `*	-10.8 o/oo	240 ± 40	AD 1640 – 1670 AD 1780 – 1790	AD 1530 – 1560 AD 1630 – 1680 AD 1740 – 1800 AD 1940 – 1950
Beta 287018	Site 6838, Feat. G TU 1; I 6 cm bs	AWF-167/557, Feat. G Bag 166	Charred material *Chamaesyce* (sp) *Akoko `*	-25.6 o/oo	250 ± 40	AD 1640 – 1660	AD 1520 – 1580 AD 1630 – 1680 AD 1770 – 1800 AD 1940 – 1950

Sample No.	SIHP No. (50-50-xx-xxxx) & Provenience	Field Site & Bag No.	Material	$^{13}C/^{12}C$ Ratio	^{13}C Conventional Age B.P.	Calibrated Age[1] (one sigma)	Calibrated Age[2] (two sigma)
Beta 287019	Site 6832, Feat. A TU 1; II 22 cm bs	AWF-141, Feat. A Bag 181	Charred *Chamaesyce* (sp) *Akoko* `	-11.3 o/oo	410 ± 40	AD 1440 – 1480	AD 1430 – 1520 AD 1580 – 1630
Beta 287020	Site 6939, Feat. C TU 2; II 27 cm bs	AWF-593, Feat. C Bag 205	Charred material *Dodonaea viscose* *'A'ali'i*	-9.8 o/oo	250 ± 40	AD 1640 – 1660	AD 1520 – 1580 AD 1630 – 1680 AD 1770 – 1800 AD 1940 – 1950
Beta 287021	Site 6848, Feat. A TU 1; III 28 cm bs	AWF-190/310, Feat. A Bag 258	Charred material cf. *Myoporum sandwicensis* *Naio* `	-10.2 o/oo	270 ± 40	AD 1540 – 1540 AD 1630 – 1660	AD 1500 – 1600 AD 1610 – 1670 AD 1780 – 1800 AD 1950 – 1950
Beta 287022	Site 6864, Feat. C TU 2; II 24 cm bs	AWF-216, Feat. C Bag 302	Charred material cf. *Dodonaea viscose* *'A'ali'*	-23.8 o/oo	250 ± 40	AD 1640 – 1660	AD 1520 – 1580 AD 1630 – 1680 AD 1770 – 1800 AD 1940 – 1950
Beta 287023	Site 6860, Feat. B TU 1; I 20 cm bs	AWF-212, Feat. B Bag 325	Charred material *Chamaesyce* (sp) *Akoko* `	-24.7 o/oo	240 ± 40	AD 1640 – 1670 AD 1780 – 1790	AD 1530 – 1560 AD 1630 – 1680 AD 1740 – 1800 AD 1940 – 1950
Beta 287024	Site 6894, Feat. A Surface within tube	AWF-324, Feat. A Bag 360	Charred material cf. *Dodonaea viscose* *'A'ali'*	-10.9 o/oo	240 ± 40	AD 1640 – 1670 AD 1780 – 1790	AD 1530 – 1560 AD 1630 – 1680 AD 1740 – 1800 AD 1940 – 1950

1. One sigma, 68% probability; calibration from Beta Analytic Radiocarbon Dating Laboratory
2. Two sigma, 95% probability; calibration from Beta Analytic Radiocarbon Dating Laboratory

7.0 SIGNIFICANCE ASSESSMENTS

The National Historic Preservation Act of 1966 (as amended) authorizes the Secretary of Interior to expand and maintain a National Register of Historic Places (NRHP) that contains a listing of districts, sites, buildings, structures and objects significant in American history, architecture, archaeology, engineering and culture. A property may be listed in the NRHP if it meets criteria for evaluation defined in 36 CFR §60.4:

> The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and
>
> (a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) That are associated with the lives of persons significant in our past; or
>
> (c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> (d) That have yielded, or may be likely to yield, information important in prehistory or history.

The State of Hawai‘i recognizes the above criteria under HRS §13-275-6, and has also added a fifth Hawai‘i Register of Historic Places (HRHP) significance criterion to the evaluation process:

> (e) That have an important value to the Native Hawaiian people or to another ethnic group of the State due to associations with cultural practices once carried out or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts – these associations being important to the group's history and cultural identity.

All archaeological sites recorded in 2010, including all sites within the current APE and those sites now outside the current APE have been assessed for significance.

All of the resources have been assessed as significant based on criterion D – that have either yielded or have the potential to yield information important to the history of Auwahi specifically and more generally for the *moku* of Kahikinui and the entire island of Maui. In addition, three sites appear to be significant because of the high degree of workmanship in tier construction; these are sites 6843, 6913, and 6956. Finally, 34 of these sites appear to be culturally important because they contain human burials, are suspected to contain human burials, or appear to be ceremonial sites; these are 6813, 6815, 6819, 6821, 6825, 6827, 6835, 6838,

6840, 6843, 6849, 6850, 6864, 6890, 6894, 6904, 6906, 6908, 6909, 6912, 6921, 6922, 6923, 6931, 6936, 6951, 6953, 6954, 6985, 6992, 6993, 7017, 7035, and 7041. The significance assessments are summarized in Table 24.

Table 24. Significance Assessments of Sites

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6813	**037/038/040/041**	Out	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6814	**042**	Out	Wind Farm	Lava Tube	Habitation	D
6815	**045**	In	Wind Farm	Complex	Ceremonial / Habitation / Transportation	D, E
6816	**067/068**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6817	**069**	In	Wind Farm	C-Shaped Wall	Habitation	D
6818	**070**	In	Wind Farm	Wall	Ranching	D
6819	**071/252/253**	Out	Gen-Tie Line	Complex	Burial / Uncertain	D, E
6820	**089**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6821	**091/092/093**	In	Wind Farm	Complex	Agriculture / Habitation / Transportation / Uncertain	D, E
6822	**095**	In	Wind Farm	Wall	Agriculture / Uncertain	D
6823	**096**	In	Wind Farm	Complex	Agriculture / Habitation	D
6824	**098**	Out	Wind Farm	Complex	Agriculture / Animal Husbandry / Habitation / Uncertain	D
6825	**100**	Out	Wind Farm	Complex	Ceremonial / Habitation / Uncertain	D, E
6826	**102**	Out	Wind Farm	Complex	Agriculture / Transportation / Uncertain	D
6827	**106/108**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6828	**107**	In	Wind Farm	Wall	Agriculture / Ranching	D
6829	**109**	In	Wind Farm	Terrace	Habitation	D
6830	**129**	In	Wind Farm	C-Shaped Wall	Agriculture / Habitation	D
6831	**133**	Out	Wind Farm	Stone Mound	Uncertain	D
6832	**141**	In	Wind Farm	Complex	Agriculture	D
6833	**142**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6834	**143**	In	Wind Farm	Complex	Agriculture / Habitation	D
6835	**145**	Out	Wind Farm	Lava Tube	Burial / Uncertain	D, E
6836	**155**	In	Wind Farm	Complex	Agriculture / Habitation	D
6837	**166**	In	Wind Farm	Wall	Uncertain	D
6838	**167/557**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6839	**168**	Out	Wind Farm	Complex	Agriculture	D
6840	**176**	Out	Wind Farm	Complex	Agriculture / Animal Husbandry / Ceremonial / Habitation / Uncertain	D, E
6841	**180/546**	In	Wind Farm	Complex	Agriculture / Habitation	D
6842	**181**	In	Wind Farm	Complex	Agriculture / Habitation	D
6843	**182/184**	In	Wind Farm	Complex	Ceremonial / Habitation / Uncertain	C, D, E
6844	**183/185**	Out	Wind Farm	Complex	Habitation / Uncertain	D
6845	**186**	In	Wind Farm	C-Shaped Wall	Habitation	D
6846	**187**	Out	Wind Farm	Terrace	Habitation	D

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6847	**188**	Out	Wind Farm	Enclosure	Habitation	D
6848	**190/310**	In	Wind Farm	Complex	Habitation / Uncertain	D
6849	**194**	Out	Wind Farm	Terrace	Ceremonial	D, E
6850	**195**	Out	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
6851	**197**	Out	Wind Farm	Complex	Habitation	D
6852	**198/199**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6853	**200**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6854	**202**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6855	**204**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6856	**207**	Out	Wind Farm	L-Shaped Wall	Habitation	D
6857	**208**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6858	**209**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6859	**211**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6860	**212**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6861	**213**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6862	**214**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6863	**215**	In	Wind Farm	Complex	Agriculture / Animal Husbandry / Habitation / Transportation / Uncertain	D
6864	**216**	In	Wind Farm	Complex	Ceremonial / Habitation / Uncertain	D, E
6865	**247**	In	Gen-Tie Line	Complex	Agriculture / Uncertain	D
6866	**249**	In	Gen-Tie Line	Complex	Agriculture / Habitation	D
6867	**250**	In	Gen-Tie Line	Wall	Ranching	D
6868	**251**	Out	Gen-Tie Line	Wall	Agriculture	D
6869	**254**	Out	Gen-Tie Line	Complex	Habitation	D
6870	**255**	Out	Gen-Tie Line	Complex	Agriculture	D
6871	**256**	Out	Gen-Tie Line	Complex	Agriculture / Habitation	D
6872	**258/259**	Out	Gen-Tie Line	Complex	Agriculture / Habitation / Ranching / Uncertain	D
6873	**260/261**	Out	Gen-Tie Line	Complex	Habitation / Uncertain	D
6874	**262/263**	In	Gen-Tie Line	Wall	Ranching	D
6875	**264**	Out	Gen-Tie Line	Lava Tube	Habitation	D
6876	**265**	In	Gen-Tie Line	Wall	Ranching	D
6877	**266**	In	Gen-Tie Line	Complex	Agriculture / Ranching	D
6878	**267**	In	Gen-Tie Line	Stone Mound	Agriculture	D
6879	**268**	In	Gen-Tie Line	Wall	Ranching	D
6880	**269**	In	Gen-Tie Line	Complex	Ranching	D
6881	**270/271**	In	Gen-Tie Line	Complex	Agriculture / Ranching / Uncertain	D
6882	**273/362**	In	Gen-Tie Line	Complex	Agriculture / Ranching	D
6883	**274/275**	Out	Gen-Tie Line	Complex	Agriculture / Uncertain	D
6884	**276**	Out	Gen-Tie Line	Stone Mound	Agriculture / Ranching	D
6885	**277**	Out	Gen-Tie Line	Stone Mound	Agriculture	D
6886	**297**	Out	Wind Farm	Complex	Habitation	D
6887	**305**	In	Wind Farm	Complex	Habitation / Uncertain	D
6888	**306**	In	Wind Farm	U-Shaped Wall	Habitation	D

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6889	**307**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6890	**308**	Out	Wind Farm	Complex	Burial / Habitation / Uncertain	D, E
6891	**309**	In	Wind Farm	Complex	Agriculture / Transportation	D
6892	**322**	In	Wind Farm	Complex	Agriculture / Habitation	D
6893	**323**	In	Wind Farm	Complex	Agriculture	D
6894	**324**	In	Wind Farm	Complex	Burial / Habitation / Uncertain	D, E
6895	**326**	In	Wind Farm	Complex	Agriculture / Habitation	D
6896	**329**	In	Wind Farm	Complex	Agriculture / Habitation	D
6897	**331**	In	Wind Farm	Complex	Agriculture / Habitation	D
6898	**332**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6899	**335**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6900	**346**	Out	Wind Farm	C-Shaped Wall	Habitation	D
6901	**349**	In	Wind Farm	C-Shaped Wall	Habitation	D
6902	**351**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6903	**353**	In	Wind Farm	Complex	Habitation / Uncertain	D
6904	**354**	In	Wind Farm	Complex	Agriculture / Burial / Uncertain	D, E
6905	**356/361**	Out	Wind Farm	Complex	Habitation	D
6906	**359/488**	In	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
6907	**367**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6908	**391**	Out	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
6909	**395-398**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6910	**423 thru 430**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6911	**440**	Out	Wind Farm	Complex	Habitation	D
6912	**441**	Out	Wind Farm	Complex	Agriculture / Burial / Uncertain	D, E
6913	**442**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	C, D
6914	**443**	Out	Wind Farm	Wall	Agriculture	D
6915	**445**	Out	Wind Farm	Complex	Uncertain	D
6916	**468**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6917	**480/481**	In	Wind Farm	Complex	Agriculture / Habitation	D
6918	**489/491**	In	Wind Farm	Complex	Habitation / Uncertain	D
6919	**495**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6920	**499**	In	Wind Farm	Wall	Habitation	D
6921	**501**	In	Wind Farm	Complex	Agriculture / Burial / Uncertain	D, E
6922	**502**	In	Wind Farm	Complex	Agriculture / Burial	D, E
6923	**503**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6924	**544**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6925	**559**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6926	**560**	Out	Wind Farm	Complex	Agriculture	D
6927	**564**	Out	Wind Farm	U-Shaped Wall	Habitation	D
6928	**582**	Out	Wind Farm	C-Shaped Wall	Agriculture	D
6929	**583**	In	Wind Farm	Complex	Habitation / Uncertain	D
6930	**584**	In	Wind Farm	Complex	Agriculture / Uncertain	D

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6931	**585**	Out	Pāpaka Road	Complex	Ceremonial / Habitation / Ranching	D, E
6932	**586**	Out	Pāpaka Road	Complex	Agriculture	D
6933	**587**	Out	Pāpaka Road	Complex	Agriculture / Animal Husbandry / Habitation / Uncertain	D
6934	**588**	Out	Pāpaka Road	Complex	Agriculture / Uncertain	D
6935	**589**	Out	Pāpaka Road	Enclosure	Ranching	D
6936	**590/596**	Out	Pāpaka Road	Complex	Agriculture / Burial / Habitation / Ranching / Uncertain	D, E
6937	**591**	In	Pāpaka Road	Complex	Agriculture	D
6938	**592**	In	Pāpaka Road	Complex	Agriculture / Habitation / Ranching / Uncertain	D
6939	**593**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
6940	**594**	In	Pāpaka Road	Complex	Agriculture / Habitation	D
6941	**595**	In	Pāpaka Road	Complex	Agriculture / Habitation	D
6942	**597**	In	Pāpaka Road	Wall	Ranching	D
6943	**598**	Out	Pāpaka Road	Complex	Ranching / Uncertain	D
6944	**599**	Out	Pāpaka Road	Wall	Ranching	D
6945	**600**	Out	Pāpaka Road	Wall	Uncertain	D
6946	**601**	In	Pāpaka Road	Wall	Ranching	D
6947	**602**	Out	Pāpaka Road	Wall	Uncertain	D
6948	**603**	In	Pāpaka Road	Wall	Uncertain	D
6949	**604**	In	Pāpaka Road	Wall	Ranching	D
6950	**605**	In	Pāpaka Road	Wall	Ranching	D
6951	**2010 A**	Out	Wind Farm	Complex	Burial / Habitation / Uncertain	D, E
6952	**2010 B**	In	Wind Farm	Overhang Shelter	Habitation	D
6953	**2010 C**	In	Wind Farm	Complex	Burial	D, E
6954	**2010 D**	Out	Wind Farm	Complex	Burial	D, E
6955	**2010 E**	Out	Wind Farm	Terrace	Agriculture	D
6956	**2010 F**	In	Pāpaka Road	Enclosure	Ranching	C, D
6957	**2010 G**	In	Pāpaka Road	Complex	Uncertain	D
6958	**2010 H**	In	Pāpaka Road	Wall	Ranching	D
6959	**2010 I**	In	Pāpaka Road	Complex	Ranching / Uncertain	D
6960	**2010 J**	In	Pāpaka Road	Wall	Ranching	D
6961	**2010 K**	In	Pāpaka Road	Wall	Ranching	D
6962	**2010 L**	In	Pāpaka Road	Complex	Agriculture	D
6963	**2010 M**	In	Pāpaka Road	Wall	Ranching	D
6964	**2010 N**	Out	Pāpaka Road	Enclosure	Habitation	D
6965	**2010 O**	In	Pāpaka Road	Wall	Ranching	D
6966	**2010 P**	In	Pāpaka Road	Cast Iron Tank	Ranching	D
6967	**2010 Q**	In	Pāpaka Road	Complex	Agriculture / Ranching	D
6968	**2010 R**	In	Pāpaka Road	Complex	Agriculture	D
6969	**2010 S**	In	Pāpaka Road	Wall	Ranching	D
6970	**2010 T**	In	Pāpaka Road	Wall	Ranching	D
6971	**2010 U**	In	Pāpaka Road	Wall	Uncertain	D
6972	**2010 V**	In	Pāpaka Road	Complex	Habitation	D

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6973	**2010 W**	Out	Pāpaka Road	Enclosure	Habitation	D
6974	**2010 X**	In	Pāpaka Road	Wall	Habitation	D
6975	**2010 Y**	In	Pāpaka Road	Complex	Ranching / Uncertain	D
6976	**2010 Z**	In	Pāpaka Road	Complex	Habitation / Uncertain	D
6977	**2010 AA**	In	Pāpaka Road	Wall	Ranching	D
6978	**2010 BB**	In	Pāpaka Road	Wall	Ranching	D
6979	**2010 CC Gen-Tie Line**	In	Gen-Tie Line	Complex	Agriculture / Habitation	D
6980	**2010 CC Pāpaka**	In	Pāpaka Road	Wall	Ranching	D
6981	**2010 DD**	In	Gen-Tie Line	Wall	Uncertain	D
6982	**2010 EE**	In	Gen-Tie Line	Wall	Uncertain	D
6983	**2010 FF**	In	Gen-Tie Line	Complex	Agriculture / Uncertain	D
6984	**2010 GG**	In	Gen-Tie Line	Complex	Agriculture / Habitation	D
6985	**2010 HH**	In	Gen-Tie Line	Complex	Agriculture / Burial / Uncertain	D, E
6986	**2010 II**	In	Gen-Tie Line	Wall	Uncertain	D
6987	**2010 JJ**	In	Gen-Tie Line	Complex	Agriculture / Habitation / Uncertain	D
6988	**2010 KK**	In	Gen-Tie Line	Complex	Agriculture / Habitation / Uncertain	D
6989	**2010 LL**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6990	**2010 MM**	Out	Wind Farm	Complex	Habitation / Uncertain	D
6991	**2010 NN**	In	Pi`ilani Highway	Wall	Ranching	D
6992	**2010 OO**	In	Pi`ilani Highway	Complex	Agriculture / Burial / Ranching / Uncertain	D, E
6993	**2010 PP**	Out	Pi`ilani Highway	Complex	Agriculture / Burial / Uncertain	D, E
6994	**2010 QQ**	In	Pi`ilani Highway	Complex	Agriculture / Ranching	D
6995	**2010 RR**	In	Gen-Tie Line	Complex	Agriculture	D
6996	**2010 SS**	In	Gen-Tie Line	Stone Mound	Agriculture	D
6997	**2010 TT**	In	Gen-Tie Line	Modified Outcrop	Agriculture	D
6998	**2010 UU**	In	Gen-Tie Line	Modified Outcrop	Uncertain	D
6999	**2010 VV**	In	Gen-Tie Line	Complex	Agriculture	D
7000	**2010 WW**	In	Gen-Tie Line	Wall	Agriculture	D
7001	**2010 XX**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7002	**2010 YY**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7003	**2010 ZZ**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7004	**2010 AAA**	In	Gen-Tie Line	Complex	Agriculture	D
7005	**2010 BBB**	In	Gen-Tie Line	Terrace	Agriculture	D
7006	**2010 CCC**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7007	**2010 DDD**	In	Gen-Tie Line	Cleared Area	Agriculture	D
7008	**2010 EEE**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7009	**2010 FFF**	In	Gen-Tie Line	Complex	Agriculture	D
7010	**2010 GGG**	In	Gen-Tie Line	Complex	Agriculture	D
7011	**2010 HHH**	In	Gen-Tie Line	Complex	Ranching	D
7012	**2010 III**	In	Gen-Tie Line	Complex	Agriculture	D
7013	**2010 JJJ**	In	Gen-Tie Line	Platform	Ranching	D

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
7014	**2010 KKK**	In	Pāpaka Road	Complex	Agriculture	D
7015	**2010 LLL**	In	Pāpaka Road	Complex	Agriculture	D
7016	**2010 MMM**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7017	**2010 NNN**	In	Pāpaka Road	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
7018	**2010 OOO**	In	Pāpaka Road	Wall	Ranching	D
7019	**2010 PPP**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7020	**2010 QQQ**	In	Pāpaka Road	Complex	Agriculture / Habitation	D
7021	**2010 RRR**	In	Pāpaka Road	Complex	Agriculture	D
7022	**2010 SSS**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7023	**2010 TTT**	In	Pāpaka Road	Barbed Wire Fence	Ranching	D
7024	**2010 UUU**	In	Pāpaka Road	Complex	Agriculture / Habitation / Ranching	D
7025	**2010 VVV**	In	Pāpaka Road	Complex	Agriculture / Uncertain	D
7026	**2010 WWW**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
7027	**2010 AAAA**	In	Wind Farm	Complex	Agriculture	D
7028	**2010 BBBB**	In	Wind Farm	Complex	Agriculture	D
7029	**2010 CCCC**	In	Wind Farm	Complex	Agriculture / Uncertain	D
7030	**2010 DDDD**	In	Wind Farm	Complex	Uncertain	D
7031	**2010 EEEE**	In	Wind Farm	Modified Outcrop	Agriculture	D
7032	**2010 FFFF**	In	Wind Farm	Wall	Uncertain	D
7033	**2010 GGGG**	In	Wind Farm	Terrace	Agriculture	D
7034	**2010 HHHH**	Out	Wind Farm	Complex	Agriculture	D
7035	**2010 IIII**	In	Wind Farm	Complex	Agriculture / Burial	D, E
7036	**2010 JJJJ**	In	Wind Farm	Complex	Agriculture	D
7037	**2010 KKKK**	In	Wind Farm	Complex	Agriculture	D
7038	**2010 LLLL**	In	Wind Farm	Complex	Agriculture	D
7039	**2010 MMMM**	In	Wind Farm	Platform	Uncertain	D
7040	**2010 NNNN**	In	Wind Farm	Stone Mound	Agriculture	D
7041	**2010 OOOO**	In	Wind Farm	Stone Mound	Agriculture / Burial / Habitation	D, E
7042	**2010 PPPP**	In	Wind Farm	Complex	Habitation / Uncertain	D
7043	**Mākena 1**	Out	Pāpaka Road	Enclosure	Habitation	D
7044	**Mākena 2**	In	Pāpaka Road	Terrace	Uncertain	D
7045	**Mākena 3**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7046	**Mākena 4**	In	Pāpaka Road	Enclosure	Uncertain	D
7047	**Mākena 5**	In	Pāpaka Road	Wall	Ranching	D
7048	**Mākena 6**	In	Pāpaka Road	Modified Outcrop	Uncertain	D
7049	**Mākena 7**	In	Pāpaka Road	Wall	Habitation	D
7050	**Mākena 8**	In	Pāpaka Road	Complex	Habitation	D

8.0 RECOMMENDED TREATMENTS

The Auwahi Wind Farm project will adversely affect a number of archaeological resources. While this is inevitable in any type of development project, considerable effort has been exercised to minimize the impact the project will have on the archaeological resources present in the Wind Farm project area. The purpose of archaeological investigations is not only to inventory what archaeological resources are present and evaluate their significance, but to mitigate the adverse effects caused by development through archaeological investigations. Some of the archaeological resources present within the APE of the project have been fully documented and will not require any further archaeological work; others will require further archaeological investigations in the form of mapping and excavations. Specific recommended treatments of all archaeological features within the APE are presented in Table 25. In order to maximize the amount of information obtained through further archaeological investigations, the following research topics are offered as a means of guiding the future archaeological investigations.

8.1 "THE ARCHAEOLOGY OF HYDROLOGY"

From the broader perspective of Hawaiian archaeology, the discovery of a range of features indicative of sophisticated water control in Auwahi is a major new contribution to our knowledge of Hawaiian land use practices. This evidence is especially noteworthy because it occurs in the context of one of the most arid environments in the Hawaiian Islands, the leeward slopes of southeast Maui in the rain-shadow of Haleakalā. This environment was extremely marginal to the classic Polynesian horticultural system based on tropical root crops, yet the pre-Contact Hawaiian population in this region managed to achieve a high population density (Kirch 2007, 2010). The inventory survey revealed numerous instances of intermittent stream channels which had various forms of artificial modification, ranging from check dams (barrages), to stone filled-terraces which appear to be designed to filter water underground, to earth-filled terraces that were probably planting surfaces. Discovery of these features was greatly enhanced by the unusually good surface visibility in Auwahi in 2010 due to extreme drought conditions.

Our working hypothesis is that with water a scarce and critical resource in Kahikinui, the Native Hawaiian population there developed technology that allowed them to capture and manipulate water in order to enhance the agricultural productivity of this marginal environment. Because storm events are infrequent, it is likely that the emphasis was not on irrigation in the usual sense of maintaining a steady flow of water to fields, but rather efforts to slow down intermittent stream flow, to divert such water into small basins and terraces that could be cultivated, and even to force the water to percolate into temporary aquifers (such as breccia deposits) which could then release water slowly over a period of days or even weeks.

The inventory survey produced detailed plan maps of a number of these features, but to fully investigate and interpret these hydrological features will require not only additional mapping,

but subsurface investigations as well. This work should be undertaken in collaboration with a professional geomorphologist/geoarchaeologist who has the technical expertise to assist in interpreting geomorphological and sedimentary evidence for past water flow patterns. We suggest that this research topic be addressed through the following specific approaches:

a. Detailed mapping of representative water control features. Such mapping cannot be limited to a two-dimensional plan view, but must include elevation and slope variables, as these will be critical to understanding waterflow patterns. Such mapping must pay attention not only to the artificially constructed aspects of these systems (e.g., walls, terraces), but to the geomorphological features such as water-worn flow channels or sedimentary lag deposits which will provide the evidence for intensity and frequency of hydrologic events. Winter (*kona*) storms were presumably the main sources of water which was being manipulated in these systems, and extreme storm events could have been very difficult to control and manage. Thus the investigations must be attuned to these attempts to control extreme flood events.

We recommend detailed mapping of Site 6841, Feature D, terrace; Site 6906 Features GGG and HHH, terraces ; and Site 7021, Features A, B, and D which are earthen berms. Site 6841, Feature D is located in a gulch with extensive agricultural terracing and is at the confluence of two draws. Site 6906 Features GGG and HHH are small agricultural terraces associated with nearby habitation structures. Site 6864, Feature D is a rock filled terrace which may have been used for habitation but is also located in a draw and could also have functioned to slow down rapid water flow. Site 7021, Features A, B, and D represent earthen berms which are likely remnants of water control features for an agricultural field system.

b. Excavation within constructed features such as earthen terraces and rock-fill filtration terraces. While detailed mapping will be critical, it is also essential to obtain subsurface evidence in order to understand how these water control features were constructed, the chronology of their construction, and details of their function. For example, a number of rock-filled terraces in some of the intermittent stream channels appear to have been designed to check water flow and drive water underground in a kind of filtration process. Excavating through these features would provide evidence of how they were constructed, and of whether percolating water left depositional traces. Again, we stress that this kind of investigation—which has rarely if ever been undertaken in Hawai‘i in the past—must involve interdisciplinary collaboration between archaeology and geomorphology/hydrology, because neither discipline in and of itself controls all of the methods necessary to interpret such complex features.

In an attempt to gather additional information to address these hydrological questions, we recommend the excavation of Site 6841, Feature D, terrace; Site 6906 Features GGG and HHH, terraces; and 7021, Features A, B, and D.

8.2 DEVELOPMENT OF THE FORMAL FIELD SYSTEM IN "GOBI DESERT"

Until recently no formal agricultural field systems had been identified on Maui Island, although extensive reticulate grids of field embankments and cross-cutting walls on Hawai'i Island (in Kohala, Kona, and Ka'ū districts) have been known since the late 1960s. The identification of a formal field system in Kaupō by Kirch et al. (2009) showed that Maui Island farmers were also engaged in this kind of highly intensive agricultural activity. Now, with the identification of remnant portions of such a regularized field system on the fringes of the sedimentary basin inland of the Pu'u Hōkū Kano cinder cone (colloquially named by our field team, the "Gobi Desert"), it is clear that such field systems must have been more wide-spread on Maui than has been previously realized.

These kinds of formalized field systems with reticulate grids of planting areas are of interest not only because they reflect a kind of intensive agricultural production upon which the late pre-Contact Hawaiian archaic states depended for their economic basis, but because they imply a level of formal control and management above what would be required strictly for agronomic reasons. That is to say, the regular spacing of field embankments, cross-cut by trails or other boundary divisions, appears to reflect the imposition of social and political controls on production, and more importantly, on the extraction of surplus.

We urge that the remnants of this field system be carefully recorded and investigated, following essentially the same methods proposed for Topic 1, i.e., with a combined archaeological-geomorphological methodology. The various surface features making up this system are subtle, as the inventory team was well aware—often they can only be clearly discerned in the low-angle light of late afternoon. Thus high-precision three-dimensional mapping will again be important to thorough document these features.

As with Topic 1, subsurface investigation will also be required to address the critical questions of when this system was constructed, and of how it functioned. We recommend linear trenching across the apparent field embankments and intervening cultivation plots, as has been carried out in similar investigations of field systems on Hawai'i Island by the Hawai'i Biocomplexity Project (Vitousek et al. 2004; Kirch, ed. 2010). We predict that remnant original soil horizons should be preserved under the field embankments, which will need to be carefully sampled. Such remnant soil horizons could provide carbonized organic materials with which to date the time of initial field system construction, and may also contain plant and other organic remains (such as endemic terrestrial gastropods) that could yield important evidence of initial environmental conditions prior to field system construction. Moreover, following methods developed by the Hawai'i Biocomplexity Project, it may be possible to compare the nutrient status of original soils preserved within field embankments with cultivated soils in the intervening plots, in order to achieve a quantitative estimate of the extent to which intensive cultivation over an extended period had an effect on nutrient availability. Such data would be extremely important to the ongoing efforts to understand how surplus production and extraction was affecting the rise of archaic states in late pre-Contact Hawai'i.

> We recommend the detailed mapping and selective excavation of the field system terraces at Site 6910, Features B, C, D, R, T, and U in the "Gobi Desert" vicinity to

address these research issues. These represent the most intact remnants of the field system including bermed terraces and water channeling features.

8.3 SETTLEMENT CHRONOLOGY IN AUWAHI—IS IT EARLIER THAN ELSEWHERE IN KAHIKINUI?

In our report we summarized various lines of evidence—ethnohistorical as well as archaeological—which point to Auwahi having held a key place within the broader Kahikinui district or *moku*. For example, the high princess Ruta Keli'iokalani received Auwahi during the Mahele land division, whereas the remainder of the district went to her half-brother Prince Lot. We have therefore hypothesized that Auwahi may have been the most important *ahupua'a* within the *moku*, probably the location for the district's *konohiki* or manager who represented the high chief. The initial suite of radiocarbon dates from our inventory survey also support this argument insofar as they suggest that the intensive occupation of Auwahi reached a peak as much as a century earlier than other parts of the district, such as Kīpapa and Nakaohu. However, this hypothesis needs to be tested on a more extensive data set, because at this point we cannot rule out the null hypothesis that the chronological differences noted to date are simply the result of sample size effects.

In any mitigation plan that is developed for the Auwahi wind farm area, it will be critical to allocate time and funds to sample and date a sufficient number of residential features so that sample size effects can be controlled. At this point, other parts of Kahikinui district are represented by more than 160 radiocarbon dates, whereas Auwahi proper has only 14 such dates. We would propose that a target of 50 radiocarbon samples from individual residential features be obtained and dated by high-precision AMS dating in order to address this question. In any such chronological investigation, it is essential that the following methodological protocols be followed: (1) Wherever possible samples should be obtained from discrete subsurface features, such as hearths or earth ovens; (2) To avoid the notorious problem of old wood and "in-built age" the charcoal samples need to be identified by a qualified archaeobotanist as to botanical taxon, and whenever possible short-lived species selected as dating samples; and, (3) samples need to be dated by AMS with d13C corrections for isotopic fractionation. The third step is critical because many Hawaiian dryland plants have C4 photosynthetic pathways that will yield erroneous ages if not corrected for isotopic fractionation. We followed these protocols in our dating of features in the inventory survey, and stress how important it is to continue to apply the same protocols if the resulting data sets are to have integrity.

To obtain the radiocarbon dates we propose the excavation of the following habitation features within the Auwahi Wind Farm area:

- Site 50-50-15-6841 Feature C, terrace.
- Site 50-50-15-6843 Feature G, L-shaped wall; Feature H, C-shaped wall; Feature I, C-shaped wall.
- Site 50-50-15-6889 Feature B, terrace; Feature C, U-shaped wall.
- Site 50-50-15-6896 Feature A, enclosure; Feature B, terrace.
- Site 50-50-15-6898 Feature A, platform; Feature G, hearth.

- Site 50-50-15-6906 Feature B, terrace; Feature FF, enclosure; Feature JJ, dark stained soil deposit; Feature OO,U-shaped wall with hearth; Feature PP, terrace; Feature YY, terrace with hearth features.
- Site 50-50-15-6910 Feature A, enclosure; Feature E, enclosure and terrace; Feature F, enclosure; Feature I, lava blister with hearth; Feature J, terrace with midden; Feature O, terrace with hearth.
- Site 50-50-15-6919 Feature E, terrace.
- Site 50-50-15-6988 Feature E, C-shaped wall and enclosure.
- Site 50-50-14-7016 Feature H, U-shaped wall; Feature O, terrace.
- Site 50-50-14-7017 Feature A, terrace.
- Site 50-50-14-7020 Feature C, modified outcrop with hearth.
- Site 50-50-14-7022 Feature F, enclosure with nearby hearth feature.

8.4 HOUSEHOLD ORGANIZATION AND STRUCTURE

Ethnohistoric accounts such as those of Malo (1951) and Kamakau (1961) inform us in general terms about the organization of daily life in traditional Hawaiian households, but they paint a monolithic portrait that does not allow for variation either between regions, or between social classes. Yet prior archaeological research in Kahikinui has already demonstrated certain kinds of household practices not previously known from either ethnohistoric or archaeological sources (Van Gilder and Kirch 1997). The extensive remains of residential features identified in the Auwahi inventory survey make it clear that there is much potential to gain further insights into Hawaiian household organization and structure in this area. Because Kahikinui was a *kua*ʻ*āina* or "back country" region, the daily lives of its people were unlikely to have been the same as those dwelling near the royal centers such as Wailuku or Hāna. With the Auwahi sites, there is an opportunity to investigate the traditional lifeways of a true rural hinterland in ancient Hawaiʻi.

Household archaeology as a subdiscipline has developed greatly over the past two to three decades, but unfortunately many of its advances have not been applied in Hawaiian Cultural Resources Management work. The continued emphasis, in much CRM mitigation in Hawaiʻi, on single 1 m^2 test units in residential sites has generally failed to add new knowledge about Hawaiian household organization and structure. What is required is more emphasis on horizontal exposure of living surfaces by which larger activity areas can be discerned, and spatial patterns of organization identified. We propose that this approach be applied in future mitigation efforts in Auwahi. It would be far more productive, in our view, to fully excavate three or four residential features than to dig random test pits in a larger sample of structures.

In addition to horizontal excavation, such investigation of ancient Auwahi residential sites will require careful analysis of the cultural content of these sites. Prior experience shows that Kahikinui residential sites are relatively poor in portable artifacts such as adzes or fishhooks. The most common remains recovered are macrobotanical remains (especially charcoal), basalt and volcanic glass lithics, and shell and vertebrate remains. These materials will need to be studied by appropriate specialists if their information potential is to be realized. The lithic

materials in particular should prove interesting, in terms of tracing links between Kahikinui households and those in adjacent districts or even other islands. XRF sourcing of basalt lithics from sites in Kīpapa and Nakaohu (Kirch, unpublished data) has shown that while most of the basalt being worked in Kahikinui sites is of local origin, some derives from at least one adz quarry in Kaupō district, and a small number of specimens were imported from other islands including Hawai'i, Moloka'i, and even O'ahu. Since Auwahi is putatively the most important *ahupua'a* within Kahikinui, we hypothesize that it may have had a higher degree of external connections (especially through its resident *konohiki*), and that more imported lithics would appear in its residential sites. This hypothesis can be tested through further analysis of lithics from excavated sites in Auwahi.

Zooarchaeological analyses of faunal remains from household sites can also yield vital clues as to rank differences between the occupants of various social units. Higher ranked individuals in ancient Hawai'i had preferential access to status foods, especially pig and dog, but also pelagic fish and even to certain birds. Analysis of the faunal remains from a priest's residence in Nakaohu (Kirch et al. 2010) have shown that the individuals residing there had access to a wide variety of status foods. It should be informative to compare a sample of Auwahi households with these prior results from other sites in Kahikinui.

To meet this research objective, we propose to conduct complete excavations of the following features:

- Site 50-50-15-6906 Feature OO, U shaped wall with hearth.
- Site 50-50-15-6896 Feature A, enclosure with midden.

8.5 POST-CONTACT TRANSFORMATIONS TO HAWAIIAN RURAL SOCIETY

Following Captain Cook's "discovery" of Hawai'i in 1778-79 and the subsequent opening up of the Hawaiian Islands to the expanding European World System, Hawaiian society (which had been entirely cloistered for at least four centuries) was subjected to devastating external influences. Foremost among these was the exposure of the Hawaiian population to a range of diseases to which they had not inherent resistance, leading to massive population decreases. It appears that the indigenous Hawaiian population shrank from a pre-Contact high of at least 400,000 (and possibly considerably more) to about 140,000 in a mere four decades. But demographic collapse was not the only effect of European contact. Missionization and conversion of the Hawaiian people to Christianity, introduction of foreign ideas about everything from marriage to land rights, introduction of new crops and animals, all of these played significant roles in changing the lifeways of the Hawaiian people from the late 18th into the 19th centuries.

While documentary sources tell us a great deal about these major transformations of Hawaiian economy, society, and politics in the post-Contact era, there is still a great deal to be learned from the evidence of archaeology. This is especially true for the most rural or *kua'āina* (literally "back country") regions, such as Kahikinui. Most of the extant documentary sources used by historians refer to the historical transformations taking place in trading centers like Kailua

(Hawai‘i Island) or Honolulu, where the White missionaries, merchants, and others were located. But the historical processes unfolding in these rapidly urbanizing centers may have been quite different from what was going on in the rural hinterlands, even as the two were linked as shown in the classic analysis of Anahulu Valley on O‘ahu by Kirch and Sahlins (1992). The rural areas were simultaneously both more resistant—and more vulnerable—to these foreign agents of change. They were more resistant in being farther from the sources of foreign influence or points of introduction of new disease vectors. But at the same time these rural areas had always been at the environmental and economic margins of traditional Hawaiian society. They were thus the most fragile, and the most susceptible to collapse under the devastation of disease and depopulation. There was as well simply the lure of new possibilities and opportunities in the centers of emerging trade and commence such as Lāhainā and Honolulu that inevitably drew people from the rural hinterlands to the new port towns.

The archaeological landscape of Auwahi not only incorporates a diversity of features from the pre-Contact period, but also many features that appear to date to the late 18th and 19th centuries. In particular, a series of features situated on *‘a‘ā* ridges to the east and west of the sedimentary basin inland of Pu‘u Hōkū Kano (aka “Gobi Desert”) are suggestive of a substantial community of Native Hawaiians who persisted into the 19th century. Site 50-50-15-6909, located on the massive *‘a‘ā* ridge on the east side of this basin, appears on the basis of survey data to have been a significant 19th century settlement, indicated by a diversity of artifacts such as glass bottles and iron artifacts, including a horse bridle, flat iron, and flensing tool probably used as a farming tool (Hawaiian *‘ō‘ō*). It is in some respects not surprising that this area should have remained as a final refuge for rural Hawaiian commoners attempting to cling to their traditional lifeways in the face of seemingly insurmountable obstacles. These features are adjacent to what is probably the most productive garden land in the *ahupua‘a*, and it is only natural that such a prized resource would have been the last to have been abandoned.

Careful and detailed investigation of these post-Contact archaeological features has the potential to reveal much about the transformation of Hawaiian lifeways in the 19th century. How, for example, did residential patterns change over time? Was the traditional *kauhale* pattern of separate activity areas abandoned for a more “western” living style of a single combined multi-function *hale*? This would be predicted following the abolition of the *kapu* system (with its mandated separate cooking and eating facilities) after 1819, but has rarely been tested archaeologically (but see Kirch and Sahlins 1992). How much access did these rural households have to foreign material culture, and how did they integrate such material objects into their lifestyles? To what extent did they continue to utilize traditional, pre-Contact material culture, such as expedient lithic technology? And, how did their subsistence patterns and foodways change with the introduction of new crops, new animals, and new culinary concepts?

All of these questions can be addressed through more detailed investigation of the Auwahi sites dating to the post-Contact era. We cannot overly stress, however, that it will not be sufficient to merely apply the minimal approach to mitigation which is all too commonly used in Hawaiian CRM work: i.e., the excavation of a few limited 1-meter square units in a sample of sites. It would be far preferable, in our view, to undertake larger areal exposures of a selected few post-Contact residential structures, in order to be able to obtain fine-grained spatial data on activity

patterns which can then be compared with similar data from pre-Contact sites in Auwahi, elsewhere in Kahikinui, and in Hawai'i. Horizontal excavation or exposure of entire house floors is too infrequently undertaken in Hawaiian archaeology, leading to a paucity of the kinds of data that are critically required if we are to make advances in our knowledge base. We would recommend that two or three post-Contact residential features be thoroughly and carefully excavated *in their entirety* than the routine opening up of 30 or 40 test pits in scattered features, none of which will provide the kinds of spatial data necessary to answer the questions posed above.

Features recommended for aerial excavation to address these research questions include:

- Site 50-50-15-6988 Feature E, an enclosure and C-shaped wall with historic artifacts.

8.6 IMPACT OF HAWAIIAN LAND USE ON DRYLAND FOREST ENVIRONMENT

The leeward slopes of southeast Maui, because of their combination of relatively young lava substrates and low rainfall, were the ecological setting in which a distinctive natural biotic community evolved over the course of several hundred thousand years—the Hawaiian dryland forest (Ziegler 2002, and Wagner et al 1999). This dryland forest had a far greater diversity of plant species than the wet forests which were typically dominated by a few trees such as *Metrosideros polymorpha* and *Acacia koa*. While both *'ōhi'a* and *koa* were present as well in the dry forests, many other species were found in abundance, such as *'liahi* (sandalwood, *Santalum* spp.), *naia* (false sandalwood, *Myoporum sandwicense*), *hala pepe (Dracaena* spp.), *māmane* (*Sophora chrysophylla*), *lama* (*Diospyros sandwicensis*), *nīoi* (*Eugenia* spp.*).* In somewhat lower elevations, thick stands of the distinctive *wiliwili* (*Erythrina sandwicensis*) with its deciduous habit unusual in the tropics covered the landscape, along with such shrubs as *'a'ali'i* (*Dodonaea* sp.) and *'akia* (*Wikstroema* sp.). In the late 19th century, the pioneering botanist Joseph Rock was struck by the remarkable biodiversity of leeward Maui—and of Auwahi in particular. Rock made a number of collecting expeditions to Auwahi to try to capture what he could of this unique environment, even though it was already under tremendous pressure from cattle grazing and other inroads.

What Rock witnessed at the end of the 19th century in the uplands of Auwahi was, however, merely the endpoint of several centuries of intensive human exploitation of this land, exploitation that began with pioneering Polynesian settlement, continued with a phase of high population density and intensive farming, and which was succeeded by the introduction of ungulates and cattle ranching. An important part of the historical record of Auwahi is how this unique dryland forest environment was transformed as a result of these successive phases of human land use and resource exploitation.

Investigating this critical aspect of the Auwahi record will require the application of the multi-disciplinary perspective of "historical ecology" (Kirch and Hunt, eds., 1997). Much of the necessary data can be obtained through the various kinds of field and laboratory investigations already outlined for topics 3, 4, and 5 above. For example, charcoal samples obtained from hearths and earth ovens in residential sites can provide important data on the kinds of plants formerly growing on the Auwahi landscape, and being exploited by the Hawaiians for firewood

and fuel. Likewise, zooarchaeological analysis of faunal assemblages will provide data on wild food resources such as native birds. Smithsonian avian paleontologist Helen James (pers. comm. to Kirch, Dec. 2010) reports that the unique Hawaiian flightless geese and other endemic birds may have persisted in leeward southeast Maui for a longer period of time following Polynesian colonization than elsewhere in the islands. New zooarchaeological data from Auwahi may help to resolve the question of when these truly unique birds went extinct.

It is anticipated that the materials recovered from the proposed feature excavations outlined above will yield the data potential to help address these questions regarding changes to the environment resulting from land use and resource exploitation.

8.7 Human Burials

All of the confirmed burial sites and the possible burial sites will be preserved in place. The specifics on how these preservation measures will be accomplished are provided in a burial treatment plan that has been submitted to the State Historic Preservation Division for review prior to being presented to the Maui/Lānaʻi Island Burial Council.

Table 25. Recommended Treatments to Features within the APE

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6815	**045**	Wind Farm	A	Trail / Walkway	Transportation	No further work
			B	Lava Tube	Ceremonial / Habitation	**Preserve**
6816	**067/068**	Wind Farm	F	Overhang Shelter	Habitation	No further work
			F	Terrace	Habitation	No further work
			H	Overhang Shelter	Habitation	No further work
6817	**069**	Wind Farm		C-Shaped Wall	Habitation	No further work
6818	**070**	Wind Farm		Wall	Ranching	No further work
6820	**089**	Wind Farm	A	L-Shaped Wall	Habitation	No further work
			B	Terrace	Agriculture	No further work
			C	Cleared Area	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			F	Platform	Agriculture / Uncertain	No further work
			F	Wall	Agriculture / Uncertain	No further work
6821	**091/092/093**	Wind Farm	A	Wall	Habitation	No further work
			C	Lava Tube	Habitation	No further work
			D	Modified Depression	Agriculture / Uncertain	No further work
			D	Wall	Agriculture / Uncertain	No further work
			E	Trail / Walkway	Transportation	No further work
6822	**095**	Wind Farm		Wall	Agriculture	No further work
				Stone Mound	Uncertain	No further work
6823	**096**	Wind Farm	A	Overhang Shelter	Agriculture	No further work
			B	Overhang Shelter	Habitation	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
			A	Wall	Agriculture	No further work
			B	Stone Mound	Agriculture / Burial	**Preserve**
			C	Overhang Shelter	Habitation	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Habitation	No further work
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work
			G	Cleared Area	Agriculture	No further work
			H	Wall	Agriculture	No further work
			I	Terrace	Agriculture	No further work
			J	Terrace	Agriculture	No further work
6827	**106/108**	Wind Farm	K	Platform	Uncertain	**Preserve**
			L	Stone Mound	Agriculture / Burial	**Preserve**
			M	Terrace	Agriculture	No further work
			N	Terrace	Agriculture	No further work
			O	C-Shaped Wall	Habitation	No further work
			O	J-Shaped Wall	Habitation	No further work
			P	Modified Outcrop	Agriculture	No further work
			Q	Terrace	Habitation	No further work
			R	Terrace	Agriculture	No further work
			S	Wall	Agriculture	No further work
			T	Stone Mound	Agriculture	No further work
			U	Terrace	Agriculture	No further work
6828	**107**	Wind Farm		Wall	Agriculture / Ranching	No further work
6829	**109**	Wind Farm		Overhang Shelter	Habitation	No further work
				Terrace	Habitation	No further work
6830	**129**	Wind Farm		C-Shaped Wall	Agriculture / Habitation	No further work
				Paved Area	Agriculture / Habitation	No further work
6832	**141**	Wind Farm	A	U-Shaped Wall	Agriculture	No further work
			B	C-Shaped Wall	Agriculture	No further work
6833	**142**	Wind Farm	A	Enclosure	Agriculture / Habitation	No further work
6834	**143**	Wind Farm	A	C-Shaped Wall	Habitation	No further work
			C	Terrace	Agriculture	No further work
6836	**155**	Wind Farm	A	C-Shaped Wall	Habitation	No further work
			B	Cleared Area	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
6837	**166**	Wind Farm		Wall	Uncertain	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6838	167/557	Wind Farm	A	Platform	Agriculture	No further work
			B	Lava Tube	Burial / Habitation	**Preserve**
			C	Stone Mound	Agriculture	No further work
			C	Cleared Area	Agriculture	No further work
			D	Wall	Agriculture	No further work
			E	Alignment	Agriculture / Uncertain	No further work
			I	C-Shaped Wall	Agriculture / Habitation	No further work
			J	Modified Lava Blister	Uncertain	No further work
6841	180/546	Wind Farm	C	Terrace	Habitation	**Detailed mapping and selected excavation**
			D	Terrace	Agriculture	**Detailed mapping and selected excavation**
6842	181	Wind Farm	A	C-Shaped Wall	Habitation	No further work
6843	182/184	Wind Farm	G	L-Shaped Wall	Habitation	**Detailed mapping and selected excavation**
			H	C-Shaped Wall	Habitation	**Detailed mapping and selected excavation**
			I	C-Shaped Wall	Habitation	**Detailed mapping and selected excavation**
6845	186	Wind Farm		C-Shaped Wall	Habitation	No further work
6848	190/310	Wind Farm	O	Terrace	Uncertain	No further work
			O	Wall	Uncertain	No further work
6857	208	Wind Farm	C	Alignment	Agriculture	No further work
			F	C-Shaped Wall	Habitation	No further work
			G	C-Shaped Wall	Uncertain	No further work
6860	212	Wind Farm	A	Terrace	Uncertain	No further work
			B	Terrace	Agriculture	No further work
6861	213	Wind Farm	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	L-Shaped Wall	Uncertain	No further work
6862	214	Wind Farm	A	L-Shaped Wall	Habitation	No further work
			B	Modified Outcrop	Uncertain	No further work
			C	Wall	Uncertain	No further work
			D	Wall	Habitation	No further work
			E	Terrace	Agriculture	No further work
			G	Cleared Area	Uncertain	No further work
			J	Terrace	Agriculture	No further work
			K	Modified Outcrop	Uncertain	No further work
			L	Alignment	Agriculture	No further work
			M	U-Shaped Wall	Agriculture	No further work
			N	Terrace	Agriculture	No further work
			O	Cleared Area	Agriculture	No further work
			P	Enclosure	Agriculture	No further work
			P	Modified Depression	Agriculture	No further work
			Q	C-Shaped Wall	Agriculture	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6863	**215**	Wind Farm	I	Enclosure	Agriculture / Animal Husbandry	No further work
6864	**216**	Wind Farm	A	Terrace	Habitation	No further work
			A	Windbreak	Habitation	No further work
			C	Overhang Shelter	Habitation	No further work
			C	Terrace	Habitation	No further work
			E	C-Shaped Wall	Ceremonial	No further work
			G	Terrace	Habitation	No further work
6865	**247**	Gen-TieLine	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Uncertain	**Preserve**
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Modified Lava Blister	Agriculture	No further work
			H	Terrace	Agriculture	No further work
			I	Terrace	Agriculture	No further work
6866	**249**	Gen-TieLine	A	J-Shaped Wall	Agriculture	No further work
			B	Terrace	Habitation	No further work
			B	U-Shaped Wall	Habitation / Uncertain	No further work
6867	**250**	Gen-TieLine		Wall	Ranching	No further work
6874	**262/263**	Gen-TieLine		Wall	Ranching	No further work
6876	**265**	Gen-TieLine		Wall	Ranching	No further work
6877	**266**	Gen-TieLine	A	Stone Mound	Agriculture / Ranching	No further work
			B	Stone Mound	Agriculture / Ranching	No further work
			C	Stone Mound	Agriculture / Ranching	No further work
			D	Stone Mound	Agriculture / Ranching	No further work
			E	Stone Mound	Agriculture / Ranching	No further work
			F	Stone Mound	Agriculture / Ranching	No further work
			G	Stone Mound	Agriculture / Ranching	No further work
6878	**267**	Gen-TieLine		Stone Mound	Agriculture	No further work
6879	**268**	Gen-TieLine		Wall	Ranching	No further work
6880	**269**	Gen-TieLine	A2	Wall	Ranching	No further work
6881	**270/271**	Gen-TieLine	A	Wall	Ranching	No further work
			B	Overhang Shelter	Habitation	**Preserve**
			C	Terrace	Uncertain	**Preserve**
6882	**273/362**	Gen-TieLine	C	Stone Mound	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			E	Wall	Ranching	No further work
6887	**305**	Wind Farm	B	Terrace	Habitation	No further work
			C	Modified Depression	Uncertain	No further work
6888	**306**	Wind Farm		U-Shaped Wall	Habitation	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6889	**307**	Wind Farm	A	Wall	Agriculture / Habitation	No further work
			B	Terrace	Habitation	**Detailed mapping and selected excavation**
			C	Terrace	Habitation	No further work
			C	U-Shaped Wall	Habitation	**Detailed mapping and selected excavation**
6891	**309**	Wind Farm	A	Terrace	Agriculture	No further work
			A	J-Shaped Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Alignment	Agriculture	No further work
			E	Trail / Walkway	Transportation	No further work
6892	**322**	Wind Farm	A	U-Shaped Wall	Agriculture / Habitation	No further work
			B	Cleared Area	Agriculture	No further work
			C	Enclosure	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			G	Terrace	Habitation	No further work
			G	Overhang Shelter	Habitation	No further work
			H	C-Shaped Wall	Agriculture	No further work
			H	Terrace	Agriculture	No further work
6893	**323**	Wind Farm	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
6894	**324**	Wind Farm	A	Lava Tube	Burial / Habitation / Uncertain	**Preserve**
6895	**326**	Wind Farm	A	U-Shaped Wall	Agriculture	No further work
			A	Terrace	Agriculture	No further work
			A	Cleared Area	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			C	Alignment	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			E	Terrace	Habitation	No further work
			F	Alignment	Agriculture	No further work
			F	Cleared Area	Agriculture	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6896	329	Wind Farm	A	Enclosure	Habitation	**Detailed mapping and complete aerial excavation**
			A	Alignment	Habitation	No further work
			B	Terrace	Habitation	**Detailed mapping and selected excavation**
			C	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Alignment	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			E	Alignment	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Alignment	Agriculture	No further work
			G	Stone Mound	Agriculture	No further work
			H	Stone Mound	Agriculture	No further work
6897	331	Wind Farm	A	Terrace	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	C-Shaped Wall	Habitation	No further work
			D	Terrace	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Enclosure	Habitation	No further work
			H	Wall	Agriculture	No further work
6898	332	Wind Farm	A	Platform	Uncertain	**Detailed mapping and selected excavation**
			B	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	C-Shaped Wall	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			F	C-Shaped Wall	Agriculture	No further work
			G	Hearth	Habitation	**Detailed mapping and selected excavation**
6899	335	Wind Farm	C	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	L-Shaped Wall	Habitation	No further work
6901	349	Wind Farm		C-Shaped Wall	Habitation	No further work
6903	353	Wind Farm	C	Terrace	Habitation	No further work
6904	354	Wind Farm	A	Modified Outcrop	Agriculture / Uncertain	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6906	359/488	Wind Farm	B	Stone Mound	Uncertain	No further work
			B	Terrace	Uncertain	**Detailed mapping and selected excavation**
			C	Modified Depression	Agriculture / Habitation	No further work
			C	Wall	Agriculture / Habitation	No further work
			G	Wall	Uncertain	No further work
			CC	Wall	Uncertain	No further work
			EE	Ditch / Channel	Agriculture	No further work
			FF	Enclosure	Habitation	**Detailed mapping and selected excavation**
			II	Heiau	Ceremonial	No further work
			JJ	Dark-stained Midden Soil Deposit	Uncertain	**Detailed mapping and selected excavation**
			LL	Stone Mound	Agriculture	No further work
			MM	Enclosure	Habitation	No further work
			MM	Hearth	Habitation	No further work
			MM	Terrace	Uncertain	No further work
			NN	Modified Depression	Agriculture	No further work
			NN	Terrace	Agriculture	No further work
			OO	U-Shaped Wall	Habitation	**Detailed mapping and complete aerial excavation**
			PP	Terrace	Habitation	**Detailed mapping and selected excavation**
			QQ	Wall	Habitation	No further work
			RR	Terrace	Agriculture	No further work
			SS	Terrace	Agriculture	No further work
			TT	Terrace	Agriculture	No further work
			VV	Terrace	Agriculture	No further work
			YY	Terrace	Agriculture / Habitation	**Detailed mapping and selected excavation**
			ZZ	Terrace	Agriculture / Uncertain	No further work
			YY	Hearth	Habitation	**Detailed mapping and selected excavation**
			GGG	Terrace	Agriculture	**Detailed mapping and selected excavation**
			HHH	Cleared Area	Agriculture	**Detailed mapping**
			HHH	Terrace	Agriculture	**Detailed mapping and selected excavation**
6909	395-398	Wind Farm	G	Enclosure	Habitation	No further work
			G	Terrace	Habitation	No further work
			H	Terrace	Habitation	No further work
			I	Terrace	Habitation	No further work
			J	Terrace	Habitation	No further work
			K	Terrace	Agriculture	No further work
			K	Alignment	Uncertain	No further work
			N	Stone Mound	Burial	**Preserve**

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6910	423 thru 430	Wind Farm	A	Enclosure	Uncertain	**Detailed mapping and selected excavation**
			B	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			C	Cleared Area	Agriculture	**Detailed mapping and selected excavation**
			C	Terrace	Agriculture	**Detailed mapping and selected excavation**
			D	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			E	Enclosure	Habitation	**Detailed mapping and selected excavation**
			E	Terrace	Habitation	**Detailed mapping and selected excavation**
			F	Enclosure	Agriculture / Uncertain	**Detailed mapping and selected excavation**
			F	Windbreak	Habitation	No further work
			F	Terrace	Uncertain	No further work
			G	Terrace	Habitation	No further work
			H	Terrace	Habitation	No further work
			I	Modified Lava Blister	Habitation	**Detailed mapping and selected excavation**
			J	Stone Mound	Habitation	No further work
			J	Terrace	Habitation	**Detailed mapping and selected excavation**
			K	Alignment	Agriculture	No further work
			L	Terrace	Habitation / Uncertain	No further work
			M	Stone Mound	Agriculture	No further work
			O	Terrace	Habitation	**Detailed mapping and selected excavation**
			O	Hearth	Habitation	**Detailed mapping and selected excavation**
			Q	Alignment	Agriculture	No further work
			Q	Cleared Area	Agriculture	No further work
			Q	Stone Mound	Agriculture	No further work
			R	Ditch / Channel	Agriculture	**Detailed mapping**
			S	Terrace, Bermed	Agriculture	No further work
			T	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			U	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
6917	480/481	Wind Farm	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			E	Enclosure	Habitation	No further work
			F	Terrace	Agriculture	No further work
			G	Paved Area	Habitation	No further work
			H	Terrace	Agriculture	No further work
			I	Paved Area	Agriculture	No further work
6918	489/491	Wind Farm	A	U-Shaped Wall	Uncertain	No further work
			B	U-Shaped Wall	Uncertain	No further work
			E	Enclosure	Habitation	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6919	**495**	Wind Farm	E	Terrace	Habitation	**Detailed mapping and selected excavation**
6920	**499**	Wind Farm		Wall	Habitation	No further work
6921	**501**	Wind Farm	B	Stone Mound	Burial	**Preserve**
6922	**502**	Wind Farm	A	Wall	Agriculture	No further work
			B	Stone Mound	Burial	**Preserve**
6923	**503**	Wind Farm	B	U-Shaped Wall	Habitation	No further work
			C	Stone Mound	Burial / Uncertain	**Preserve**
			D	Modified Outcrop	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			F	Modified Outcrop	Agriculture	No further work
6924	**544**	Wind Farm	A	Terrace	Agriculture	No further work
			D	C-Shaped Wall	Habitation	No further work
			E	Stone Mound	Uncertain	No further work
			F	Stone Mound	Uncertain	No further work
			G	Stone Mound	Uncertain	No further work
			H	Stone Mound	Uncertain	No further work
			K	Terrace	Agriculture	No further work
6925	**559**	Wind Farm	MM	Terrace	Agriculture	No further work
			RR	Terrace	Uncertain	No further work
6929	**583**	Wind Farm	A	Wall	Uncertain	No further work
			B	Overhang Shelter	Habitation / Uncertain	No further work
6930	**584**	Wind Farm	D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			T	Modified Outcrop	Uncertain	No further work
			W	Terrace	Uncertain	No further work
			X	Terrace	Uncertain	No further work
			Y	Terrace	Uncertain	No further work
			Z	Terrace	Uncertain	No further work
			AA	Terrace	Agriculture	No further work
			BB	Terrace	Agriculture	No further work
			CC	Terrace	Agriculture	No further work
			DD	Terrace	Uncertain	No further work
			EE	Stone Mound	Agriculture / Burial	**Preserve**
			GG	Terrace	Uncertain	No further work
			HH	Terrace	Uncertain	No further work
			JJ	Terrace	Uncertain	No further work
6937	**591**	Pāpaka Road	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6938	592	Pāpaka Road	A	Wall	Agriculture / Ranching	No further work
			B	Wall	Uncertain	No further work
			C	Terrace	Agriculture	No further work
			D	Enclosure	Agriculture	No further work
			E	Overhang Shelter	Habitation	No further work
			F	Overhang Shelter	Habitation	No further work
			F	Terrace	Habitation	No further work
			G	Overhang Shelter	Habitation	No further work
			G	Terrace	Habitation	No further work
			G	Stone Mound	Habitation	No further work
			H	Enclosure	Agriculture	No further work
			I	Wall	Ranching	No further work
			J	Wall	Uncertain	No further work
			K	Wall	Ranching	No further work
			L	Lava Tube	Habitation	No further work
			L	Terrace	Habitation	No further work
			M	Terrace	Agriculture	No further work
6939	593	Pāpaka Road	A	Enclosure	Habitation	No further work
			B	Terrace	Habitation	No further work
			C	Terrace	Uncertain	No further work
			D	Terrace	Agriculture	No further work
6940	594	Pāpaka Road	A	Enclosure	Habitation	No further work
			B	Enclosure	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Enclosure	Ranching	No further work
			G	Terrace	Agriculture	No further work
			H	Terrace	Agriculture	No further work
6941	595	Pāpaka Road	A	Wall	Agriculture	No further work
			B	Overhang Shelter	Habitation	No further work
			C	Overhang Shelter	Habitation	No further work
6942	597	Pāpaka Road		Wall	Ranching	No further work
6946	601	Pāpaka Road		Wall	Ranching	No further work
6948	603	Pāpaka Road		Wall	Uncertain	No further work
6949	604	Pāpaka Road		Wall	Ranching	No further work
6950	605	Pāpaka Road		Wall	Ranching	No further work
6952	2010 B	Wind Farm		Overhang Shelter	Habitation	No further work
6953	2010 C	Wind Farm	A	Stone Mound	Burial	**Preserve**
			B	Stone Mound	Burial	**Preserve**
			C	Stone Mound	Burial	**Preserve**
6956	2010 F	Pāpaka Road		Enclosure	Ranching	No further work
6957	2010 G	Pāpaka Road	A	Stone Mound	Uncertain	No further work
			B	Wall	Uncertain	No further work
6958	2010 H	Pāpaka Road		Wall	Ranching	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6959	**2010 I**	Pāpaka Road	A	Wall	Ranching	No further work
			B	Modified Outcrop	Uncertain	No further work
6960	**2010 J**	Pāpaka Road		Wall	Ranching	No further work
6961	**2010 K**	Pāpaka Road		Wall	Ranching	No further work
6962	**2010 L**	Pāpaka Road	B	Wall	Agriculture	No further work
6963	**2010 M**	Pāpaka Road		Wall	Ranching	No further work
6965	**2010 O**	Pāpaka Road		Wall	Ranching	No further work
6966	**2010 P**	Pāpaka Road		Cast Iron Tank	Ranching	No further work
6967	**2010 Q**	Pāpaka Road	A	Wall	Ranching	No further work
			B	Enclosure	Agriculture	No further work
6968	**2010 R**	Pāpaka Road	A	Wall	Agriculture	No further work
			A	Alignment	Agriculture	No further work
			B	Terrace	Agriculture	No further work
6969	**2010 S**	Pāpaka Road		Wall	Ranching	No further work
6970	**2010 T**	Pāpaka Road		Wall	Ranching	No further work
6971	**2010 U**	Pāpaka Road		Wall	Uncertain	No further work
6972	**2010 V**	Pāpaka Road	A	Terrace	Habitation	No further work
6974	**2010 X**	Pāpaka Road		Wall	Habitation	No further work
6975	**2010 Y**	Pāpaka Road	A	Wall	Ranching	No further work
6976	**2010 Z**	Pāpaka Road		Enclosure	Habitation	No further work
				Terrace	Habitation	No further work
6977	**2010 AA**	Pāpaka Road		Wall	Ranching	No further work
6978	**2010 BB**	Pāpaka Road		Wall	Ranching	No further work
6979	**2010 CC Gen-TieLine**	Gen-TieLine	A	Terrace	Habitation	No further work
			A	U-Shaped Wall	Habitation	No further work
			B	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work
6980	**2010 CC Pāpaka**	Pāpaka Road		Wall	Ranching	No further work
6981	**2010 DD**	Gen-TieLine		Wall	Uncertain	No further work
6982	**2010 EE**	Gen-TieLine		Wall	Uncertain	No further work
6983	**2010 FF**	Gen-TieLine	A	Terrace	Agriculture / Uncertain	No further work
			B	Terrace	Uncertain	No further work
			C	Alignment	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Cleared Area	Agriculture	No further work
			F	Terrace	Uncertain	No further work
			G	U-Shaped Wall	Uncertain	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6984	**2010 GG**	Gen-TieLine	A	Alignment	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Habitation	No further work
			D	Terrace	Habitation	No further work
			E	Terrace	Agriculture	No further work
6985	**2010 HH**	Gen-TieLine	A	Terrace	Agriculture	No further work
			B	Modified Outcrop	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			C	Modified Outcrop	Uncertain	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Modified Outcrop	Agriculture / Burial / Uncertain	**Preserve**
			G	Stone Mound	Agriculture / Burial / Uncertain	**Preserve**
6986	**2010 II**	Gen-TieLine		Wall	Uncertain	No further work
6987	**2010 JJ**	Gen-TieLine	A	Modified Outcrop	Uncertain	No further work
			B	U-Shaped Wall	Habitation	No further work
			C	Wall	Uncertain	No further work
			D	Terrace	Agriculture	No further work
6988	**2010 KK**	Gen-TieLine	A	Terrace	Agriculture	No further work
			B	Wall	Uncertain	No further work
			C	Wall	Habitation	No further work
			D	Wall	Uncertain	No further work
			E	C-Shaped Wall	Habitation	**Detailed mapping and complete aerial excavation**
			E	Enclosure	Habitation	**Detailed mapping and complete aerial excavation**
			F	Alignment	Uncertain	No further work
			F	Wall	Uncertain	No further work
6989	**2010 LL**	Wind Farm	A	Stone Mound	Agriculture	No further work
6991	**2010 NN**	Pi`ilani Hwy		Wall	Ranching	No further work
6992	**2010 OO**	Pi`ilani Hwy	C	Terrace	Uncertain	No further work
			D	Stone Mound	Burial / Uncertain	**Preserve**
			E	Wall	Uncertain	No further work
6994	**2010 QQ**	Pi`ilani Hwy	A	Wall	Ranching	No further work
6995	**2010 RR**	Gen-TieLine	10	Terrace	Agriculture	No further work
6996	**2010 SS**	Gen-TieLine		Stone Mound	Agriculture	No further work
6997	**2010 TT**	Gen-TieLine		Modified Outcrop	Agriculture	No further work
6998	**2010 UU**	Gen-TieLine		Modified Outcrop	Uncertain	No further work
6999	**2010 VV**	Gen-TieLine	A	Stone Mound	Agriculture	No further work
			B	Platform	Agriculture	No further work
7000	**2010 WW**	Gen-TieLine		Wall	Agriculture	No further work
7001	**2010 XX**	Gen-TieLine		Stone Mound	Agriculture	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7002	**2010 YY**	Gen-TieLine		Stone Mound	Agriculture	No further work
7003	**2010 ZZ**	Gen-TieLine		Stone Mound	Agriculture	No further work
7004	**2010 AAA**	Gen-TieLine	A	Alignment	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
7005	**2010 BBB**	Gen-TieLine		Terrace	Agriculture	No further work
7006	**2010 CCC**	Gen-TieLine		Stone Mound	Agriculture	No further work
7007	**2010 DDD**	Gen-TieLine		Cleared Area	Agriculture	No further work
7008	**2010 EEE**	Gen-TieLine		Stone Mound	Agriculture	No further work
7009	**2010 FFF**	Gen-TieLine		Modified Outcrop	Agriculture	No further work
				Alignment	Agriculture	No further work
7010	**2010 GGG**	Gen-TieLine		Stone Mound	Agriculture	No further work
7011	**2010 HHH**	Gen-TieLine	2	Stone Mound	Ranching	No further work
7012	**2010 III**	Gen-TieLine		Stone Mound	Agriculture	No further work
7013	**2010 JJJ**	Gen-TieLine		Platform	Ranching	No further work
7014	**2010 KKK**	Pāpaka Road	A	Alignment	Agriculture	No further work
			B	Alignment	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Modified Outcrop	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work
			H	Terrace	Agriculture	No further work
			I	Stone Mound	Agriculture	No further work
			I	Terrace	Agriculture	No further work
7015	**2010 LLL**	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Modified Outcrop	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7016	2010 MMM	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Stone Mound	Agriculture	No further work
			H	U-Shaped Wall	Habitation / Uncertain	**Detailed mapping and selected excavation**
			H	Terrace	Habitation / Uncertain	No further work
			I	Wall	Agriculture	No further work
			J	Terrace	Agriculture	No further work
			K	C-Shaped Wall	Agriculture	No further work
			L	Enclosure	Uncertain	No further work
			L	Terrace	Uncertain	No further work
			M	Wall	Agriculture	No further work
			N	Terrace	Agriculture	No further work
			O	Terrace	Uncertain	**Detailed mapping and selected excavation**
			P	Modified Outcrop	Uncertain	No further work
			Q	Terrace	Agriculture	No further work
			R	Stone Mound	Agriculture	No further work
7017	2010 NNN	Pāpaka Road	A	Terrace	Ceremonial / Habitation	**Detailed mapping and selected excavation**
			B	Alignment	Uncertain	No further work
			B	Stone Mound	Uncertain	No further work
			C	Stone Mound	Agriculture	No further work
7018	2010 OOO	Pāpaka Road		Wall	Ranching	No further work
7019	2010 PPP	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			D	Terrace	Habitation	No further work
			D	Wall	Habitation	No further work
			E	Terrace	Agriculture / Uncertain	No further work
7020	2010 QQQ	Pāpaka Road	A	Terrace	Habitation	No further work
			B	Stone Mound	Agriculture	No further work
			C	Terrace	Habitation	**Detailed mapping and selected excavation**
7021	2010 RRR	Pāpaka Road	A	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			B	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			D	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7022	2010 SSS	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Terrace	Uncertain	No further work
			C	C-Shaped Wall	Agriculture / Uncertain	No further work
			D	C-Shaped Wall	Agriculture / Habitation	No further work
			E	C-Shaped Wall	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			F	Enclosure	Uncertain	**Detailed mapping and selected excavation**
			F	Hearth	Habitation	No further work
			H	Terrace	Agriculture	No further work
7023	2010 TTT	Pāpaka Road		Barbed Wire Fence	Ranching	No further work
7024	2010 UUU	Pāpaka Road	A	Wall	Agriculture / Ranching	No further work
			B	Alignment	Ranching	No further work
			C	Wall	Ranching	No further work
7025	2010 VVV	Pāpaka Road	A	Stone Mound	Agriculture	No further work
			B	Alignment	Uncertain	No further work
7026	2010 WWW	Wind Farm	A	Terrace	Uncertain	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			D	Enclosure	Agriculture	No further work
			E	Terrace	Habitation	No further work
7027	2010 AAAA	Wind Farm	A2	Modified Outcrop	Agriculture	No further work
7028	2010 BBBB	Wind Farm	B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
7029	2010 CCCC	Wind Farm	A	Terrace	Uncertain	No further work
			B	Terrace	Uncertain	No further work
7030	2010 DDDD	Wind Farm	A	Alignment	Uncertain	No further work
7031	2010 EEEE	Wind Farm		Modified Outcrop	Agriculture	No further work
7032	2010 FFFF	Wind Farm		Wall	Uncertain	No further work
7033	2010 GGGG	Wind Farm		Terrace	Agriculture	No further work
7035	2010 IIII	Wind Farm	A	Modified Outcrop	Agriculture	No further work
			B	Stone Mound	Burial	**Preserve**
			C	Stone Mound	Burial	**Preserve**
			D	Stone Mound	Burial	**Preserve**
			E	Stone Mound	Burial	**Preserve**
7036	2010 JJJJ	Wind Farm	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
7037	2010 KKKK	Wind Farm	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
7038	2010 LLLL	Wind Farm	A2	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Ditch / Channel	Agriculture	No further work
7039	2010 MMMM	Wind Farm		Platform	Uncertain	No further work
7040	2010 NNNN	Wind Farm		Stone Mound	Agriculture	No further work

SIHP No. (50-50-xx-xxx)	Field No. (AWF-xxx)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7041	**2010 OOOO**	Wind Farm		Alignment	Agriculture / Burial	**Preserve**
				Stone Mound	Agriculture / Burial	**Preserve**
				Hearth	Habitation	No further work
7042	**2010 PPPP**	Wind Farm	A	Terrace	Habitation	No further work
			B	Terrace	Habitation	No further work
			C	Terrace	Habitation	No further work
			D	Terrace	Habitation	No further work
			E	Alignment	Uncertain	No further work
			F	Stone Mound	Uncertain	No further work
7044	**Mākena 2**	Pāpaka Road		Terrace	Uncertain	No further work
7045	**Mākena 3**	Pāpaka Road	A	Enclosure	Agriculture / Habitation	No further work
			B	Cleared Area	Agriculture	No further work
7046	**Mākena 4**	Pāpaka Road		Enclosure	Uncertain	No further work
7047	**Mākena 5**	Pāpaka Road		Wall	Ranching	No further work
7048	**Mākena 6**	Pāpaka Road		Modified Outcrop	Uncertain	No further work
7049	**Mākena 7**	Pāpaka Road		Wall	Habitation	No further work
7050	**Mākena 8**	Pāpaka Road		Cleared Area	Habitation	No further work
				Windbreak	Habitation	No further work

Key:

Preserve

Detailed mapping

Detailed mapping and selected excavation

Detailed mapping and complete aerial excavation

9.0 SUMMARY AND DISCUSSION

The Auwahi Wind Farm project area is located within ʻUlupalakua Ranch, which has been a privately held property for hundreds of years. Access is restricted on the ranch, being limited to ranch personnel and adjacent property owners. As such, the archaeological sites are in relatively pristine condition as compared to other areas on Maui where access is not as restricted. Previous impacts to archaeological sites in the project area have occurred primarily as a result of cattle ranching activities. Undoubtedly some of the traditional structures were partially dismantled in 1800s and early 1900s so that the available fieldstone could be used in the creation of cattle walls and related enclosures. Ranch access roads have also impacted some of the traditional features. Hunting activity was also observed and may have impacted some of the resources. However, the ranch is very pro-active with regard to minimizing impacts to archaeological features (pre-Contact and historic) as they feel it is part of the ranch heritage and stewardship.

The current drought conditions, although extremely difficult and trying for the ranch, afforded the archaeological crew a unique opportunity with regard to identifying low lying and subtle agricultural features. The evidence for remnant terracing and altered landscapes was clearly visible due to the lack of low lying vegetation, which covered much of the project area during the 2007 survey. Hence, our recording efforts were much more complete.

Density of Settlement

We continue to be astonished about the density of settlement in this portion of Auwahi. In the ca. 282 acres that make up the wind farm site we recorded 170 sites comprised of 995 features. This calculates to about 3.5 structural features per acre. The results of the 2007 pedestrian survey indicated that the density of settlement is constant over the entire 1,450 acres that make up the south wind farm. Using our 3.5 features per acre figure, we could expect that the entire 1,450 acre parcel could contain more than 5,075 features. This is an incredibly dense settlement.

One of the main questions relating to this settlement density is the chronological factor. Did this settlement develop over several hundreds of years, where possibly some of the features functioned for short periods and then were abandoned, so that the density of settlement was not as great as it may appear? Conversely, was the settlement of Auwahi fairly short with all of the features being contemporaneous and being used at the same time; this would suggest a very intense settlement? This question is discussed below

Pattern of Settlement

The terrain in the APE is relatively steep and rocky. It is composed of both low and high ridges with both shallow and deep intervening gulches and swales. The pattern of settlement in the wind farm reflects these geographic differences. The habitation and ceremonial features are situated atop the rocky ridges. These ridges afford panoramic views of Auwahi as well as up and down the coast. Some of the features are also afforded views of the Big Island of Hawaiʻi on clear days. One can often see the mountains of Mauna Kea and Mauna Loa as well as portions of the Kohala Coast.

Agricultural features are found in the gulch drainages, swales, or flat areas below ridge lines. These areas often contain considerably more soil than the ridgelines. Almost every flat piece of land contained modifications for the cultivation of crops.

Agriculture

The Wind Farm site consists of extremely inhospitable terrain. The area is relatively steep, extremely rocky, arid, and very windy. This is not the type of area one would think of as an intensively cultivated area. But it was. As noted above almost every flat piece of land between and at the base of ridges was cultivated. Not only do these areas contain more soil than the ridges, the ridges afford some protection from the strong winds that characterize this area.

The agricultural systems were quite complex. The flat and relatively flat areas were modified with retaining walls to create larger cultivation areas. We also found evidence of water control and management in the gulches. These water control features included dams and diversion walls. While this area is extremely arid, it is also characterized by short and heavy down pours of rain. The control of this moisture was crucial in successful crop cultivation. By slowing the transport of water and diverting these water flows to fields, more crops could be successfully grown.

Heiau

Five "notched" *heiau* were recorded within the wind farm. This seems to be a high density of *heiau* in a small area. We currently think that these *heiau* were associated with the agricultural pursuits that dominated this area, but why are there so many? As of now we have more questions than answers: (1) were these *heiau* contemporary with each other, or was one *heiau* abandoned before another was built; (2) were these *heiau* associated with different land divisions such as *'ili* within the *ahupua'a*; (3) were these *heiau* ceremonial structures for related extended families. It is not clear whether we will obtain answers to these types of questions, but they remain interesting.

Postulated Activities

Hawaiians in pre-Contact times were living, having children (deciduous tooth found), and dying (presence of burials) in this area of Auwahi. Some of the specific activities taking place here can be outlined as follows:

- Agricultural pursuits (including planting, harvesting, and water control) was probably the dominant activity taking place.
- Food preparation is indicated by the number of stone lined hearths found during the survey and substantiated by the *poi* pounder fragment and the pestle; that were found.
- Basalt adze preforms, flakes, hammerstones, a grinding stone, and complete finished adze found in the project area indicates that stone adzes were probably made or repaired here, and that some forms of wood working was taking place.
- The two *'ulu maika* and the two *papamū* suggest that recreation played some part in the lives of the people of Auwahi. Furthermore it is possible that the area contained an *'ulu maika* tack that is no longer visible.
- *He'e* or octopus fishing was also taking place on the coast. Several octopus fishing sinkers and lures were found.

- Contact with the coast is also indicated by the sparse marine shell midden that was observed on the surface of some of the features and that was recovered from the test excavations.

Diet

It is very premature to state anything about the diet of the Hawaiians living in Auwahi, but there are a few general statements that can be made. By inference (the abundance of agricultural plots), vegetable foods, probably mostly *ʻuala* or sweet potato, made up the majority of the diet. Added to this were protein sources from marine and terrestrial environments that included shell fish, fish, dog, and pig. Birds, both the domestic chicken and wild avian species may have also been components, but definite statements on the avian component of the diet must await the results of the midden analyses.

9.1 SITE AVOIDANCE

Since the inception of archaeological investigations in 2007, an emphasis has been placed on minimizing the impact of construction on the archaeological resources present in Auwahi. This report has shown that design changes have been continually made in an effort to minimize impacts to archaeological sites. This effort has been focused on avoiding impact to ceremonial/religious structures and human burials. This effort will continue. Another measure of the degree of impact is the relative number of features that will be impacted. It was shown above that over 995 features are located in the entire APE, with over 501 features located in the 282 acre Wind Farm parcel APE. This calculates to 1.8 features per acre within the Wind Farm APE. However, not all of these features will be impacted by construction, as whole site clusters were recorded where only portions will be impacted. If, based on our calculations above we assume that the 1,450 acre south parcel may have over 2,610 features, then even if all 501 features are impacted (which they will not be) this represents only 19 percent of the total number of calculated features within the 1,450 acre parcel.

9.2 AUWAHI IN A REGIONAL KAHIKINUI PERSPECTIVE

As noted earlier in this report, Kahikinui was one of twelve traditional *moku* or political districts into which the island of Maui was subdivided at the time of initial European contact. The western boundary of Auwahi (which adjoins Kanaio *ahupuaʻa* in the *moku* of Honuaʻula) also forms the western boundary of the *moku* of Kahikinui. Kahikinui then extends to the east of Auwahi for some 9 kilometers until its eastern boundary is reached at the Waiʻōpai (which shares its own eastern boundary with Nākula in the moku of Kaupō). Encompassing roughly 100 square kilometers, Kahikinui takes up much of the southeastern slope of the great volcano of Haleakalā. The purpose of this concluding section is to review the results of our Auwahi survey within the broader perspective of the Kahikinui District as a whole. By examining Auwahi within this *moku*-level context, the significance of many of the Auwahi features are highlighted. At the same time, the new results from Auwahi help to understand wider patterns throughout the district.

Kahikinui is, without doubt, the most arid part of Maui, owing to its location in the rain shadow of Haleakalā. This arid climate, combined with the relatively young geological age of the lava flow surfaces which make up the Kahikinui landscape, make it a highly distinctive environment for human habitation and land use. More than in any other part of Maui, the pre-Contact Hawaiian occupants of Kahikinui had to adapt to harsh climatic conditions that were on the margins for tropical root-crop horticulture. Almost all of Kahikinui's annual rainfall comes as a result of the winter (*kona*) storms. This would have restricted cropping of sweet potato and yams to a relatively short growing period roughly between October and March. Furthermore, the young geological substrate also results in a forbidding coastline dominated by low sea cliffs and the absence of a fringing reef. This coastal geomorphology makes access to the shoreline for fishing or shellfish gathering difficult at best, while the absence of a reef means that marine biomass is low. Thus, a harsh horticultural landscape was coupled with low marine biodiversity and productivity, rendering Kahikinui an even more challenging landscape for human occupation.

In spite of these environmental challenges, Kahikinui was home to a large and vibrant population of Native Hawaiians for at least four centuries, from around AD 1400 until 1800. The high density of archaeological features throughout Auwahi as well as in the other parts of Kahikinui which have been investigated to date, is remarkable. These archaeological features are a testament to the adaptability and ingenuity of the Native Hawaiians, who were able to create successful lifestyles in a marginal and challenging land. In the 19th century, the district's population began to fall precipitously as result of the European-introduced diseases that swept through the islands. Kahikinui was finally abandoned by Native Hawaiians around the close of the 19th century, after the Hawaiian Government leased the land to Portuguese cattle ranchers, making the traditional farming mode of life untenable.

9.3 AUWAHI AND THE AHUPUA'A OF KAHIKINUI

In the traditional Hawaiian land system, districts or *moku* were subdivided into pie-shaped land units or territories called *ahupua'a*. Each *ahupua'a* (in theory at least) ran from the mountain peak or crest down to the sea, thus cross-cutting the ecological grain of the land and including segments of all of the main resource zones: upper forests (source of timber and bird's feathers), lower forests (used for taro planting), a main zone of agricultural lands, the coastal zone where habitations were often concentrated, and the coast with its littoral resources of shellfish and fish. Individual *ahupua'a* were periodically awarded to chiefs (*ali'i*) by the king (*Ali'i nui*), usually at the moment of succession to the kingship, either after a war of conquest or at the death of a king (Kirch 2010a). The chief who controlled the *ahupua'a*, called the *ali'i-'ai-ahupua'a*, typically appointed a land overseer, the *konohiki*, who resided in the territory and was responsible for its daily management. This *konohiki* made sure that the population of commoners (*maka'āinana*) who resided in the *ahupua'a* kept up their gardens and farms, and were prepared to present the annual tribute (*ho'okupu*) to the chief and the king.

For most of the lands in Hawai'i, the specific boundaries of *ahupua'a* territories are well known, because these were codified at the time of the Mahele 'Āina, or division of lands between the king, principal chiefs, and the government between 1846-54 (Chinen 1958; Kirch and Sahlins

1992). As discussed earlier, however, Kahikinui was rather unusual in that—with the exception of Auwahi—all of the lands of the *moku* were awarded to Prince Lot (grandson of King Kamehameha I, later to become Kamehameha V). Auwahi was not included in the award to Prince Lot, but rather was given to his half-sister the high chiefess Ruth Keli‘iokalani (great granddaughter of Kamehameha I), who kept the *ahupua‘a* in her possession until after her death, when it became a part of ‘Ulupalakua Ranch. The remainder of Kahikinui, given over to Prince Lot, was presumably also subdivided into several different, named *ahupua‘a*. But because this vast region was transferred as a single unit to the prince, these *ahupua‘a* were not specifically named in the Mahele Book of awards. Moreover, because Lot was dissatisfied with his receipt of the Kahikinui lands, he rapidly arranged to have them transferred to the Hawaiian Government, in exchange for more productive lands elsewhere. With the entire area of Kahikinui (excepting Auwahi) now in Government hands, there was again no particular interest in delineating the specific boundaries between *ahupua‘a* within Kahikinui, because these were not held by separate private landholders.

For these reasons, the only *ahupua‘a* territory within the ancient *moku* of Kahikinui that can be unambiguously defined is that of Auwahi. Its western and eastern boundaries were defined by the Hawaiian Government’s Boundary Commission in the 1870s. The vast expanse of land to the east of Auwahi, extending past the Luala‘ilua Hills all the way to deep Manawainui Gulch and beyond to the eastern border of Kahikinui at Wai‘ōpai was surely divided into several *ahupua‘a*. Clues as to the names of these *ahupua‘a* are provided by early maps of the region. The earliest printed map of the Hawaiian Islands was made by Samuel P. Kalama in 1838 while at the missionary school at Lāhaināluna on Maui, in 1838 (Moffat and Fitzpatrick 1995:26-25, figure 10). This map labels the following major land units, from west to east in Kahikinui: Auwahi (spelled Auahi), Luala‘ilua, Alena, and Kīpapa. The first accurate survey of Kahikinui District was undertaken by W. R. Lawrence in July, 1882, for the Hawaiian Government Survey under the overall direction of W. D. Alexander. The original drafted map of this survey, preserved in the archives of the State Survey Office, has penciled place names that appear to indicate *ahupua‘a*, or at least major land divisions (although no boundaries between these divisions are delineated. These names, from the eastern boundary of Auwahi proceeding eastward are: Alena, Kīpapa, Na Kaahu, and Na Kaohu. The first version of the “modern” map of Maui was a collaborative effort of the Hawaiian Territorial Survey, the U. S. Geological Survey, and the U. S. Coast and Geodetic Survey, undertaken in 1928 (published in quadrangle sheets at a scale of 1:62,500 by the USGS). The Mākena and Haleakalā Quadrangles show Auwahi with its boundaries, and for the rest of Kahikinui give land names (without boundaries delineated) in west to east order: Alena, Kīpapa, Nakaohu, Nakaaha, Mahamenui, Manawainui, and Wai‘ōpai (Figure 181). Interestingly, Luala‘ilua appears on this map only as the name of the cinder cones, and not as a larger land unit. This suggests the possibility that Luala‘ilua was not an *ahupua‘a*, but was a kind of boundary zone between Auwahi and Alena.

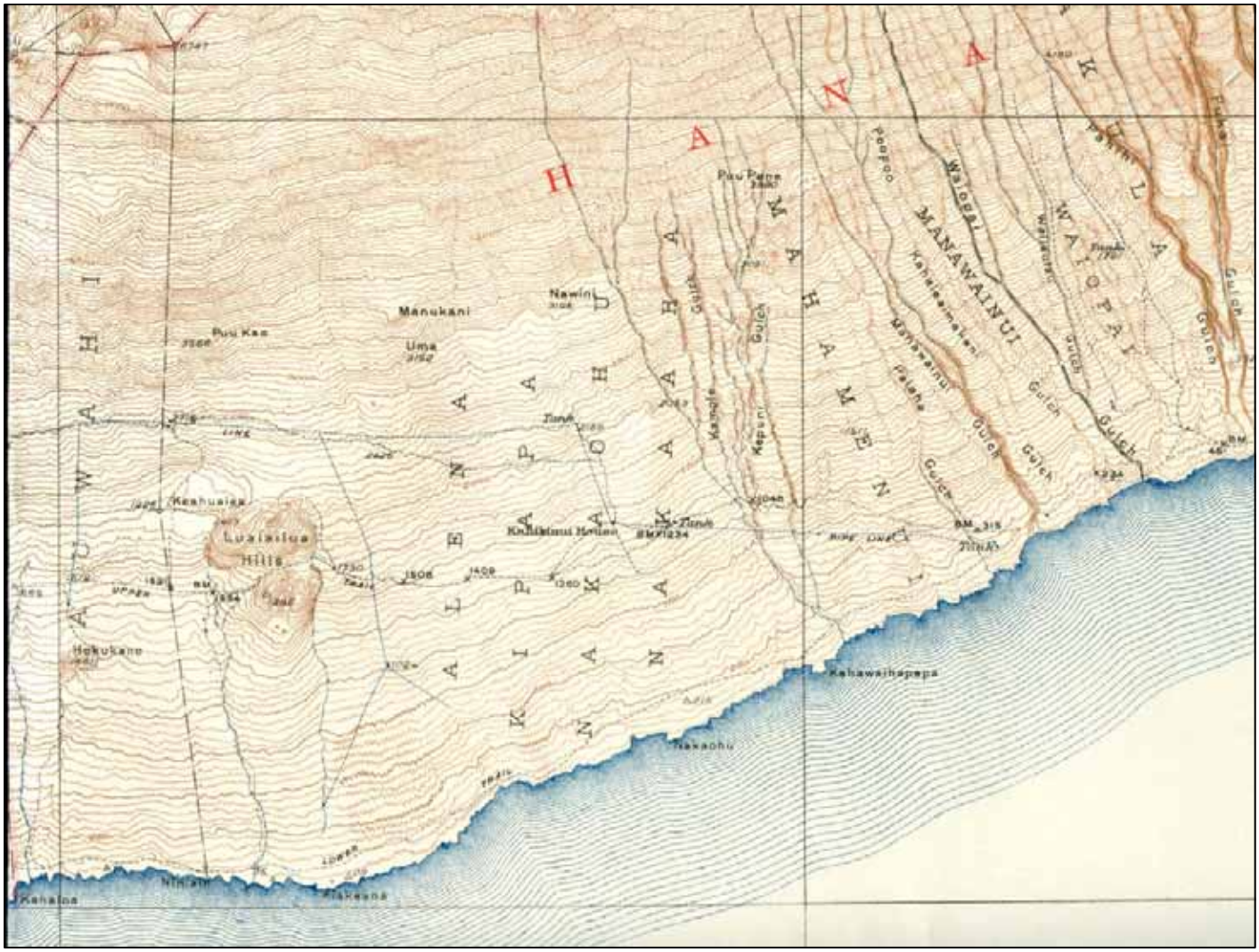


Figure 181. Map of Kahikinui District showing the various place names which are believed to represent individual *ahupua'a*, or in some cases possibly '*ili*, land units. (Map by U. S. Geological Survey, 1942.)

To summarize, Auwahi was just one of several *ahupua'a* that in aggregate constituted the large *moku* of Kahikinui. However, it remains uncertain exactly how many *ahupua'a* the rest of Kahikinui was subdivided into. Certainly Alena and Kīpapa seem to have unquestioned status as *ahupua'a* names, as they appear on the early Kalama map from 1838. The other names which appear on the 1928 USGS map, and which have continued to be published on subsequent editions up until the present, may also have been *ahupua'a*. Alternatively, they may have been smaller unit, such as *'ili*, within a large single *ahupua'a* of Kīpapa.

For the present study, the most important implication of all this is that Auwahi was unquestionably an independent *ahupua'a* within the larger *moku* of Kahikinui. Moreover, the fact that this land unit was conferred on one of the highest-ranked chiefesses in the Hawaiian Kingdom during the Mahele 'Āina of 1848, Princess Ruta Keli'iokalani (grand-daughter of King Kamehameha I), suggests that the *ahupua'a* had a special status, for such a high-ranked personage would not be awarded an unimportant territory. Clearly, at the time of the Mahele all of Kahikinui was in the control of the Kamehameha family (and presumably had been so since the conquest of Maui by Kamehameha after the death of Maui King Kahekili in the late 18th century). But Keli'iokalani outranked her half-brother Lot, in part due to her pedigree which traced back to Kānekapolei, a former wife of the great Hawai'i king Kalani'ōpu'u and an early wife of Kamehameha I. Thus, the fact that Auwahi was awarded to Keli'iokalani is indicative that the *ahupua'a* had a special status within Kahikinui. Indeed, although there is no direct historical proof of this, one presumes that she expressly wanted this *ahupua'a* and had requested it in the negotiations leading up to the Mahele. This interpretation of Auwahi as particularly important within the larger *moku* is also supported by the archaeological observation that the most important coastal settlement, containing the largest individual residential platforms and several *heiau*, is situated on the coast at Makee, within Auwahi. For these and other reasons, it is likely that Auwahi was the most important *ahupua'a* in the entire district. It was probably the residence of the *konohiki* who represented Keli'iokalani, as she herself would not have resided there. In the following pages, we will summarize other evidence that further reinforces this interpretation, notably that Auwahi is likely to have had some of the most intensively cultivated zones within the entire district, and that it was a locus of high population density.

9.4 CHRONOLOGY OF OCCUPATION AND LAND USE IN AUWAHI

Recent archaeological excavations and re-dating of key sites throughout Eastern Polynesia, including Hawai'i, have led to a shortening of the Hawaiian cultural sequence. It appears unlikely that the Hawaiian archipelago was settled before A.D. 800, and may not have been colonized by the first Polynesians until closer to A.D. 1000 (Kirch and McCoy 2007; Dye and Pantaleo 2010). This has required a revision in the Hawaiian cultural sequence originally proposed by Kirch (1985:figure 239), with four periods prior to European contact: Colonization, Developmental, Expansion, and Protohistoric. Instead, following a proposal by Kirch and McCoy (2007), the first two periods are collapsed into a shorted Foundation Period, from initial settlement (ca. A.D. 800/1000) to A.D. 1200. This is then followed by an Early Expansion Period (A.D. 1200-1400), a Late Expansion Period (A.D. 1400-1650), and a Protohistoric Period (A.D. 1650-1778). This revised sequence has recently been summarized by Kirch (2010a, table 4.1). We

will refer to this sequence in the following analysis of radiocarbon dates from Auwahi and from the larger Kahikinui region.

Prior to our current project, only two radiocarbon dates had been obtained from sites within Auwahi *ahupua'a*. Both dates were from excavations by Kirch at the coastal village site of Makee. A *heiau* site returned an age of 390 ± 40 BP (Beta-183146) while an adjacent fishing shrine was dated to 160 ± 40 BP (Beta-183147) (Oceanic Archaeology Laboratory, unpublished data). These dates suggested that Polynesian use of at least the coastal zone had commenced by the 15th century, but gave no indication of the timing of the extensive inland occupation.

For several *ahupua'a* to the east of Auwahi, however, a more extensive radiocarbon database had been developed over about 15 years of excavations, by the U. C. Berkeley Oceanic Archaeology Laboratory group (Kirch 1997), by the State Historic Preservation Division's investigations on behalf of the Department of Hawaiian Home Lands (Dixon et al. 2000), and by the University of Northern Illinois' study of several *heiau* sites in the district (Kolb 2006). The largest subset of dates comes from Kīpapa, but Nakaohu, Mahamenui, and Manawainui *ahupua'a* are also represented. In all, 162 radiocarbon dates have been obtained. This is a high-quality database in that virtually all of the samples were botanically identified prior to dating (thus eliminating the recurring problem of "old wood"), and because almost all of the dates were run using the high-precision AMS (accelerator mass spectrometry) method. In fact, this is one of the largest radiocarbon databases for any single district or region within the Hawaiian Islands. The Kahikinui radiocarbon database has been used by Kirch (2007) to estimate pre-contact populations trends in the district, and by Kirch (2010a:128-136) as part of a larger meta-analysis of Hawaiian demography.

Figure 182 is a histogram plot of the 162 Kahikinui radiocarbon dates (excluding our recent sample of 16 dates from Auwahi) by 100-year calibrated age intervals. (By "calibrated" we mean that the plotted ages are not radiocarbon ages but calendar ages derived from the Oxcal calibration program.) Because radiocarbon ages are not "dates" in a strict sense, but rather sets of probability distributions, often with multiple possible intercepts on the calibration curve, plotting dates as in Figure 182 requires making a decision about which of several possible calibration intercepts to accept. In this case the preferred intercept for each radiocarbon date is that with the single highest probability (probabilities are generated as part of the Oxcal calibration program).

As can be seen in Figure 182, there are only two radiocarbon dates older than A.D. 1400. These dates suggest the likelihood of some human activities in the Kahikinui region during the late Foundation and Early Expansion Periods, but are unlikely to signal permanent land use or occupation. More likely, they relate to initial Polynesian exploration of the region. During the period from A.D. 1400-1499, however, ten radiocarbon dates from several sites can be taken as evidence that Hawaiians had begun to establish a permanent presence in the region. This corresponds to the onset of the Late Expansion Period in the revised Hawaiian sequence, a period known from Hawai'i Island to have been one of major expansion of leeward agricultural field systems (Ladefoged and Graves 2008). The numbers of Kahikinui radiocarbon dates then increase significantly for the next two centuries, from A.D. 1500-1699, reflecting a growing

population and expansion of settlement. Most striking, however, is the more than doubling of dates in the final 100-year interval, from A.D. 1700-1799. This is the Protohistoric Period, prior to and overlapping with the first arrival of Europeans into the islands. Based on the Kahikinui radiocarbon database, it seems that the highest density of settlement and population in the district was reached in this final century of the pre-Contact era.

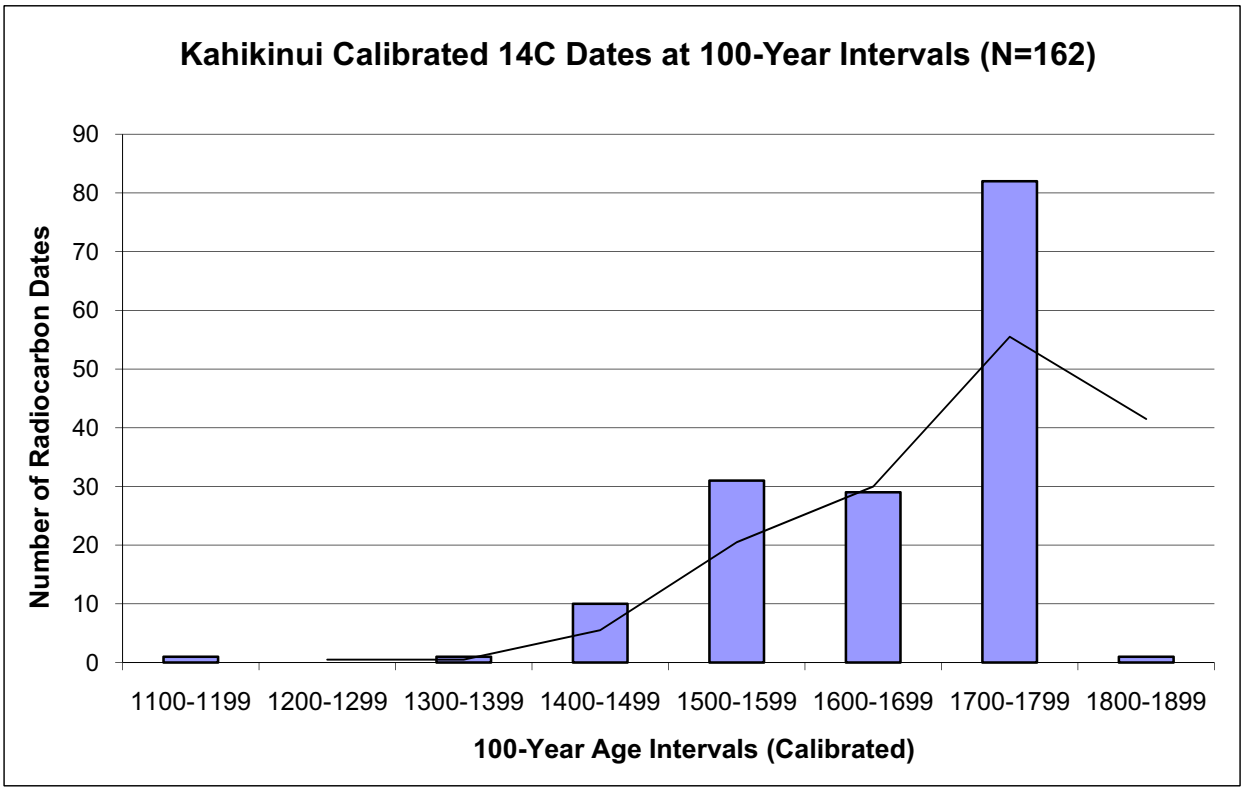


Figure 182. Histogram plot of 162 radiocarbon dates from Kahikinui archaeological sites (excluding Auwahi). Dates have been plotted based on their highest probability intercepts. The trendline is a 2-period moving average. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

The broader radiocarbon database for Kahikinui provides a context within which the new set of 14 AMS radiocarbon dates from Auwahi sites obtained by this project can be evaluated. Figure 183 is an Oxcal-generated plot of all of the new Auwahi dates. The dates have been arrayed from oldest (top) to youngest. As is evident, there are multiple intercepts for all dates, and the problem of multiple intercepts becomes more acute with the youngest age samples. However, none of the dated samples came from sites with any post-Contact Euro-American artifacts, so we can rule out the intercepts that extend from ca. A.D. 1800 to the present. Again applying the procedure of choosing the single, highest probability intercept for each date, we can convert the somewhat "messy" plot in Figure 183 to a histogram of date distribution by 100-year intervals, as in Figure 184.

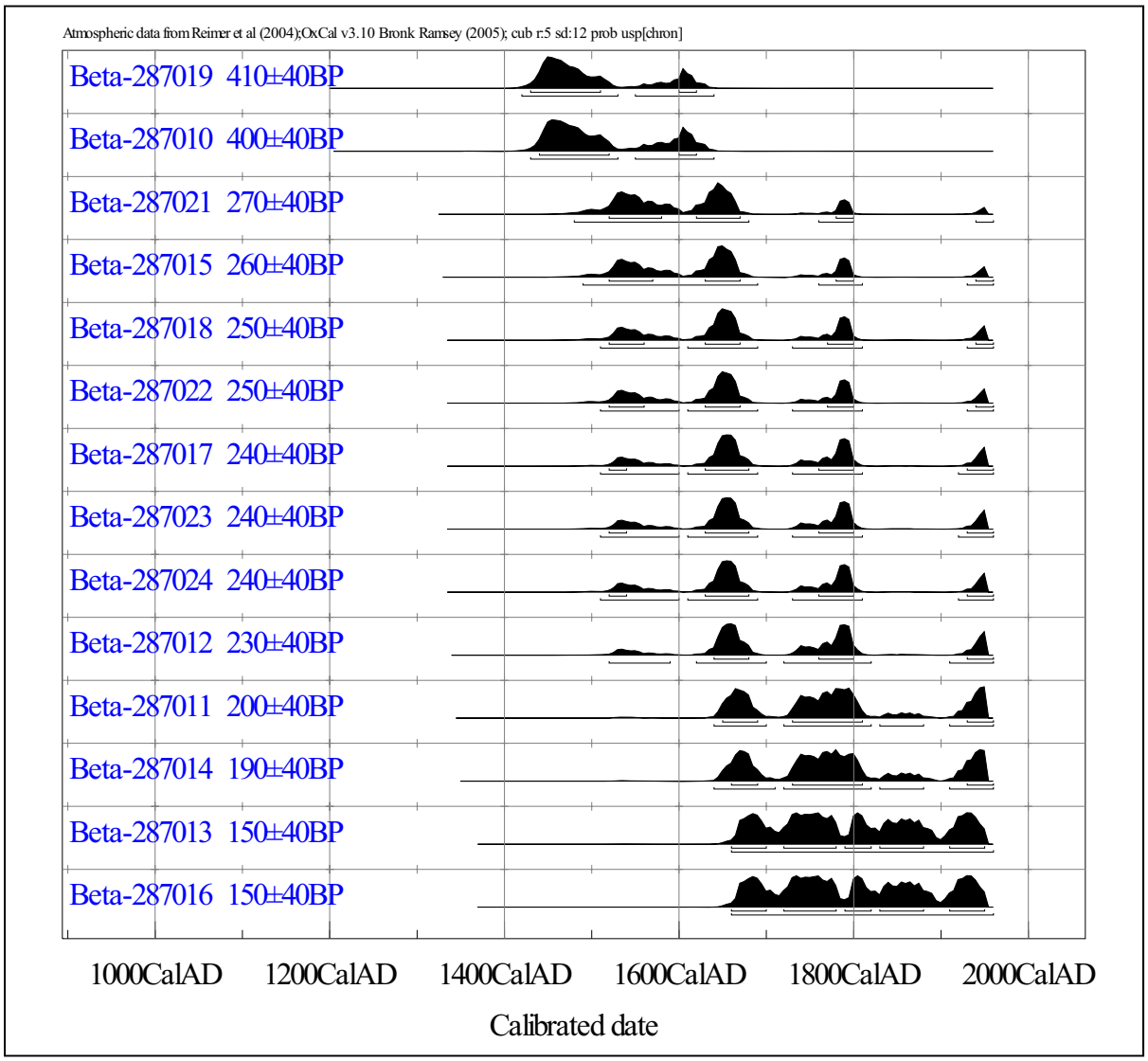


Figure 183. Oxcal generated chart of the 14 dates from Auwahi by this project. The black histograms for each date are probability distributions indicating the likelihood that the radiocarbon age corresponds to a particular calendar year. As can be seen, "dates" have multiple probability intercepts.

Figure 184 exhibits a temporal distribution that is similar in certain respects to the larger Kahikinui regional sample (Figure 182), but also differs in a possibly significant respect. As with the rest of the district, it is evident that Auwahi *ahupua'a* did not begin to see permanent human occupation and land use until the 15th century A.D., that is the beginning of the Late Expansion Period. The slight differences between A.D. 1400-1499 and 1500-1599 are probably not significant, and most likely reflect sample size issues. However, the large increase in number of dates in the interval from A.D. 1600-1699 is noteworthy, and must be interpreted as a major

increase in the intensity of land use and population. Moreover, this increase occurs earlier in Auwahi (17th century) than in the rest of the *moku* (18th century). Indeed, the Auwahi plot shows a decrease in the frequency of dates in the period from A.D. 1700-1799. We need to be cautious in our interpretation of these trends, because admittedly the Auwahi sample size is still small, and limited to just a part of the entire *ahupua'a*. Further dates, and dates from the *mauka* areas inland of the highway, might alter these trends.

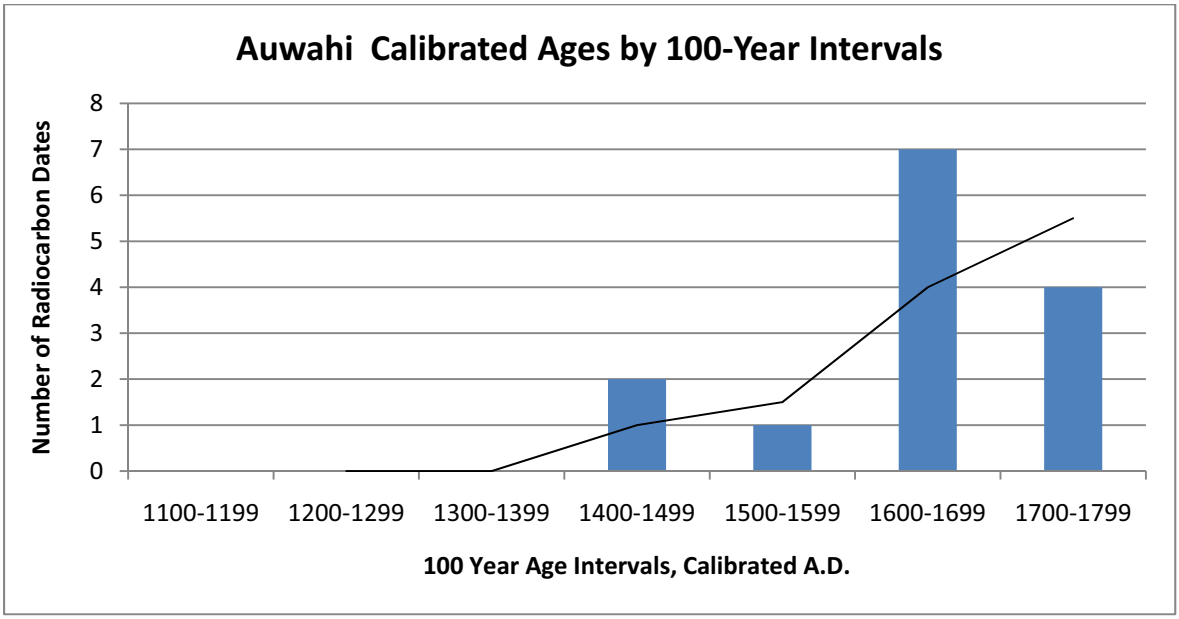


Figure 184. Histogram plot of 14 radiocarbon dates from Auwahi archaeological sites. Dates have been plotted based on their highest probability intercepts. The trend line is a 2-period moving average.

Nonetheless, there are reasons to think that a slightly earlier period of intensification of occupation and land use may have occurred in Auwahi, as opposed to other *ahupua'a* of the district. The geology and soils of Auwahi are among the best suited in all of Kahikinui for Hawaiian dryland farming, being relatively young and hence nutrient-rich, but not so young as to be too rocky for cultivation (as is the case with most of Alena *ahupua'a*). Auwahi also enjoys by far the best canoe landing, and better access to shoreline and marine resources than areas farther to the east. For these reasons, a slightly earlier build up in population within Auwahi would be understandable.

Figure 185 plots all of the available radiocarbon dates for Kahikinui, including the 16 new samples from this project, distributed by *ahupua'a* unit and across the 100-year temporal units. In this chart, the relatively low frequency of Auwahi dates in the period from A.D. 1500-1599, as compared with the trends for Kīpapa and Nakaohu, is noteworthy. If our hypothesis that environmental conditions in Auwahi were conducive to earlier settlement is correct, we would expect more dates in this interval. Again, however, this may simply be a matter of sample size, and of the fact that to date our samples are concentrated in the lower elevation zones. It is also worth noting that the pattern for Manawainui—at the opposite, eastern end of the district from

Auwahi—does not exhibit any significant evidence for human occupation until the final century prior to contact. Just as Auwahi may have been one of the most inviting parts of Kahikinui for settlement, Manawainui was probably the most challenging, due to its older and more nutrient-leached soils, and to its very low annual rainfall (Kirch et al. 2004; Holm 2006).

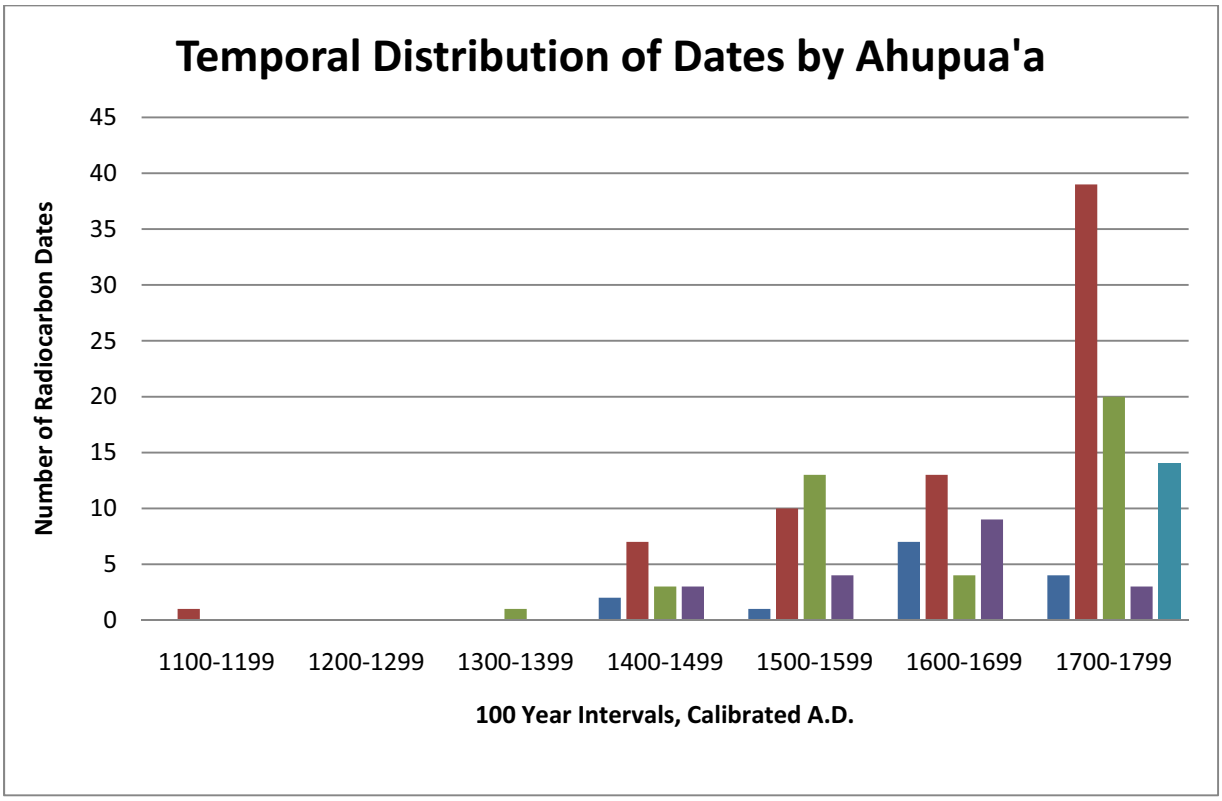


Figure 185. The temporal distribution by 100-year age intervals of radiocarbon dates from five *ahupua'a* of Kahikinui (Auwahi, Kīpapa, Nakaohu, Mahamenui, and Mahawainui from left to right).

9.5 Settlement Patterns, Population Density and Distribution

Having compared the broad temporal patterns of site distribution in Auwahi with those across the Kahikinui District, we now turn to a similar comparison of spatial patterns. In the most general sense, the entire Kahikinui region consists of lava flow slopes forming the southeastern flank of Haleakalā volcano. When one begins to examine the landscape more closely, however, significant differences are apparent. The eastern half of Kahikinui from Mahamenui to Manawainui is considerable older in geological terms, with the slopes consisting of lava flows from the shield-building stage, known as the Kula Volcanic Series. Being fairly old, these surfaces have more deeply weathered soils, and are dissected by intermittent stream gullies and gulches. The last of the Kula series flows was dated by Kirch et al. (2004) to about 226,000 years ago. One flow in the eastern part of the district is, however, an exception: the Pu'u Pane substrate which emanates from the flanking cinder cone of that name and dates to about 96,000

years ago. In contrast, the western half of the district, including Auwahi, is made up primarily of lava flows which have emanated from the volcano's southwestern rift zone, as a part of a more recent rejuvenation stage, known as the Hana Volcanic Series (Stearns and MacDonald 1942; Sherrod et al. 2007). These substrates range in age from as old as 130,000 years, to as young as 5,000 years. The very young flows, especially that which dominates Alena *ahupua'a*, consist almost entirely of *'a'ā* lava, and were not amenable to cultivation. But a considerable expanse of lavas between about 10-50,000 years old provided substrates highly suited to the cultivation of dryland crops, especially sweet potato. The greatest concentration of such ideal-age lava substrates are in Auwahi and Kīpapa-Nakaohu. The broad spatial patterns of the Kula and Hana Volcanic Series flows across Kahikinui are illustrated in Figure 186.

Over the past 15 years, large segments of Kahikinui District have been archaeologically surveyed, primarily by the U. C. Berkeley Oceanic Archaeology Laboratory, and by the State Historic Preservation Division (Kirch, ed., 1997; Dixon et al. 2000). Figure 187 shows the principal areas of intensive survey and the approximate area in square kilometers covered for each survey block. Colored dots indicate individual archaeological features. The most extensive single area covered by intensive survey to date is that of Kīpapa-Nakaohu, for which the U. C. Berkeley team under Kirch's direction has now obtained data on more than 3,000 individual features over a 12.8 km^2 area. The Mahamenui and Manawainui area surveys are reported on in detail by Holm (2006). The Kīpapa-Nakaohu area consists of substrates of younger Hana Series lavas, and thus is most similar to the landscape of Auwahi. The Mahamenui survey area was concentrated primarily on the 96,000 year old Pu'u Pane flow, while the Manawainui area lies on the older Kula Volcanic Series flow slopes. Because of these fundamental differences in their underlying substrates—and the implications for intensive agriculture—the settlement patterns in Mahamenui and Manawainui are predicted to show the greatest contrasts with Auwahi. Likewise, the settlement patterns of the Kīpapa-Nakaohu area which has substrates very similar in age to those of Auwahi, should present settlement and land use patterns similar to the latter. Auwahi also has a peculiar geomorphological characteristic, the presence of the large cinder cone of Pu'u Hōkū Kano, which clearly would disrupt the distribution of human land use and occupation features. The presence of this geological feature needs to be kept in mind when any comparisons are made between these areas.

Figure 188 displays an analysis of settlement density by elevation above sea level, for the three main survey zones of Kīpapa-Nakaohu, Mahamenui, and Manwainui. As can be seen both in the distribution map of features, and in the summary histograms which plot site density by elevational zones (the insets), in all cases there is a high density of features immediately along the coastline. This undoubtedly reflects the importance of exploitation of coastal resources, but most of these features upon close investigation and excavation proved to be only for temporary or intermittent use. Moving inland from the coast, there is a zone with relatively low feature density. Then between about 100-200 meters above sea level, sites begin to appear in increasing numbers, and then reach their peak density between about 400 and 800 masl. Above 800 masl, site density drops off rapidly and falls to essentially zero at about 1000 masl.

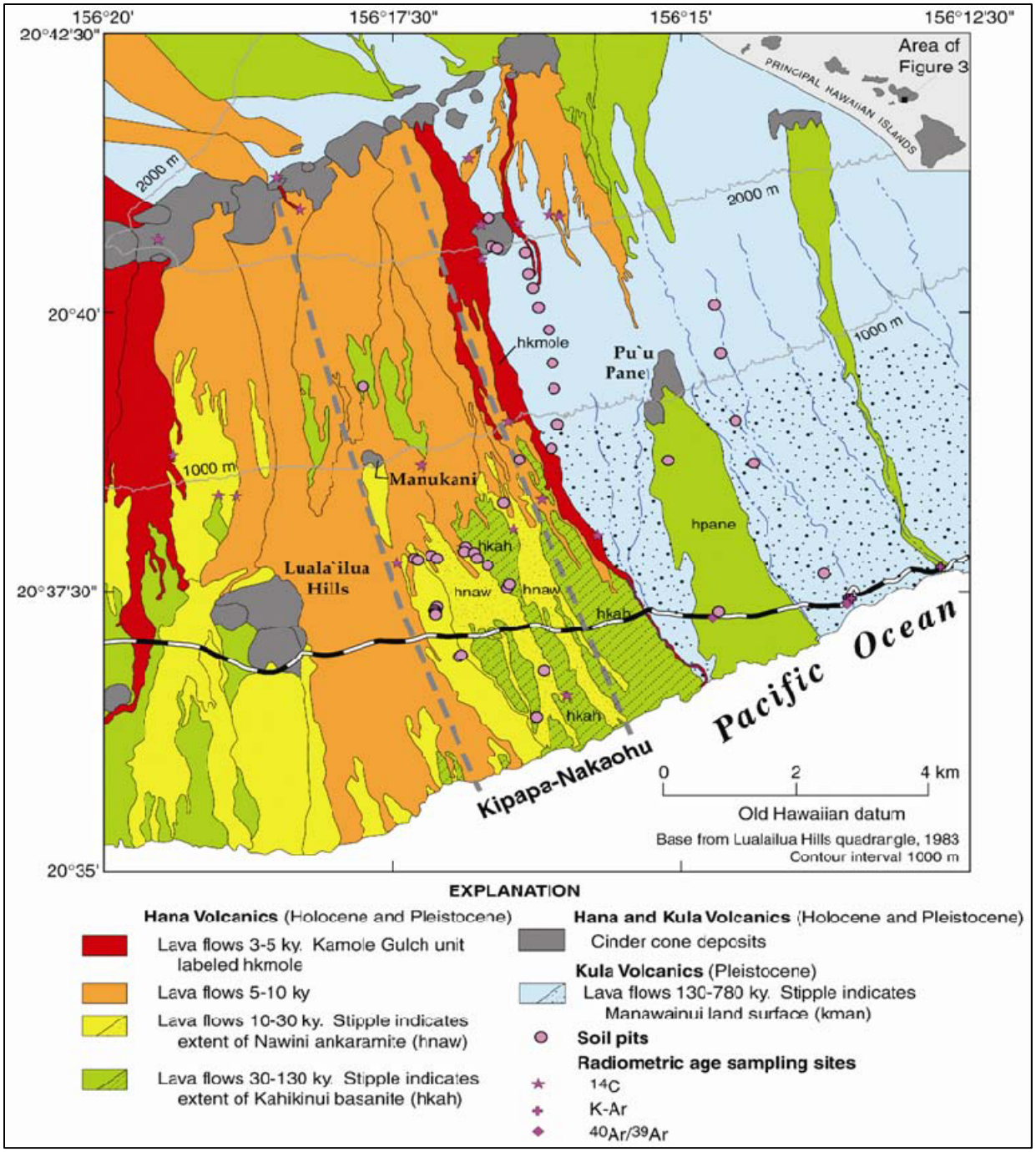


Figure 186. Simplified geologic map of the Kahikinui District showing the distribution of substrates according to age categories (from Kirch et al. 2004). The older Kula Volcanic Series is shown in blue. The orange colored areas are of very young lava flows not amenable to cultivation. Areas shaded green and yellow have substrates with ages best suited to intensive cultivation.

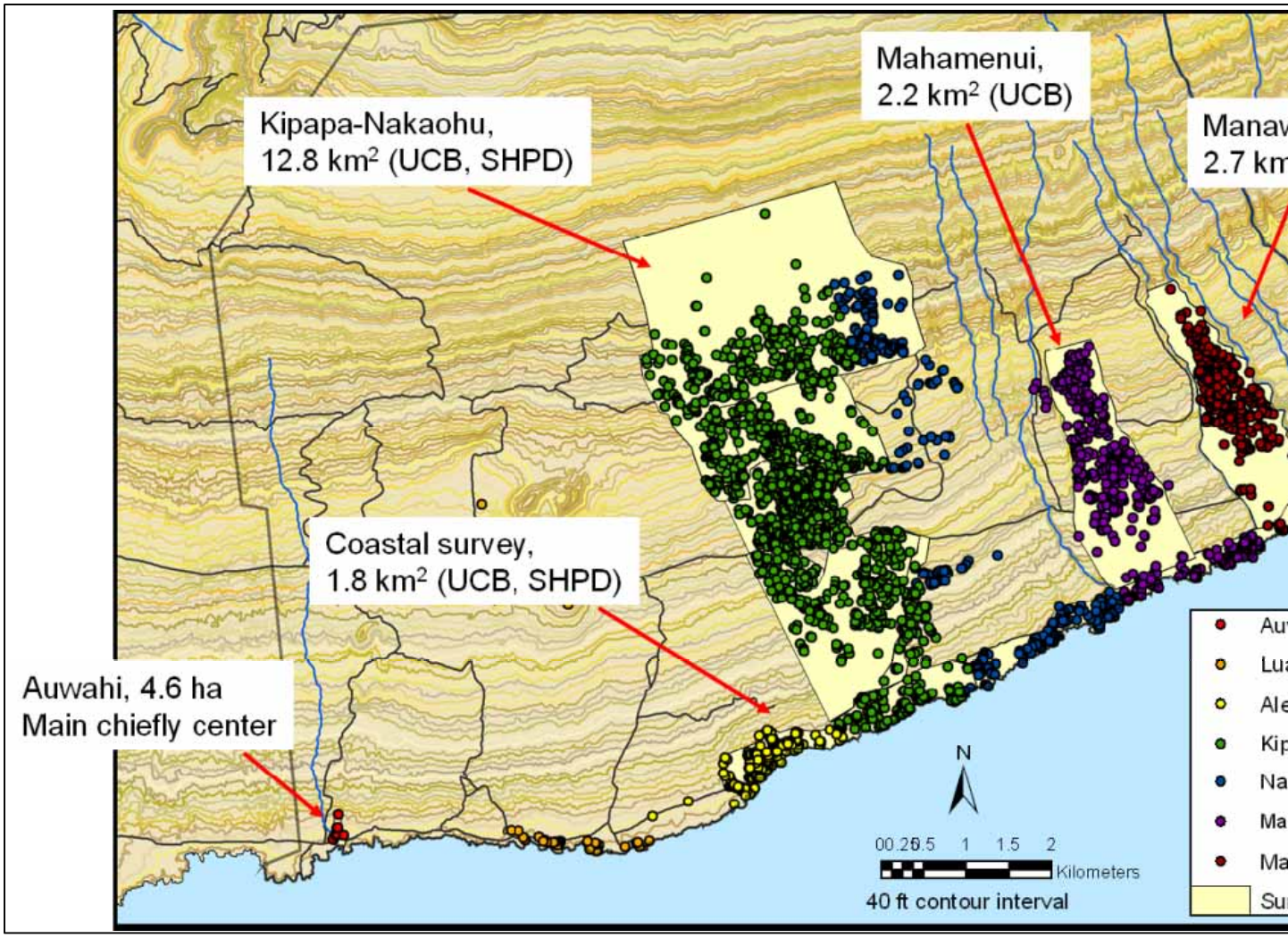


Figure 187. Major zones of archaeological survey in Kahikinui District. (Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

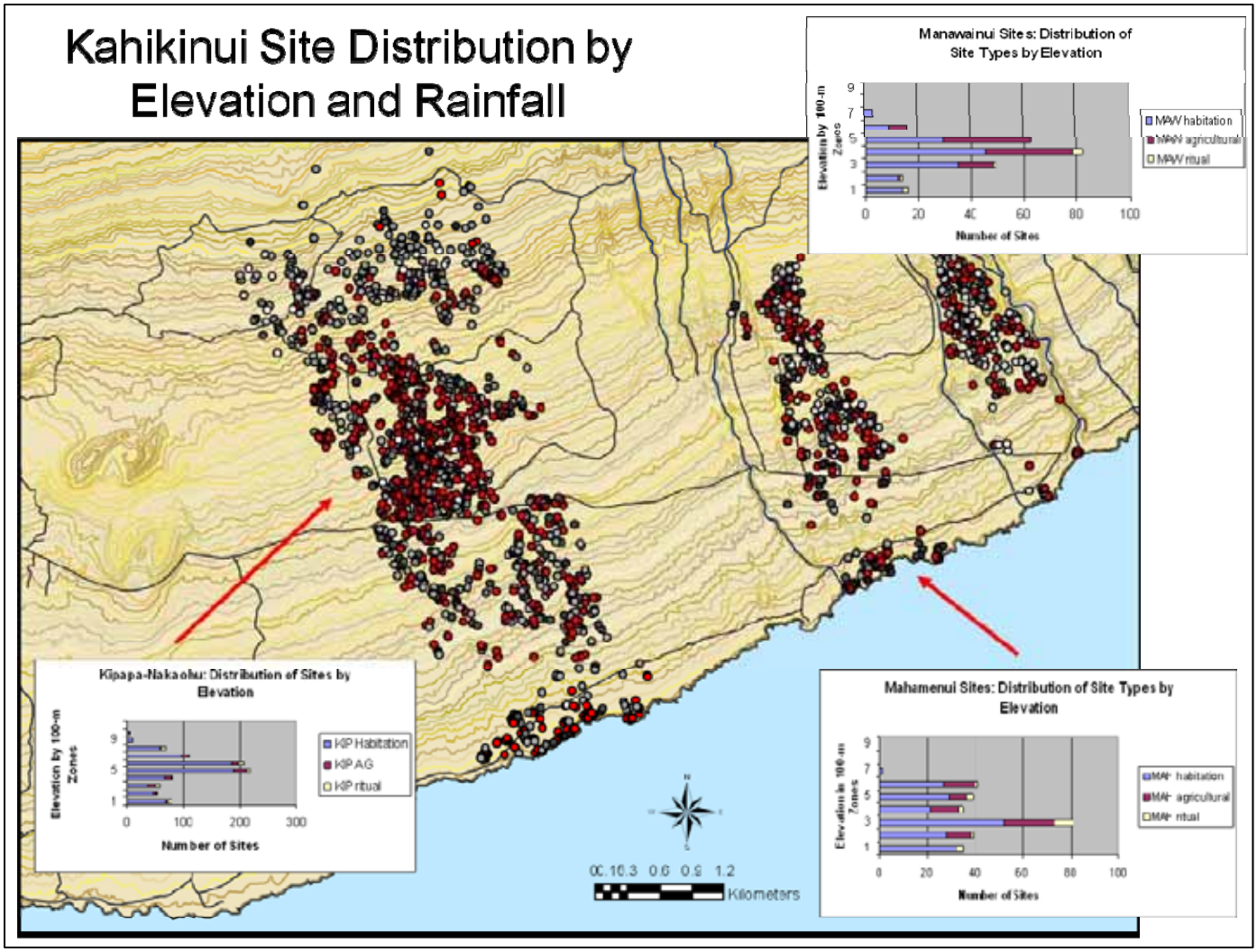


Figure 188. Spatial distribution of archaeological features in Kīpapa-Nakaohu, Mahamenui, and Manawainui. Inset charts show the frequency of feature categories by elevation. Rainfall increases as function of elevation. Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.

Elevation is a key variable in settlement distribution in Kahikinui because it is a proxy for rainfall. Elevation per se was not the key controlling variable in site distribution, but rather the amount of annual rainfall which was correlated with elevation, and which was essential for the dryland cropping of sweet potato and other cultigens. The correlation between elevation and rainfall in Kahikinui is depicted in Figure 189. Rainfall along the coast is roughly 400 mm or less per year, which is well below the annual minimum of about 750 mm needed for sweet potato cultivation (Purseglove 1968:82). By about 400 masl elevation, however, rainfall rises to around 750 mm, and continues to climb up to a maximum of around 800-1000 mm. It is in this zone from roughly 750 to 1000 mm of annual rainfall that the ancient Hawaiian farmers were able to produce annual crops of sweet potato and other dryland cultigens, which made life on these arid slopes possible.

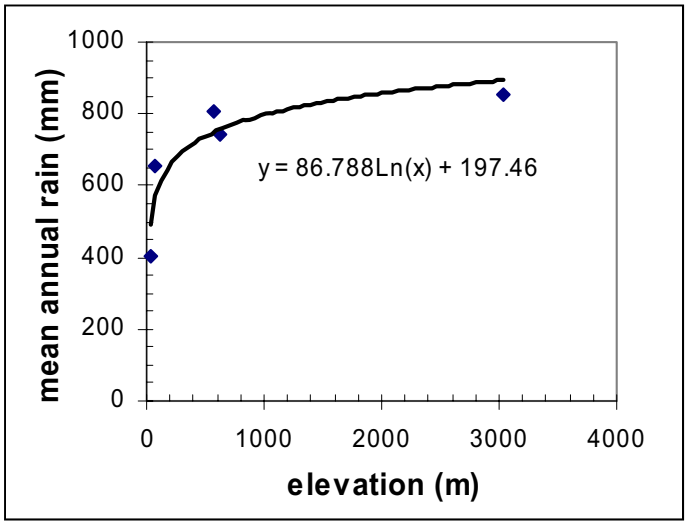


Figure 189. Kahikinui rainfall as a function of elevation.

The survey data generated by our current project can be compared with these district-wide patterns, to test whether or not Auwahi conforms to the same general settlement pattern, or shows unique characteristics. It must be kept in mind that the present survey was limited to the areas within the boundaries of the proposed wind farm. Consequently, our survey area excludes both the lowest elevation areas, adjacent to the coast, and those parts of the *ahupuaʻa* at elevations higher than about 400 meters (*mauka* of the highway). However, the present survey provides an excellent picture of settlement patterns in the elevational range from 100 to 400 masl.

The settlement patterns and site distribution and density within the areas covered by our project conform generally to expectations based on prior survey work in Kīpapa-Nakaohu, Mahamenui, and Manawainui. The density of features, especially those associated with permanent habitation and cultivation, show a significant drop off below about 250 masl. However, Auwahi's high site density extends lower toward the coastal zone than in other areas such as Kīpapa-Nakaohu. This could in part be a function of a slightly higher annual rainfall in Auwahi (which is closer to southwestern rift of Haleakalā and may therefore receive rainfall

from cloud cover extending over this flank of the mountain. Unfortunately the available rainfall records are too spotty to test this hypothesis. The lower elevational extent of permanent habitations in Auwahi may also reflect local practices of surface water concentration and management in the small gulches and gullies that descend below Pu‘u Hōkū Kano, a point we will discuss further below. Whatever the explanation, Auwahi does seem to have an unusually high density of habitation and cultivation features, matching the highest densities in Kīpapa-Nakaohu, and certainly higher than in Manawainui to the east. This again highlights the importance of the *ahupua‘a* of Auwahi within the overall Kahikinui District settlement pattern.

The overall patterns of settlement distribution within the areas of Auwahi that we have surveyed also show close similarities to patterns in the Kīpapa-Nakaohu area, as expected. These include the use of *‘a‘ā* ridge lines for habitation clusters (small groups of residential terraces, enclosures, C- and U-shapes, and so forth), with intervening low swales and flats evidently being used for cultivation. The same pattern of *kauhale* clusters previously noted for Kīpapa-Nakaohu (Van Gilder and Kirch 1997; Van Gilder 2005) is replicated in Auwahi, demonstrating a consistency in residential architecture throughout the *moku* of Kahikinui.

9.6 Agricultural Systems and Water Control

The pioneering ethnographer of Hawaiian agricultural practices, Edward S. C. Handy, called the southeastern flanks of Haleakalā, from Kaupō to Honua‘ula, “the greatest continuous dry planting area in the Hawaiian Islands” (1940:161). In spite of its considerable aridity, Kahikinui and the adjacent districts to Kaupō to the east and Honua‘ula to the west collectively comprised a major zone of rain-fed, non-irrigated cultivation, primarily of sweet potatoes, but also of yams, dryland taro, and secondary crops (e.g., paper mulberry and *ti*). Our investigations in Auwahi have expanded our understanding of the range of agricultural practices used by the pre-Contact Hawaiians in this marginal environment. In addition, our survey has revealed a previously unrecognized degree of micro-environmental management of small, ephemeral watercourses and drainage channels across the Auwahi landscape. In part, this heightened awareness of landscape features which are often topographically low and subtle is a consequence of the extreme drought conditions in Auwahi in 2010, which made surface visibility extraordinarily clear. Many of the agronomic and water control features that we identified in our survey might have been missed under normal levels of vegetation cover; indeed, many features were not observed in the prior 2007 survey of the same area. This is not a critique of the previous archaeological survey team, which was well trained and experienced in Hawaiian archaeology. It is simply a statement of the reality of survey work when the terrain is obscured by thick invasive vegetation (dominated by such plants as lantana, *koa haole*, and the nearly impenetrable *Glycine* vine). Having the advantage of virtually no obscuring vegetation cover in 2010, as a result of several years of continuous drought, visibility rose to levels that otherwise are only matched after a wildfire (see Holm and Kirch 2007).

Kirch (2010b) has synthesized the characteristics of pre-Contact Hawaiian agriculture across the Kahikinui landscape, based on 15 years of investigations by the U. C. Berkeley team, and since 2000 by the collaborative Hawai‘i Biocomplexity Project (see also Coil 2004; Coil and Kirch 2005; Hartshorn et al. 2006; Holm 2006; Kirch et al. 2005). In contrast with other leeward slope

environments such as Kohala and Kona on Hawai‘i Island, which are dominated by vast “field systems” consisting of reticulate grids of field embankments, walls, and trails (Kirch 1985; Vitousek et al. 2004; Kirch 2010a), the Kahikinui agricultural landscape was in general less formally organized. Adapting their horticultural practices to the highly varied landscape mosaic of young lava flows—an especially “patchy” kind of environment—the ancient Hawaiian farmers in Kahikinui did not attempt to impose a formal grid system of field plots across the entire landscape. Rather, they adapted their agriculture to the microenvironmental habitats of lava ridges and intervening swales or depressions, favoring the ridges for habitation (and some kinds of cultivation involving mounds, perhaps for gourds or other crops), and reserving the swales for cultivation. These swales are natural features of the ‘*a*‘*ā* topography, formed on the surface of the massive lava flows (Figure 190). They range considerably in area and depth, but are often 50-100 m in length. These natural depressions act as sediment traps, gradually accumulating both wind-blown fine particles as well as materials washed off the adjacent slopes during heavy rains. The swale floors thus build up organically enriched deposits which may be up to 1 m or more in depth, and provide ideal soil media for cultivation.

Figure 190. A medium sized natural swale in the ‘*a*‘*ā* lava topography of Auwahi, below Pu‘u Hōkū Kano. This swale has a level soil surface and artificially constructed walls around its perimeter. It is typical of swales throughout Kahikinui used for intensive cultivation. (Photo by P. V. Kirch, 2007.)

This swale mode of cultivation, previously shown to be the dominant pattern across Kahikinui, is especially well reflected in the survey data from Auwahi. However, the new Auwahi data from this project also revealed an unexpected example of the formal, reticulate field system kind of cultivation not previously documented from Kahikinui, but known primarily from Hawai‘i Island. Recently, such a formal field system was identified by Kirch et al. (2010) in the

Kaupō district to the east of Kahikinui, the first time that this kind of agricultural system had been reported for Maui Island. As can be seen in Figure 191, the Kaupō field system consists of a tightly packed grid of field embankments running along the contours, with cross-cutting walls running up-and-down slope (*mauka-makai*) at fairly regular intervals. The closely spaced field embankments (averaging about 8-9 m between them) are interpreted as delineating individual farming plot boundaries, while the longer walls are probably territorial boundaries (perhaps ʻ*ili* units in the traditional Hawaiian land system).

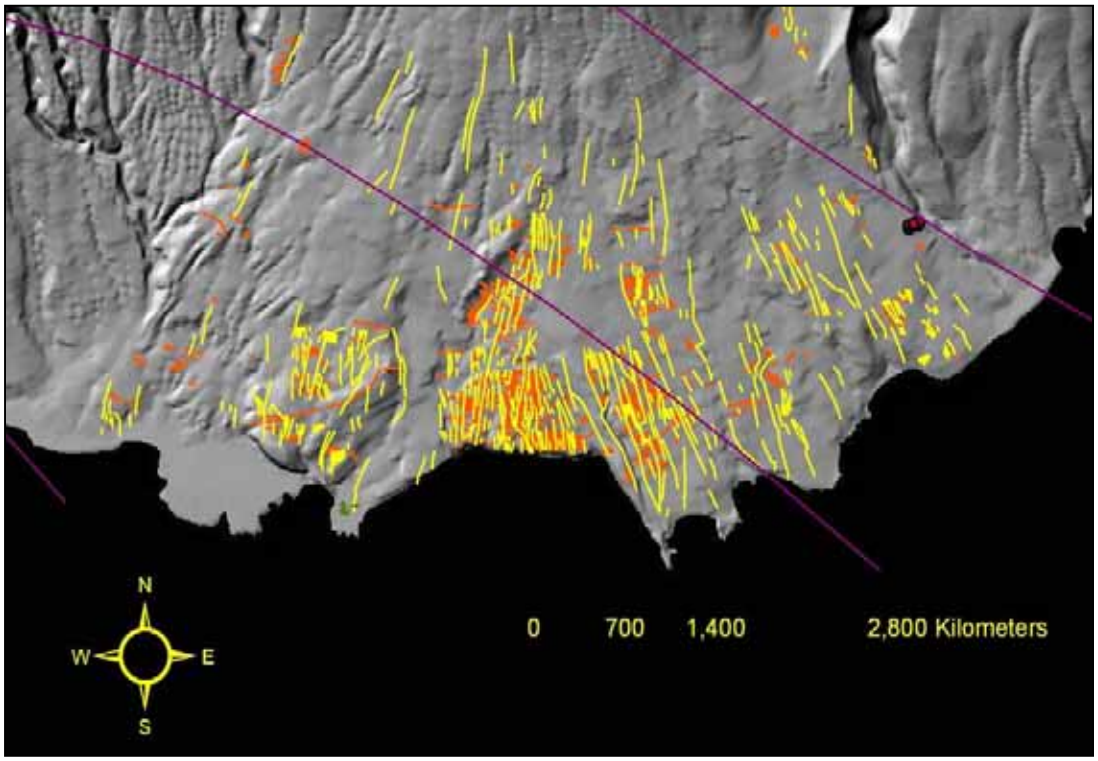


Figure 191. Map of a portion of the Kaupō Field System, based on aerial photo analysis of field embankment and wall patterns. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

The discovery of the Site 50-50-15-6910 complex of features on the fringes of the large sedimentary basin that lies inland of Puʻu Hōkū Kano is the first archaeological record of such a formal field system in the Kahikinui region. It appears that prior to historic period disturbance, especially from intensive cattle grazing in the area, this field system probably covered the entire extent of this sedimentary basin, a rich accumulation of alluvium that was washed into the sediment trap created by the 30-50,000 year old Puʻu Hōkū Kano cinder cone. From our mapping of the remnant parts of this field system, it had a structure much like that recorded for the Kaupō field system. That is, field embankments were regularly spaced about 9-11 meters apart, with intervening low walls or bunds that subdivided the system into sets of plots, probably some kind of social or land tenure division. The existence of the 6910 complex shows that—when local environmental conditions were favorable—the Hawaiian land managers preferred to lay out the agricultural landscape in this kind of reticulate grid. Such a formal grid

system was presumably the material reflection of the highly developed and hierarchical Hawaiian system of land tenure, with its nested units beginning with the *moku*, down through the *ahupua'a*, to the *'ili*, and extending to the smallest cultivated parcels such as the *mo'o* and *paukū*.

Equally important as the discovery of a formalized field system was the realization during the course of our field studies that the ancient Hawaiians who made a living on the lava flows of Auwahi had practiced a variety of sophisticated water control practices.[3] The importance of water in such an arid landscape as Kahikinui hardly needs to be stressed. Stock et al. (2003) discuss the paleohydrology of Kahikinui, determining that the small drainage channels present on the younger Hāna Volcanic Series lava flows (as in Kīpapa-Nakaohu, and also in Auwahi) show no evidence of having had permanent flow in the past. Rather, these channels have been carved by intermittent flooding at times of seasonal *kona* (winter) storms. Stock et al. (2003) also argue that in pre-Contact times the heavier forest cover that was present on the upper Kahikinui slopes would have resulted in considerably higher "fog drip" precipitation. This likely resulted in a higher water table than is present today, and better water-holding capacity of the landscape during periods of rainfall.

Virtually every drainage channel examined during our archaeological survey of Auwahi exhibits artificial manipulation and rearrangement. Typical features include cross-channel stone barrages, walling along channel sides, and stone-filled terraces within channel bottoms. Some of these features, such as the cross-channel barrage terraces, may have been intended for soil capture and actual crop planting. Other features, however, appear designed to slow down water flow, causing the intermittent channel flows to percolate into the adjacent porous lava. In some cases we noted shallow diversion channels that would have fed some water flow out of channels and into adjacent natural basins or swales; these latter could then have been planted.

9.7 THE RITUAL LANDSCAPE

Paralleling the traditional Hawaiian land system with its hierarchically nested land units was a complex hierarchy of temples (*heiau*) distributed across the landscape. Indeed, the Hawaiian land use system and the economy were controlled through the system of temples, with various cults and rites organized on a seasonal basis (Valeri 1985; Kirch 2010a:55-66). At the top of this hierarchy were the *luakini* or state temples where the king and his high priest (*kahuna nui*) offered human sacrifices to the war god Kū. The king also had his own Hale o Lono, or temple dedicated to Lono, god of thunder, rain, the sweet potato and dryland cultivation. It was from this Lono temple that the annual Makahiki procession went forth each year to collect the *ho'okupu* or tribute from each *ahupua'a* territory. Major state temples associated with the famous Maui king Kekaulike are known in the adjacent district of Kaupō (Kirch et al. 2009). Below this

[3] We would be remiss here not to acknowledge the interest taken by Mr. Sumner Erdman of 'Ulupalakua Ranch in this aspect of Auwahi archaeology. Observing various water control features on the ground, Mr. Erdman brought these to our attention, and continually pushed us to think about the implications of an "archaeology of hydrology." We appreciate his keen interest in this aspect of Auwahi's history.

topmost level in the temple system were a variety of *heiau* associated with the *ahupuaʻa* chiefs, falling into a general category of *heiau hoʻoʻuluʻai*, or "temples to increase food." There were separate *heiau* for the rites of Lono and of Kāne (the latter being the deity of flowing water and of taro). At an even lower level in this hierarchical system were small *heiau* contained within (or perhaps attached to in some cases), the *mua* or men's eating houses of the commoner population. Based on settlement pattern data from the Kīpapa-Nakaohu area, it is possible that several individual households in a neighborhood may have shared such a common *mua*. A fourth distinct category of temples consisted of *koʻa* or fishing shrines, dedicated to Kūʻula, god of fishermen, and usually located along the coast.

Previous archaeological investigations in Kahikinui have identified more than 40 structures that are interpreted as *heiau* (Figure 192). Only a single *heiau*, Kōholuapapa situated to the west of the Lualaʻilua Hills and close to the present boundary between Auwahi and the Hawaiian Home Lands, was reputedly a *luakini* type temple. This, however, is considerably smaller than the great state temples of Loʻaloʻa and Kānehemomalo in Kaupō associated with king Kekaulike. If it was indeed used as a *luakini*, Kōholuapapa was probably officiated at by the king while making a tour of his various *moku*, rather than as a regular state temple. One other large temple (KIP-1010), with no known Hawaiian name, lies in the uplands of Nakaohu, and may have been the principal agricultural temple for the central part of Kahikinui. Most of the temples identified to date are smaller than Kōholuapapa or KIP-1010, and would fall into the categories of *heiau hoʻoʻuluʻai* or of *heiau* within men's houses. In addition, a number of fishing shrines have been identified along the Kahikinui coastline. Kirch (2004) analyzed the temple sites of Kahikinui, demonstrating that their orientations fall into three discrete clusters: East, Northeast, and North. He argues that these clusters were associated with the cults of Kāne (East), Lono (Northeast), and Kū (North).

The Auwahi survey has added five more examples of *heiau* to the Kahikinui corpus. All of these are relatively small structures that were presumably *heiau hoʻoʻuluʻai*, or agricultural temples. They are all of the structural form known as "notched" *heiau* due to their six-sided plans. As with previously recorded *heiau* in Kahikinui, these five structures also fall within the specific orientation clusters noted earlier. Site 50-50-15-6908, for example, is situated on the eastern slope of a lava ridge so as to command an uninterrupted view towards the Lualaʻilua Hills. Not only are the walls of this temple themselves on a perfect E-W/N-S alignment, but from this temple one would have been able to observe (and to track, using the topographic features of the cinder cones in the distance), both the equinox and solstice risings of the sun, as well as the rising of Pleiades (important for setting the yearly calendar and timing of the Makahiki). Two other temples (Sites 50-50-15-6825 and 50-50-15-6840A) were constructed so that their axes are oriented toward the north, which is the high summit of Haleakalā. In particular, both structures seem to be oriented to a major reddish-colored cinder cone high on the mountain's rim. Red is the sacred color in Hawaiʻi and Polynesia generally, and the prominence of this red volcanic cone may have had particular significance to the Hawaiians who lived in Kahikinui. Kirch has previously identified other temples in Kīpapa-Nakaohu that are oriented to this same cinder cone.

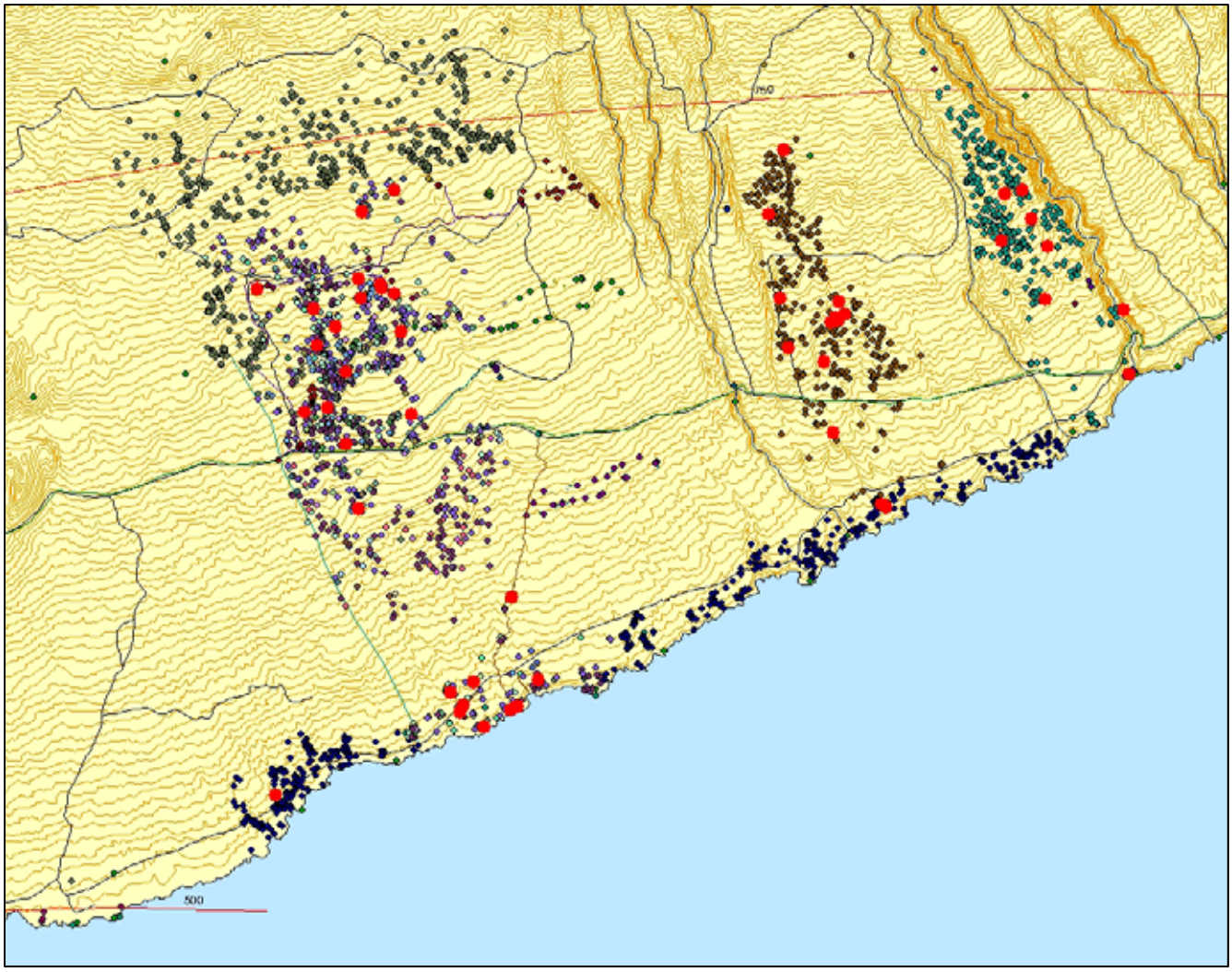


Figure 192. Map of the Kīpapa-Nakaohu to Manawainui section of Kahikinui District, with archaeological sites (individual dots) and the distribution of mapped *heiau* (red dots). (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

10.0 BIBLIOGRAPHY

Anonymous
1963 Historic Site Recognized: Santa Ynez Shrine at ʻUlupalakua [*sic*], Blessed. *The Maui News*, February 13 (p. 14).

Apple, Russell A.,
1965 *Hawaiian Archaeology: Trails*. Bernice P. Bishop Museum Special Publication No. 53. Honolulu.

Ashdown, Inez
1973 Story of Santa Ynez Shrine. Manuscript on file, SHPD - Maui Annex, Wailuku.

Baldwin, E. D.
Ms Personal Recollections of my Life, Written for the Benefit of my Children. Typescript copy of portions relating to Kahikinui, made by E. S. Sterling; copy in P. S. Chapman papers.

Bartholomew, G.
1994 *Maui Remembers: A Local History*. Mutual Publishing, Honolulu.

Beckwith, Martha
1970 *Hawaiian Mythology*. Honolulu: University of Hawaiʻi Press.

Chapman, P. S. and P. V. Kirch
1979 *Archaeological Excavations at Seven Sites, Southeast Maui, Hawaiian Islands*. Report 79-1, Department of Anthropology, B. P. Bishop Museum. Honolulu.

Cheever, Rev. Henry T.
1851 *Life in the Sandwich Islands: Or, The Heart of the Pacific, as It Is and Was*. London: Richard Bentley.

Chinen, J. J.
1958 *The Great Mahele: Hawaii's Land Division of 1848*. Honolulu: University of Hawaiʻi Press.

Coil, J. H.
2004 "The Beauty that Was": Archaeological Investigations of Ancient Hawaiian Agriculture and Environmental Change in Kahikinui, Maui. Ph.D. Dissertation, University of California, Berkeley.

Coil, J. and P. V. Kirch
2005 An Ipomoean landscape: Archaeology and the sweet potato in Kahikinui, Maui, Hawaiian Islands. In C. Ballard, P. Brown, R. M. Bourke, and T. Harwood, eds., *The Sweet Potato in the Pacific: A Reappraisal*, pp. 71-84. Oceania Monograph 56 and Ethnology Monograph 19. Sydney and Pittsburgh.

Commissioner of Public Lands, Territory of Hawai‘i
1929 *Indices of Awards Made by The Board of Commissioners to Quiet Land Titles in the Hawaiian Islands*. Honolulu: Territorial Office Building.

Coulter, John Wesley
1931 *Population and Utilization of Land and Sea in Hawai‘i, 1853*. Bernice P. Bishop Museum Bulletin 88. Honolulu.

Daws, Gavan
1968 *Shoal of Time: A History of the Hawaiian Islands*. New York: Macmillan.

Dixon, B., P. J. Conte, V. Nagahara, W. K. Hodgins
2000 Kahikinui Mauka: Archaeological Research in the Lowland Dry Forest of Leeward East Maui. Report Prepared for Department of Hawaiian Home Lands. Honolulu: Historic Preservation Division, Department of Land and Natural Resources, State of Hawai‘i.

Dunmore, J., ed.
1994 *The Journal of Jean-François de Galaup de la Pérouse 1785-1788*. Hakluyt Society, Second Series No. 179. London: The Hakluyt Society.

Dye, T. S. and J. Pantaleo
2010 Age of the O18 site, Hawai‘i. *Archaeology in Oceania* 45:113-119.

Erkelens, C.
1995 Phase I Archaeological Investigation, Cultural Resources Survey, Hawai‘i Geothermal Project, Makawao and Hāna Districts, South Shore of Maui, Hawai‘i. Prepared for Oak Ridge National Laboratory. Honolulu: International Archaeological Research Institute, Inc.

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 in cooperation with the University of Hawai‘i Agricultural Experiment Station. Washington D. C.

Hammatt, H. H. and W. Folk
1994 Archaeological Reconnaissance of an 8,300-Acre Project Area, Kahikinui, Maui, TMK 1-9-01:3. Prepared for R. M. Towill Corporation. Honolulu: Cultural Surveys Hawai‘i.

Handy, E. S. Craighill
1940 *The Hawaiian Planter. Volume I, His Plants, Methods and Areas of Cultivation*. Bernice P. Bishop Museum Bulletin 161. Honolulu.

Hartshorn, A. S., O. A. Chadwick, P. M. Vitousek, and P. V. Kirch
2006 Prehistoric agricultural depletion of soil nutrients in Hawai‘i. *Proceedings of the National Academy of Sciences* 103:11092-11097.

Hiroa, Te Rangi (P. H. Buck)
1945 *An Introduction to Polynesian Anthropology*. B. P. Bishop Museum Bulletin 187. Honolulu.

Holm, L. A.
2006 *The Archaeology and the ‘Āina of Mahamenui and Manawainui, Kahikinui, Maui Island.* Ph.D. Dissertation, University of California, Berkeley.

Holm, L. A. and P. V. Kirch
2007 Up in smoke: Assumptions of survey visibility and site recovery. *Hawaiian Archaeology* 11:83-100.

Jones, S. and P. V. Kirch
2007 Indigenous Hawaiian fishing practices in Kahikinui, Maui: A zooarchaeological approach. *Hawaiian Archaeology* 11:39-53.

Kamakau, Samuel
1961 *Ruling Chiefs of Hawai‘i*. Second edition. Kamehameha Schools Press, Honolulu.

1976 *The Works of the People of Old: Nā Hana a ka Po‘e Kāhiko*. Bernice P. Bishop Museum Special Publication No. 61. Honolulu.

1991 *Tales and Traditions of the People of Old. Nā Mo‘olelo a ka Po‘e Kāhiko*. Honolulu: Bishop Museum Press.

Kirch, Patrick Vinton
1985 *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory*. Honolulu: University of Hawai‘i Press.

Kirch, P. V. (ed.)
1997 *Nā Mea Kāhiko o Kahikinui: Studies in the Archaeology of Kahikinui, Maui, Hawaiian Islands*. Oceanic Archaeological Laboratory, Special Publication No. 1. Berkeley: Archaeological Research Facility.

Kirch, Patrick Vinton
2004 Temple sites in Kahikinui, Maui, Hawaiian Islands: Their orientations decoded. *Antiquity* 78:102-114.

2007 Paleodemography in Kahikinui, Maui: An archaeological approach. In P. V. Kirch and J.-L. Rallu, eds., *The Growth and Collapse of Pacific Island Societies: Archaeological and Demographic Perspectives*, pp. 90-107. Honolulu: University of Hawai‘i Press.

2010a *How Chiefs Became Kings: Divine Kingship and the Rise of Archaic States in Ancient Hawai‘i*. Berkeley: University of California Press.

2010b The archaeology of dryland farming systems in southeastern Maui. In P. V. Kirch, Ed., *Roots of Conflict: Soils, Agriculture, and Sociopolitical Complexity in Ancient Hawai‘i*, pp. 65-88. Santa Fe: School of Advanced Research Press.

Kirch, P. V., J. Coil, A. S. Hartshorn, M. Jeraj, P. M. Vitousek, and O. A. Chadwick
2005 Intensive dryland farming on the leeward slopes of Haleakalā, Maui, Hawaiian Islands: Archaeological, archaeobotanical, and geochemical perspectives. *World Archaeology* 37(2):240-258.

Kirch, P., A. Hartshorn, O. Chadwick, P. Vitousek, D. Sherrod, J. Coil, L. Holm, and W. Sharp.
2004 Environment, agriculture, and settlement patterns in a marginal Polynesian landscape. *Proceedings of the National Academy of Sciences, U.S.A.* 101:9936-9941.

Kirch, P. V., J. Holson, and A. Baer
2009 Intensive dryland agriculture in Kaupō, Maui, Hawaiian Islands. *Asian Perspectives* 48:265-290.

Kirch, P. V. and P. McCoy
2007 Reconfiguring the Hawaiian cultural sequence: Results of re-dating the Hālawa Dune Site (MO-A1-3), Moloka‘i Island. *Journal of the Polynesian Society* 116:385-406.

Kirch, P. V., S. Millerstrom, S. Jones, and M. McCoy
2010 Dwelling Among the Gods: A Late Pre-Contact Priest's House in Kahikinui, Maui, Hawaiian Islands. *Journal of Pacific Archaeology* 1(2): 145-160.

Kirch, Patrick Vinton and Marshall Sahlins
1992 *Anahulu: The Anthropology of History in the Kingdom of Hawai‘i.* Chicago: University of Chicago Press.

Kirch, P. V. and W. Sharp
2005 Coral ^{230}Th dating of the imposition of a ritual control hierarchy in pre-Contact Hawai‘i. *Science* 307:102-104.

Kirch, Patrick V., and Cynthia Van Gilder
1996 Pre-Contact and early historic cultural landscapes in Kahikinui District, Maui: A Progress Report. *Hawaiian Archaeology* 4:38-52.

Kolb, Michael J.
1992 Diachronic Design Changes in Heiau Temple Architecture form the Island of Maui, Hawai‘i. *Asian Perspectives* 31(1):9-37.

2006 The origins of monumental architecture in ancient Hawai‘i. *Current Anthropology* 47:657-65.

Kolb, M.A. and E. C. Radewagen
1997 Nā Heiau o Kahikinui: The Temples of Kahikinui. In P.V. Kirch (ed.) *Nā Mea Kāhiko of Kahikinui: Studies in the Archaeology of Kahikinui, Maui.* Oceanic Archaeological Laboratory, Special Publication No. 1. Berkeley: Archaeological Research Facility.

Kuykendall, Ralph S.
1938 *The Hawaiian Kingdom. Volume I, 1778-1854, Foundation and Transformation*. Honolulu: University of Hawai‘i Press.

Ladefoged, T. N. and M. W. Graves
2008 Variable development of dryland agriculture in Hawai‘i: A fine-grained chronology from the Kohala Field System, Hawai‘i Island. *Current Anthropology* 49:771-802.

Macdonald, G. A. and A. T. Abbott
1970 *Volcanoes in the Sea: The Geology of Hawai‘i*. Honolulu: University of Hawai‘i Press.

Malo, David
1951 *Hawaiian Antiquities (Mo‘olelo Hawai‘i)*. Bernice P. Bishop Museum Special Publication No. 2. Honolulu: Bishop Museum Press.

Medeiros, A. C., Jr., L. L. Loope, and R. A. Holt
1986 *Status of Native Flowering Plant Species on the South Slope of Haleakalā, East Maui, Hawai‘i*. Technical Report 59, Cooperative National Park Resources Study Unit, University of Hawai‘i at Mānoa.

Millerstrom, S. and P. V. Kirch
2005 Petroglyphs of Kahikinui, Maui, Hawaiian Islands: Rock images within a Polynesian settlement landscape. *Proceedings of the Prehistoric Society* 70:107-128.

Moffat, R. M. and G. L. Fitzpatrick
1995 *Surveying the Mahele: Mapping the Hawaiian Land Revolution*. Honolulu: An Editions Limited Book.

Pukui, Mary Kawena, Samuel T. Elbert, and Esther T. Mookini
1974 *Place Names of Hawai‘i*. Honolulu: University of Hawai‘i Press.

Purseglove, J. W.
1968 *Tropical Crops: Dicotyledons I*. New York: John Wiley and Sons.

Rae, James
Ms. (1853). Journal of a Tour Around East Maui. Typescript copy by P. S. Chapman, of original manuscript in University of Hawai‘i Library (Rae Collection).

Schoofs, R.
1978 *Pioneers of the Faith: History of the Catholic Mission in Hawai‘i (1827-1940)*. Louis Boeynaems, Honolulu.

Schmitt, R.
1973 *The Missionary Censuses of Hawai‘i.* Pacific Anthropological Records No. 20. Department of Anthropology, Bishop Museum, Honolulu.

Sherrod, D. R., J. M. Sinton, S. E. Watkins, and K. M. Brunt
2007 *Geologic Map of the State of Hawai‘i*. USGS Open File Report 2007-1089. Washington D.C.: Department of the Interior.

Stearns, H. T. and G. A. Macdonald
1942 *Geology and Ground-Water Resources of the Island of Maui, Hawai‘i*. Bulletin 7, Division of Hydrography, Territory of Hawai‘i. Honolulu.

Sterling, E.
1998 *Sites of Maui*. Honolulu: Bishop Museum Press.

Stock, J., J. Coil, and P. V. Kirch
2003 Paleohydrology of arid southeastern, Maui, Hawaiian Islands, and its implications for prehistoric human settlement. *Quaternary Research* 59:12-24.

Valeri, V.
1985 *Kingship and Sacrifice: Ritual and Society in Ancient Hawai‘i*. Chicago: University of Chicago Press.

Van Gilder, C.
2005 Families on the Land: Archaeology and Identity in Kahikinui, Maui. Ph.D. Dissertation. Berkeley: University of California.

Van Gilder, C. and P. V. Kirch
1997 Household archaeology in the *ahupua‘a* of Kīpapa and Nakaohu. In P. V. Kirch, ed., *Nā Mea Kāhiko o Kahikinui: Studies in the Archaeology of Kahikinui, Maui*, pp. 45-60. Oceanic Archaeology Laboratory, Special Publication No. 1. Berkeley: Archaeological Research Facility, University of California.

Van Gilder, C. L.
2005 Families on the Land: Archaeology and Identity in Kahikinui, Maui. Ph.D. Dissertation, University of California, Berkeley.

Vitousek, P. M., T. Ladefoged, P. V. Kirch, A. Hartshorn, M. Graves, S. Hotchkiss, S. Tuljapurkar, and O. Chadwick
2004 Soils, agriculture, and society in pre-Contact Hawai‘i. *Science* 304:1665-1669.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer
1999 *Manual of Flowering Plants, Revised Edition* (Volume 1). Honolulu: University of Hawai‘i Press and Bishop Museum Press.

Walker, W.
1931 Archaeology of Maui. Unpublished manuscript on file, Library, B. B. Bishop Museum. Honolulu.

Zeigler, Alan C.
2002 *Hawaiian Natural History, Ecology, and Evolution*. Honolulu: University of Hawai‘i Press.

APPENDICES (SEE ENCLOSED CD)

APPENDIX A. 2007 Site Data

APPENDIX B. Site Attribute Table

APPENDIX C. 2010 Site Records

APPENDIX D. Artifact and Manuport Catalogue

APPENDIX E. Test Excavation Quantitative Tables

APPENDIX F. Radiocarbon Data Sheets

Appendix E-2
Supplemental Report to the AIS

Pacific Legacy

Historic Preservation

DRAFT

Supplemental Report to the Archaeological Inventory Survey for the Proposed Auwahi Wind Farm Ahupuaʻa of Auwahi, District of Kahikinui, Island of Maui, Hawaiʻi

[TMK (2) 1-9-001:006]

Pacific Legacy: Exploring the past, informing the present, enriching the future.

CULTURAL RESOURCES CONSULTANTS

Hawaiʻi Offices:
Kailua, Oʻahu
Hilo, Hawaiʻi

California Offices:
Arnold
Berkeley
El Dorado Hills
Quartz Hill

DRAFT

Supplemental Report to the Archaeological Inventory Survey for the Proposed Auwahi Wind Farm Ahupuaʻa of Auwahi, District of Kahikinui, Island of Maui, Hawaiʻi

[TMK (2) 1-9-001:006]

Prepared by:
William A. Shapiro, M.A.
Paul L. Cleghorn, Ph.D.
Patrick V. Kirch, Ph.D.
Lisa Holm, Ph.D.
and
Elizabeth L. Kahahane, B.A.

Pacific Legacy, Inc.
30 Aulike Street, Suite 301
Kailua, HI 96734

Prepared for:
Auwahi Wind Farm, LLC
101 Ash Street
San Diego, CA 92101-3017

June 2011

ABSTRACT

This report presents a supplement to an archaeological inventory survey report conducted at the proposed Auwahi Wind Farm located on ʻUlupalakua Ranch Lands in the *ahupuaʻa* of Auwahi, Kahikinui District, Island of Maui. The Auwahi Wind Farm project consists of several components: a 160.5 acre wind farm; a 5 mile long construction access road, and 9 miles of transmission line terminating at a proposed new interconnect substation. The original archaeological inventory survey was conducted in two phases. In 2007, the 1,450 acre wind farm parcel, transmission line, and access road routes underwent a 100 percent pedestrian survey. Using data provided by this survey engineers designed wind farm facilities to avoid as many of the archaeological resources as possible and especially avoiding those that were thought to be most sensitive (i.e., ceremonial/religious structures and possible human burials). In 2010, a detailed recording and testing phase was conducted on those archaeological resources that were within the area of potential effect (APE). The results of this work are reported in the Pacific Legacy 2011 archaeological inventory survey (AIS) report (Shapiro et al. 2011).

Subsequent to the completion of the AIS report, project design changes were implemented to avoid engineering and archaeological concerns regarding potential impacts to lava tube systems and culturally sensitive resources which were located within the original wind farm APE. A revised APE was designed to avoid these concerns which resulted in the need to conduct additional archeological investigations. Thirty-eight sites comprising a total of 186 features underwent additional detailed recording and evaluation due to the revisions in the APE. This work was conducted in April of 2011 and consisted only of the detailed recording of features and site areas not previously documented within the revised APE. This report documents these newly recorded resources including their recommended treatments and mitigation measures as a supplement to the earlier AIS report (Shapiro et al. 2011).

TABLE OF CONTENTS

1.0 INTRODUCTION **1**

1.1 Project Description 6
1.2 Pacific Legacy Staff 12

2.0 METHODS **13**

3.0 2011 DETAILED RECORDING RESULTS **15**

3.1 Interconnect Substation 15
3.2 Generator-Tie Line 15
3.3 Wind Farm 18
3.4 Summary of Resources Recorded 35

4.0 SIGNIFICANCE ASSESSMENTS **58**

5.0 RECOMMENDED TREATMENTS **66**

5.1 "The Archaeology of Hydrology" 66
5.2 Development of the Formal Field System in "Gobi Desert" 67
5.3 Settlement Chronology in Auwahi—Is it Earlier than Elsewhere in Kahikinui? 69
5.4 Household Organization and Structure 70
5.5 Post-Contact Transformations to Hawaiian Rural Society 71
5.6 Impact of Hawaiian Land Use on Dryland Forest Environment 73

6.0 SUMMARY AND DISCUSSION **90**

6.1 Site Avoidance 92
6.2 Auwahi in a Regional Kahikinui Perspective 92
6.3 Auwahi and the Ahupuaʻa of Kahikinui 93
6.4 Chronology of Occupation and Land Use in Auwahi 96
6.5 Settlement Patterns, Population Density and Distribution 101
6.6 Agricultural Systems and Water Control 107
6.7 The Ritual Landscape 110

7.0 REFERENCES CITED **113**

APPENDIX A. Site Records

APPENDIX B. Site Attribute Table

LIST OF FIGURES

Figure 1. The Auwahi Wind Farm vicinity map (courtesy of Tetra Tech). 2
Figure 2. The Auwahi Wind Farm project components (courtesy of Tetra Tech). 3
Figure 3. The Auwahi Wind Farm plan map (courtesy of Tetra Tech). 4
Figure 4. APE Changes: Interconnection Substation. 7
Figure 5. APE Changes: Generator-Tie Line. 8
Figure 6. APE Changes: Wind Farm, north portion. 9
Figure 7. APE Changes: Wind Farm, mid-portion. 10
Figure 8. APE Changes: Wind Farm, south portion. 11
Figure 9. Map of Site AWF-312. 20
Figure 10. Detail Map of Site AWF-312. 21
Figure 11. Overview of Site AWF-312 showing Feature F wall (foreground at meter stick), Feature G cleared area and Feature H wall behind crew member in center (view to SE). 22
Figure 12. Overview rock retaining wall supporting terrace Features A and B at Site AWF-318 (view to SE). 23
Figure 13. Overview of enclosure Feature F at Site AWF-333/336 (view to E). 25
Figure 14. Overview of crew recording terrace Features I (background) and J (foreground) at Site AWF-333/336 with swale at right likely used for agriculture (view to N). 26
Figure 15. Overview west of Feature D mound at Site AWF-354 (view to W). 27
Figure 16. Overview of entrance to Feature B, lava tube/shelter at Site AWF-2011 H (view to NE). 29
Figure 17. Overview of lava tube entrance (Feature A) at Site AWF-2011 K (view to S). 31
Figure 18. View of interior of Feature A lava tube showing rock wall beyond entrance at Site AWF-2011 K (view to S). 31
Figure 19. Overview of terrace Feature E at Site AWF-2011 M (view to SE). 32
Figure 20. Close-up of Artifact 2 (wood bowl) from Feature B cupboard at Site AWF-2011 P. 34
Figure 21. Site AWF-2011 Q enclosure with Puʻu Hōkūkano cinder cone in background (view to W). 35
Figure 22. Over all map of Wind Farm. 40
Figure 23. Site location map of northern portion of Wind Farm. 41
Figure 24. Site location map of central portion of Wind Farm. 42
Figure 25. Site location map of southern portion of Wind Farm. 43
Figure 26. Site location map of Interconnection Substation and NW End of Generator-Tie Line. 44
Figure 27. Site location map of Substation Access Road and Generator-Tie Line near Kula Highway. 45
Figure 28. Site location map of Generator-Tie Line section between Figures 17 and 19. 46
Figure 29. Site location map of Generator-Tie Line section between Figures 18 and 20. 47
Figure 30. Site location map of Generator-Tie Line section between Figures 19 and 21. 48
Figure 31. Site location map of Generator-Tie Line section between Figures 20 and 22. 49
Figure 32. Site location map of Generator-Tie Line section between Figures 21 and 23. 50
Figure 33. Site location map of southeastern end of Generator-Tie Line. 51
Figure 34. Site location map of northwestern end of Pāpaka Road. 52
Figure 35. Site location map of Pāpaka Road between Figures 24 and 26. 53

Figure 36. Site location map of Pāpaka Road between Figures 25 and 27. 54
Figure 37. Site location map of Pāpaka Road between Figures 26 and 28. 55
Figure 38. Site location map of Pāpaka Road between Figures 27 and 29. 56
Figure 39. Site location map of eastern end of Pāpaka Road. 57
Figure 40. Map of Kahikinui District showing the various place names which are believed to represent individual *ahupua'a*, or in some cases possibly *'ili*, land units. (Map by U. S. Geological Survey, 1942.) 95
Figure 41. Histogram plot of 162 radiocarbon dates from Kahikinui archaeological sites (excluding Auwahi). Dates have been plotted based on their highest probability intercepts. The trendline is a 2-period moving average. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 98
Figure 42. Oxcal generated chart of the 14 dates from Auwahi by this project. The black histograms for each date are probability distributions indicating the likelihood that the radiocarbon age corresponds to a particular calendar year. As can be seen, "dates" have multiple probability intercepts. 99
Figure 43. Histogram plot of 14 radiocarbon dates from Auwahi archaeological sites. Dates have been plotted based on their highest probability intercepts. The trend line is a 2-period moving average. 100
Figure 44. The temporal distribution by 100-year age intervals of radiocarbon dates from five *ahupua'a* of Kahikinui. 101
Figure 45. Simplified geologic map of the Kahikinui District showing the distribution of substrates according to age categories (from Kirch et al. 2004). The older Kula Volcanic Series is shown in blue. The orange colored areas are of very young lava flows not amenable to cultivation. Areas shaded green and yellow have substrates with ages best suited to intensive cultivation. 103
Figure 46. Major zones of archaeological survey in Kahikinui District. (Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 104
Figure 47. Spatial distribution of archaeological features in Kīpapa-Nakaohu, Mahamenui, and Manawainui. Inset charts show the frequency of feature categories by elevation. Rainfall increases as function of elevation. Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley. 105
Figure 48. Kahikinui rainfall as a function of elevation. 106
Figure 49. A medium sized natural swale in the *'a'ā* lava topography of Auwahi, below Pu'u Hōkūkano. This swale has a level soil surface and artificially constructed walls around its perimeter. It is typical of swales throughout Kahikinui used for intensive cultivation. (Photo by P. V. Kirch, 2007.) 108
Figure 50. Map of a portion of the Kaupō Field System, based on aerial photo analysis of field embankment and wall patterns. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 109
Figure 51. Map of the Kīpapa-Nakaohu to Manawainui section of Kahikinui District, with archaeological sites (individual dots) and the distribution of mapped *heiau* (red dots). (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.) 112

LIST OF TABLES

Table 1. 2011 Updated and Recorded Sites (N=38) 16
Table 2. Listing of Sites and Features in the Revised APE 36
Table 3. Significance Assessments of Sites 59
Table 4. Recommended Treatments to Features Within the APE 74

Frontispiece: View Northeast of Enclosure, Feature F at Site AWF-333/336.

1.0 INTRODUCTION

This is a supplemental report to the archaeological inventory survey (AIS) for the proposed Auwahi Wind Farm located in the *ahupuaʻa* of Auwahi, District of Kahikinui, Island of Maui, Hawaiʻi [TMK (2) 1-9-001:006]. This supplemental report has been generated in response to design changes to the wind farm that included reducing the area of potential effect (APE) by almost fifty percent. This introduction traces the history of archaeological investigations associated with this project, describes the project, defines the revised APE, and lists the staff responsible for the additional field investigations. This report relies heavily on the original AIS for this project (Shapiro et al. 2011), which should also be consulted to obtain a fuller understanding of the investigations carried out in Auwahi. The results of the supplemental field work did not substantially change our current interpretations of the prehistory and history of the Auwahi project area, hence our discussion section (Section 6) remains essentially unchanged from that presented in Shapiro et al. 2011), but is included in the current report for the sake of readers that do not have access to the original AIS (ibid.). However, there are changes to the sites that are evaluated for their significance and for the treatment of sites within the APE. The current report assesses the significance of all cultural resources found within the revised APE and recommends appropriate treatments for these resources to mitigate adverse effects associated with this project.

Auwahi Wind Farm, LLC proposes to develop a wind energy project, called the Auwahi Wind Farm, in the southern half of the Auwahi Ahupuaʻa of Maui Island, Hawaiʻi, which is currently a holding of ʻUlupalakua Ranch [TMK (2) 1-9-001:006]. Under contract to Auwahi Wind Farm, LLC, Pacific Legacy conducted an archaeological inventory survey of the proposed wind farm, as well as a proposed transmission line and electrical substation, and a construction access road (Figures 1, 2, and 3). The survey was conducted to facilitate an Environmental Impact Statement for the project that is being prepared by Tetra Tech, Inc. The Department of Land and Natural Resources State Historic Preservation Division (SHPD) requires that an archaeological inventory survey be conducted to evaluate the significance of prehistoric, historic, and burial sites within the proposed project area (HRS 6E-42 and Hawaiʻi Administrative Rules 13-276-5 and 13-284-5).

The archaeological inventory survey was conducted in two phases as proposed in an archaeological inventory survey plan prepared by Pacific Legacy in 2007 and submitted to the State Historic Preservation Division (Pacific Legacy 2007). The two phases consisted of a large scale pedestrian survey, followed by an intensive recording and testing phase. The results of this work are presented in the report for the archaeological inventory survey (Shapiro et al. 2011) which is currently under final review and production.

This two-phase approach was developed through consultations with the State Historic Preservation Division (SHPD). Representatives of CH2M Hill, Shell WindEnergy (the previous planner and developer respectively), and Pacific Legacy met with the SHPD Maui Lead Archaeologist on 13 February 2007 to introduce the project and to discuss with SHPD plans for the archaeological inventory survey. Pacific Legacy proposed to conduct the archaeological

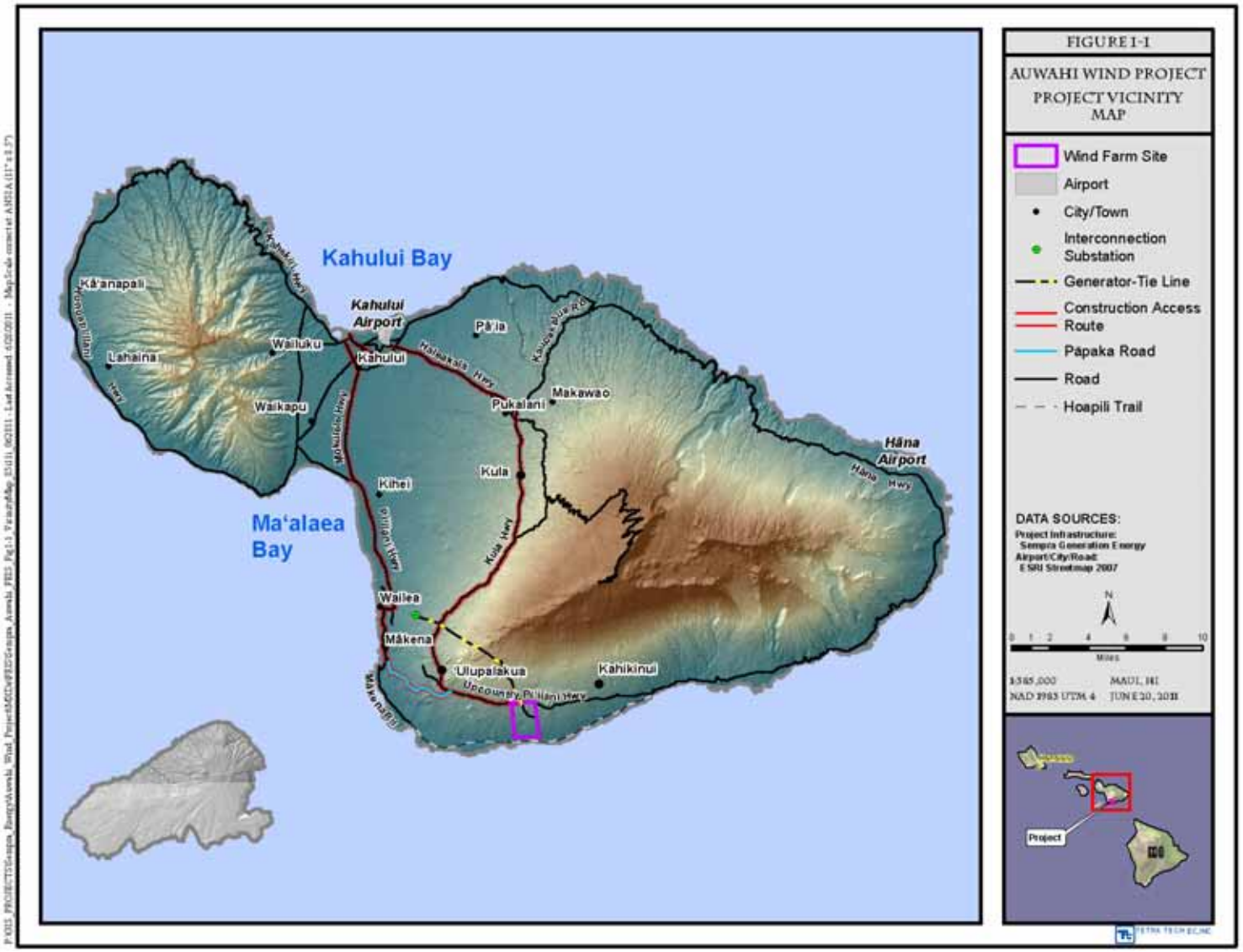


Figure 1. The Auwahi Wind Farm vicinity map (courtesy of Tetra Tech).

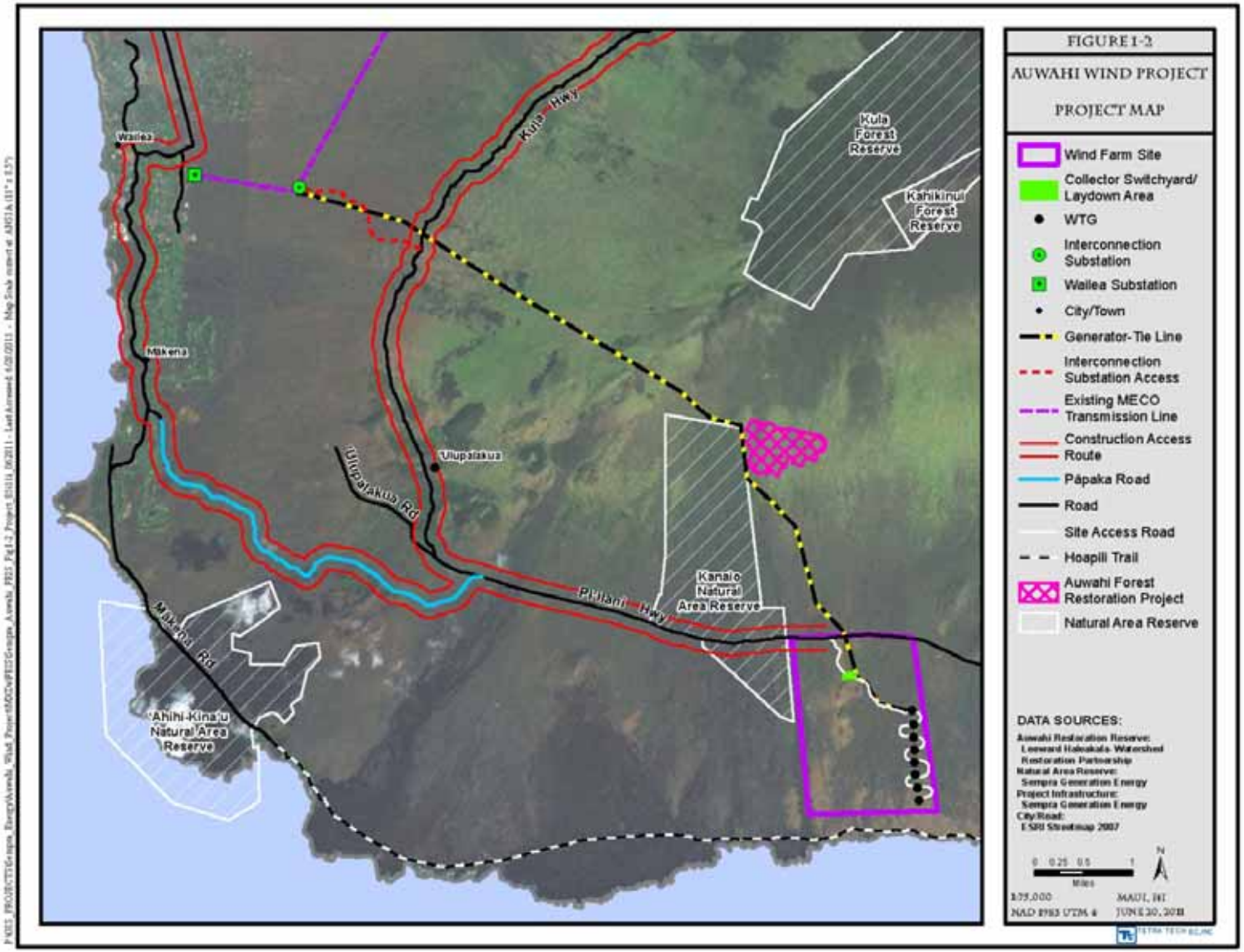


Figure 2. The Auwahi Wind Farm project components (courtesy of Tetra Tech).

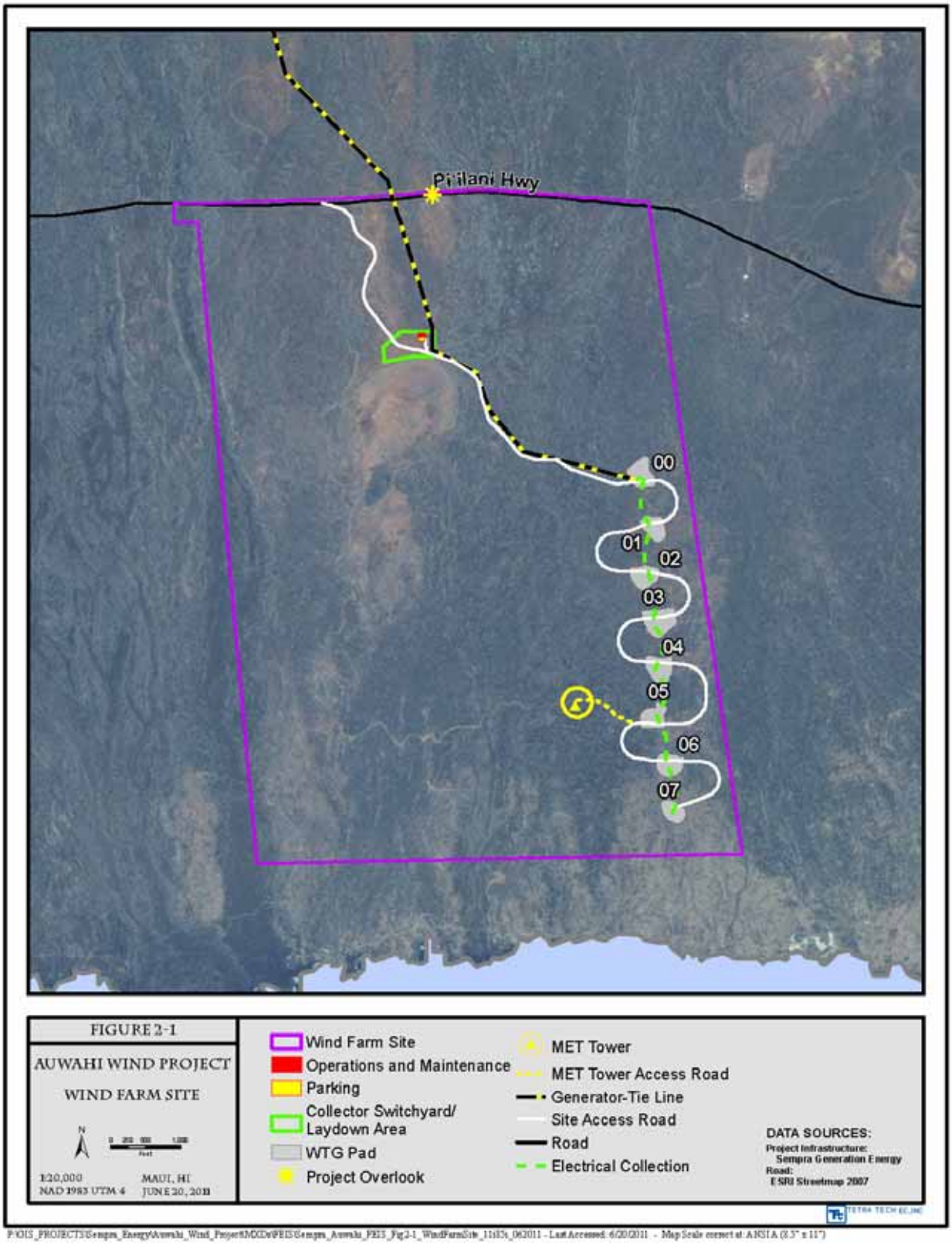


Figure 3. The Auwahi Wind Farm plan map (courtesy of Tetra Tech).

investigations in two phases. The first phase would be to conduct a survey of a larger study area based on Shell WindEnergy's conceptual design at the time. This would be completed first. The information gathered during the initial survey would be incorporated into the project design, as avoidance of resources was the preferred outcome. The second phase, consisting of two tasks (detailed recording and evaluation) would be completed after the locations of specific project components could be determined (e.g., roads, turbine pads, and staging areas). Therefore, not all resources within the project area would be subject to further study. Only those resources found to be within the area of potential effect (APE) would be subject to detailed recording and evaluation. In accordance with this proposal, it was agreed that the first phase of the study could begin. SHPD requested a written plan for the conduct of the archaeological study, which was submitted on 11 April 2007.

The first phase, conducted in 2007, was an extensive pedestrian survey of the wind farm consisting of approximately 1,450 acres, approximately 9 miles of transmission line, and approximately 5 miles of existing roadway for construction access. The purpose of this pedestrian survey was twofold: (1) identify cultural resources in a proactive manner to aid in the design and placement of wind farm components (including roadways, transmission lines, turbine pads, and staging areas) to avoid important cultural resources; and (2) to provide abroad context to evaluate the sites and features to be impacted by construction of the wind farm (Holm et al. 2007). At the conclusion of the pedestrian survey phase, engineers used the data generated to design the wind farm components (including roadways, transmission lines, turbine pads, and staging areas) to avoid important cultural resources.

The second phase of archaeological investigations took place in 2010, after the project layout was determined. This phase consisted of detailed recording (GPS coordinates, mapping, photographing, and written descriptions) of all sites and features to be impacted by the construction of the wind farm components. During the course of fieldwork several significant ceremonial and burial sites were encountered in the APE. Consultations with design engineers were immediately held and design changes were made so that these sensitive sites would be avoided by construction activities.

Subsequent to the final preparation and review of the 2011 archaeological inventory survey (AIS) report, additional project design changes were proposed by Auwahi Wind Farm, LLC in order to alleviate engineering and archaeological concerns with regard to potential impacts to lava tube systems and sensitive cultural resources. As a result, additional fieldwork was conducted in April of 2011 to provide detailed recording of sites and features within the revised APE. This report documents the results and findings of the April 2011 supplemental detailed recording. For details regarding the project background, results of the previous inventory survey and detailed recording, recommended treatments and regional synthesis, the reader is referred to the 2011 AIS report.

1.1 PROJECT DESCRIPTION

The project area is located on undeveloped land on the south coast of East Maui. It is located south of the Pi‘ilani Highway within approximately 1,450 acres; the actual wind farm consisting of eight turbine pads and associated access roads and staging area covers ca. 160 acres. The general project location and the various component parts are depicted in Figures 1-3. The proposed wind energy development project would provide 21 megawatts (MW) of clean, renewable energy to Maui Island. In addition to the wind turbines pads, access roads will have to be constructed. The access roads would be approximately 10.4 m (38 feet) wide, including shoulders. Other planned components within the project area include a construction staging area and an on-site substation.

In addition to the wind farm, Auwahi Wind Farm, LLC proposes to construct a ca. 9 mile long Generator-Tie Line and substation to link the energy generated by the Auwahi Wind Farm with the Maui Electric Company electrical grid (Figure 2). Auwahi Wind Farm, LLC also proposes to improve the existing ca. 5 mile long ‘Ulupalakua Ranch Pāpaka Road to be used to transport construction materials from the coast up to the wind farm site. In summary, the area of potential effect (APE) for the project is:

- an improved series of ranch road corridors collectively referred to as Pāpaka Road that extends for 4.7 miles and measures 20 m on either side of the centerline;
- 8 2.1 acre turbine pads;
- access road corridors connecting the turbine pads that measure 20 m on either side of centerline (the final size of the actual roads will be 10.4 m [38 feet] wide within these 40 m wide corridors to provide flexibility in final design that will allow avoidance of features);
- a 30 m wide Generator-Tie Line corridor that extends for 9 miles north and west from the wind farm to a proposed Interconnection substation;
- a 0.6 ha (1.6 acre) acre Interconnection substation at the NW terminus of the Generator-Tie Line; and
- 10 m on each side of Pi‘ilani Highway between the intersection with Pāpaka Road and the Wind Farm (c. 3.7 miles) in order to eliminate various dips in the roadway so that the project components could be transported.

The revised 2011 APE for the proposed Auwahi Wind Farm project consisted of three primary components which resulted in the need to record, or update and evaluate a total of 38 archaeological sites comprising 347 features.

The first area consisted of a slight adjustment to the proposed location of the interconnect substation at the NW terminus of the transmission line (Figure 4). The second area consisted of adjustments to the APE along the proposed gen-tie line route north of Pi‘ilani Highway (Figures 5 and 6). The third change to the APE was located in the proposed wind farm parcel south of Pi‘ilani Highway (Figures 7 and 8). The original western string of turbine pads has been eliminated and only the eight eastern pads are currently planned for development. The primary APE changes within the wind farm occurred along the access road from the lay down

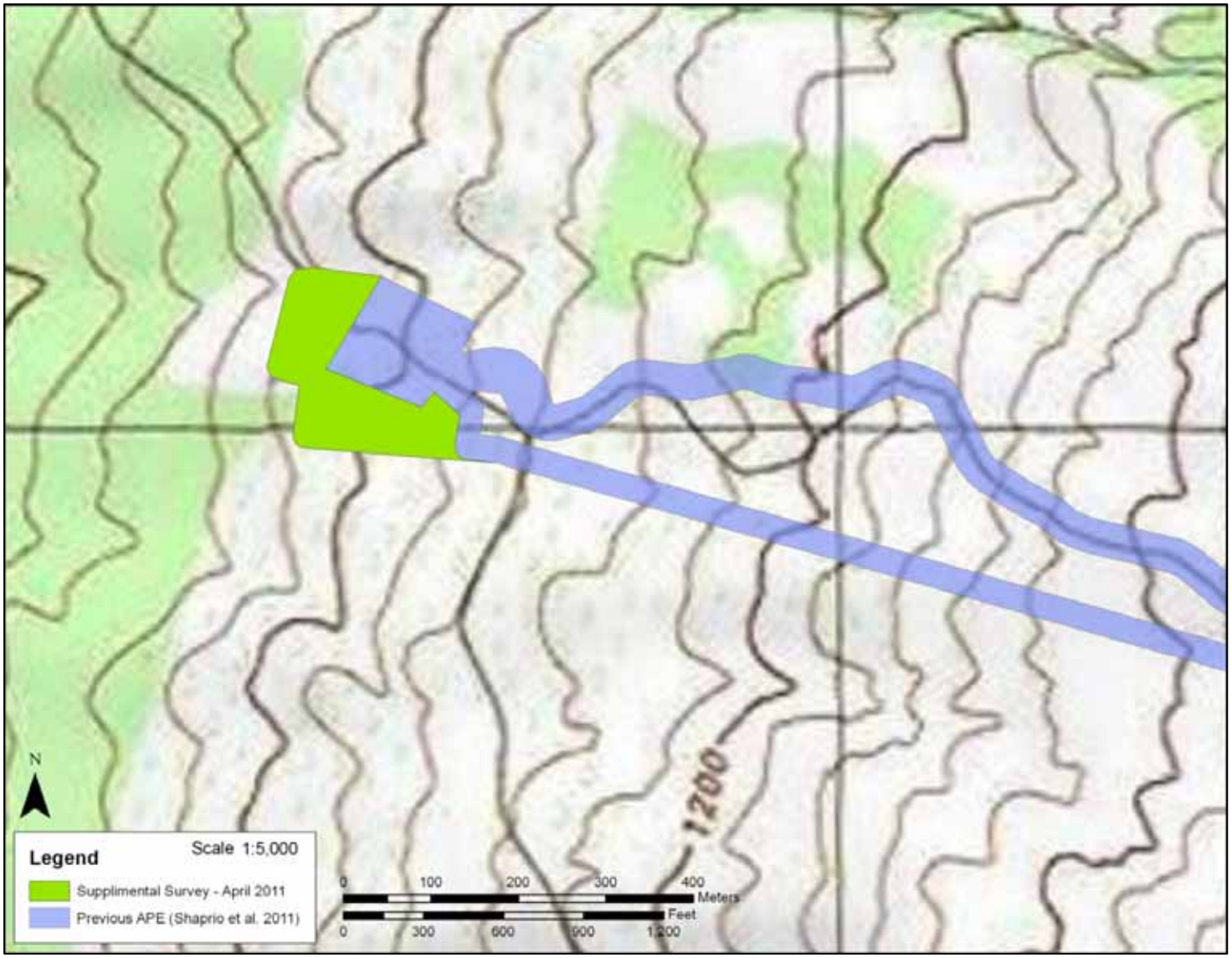


Figure 4. APE Changes: Interconnection Substation.

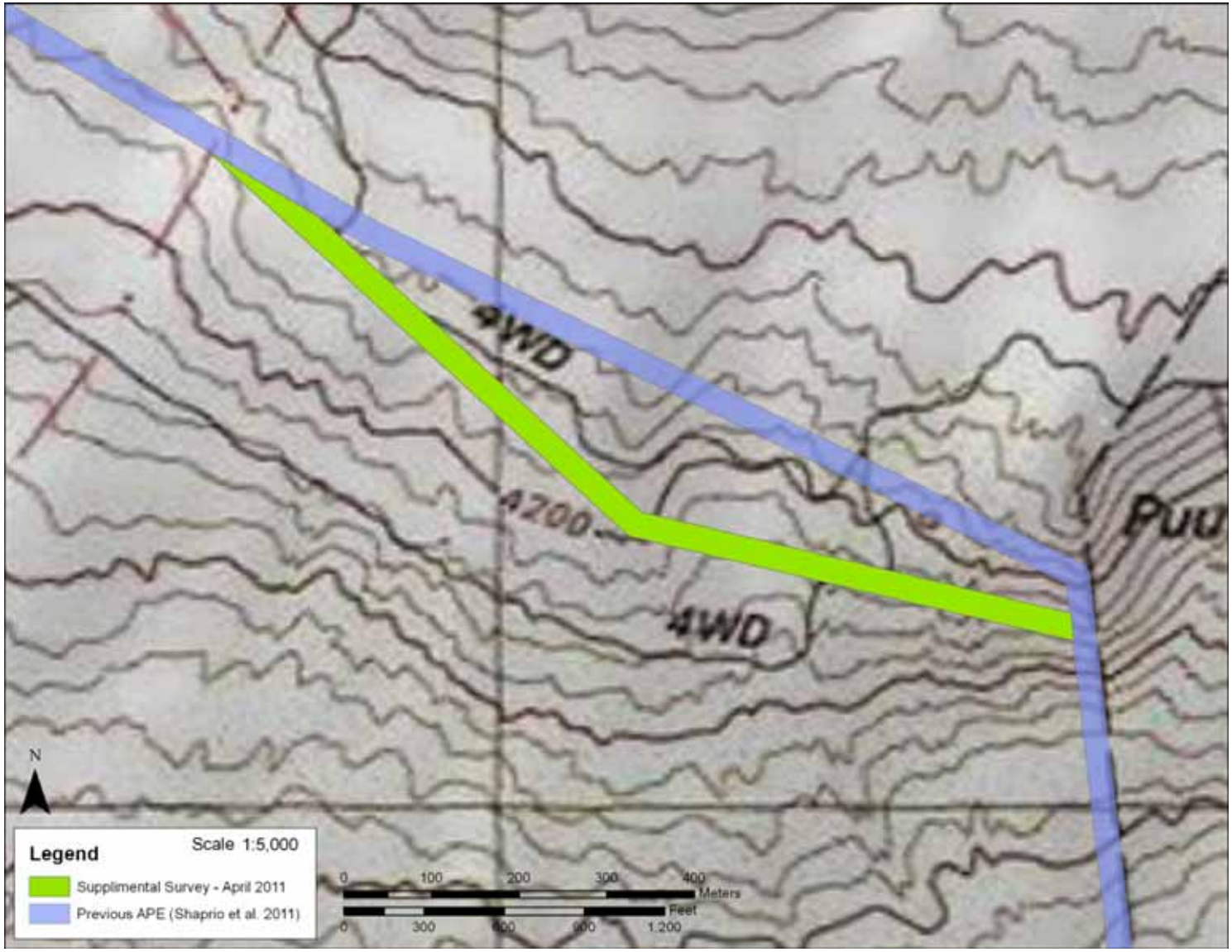


Figure 5. APE Changes: Generator-Tie Line.

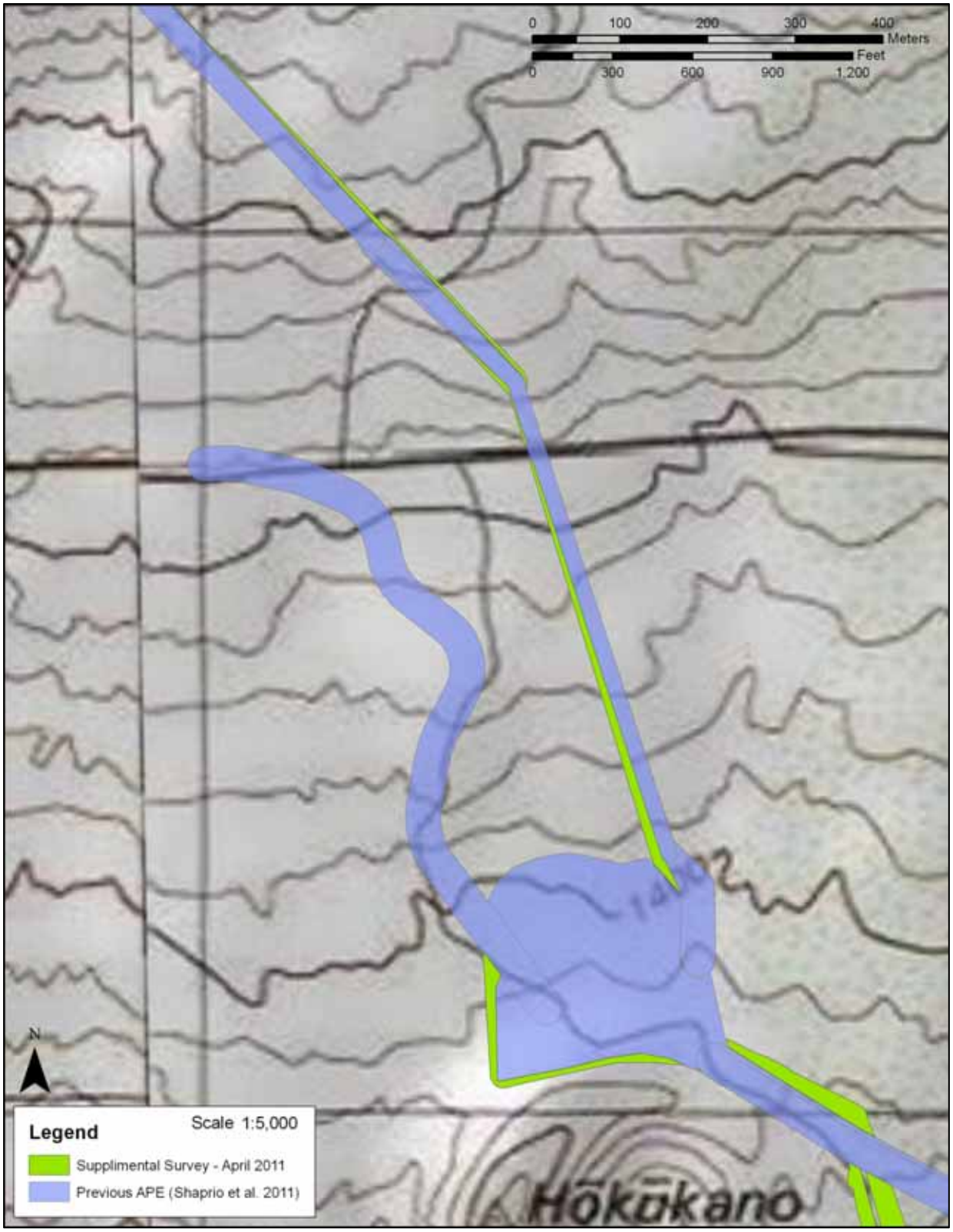


Figure 6. APE Changes: Wind Farm, north portion.

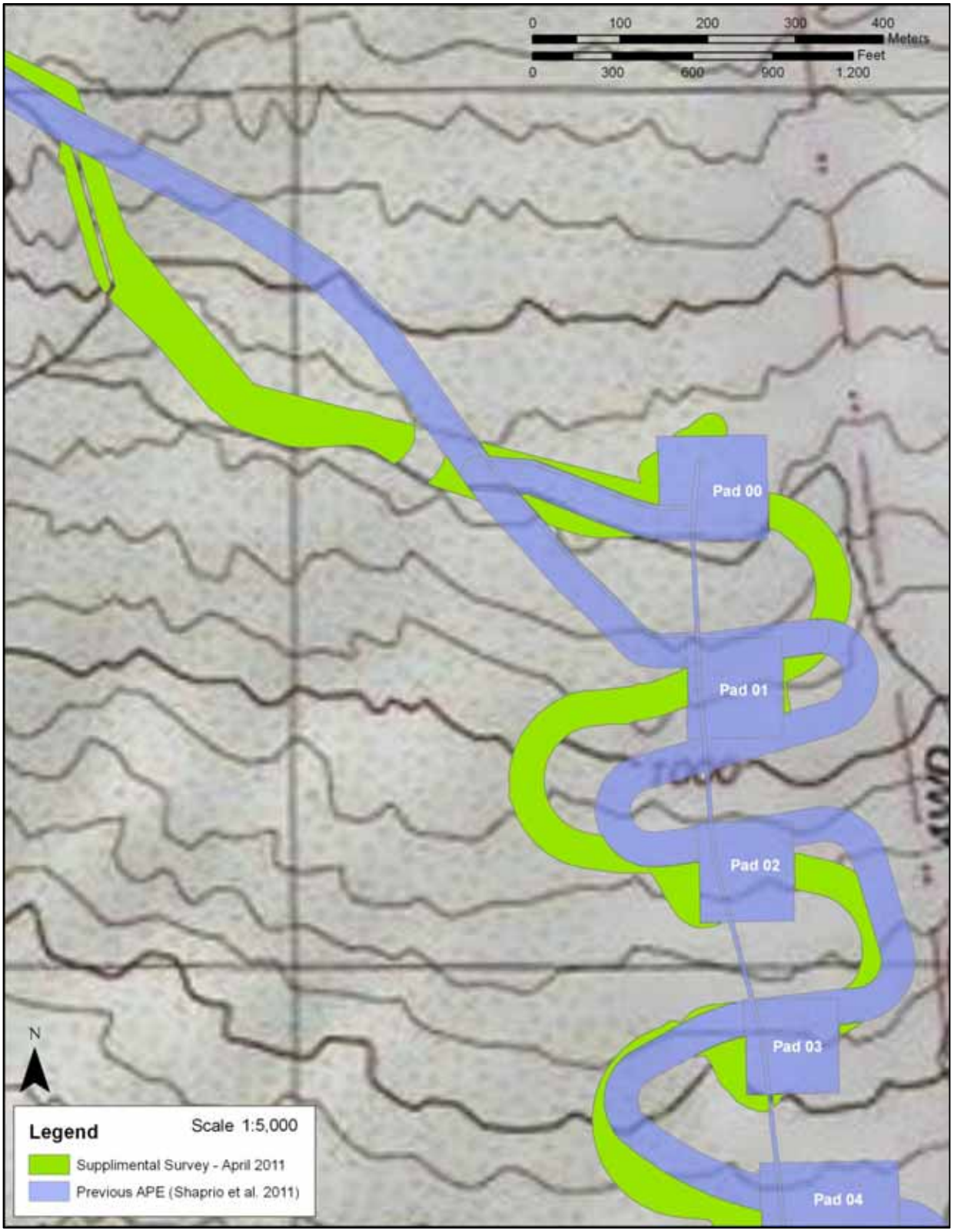


Figure 7. APE Changes: Wind Farm, mid-portion.

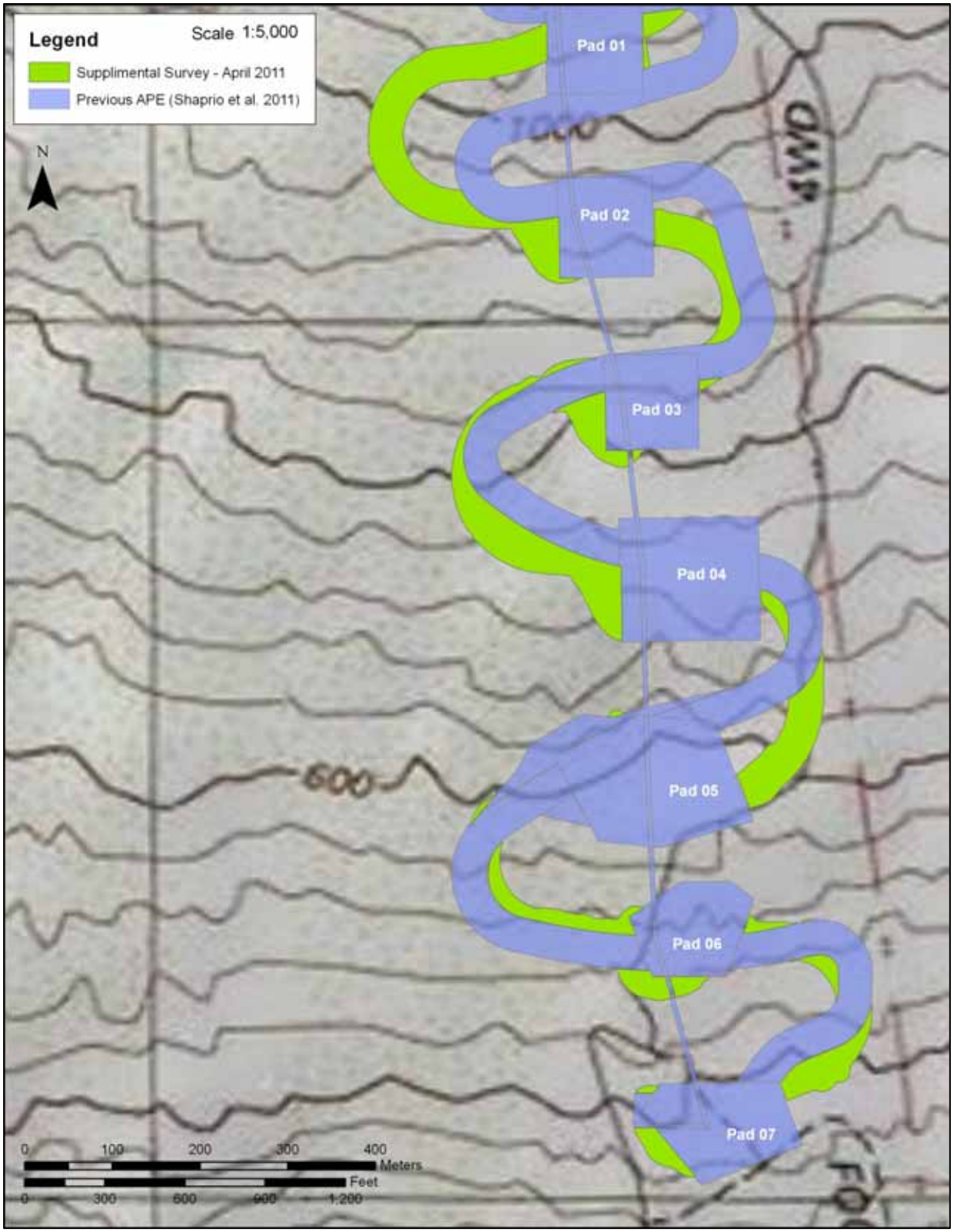


Figure 8. APE Changes: Wind Farm, south portion.

area to the various pads. Most of these APE access road changes resulted from a desire to avoid engineering and archaeological concerns with regard to the discovery of a system of lava tubes and several highly sensitive site areas identified during the 2010 fieldwork and discussed in the AIS report (Shapiro et al. 2011). This preemptive APE adjustment will result in the protection and avoidance of the identified lava tube features and several high sensitivity archaeological resources including high status residences and ceremonial sites.

1.2 PACIFIC LEGACY STAFF

The co-Principal Investigators for this project are Paul L. Cleghorn, Ph.D. and John Holson, M.A. from Pacific Legacy. Patrick V. Kirch, Ph.D. from the University of California at Berkeley has acted as a consultant for the project. Paul Cleghorn conducted two site visits during the April 2011 supplemental field work.

The 2011 Pacific Legacy crew conducting the detailed recording and evaluation within the revised APE consisted of Project Supervisors William Shapiro, M.A. and James McIntosh, B.A., and archaeological technicians Kat Chao, B.A.; Patrick Day, Caleb Fechner, B.A.; Kim Mooney, B.A.; Kelene Pfennig, B.A.; Mary Schmidt, B.A.; and Dan Trout, B.A. This team was also part of the 2010 recording and evaluation efforts.

2.0 METHODS

The recent detailed recording and site evaluation work was conducted by a seven-person crew between 4 April and 30 April 2011. The methods employed followed those used during the 2010 detailed recording and evaluation efforts. The work initially consisted of relocating the previously identified resources from the 2007 inventory survey and the newly identified resources discovered during the 2010 fieldwork which were located in the revised APE. As previously mentioned, for most of the wind farm project area, only those portions of sites within the original APE were subjected to detailed recording in 2010. Due to the APE revisions, many of the previously recorded site features (including high status residences and ceremonial sites in the western turbine pad line) are now outside of the revised APE. However, additional features which had yet to be recorded in detail and evaluated were now within the revised APE and these features were the focus of the 2011 fieldwork effort.

The revised APE includes a total of 38 sites comprised of 347 features. The 2011 fieldwork focused on the detailed recording of 186 features within the revised APE. The relocation of the sites and features was facilitated through the use of Trimble Explorer GPS units and the previously collected GPS data from the 2007 inventory survey and the 2010 detailed recording. Relocated sites were marked with pink flagging with their temporary site number designations written on the flagging in permanent marker to facilitate future recording. During the relocation efforts, a few newly identified resources were also encountered within the APE and these were similarly recorded in detail. These were identified as a result of the better visibility resulting from recent draught conditions.

After the sites were relocated, the field crews then began hand clearing the vegetation from the site areas so that each of the individual features within the revised APE could be more thoroughly examined and recorded. Site clearing was accomplished with the use of hand tools (machetes and pruning clippers). Once the site areas and individual feature components within the APE were cleared of vegetation, the detailed recording of the sites and features could commence.

Detailed recording included the gathering of data sufficient to complete Archaeological Site and Feature Record Forms. Data collection included observations on the nature of each feature and site area which included interpretations as to their function. This information is necessary for the significance evaluation of the various features. Sub-meter accuracy GPS data was obtained for each individual feature at all the sites within the APE. This allowed for the precise location of each feature in the event that project design changes were necessary and as a result significant features could be avoided as much as possible. GPS readings were also collected for each site datum and for each individual feature, as well as for diagnostic artifacts. Site maps were prepared using tape and compass and/or the collected GPS reference data. Representative detailed feature maps were also prepared using tape and compass. Digital photographs were taken for each of the individual features, artifacts, and site areas.

Additional archaeological inventory survey was required in certain areas (the transmission line and interconnect substation) as a result of project design changes. During the supplemental survey, crew members were spaced at transect intervals varying from 10 to 15 m wide to provide complete survey coverage within the revised APE. New survey area APE boundaries were based on the information and maps provided by Sempra engineers and were supplemented with Trimble GPS shape files for the new project component changes. This insured that the revised APE areas were completely inventoried for cultural resources. When newly identified resources were discovered, they were flagged, cleared and recorded following the methods which were described above.

This report uses both permanent SIHP assigned numbers (e.g., 6979) and temporary field numbers (e.g., AWF-327). Permanent site numbers were assigned to the sites documented in the original AIS report (Shapiro et al. 2011). A request for permanent site numbers has been made to the SHPD, but these had not been received by the time this draft report needed to be submitted. Permanent site numbers will replace the temporary numbers at the time this report is revised.

3.0 2011 DETAILED RECORDING RESULTS

The detailed recording in 2011 included work in three project areas where the original APE was revised to accommodate engineering and archaeological concerns – interconnect substation, gen-tie line, and wind farm. The revisions to the APE necessitated recording/updating and evaluating 38 archaeological sites comprising 347 features. Table 1 shows the 38 sites which were updated or recorded within the revised APE. The following section briefly describes these sites in each of the three revised APE project areas; the interconnect substation, the transmission line route from the wind farm to the substation, and the wind farm parcel where the wind farm turbine pads are proposed. For details on the sites and features the reader is referred to the individual site records in Appendix A.

3.1 INTERCONNECT SUBSTATION

The interconnect substation is located at the northwest portion of the project area at the western terminus of the transmission line. The original APE for the substation was slightly expanded to the south and west by a few acres to better accommodate engineering and construction designs (see Figure 4). As a result, four newly identified resources were identified during the survey of the revised APE. This area of the wind farm has a relatively low density of archaeological features.

Three of the newly recorded resources (Sites AWF-2011 A, AWF-2011 B, and AWF-2011 C) consist of clearing mounds. The fourth site (AWF-2011 D) consists of the remnants of an historic wood post fence. According to ʻUlupalakua Ranch personnel, the proposed substation vicinity was formerly used as an animal pen location the remains of which have been previously dozed and removed. The clearing mounds are likely associated with this ranching activity rather than related to traditional agricultural activity.

3.2 GENERATOR-TIE LINE

The transmission line route extends from the wind farm south parcel to the interconnect substation. Adjustments to the APE were made along the Generator-Tie Line route north of Piʻilani Highway which resulted in the need to record additional features at eight previously recorded archaeological sites. These eight sites are briefly discussed below with a focus on the newly recorded features identified in the revised APE. For additional details on the various features see the site records in Appendix A.

Site 50-50-14-6959

This site complex was originally recorded in 2010 and consists of seven feature areas (A-G) associated with agriculture and temporary habitation; including a U-shaped wall, agricultural mound, terraces, and planting areas. The original site record (see Appendix A) noted that additional features extended beyond the project area which were not recorded in detail. In 2011, four additional features were identified within the revised APE. These include an agricultural terrace (Feature K) and three agricultural clearing mounds (Features H, I, and J). For details of these features see the updated site record in Appendix A.

Table 1. 2011 Updated and Recorded Sites (N=38)

Wind Farm Project Area	Site Number (50-50- or AWF-)	2011 Features Recorded	Notes
Interconnect Substation	AWF-2011 A	1	Newly recorded with 1 feature
Interconnect Substation	AWF-2011 B	1	Newly recorded with 1 feature
Interconnect Substation	AWF-2011 C	1	Newly recorded with 1 feature
Interconnect Substation	AWF-2011 D	1	Newly recorded with 1 feature
Gen-Tie Line	6979	4	Recorded in 2010; 4 new features added in 2011
Gen-Tie Line	6981	1	Recorded in 2010; wall feature updated
Gen-Tie Line	6982	1	Recorded in 2010; wall feature updated
Gen-Tie Line	6983	3	Recorded in 2010; 3 new features added in 2011
Gen-Tie Line	6984	3	Recorded in 2010; 3 new features added in 2011
Gen-Tie Line	6985	12	Recorded in 2010; 12 new features added in 2011
Gen-Tie Line	6987	3	Recorded in 2010; 3 new features added in 2011
Gen-Tie Line	6988	5	Recorded in 2010; 5 new features added in 2011
Wind Farm	AWF-165	2	Newly recorded with 2 features
Wind Farm	AWF-169/2011 L	12	Newly recorded with 12 features
Wind Farm	AWF-312	22	Newly recorded with 22 features
Wind Farm	AWF-316	3	Newly recorded with 3 features
Wind Farm	AWF-318	9	Newly recorded with 9 features
Wind Farm	AWF-325	1	Newly recorded with 1 feature
Wind Farm	AWF-326	5	Recorded in 2010; 5 new features recorded in 2011
Wind Farm	AWF-327	3	Newly recorded with 3 features
Wind Farm	6897	0	Recorded in 2010; site record updated to include new artifacts
Wind Farm	AWF-333/336	16	Newly recorded with 16 features
Wind Farm	6904	11	Recorded in 2010; 11 new features recorded and previous features updated
Wind Farm	AWF-358	16	Newly recorded with 16 features
Wind Farm	AWF-568	4	Newly recorded with 4 features
Wind Farm	7026	1	Recorded in 2010; 1 new feature recorded in 2011
Wind Farm	AWF-2011 E	1	Newly recorded with 1 feature
Wind Farm	AWF-2011 F	1	Newly recorded with 1 feature
Wind Farm	AWF-2011 G	7	Newly recorded with 7 features
Wind Farm	AWF-2011 H	6	Newly recorded with 6 features
Wind Farm	AWF-2011 I	8	Newly recorded with 8 features
Wind Farm	AWF-2011 J	2	Newly recorded with 2 features
Wind Farm	AWF-2011 K	8	Newly recorded with 8 features
Wind Farm	AWF-2011 M	7	Newly recorded with 7 features
Wind Farm	AWF-2011 N	1	Newly recorded with 1 feature
Wind Farm	AWF-2011 O	1	Newly recorded with 1 feature
Wind Farm	AWF-2011 P	2	Newly recorded with 2 features
Wind Farm	AWF-2011 Q	1	Newly recorded with 1 feature

Site 50-50-15-6981

This site was recorded in 2010 and consists of a stone wall which extends north-south along the west edge of a narrow ridge. It is in fair condition with sections of it appearing more like a rock alignment while other segments are stacked three courses high (70 cm) and 55 cm wide. The site record was updated in 2011 to document that the wall extended 4 m to the north into the revised APE at which point it diffuses into the natural bedrock ridge line. No additional features were identified with the site within the revised APE.

Site 50-50-15-6982
This site consists of a stone wall which was originally recorded in 2010. It trends north-south along a ridge line and was noted as extending beyond the project boundary during its original recording. It is in fair condition with a maximum height of 1.2 m and width of 0.5 m. The site record was updated in 2011 to document that the wall extends northward into the revised APE and continues beyond the current project area boundaries. No additional features were identified with the site.

Site 50-50-15-6983
This complex was recorded in 2010 and represented an agricultural complex with seven features (A-G) reflecting cultivation activity and associated temporary habitation. The features consisted of terraces, cleared areas and alignments, low walls, mounds and a U-shaped wall (see the Site Record in Appendix A for details). In 2011, three additional agricultural features (H-J) were identified at the site extending into the revised APE. Feature H is an L-shaped wall which extends beyond the revised APE, with a maximum height of 0.75 m and wall lengths of 12.3 m and 9.8 m. Feature I is a wall segment 6.45 m in length, 0.5 m wide by 0.43 m high. Feature J is a stone terrace which measures approximately 2 m long by 0.5 m wide and is 0.8 m high. All three of the newly recorded features were in fair to poor condition and appeared to be associated with agricultural pursuits.

Site 50-50-15-6984
This complex represents an agricultural and habitation site which was recorded in 2010 with five features (A-E) consisting of terraces, clearing mounds and modified outcrops. Three additional features were recorded at the site in 2011 within the revised APE; Features (F-H). Feature F is a stone mound, Feature G is a tumbled wall segment, and Feature H is a terrace (see Appendix A for details). These features represent additional agricultural and associated habitation components of the site. A large unrecorded habitation complex was noted adjacent to the site beyond the revised APE project area.

Site 50-50-15-6985
This site complex was recorded in 2010 with seven feature areas (Features A-G) reflecting agricultural activity and possible burial mounds. Feature A is a rough terrace, Features B and C are modified outcrops, Features D and E are terraces, Feature F is a series of three associated terraces, and Feature G consists of three mounds with one of them containing a large piece of branch coral suggesting it may represent a burial feature or religious offering (see Appendix A for feature details). Twelve additional features (H-S) were identified at the site within the revised APE in 2011. These consist of mounds, terraces and a wall which primarily represent agricultural features. However, mound features O, P, Q, and S have uncertain functions and may represent burial features based on their more formalized closely piled construction and their association with other features.

Site 50-50-15-6987
This is consists of an agricultural and habitation complex which was initially recorded in 2010 with four feature areas (Features A-D) consisting of a modified outcrop, a U-shaped wall, a free standing wall and a series of four agricultural terraces (see Appendix A for details). Three new features (E-G) were recorded at the site in 2011 within the revised APE. Feature E is a stone

wall remnant, Feature F is a square enclosure, and Feature G is a modified outcrop with historic ceramic fragments. The newly recorded features appear to be associated with agricultural activity and related habitation.

Site 50-50-15-6988
This site complex was originally recorded in 2010 as six feature areas reflecting habitation, agriculture and historic ranching activity. The site contained a wide range of cultural materials suggesting both traditional and historic period use. The six features (A-F) consisted of a terrace, a wall segment, an enclosure with wall, a terraced wall, an enclosure with U-shape, and wall segments. In addition to traditional cultural constituents (i.e., shell midden, water worn and branch coral, water worn stones, etc.) the site contained several historic artifacts including ceramics, metal hoops, cast iron fragments, glass fragments and a cast iron, pressing iron (see site record in Appendix A). Five additional features were recorded at the site in 2011 (Features G-K) within the revised APE which include three terraces and a wall and wall remnant which appear to be agriculturally related. The site may reflect use during the contact period or perhaps original traditional use of the area followed by historic period reuse.

3.3 WIND FARM
The Wind Farm area is located south of Piʻilani Highway (see Figure 3). Originally proposed as 16 turbine pads (with two north-south lines of eight pads each), the project area was redesigned to avoid the western string where several sensitive archaeological sites were recorded and evaluated in 2010. Due to the elimination of the western turbine pads, the access road system needed to be adjusted which resulted in revisions to the APE within the Wind Farm area. As a result of these APE changes, portions of 26 archaeological sites are now within the revised APE in the wind farm area. This section provides a brief summary of the newly recorded features at these 26 sites with the detailed site and feature records included in Appendix A; with overall sites attributes summarized in Appendix B.

Site AWF-165
This site consists of two C-shaped walls which are approximately 7 m apart. Both of the features open to the southwest providing protection from the prevailing northeast trade winds. Feature A is the northernmost C-shape with an interior space measuring approximately 2.3 m east-west by 2.5 m north-south with walls ranging from 10 to 26 cm high. Feature B is larger with the interior measuring approximately 3.5 m east-west by 7.0 m north-south and maximum wall height of 80 cm. Both features are in poor condition and are believed to represent temporary habitation features. No midden or other cultural constituents were observed. The site is likely associated with nearby sites AWF-2011 K and AWF-2011 L.

Site AWF-169/2011 L
This site complex is comprised of 12 features primarily reflecting agricultural activity but also suggesting habitation and uncertain functions (possible boundary marker and storage). Additional features were noted extending beyond the revised APE but these were not recorded. The site includes several stone mounds (Features A, B, G, H, and I) which are likely agricultural clearing features but may also represent clearing for habitation areas. Other features include an agricultural planting circle (Feature C), a temporary habitation C-shaped wall (Feature D), a

modified lava blister which may represent a storage feature (Feature E), a rock wall which incorporates a small piece of branch coral (Feature F), two agricultural terraces (Features J and K) and a stone mound/cairn (Feature L) which may represent an agricultural marker. This site is likely associated with nearby Site AWF-2011 K to the west.

Site AWF-312

This large site complex is comprised of 22 features reflecting agriculture, habitation and high status habitation or ceremonial functions. The features include two C-shaped walls (Features A and Q), cleared areas (Features B, G, and M), a platform (Feature C); a circular alignment which may reflect a platform remnant (Feature T), five stone mounds (Features D, E, O, P, and U), stone walls (Features F, H, and L), three modified *ʻaʻā* lava pits or post holes (Features I, J, and K), an L-shaped rock alignment (Feature N), a small enclosure (Feature V), and two terraces (Features R and S). An existing dirt access road extends through the southern portion of the site (Figure 9). Two of the site features were identified during the 2007 inventory survey but never formally recorded as they were beyond the original APE, but now are located within the revised APE.

The most impressive portion of the site is located in the north central portion in the vicinity of Features C, F, G, H, I, J, K, and T. This appears to represent the disturbed remains of a high status residence or a ceremonial complex, including a possible *heiau* (Figure 10). The disturbed wall remnants of Features F and H are substantial in size (nearly a meter high and wide) with core filling and well faced in sections. Within the "L" shape of Feature F wall is a level area cleared of rock which was designated Feature G. The three modified *ʻaʻā* lava pits or post holes (Features I, J, and K) are in an east west alignment south of the Feature F wall and west of the Feature H wall and may represent post or image supports. Feature C is a rectangular platform measuring 2.6 m by 2.0 m with a height of 65 cm. Feature T is a circular stone alignment measuring 2.2 m by 3.3 m and may represent the base stones of a former platform. All of these components are in relative close proximity to each other, and although disturbed (likely from cattle and former rock acquisition) represent a substantial effort in planning and construction (Figure 11). Site AWF-312 is associated with nearby sites AWF-297, AWF-316, AWF-318 and AWF-2011 M.

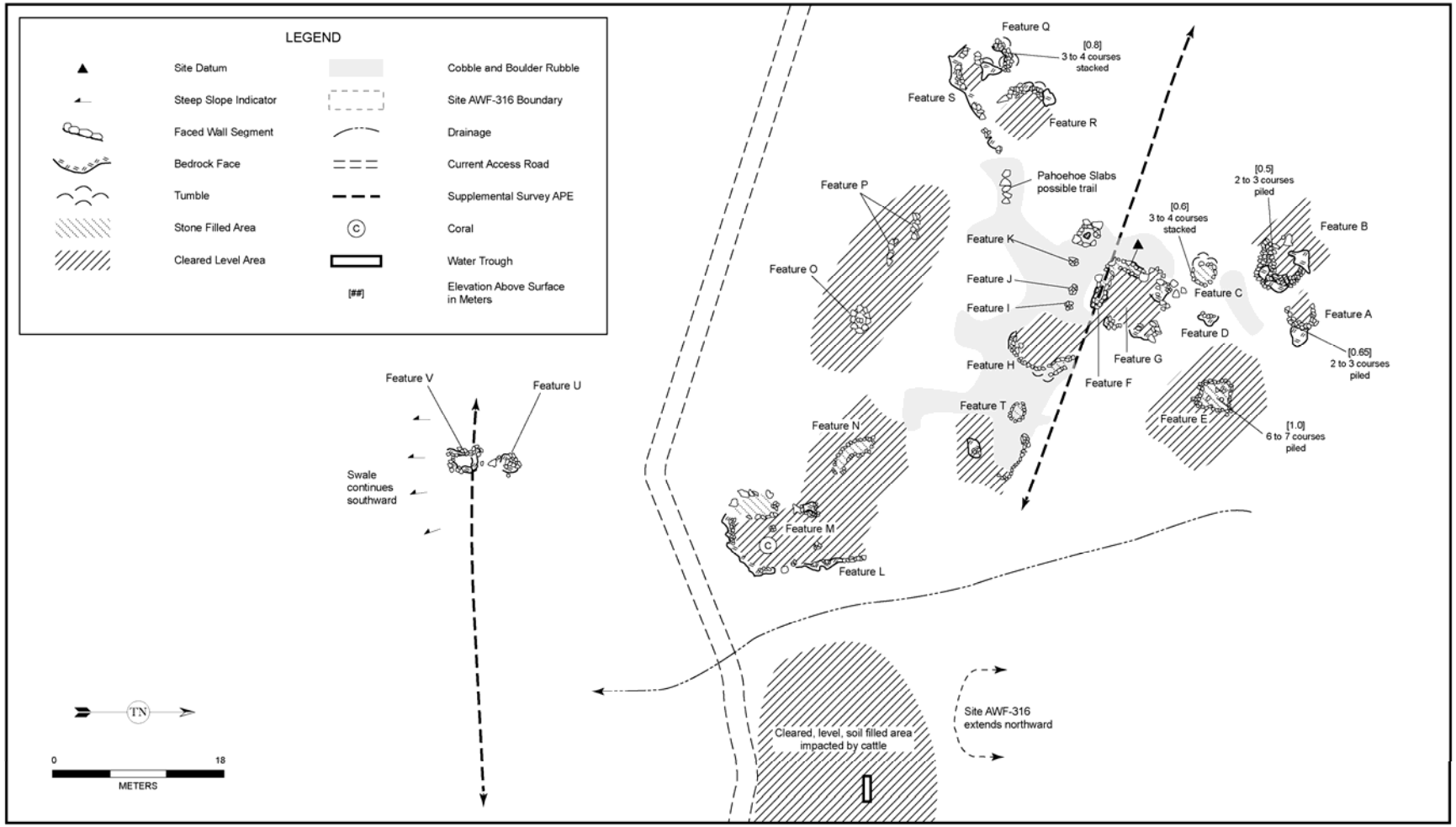


Figure 9. Map of Site AWF-312.

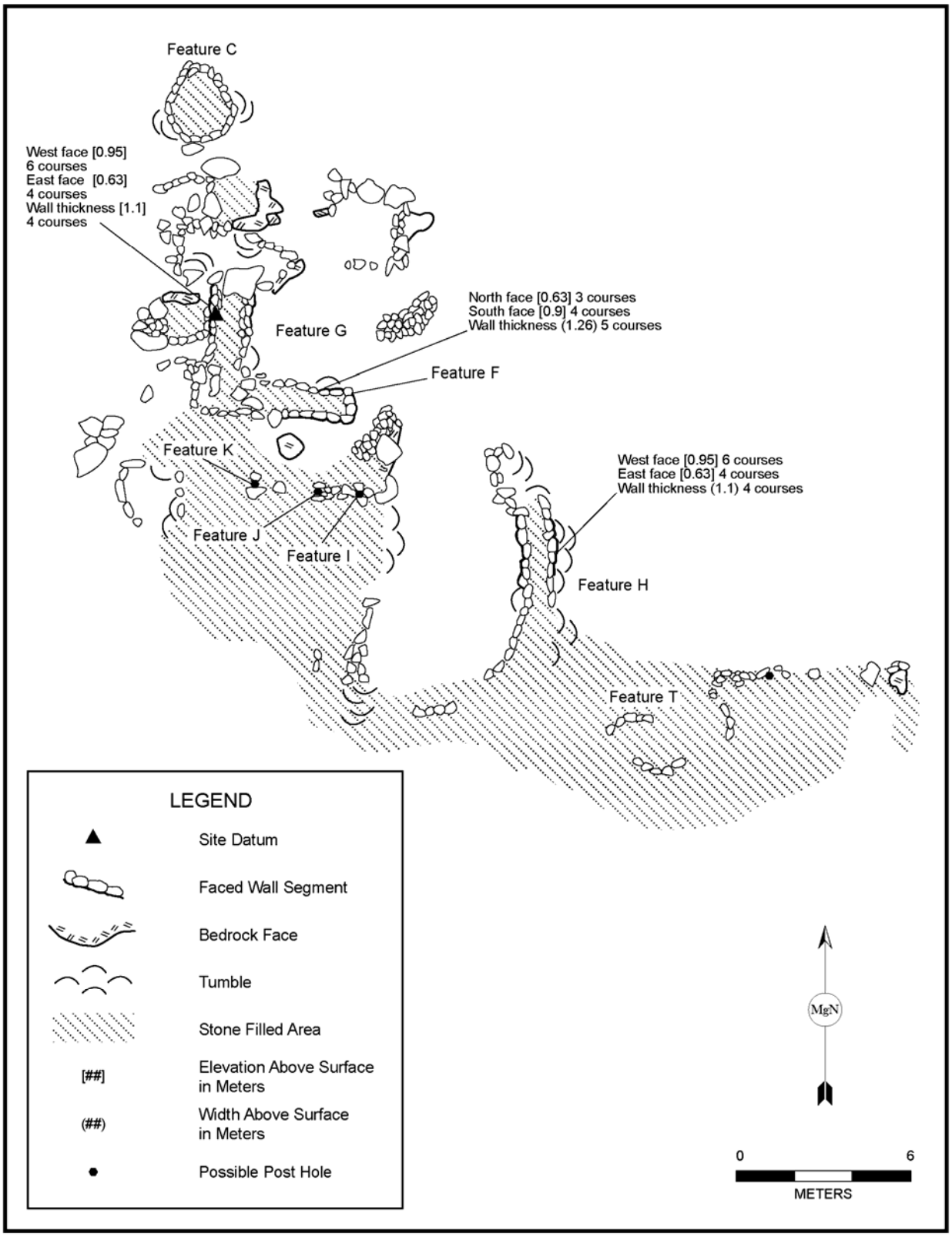


Figure 10. Detail Map of Site AWF-312.

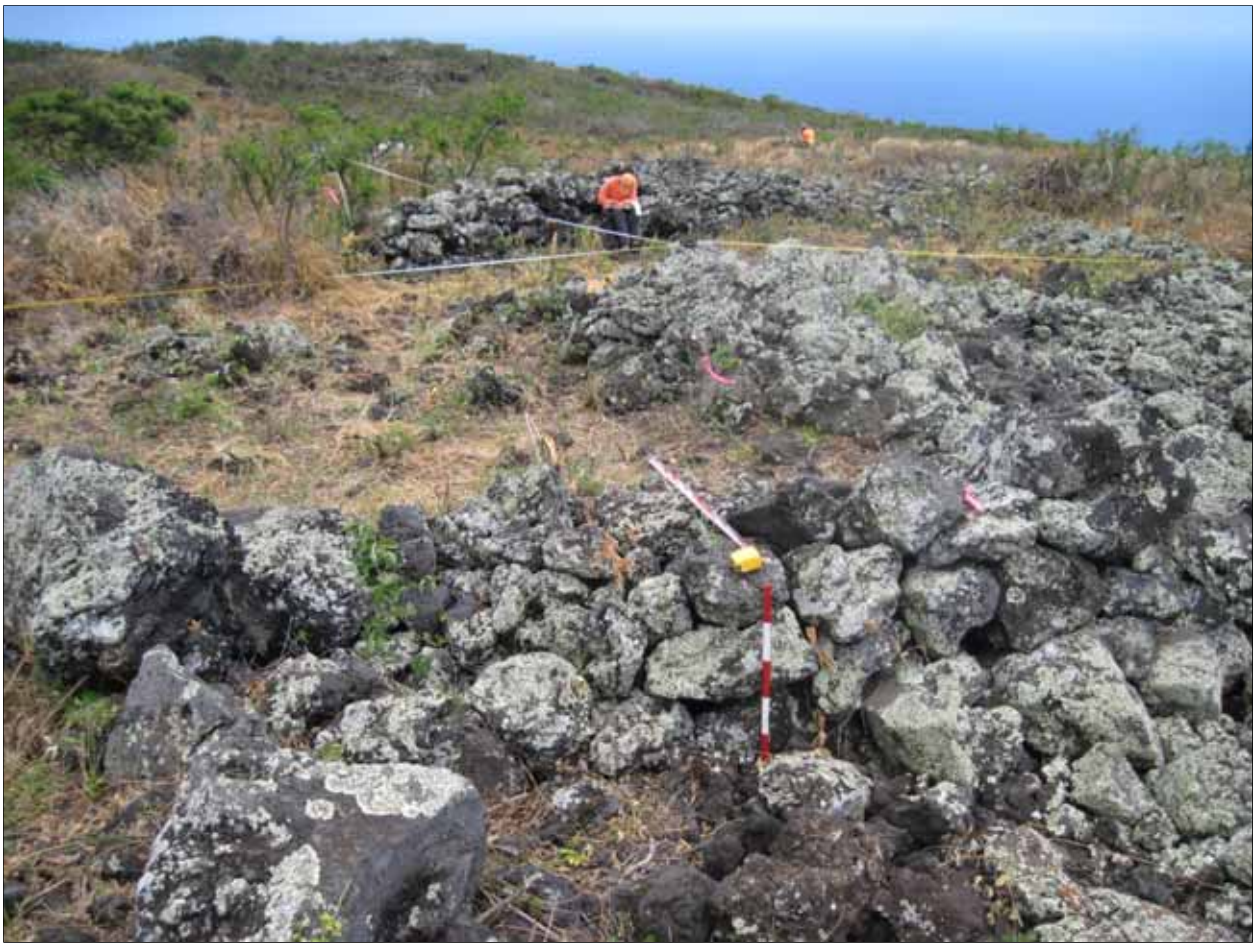


Figure 11. Overview of Site AWF-312 showing Feature F wall (foreground at meter stick), Feature G cleared area and Feature H wall behind crew member in center (view to SE).

Site AWF-316

This site consists of three terraces reflecting habitation and agricultural activity. The site is adjacent and east of Site AWF-312 being separated from it by the upper end of a drainage (which turns into a substantial water worn stream channel several hundred meters downstream leading to the large ceremonial, habitation and agricultural complex at Site AWF-176). Terrace Features A and B have nice level flats with soil development and the terraces walls are substantial in size suggesting they could have been used for habitation, although their proximity to the drainage would have allowed for agricultural functions as well. No midden or artifacts were observed at Feature A, but midden and coral fragments were noted at Feature B. The Feature C terrace flat is rockier with patches of soil, is relatively smaller in size and not as suitable for habitation, although it does contain small shell midden fragments. A large flat area adjacent and below the terraces is currently used as a cattle watering trough location and would have also provided an excellent spot for agricultural pursuits due to its soil development and proximity to the drainage.

Site AWF-318

This agricultural and habitation complex is comprised on nine features including two habitation terraces, three modified outcrops, three cleared areas and a C-shaped wall. The existing dirt access road extends through the northern portion of the site. The most impressive features are two adjacent crescent shaped soil filled habitation terraces; the upper terrace (Feature A) contains the remnant of a rectangular fire hearth, with the lower terrace (Feature B) being adjacent and *makai* of Feature A with an impressive retaining wall and a coral abrader artifact. Feature A measures approximately 9 m long and 3 m wide with the fire hearth interior measuring 38 cm by 28 cm. Feature A also contains a basalt flake, *porites* coral fragments and clam shell fragments. Feature B terrace measures approximately 6 m by 2.5 m and contains shell midden, coral fragments and charcoal flecking. The retaining wall supporting the two terrace features is 11.8 m long with a height of 0.8 to 1.4 m (Figure 12). The site is associated with nearby Sites AWF-312, AWF-321 and AWF-322.

Figure 12. Overview rock retaining wall supporting terrace Features A and B at Site AWF-318 (view to SE).

Site AWF-325
This site consists of a U-shaped wall which is constructed on a relatively level area of exposed *pāhoehoe* bedrock. It opens to the south-southwest providing shelter from the northeast trade winds. The opening is 3.1 m wide and from the opening it extends 3.7 m to the back wall. The wall averages 0.35 to 0.55 cm high and 1 m wide. The feature is in poor to fair condition with much of the wall being tumbled although sections of it still exhibit stacking of two to four courses of stone. No cultural materials were observed at the site. It likely functioned as a temporary habitation area and is associated with nearby site AWF-326.

Site AWF-326
This complex was originally recorded in 2010 consisting of six features (A-F) related to agriculture and habitation. The six features included a large rectangular C or U-shaped wall, a stone terrace, a stone mound complex, a stone terrace with mounds, a stone terrace with mound, and stone clearing alignment with stacked planting area. Additional features were noted extending beyond the revised APE during the 2010 recording. Five additional features were recorded in 2011 within the revised APE reflecting additional agricultural and habitation activity. These features include: Feature G, a stone mound; Feature H, an L-shaped rock filled terrace; Feature I, a rough stone platform; Feature J, a soil filled terrace; and Feature K, a stone filled terrace.

Site AWF-327
This temporary habitation complex was originally identified during the 2007 pedestrian survey but not formally recorded until 2011 as the site area was originally outside the APE. Three features were identified at the site extending into the revised APE. Feature A is linear mound which may represent a wall remnant associated with Feature B, a small enclosure. The Feature B enclosure is incorporated into an L-shaped wall designated as Feature C. All three of these features are in close proximity (within a few meters) to each other. A cleared flat area extends west of the wall forming the eastern edge of Feature B (enclosure) and Feature C (L-shaped wall). Pieces of *porites* coral were identified at Features B and C but no shell midden was observed. The eastern wall forming the enclosure (Feature B) and L-shaped wall (Feature C) incorporates *pāhoehoe* slabs which have been set on their ends with core filling, with the maximum wall height being 60 cm at Feature B and 95 cm at Feature C.

Site AWF-331
This agricultural and temporary habitation complex was originally recorded in 2010 and consisted of 8 feature areas including six agricultural related feature areas (Features A, B, D, E, F, and H) consisting of stone clearing mounds, agricultural terraces, cleared areas for planting and a rock wall. Two habitation features were also noted; Feature C is a C-shaped wall and Feature G is an enclosure. Sparse amounts of cowrie shell and a *porites* coral fragment were the only cultural constituents identified at the site. In 2011, two pieces of flaked stone (a basalt flake and basalt core) were identified within the site area and an update to the site record was prepared.

Site AWF-333/336

This newly recorded site complex is comprised of 16 features associated with agriculture, habitation and possible burial functions. The site is situated along a ridge and side slope overlooking a swale/sediment basin to the east which would have provided an excellent location for agricultural pursuits. The features include four walls (Features A, E, L, and O), three mounds (Features B, C and D, with D being a likely burial feature), an enclosure (Feature F; Figure 13), a rock alignment (Feature G), a modified overhang (Feature H), four terraces (Features I, J, K, and M, with Feature J being a habitation terrace; Figure 14), and two modified outcrops (Features N and P). Feature F may have had a ceremonial function in addition to its habitation function because of the presence of branch coral in the enclosure. The site likely extends beyond the APE corridor, but this area was not thoroughly explored, only those features visible or adjacent from the APE were noted. The habitation features F and J contained sparse amounts of shell midden suggesting that these represent habitation features associated with the agricultural activity. The Feature D mound is more formally constructed than your typical agricultural clearing mound and its size and shape is suggestive of a burial feature.

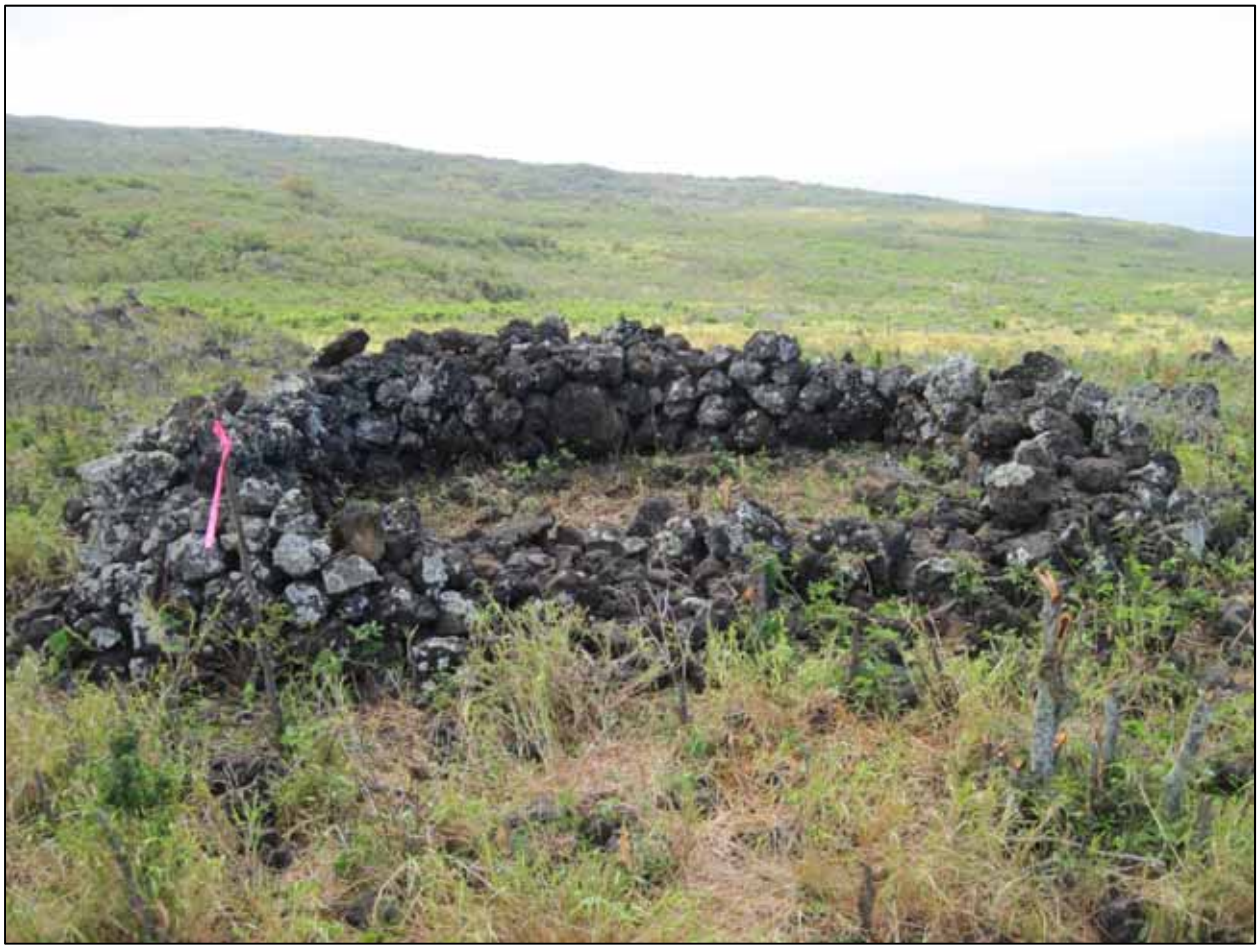


Figure 13. Overview of enclosure Feature F at Site AWF-333/336 (view to E).

Figure 14. Overview of crew recording terrace Features I (background) and J (foreground) at Site AWF-333/336 with swale at right likely used for agriculture (view to N).

Site AWF-354

This site was originally recorded in 2010 as an agricultural complex with a possible burial feature and marker. Feature A is a terrace constructed from modifying an outcrop. Its function is uncertain and may be related to agriculture or temporary habitation. Feature B consists of agricultural terraces, Feature C is a prominent rock cairn (likely a marker) and Feature D is a well constructed triangular mound which may represent a burial feature (Figure 15). In 2011, the site was revisited and updated due to the changes in the APE. Eleven additional features were identified and the Feature B agricultural terrace system was expanded to include five related terraces. The additional features include two agricultural terraces (Features E and O) and nine rock mounds (Features F-N) which are likely agricultural but are in the vicinity of Feature D which may represent a burial based on its size and construction. The site is located in a swale/sediment basin and adjacent ridgeline which would have provided a good location for agricultural pursuits. Additional features are likely located on the ridge beyond the APE.

Figure 15. Overview west of Feature D mound at Site AWF-354 (view to W).

Site AWF-358

This complex of 16 features represents agricultural and habitation activity. The features include nine terraces (Features A, B, C, D, E, G, H, J, and K) with Features A, B, and C possibly associated with habitation due to their size and construction. The massive retaining wall associated with Feature A terrace is reminiscent of a high status residence although its poor condition and steep slope of *ʻaʻā* flow on the back of the feature obscure its interpretation. A large water worn stone (25 cm by 16 cm by 10 cm) located at the Feature A terrace retaining wall was the only cultural constituent observed at the site. In addition to the terraces, the site also contains four clearing mounds (Features F, I, M, and N) and rock lined, cleared areas which appear to represent planting circles (Features L, O, and P). Additional features are likely located beyond the APE corridor but time constraints prohibited exploration beyond the APE. The site is likely associated with nearby Site AWF-354 to the south.

Site AWF-568

This small habitation and agricultural complex is comprised of four features. Features A is a U-shaped wall while Features B, C, and D represent agricultural clearing mounds. The site is located adjacent to a swale which would have provided a good location for agriculture.

Additional features were noted to the east beyond the APE, but this area was not examined in detail. No cultural constituents were observed at the features. The site is associated with nearby site complex AWF-333/336 to the northwest.

Site 50-50-15-7026
This site was first identified and recorded during the 2010 fieldwork. It was recorded as an agricultural and temporary habitation complex consisting of at least six features, however only two of them were recorded in detail as the remaining features were outside of the APE and time constraints did not allow for detailed recording of them. Feature A is a terrace which may have been impacted by construction of the existing dirt access ranch road. Feature B consists of two agricultural clearing mounds. Additional features noted but not fully recorded include Feature C an agricultural clearing mound, Features D an enclosure remnant, Feature E a habitation terrace and Features F another enclosure remnant. In 2011, the site was revisited and an additional feature was recorded; Feature G a C-shaped wall which appears to be associated with temporary habitation.

Site AWF-2011 E
This newly identified and recorded single feature site consists of a circular alignment of *pāhoehoe* slabs located within a flat *pāhoehoe* lava flow. Five of the *pāhoehoe* boulder slabs have been set on their ends while the remaining slabs forming the alignment are flat or tilted. A relatively flat and cleared space is formed within the interior of the alignment measuring approximately 1.4 m north-south by 1.2 m east-west. The feature is in poor to fair condition with the most intact portion of the alignment being on the east and northeast sides. This would have provided shelter from the trade winds suggesting the feature may represent the remains of a C-shaped wall structure used for temporary habitation. No cultural constituents were observed at the feature.

Site AWF-2011 F
This single feature site consists of a terrace with an L-shaped retaining wall. The wall supports a cleared flat measuring approximately 3 m north-south by 4.5 m east west. The eastern wall of the terrace is 60 cm high and may have served as a windbreak, while the southern side of the wall is flush with the terrace surface which is approximately 40 cm above the surrounding terrain. The area has been disturbed by ranching activity and a number of boulders have been pushed by heavy equipment just south of the site. The only cultural constituent observed was an historic saw blade located approximately 10 m southwest of the terrace. The terrace could have been used for temporary habitation or possibly for agriculture.

Site AWF-2011 G
This agricultural complex is comprised of seven features. Features A and G are C-shaped rock alignments but due to their small size, rocky interior, and orientation appear to have functioned as agricultural planting locations. Feature B is a small stone filled terrace that may have functioned as an activity area related to agriculture. Features C, D, E, and F are modified outcrops which appear to be associated with agricultural clearing activity near the two drainages that extend through the site. No midden or other cultural constituents were observed at any of the features.

Site AWF-2011 H

This habitation complex is composed of six features; Feature A is a C-shaped wall, Feature B is a lava tube, Feature C is a L-shaped wall with an adjoining cleared flat, Feature D is a stone mound, and Features E and F are stone filled terraces. Constituents observed include shell midden, *porites* coral, water worn stones, basalt flakes, a basalt core and a coral abrader. The site is located in an area of *'a'ā* lava outcrops in a densely vegetated area. The most impressive feature at the site is the lava tube/shelter (Feature B) which contains shell midden, basalt artifacts, the coral abrader, *porites* coral fragments, water worn stones and charcoal fragments reflecting habitation use. The entrance to the shelter is 5 m long with a maximum height of 1.5 m (Figure 16). Rock retaining walls and terracing is located just outside the entrance as well as within the shelter interior. The C-shaped wall, L-shaped wall and stone filled terraces are interpreted as habitation features. The stone clearing mounds function is uncertain but appears to be related to the clearing of the habitation features as there were no agricultural features noted in the site vicinity. The site may be related to the agricultural mound complex of Site AWF-2011 I which is located approximately 50 m to the northeast.

Figure 16. Overview of entrance to Feature B, lava tube/shelter at Site AWF-2011 H (view to NE).

Site AWF-2011 I
This agricultural complex consists of eight stone clearing mounds (Features A-H). Three of the mounds are located on a finger ridge while the remaining mounds are located within a small swale which would have been a good location for agriculture. No cultural constituents were observed within the mounds or site area. It is likely associated with nearby sites AWF-2011 G approximately 50 m to the east and AWF-2011 H approximately 50 m to the southwest.

Site AWF-2011 J
This site consists of two temporary habitation features. Feature A is a C-shaped wall with an adjacent boulder alignment and a few basalt flakes. The C-shape measures 2.5 m by 3.0 m with its walls ranging in height from 10 to 50 cm. The C-shape incorporates *pāhoehoe* slabs some of which are set on their ends. Feature B is a stone filled terrace measuring approximately 2.0 by 1.0 m in size and is believed to be associated temporary habitation as there is no soil within or near the feature location. No midden or artifacts were identified in the Feature B area.

Site AWF-2011 K
This habitation and agricultural complex consists of eight feature areas including an extensive lava tube system. The site is located upon a lava flow ridgeline with dense vegetation. Feature A is the main lava tube which extends southeast from its opening for at least 40 m. The tube opening measures approximately 180 cm wide and 90 cm high (Figure 17). Inside the Feature A lava tube at 4 m from the entrance is a tumbled wall which spans the width of the tube chamber and measures approximately 40 cm high (Figure 18). The wall would have deterred entry into the cave and is suggestive of a burial or refuge cave feature. The tube chamber was explored to the southeast for a distance of approximately 40 m but the lava tube continues beyond that point. The only materials observed within the explored portions of the Feature A lava tube were the tumbled wall, a few pieces of *porites* coral fragments and some charcoal flecking. It was decided to adjust the APE to the east of this site to avoid the archaeological and engineering challenges which would have occurred with regard to the lava tube system. As such, the Feature A tube was not explored further as it is going to be avoided by the project. The following is a brief description of the remaining features which will be similarly avoided due to the shift of the revised APE to the east of the lava ridge.

Feature B is a smaller lava tube with two entrances which is located 3.5 m northwest of the larger Feature A lava tube. From the entrances, Feature B extends to the northwest for 4-5 m at which point the tube chamber terminates. The northern entrance is 1.4 m wide and 80 cm high while the southern entrance is 60 cm wide and only 30 cm high. There is a large amount of boulder and cobble rubble at the north entrance suggesting that it may have been formerly filled in. No cultural constituents were observed within the Feature B lava tube. Feature C is a small lava tube with a piled stone terrace at the entrance. The lava tube chamber is small measuring 3 m by 2 m by 80 cm high with an unidentifiable piece of marine shell midden and two fragments of *porites* coral being present. Feature D is a stone filled terrace whose wall is 3.6 m long and 65-80 cm high with a cleared flat to the west measuring 3.4 m by 4.0 m. Features E, F and G are stone clearing mounds which appear to be related to agriculture. Feature H is a small lava tube or lava blister with piled stones at the entrance, its function is uncertain as it is too small for a living space but may have been a storage feature. The site is related to nearby site AWF-169/2011 L to the east.

Figure 17. Overview of lava tube entrance (Feature A) at Site AWF-2011 K (view to S).

Figure 18. View of interior of Feature A lava tube showing rock wall beyond entrance at Site AWF-2011 K (view to S).

Site AWF-2011 M

This habitation and agricultural complex is comprised of seven features and is associated with nearby Site AWF-312 to the east. Feature A is a C-shaped wall represents a temporary habitation feature associated with adjacent agricultural activity. Features B and D are stone clearing mounds and Feature C is a modified outcrop, with all three features located along a seasonal drainage which would have provided a water source for cultivation. Features E, F, and G are terraces which are associated with agriculture and habitation. The most impressive terrace is Feature E which incorporates a natural bedrock outcrop along its east and southeast retaining wall which is a meter above the surrounding terrain and intermittent drainage to the east of the terrace. The terrace retains a flat soil filled area which measures 4.8 m east-west by 5.3 m north-south and would have been an excellent location for habitation or agricultural pursuits (Figure 19). No cultural constituents were observed on Feature E terrace. The Feature F terrace is located *mauka* and east of Feature E and has been impacted by the construction of the dirt access ranch road. Although difficult to discern due to its impacts, Feature F appears to be agriculturally related due to its proximity to the drainage/swale. Feature G is a small stone filled terrace located across the drainage/swale from Feature F and also appears to be agriculturally related. No cultural materials were observed at terrace Features G or F.

Figure 19. Overview of terrace Feature E at Site AWF-2011 M (view to SE).

Site AWF-2011 N
This single feature site consists of the disturbed remains of an L-shaped wall. The dirt access road is located adjacent and east of the feature which likely represents the structural remains of and which likely represents a former enclosure or walled terrace which was impacted during the road construction. The wall is core-filled and measures 2.2 m long by 2.2 m wide being 50-90 cm thick and 20-70 cm high above the ground surface. The flat interior remnant of the structure measures 2.4 m by 2.3 m. Although disturbed along its eastern edge, the remaining portion of the feature is in relatively good condition. A fragment of branch coral was identified in the disturbed eastern portion of the feature which is believed to represent the remains of a habitation feature.

Site AWF-2011 O
This site consists of a terrace reflecting temporary habitation or agricultural use. It is located on a finger ridge and constructed by rough stacking and piling of boulders and cobbles on its down slope western edge to retain a level soil area behind it to the east. The terrace retaining wall is 40 to 75 cm high with the terrace flat being 4.2 m long by 2.0 m wide. The terrace is divided by an east-west rock alignment forming an upper section to the north and a slightly lower section to the south. No midden or other cultural constituents were observed at the site.

Site AWF-2011 P
This complex consists of two features which appear to represent the disturbed remains of a high status residential structure or possibly a ceremonial complex. The site is located on a lava ridge with a prominent overlook of the surrounding area. Feature A is a large U-shaped wall remnant which is located on the ridge crest. Active cattle watering features are located on either side of the ridge. The U-shaped wall is in three disturbed segments which incorporate bedrock escarpments from the ridge into its construction. It opens to the southeast and the interior measures approximately 12 m long by 6 m wide. The wall is very disturbed with much of it having tumbled or have been removed for reuse. However, the intact sections of the wall are fairly massive being 1.2 m thick and nearly a meter high with faced sections. A large water worn cobble (Artifact 1) measuring 45 cm long by 28 cm wide and 12 cm thick was noted adjacent and east of the wall and may represent a former upright stone. Two smaller water worn stones and shell midden were also noted at the feature.

Feature B is a sealed cupboard which is incorporated into the bedrock forming the Feature A wall. The cupboard measures approximately 1.3 to 1.8 m deep with a width of 80 cm and a height of 30 to 50 cm. Within the cupboard is a bowl shaped wooden artifact (Artifact 2) with rough axe-like hew marks (Figure 20). The artifact measures approximately 45 cm long by 15-20 cm wide with the carved out portion measuring 25 cm long by 12-14 cm wide and 7-9 cm deep. The artifact was the only cultural material observed within the cupboard feature. The wooden artifact and feature area were previously shown to the crew by ʻUlupalakua ranch staff during the 2010 fieldwork at which time it was outside the APE. Although the site has been heavily disturbed, its setting on the prominent ridgeline along with its construction and the presence of unique artifacts suggest the site had a ceremonial or high status function unlike the typical agricultural or temporary habitation features present in the project area.

Figure 20. Close-up of Artifact 2 (wood bowl) from Feature B cupboard at Site AWF-2011 P.

Site AWF-2011 Q

This single feature site consists of a rectangular stone walled enclosure (Figure 21). It measures approximately 6 m north-south by 4.5 m east-west with walls averaging a meter thick and maximum height of 1.2 m. The interior of the enclosure is dirt filled with the wall interior being well stacked and faced in sections. The wall construction is core filled with larger cobbles and boulders on the exterior and smaller cobbles and pebbles filling the wall interior. Pockets of ashy soil were noted in the interior although no hearth feature was observed. A piece of *porites* coral and a few water worn boulders were noted at the feature. The feature appears to represent a habitation structure based on the dark stained and ashy soil within the enclosure. It is located approximately 30 m southeast of the southernmost feature (Feature OO) at the extensive habitation and agricultural complex of Site 50-50-15-6906 and is likely associated with the features at the southern end of this complex.

Figure 21. Site AWF-2011 Q enclosure with Puʻu Hōkūkano cinder cone in background (view to W).

3.4 SUMMARY OF RESOURCES RECORDED

A total of 264 sites were recorded during the 2010 and 2011 fieldwork for the Auwahi Wind Farm Project (Shapiro et al 2011). Some of these represent individual features while others consist of feature complexes (related features in proximity to each other or on the same landform). Of these, portions of 161 sites or feature complexes, composed of more than 638 individual features, are located within or immediately adjacent to the revised APE.

The features within the site areas represent a variety of resource types which can be grouped by functional category. These include:

Agricultural
Animal Husbandry
Burial
Ceremonial

Habitation
Ranching
Transportation

A tabulation of all of these resources is presented in Table 2; and Figures 22-39 depict the distribution of these resources. Appendix A presents individual site and feature forms and Appendix B presents a comprehensive data table for the attributes recorded at these newly recorded resources. The reader is referred to Appendix B and Appendix C in the Auwahi AIS report (Shapiro et al. 2011) for details regarding the sites and features which were recorded in 2010 for which no updated recording was required in 2011. It must be noted that many of the larger site complexes can have features reflecting more than one function (e.g., Site XX contains habitation, agricultural, and ceremonial features). In Table 4, sites listed as "in" have some (but not necessarily all) features located within the revised APE; those listed as "out" have no features within the revised APE.

Table 2. Listing of Sites and Features in the Revised APE

	Site Number (50-50- or AWF-)		Site Type	Function	No. of Features
Wind Farm	6820		Complex	Agriculture / Habitation / Uncertain	6
	6821		Complex	Agriculture / Habitation / Transportation / Uncertain	7
	6827		Complex	Agriculture / Burial / Habitation / Uncertain	23
	6828		Wall	Agriculture / Ranching	1
	6829		Complex	Habitation	2
	6832		Complex	Agriculture	2
	6833		Complex	Agriculture / Habitation / Uncertain	1
	6834		Complex	Agriculture / Habitation	4
	6837		Wall	Uncertain	1
		169/2011-L	Complex	Agriculture / Habitation / Uncertain	7
	6857		Complex	Agriculture / Habitation / Uncertain	7
		312	Complex	Agriculture / Ceremonial / Habitation / Uncertain	15
		316	Complex	Agriculture / Habitation	1
		318	Complex	Agriculture / Habitation	6
	6892		Complex	Agriculture / Habitation	8
	6893		Complex	Agriculture	2
	6894		Complex	Burial / Habitation / Uncertain	2
		325	U-Shaped Wall	Habitation	1
	6895		Complex	Agriculture / Habitation / Uncertain	16
		327	Complex	Habitation	3
	6896		Complex	Agriculture / Habitation	12
	6897		Complex	Agriculture / Habitation	9
	6898		Complex	Agriculture / Habitation / Uncertain	8
		333/336	Complex	Agriculture / Burial / Ceremonial / Habitation / Uncertain	10
	6899		Complex	Agriculture / Habitation / Uncertain	4
	6904		Complex	Agriculture / Burial / Habitation / Uncertain	12
		358	Complex	Agriculture / Habitation / Uncertain	13
	6906		Complex	Agriculture / Habitation / Uncertain	29
	6909		Complex	Agriculture / Burial / Habitation / Uncertain	8
	6910		Complex	Agriculture / Habitation / Uncertain	29
	6918		Complex	Habitation / Uncertain	4
	6919		Complex	Agriculture / Habitation / Uncertain	4
	6920		Wall	Habitation	1
	6921		Complex	Agriculture / Burial / Uncertain	1

	Site Number (50-50- or AWF-)		Site Type	Function	No. of Features
Wind Farm	6922		Complex	Agriculture / Burial	2
	6923		Complex	Agriculture / Burial / Habitation / Uncertain	5
	6924		Complex	Agriculture / Habitation / Uncertain	7
		568	Complex	Agriculture / Habitation	3
	6929		Complex	Habitation / Uncertain	2
	6930		Complex	Agriculture/ Burial / Uncertain	18
	6989		Complex	Agriculture / Uncertain	3
	7026		Complex	Agriculture / Habitation / Uncertain	6
	7027		Complex	Agriculture	1
	7028		Complex	Agriculture	2
	7029		Complex	Agriculture / Uncertain	2
	7030		Complex	Uncertain	1
	7031		Modified Outcrop	Agriculture	1
	7032		Wall	Uncertain	1
	7033		Terrace	Agriculture	1
	7035		Complex	Agriculture / Burial	5
	7036		Complex	Agriculture	2
	7037		Complex	Agriculture	2
	7038		Complex	Agriculture	3
	7039		Platform	Uncertain	1
	7040		Stone Mound	Agriculture	1
	7041		Complex	Agriculture / Burial / Habitation	3
	7042		Complex	Habitation / Uncertain	6
		2011 E	Alignment	Uncertain	1
		2011 F	Terrace	Agriculture / Habitation	1
		2011 G	Complex	Agriculture	7
		2011 J	Complex	Habitation	1
		2011 K	Complex	Agriculture / Burial / Habitation / Uncertain	3
		2011 M	Complex	Agriculture / Habitation / Uncertain	6
		2011 N	L-Shaped Wall	Habitation	1
		2011 O	Terrace	Agriculture / Habitation	1
		2011 P	Complex	Ceremonial / Habitation	2
		2011 Q	Enclosure	Habitation	1
	TOTAL No. of SITES = 67			**TOTAL FEATURES =**	**361**
Pāpaka Road	6937		Complex	Agriculture	2
	6938		Complex	Agriculture / Habitation / Ranching / Uncertain	17
	6939		Complex	Agriculture / Habitation / Uncertain	4
	6940		Complex	Agriculture / Habitation / Ranching / Uncertain	8
	6941		Complex	Agriculture / Habitation	3
	6942		Wall	Ranching	1
	6946		Wall	Ranching	1
	6947		Wall	Uncertain	1
	6948		Wall	Ranching	1
	6949		Wall	Ranching	1
	6956		Enclosure	Ranching	1
	6957		Complex	Uncertain	2
	6958		Wall	Ranching	1
	6959		Complex	Ranching / Uncertain	2
	6960		Wall	Ranching	1
	6961		Wall	Ranching	1
	6962		Complex	Agriculture	1
	6963		Wall	Ranching	1
	6965		Wall	Ranching	1
	6966		Cast Iron Tank	Ranching	1
	6967		Complex	Agriculture / Ranching	2

	Site Number (50-50- or AWF-)		Site Type	Function	No. of Features
Pāpaka Road	6968		Complex	Agriculture	3
	6969		Wall	Ranching	1
	6970		Wall	Ranching	1
	6971		Wall	Uncertain	1
	6972		Complex	Habitation	1
	6974		Wall	Habitation	1
	6975		Complex	Ranching / Uncertain	1
	6976		Complex	Habitation	2
	6977		Wall	Ranching	1
	6978		Wall	Ranching	1
	6980		Wall	Ranching	1
	7014		Complex	Agriculture	12
	7015		Complex	Agriculture	6
	7016		Complex	Agriculture / Habitation / Uncertain	21
	7017		Complex	Agriculture / Ceremonial / Habitation / Uncertain	4
	7018		Wall	Ranching	1
	7019		Complex	Agriculture / Habitation / Uncertain	6
	7020		Complex	Agriculture / Habitation	3
	7021		Complex	Agriculture	3
	7022		Complex	Agriculture / Habitation / Uncertain	9
	7023		Barbed Wire Fence	Ranching	1
	7024		Complex	Agriculture / Habitation / Ranching	3
	7025		Complex	Agriculture / Uncertain	2
	7044		Terrace	Uncertain	1
	7045		Complex	Agriculture / Habitation	2
	7046		Enclosure	Uncertain	1
	7047		Wall	Ranching	1
	7048		Modified Outcrop	Uncertain	1
	7049		Complex	Habitation	1
	7050		Complex	Habitation	2
	Total No. of SITES = 51			**TOTAL FEATURES =**	**147**
Generator-Tie Line	6865		Complex	Agriculture / Uncertain	7
	6867		Wall	Ranching	1
	6874		Wall	Ranching	1
	6876		Wall	Ranching	1
	6877		Complex	Agriculture /Ranching	5
	6878		Complex	Agriculture	1
	6879		Wall	Ranching	1
	6880		Complex	Ranching	1
	6881		Complex	Agriculture / Habitation / Ranching / Uncertain	3
	6882		Complex	Agriculture /Ranching	3
	6979		Complex	Agriculture / Habitation	13
	6981		Wall	Uncertain	1
	6982		Wall	Uncertain	1
	6983		Complex	Agriculture / Uncertain	11
	6984		Complex	Agriculture / Habitation	8
	6985		Complex	Agriculture / Burial / Habitation / Uncertain	20
	6986		Wall	Uncertain	1
	6987		Complex	Agriculture / Habitation / Uncertain	7
	6988		Complex	Agriculture / Habitation / Ranching / Uncertain	14
	6995		Complex	Agriculture	1
	6996		Stone Mound	Agriculture	1
	6997		Modified Outcrop	Agriculture	1
	6998		Modified Outcrop	Uncertain	1
	6999		Complex	Agriculture	2

	Site Number (50-50- or AWF-)		Site Type	Function	No. of Features
Generator-Tie Line	7000		Wall	Agriculture	1
	7001		Stone Mound	Agriculture	1
	7002		Stone Mound	Agriculture	1
	7003		Stone Mound	Agriculture	1
	7004		Complex	Agriculture	3
	7005		Terrace	Agriculture	1
	7006		Stone Mound	Agriculture	1
	7008		Stone Mound	Agriculture	1
	7009		Complex	Agriculture	2
	7010		Complex	Agriculture	1
	7011		Complex	Ranching	1
	7012		Complex	Agriculture	1
	7013		Platform	Ranching	1
		2011 B	Stone Mound	Agriculture / Ranching	1
		2011 C	Stone Mound	Agriculture / Ranching	1
		2011 D	Barbed Wire Fence	Agriculture / Ranching	1
	TOTAL No. of SITES = 40			**TOTAL FEATURES =**	**125**
Pi'ilani Highway	6991		Wall	Ranching	1
	6992		Complex	Burial / Uncertain	3
	6994		Complex	Agriculture / Ranching	1
	TOTAL No. of SITES = 3			**TOTAL FEATURES =**	**5**

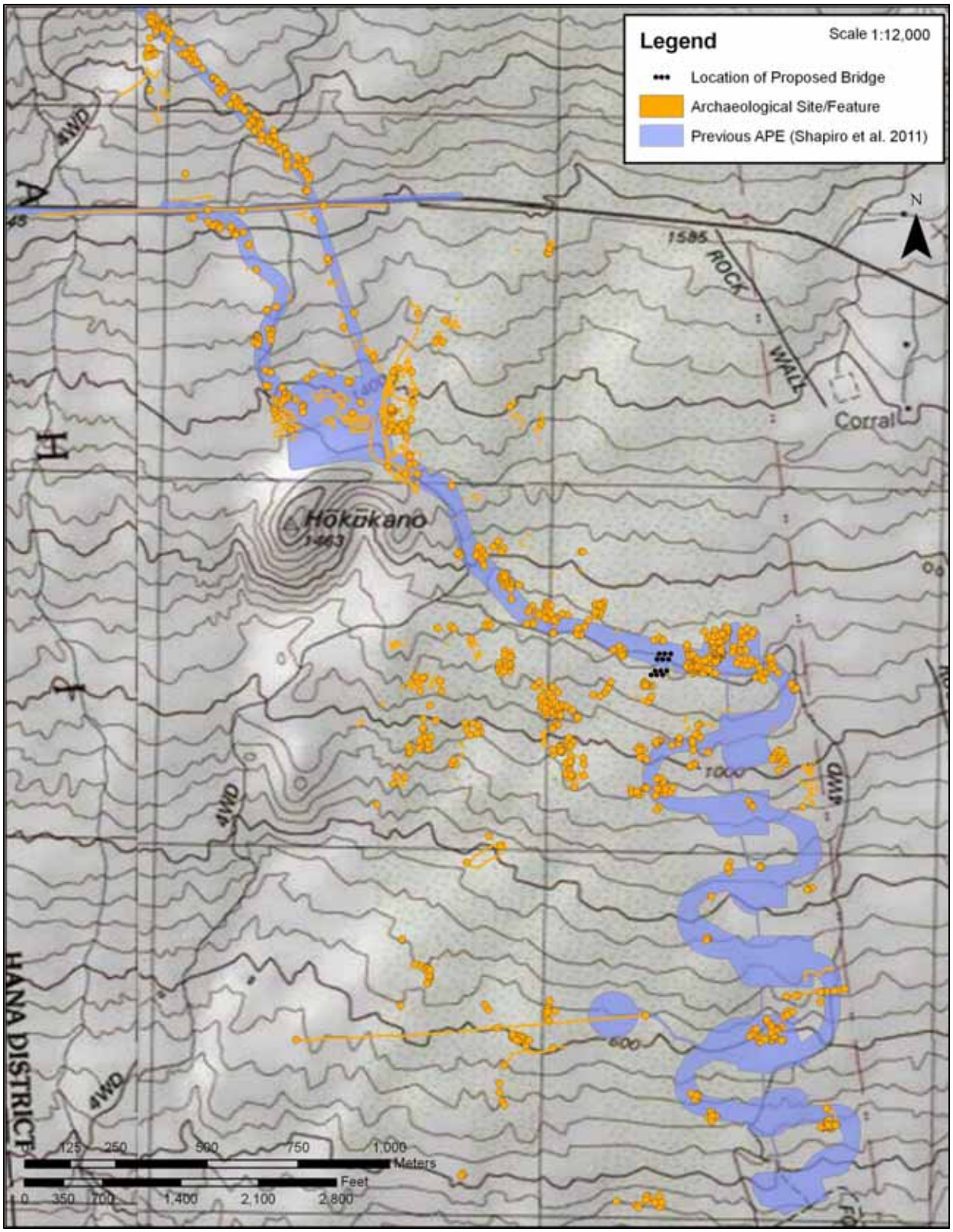


Figure 22. Over all map of Wind Farm.

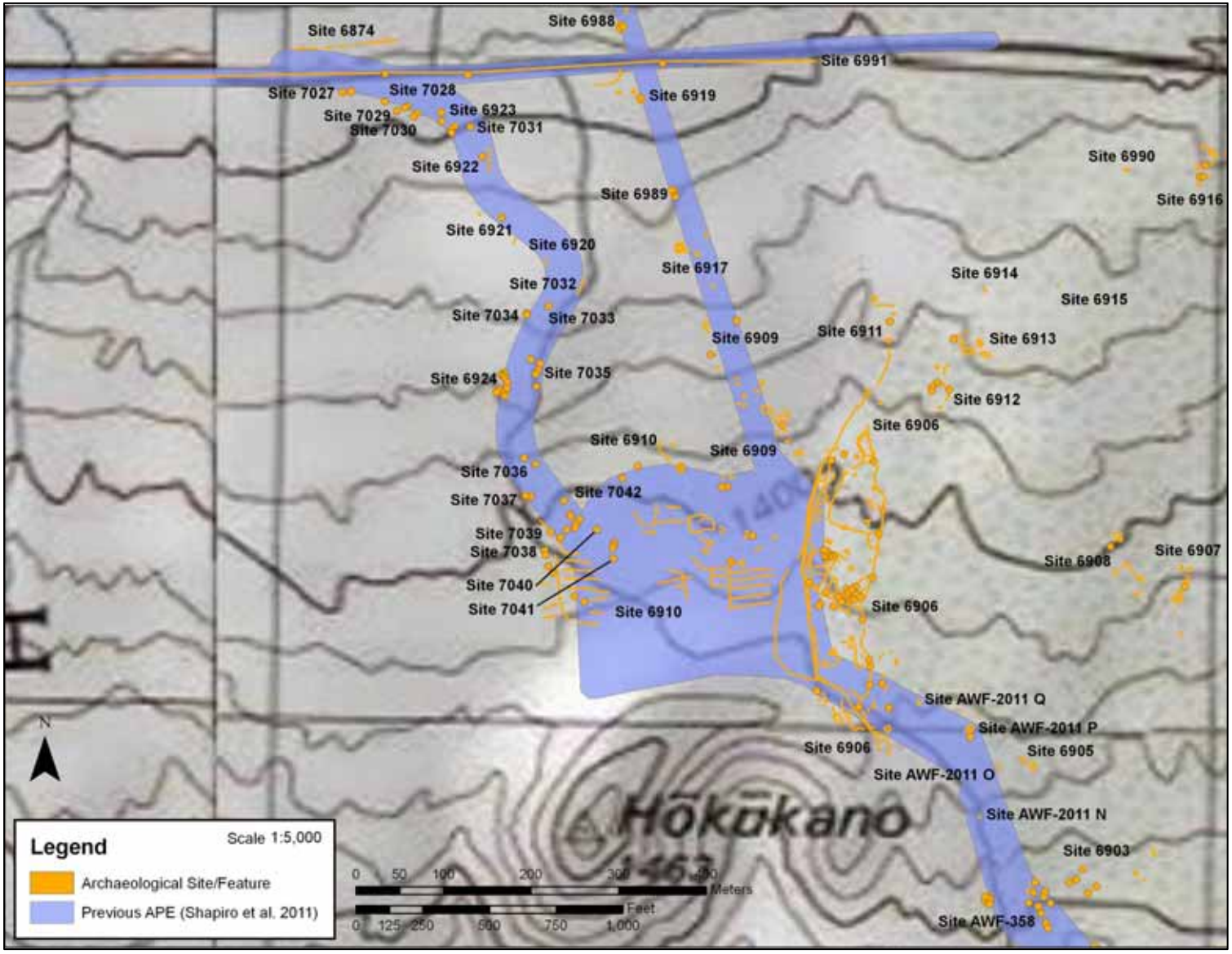


Figure 23. Site location map of northern portion of Wind Farm.

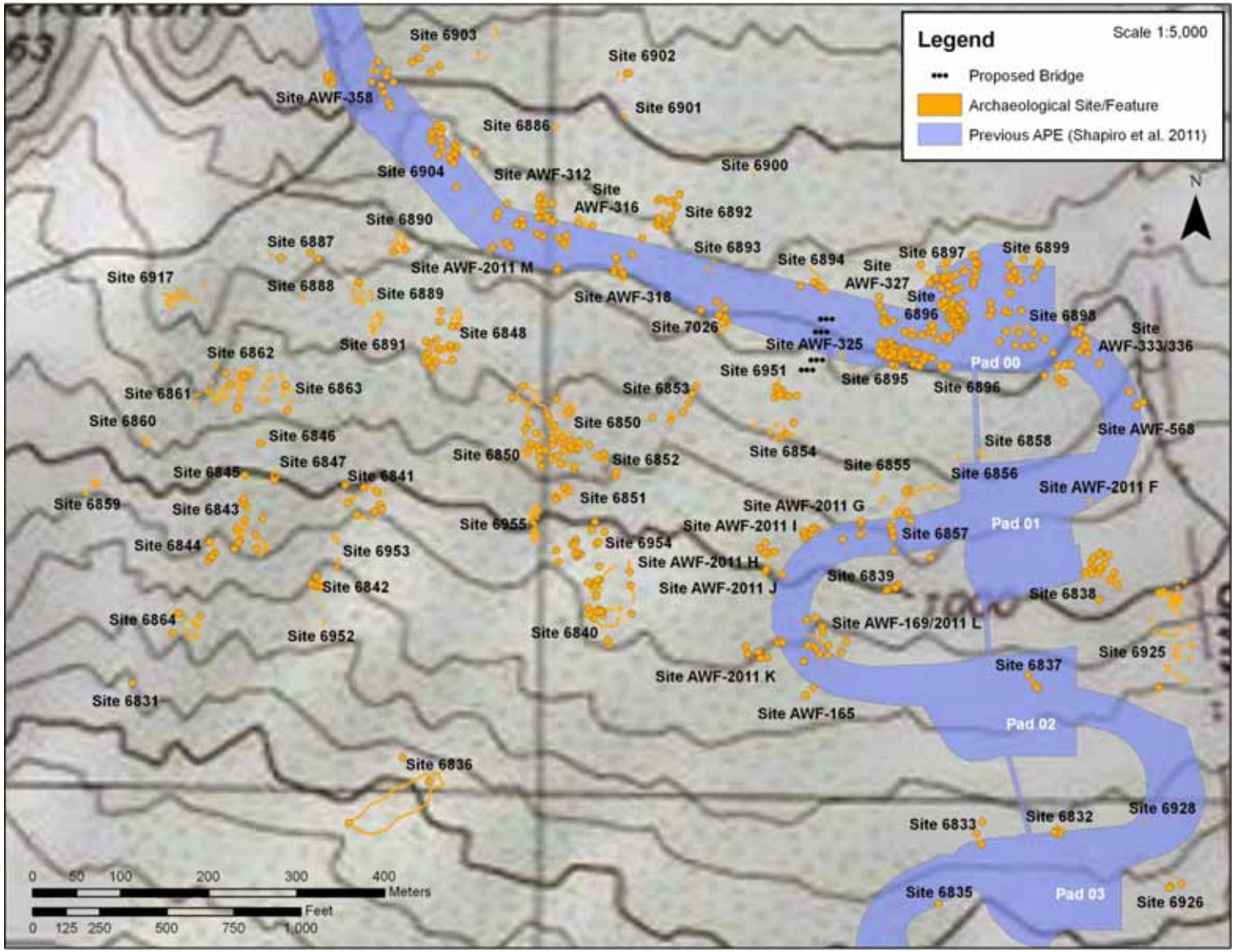


Figure 24. Site location map of central portion of Wind Farm.

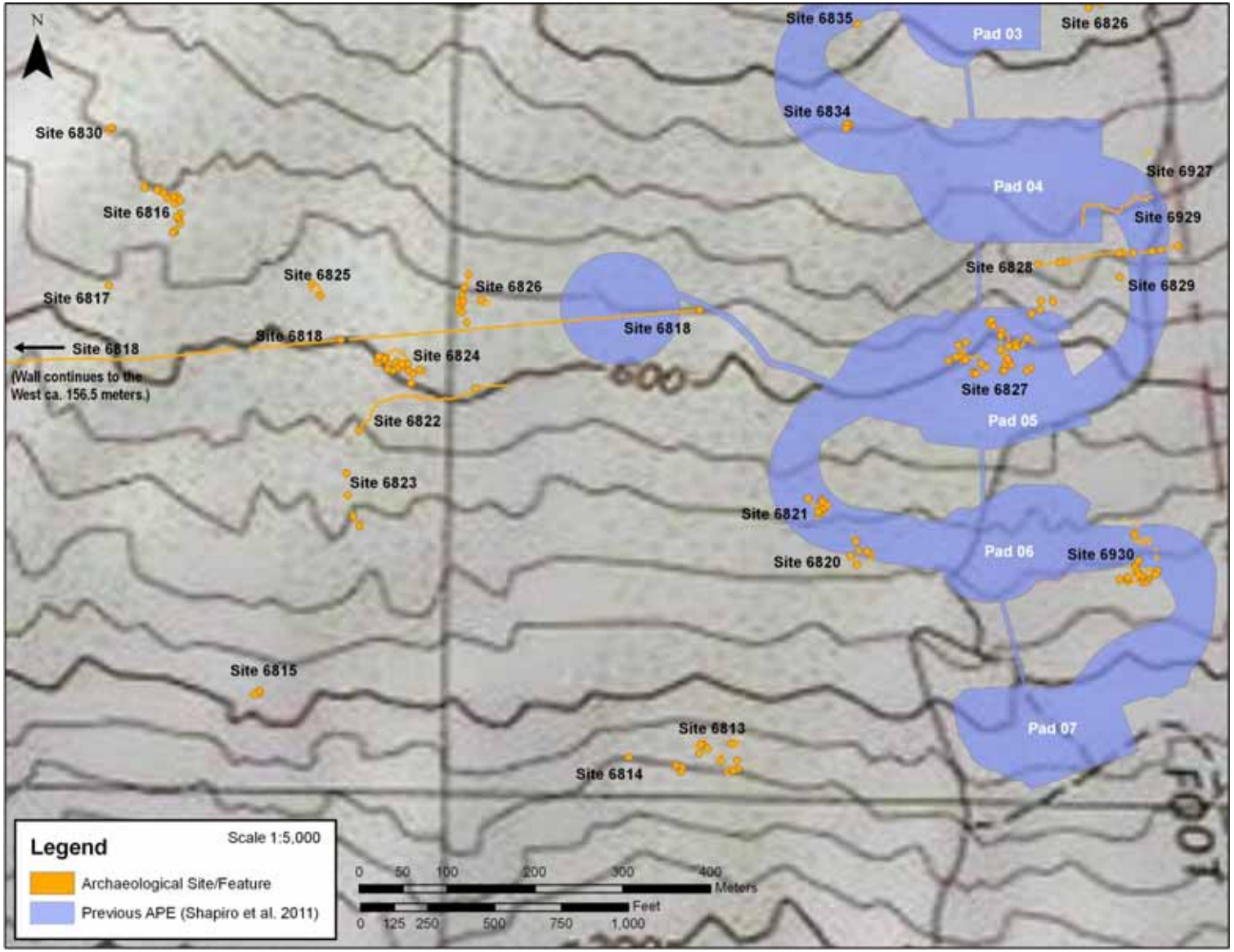


Figure 25. Site location map of southern portion of Wind Farm.

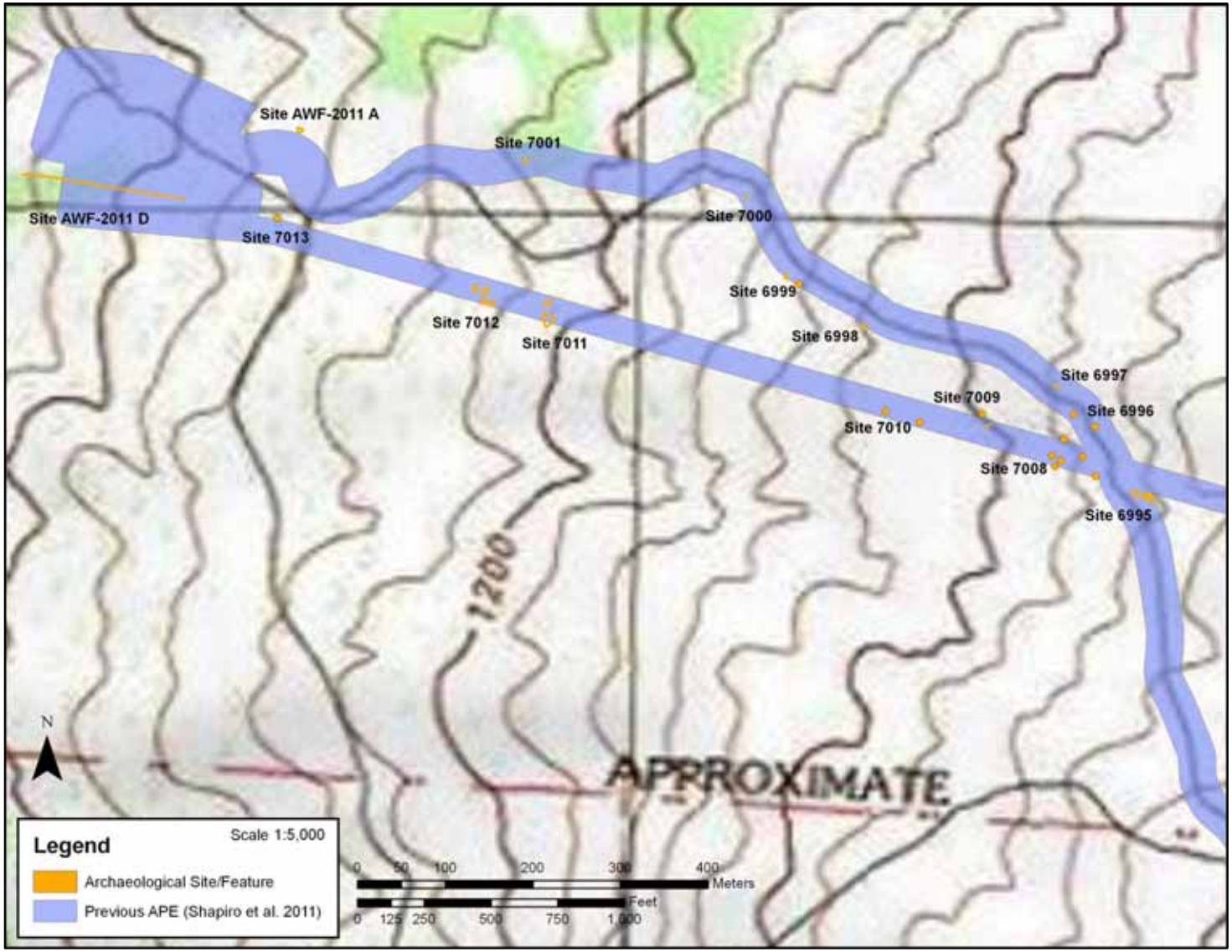


Figure 26. Site location map of Interconnection Substation and NW End of Generator-Tie Line.

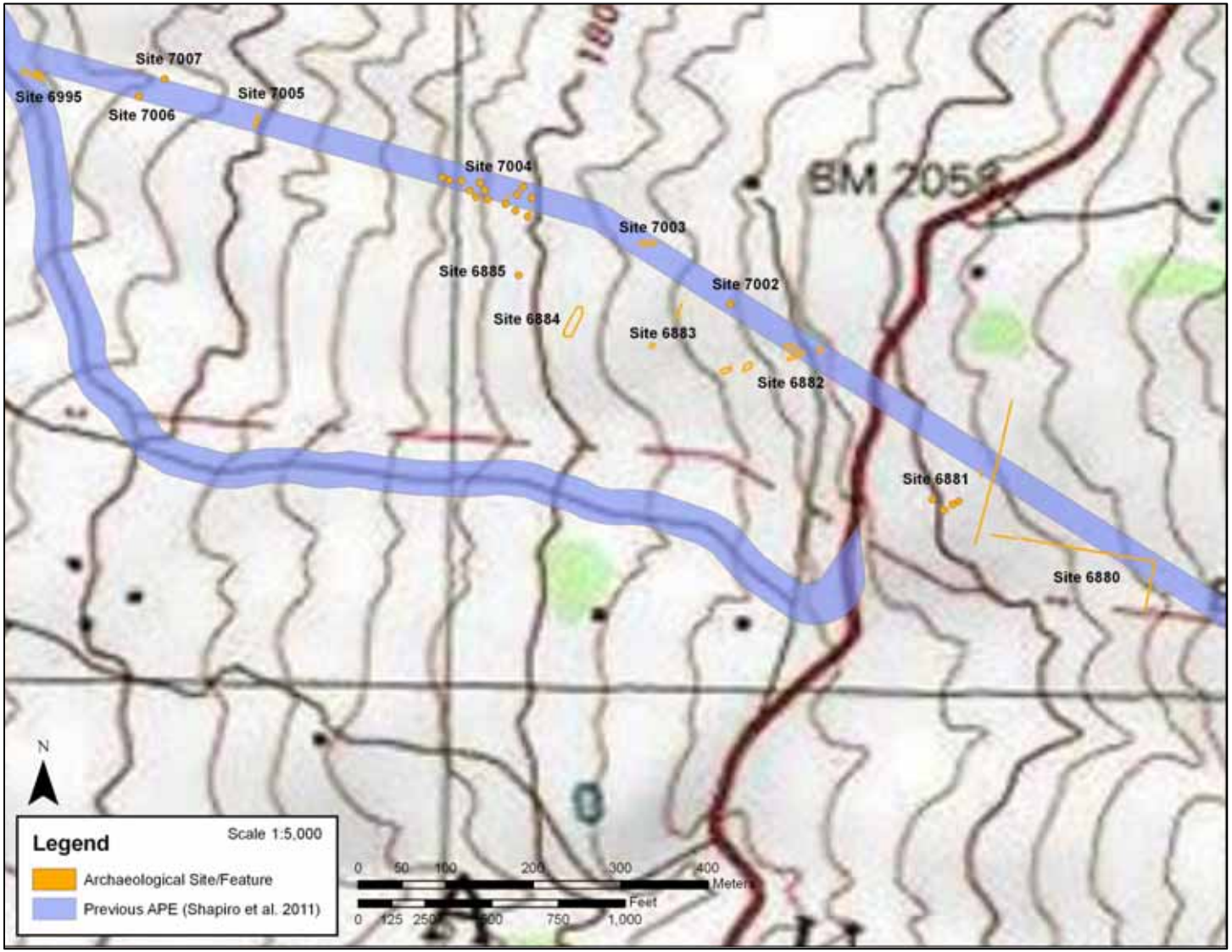


Figure 27. Site location map of Substation Access Road and Generator-Tie Line near Kula Highway.

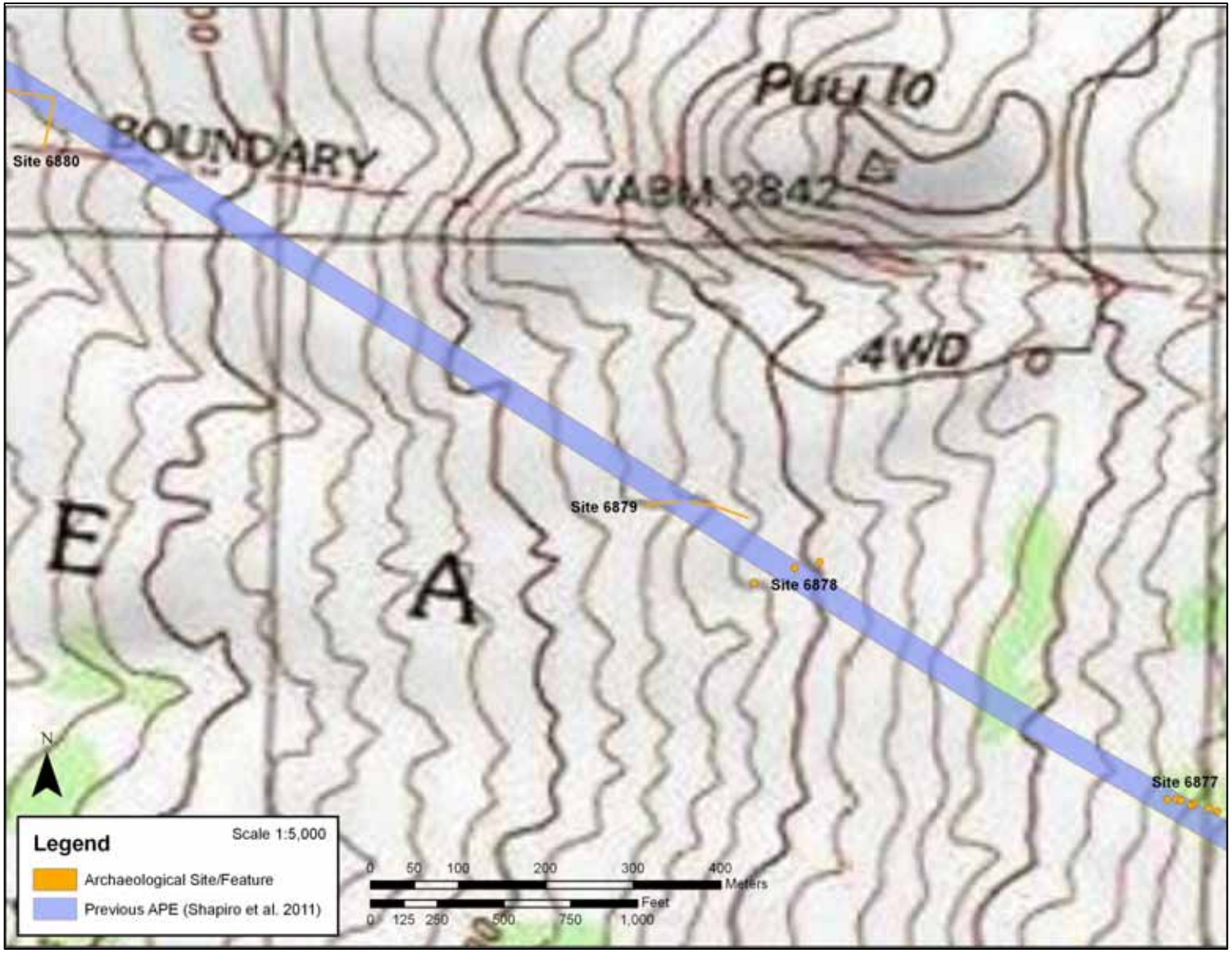


Figure 28. Site location map of Generator-Tie Line section between Figures 17 and 19.

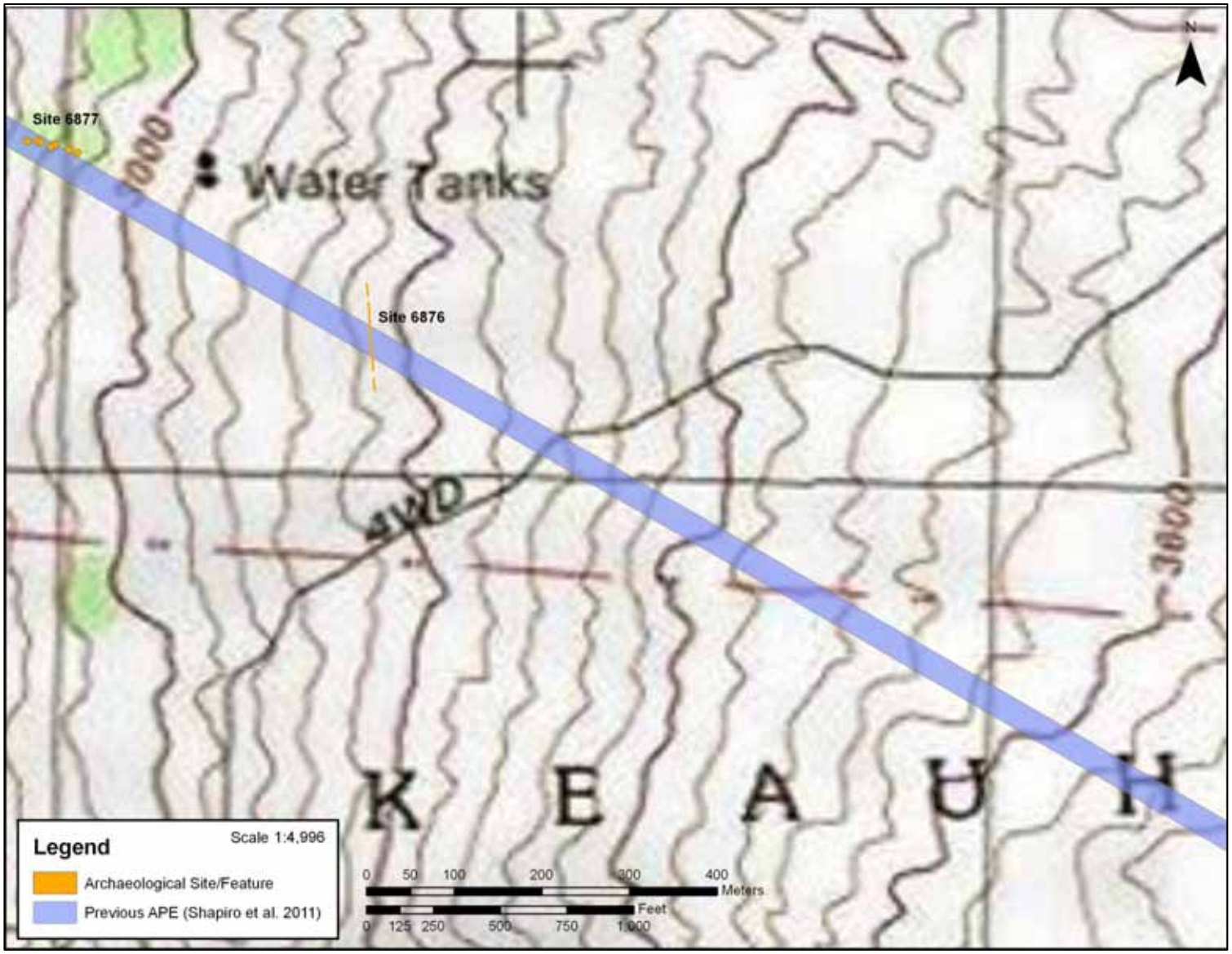


Figure 29. Site location map of Generator-Tie Line section between Figures 18 and 20.

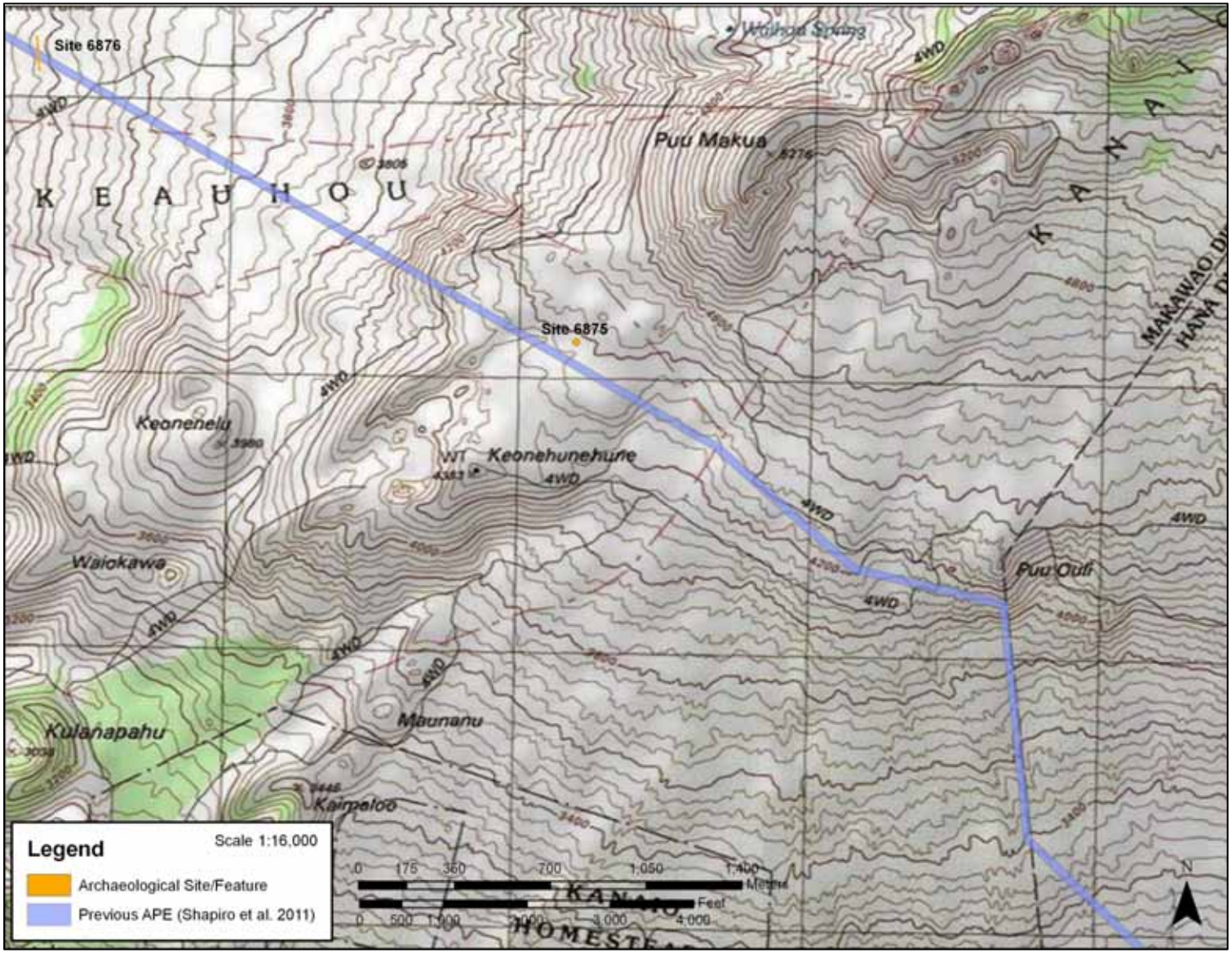


Figure 30. Site location map of Generator-Tie Line section between Figures 19 and 21.

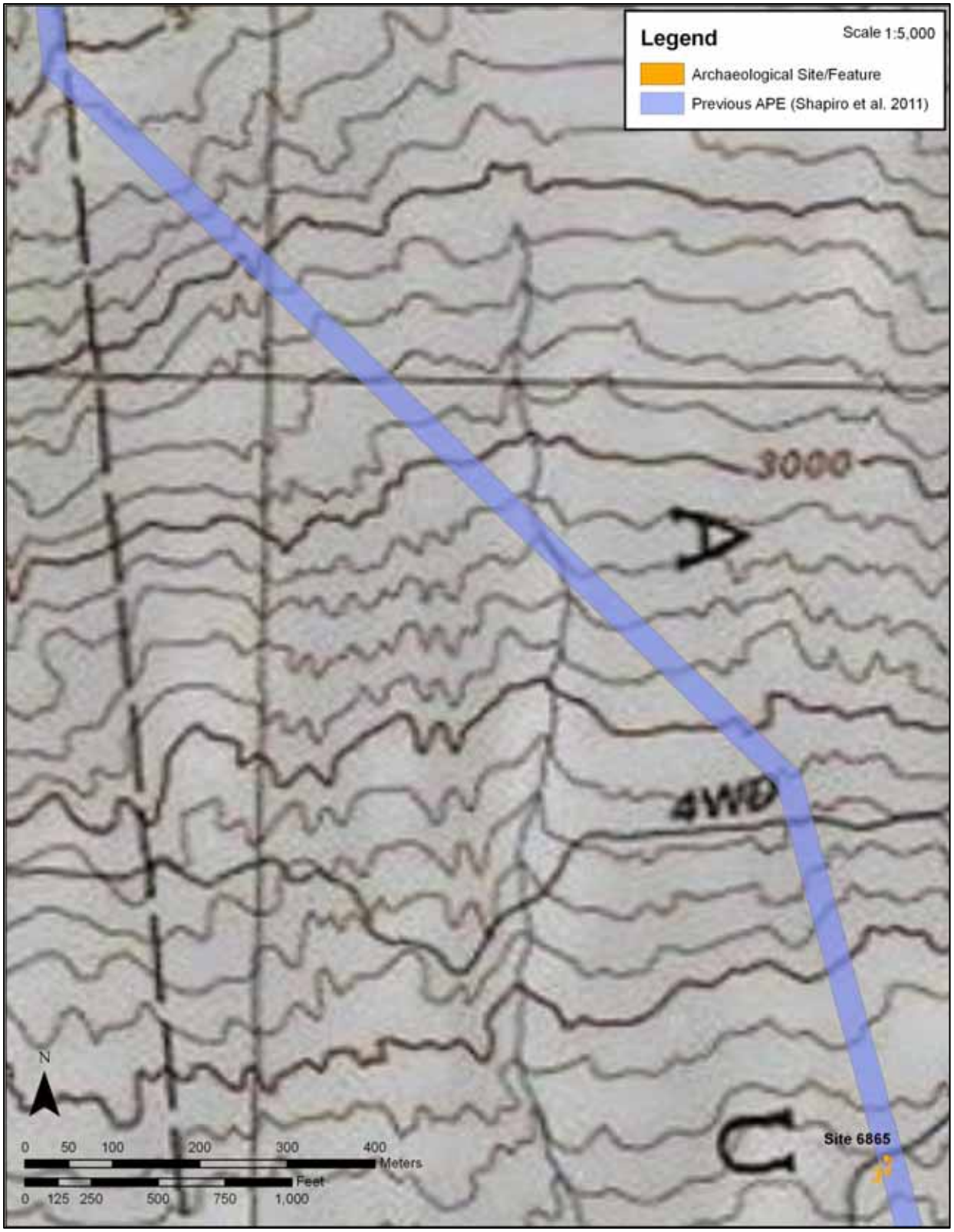


Figure 31. Site location map of Generator-Tie Line section between Figures 20 and 22.

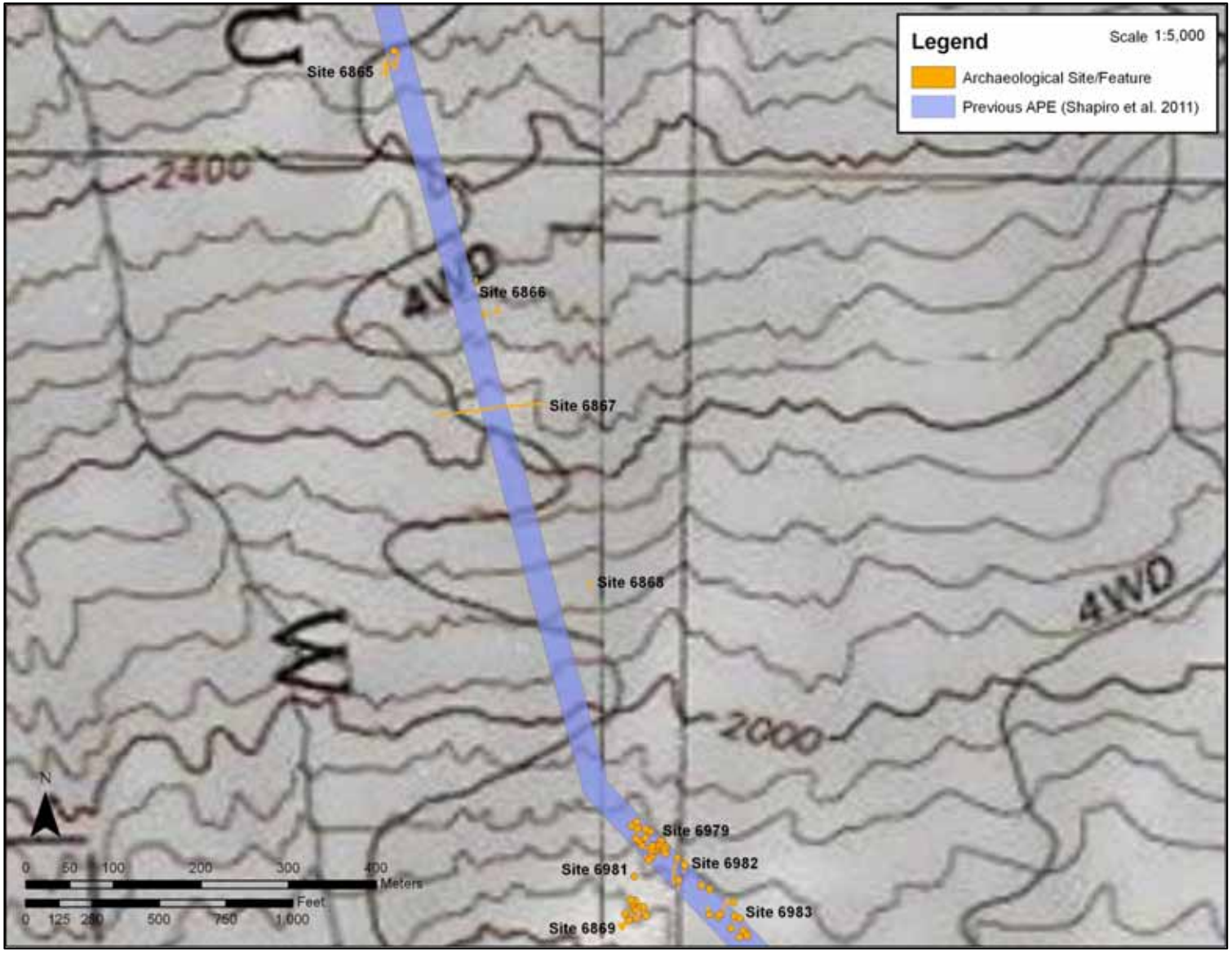


Figure 32. Site location map of Generator-Tie Line section between Figures 21 and 23.

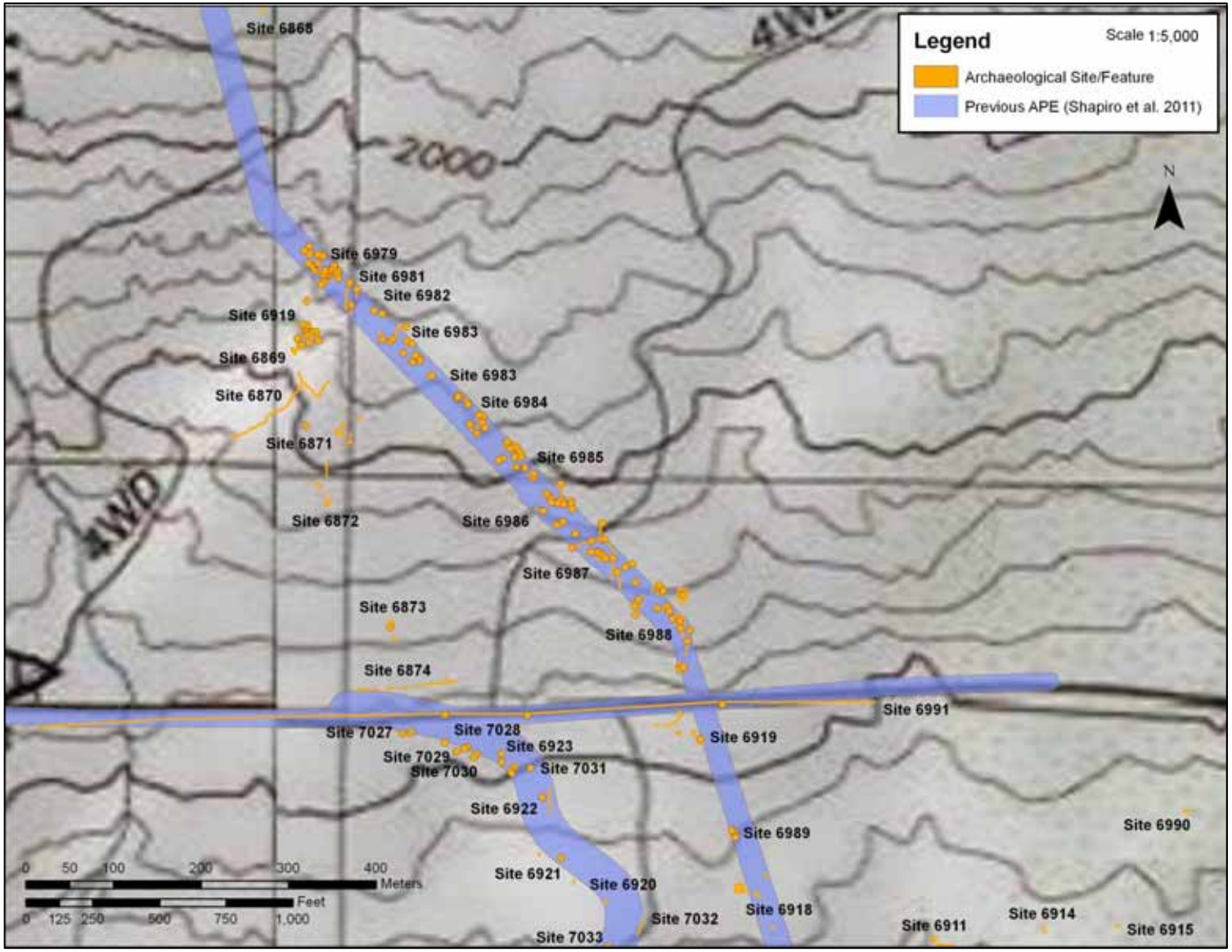


Figure 33. Site location map of southeastern end of Generator-Tie Line.

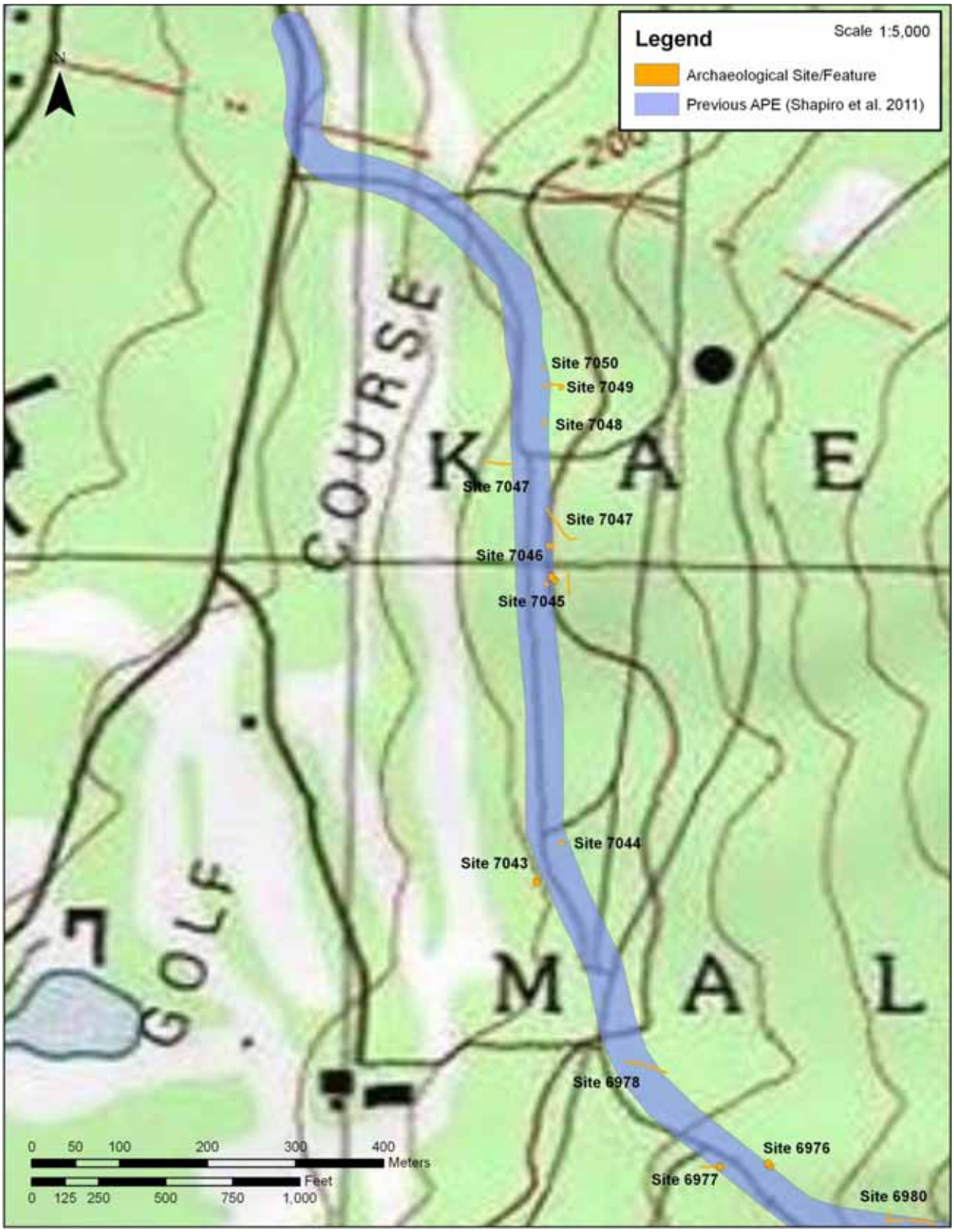


Figure 34. Site location map of northwestern end of Pāpaka Road.

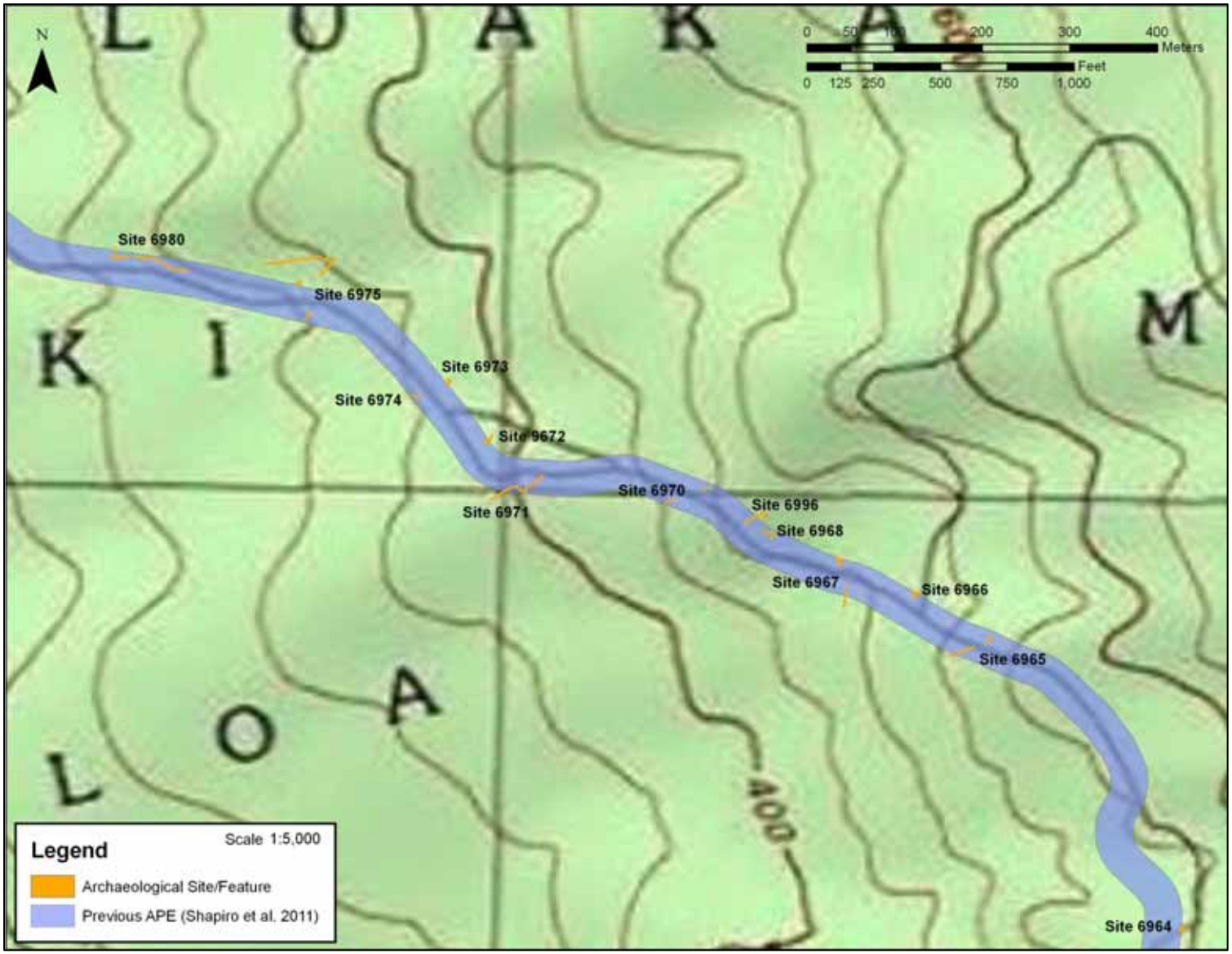


Figure 35. Site location map of Pāpaka Road between Figures 24 and 26.

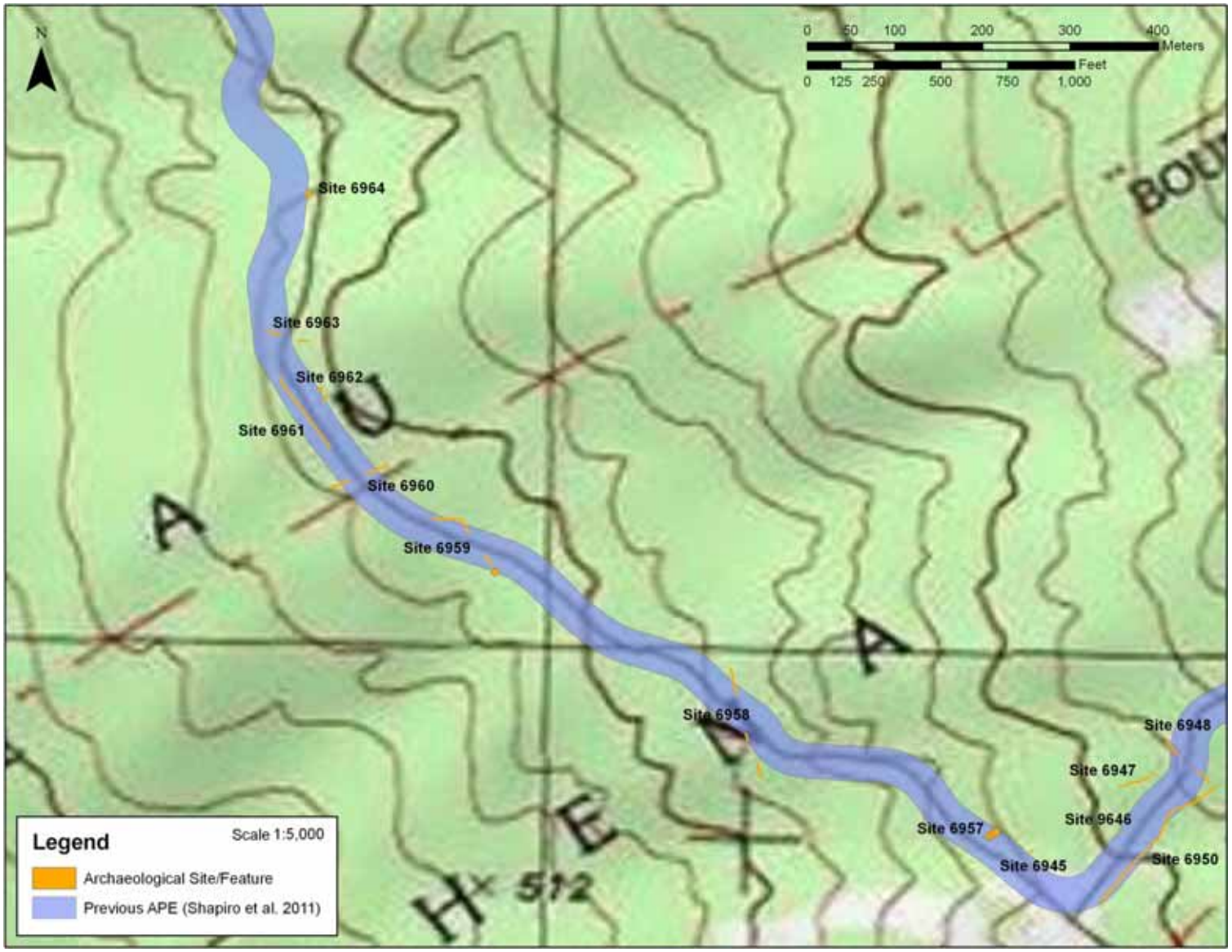


Figure 36. Site location map of Pāpaka Road between Figures 25 and 27.

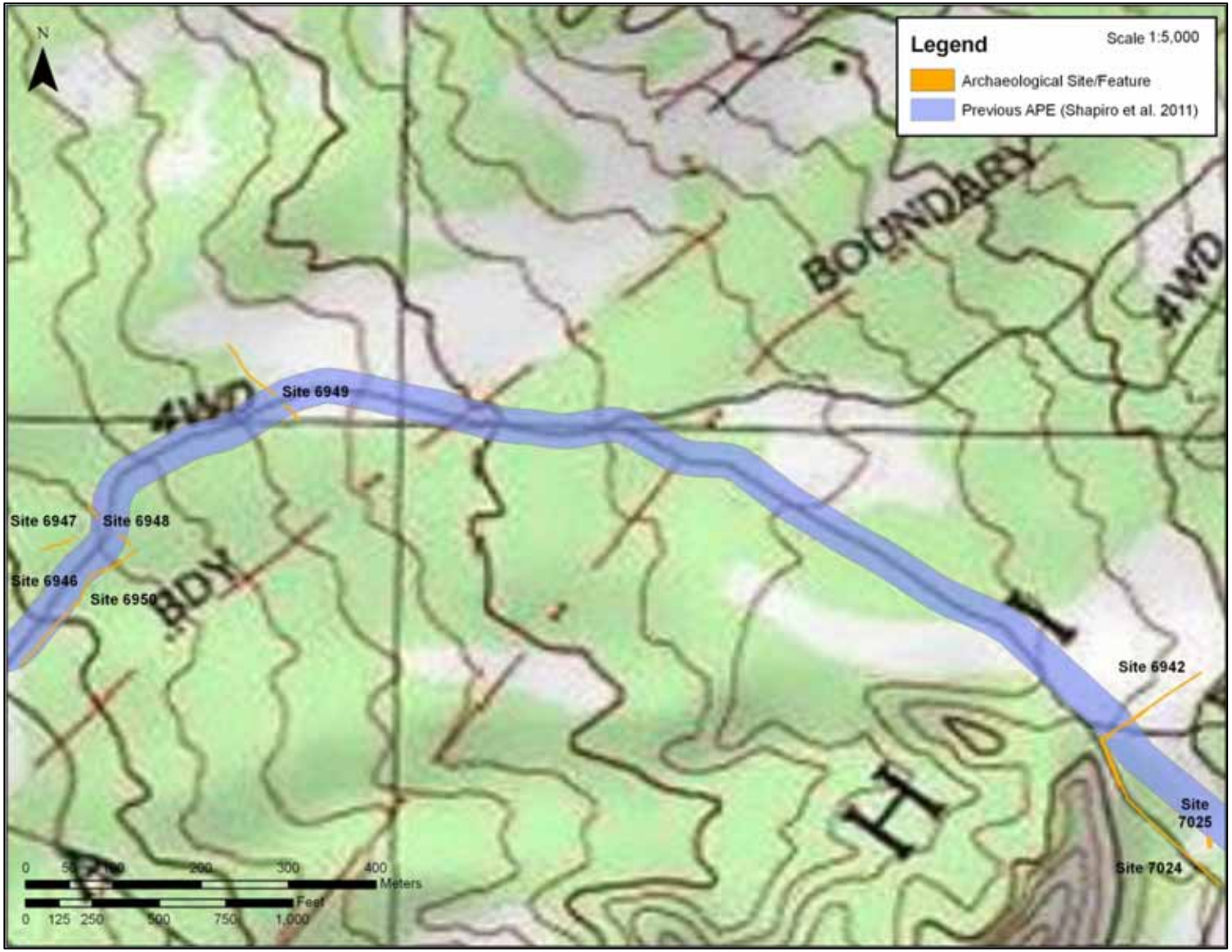


Figure 37. Site location map of Pāpaka Road between Figures 26 and 28.

Figure 38. Site location map of Pāpaka Road between Figures 27 and 29.

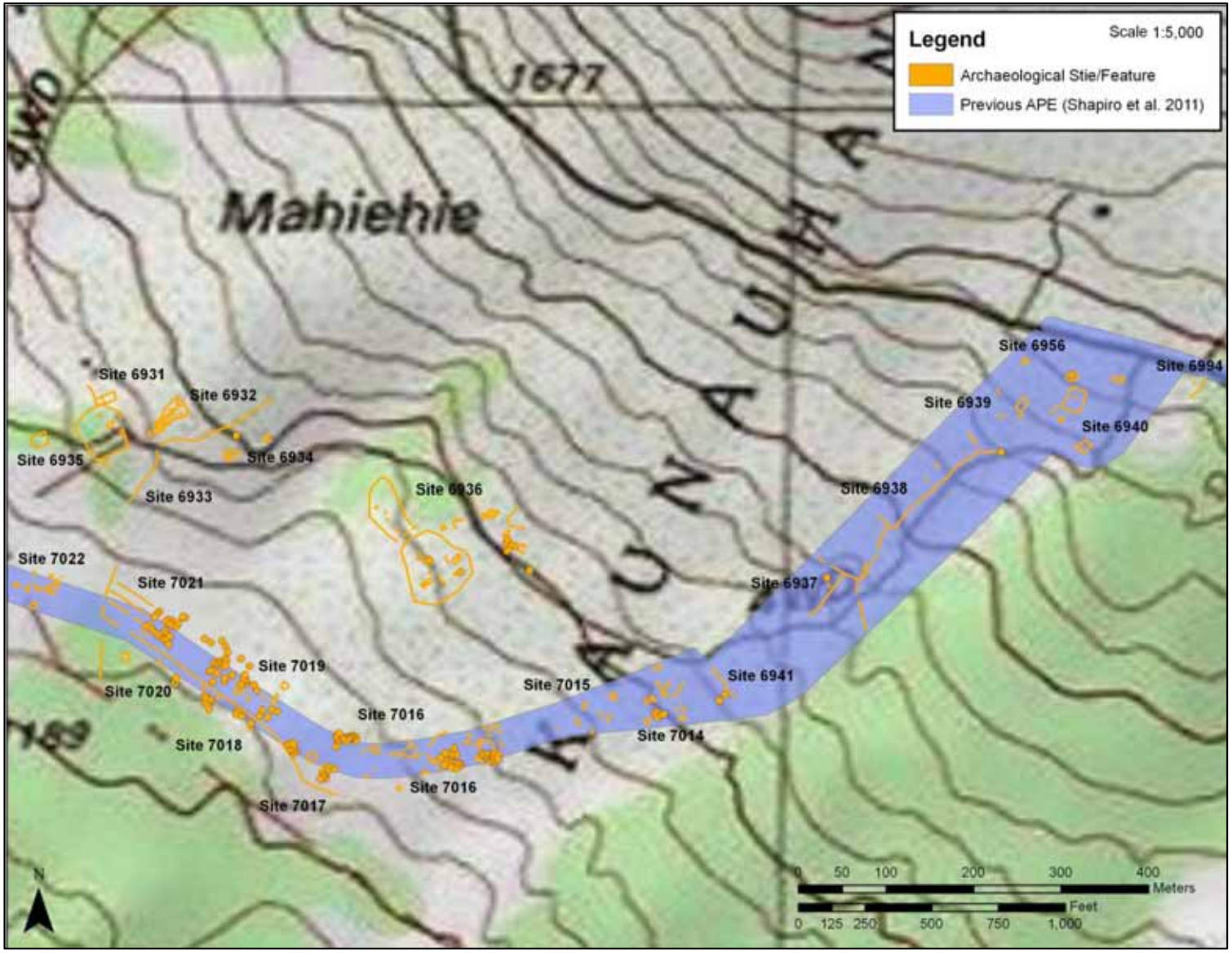


Figure 39. Site location map of eastern end of Pāpaka Road.

4.0 SIGNIFICANCE ASSESSMENTS

The National Historic Preservation Act of 1966 (as amended) authorizes the Secretary of Interior to expand and maintain a National Register of Historic Places (NRHP) that contains a listing of districts, sites, buildings, structures and objects significant in American history, architecture, archaeology, engineering and culture. A property may be listed in the NRHP if it meets criteria for evaluation defined in 36 CFR §60.4:

> The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and
>
> (a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) That are associated with the lives of persons significant in our past; or
>
> (c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> (d) That have yielded, or may be likely to yield, information important in prehistory or history.

The State of Hawai‘i recognizes the above criteria under HRS §13-275-6, and has also added a fifth Hawai‘i Register of Historic Places (HRHP) significance criterion to the evaluation process:

> (e) That have an important value to the Native Hawaiian people or to another ethnic group of the State due to associations with cultural practices once carried out or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts – these associations being important to the group's history and cultural identity.

All archaeological sites recorded in 2010, including all sites within the current APE and those sites now outside the current APE have been assessed for significance.

All of the resources have been assessed as significant based on criterion D – that have either yielded or have the potential to yield information important to the history of Auwahi specifically and more generally for the *moku* of Kahikinui and the entire island of Maui. In addition, three sites appear to be significant because of the high degree of workmanship in their construction (criterion C); these are sites 6843, 6913, and 6956. Finally, 39 of these sites appear to be culturally important because they contain human burials, are suspected to contain human burials, or appear to be ceremonial sites (criterion E); these are 6813, 6819, 6821, 6825, 6835, 6838,

6840, 6843, 6849, 6850, 6864, 6904, 6906, 6908, 6815, 6827, 6890, 6894, 6909, 6912, 6921, 6922, 6923, 6931, 6936, 6951, 6953, 6954, 6985, 6992, 6993, 7017, 7035, 7041, AWF-312, AWF-333/336, AWF-568, AWF-2011 K, and AWF-2011 P. The significance assessments are summarized in Table 3.

Table 3. Significance Assessments of Sites

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6813	**037/038/040/041**	Out	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6814	**042**	Out	Wind Farm	Lava Tube	Habitation	D
6815	**045**	In	Wind Farm	Complex	Ceremonial / Habitation / Transportation	D, E
6816	**067/068**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6817	**069**	In	Wind Farm	C-Shaped Wall	Habitation	D
6818	**070**	In	Wind Farm	Wall	Ranching	D
6819	**071/252/253**	Out	Gen-Tie Line	Complex	Burial / Uncertain	D, E
6820	**089**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6821	**091/092/093**	In	Wind Farm	Complex	Agriculture / Habitation / Transportation / Uncertain	D, E
6822	**095**	In	Wind Farm	Wall	Agriculture / Uncertain	D
6823	**096**	In	Wind Farm	Complex	Agriculture / Habitation	D
6824	**098**	Out	Wind Farm	Complex	Agriculture / Animal Husbandry / Habitation / Uncertain	D
6825	**100**	Out	Wind Farm	Complex	Ceremonial / Habitation / Uncertain	D, E
6826	**102**	Out	Wind Farm	Complex	Agriculture / Transportation / Uncertain	D
6827	**106/108**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6828	**107**	In	Wind Farm	Wall	Agriculture / Ranching	D
6829	**109**	In	Wind Farm	Terrace	Habitation	D
6830	**129**	In	Wind Farm	C-Shaped Wall	Agriculture / Habitation	D
6831	**133**	Out	Wind Farm	Stone Mound	Uncertain	D
6832	**141**	In	Wind Farm	Complex	Agriculture	D
6833	**142**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6834	**143**	In	Wind Farm	Complex	Agriculture / Habitation	D
6835	**145**	Out	Wind Farm	Lava Tube	Burial / Uncertain	D, E
6836	**155**	In	Wind Farm	Complex	Agriculture / Habitation	D
6837	**166**	In	Wind Farm	Wall	Uncertain	D
6838	**167/557**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6839	**168**	Out	Wind Farm	Complex	Agriculture	D
6840	**176**	Out	Wind Farm	Complex	Agriculture / Animal Husbandry / Ceremonial / Habitation / Uncertain	D, E
6841	**180/546**	In	Wind Farm	Complex	Agriculture / Habitation	D
6842	**181**	In	Wind Farm	Complex	Agriculture / Habitation	D
6843	**182/184**	In	Wind Farm	Complex	Ceremonial / Habitation / Uncertain	C, D, E
6844	**183/185**	Out	Wind Farm	Complex	Habitation / Uncertain	D
6845	**186**	In	Wind Farm	C-Shaped Wall	Habitation	D
6846	**187**	Out	Wind Farm	Terrace	Habitation	D

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6847	**188**	Out	Wind Farm	Enclosure	Habitation	D
6848	**190/310**	In	Wind Farm	Complex	Habitation / Uncertain	D
6849	**194**	Out	Wind Farm	Terrace	Ceremonial	D, E
6850	**195**	Out	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
6851	**197**	Out	Wind Farm	Complex	Habitation	D
6852	**198/199**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6853	**200**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6854	**202**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6855	**204**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6856	**207**	Out	Wind Farm	L-Shaped Wall	Habitation	D
6857	**208**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6858	**209**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6859	**211**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6860	**212**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6861	**213**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6862	**214**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6863	**215**	In	Wind Farm	Complex	Agriculture / Animal Husbandry / Habitation / Transportation / Uncertain	D
6864	**216**	In	Wind Farm	Complex	Ceremonial / Habitation / Uncertain	D, E
6865	**247**	In	Gen-Tie Line	Complex	Agriculture / Uncertain	D
6866	**249**	In	Gen-Tie Line	Complex	Agriculture / Habitation	D
6867	**250**	In	Gen-Tie Line	Wall	Ranching	D
6868	**251**	Out	Gen-Tie Line	Wall	Agriculture	D
6869	**254**	Out	Gen-Tie Line	Complex	Habitation	D
6870	**255**	Out	Gen-Tie Line	Complex	Agriculture	D
6871	**256**	Out	Gen-Tie Line	Complex	Agriculture / Habitation	D
6872	**258/259**	Out	Gen-Tie Line	Complex	Agriculture / Habitation / Ranching / Uncertain	D
6873	**260/261**	Out	Gen-Tie Line	Complex	Habitation / Uncertain	D
6874	**262/263**	In	Gen-Tie Line	Wall	Ranching	D
6875	**264**	Out	Gen-Tie Line	Lava Tube	Habitation	D
6876	**265**	In	Gen-Tie Line	Wall	Ranching	D
6877	**266**	In	Gen-Tie Line	Complex	Agriculture / Ranching	D
6878	**267**	In	Gen-Tie Line	Stone Mound	Agriculture	D
6879	**268**	In	Gen-Tie Line	Wall	Ranching	D
6880	**269**	In	Gen-Tie Line	Complex	Ranching	D
6881	**270/271**	In	Gen-Tie Line	Complex	Agriculture / Ranching / Uncertain	D
6882	**273/362**	In	Gen-Tie Line	Complex	Agriculture / Ranching	D
6883	**274/275**	Out	Gen-Tie Line	Complex	Agriculture / Uncertain	D
6884	**276**	Out	Gen-Tie Line	Stone Mound	Agriculture / Ranching	D
6885	**277**	Out	Gen-Tie Line	Stone Mound	Agriculture	D
6886	**297**	Out	Wind Farm	Complex	Habitation	D
6887	**305**	In	Wind Farm	Complex	Habitation / Uncertain	D
6888	**306**	In	Wind Farm	U-Shaped Wall	Habitation	D

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6889	**307**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6890	**308**	Out	Wind Farm	Complex	Burial / Habitation / Uncertain	D, E
6891	**309**	In	Wind Farm	Complex	Agriculture / Transportation	D
6892	**322**	In	Wind Farm	Complex	Agriculture / Habitation	D
6893	**323**	In	Wind Farm	Complex	Agriculture	D
6894	**324**	In	Wind Farm	Complex	Burial / Habitation / Uncertain	D, E
6895	**326**	In	Wind Farm	Complex	Agriculture / Habitation	D
6896	**329**	In	Wind Farm	Complex	Agriculture / Habitation	D
6897	**331**	In	Wind Farm	Complex	Agriculture / Habitation	D
6898	**332**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6899	**335**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6900	**346**	Out	Wind Farm	C-Shaped Wall	Habitation	D
6901	**349**	In	Wind Farm	C-Shaped Wall	Habitation	D
6902	**351**	Out	Wind Farm	Complex	Agriculture / Habitation	D
6903	**353**	In	Wind Farm	Complex	Habitation / Uncertain	D
6904	**354**	In	Wind Farm	Complex	Agriculture / Burial / Uncertain	D, E
6905	**356/361**	Out	Wind Farm	Complex	Habitation	D
6906	**359/488**	In	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
6907	**367**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6908	**391**	Out	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
6909	**395-398**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6910	**423 thru 430**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6911	**440**	Out	Wind Farm	Complex	Habitation	D
6912	**441**	Out	Wind Farm	Complex	Agriculture / Burial / Uncertain	D, E
6913	**442**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	C, D
6914	**443**	Out	Wind Farm	Wall	Agriculture	D
6915	**445**	Out	Wind Farm	Complex	Uncertain	D
6916	**468**	Out	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6917	**480/481**	In	Wind Farm	Complex	Agriculture / Habitation	D
6918	**489/491**	In	Wind Farm	Complex	Habitation / Uncertain	D
6919	**495**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6920	**499**	In	Wind Farm	Wall	Habitation	D
6921	**501**	In	Wind Farm	Complex	Agriculture / Burial / Uncertain	D, E
6922	**502**	In	Wind Farm	Complex	Agriculture / Burial	D, E
6923	**503**	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
6924	**544**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6925	**559**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
6926	**560**	Out	Wind Farm	Complex	Agriculture	D
6927	**564**	Out	Wind Farm	U-Shaped Wall	Habitation	D
6928	**582**	Out	Wind Farm	C-Shaped Wall	Agriculture	D
6929	**583**	In	Wind Farm	Complex	Habitation / Uncertain	D
6930	**584**	In	Wind Farm	Complex	Agriculture / Uncertain	D

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6931	**585**	Out	Pāpaka Road	Complex	Ceremonial / Habitation / Ranching	D, E
6932	**586**	Out	Pāpaka Road	Complex	Agriculture	D
6933	**587**	Out	Pāpaka Road	Complex	Agriculture / Animal Husbandry / Habitation / Uncertain	D
6934	**588**	Out	Pāpaka Road	Complex	Agriculture / Uncertain	D
6935	**589**	Out	Pāpaka Road	Enclosure	Ranching	D
6936	**590/596**	Out	Pāpaka Road	Complex	Agriculture / Burial / Habitation / Ranching / Uncertain	D, E
6937	**591**	In	Pāpaka Road	Complex	Agriculture	D
6938	**592**	In	Pāpaka Road	Complex	Agriculture / Habitation / Ranching / Uncertain	D
6939	**593**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
6940	**594**	In	Pāpaka Road	Complex	Agriculture / Habitation	D
6941	**595**	In	Pāpaka Road	Complex	Agriculture / Habitation	D
6942	**597**	In	Pāpaka Road	Wall	Ranching	D
6943	**598**	Out	Pāpaka Road	Complex	Ranching / Uncertain	D
6944	**599**	Out	Pāpaka Road	Wall	Ranching	D
6945	**600**	Out	Pāpaka Road	Wall	Uncertain	D
6946	**601**	In	Pāpaka Road	Wall	Ranching	D
6947	**602**	Out	Pāpaka Road	Wall	Uncertain	D
6948	**603**	In	Pāpaka Road	Wall	Uncertain	D
6949	**604**	In	Pāpaka Road	Wall	Ranching	D
6950	**605**	In	Pāpaka Road	Wall	Ranching	D
6951	**2010 A**	Out	Wind Farm	Complex	Burial / Habitation / Uncertain	D, E
6952	**2010 B**	In	Wind Farm	Overhang Shelter	Habitation	D
6953	**2010 C**	In	Wind Farm	Complex	Burial	D, E
6954	**2010 D**	Out	Wind Farm	Complex	Burial	D, E
6955	**2010 E**	Out	Wind Farm	Terrace	Agriculture	D
6956	**2010 F**	In	Pāpaka Road	Enclosure	Ranching	C, D
6957	**2010 G**	In	Pāpaka Road	Complex	Uncertain	D
6958	**2010 H**	In	Pāpaka Road	Wall	Ranching	D
6959	**2010 I**	In	Pāpaka Road	Complex	Ranching / Uncertain	D
6960	**2010 J**	In	Pāpaka Road	Wall	Ranching	D
6961	**2010 K**	In	Pāpaka Road	Wall	Ranching	D
6962	**2010 L**	In	Pāpaka Road	Complex	Agriculture	D
6963	**2010 M**	In	Pāpaka Road	Wall	Ranching	D
6964	**2010 N**	Out	Pāpaka Road	Enclosure	Habitation	D
6965	**2010 O**	In	Pāpaka Road	Wall	Ranching	D
6966	**2010 P**	In	Pāpaka Road	Cast Iron Tank	Ranching	D
6967	**2010 Q**	In	Pāpaka Road	Complex	Agriculture / Ranching	D
6968	**2010 R**	In	Pāpaka Road	Complex	Agriculture	D
6969	**2010 S**	In	Pāpaka Road	Wall	Ranching	D
6970	**2010 T**	In	Pāpaka Road	Wall	Ranching	D
6971	**2010 U**	In	Pāpaka Road	Wall	Uncertain	D
6972	**2010 V**	In	Pāpaka Road	Complex	Habitation	D

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
6973	**2010 W**	Out	Pāpaka Road	Enclosure	Habitation	D
6974	**2010 X**	In	Pāpaka Road	Wall	Habitation	D
6975	**2010 Y**	In	Pāpaka Road	Complex	Ranching / Uncertain	D
6976	**2010 Z**	In	Pāpaka Road	Complex	Habitation / Uncertain	D
6977	**2010 AA**	In	Pāpaka Road	Wall	Ranching	D
6978	**2010 BB**	In	Pāpaka Road	Wall	Ranching	D
6979	**2010 CC Gen-Tie Line**	In	Gen-Tie Line	Complex	Agriculture / Habitation	D
6980	**2010 CC Pāpaka**	In	Pāpaka Road	Wall	Ranching	D
6981	**2010 DD**	In	Gen-Tie Line	Wall	Uncertain	D
6982	**2010 EE**	In	Gen-Tie Line	Wall	Uncertain	D
6983	**2010 FF**	In	Gen-Tie Line	Complex	Agriculture / Uncertain	D
6984	**2010 GG**	In	Gen-Tie Line	Complex	Agriculture / Habitation	D
6985	**2010 HH**	In	Gen-Tie Line	Complex	Agriculture / Burial / Uncertain	D, E
6986	**2010 II**	In	Gen-Tie Line	Wall	Uncertain	D
6987	**2010 JJ**	In	Gen-Tie Line	Complex	Agriculture / Habitation / Uncertain	D
6988	**2010 KK**	In	Gen-Tie Line	Complex	Agriculture / Habitation / Uncertain	D
6989	**2010 LL**	In	Wind Farm	Complex	Agriculture / Uncertain	D
6990	**2010 MM**	Out	Wind Farm	Complex	Habitation / Uncertain	D
6991	**2010 NN**	In	Pi`ilani Highway	Wall	Ranching	D
6992	**2010 OO**	In	Pi`ilani Highway	Complex	Agriculture / Burial / Ranching / Uncertain	D, E
6993	**2010 PP**	Out	Pi`ilani Highway	Complex	Agriculture / Burial / Uncertain	D, E
6994	**2010 QQ**	In	Pi`ilani Highway	Complex	Agriculture / Ranching	D
6995	**2010 RR**	In	Gen-Tie Line	Complex	Agriculture	D
6996	**2010 SS**	In	Gen-Tie Line	Stone Mound	Agriculture	D
6997	**2010 TT**	In	Gen-Tie Line	Modified Outcrop	Agriculture	D
6998	**2010 UU**	In	Gen-Tie Line	Modified Outcrop	Uncertain	D
6999	**2010 VV**	In	Gen-Tie Line	Complex	Agriculture	D
7000	**2010 WW**	In	Gen-Tie Line	Wall	Agriculture	D
7001	**2010 XX**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7002	**2010 YY**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7003	**2010 ZZ**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7004	**2010 AAA**	In	Gen-Tie Line	Complex	Agriculture	D
7005	**2010 BBB**	In	Gen-Tie Line	Terrace	Agriculture	D
7006	**2010 CCC**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7007	**2010 DDD**	In	Gen-Tie Line	Cleared Area	Agriculture	D
7008	**2010 EEE**	In	Gen-Tie Line	Stone Mound	Agriculture	D
7009	**2010 FFF**	In	Gen-Tie Line	Complex	Agriculture	D
7010	**2010 GGG**	In	Gen-Tie Line	Complex	Agriculture	D
7011	**2010 HHH**	In	Gen-Tie Line	Complex	Ranching	D
7012	**2010 III**	In	Gen-Tie Line	Complex	Agriculture	D
7013	**2010 JJJ**	In	Gen-Tie Line	Platform	Ranching	D

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
7014	**2010 KKK**	In	Pāpaka Road	Complex	Agriculture	D
7015	**2010 LLL**	In	Pāpaka Road	Complex	Agriculture	D
7016	**2010 MMM**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7017	**2010 NNN**	In	Pāpaka Road	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
7018	**2010 OOO**	In	Pāpaka Road	Wall	Ranching	D
7019	**2010 PPP**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7020	**2010 QQQ**	In	Pāpaka Road	Complex	Agriculture / Habitation	D
7021	**2010 RRR**	In	Pāpaka Road	Complex	Agriculture	D
7022	**2010 SSS**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7023	**2010 TTT**	In	Pāpaka Road	Barbed Wire Fence	Ranching	D
7024	**2010 UUU**	In	Pāpaka Road	Complex	Agriculture / Habitation / Ranching	D
7025	**2010 VVV**	In	Pāpaka Road	Complex	Agriculture / Uncertain	D
7026	**2010 WWW**	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
7027	**2010 AAAA**	In	Wind Farm	Complex	Agriculture	D
7028	**2010 BBBB**	In	Wind Farm	Complex	Agriculture	D
7029	**2010 CCCC**	In	Wind Farm	Complex	Agriculture / Uncertain	D
7030	**2010 DDDD**	In	Wind Farm	Complex	Uncertain	D
7031	**2010 EEEE**	In	Wind Farm	Modified Outcrop	Agriculture	D
7032	**2010 FFFF**	In	Wind Farm	Wall	Uncertain	D
7033	**2010 GGGG**	In	Wind Farm	Terrace	Agriculture	D
7034	**2010 HHHH**	Out	Wind Farm	Complex	Agriculture	D
7035	**2010 IIII**	In	Wind Farm	Complex	Agriculture / Burial	D, E
7036	**2010 JJJJ**	In	Wind Farm	Complex	Agriculture	D
7037	**2010 KKKK**	In	Wind Farm	Complex	Agriculture	D
7038	**2010 LLLL**	In	Wind Farm	Complex	Agriculture	D
7039	**2010 MMMM**	In	Wind Farm	Platform	Uncertain	D
7040	**2010 NNNN**	In	Wind Farm	Stone Mound	Agriculture	D
7041	**2010 OOOO**	In	Wind Farm	Stone Mound	Agriculture / Burial / Habitation	D, E
7042	**2010 PPPP**	In	Wind Farm	Complex	Habitation / Uncertain	D
7043	**Mākena 1**	Out	Pāpaka Road	Enclosure	Habitation	D
7044	**Mākena 2**	In	Pāpaka Road	Terrace	Uncertain	D
7045	**Mākena 3**	In	Pāpaka Road	Complex	Agriculture / Habitation / Uncertain	D
7046	**Mākena 4**	In	Pāpaka Road	Enclosure	Uncertain	D
7047	**Mākena 5**	In	Pāpaka Road	Wall	Ranching	D
7048	**Mākena 6**	In	Pāpaka Road	Modified Outcrop	Uncertain	D
7049	**Mākena 7**	In	Pāpaka Road	Wall	Habitation	D
7050	**Mākena 8**	In	Pāpaka Road	Complex	Habitation	D
	165	Out	Wind Farm	Complex	Habitation	D
	169/2011 L	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
	312	In	Wind Farm	Complex	Agriculture / Ceremonial / Habitation / Uncertain	D, E
	316	In	Wind Farm	Complex	Agriculture / Habitation	D
	318	In	Wind Farm	Complex	Agriculture / Habitation	D

SIHP No. (50-50-)	Field No. (AWF-)	In / Out of APE	Project Area	Site/Feature Type	Possible Function	Significance
	325	In	Wind Farm	U-shaped Wall	Habitation	D
	327	In	Wind Farm	Complex	Habitation	D
	333/336	In	Wind Farm	Complex	Agriculture / Burial / Ceremonial / Habitation / Uncertain	D, E
	358	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
	568	In	Wind Farm	Complex	Agriculture / Burial / Habitation	D, E
	2011 A	Out	Gen-Tie Line	Stone Mound	Agriculture / Ranching	D
	2011 B	In	Gen-Tie Line	Stone Mound	Agriculture	D
	2011 C	In	Gen-Tie Line	Stone Mound	Agriculture / Ranching	D
	2011 D	In	Gen-Tie Line	Fence Line	Agriculture / Ranching	D
	2011 E	In	Wind Farm	Alignment	Uncertain	D
	2011 F	In	Wind Farm	Terrace	Agriculture / Habitation	D
	2011 G	In	Wind Farm	Complex	Agriculture	D
	2011 H	Out	Wind Farm	Complex	Habitation / Uncertain	D
	2011 I	Out	Wind Farm	Complex	Agriculture	D
	2011 J	In	Wind Farm	Complex	Habitation	D
	2011 K	In	Wind Farm	Complex	Agriculture / Burial / Habitation / Uncertain	D, E
	2011 M	In	Wind Farm	Complex	Agriculture / Habitation / Uncertain	D
	2011 N	In	Wind Farm	L-Shaped Wall	Habitation	D
	2011 O	In	Wind Farm	Terrace	Agriculture / Habitation	D
	2011 P	In	Wind Farm	Complex	Ceremonial / Habitation	D, E
	2011 Q	In	Wind Farm	Enclosure	Habitation	D

5.0 RECOMMENDED TREATMENTS

The Auwahi Wind Farm project will adversely affect a number of archaeological resources. While this is inevitable in any type of development project, considerable effort has been exercised to minimize the impact the project will have on the archaeological resources present in the Wind Farm project area. The purpose of archaeological investigations is not only to inventory what archaeological resources are present and evaluate their significance, but to mitigate the adverse effects caused by development through archaeological investigations. Some of the archaeological resources present within the APE of the project have been fully documented and will not require any further archaeological work; others will require further archaeological investigations in the form of mapping and excavations. Specific recommended treatments of all archaeological features within the APE are presented in Table 4. In order to maximize the amount of information obtained through further archaeological investigations, the following research topics are offered as a means of guiding the future archaeological investigations.

5.1 "THE ARCHAEOLOGY OF HYDROLOGY"

From the broader perspective of Hawaiian archaeology, the discovery of a range of features indicative of sophisticated water control in Auwahi is a major new contribution to our knowledge of Hawaiian land use practices. This evidence is especially noteworthy because it occurs in the context of one of the most arid environments in the Hawaiian Islands, the leeward slopes of southeast Maui in the rain-shadow of Haleakalā. This environment was extremely marginal to the classic Polynesian horticultural system based on tropical root crops, yet the pre-Contact Hawaiian population in this region managed to achieve a high population density (Kirch 2007, 2010a). The inventory survey revealed numerous instances of intermittent stream channels which had various forms of artificial modification, ranging from check dams (barrages), to stone filled-terraces which appear to be designed to filter water underground, to earth-filled terraces that were probably planting surfaces. Discovery of these features was greatly enhanced by the unusually good surface visibility in Auwahi in 2010 due to extreme drought conditions.

Our working hypothesis is that with water a scarce and critical resource in Kahikinui, the Native Hawaiian population there developed technology that allowed them to capture and manipulate water in order to enhance the agricultural productivity of this marginal environment. Because storm events are infrequent, it is likely that the emphasis was not on irrigation in the usual sense of maintaining a steady flow of water to fields, but rather efforts to slow down intermittent stream flow, to divert such water into small basins and terraces that could be cultivated, and even to force the water to percolate into temporary aquifers (such as breccia deposits) which could then release water slowly over a period of days or even weeks.

The inventory survey produced detailed plan maps of a number of these features, but to fully investigate and interpret these hydrological features will require not only additional mapping,

but subsurface investigations as well. This work should be undertaken in collaboration with a professional geomorphologist/geoarchaeologist who has the technical expertise to assist in interpreting geomorphological and sedimentary evidence for past water flow patterns. We suggest that this research topic be addressed through the following specific approaches:

a. Detailed mapping of representative water control features. Such mapping cannot be limited to a two-dimensional plan view, but must include elevation and slope variables, as these will be critical to understanding waterflow patterns. Such mapping must pay attention not only to the artificially constructed aspects of these systems (e.g., walls, terraces), but to the geomorphological features such as water-worn flow channels or sedimentary lag deposits which will provide the evidence for intensity and frequency of hydrologic events. Winter (*kona*) storms were presumably the main sources of water which was being manipulated in these systems, and extreme storm events could have been very difficult to control and manage. Thus the investigations must be attuned to these attempts to control extreme flood events.

We recommend detailed mapping of Site 6906 Features GGG and HHH, terraces; and Site 7021, Features A, B, and D which are earthen berms. Site 6906 Features GGG and HHH are small agricultural terraces associated with nearby habitation structures. Site 7021, Features A, B, and D represent earthen berms which are likely remnants of water control features for an agricultural field system.

b. Excavation within constructed features such as earthen terraces and rock-fill filtration terraces. While detailed mapping will be critical, it is also essential to obtain subsurface evidence in order to understand how these water control features were constructed, the chronology of their construction, and details of their function. For example, a number of rock-filled terraces in some of the intermittent stream channels appear to have been designed to check water flow and drive water underground in a kind of filtration process. Excavating through these features would provide evidence of how they were constructed, and of whether percolating water left depositional traces. Again, we stress that this kind of investigation—which has rarely if ever been undertaken in Hawai'i in the past—must involve interdisciplinary collaboration between archaeology and geomorphology/hydrology, because neither discipline in and of itself controls all of the methods necessary to interpret such complex features.

In an attempt to gather additional information to address these hydrological questions, we recommend the excavation of Site 6906 Features GGG and HHH, terraces; and Site 7021, Features A, B, and D.

5.2 Development of the Formal Field System in "Gobi Desert"

Until recently no formal agricultural field systems had been identified on Maui Island, although extensive reticulate grids of field embankments and cross-cutting walls on Hawai'i Island (in Kohala, Kona, and Ka'ū districts) have been known since the late 1960s. The identification of a formal field system in Kaupō by Kirch et al. (2009) showed that Maui Island farmers were also

engaged in this kind of highly intensive agricultural activity. Now, with the identification of remnant portions of such a regularized field system on the fringes of the sedimentary basin inland of the Puʻu Hōkūkano cinder cone (colloquially named by our field team, the "Gobi Desert"), it is clear that such field systems must have been more wide-spread on Maui than has been previously realized.

These kinds of formalized field systems with reticulate grids of planting areas are of interest not only because they reflect a kind of intensive agricultural production upon which the late pre-Contact Hawaiian archaic states depended for their economic basis, but because they imply a level of formal control and management above what would be required strictly for agronomic reasons. That is to say, the regular spacing of field embankments, cross-cut by trails or other boundary divisions, appears to reflect the imposition of social and political controls on production, and more importantly, on the extraction of surplus.

We urge that the remnants of this field system be carefully recorded and investigated, following essentially the same methods proposed for the research topic discussed in Section 5.1, i.e., with a combined archaeological-geomorphological methodology. The various surface features making up this system are subtle, as the inventory team was well aware—often they can only be clearly discerned in the low-angle light of late afternoon. Thus high-precision three-dimensional mapping will again be important to thorough document these features.

As with the section 5.1 research topic, subsurface investigation will also be required to address the critical questions of when this system was constructed, and of how it functioned. We recommend linear trenching across the apparent field embankments and intervening cultivation plots, as has been carried out in similar investigations of field systems on Hawaiʻi Island by the Hawaiʻi Biocomplexity Project (Vitousek et al. 2004; Kirch, ed. 2011). We predict that remnant original soil horizons should be preserved under the field embankments, which will need to be carefully sampled. Such remnant soil horizons could provide carbonized organic materials with which to date the time of initial field system construction, and may also contain plant and other organic remains (such as endemic terrestrial gastropods) that could yield important evidence of initial environmental conditions prior to field system construction. Moreover, following methods developed by the Hawaiʻi Biocomplexity Project, it may be possible to compare the nutrient status of original soils preserved within field embankments with cultivated soils in the intervening plots, in order to achieve a quantitative estimate of the extent to which intensive cultivation over an extended period had an effect on nutrient availability. Such data would be extremely important to the ongoing efforts to understand how surplus production and extraction was affecting the rise of archaic states in late pre-Contact Hawaiʻi.

> We recommend the detailed mapping and selective excavation of the field system terraces at Site 6910, Features B, C, D, R, T, and U in the "Gobi Desert" vicinity to address these research issues. These represent the most intact remnants of the field system including bermed terraces and water channeling features.

5.3 SETTLEMENT CHRONOLOGY IN AUWAHI—IS IT EARLIER THAN ELSEWHERE IN KAHIKINUI?

In our report we summarized various lines of evidence—ethnohistorical as well as archaeological—which point to Auwahi having held a key place within the broader Kahikinui district or *moku*. For example, the high princess Ruta Keliʻiokalani received Auwahi during the Mahele land division, whereas the remainder of the district went to her half-brother Prince Lot. We have therefore hypothesized that Auwahi may have been the most important *ahupua'a* within the *moku*, probably the location for the district's *konohiki* or manager who represented the high chief. The initial suite of radiocarbon dates from our inventory survey also support this argument insofar as they suggest that the intensive occupation of Auwahi reached a peak as much as a century earlier than other parts of the district, such as Kīpapa and Nakaohu. However, this hypothesis needs to be tested on a more extensive data set, because at this point we cannot rule out the null hypothesis that the chronological differences noted to date are simply the result of sample size effects.

In any mitigation plan that is developed for the Auwahi wind farm area, it will be critical to allocate time and funds to sample and date a sufficient number of residential features so that sample size effects can be controlled. At this point, other parts of Kahikinui district are represented by more than 160 radiocarbon dates, whereas Auwahi proper has only 14 such dates. We would propose that a target of 50 radiocarbon samples from individual residential features be obtained and dated by high-precision AMS dating in order to address this question. In any such chronological investigation, it is essential that the following methodological protocols be followed: (1) Wherever possible samples should be obtained from discrete subsurface features, such as hearths or earth ovens; (2) To avoid the notorious problem of old wood and "in-built age" the charcoal samples need to be identified by a qualified archaeobotanist as to botanical taxon, and whenever possible short-lived species selected as dating samples; and, (3) samples need to be dated by AMS with d13C corrections for isotopic fractionation. The third step is critical because many Hawaiian dryland plants have C4 photosynthetic pathways that will yield erroneous ages if not corrected for isotopic fractionation. We followed these protocols in our dating of features in the inventory survey, and stress how important it is to continue to apply the same protocols if the resulting data sets are to have integrity.

To obtain the radiocarbon dates we propose the excavation of the following habitation features within the Auwahi Wind Farm area:

- Site 50-50-15-6896 Feature A, enclosure; Feature B, terrace.
- Site 50-50-15-6898 Feature A, platform; Feature G, hearth.
- Site 50-50-15-6906 Feature B, terrace; Feature FF, enclosure; Feature JJ, dark stained soil deposit; Feature OO,U-shaped wall with hearth; Feature PP, terrace; Feature YY, terrace with hearth features.
- Site 50-50-15-6910 Feature A, enclosure; Feature E, enclosure and terrace; Feature F, enclosure; Feature I, lava blister with hearth; Feature J, terrace with midden; Feature O, terrace with hearth.
- Site 50-50-15-6919 Feature E, terrace.
- Site 50-50-15-6988 Feature E, C-shaped wall and enclosure.

- Site 50-50-14-7016 Feature H, U-shaped wall; Feature O, terrace.
- Site 50-50-14-7017 Feature A, terrace.
- Site 50-50-14-7020 Feature C, modified outcrop with hearth.
- Site 50-50-14-7022 Feature F, enclosure with nearby hearth feature.
- Site AWF-312 Features G, H and T; cleared area, wall and a rock alignment.
- Site AWF-333/336 Feature J, terrace.
- Site AWF-2011 M, Feature E, terrace.
- Site AWF-2011 P, Feature A, U-shaped wall remnant.
- Site AWF-2011 Q, enclosure.

5.4 HOUSEHOLD ORGANIZATION AND STRUCTURE

Ethnohistoric accounts such as those of Malo (1951) and Kamakau (1961) inform us in general terms about the organization of daily life in traditional Hawaiian households, but they paint a monolithic portrait that does not allow for variation either between regions, or between social classes. Yet prior archaeological research in Kahikinui has already demonstrated certain kinds of household practices not previously known from either ethnohistoric or archaeological sources (Van Gilder and Kirch 1997). The extensive remains of residential features identified in the Auwahi inventory survey make it clear that there is much potential to gain further insights into Hawaiian household organization and structure in this area. Because Kahikinui was a *kuaʻāina* or "back country" region, the daily lives of its people were unlikely to have been the same as those dwelling near the royal centers such as Wailuku or Hāna. With the Auwahi sites, there is an opportunity to investigate the traditional lifeways of a true rural hinterland in ancient Hawaiʻi.

Household archaeology as a subdiscipline has developed greatly over the past two to three decades, but unfortunately many of its advances have not been applied in Hawaiian Cultural Resources Management work. The continued emphasis, in much CRM mitigation in Hawaiʻi, on single 1 m^2 test units in residential sites has generally failed to add new knowledge about Hawaiian household organization and structure. What is required is more emphasis on horizontal exposure of living surfaces by which larger activity areas can be discerned, and spatial patterns of organization identified. We propose that this approach be applied in future mitigation efforts in Auwahi. It would be far more productive, in our view, to fully excavate three or four residential features than to dig random test pits in a larger sample of structures.

In addition to horizontal excavation, such investigation of ancient Auwahi residential sites will require careful analysis of the cultural content of these sites. Prior experience shows that Kahikinui residential sites are relatively poor in portable artifacts such as adzes or fishhooks. The most common remains recovered are macrobotanical remains (especially charcoal), basalt and volcanic glass lithics, and shell and vertebrate remains. These materials will need to be studied by appropriate specialists if their information potential is to be realized. The lithic materials in particular should prove interesting, in terms of tracing links between Kahikinui households and those in adjacent districts or even other islands. XRF sourcing of basalt lithics from sites in Kīpapa and Nakaohu (Kirch, unpublished data) has shown that while most of the

basalt being worked in Kahikinui sites is of local origin, some derives from at least one adz quarry in Kaupō district, and a small number of specimens were imported from other islands including Hawai‘i, Moloka‘i, and even O‘ahu. Since Auwahi is putatively the most important *ahupua‘a* within Kahikinui, we hypothesize that it may have had a higher degree of external connections (especially through its resident *konohiki*), and that more imported lithics would appear in its residential sites. This hypothesis can be tested through further analysis of lithics from excavated sites in Auwahi.

Zooarchaeological analyses of faunal remains from household sites can also yield vital clues as to rank differences between the occupants of various social units. Higher ranked individuals in ancient Hawai‘i had preferential access to status foods, especially pig and dog, but also pelagic fish and even to certain birds. Analysis of the faunal remains from a priest's residence in Nakaohu (Kirch et al. 2010) have shown that the individuals residing there had access to a wide variety of status foods. It should be informative to compare a sample of Auwahi households with these prior results from other sites in Kahikinui.

To meet this research objective, we propose to conduct complete excavations of the following features:

- Site 50-50-15-6906 Feature OO, U shaped wall with hearth.
- Site 50-50-15-6896 Feature A, enclosure with midden.
- Site AWF-2011 Q, enclosure

5.5 POST-CONTACT TRANSFORMATIONS TO HAWAIIAN RURAL SOCIETY

Following Captain Cook's "discovery" of Hawai‘i in 1778-79 and the subsequent opening up of the Hawaiian Islands to the expanding European World System, Hawaiian society (which had been entirely cloistered for at least four centuries) was subjected to devastating external influences. Foremost among these was the exposure of the Hawaiian population to a range of diseases to which they had not inherent resistance, leading to massive population decreases. It appears that the indigenous Hawaiian population shrank from a pre-Contact high of at least 400,000 (and possibly considerably more) to about 140,000 in a mere four decades. But demographic collapse was not the only effect of European contact. Missionization and conversion of the Hawaiian people to Christianity, introduction of foreign ideas about everything from marriage to land rights, introduction of new crops and animals, all of these played significant roles in changing the lifeways of the Hawaiian people from the late 18th into the 19th centuries.

While documentary sources tell us a great deal about these major transformations of Hawaiian economy, society, and politics in the post-Contact era, there is still a great deal to be learned from the evidence of archaeology. This is especially true for the most rural or *kua‘āina* (literally "back country") regions, such as Kahikinui. Most of the extant documentary sources used by historians refer to the historical transformations taking place in trading centers like Kailua (Hawai‘i Island) or Honolulu, where the White missionaries, merchants, and others were located. But the historical processes unfolding in these rapidly urbanizing centers may have

been quite different from what was going on in the rural hinterlands, even as the two were linked as shown in the classic analysis of Anahulu Valley on Oʻahu by Kirch and Sahlins (1992). The rural areas were simultaneously both more resistant—and more vulnerable—to these foreign agents of change. They were more resistant in being farther from the sources of foreign influence or points of introduction of new disease vectors. But at the same time these rural areas had always been at the environmental and economic margins of traditional Hawaiian society. They were thus the most fragile, and the most susceptible to collapse under the devastation of disease and depopulation. There was as well simply the lure of new possibilities and opportunities in the centers of emerging trade and commence such as Lāhainā and Honolulu that inevitably drew people from the rural hinterlands to the new port towns.

The archaeological landscape of Auwahi not only incorporates a diversity of features from the pre-Contact period, but also many features that appear to date to the late 18th and 19th centuries. In particular, a series of features situated on *ʻaʻā* ridges to the east and west of the sedimentary basin inland of Puʻu Hōkūkano (aka "Gobi Desert") are suggestive of a substantial community of Native Hawaiians who persisted into the 19th century. Site 50-50-15-6909, located on the massive *ʻaʻā* ridge on the east side of this basin, appears on the basis of survey data to have been a significant 19th century settlement, indicated by a diversity of artifacts such as glass bottles and iron artifacts, including a horse bridle, flat iron, and flensing tool probably used as a farming tool (Hawaiian *ʻōʻō*). It is in some respects not surprising that this area should have remained as a final refuge for rural Hawaiian commoners attempting to cling to their traditional lifeways in the face of seemingly insurmountable obstacles. These features are adjacent to what is probably the most productive garden land in the *ahupuaʻa*, and it is only natural that such a prized resource would have been the last to have been abandoned.

Careful and detailed investigation of these post-Contact archaeological features has the potential to reveal much about the transformation of Hawaiian lifeways in the 19th century. How, for example, did residential patterns change over time? Was the traditional *kauhale* pattern of separate activity areas abandoned for a more "western" living style of a single combined multi-function *hale*? This would be predicted following the abolition of the *kapu* system (with its mandated separate cooking and eating facilities) after 1819, but has rarely been tested archaeologically (but see Kirch and Sahlins 1992). How much access did these rural households have to foreign material culture, and how did they integrate such material objects into their lifestyles? To what extent did they continue to utilize traditional, pre-Contact material culture, such as expedient lithic technology? And, how did their subsistence patterns and foodways change with the introduction of new crops, new animals, and new culinary concepts?

All of these questions can be addressed through more detailed investigation of the Auwahi sites dating to the post-Contact era. We cannot overly stress, however, that it will not be sufficient to merely apply the minimal approach to mitigation which is all too commonly used in Hawaiian CRM work: i.e., the excavation of a few limited 1 m square units in a sample of sites. It would be far preferable, in our view, to undertake larger areal exposures of a selected few post-Contact residential structures, in order to be able to obtain fine-grained spatial data on activity patterns which can then be compared with similar data from pre-Contact sites in Auwahi, elsewhere in Kahikinui, and in Hawaiʻi. Horizontal excavation or exposure of entire house floors is too infrequently undertaken in Hawaiian archaeology, leading to a paucity of the kinds of data that

are critically required if we are to make advances in our knowledge base. We would recommend that two or three post-Contact residential features be thoroughly and carefully excavated *in their entirety* than the routine opening up of 30 or 40 test pits in scattered features, none of which will provide the kinds of spatial data necessary to answer the questions posed above.

Features recommended for aerial excavation to address these research questions include:

- Site 50-50-15-6988 Feature E, an enclosure and C-shaped wall with historic artifacts.

5.6 IMPACT OF HAWAIIAN LAND USE ON DRYLAND FOREST ENVIRONMENT

The leeward slopes of southeast Maui, because of their combination of relatively young lava substrates and low rainfall, were the ecological setting in which a distinctive natural biotic community evolved over the course of several hundred thousand years—the Hawaiian dryland forest (Ziegler 2002, and Wagner et al 1999). This dryland forest had a far greater diversity of plant species than the wet forests which were typically dominated by a few trees such as *Metrosideros polymorpha* and *Acacia koa*. While both *ʻōhiʻa* and *koa* were present as well in the dry forests, many other species were found in abundance, such as *ʻiliahi* (sandalwood, *Santalum* spp.), *naio* (false sandalwood, *Myoporum sandwicense*), *hala pepe (Dracaena* spp.), *māmane* (*Sophora chrysophylla*), *lama* (*Diospyros sandwicensis*), *nīoi* (*Eugenia* spp.*).* In somewhat lower elevations, thick stands of the distinctive *wiliwili* (*Erythrina sandwicensis*) with its deciduous habit unusual in the tropics covered the landscape, along with such shrubs as *ʻaʻaliʻi* (*Dodonaea* sp.) and *ʻakia* (*Wikstroema* sp.). In the late 19th century, the pioneering botanist Joseph Rock was struck by the remarkable biodiversity of leeward Maui—and of Auwahi in particular. Rock made a number of collecting expeditions to Auwahi to try to capture what he could of this unique environment, even though it was already under tremendous pressure from cattle grazing and other inroads.

What Rock witnessed at the end of the 19th century in the uplands of Auwahi was, however, merely the endpoint of several centuries of intensive human exploitation of this land, exploitation that began with pioneering Polynesian settlement, continued with a phase of high population density and intensive farming, and which was succeeded by the introduction of ungulates and cattle ranching. An important part of the historical record of Auwahi is how this unique dryland forest environment was transformed as a result of these successive phases of human land use and resource exploitation.

Investigating this critical aspect of the Auwahi record will require the application of the multi-disciplinary perspective of "historical ecology" (Kirch and Hunt, eds., 1997). Much of the necessary data can be obtained through the various kinds of field and laboratory investigations already outlined for topics 3, 4, and 5 above. For example, charcoal samples obtained from hearths and earth ovens in residential sites can provide important data on the kinds of plants formerly growing on the Auwahi landscape, and being exploited by the Hawaiians for firewood and fuel. Likewise, zooarchaeological analysis of faunal assemblages will provide data on wild food resources such as native birds. Smithsonian avian paleontologist Helen James (pers. comm. to Kirch, Dec. 2010) reports that the unique Hawaiian flightless geese and other endemic birds

may have persisted in leeward southeast Maui for a longer period of time following Polynesian colonization than elsewhere in the islands. New zooarchaeological data from Auwahi may help to resolve the question of when these truly unique birds went extinct.

It is anticipated that the materials recovered from the proposed feature excavations outlined above will yield the data potential to help address these questions regarding changes to the environment resulting from land use and resource exploitation.

Table 4. Recommended Treatments to Features Within the APE

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6820	**089**	Wind Farm	A	L-Shaped Wall	Habitation	No further work
			B	Terrace	Agriculture	No further work
			C	Cleared Area	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			F	Platform	Agriculture / Uncertain	No further work
			F	Wall	Agriculture / Uncertain	No further work
6821	**091/092/093**	Wind Farm	A	Wall	Habitation	No further work
			B	L-Shaped Wall	Habitation	No further work
			B	Terrace	Habitation	No further work
			C	Lava Tube	Habitation	No further work
			D	Modified Depression	Agriculture / Uncertain	No further work
			D	Wall	Agriculture / Uncertain	No further work
			E	Trail / Walkway	Transportation	No further work
6827	**106/108**	Wind Farm	A	Wall	Agriculture	No further work
			B	Stone Mound	Agriculture / Burial	**Preserve**
			C	Overhang Shelter	Habitation	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Habitation	No further work
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work
			G	Cleared Area	Agriculture	No further work
			H	Wall	Agriculture	No further work
			I	Terrace	Agriculture	No further work
			J	Terrace	Agriculture	No further work
			K	Platform	Uncertain	**Preserve**
			L	Stone Mound	Agriculture / Burial	**Preserve**
			M	Terrace	Agriculture	No further work
			N	Terrace	Agriculture	No further work
			O	C-Shaped Wall	Habitation	No further work
			O	J-Shaped Wall	Habitation	No further work
			P	Modified Outcrop	Agriculture	No further work
			Q	Terrace	Habitation	No further work
			R	Terrace	Agriculture	No further work
			S	Wall	Agriculture	No further work
			T	Stone Mound	Agriculture	No further work
			U	Terrace	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6828	**107**	Wind Farm		Wall	Agriculture / Ranching	No further work
6829	**109**	Wind Farm		Overhang Shelter	Habitation	No further work
				Terrace	Habitation	No further work
6832	**141**	Wind Farm	A	U-Shaped Wall	Agriculture	No further work
			B	C-Shaped Wall	Agriculture	No further work
6833	**142**	Wind Farm	A	Enclosure	Agriculture / Habitation	No further work
6834	**143**	Wind Farm	A	C-Shaped Wall	Habitation	No further work
			B	Terrace	Agriculture / Habitation	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
6837	**166**	Wind Farm		Wall	Uncertain	No further work
	169/2011-L	Wind Farm	A	Stone Mound	Agriculture / Habitation	No further work
			B	Stone Mound	Agriculture / Habitation	No further work
			C	Alignment	Agriculture	No further work
			D	C-Shaped Wall	Habitation	No further work
			E	Modified Lava Blister	Habitation / Uncertain	No further work
			F	Wall	Agriculture	No further work
			J	Terrace	Agriculture	No further work
6857	**208**	Wind Farm	B	Terrace	Habitation	No further work
			C	Alignment	Agriculture	No further work
			F	C-Shaped Wall	Habitation	No further work
			G	C-Shaped Wall	Uncertain	No further work
			H	Terrace	Habitation	No further work
			I	Stone Mound	Agriculture	No further work
			J	Terrace	Agriculture	No further work
6865	**247**	Gen-TieLine	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Uncertain	**Preserve**
			F	Terrace	Agriculture	No further work
			G	Modified Lava Blister	Agriculture	No further work
			H	Terrace	Agriculture	No further work
6867	**250**	Gen-TieLine		Wall	Ranching	No further work
6874	**262/263**	Gen-TieLine		Wall	Ranching	No further work
6876	**265**	Gen-TieLine		Wall	Ranching	No further work
6877	**266**	Gen-TieLine	B	Stone Mound	Agriculture / Ranching	No further work
			C	Stone Mound	Agriculture / Ranching	No further work
			D	Stone Mound	Agriculture / Ranching	No further work
			E	Stone Mound	Agriculture / Ranching	No further work
			F	Stone Mound	Agriculture / Ranching	No further work
6878	**267**	Gen-TieLine		Stone Mound	Agriculture	No further work
6879	**268**	Gen-TieLine		Wall	Ranching	No further work
6880	**269**	Gen-TieLine	A2	Wall	Ranching	No further work
6881	**270/271**	Gen-TieLine	A	Wall	Ranching	No further work
			B	Overhang Shelter	Habitation	**Preserve**
			C	Terrace	Uncertain	**Preserve**

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6882	**273/362**	Gen-TieLine	C	Stone Mound	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			E	Wall	Ranching	No further work
	312	Wind Farm	H	Wall	Ceremonial / Habitation	**Detailed mapping and selected excavation**
			I	Modified *ʻAʻā* Post Hole	Uncertain	No further work
			J	Modified *ʻAʻā* Post Hole	Uncertain	No further work
			K	Modified *ʻAʻā* Post Hole	Uncertain	No further work
			L	L-Shaped Wall	Habitation	No further work
			M	Cleared Area	Habitation	No further work
			N	Alignment	Agriculture	No further work
			O	Stone Mound	Agriculture	No further work
			P	Stone Mound	Agriculture	No further work
			Q	C-Shaped Wall	Habitation	No further work
			R	Terrace	Habitation	No further work
			S	Terrace	Habitation	No further work
			T	Alignment	Ceremonial / Habitation	**Detailed mapping and selected excavation**
			U	Stone Mound	Habitation	No further work
			V	Enclosure	Habitation	No further work
	316	Wind Farm	C	Terrace	Agriculture / Habitation	No further work
	318	Wind Farm	C	Modified Outcrop	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			F	Cleared Area	Agriculture	No further work
			G	Modified Outcrop	Agriculture	No further work
			H	Cleared Area	Agriculture	No further work
			I	C-Shaped Wall	Habitation	No further work
6892	**322**	Wind Farm	A	U-Shaped Wall	Agriculture / Habitation	No further work
			B	Cleared Area	Agriculture	No further work
			C	Enclosure	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			G	Terrace	Habitation	No further work
			G	Overhang Shelter	Habitation	No further work
			H	C-Shaped Wall	Agriculture	No further work
			H	Terrace	Agriculture	No further work
6893	**323**	Wind Farm	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
6894	**324**	Wind Farm	A	Lava Tube	Burial / Habitation / Uncertain	**Preserve**
			C	Terrace	Habitation	No further work
	325	Wind Farm		U-Shaped Wall	Habitation	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6895	326	Wind Farm	A	U-Shaped Wall	Agriculture	No further work
			A	Terrace	Agriculture	No further work
			A	Cleared Area	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			C	Alignment	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			E	Terrace	Habitation	No further work
			F	Alignment	Agriculture	No further work
			F	Cleared Area	Agriculture	No further work
			G	Stone Mound	Uncertain	No further work
			H	Terrace	Uncertain	No further work
			I	Platform	Uncertain	No further work
			K	Terrace	Habitation	No further work
	327	Wind Farm	A	Stone Mound	Habitation	No further work
			B	Enclosure	Habitation	No further work
			C	L-Shaped Wall	Habitation	No further work
6896	329	Wind Farm	A	Enclosure	Habitation	**Detailed mapping and complete aerial excavation**
			A	Alignment	Habitation	No further work
			B	Terrace	Habitation	**Detailed mapping and selected excavation**
			C	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Alignment	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			E	Alignment	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Alignment	Agriculture	No further work
			G	Stone Mound	Agriculture	No further work
			H	Stone Mound	Agriculture	No further work
6897	331	Wind Farm	A	Terrace	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	C-Shaped Wall	Habitation	No further work
			D	Terrace	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Enclosure	Habitation	No further work
			H	Cleared Area	Agriculture	No further work
			H	Wall	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6898	**332**	Wind Farm	A	Platform	Uncertain	**Detailed mapping and selected excavation**
			B	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	C-Shaped Wall	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			F	C-Shaped Wall	Agriculture	No further work
			G	Hearth	Habitation	**Detailed mapping and selected excavation**
	333/336	Wind Farm	A	Wall	Agriculture	No further work
			G	Alignment	Habitation	No further work
			H	Overhang Shelter	Agriculture / Habitation / Uncertain	No further work
			I	Terrace	Agriculture	No further work
			J	Terrace	Habitation	**Detailed mapping and selected excavation**
			K	Terrace	Agriculture	No further work
			L	L-Shaped Wall	Uncertain	No further work
			M	Terrace	Uncertain	No further work
			N	Terrace	Uncertain	No further work
			O	Wall	Agriculture	No further work
6899	**335**	Wind Farm	C	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	L-Shaped Wall	Habitation	No further work
6904	**354**	Wind Farm	A	Terrace/Modified Outcrop	Agriculture / Uncertain	No further work
			B	Terrace	Agriculture / Habitation	No further work
			D	Mound	Agriculture / Burial	**Preserve**
			E	Terrace	Agriculture	No further work
			F	Mound	Agriculture / Burial	**Preserve**
			G	Mound	Agriculture / Burial	**Preserve**
			H	Mound	Agriculture / Burial	**Preserve**
			I	Mound	Agriculture / Burial	**Preserve**
			J	Mound	Agriculture / Burial	**Preserve**
			K	Mound	Agriculture / Burial	**Preserve**
			L	Mound	Agriculture / Burial	**Preserve**
			O	Terrace	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
			A	Terrace	Habitation / Uncertain	No further work
			B	Terrace	Uncertain	No further work
			C	Terrace	Agriculture / Habitation / Uncertain	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Stone Mound	Agriculture	No further work
	358	Wind Farm	G	Terrace	Agriculture	No further work
			H	Terrace	Agriculture	No further work
			I	Stone Mound	Agriculture	No further work
			J	Terrace	Agriculture	No further work
			K	Terrace	Agriculture	No further work
			N	Stone Mound	Agriculture	No further work
			P	Alignment	Agriculture	No further work
			B	Stone Mound	Uncertain	No further work
			B	Terrace	Uncertain	**Detailed mapping and selected excavation**
			C	Modified Depression	Agriculture / Habitation	No further work
			C	Wall	Agriculture / Habitation	No further work
			G	Wall	Uncertain	No further work
			CC	Wall	Uncertain	No further work
			EE	Ditch / Channel	Agriculture	No further work
			FF	Enclosure	Habitation	**Detailed mapping and selected excavation**
			II	Heiau	Ceremonial	No further work
			JJ	Dark-stained Midden Soil Deposit	Uncertain	**Detailed mapping and selected excavation**
			LL	Stone Mound	Agriculture	No further work
			MM	Enclosure	Habitation	No further work
			MM	Hearth	Habitation	No further work
			MM	Terrace	Uncertain	No further work
			NN	Modified Depression	Agriculture	No further work
6906	**359/488**	Wind Farm	NN	Terrace	Agriculture	No further work
			OO	U-Shaped Wall	Habitation	**Detailed mapping and complete aerial excavation**
			PP	Terrace	Habitation	**Detailed mapping and selected excavation**
			QQ	Wall	Habitation	No further work
			RR	Terrace	Agriculture	No further work
			SS	Terrace	Agriculture	No further work
			TT	Terrace	Agriculture	No further work
			VV	Terrace	Agriculture	No further work
			YY	Terrace	Agriculture / Habitation	**Detailed mapping and selected excavation**
			YY	Hearth	Habitation	**Detailed mapping and selected excavation**
			ZZ	Terrace	Agriculture / Uncertain	No further work
			GGG	Terrace	Agriculture	**Detailed mapping and selected excavation**
			HHH	Cleared Area	Agriculture	**Detailed mapping**
			HHH	Terrace	Agriculture	**Detailed mapping and selected excavation**

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6909	395-398	Wind Farm	G	Enclosure	Habitation	No further work
			G	Terrace	Habitation	No further work
			H	Terrace	Habitation	No further work
			I	Terrace	Habitation	No further work
			J	Terrace	Habitation	No further work
			K	Terrace	Agriculture	No further work
			K	Alignment	Uncertain	No further work
			N	Stone Mound	Burial	**Preserve**
6910	423 thru 430	Wind Farm	A	Enclosure	Uncertain	**Detailed mapping and selected excavation**
			B	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			C	Cleared Area	Agriculture	**Detailed mapping and selected excavation**
			C	Terrace	Agriculture	**Detailed mapping and selected excavation**
			D	Terrace	Agriculture	No further work
			D	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			E	Enclosure	Habitation	**Detailed mapping and selected excavation**
			E	Terrace	Habitation	**Detailed mapping and selected excavation**
			F	Enclosure	Agriculture / Uncertain	**Detailed mapping and selected excavation**
			F	Windbreak	Habitation	No further work
			F	Terrace	Uncertain	No further work
			G	Terrace	Habitation	No further work
			H	Terrace	Habitation	No further work
			I	Modified Lava Blister	Habitation	**Detailed mapping and selected excavation**
			J	Stone Mound	Habitation	No further work
			J	Terrace	Habitation	**Detailed mapping and selected excavation**
			K	Alignment	Agriculture	No further work
			L	Terrace	Habitation / Uncertain	No further work
			M	Stone Mound	Agriculture	No further work
			O	Terrace	Habitation	**Detailed mapping and selected excavation**
			O	Hearth	Habitation	**Detailed mapping and selected excavation**
			Q	Alignment	Agriculture	No further work
			Q	Cleared Area	Agriculture	No further work
			Q	Stone Mound	Agriculture	No further work
			R	Ditch / Channel	Agriculture	**Detailed mapping**
			S	Terrace, Bermed	Agriculture	No further work
			T	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			U	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			V	Stone Mound	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6918	**489/491**	Wind Farm	A	U-Shaped Wall	Uncertain	No further work
			B	U-Shaped Wall	Uncertain	No further work
			D	Terrace	Habitation	No further work
			E	Enclosure	Habitation	No further work
6919	**495**	Wind Farm	C	C-Shaped Wall	Agriculture / Habitation	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Habitation	No further work
			E	Terrace	Habitation	**Detailed mapping and selected excavation**
6920	**499**	Wind Farm		Wall	Habitation	No further work
6921	**501**	Wind Farm	B	Stone Mound	Burial	**Preserve**
6922	**502**	Wind Farm	A	Wall	Agriculture	No further work
			B	Stone Mound	Burial	**Preserve**
6923	**503**	Wind Farm	B	U-Shaped Wall	Habitation	No further work
			C	Stone Mound	Burial / Uncertain	**Preserve**
			D	Modified Outcrop	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			F	Modified Outcrop	Agriculture	No further work
6924	**544**	Wind Farm	A	Terrace	Agriculture	No further work
			D	C-Shaped Wall	Habitation	No further work
			E	Stone Mound	Uncertain	No further work
			F	Stone Mound	Uncertain	No further work
			G	Stone Mound	Uncertain	No further work
			H	Stone Mound	Uncertain	No further work
			K	Terrace	Agriculture	No further work
	568	Wind Farm	A	U-Shaped Wall	Habitation	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
6929	**583**	Wind Farm	A	Wall	Uncertain	No further work
			B	Overhang Shelter	Habitation / Uncertain	No further work
6930	**584**	Wind Farm	A	L-Shaped Wall	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			C	Stone Mound	Burial	**Preserve**
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			T	Modified Outcrop	Uncertain	No further work
			W	Terrace	Uncertain	No further work
			X	Terrace	Uncertain	No further work
			Y	Terrace	Uncertain	No further work
			Z	Terrace	Uncertain	No further work
			AA	Terrace	Agriculture	No further work
			BB	Terrace	Agriculture	No further work
			CC	Terrace	Agriculture	No further work
			DD	Terrace	Uncertain	No further work
			EE	Stone Mound	Agriculture / Burial	**Preserve**
			GG	Terrace	Uncertain	No further work
			HH	Terrace	Uncertain	No further work
			JJ	Terrace	Uncertain	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6937	**591**	Pāpaka Road	A	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
6938	**592**	Pāpaka Road	A	Wall	Agriculture / Ranching	No further work
			B	Wall	Uncertain	No further work
			C	Terrace	Agriculture	No further work
			D	Enclosure	Agriculture	No further work
			E	Overhang Shelter	Habitation	No further work
			F	Overhang Shelter	Habitation	No further work
			F	Terrace	Habitation	No further work
			G	Overhang Shelter	Habitation	No further work
			G	Terrace	Habitation	No further work
			G	Stone Mound	Habitation	No further work
			H	Enclosure	Agriculture	No further work
			I	Wall	Ranching	No further work
			J	Wall	Uncertain	No further work
			K	Wall	Ranching	No further work
			L	Lava Tube	Habitation	No further work
			L	Terrace	Habitation	No further work
			M	Terrace	Agriculture	No further work
6939	**593**	Pāpaka Road	A	Enclosure	Habitation	No further work
			B	Terrace	Habitation	No further work
			C	Terrace	Uncertain	No further work
			D	Terrace	Agriculture	No further work
6940	**594**	Pāpaka Road	A	Enclosure	Habitation	No further work
			B	Enclosure	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Enclosure	Ranching	No further work
			G	Terrace	Agriculture	No further work
			H	Terrace	Agriculture	No further work
6941	**595**	Pāpaka Road	A	Wall	Agriculture	No further work
			B	Overhang Shelter	Habitation	No further work
			C	Overhang Shelter	Habitation	No further work
6942	**597**	Pāpaka Road		Wall	Ranching	No further work
6946	**601**	Pāpaka Road		Wall	Ranching	No further work
6948	**603**	Pāpaka Road		Wall	Uncertain	No further work
6949	**604**	Pāpaka Road		Wall	Ranching	No further work
6950	**605**	Pāpaka Road		Wall	Ranching	No further work
6956	**2010 F**	Pāpaka Road		Enclosure	Ranching	No further work
6957	**2010 G**	Pāpaka Road	A	Stone Mound	Uncertain	No further work
			B	Wall	Uncertain	No further work
6958	**2010 H**	Pāpaka Road		Wall	Ranching	No further work
6959	**2010 I**	Pāpaka Road	A	Wall	Ranching	No further work
			B	Modified Outcrop	Uncertain	No further work
6960	**2010 J**	Pāpaka Road		Wall	Ranching	No further work
6961	**2010 K**	Pāpaka Road		Wall	Ranching	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6962	**2010 L**	Pāpaka Road	B	Wall	Agriculture	No further work
6963	**2010 M**	Pāpaka Road		Wall	Ranching	No further work
6965	**2010 O**	Pāpaka Road		Wall	Ranching	No further work
6966	**2010 P**	Pāpaka Road		Cast Iron Tank	Ranching	No further work
6967	**2010 Q**	Pāpaka Road	A	Wall	Ranching	No further work
			B	Enclosure	Agriculture	No further work
6968	**2010 R**	Pāpaka Road	A	Wall	Agriculture	No further work
			A	Alignment	Agriculture	No further work
			B	Terrace	Agriculture	No further work
6969	**2010 S**	Pāpaka Road		Wall	Ranching	No further work
6970	**2010 T**	Pāpaka Road		Wall	Ranching	No further work
6971	**2010 U**	Pāpaka Road		Wall	Uncertain	No further work
6972	**2010 V**	Pāpaka Road	A	Terrace	Habitation	No further work
6974	**2010 X**	Pāpaka Road		Wall	Habitation	No further work
6975	**2010 Y**	Pāpaka Road	A	Wall	Ranching	No further work
6976	**2010 Z**	Pāpaka Road		Enclosure	Habitation	No further work
				Terrace	Habitation	No further work
6977	**2010 AA**	Pāpaka Road		Wall	Ranching	No further work
6978	**2010 BB**	Pāpaka Road		Wall	Ranching	No further work
6979	**2010 CC Gen-TieLine**	Gen-TieLine	A	Terrace	Habitation	No further work
			A	U-Shaped Wall	Habitation	No further work
			B	Stone Mound	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work
			H	Stone Mound	Agriculture	No further work
			I	Stone Mound	Agriculture	No further work
			J	Stone Mound	Agriculture	No further work
			K	Terrace	Agriculture	No further work
6980	**2010 CC Pāpaka**	Pāpaka Road		Wall	Ranching	No further work
6981	**2010 DD**	Gen-TieLine		Wall	Uncertain	No further work
6982	**2010 EE**	Gen-TieLine		Wall	Uncertain	No further work
6983	**2010 FF**	Gen-TieLine	A	Terrace	Agriculture / Uncertain	No further work
			B	Terrace	Uncertain	No further work
			C	Alignment	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Cleared Area	Agriculture	No further work
			F	Terrace	Uncertain	No further work
			G	U-Shaped Wall	Uncertain	No further work
			H	Wall	Agriculture	No further work
			I	Wall	Agriculture	No further work
			J	Terrace	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6984	2010 GG	Gen-TieLine	A	Alignment	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Habitation	No further work
			D	Terrace	Habitation	No further work
			E	Terrace	Agriculture	No further work
			F	Stone Mound	Agriculture / Habitation	No further work
			G	Wall	Agriculture / Habitation	No further work
			H	Terrace	Agriculture / Habitation	No further work
6985	2010 HH	Gen-TieLine	A	Terrace	Agriculture	No further work
			B	Modified Outcrop	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			C	Modified Outcrop	Uncertain	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Modified Outcrop	Agriculture / Burial / Uncertain	**Preserve**
			G	Stone Mound	Agriculture / Burial / Uncertain	**Preserve**
			H	Stone Mound	Agriculture / Habitation	No further work
			I	Terrace	Agriculture / Habitation	No further work
			J	Stone Mound	Agriculture / Habitation	No further work
			K	Terrace	Agriculture / Habitation	No further work
			L	Stone Mound	Agriculture / Habitation	No further work
			M	Wall	Agriculture / Habitation	No further work
			N	Stone Mound	Agriculture / Habitation	No further work
			O	Stone Mound	Agriculture / Burial / Uncertain	**Preserve**
			P	Stone Mound	Agriculture / Burial / Uncertain	**Preserve**
			R	Terrace	Uncertain	**Preserve**
			S	Stone Mound	Agriculture / Burial / Uncertain	No further work
6986	2010 II	Gen-TieLine		Wall	Uncertain	No further work
6987	2010 JJ	Gen-TieLine	A	Modified Outcrop	Uncertain	No further work
			B	U-Shaped Wall	Habitation	No further work
			C	Wall	Uncertain	No further work
			D	Terrace	Agriculture	No further work
			E	Wall	Agriculture / Habitation	No further work
			F	Enclosure	Habitation	No further work
			G	Modified Outcrop	Habitation	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
6988	2010 KK	Gen-TieLine	A	Terrace	Agriculture	No further work
			B	Wall	Uncertain	No further work
			C	Enclosure	Habitation	No further work
			C	Wall	Habitation	No further work
			D	Wall	Uncertain	No further work
			E	C-Shaped Wall	Habitation	**Detailed mapping and complete aerial excavation**
			E	Enclosure	Habitation	**Detailed mapping and complete aerial excavation**
			F	Alignment	Uncertain	No further work
			F	Wall	Uncertain	No further work
			G	Terrace	Habitation	No further work
			H	Wall	Agriculture	No further work
			I	Terrace	Agriculture	No further work
			J	Terrace	Agriculture	No further work
			K	Wall	Agriculture	No further work
6989	2010 LL	Wind Farm	A	Stone Mound	Agriculture	No further work
			B	Terrace	Uncertain	No further work
			C	Stone Mound	Agriculture / Uncertain	No further work
6991	2010 NN	Pi`ilani Hwy		Wall	Ranching	No further work
6992	2010 OO	Pi`ilani Hwy	C	Terrace	Uncertain	No further work
			D	Stone Mound	Burial / Uncertain	**Preserve**
			E	Wall	Uncertain	No further work
6994	2010 QQ	Pi`ilani Hwy	A	Wall	Ranching	No further work
6995	2010 RR	Gen-TieLine	10	Terrace	Agriculture	No further work
6996	2010 SS	Gen-TieLine		Stone Mound	Agriculture	No further work
6997	2010 TT	Gen-TieLine		Modified Outcrop	Agriculture	No further work
6998	2010 UU	Gen-TieLine		Modified Outcrop	Uncertain	No further work
6999	2010 VV	Gen-TieLine	A	Stone Mound	Agriculture	No further work
			B	Platform	Agriculture	No further work
7000	2010 WW	Gen-TieLine		Wall	Agriculture	No further work
7001	2010 XX	Gen-TieLine		Stone Mound	Agriculture	No further work
7002	2010 YY	Gen-TieLine		Stone Mound	Agriculture	No further work
7003	2010 ZZ	Gen-TieLine		Stone Mound	Agriculture	No further work
7004	2010 AAA	Gen-TieLine	A	Alignment	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
7005	2010 BBB	Gen-TieLine		Terrace	Agriculture	No further work
7006	2010 CCC	Gen-TieLine		Stone Mound	Agriculture	No further work
7008	2010 EEE	Gen-TieLine		Stone Mound	Agriculture	No further work
7009	2010 FFF	Gen-TieLine		Modified Outcrop	Agriculture	No further work
				Alignment	Agriculture	No further work
7010	2010 GGG	Gen-TieLine		Stone Mound	Agriculture	No further work
7011	2010 HHH	Gen-TieLine	2	Stone Mound	Ranching	No further work
7012	2010 III	Gen-TieLine		Stone Mound	Agriculture	No further work
7013	2010 JJJ	Gen-TieLine		Platform	Ranching	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7014	**2010 KKK**	Pāpaka Road	A	Alignment	Agriculture	No further work
			B	Alignment	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Modified Outcrop	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			D	Cleared Area	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work
			H	Terrace	Agriculture	No further work
			I	Stone Mound	Agriculture	No further work
			I	Terrace	Agriculture	No further work
7015	**2010 LLL**	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Modified Outcrop	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
7016	**2010 MMM**	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
			D	Terrace	Agriculture	No further work
			E	Stone Mound	Agriculture	No further work
			E	Terrace	Agriculture	No further work
			F	Terrace	Agriculture	No further work
			G	Stone Mound	Agriculture	No further work
			H	U-Shaped Wall	Habitation / Uncertain	**Detailed mapping and selected excavation**
			H	Terrace	Habitation / Uncertain	No further work
			I	Wall	Agriculture	No further work
			J	Terrace	Agriculture	No further work
			K	C-Shaped Wall	Agriculture	No further work
			L	Enclosure	Uncertain	No further work
			L	Terrace	Uncertain	No further work
			M	Wall	Agriculture	No further work
			N	Terrace	Agriculture	No further work
			O	Terrace	Uncertain	**Detailed mapping and selected excavation**
			P	Modified Outcrop	Uncertain	No further work
			Q	Terrace	Agriculture	No further work
			R	Stone Mound	Agriculture	No further work
7017	**2010 NNN**	Pāpaka Road	A	Terrace	Ceremonial / Habitation	**Detailed mapping and selected excavation**
			B	Alignment	Uncertain	No further work
			B	Stone Mound	Uncertain	No further work
			C	Stone Mound	Agriculture	No further work
7018	**2010 OOO**	Pāpaka Road		Wall	Ranching	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7019	**2010 PPP**	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			D	Terrace	Habitation	No further work
			D	Wall	Habitation	No further work
			E	Terrace	Agriculture / Uncertain	No further work
7020	**2010 QQQ**	Pāpaka Road	A	Terrace	Habitation	No further work
			B	Stone Mound	Agriculture	No further work
			C	Terrace	Habitation	**Detailed mapping and selected excavation**
7021	**2010 RRR**	Pāpaka Road	A	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			B	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
			D	Terrace, Bermed	Agriculture	**Detailed mapping and selected excavation**
7022	**2010 SSS**	Pāpaka Road	A	Terrace	Agriculture	No further work
			B	Terrace	Uncertain	No further work
			C	C-Shaped Wall	Agriculture / Uncertain	No further work
			D	C-Shaped Wall	Agriculture / Habitation	No further work
			E	C-Shaped Wall	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			F	Enclosure	Uncertain	**Detailed mapping and selected excavation**
			F	Hearth	Habitation	No further work
			H	Terrace	Agriculture	No further work
7023	**2010 TTT**	Pāpaka Road		Barbed Wire Fence	Ranching	No further work
7024	**2010 UUU**	Pāpaka Road	A	Wall	Agriculture / Ranching	No further work
			B	Alignment	Ranching	No further work
			C	Wall	Ranching	No further work
7025	**2010 VVV**	Pāpaka Road	A	Stone Mound	Agriculture	No further work
			B	Alignment	Uncertain	No further work
7026	**2010 WWW**	Wind Farm	A	Terrace	Uncertain	No further work
			B	Stone Mound	Agriculture	No further work
			C	Stone Mound	Agriculture	No further work
			D	Enclosure	Agriculture	No further work
			E	Terrace	Habitation	No further work
			G	C-Shaped Wall	Habitation	No further work
7027	**2010 AAAA**	Wind Farm	A2	Modified Outcrop	Agriculture	No further work
7028	**2010 BBBB**	Wind Farm	B	Terrace	Agriculture	No further work
			C	Terrace	Agriculture	No further work
7029	**2010 CCCC**	Wind Farm	A	Terrace	Uncertain	No further work
			B	Terrace	Uncertain	No further work
7030	**2010 DDDD**	Wind Farm	A	Alignment	Uncertain	No further work
7031	**2010 EEEE**	Wind Farm		Modified Outcrop	Agriculture	No further work
7032	**2010 FFFF**	Wind Farm		Wall	Uncertain	No further work
7033	**2010 GGGG**	Wind Farm		Terrace	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
7035	**2010 IIII**	Wind Farm	A	Modified Outcrop	Agriculture	No further work
			B	Stone Mound	Burial	**Preserve**
			C	Stone Mound	Burial	**Preserve**
			D	Stone Mound	Burial	**Preserve**
			E	Stone Mound	Burial	**Preserve**
7036	**2010 JJJJ**	Wind Farm	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
7037	**2010 KKKK**	Wind Farm	A	Terrace	Agriculture	No further work
			B	Terrace	Agriculture	No further work
7038	**2010 LLLL**	Wind Farm	A2	Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Ditch / Channel	Agriculture	No further work
7039	**2010 MMMM**	Wind Farm		Platform	Uncertain	No further work
7040	**2010 NNNN**	Wind Farm		Stone Mound	Agriculture	No further work
7041	**2010 OOOO**	Wind Farm		Alignment	Agriculture / Burial	**Preserve**
				Stone Mound	Agriculture / Burial	**Preserve**
				Hearth	Habitation	No further work
7042	**2010 PPPP**	Wind Farm	A	Terrace	Habitation	No further work
			B	Terrace	Habitation	No further work
			C	Terrace	Habitation	No further work
			D	Terrace	Habitation	No further work
			E	Alignment	Uncertain	No further work
			F	Stone Mound	Uncertain	No further work
	2011 B	Gen-TieLine		Stone Mound	Agriculture / Ranching	No further work
	2011 C	Gen-TieLine		Stone Mound	Agriculture / Ranching	No further work
	2011 D	Gen-TieLine		Barbed Wire Fence	Agriculture / Ranching	No further work
	2011 E	Wind Farm		Alignment	Uncertain	No further work
	2011 F	Wind Farm		Terrace	Agriculture / Habitation	No further work
	2011 G	Wind Farm	A	C-Shaped Wall	Agriculture	No further work
			B	Terrace	Agriculture	No further work
			C	Modified Outcrop	Agriculture	No further work
			D	Modified Outcrop	Agriculture	No further work
			E	Modified Outcrop	Agriculture	No further work
			F	Modified Outcrop	Agriculture	No further work
			G	C-Shaped Wall	Agriculture	No further work
	2011 J	Wind Farm	B	Terrace	Habitation	No further work
	2011 K	Wind Farm	A	Lava Tube	Burial / Habitation / Uncertain	**Preserve**
			B	Lava Tube	Burial / Habitation / Uncertain	**Preserve**
			H	Lava Tube	Uncertain	No further work
	2011 M	Wind Farm	A	C-Shaped Wall	Habitation	No further work
			C	Modified Outcrop	Agriculture	No further work
			D	Stone Mound	Agriculture	No further work
			E	Terrace	Agriculture / Habitation / Uncertain	**Detailed mapping and selected excavation**
			F	Terrace	Agriculture	No further work
			G	Terrace	Agriculture	No further work

SIHP No. (50-50-)	Field No. (AWF-)	Project Area	Feature	Site / Feature Type	Possible Function	Recommended Treatment
	2011 N	Wind Farm		Wall	Habitation	No further work
	2011 O	Wind Farm		Terrace	Agriculture / Habitation	No further work
	2011 P	Wind Farm	A	U-Shaped Wall	Ceremonial / Habitation	**Detailed mapping and selected excavation**
			B	Modified Puka	Habitation	No further work
	2011 Q	Wind Farm		Enclosure	Habitation	**Detailed mapping and selected excavation**
7044	**Mākena 2**	Pāpaka Road		Terrace	Uncertain	No further work
7045	**Mākena 3**	Pāpaka Road	A	Enclosure	Agriculture / Habitation	No further work
			B	Cleared Area	Agriculture	No further work
7046	**Mākena 4**	Pāpaka Road		Enclosure	Uncertain	No further work
7047	**Mākena 5**	Pāpaka Road		Wall	Ranching	No further work
7048	**Mākena 6**	Pāpaka Road		Modified Outcrop	Uncertain	No further work
7049	**Mākena 7**	Pāpaka Road		Wall	Habitation	No further work
7050	**Mākena 8**	Pāpaka Road		Cleared Area	Habitation	No further work
				Windbreak	Habitation	No further work

Key:

Preserve
Detailed mapping
Detailed mapping and selected excavation
Detailed mapping and complete aerial excavation

6.0 SUMMARY AND DISCUSSION

The Auwahi Wind Farm project area is located within ʻUlupalakua Ranch, which has been a privately held property for hundreds of years. Access is restricted on the ranch, being limited to ranch personnel and adjacent property owners. As such, the archaeological sites are in relatively pristine condition as compared to other areas on Maui where access is not as restricted. Previous impacts to archaeological sites in the project area have occurred primarily as a result of cattle ranching activities. Undoubtedly some of the traditional structures were partially dismantled in 1800s and early 1900s so that the available fieldstone could be used in the creation of cattle walls and related enclosures. Ranch access roads have also impacted some of the traditional features. Hunting activity was also observed and may have impacted some of the resources. However, the ranch is very pro-active with regard to minimizing impacts to archaeological features (pre-Contact and historic) as they feel it is part of the ranch heritage and stewardship.

The current drought conditions, although extremely difficult and trying for the ranch, afforded the archaeological crew a unique opportunity with regard to identifying low lying and subtle agricultural features. The evidence for remnant terracing and altered landscapes was clearly visible due to the lack of low lying vegetation, which covered much of the project area during the 2007 survey. Hence, our recording efforts were much more complete.

Density of Settlement

We continue to be astonished about the density of settlement in this portion of Auwahi. In the ca. 160 acres that make up the wind farm site we recorded 67 sites comprised of 361 features. This calculates to about 2.3 structural features per acre. The results of the 2007 pedestrian survey indicated that the density of settlement is constant over the entire 1,450 acres that make up the south wind farm. Using our 2.3 features per acre figure, we could expect that the entire 1,450 acre parcel could contain more than 3,335 features. This is an incredibly dense settlement.

One of the main questions relating to this settlement density is the chronological factor. Did this settlement develop over several hundreds of years, where possibly some of the features functioned for short periods and then were abandoned, so that the density of settlement was not as great as it may appear? Conversely, was the settlement of Auwahi fairly short with all of the features being contemporaneous and being used at the same time; this would suggest a very intense settlement? This question is discussed below

Pattern of Settlement

The terrain in the APE is relatively steep and rocky. It is composed of both low and high ridges with both shallow and deep intervening gulches and swales. The pattern of settlement in the wind farm reflects these geographic differences. The habitation and ceremonial features are situated atop the rocky ridges. These ridges afford panoramic views of Auwahi as well as up and down the coast. Some of the features are also afforded views of the Big Island of Hawaiʻi on clear days. One can often see the mountains of Mauna Kea and Mauna Loa as well as portions of the Kohala Coast.

Agricultural features are found in the gulch drainages, swales, or flat areas below ridge lines. These areas often contain considerably more soil than the ridgelines. Almost every flat piece of land contained modifications for the cultivation of crops.

Agriculture

The wind farm site consists of extremely inhospitable terrain. The area is relatively steep, extremely rocky, arid, and very windy. This is not the type of area one would think of as an intensively cultivated area. But it was. As noted above almost every flat piece of land between and at the base of ridges was cultivated. Not only do these areas contain more soil than the ridges, the ridges afford some protection from the strong winds that characterize this area.

The agricultural systems were quite complex. The flat and relatively flat areas were modified with retaining walls to create larger cultivation areas. We also found evidence of water control and management in the gulches. These water control features included dams and diversion walls. While this area is extremely arid, it is also characterized by short and heavy down pours of rain. The control of this moisture was crucial in successful crop cultivation. By slowing the transport of water and diverting these water flows to fields, more crops could be successfully grown.

Heiau

Five "notched" *heiau* were recorded within the wind farm. This seems to be a high density of *heiau* in a small area. We currently think that these *heiau* were associated with the agricultural pursuits that dominated this area, but why are there so many? As of now we have more questions than answers: (1) were these *heiau* contemporary with each other, or was one *heiau* abandoned before another was built; (2) were these *heiau* associated with different land divisions such as *'ili* within the *ahupua'a*; (3) were these *heiau* ceremonial structures for related extended families. It is not clear whether we will obtain answers to these types of questions, but they remain interesting.

Postulated Activities

Hawaiians in pre-Contact times were living, having children (deciduous tooth found), and dying (presence of burials) in this area of Auwahi. Some of the specific activities taking place here can be outlined as follows:

- Agricultural pursuits (including planting, harvesting, and water control) was probably the dominant activity taking place.
- Food preparation is indicated by the number of stone lined hearths found during the survey and substantiated by the *poi* pounder fragment and the pestle; that were found.
- Basalt adze preforms, flakes, hammerstones, a grinding stone, and complete finished adze found in the project area indicates that stone adzes were probably made or repaired here, and that some forms of wood working was taking place.
- The two *'ulu maika* and the two *papamū* suggest that recreation played some part in the lives of the people of Auwahi. Furthermore it is possible that the area contained an *'ulu maika* tack that is no longer visible.
- *He'e* or octopus fishing was also taking place on the coast. Several octopus fishing sinkers and lures were found.

- Contact with the coast is also indicated by the sparse marine shell midden that was observed on the surface of some of the features and that was recovered from the test excavations.

Diet

It is very premature to state anything about the diet of the Hawaiians living in Auwahi, but there are a few general statements that can be made. By inference (the abundance of agricultural plots), vegetable foods, probably mostly *ʻuala* or sweet potato, made up the majority of the diet. Added to this were protein sources from marine and terrestrial environments that included shell fish, fish, dog, and pig. Birds, both the domestic chicken and wild avian species may have also been components, but definite statements on the avian component of the diet must await the results of the midden analyses.

6.1 Site Avoidance

Since the inception of archaeological investigations in 2007, an emphasis has been placed on minimizing the impact of construction on the archaeological resources present in Auwahi. This report has shown that design changes have been continually made in an effort to minimize impacts to archaeological sites. This effort has been focused on avoiding impact to ceremonial/religious structures and human burials. This effort will continue. Another measure of the degree of impact is the relative number of features that will be impacted. It was shown that over 361 features are located in the 160 acre Wind Farm parcel APE. This calculates to 2.3 features per acre within the Wind Farm APE. However, not all of these features will be impacted by construction, as whole site clusters were recorded where only portions will be impacted. If, based on our calculations above we assume that the 1,450 acre south parcel may have over 3,335 features, then even if all 361 features are impacted (which they will not be) this represents only 14 percent of the total number of calculated features within the 1,450 acre parcel.

6.2 Auwahi in a Regional Kahikinui Perspective

As noted earlier in this report, Kahikinui was one of twelve traditional *moku* or political districts into which the island of Maui was subdivided at the time of initial European contact. The western boundary of Auwahi (which adjoins Kanaio *ahupuaʻa* in the *moku* of Honuaʻula) also forms the western boundary of the *moku* of Kahikinui. Kahikinui then extends to the east of Auwahi for some 9 kilometers until its eastern boundary is reached at the Waiʻōpai (which shares its own eastern boundary with Nākula in the moku of Kaupō). Encompassing roughly 100 square kilometers, Kahikinui takes up much of the southeastern slope of the great volcano of Haleakalā. The purpose of this concluding section is to review the results of our Auwahi survey within the broader perspective of the Kahikinui District as a whole. By examining Auwahi within this *moku*-level context, the significance of many of the Auwahi features are highlighted. At the same time, the new results from Auwahi help to understand wider patterns throughout the district.

Kahikinui is, without doubt, the most arid part of Maui, owing to its location in the rain shadow of Haleakalā. This arid climate, combined with the relatively young geological age of the lava flow surfaces which make up the Kahikinui landscape, make it a highly distinctive environment for human habitation and land use. More than in any other part of Maui, the pre-Contact Hawaiian occupants of Kahikinui had to adapt to harsh climatic conditions that were on the margins for tropical root-crop horticulture. Almost all of Kahikinui's annual rainfall comes as a result of the winter (*kona*) storms. This would have restricted cropping of sweet potato and yams to a relatively short growing period roughly between October and March. Furthermore, the young geological substrate also results in a forbidding coastline dominated by low sea cliffs and the absence of a fringing reef. This coastal geomorphology makes access to the shoreline for fishing or shellfish gathering difficult at best, while the absence of a reef means that marine biomass is low. Thus, a harsh horticultural landscape was coupled with low marine biodiversity and productivity, rendering Kahikinui an even more challenging landscape for human occupation.

In spite of these environmental challenges, Kahikinui was home to a large and vibrant population of Native Hawaiians for at least four centuries, from around AD 1400 until 1800. The high density of archaeological features throughout Auwahi as well as in the other parts of Kahikinui which have been investigated to date, is remarkable. These archaeological features are a testament to the adaptability and ingenuity of the Native Hawaiians, who were able to create successful lifestyles in a marginal and challenging land. In the 19th century, the district's population began to fall precipitously as result of the European-introduced diseases that swept through the islands. Kahikinui was finally abandoned by Native Hawaiians around the close of the 19th century, after the Hawaiian Government leased the land to Portuguese cattle ranchers, making the traditional farming mode of life untenable.

6.3 AUWAHI AND THE AHUPUA'A OF KAHIKINUI

In the traditional Hawaiian land system, districts or *moku* were subdivided into pie-shaped land units or territories called *ahupua'a*. Each *ahupua'a* (in theory at least) ran from the mountain peak or crest down to the sea, thus cross-cutting the ecological grain of the land and including segments of all of the main resource zones: upper forests (source of timber and bird's feathers), lower forests (used for taro planting), a main zone of agricultural lands, the coastal zone where habitations were often concentrated, and the coast with its littoral resources of shellfish and fish. Individual *ahupua'a* were periodically awarded to chiefs (*ali'i*) by the king (*Ali'i nui*), usually at the moment of succession to the kingship, either after a war of conquest or at the death of a king (Kirch 2010b). The chief who controlled the *ahupua'a*, called the *ali'i-'ai-ahupua'a*, typically appointed a land overseer, the *konohiki*, who resided in the territory and was responsible for its daily management. This *konohiki* made sure that the population of commoners (*maka'āinana*) who resided in the *ahupua'a* kept up their gardens and farms, and were prepared to present the annual tribute (*ho'okupu*) to the chief and the king.

For most of the lands in Hawai'i, the specific boundaries of *ahupua'a* territories are well known, because these were codified at the time of the Mahele 'Āina, or division of lands between the king, principal chiefs, and the government between 1846-54 (Chinen 1958; Kirch and Sahlins

1992). As discussed earlier, however, Kahikinui was rather unusual in that—with the exception of Auwahi—all of the lands of the *moku* were awarded to Prince Lot (grandson of King Kamehameha I, later to become Kamehameha V). Auwahi was not included in the award to Prince Lot, but rather was given to his half-sister the high chiefess Ruta Keli‘iokalani (great granddaughter of Kamehameha I), who kept the *ahupua‘a* in her possession until after her death, when it became a part of ‘Ulupalakua Ranch. The remainder of Kahikinui, given over to Prince Lot, was presumably also subdivided into several different, named *ahupua‘a*. But because this vast region was transferred as a single unit to the prince, these *ahupua‘a* were not specifically named in the Mahele Book of awards. Moreover, because Lot was dissatisfied with his receipt of the Kahikinui lands, he rapidly arranged to have them transferred to the Hawaiian Government, in exchange for more productive lands elsewhere. With the entire area of Kahikinui (excepting Auwahi) now in Government hands, there was again no particular interest in delineating the specific boundaries between *ahupua‘a* within Kahikinui, because these were not held by separate private landholders.

For these reasons, the only *ahupua‘a* territory within the ancient *moku* of Kahikinui that can be unambiguously defined is that of Auwahi. Its western and eastern boundaries were defined by the Hawaiian Government’s Boundary Commission in the 1870s. The vast expanse of land to the east of Auwahi, extending past the Luala‘ilua Hills all the way to deep Manawainui Gulch and beyond to the eastern border of Kahikinui at Wai‘ōpai was surely divided into several *ahupua‘a*. Clues as to the names of these *ahupua‘a* are provided by early maps of the region. The earliest printed map of the Hawaiian Islands was made by Samuel P. Kalama in 1838 while at the missionary school at Lāhaināluna on Maui, in 1838 (Moffat and Fitzpatrick 1995:26-25, figure 10). This map labels the following major land units, from west to east in Kahikinui: Auwahi (spelled Auahi), Luala‘ilua, Alena, and Kīpapa. The first accurate survey of Kahikinui District was undertaken by W. R. Lawrence in July, 1882, for the Hawaiian Government Survey under the overall direction of W. D. Alexander. The original drafted map of this survey, preserved in the archives of the State Survey Office, has penciled place names that appear to indicate *ahupua‘a*, or at least major land divisions (although no boundaries between these divisions are delineated. These names, from the eastern boundary of Auwahi proceeding eastward are: Alena, Kīpapa, Na Kaahu, and Na Kaohu. The first version of the “modern” map of Maui was a collaborative effort of the Hawaiian Territorial Survey, the U. S. Geological Survey, and the U. S. Coast and Geodetic Survey, undertaken in 1928 (published in quadrangle sheets at a scale of 1:62,500 by the USGS). The Mākena and Haleakalā Quadrangles show Auwahi with its boundaries, and for the rest of Kahikinui give land names (without boundaries delineated) in west to east order: Alena, Kīpapa, Nakaohu, Nakaaha, Mahamenui, Manawainui, and Wai‘ōpai (Figure 40). Interestingly, Luala‘ilua appears on this map only as the name of the cinder cones, and not as a larger land unit. This suggests the possibility that Luala‘ilua was not an *ahupua‘a*, but was a kind of boundary zone between Auwahi and Alena.

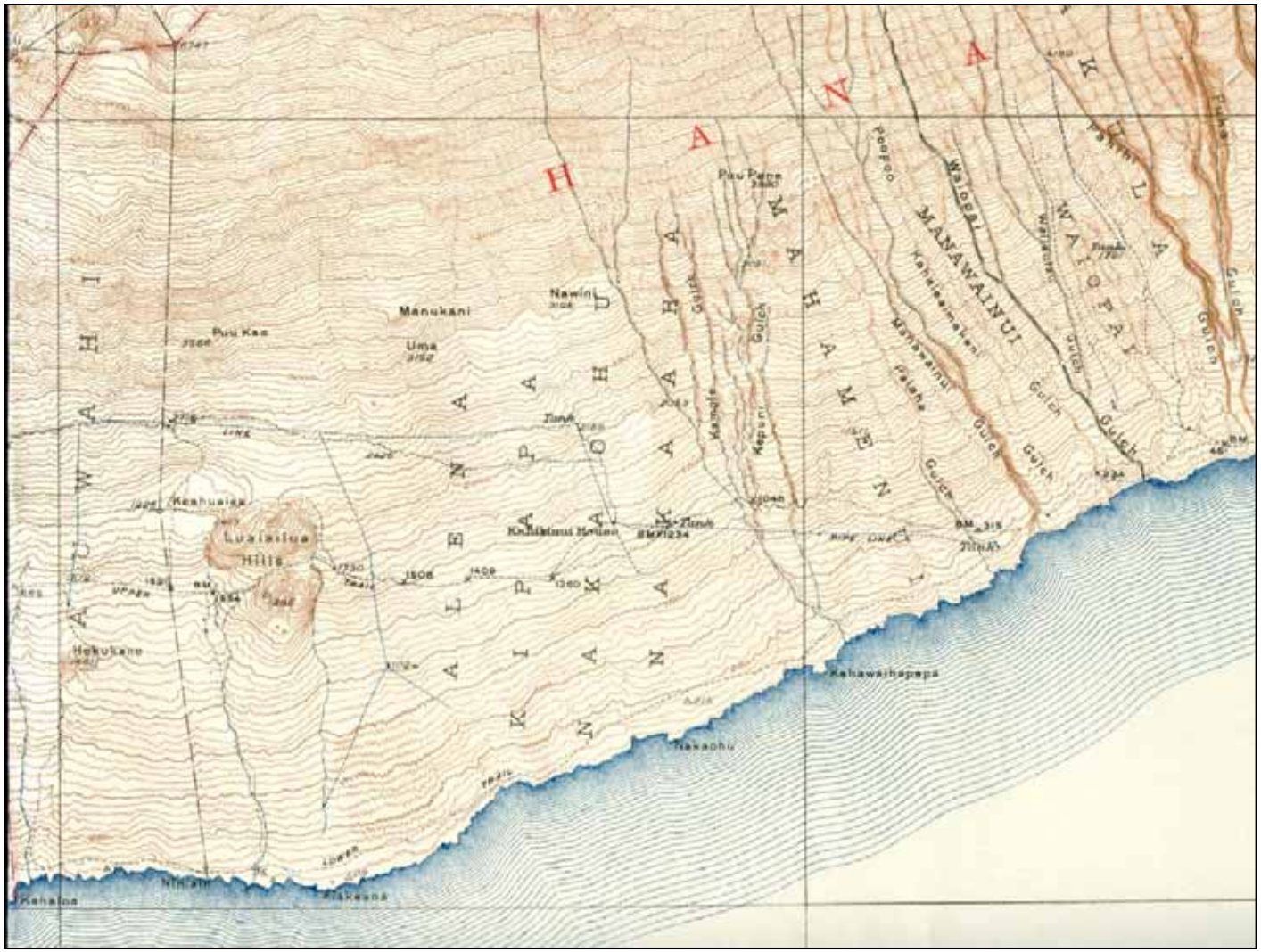


Figure 40. Map of Kahikinui District showing the various place names which are believed to represent individual *ahupua'a*, or in some cases possibly '*ili*, land units. (Map by U. S. Geological Survey, 1942.)

To summarize, Auwahi was just one of several *ahupua'a* that in aggregate constituted the large *moku* of Kahikinui. However, it remains uncertain exactly how many *ahupua'a* the rest of Kahikinui was subdivided into. Certainly Alena and Kīpapa seem to have unquestioned status as *ahupua'a* names, as they appear on the early Kalama map from 1838. The other names which appear on the 1928 USGS map, and which have continued to be published on subsequent editions up until the present, may also have been *ahupua'a*. Alternatively, they may have been smaller unit, such as *'ili*, within a large single *ahupua'a* of Kīpapa.

For the present study, the most important implication of all this is that Auwahi was unquestionably an independent *ahupua'a* within the larger *moku* of Kahikinui. Moreover, the fact that this land unit was conferred on one of the highest-ranked chiefesses in the Hawaiian Kingdom during the Mahele 'Āina of 1848, Princess Ruta Keli'iokalani (grand-daughter of King Kamehameha I), suggests that the *ahupua'a* had a special status, for such a high-ranked personage would not be awarded an unimportant territory. Clearly, at the time of the Mahele all of Kahikinui was in the control of the Kamehameha family (and presumably had been so since the conquest of Maui by Kamehameha after the death of Maui King Kahekili in the late 18th century). But Keli'iokalani outranked her half-brother Lot, in part due to her pedigree which traced back to Kānekapōlei, a former wife of the great Hawai'i king Kalani'ōpu'u and an early wife of Kamehameha I. Thus, the fact that Auwahi was awarded to Keli'iokalani is indicative that the *ahupua'a* had a special status within Kahikinui. Indeed, although there is no direct historical proof of this, one presumes that she expressly wanted this *ahupua'a* and had requested it in the negotiations leading up to the Mahele. This interpretation of Auwahi as particularly important within the larger *moku* is also supported by the archaeological observation that the most important coastal settlement, containing the largest individual residential platforms and several *heiau*, is situated on the coast at Makee, within Auwahi. For these and other reasons, it is likely that Auwahi was the most important *ahupua'a* in the entire district. It was probably the residence of the *konohiki* who represented Keli'iokalani, as she herself would not have resided there. In the following pages, we will summarize other evidence that further reinforces this interpretation, notably that Auwahi is likely to have had some of the most intensively cultivated zones within the entire district, and that it was a locus of high population density.

6.4 CHRONOLOGY OF OCCUPATION AND LAND USE IN AUWAHI

Recent archaeological excavations and re-dating of key sites throughout Eastern Polynesia, including Hawai', have led to a shortening of the Hawaiian cultural sequence. It appears unlikely that the Hawaiian archipelago was settled before A.D. 800, and may not have been colonized by the first Polynesians until closer to A.D. 1000 (Kirch and McCoy 2007; Dye and Pantaleo 2010). This has required a revision in the Hawaiian cultural sequence originally proposed by Kirch (1985: figure 239), with four periods prior to European contact: Colonization, Developmental, Expansion, and Protohistoric. Instead, following a proposal by Kirch and McCoy (2007), the first two periods are collapsed into a shorted Foundation Period, from initial settlement (ca. A.D. 800/1000) to A.D. 1200. This is then followed by an Early Expansion Period (A.D. 1200-1400), a Late Expansion Period (A.D. 1400-1650), and a Protohistoric Period (A.D. 1650-1778). This revised sequence has recently been summarized by Kirch (2010b, table 4.1). We

will refer to this sequence in the following analysis of radiocarbon dates from Auwahi and from the larger Kahikinui region.

Prior to our current project, only two radiocarbon dates had been obtained from sites within Auwahi *ahupua'a*. Both dates were from excavations by Kirch at the coastal village site of Makee. A *heiau* site returned an age of 390 ± 40 BP (Beta-183146) while an adjacent fishing shrine was dated to 160 ± 40 BP (Beta-183147) (Oceanic Archaeology Laboratory, unpublished data). These dates suggested that Polynesian use of at least the coastal zone had commenced by the 15th century, but gave no indication of the timing of the extensive inland occupation.

For several *ahupua'a* to the east of Auwahi, however, a more extensive radiocarbon database had been developed over about 15 years of excavations, by the U. C. Berkeley Oceanic Archaeology Laboratory group (Kirch 1997), by the State Historic Preservation Division's investigations on behalf of the Department of Hawaiian Home Lands (Dixon et al. 2000), and by the University of Northern Illinois' study of several *heiau* sites in the district (Kolb 2006). The largest subset of dates comes from Kīpapa, but Nakaohu, Mahamenui, and Manawainui *ahupua'a* are also represented. In all, 162 radiocarbon dates have been obtained. This is a high-quality database in that virtually all of the samples were botanically identified prior to dating (thus eliminating the recurring problem of "old wood"), and because almost all of the dates were run using the high-precision AMS (accelerator mass spectrometry) method. In fact, this is one of the largest radiocarbon databases for any single district or region within the Hawaiian Islands. The Kahikinui radiocarbon database has been used by Kirch (2007) to estimate pre-contact populations trends in the district, and by Kirch (2010b:128-136) as part of a larger meta-analysis of Hawaiian demography.

Figure 41 is a histogram plot of the 162 Kahikinui radiocarbon dates (excluding our recent sample of 16 dates from Auwahi) by 100-year calibrated age intervals. (By "calibrated" we mean that the plotted ages are not radiocarbon ages but calendar ages derived from the Oxcal calibration program.) Because radiocarbon ages are not "dates" in a strict sense, but rather sets of probability distributions, often with multiple possible intercepts on the calibration curve, plotting dates as in Figure 182 requires making a decision about which of several possible calibration intercepts to accept. In this case the preferred intercept for each radiocarbon date is that with the single highest probability (probabilities are generated as part of the Oxcal calibration program).

As can be seen in Figure 41, there are only two radiocarbon dates older than A.D. 1400. These dates suggest the likelihood of some human activities in the Kahikinui region during the late Foundation and Early Expansion Periods, but are unlikely to signal permanent land use or occupation. More likely, they relate to initial Polynesian exploration of the region. During the period from A.D. 1400-1499, however, ten radiocarbon dates from several sites can be taken as evidence that Hawaiians had begun to establish a permanent presence in the region. This corresponds to the onset of the Late Expansion Period in the revised Hawaiian sequence, a period known from Hawai'i Island to have been one of major expansion of leeward agricultural field systems (Ladefoged and Graves 2008). The numbers of Kahikinui radiocarbon dates then increase significantly for the next two centuries, from A.D. 1500-1699, reflecting a growing population and expansion of settlement. Most striking, however, is the more than doubling of

dates in the final 100-year interval, from A.D. 1700-1799. This is the Protohistoric Period, prior to and overlapping with the first arrival of Europeans into the islands. Based on the Kahikinui radiocarbon database, it seems that the highest density of settlement and population in the district was reached in this final century of the pre-Contact era.

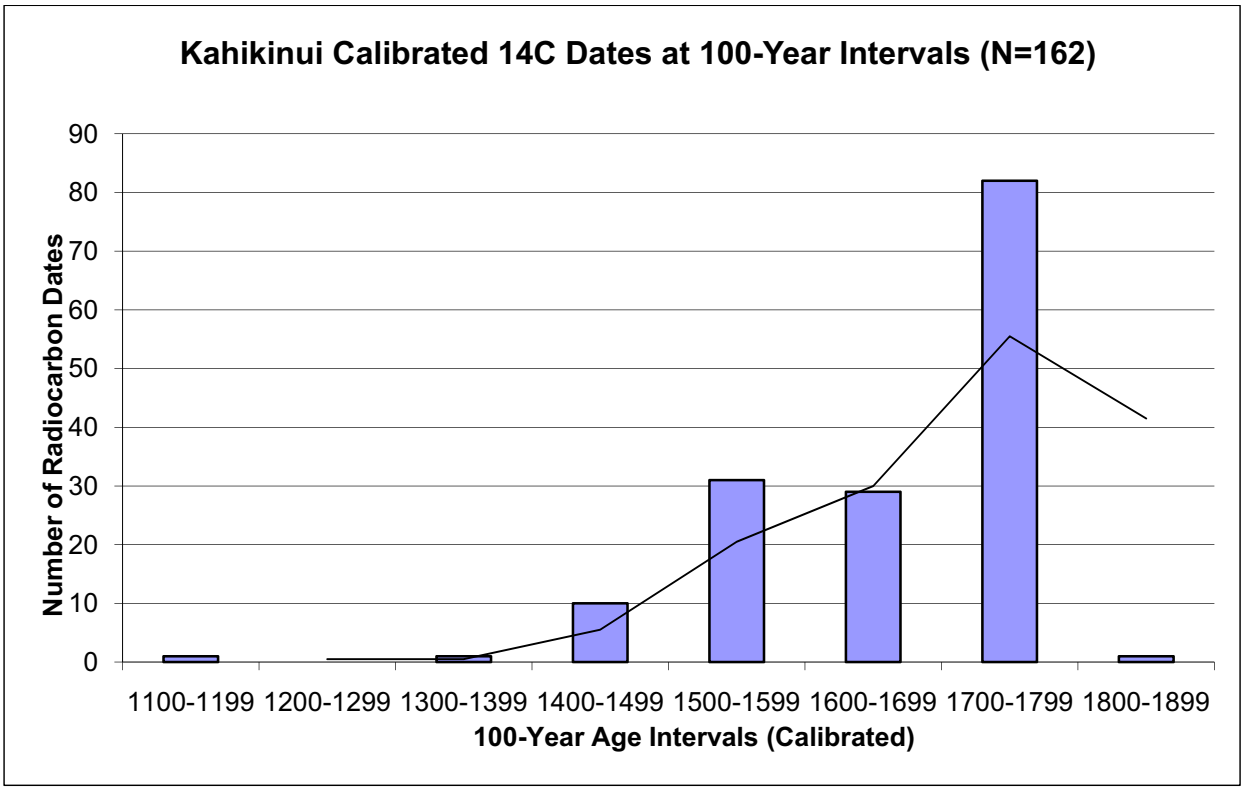


Figure 41. Histogram plot of 162 radiocarbon dates from Kahikinui archaeological sites (excluding Auwahi). Dates have been plotted based on their highest probability intercepts. The trendline is a 2-period moving average. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

The broader radiocarbon database for Kahikinui provides a context within which the new set of 14 AMS radiocarbon dates from Auwahi sites obtained by this project can be evaluated. Figure 183 is an Oxcal-generated plot of all of the new Auwahi dates. The dates have been arrayed from oldest (top) to youngest. As is evident, there are multiple intercepts for all dates, and the problem of multiple intercepts becomes more acute with the youngest age samples. However, none of the dated samples came from sites with any post-Contact Euro-American artifacts, so we can rule out the intercepts that extend from ca. A.D. 1800 to the present. Again applying the procedure of choosing the single, highest probability intercept for each date, we can convert the somewhat "messy" plot in Figure 42 to a histogram of date distribution by 100-year intervals, as in Figure 43.

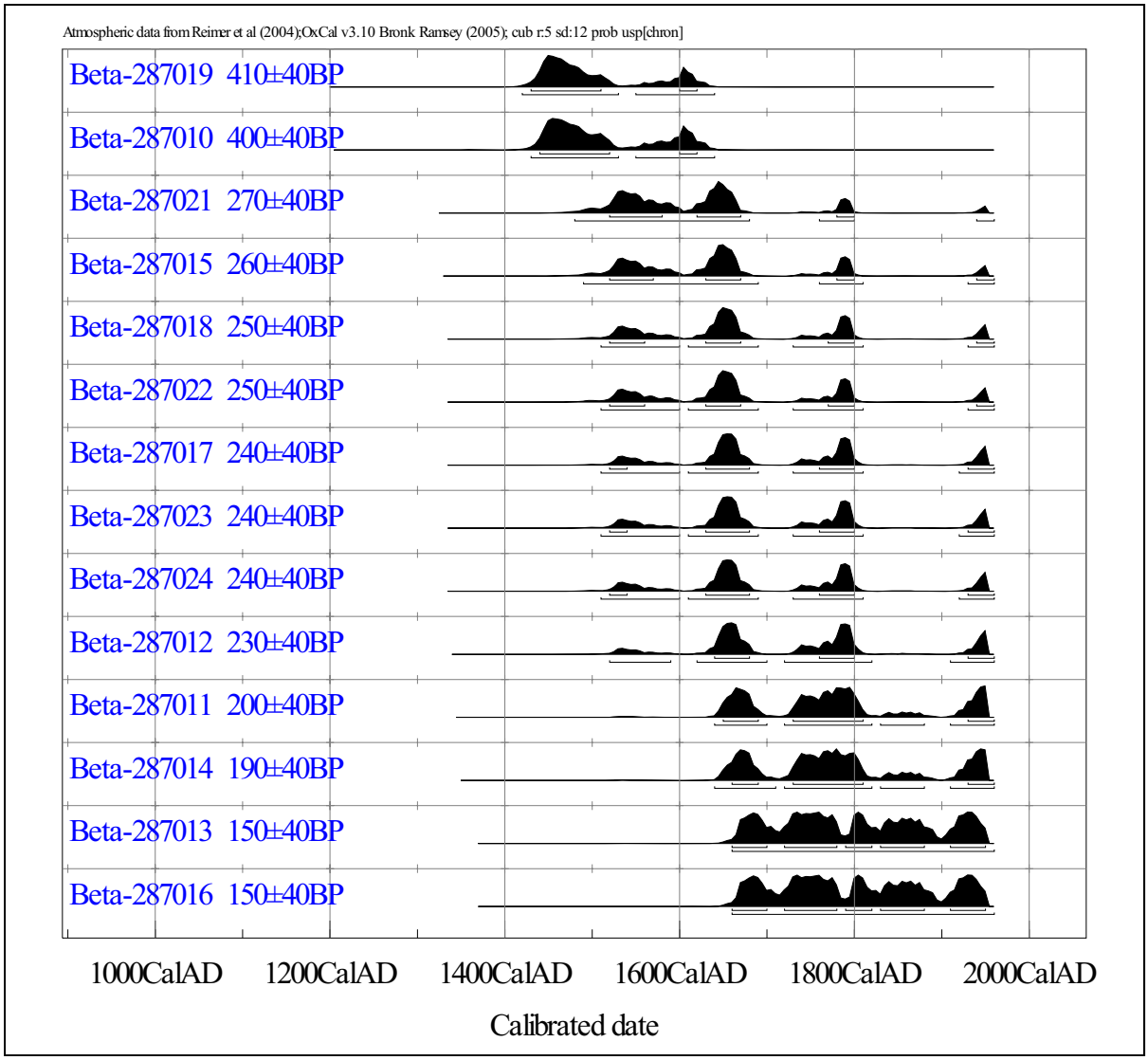


Figure 42. Oxcal generated chart of the 14 dates from Auwahi by this project. The black histograms for each date are probability distributions indicating the likelihood that the radiocarbon age corresponds to a particular calendar year. As can be seen, "dates" have multiple probability intercepts.

Figure 43 exhibits a temporal distribution that is similar in certain respects to the larger Kahikinui regional sample (Figure 41), but also differs in a possibly significant respect. As with the rest of the district, it is evident that Auwahi *ahupua'a* did not begin to see permanent human occupation and land use until the 15th century A.D., that is the beginning of the Late Expansion Period. The slight differences between A.D. 1400-1499 and 1500-1599 are probably not significant, and most likely reflect sample size issues. However, the large increase in number of dates in the interval from A.D. 1600-1699 is noteworthy, and must be interpreted as a major increase in the intensity of land use and population. Moreover, this increase occurs earlier in

Auwahi (17th century) than in the rest of the *moku* (18th century). Indeed, the Auwahi plot shows a decrease in the frequency of dates in the period from A.D. 1700-1799. We need to be cautious in our interpretation of these trends, because admittedly the Auwahi sample size is still small, and limited to just a part of the entire *ahupua'a*. Further dates, and dates from the *mauka* areas inland of the highway, might alter these trends.

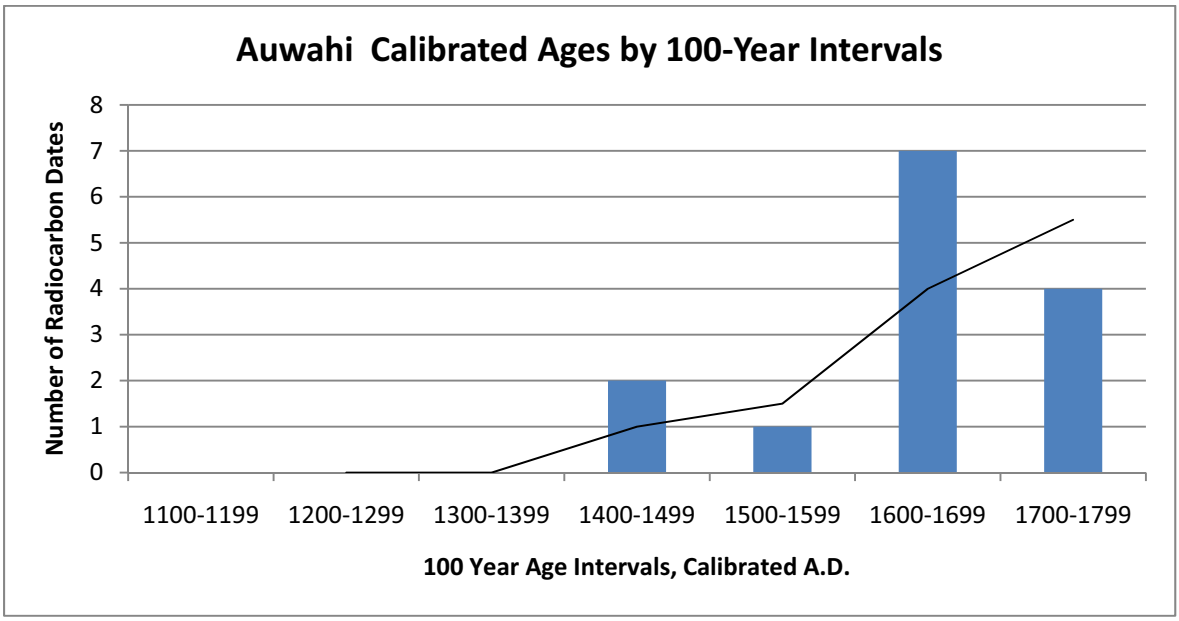


Figure 43. Histogram plot of 14 radiocarbon dates from Auwahi archaeological sites. Dates have been plotted based on their highest probability intercepts. The trend line is a 2-period moving average.

Nonetheless, there are reasons to think that a slightly earlier period of intensification of occupation and land use may have occurred in Auwahi, as opposed to other *ahupua'a* of the district. The geology and soils of Auwahi are among the best suited in all of Kahikinui for Hawaiian dryland farming, being relatively young and hence nutrient-rich, but not so young as to be too rocky for cultivation (as is the case with most of Alena *ahupua'a*). Auwahi also enjoys by far the best canoe landing, and better access to shoreline and marine resources than areas farther to the east. For these reasons, a slightly earlier build up in population within Auwahi would be understandable.

Figure 44 plots all of the available radiocarbon dates for Kahikinui, including the 16 new samples from this project, distributed by *ahupua'a* unit and across the 100-year temporal units. In this chart, the relatively low frequency of Auwahi dates in the period from A.D. 1500-1599, as compared with the trends for Kīpapa and Nakaohu, is noteworthy. If our hypothesis that environmental conditions in Auwahi were conducive to earlier settlement is correct, we would expect more dates in this interval. Again, however, this may simply be a matter of sample size, and of the fact that to date our samples are concentrated in the lower elevation zones. It is also worth noting that the pattern for Manawainui—at the opposite, eastern end of the district from Auwahi—does not exhibit any significant evidence for human occupation until the final century

prior to contact. Just as Auwahi may have been one of the most inviting parts of Kahikinui for settlement, Manawainui was probably the most challenging, due to its older and more nutrient-leached soils, and to its very low annual rainfall (Kirch et al. 2004; Holm 2006).

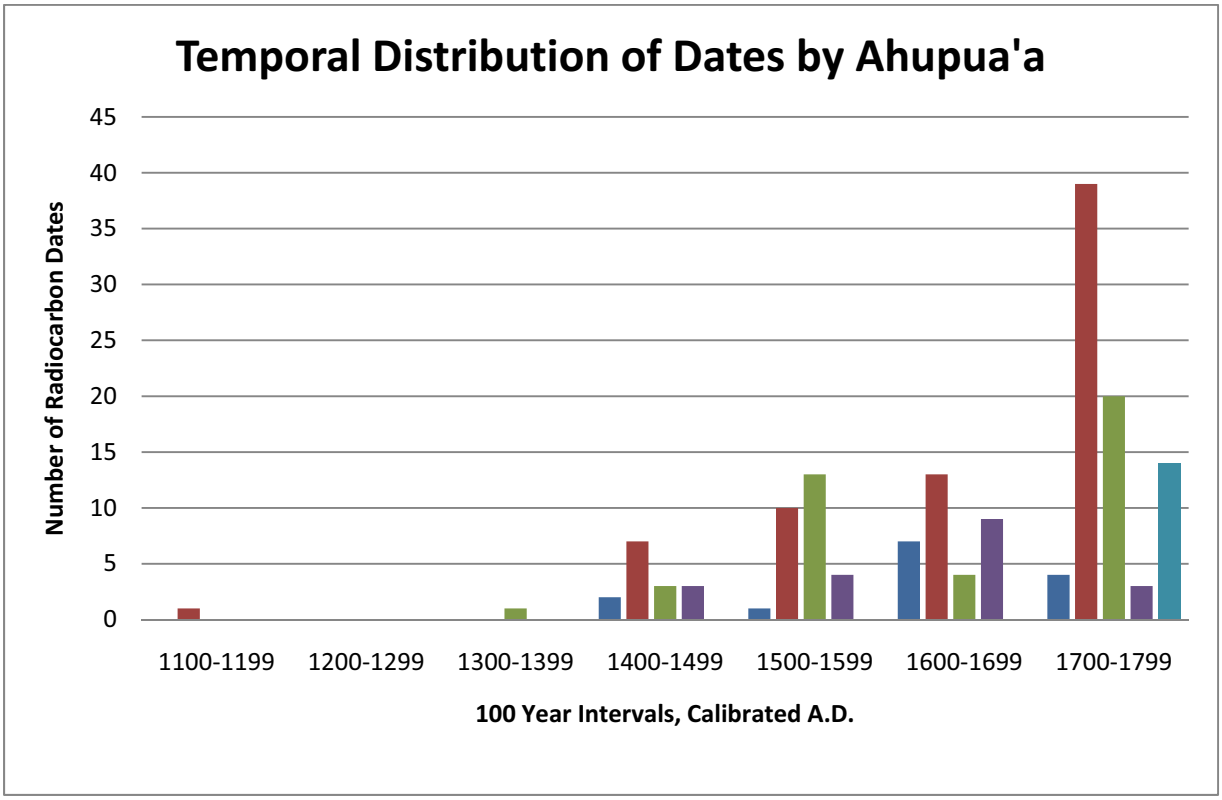


Figure 44. The temporal distribution by 100-year age intervals of radiocarbon dates from five *ahupua‘a* of Kahikinui.

6.5 Settlement Patterns, Population Density and Distribution

Having compared the broad temporal patterns of site distribution in Auwahi with those across the Kahikinui District, we now turn to a similar comparison of spatial patterns. In the most general sense, the entire Kahikinui region consists of lava flow slopes forming the southeastern flank of Haleakalā volcano. When one begins to examine the landscape more closely, however, significant differences are apparent. The eastern half of Kahikinui from Mahamenui to Manawainui is considerable older in geological terms, with the slopes consisting of lava flows from the shield-building stage, known as the Kula Volcanic Series. Being fairly old, these surfaces have more deeply weathered soils, and are dissected by intermittent stream gullies and gulches. The last of the Kula series flows was dated by Kirch et al. (2004) to about 226,000 years ago. One flow in the eastern part of the district is, however, an exception: the Pu‘u Pane substrate which emanates from the flanking cinder cone of that name and dates to about 96,000 years ago. In contrast, the western half of the district, including Auwahi, is made up primarily of lava flows which have emanated from the volcano’s southwestern rift zone, as a part of a

more recent rejuvenation stage, known as the Hana Volcanic Series (Stearns and MacDonald 1942; Sherrod et al. 2007). These substrates range in age from as old as 130,000 years, to as young as 5,000 years. The very young flows, especially that which dominates Alena *ahupua'a*, consist almost entirely of *'a'ā* lava, and were not amenable to cultivation. But a considerable expanse of lavas between about 10-50,000 years old provided substrates highly suited to the cultivation of dryland crops, especially sweet potato. The greatest concentration of such ideal-age lava substrates are in Auwahi and Kīpapa-Nakaohu. The broad spatial patterns of the Kula and Hana Volcanic Series flows across Kahikinui are illustrated in Figure 45.

Over the past 15 years, large segments of Kahikinui District have been archaeologically surveyed, primarily by the U. C. Berkeley Oceanic Archaeology Laboratory, and by the State Historic Preservation Division (Kirch, ed., 1997; Dixon et al. 2000). Figure 46 shows the principal areas of intensive survey and the approximate area in square kilometers covered for each survey block. Colored dots indicate individual archaeological features. The most extensive single area covered by intensive survey to date is that of Kīpapa-Nakaohu, for which the U. C. Berkeley team under Kirch's direction has now obtained data on more than 3,000 individual features over a 12.8 km^2 area. The Mahamenui and Manawainui area surveys are reported on in detail by Holm (2006). The Kīpapa-Nakaohu area consists of substrates of younger Hana Series lavas, and thus is most similar to the landscape of Auwahi. The Mahamenui survey area was concentrated primarily on the 96,000 year old Pu'u Pane flow, while the Manawainui area lies on the older Kula Volcanic Series flow slopes. Because of these fundamental differences in their underlying substrates—and the implications for intensive agriculture—the settlement patterns in Mahamenui and Manawainui are predicted to show the greatest contrasts with Auwahi. Likewise, the settlement patterns of the Kīpapa-Nakaohu area which has substrates very similar in age to those of Auwahi, should present settlement and land use patterns similar to the latter. Auwahi also has a peculiar geomorphological characteristic, the presence of the large cinder cone of Pu'u Hōkūkano, which clearly would disrupt the distribution of human land use and occupation features. The presence of this geological feature needs to be kept in mind when any comparisons are made between these areas.

Figure 47 displays an analysis of settlement density by elevation above sea level, for the three main survey zones of Kīpapa-Nakaohu, Mahamenui, and Manwainui. As can be seen both in the distribution map of features, and in the summary histograms which plot site density by elevational zones (the insets), in all cases there is a high density of features immediately along the coastline. This undoubtedly reflects the importance of exploitation of coastal resources, but most of these features upon close investigation and excavation proved to be only for temporary or intermittent use. Moving inland from the coast, there is a zone with relatively low feature density. Then between about 100-200 m above sea level, sites begin to appear in increasing numbers, and then reach their peak density between about 400 and 800 masl. Above 800 masl, site density drops off rapidly and falls to essentially zero at about 1000 masl.

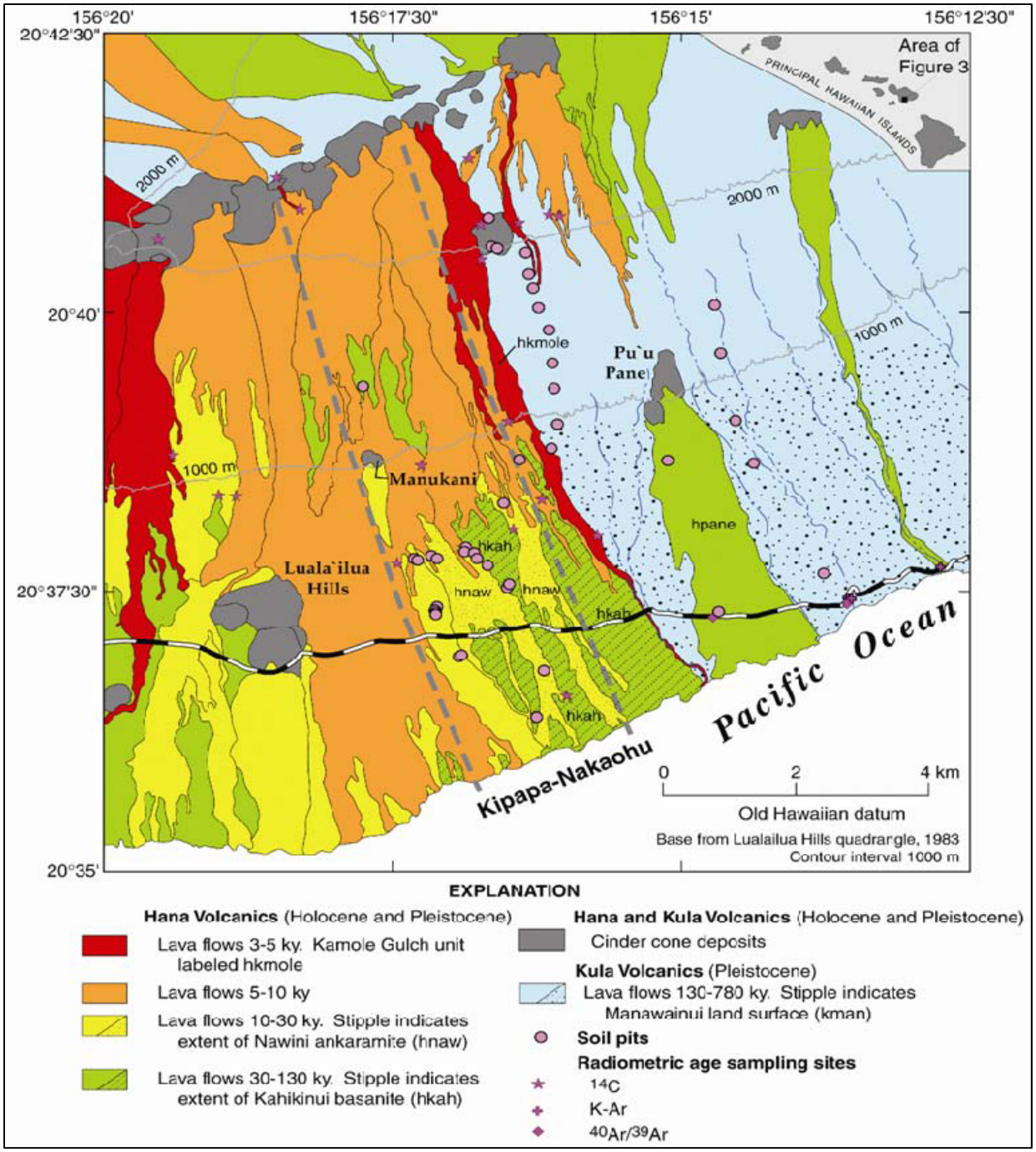


Figure 45. Simplified geologic map of the Kahikinui District showing the distribution of substrates according to age categories (from Kirch et al. 2004). The older Kula Volcanic Series is shown in blue. The orange colored areas are of very young lava flows not amenable to cultivation. Areas shaded green and yellow have substrates with ages best suited to intensive cultivation.

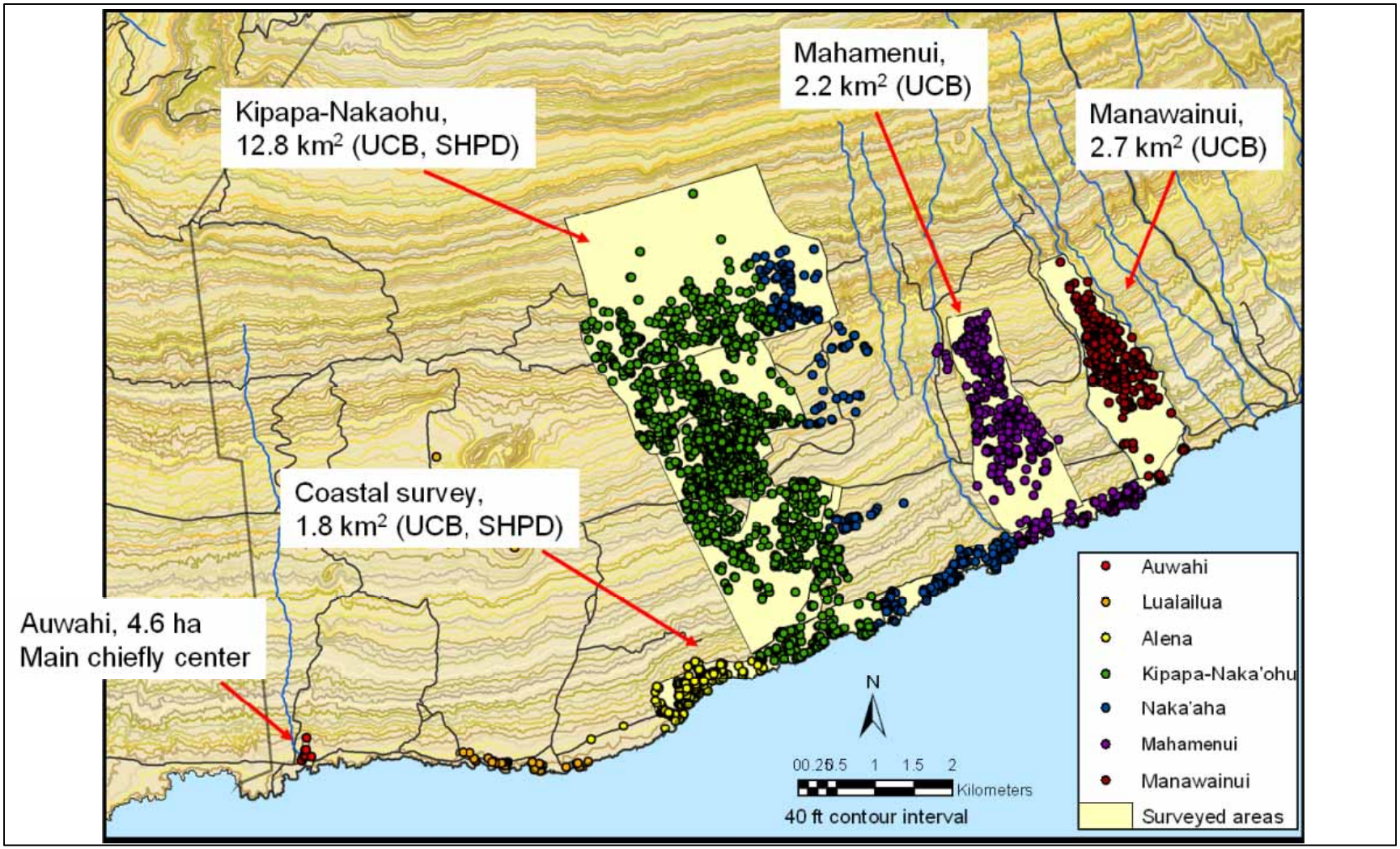


Figure 46. Major zones of archaeological survey in Kahikinui District. (Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

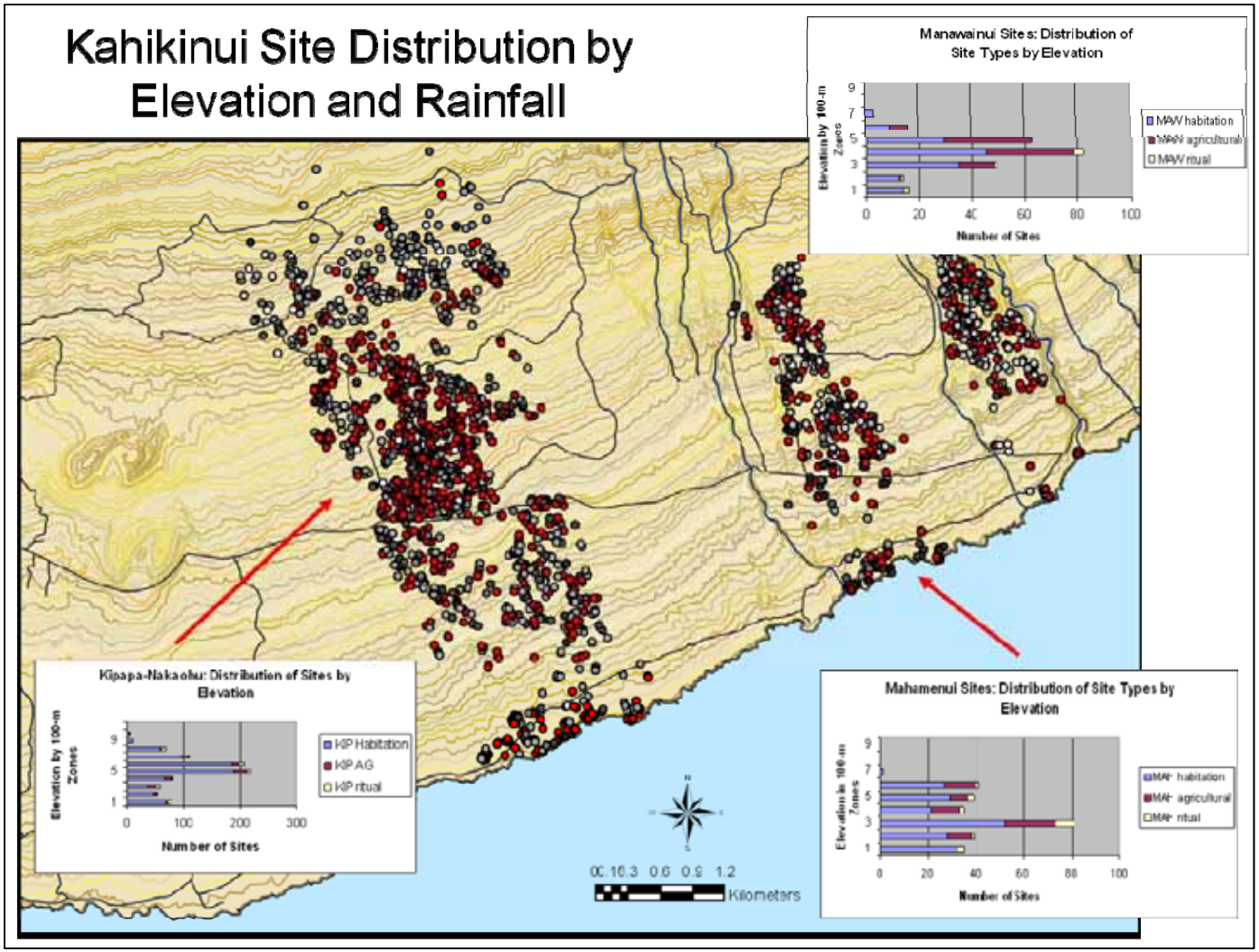


Figure 47. Spatial distribution of archaeological features in Kīpapa-Nakaohu, Mahamenui, and Manawainui. Inset charts show the frequency of feature categories by elevation. Rainfall increases as function of elevation. Compiled from unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.

Elevation is a key variable in settlement distribution in Kahikinui because it is a proxy for rainfall. Elevation per se was not the key controlling variable in site distribution, but rather the amount of annual rainfall which was correlated with elevation, and which was essential for the dryland cropping of sweet potato and other cultigens. The correlation between elevation and rainfall in Kahikinui is depicted in Figure 48. Rainfall along the coast is roughly 400 mm or less per year, which is well below the annual minimum of about 750 mm needed for sweet potato cultivation (Purseglove 1968:82). By about 400 masl elevation, however, rainfall rises to around 750 mm, and continues to climb up to a maximum of around 800-1000 mm. It is in this zone from roughly 750 to 1000 mm of annual rainfall that the ancient Hawaiian farmers were able to produce annual crops of sweet potato and other dryland cultigens, which made life on these arid slopes possible.

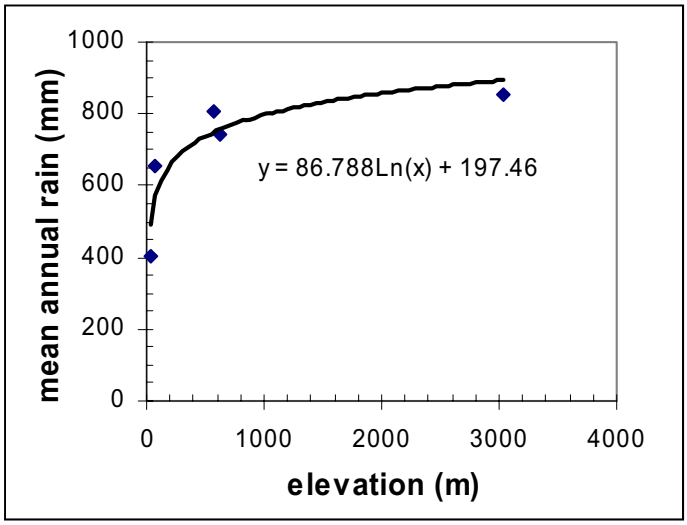


Figure 48. Kahikinui rainfall as a function of elevation.

The survey data generated by our current project can be compared with these district-wide patterns, to test whether or not Auwahi conforms to the same general settlement pattern, or shows unique characteristics. It must be kept in mind that the present survey was limited to the areas within the boundaries of the proposed wind farm. Consequently, our survey area excludes both the lowest elevation areas, adjacent to the coast, and those parts of the *ahupuaʻa* at elevations higher than about 400 m (*mauka* of the highway). However, the present survey provides an excellent picture of settlement patterns in the elevational range from 100 to 400 masl.

The settlement patterns and site distribution and density within the areas covered by our project conform generally to expectations based on prior survey work in Kīpapa-Nakaohu, Mahamenui, and Manawainui. The density of features, especially those associated with permanent habitation and cultivation, show a significant drop off below about 250 masl. However, Auwahi's high site density extends lower toward the coastal zone than in other areas such as Kīpapa-Nakaohu. This could in part be a function of a slightly higher annual rainfall in Auwahi (which is closer to southwestern rift of Haleakalā and may therefore receive rainfall from cloud cover extending over this flank of the mountain. Unfortunately, the available rainfall

records are too spotty to test this hypothesis. The lower elevational extent of permanent habitations in Auwahi may also reflect local practices of surface water concentration and management in the small gulches and gullies that descend below Puʻu Hōkūkano, a point we will discuss further below. Whatever the explanation, Auwahi does seem to have an unusually high density of habitation and cultivation features, matching the highest densities in Kīpapa-Nakaohu, and certainly higher than in Manawainui to the east. This again highlights the importance of the *ahupuaʻa* of Auwahi within the overall Kahikinui District settlement pattern.

The overall patterns of settlement distribution within the areas of Auwahi that we have surveyed also show close similarities to patterns in the Kīpapa-Nakaohu area, as expected. These include the use of *ʻaʻā* ridge lines for habitation clusters (small groups of residential terraces, enclosures, C- and U-shapes, and so forth), with intervening low swales and flats evidently being used for cultivation. The same pattern of *kauhale* clusters previously noted for Kīpapa-Nakaohu (Van Gilder and Kirch 1997; Van Gilder 2005) is replicated in Auwahi, demonstrating a consistency in residential architecture throughout the *moku* of Kahikinui.

6.6 Agricultural Systems and Water Control

The pioneering ethnographer of Hawaiian agricultural practices, Edward S. C. Handy, called the southeastern flanks of Haleakalā, from Kaupō to Honuaʻula, "the greatest continuous dry planting area in the Hawaiian Islands" (1940:161). In spite of its considerable aridity, Kahikinui and the adjacent districts to Kaupō to the east and Honuaʻula to the west collectively comprised a major zone of rain-fed, non-irrigated cultivation, primarily of sweet potatoes, but also of yams, dryland taro, and secondary crops (e.g., paper mulberry and *ti*). Our investigations in Auwahi have expanded our understanding of the range of agricultural practices used by the pre-Contact Hawaiians in this marginal environment. In addition, our survey has revealed a previously unrecognized degree of micro-environmental management of small, ephemeral watercourses and drainage channels across the Auwahi landscape. In part, this heightened awareness of landscape features which are often topographically low and subtle is a consequence of the extreme drought conditions in Auwahi in 2010, which made surface visibility extraordinarily clear. Many of the agronomic and water control features that we identified in our survey might have been missed under normal levels of vegetation cover; indeed, many features were not observed in the prior 2007 survey of the same area. This is not a critique of the previous archaeological survey team, which was well trained and experienced in Hawaiian archaeology. It is simply a statement of the reality of survey work when the terrain is obscured by thick invasive vegetation (dominated by such plants as lantana, *koa haole*, and the nearly impenetrable *Glycine* vine). Having the advantage of virtually no obscuring vegetation cover in 2010, as a result of several years of continuous drought, visibility rose to levels that otherwise are only matched after a wildfire (see Holm and Kirch 2007).

Kirch (2010a) has synthesized the characteristics of pre-Contact Hawaiian agriculture across the Kahikinui landscape, based on 15 years of investigations by the U. C. Berkeley team, and since 2000 by the collaborative Hawaiʻi Biocomplexity Project (see also Coil 2004; Coil and Kirch 2005; Hartshorn et al. 2006; Holm 2006; Kirch et al. 2005). In contrast with other leeward slope environments such as Kohala and Kona on Hawaiʻi Island, which are dominated by vast "field

systems" consisting of reticulate grids of field embankments, walls, and trails (Kirch 1985; Vitousek et al. 2004; Kirch 2010a), the Kahikinui agricultural landscape was in general less formally organized. Adapting their horticultural practices to the highly varied landscape mosaic of young lava flows—an especially "patchy" kind of environment—the ancient Hawaiian farmers in Kahikinui did not attempt to impose a formal grid system of field plots across the entire landscape. Rather, they adapted their agriculture to the microenvironmental habitats of lava ridges and intervening swales or depressions, favoring the ridges for habitation (and some kinds of cultivation involving mounds, perhaps for gourds or other crops), and reserving the swales for cultivation. These swales are natural features of the *ʻaʻā* topography, formed on the surface of the massive lava flows (Figure 49). They range considerably in area and depth, but are often 50-100 m in length. These natural depressions act as sediment traps, gradually accumulating both wind-blown fine particles as well as materials washed off the adjacent slopes during heavy rains. The swale floors thus build up organically enriched deposits which may be up to 1 m or more in depth, and provide ideal soil media for cultivation.

Figure 49. A medium sized natural swale in the *ʻaʻā* lava topography of Auwahi, below Puʻu Hōkūkano. This swale has a level soil surface and artificially constructed walls around its perimeter. It is typical of swales throughout Kahikinui used for intensive cultivation. (Photo by P. V. Kirch, 2007.)

This swale mode of cultivation, previously shown to be the dominant pattern across Kahikinui, is especially well reflected in the survey data from Auwahi. However, the new Auwahi data from this project also revealed an unexpected example of the formal, reticulate field system kind of cultivation not previously documented from Kahikinui, but known primarily from Hawaiʻi Island. Recently, such a formal field system was identified by Kirch et al. (2010) in the Kaupō district to the east of Kahikinui, the first time that this kind of agricultural system had

been reported for Maui Island. As can be seen in Figure 50, the Kaupō field system consists of a tightly packed grid of field embankments running along the contours, with cross-cutting walls running up-and-down slope (*mauka-makai*) at fairly regular intervals. The closely spaced field embankments (averaging about 8-9 m between them) are interpreted as delineating individual farming plot boundaries, while the longer walls are probably territorial boundaries (perhaps ʻ*ili* units in the traditional Hawaiian land system).

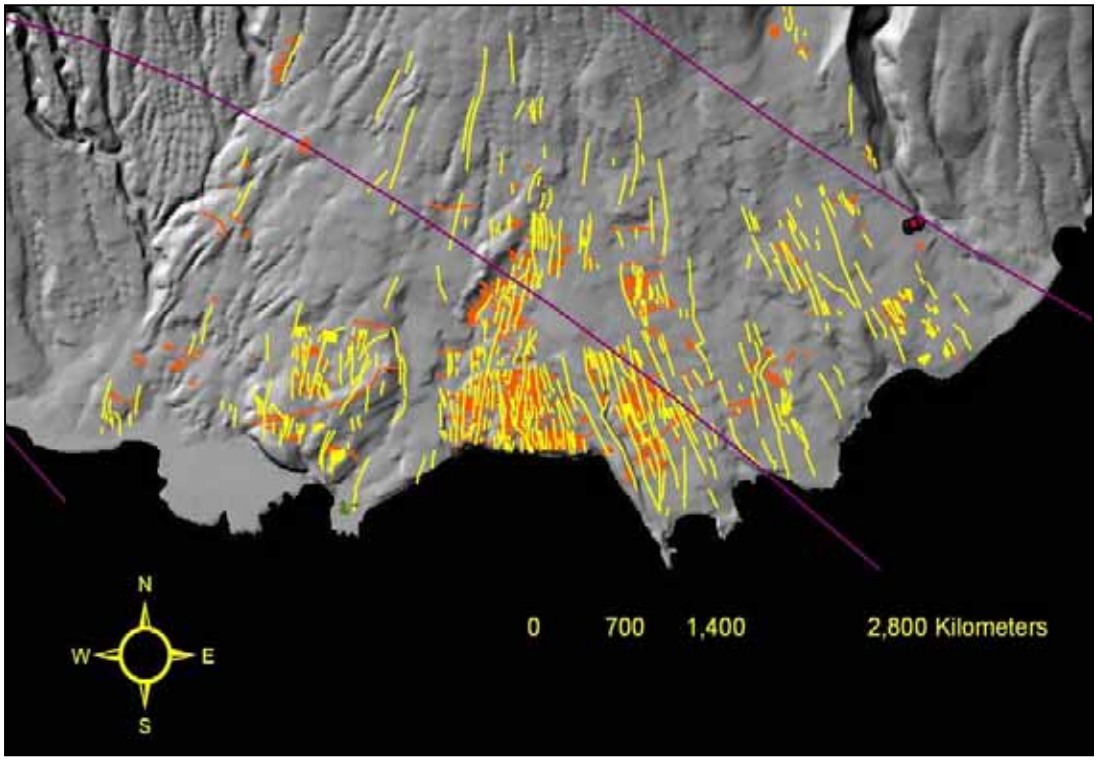


Figure 50. Map of a portion of the Kaupō Field System, based on aerial photo analysis of field embankment and wall patterns. (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

The discovery of the 50-50-15-6910 complex of features on the fringes of the large sedimentary basin that lies inland of Puʻu Hōkūkano is the first archaeological record of such a formal field system in the Kahikinui region. It appears that prior to historic period disturbance, especially from intensive cattle grazing in the area, this field system probably covered the entire extent of this sedimentary basin, a rich accumulation of alluvium that was washed into the sediment trap created by the 30-50,000 year old Puʻu Hōkūkano cinder cone. From our mapping of the remnant parts of this field system, it had a structure much like that recorded for the Kaupō field system. That is, field embankments were regularly spaced about 9-11 m apart, with intervening low walls or bunds that subdivided the system into sets of plots, probably some kind of social or land tenure division. The existence of the 6910 complex shows that—when local environmental conditions were favorable—the Hawaiian land managers preferred to lay out the agricultural landscape in this kind of reticulate grid. Such a formal grid system was presumably the material reflection of the highly developed and hierarchical Hawaiian system of land tenure,

with its nested units beginning with the *moku*, down through the *ahupua'a*, to the *'ili*, and extending to the smallest cultivated parcels such as the *mo'o* and *paukū*.

Equally important as the discovery of a formalized field system was the realization during the course of our field studies that the ancient Hawaiians who made a living on the lava flows of Auwahi had practiced a variety of sophisticated water control practices.[1] The importance of water in such an arid landscape as Kahikinui hardly needs to be stressed. Stock et al. (2003) discuss the paleohydrology of Kahikinui, determining that the small drainage channels present on the younger Hāna Volcanic Series lava flows (as in Kīpapa-Nakaohu, and also in Auwahi) show no evidence of having had permanent flow in the past. Rather, these channels have been carved by intermittent flooding at times of seasonal *kona* (winter) storms. Stock et al. (2003) also argue that in pre-Contact times the heavier forest cover that was present on the upper Kahikinui slopes would have resulted in considerably higher "fog drip" precipitation. This likely resulted in a higher water table than is present today, and better water-holding capacity of the landscape during periods of rainfall.

Virtually every drainage channel examined during our archaeological survey of Auwahi exhibits artificial manipulation and rearrangement. Typical features include cross-channel stone barrages, walling along channel sides, and stone-filled terraces within channel bottoms. Some of these features, such as the cross-channel barrage terraces, may have been intended for soil capture and actual crop planting. Other features, however, appear designed to slow down water flow, causing the intermittent channel flows to percolate into the adjacent porous lava. In some cases we noted shallow diversion channels that would have fed some water flow out of channels and into adjacent natural basins or swales; these latter could then have been planted.

6.7 THE RITUAL LANDSCAPE

Paralleling the traditional Hawaiian land system with its hierarchically nested land units was a complex hierarchy of temples (*heiau*) distributed across the landscape. Indeed, the Hawaiian land use system and the economy were controlled through the system of temples, with various cults and rites organized on a seasonal basis (Valeri 1985; Kirch 2010b:55-66). At the top of this hierarchy were the *luakini* or state temples where the king and his high priest (*kahuna nui*) offered human sacrifices to the war god Kū. The king also had his own Hale o Lono, or temple dedicated to Lono, god of thunder, rain, the sweet potato and dryland cultivation. It was from this Lono temple that the annual Makahiki procession went forth each year to collect the *ho'okupu* or tribute from each *ahupua'a* territory. Major state temples associated with the famous Maui king Kekaulike are known in the adjacent district of Kaupō (Kirch et al. 2009). Below this topmost level in the temple system were a variety of *heiau* associated with the *ahupua'a* chiefs, falling into a general category of *heiau ho'o'ulu'ai*, or "temples to increase food." There were

[1] We would be remiss here not to acknowledge the interest taken by Mr. Sumner Erdman of 'Ulupalakua Ranch in this aspect of Auwahi archaeology. Observing various water control features on the ground, Mr. Erdman brought these to our attention, and continually pushed us to think about the implications of an "archaeology of hydrology." We appreciate his keen interest in this aspect of Auwahi's history.

separate *heiau* for the rites of Lono and of Kāne (the latter being the deity of flowing water and of taro). At an even lower level in this hierarchical system were small *heiau* contained within (or perhaps attached to in some cases), the *mua* or men's eating houses of the commoner population. Based on settlement pattern data from the Kīpapa-Nakaohu area, it is possible that several individual households in a neighborhood may have shared such a common *mua*. A fourth distinct category of temples consisted of *koʻa* or fishing shrines, dedicated to Kūʻula, god of fishermen, and usually located along the coast.

Previous archaeological investigations in Kahikinui have identified more than 40 structures that are interpreted as *heiau* (Figure 51). Only a single *heiau*, Kōholuapapa situated to the west of the Lualaʻilua Hills and close to the present boundary between Auwahi and the Hawaiian Home Lands, was reputedly a *luakini* type temple. This, however, is considerably smaller than the great state temples of Loʻaloʻa and Kānehemomalo in Kaupō associated with king Kekaulike. If it was indeed used as a *luakini*, Kōholuapapa was probably officiated at by the king while making a tour of his various *moku*, rather than as a regular state temple. One other large temple (KIP-1010), with no known Hawaiian name, lies in the uplands of Nakaohu, and may have been the principal agricultural temple for the central part of Kahikinui. Most of the temples identified to date are smaller than Kōholuapapa or KIP-1010, and would fall into the categories of *heiau hoʻoʻuluʻai* or of *heiau* within men's houses. In addition, a number of fishing shrines have been identified along the Kahikinui coastline. Kirch (2004) analyzed the temple sites of Kahikinui, demonstrating that their orientations fall into three discrete clusters: East, Northeast, and North. He argues that these clusters were associated with the cults of Kāne (East), Lono (Northeast), and Kū (North).

The Auwahi survey has added five more examples of *heiau* to the Kahikinui corpus. All of these are relatively small structures that were presumably *heiau hoʻoʻuluʻai*, or agricultural temples. They are all of the structural form known as "notched" *heiau* due to their six-sided plans. As with previously recorded *heiau* in Kahikinui, these five structures also fall within the specific orientation clusters noted earlier. Site 50-50-15-6908, for example, is situated on the eastern slope of a lava ridge so as to command an uninterrupted view towards the Lualaʻilua Hills. Not only are the walls of this temple themselves on a perfect E-W/N-S alignment, but from this temple one would have been able to observe (and to track, using the topographic features of the cinder cones in the distance), both the equinox and solstice risings of the sun, as well as the rising of Pleiades (important for setting the yearly calendar and timing of the Makahiki). Two other temples (50-50-15-6825 and 50-50-15-6840A) were constructed so that their axes are oriented toward the north, which is the high summit of Haleakalā. In particular, both structures seem to be oriented to a major reddish-colored cinder cone high on the mountain's rim. Red is the sacred color in Hawai'i and Polynesia generally, and the prominence of this red volcanic cone may have had particular significance to the Hawaiians who lived in Kahikinui. Kirch has previously identified other temples in Kīpapa-Nakaohu that are oriented to this same cinder cone.

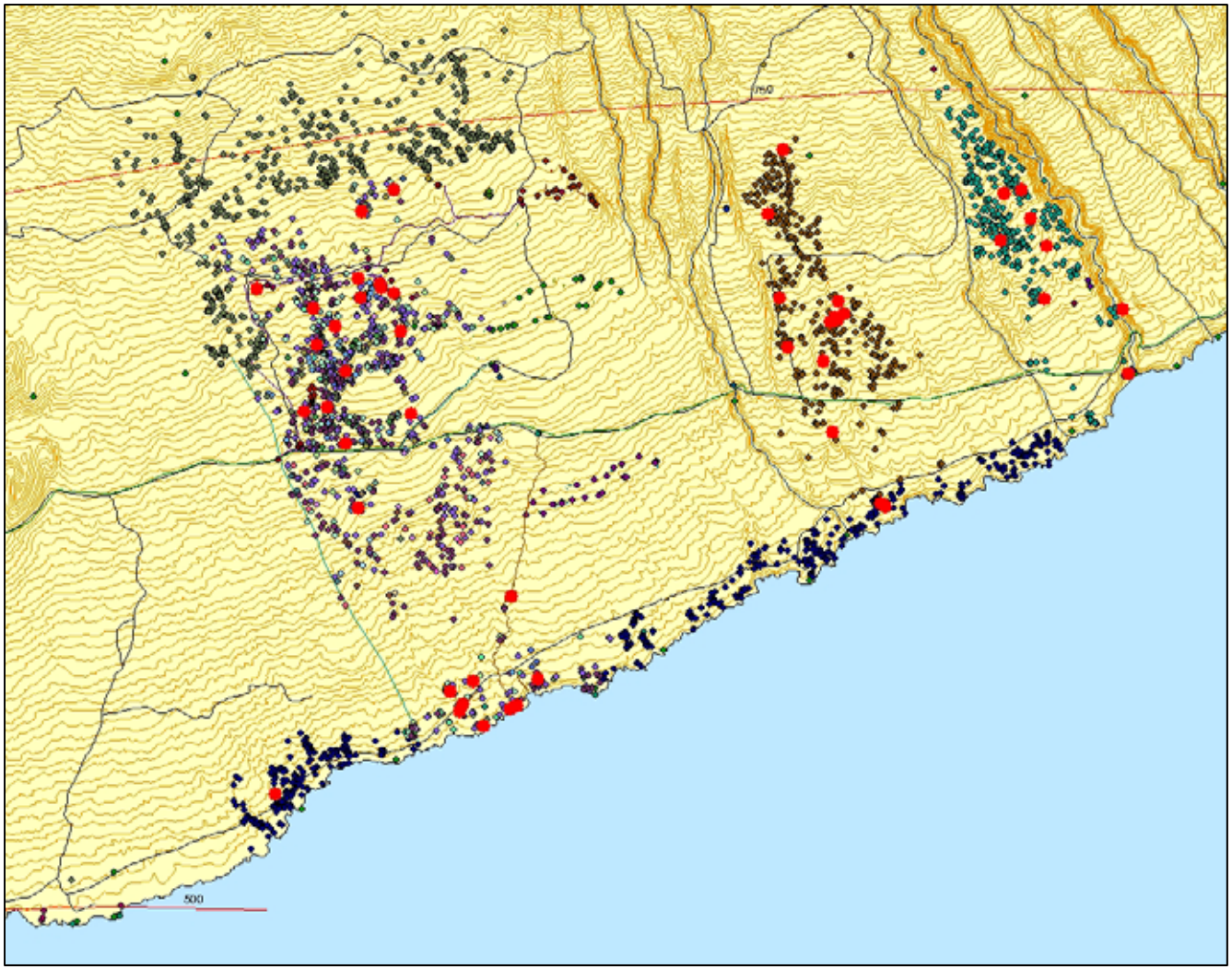


Figure 51. Map of the Kīpapa-Nakaohu to Manawainui section of Kahikinui District, with archaeological sites (individual dots) and the distribution of mapped *heiau* (red dots). (Based on unpublished data in the Oceanic Archaeology Laboratory, University of California, Berkeley.)

7.0 REFERENCES CITED

Chinen, J. J.
1958 *The Great Mahele: Hawai'i's Land Division of 1848*. Honolulu: University of Hawai'i Press.

Coil, J. H.
2004 "The Beauty that Was": Archaeological Investigations of Ancient Hawaiian Agriculture and Environmental Change in Kahikinui, Maui. Ph.D. Dissertation, University of California, Berkeley.

Coil, J. and P. V. Kirch
2005 An Ipomoean landscape: Archaeology and the sweet potato in Kahikinui, Maui, Hawaiian Islands. In C. Ballard, P. Brown, R. M. Bourke, and T. Harwood, eds., *The Sweet Potato in the Pacific: A Reappraisal*, pp. 71-84. Oceania Monograph56 and Ethnology Monograph 19. Sydney and Pittsburgh.

Dixon, B., P. J. Conte, V. Nagahara, W. K. Hodgins
2000 *Kahikinui Mauka: Archaeological Research in the Lowland Dry Forest of Leeward East Maui*. Report Prepared for Department of Hawaiian Home Lands. Honolulu: Historic Preservation Division, Department of Land and Natural Resources, State of Hawai'i.

Dye, T. S. and J. Pantaleo
2010 Age of the O18 site, Hawai'i. *Archaeology in Oceania* 45:113-119.

Handy, E. S. Craighill
1940 *The Hawaiian Planter. Volume I, His Plants, Methods and Areas of Cultivation*. Bernice P. Bishop Museum Bulletin 161. Honolulu.

Hartshorn, A. S., O. A. Chadwick, P. M. Vitousek, and P. V. Kirch
2006 Prehistoric agricultural depletion of soil nutrients in Hawai'i. *Proceedings of the National Academy of Sciences* 103:11092-11097.

Holm, L. A.
2006 *The Archaeology and the 'Āina of Mahamenui and Manawainui, Kahikinui, Maui Island*. Ph.D. Dissertation, University of California, Berkeley.

Holm, L. and P. V. Kirch
2007 Up in smoke: Assumptions of survey visibility and site recovery. *Hawaiian Archaeology* 11:83-100.

Holm, L. P. Kirch, J. Holson, and P. Cleghorn
2008 Summary Results of the Pedestrian Survey for the Proposed Auwahi South Wind Farm, Transmission Line, and Access Road, Auwahi, Maui Island, Hawai'i. On file at Pacific Legacy, Inc., Kailua, O'ahu.

Kamakau, Samuel
1961 *Ruling Chiefs of Hawai'i*. Second edition. Kamehameha Schools Press, Honolulu.

Kirch, P. V.
1985 *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory*. Honolulu: University of Hawai'i Press.

2004 Temple sites in Kahikinui, Maui, Hawaiian Islands: Their orientations decoded. *Antiquity* 78:102-114.

2007 Paleodemography in Kahikinui, Maui: An Archaeological Approach. In P. V. Kirch and J.-L. Rallu, eds., *The Growth and Collapse of Pacific Island Societies: Archaeological and Demographic Perspectives*, pp. 90-107. Honolulu: University of Hawai'i Press.

2010a The archaeology of dryland farming systems in southeastern Maui. In P. V. Kirch, Ed., *Roots of Conflict: Soils, Agriculture, and Sociopolitical Complexity in Ancient Hawai'i*, pp. 65-88. Santa Fe: School of Advanced Research Press.

2010b *How Chiefs Became Kings: Divine Kingship and the Rise of Archaic States in Ancient Hawai'i*. Berkeley: University of California Press.

Kirch, P. V. (ed.)
1997 *Nā Mea Kāhiko o Kahikinui: Studies in the Archaeology of Kahikinui, Maui, Hawaiian Islands*. Oceanic Archaeological Laboratory, Special Publication No. 1. Berkeley: Archaeological Research Facility.

2011 *Roots of Conflict: Soils, Agriculture, and Sociapolitical Change in Ancient Hawai'i.* Santa Fe: School for Advanced Research Press.

Kirch, P. V., J. Coil, A. S. Hartshorn, M. Jeraj, P. M. Vitousek, and O. A. Chadwick
2005 Intensive dryland farming on the leeward slopes of Haleakalā, Maui, Hawaiian Islands: Archaeological, archaeobotanical, and geochemical perspectives. *World Archaeology* 37(2):240-258.

Kirch, P., A. Hartshorn, O. Chadwick, P. Vitousek, D. Sherrod, J. Coil, L. Holm, and W. Sharp.
2004 Environment, agriculture, and settlement patterns in a marginal Polynesian landscape. *Proceedings of the National Academy of Sciences, U.S.A.* 101:9936-9941.

Kirch, P. V., J. Holson, and A. Baer
2009 Intensive dryland agriculture in Kaupō, Maui, Hawaiian Islands. *Asian Perspectives* 48:265-290.

Kirch, P. and T. Hunt (eds)
1997 *Historical Ecology in the Pacific Islands.* New Haven: Yale University Press.

Kirch, P. V. and P. McCoy
2007 Reconfiguring the Hawaiian cultural sequence: Results of re-dating the Hālawa Dune Site (MO-A1-3), Moloka‘i Island. *Journal of the Polynesian Society* 116:385-406.

Kirch, P. V., S. Millerstrom, S. Jones, and M. McCoy
2010 Dwelling Among the Gods: A Late Pre-Contact Priest's House in Kahikinui, Maui, Hawaiian Islands. *Journal of Pacific Archaeology* 1(2): 145-160.

Kirch, Patrick Vinton and Marshall Sahlins
1992 *Anahulu: The Anthropology of History in the Kingdom of Hawai‘i.* Chicago: University of Chicago Press.

Kolb, Michael J.
1992 Diachronic Design Changes in Heiau Temple Architecture form the Island of Maui, Hawai‘i. *Asian Perspectives* 31(1):9-37.

2006 The origins of monumental architecture in ancient Hawai‘i. *Current Anthropology* 47:657-65.

Malo, David
1951 *Hawaiian Antiquities (Mo‘olelo Hawai‘i)*. Bernice P. Bishop Museum Special Publication No. 2. Honolulu: Bishop Museum Press.

Pacific Legacy
2007 Plan for an Archaeological Survey for the Proposed Auwahi Wind Farm, Transmission Line, and Construction Access Road, Southeast Maui. On file in the SHPD library, Wailuku, Maui.

Shapiro, W., P. Cleghorn, P. Kirch, L. Holm, E. Kahahane, and K. Mooney
2011 Archaeological Inventory Survey for the Proposed Auwahi Wind Farm, Ahupua‘a of Auwahi, Island of Maui, Hawai‘i (FINAL). On file in the SHPD library, Wailuku, Maui.

Sherrod, D. R., J. M. Sinton, S. E. Watkins, and K. M. Brunt
2007 *Geologic Map of the State of Hawai‘i*. USGS Open File Report 2007-1089. Washington D.C.: Department of the Interior.

Stearns, H. T. and G. A. Macdonald
1942 *Geology and Ground-Water Resources of the Island of Maui, Hawai‘i*. Bulletin 7, Division of Hydrography, Territory of Hawai‘i. Honolulu.

Stock, J., J. Coil, and P. V. Kirch
2003 Paleohydrology of arid southeastern, Maui, Hawaiian Islands, and its implications for prehistoric human settlement. *Quaternary Research* 59:12-24.

Valeri, V.
1985 *Kingship and Sacrifice: Ritual and Society in Ancient Hawai'i*. Chicago: University of Chicago Press.

Van Gilder, C. and P. V. Kirch
1997 Household archaeology in the *ahupua'a* of Kīpapa and Nakaohu. In P. V. Kirch, ed., *Nā Mea Kāhiko o Kahikinui: Studies in the Archaeology of Kahikinui, Maui*, pp. 45-60. Oceanic Archaeology Laboratory, Special Publication No. 1. Berkeley: Archaeological Research Facility, University of California.

Vitousek, P. M., T. Ladefoged, P. V. Kirch, A. Hartshorn, M. Graves, S. Hotchkiss, S. Tuljapurkar, and O. Chadwick
2004 Soils, agriculture, and society in pre-Contact Hawai'i. *Science* 304:1665-1669.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer
1999 *Manual of Flowering Plants, Revised Edition* (Volume 1). Honolulu: University of Hawai'i Press and Bishop Museum Press.

Zeigler, Alan C.
2002 *Hawaiian Natural History, Ecology, and Evolution*. Honolulu: University of Hawai'i Press.

APPENDICES (SEE ENCLOSED CD)

APPENDIX A. Site Records

APPENDIX B. Site Attribute Table