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AUWAHI WIND FARM PROJECT
HABITAT CONSERVATION PLAN

Prepared for

Auwahi Wind Energy, LLC

Prepared by

TETRA TECH EC, INC.

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ACRONYMS AND ABBREVIATIONS

agl	above ground level
APLIC	Avian Power Line Interaction Committee
asl	above sea level
ATST	Advanced Technology Solar Telescope
BESS	battery energy storage system
BLNR	Hawai‘i Department of Land and Natural Resources, Board of Land and Natural Resources
BMP	Best Management Practice
CFR	U.S. Code of Federal Regulations
cm	centimeter
DHHL	Department of Hawaiian Home Lands
DOE	U.S. Department of Energy
DOFAW	Hawai‘i Department of Land and Natural Resources/Division of Forestry and Wildlife
DLNR	Hawai‘i Department of Land and Natural Resources
EA	environmental assessment
EIS	environmental impact statement
EISPN	Environmental Impact Statement Preparation Notice
ESRC	Endangered Species Recovery Committee
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
FONSI	finding of no significant impact
ft	foot or feet
ha	hectare
HECO	Hawaiian Electric Company
HELCO	Hawai‘i Electric Light Company
HCP	Habitat Conservation Plan
HRS	Hawai‘i Revised Statutes
ITL	Incidental Take License
ITP	Incidental Take Permit
km	kilometer
kph	kilometers per hour

kV	kilovolt
KWP	Kaheawa Wind Power
KWP I	Kaheawa Wind Power facility no. 1
LHWRP	Leeward Haleakalā Watershed Restoration Partnership
m	meter
MBTA	Migratory Bird Treaty Act of 1918
MECO	Maui Electric Company
MGD	million gallons per day
mg/L	milligrams per liter
MOU	Memorandum of Understanding
mph	miles per hour
NARS	Natural Area Reserve System
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NRPH	National Register of Historic Places
O&M	operations and maintenance
ROW	right of way
rpm	rotations per minute
SCADA	supervisory control and data acquisition
SWPPP	Stormwater Pollution Prevention Plan
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USFSW	U.S. Fish and Wildlife Service
USGS-BRD	U.S. Geological Survey Biological Resources Division
V	volt
WTG	wind turbine generator

1.0 INTRODUCTION AND PROJECT OVERVIEW

1.1 INTRODUCTION

Auwahi Wind Energy LLC (Auwahi Wind or Applicant) proposes to construct and operate a wind farm (the Project) with a net generating capacity of 21 megawatts (MW), augmented with a battery energy storage system (BESS) in east Maui, Hawai‘i. In addition to the wind turbine generators (WTG) and the BESS, the proposed Project would include an electrical collection system, an operations and maintenance (O&M) facility and related infrastructure, an approximately 9-mile (15-kilometer [km]) 34.5-kilovolt (kV) generator-tie line, an interconnection substation, and an approximately 27-mile (44-km) construction access route from the Port of Kahului to the Project site (Figures 1-1 and 1-2). Construction is expected to begin in March 2012, and the Project is expected to be operational in December 2012. The Project will be located on ‘Ulupalakua Ranch in the southern half of the Auwahi Ahupaua’a. The ‘Ulupalakua Ranch has a long history of environmental stewardship and has proactively worked with state and federal agencies and local conservation groups to implement preservation and restoration projects on ranch lands. Based in part on the benefits expected from the Project, ‘Ulupalakua Ranch was able to donate an easement to the Maui Coastal Land Trust to preserve 12,000 acres in perpetuity as agricultural lands.

Construction and operation of the Project has the potential to result in incidental take of species listed under the federal Endangered Species Act (ESA) of 1973, as amended, and the State of Hawai‘i endangered species statutes, including the ‘ua ‘u or Hawaiian petrel (*Pterodroma sandwichensis*); ‘a ‘o, nēnē or Hawaiian goose (*Branta sandvicensis*); ōpe‘ape‘a or Hawaiian hoary bat (*Lasiurus cinereus semotus*); and Blackburn’s sphinx moth (*Manduca blackburni*). Individuals of these species have the potential to be killed or injured if they collide or otherwise interact with WTGs or other Project facilities The Blackburn’s sphinx moth could be negatively affected during construction through disturbance as a result of ground clearing or other construction activities, such as by collision with construction equipment. Indirect take could also occur; it is possible that the death of an adult seabird or bat colliding with a WTG or associated structures could result in loss of eggs or dependent young. Other federally or state-listed animal species that occur on Maui do not reside within nor are expected to transit through the Project limits. Two federal- and state-listed endangered plant species, ‘iliahi (*Santalum freycinetianum*) and Ko’oloa ‘ula (*Abutilon menziesii*), and one candidate for federal listing, ‘aiea (*Nothocestrum latifolium*), were documented within the generator-tie line corridor (Guinther and Montgomery 2011). A single individual of each species was documented; no other threatened or endangered plant species were documented within this Project.

Due to the potential for incidental take of these species, Auwahi Wind has consulted with the U.S. Fish and Wildlife Service (USFWS) and the Hawai‘i Department of Land and Natural Resources (DLNR)/Division of Forestry and Wildlife (DOFAW) to acquire an Incidental Take Permit (ITP) and an Incidental Take License (ITL) issued by these agencies, respectively. These permits are issued in accordance with ESA Section 10(a)(1)(B) and Hawai‘i Revised Statutes (HRS) Section 195 D, respectively, and require the preparation of a Habitat Conservation Plan (HCP). To satisfy National Environmental Policy Act (NEPA) requirements resulting from the issuance of the ITP, the USFWS will prepare an environmental assessment (EA). To satisfy HRS Chapter 343, the County of Maui will be the accepting agency for an environmental impact statement (EIS) prepared pursuant to which will describe and analyze the environmental impacts of this HCP and the associated Incidental Take License. The listed species covered in this HCP are collectively referred to as Covered Species.

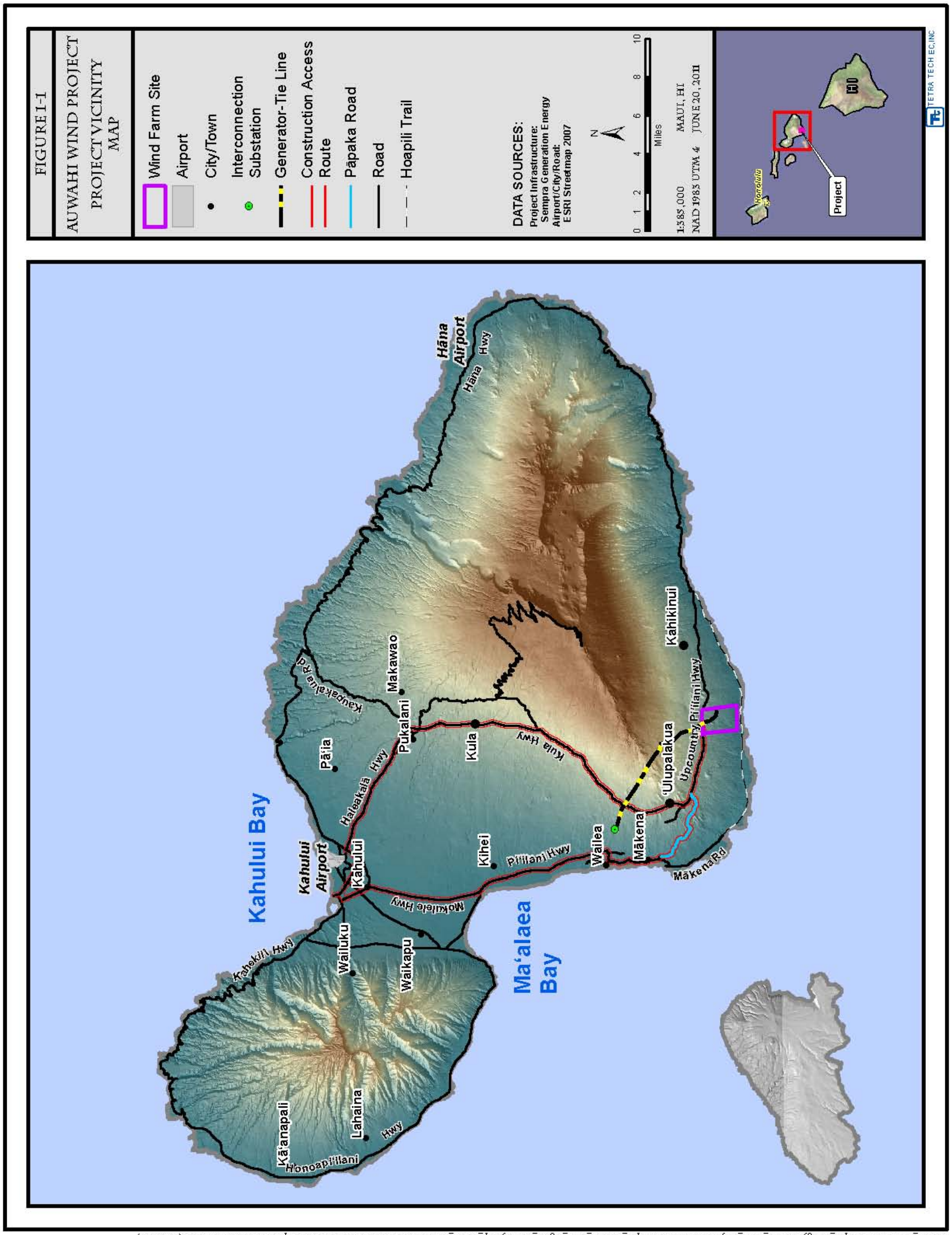

FIGURE 1-1
AUWAHI WIND PROJECT
PROJECT VICINITY MAP
Wind Farm Site
Airport
City/Town
Interconnection Substation
Generator-Tie Line
Construction Access Route
Pāpaka Road
Road
Hoapili Trail
DATA SOURCES:
Project Infrastructure: Sempra Generation Energy
Airport/City/Road: ESRI Streetmap 2007
N
0 1 2 4 6 8 10
Miles
1:385,000 MAUI, HI
NAD 1983 UTM 4 JUNE 20, 2011
Project
TETRA TECH EC, INC
Kahului Bay
Ma'alaea Bay
Hāna Airport
Hāna Hwy
Kaupakalua Rd
Makawao
Pukalani
Pā'ia
Haleakala Hwy
Kahului Airport
Kahului
Kula
Kula Hwy
Kahikinui
Pi'ilani Hwy
Upcountry
'Ulupalakua
Kīhei
Pi'ilani Hwy
Wailea
Mākena
Mākena Rd
Mokulele Hwy
Wailuku
Waikapu
Kahekili Hwy
Kā'anapali
Lahaina
Honoapi'ilani Hwy
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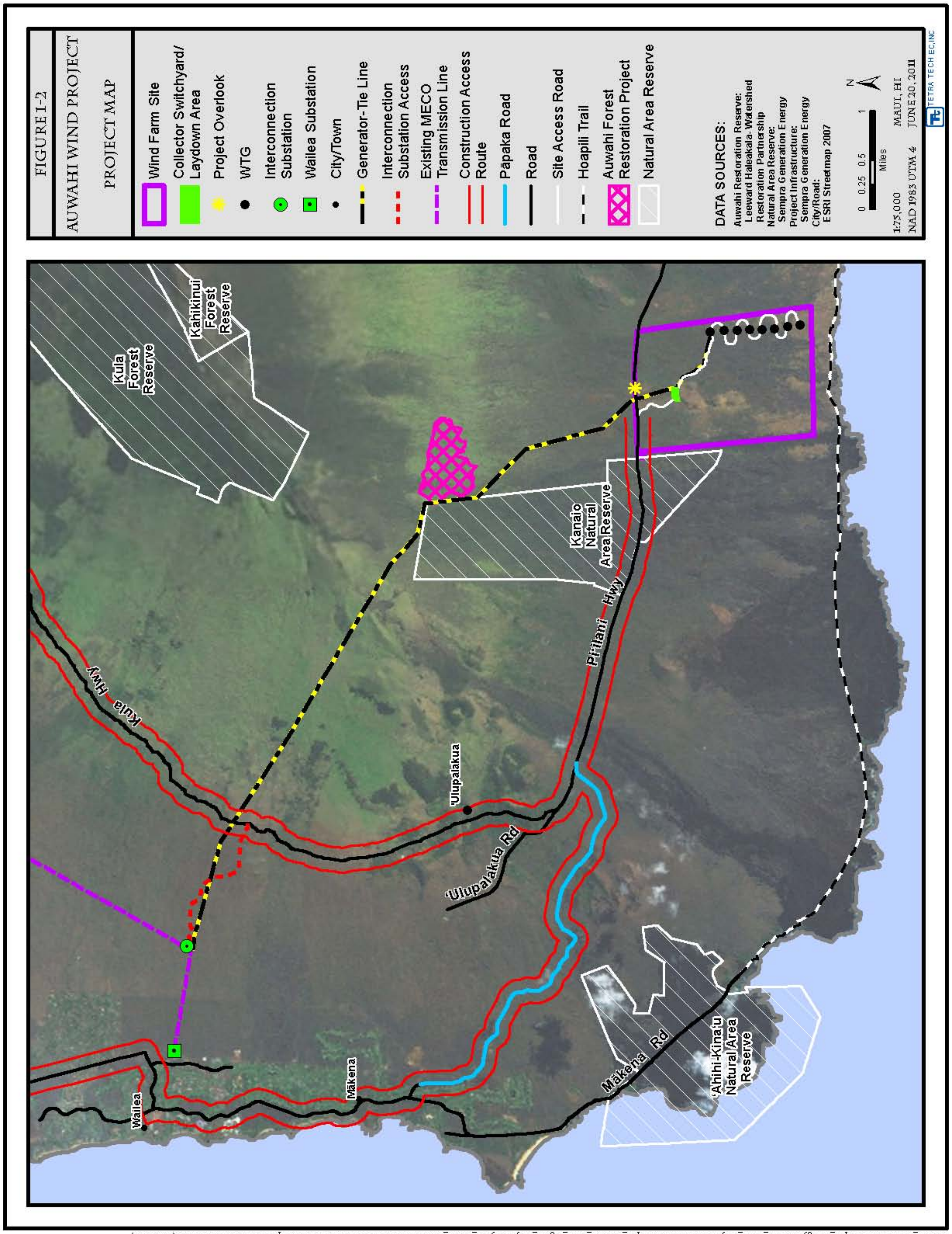

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1.2 APPLICANT HISTORY AND INFORMATION

Auwahi Wind, a subsidiary of Sempra Generation, was purchased from Shell Wind Energy, Inc., 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. In total, Sempra Generation has more than 2,700 MW of generating capacity in operation, including natural gas, wind, and solar photovoltaic projects.

1.3 PROJECT DESCRIPTION

The proposed Project is located almost entirely on the Auwahi Parcel of the ʻUlupalakua Ranch, approximately 10 miles (16 km) south of Kula, in the Hāna, Kula, and Kihei Districts of Maui. It consists of three major components (Figures 1-1 and 1-2):

- A 1,466-acre (5.9 square km) wind farm site, located on the southern portion of the Auwahi Parcel that is bordered by the Pacific Ocean to the south and Upcountry Piʻilani Highway to north with state-owned undeveloped lands adjacent to the west and east of the site.
- An approximately 9-mile (15-km), 34.5-kV generator-tie line and an interconnection substation that will facilitate the connection of the wind farm to the Maui Electric Company's (MECO) electrical grid system. The generator-tie line would originate within the wind farm site and extend north and west on ʻUlupalakua Ranch property, crossing both Upcountry Piʻilani Highway and Kula Highway to connect to the existing MECO Wailea-Kealahou 69-kV transmission line at the proposed point of interconnection located approximately 1 mile (1.6 km) east of MECO's Wailea substation.
- An approximately 27-mile (44-km) construction access route for the transportation of equipment from Kahului Harbor to the proposed wind farm site. The construction access route would primarily follow existing state and county highways as well as approximately 4.6 miles (7.4 km) of pastoral roads between Mākena Alanui Road and Upcountry Piʻilani 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.

The wind farm site and generator-tie line corridor are active agriculture and ranch lands that would continue to be used as pasture following construction of the Project. Construction and O&M activities associated with each of these Project components are described in detail below.

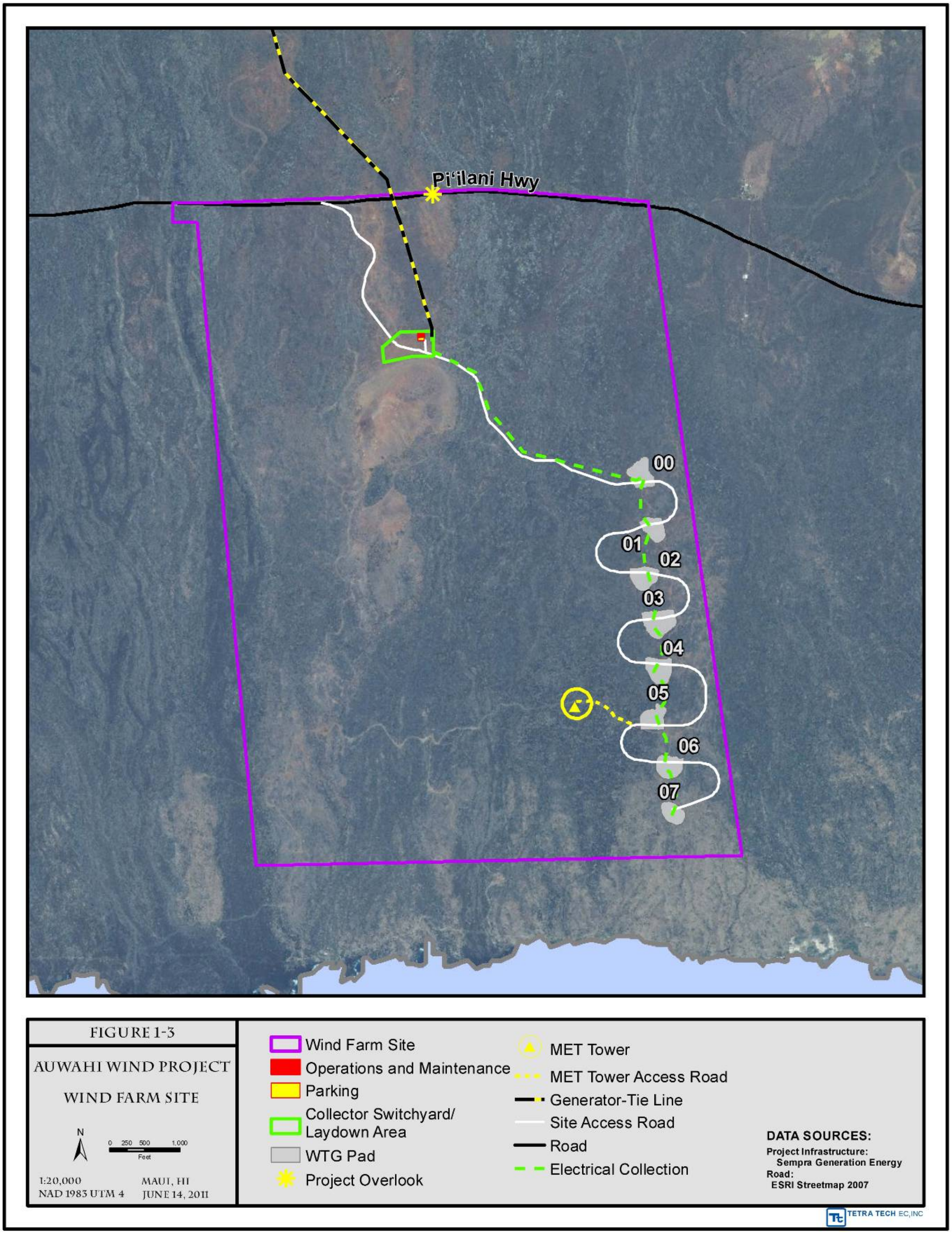
1.3.1 Project Design and Components

1.3.1.1 Wind Farm Site

The wind farm site would include the following facilities: turbine pads and access roads, construction staging and equipment laydown area, WTGs, underground and overhead electrical collection systems, an O&M building, and one permanent meteorological (met) tower (Figure 1-3).

Turbine Pads

Auwahi Wind considered three different WTG models for constructability, reliability, performance, and availability: the 1.5-MW General Electric (GE), the 2.3-MW Siemens, and the 3.0-MW Siemens. The dynamic nature of the turbine market (e.g., ongoing changes in supply, demand, pricing, and potential environmental impacts).


Pi'ilani Hwy
00
01
02
03
04
05
06
07
FIGURE 1-3
AUWAHI WIND PROJECT
WIND FARM SITE
N
0 250 500 1,000
Feet
1:20,000
NAD 1983 UTM 4
MAUI, HI
JUNE 14, 2011
Wind Farm Site
Operations and Maintenance
Parking
Collector Switchyard/ Laydown Area
WTG Pad
Project Overlook
MET Tower
MET Tower Access Road
Generator-Tie Line
Site Access Road
Road
Electrical Collection
DATA SOURCES:
Project Infrastructure:
Sempra Generation Energy
Road:
ESRI Streetmap 2007
TETRA TECH EC,INC

resulted in the deferral of the selection of the final WTG model until the permitting process was underway. Each WTG model has a different generating capacity and therefore would require a different number of turbines (15 1.5-MW GE turbines, 10 2.3-MW Siemens turbines, or 8 3.0-MW Siemens turbines). As a result, the layout and configuration of the wind farm site would vary by manufacturer and model. Therefore, site surveys were conducted for the maximum build-out scenario (i.e., greatest number of turbines) plus an additional turbine pad to allow flexibility in case one or more turbine pads became unfeasible for constructability reasons or natural resource-related issues. Ultimately, Auwahi Wind selected the Siemens 3.0-MW WTG for the Project primarily because it would reduce impacts to natural resources (see Chapter 8 for additional discussion). The 3.0-MW Siemens WTG is a gearless direct-drive machine with a hub height of 263 feet (ft; 80 m) and a rotor diameter of 331 ft (101 m), resulting in a maximum height (height to the top of the blade) of 428 ft (130.5 m). This model is more efficient and would require less ground disturbance than the 1.5-MW GE or 2.3-MW Siemens models.

- **Construction Activities.** At the WTG locations, an average area of approximately 2.4 acres (1.0 hectare [ha]) would be required for a crane pad and for off-loading, storage, and assembly of the tower sections, nacelle, rotor hub, and blades. These crane pad and laydown areas would be cleared and graded to provide a level and stable surface for the tower components and erection crane. The WTGs would be assembled at each laydown area immediately before installation utilizing a combination of forklifts, medium-size cranes (90 to 130 tons [82 to 118 metric tones]) and a main erection crane (as large as 600 tons [544 metric tones]), located on a compacted gravel crane pad. Medium-size cranes (130 tons [118 metric tones]) will also be utilized for off-loading and erection or setting of the various tower and WTG generation components. Construction equipment requiring access to these areas would include both wheeled and tracked vehicles.
- **Operation and Maintenance Activities.** Following construction, the cleared and leveled areas at the WTG pads would be reseeded with natural vegetation. An average area of approximately 0.3 acre (0.1 ha) would be required for the operating turbines. The graveled areas around the WTG pads would be maintained by grading and compacting to minimize naturally occurring erosion.

  During the operations phase of the Project, preventative maintenance and troubleshooting activities would be routinely performed on each WTG. These activities would typically include an inspection and servicing of all major mechanical components, lubrication systems, generators, blades, electrical and transformer components, communication and supervisory control and data acquisition (SCADA) components, and meteorological instrumentation. Routine servicing typically does not require heavy equipment, such as large cranes, but does require service vehicle access. However, in the event of a major component replacement (e.g., blades or generators), heavy equipment similar to that used during construction, would be required. If a major component replacement were necessary, the access road, crane pad, and staging area would be used in a similar manner as for the original assembly area, with similar disturbance and mitigation.

Access Roads

- **Construction Activities.** A series of internal access roads would be constructed within the wind farm site to accommodate construction and maintenance activities (Figure 1-3). The internal access roads would be a minimum of 105 feet (32.0 meters) during construction, but could be expanded to 138 feet (42.0 meters) in certain defined areas to allow for adequate passage for the crawler crane and transport trucks, and would include turn-around areas at certain WTG pad locations. In total the access roads would be approximately 3.5 miles (5.6 km) long. All access roads would have a gravel surface, as discussed below, stormwater collection and erosion control features, and would be maintained as such throughout Project construction and operation.

The proposed WTG access road layout includes several switchbacks to reduce the overall gradient of the existing slopes. It is also designed to have less than a 2 percent crown or cross-slope. Ditches and culverts would be installed to collect and convey stormwater runoff, as needed.

- **Operation and Maintenance Activities.** During operations, road widths would be maintained at 25 feet (7.6 meters) to 38 feet (11.6 meters) wide. Access roads would be maintained in good working order by grading and compacting to minimize naturally occurring erosion. Maintenance vehicles and service trucks would continue to use the access roads for routine maintenance of the WTGs.

Construction Staging and Equipment Laydown Area

- **Construction Activities.** A construction staging and equipment laydown area would be built and used during construction for temporary storage of plant equipment, construction materials and equipment, vehicle parking and refueling, water storage, waste disposal and collection receptacles, sanitary facilities, and temporary modular office space. Refueling of construction vehicles would take place onsite using a vendor-supplied fuel truck or skid-mounted tanks on pick-up trucks. Fuel stored onsite would be provided with secondary containment. Ultimately, the permanent O&M building would be constructed in the construction staging and equipment laydown area.

  The construction staging and equipment laydown area would consist of an approximately 4.9-acre (2.0-ha) compacted gravel pad constructed adjacent to the proposed collector switchyard (Figure 1-3). Construction activities consist of clearing and grubbing, topsoil stripping, grading to control stormwater runoff and drainage, compaction, utility trenching, and placement of aggregate surfacing. Following construction, the temporary affected area will be restored and planted with native vegetation or pasture grasses.

- **Operation and Maintenance Activities.** Following construction, gravel will be removed from the temporary construction staging and laydown area and the area will be restored with natural vegetation. A permanent, 0.2-acre (0.08-ha) storage area will be maintained during O&M to store spare WTG components, such as blades. The permanent O&M building providing offices for the plant O&M staff and vehicle parking for plant operations would be in this area. The graveled areas for parking and spare parts will be maintained by the operations staff to minimize erosion and control stormwater runoff and drainage.

Foundations

- **Construction Activities.** The proposed Project would require approximately 3,100 cubic yards (2,370 cubic meters) of concrete for construction of foundations for the WTGs, met tower, the O&M building, and other equipment pads. Existing batch plants on Maui would be able to supply all of the proposed Project's concrete requirements. Staging of concrete trucks will occur within the construction staging area.

Underground Electrical Collection System

- **Construction Activities.** Power generated by each of the WTGs would be collected by a series of underground power cables (electrical collection). These underground power cables would transition to two above ground, pole-mounted circuits at the northernmost WTG location (pad 00) and would become an overhead generator-tie line that would run 9 miles (14.5-km) to the interconnection substation.
- For each WTG, low-voltage (690-volt [V]) cables would deliver power from the generator in each WTG nacelle through the foundation to a pad-mounted transformer located adjacent to each WTG foundation. The transformer would step up the low-voltage power from 690 V to medium voltage power at 34.5 kV in order to connect to the 34.5 kV underground electrical collection cables. The underground electrical cable runs from WTG to WTG. The electrical collection system would consist of up to two separate 34.5-kV feeder circuits, one circuit for the southern four turbines, and one circuit for the northern four turbines. The underground electrical collection cable would "daisy-chain" between each pad-mount transformer. The size of cable would increase as more turbines are added in series due to the larger amount of load the cable would need to carry. The cables would be directly buried in trenches and would terminate at riser structures located adjacent to the northernmost WTG pad locations and transition to an overhead generator-tie line to the interconnection substation. Each of the two riser structures (one for each circuit) would have a manual gang-operated disconnect switch that would allow each 3-phase circuit to be isolated from the generation tie line.
- The trenches for the underground cables would be excavated by rubber tire or tracked equipment to the required burial depth, typically 36 inches (91 cm). Depending on the subsurface conditions, blasting may be required to install the trenches. Each trench would contain three power cables (one for each phase), plus a ground wire and a fiber optic communication cable for the SCADA system (to transmit data from the WTG controllers to the interconnection substation and O&M building). The cable trench would be backfilled with select fill material to protect the cables from damage or possible contact and to provide appropriate media for heat dissipation from the cables. It is estimated that approximately 3 acres (1.2 ha) of temporary ground disturbance would be necessary to construct the underground electrical collection system. Following construction, the collection system trenches would be marked to avoid inadvertent excavation and the surface would be restored and replanted with natural vegetation.
- **Operation and Maintenance Activities.** Using small trucks, qualified personnel would routinely monitor, inspect, and maintain the communication and electrical collector cables throughout the O&M phase of the Project. Heavy construction or excavation equipment would only be required if any underground cables were determined to have failed.

Operations and Maintenance Building

- **Construction Activities.** The proposed Project would incorporate an O&M building located within the proposed laydown area. The building footprint and concrete slab would be approximately 50 ft by 80 ft (15 m by 24 m), an area of 0.1 acre (0.04 ha). The O&M building would be a pre-engineered, metal building with an operations room, offices, communications and SCADA equipment, a warehouse, storage space, a kitchen area, and bathrooms.

In addition to the interior facilities, there would be parking and permanent outdoor storage for major components such as replacement WTG blades adjacent to the O&M building. The approximately 0.1-acre (0.04-ha) parking and outdoor storage area would be constructed with compacted gravel and would likely be enclosed by a 7-ft (2-m)-high chain-link fence topped by three strands of barbed wire, with posts set in concrete.

Utilities for the O&M building would include a septic system, an onsite well or water storage tank, electricity, and communication services. A septic system would be designed based on the results of the percolation test to be completed during future geotechnical studies. This septic system and all utilities would be designed in compliance with all applicable state and county regulations and requirements.

- **Operation and Maintenance Activities.** Activities associated with the O&M building would include basic maintenance and upkeep of the facility. Permanent infrastructure would include water and wastewater systems, potentially an onsite well, and a septic system.

Meteorological Monitoring Tower

- **Construction Activities.** One permanent met tower would be installed within the Project to measure and record weather data to track the performance of the WTGs. The met tower would have a height of 262 ft (80 m), guy radius of 208 ft (63 m), and a tower rating of 80 miles per hour (mph) (129 kilometers per hour [kph]) wind speed. Meteorological data include wind speed and direction, barometric pressure, humidity, and ambient temperature. This equipment would be used by the wind farm operator to monitor and actively assess Project performance. Either a lattice tower or a monopole tower would be installed.

  For determining impacts, a conservative approach for the permanent guyed met tower (fitted with bird diverters and white, 1-inch [2.5-cm] poly tape) would be to assume a circular area with a 210-ft (64-m) horizontal radius (guy radius). This would be a maximum total impact area of approximately 3.1 acres (1.2 ha), of which 0.2 acre (0.1 ha) would be permanently impacted. Construction of the met tower would require site preparation (e.g., clearing and grubbing); grading; installation of a foundation, underground electrical and communication lines; and onsite assembly of the tower.

- **Operation and Maintenance Activities.** Met towers require routine monitoring and maintenance activities during their operation, but do not typically require heavy equipment for servicing.

1.3.1.2 Generator-tie Line Corridor

The generator-tie line corridor includes the following two facilities: the 34.5-kV generator-tie line and the 69-kV interconnection substation.

34.5-kV Generator-tie Line

- **Construction Activities.** The 34.5-kV generator-tie line would connect the wind farm site with the 69-kV interconnection substation at the point of interconnection. The generator-tie line facilities would be constructed using wood poles. The poles would support the two three-phase 34.5-kV generator-tie line (i.e., six conductors), associated insulators and accessories, and an OPGW. All the required poles would be within the established corridor, approximately 60 ft (18 m) wide and 9 miles (14.5 km) long. The poles are anticipated to be approximately 60 ft (18 m) tall, similar to the existing wood poles supporting MECO's Wailea-Kealahou transmission line. Taller poles may be required along a small section of the generator-tie line (less than 1,000 ft [305 m]) if it is necessary to span a Fresnel (beam) zone along the alignment. These structure heights could approach approximately 100 ft [31 m]. Final structure heights will be determined as part of detailed engineering and design. Poles with guy wires would only be used at inflection points along the generator-tie line and are expected to be less than 10 percent of the overall poles. The exact location of each pole would be determined based on detailed engineering that would take into consideration a variety of factors, including existing access roads, terrain, environmental constraints, and cost. Temporary disturbance associated with the generator tie-line would be approximately 63.0 acres (25.2 ha)

The generator-tie line would have a height at or below 60 ft (18 m) above the ground (height of the poles with lines sagging between poles). Conductors will be arranged vertically, such that the static ground wire will be positioned above the generator-tie line. This configuration, versus a horizontal arrangement, was selected to maximize efficiency by minimizing the need for an additional transmission line corridor should future users wish to tie-in to the line. The generator-tie line would be designed to minimize the potential for collision by birds by fitting an approximately 1.6 mile (1.0 km) stretch identified as having the highest collision risk with bird flight diverters.

Generator-tie line construction would utilize standard industry procedures including surveying, corridor preparation, materials hauling, pull sites, staging areas, structure assembly and erection, ground wire, conductor stringing, cleanup, and revegetation. Specific methods of access have not been determined but they would maximize use of existing ranch roads or areas suited for off-road driving to the extent possible to minimize impacts.

- **Operations and Maintenance Activities.** Permanent disturbance associated with generator-tie line structures would be approximately 2.0 acres (0.8 ha). Qualified personnel would routinely monitor, inspect, and maintain the generator-tie line facilities throughout the O&M phase. These maintenance activities would be accomplished with the use of off-road vehicles and light trucks. Heavy construction equipment would only be required if overhead facilities need to be repaired or replaced.

69-kV Interconnection Substation

- **Construction Activities.** An area of approximately 6.4 acres (2.6 ha) would be cleared and graded during construction of the substation pad, below-grade raceway (e.g., the conduit, ductbank, and trench) and ground grid. The fenced dimension of the interconnection substation would be approximately 5.0 acres (2.0 ha). The substation would be shared by Auwahi Wind and MECO.

  The substation area would be cleared and graded to control stormwater runoff and the substation pad would be compacted with well-graded material. Foundations would be installed for the components. Below-grade raceway (e.g., the conduit, ductbank, and trench) and ground grid would be installed in the sub-grade. Vehicle access would be provided on the east and north sides of the substation, with a fence line separating the Auwahi Wind and MECO facilities. Following installation of all equipment, a final layer of crushed rock surfacing would be placed and a perimeter fence would be erected and grounded. Substation testing and commissioning would be done before energizing the Project.

  The substation area would include the battery energy storage system (BESS) that consists of batteries, inverters, step up transformers, and a control system to meet HECO performance requirements. MECO control system operators can send signals or commands to the BESS to adjust the voltage at the point of interconnection. Also, the operators can curtail wind farm output during low loading hours typically from 12 a.m. to 7 a.m. The BESS is designed to manage the ramp rate of wind power being injected into the MECO system to keep the ramp rate within specified limits. The BESS will smooth the fluctuations in wind power coming from the wind farm and allow the wind power output to be injected into the MECO electric system. The design life of the BESS is 20 years. The BESS will consist of approximately ten 50-foot (15.2-m) shipping containers of battery cells. A portion of the battery cells may need to be replaced at intervals of approximately five years. The interconnection substation access road from Kula Highway that was improved to build the substation will be used for battery removal and replacement. The removed batteries would be shipped of island as part of the manufacturers recycling program. Depending on the type of battery, the capacity of the BESS can fade over time, so additional capacity will be installed to compensate for the anticipated capacity fade. The facility could add more energy storage to further smooth the wind power output but extra storage would be an additional cost and exceed the utility's performance requirements.

- **Operation and Maintenance Activities.** Qualified personnel would operate and maintain the interconnection substation. Maintenance activities would include routine inspections of each component and monitoring of equipment and electronics according to the manufacturer's recommendations and owner's requirements, and in accordance with regulatory requirements. Routine maintenance of the interconnection substation would not typically require heavy construction equipment. However, if a major component failure occurred (e.g., a failure of a main transformer) then appropriate construction equipment would be required to replace the component.

69-kV Interconnection Substation Access Road

- **Construction Activities.** The proposed interconnection substation site is located approximately 1.7 miles (2.8 km) below Kula Highway. To the maximum extent possible, the access road to the interconnection substation would follow the route of existing ranch roads. The existing ranch roads and proposed newly constructed portions would be 20 ft (6.1 m) wide with a maximum grade of 15 percent and a minimum turning radius of 100 ft (30.5 m) so that a truck similar to a WB-62 carrying transformers could access the site. Approximately 16.3 acres (6.5 ha) would be disturbed during construction of the substation access road, of which 4.2 acres (1.7 ha) would be permanently impacted. The road would have an all-weather graveled surface with adequate compaction to accommodate the specialized transportation equipment. The road would be designed to adequately manage stormwater runoff and minimize erosion, as required. Drainage measures could include ditches and culverts to collect and convey stormwater. Following construction, any deteriorated roadway surfaces would be repaired and restored.

- **Operation and Maintenance Activities.** Following construction, the access road to the 69-kV interconnection substation would be used for routine O&M activities but it would be closed to the public. The access roads would be maintained in good working order by grading and compacting to minimize naturally occurring erosion.

1.3.1.3 Construction Access Route

Most of the materials and equipment required for the proposed Project, including the turbine components and construction materials and equipment, would be imported to Maui through

Kahului Harbor, the island's only commercial port, and then transported to the proposed Project site. The construction access route consists of two routes which will share the traffic burden association with construction of the Project. The Papaka Route (Route A) extends from Kahului to the Mokulele Highway, through Kihei, Wailea, and Makena, and along Upcountry Piilani Highway to the wind farm site. The Kula Route (Route B), a more direct route from Kahului Harbor, uses Haleakala and Kula highways. Several portions of Route B do not have dimensions or weight limits adequate for the size of transport truck required for hauling turbine components; however, this route is suitable for other construction vehicles such as worker vehicles, dump trucks, and typical semi-trucks.

Because most of the major turbine components are considered "superloads," special transportation equipment (e.g., multi-axle transport trailers, Schnabel trailers with hydraulic lifts, and steerable blade-trailers) would be required. To accommodate these superloads, portions of Kula Highway (referred to as Upcountry Pi'ilani Highway) and Pāpaka Road would require permanent modifications. Approximately nine bumps with a rise greater than 20 inches (50.9 centimeters) over a 100-foot (30.5-meter) length may require modification and possibly two S-curves would need to be widened. The level of modification would depend on a number of factors including selection of the transportation provider (by the construction contractor) and availability of specialized transportation equipment. For example, if it were determined that the removal of a bump was required, the construction contractor could either (1) re-contour the road profile by removing the bump, or (2) temporarily fill in the areas approaching and exiting the bump (i.e., provide a more gradual transition). The affected zones of construction could be 200 to 400 feet (61 to 122 m) long, and would typically be limited to the existing width of the road including the shoulders. Curve widening may be required in one or two locations. If required, the construction contractor would excavate the inside shoulder of the curve to provide a smoother, horizontal transition into and away from the curve. The affected zones of construction could be 200 to 400 feet (61 to 122 m) long and may extend 40 to 50 feet (12 to 15 m) onto the inside shoulder of the curve. Any temporary or permanent road modifications proposed by the construction contractor would be coordinated with the County of Maui. Temporary road improvements would also be necessary at the intersections of Pi'ilani Highway and Wailea Ike Drive, Wailea Ike Drive and Wailea Alanui Drive, and Mākena Alanui Road and Mākena Golf Road. These improvements would all occur within the existing road bed for the Project. A total of approximately 50.6 acres (20.2 ha) would be disturbed in association with construction access route modifications, of which 11.2 acres (4.5 ha) would be permanent. Following construction, the construction access route would continue to be used for normal public traffic and routine O&M activities.

1.3.1.4 Site Clean-Up

All portions of the proposed Project would be maintained in an orderly and clean manner throughout construction. At the completion of the construction phase, a final cleanup of all components of the proposed Project would be done. All construction-related waste would be properly handled in accordance with county, state, and federal policies and permit requirements and removed from the area for disposal or recycling as appropriate. Areas with disturbed soil that would not be used during operations would be stabilized and returned to cattle grazing.

1.3.1.5 Decommissioning and Restoration

The proposed Project has an estimated life of 20 years based on the projected useful life of the WTGs. After that time, the Applicant would evaluate whether to continue operations of the Project or decommission it. Should the Project be extended, the facility would potentially be upgraded and repowered with renegotiated leases (and any necessary extensions of Project permits and approvals, such as the ITP and ITL, would need to be obtained). If the Project is decommissioned, the goal of decommissioning would be to remove the power generation equipment and return the site to a condition as close to its pre-construction state as possible within 2 years within 2 years as contractually required in both the Land Lease with ʻUlupalakua Ranch and the PPA with Maui Electric. All decommissioning- and restoration-related waste would be properly handled and disposed of or recycled, as appropriate, in accordance with county, state, and federal laws and permit requirements. Foundations would be removed to a depth below grade, and roads would be left for use by ʻUlupalakua Ranch. Major activities required for decommissioning would typically occur in reverse order to those of construction and are listed below:

- WTG foundation and met tower removal. Concrete and steel would be hauled offsite. Foundations would be filled with native weed-free aggregate and soils;
- Electrical collection system removal for above-ground structures and decommissioning in place for below-ground cables;
- Sale or demolition of the O&M building. The on-site septic system would be abandoned consistent with state and local requirements, unless needed for a future use of the site;
- Generator-tie line removal. Foundation holes would be filled with native weed-free soil;
- Road removal (as required by permit and/or site control agreements by landowners). Road disturbances would be re-graded to original contours where cut and fill made recontouring feasible. Any roads left in place would become the responsibility of the landowner;
- Grading disturbed areas to preconstruction contours where feasible;
- Revegetation with native or pasture grass species to ensure establishment of vegetation. Where applicable, restored areas would be stabilized and returned to cattle grazing; and
- Recycling and disposal of materials, WTG components, and any hazardous and regulated materials and wastes would be conducted per applicable local, state, and federal regulations.

Decommissioning would restore the visual and ecological character of the landscape and also remove effects to other environmental and public resources that may have occurred as a result of Project operations

1.3.2 Purpose and Need for the Project

Hawaiʻi is one of the world's most remote island chains, has no fossil fuel resources of its own, and is the most dependent upon imported energy of all the 50 United States. In 2005, approximately 95 percent of Hawaiʻi's primary energy was derived from imported fossil fuels, such as petroleum and coal (Global Energy Concepts 2006). Consequently, Hawaiʻi's consumer energy prices are some of the highest in the nation and Hawaiʻi has been, and is, especially vulnerable to fluctuations in fossil fuel availability and price.

In an attempt to reduce its dependence on imported fuels, Hawaiʻi has established Renewable Portfolio Standards (RPS) (HRS § 269-92), which require Hawaiian Electric Company (HECO) and its affiliates, Hawaiʻi Electric Light Company (HELCO) and MECO, to generate renewable energy equivalent to 10 percent of their net electricity sales by the year 2010, 15 percent by 2015, 25 percent by 2020, and 40 percent by 2030. In addition, the Global Warming Solutions Act of 2007 requires that Hawaiʻi's greenhouse gas emissions be reduced to levels at or below 1990 levels by January 2020. On January 28, 2008, Hawaiʻi also signed a Memorandum of Understanding (MOU) with the

U.S. Department of Energy (DOE) that established the Hawai'i Clean Energy Initiative, under which at least 70 percent of Hawai'i's energy needs would be supplied by renewable resources by the year 2030. Hawai'i has identified three priorities that are crucial to meeting this goal: transforming the regulatory environment to facilitate clean energy development, collaborating with island utility companies to increase renewable energy generation, and integrating renewable energy into utility grids (USDOE 2010).

These regulations and initiatives reflect Hawai'i's commitment to reduce petroleum-based energy generation and increase its portfolio of renewable energy projects. Collectively, these directives demonstrate the overwhelming need for the development and implementation of renewable energy projects throughout Hawai'i.

The purpose of the Project would be to provide clean, renewable energy for the island of Maui. Implementation of the Project would contribute to Hawai'i's portfolio of renewable energy projects, as well as provide environmental and economic benefits to Hawai'i and the local community. The Project would also demonstrate how renewable energy can coexist with agricultural and ranching in rural Maui. After the Project is developed, 'Ulupalakua Ranch will continue to use the parcel for cattle pasture as it has done for decades.

Wind energy is an abundant, infinitely renewable resource. The addition of wind-generated energy would diversify Maui's power supply and contribute to Hawai'i's energy independence and security, as well as help to meet the State's regulatory requirements and initiatives. Generation and integration of wind energy into the electric grid will decrease fossil fuel consumption, thereby reducing greenhouse gas emissions, particulate-related health effects, and other forms of pollution associated with coal or diesel fuel generation. As of December 2009, 23.7 percent of MECO's sales were from renewable energy sources (HECO 2010). As proposed, the Project could provide 78,500 megawatt-hours per year (MWh/year) of electricity to MECO's grid, enough to provide electricity to approximately 6,600 homes, based on the average statistics reported by the American Wind Energy Association (AWEA 2010).

The proposed Project would also result in economic benefits, as it would contribute to the local economy, generate new jobs, and provide a stable, long-term source of tax revenue for Hawai'i and Maui County without disrupting the rural way of life in East Maui. Furthermore, the power generated by the wind farm would be sold under a long-term, set base price contract with fixed annual escalation and, as such, the proposed Project would provide long-term price stability for energy production.

1.3.3 Project Schedule and Timeline

The Project is proposed to begin construction in March 2012 and begin commercial operation by December 1, 2012.

1.3.4 List of Preparers

This HCP was prepared by Alicia Oller, M.S., Brita Woeck, M.S., Laura Nagy, Ph.D., and Jason Jones, Ph.D., of Tetra Tech. Reviews and input were provided by Mitch Dmohowski and Tom Jennings of Sempra Generation; David Moser of Ebbin Moser + Skaggs LLP; and Sumner Erdman of 'Ulupalakua Ranch. Additional input and review was provided by Scott Fretz, Fern Duvall, and Sandee Hufana of DOFAW and Dawn Greenlee, Bill Standley, and Patrice Ashfield of the USFWS, as well as members of the Endangered Species Recovery Committee (ESRC).

1.4 Regulatory Framework and Relationship to Other Plans, Policies, and Laws

1.4.1 Endangered Species Act

The ESA and its implementing regulations prohibit the take of any fish or wildlife species that is federally listed as threatened or endangered without prior approval pursuant to either Section 7 or Section 10 (a)(1)(B) of the ESA. Section 9 of the ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The term harm means an act that actually kills or injures a federally listed wildlife species, and may include significant habitat modification or degradation (50 Code of Federal Regulations [CFR] §17.3). In addition, Section 9 of the ESA details generally prohibited acts and Section 11 provides for both civil and criminal penalties for violators regarding species federally listed as threatened or endangered.

ESA section 4(f) requires the USFWS to develop and implement recovery plans for the conservation and survival of listed species. Recovery plans must describe specific management actions, establish objectives and measurable criteria for delisting, and estimate the time and cost to carry out measures needed to achieve recovery. The USFWS has developed recovery plans for the Hawaiian petrel, Hawaiian hoary bat, nēnē, and Blackburn's sphinx moth (USFWS 1983, 2004, 2005a,b). The biological goals and objectives identified in Section 5.1.1 are consistent with these recovery plans.

In 1982, Congress amended the ESA to allow a private applicant to incidentally take an ESA-listed species that would otherwise be prohibited under Section 9(a)(1)(B). When a non-federal landowner wishes to proceed with an activity that is legal in all other respects, but that may result in the incidental taking of a listed species, an ITP, as defined under Section 10 of the ESA, is required. Incidental take is defined as take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (50 CFR § 17.3). An HCP must accompany an application for an ITP to demonstrate that all reasonable and prudent efforts have been made to avoid, minimize, and mitigate for the effects of the potential incidental take. To that end, an HCP specifies: (i) the impact that will likely result from the taking; (ii) the steps that will be taken to "minimize and mitigate" these impacts, including the funding available to implement these steps; (iii) alternatives to the taking that were considered and why such alternatives are not being pursued; and (iv) any other measures required by the USFWS as necessary or appropriate to the HCP.

Guidance for preparation and required components of an HCP are provided in the USFWS HCP Handbook (USFWS and NMFS 1996). The USFWS and National Marine Fisheries Service (NMFS) issued an addendum to the handbook in 2000 (USFWS and NMFS 2000). Known as the Five-point Policy, this addendum provides additional guidance on: (i) establishing and stating biological goals for HCPs; (ii) clarifying and expanding the use of adaptive management where there is uncertainty about the experimental design and scientific evidence with respect to the HCP's approach to conservation; (iii) clarifying the purpose and means of how to undertake species and habitat monitoring; (iv) providing criteria to be considered by USFWS and NMFS in determining incidental take permit duration; and (v) expanding public participation. Under the Five-point Policy, the USFWS and NMFS afford greater opportunity for public participation in the HCP development process by lengthening the public comment period for most HCPs from 30 to 60 days.

1.4.2 National Environmental Policy Act

Issuance of an ITP is a federal action subject to compliance with the requirements of NEPA. The purpose of NEPA is to promote agency analysis and public disclosure of the environmental issues surrounding a proposed federal action. The scope of NEPA goes beyond that of the ESA by considering the impact of a federal action on non-wildlife resources such as water quality, air quality, and cultural resources. The USFWS will prepare and provide for public review an EA to evaluate the potential environmental impacts of issuing an ITP and approving the implementation of the proposed Project HCP. The purpose of the EA is to determine if ITP issuance and HCP implementation will significantly affect the quality of the human environment. If the USFWS determines significant impacts are likely to occur, an Environmental Impact Statement (EIS) for the proposed action will be prepared and distributed for public review; otherwise, if the USFWS determines no significant impacts are likely, it will issue a Finding of No Significant Impact (FONSI). The USFWS will not make a decision on ITP issuance until after the NEPA process is complete.

1.4.3 Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act of 1918 (MBTA), as amended (16 U.S.C. [United States Code] §§ 703-712), taking, killing or possessing migratory birds is unlawful. Birds protected under this act include most native birds, including their body parts (e.g., feathers), nests, and eggs. A list of birds protected under the MBTA implementing regulations is provided at 50 CFR § 10.13.

Unless permitted by regulations, under the MBTA it is unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried, or received any migratory bird, part, nest, egg, or product. The MBTA provides no inherent process for authorizing incidental take of MBTA-protected birds. The Hawaiian petrel is protected under the MBTA. If the HCP is approved and USFWS issues an ITP to Auwahi Wind, the terms and conditions of that ITP will constitute a special purpose permit under 50 CFR § 21.27 for the take of the Hawaiian petrel under the MBTA. Therefore, any such take of the Covered Species will not be in violation of the MBTA.

1.4.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §40 *et seq.*), requires federal agencies to take into account the effects of their proposed actions on properties eligible for inclusion in the National Register of Historic Places. "Properties" are defined herein as "cultural resources," which includes prehistoric and historic sites, buildings, and structures that are listed on or eligible to the National Register of Historic Places. An undertaking is defined as a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a federal agency; including those carried out by or on behalf of a federal agency; those carried out with federal financial assistance; those requiring a federal permit, license or approval; and those subject to state or local regulation administered pursuant to a delegation or approval by a federal agency. The issuance of an ITP is an undertaking subject to Section 106 of the National Historic Preservation Act. Cultural and archeological resources surveys have been conducted for the Project. The USFWS will coordinate with the State Historic Preservation Office on cultural resources and address any potential issues in the EA.

1.4.5 Hawai'i Revised Statutes (HRS Chapter 195D)

Hawai'i Revised Statutes (HRS) Section 195D-4 states that any species of aquatic life, wildlife, or land plant that has been determined to be an endangered or threatened species under the ESA shall be deemed so under this State chapter, as well as any other indigenous species designated by DLNR as endangered or threatened by rule. The "take" of any endangered or threatened species is prohibited by both the ESA and this state statute (Section 195D-4[e]). Similar to the ESA, section 195D-2 defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife, or to cut, collect, uproot, destroy, injure, or possess endangered or threatened species of aquatic life or land plants, or to attempt to engage in any such conduct."

The Board of Land and Natural Resources (BLNR) may issue an ITL to permit take otherwise prohibited under subsection 195D-4(e) if the take is incidental to and not the purpose of, the carrying out of an otherwise lawful activity. As part of the ITL application process, an applicant must develop, fund, and implement a BLNR-approved HCP to minimize and mitigate the effects of the incidental take. The HCP must also result in a net environmental benefit, and increase the likelihood that the species will survive and recover. State law created the Endangered Species Recovery Committee (ESRC), an appointed group that must approve the final HCP at several points in the process, before an ITL can be issued by DOFAW/DLNR. ESRC members include representatives of the USFWS, DOFAW, the U.S. Geological Survey Biological Resources Division (USGS-BRD), the University of Hawaiʻi Environmental Center, and other professionals with expertise in the area of conservation biology. The required components of a state HCP are listed in Section 195D-21. Section 195D-5(i) directs the DLNR to work cooperatively with federal agencies in concurrently processing state and federal HCPs and ITP/ITL applications.

1.4.6 State Environmental Review

DOFAW/DLNR has determined that the approval of an HCP and issuance of an ITL under HRS Chapter 195D will be accompanied by environmental review pursuant to HRS Chapter 343. The Project already requires Chapter 343 environmental review because one portion of Pāpaka Road to be widened as part of the Project occurs within the State conservation district.

Auwahi Wind prepared an Environmental Impact Statement Preparation Notice (EISPN), which was released for public comment on March 23, 2010. A Draft Environmental Impact Statement was released for public comment on March 8, 2011. The Final Environmental Impact Statement (FEIS) is expected to be published by Maui County (accepting agency) in August 2011. The FEIS describes and analyzes the environmental impacts of this HCP and associated ITL. The FEIS acceptance will complete the state environmental review process for the Project.

2.0 DESCRIPTION OF THE HABITAT CONSERVATION PLAN

2.1 PURPOSE AND NEED FOR THE HCP

This HCP has been prepared to meet the requirements of the ESA and the HRS Chapter 195D, which apply to the development and operation of the proposed Project. An HCP is needed because components of the Project have the potential to result in take of endangered and threatened species that inhabit or traverse through the Project area, including Hawaiian hoary bat, Hawaiian petrel, nēnē, and Blackburn's sphinx moth. Pursuant to Section 10(a)(1)(b) of the ESA, incidental take by a non-federal entity may be authorized though the issuance of an ITP. Under HRS Section 195D-4(g), DLNR will authorize take through the issuance of an ITL. An HCP must be prepared in support of the application for both the ITP and ITL. The HCP establishes the measures and means required to meet the conservation needs of endangered and threatened species in the Project area, while at the same time preserving Auwahi Wind's ability to pursue its development objectives with assurances from the USFWS and DLNR that incidental take of Covered Species is authorized.

The purposes of the HCP are to: 1) determine the potential impacts that the Project may have on the listed species or species under consideration for listing; (2) to address the potential incidental take of the listed species by setting forth measures that are intended to ensure that any take caused by the Project will be incidental; 3) ensure that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; to provide procedures to deal with changed and unforeseen circumstances; 4) ensure that adequate funding for the HCP will be provided; and 5) ensure that the take of the listed species will not appreciably reduce the likelihood of the survival and recovery of these species in the wild. Implementation of the HCP will provide a conservation benefit to the Covered Species.

The need for the HCP is to authorize, pursuant to the ESA and HRS Chapter 195D, the take of threatened or endangered species (or species under consideration for listing) incidental to the construction and operation of the Project. In order to obtain such authorization, Auwahi Wind developed an HCP that meets the USFWS and DLNR issuance criteria for an ITP and ITL. Furthermore, as a business entity, Auwahi Wind requires a stable and predictable operating and regulatory environment. The HCP assists Auwahi Wind with regulatory compliance under the ESA and HRS Chapter 195D, serving as a vehicle for obtaining regulatory stability and predictability.

2.2 SCOPE AND TERM

2.2.1 HCP Scope

The scope of the Project HCP is the area where incidental take authorization would be provided, and includes all areas where construction and operation of the Project and associated facilities (e.g., turbines, roads, operations/maintenance buildings, substation, and generator-tie line facilities) have the potential to result in take of the Covered Species. This generally includes the portion of the 'Ulupalakua Ranch proposed for development, locations of external access routes, generator-tie line facilities, and mitigation areas (Figures 1-1, 1-2, and 1-3).

2.2.2 HCP Term

The Project HCP is a 25-year plan and the relevant authorizations and permits have a term of 25 years. Accordingly, assessments of take made within this HCP are based on a 25-year time period. The HCP identifies provisions for adaptive management and monitoring to allow for flexibility in implementing and adjusting appropriate mitigation to compensate for Project-related incidental impacts. The adaptive management and post-construction monitoring provisions of this HCP allow flexibility and responsiveness to new information and technology over the life of the Project. Prior to the expiration of the Project HCP permits, and to the extent allowed by then-applicable laws and regulations, Auwahi Wind may apply to renew or amend the HCP and its associated permits and authorizations to extend its term.

2.3 SURVEY AND RESOURCES

The following resources were used during the preparation of the HCP:

- Endangered bird and bat surveys conducted during Fall 2006 and Spring 2010 at the south Auwahi wind resource area, Maui, Hawaiʻi (Hamer Environmental 2010a);
- Avian Risk of Collision Analysis for the South Auwahi Wind Resource Area, Maui, Hawaiʻi (Hamer Environmental 2010b);
- Botanical, Avian, and Terrestrial Mammalian Resources Survey for the Auwahi Wind Project, ʻUlupalakua Ranch , Island of Maui (David and Guinther 2008, revised in 2011);
- Draft Survey of Invertebrate Resources for the Shell Wind Energy Inc., Auwahi Parcel, ʻUlupalakua Ranch, Hana District, Island of Maui (Montgomery 2008);
- Botanical and invertebrate surveys conducted by Eric Guinther and Steve Montgomery in March-April 2011 (Guinther 2011; Guinther and Montgomery 2011);
- Anabat acoustic monitoring study (ongoing);
- Initial petrel survey at Kahikinui Forest Reserve on the DHHL parcel in April 2011;
- Various reports prepared for the Applicant providing information on other resources in the Project area (as cited throughout);
- Personal communications and unpublished data provided by ʻUlupalakua Ranch and LHWRP.
- Personal communications and unpublished data provided by various DOFAW, National Park Service (NPS), and USFWS biologists and current and/or proposed studies; and
- Annual reports and HCPs from existing and proposed wind farm projects in Hawaiʻi and other locations in the U.S.

3.0 ENVIRONMENTAL SETTING

3.1 REGIONAL LOCATION

Maui is the second largest of the Hawaiian Islands and is 48 miles (77 km) long and 26 miles (42 km) wide, for an area of 728 sq miles (1,886 sq km). The island is composed of two volcanic mountains, Haleakalā and West Maui, separated by a low-lying isthmus that was created as the lava from Haleakalā flowed into West Maui. Haleakalā forms East Maui, and is 10,025 ft above sea level (asl) (3,056 m) and 33 miles (53 km) across. At 570 sq miles (1,476 sq km), it comprises approximately 77 percent of the island (USGS 1996). West Maui is 5,788 ft (1,764 m) asl and 18 miles (29 km) across.

Haleakalā is a shield volcano that is believed to have started forming about 2 million years ago, reaching the ocean surface about 1.5 million years ago (USGS 1996). Subsequently, its flows merged with other nearby volcanoes, including West Maui, Kahoʻolawe, Lanaʻi, East Molokaʻi, West Molokaʻi and Penguin Bank (Stearns 1966), covering at least 6,200 sq miles (16,058 sq km). Over the course of the last 400,000 years, the volcanoes subsided to form four distinct islands: Maui, Molokaʻi, Lanaʻi, and Kahoʻolawe. Haleakalā was formed over three rift (fissure) zones, extending to the northwest, east and southwest, each marked by a series of cinder cones (Stearns 1966). Volcanic activity at Haleakalā in the past 30,000 years has occurred along the southwest and east rift zones, with approximately ten eruptions in the past 1,000 years (USGS 1996).

3.2 LAND USE

The Project is located entirely within the state agricultural land use district and Maui County agricultural zoning boundaries, with the exception of either end of Pāpaka Road (Figure 1-2). The easternmost 2,000 ft (610 m) of the roadway is located in a State conservation district (Resource, Protective, and General subzones) and the westernmost 1,960 ft (597 m) of the roadway is located in a State urban district. The portion within the State conservation district is the only portion of the Project not within the county zoning jurisdiction. The Project is located entirely on land owned by ʻUlupalakua Ranch. The generator-tie line is also located on ʻUlupalakua Ranch property, although it crosses Piʻilani Highway, which is within a county easement, and Kula Highway, which is owned by the state. The proposed Project and generator-tie line occur on actively grazed pastureland.

3.3 TOPOGRAPHY AND GEOLOGY

The geologic profile underlying the proposed Project consists primarily of recent basalt flows of the Hana Volcanic series, which is considered to be suitable substrate for construction of the Project (Black & Veatch 2008). Although no large lava tubes were encountered in the borings during the geotechnical investigation, a subsurface void was observed to the west of Puʻu Hokukano. In addition, a buried soil layer was found between basalt flows at a relatively shallow depth of approximately 6.5 ft to 10 ft (2 m to 3 m), north of Puʻu Hokukano (Black & Veatch 2008). During subsequent field surveys, lava tubes were encountered within the wind farm site footprint. In some locations, the wind farm site access roads may cross over lava tubes. A detailed geotechnical investigation would be conducted prior to construction to confirm the absence of subsurface voids and buried soils in the footprint of the Project facilities.

In general, the topography of this region is steep and rugged, as is common on the slopes of shield volcanoes. The proposed wind farm site ranges in elevation from approximately 1,600 ft (488 m) asl on the northern edge to 200 ft (61 m) asl on the southern edge, which equates to an approximately

14 percent slope. The slope is fairly uniform across the site, with the exception of Puʻu Hokukano that rises to approximately 1,460 ft (445 m) asl near the center of the site, approximately 250 ft (76 m) above the surrounding terrain. The generator-tie line would extend from the proposed Project to an elevation of approximately 960 ft (293 m) asl at the existing Wailea substation. The generator-tie line would have a maximum elevation of approximately 4,400 ft (1,341 m) asl as it crosses the southwest rift zone. Pāpaka Road ranges from approximately 80 ft (24 m) asl at its western end to approximately 1,780 ft (543 m) asl at its eastern end. The eastern end of Pāpaka Road connects with Upcountry Piʻilani Highway which drops to approximately 1,608 ft (490 m) asl at the entrance to the wind farm site.

3.4 SOILS

According to the US Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Soil Survey (USDA 2010) and the Soil Survey of the Islands of Kauaʻi, Oʻahu, Maui, Molokaʻi and Lānaʻi (Foote et al. 1972), the soils in the Project area consist predominantly of the Oanapuka Series , with some areas of very stony land and lava flows and a small inclusion of cinder land on and directly adjacent to Puʻu Hokukano. The generator-tie line and Pāpaka Road traverse a broad spectrum of habitats over a range of elevations, which is reflected by a variety of soil types (Table 3-1).

Table 3-1. Soil Characteristics

Soil Name	Slope (%)	Description
Oanapuka extremely stony silt loam (OED)	7-25	Well drained, very stony soils on low uplands; developed in volcanic ash and material derived from cinders
Very stony land (rVS)	7-30	Areas where 50-90 percent of the surface is covered with stones and boulders
Lava flows, a`a (rLW)	—	Consists of young lava flows
Cinder land (rCI)	—	Areas of bedded magmatic ejecta; mixture of cinders, pumice and ash
Very stony land (rVS)	7-30	Areas where 50-90 percent of the surface is covered with stones and boulders
Uma rocky loamy coarse sand (URD)	7-25	Excessively drained, sandy soils on intermediate mountain slopes, with rock outcrops over 5-10 percent of the surface
Uma loamy coarse sand (UME)	15-40	Excessively drained, sandy soils on smooth, intermediate mountain slopes
Lava flows, a`a (rLW)	—	Consists of young lava flows
Uma loamy coarse sand (UMF)	40-70	Excessively drained, sandy soils on smooth, intermediate mountain slopes
ʻUlupalakua silt loam (ULD)	7-25	Soil on smooth, intermediate mountain slopes
Io silt loam (ISD)	7-25	Well-drained soils on smooth, low mountain slopes
Kula very rocky loam (KxbE)	12-40	Well-drained soils on uplands with rock outcrops over 10-25 percent of the surface

Table 3-1. Soil Characteristics (continued)

Soil Name	Slope (%)	Description
Kamaole very stony silt loam (KGKC)	3-15	Well-drained soils on uplands; developed in volcanic ash
Kula loam (KxD)	12-20	Well-drained soils; nearly free of cobblestones
Oanapuka extremely stony silt loam (OED)	7-25	Well drained, very stony soils on low uplands
Makena loam, stony complex (MXC)	3-15	Well drained soil on upland; developed in volcanic ash
Lava flows, a`a (rLW)	—	Consists of young lava flows
Very stony land (rVS)	7-30	Areas where 50-90 percent of the surface is covered with stones and boulders
Kula very rocky loam (KxbE)	12-40	Well-drained soils on uplands with rock outcrops over 10-25 percent of the surface
Io silt loam (ISD)	7-25	Well-drained soils on smooth, low mountain slopes

3.5 HYDROLOGY AND WATER RESOURCES

The western half of the proposed Project is in the Kanaiʻo watershed and the eastern half is in the Kipapa watershed (Table 3-2). The generator-tie line spans the Kanaiʻo and Wailea watersheds, with the boundary located along the southwest rift zone. Pāpaka Road crosses through the Kanaiʻo, Ahihi Kinau, Mooloa, and Wailea watersheds.

Table 3-2. Characteristics of Watersheds in the Proposed Project Area

Watershed Name	Watershed area (acres)	Perennial Streams	Range of Annual Rainfall (inches)
Ahihi Kinau	2986.7	None	15.75 to 29.53
Kanaiʻo	18409.9	None	15.75 to 39.37
Kipapa	20743.4	None	19.69 to 39.37
Mooloa	1212.6	None	9.84 to 29.53
Wailea	21985.5	None	9.84 to 39.37

Source: Hawaiʻi Institute of Marine Biology (2006)

The proposed Project is located in the Lualailua aquifer subunit (aquifer code 60603) of the Kahikinui aquifer unit (aquifer code 606) that has a sustainable yield of 11 and 36 million gallons per day (MGD; 41,640 kL per day), respectively (CWRM 2008). The Laulailua aquifer consists of an upper unconfined aquifer, and lower basal aquifer. The unconfined aquifer consists of perched fresh water (less than 250 milligrams per liter [mg/L] of chlorine [Cl^-]) that has potential use as a drinking water source, and has a high vulnerability to contamination. The basal aquifer is an unconfined flank aquifer with low salinity (250 to 1,000 mg/L Cl^-), is a potential drinking water source, and is moderately vulnerable to contamination (Mink and Lau 1990).

The generator-tie line and Pāpaka Road both cross into the Kamaole aquifer (aquifer code 60304) of the Central aquifer unit (aquifer code 603) that have sustainable yields of 11 and 27 MGD (41,640 kL per day), respectively (CWRM 2008). The Kamaole subunit is composed of an upper dyke impounded aquifer and a lower, basal unconfined flank aquifer. The upper unconfined aquifer has potential drinking water use, has fresh to low salinity (less than 250 to 1,000 mg/L Cl^-), is irreplaceable, and has a moderate to high vulnerability to contamination. The basal aquifer is not used as a drinking water source, has moderate to high salinity (1,000 to 5,000 mg/L Cl^-), is replaceable, and has a moderate to high vulnerability to contamination (Mink and Lau 1990).

Given the steep terrain and lack of surface water features, it is believed that the groundwater levels are deep below the ground surface throughout the proposed Project site and vicinity. No groundwater was encountered in the borings (ranging from 32 ft to 41 ft [9.8 m to 12.5 m] deep) conducted during the geotechnical investigation (Black & Veatch 2008).

No "waters of the U.S." are in or near the Project that are subject to jurisdiction under Section 404 of the Clean Water Act (David and Guinther 2010).

3.6 TERRESTRIAL FLORA

The Project is located on the leeward side of Haleakalā in the Hawaiian dry tropical forest ecoregion. The majority of the Project vegetative communities are dryland grassland, shrubland, and pasture dominated by non-native plant species. The introduction of grazing, fire and non-native species in the region reduced the expanses of native vegetation to remnant patches of wiliwili (*Erythrina sandwicensis)* forest, scattered mature native trees such as hao (*Rauvolfia sandwicensis*) and naio and native vegetation within recent lava flows (David and Guinther 2011).

A list of special status plants that could potentially occur in the Project Area was obtained from the Hawaii Biodiversity and Mapping Database based on known records in the vicinity. Critical habitat for 10 plant species has been identified to the east and west of a portion of the generator-tie line and the Project (Figure 3-1; USFWS 2003a). Other native plant reserves in the vicinity of the Project area include the Auwahi Forest Restoration Project, located east of the generator-tie line corridor. Additionally, the State of Hawai'i's Natural Area Reserve System (Kanaio NARS) is located on the western boundary of the southeastern portion of the generator-tie line. The Project is outside of the boundaries of botanical reserves and critical habitat areas (Figure 3-1).

A reconnaissance-level botanical survey of the proposed Project was conducted in May 2007 and a more in-depth botanical survey, focusing on specific areas where direct disturbance is proposed, was conducted from May to October 2010 (David and Guinther 2011). An additional botanical survey was conducted to capture wet-season conditions in March and April 2011 (Guinther 2011). The objectives of these surveys were to map vegetation communities within the Project and to determine the presence of any federal- or state-listed, other special status, or rare plant species (Figure 3-2). Some species documented during the 2007 surveys, which covered a broader area than the currently proposed Project, were not documented in 2010 or 2011, including the endangered mahōe and the federal species of concern island nesoluma (*Nesoluma polynesicum*). These species still have the potential to occur within the proposed Project vicinity depending on conditions from year to year. Prior to construction, additional botanical surveys would be conducted to document any new occurrences of special status and rare plant species within areas to be disturbed by construction.

Listed plant species are known to occur in the adjacent NARS and Auwahi Forest Restoration Project. During the Project surveys one federally endangered species, Ko'oloa 'ula or red 'ilima (*Abutilon menziesii*), was documented within the wind farm site, adjacent to WTG pad 5, but outside of any area of potential disturbance. One candidate for listing, 'aiea (*Nothocestrum latifolium*), was documented in the wind farm site near the met tower, within an area of permanent disturbance. One federal species of concern, maiapilo (*Capparis sandwichiana*), was also documented. Four maiapilo plants were located adjacent to the internal wind farm access road near WTG 5, one of which occurs

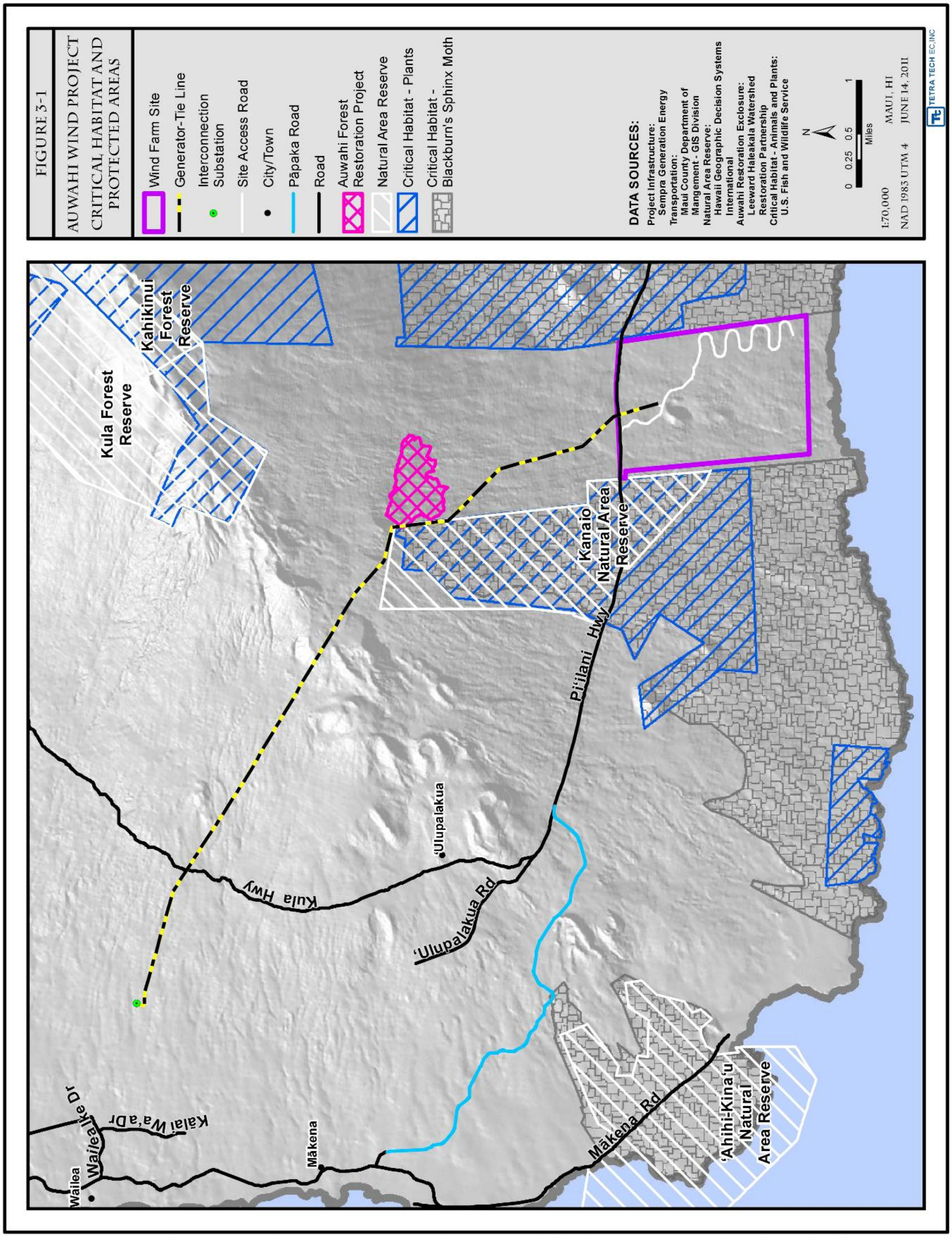


FIGURE 3-1
AUWAHI WIND PROJECT
CRITICAL HABITAT AND PROTECTED AREAS
Wind Farm Site
Generator-Tie Line
Interconnection Substation
Site Access Road
City/Town
Pāpaka Road
Road
Auwahi Forest Restoration Project
Natural Area Reserve
Critical Habitat - Plants
Critical Habitat - Blackburn's Sphinx Moth
DATA SOURCES:
Project Infrastructure: Sempra Generation Energy
Transportation: Maui County Department of Mangement - GIS Division
Natural Area Reserve: Hawaii Geographic Decision Systems International
Auwahi Restoration Exclosure: Leeward Haleakala Watershed Restoration Partnership
Critical Habitat - Animals and Plants: U.S. Fish and Wildlife Service
N
0 0.25 0.5 1
Miles
1:70,000
NAD 1983 UTM 4
MAUI, HI
JUNE 14, 2011
TETRA TECH EC,INC
Kula Forest Reserve
Kahikinui Forest Reserve
Kanaio Natural Area Reserve
Pi'ilani Hwy
Kula Hwy
'Ulupalakua
'Ulupalakua Rd
Mākena Rd
Mākena
'Āhihi-Kina'u Natural Area Reserve
Wailea
Wailea Ike Dr
Kalai Wa'a Dr

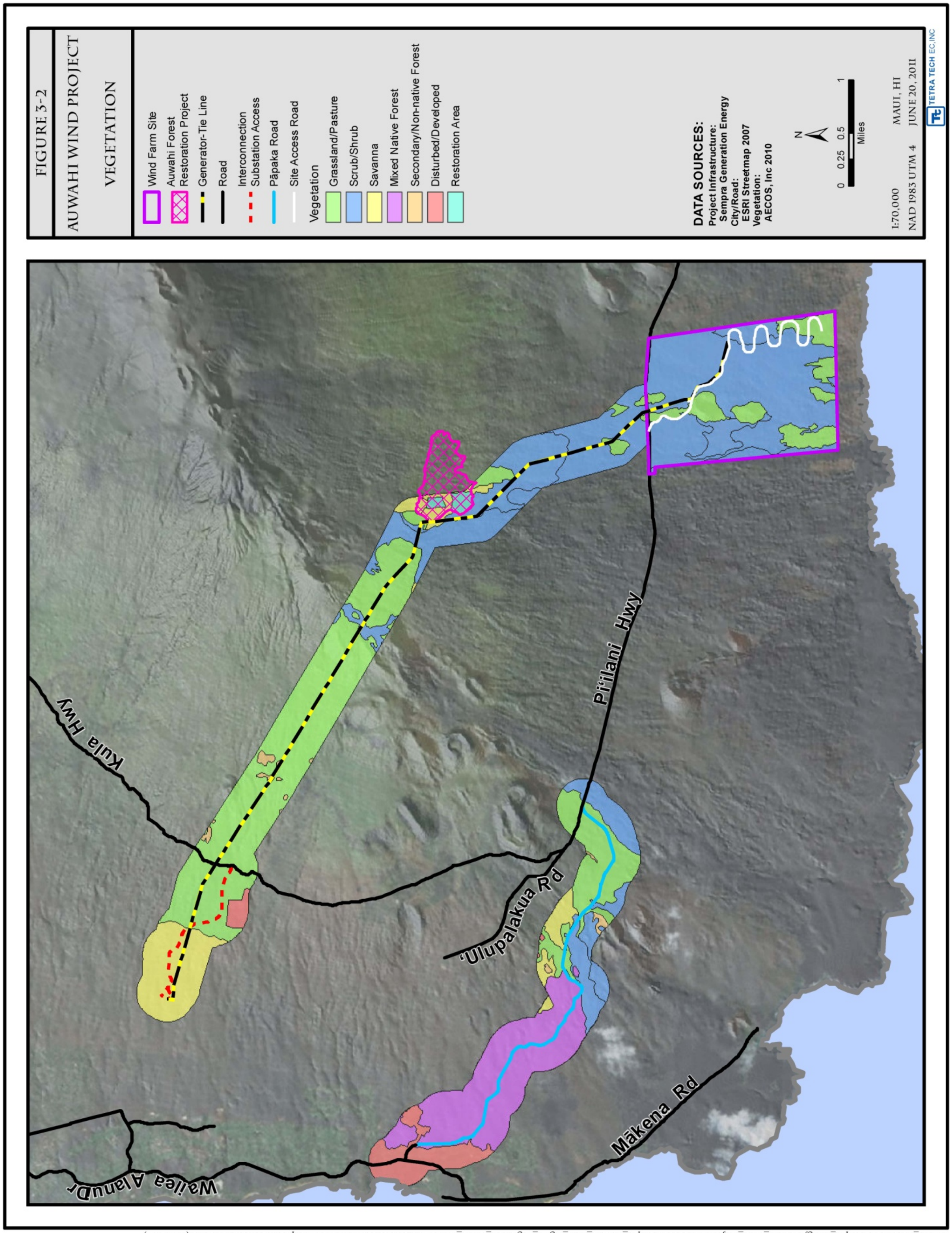


FIGURE 3-2
AUWAHI WIND PROJECT
VEGETATION
Wind Farm Site
Auwahi Forest Restoration Project
Generator-Tie Line
Road
Interconnection Substation Access
Pāpaka Road
Site Access Road
Vegetation
Grassland/Pasture
Scrub/Shrub
Savanna
Mixed Native Forest
Secondary/Non-native Forest
Disturbed/Developed
Restoration Area
DATA SOURCES:
Project Infrastructure: Sempra Generation Energy
City/Road: ESRI Streetmap 2007
Vegetation: AECOS, Inc 2010
N
0 0.25 0.5 1
Miles
1:70,000
NAD 1983 UTM 4
MAUI, HI
JUNE 20, 2011
TETRA TECH EC, INC
Kula Hwy
Pi'ilani Hwy
'Ulupalakua Rd
Mākena Rd
Wailea Alanui Dr
P:\GIS_PROJECTS\Sempra_Energy\Auwahi_Wind_Project\MXDs\HCP\Sempra_Auwahi_HCP_Fig3-2_Vegetation_85x11_062311 - Last Accessed: 6/23/2011 - Map Scale correct at: ANSI A (11" x 8.5")

in an area of temporary disturbance. There are scattered remnants of wiliwili forest (isolated trees and some well-developed groves) within this area. Although wiliwili is not a listed species, it is endemic to Hawaii and is considered a keystone species of the native dry forest ecosystem, one of the most endangered ecosystems in the Hawaiian Islands (USGS 2006). However, the understory of the wiliwili tree groves in the Project is no longer intact and is often dominated by non-native grasses.

One federal and state-listed endangered species, 'iliahi (*Santalum freycinetianum*), and one candidate for federal listing, ‘aiea, were documented within the generator-tie line corridor, A single individual of ‘iliahi occurs in an area of permanent disturbance and a single individual of ‘aiea occurs in an area of temporary disturbance. Another candidate for federal listing, hole’i (*Ochrosia haleakalae*), was documented approximately 490 ft (150 m) east of the generator-tie line centerline, and outside of any area of potential disturbance. One federal species of concern, maiapilo (*Capparis sandwichiana*), was documented in the vicinity of the construction access route (David and Guinther 2011). Three individual maiapilo occur within an area of temporary disturbance along Pāpaka Road; other plants of this species occur adjacent to the construction access road but outside of the areas of disturbance. A single occurrence of island nesoluma, based on Natural Heritage data, is located several miles from the road and outside of the disturbance footprint.

The wind farm site is characterized by a combination of dry, rocky pastureland and scrubland vegetation on rugged lava flows. This area is heavily exposed to grazing by cattle and feral ungulates, and is generally dominated by non-native shrubs and other low-growing woody plants (Appendix A), though pockets of grassland or barren, rocky ground are also present. Dominant species include natal redtop (*Melinus repens*), glycine (*Neonotonia wightii*), and koa haole (*Leucaena leucocephala*). There are several well-developed groves of wiliwili, a few scattered native trees such as hao (*Rauvolfia sandwicensis*), and some large specimens of naio (*Myoporum sandwicense).*

The generator-tie line traverses several plant communities along its route, which travels inland from the wind farm site, toward the Southwest Rift ridgeline, crosses the ridgeline, and then descends to the Wailea substation. Vegetation communities include: dry shrubland/scrub vegetation (from the wind farm site upslope to approximately 4,000 ft (1,220 m) asl dominated by koa haole, glycine, lantana (*Lantana camara*), buffel grass (*Cenchrus ciliaris*), narrow-leaved plantain (*Plantago lanceolata*)); grasslands and pastures (from approximately 4,000 ft to 1,000 ft [1,220 m to 305 m] asl on the windward slope) dominated by kikuyu grass (*Pennisetum clandestinum*) and Guinea grass (*Urochloa maxima*); and savanna (below 1,200 ft [365 m] asl on the windward slope) consisting of grassland with scattered trees and dominated by kikuyu grass, sweet vernal grass (*Anthoxanthum odoratum*), and kiawe trees (Appendix A). Areas crossed by the generator-tie line are also grazed by cattle and feral ungulates and are dominated by non-native species interspersed with patches of native vegetation. The savannah transitions to dryland forest based on increased canopy cover below 800 ft (240 m) asl but this vegetation community occurs outside the generator-tie line corridor. The most significant remaining dryland forest in the vicinity is located within the adjacent Kanaio NAR, located west and outside of the generator-tie line corridor (Figure 3-2; David and Guinther 2011).

The eastern half of Pāpaka Road, between Upcountry Pi‘ilani Highway and approximately 780 ft (238 m) asl, is characterized by a combination of dry rocky pastureland and scrub vegetation (Appendix A). Common to abundant species include koa haole, indigo (*Indigofera suffruticosa*), ‘ākia (*Wikstroemia oahuensis*), ‘a‘ali‘i, glycine, air plant (*Kalanchoë pinnata*), and ‘uhaloa (*Waltheria indica*). A relatively recent lava flow located along the west side of the Pu‘u Naio cinder cone supports native species including natal redtop, ‘a‘ali‘i, common sword fern (*Nephrolepis multiflora*), and lantana.

Downslope, the vegetation changes gradually to a kiawe/buffel grass association mixed with groves of wiliwili.

3.7 NON-LISTED WILDLIFE

The grassland, dryland forest and remnant native vegetation in the Project area provide habitat for native invertebrates; migratory, native and non-native birds; and a variety of introduced mammals. Federal- and state-listed wildlife species that occur in the Project area are discussed in Section 3.8 below.

The invertebrate survey results, which covered a much larger area than the currently proposed Project, indicated that the proposed Project site and surrounding area support a variety of native terrestrial mollusks and native and adventive arthropod species, including the federal- and state-listed Blackburn's sphinx moth. This species is addressed in detail in Section 3.8 below. Also observed was a species of Hawaiian yellow-faced bee (*Hylaeus* spp.). Seven yellow-faced bee species are currently the subject of a federal 12-month status review, four of which are also federal species of concern and state special status species. In total, 36 of the 49 total invertebrate species documented are endemic or indigenous to the Hawaiian Islands (Table 3-3; Montgomery 2008). Twenty-one species were documented in the wind farm site, 34 species were documented along the proposed generator-tie line corridor, and 16 species were documented along the construction access route.

Table 3-3. Species Detected during the Invertebrate Surveys at the Project

Order	Number of Species
Pulmonata (Snails and Slugs)	2
Araneae (Spiders)	1
Coleoptera (Beetles)	1
Diptera (Flies)	10
Lepidoptera (Moths and Butterflies)	25
Heteroptera (True Bugs)	2
Homoptera (Cicadas, Hoppers, Aphids)	1
Hymenoptera (Wasps, Bees, Ants)	6
Odonata (Dragonflies and Damselflies)	1

During the environmental surveys, 11 mammalian species and 28 avian species were observed either during surveys or as incidentals (Table 3-4; David and Guinther 2011). All but 3 documented species are common and not native to the Hawaiian Islands. The native avian species observed include the pueo or Hawaiian short-eared owl and amikihi, which are endemic species, and the Pacific golden plover, which is indigenous to Hawai'i and a migrant that winters in coastal and upland areas of the main Hawaiian Islands. The Hawaiian short-eared owl is considered a Species of Concern by the USFWS but is not listed as threatened or endangered on Maui under either the ESA or HRS Chapter 195D (Mitchell et al. 2005). Nine avian species protected by the MBTA (50 CFR Chapter 10.13) were documented during surveys (Table 3-4).

Table 3-4. Species Detected During the Avian and Terrestrial Mammal Surveys at the Project

Birds	
African silverbill (*Lonchura cantans*)	Java sparrow (*Padda oryzivora*)
Hawaiʻi ʻamakihi (*Hemignathus virens wilsoni*)[1/]	mourning dove (*Zenaida macroura*)[2/]
barn owl (*Tyto alba*)[1/2/]	northern cardinal (*Cardinalis cardinalis*)[2/]
black francolin (*Francolinus francolinus*)	northern mockingbird (*Mimus polyglottos*)[2/]
California quail (*Callipepla californica*)	nutmeg mannikin (*Lonchura punctulata*)
cattle egret (*Bubulcus ibis*) [2/]	Pacific golden-plover (*Pluvialis fulva*)[2/ 3/]
chukar (*Alectoris chukar*)	red junglefowl (*Gallus gallus*)
common myna (*Acridotheres tristis*)	red-crested cardinal (*Paroaria coronata*)
common peafowl (*Pavo cristatus*)	ring-necked pheasant (*Phasianus colchicus*)
gray francolin (*Francolinus pondicerianus*)	short-eared owl (*Asio flammeus sandwichensis*)[1/2/3]
house finch (*Carpodacus mexicanus*)[2/]	sky lark (*Alauda arvensis*) [2/ *]
Japanese bush-warbler (*Cettia diphone*)	sooty tern (*Onychoprion fuscatus*) [2/3/]
Japanese quail (*Coturnix japonica*)	spotted dove (*Streptopelia chinensis*)
Japanese white-eye (*Zosterops japonicus*)	zebra dove (*Geopelia striata*)
Mammals	
axis deer (*axis axis*)	domestic horse (*Equus c. caballus*)
domestic cat (*Felis catus*)	European house mouse (*Mus musculus*)
domestic cattle (*Bos taurus*)	feral pig, wild boar (*Sus scrofa*)
domestic dog (*Canis. familiaris*)	roof rat (*Rattus rattus*)
elk (*Cervus elaphus*)	small Indian mongoose (*Herpestes auropunctatus*)
feral goat (*Capra a. hircus*)	

1/ Documented during invertebrate surveys (Montgomery 2008).
2/ Protected by the Migratory Bird Treaty Act.
3/ Documented during the fall radar surveys (Hamer 2010a).

3.8 LISTED WILDLIFE

There are five federal- and state-listed wildlife species known to occur or with the potential to occur in the Project area (Table 3-5). These species are the Hawaiian hoary bat, Hawaiian petrel, Newell's shearwater (*Puffinus auricularis newelli*), nēnē, and Blackburn's sphinx moth.

The Newell's shearwater is unlikely to occur in the Project area. Although Newell's shearwaters have been observed on Maui, there are no confirmed breeding colony locations (although they are suspected to nest on the island). In West Maui, recent radar and audio-visual surveys suggest that Newell's shearwaters may be potentially nesting in the upper portions of the Kahakuloa Valley but this has not been confirmed (KWP 2010). Newell's shearwaters were not confirmed during radar surveys conducted at the Project and are not expected to fly over the Project area (Duvall pers. comm. 2010). Hence, incidental take of this species is not expected to occur during the life of the Project. As a result, the Newell's shearwater is not included as a Covered Species under the HCP, following recommendations of the USFWS and DOFAW.

Table 3-5. Listed Species Potentially Occurring or Known to Occur in the Project Area

Common Name	Status[1]	Year Listed	Critical Habitat Present
Hawaiian hoary bat	SE, FE	1970	None
Hawaiian petrel	SE, FE	1967	None
nēnē	SE, FE	1967	None
Blackburn's sphinx moth	SE, FE	2000	None; critical habitat located to east and west of Project

1/ SE = State endangered; FE = Federal endangered

3.8.1 Hawaiian Hoary Bat

3.8.1.1 Distribution, Population Estimates, and Ecology

The Hawaiian hoary bat is the only fully terrestrial native mammal in the Hawaiian Islands. Reports of the Hawaiian hoary bat are known from all the main islands except Niihau (HBMP 2007), although this species is most often seen on Hawai'i, Maui, and Kaua'i (Kepler and Scott 1990). Today, the largest populations and only known breeding populations are thought to occur on Kaua'i and Hawai'i. Duvall and Glassmann-Duvall (1991) suggested that at least one resident, potentially breeding, population of the Hawaiian hoary bat exists on Maui.

Relatively little research has been conducted on the Hawaiian hoary bat and data regarding its habitat and population status are very limited. Population estimates for this species range from hundreds to a few thousand; however, these estimates are based on limited and incomplete data due to the difficulty in estimating populations of patchily distributed bats (USFWS 2007).

Breeding activity takes place between April and August with pregnancy and birth of two young (twins) occurring from April to June. Lactating females have been documented from June to August and post-lactating females have been documented from September to December (Menard 2001). Until weaning, young of the year are completely dependent on the female for survival.

The Hawaiian hoary bat has been observed in a variety of habitats that include open pastures and more heavily forested areas in both native and non-native habitats (DLNR 2005a). Typically, this species feeds over streams, bays, along the coast, over lava flows or at forest edges. The Hawaiian hoary bat is an insectivore and prey items include a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites (Whitaker and Tomich 1983). Hawaiian hoary bats are known to roost solitarily in tree foliage and have only rarely been seen exiting lava tubes, leaving cracks in rock walls, or hanging from human-made structures. Foliage roosting has been documented in hala (*Pandanus tectorus*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), pukiawe (*Styphelia tameiameiae*), Java plum (*Syzygium cumini*), kiawe, avocado (*Persea americana*), shower trees (*Cassie javanica*), 'ohi'a trees (*Meterosideros polymorpha*), and fern clumps; they are suspected to roost in eucalyptus (*Eucalyptus* spp.) and Sugi pine (*Cyrptomeria japonica*) stands (USFWS 1998; DLNR 2005a).

Hawaiian hoary bats are found in both wet and dry areas from sea level to 13,000 ft (2,962 m) asl, with most observations occurring below 7,500 ft (2,286 m) asl. While the Hawaiian hoary bat may migrate between islands and within topographical gradients on the islands, long distance migration like that of the North American hoary bat is unknown (USFWS 1998). Seasonal and altitudinal differences in bat activity have been suggested (Menard 2001), but the timing and extent of this variation is unknown.

3.8.1.2 Threats

The main threats to the Hawaiian hoary bat may be reduction in tree cover, increases in pesticide use, reduction in prey availability due to the introduction of non-native insects, and predation. It is unknown what effect these threats have on local population dynamics. Observation and specimen records do suggest that this species is now absent from historically occupied ranges; however, the magnitude of any population decline is unknown. The hoary bat is one of the bat species most frequently killed by wind turbines in the continental US, primarily during fall migration (Kunz et al. 2007). It is not known if Hawaiian hoary bat seasonal movements expose them to the same turbine collision risks encountered by hoary bats during migration. One Hawaiian hoary bat has been killed to date at the Kaheawa Wind Power facility (KWP I) since beginning operation in 2006 (KWP 2010).

3.8.1.3 Occurrence on Maui and in the Project Area

Historically, Hawaiian hoary bats have been observed in the Project area (David and Guinther 2011). However, Hawaiian hoary bats were not observed or acoustically detected during radar surveys at the Project site during July and October 2006 surveys (Hamer 2010a) or at any time during diurnal surveys on site (Montgomery 2008, David and Guinther 2011). Biologists recorded a single Hawaiian hoary bat audio detection and observed bat-like targets on the radar screen during the Spring 2010 surveys (Hamer 2010a). Two Anabat detectors were erected on the temporary met tower located within the turbine string in July 2010 and monitoring is ongoing and will continue through July 2011. To-date, very low levels of bat activity have been recorded. Preliminary results of acoustic monitoring surveys within the wind farm site indicate that over the first 6-month period of monitoring (through mid-January 2011), a total of 47 bat passes were recorded resulting in 0.17 bat passes per detector night, with a maximum of 3 calls recorded in one night. These results are consistent with the lack of forest within the Project to provide suitable habitat for roosting and breeding such that the occurrence of this species on the Project area is likely infrequent. Thus they are not expected to breed or roost within the Project area due to the absence of suitable habitat, but may use the Project area for foraging.

3.8.2 Hawaiian Petrel

3.8.2.1 Distribution, Population Estimates, and Ecology

The endemic Hawaiian petrel is one of the larger species in the *Pterodroma* genus. This species formerly nested in large numbers on all of the main islands in the Hawaiian chain except Ni'ihau. Currently, Hawaiian petrels nest at high elevations on Maui, primarily in Haleakalā National Park, and in smaller colonies on Kaua'i, Hawaiʻi, and Molokai. Population estimates for the species are mainly based on at-sea numbers with the total population of Hawaiian petrels estimated to be 20,000, with an estimated 4,500 to 5,000 nesting pairs on Kauai and Maui (Mitchell et al. 2005). A recently rediscovered colony on Lānaʻi is thought to number over 1,000 birds (Tetra Tech 2008).

During the non-breeding season, Hawaiian petrels are found far offshore, primarily in equatorial waters of the eastern tropical Pacific. Adult Hawaiian petrels are long lived (up to 30 years) and return to their colonies, and to the same burrows, each year between March and April. Nesting colonies are typically on steep slopes at high elevation, xeric habitats or wet, dense forests (8,200 to 9,840 ft [2,500 to 3,000 m] asl on Maui). Nests may be in burrows, crevices, or cracks in lava tubes in both sparsely vegetated areas and areas with dense vegetation (e.g., uluhe fern [*Dicranopteris linearis*]). In the nesting colony in the south rim of the Haleakalā Crater, nests occur in more densely vegetated areas of shrub cover (Simons and Hodges 1998).

One egg is laid by the female, which is incubated alternately by both parents for approximately 55 days. The egg is not replaced if it is lost to predation. When eggs hatch in July or August, both adults make nocturnal flights out to sea to bring food back to the nestlings. In October and November, the fledged young depart for the open ocean. Petrels exhibit strong philopatry, returning to their natal colony to breed and returning to the same nesting site over many years (Cruz and Cruz 1990; Podolsky and Kress 1992). Adults do not breed until age 6 and may not breed every year, although they all return to the colony to socialize (USFWS 1983; Mitchell et al. 2005). During their pre-breeding period, they may "wander" or "prospect," visiting a number of potential breeding sites (established colonies, former breeding sites and uncolonized sites); factors such as availability of mates, food abundance, the presence of predators and conspecifics could all be important for deciding where to breed (Podolsky and Kress 1992). Hawaiian petrels feed their young mostly at night and movements take place during crepuscular periods. On Kauai, Hawaiian petrels traveled primarily inland in the evening, seaward in the morning, and in both directions during the night (Day and Cooper 1995).

3.8.2.2 Threats

A variety of threats have been documented for the Hawaiian petrel but the greatest limiting factors include habitat degradation at breeding colonies and disturbance or predation by introduced animals during the breeding season (USFWS 1983; Carlile et al. 2003; Mitchell et al. 2005). Introduced ungulates, including feral goats, pigs, axis deer, and cattle, browse on native vegetation and groundcover within petrel colonies and trample and collapse burrows causing nest abandonment. The soil disturbance caused by ungulates also facilitates the introduction and spread of invasive plants, which further reduces habitat suitability for petrels (Reeser and Harry 2005). Ungulates also create trails in the colony that increase access for predators to active burrows. Annual monitoring of nests at Haleakalā National Park has shown that predation by cats and mongooses causes more than 60 percent of all egg and chick mortality in some years (Simons 1998 as cited in Carlile et al. 2003). Rats also prey upon Hawaiian petrels, but to a lesser extent. Even an individual predator, such as a small Indian mongoose, can be extremely destructive to and decimate a population of colony-nesting seabirds (Hodges and Nagata 2001). Development of new fisheries may directly or indirectly harm seabird populations by eliminating predatory fish needed to drive petrel prey species closer to the surface. Also, live bait needed for these fisheries could potentially decrease the availability of prey items. Development of a squid fishery, a primary food source, could also impact Hawaiian petrels (USFWS 1983).

In addition, petrels sometimes collide with power lines, fences, and other structures (Hodges 1994) or become disoriented by lights (Telfer et al. 1987). Adults apparently are not attracted to lights to the same degree as fledglings, but they do collide with power lines. One Hawaiian petrel fatality, presumed to have resulted from a WTG collision, has been reported at KWP I since the beginning of operations in January 2006 (KWP 2010).

3.8.2.3 Occurrence on Maui and in the Project Area

Haleakalā in east Maui supports Hawaii's largest known nesting colony of Hawaiian petrels (Hodges and Nagata 2001; USFWS 2005a) with approximately 1,000 known burrows. The nests are within the crater of the dormant shield volcano, with the highest concentration on the western rim between 7,870 ft and 10,020 ft [2,400 m and 3,055 m] asl. A small subcolony has been located along the south rim of the crater (Simons and Hodges 1998).

Radar surveys conducted at the Project in October 2006 and May 2010 documented mean passage rates of 12.01 (fall) and 7.31 (spring) petrel targets per hour (Hamer 2010a). The spring passage rates are expected to be higher than the fall rates because the non-breeders are still on-island during the spring. The relatively higher fall 2006 data may include an unknown number of sooty terns (Hamer pers. comm. 2010) as they were detected by outside observers but could not be distinguished from targets on the radar screen. Additionally, radar surveys had been conducted by other entities in the vicinity of where the Auwahi generator-tie line crosses a ridge that is adjacent to the communication towers owned by Island Airwaves. The towers are located on the ʻUlupalakua Ranch within a 3-acre (1.2-ha) parcel at roughly 4,450 ft [1,356 m] asl. Radar surveys were conducted over 5 nights in 2007. Petrel passage rates over this area averaged 2.3 petrel targets per hour (Gall and Day 2007 as cited in USFWS 2008).

Field studies and research conducted in support of the KWP I HCP confirmed the presence of a small nesting colony in West Maui in the lower portion of Kahakuloa Valley (Makamakaole Colony), later corroborated by DLNR/DOFAW biologists, and documented evidence of a potential nesting colony in the West Maui Mountains in the upper portions of Kahakuloa and Honokōhau (KWP 2010).

3.8.3 Nēnē

3.8.3.1 Distribution, Population Estimates, and Ecology

The nēnē is the only extant endemic goose in the Hawaiian Archipelago and was reintroduced on Maui as part of its recovery plan. Fossil evidence suggests that the nēnē occurred on all of the main Hawaiian Islands. However, the current population occurs from just above sea level to approximately 8,850 ft [2,700 m] asl on the islands of Kauaʻi, Maui, Hawaiʻi, and Moloka'i, a distribution influenced largely by the locations of release sites of captive-bred birds (Banko et al. 1999). The statewide population is over 1,300 birds with approximately 450 on Maui (250-300 in Haleakalā National Park). Populations are increasing on Kauaʻi and Moloka'i while the Hawaiʻi Island and Maui populations are static (HNP 2009).

Nēnē nest on sparsely vegetated lava flows or on the vegetated edges of kipukas (islands of vegetation around which lava once flowed that are now characterized by older vegetation than the surrounding areas). Nēnē do not appear to require standing water as a habitat component. Historically, nēnē bred in lowland habitats; however, these areas have been destroyed by development or have become inundated with predators and now nesting occurs at higher elevations (Banko et al. 1999). Nēnē nest between October and March, during the wet winter season. Clutch size is typically three to five eggs, and the young are able to fly at approximately 10 to 12 weeks. Typically, nēnē do not renest in the same season if the first attempt fails. During the nonbreeding season, nēnē forage in pastures and grassland habitats. Nēnē are year-round residents, making only island-wide movements of up to 6 miles (10 km).

3.8.3.2 Threats

The 2004 draft recovery plan for nēnē (USFWS 2004) lists predation by non-native mammals as the greatest factor limiting nēnē populations. In Haleakalā National Park, rats and mongooses were observed to be the main predators (Baker and Baker 1995). Other threats to the species include lack of access to seasonally important lowland habitats, insufficient nutritional resources for breeding females and for goslings, human-caused disturbance and mortality (e.g., road mortality, disturbance by hikers), behavioral problems related to captive propagation, and inbreeding depression.

3.8.3.3 Occurrence on Maui and in the Project Area

On Maui, the nēnē is found primarily within the boundaries of Haleakalā National Park at elevations between 6,300 ft and 7,700 ft (1,920 m and 2,347 m) asl (Banko et al. 1999). They also occur in the West Maui Mountains, and around the towns of Lahaina and Wailuku (USFWS 2004). During radar surveys on May 26, 2010, 7 overlapping nēnē vocalizations were heard adjacent to the Project area. Nēnē have not been observed or heard vocalizing during any other surveys conducted to date on the Project or incidentally. Because the nēnē detection appears to have been a rare, single event and that suitable habitat does not exist in the Project area, Auwahi Wind anticipates there is only a small chance that nēnē could fly through the wind farm or across the generator-tie line.

3.8.4 Blackburn's Sphinx Moth

3.8.4.1 Distribution, Population Estimates, and Ecology

The Blackburn's sphinx moth is one of Hawai'i's largest native insects and a federal-listed insect in Hawai'i. This species once occurred on all seven of the Hawaiian Islands and now is found only on Hawai'i, Maui, and Kaho'olawe. This species was believed extinct until 1984, when a single population was rediscovered on east Maui (USFWS 2003b). Additional populations on the two other islands were subsequently rediscovered. The Blackburn's sphinx moth population numbers are known to be small based upon past sampling results; however, no reasonably accurate estimates of population sizes have been made at this point due to the adult's wide-ranging behavior and its overall rarity (Black 2005). Populations likely vary from year to year and from season to season in association with climatic and environmental conditions that affect the quality and quantity of available habitat and food.

Adults can be found year-round, but are most active from January through April and from September through November. Larvae take 65 days to develop to adulthood, but pupae may remain in torpor in the soil for up to a year. Larvae sightings have only been documented between the months of October and May (USFWS 2005c). The lifespan for this species is unknown, but is presumed to be short.

The Blackburn's sphinx moth is most commonly found in dry to mesic forests throughout its current range between sea level and 5,000 ft (1,525 m), and is known to inhabit this habitat on Maui. Larvae of the Blackburn's sphinx moth feed on plants in the nightshade family (Solanaceae). The native host plants are trees within the genus *Nothocestrum* ('aiea; *N. latifolium* and *N. breviflorum*; Riotte 1986), on which the larvae consume leaves, stems, flowers, and buds. However, many of the host plants recorded for this species are not native to the Hawaiian Islands, including *Nicotiana tabacum* (commercial tobacco), *Nicotiana glauca* (tree tobacco), *Solanum melongena* (eggplant), *Lycopersicon sculentum* (tomato), and possibly *Datura stramonium* (Jimson weed; Riotte 1986). Although Blackburn's sphinx moth larvae feed on the non-native tree tobacco, USFWS does not consider this plant to be a necessary biological requirement for this species due to the ephemeral nature of this plant species and its intolerance to drought. Three plant species—maiapilo, 'ilie'e (*Plumbago zeylanica*, and koali 'awa (*Ipomea indica*; native morning glory)—are thought to be food plants of adults.

3.8.4.2 Threats

The primary threats to the species are predation by ants and parasitic wasps that prey on the eggs and larvae, and the continued decline of its native larval host plants (USFWS 2005c). The continued decline of the species' native larval host plants is partly a result of grazing by feral ungulates, wildfire, introduced plants, human development and ranching. Blackburn's sphinx moths are also susceptible to over-collection for personal collections or for trade. No known populations occur entirely within protected areas, and the species is endangered throughout its range.

3.8.4.3 Occurrence on Maui and in the Project Area

Of the seven islands, the Blackburn's sphinx moth historically was most common on Maui where the largest and most persistent population of this species currently occurs. The largest remaining stand of ‘aiea trees in Hawai‘i is located on Maui in the Kanaio Natural Area Reserve, adjacent to the Project (Mitchell et al. 2005). The USFWS designated critical habitat for this species in the vicinity of the Project, in critical habitat unit 9. Unit 9 contains what is likely the largest, extant moth population or meta-population in its range. This unit contains native ‘aiea and introduced larval host plants as well as numerous nectar-supplying plants for adults. Areas within this unit may serve as a source area for local populations and habitat for dispersing adult moths. Although the Auwahi parcel of ‘Ulupalakua Ranch was originally considered for inclusion in the critical habitat unit, ultimately the ‘Ulupalakua Ranch land (and the Haleakalā Ranch) was removed from the critical habitat unit because “the landowners’ ongoing conservation activities on these ranches provided more benefits for the species than would be provided by critical habitat designation” (USFWS 2005c, p. 38).

The species’ non-native host plant, tree tobacco, has been observed on the Project during the invertebrate and botanical resources surveys conducted in 2007, 2010, and 2011. In 2010 and 2011, ‘aiea plants were documented within the wind farm site and along the generator-tie line corridor. In 2008, three adult male Blackburn’s sphinx moths and one larva were observed on the Project during invertebrate surveys (Montgomery 2008). The single larva was observed on one of the tree tobacco plants, and no larvae were observed on the eight ‘aiea plants examined outside the generator-tie line corridor; the native host plant was also documented within the Project during 2010 botanical surveys. In March and April, 2011, an additional survey for Blackburn’s sphinx moth was conducted to capture wet season conditions. Seven larvae and 2 eggs were observed on tree tobacco plants adjacent to the construction access route; three additional tree tobacco showed possible evidence of larvae feeding.

4.0 GOALS AND CONSERVATION MEASURES

This section describes the biological goals and objectives of the HCP, as well as measures that would be implemented to avoid and minimize impacts to the Covered Species. This section is prepared in accordance with Sections 10(a)(2)(A) and 10(a)(2)(B) of the ESA, Section 195D-21(b)(2)(D) of the HRS, and federal regulations (50 CFR §§ 17.21 and 17.22). These regulations require, among other items, that an HCP include measurable goals and objectives and specify the steps that will be taken to minimize and mitigate the effects of any taking allowed by the HCP.

4.1 BIOLOGICAL GOALS AND OBJECTIVES

Auwahi Wind has worked collaboratively with the USFWS and DOFAW to assess the potential for the proposed Project to cause adverse effects to the Covered Species. The purpose of identifying these goals and objectives is to establish a framework for developing the conservation measures for the HCP as outlined in the USFWS Five-point Policy guidance for the HCP process (USFWS and NMFS 2000).

The biological goals and objectives for the Hawaiian petrel, nēnē, and Hawaiian hoary bat are species-based because the proposed Project is anticipated to directly or indirectly affect individuals through collisions with Project facilities, but would have only no (petrel) or negligible (bat and nēnē) impacts on the amount or quality of their terrestrial habitats. The biological goals and objectives for the Blackburn's sphinx moth are both habitat- and individual-based. For the moth, the proposed Project has the potential to indirectly affect these species through impacts to their host plants that are present in the Project area and could cause direct harm to larvae during construction. Through minimization and mitigation measures (Sections 4.2 and 6.0, respectively), the Project HCP is designed to provide a net benefit to the Covered Species.

4.1.1 Goals

Biological goals are intended to be broad, guiding principles that clarify the purpose and direction of the HCP (USFWS and NMFS 2000). The specific goals of this HCP are to:

- Avoid, minimize, and mitigate the potential effects on the Covered Species associated with construction and operation of the Project;
- Increase the knowledge and understanding of the occurrence and behavior of the Covered Species in the Project vicinity;
- Adhere to the goals of the recovery plans for each of the Covered Species; and
- Provide a net conservation benefit to each of the Covered Species.

4.1.2 Objectives

The biological objectives for achieving the HCP goals are to:

- Offset the potential direct and indirect effects of the Project on the Hawaiian hoary bat by implementing a mitigation plan that includes providing funding for management, habitat restoration and preservation, and/or research funding;
- Offset the potential direct and indirect effects of the Project on the Hawaiian petrel by implementing a mitigation plan that includes providing funding for petrel habitat and colony management such as fencing, ungulate removal, predator control, and burrow monitoring;

- Offset the potential direct and indirect effects of the Project on the nēnē by providing funding toward management, research, education, or rehabilitation; and
- Offset the potential direct and indirect effects of the Project on Blackburn's sphinx moth during construction through pre-construction avoidance measures and by providing funding toward habitat restoration.

4.2 AVOIDANCE AND MINIMIZATION OF IMPACTS

Sections 10(a)(2)(A)(ii) and 10(a)(2)(B)(ii) of the ESA require that an HCP describe the steps that will be taken to avoid, minimize and mitigate the effects of the taking provided for in the plan, and that, for an HCP to be approved, such taking be minimized and mitigated to the maximum extent practicable where complete avoidance is not possible. Auwahi Wind will take appropriate steps to avoid adverse effects to the Covered Species. Auwahi Wind has incorporated measures to avoid and minimize take of the Covered Species that are identified below including construction timing considerations, pre-construction surveys, selection of Project components, and micrositing considerations.

4.2.1 General Project Development Measures

- A daytime speed limit of 25 mph (40 kph) and a nighttime speed limit of 10 mph (16 kph) will be observed on Project area roads to minimize the potential for vehicle collisions with Covered Species.
- Truck and heavy-equipment traffic will be limited to existing disturbed areas to the extent practicable.
- The spread of invasive, non-native plant species caused by Project construction will be minimized through best management practices (BMPs), such as cleaning and inspecting equipment coming to the site, and by replanting disturbed areas with native species or pasture grasses to be compatible with continued grazing (see Appendix B for potential species list).
- Trash, especially food stuffs, will be removed from the construction area on a regular basis to avoid attraction of ants and other animals such as mongooses, cats, and rats that may negatively affect the Covered Species.
- A Project biologist will be on-staff during Project operations to conduct post-construction monitoring surveys, to assist with mitigation measures, and to address any potential wildlife issues that may arise.

4.2.2 Pre-construction Surveys and Timing Considerations

- Prior to any construction activities, listed plant species will be protected with enclosures and impacts to individual listed plants will be avoided. To further reduce impacts to the Blackburn's sphinx moth, the species' native host plant ('aiea) and native food plant (maiapilo) will also be protected with enclosures within the Project disturbance areas and avoided where possible.
- A survey and relocation plan for the Blackburn's sphinx moth, based on USFWS and DOFAW protocol, will be implemented by a qualified entomologist. Pre-construction clearance surveys will be conducted 90 days prior to the start of construction for Blackburn's sphinx moth adults and larvae. These surveys will identify and map plants in the Solanaceae

family (i.e., tree tobacco, the plant species Blackburn's sphinx moths are most commonly associated with) and those plants with Blackburn's sphinx moth or larvae within the Project area. Unoccupied solanaceous plants will be removed to prevent future use by the Blackburn's sphinx moth. Should any larvae or moths be found just prior to construction, the larvae and moths will be removed and relocated by the authorized entomologist to an approved nearby location outside the area of disturbance that contains suitable moth habitat to avoid direct take. These occupied areas will be flagged and avoided during construction until the moth or larvae can be relocated. The pre-construction surveys and associated plant removal/moth relocation will help to reduce the likelihood of the Blackburn's sphinx moth occurring in the Project area during construction and ultimately the potential direct take from ground disturbance during construction.

- Construction activity will occur as much as possible in daylight during the seabird breeding season to minimize the use of nighttime lighting that could be an attraction to seabirds. Construction at night would be necessary during a small time period in the event that high winds above 25 mph (40 kph) during daytime hours would prohibit turbine erection. The need for erecting the turbine towers at night will likely be infrequent, restricted to the period of September to December 2012, and each instance will likely only require a few hours of nighttime activity. Additional limited Project activities, such as the transportation of some Project equipment and the pouring of concrete pads, may occur at night as well to minimize daytime construction traffic, but will be kept to a minimum. Each turbine foundation will require one day to pour the concrete; a total of eight days spaced throughout May – August 2012. In instances where nighttime construction is unavoidable, lighting will be limited, as much as is safe and practicable, to one tower at a time. An environmental monitor will be onsite during those periods of night construction. If the monitor observes that any Covered Species are being attracted to the construction lighting, such lighting will be turned off as soon as it is safe to do so. In the unlikely event that construction lighting results in the grounding of Covered Species, the monitor will retrieve and assist such individuals in accordance with the Downed Wildlife Protocols.

- Hawaiian hoary bats roost in non-native and native woody vegetation that is at least 15 ft (4.5 m) or taller. To minimize potential impacts to the Hawaiian hoary bat, woody plants greater than 15 ft (4.5 m) tall that are of species known to be potential roost trees will not be removed or trimmed between May 15 and August 15 during the installation and ongoing maintenance of the Project structures. Disturbance of trees or shrubs suitable for bat roosting will be minimized during the April through mid-May early period of the bat breeding season. The primary area of concern for the Project is the portion of the generator-tie line in the area between the NARS and Auwahi Forest Restoration Project.

4.2.3 Project Components and Siting Considerations

- At the time of installation, the permanent met tower guy wires will be fitted with bird flight diverters and white, 1-inch [2.5-cm] poly tape, to increase visibility and subsequently increase the likelihood of avoidance by the seabirds and bats. This tape has proven effective in minimizing petrel collisions on other projects within the Hawaiian Islands when wrapped on the guy wires (Hodges and Nagata 2001; Tetra Tech 2008). Flagging will be used to minimize perching should a lattice tower model be installed.

- The wind farm is sited in an area with limited forested areas to avoid potential impacts to bat roosting habitat.

- The proposed WTG model has significantly slower rotational speeds (6 to 16 rotations per minute [rpm]) compared to older designs (28.5 to 34 rpm). This increases the visibility of turbine blades during operation and decreases collision risk (Thelander et al. 2003). Additionally, the selection of the 3.0-MW Siemens model results in the least ground disturbance because only 8 turbines will be installed compared to the other turbine models considered that would require 15 or 10 turbines (1.5-MW GE and 2.3-MW Siemens; see Chapter 8 for additional discussion).
- A Federal Aviation Administration (FAA) endorsement of a minimal lighting plan has be requested to reduce the likelihood of attracting or disorienting seabirds, bats, and insects.
- To minimize impacts to wildlife, onsite lighting will be minimized at the O&M building and substation by using fixtures that will be shielded and/or directed downward and utilized only on infrequent occasions when workers are at the site at night.
- The proposed substation and interconnect to MECO's transmission lines will be designed and installed using industry-standard measures to reduce the possibility of wildlife collisions by fitting bird flight diverters on the generator-tie line in high risk areas. The height of the generator-tie lines will generally be lower than 65.5 ft [20 m] agl where permissible by terrain features which should reduce the potential for collision by seabirds.

4.2.4 Invasive Plant Species Management

Auwahi Wind will work actively to minimize and reduce the ingress of certain undesirable invasive plant species such as fireweed (*Senecio madagascariensis*), a pasture weed that is highly toxic to grazing livestock and quick to recolonize disturbed areas. Auwahi Wind intends to implement measures to minimize and avoid the introduction of invasive species to ʻUlupalakua Ranch including:

- All equipment, materials, and vehicles brought onto the site during construction will be cleaned and inspected to prevent the introduction of invasive or harmful non-native species. An inspection station will be located at the staging area close to Piʻilani Highway.
- To minimize the introduction and spread of invasive plant species, potential off-site sources of materials (e.g., gravel, fill) will be inspected, and the import of materials from sites that are known or likely to contain seeds or propagules of invasive species will be prohibited.
- Vehicle operators transporting materials to the proposed Project site from off site will be required to follow protocols for removing soils and plant material from vehicles and equipment prior to entry onto the site.
- The Hawaiʻi Department of Agriculture and Maui Invasive Species Commission will be consulted to establish protocols and training orientation methods for screening invasive species introductions during construction.
- As part of the fire management plan, Auwahi Wind will conduct surveys for invasive species of fire-prone grasses, with an emphasis on barbed wire grass and fountaingrass (*P. setaceum*). The survey extent will include, at a minimum, all areas within 33 ft (10 m) of disturbance resulting from construction within the wind farm site, the connection substation site, and within roadways constructed or utilized more than once monthly for wind farm construction or maintenance. Individuals or colonies observed will be exterminated by Auwahi Wind Energy via a means that includes killing the root system. Consideration will also be given to killing individuals before they produce seed whenever possible.

4.2.5 Fire Prevention During Construction and Operation

- Fire risk associated with generator-tie line construction and operation is extremely low. The agencies' area of concern is along the pinch point corridor between the State NAR land and the Auwahi Forest Restoration Project, due to the presence of native vegetation. However, the probability of a fire in this 1.5-mile (2.4 km)-long area is approximately 0.05 percent over the lifetime of the Project (see the Fire Management Plan in Appendix C). Downed generator tie-lines represent an ignition threat which usually stems from a weather event that causes degraded wood poles to blow over in high winds, or from a hazard tree coming into contact with the line itself. In addition to downed lines, poorly maintained lines can produce sparks and arcing that may cause a fire ignition in rare cases. Thus, design and maintenance are keys to the integrity of the line.

  As noted above in Section 1.3.1.2 the generator-tie line would consist of a vertically arranged three-phase 34.5-kV line (i.e., three conductors), designed and constructed according to industry standards. As configured the line is capable of carrying the entire wind farm output. During normal operations, assuming full output from the wind farm, only half of the plant output will be carried on each individual circuit. Under these conditions the current flow on each circuit will be approximately 211 Amperes and the associated conductor temperature will be 132 degrees Fahrenheit (F), far below the design temperature criteria of 212 degrees F for calculating line clearances. Therefore, the generator-tie line will easily maintain the minimum required 18.5-foot (5.6-meter) ground clearance under maximum line sag conditions at 212 degrees F. Consequently, there should be no issue with line conductors sagging down towards the ground and starting a fire based on the National Electric Safety Code (NESC) design for this line. In the unlikely event that the full plant output of 24 MW is carried on a single circuit, current flow would be 423 Amperes and conductor temperature would be 171 degrees F, also well below the design criteria of 212 degrees F. With full wind farm plant output on only one of the two circuits, the single circuit would load within 80 percent of the maximum design rating, which is a typical engineering design standard. It is important to note that design calculations are based on wind speed of 2 ft per second (0.6 m per second) or 1.62 mph (2.61 kph) and 104 degrees F ambient temperature assumptions. In reality, the line will be fully loaded only when wind speeds are above 29 mph (47 kph), so there will be a significant natural cooling effect to reduce conductor temperature even further below the calculated value of 171 degrees F at 1.36 mph (2.62 kph). This effect is one of the benefits of loading a generator-tie line for a wind project.

  In terms of the structural loading on the line, poles, insulators, and related line elements, higher class poles and/or shorter span lengths can be utilized to meet extreme wind design conditions of up to 105 mph (169 kph) for Hawai'i and extra loading due to the addition of bird diverters on the line. Also, line insulators can be designed for extra creepage to further protect the line from faults that could be a source of ignition. Although the line voltage is 34.5 kV, Auwahi Wind would use one class higher insulators (69 kV) for added strength and shorten the span lengths between poles to withstand severe weather conditions and strong wind uplift forces due to undulating topography near the line. The benefit of higher rated insulators will be greater arcing and leakage distance to counteract salt contamination, soiling (i.e., build up on exterior of the insulator due to dust or pollution), and provide greater horizontal conductor separation to reduce the source of ignition (electrical faults). Basically, the design of the generator-tie line will reduce the risk of fire because the line will be normally operated with each circuit carrying only half of the full wind farm output and be structurally designed to meet or exceed NESC requirements and withstand extreme weather conditions.

To further reduce the risk of fire during construction and operations, Auwahi Wind will implement the measures outlined in the Fire Management Plan (Appendix C) and conduct regular maintenance of the generator-tie line and the turbines.

  - A scheduled maintenance system will be established by Auwahi Wind during Project operations as a repository of key information about fire prevention activities associated with the generator-tie line. This system will be used and updated by Project O&M personnel who are trained in fire management practices. The system will also maintain records of best practices in fire prevention. One way to improve fire prevention performance over the long term is to adopt practices that have proven to be valuable and effective elsewhere in the industry and can be applied at the Project.
  - The generator-tie line poles will be inspected regularly to determine if there is any degradation or structural problem preventing them from withstanding high winds. As part of the fire management plan, trained personnel will maintain the generator-tie line conductors and remove any overhanging limbs or trees, as necessary, to prevent branches from falling onto the power line. However, most of the generator-tie line traverses pasture.
  - Generator-tie line insulators will be maintained as needed. Furthermore, vegetation will be maintained at least 16 ft (5 m) radius around the conductors in all directions. Most of the generator-tie line traverses pasture. Brushing or brush removal around the base of the poles is a precautionary measure to prevent fires from starting or keep them from spreading and affecting the integrity of wood pole structures along the generator-tie line. Furthermore, regular grazing by cattle is an integral part of the fuel management approach.

- Auwahi Wind is part of a $1 billion wildfire liability insurance program through its parent corporation, Sempra Energy. The insurance coverage not only pays for bodily injury and repair/replacement of the dwellings and personal property of third parties but also pays for replanting and refurbishing of vegetation that is damaged by wildfires caused by the legal liability of Auwahi Wind in the operations of the wind farm
- Fire risk associated with WTG operation is very low and will be prevented by the design features of the turbine model selected. The direct drive design of the Siemens 3.0-MW turbine eliminates the gearbox and therefore the need for gearbox lubricating oil inside the nacelle. Therefore, this WTG design has no risk of gearbox-related fires.

5.0 ASSESSMENT OF POTENTIAL IMPACTS AND TAKE LIMITS

The issuance of an ITP/ITL requires establishing the number of individuals of or habitat for each Covered Species authorized for incidental take during a defined period. The following subsections describe potential direct and indirect impacts from the proposed Project to the Hawaiian hoary bat, Hawaiian petrel, nēnē, and Blackburn's sphinx moth. Implementation of the measures described in Section 4.2 is expected to minimize the potential for take of species resulting from the proposed covered activities. Temporary impacts associated with construction of the Project are identified as well as permanent impacts resulting from Project operations. For each species, the approach taken for estimating take levels over a 25-year term is described. Anticipated levels of take for the Covered Species are based on modeling, post-construction monitoring results at other Hawaiian wind projects, and field surveys conducted on the Project site.

For the Hawaiian hoary bat and Hawaiian petrel, a three-tiered approach to take and mitigation has been developed based on the best available scientific information. Each tier represents a level of take and associated compensatory mitigation measures. Reaching Tier 1 levels of take for a species triggers initiation of Tier 2 associated mitigation, with a similar trigger to move from Tier 2 to Tier 3.

For the nēnē and Blackburn's sphinx moth, the likelihood of Project-related effects is low due to the absence of the species from the Project area (nēnē) or due to measures that would avoid or minimize take (moth). Thus, in consultation with the USFWS and DOFAW, a maximum take limit has been established for the nēnē over the 25-year period. Direct impacts to Blackburn's sphinx moths are anticipated to be largely avoided, so no take level has been established; however, it is recognized that some potential impacts could occur to habitat that will be mitigated. For all species, mitigation is described in detail in Section 6.0.

5.1 HAWAIIAN HOARY BAT

Across the United States, hoary bats account for the majority of wind farm fatalities, primarily during the fall migration period (Arnett et al. 2008). It is unknown if the Hawaiian hoary bat exhibits the same propensity to collide with WTGs as its North American relative, given that the subspecies is not known to migrate long distances. However, there is the potential for Hawaiian hoary bats to collide with WTGs or succumb to barotrauma while foraging. This species forages for insects in open areas such as grasslands and shrublands, habitats which exist in the Project area. However, roosting habitat does not occur within the Project. It is not known how far Hawaiian hoary bats forage from roost sites in forested areas.

Bat activity is anticipated to be low at the Project due to the absence of roosting habitat and the low level of activity detected during radar and acoustic surveys (Hamer 2010a, Tetra Tech 2011). Biologists recorded a single Hawaiian hoary bat audio detection and observed bat-like targets on the radar screen during the Spring 2010 radar survey and only a few Hawaiian hoary bats have been documented in the Project area either by acoustic monitoring or visual incidental observations by ranch staff over the years. Furthermore, after close to 4 years of operation, only one Hawaiian hoary bat fatality has been reported at KWP I (Hufana pers. comm. 2010). Acoustic monitoring surveys conducted at KWP1 have indicated low bat activity as well. Although the topography of the KWP1 and Project sites is similar, KWP1 contains more forest habitat in the vicinity suitable for roosting, and therefore bat use would be expected to be greater there than at the Project. Preliminary results of acoustic monitoring surveys within the Auwahi wind farm site initiated in July 2010 indicate that over the subsequent 6-month period (through mid-January 2011), a total of 47 bat passes were recorded resulting in 0.17 bat passes/detector night. This level of bat activity is low in comparison to similar studies on both the mainland and Hawaiʻi (Bonaccorso pers. comm. 2008; Kepler and Scott 1990; Menard 2001), as expected due to lack of suitable foraging and roosting habitat within the Project area. Acoustic monitoring in the Project will continue through July 2011.

5.1.1 Direct Take

There are four potential sources of direct bat mortality associated with the Project. The first is vehicle collisions. This source of mortality is considered negligible given the limited nighttime traffic expected in the Project area and low speed limits posted and strictly enforced on Project roads. The second is associated with construction- and maintenance-related clearing or trimming of woody vegetation taller than 15 ft (4.5 m) during the bat breeding season. However, this source of potential mortality is negligible, as such vegetation only occurs along a short portion of the new generator-tie line, and Auwahi Wind will not remove or trim such vegetation during the April to August breeding season. The third is collisions with stationary (e.g., met tower, generation tie-lines) and near-stationary (e.g., crane booms) objects. These sources of mortality are also considered negligible given the general ability of bats to avoid colliding with stationary objects. The fourth, and relatively most likely, potential source of direct bat mortality, used as the basis for quantifying direct take here, is a collision or other negative interaction with an operational WTG.

Given the similarities in landscape features (e.g., slope, aspect) and the number of WTGs between KWP I and the Project, it is reasonable to use the KWP I data to estimate potential direct take resulting from WTG interactions at the Project. A single fatality was observed at the KWP I site (KWP 2010), which translates to an estimated bat mortality of 0.023 bat per WTG per year at KWP I. In recognition that bat fatalities are more difficult to detect than are avian fatalities, it is assumed that for every recorded adult fatality, an additional 3 adult fatalities may have gone undetected (Arnett 2005; Jain et al. 2007; Fiedler et al. 2007). Thus, transferring the KWP I per WTG estimate to the Project for the 8-WTG Siemens array, and multiplying by 4 to account for unobserved take of adults (adjusted take of 0.092 bats per WTG), results in an estimated direct bat mortality of 0.736 bat per year. This estimated annual mortality rate is considered conservative for the Project given the lack of suitable habitat.

5.1.2 Indirect Take

The take of a bat during the breeding season may result in the indirect loss or take of a dependent offspring. Several variables are needed to assess both the potential for and magnitude of this indirect take: the proportion of take assumed to be adult, the proportion of the take that is assumed to be female as only female bats care for young, the proportion of the year that is the breeding period, the likelihood that the loss of a reproductively active female results in the loss of its offspring, and average reproductive success. The rationale and values used to estimate indirect take are outlined in Table 5-1 and result in an indirect take estimate of 0.283 young per year.

5.1.3 Authorized Take Request for the ITP

Based on the assumptions and analysis above, the maximum estimated annual take resulting from Project construction and operation is 0.736 adult bat per year and 0.283 young per year, or 1.019 bats per year combined (Table 5-1).

A tiered approach was taken for determining the requested authorized take levels for the Hawaiian hoary bat. Given the limited bat habitat present within the Project area, the expected low levels of activity, and the fact that WTGs will be regularly curtailed during the night (see below) the calculated level of take is not expected to occur. There are no obvious biological breaking points to establish a tiered approach; therefore, the three tiers were created relative to the maximum estimated take.

Table 5-1. Annual Indirect Take Estimate for Hawaiian Hoary Bat

Component	Description/Rationale	Estimate
A. Annual Direct Take (bats/year)	Estimate annual direct take	0.736
B. Proportion of take that is adult	As a conservative estimate, it was assumed that all take would be of adult bats, despite the potential for newly volant young (i.e., young of the year) to pass through the Project area during the fall.	1.00
C. Proportion of take that is female	Hawaiian hoary bats are assumed to have an adult sex ratio of 1:1 and no sex-based differential susceptibility to WTG interactions. Therefore, female bats should comprise 50 percent of total take.	0.50
D. Proportion of "year" that is breeding period (5 of 12 months)	Adult hoary bats potentially occur at the Project throughout the year. However, as the breeding season only spans April through August (Menard 2001, cited in Cooper and Day 2009), it is only the loss of adult bats during this 5-month period that may result in the indirect loss of dependent young.	0.42
E. Proportion of taken breeding adults with dependent young	Until weaning, young of the year are completely dependent on the female for survival. Therefore, all female mortality during the breeding season results in the loss of her young.	1.00
F. Average offspring/pair	Data are limited, average reproductive success in terms of young/year based on Bogan (1972) and Koehler and Barclay (2000).	1.83
G. Annual Indirect Take (young/year)	Multiplying Lines A through F results in an indirect take estimate.	0.283

Tier 1 take level is defined as 25 percent of estimated maximum take values, Tier 2 is defined as 50 percent of estimated maximum take, and Tier 3 defined as is the estimated maximum take.

The take limits for each tier were derived by extrapolating the annual estimated take (0.184 adult per year for Tier 1, 0.368 adult per year for Tier 2, and 0.736 adult per year for Tier 3) over the 25-year Project life span and rounding up to the nearest whole number. Indirect take was calculated based on the adjusted number of adult fatalities. Furthermore, the WTGS are expected to be curtailed (turned-off) on a regular basis between 2300 hrs and 0600 hrs due to the low demand for power from MECO during this time period. The expected risk and magnitude of bat collisions will be reduced below the estimates because the WTGs blades will not be spinning during these periods of night-time curtailment.

Requested ITP and ITL Authorization

- Tier 1: 5 adults and 2 young over the 25-year permit period
- Tier 2: 10 adults and 4 young over the 25-year permit period
- Tier 3: 19 adults and 8 young over the 25-year permit period

Each tier represents the total take requested (i.e., take is not additive among tiers). Actual take will be adjusted based on the post-construction fatality monitoring plan (Appendix D) according to observed searcher efficiency and carcass removal rates. Should the post-construction monitoring results indicate that take levels will exceed Tier 1 levels, Tier 2 mitigation will be initiated; if Tier 2 levels are exceeded, Tier 3 mitigation will be initiated (Section 6.0).

Recent population estimates for Hawaiian hoary bat have ranged from several hundred to several thousand (Bonaccorso pers. comm. 2010; Menard 2001). Although the greatest overall numbers of this species are thought to occur on the islands of Hawai‘i and Kaua‘i (Menard 2001), systematic monitoring has not been conducted on Maui to estimate the size of its local population. Therefore, it is difficult to assess the effect that take of Hawaiian hoary bat resulting from the proposed Project may have on the local population of this species. However, the levels of bat activity are expected to be low onsite; accordingly, the identified tiered levels of take are relatively low and are unlikely to result in a significant impact on the overall population of the Hawaiian hoary bat.

5.2 HAWAIIAN PETREL

Seabird and waterfowl species have been documented detecting and avoiding WTGs and other human-made structures (e.g., transmission lines) in low-light conditions (Winkleman 1995; Dirksen et al. 1998; Desholm and Kahlert 2005; Desholm et al. 2006; Tetra Tech 2008). Petrels are adept at flying through forests to and from their nests during low-light conditions and variable weather conditions and may exhibit strong avoidance behaviors when approaching WTGs or other structures. Petrels have been observed exhibiting avoidance behaviors at communication towers on Lanai (Tetra Tech 2008) by adjusting flight directions away from the tower or by approaching the tower and turning away from the structure to avoid it. Only 1 petrel fatality has been reported at KWP I wind farm during almost 4 years of operation and monitoring which further supports that petrels exhibit avoidance behavior with WTGs (KWP 2010). It is reasonable to assume that 1) petrels have the behavioral and physical capabilities to avoid towers and Project components, and 2) a high proportion of petrels would detect and avoid large structures.

The Haleakalā Hawaiian petrel colony is located approximately 5 miles (8 km) northeast of the Project, and petrels fly to sea to forage for food for their young during the breeding season. Therefore, potential direct impacts could occur to petrels due to collision with WTGs or other Project facilities when flying to and from the colony. As Haleakalā is an active petrel breeding colony, the potential for indirect take of petrels exists if an adult is killed while incubating an egg or rearing a chick. However, not all losses of an adult during the nesting season will result in the loss of that year's young because not all adults are breeders. During the spring season, a large number of non-breeding individuals (both adults and juveniles) may also be present on the island; these individuals typically exit the colony by late August (Warham 1990; Ainley et al. 1997; Simons and Hodges 1998).

Radar and visual surveys were conducted at the Project site in 2006 and 2010. Mean movement rates during the fall 2006 period were 12.01 targets per hour per 3 km at an average flight altitude of 757 ±56 ft (231 ± 17 m) agl. Of the petrel targets for which flight height was collected during fall, 24 percent were recorded within the rotor swept area (Hamer 2010a). Mean movement rates during the spring 2010 period were 7.31 targets per hour per 3 km at an average flight altitude of 620 ± 72 ft (189 ± 22 m) agl. Of the targets for which flight height data were recorded, 46 percent were flying below the maximum Siemens 3.0-MW WTG height of 427 ft (130 m) agl (Hamer 2010a). All targets were flying within the height of the rotor swept area between 29.5 m to 130.5 m agl. However, typical fall passage rates would be expected to be approximately 20 to 30 percent lower than spring passage rates. In spring, non-breeders are still present on Maui, but typically exit the colony by late August. Thus, the fall 2006 survey appears to include an undetermined number of non-petrel/shearwater targets such as sooty terns that seem to be inflating the fall passage rate. Hamer Environmental observed a number of sooty terns during the fall 2006 survey on Maui and shortly thereafter during similar surveys on Hawai‘i (Hamer pers. comm. 2010).

5.2.1 Direct Take

Potential sources of direct mortality of petrels at the Project include collisions with WTGs, met towers, construction cranes, and generator-tie lines. Passage rates of petrels through the Project area, as determined by the fall 2006 and spring 2010 radar surveys, were used as the basis for estimating direct take due to collisions with WTGs which are the most likely source of collision. Evidence suggests that petrels are capable of high levels of avoidance of vertical structures (Cooper and Day 1998; Tetra Tech 2008; KWP 2009, 2010). In the context of wind energy facilities, avoidance rate is defined as the probability that an individual bird that nears the airspace of a WTG is able to avoid colliding with it. A high level of WTG avoidance is supported by mortality data collected during KWP I post-construction monitoring (KWP 2010), which suggest that the avoidance rate is at least 97 percent. Hamer (2010b; Appendix E) estimated annual direct take of Hawaiian petrels resulting from collision with the Siemens 3.0-MW WTGs at the Project to range from 0.662 to 2.487 petrels per year, at avoidance rates of 99 and 95 percent, respectively (Table 5-2).

Table 5-2. Direct Take Estimates for Hawaiian Petrel

Source of Potential Direct Take	Avoidance Rate of 95%	Avoidance Rate of 99%
Annual Direct Take from Siemens WTGs[1/]	2.487	0.662
Annual Direct Take from Met Tower	0.040	0.040
Annual Direct Take from Generator-tie	0.100	0.100
Annual Direct Take	2.627	0.802

1/ From Hamer 2010b.

In addition to collisions with operational WTGs, petrels may also collide with met towers. For KWP II, the avoidance rate for collisions with a met tower was estimated at 95 percent, resulting in an annual take estimate of 0.04 petrels/year/tower, which we have applied to the Project single guyed-met tower (Cooper and Day 2009; Table 5-2). The Project met tower will also be marked with flagging and bird diverters to increase visibility as was done at KWP I. This potential take estimate may be an overestimate; after 2 years of monitoring six met towers on Lanai, no take of petrels has been documented (Standley pers. comm. 2010). Given the limited time period during which cranes will be on site (during only a portion of which they will be vertical or in operation), the potential for petrel-crane collisions is assumed to be negligible and is not considered further.

The construction of the Project will necessitate the construction of 9 miles (15 km) of overhead generator-tie lines. Although there is some potential for petrels to collide with the generator-tie line along its corridor, based on discussions with USFWS, DOFAW and the ESRC, the only area identified as being of concern was the approximately 1.6 miles (2.6 km) of the generator-tie line that runs perpendicular to the ridge running south west of the Haleakalā crater. This area stands in starkest relief to the surrounding landscape and, as a result, should present the highest collision risk. The highest component of this line (i.e., top of pole) will be no higher than 65.5 ft (20 m) above ground level in this segment, with the actual height dependent on terrain features. To minimize collision risk in this area, lines will be marked with bird diverters. Observations of petrels on Kauai (Day et al. in review, cited in Cooper and Day 2009) suggest that petrels are highly capable of avoiding transmission lines. As a result, take resulting from collision with the 9-mile (15-km) generator-tie line is assumed to be very small (0.1 petrels/year, following Cooper and Day 2009; Table 5-2).

Collisions between construction and maintenance vehicles and healthy, free-flying petrels are highly unlikely due to the temporal disconnect between bird activity and construction activity periods; their probability will be further minimized by the implementation of low speed limits (25 mph [40 kph]) on Project roads, which would be strictly enforced. Project vehicles do have the potential to collide with petrels that have been injured by collisions with WTGs, met towers or collection systems. As these collisions involve birds already accounted for in the preceding calculations, no additional take estimates are warranted. In addition, an environmental monitor will be onsite during any periods of night construction to assist with any downed birds that may be attracted to the lights, thereby minimizing the potential for collisions with downed birds.

5.2.2 Indirect Take

The incidental take of a petrel during the breeding season may result in the indirect loss or take of a dependent chick. Several variables are needed to assess both the potential for and magnitude of this indirect take: the proportion of take assumed to be adult, the proportion of the activity period (i.e., period during which adults are visiting the colony) during which adults may be expected to have eggs or chicks, the likelihood that a given adult is reproductively active, the likelihood that the loss of a reproductively active adult results in the loss of its chick, and average reproductive success (Table 5-3). Indirect take of petrels associated with the Project is estimated to be 0.283 or 0.928 petrel per year, for the 99 percent and 95 percent avoidance rates, respectively.

Table 5-3. Indirect Take Estimate for Hawaiian Petrel

Component	Rationale/Description	Avoidance Rate	
		95%	**99%**
A. Annual Direct Take (adults/year)	Annual direct take from Table 5-2	2.627	0.802
B. Proportion of take that is adult	Assumed that 100 percent of direct take was of adult birds because juveniles (i.e., non-breeders under the age of six) rarely visit the breeding colony during the breeding season (Simons and Hodges 1998).	1.00	1.00
C. Proportion of "year" that is breeding period (6 of 8 months)	Although adult birds may be present at the colony over an 8-month period (March-October), only six of these months represent the breeding period (Simons and Hodges 1998).	0.75	0.75
D. Proportion of adults that breed	The proportion of adults attending the breeding colony that attempt to breed in a given year (Simons and Hodges 1998).	0.89	0.89
E. Proportion of taken breeding adults with dependent young	The impact of the loss of a single parent on a dependent chick varies within the breeding season: During May to September, both parents are deemed critical to chick survival. During May-August, only 89 percent of adults are breeding (89 percent breeding * 1 chick/pair * 100% parental contribution). By September, only reproductively active adults are present on the colony (100 percent breeding * 1 chick/pair * 100 percent parental contribution).	0.84	0.84

Table 5-3. Indirect Take Estimate for Hawaiian Petrel (continued)

Component	Rationale/Description	Avoidance Rate	
	In October, the chick is no longer dependent on both parents (100 percent breeding * 1 chick/pair * 50 percent parental contribution). The proportion of taken breeding adults with dependent young was calculated as: ((0.89*1*1*4 months) + (1.00*1*1*1 month) + (0.5*1*1*1 month))/6 months = 0.84.		
F. Average chicks/pair	Average reproductive success for petrels on Maui (Simons and Hodges 1998).	0.63	0.63
G. Annual Indirect Take (chicks/year)	Multiplying Lines A through F.	0.928	0.283

5.2.3 Total Take Estimate (25 years)

Combining the direct and indirect take estimates for each level of avoidance, provides a range of Project total take of adults and juveniles (Table 5-4).

Table 5-4. Total Take Estimate for Hawaiian Petrels (25 years)

	Adults	Juveniles
99% avoidance		
Annual average	0.802	0.283
Over 25 years	20.050	7.075
95% avoidance		
Annual average	2.627	0.928
Over 25 years	65.675	23.200

The population size of the Haleakalā colony is estimated at 475 to 650 breeding pairs or 950 to 1300 adult individuals (Simons and Hodges 1998). Annual take of adults predicted at 99 percent and 95 percent avoidance represents an additive mortality equivalent to 0.08 and 0.27 percent of the low end of the population estimate, respectively. Thus, any additive mortality resulting from Project construction and operation is unlikely to have population-level impacts on the local breeding colony.

5.2.4 Authorized Take Request for ITP

A tiered approach was taken for determining the requested authorized take levels for the Hawaiian petrel. The tiered approach provides assurance that if actual take levels (as determined by post-construction fatality monitoring) are higher than anticipated, additional specific mitigation measures will be automatically triggered. The requested Tier 1 and Tier 3 levels were based on anticipated annual adjusted take levels assuming 99 percent and 95 percent avoidance, respectively, over the life of the Project (Table 5-4). Tier 2 was based on 50 percent of the Tier 3 (or maximum) take level. That is, the take limit for each tier is the modeled estimated annual take for adults and juveniles extrapolated over a 25-year time frame and then rounded up to the nearest whole number. Estimated annual take assuming an avoidance rate of 99 percent was deemed appropriate for Tier 1 based on observations of petrels consistently avoiding vertical structures (Tetra Tech 2008) and the mortality data collected at KWP I (i.e., only a single fatality observed in 4 years of monitoring; KWP 2010). Furthermore, the WTGs are expected to be curtailed (turned-off) on a regular basis between 2300 hrs and 0600 hrs due to the low demand for power from MECO during this time period. Since the WTG blades will not be spinning during these periods of night time curtailment, the expected risk of petrel collisions will be reduced further given that this period of curtailment partially coincides with the dawn peak period of petrel activity.

Requested ITP and ITL Authorization

- Tier 1: 19 adults and 7 chicks over the 25-year permit period.
- Tier 2: 32 adults and 12 chicks over the 25-year permit period.
- Tier 3: 64 adults and 23 chicks over the 25-year permit period.

Each tier represents the total take requested and is not additive for each level. Should the post-construction fatality monitoring (Appendix D) results indicate that take levels will exceed Tier 1 levels, Tier 2 mitigation will be initiated; if Tier 2 levels are exceeded, Tier 3 mitigation will be initiated (Section 6.0).

5.3 NĒNĒ

During the spring 2010 radar study, biologists documented nēnē vocalizations during one night of radar surveys in the Project vicinity (Hamer 2010a); however, nēnē have not been historically known to frequent ʻUlupalakua Ranch below 2000 feet due to lack of habitat (David pers. comm. 2010; Erdman pers. comm. 2009). Nēnē have not been observed in the wind farm site, and less than 5 nēnē sitings have been noted on the entire Ranch over the past 20 years. Nēnē are known to occur on Maui but, as previously discussed, considered highly unlikely to fly over or visit the Project vicinity. Therefore, the likelihood of collision with WTGs or other Project facilities such as the generator-tie line is considered extremely low. However, in the slight chance that a nēnē would fly across the Project and collide with one of the WTGs, the generator-tie line or a crane (as described above for the Hawaiian petrel), the nēnē has been included as a Covered Species in the HCP, and only one level of take is requested. The take limit request for the 25-year permit period of the HCP is five nēnē. Should the post-construction fatality monitoring (Appendix D) results indicate that take will exceed five nēnē, Auwahi Wind will reopen consultation with USFWS and DLNR. Any mortality resulting from Project construction and operation is unlikely to have population-level impacts on the Maui population over the 25-year permit period.

5.4 BLACKBURN'S SPHINX MOTH

Blackburn's sphinx moth larvae were detected during field surveys in 2008 and 2011; the host plants verified to occur within the Project footprint are the invasive tree tobacco (*Nicotiana glauca*) and two ʻaiea (*Nothocestrum* sp.; native host plant located in the generator tie-line and the wind farm site) (Montgomery 2008; David and Guinther 2011; Guinther 2011). Native adult food plants, maiapilo and moonflower (*Ipomea tuboides*), were documented near Pāpaka Road and within the wind farm site. The ʻaiea will be fenced and avoided during construction. Maiapilo and moon flower, where present within areas of disturbance, will also be avoided to the maximum extent practicable. The Project is situated in a region where adjacent and nearby parcels of land support stands of the native *Nothocestrum* species and where the moth is known to occur. Host plants in the remaining undeveloped portions of the Project area would be unaffected by Project construction and operations and would continue to provide habitat for the moth.

Auwahi Wind anticipates that direct impacts to Blackburn's sphinx moth and larvae can be largely avoided by conducting pre-construction surveys for moths and larvae by a qualified entomologist according to the DOFAW- and USFWS-approved protocol. The surveys involve assessing tree tobacco plants for the presence of Blackburn's sphinx moth eggs, larvae, or signs indicating the possibility of pupating larvae (e.g., chewed stems or other browsing). If none of these signs are present, entire young plants and the above-ground portion of the mature plants are removed. On more mature plants, signs of pupating larvae may be less visible and root disturbance may dislodge larvae which can remain in the ground around the host plant, typically within 33 ft (10 m). Thus, around these cut stems the protocol requires that a 33-ft (10-m) disturbance-free buffer around the woody host plant be established to prevent disturbance to any pupating larvae. The plant roots can be removed 90 days following the initial survey.

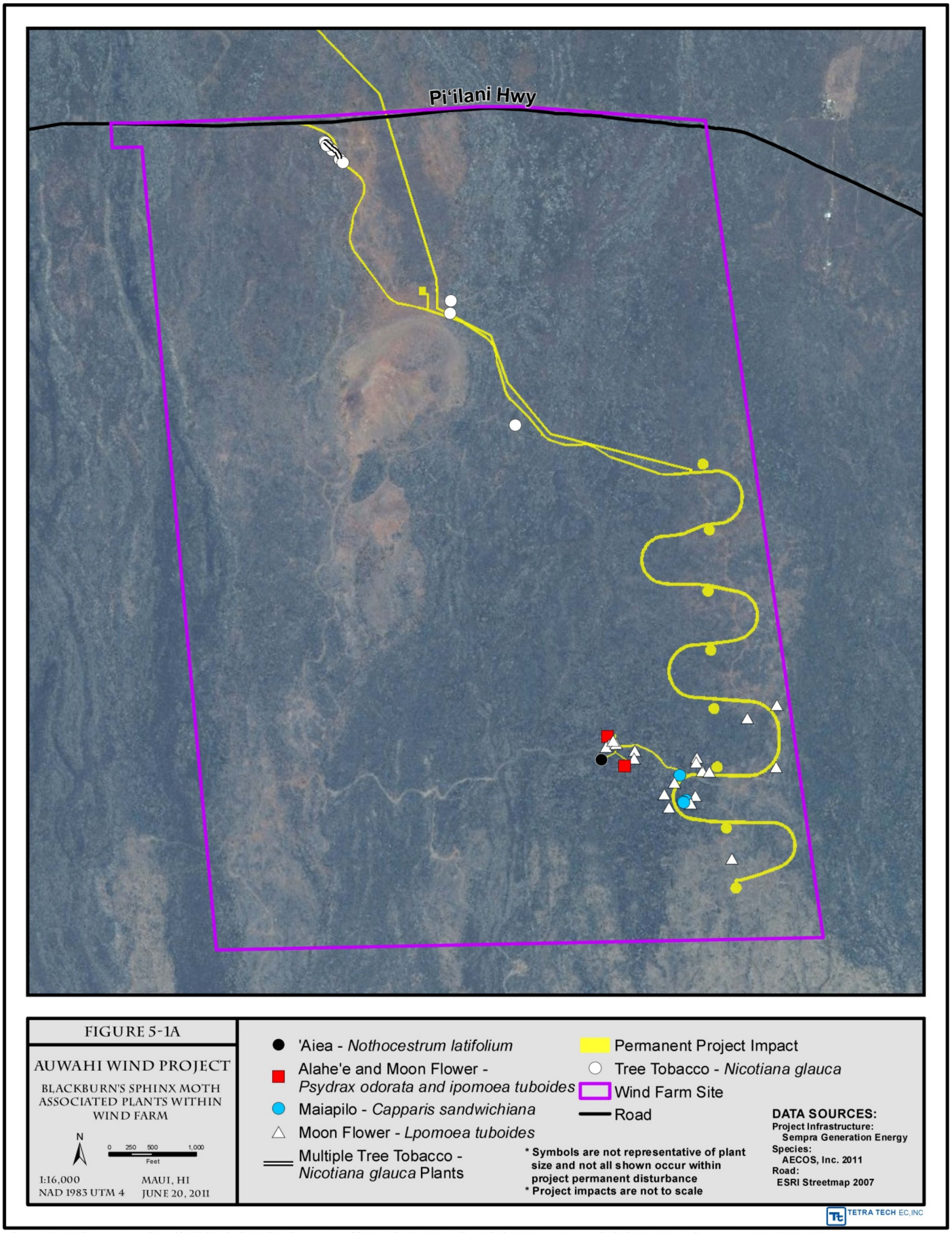
A wet season survey was conducted in March-April 2011 (i.e., approximately one year prior to the initiation of construction). Tree tobacco was inspected and those tree tobacco plants without evidence of eggs or larvae were removed. Those few plants with larvae were left in place. This effort removed the invasive host plants within the disturbance area reduces potential impacts. Another survey will be conducted within the disturbance area 90 days prior to construction to repeat this survey, remove tree tobacco with no signs of moths, and relocate moths. By clearing the non-native host plants and relocating any remaining moths or larvae prior to construction, direct impacts to the Blackburn's sphinx moth will likely be avoided. However, there may be a very minor incidental impact to eggs or pupating larvae not observed or relocated.

In general, all life stages of Blackburn's sphinx moth generally remain on or in proximity to their host plants. The adults would most likely not fly high enough to occur within the rotor swept area of the turbines as they tend to stay close to the host plants (Montgomery pers. comm. 2011). The proposed generator-tie line is located adjacent to the Kanaio Reserve, one of two regional populations of the moth that are regarded as a possible source areas for dispersing or colonizing moth adults. Therefore, there is the possibility that individual adult moths could wander into work areas as they disperse, and thus would be at risk of collision with construction equipment or vehicles; however, site speed limits of 25 mph or less will minimize this likelihood. Given that construction would be temporary and spatially localized, as equipment and vehicles would move along the corridor, the Project should result in negligible effects to the species.

There are no estimates of the numbers of Blackburn's sphinx moths that reside in or near the Project site; therefore, it is not possible to quantify the exact number of individuals that could be taken by the removal of its nonnative host plant during Project construction or harmed as a result of collision with construction equipment or vehicles. The pre-construction surveys within the Project will identify the number of moths or larvae located near host plants, if any. These individuals will be removed and relocated to the same species of host plant, where possible, in the vicinity of where the moth or larvae were found but well outside of the Project disturbance area. Therefore, it is anticipated that direct impact will mostly be avoided from clearing and construction activities. However, there is potential for very minor incidental take of eggs or pupae not relocated and from moth collision with construction equipment because known habitat occurs adjacent to the Project.

USFWS and DOFAW are requiring that impacts to the Blackburn's sphinx moth be quantified by calculating the acreage of permanently disturbed vegetation, including areas where Blackburn's sphinx moth larval host or adult food plants have not been documented within the wind farm site and Pāpaka Road. Figures 5-1a, b, and c show the few moth-associated plants located in relation to the area of permanent disturbance. Although very few plants would be affected by construction of the project, the area of permanent disturbance in the wind farm site and Pāpaka Road would be approximately 28 acres primarily due to turbine access roads and Pāpaka Road.

There is also one ‘aiea located in an area of temporary disturbance along the generator-tie line corridor and one ‘aiea located near the met tower in an area of permanent disturbance (path accessing a guy line anchor); however, because there is flexibility in the finalization of generator-tie line pole locations and conducting work within the wind farm site, it is assumed that these plants would be fenced and avoided during construction. Therefore, take authorization is requested for any minor incidental take of Blackburn's sphinx moth individuals or habitat during Project construction and operations. Mitigation for these Project effects is described in Section 6.0.



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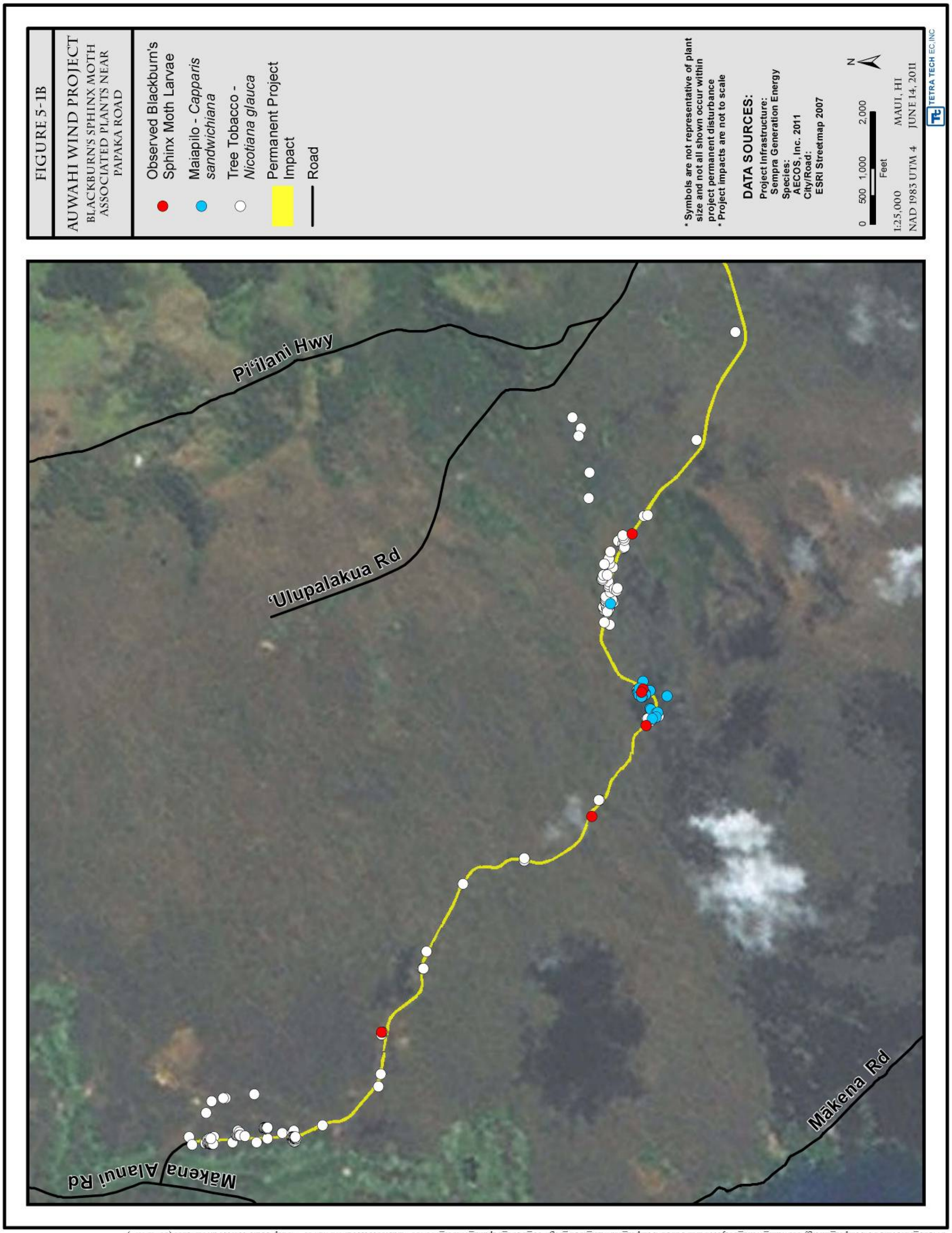
FIGURE 5-1B
AUWAHI WIND PROJECT
BLACKBURN'S SPHINX MOTH ASSOCIATED PLANTS NEAR PAPAKA ROAD
Observed Blackburn's Sphinx Moth Larvae
Maiapilo - Capparis sandwichiana
Tree Tobacco - Nicotiana glauca
Permanent Project Impact
Road
* Symbols are not representative of plant size and not all shown occur within project permanent disturbance
* Project impacts are not to scale
DATA SOURCES:
Project Infrastructure: Sempra Generation Energy
Species: AECOS, Inc. 2011
City/Road: ESRI Streetmap 2007
0 500 1,000 2,000 Feet
1:25,000
NAD 1983 UTM 4
MAUI, HI
JUNE 14, 2011
TETRA TECH EC, INC
Pi'ilani Hwy
'Ulupalakua Rd
Mākena Alanui Rd
Mākena Rd
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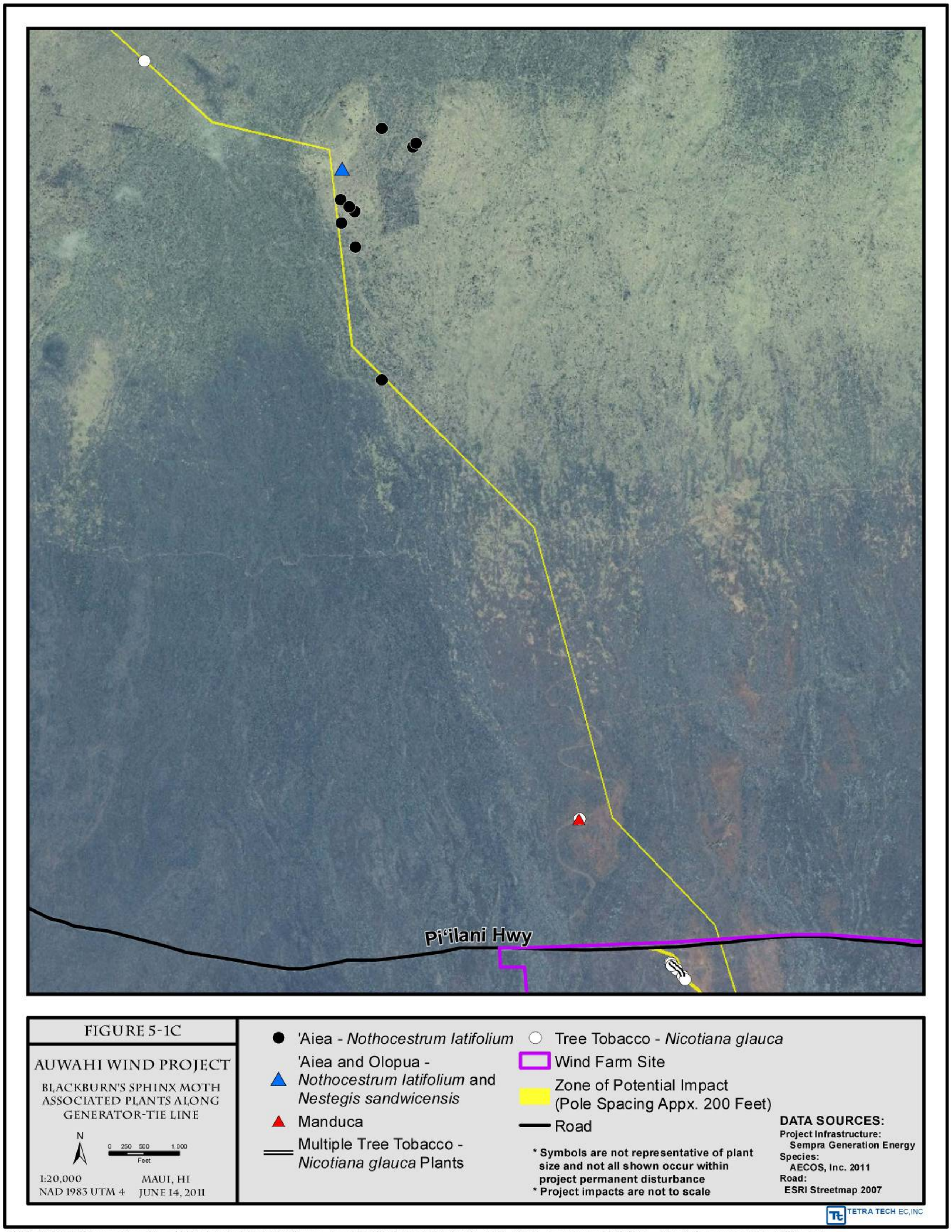

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6.0 COMPENSATORY MITIGATION FOR POTENTIAL IMPACTS

In addition to the need for avoidance and minimization measures, Section 10(a)(2)(A) of the ESA and HRS Chapter 195D require that an HCP describe the steps that will be taken to mitigate the effects of the taking authorized by the proposed ITP/ITL. Unlike incidental take avoidance and minimization measures (Section 4.2), which are designed to reduce the amount of take, mitigation measures are designed to offset or compensate for the actual effects of unavoidable incidental take that occurs under the Project HCP.

Auwahi Wind has worked with USFWS, DOFAW, and the ESRC to identify and select appropriate mitigation measures to compensate for the take of the Covered Species. Several criteria were considered in developing the proposed mitigation plan for this Project, including:

- The mitigation program should be based on sound biological principles, be practical, and commensurate with currently anticipated levels of take;
- Mitigation measures should have measurable goals and objectives that allow success to be assessed, and should have flexibility to adjust to higher or lower levels of anticipated take;
- Mitigation measures should be species-specific and should contribute to recovery (i.e., be consistent with recovery plan objectives) and have a net benefit to the species;
- Mitigation may include habitat enhancement or restoration of degraded or former habitats; and
- Mitigation alternatives may include studies/strategies that provide new information.

The mitigation proposed to compensate for unavoidable impacts consists of a three-tiered approach for the Hawaiian hoary bat and Hawaiian petrel, based on recommendations provided by USFWS and DOFAW, as described in Section 5.0. For these species, initial mitigation efforts are designed to compensate for take at the Tier 1 authorized take level. Only one mitigation level is presented for the nēnē and Blackburn's sphinx moth due to the low anticipated level of take.

The mitigation measures (Figure 6-1; Table 6-1) would meet the mitigation criteria required of Auwahi Wind by DOFAW and USFWS, and would be complementary to other management activities that may be taking place for the benefit of the Covered Species. Over the term of the ITL/ITP, mitigation measures may be subject to modification in cooperation with the USFWS and DOFAW (and in accordance with the Amendment procedures described in Section 9 of this HCP) depending on the measured levels of take and the mitigation measures implemented. Should the net benefit provided by the mitigation implemented for a tier level exceed what was needed for that level of take, the additional net benefit from the mitigation will be applied to the next higher tier if reached.

Should the mortality rates of the Covered Species be so low that mitigation credit could be accrued for those species that exceeds that needed to compensate for incidental take by Auwahi Wind at the Project, Auwahi Wind may use the portion of mitigation credit accrued above the level of take at the end of Project operations or ITP/ITL 25-year term. Auwahi Wind can use this excess credit to mitigate for the authorized take of these same species at other wind power projects or any other type of project on Maui or elsewhere in Hawai‘i as approved by the USFWS and DLNR. Auwahi Wind would also be able to sell this credit to any other entity in need of mitigation for the same Covered Species for any other type of project occurring on Maui or elsewhere in Hawai‘i that receives take authorization from the USFWS and DLNR. The transfer of credit would be conducted with approval of USFWS and DLNR. The commercial value of the credit would be determined through negotiation between Auwahi Wind and the receiving entity.

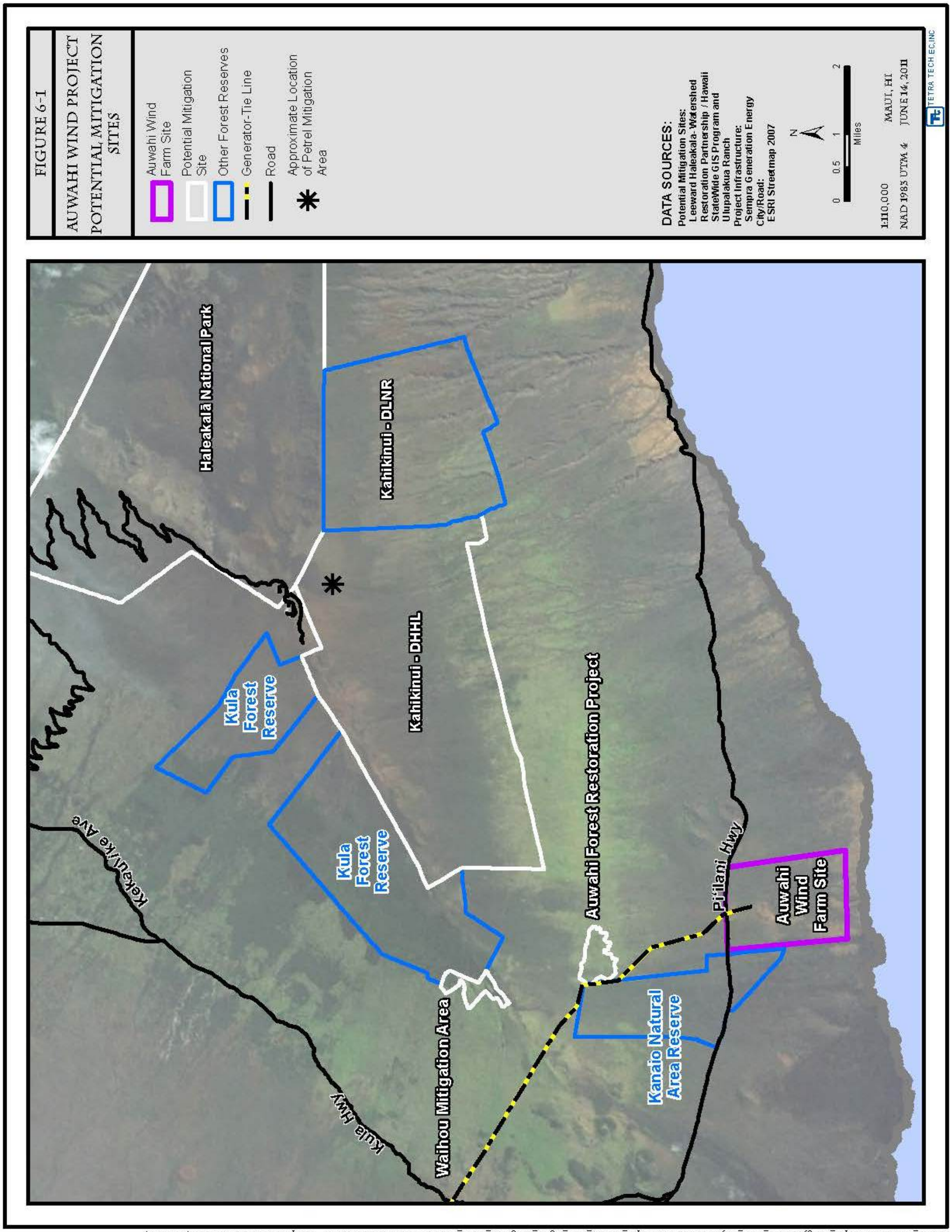

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Table 6-1. Proposed Mitigation for Covered Species

Covered Species	Tiered or One-Time	Tier 1 or One-Time	Tier 2	Tier 3
Hawaiian hoary bat	Tiered	Implement at Waihou Mitigation Area. Bat habitat restoration measures include fencing, ungulate removal, and outplanting.	Research such as acoustic monitoring or radio telemetry study.	Use research to evaluate appropriate mitigation – additional area for bat habitat restoration available at Waihou Mitigation Area or conduct additional research.
Hawaiian petrel	Tiered	Implement petrel management measures including conducting a predator control and monitoring at the Kahikinui Forest Project.	Implement additional petrel management measures at the Kahikinui Forest Project or other appropriate management program.	Implement additional petrel management measures at the Kahikinui Forest Project or other appropriate management program.
Nēnē	One-time	Funding to conduct predator control at Haleakalā Ranch or support egg and gosling rescue at Haleakalā National Park.	NA	NA
Blackburn's sphinx moth	One-time	Funding to the LHWRP to restore dryland forest in the Auwahi Forest Restoration Project including outplantings of larval and adult host plants.	NA	NA

LHWRP – Leeward Haleakalā Watershed Restoration Partnership

6.1 MITIGATION LOCATIONS

The three primary locations targeted to provide mitigation for the Covered Species are the Waihou Mitigation Area, the Auwahi Forest Restoration Project and the Kahikinui Forest Project. These projects focus on the preservation, management, and restoration of remnant native or degraded habitats and forest with the goal of creating or enhancing habitat for rare or listed plant and wildlife species including the Covered Species. Native habitats on Maui have been degraded by feral ungulates, introduced predators, invasive plant species, and other land management activities. Microsites within the dryland and mesic forests on Maui that historically fostered unassisted, natural establishment of seedlings and saplings (shaded understory sites) have been so extensively damaged that some native species have not reproduced naturally in the last 50 to several hundred years (USGS 2006).

6.1.1 Waihou Mitigation Area

The Waihou Mitigation Area, located on ʻUlupalakua Ranch, creates a travel corridor that connects suitable bat habitat to other conservation areas such as the Polipoli area within the Kula Forest Reserve (Figures 6-1 and 6-2). The approximately 350–acre (142-ha) area includes four parcels, all owned by the ranch: Pu'u Makua (195 acres [79 ha]), Duck Ponds (53 acres [21 ha]), Cornwell Spring (41acres [17 ha]), and the Kaumaea Loko (61 acres [25 ha]). The Waihou Mitigation Area is a mosaic of vegetative communities dominated by pastureland (Figure 6-3). All parcels have had some level of plantings, although on a small scale, and are enclosed with cattle fencing. The Cornwell Spring area is partially forested with koa and Pacific ash with the remainder pastureland. The Kaumaea Loko area is currently dominated by kikuyu and matching funding is currently available to add an ungulate-proof fence and to reforest portions of the area by outplanting. The Duck Ponds are partially forested with Monterey pines and the remainder is pastureland, while Pu'u Makua is dominated by pastureland. None of these parcels are currently protected by a conservation easement or have guaranteed funding for long-term management measures such as forest restoration, ungulate removal, and invasive species control management. The restoration and management activities outlined in Section 6-2 demonstrate how the restoration of these parcels will provides additional bat breeding, foraging, and traveling habitat and will provide a contiguous corridor with other state reserves protecting bat habitat.

6.1.2 Auwahi Forest Restoration Project

The Auwahi Forest Restoration Project was initiated in 1997 by a coalition of private and public agencies spearheaded by the USGS and ʻUlupalakua Ranch. The Auwahi Forest Restoration Project is located on ʻUlupalakua Ranch and is protected by an agricultural conservation easement. The goal of this project is to protect the remnants of the native dryland forest and reestablish natural forest processes (e.g., seed dispersal and germination) that will support a self-sustaining forest ecosystem. To this end, the Auwahi Forest Restoration Project consists of a three-pronged approach including 1) fencing tracts of high quality forest to exclude ungulates, 2) eliminating kikuyu grass and other invasive species using both herbicides and hand pulling, and 3) outplanting of native tree, shrub, vine, and grass species that were elements of the original forest community (USGS 2006). Success of this approach has been demonstrated by the increase in native tree and shrub growth, including several endangered plant species, where these efforts have been implemented within the Auwahi Forest Restoration Project (USGS 2006). The entire restoration project consists of approximately 188 acres (76 ha; Figure 6-1). Fencing was installed in 1997 and outplanting was completed at the initial

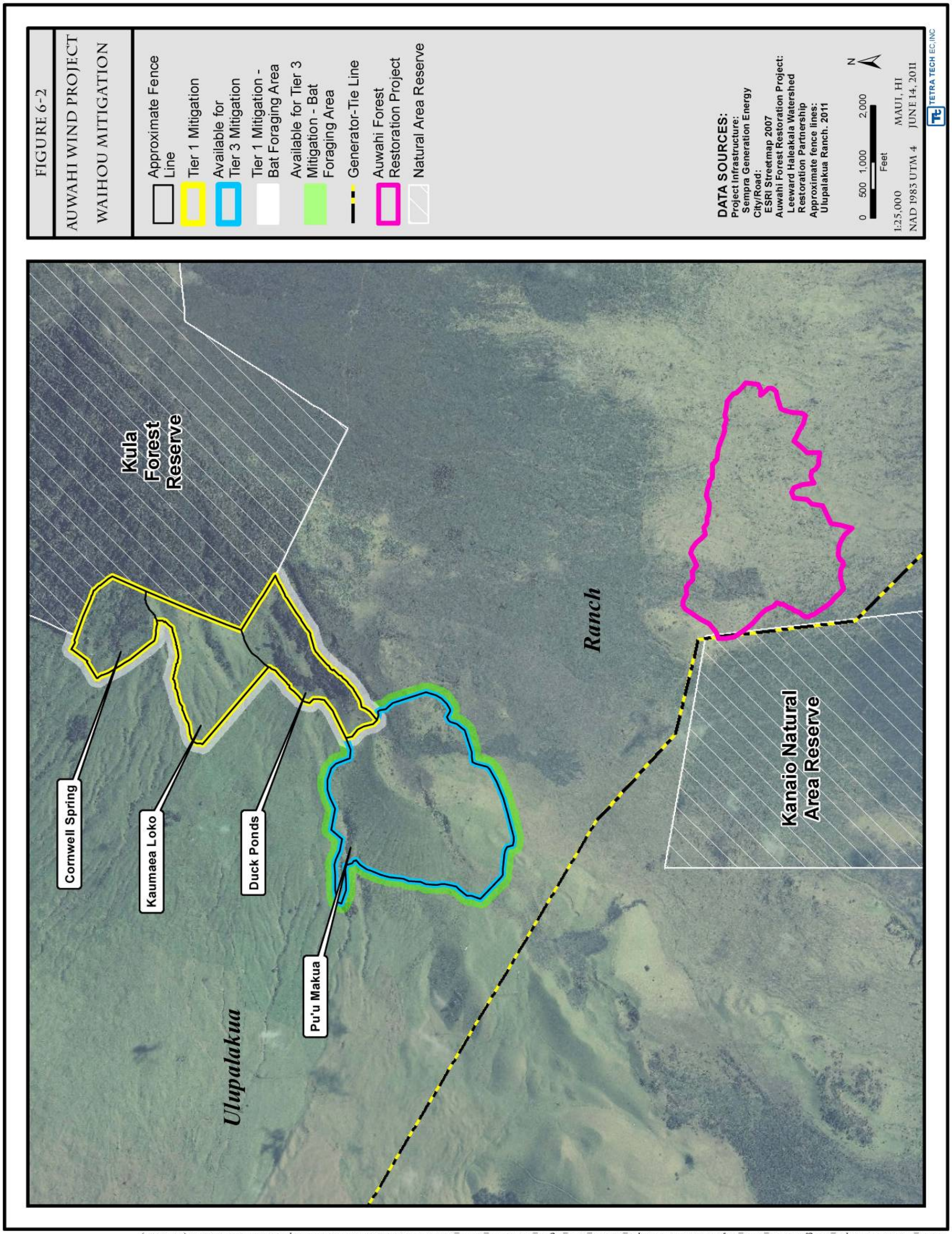
FIGURE 6-2
AUWAHI WIND PROJECT
WAIHOU MITIGATION
Approximate Fence Line
Tier 1 Mitigation
Available for Tier 3 Mitigation
Tier 1 Mitigation - Bat Foraging Area
Available for Tier 3 Mitigation - Bat Foraging Area
Generator-Tie Line
Auwahi Forest Restoration Project
Natural Area Reserve
DATA SOURCES:
Project Infrastructure:
Sempra Generation Energy
City/Road:
ESRI Streetmap 2007
Auwahi Forest Restoration Project:
Leeward Haleakala Watershed Restoration Partnership
Approximate fence lines:
Ulupalakua Ranch. 2011
0 500 1,000 2,000
Feet
1:25,000
NAD 1983 UTM 4
MAUI, HI
JUNE 14, 2011
TETRA TECH EC, INC
Kula Forest Reserve
Ranch
Kanaio Natural Area Reserve
Ulupalakua
Cornwell Spring
Kaumaea Loko
Duck Ponds
Pu'u Makua
P:\GIS_PROJECTS\Sempra_Energy\Auwahi_Wind_Project\MXDs\HCP\Sempra_Auwahi_HCP_Fig6-2_WaihouMit_85i11i_061411 - Last Accessed: 6/15/2011 - Map Scale correct at: ANSI A (11" x 8.5")

Figure 6-3. Photos of the Waihou Mitigation Area

10-acre (4-ha) portion of the Auwahi Forest Restoration Project. This site served as the pilot project for subsequent restoration efforts (USGS 2006). Outplanting is nearly complete for an additional 23 acres (9 ha) of the Auwahi Forest Restoration Project. Native shrubs and trees have recovered and now dominate both of these areas, providing a contrast to the surrounding pasturelands. The Auwahi site includes ʻohiʻa, a species of tree documented as a roost tree for Hawaiian hoary bats (USGS 2006; Gorressen et al. 2008). Fencing of the remaining 155 acres (63 ha) of the Auwahi Forest Restoration Project has been completed but this area has not been outplanted.

6.1.3 Kahikinui Forest Project

The objective of the Kahikinui Forest Project is to protect and restore remnant native habitats and forest along the southern slope of Haleakalā. The Leeward Haleakalā Watershed Restoration Partnership (LHWRP) and DLNR propose to manage the Kahikinui Forest Project and restore the native forest by installing adequate fencing to protect the area from non-native ungulates, followed by the removal of ungulates and predators (cats and mongooses) from within the fence line, and finally elimination of invasive weeds and reforestation with native plant species. The LHWRP is a coalition that was formed in June 2003 by 11 private and public landowners and supporting agencies. The LHWRP is partnering with the Department of Hawaiian Home Lands (DHHL) and DLNR to implement this overall program on all their lands which encompass approximately 8,000 acres (3,237 ha), with initial focus placed on 5,200 acres (2,104 ha) of DHHL lands (Medeiros pers. comm. 2010). Prior to the 1800s, the leeward flanks of Haleakalā were covered in extensive koa forests. These koa forests, among the most robust and diverse in the archipelago, supported abundant native Hawaiian flora and fauna, some of it found nowhere else in the world. Through fog interception, these forests, which were over 100 feet (30 m) tall, contributed to a greater volume of water than other areas in this region of limited rainfall. In the past 200 years, systematic deforestation due to overgrazing by feral ungulates has reduced forest cover to less than 5-10 percent of former extents, none of it intact. In response to this decline, the LHWRP and DLNR's goal is to restore native watershed forests on Haleakalā from Makawao through ʻUlupalakua to Kaupō (Medeiros pers. comm. 2010).

Restoration of the watershed and forests will benefit a number of native Hawaiian species including the Hawaiian hoary bat and Hawaiian petrel. Furthermore, active petrel burrows have been identified in the upper portion of Kahikinui Forest Project where the landscape is mostly unvegetated (Figure 6-4) and we expect after an additional survey that sufficient burrows will be identified to manage for this Project.

Figure 6-4. Photos of the Kahikinui Forest Project Petrel Mitigation Area

The LHWRP will construct a 7-ft (21-m) high ungulate-proof fence with no gaps at the ground, the standard for exclusion of feral ungulates (Reeser and Harry 2005; Medeiros 2011). The fence is designed to encompass the perimeter of the Kahikinui Forest Project so that it will connect the DHHL and DLNR properties resulting in the protection of the entire 8,000-acre (3,237-ha) project.

The current proposal includes 7.8 miles (13.1 km) of new fence and 1.7 miles (2.8 km) of upgrades to the existing fence. Once the fence is in place, introduced ungulates, including feral goats, pigs, axis deer, and cattle, will be removed from the Kahikinui Forest Project. These introduced ungulates browse on native vegetation and groundcover and may affect the Covered Species by trampling and collapsing petrel burrows causing nest abandonment within colonies. The soil disturbance caused by ungulates also facilitates the introduction and spread of invasive plants, which further reduces habitat suitability for the Covered Species (Reeser and Harry 2005). Ungulates also create trails in the colony that increase access for predators to active burrows. Once ungulates have been removed from within the fenced area, additional mitigation measures such as predator control and vegetation restoration can be undertaken.

6.2 HAWAIIAN HOARY BAT

The recovery plan for the Hawaiian hoary bat (USFWS 1998) states that bat populations can be threatened by habitat loss, pesticides, predation, and roost disturbance. The recovery criteria identified in the Hawaiian hoary bat recovery plan (USFWS 1998) list protecting and managing key roosting and foraging areas and research essential to the conservation of the subspecies as the first two actions needed for the species recovery. Based on recommendations from USFWS and DOFAW, bat mitigation will be implemented per tier: Tier 1—habitat conservation and enhancement; Tier 2—research study; and Tier 3—adaptive management to incorporate either additional habitat preservation or bat management reflecting the results of the research. Mitigation for Tier's 1 and 2 will be initiated within 30 days of the issuance of the ITP. Tier 3 mitigation will be initiated if the Tier 3 take level is triggered. Associated costs are summarized in Table 6-2.

Table 6-2. Funding Matrix for the Auwahi Wind Project

	Tier, Ongoing, or One-time	Event	One-time Cost	Cost per year	Years effort	Total	Time of Payment/Execution
General Measures	One-time	Pre-construction survey for Blackburn's sphinx moth	$20,000	---	---	$20,000	Prior to initiation of construction and ground clearing
	Ongoing	Wildlife Education and Incidental Reporting Program	$5,000	$1,500	24	$41,000	Prior to and throughout operations
	Ongoing	Downed Wildlife Post-Construction Monitoring and Reporting and Mitigation Monitoring	$40,000	$21,500 Year 1, $120,250 per year Years 2-3 $70,000-$95,000 per year Years 4-25	24	$1,810,000	Initiate at time of commissioning; conduct first 2 years of intense effort and then less intense effort over life of ITP/ITL
	Subtotal General Measures					***$1,871,000***	
Hawaiian Hoary Bat	Tier 1	Retrofit fencing and restoration measures at the Waihou Mitigation Project	$522,000	---	---	$522,000	Initiate mitigation within 30 days of obtaining ITP/ITL
		Acoustic monitoring onsite	$40,000	---	---	$40,000	Years 1 and 2 of operation
	Tier 2	Monitoring/ Research	$150,000-$300,000	---		$150,000 - $300,000	Initiate by Year 2 of operation.
		Subtotal Tier 1, 2				***$862,000***	

Table 6-2. Funding Matrix for the Auwahi Wind Project (continued)

	Tier, Ongoing, or One-time	Event	One-time Cost	Cost per year	Years effort	Total	Time of Payment/Execution
Hawaiian Hoary Bat (continued)	Tier 3	Additional restoration activities or research	$200,00 - 450,000	---	---	$200,000 - 450,000	Timing and amount to be determined based on coordination with DOFAW and USFWS
		Subtotal Bats				***$1,062,000 – 1,312,000***	
	Bat Contingency Fund		$100,000	---	---	$100,000	Establish assurance of funding within 6 months of obtaining ITP/ITL. Funds are only used if proposed mitigation requires additional funds to complete work than identified in these tiers.
Hawaiian Petrel	Tier 1	Baseline burrow monitoring	$70,000	---	---	$70,000	Completed April-June 2011
		Predator-proof fencing or trapping, predator eradication, and burrow monitoring	$338,000	$57,000 per year Years 1-2;	2	$452,000	Initiate mitigation within 30 days of obtaining ITP/ITL
		Subtotal Tier 1				***$522,000***	
	Tier 2	Covered by tier 1 mitigation; continued monitoring	---	$33,000 Years 3-5	3	$99,000	Years 1 and 2 after reaching net benefit for Tier 1 take.
	Tier 3	Covered by tier 1 mitigation; continued monitoring	---	$33,000 Years 6-20	15	$495,000	Years 1 and 2 after reaching net benefit for Tier 2 take.
		Subtotal Petrels				***$1,116,000***	

Table 6-2. Funding Matrix for the Auwahi Wind Project (continued)

	Tier, Ongoing, or One-time	Event	One-time Cost	Cost per year	Years effort	Total	Time of Payment/Execution
Hawaiian Petrel (continued)	Petrel Contingency Fund		$250,000	---	---	$250,000	Establish assurance of funding within 6 months of obtaining ITP/ITL. Funds are only used if proposed mitigation requires additional funds to complete work than identified in these tiers.
Nēnē	One-Time	Research or Management Funding	$25,000	---	---	$25,000	Within 30 days of obtaining ITP/ITL
Blackburn's Sphinx Moth	Two payments	Restoration of 6 acres of Dryland Forest	$144,000	---	---	$144,000	First payment within 30 days of obtaining ITP/ITL
Totals							
General						$1,871,000	
Tier 1 (including one-time and upfront mitigation covering multiple tiers)						$1,253,000	
Tier 2						$399,000	
Tier 3						$945,000	
Subtotal Tiers 1 - 3						***$2,597,000***	
Subtotal Mitigation and Monitoring						***$4,468,000***	
Contingency Funds						$350,000	

6.2.1 Tier 1 Mitigation

The Auwahi mitigation for bats is based on the recommendations received from USFWS and DOFAW in May 2011. USFWS and DOFAW received the results of Home Range Tools for ArcGIS®, Version 1.1 (compiled September 19, 2007) calculations based on Hawaiian hoary bat tracking data collected by USGS-BRD Wildlife Ecologist, Dr. Frank Bonaccorso. This dataset from a two-week tracking study indicated that the mean core area of rainforest habitat on the island of Hawai'i used by 14 male bats was 84.3 acres (34.1 hectares) and the average size of the core area utilized by the 11 females in the dataset was 41.2 acres (16.7 ha). Male bat core areas do not appear to overlap; female core areas may overlap with male core areas. A core area was defined as the area that incorporates 50 percent of tracked movements; therefore, the USFWS and DOFAW feel that the core area is a minimum habitat requirement for bats.

The Tier 1 requested take level for bats of 5 adults and 2 juveniles equates to a total of 6 adults (assuming 30 percent of juveniles survive to adulthood based on little brown bat survival; Humphrey 1982). USFWS and DOFAW recommended that native habitat should be restored at a ratio of 84.3 acres (34.1 hectares) per male bat taken. Assuming a 50:50 adult sex ratio, the potential take of 6 adults would result in the take of 3 adult male bats. Therefore, the USFWS and DOFAW recommended mitigation for the take of 3 adult male bats is the restoration of 252.9 acres. Assuming that one core area supports one bat at a given time, and assuming that the lifespan of a Hawaiian hoary bat is approximately 6 years (similar to mainland subspecies), then it could be conservatively assumed that one core area could be used by, or benefit, up to 4 male bats over the 25-year permit term. Additionally, benefits of restoration would presumably extend beyond the 25-year term of the ITP/ITL. However, Auwahi Wind recognizes that the benefits of the restoration activities may take some time, so has conservatively assumed that 2 male bats will benefit from the enhancement or preservation of each core area of habitat over the life of the Project. Based on this assumption, the mitigation acreage required is 126.5 acres.

The USFWS and DOFAW prefer that Hawaiian hoary bat mitigation occur on 'Ulupalakua Ranch or other private lands rather than state lands. The mitigation area identified to compensate for potential take of bats by the Project occurs on the northern section of the 'Ulupalakua Ranch referred to as the Waihou Mitigation Area (Figure 6-4). The Waihou Mitigation Area contains degraded and remnant patches of rare, native forest ecosystems that are the focus of restoration and management, and provide suitable foraging , breeding, and roosting habitat for Hawaiian hoary bats (Erdman pers. comm. 2011; Medeiros pers. comm. 2011). This mitigation area will provide additional benefits for Hawaiian hoary bat mitigation because it is adjacent to the Kula Forest Reserve, which currently has extensive native vegetation and bat habitat; creates a travel corridor between Kula Forest Reserve, Auwahi Forest Restoration Project, and the Kanaio Forest Reserve which can offset habitat fragmentation/genetic concerns; and has existing water sources in the form of ponds and springs that provide food for breeding and non-breeding bats. Mitigation at the Waihou Mitigation Area will entail ungulate fencing (either by installing ungulate fencing or upgrading existing cattle fence), removing ungulates, removing or managing invasive vegetation, conducting native forest restoration activities (either outplantings or natural regeneration, where appropriate), and establishing a conservation easement for perpetuity to conserve the area for bats. Ulupalakua Ranch is a partner and has consented to creating and implementing the management activities in this bat mitigation area with Auwahi Wind.

The following provides a summary of the management activities to occur within the mitigation area. A more detailed management plan will be developed for the Waihou Mitigation Area by permit issuance.

Tier 1 mitigation will occur within the 154-acre (62-ha) area comprised of the Cornwell Spring, Kaumaea Loko, and Duck Pond parcels of the Waihou Mitigation Area and the foraging area immediately surrounding the parcels(Table 6-3). These parcels will be placed in to a permanent conservation easement as agreed upon by ‘Ulupalakua Ranch. The Cornwell Spring area is 41acres (17 ha), the Kaumaea Loko area is 61 acres (25 ha), and the Duck Pond area is 53-acres (21-ha). Because ‘Ulupalakua Ranch will be receiving some matching federal funds toward the fencing and planting of the Kaumaea Loko area, USFWS stated Auwahi Wind can count 50 percent of the acreage of Kaumaea Loko towards its bat mitigation. Therefore, the total acreage counted for mitigation is 124 acres (41 + 30 + 53 acres), although 154 acres will be put into conservation easement.

Additionally, Auwahi Wind assumes that the area 148 feet (45 m) outside of the conservation easements will be used as foraging areas by the hoary bats if they are maintained in pasture, as hoary bats often forage in open areas (Greenlee pers. comm. 2011). This buffer will also provide a fire management buffer for the life of the Project. Thus, this additional foraging area will add an additional 44 acres to the Tier 1 mitigation.

To protect these parcels from ungulates, the existing cattle fence will be retrofitted to be ungulate-proof fencing. Retrofitting will begin within the first year of permit issuance and be completed within 2 years of permit issuance. Retrofitting the fence was selected because it is cost effective and minimizes disturbance to other resources. The Kaumaea Loko will have new ungulate fencing and will not need to be retrofitted. Combined over all the parcels, this fence will result in the complete enclosure of an approximately 154-acre (62-ha) area. The fence will be inspected annually to identify any issues and to ensure its integrity throughout the life of the permit.

After the ungulate-proof fence retrofitting is completed, ungulates will be removed from within the fenced area within 2 years of fence completion. Auwahi Wind will work with Ulupalakua Ranch to manage the parcels to include both forested areas (though outplanting and natural regeneration) and open areas. Species chosen for plantings will depend on the location within the parcel but will likely include predominately koa, 'ohia lehua, 'a'ali'i, and kōlea lau nui, along with additional native trees and understory plantings (Appendix B includes a list of potential plants to be used). Costs were based on estimates of labor, equipment, and materials estimates provided by the ‘Ulupalakaua Ranch and LHWRP (Table 6-2).

6.2.2 Tier 2 Mitigation

The Tier 2 requested take level for bats of 10 adults and 4 juveniles equates to a total of 11 adults (assuming 30 percent of juveniles survive to adulthood based on little brown bat survival; Humphrey 1982) and will require mitigation for an additional 5 adult bats over the Tier 1 mitigation. Based on the USFWS and DOFAW recommendation, Auwahi Wind will fund research projects that contribute to the overall knowledge of the Hawaiian hoary bat on Maui. Auwahi Wind will initiate this research within 2 years of the issuance of the ITP regardless of take levels.

Auwahi Wind will provide $150,000 to $300,000 for a Hawaiian hoary bat research project to provide additional data that contribute to the knowledge of the Hawaiian hoary bat on Maui. Auwahi Wind will work with Dr. Frank Bonaccorso and his research team to either design a radio telemetry study within the mitigation area or to use acoustic surveys to help evaluate bat population trends on Maui, as required in the Hawaiian hoary bat recovery plan. If the radio-telemetry option it chosen, it will be designed to e 1) estimate of male and female core areas and home ranges, 2) identify habitat associated with foraging and roosting, and 3) collect data for genetic evaluation of effective population size. Data will be collected over an approximately 4- to 8-week period after the young of the year have become independent. Data will be collected in 3 separate years. The initial year of data collection will be within 2 years of commercial operation of the wind farm and during the initial restoration efforts of the mitigation parcel. The second and third years of data collection will be at years 8 and 16 of commercial operation of the Project. This will ensure that data have been collected when the mitigation site is in different stages of vegetative development.

If the acoustic sampling to evaluate bat population trends on Maui is selected, Auwahi Wind will contribute funding to Dr. Bonaccorso's research program to apply the acoustic sampling techniques on Maui used on the Big Island. This would entail identifying potential sampling locations on Maui, deploying acoustic detectors, and then analyzing the data using occupancy models.

Table 6-3. Comparison of Existing Conditions and Proposed Conditions After Bat Mitigation Is Implemented

				Existing Conditions			Proposed Conditions		
Plot	**Acres - to be forested**	**Acres – potential foraging**	**Acres – total bat benefit**	**Easement**	**Fence**	**Forest Restoration Completed**	**Easement**	**Fence**	**Forest Restoration Completed**
Tier 1 Mitigation									
Cornwell Spring Area	41	9.3	50.3	Agriculture	Cattle	50% forested in koa forest, and ~20% in non-native forest (Pacific ash dominant)	Conservation (perpetuity) + assured funding for maintenance	Ungulate	Plant with native understory plants and koa and other native trees, replace Pacific ash with native trees
Kaumaea Loko area	61	14.5	75.5	Agriculture	Cattle	~5% with native trees	Conservation (perpetuity) + assured funding for maintenance	Ungulate	Plant with native understory plants and koa and other native trees
Duck ponds	53	20	73	Agriculture	Cattle	~60% forested, dominated by Monterey pines	Conservation (perpetuity) + assured funding for maintenance	Ungulate	Plant with native understory plants and koa and other native trees
Total Tier 1	**155**	**43.8**	**198.8**						
Pu'u Makua	195	41	236	Agriculture	Cattle	~10 % forested	Conservation (perpetuity) + assured funding for maintenance	Ungulate	Plant with native understory plants and koa and other native trees
Tier 3 Total Potential Acres Available	**195**	**41**	**236**						

A formal research plan and study design will be provided to USFWS and DOFAW for review within 1 year of the issuance of the ITP. The research plan will be finalized before the initiation of the study, which will occur within 2 years after the issuance of the ITP. Research reports will be completed after each year's data collection and for the later years will include a comparison to the previous year's results. Reports will be provided to USFWS and DOFAW as part of Auwahi Wind's annual reports. If logistical or other constraints prevent the execution of the study described above, Auwahi Wind will provide a total of $300,000 towards a different applied search study, as agreed upon by USFWS and DOFAW.

6.2.3 Tier 3 Mitigation

Given the lack of bat roosting habitat on the project site, the monitoring data from another Maui wind project, and Auwahi Wind's anticipated night-time curtailment, it is expected that Tier 3 is very unlikely to be triggered. However, due to Auwahi Wind's cautious approach and the uncertainty associated with estimating bat fatalities, Auwahi Wind has included this third tier of take and mitigation out of an abundance of caution.

As discussed in section 6.2.5 below, mitigation levels were established based upon a 24-hour operation of the wind farm for the life of the Project, such operation will not take place. Instead, the WTGs are expected to be curtailed (turned off) and during times when bats are expected to be active. As a result, triggering Tier 3 is likely to be low. Thus, Auwahi Wind has taken a conservative approach.

The Tier 3 requested take level of 19 adults and 8 young equates to a total of 21 adult bats (assuming 30 percent of juveniles survive to adulthood based on little brown bat survival; Humphrey 1982), requiring mitigation for an additional 10 adult bats over the Tier 2 level. Should the Tier 3 mitigation be required, Auwahi Wind will use the results of the research conducted to date in Tier 2 and data from other applicable studies to identify appropriate mitigation measures to be implemented potentially including the restoration of native forest habitat.

In the unlikely event that Tier 3 take is reached and Tier 3 mitigation triggered, Auwahi Wind will focus mitigation efforts on one or more alternate mitigation sites and/or additional research in consultation with the USFWS and DOFAW. Selection of site and mitigation focus will depend on agency recommendation and timing, such that mitigation activities will integrate with and enhance ongoing management actions at the selected site. The Waihou Mitigation Area, the Kahikinui Forest Project, and the Auwahi Forest Restoration Project will serve as potential Tier 3 mitigation sites for bat mitigation. Within the Waihou Mitigation Area (first priority), Auwahi Wind has the option to expand the fenced portion to include all or part of the 195–acre (79-ha) Pu'u Makua area to be placed in a permanent conservation easement. This parcel would include up to 41 acres (16.6 ha) of bat foraging area. Furthermore, should DOFAW establish a pooled-partnership for bat mitigation at the Kahikinui Forest Project or another appropriate bat mitigation site during the term of this HCP, Auwahi Wind will consider this as a possible mitigation option in lieu of some or all of the mitigation described above, subject to approval by DOFAW and USFWS.

Auwahi Wind would ensure adequate funding is available when Tier 3 mitigation is triggered to implement appropriate Tier 3 bat management measures such as habitat enhancement, restoration, monitoring, or additional research as determined to be appropriate in consultation with USFWS and DOFAW. The mitigation program identified to be appropriate for Tier 3 as agreed upon by Auwahi Wind, USFWS, and DOFAW will be initiated within 30 days of that agreement.

6.2.4 Contingency Funds

Auwahi Wind will establish a $100,000 cost overrun contingency fund for the Hawaiian hoary bat for the mitigation described for Tiers 1–3. This fund will ensure the described mitigation will be implemented should actual costs be higher than estimated. The funding will be provided in the form of a letter of credit, guarantee, or similar financial instrument.

6.2.5 Net Benefit

The Waihou Mitigation Area is a long-term effort that, among other goals, provides immediate protection for bat foraging and roosting habitat. Additionally, the mitigation project would reestablish naturally regenerating native forests on Maui. Auwahi Wind's contributions to and efforts in support of the Waihou Mitigation Area would create, protect, and enhance suitable habitat for Hawaiian hoary bats over the life of the Project. A net benefit to the species will be realized by these mitigation efforts in two ways: one, the projected benefit to 21 adult bats does not account for young produced by the bats using the restored and protected habitat; and, two, the protected habitat would continue to be used by adult bats and their offspring beyond the term of the ITP/ITL.

The net benefits provided by the Waihou Mitigation Area include the following:

- Immediate protection for bat foraging/roosting habitat,
- Creation of a forest/grazing (i.e., forest/open area) interface for preferred bat foraging areas both within and adjacent to the mitigation area,
- Creation of additional roost trees, maternity trees, foraging areas,
- Increased site stability, particularly in drought years, due to diversity of native plants adapted to drought conditions,
- Increased insect diversity due to increased plant diversity, more abundant and stable food resources, and
- Protection of springs and other water sources for water and food requirements.

Furthermore, the assessment of potential impacts (Section 5.1) assumes that all WTGs will operate continuously (24 hours a day, 7 days a week), and the proposed mitigation measures are based on those potential impacts. However, the WTGs are expected to be curtailed (turned off) on a regular basis between approximately 2300 hrs and 0600 hrs (29 percent of a 24-hour day) due to the low demand for power from MECO during that time period. This time period overlaps the portion of the day during which bats are likely to be the most active. As a result, the actual amount of take caused by the WTGs will likely be significantly less than estimated in this HCP. Since Auwahi Wind has not reduced its bat mitigation based on this likely smaller amount of take, Auwahi Wind will in effect be over-estimating take and thus associated mitigation for bats. This further ensures that the mitigation provided in this HCP will result in a net benefit to the Hawaiian hoary bat.

6.3 HAWAIIAN PETREL

The primary limiting factors for the Hawaiian petrel population on Maui include predation by introduced animals and habitat degradation and disturbance at breeding colonies (Carlile et al. 2003). Therefore, in keeping with the USFWS' Recovery Plan and to mitigate its unavoidable impacts, Auwahi Wind will conduct habitat management and predator control at a confirmed Hawaiian petrel breeding colony, in order to improve reproductive success. As discussed below, Auwahi Wind has determined the number of active petrel burrows it must manage to achieve the required mitigation and net benefit requirements. Having already confirmed through an initial survey in April 2011 that Hawaiian petrels are breeding within the Kahikinui Forest Project, the next step will be to conduct detailed surveys during the summer of 2011 to document active burrows and delineate the boundaries of the breeding colony area to be managed. This will be followed by implementing management activities to remove predators and improve breeding success.

The activities proposed here would benefit the petrels in multiple ways. First, the surveys will provide information about the number and location of petrel burrows within the previously unsurveyed Kahikinui Forest Project, thereby providing important information about the distribution of petrels on Maui. Second, predator management will increase survival and reproduction of petrels, thus changing the population growth rate and the probability that the species will move toward recovery. Third, anecdotal evidence from Haleakalā National Park indicates that when predator and ungulate control is implemented, the population appears to increase. Auwahi Wind is using population models to provide an estimate of the number of burrows required to mitigate for potential Project. ITP/ITL

6.3.1 Survey Activities

6.3.1.1 Spring 2011 Reconnaissance Surveys

Auwahi Wind conducted an initial 2-day reconnaissance survey of the Kahikinui Forest Project in April 2011. The purposes of this survey, which was knowingly conducted prior to the start of petrel nesting activity, were to determine 1) whether petrel nesting is occurring in the Kahikinui Forest Project (something that has been suspected but never previously verified); 2) identify general areas within the Kahikinui Forest Project where petrel burrows are located; and 3) identify specific burrows with active or old signs of petrel use. The reconnaissance survey confirmed that petrels are nesting in the Kahikinui Forest Project; surveyors identified 18 burrows with active or old sign of petrel use (e.g., droppings, egg shell fragments, feathers, or tracks) and an additional 10 burrows without obvious petrel sign ; (Figure 6-5).

6.3.1.2 Summer 2011 Focused Surveys

In June and July 2011, Auwahi Wind will conduct focused petrel surveys in the Kahikinui Forest Project. During this summer period, petrels will have returned to the breeding colony, enabling Auwahi Wind to verify the location of currently active petrel burrows, and then delineate an area within the Kahikinui Forest Project that contains a sufficient number of currently active burrows that can effectively be managed to improve breeding success.

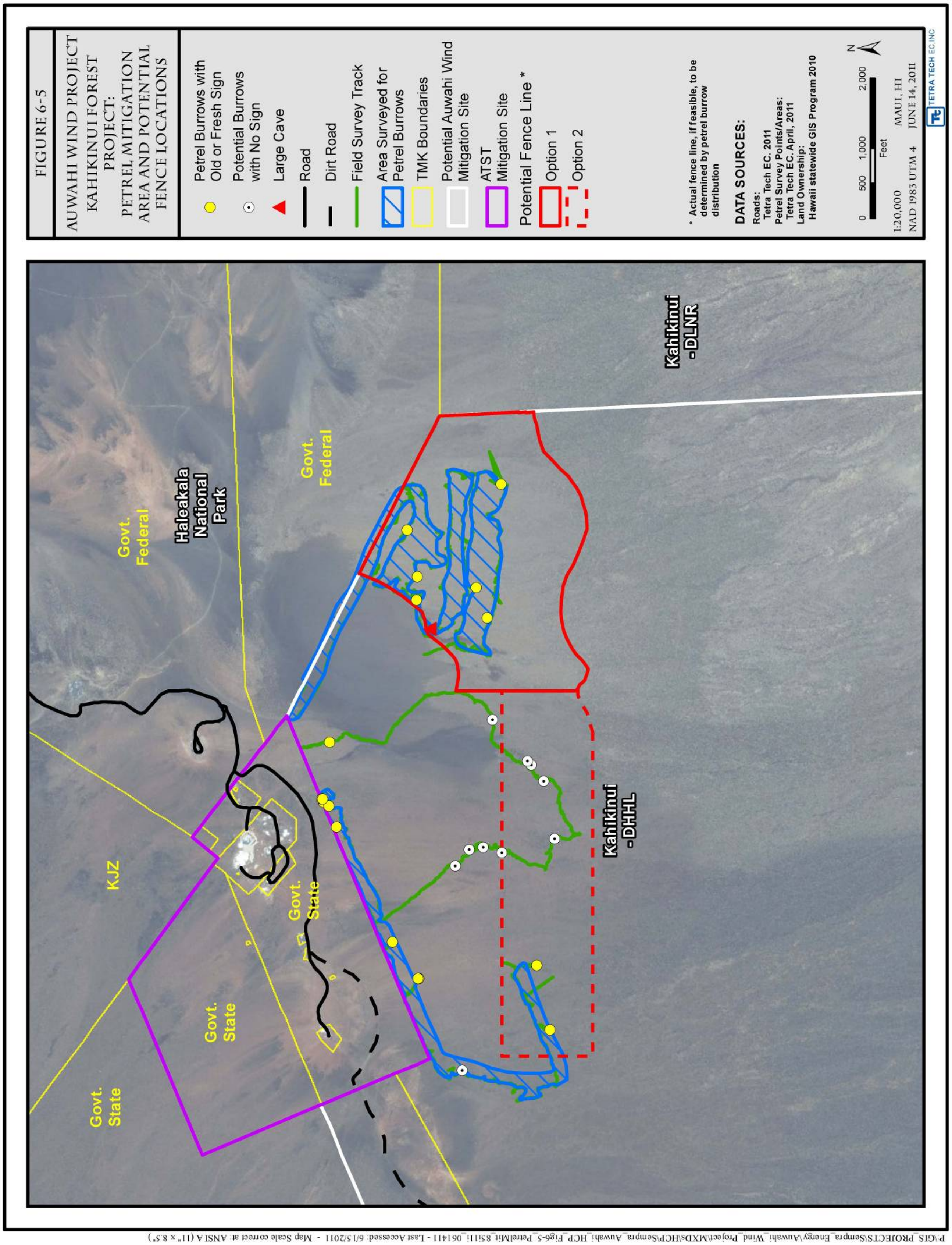
FIGURE 6-5
AUWAHI WIND PROJECT
KAHIKINUI FOREST PROJECT:
PETREL MITIGATION AREA AND POTENTIAL FENCE LOCATIONS
Petrel Burrows with Old or Fresh Sign
Potential Burrows with No Sign
Large Cave
Road
Dirt Road
Field Survey Track
Area Surveyed for Petrel Burrows
TMK Boundaries
Potential Auwahi Wind Mitigation Site
ATST Mitigation Site
Potential Fence Line *
Option 1
Option 2
* Actual fence line, if feasible, to be determined by petrel burrow distribution
DATA SOURCES:
Roads:
Tetra Tech EC. 2011
Petrel Survey Points/Areas:
Tetra Tech EC. April, 2011
Land Ownership:
Hawaii statewide GIS Program 2010
0 500 1,000 2,000
Feet
N
1:20,000
NAD 1983 UTM 4
MAUI, HI
JUNE 14, 2011
TETRA TECH EC, INC
Haleakala National Park
Govt. Federal
Govt. Federal
Kahikinui -DLNR
Kahikinui -DHHL
KJZ
Govt. State
Govt. State
Govt. State
P:\GIS_PROJECTS\Sempra_Energy\Auwahi_Wind_Project\MXDs\HCP\Sempra_Auwahi_HCP_Fig6-5_PetrelMit_85x11_061411 - Last Accessed: 6/15/2011 - Map Scale correct at: ANSI A (11" x 8.5")

6.3.2 Determination of Size of Petrel Colony to be Managed

To provide information on the number of petrel burrows over which to manage predator control, a deterministic matrix model was used to model how the changes in vital rates due to predator control impact the population growth rate. This simple model is commonly used in population ecology to calculate the population growth rate (i.e., lambda) using stage-specific information on survival and reproduction. A lambda value of 1 indicates a stable population, less than 1 a declining population, and greater than 1 an increasing population.

Auwahi Wind created a 7-stage matrix model where stage 1 represents the young that survive their first year, stages 2 through 6 represent non-breeding juveniles, and stage 7 represents breeding adults (Figure 6-6). Auwahi Wind used demographic values provided by the USFWS (Greenlee pers. comm. 2011) to represent vital rates under baseline conditions and when petrels are protected by predator control (Table 6-4).

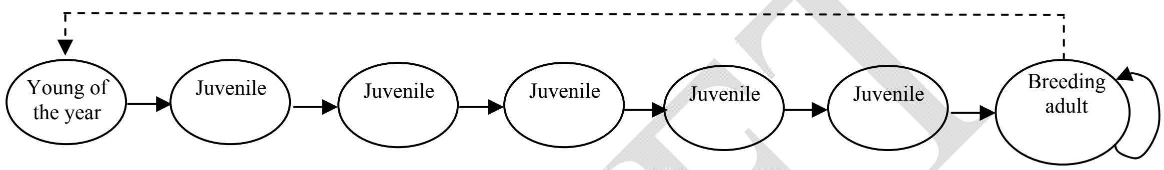

Figure 6-6. Visualization of a Hawaiian Petrel Matrix Model

Note: Solid arrows represent survival between and within stages and the dashed arrow represents reproduction.

6.3.3 Estimation of Timing of Predator Control Benefits

Auwahi Wind evaluated population and net benefit projections under scenarios with and without predator control as followings:

1. **Estimate the starting size of the breeding population (i.e., population at time T):** Auwahi Wind first estimated the number of active burrows that might be found on the mitigation sites and then adjusted this number to reflect the number of breeding pairs. The number of breeding pairs is equal to the number of breeding females, which is the starting size of the breeding population.
2. **Estimate population size over the Project's operation period of 20 years (i.e., population size at time T+1):** For the first year, Auwahi Wind took the starting size of the breeding population and multiplied it by lambda to generate the population size in the following year (T+1). For each subsequent year, Auwahi Wind took the population size in each subsequent year and multiplied it by lambda.
3. **Compare the difference between the population size with and without predator control:** For each year, Auwahi Wind calculated the net benefit by taking the difference in the number of females in the current (unmanaged) population versus in the predator controlled population. This value was then multiplied by two to represent the difference in the overall population (i.e., males and females).
4. **Determine how many years of predator control are required:** Based on the number of petrels needed for each tier, Auwahi Wind then identified the year of the permit term at which predator control reaches a net benefit.

Tetra Tech performed an iterative series of analyses and determined that implementing a predator-control plan for a population of 25 breeding pairs (33 active burrows) will provide a net benefit sufficient to mitigate all potential take at the Tier 1 and Tier 2 levels (Table 6-5a). Predator control for a population of 48 breeding pairs (64 active burrows) will provide a net benefit sufficient to mitigate take at the Tier 3 level over the life of the permit (Table 6-5b). Tetra Tech has evaluated mitigation based on a 20 year period because this is likely to be the period when the wind farm is in operation.

Table 6-4. Vital Rates used in the Population Model for Current Condition and Anticipated Conditions Under Predator Control and the Associated Population Growth Rate (Lambda)

	Survival - Breeding Adults	Survival - Juvenile	Fledglings per Female	Female Fledgling per female	Lambda
Baseline vital rates	0.850	0.8034	0.55	0.275	0.939
Anticipated vital rates with predator control	0.930	0.8034	0.60	0.300	1.000

6.3.4 Immigration

All population models rely on key assumptions. In the population projections based on the deterministic matrix models, Auwahi Wind assumed that the mitigated population was closed (i.e., no emigration or immigration) in order to calculate lambda. However, given the active Haleakalā National Park population adjacent to this population, this assumption is likely to be violated, as has been found in other seabird populations experiencing cat predation (Bonnaud et al. 2009). Therefore, our estimate is likely to be conservative because petrels may "wander" or "prospect," visiting a number of potential breeding sites, including established colonies, former breeding sites, and uncolonized sites. The presence of breeding birds has shown to be one of the strongest indicators that a potential breeding site is both safe and productive (Podolsky and Kress 1989). Thus, assuming that the managed Haleakalā breeding population serves as a source population for peripheral breeding colonies, it is likely that pre-breeders from Haleakalā may prospect and ultimately be recruited to the Kahikinui Forest Project colony and vice versa.

Predator control would both protect and enhance the existing colony at the Kahikinui Forest Project, and therefore immigration into and out of the population over time would likely increase over the term of the ITP/ITL.

Table 6-5a. Population and Net Benefit Projections under baseline (unmitigated population; $\lambda = 0.939$) and predator control (mitigated population; $\lambda = 1.000$) scenarios needed to mitigate for Tiers 1 and 2

	Population Size (Number of Females)		**Net Benefit**	**Total Net Benefit**	
Year	**Baseline**	**Predator Control**	**Females**	**Males + Females**	**Tier**
1	19.8	24.8	5.0	9.9	
2	18.6	24.7	6.1	12.3	
3	17.5	24.7	7.2	14.5	
4	16.4	24.7	8.3	16.5	
5	15.4	24.6	9.2	18.5	
6	14.5	24.6	10.1	20.3	
7	13.6	24.6	11.0	22.0	Tier 1 achieved
8	12.8	24.6	11.8	23.6	
9	12.0	24.5	12.5	25.1	
10	11.2	24.5	13.2	26.5	
11	10.6	24.6	13.9	27.8	
12	9.9	24.4	14.5	29.0	
13	9.3	24.4	15.1	30.2	
14	8.7	24.4	15.6	31.3	
15	8.2	24.3	16.1	32.3	
16	7.7	24.3	16.6	33.2	
17	7.2	24.3	17.0	34.1	
18	6.8	24.3	17.5	35.0	
19	6.4	24.2	17.8	35.7	
20	6.0	24.2	18.2	36.4	Tier 2 achieved

Table 6-5b. Population and Net Benefit Projections under baseline (unmitigated population; $\lambda = 0.939$) and predator-control (mitigated population; $\lambda = 1.000$) scenarios needed to mitigate for Tiers 1 through 3

	Population Size (Number of Females)		Net Benefit	Total Net Benefit	
Year	Baseline	Predator Control	Females	Males + Females	Years of Predator Control and Tier
1	39.6	49.5	9.9	19.8	
2	37.2	49.4	12.3	24.5	Tier 1 achieved
3	35.0	49.4	14.5	29.0	
4	32.8	49.3	16.5	33.1	
5	30.8	49.3	18.5	37.0	Tier 2 achieved
6	29.0	49.2	20.3	40.6	
7	27.2	49.2	22.0	44.0	
8	25.5	49.1	23.6	47.2	
9	24.0	49.0	25.1	50.2	
10	22.5	49.0	26.5	53.0	
11	21.1	49.0	27.8	55.6	
12	19.8	48.9	29.0	58.0	
13	18.6	48.8	30.2	60.3	
14	17.5	48.7	31.3	62.5	
15	16.4	48.7	32.3	64.5	
16	15.4	48.6	33.2	66.4	
17	14.5	48.6	34.1	68.2	
18	13.6	48.5	35.0	69.8	
19	12.8	48.5	35.7	71.4	
20	12.0	48.4	36.4	72.8	Tier 3 achieved

Note: Using numbers from Simons 1984 (higher numbers) because those were developed based on trapping. Can expect even higher numbers with a predator fence.

6.3.5 Breeding Colony Habitat Management and Predator Control

Predator control has a positive impact on the survival of adult and young petrels and can be accomplished through trapping or installation of predator-proof fencing. Even an individual predator can be extremely destructive to a population of colony-nesting seabirds given the long lifespan, low annual productivity, and other reproductive characteristics of these species which make the replacement of depredated adults a slow process (Simons 1984). Predation accounted for approximately 41 percent of all bird and egg fatalities documented between 1961 and 1996 in Haleakalā National Park (Hodges and Nagata 2001). Similarly, annual monitoring of nests at Haleakalā National Park has shown that predation by cats and mongooses causes more than 60 percent of all egg and chick mortality in some years (Simons 1998 as cited in Carlile et al. 2003). Rats also prey upon Hawaiian petrels and their eggs. Predator removal has been shown to both improve petrel nesting activity and nesting success, as well as adult survival (Hodges and Nagata 2001). Simons (1984, 1985) found that annual adult survival ranged from 0.80 with extreme predation to 0.93 when the adults were undisturbed.

This plan will incorporate the logistical details about implementing mitigation and monitoring.

Mitigation will either be based on the installation of a predator-proof fence or predator trapping, the details of which will be outlined in a separate petrel management plan which will be created and finalized by Fall 2012. The final mitigation option will be chosen after the summer petrel survey because the spatial arrangement of active petrel burrows will dictate which option is logistically feasible (i.e., costs, topographical challenges, weather-related fencing concerns, access concerns, visual resources concerns). Auwahi Wind will initiate predator control on the parcel of the Kahikinui Forest Project that contains the required number of burrows for both Tier 1 and Tier 2 to ensure a net benefit, as demonstrated by the population projection, and may include Tier 3 depending on burrow distribution. Based on the reconnaissance survey, Auwahi Wind estimates that an area of approximately 200 acres ultimately will be managed pursuant to this HCP (Figure 6-5, Option 1). A second option was also depicted on Figure 6-5 to account for a likely worst-case scenario with respect to potential environmental impacts. The actual boundary of the fence within the Kahikinui Forest Project, if used, that will be managed will be delineated based on the results of these summer focused surveys and will be included in the Final HCP.

If the fencing option is implemented, the fence will be 6-7 ft above ground level with three strands of white polytape incorporated into the fence where the fence poses a potential flight hazard to seabirds (e.g., ridge lines). Eradication of predators within the fence line will be conducted using live traps on a 250-meter grid or other appropriate arrangement during the breeding season for 1 to 2 years until eradication is complete. Given that frequent trap checks must be conducted to ensure the welfare of trapped animals and avoid take of seabirds, and that regular physical checks by foot may not be feasible due to the remoteness of the site, traps would be fitted with a telemetered trap-signaling device. This system, which involves fitting each trap with a radio transmitter, battery, and antenna, enables remote daily trap checking via reception of a radio signal. The absence of a radio signal indicates a sprung trap or an equipment failure requiring maintenance (Benevides et al. 2008). During the non-breeding season, alternative methods such as hunting may be used to complete the eradication if necessary. Based on NPS experience, up to 2 years of this intensive cat and mongoose control may be necessary to complete the initial eradication of these species within the fence line (Greenlee pers. comm. 2011). If predator-proof fencing is installed, the fence will provide predator control for the life of the Project, and therefore benefits will continue over 20 years.

If consultations with fencing experts indicate that construction of a fence around the petrel colony is not feasible due to topographic or other constraints, Auwahi Wind will initiate predator trapping within the colony. Based on conversation with the USFWS, predator trapping alone may require more burrows to achieve a net benefit than with the installation of a predator-proof fence. If the trapping-only option is implemented, trapping and monitoring protocols will follow the protocols established by the NPS for managing the Haleakalā National Park colony (Bailey pers. comm. 2010; Hodges and Nagata 2001). As outlined above, trapping will be conducted using live traps on a 250-meter grid or other appropriate arrangement. Traps will either be checked to ensure the welfare of trapped animals and avoid take of seabirds or traps will be fitted with a telemetered trap-signaling device. Trapping will be conducted for 20 years unless results indicate trapping is no longer required for this population. In addition, the benefits of trapping are likely to carry beyond the trapping period because of the time delay before additional cats and mongoose move into the area (Bailey pers. comm. 2010).

The timeline for implementing petrel mitigation is outlined in Table 6-6.

A draft petrel management plan and monitoring design will be provided to USFWS and DOFAW prior to the issuance of the ITP. The plan will be finalized within 1 year of commercial operation. Updates on this management plan will be provided as part of the annual report.

Table 6-6. Petrel Mitigation Timeline

Date	Event
Summer 2011	Petrel burrow surveys
Fall 2011	Identify specific mitigation area and predator control method
March 2012	Project construction initiated
Fall 2012	Finalize petrel management plan
December 2012	Project in commercial operation
Winter 2012-2027	Initiate and execute predator management and monitoring

6.3.6 Monitoring

Burrows will be monitored following NPS methods. Auwahi Wind will evaluate the number of active burrows and reproductive success on their mitigation parcel. Monitoring will occur annually for the first 3 years. An additional 5 years of monitoring will occur at certain points during the life of the mitigation. Actual survey years will depend on information gathered from the initial 3 years and other information gained about petrel biology.

6.3.7 Net Benefit

The Kahikinui Forest Project is a long-term effort that, among other goals, seeks to protect and enhance existing petrel colonies, and create and restore petrel habitat on Maui. Largely through the implementation of predator control measures within the Kahikinui Forest Project, Auwahi Wind's mitigation strategy is projected to result in the net production of individual adult petrels within 20 years of mitigation initiation, thereby offsetting potential take. A net benefit to the species will be realized by these mitigation efforts because new immigrating adults recruiting into the focal colony will be producing offspring that have not been accounted for in the population projections. In addition, components of the mitigation efforts (e.g., installation of predator-proof fencing and predator eradication) may continue to benefit the focal colony beyond the term of the ITP/ITL.

The assessment of potential impacts (Section 5.2) assumes that all WTGs will operate continuously (24 hours a day, 7 days a week), and the proposed mitigation measures are based on those potential impacts. However, the WTGs are expected to be curtailed (turned off) on a regular basis between approximately 11pm and 6am (or 29 percent of a 24-hour day) due to the low demand for power from MECO during that time period. This time period partially overlaps with the timing of peak petrel movement activity through the Project (Hamer 2010a). As a result, the actual amount of take caused by the WTGs likely will be less than estimated in this HCP.

6.3.8 Costs

Costs and estimated time of payment for the petrel mitigation measures described above are provided in Table 6-2. Costs for installation of a predator-proof fence, eradication, and monitoring were based on conducting these activities for an approximately 200-acre parcel. Ultimately the location, length, and configuration of the fence and the configuration of the trapping grid will depend on the distribution of burrows within the colony, topographic and substrate characteristics of the site, and other logistics with the objective being to avoid any adverse impacts to the colony. Monitoring costs were based on parameters provided by the LHWRP and the NPS. Auwahi Wind will initiate petrel mitigation activity within 30 days. Once the required net benefit is achieved for each tier outlined above, Auwahi Wind will be deemed to have fulfilled mitigation requirements for the Hawaiian petrel.

6.3.9 Contingencies

As discussed in section 6.2.5 above, mitigation levels were established based upon a 24-hour operation of the wind farm for the life of the Project but such operation will almost certainly not take place. Instead, the WTGs are expected to be curtailed (turned off) during the night. As a result, the probability of triggering Tier 3 mitigation is expected to be low. Moreover, in the event that the Kahikinui Forest Project parcel does not contain a sufficient number of burrows to satisfy mitigation requirements for Tier 1, or if measured benefits are not enough to cover take under Tiers 2 or 3, should these levels be triggered, Auwahi Wind will focus mitigation efforts on one or more of the alternate mitigation sites described below, in consultation with the USFWS and DOFAW (Sections 6.3.7.1-6.3.7.4). Selection of site and mitigation focus will depend on agency recommendations and timing, such that Auwahi Wind mitigation activities will integrate with and enhance ongoing management actions at the selected site.

6.3.9.1 ATST Mitigation Site

If the predator control cannot be implemented or if Tier 3 mitigation is required, Auwahi could assume management of the ATST mitigation parcel after their mitigation responsibilities have been met (ATST 2010). The ATST site is located on the leeward slope of Haleakalā adjacent to the Kahikinui Forest Project parcel and currently supports 164 burrows (Greenlee pers. comm. 2011). As described in the ATST HCP, the ATST mitigation area will be fenced with ungulate-proof fence, ungulates removed from within the fence line, and predator control and monitoring efforts completed. Predator control consists of short-term cat trapping and rodent control around the petrel colony (ATST 2010). The ATST HCP assumes that with the implementation of these mitigation measures a net benefit for petrel take under the associated ITP/ITL will be reached 6 to 10 years after construction. At that point, the ATST project would no longer be required to continue cat trapping and burrow monitoring efforts. Under this alternative scenario Auwahi Wind would take over these mitigation activities at the ATST site once a net mitigation benefit for that project has been reached. This alterative could be implemented if Tier 3 mitigation is required. It is assumed that annual fence monitoring, burrow monitoring, and predator control would be comparable to annual costs established for the Kahikinui Forest Project. The duration of ongoing maintenance and monitoring would be determined based on the level of mitigation required in coordination with the USFWS and DOFAW.

6.3.9.2 ATST Mitigation Site – Fence Modification

Another alternative if the predator control at Kahikinui Forest Project cannot be implemented is that Auwahi Wind will provide funding to upgrade the ungulate fencing to predator control fencing. If ATST's 164 burrows are fenced, then there will be an increase in petrels during the first 10 years above that expected from predator trapping as modeled by ATST when using vital rates suggested by USFWS (Greenlee pers. comm. 2011).

6.3.9.3 Additional Management Activities at the Kahikinui Forest Project

If additional mitigation is required for Tier 3, Auwahi Wind will consider implementing rat control at the Kahikinui Forest Project in order to increase the reproductive success of the petrels, thereby reducing the number of active burrows required for mitigation. If this contingency is implemented, Auwahi Wind assumes it would be covered by the Programmatic EIS currently in preparation to permit broadcast rodenticide application. Broadcast aerial rodenticide is expected to be more effective and result in fewer disturbances to petrel colonies than maintaining a rat bait grid (Greenlee pers. comm. 2011). Under this contingency, approximately $50,000 would be provided for a one-time application of aerial rodenticide at the colony and a surrounding 1,000 meters buffer. Subsequent years of rodenticide use may be needed.

6.3.9.4 Haleakalā National Park

Another alternative for petrel mitigation would be to provide funding or assist the NPS with management and monitoring efforts of the Hawaiian petrel colony in the crater or another more remote location within Haleakalā National Park. Under this option, Auwahi Wind would contribute funds toward or assist with implementing predator control and monitoring. Trapping and monitoring protocols will follow the protocols that have already been established by the NPS for managing the colony and being implemented (Hodges and Nagata 2001; Bailey pers. comm. 2010). Annual costs are assumed to be comparable to those established for the Kahikinui Forest Project.

6.3.9.5 DOFAW Pooled Partnership Funding

Should a DOFAW pooled-partnership restoration funding opportunity for petrel mitigation at the Kahikinui Forest Project become available during the term of this HCP, Auwahi Wind will also consider contributing an agreed-upon amount to the partnership in lieu of petrel mitigation at the Kahikinui Forest Project.

6.3.10 Contingency Funds

Auwahi Wind will establish a $250,000 cost overrun contingency fund for the petrel for the mitigation described for Tiers 1–3, if needed, to ensure the funds are available should actual costs be higher than estimated here. The funding will be provided in the form of a letter of credit, guarantee, or similar financial instrument.

6.4 NĒNĒ

The recovery plan for nēnē (USFWS 2004) lists protection and management of habitat, research, establishment of additional populations, captive breeding, and outreach and education as recovery actions needed to address these limiting factors. Therefore, as recommended by USFWS and DOFAW, Auwahi Wind will contribute $25,000 to DOFAW to conduct predator control at Haleakalā Ranch or to the NPS to support egg and gosling rescue at Haleakalā National Park. Predator control at Haleakalā Ranch will help DOFAW establish the nēnē being introduced to this area. Nēnē are particularly vulnerable to predation during nesting and before the goslings fledge. The nēnē population at Haleakalā National Park is subject to high predation of eggs and goslings. In addition, because of adverse weather conditions at Haleakalā National Park, many eggs and goslings are lost to inclement weather. Funds to support egg and gosling rescue at Haleakalā National Park would help the NPS better address these issues. This contribution of $25,000 is commensurate with the requested take of 5 nēnē over the 25-year permit term. These management activities will contribute to reversing trends in the declining nēnē population, and therefore will provide a net benefit to the species.

6.5 BLACKBURN'S SPHINX MOTH

6.5.1 Mitigation Plan

Auwahi Wind anticipates that direct impacts to larvae and adult Blackburn's sphinx moths will be avoided to the maximum extent possible but that indirect impacts to individuals could occur. Mitigation for Blackburn's sphinx moth was developed based on permanent habitat impacts. This proposed mitigation is consistent with the measures identified in the USFWS' recovery plan for this species (USFWS 2005c). The specific mitigation measures and calculations for mitigation impacts are outlined below.

The Recovery Plan lists planting of ‘aiea as a conservation action for the Blackburn’s sphinx moth (USFWS 2005c). Therefore, Auwahi Wind will provide funding to the LHWRP for ‘aiea outplanting in the Auwahi Forest Restoration Project, where the moth is already known to occur (USGS 2006). The LHWRP will restore dryland forests, which will benefit native wildlife in general, and will enhance fitness for Blackburn’s sphinx moth by planting approximately 250 stems of ‘aiea per acre of mitigation.

Mitigation calculations were based on Blackburn’s sphinx moth and botanical surveys conducted in March and April 2011 (see Section 5.4 for details).

Impacts of the project to Blackburn’s sphinx moth occur on degraded habitats, some of which include remnant native plants. Pursuant to guidance from the USFWS, impact acreage was separated into either permanent disturbance based on the presence or absence of native plants adjacent to the permanent impacts (Greenlee pers. comm. 2011). Based on this separation, Auwahi Wind will mitigate by providing funding to restore native host trees at a ratio of 0.2 restored acre (0.08 ha) for every acre of permanent impact to vegetative areas adjacent to areas where native plants are absent. Thus, the 27.7 acres (11.2 ha) of permanent impact will result in 5.5 acres (2.2 ha; 27.7 acres x 0.2 = 5.5 acres) of mitigation. Vegetative communities adjacent to native host plants will be mitigated at the rate of 2 acres (0.8 ha) for every acre of permanent impact. Thus, the 0.3 acres of permanent impact will result in 0.6 acre (0.2 ha; 0.3 acres x 2 = 0.6 acre) of mitigation for a total of 6 acres (2 ha) of habitat restoration.

Auwahi Wind will provide $144,000 (6 acres x $24,000 per acre, Table -2) to the LHWRP to restore 6 acres (2 ha) of dryland forest at the Auwahi Forest Restoration Project. The restoration of native habitat at the Auwahi Forest Restoration Project will mitigate any potential direct or indirect impacts associated with the Project and will provide a net benefit for the Blackburn’s sphinx moth by protecting and enhancing suitable habitat. The initial payment for the first 3 acres of restoration will be made to the LHWRP within 30 days of permit issuance and the remaining funds paid by year 2. The 6 acres would be planted within 3 years of the payment to the LHWRP. Once payment is made to LHWRP, Auwahi Wind will be deemed to have fulfilled mitigation requirements for the Blackburn’s sphinx moth.

6.5.2 Net Benefit

The mitigation will provide a net benefit because the noxious tree tobacco is being replaced by the native ‘aiea. ‘Aiea is considered superior to the non-native host plant because it is more resistant during drought conditions and is longer lived than tree tobacco (USFWS 2005). In addition, the ‘aiea will be planted in the Auwahi Forest Restoration Project, which provides a variety of nectar species, including those used by the yellow-faced bee. Through natural regeneration on this land, benefits from this mitigation should occur beyond the lifespan of this Project.

7.0 MONITORING AND REPORTING

Monitoring and reporting will address legal compliance with the provisions and take limitations of the HCP and the associated ITP/ITL, and effectiveness of the mitigation efforts. Monitoring will ensure that the authorized levels of take are not exceeded, and that the effects of take are minimized and mitigated as outlined in the HCP. Monitoring will also assess the success of the HCP's mitigation program. The HCP's adaptive management strategy (Section 9.6) provides a mechanism for modifying or adding minimization measures or adjusting mitigation as deemed necessary by monitoring results. Annual reports will be provided to USFWS and DLNR to allow them to independently verify that Auwahi Wind has performed required tasks and activities according to the provisions of the HCP. As part of agency compliance monitoring, DOFAW may work in cooperation with Auwahi Wind to participate in post-construction monitoring activities in a manner mutually agreeable to both parties.

7.1 PROJECT-SPECIFIC TAKE

7.1.1 Monitoring Direct Take

A post-construction monitoring plan (PCMP) will be implemented as a means to document impacts to the Covered Species as a result of operation of the Project, and to ensure compliance with the authorized provisions and take limitations of the HCP and the associated ITP/ITL (Appendix D). The monitoring protocol is consistent with post-construction monitoring being conducted, or proposed, for other wind projects in Hawai'i and elsewhere in the continental United States (Erickson et al. 2004; Arnett 2005; Kerns et al. 2005; KWP 2008, 2009; Tetra Tech 2008; Arnett et al. 2009; SWCA 2010). Any changes to the protocol from the baseline provided herein would require review and approval by USFWS and DLNR.

Key components of the post-construction fatality monitoring plan include:

- Use of Auwahi Wind technical staff and/or third-party contractors trained by experienced biologists with expertise in wind turbine-bird/bat interaction studies and implementing wind energy post-construction monitoring protocol;
- Standardized carcass searches conducted during the initial 2-year post-construction monitoring period under the operating wind turbines approximately once per week from March through September and then two times per week during the petrel fledging period in October and November (8-week period). In December to February, surveys will be conducted monthly and thereafter as determined necessary based upon the initial monitoring. Search intensity may be modified based on the result of the initial monitoring period;
- Carcass removal and searcher efficiency trials to adjust observed fatality numbers for bias associated with the removal of carcasses by scavengers or other means and the ability of searchers to locate carcasses, respectively;
- A Wildlife Education and Incidental Reporting Program for reporting incidental observations of Project-related fatalities within the wind farm site and the generator-tie line made by onsite staff;
- Downed Wildlife Protocol for the recovery, handling, and reporting of downed wildlife (Appendix D); and

- After the initial 2 years of monitoring, monitoring efforts may be reduced in frequency if available data suggest a low frequency or potential for fatalities of Covered Species (Appendix D). The Wildlife Education and Incidental Reporting Program will supplement the post-construction mortality monitoring to report potential wildlife injuries or fatalities.

The Wildlife Education and Incidental Reporting program will be executed for contractors, Project staff members, and other 'Ulupalakua Ranch staff who are on site on a regular basis. Staff members will be provided with printed reference materials that include: photographs of each of the Covered Species and information on their biology and habitat requirements; threats to the species onsite; and measures being taken for their protection under this HCP. This training enables staff to identify the Covered Species that may occur in the Project area, record observations of these species, and take appropriate steps for documentation and reporting when any Covered Species is encountered during construction or operation of the Project including when downed birds or bats are found. The Wildlife Education and Incidental Reporting program will facilitate incidental reporting of observations within the wind farm site, as well as within the generator-tie line corridor where Auwahi Wind and 'Ulupalakua Ranch staff are regularly present during the course of normal Project and ranch operations. Incidental reporting will inform the Project post-construction monitoring program (Appendix D) of any wildlife fatalities that occur outside of standardized fatality surveys within the Project, as well as provide supplementary information on impacts associated with the generator-tie line where standardized post-construction monitoring will not occur. The program will be prepared by a qualified biologist and will be approved in advance by the USFWS and DOFAW. Over the term of this HCP, the program will be updated as necessary.

The protocol for recovery, handling, and reporting of downed wildlife has been developed in cooperation with the USFWS and DOFAW. Regular Project staff will be trained in this protocol during the wildlife education briefings and will be responsible for documenting observed fatalities or injury to wildlife. The USFWS and DOFAW will be notified promptly upon discovery of an injured or dead state- or federal-listed species. The Downed Wildlife Protocol is included in the Project post-construction monitoring plan (Attachment 1 of Appendix D). This protocol includes:

- Procedures to follow upon the discovery of a downed seabird or bat including a prioritized contact list of DOFAW and USFWS staff; and
- Guidelines for handling, if permitted, injured wildlife or carcasses.

Federal- or state-listed species found injured or dead will be left in place for collection by USFWS or DOFAW personnel or collected and frozen if directed by USFWS or DOFAW. Non-listed species may be collected by staff members included on the USFWS Special Purpose Permit and the DOFAW Protected Wildlife Permit issued for the Project, which grant permission and include provisions for handing native wildlife.

7.1.2 Estimating Indirect Take

Monitoring of direct take will also be used to assess Project-related indirect take. It is assumed that take of an adult seabird or bat during the breeding season may result in the indirect loss or take of a dependent young. Thus, for every seabird or bat carcass detected during the breeding season, modifiers will be applied to estimate indirect take to account for the likelihood that a given adult is reproductively active, the likelihood that the loss of a reproductively active adult results in the loss of its young, and average reproductive success (Section 5.2).

7.2 Non-Fatality Monitoring

7.2.1 Hawaiian Hoary Bats

Monitoring for Hawaiian hoary bats will occur at both the Project site and the mitigation site. Auwahi Wind will conduct bat acoustic monitoring during the first 2 years of operation at the Project. Monitoring at the mitigation site will be accomplished by using radio telemetry of Hawaiian hoary bats (Section 6.2.2, Tier 2 Mitigation).

7.2.2 Hawaiian Petrels

Petrel burrows will be monitored following methods used by NPS. Auwahi Wind will evaluate the number of active burrows and reproductive success on their mitigation parcel. Monitoring will occur annually for the first 3 years. An additional 5 years of monitoring will occur at certain points during the life of the mitigation. Actual survey years will depend on information gathered from the initial 3 years and other information gained about petrel biology.

7.3 Reporting

Auwahi Wind will prepare and submit annual reports summarizing the results of post-construction monitoring and mitigation conducted to date. Report components will include:

- A summary of post-construction fatality monitoring conducted to date including a description of survey protocol implemented, any adjustments made subsequent to the previous reporting period, and a summary of turbine operational parameters;
- A summary of direct take, including both observed and adjusted levels, for each species and associated indirect take calculations;
- A summary of other downed wildlife documented and incidental observations (fatalities documented independently of the standardized searches);
- Results of the carcass removal and searcher efficiency trials;
- A discussion of the efficacy of the current monitoring protocols and whether or not adjustments need to be made;
- A summary of HCP mitigation efforts conducted to date and the success of these efforts based on the results of mitigation monitoring;
- Recommended changes to the mitigation plan, if any, based on the results of mitigation monitoring; and
- A discussion of changed circumstances or adaptive management measures, if necessary.

Annual reports will be submitted to the USFWS and DOFAW by August 31 of each year to coincide with DOFAW's fiscal year end. Auwahi Wind will confer with the USFWS and DOFAW following the submittal of the annual report to review the results and discuss future HCP implementation issues. Annual reports will also be made available to the ESRC.

In accordance with the Project Downed Wildlife Protocol (Attachment 1 of Appendix D), USFWS and DOFAW biologists will be notified by phone within 24 hours of the discovery of a dead or injured individual of the Covered Species. A Downed Wildlife Incident Report (Attachment 3 in Appendix D) will be filed within 3 business days and cumulative adjusted take will be reported to the USFWS and DOFAW within 3 weeks. All non-covered avian species will be documented, following the protocol for downed Covered Species. Auwahi Wind will consult with the USFWS and DOFAW to review the results of post-construction monitoring annually in relation to anticipated maximum anticipated take limits to assess how close the Project is to exceeding established tiers, and will discuss changed circumstances or adaptive management measures as necessary.

8.0 ALTERNATIVES

Section 10(a)(2)(A)(iii) of the ESA requires that alternatives to the incidental take of listed species be considered and that reasons such alternatives are not implemented be discussed. The following section describes alternatives that were evaluated during the selection of the proposed Project design.

8.1 ALTERNATIVE 1: NO ACTION ALTERNATIVE

Under the federal No Action alternative, Auwahi Wind would not be granted the ITP and thus the Auwahi Wind Project would not be constructed or operated. Under this alternative, there would be no additional impact to the Covered Species as no project component would be built. The Ulupalakua Ranch would continue current operations and there would be no change to the existing on-site conditions, nor risk to the Covered Species associated with collision with WTGs or other project structures.

8.2 ALTERNATIVE 2: PROPOSED ACTION

Based on high-resolution wind resource maps developed by the Hawaiʻi Wind Working Group (2004), the Auwahi parcel of ʻUlupalakua Ranch was identified as a suitable location for a wind farm project as it has a consistent wind power density regime. The Auwahi parcel is also located in a remote and undeveloped portion of the island, and is zoned for agriculture, within which wind farms are considered a compatible use. The Proposed Action is described in detail in Section 1.3 - Project Description.

8.3 ALTERNATIVE 3: OFF-ISLAND MITIGATION

Under the Off-island Mitigation Alternative mitigation for the Hawaiian petrel under the HCP would occur outside of Maui. Under this alternative, Auwahi Wind would provide funding to Hawaii Volcanoes National Park (HVNP) on Hawaii Island for management of the petrel colony at Mauna Loa. The main colony currently supports approximately 90 petrel burrows of which 60 are active; there are also two subcolonies totaling 30 active burrows that are currently unmanaged. Construction of a predator-proof fence around the main colony has been proposed but funding had not been secured (Hu pers. comm. 2011). If this alternative were executed, Auwahi Wind would provide funding to HVNP toward fence installation, based on the level of mitigation required in coordination with the USFWS and DOFAW, plus additional funding for annual monitoring and maintenance of the fence. If the fence were to be constructed by the time mitigation at the Mauna Loa site is needed, Auwahi Wind would consider providing funding to the HVNP to implement predator control and burrow monitoring at the two outlying subcolonies. The duration of predator control and burrow monitoring required for Auwahi Wind under this alternative would be determined based on the level of mitigation required in coordination with the USFWS and DOFAW.

This alternative was initially considered because Mauna Loa supports a sufficient number of petrel burrows for mitigation activities to produce the required benefits to compensate for the requested take authorization, and it is already the subject of an established petrel management program. Thus it provided a level of comfort in that there is an existing level of knowledge of the population. However, the USFWS and DOFAW concluded that because take authorization under the ITP would impact the Maui petrel population, mitigation directly aimed at benefiting petrels on Maui was more appropriate. Therefore, the Off-island Mitigation Alternative is not considered further here.

8.4 ALTERNATIVE 4: ALTERNATE PROJECT SIZES

The state EISPN describes the variations in the generating capacity that have been considered throughout the planning phase of the proposed project. However, the amount of wind-generated energy that the existing electrical grid can accept is limited. Consequently, MECO has determined that the grid can accept no more than approximately 21 MW of energy, as is currently proposed. A further reduction in generating capacity would make the Project not economically feasible for Auwahi Wind.

As noted in Chapter 1 Auwahi Wind considered three WTG models: the 1.5-MW GE, 2.3-MW Siemens, and 3.0-MW Siemens models. The dimensions of the GE and Siemens WTGs differ, with tower heights of 262 ft (80 m) and blade lengths ranging from 135.3 to 166 ft (41.25 to 50.5 m). Total height from ground level to the tip of the blade would range from 398 feet (121.3 m) to 428 feet (130.5 m). The dimensions of the two Siemens WTGs are the same; however, the 3.0 WTG is a gearless direct-drive machine that is more efficient than the 2.3 WTG, which has a gear box. Due to their different capacities each WTG model would result in a different numbers of turbines required to meet the 21-MW generating capacity of the wind farm: 15 1.5-MW GEs, 10 2.3-MW Siemens, and 8 3.0-MW Siemens. Final turbine model selection was based on constructability, reliability, performance, and availability and minimization of impacts to threatened and endangered species. Ultimately, the 1.5-MW GE and 2.3-MW Siemens models were not selected because they would be less efficient and would require greater ground disturbance and therefore result in greater impacts on natural resources including birds and bats than the 3.0-MW Siemens model.

9.0 PLAN IMPLEMENTATION

9.1 RESPONSIBILITIES

This HCP will be administered by Auwahi Wind with guidance from USFWS and DLNR/DOFAW in addition to other experts in the area of conservation biology associated with other government agencies (e.g., NPS, USGS), academia, various conservation organizations or partnerships, and consulting firms. As appropriate, any issues that arise during plan implementation may be brought before the ESRC for consideration.

Auwahi Wind will meet with the USFWS, DLNR/DOFAW, and ESRC annually to provide an update on plan implementation, including the status and effectiveness of monitoring and mitigation efforts and observed levels of incidental take. These meetings will also provide an opportunity to consider the need for adaptive management measures or modifications to monitoring protocols or mitigation strategies. The USFWS, DLNR/DOFAW, and ESRC may request additional meetings should the need to discuss immediate concerns or questions arise.

9.2 SCOPE AND DURATION

The HCP is designed to authorize potential incidental take of four Covered Species as a result of construction and operation of the Project for a permit term of 25 years. The HCP and corresponding ITL and ITP may be amended or extended, if necessary, in accordance with then-applicable laws and regulations.

9.3 CHANGED CIRCUMSTANCES, UNFORESEEN CIRCUMSTANCES, AND NO SURPRISES POLICY

ESA regulations require that an HCP specify the procedures to be used for dealing with changed or unforeseen circumstances that may arise during the implementation of the HCP. The HCP Assurances ("No Surprises") Rule (50 CFR §17.22[b][5]) defines "unforeseen circumstances" and "changed circumstances" and describes the obligations of Auwahi Wind and USFWS. DLNR provides similar assurances, but without differentiating between Changed Circumstances and Unforeseen Circumstances. These assurances are specified in HRS Section 195D-23.

9.3.1 Changed Circumstances

Changed circumstances include those circumstances affecting a species or geographic area covered by a conservation plan or agreement that can reasonably be anticipated and planned for over the life of the project (50 CFR §17.3). For the Project, changed circumstances may include: the listing of a new species or delisting of one of the Covered Species; disease outbreaks in any listed species; wildfire, hurricanes, major storm events, or other natural disasters that may affect the Project area or mitigation sites; or changes in the prices of raw materials or labor. Procedures to respond to these scenarios are outlined below.

- In the event that a new species on Maui becomes listed, Auwahi Wind will evaluate the likelihood of incidental take of the species due to Project operation. If incidental take appears possible, Auwahi Wind will reinitiate consultation with the USFWS and DLNR/DOFAW to discuss whether mitigation measures in place provide a net benefit to the newly listed species or if additional measures are warranted. If warranted, Auwahi Wind would then seek coverage for the newly listed species under an amendment to the existing HCP. Should any of the Covered Species become delisted over the life of the Project, Auwahi Wind will continue to perform mitigation measures for that species in accordance with the HCP, unless the USFWS and DLNR/DOFAW agree that such actions may be discontinued.

- If a listed species that is not a Covered Species is translocated to the vicinity of the Project by the USFWS or DOFAW or pursuant to their approval, thereby creating the potential for take of that listed species that did not previously occur, Auwahi Wind will consult with USFWS and DLNR should take occur, but no additional mitigation or operational restrictions would be required by Auwahi Wind.
- Disease is not considered a major threat to the Covered Species. Hawaiian petrel chicks have been found to have mild symptoms of avian pox, but no disease outbreaks have been documented. Should a disease become prevalent and be identified as a threat to the survival of a Covered Species by the USFWS and DLNR/DOFAW, Auwahi Wind will consult with these agencies to determine whether changes in monitoring, mitigation or other aspects of HCP implementation are necessary to provide assistance in documenting or reducing the impact of the disease. Such changes would be funded under the existing HCP implementation budget.
- Natural disasters have the potential to destroy mitigation sites or impede access to the Project area for monitoring. If the destruction is substantial enough to render mitigation sites unsalvageable or if the mitigation site is altered in such a way as to become unsuitable for use by the Covered Species, Auwahi Wind will carry out any remaining mitigation at a comparable site chosen in consultation with the USFWS and DLNR/DOFAW. As deemed necessary, alternate mitigation measures may include rehabilitating seabird nesting habitat or dryland forest (e.g., debris removal), contribution to revegetation efforts, or rehabilitation of Covered Species. Any changes in monitoring, reporting, or mitigation would be performed under the existing HCP implementation budget.
- Auwahi Wind will perform annual reviews of the previous year's Project costs for monitoring and mitigation. Expenses for subsequent years will be adjusted to meet projected costs based on the previous year's expenditures, and cumulative Project expenditures to date.
- If global climate change significantly alters the status of the Covered Species, any changes to the mitigation measures would be completed under the budget established for mitigation in this HCP. The current vegetative communities used by the Covered Species within the region would most likely not be affected by weather patterns, average levels of precipitation, average temperatures, and sea level. Covered seabird species could be affected by changes to their food resources at sea (IPCC 2007).

Auwahi Wind will report any changed circumstances as they occur to the USFWS and DLNR/DOFAW. The USFWS and DLNR/DOFAW will work with Auwahi Wind to discuss any necessary changes in the implementation of the HCP. Auwahi Wind will implement such changes as soon as possible. This may include modifications to the conservation and mitigation measures deemed necessary to respond to the changed circumstance as provided for and specified in the HCP's adaptive management strategy in Section 9.5 (50 CFR § 17.22[b][i and ii] and 50 CFR § 17.32[b][5][i and ii]). If the HCP is otherwise being properly implemented, the USFWS will not require any conservation or mitigation measures in addition to those provided for in the HCP without the consent of Auwahi Wind (50 CFR § 17.22[b][5][i and ii] and 50 CFR § 17.32[b][5][i and ii]).

9.3.2 Unforeseen Circumstances and "No Surprises" Policy

Unforeseen circumstances include circumstances that were not anticipated by Auwahi Wind or the USFWS and DLNR/DOFAW during the preparation of the HCP that result in a substantial and adverse change in the status of the Covered Species (50 CFR § 17.3). Should the USFWS determine, based on considerations outlined in 50 CFR § 17.22(b)(5)(iii)(c), that unforeseen circumstances have arisen during the permit term, the USFWS and DLNR/DOFAW will consider potential measures to address the changed conditions.

The Hawaiian petrel, Hawaiian hoary bat, nēnē, and Blackburn's sphinx moth are considered adequately addressed under this HCP and are, therefore, covered by the USFWS's "No Surprises" assurances. In the event that it is demonstrated by the USFWS and DLNR/DOFAW that unforeseen circumstances exist during the life of the Project, and additional conservation and mitigation measures are deemed necessary to respond to unforeseen circumstances, the USFWS may require additional measures of Auwahi Wind where the HCP is being properly implemented, but only if such measures are limited to modifications within the HCP or related permit documents, and the original terms of the HCP are maintained to the maximum extent practicable.

Notwithstanding the foregoing paragraph:

- The USFWS and DLNR shall not require the commitment of additional land, water, or financial compensation by Auwahi Wind without the consent of Auwahi Wind or impose additional restrictions on the use of land, water, or natural resources otherwise available for use by Auwahi Wind under the original terms of the HCP, including additional restrictions on covered actions that are permitted under the HCP.
- The USFWS and DLNR shall have the burden of demonstrating that such extraordinary circumstances exist, using the best scientific and commercial data available. Their findings must be clearly documented and based upon reliable technical information regarding the status and habitat requirements of the affected species.
- In determining whether any event constitutes an unforeseen circumstance, the USFWS and DLNR will consider, but not be limited to, the following factors: 1) size of the current range of affected species; 2) percentage of range adversely affected by the HCP; 3) percentage of range conserved by the HCP; 4) ecological significance of that portion of the range affected by the HCP; 5) level of knowledge about the affected species and the degree of specificity of the species' conservation program under the HCP; and 6) whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.
- The USFWS and DLNR shall not seek additional mitigation for a species from the HCP permittee where the terms of a properly functioning HCP agreement were designed to provide an overall net benefit for that species and contained measurable criteria for the biological success of the HCP which have been or are being met.
- Nothing in this policy shall be construed to limit or constrain the USFWS, DLNR, or any other governmental agency from taking additional actions at its own expense to protect or conserve a species included in an HCP.

9.4 Funding and Assurances

The ESA and HRS require that HCPs detail the funding that will be made available to implement the proposed monitoring and mitigation plans. Measures requiring funding for HCP implementation typically include activities associated with Project implementation (e.g., pre-construction surveys or post-construction monitoring), as well as on-site and off-site mitigation measures (e.g., acquisition of mitigation lands, restoration, or contributions to research).

Auwahi Wind has sufficient financial assets to implement the terms of this HCP and will be responsible for funding post-construction fatality monitoring and the proposed mitigation measures. Assurance of adequate funding will be provided in the form of a bond, letter of credit, guarantee, or similar financial instrument. Auwahi Wind understands that failure to provide adequate funding and consequent failure to implement the terms of this HCP in full could result in a temporary permit suspension or permit revocation. An estimate of the costs for implementing the HCP was provided in Table 6-2.

9.5 Adaptive Management

The U.S. Department of the Interior defines adaptive management as a structured approach to decision making in the face of uncertainty that makes use of the experience of management and the results of research in an embedded feedback loop of monitoring, evaluation, and adjustments in management strategies (Williams et al. 2009). Uncertainties may include the lack of biological information for the Covered Species, lack of knowledge about the effectiveness of mitigation or management techniques or the anticipated effects of the Project. Adaptive management is a required component of HCPs that allows for flexibility over time during the implementation of the HCP as new information is gained. Adaptive management requires explicit and measurable objectives, and identifies what actions are to be taken and when.

Uncertainties exist in the anticipated effect of the operation of the Project on the Covered Species. The tiered mitigation approach was developed to address this source of uncertainty, beginning with a Tier 1 level of take and associated mitigation strategy. If the Tier 1 take limit is reached, Auwahi Wind will evaluate if the Tier 2 take predictions and associated mitigation are warranted or require other actions based on operational limits, site conditions, or other Project considerations. Approaching the Tier 3 take limit will trigger additional consultation with the USFWS and DLNR/DOFAW. To ensure accurate measurement of take, carcass detection rates will be adjusted based on searcher efficiency and scavenger activity trials. Thus, mitigation will match incidental take on a continuous basis to ensure the long-term biological goals of the HCP are accomplished over the life of the Project. Should the mitigation completed for a tier level exceed the net benefit expected for that tier level, the additional mitigation credit would be applied to the next tier.

9.6 Revisions and Amendments

It is necessary to establish a procedure whereby the ITP/ITL can be amended. However, it is important that the cumulative effect of any amendments will not jeopardize any threatened or endangered species. Amendments must be evaluated based on their effect on the species as a whole. The USFWS and DLNR must be consulted on all proposed amendments that may affect any federal- or state-listed species.

9.6.1 Minor Amendments to the HCP

Minor amendments involve routine administrative revisions, minor changes to the operation and management program, minor changes to the post-construction monitoring and mitigation monitoring programs, minor revisions to the mitigation plan, or minor changes to the development area and design that do not diminish the level or means of mitigation. Such minor amendments do not materially alter the terms of the ITP/ITL. Upon the written request by Auwahi Wind, the USFWS and DLNR are authorized to approve minor amendments to the HCP.

9.6.2 Major Amendments to the HCP

Other amendments will be considered a major amendment to the ITP/ITL. Examples of a major amendment would be adding a new species to the list of Covered Species, or extending the HCP and ITP/ITL beyond its original 25-year term. A major amendment requires submittal to USFWS and DLNR of a written application, and implementation of all permit processing procedures applicable to an original ITP/ITL. A request for an amendment or extension should be submitted a minimum of 6 months prior to the expiration of the ITP/ITL. The HCP will remain valid and in effect during the processing of this request if the renewal or extension is processed during the original permit term.

9.6.3 Amendments to Locally Approved Development Plans

It is acknowledged that the state and/or local agencies having land use regulatory jurisdiction are authorized in accordance with applicable law to approve, without consulting the USFWS or DLNR, amendments to development plans for the Project area that do not encroach on any endangered species habitat or result in any additional take of the Covered Species beyond that described in this HCP.

10.0 PERSONAL COMMUNICATIONS

Bailey, Cathleen. 2010. Wildlife Biologist. Haleakalā National Park. Personal communication regarding potential mitigation options at Haleakalā National Park.

Bonaccorso, Frank. 2008. U.S. Geological Survey Biological Resources Division. Personal communications regarding the Hawaiian hoary bat.

Bonaccorso, Frank. 2010. Pacific Island Ecosystems Research Center, U.S. Geological Survey/BRD. Personal communication regarding the Hawaiian hoary bat on Maui.

David, Reggie. 2010. Senior Scientist/President, Rana Biological Consulting, Inc. Personal communications regarding Newell's shearwater and Hawaiian petrel populations on Maui.

Duvall, Fern. 2010. Wildlife Biologist, Division of Forestry and Wildlife, Department of Land and Natural Resources. Personal communication regarding seabirds on Maui.

Erdman, Sumner. 2010. Personal communication between Sumner Erdman and Alicia Oller, Tetra Tech EC Inc. Personal communication regarding nēnē on ʻUlupalakua Ranch.

Erdman, Sumner. 2009. Personal communication between Sumner Erdman and Reggie David. Cited in the Auwahi Wind Farm Project Environmental Impact Statement Preparation Notice prepared by Tetra Tech EC Inc., for the Maui County Planning Commission on behalf of Auwahi Wind Energy, LLC

Fretz, Scott. 2010. Wildlife Program Manager. Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communication and meetings regarding a variety of issues associated with the Auwahi Wind Farm Project.

Greenlee, Dawn. 2011. Wildlife Biologist, U.S. Fish and Wildlife Service. Personal communication regarding a variety of issues associated with the Auwahi Wind Farm Project.

Hamer, Tom. 2010. Senior Scientist/ President, Hamer Environmental. Personal communication concerning preliminary observations from the seabird/bat radar and avoidance studies.

Hu, Darcy. 2011. Wildlife Biologist, Hawaii Volcanoes National Park. Personal communication regarding Hawaiian petrel colony management.

Hufana, Sandee. DOFAW. 2010. Personal communication regarding bird and bat fatalities that have occurred at the Kaheawa Wind Farm project.

Medeiros, Arthur. 2010. Leeward Haleakala Watershed Restoration Partnership. Personal communications regarding the Auwahi Forest Restoration Project.

Medeiros, Arthur. 2011. Leeward Haleakala Watershed Restoration Partnership. Personal communications regarding the Auwahi Forest Restoration Project.

Montgomery, PhD., Stephen. 2011. Entomologist. Personal communication regarding Blackburn's sphinx moth.

Sempra Generation. 2011. Personal communication on low risk of fire from turbines as provided by Siemens and GE turbine manufacturer.

Standley, Bill. 2010. Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Pacific Islands Office. Personal communication and meetings regarding a variety of issues associated with the Auwahi Wind Farm Project.

11.0 REFERENCES

Ainley, D.G., T.C. Telfer, and M. H. Reynolds. 1997. Townsends' and Newell's Shearwater *Puffinus auricularis*. In *The Birds of North America*, No. 297 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Arnett, E.B., ed. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX.

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fiedler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, and R.D. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. *Journal of Wildlife Management* 72:61–78.

Arnett, E.B., M.R. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009. Patterns of Bat Fatality at the Casselman Wind Project in South-Central Pennsylvania. An annual report submitted to the Bats and Wind Energy Cooperative and the Pennsylvania Game Commission. Bat Conservation International. Austin, TX.

AWEA (American Wind Energy Association). 2010. Wind Power and Reliability Factsheet. Available online at: http://www.awea.org/la_pubs_factsheets.cfm

Baker, P.E. and H. Baker. 1995. Nene Report: Egg and Gosling Mortality in Haleakala National Park, 1994-95. Unpublished report to Hawai'i Division of Forestry and Wildlife, HI.

Banko, Paul C., Jeffrey M. Black and Winston E. Banko. 1999. Hawaiian Goose (*Branta sandvicensis*). In *The Birds of North America Online* (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online.

Benevides, F.L, Jr., H. Hansen, and S. Hess. 2008. Design and evaluation of a simple signaling device for live traps. *Journal of Wildlife Management* 72: 1434-1436.

Black, S.H. 2005. Species Profile: *Manduca blackburni*. In *Red List of Pollinator Insects of North America* (M.D. Shepherd, D.M. Vaughn, and S. H. Black, eds). CD-ROM Version 1 (May 2005). Portland, OR: The Xerces Society for Invertebrate Conservation.

Black & Veatch. 2008. Auwahi Wind Project Kanaio, Hawai'i, Preliminary Geotechnical Investigation Report. Shell WindEnergy, Inc.

Bogan, M.A. 1972. Observations on parturition and development in the hoary bat *Lasiurus cinereus*. *Journal of Mammalogy* 53:611–614.

Bonnaud, E., K. Bourgeois, E. Vidal, J. Legrand, and M. Le Corre. 2009. How can Yelkouan Shearwater survive feral cat predation? A meta-population structure as a solution? *Population Ecology* 51: 261–270.

Carlile, N., D. Priddel, F. Zino, C. Natividad, and D. Wingate. 2003. A review of four successful recovery programmes for threatened sub-tropical petrels. *Marine Ornithology* 31:185–192.

CWRM (Commission on Water Resources Management). 2008. Hawai'i Water Plan, Water Resource Protection Plan. Prepared for State of Hawai'i Commission on Water Resource Management. Prepared by Wilson Okamoto Corporation. Available online at: http://hawaii.gov/dlnr/cwrm/planning_wrpp.htm (accessed April 21, 2010).

Cooper, B.A., and R.H. Day. 1998. Summer behavior and mortality of Dark-rumped Petrels and Newell's Shearwaters at power lines on Kaua'i. *Colonial Waterbirds* 21:11–19.

Cooper, B.A., and R. H. Day. 2009. Radar and Visual Studies of Seabirds at the Proposed KWP II Down-road Alternative Wind Energy Facility, Maui Island, Hawai'i, Summer 2009. Draft report prepared for FirstWind LLC.

Cruz F. and J. Cruz. 1990. Breeding, morphology, and growth of the endangered dark-rumped petrel. *The Auk* 107:317–326.

David, R.E., and E. Guinther. 2010. A Survey of Botanical, Avian, and Terrestrial Mammalian Resources for the Auwahi Wind Farm Project, 'Ulupalakua Ranch, Island of Maui. Prepared for Auwahi Wind Energy, LLC, San Diego, CA.

Day, R.H., and B.A. Cooper. 1995. Patterns of movement of dark-rumped petrels and Newell's shearwaters on Kauai. *Condor* 97:1011–1027.

Desholm, M., and J. Kahlert. 2005. Avian collision risk at an offshore wind farm. *Biology Letters* 1: 296–298. [published online; available at doi: 10:1098/rsbl.2005.0336]

Desholm, M., A.D. Fox, P.D.L. Beasley, and J. Kahlert. 2006. Remote techniques for counting and estimating the number of bird–wind turbine collisions at sea: a review. *Ibis* 148:76–89.

Dirksen, S.E., A.L. Spaans, and J. Winden. 1998. Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. In *Proceedings of International Workshop on Wind Energy and Landscape, Genoa, 26–27 July 1997*. Pp. 99–108. Balkema, Rotterdam.

DLNR (Division of Land and Natural Resources). 2005a. 'Ōpe'ape'a or Hawaiian Hoary Bat. Hawai'i's Comprehensive Wildlife Conservation Strategy. October 1.

Duvall, F., and R. Gassmann-Duvall. 1991. No bats on Maui? Look again. *'Elepaio* 51(3):1–2.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project Wildlife Monitoring Annual Report, Results for the Period July 2001 - December 2003. Technical report prepared by WEST, Inc. and submitted to FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee.

Fiedler, J.K., T.H. Henry, C.P. Nicholson, and R.D. Tankersley. 2007. Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005. Tennessee Valley Authority, Knoxville, TN.

Foote, D.E., E.L. Hill, S. Nakamura, and F. Stephens. 1972. Soil Survey of the Islands of Kauai, Oahu, Maul, Molokai, and Lanai. State of Hawai'i. Soil Conservation Service, USDA.

Gall, A.E., and R.H. Day. 2007. Movements and Estimated Fatality of Hawaiian Petrels at a Communications Tower on Maui Island, Hawai'i. Final report prepared for KC Environmental, Inc.

Global Energy Concepts, LLC. 2006. A Catalog of Potential Sites for Renewable Energy in Hawai'i. Produced for the State of Hawai'i Department of Land and Natural Resources and the Department of Business, Economic Development, and Tourism, in response to Act 95, Session Laws of Hawai'i 2004. December. Available online at: http://Hawaii.gov/dbedt/info/energy/publications/ cpsre07.pdf (accessed June 12, 2010).

Gorresen, P.M., A.C. Miles, C.M. Todd, F.J. Bonaccorso, and T.E. Weller. 2008. Assessing bat detectability and occupancy with multiple automated echolocation detectors. *Journal of Mammalogy* 89: 11–17.

Guinther, D., and S. Montgomery. 2011. GIS Data of Spring 2011 Botanical and Invertebrate Surveys Conducted for the Auwahi Wind Project, ʻUlupalakua Ranch, Maui.

HNP (Haleakalā National Park). 2009. Endangered Species Management. Prepared 10/18/05.

Hamer (Hamer Environmental, L.P.). 2010a. Endangered Bird and Bat Surveys Conducted during Fall 2006 and Spring 2010, 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

Hamer. 2010b. Avian Risk of Collision Analysis for the South Auwahi Wind Resource Area, Maui, Hawaiʻi. Prepared for Sempra Generation, San Diego, CA. Prepared by Hamer Environmental, L.P. Mount Vernon, WA.

Hawaiʻi Wind Working Group. 2004. Hawaiʻi's Windiest Locations. September 20. Available online at: http://hawaii.gov/dbedt/ert/wwg/windy.html (accessed June 3, 2010).

HBMP (Hawaiʻi Biodiversity Mapping Program). 2007. Hawaiian Hoary Bat. Available online at: http://hbmp.hawaii.edu/printpage.asp?spp=AMACC05031

HECO (Hawaiian Electric Company). 2010. Fact Sheet: Power Facts. Available online at: http://www.heco.com/vcmcontent/StaticFiles/ pdf/PowerFacts_6-2010.pdf (accessed June 21, 2010).

Hodges, C.S. 1994. Effects of Introduced Predators on the Survival and Fledging Success of the Endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*). M.S. Thesis, University of Washington, Seattle, WA.

Hodges, C.S.N., and R.J. Nagata. 2001. Effects of predator control on the survival and breeding success of the endangered Hawaiian dark-rumped petrel. *Studies in Avian Biology* 22:308–318.

Humphrey, S.R. 1982. Bats, Vespertilionidae and Molossidae. In *Wild Mammals of North America: Biology, Management, and Economics* (J.A. Chapman and G.A. Feldhamer, eds). Pp 52-70. John Hopkins University Press, Baltimore.

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: Technical Summary of the Working Group I Report. Available online at: http://www.ipcc.ch (Accessed on June 23, 2008).

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual Report for the Maple Ridge Wind Power Project Post-Construction Bird and Bat Fatality Study – 2006. Annual report prepared for PPM Energy and Horizon Energy, Curry and Kerlinger LLC, Cape May Point, New Jersey.

KWP (Kaheawa Wind Power, LLC). 2008. Kaheawa Pastures Wind Energy Generation Facility Habitat Conservation Plan Year 2 HCP Implementation.

KWP. 2009. Kaheawa Pastures Wind Energy Facility, Habitat Conservation Plan: Year 3 Annual Report. First Wind Energy, LLC, Environmental Affairs, Newton, MA.

KWP. 2010. Kaheawa Wind Power II Wind Energy Generation Facility Draft Habitat Conservation Plan. Ukumehame, Maui, Hawaiʻi. April.

Kepler, C.B., and J.M. Scott. 1990. Notes on the distribution and behavior of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), 1964-1983. *'Elapaio* 50:59–64.

Kerns, J., W.P. Erickson, and E.B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24–95. In *Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines* (E.B. Arnett, technical editor). A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX.

Koehler, C.E., and R.M.R. Barclay. 2000. Post-natal growth and breeding biology of the hoary bat (*Lasiurus cinereus*). *Journal of Mammalogy* 81:234-244.

Kunz, T,H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Strickland, R. W. Thresher, and M.D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. *Frontiers in Ecology* 5:315-324.

Menard, T. 2001. Activity Patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) in Relation to Reproductive Time Periods. M.S Thesis. University of Hawai'i.

Mink, J.F. and Lau, L.S. 1990. Aquifer Identification and Classification for Oahu: Groundwater Protection Strategy for Hawai'i. Honolulu (HI): Water Resources Research Center, University of Hawai'i at Manoa. WRRC technical report, 179.

Mitchell, C., C. Ogura, D.W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawai'i's Comprehensive Wildlife Conservation Strategy. Department of Land and Natural Resources. Honolulu, HI. Available online at: http://www.state.hi.us/lnr/ofaw/ wcs/index.html (accessed April 14, 2010).

Montgomery, S.L. 2008. A Survey of Invertebrate Resources for the Shell WindEnergy Inc. Auwahi parcel, 'Ulupalakua Ranch, Hana District, Island of Maui.

NPS (National Park Service). 2009. Hawaiian Petrel Monitoring Protocol — Pacific Island Network. Natural Resource Report NPS/PWR/PACN/NRR—2009/DRAFT. National Park Service, Fort Collins, CO.

Podolsky, R. and S. Kress. 1992. Attraction of the endangered dark-rumped petrel to recorded vocalizations in the Galapagos Islands. *Condor* 94: 448–453.

Podolsky, R.H., and S.W. Kress. 1989. Factors affecting colony formation in Leach's storm-petrel to uncolonized islands in Maine. *Auk* 106: 332–336

Reeser, D., and B. Harry. 2005. Controlling ungulate populations in native ecosystems in Hawai'i. Position Paper. Hawai'i Conservation Alliance.

Riotte, J.C.E. 1986. Re-evaluation of *Manduca blackburni* (Lepidoptera: Sphingidae). *Proceedings of the Hawai'i Entomological Society* 27:79–90.

Simons, T.R. 1984. A population model of the endangered Hawaiian dark-rumped petrel. *Journal of Wildlife Management* 48: 1065–1076.

Simons, T.R. 1985. Biology and behavior of the endangered Hawaiian Dark-rumped Petrel. *Condor* 87: 229–245.

Simons 1998, as cited in Carlile, N., D. Priddel, F. Zino, C. Natividad, and D. Wingate. 2003. A review of four successful recovery programmes for threatened sub-tropical petrels. *Marine Ornithology* 31:185-192.

Simons, T.R., and C.N. Hodges. 1998. Dark-rumped Petrel (*Pterodroma phaeopygia*). In *The Birds of North America Online* (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. Available online at: http:/bna.birds.cornell.edu/bna/species/345

Stearns, H.T. 1966. *Geology of the State of Hawai'i.* Pacific Books, Palo Alto, CA. 266 pp.

SWCA (SWCA Environmental Consultants). 2010. Kahuku Wind Power Habitat Conservation Plan. Kahului, Hawai'i.

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.

Tetra Tech. 2008. Habitat Conservation Plan for the Construction and Operation of Lanai Met Towers, Lanai, Hawai'i (Revised February 8, 2008, TTEC-PTLD-2008-080). Unpublished report by Tetra Tech EC, Honolulu, HI, for Castle and Cooke LLC, Lanai City, HI.

Thelander, C.G., K.S. Smallwood, and L. Rugge. 2003. Bird Risk Behaviours and Fatalities at the Altamont Pass Wind Resource Area. Report to the National Renewable Energy Laboratory, CO.

USDA (United States Department of Agriculture). 2010. Custom Soil Resource Report for Island of Maui. Available online at: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Generated on April 19, 2010.

USDOE (U.S. Department of Energy). 2010. Hawai'i Clean Energy Initiative. Available online at: http://www.hawaiicleanenergyinitiative.org/objectives.html

USFWS (U.S. Fish and Wildlife Service). 1983. Hawaiian Dark-Rumped Petrel and Newell's Manx Shearwater Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 1998. Recovery Plan for the Hawaiian Hoary Bat. U.S. Fish and Wildlife Service, Portland, OR.

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).

USFWS. 2003b. Designation of Critical Habitat for the Blackburn's Sphinx Moth: Final Rule. 68 Federal Register 34710. Honolulu, HI.

USFWS. 2004. Draft Revised Recovery Plan for the Nene or Hawaiian Goose (*Branta sandvicensis*). U.S. Fish and Wildlife Service, Portland, OR.

USFWS. 2005a. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, OR.

USFWS. 2005b. Draft Revised Recovery Plan for Hawaiian Waterbirds, Second Draft of Second Revision. U.S. Fish and Wildlife Service, Portland, OR. 156 pp.

USFWS. 2005c. Draft Recovery Plan for the Blackburn's Sphinx Moth (*Manduca blackburni*). Region 1 U.S. Fish and Wildlife Service. Portland, OR.

USFWS. 2007. Threatened and Endangered Animals in the Hawaiian and Pacific Islands. Available online at: http://pacificislands.fws.gov/wesa/hawanimalsindex.html.

USFWS. 2008. Biological Opinion for the Federal Communications Commission-Maui Tower Broadcasters General Broadcast Area and the IAI Towers Project.

USFWS and NMFS (National Marine Fisheries Service). 1996. Habitat Conservation Planning and Incidental Take Permit Processing Handbook. U.S. Fish and Wildlife Service.

USFWS and NMFS. 2000. Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process; Notice. Federal Register 65 (106): 35242-35257, Thursday, June 1, 2000.

USGS (U.S. Geological Survey). 1996. Hawaiian Volcano Observatory. Volcano Watch. November 27. Available online at: http://hvo.wr.usgs.gov/volcanowatch/1996/96_11_27.html (accessed April 15, 2010).

USGS. 2006. Restoration of Native Dryland Forests at Auwahi, Maui. USGS-FS 2006-3035.

Warham, J. 1990. *The Petrels: Their Ecology and Breeding Systems.* Academic Press, San Diego, CA.

Whitaker, J.O., Jr., and P.Q. Tomich. 1983. Food habits of the hoary bat, *Lasiurus cinereus*, from Hawai'i. *Journal of Mammalogy* 64:151–152.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Winkelman, J.E. 1995. Bird/wind turbine investigations in Europe (Appendix 2B). In *Proceedings of National Avian–Wind Power Planning Meeting I, Lakewood, CO, 1994*. (LGL Ltd., ed.) Pp. 110–140.

Appendix A
Botanical, Avian and Terrestrial Mammalian Surveys Conducted for the Auwahi Wind Farm Project, ‘Ulupalakua Ranch, Island of Maui

Appendix B
Auwahi Wind Project Revegetation Potential Plant List

Auwahi Wind Project Revegetation Potential Plant List

Common Name	***Scientific Name***
Trees	
wiliwili	*Erythrina sandwicensis*
'iliahialo'e	*Santalum ellipiticum*
'ohe makai	*Reynoldsia sandwicensis*
alahe'e	*Canthium odoratum*
'akoko	*Chamaesyce celastroides*
naio	*Myoporum sandwicense*
hao	*Rauvolfia sandwicensis*
'aiea	*Nothocestrum latifolium*
koai'a	*Acacia koai'a*
keahi	*Nesoluma polynesicum*
lama	*Diospyros sandwicensis*
Shrubs	
'a'ali'i	*Dodonaea viscosa*
kuluʻī	*Nototrichium sandwicense*
'aweoweo	*Chenopodium oahuense*
maiapilo	*Capparis sandwichiana*
pua kala	*Argemone glauca*
'uhaloa	*Waltheria indica*
kolomona	*Senna gaudichaudii*
unknown	*Achyranthes splendens*
ma'o	*Gossypium tomentosum*
'akia	*Wikstroemia monticola*
Grasses	
pili	*Heteropogon contortus*
mountain pili	*Panicum tenufolium*
kawelu	*Eragrostis variabilis*
Guinea grass	*Panicum maximum*
Bufflegrass	*Pennisetum ciliare*
	Paspalum sp.
Ground Layer	
nehe	*Lipochaeta lavarum*
'ilihe'e	*Plumbago zeylanica*
'ilima	*Sida fallax*
'ala'ala wai nui	*Peperomia leptostachya*
'ulei	*Osteomeles anthyllidifolia*

ʻĀwikiwiki	*Canavalia pubescens*

List of Candidate Tree Species for the Waihou Mitigation Area	
Common Name	***Scientific Name***
'Ohia lehua	*Metrosideros polymorpha**
Koa	*Acacia koa**
'A'ali'i	*Dodonaea viscosa**
Kōlea lau nui	*Myrsine lessertiana**
Ulei	*Osteomeles anthyllidifolia***
'Ōlapa	*Cheirodendron trigynum***
Naio	*Myoporum sandwicense***
Māmane	*Sophora chrysophylla***
Maua	*Xylosma hawaiiense***
'Ohe mauka	*Polyscias oahuensis* (formerly genus *Tetraplasandra*)***
'Ohe 'ohe	*Polyscias kavaense* (formerly genus *Tetraplasandra*)***
Kawa'u	*Ilex anomala****
Pilo	*Comprosma foliosa vontempsky****
Olomea	*Perrottetia sandwicensis****
Ha'iwale	*Cyrtandra sp.****
'Opuhe	*Urera glabra****

*Will be most prevalently planted species
**Secondly most planted species
***Dependent upon availability and viability of seeds

Appendix C
Auwahi Wind Farm Fire Management Plan

Appendix D
Auwahi Wind Farm Project Post-construction Monitoring Plan

Appendix E
Avian Risk of Collision Analysis for the South Auwahi Wind Resource Area, Maui, Hawaiʻi

Appendix A
Botanical, Avian and Terrestrial Mammalian Surveys Conducted for the Auwahi Wind Farm Project, ‘Ulupalakua Ranch, Island of Maui

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

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Revised

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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.

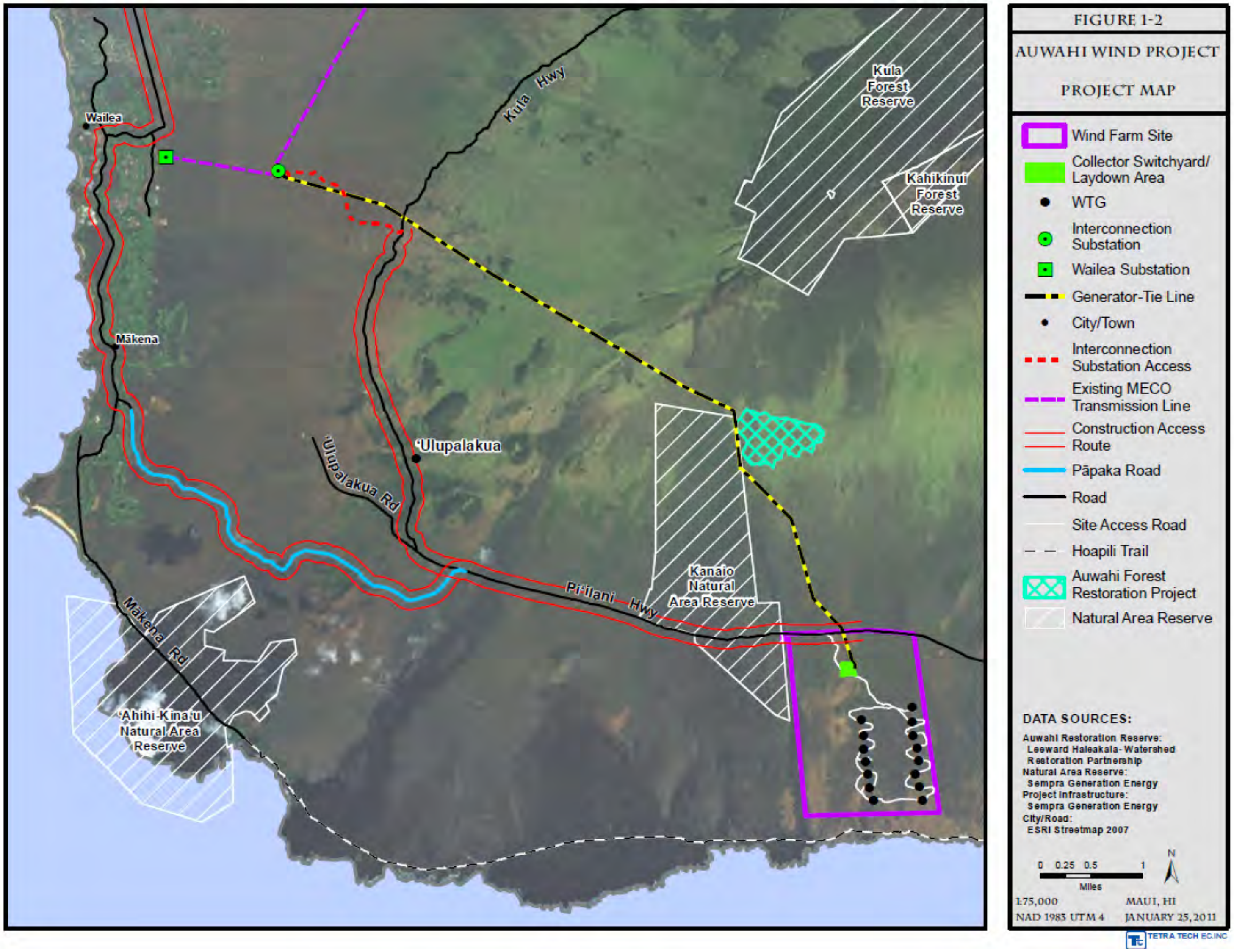

Figure 1. Auwahi Wind Farm Map of southwest East Maui Mountains showing Project components and biologically sensitive areas

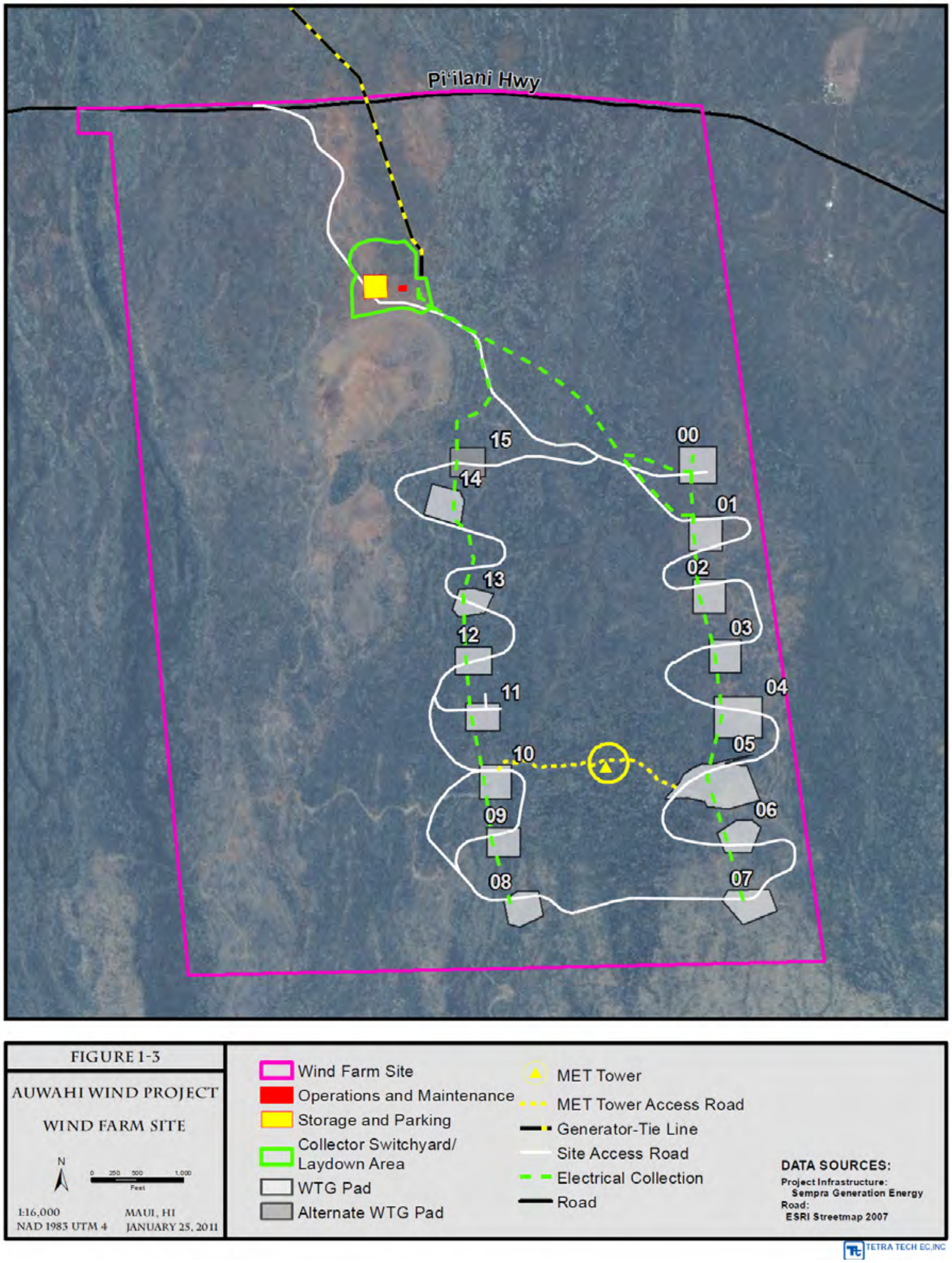

Figure 2. Auwahi Wind Farm site showing layout of Project components

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 Piʻilani Highway and continue upslope (*mauka*) through mixed dryland scrub and pasture. West of Puʻu ʻOuli, 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 ʻUlupalakua 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 Piʻilani 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 *wiliwil*i) 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 *wiliwil*i) 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 *wiliwil*i) 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 Piʻilani 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.

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[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	*'ākia*	**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 Pi'ilani Highway); anticipated, but not recorded at this site.

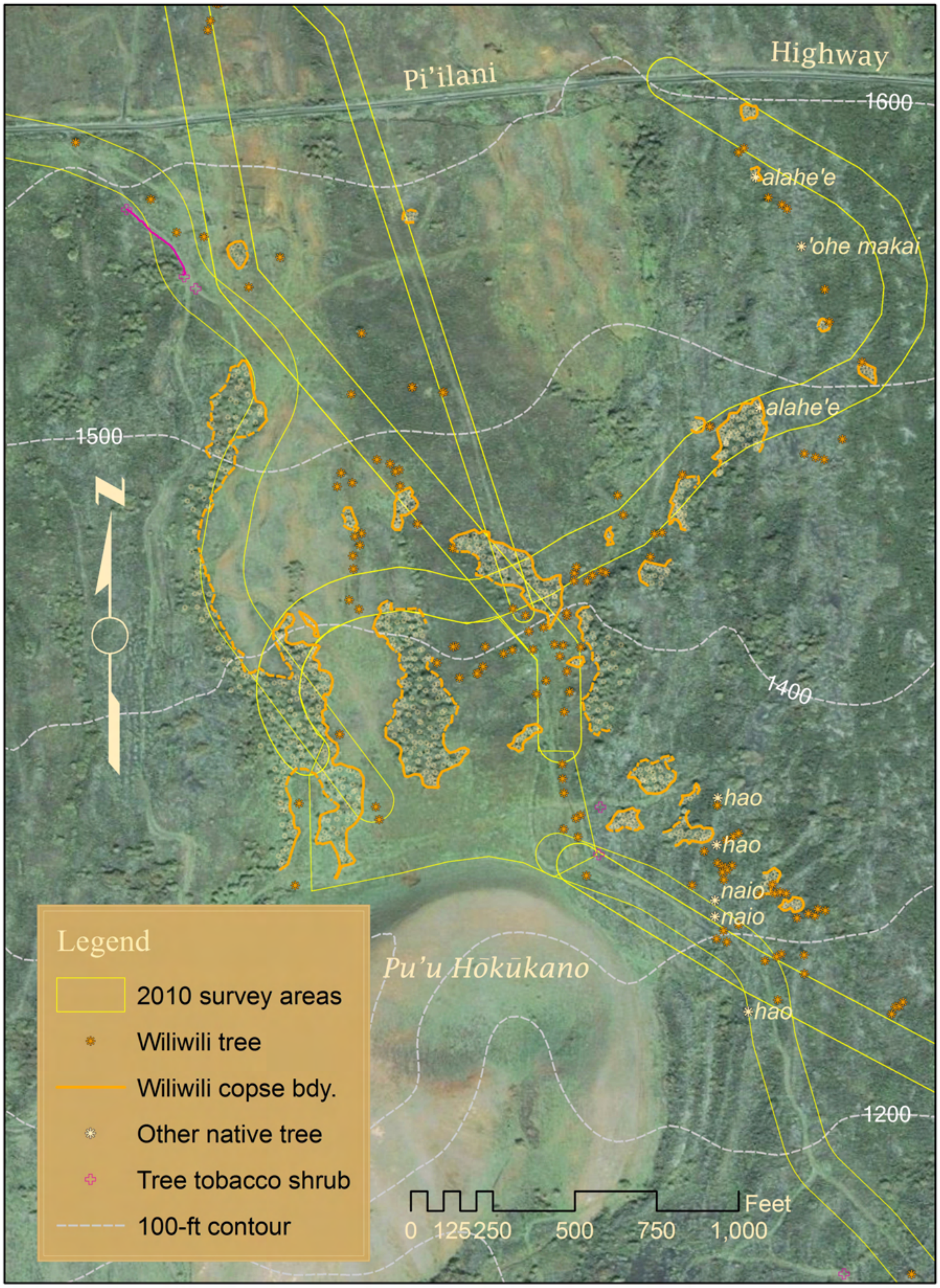

Figure 5. Botanical survey map for the wind farm site between Pi'ilani Highway and Pu'u Hōkūkano.

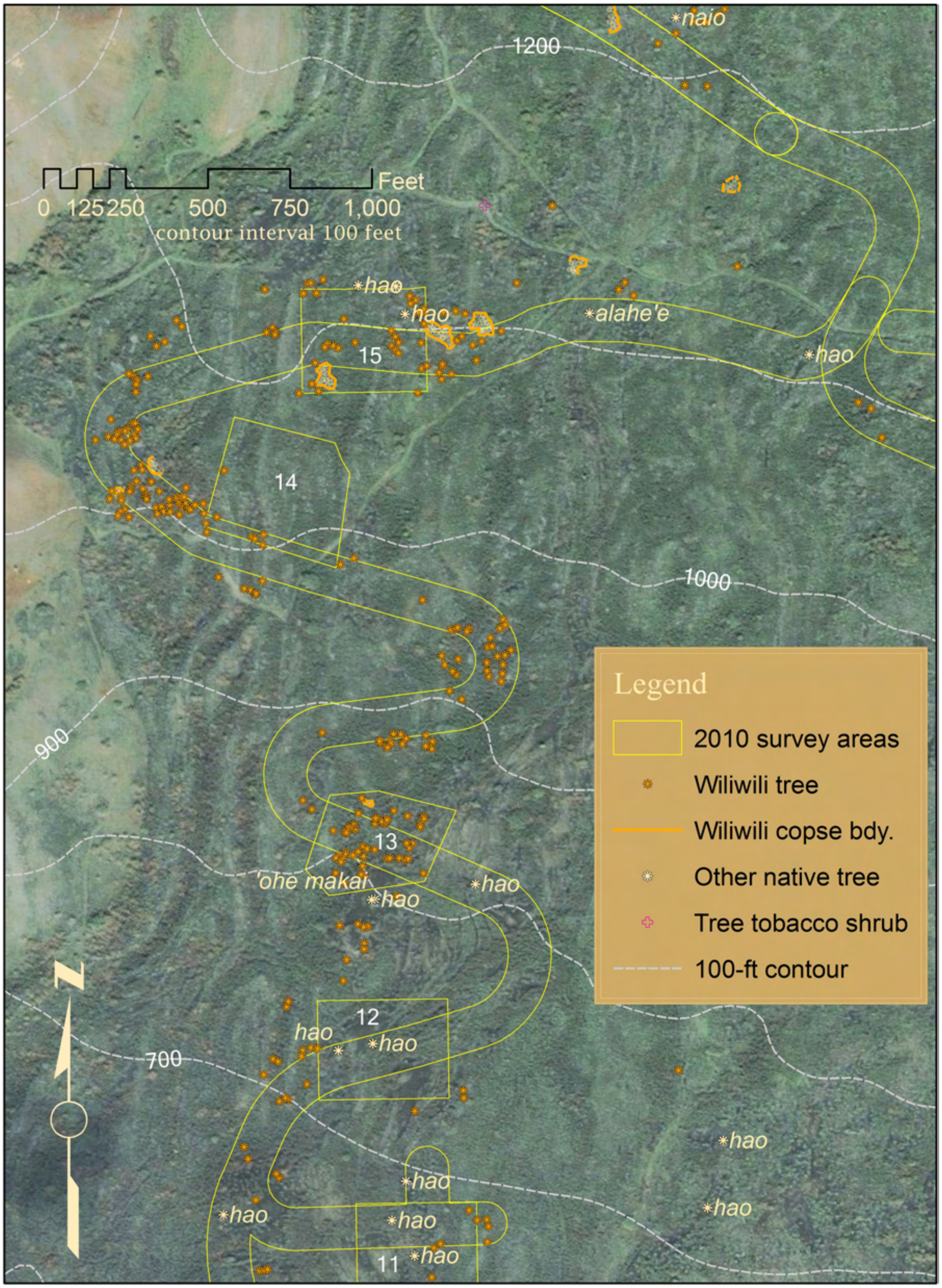

Figure 6. Botanical survey map for the wind farm site, wind turbine pads 11 through 15 and associated access roads (upper west side).

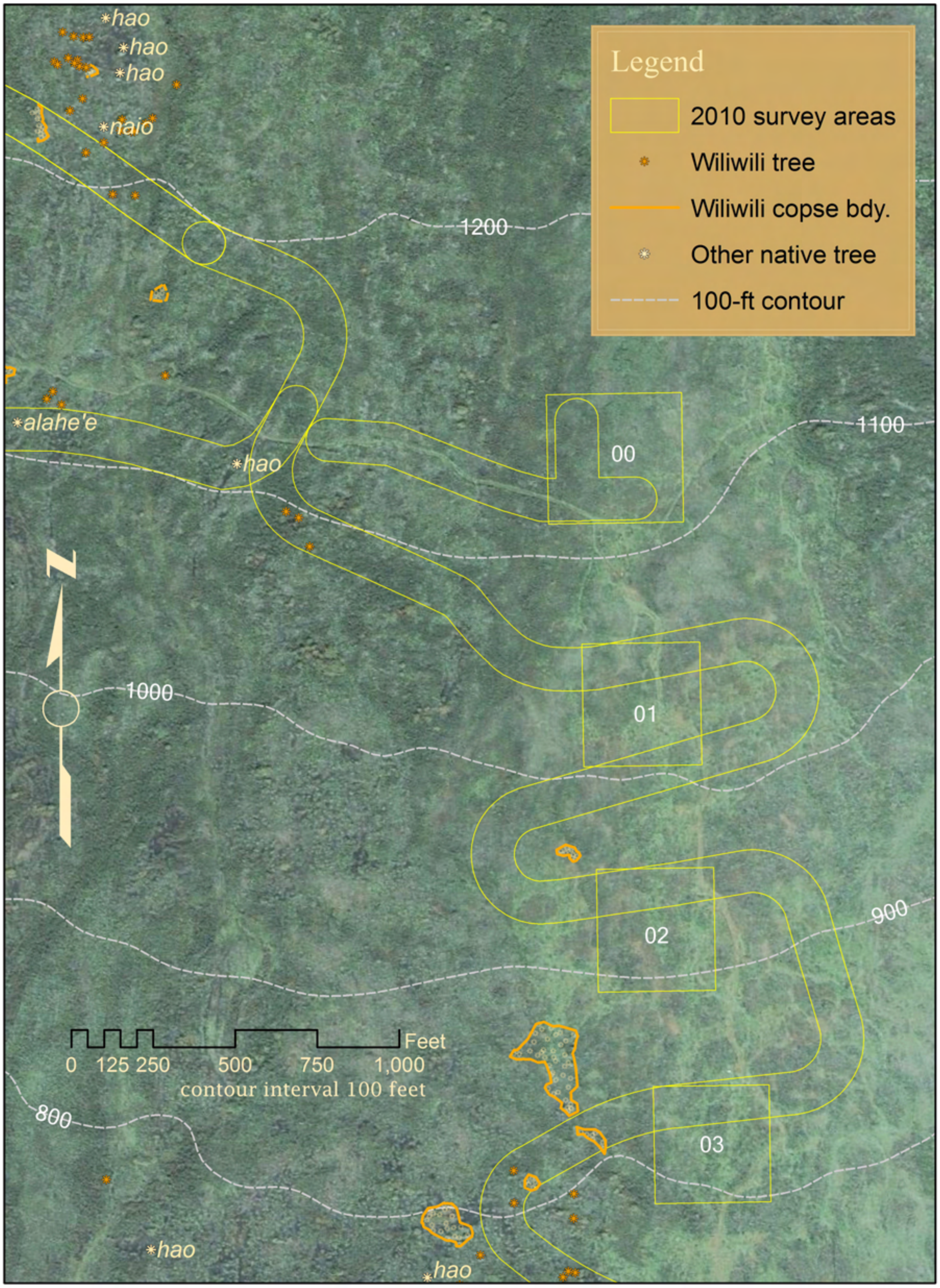

Figure 7. Botanical survey map for the wind farm site, wind turbine pads 00 through 03 and associated access roads (upper east side).

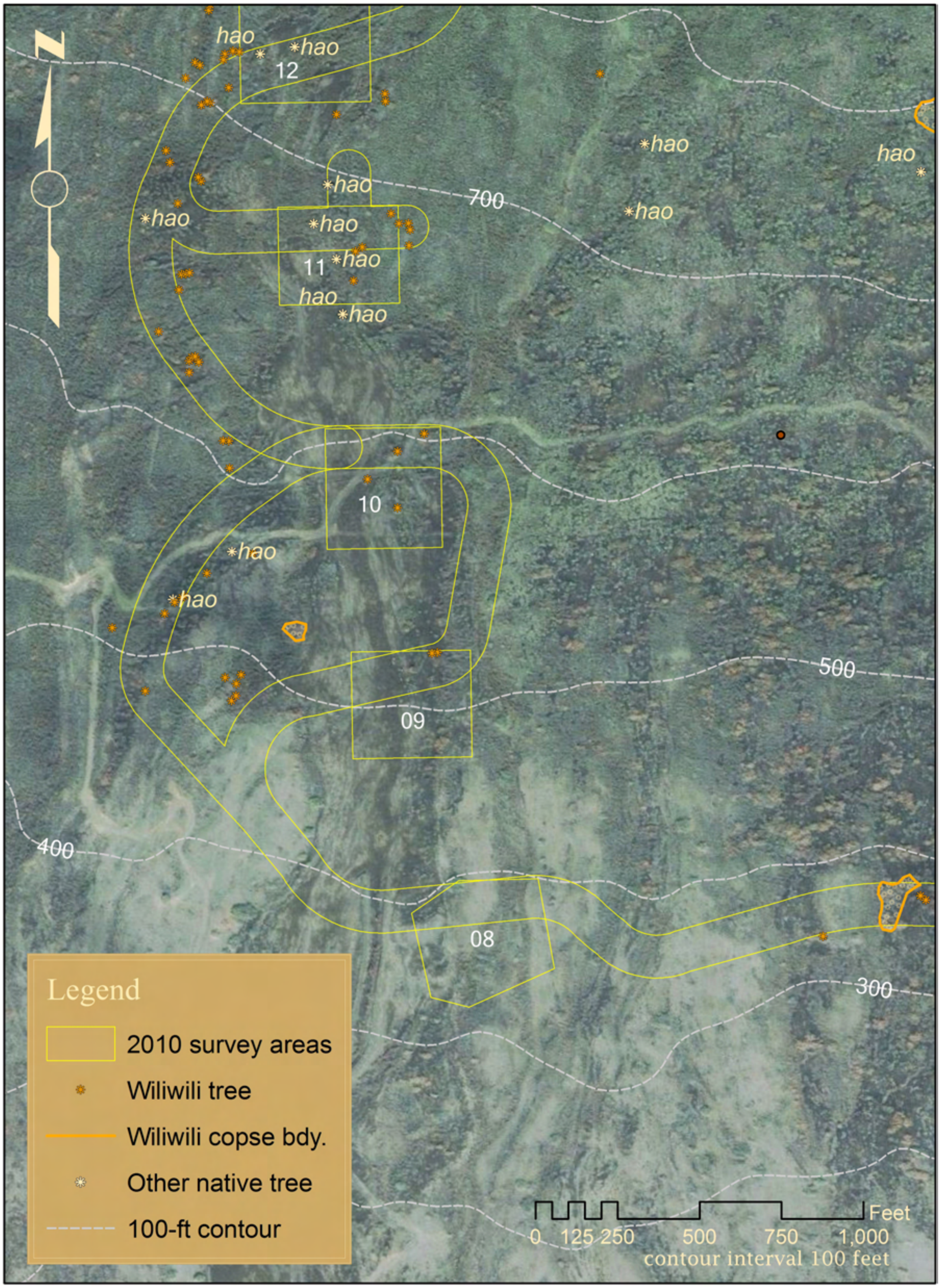

Figure 8. Botanical survey map for the wind farm site, wind turbine pads 08 through 12 and associated access roads (lower west side).

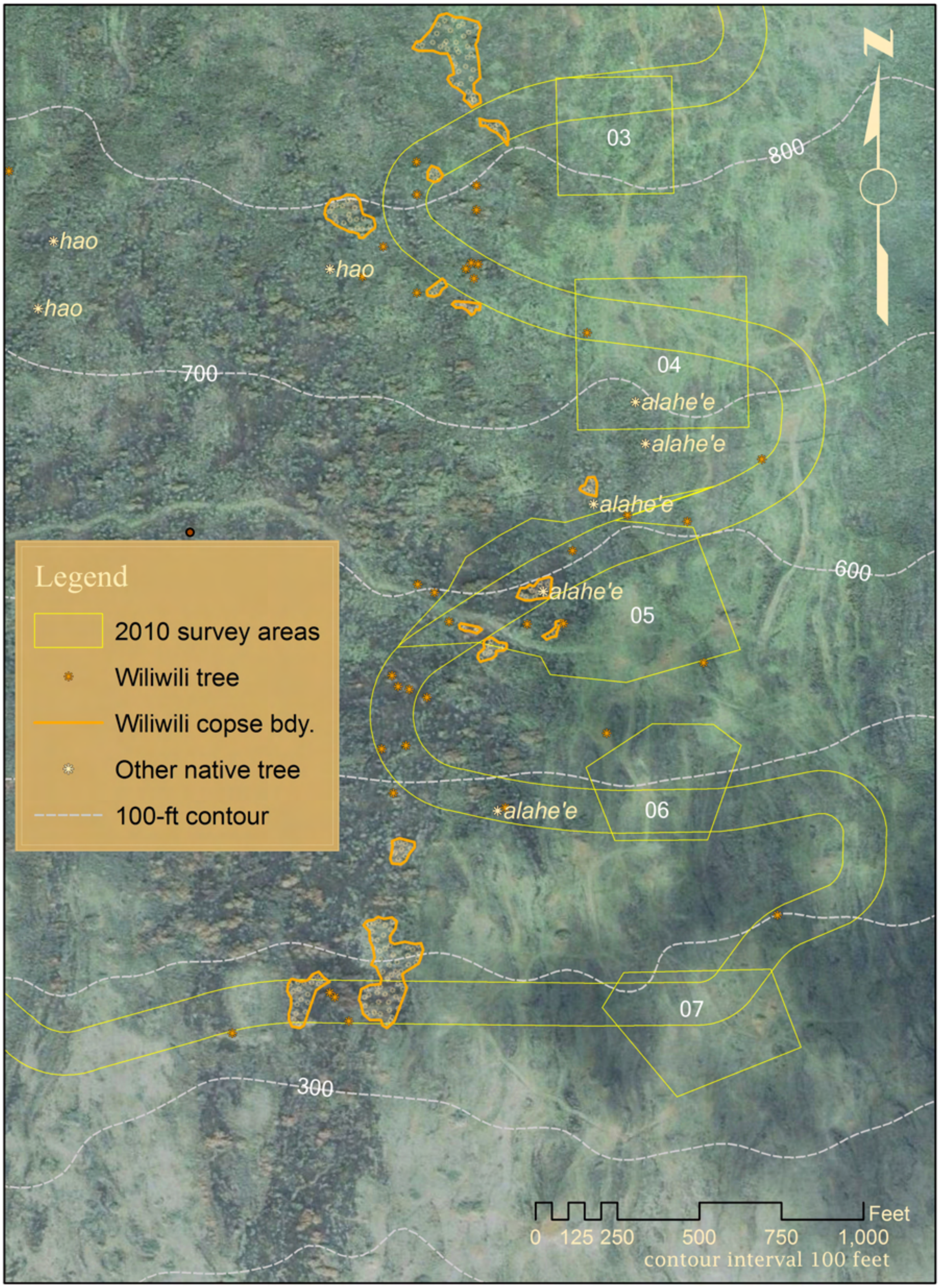

Figure 9. Botanical survey map for the wind farm site, wind turbine pads 03 through 07 and associated access roads (lower east side).

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	*'āheahea*	**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	*'iliahi*	**End.**	R	--	--	(4)
Santalum freycinetianum var. lanaiense Rock	*'iliahi*	**End.**	--	R	--	<E>
SAPINDACEAE						
Alectryon macrococcus Radlk.	*māhoe*	**End.**	--	R	--	<E>
Dodonaea viscosa Jacq.	*'a'ali'i*	**Ind.**	O	AA	R	(1)
SAPOTACEAE						
Pouteria sandwicensis (A. Gray) Baehna & Degener.	*'āla'a*	**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	*'aiea*	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.	*'uhaloa*	**Ind.**	C	--	U	
THYMELIACEAE						
Wikstroemia oahuensis (A. Gray) Rock	*'ākia*	**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.

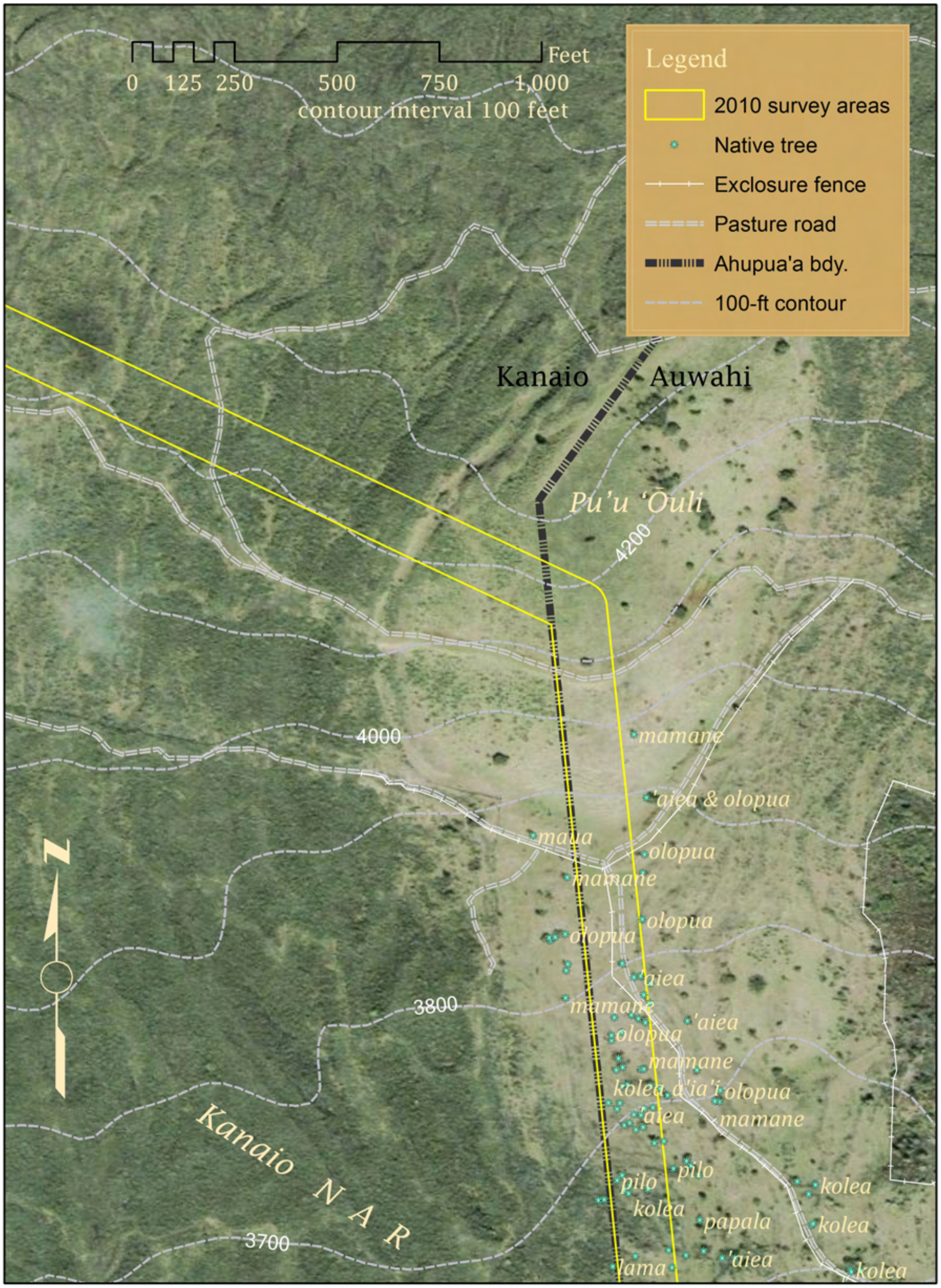

Figure 10. Botanical survey map for the upper east side generator tie-line between 3700 and 4300 feet ASL.

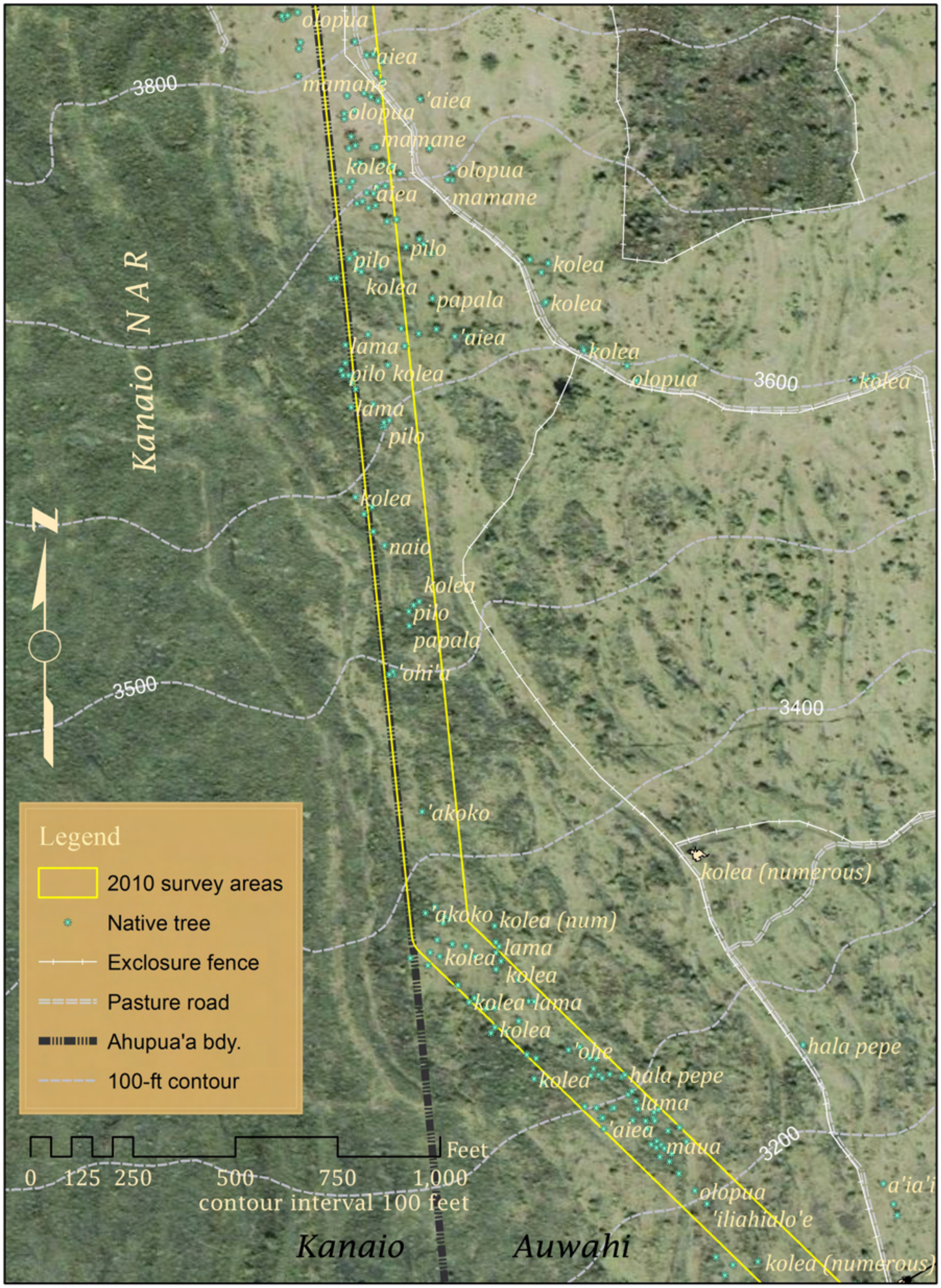

Figure 11. Botanical survey map for the upper east side generator tie-line between 3200 and 3800 feet ASL.

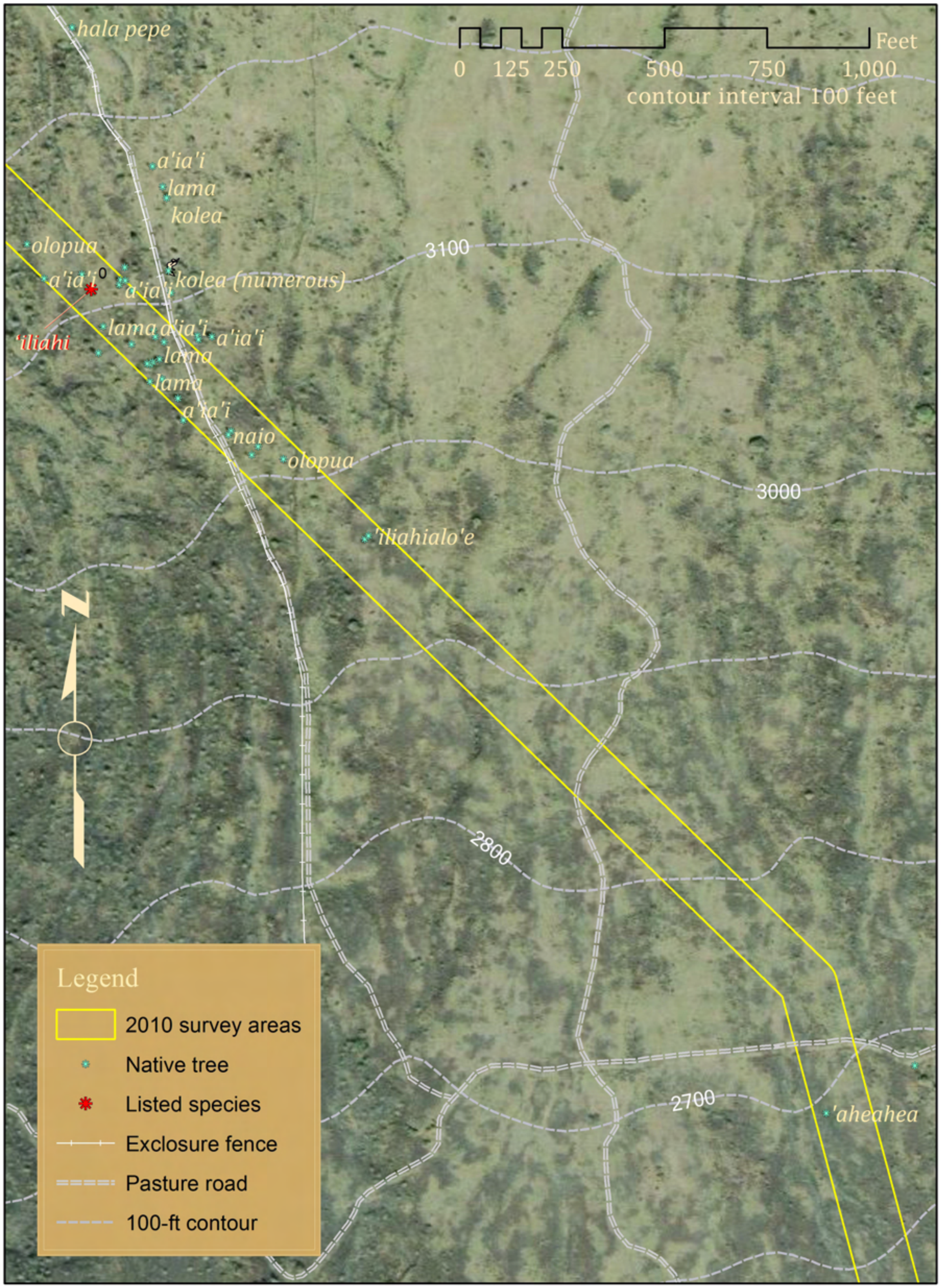

Figure 12. Botanical survey map for the east side generator tie-line between 2100 and 2600 feet ASL.

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

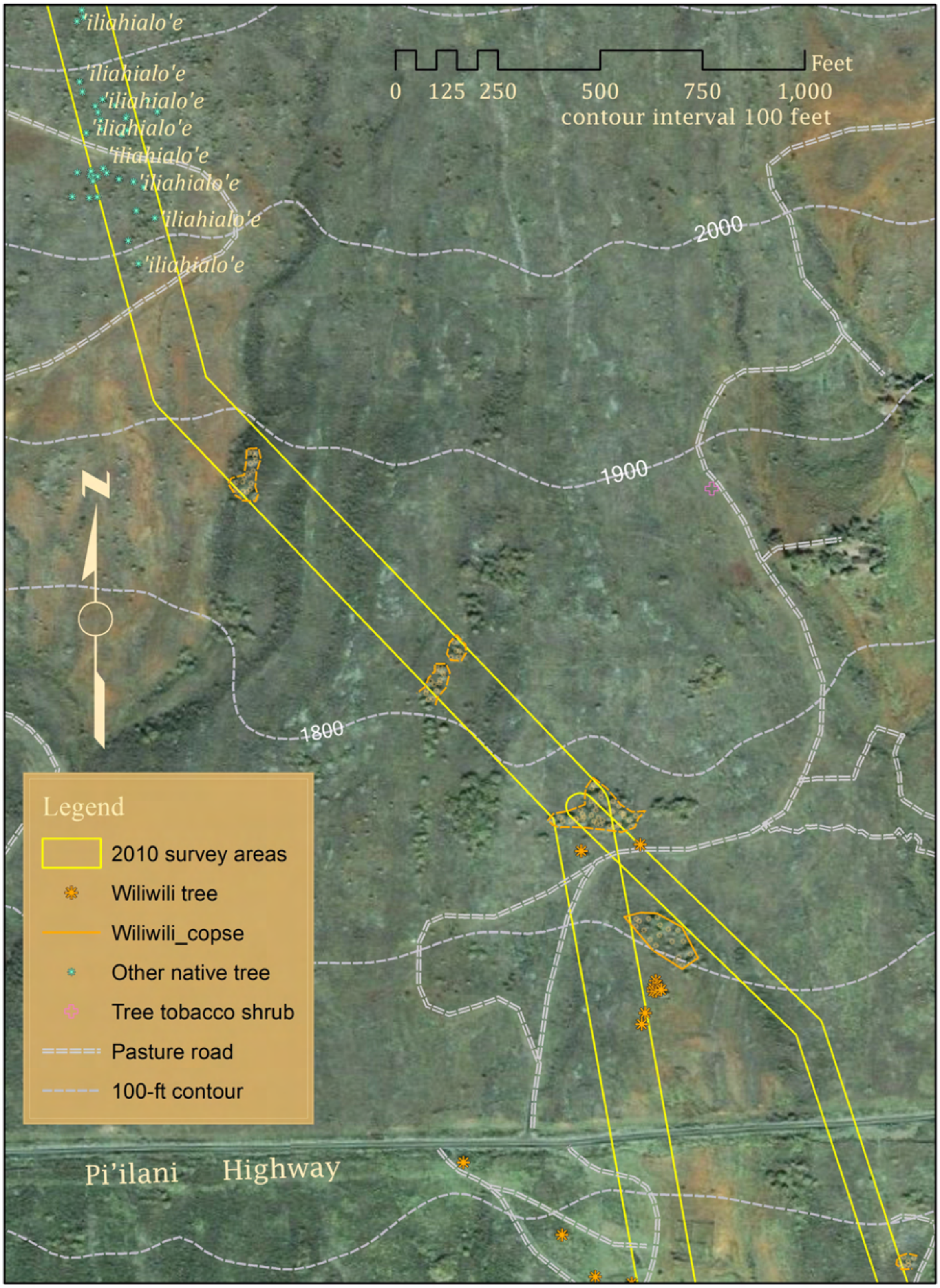

Figure 14. Botanical survey map for the east side generator tie-line between 1600 (Pi'ilani Highway) and 2100 feet ASL.

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	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	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 ʻawa*	**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.	*ʻala ʻala 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	*ʻilima*	**Ind.**	O2	O2	

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	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	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.

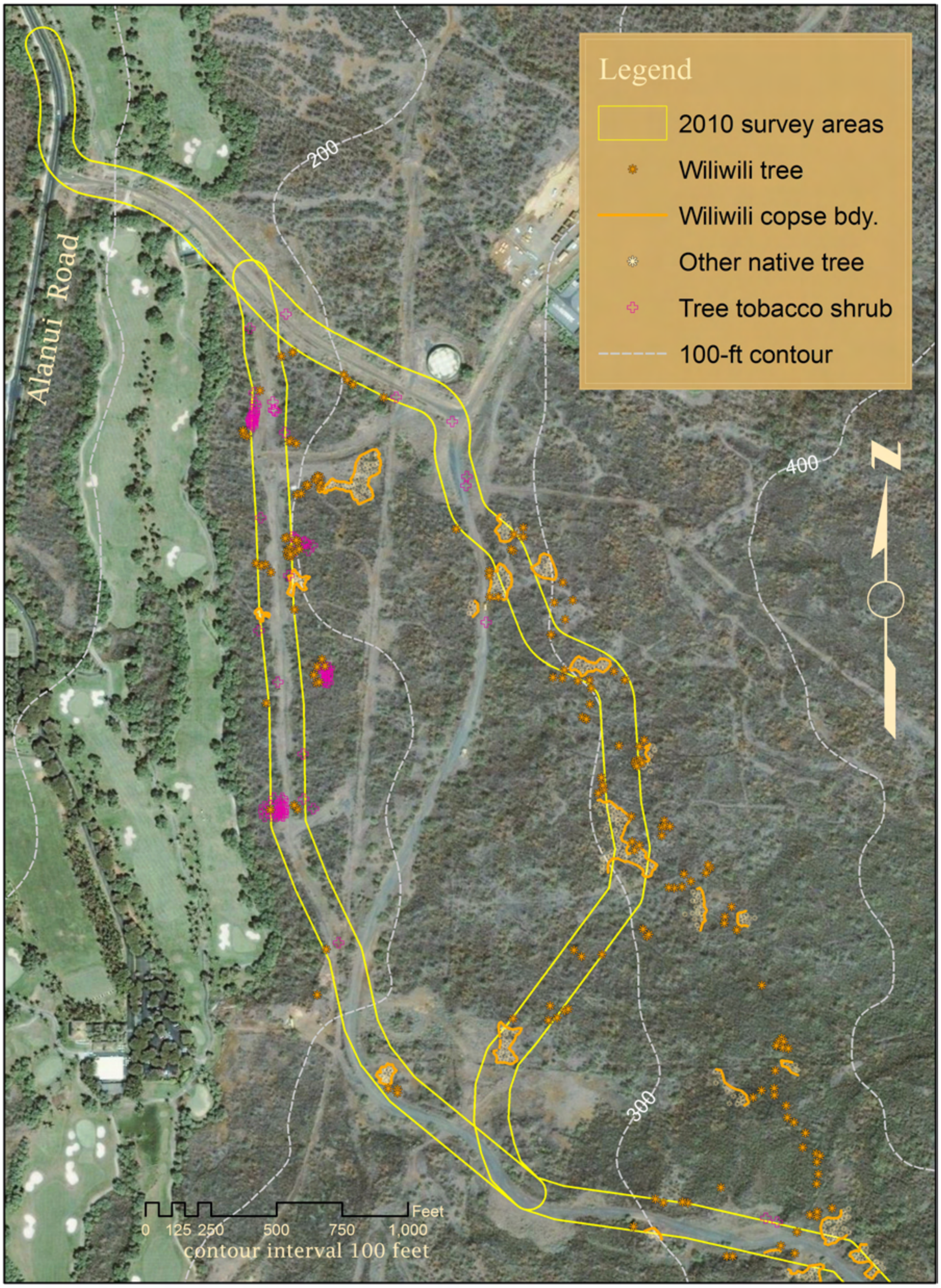

Figure 15. Botanical survey map for west end of construction access road between 100 (Alanui Road) and 350 feet ASL.

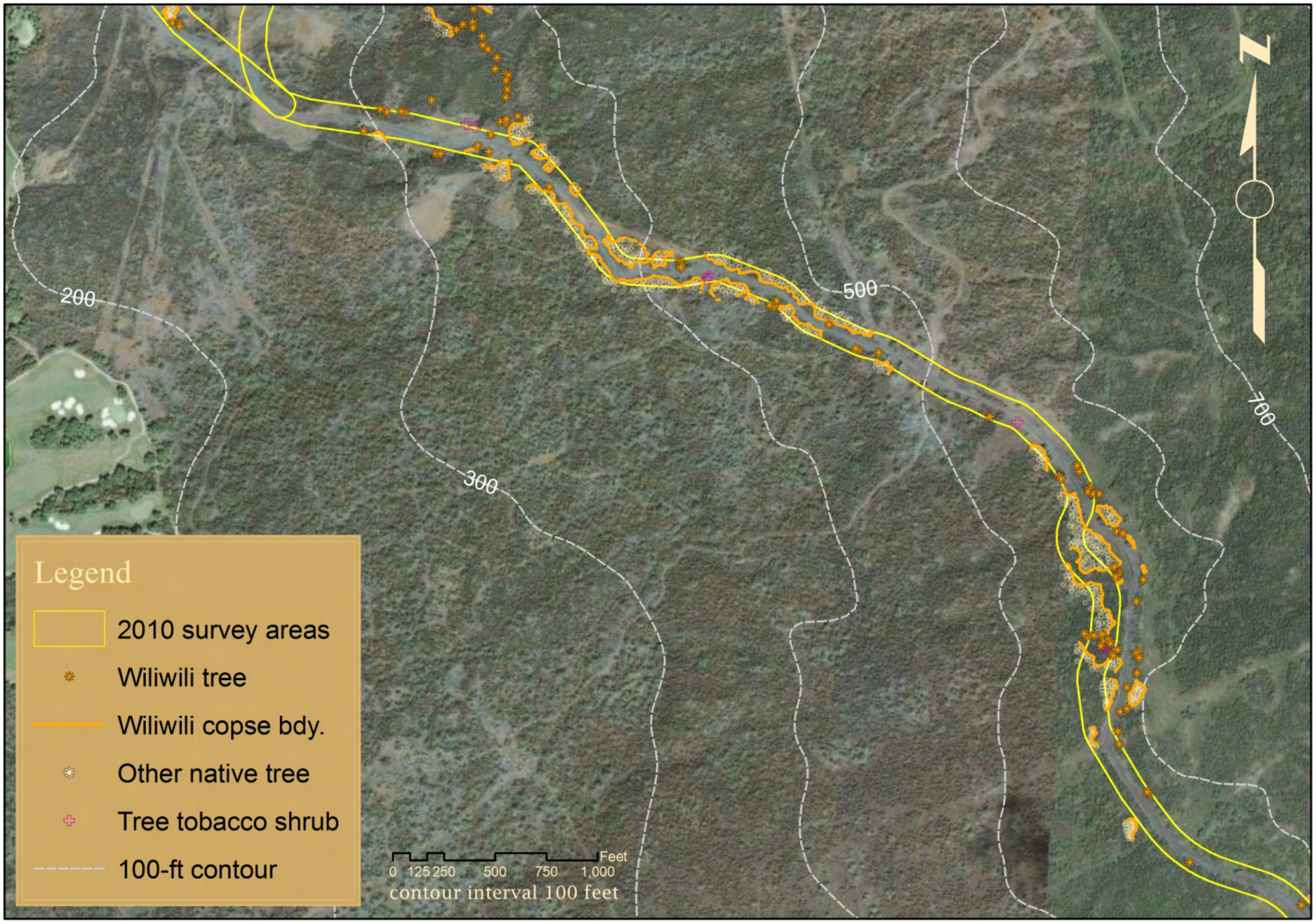

Figure 16. Botanical survey map for western part of construction access road between 250 and 550 feet ASL.

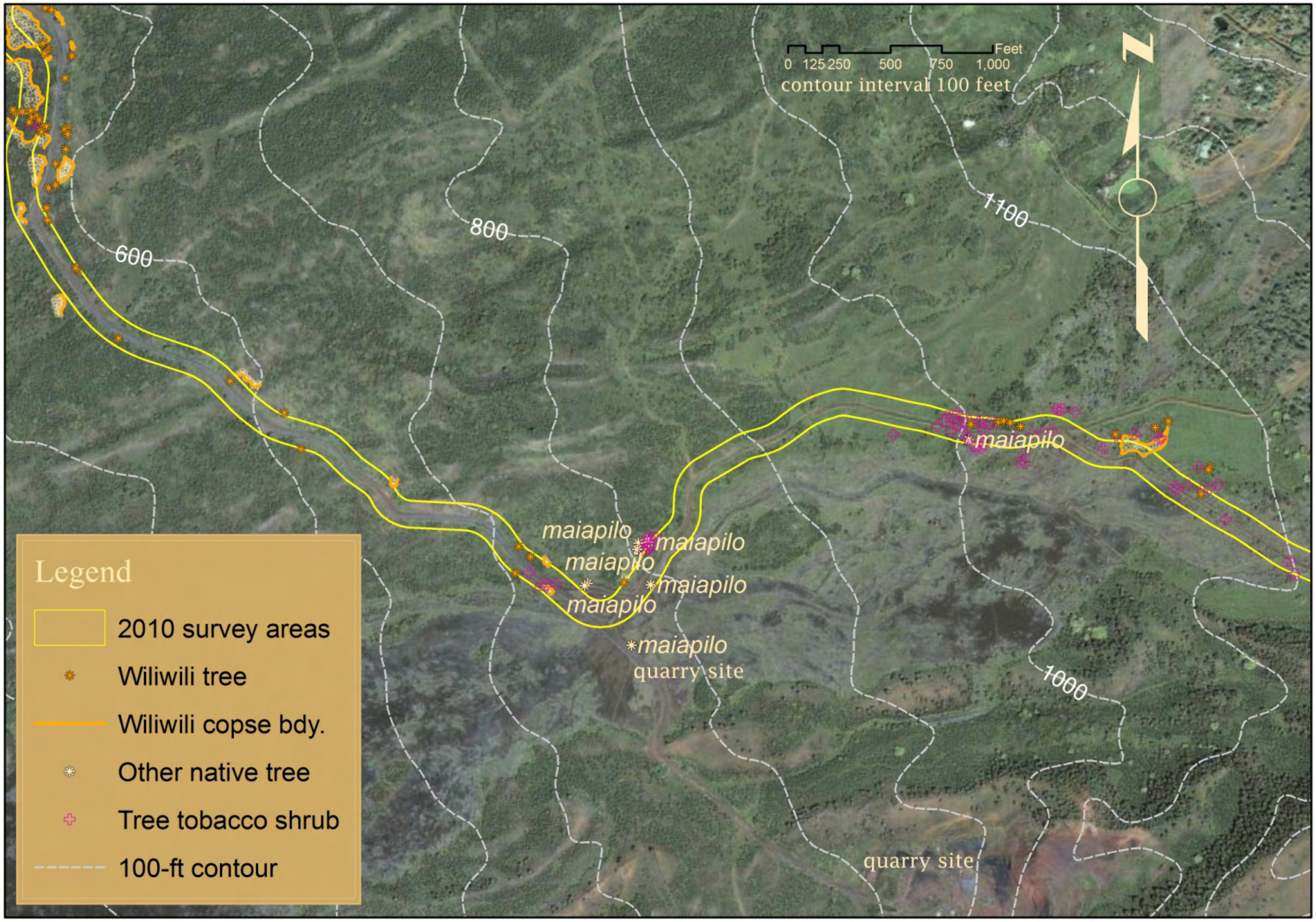

Figure 17. Botanical survey map for construction access road between 550 and 1100 feet ASL.

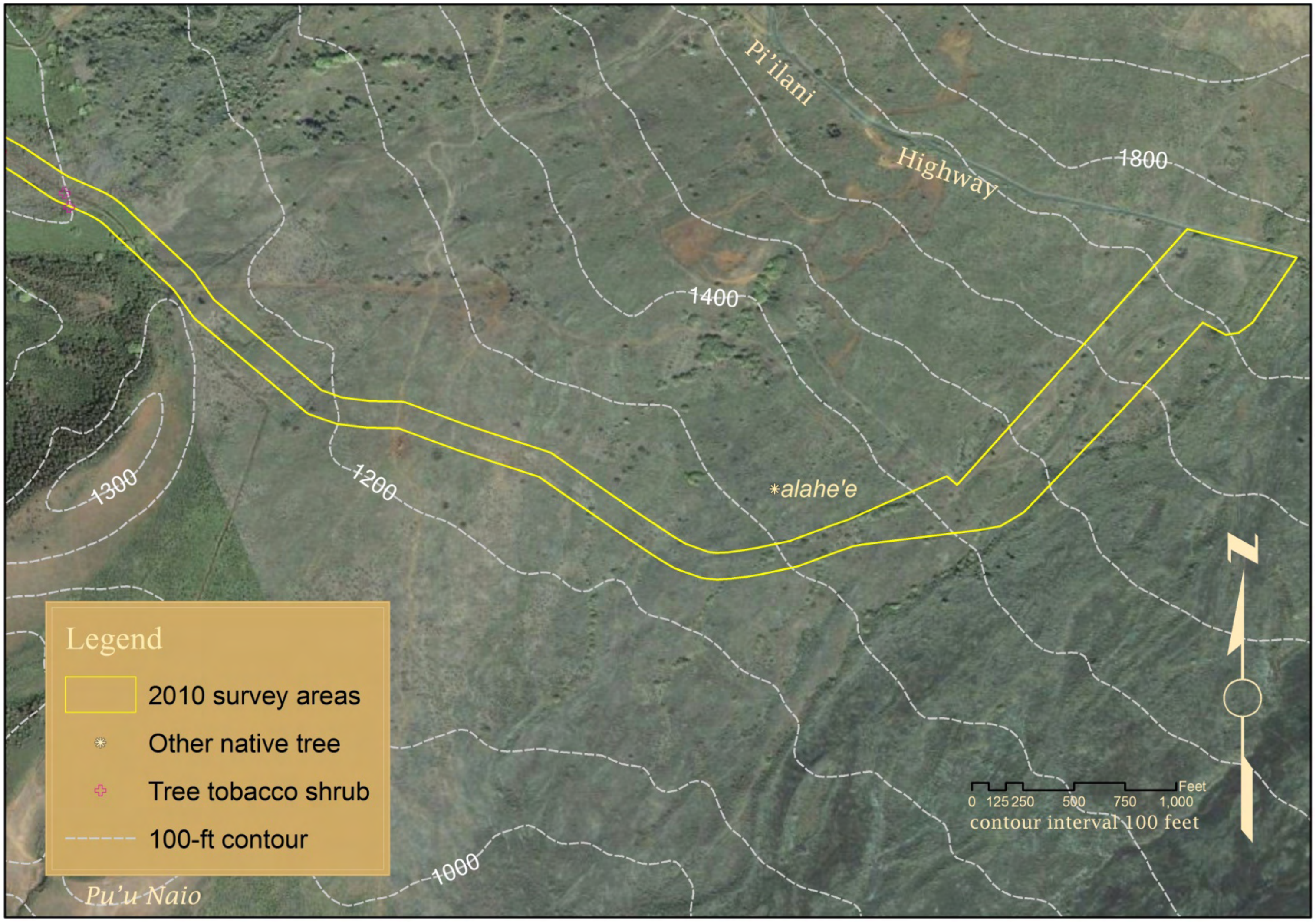

Figure 18. Botanical survey map for east end of construction access road between 1100 and 1750 feet ASL (Pi'ilani Higway).

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 ʻUlupalakui 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.

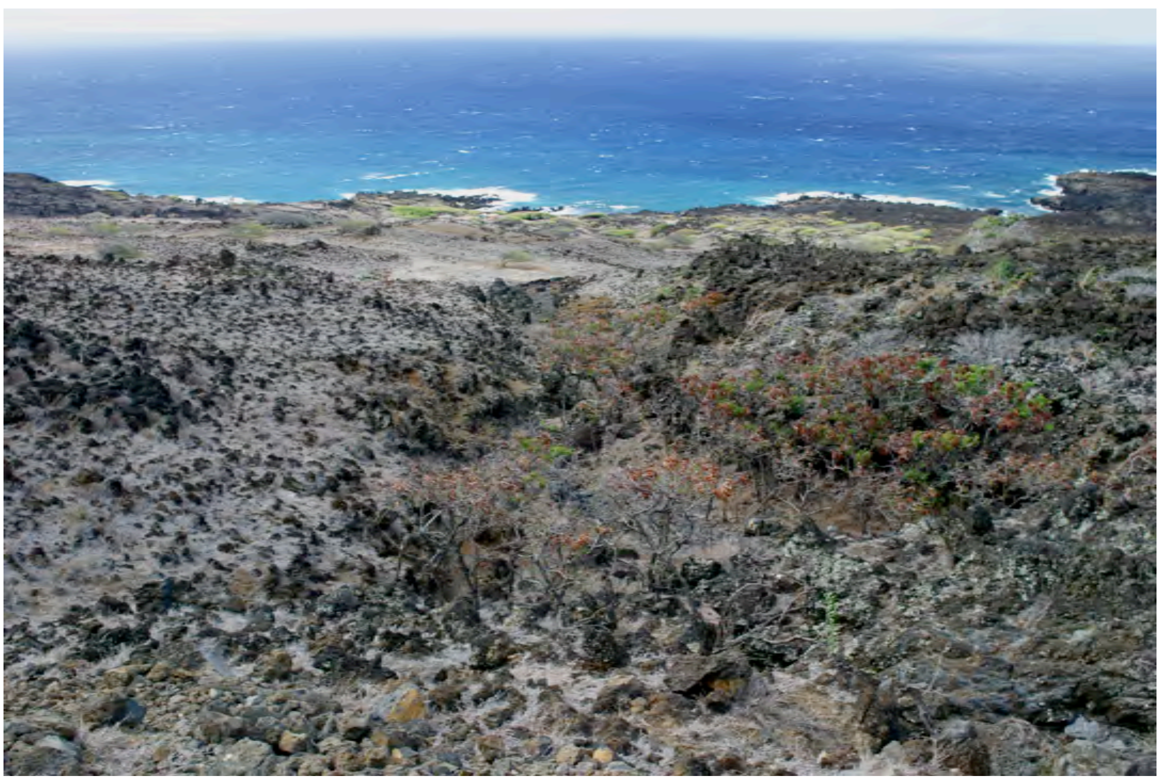

Figure 19. Swale of "intermittent stream" shown in Guinther (2010) seen from 250-ft elevation looking towards the outlet at the shore.

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 ʻUlupalakua 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 puʻu (Kalanapahi cinder cone) downslope, which is Not used for cattle grazing. Slope on right is Keonenelu cinder cone.

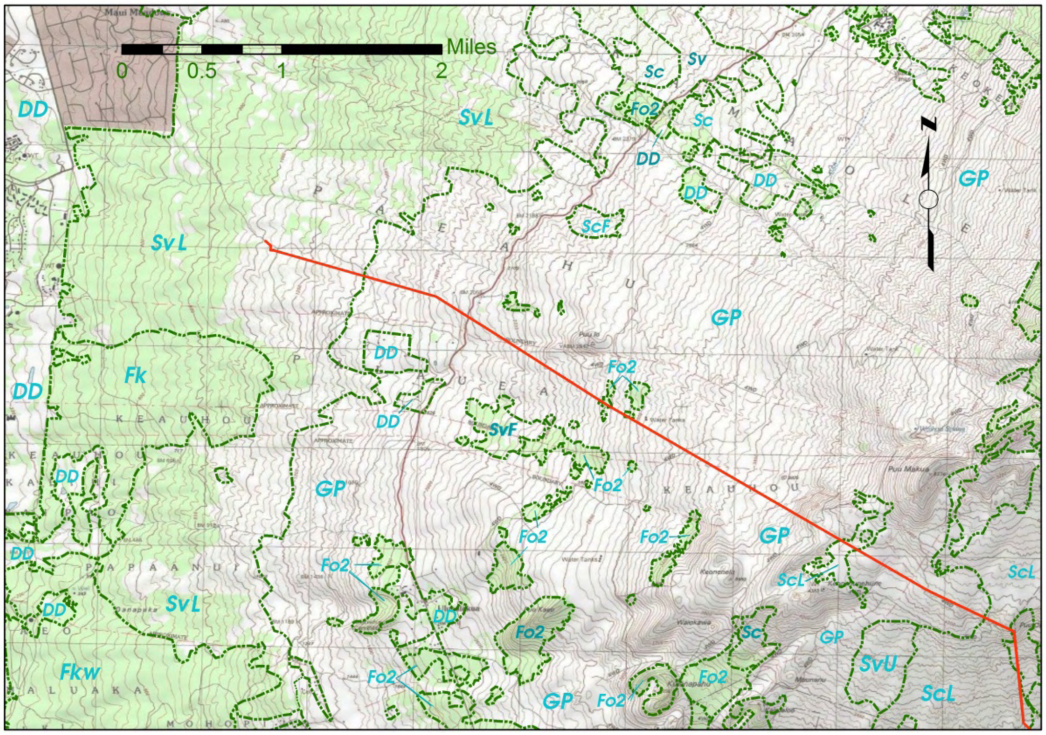

Figure 21. Vegetation zones for the western half of the generator tie-line (in red) crossing upland pasture and lowland savanna of 'Ulupalakua Ranch. For key see Table 6.

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”.

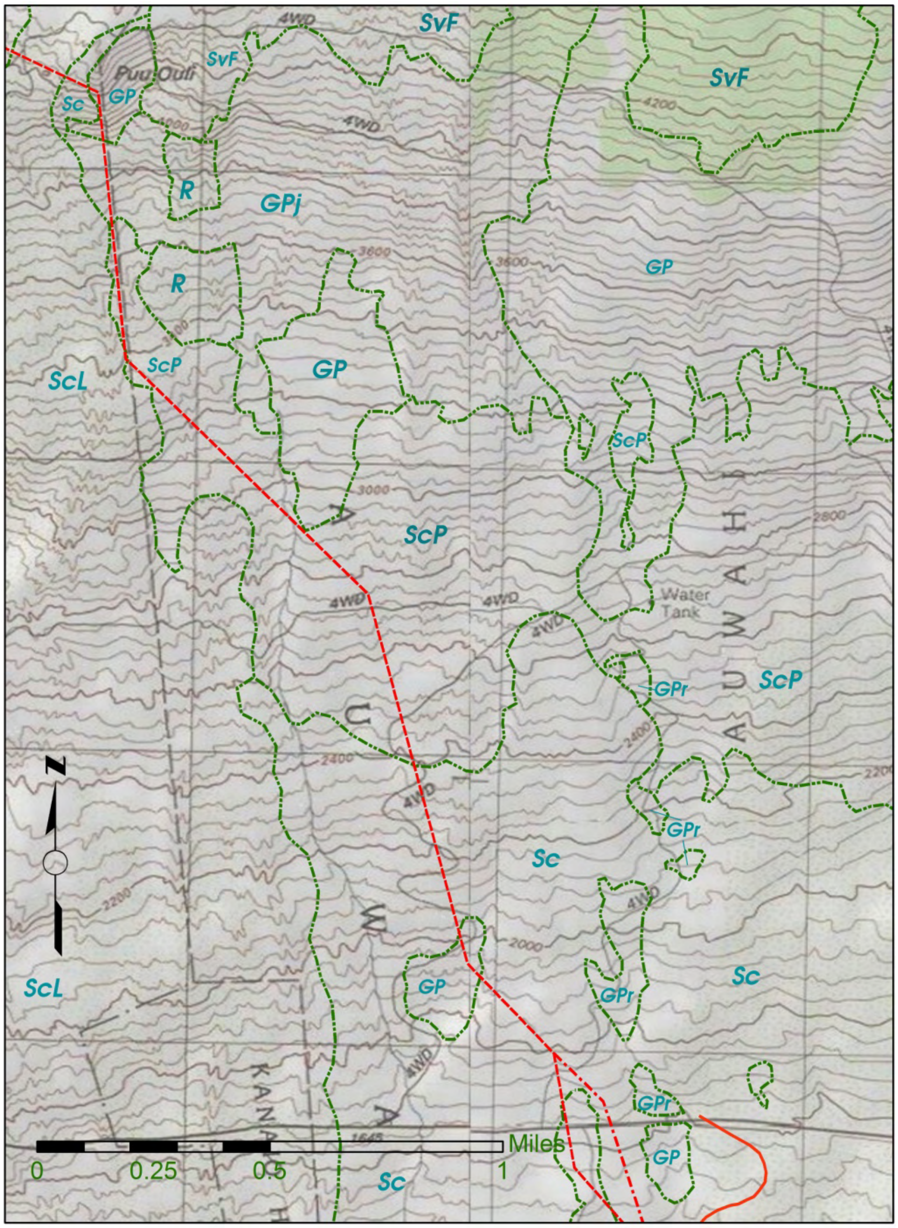

Figure 23. Vegetation zones for the eastern half of the generator tie-line (in red) crossing upland savanna and scrub pasture, scrub lands of ‘Ulupalakua Ranch. For key see Table 6.

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***).

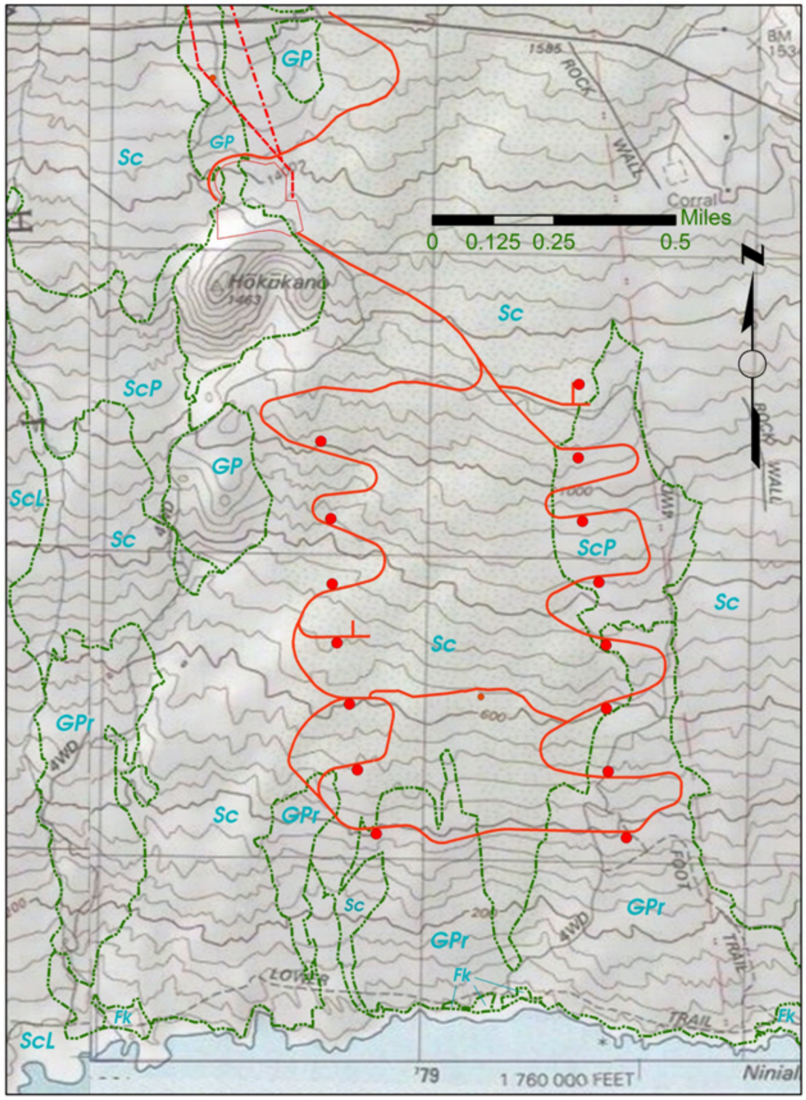

Figure 26. Vegetation zones for the Auwahi Wind Farm site. Scrub vegetation predominates on lava flows of various ages, with small areas of grassland pasture and very rocky pasture present in some areas. For key see Table 6.

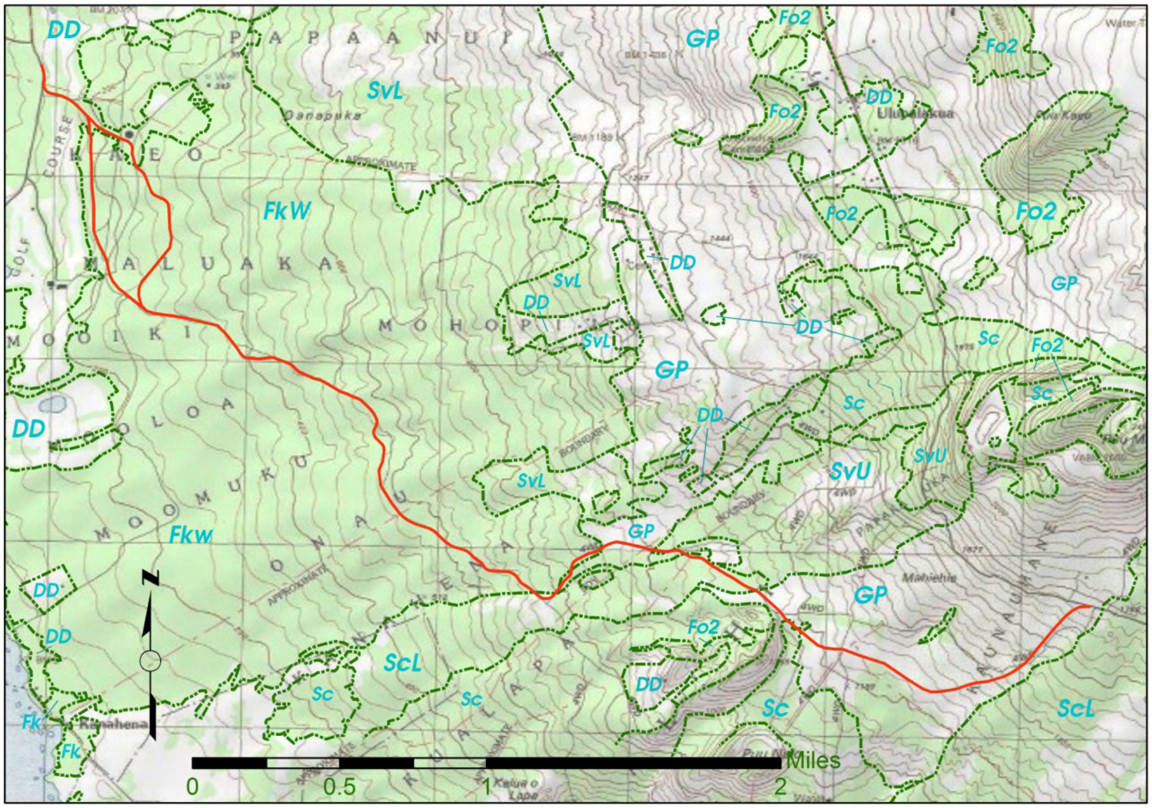

Figure 27. Vegetation zones for the construction access road (Papaka Road; in red) crossing mostly mixed kiawe/wiliwili forest and pasture of ʻUlupalakua Ranch. For key see Table 6.

Wiliwili (Erythrina) Forest is a vegetation type recognized by Gagne and Cuddihy (1990). The *wiliwili* is a summer deciduous tree and a Hawaiʻi 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.

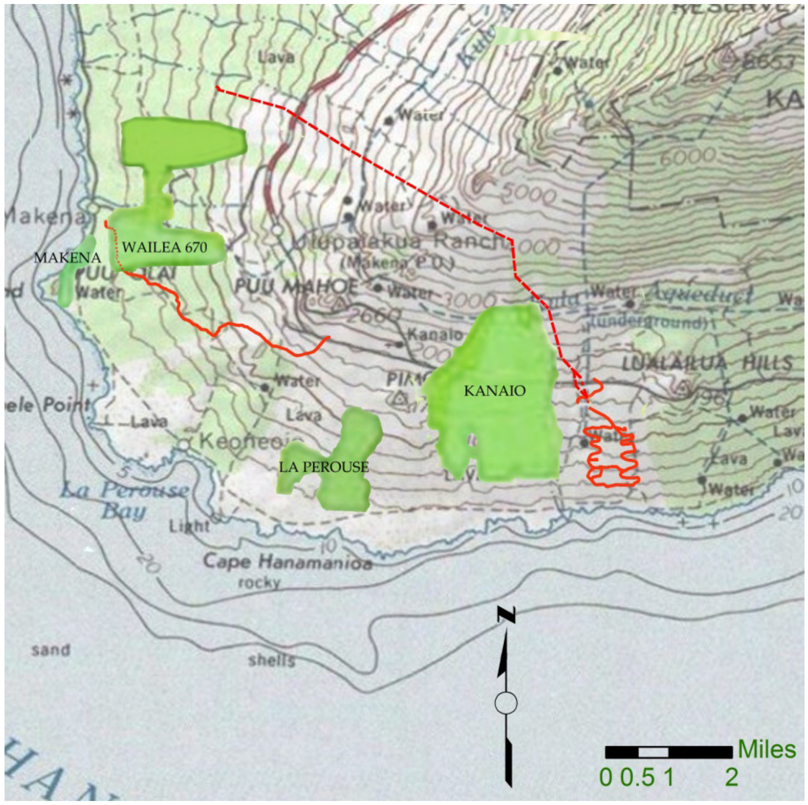

Figure 28. Wiliwili forest remnants (green areas) as mapped by Price (Altenburg, 2007) shown on a topographic map with Auwahi wind farm project elements in red.

Since 2005, an introduced insect (the Erythrina gall wasp, *Quadrastichus erythrinae*) has preyed exclusively on several *Erythrina* species in Hawaiʻi, 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 ʻUlupalakua 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 Puʻu Naio. This forest area is generally degraded, although the *wiliwili* sometimes form dense copses with an understory of *ʻilima* 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 Puʻu 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, *ʻohai* 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 Honoaʻula and moku of Kahikinui, and the boundary between the *ahupuaʻa* of Kanaio and “Aʻuahi” (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 Puʻu Ouli and the ranch road near the top of Puʻu 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 Hawaiʻi, 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 Piʻilani 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 Pi'ilani 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

Lāna'i 'iliahi

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, *Lāna'i 'iliahi* 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 Pu'u O'uli 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, Hawai'i. 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, Hawai'i. 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 B
Auwahi Wind Project Revegetation Potential Plant List

Auwahi Wind Project Revegetation Potential Plant List

Common Name	*Scientific Name*
Trees	
wiliwili	*Erythrina sandwicensis*
'iliahialo'e	*Santalum ellipiticum*
'ohe makai	*Reynoldsia sandwicensis*
alahe'e	*Canthium odoratum*
'akoko	*Chamaesyce celastroides*
naio	*Myoporum sandwicense*
hao	*Rauvolfia sandwicensis*
'aiea	*Nothocestrum latifolium*
koai'a	*Acacia koai'a*
keahi	*Nesoluma polynesicum*
lama	*Diospyros sandwicensis*
Shrubs	
'a'ali'i	*Dodonaea viscosa*
kuluʻī	*Nototrichium sandwicense*
'aweoweo	*Chenopodium oahuense*
maiapilo	*Capparis sandwichiana*
pua kala	*Argemone glauca*
'uhaloa	*Waltheria indica*
kolomona	*Senna gaudichaudii*
unknown	*Achyranthes splendens*
ma'o	*Gossypium tomentosum*
'akia	*Wikstroemia monticola*
Grasses	
pili	*Heteropogon contortus*
mountain pili	*Panicum tenufolium*
kawelu	*Eragrostis variabilis*
Guinea grass	*Panicum maximum*
Bufflegrass	*Pennisetum ciliare*
	Paspalum sp.
Ground Layer	
nehe	*Lipochaeta lavarum*
'ilihe'e	*Plumbago zeylanica*
'ilima	*Sida fallax*
'ala'ala wai nui	*Peperomia leptostachya*
'ulei	*Osteomeles anthyllidifolia*
ʻĀwikiwiki	*Canavalia pubescens*

List of Candidate Tree Species for the Waihou Mitigation Area	
Common Name	***Scientific Name***
'Ohia lehua	*Metrosideros polymorpha**
Koa	*Acacia koa**
'A'ali'i	*Dodonaea viscosa**
Kōlea lau nui	*Myrsine lessertiana**
Ulei	*Osteomeles anthyllidifolia***
'Ōlapa	*Cheirodendron trigynum***
Naio	*Myoporum sandwicense***
Māmane	*Sophora chrysophylla***
Maua	*Xylosma hawaiiense***
'Ohe mauka	*Polyscias oahuensis* (formerly genus *Tetraplasandra*)***
'Ohe 'ohe	*Polyscias kavaense* (formerly genus *Tetraplasandra*)***
Kawa'u	*Ilex anomala****
Pilo	*Comprosma foliosa vontempsky****
Olomea	*Perrottetia sandwicensis****
Ha'iwale	*Cyrtandra sp.****
'Opuhe	*Urera glabra****

*Will be most prevalently planted species
**Secondly most planted species
***Dependent upon availability and viability of seeds

As the overstory canopy fills in the understory would eventually be planted with appropriate ferns, *peperomia sp.*, *Phyllostegia sp.* and other small herbs from propagules/seeds colleted from nearby areas. Already there is remnant Laukahi (*Dryopteris wallichiana)* persisting at the site. There is also great potential for re-introducing Hāpu'u *(Cibotium spp.)* and 'Ama'u *(Sadleria spp.)*

Appendix C
Auwahi Wind Farm 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

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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
MECO	Maui Electric Company
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 Hawaiʻi Department of Land and Natural Resources

The State of Hawaiʻi 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 Hawaiʻi Department of Hawaiian Homelands

The State of Hawaiʻi 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.

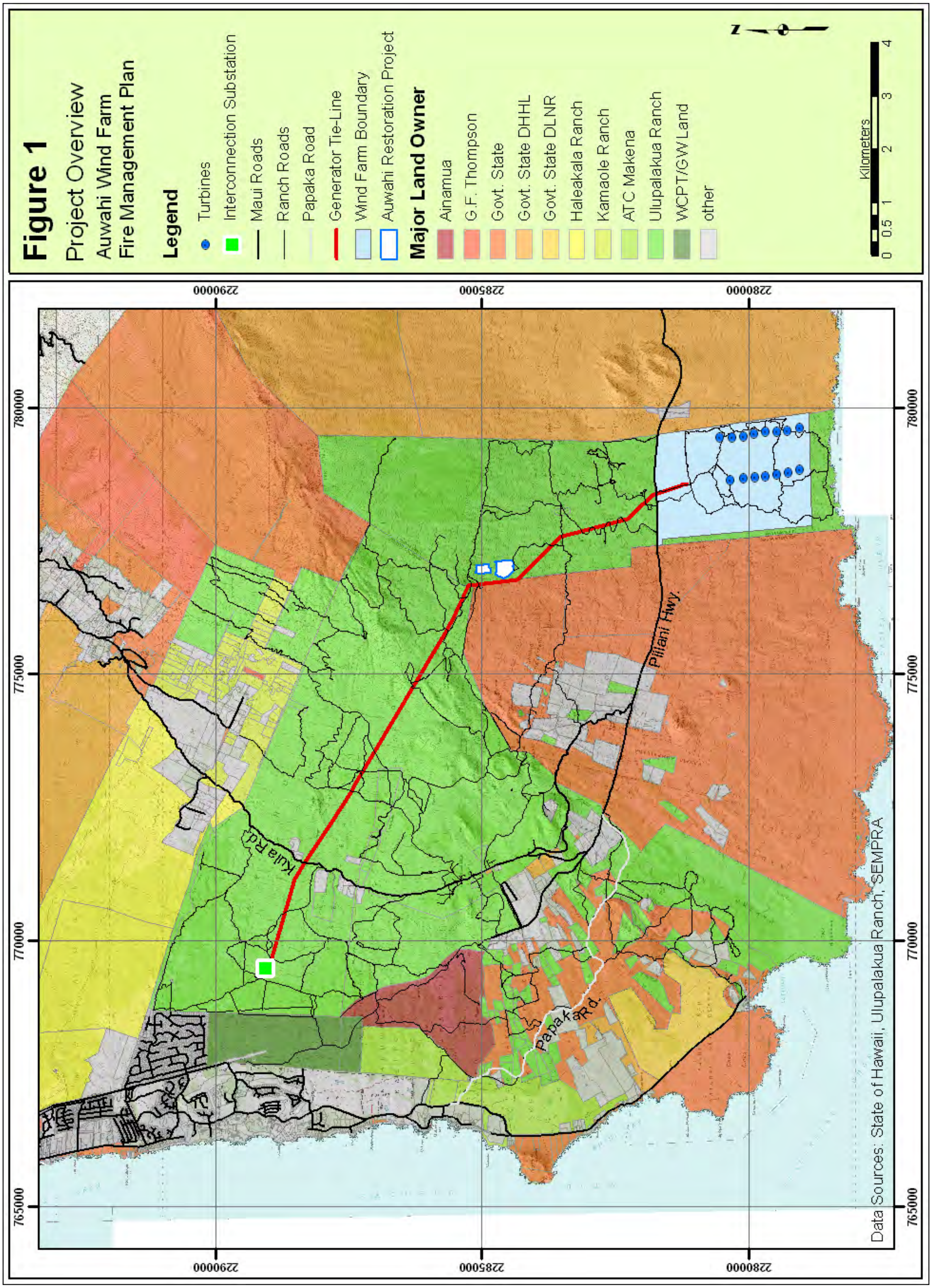


Figure 1
Project Overview
Auwahi Wind Farm
Fire Management Plan
Legend
Turbines
Interconnection Substation
Maui Roads
Ranch Roads
Papaka Road
Generator Tie-Line
Wind Farm Boundary
Auwahi Restoration Project
Major Land Owner
Ainamua
G.F. Thompson
Govt. State
Govt. State DHHL
Govt. State DLNR
Haleakala Ranch
Kamaole Ranch
ATC Makena
Ulupalakua Ranch
WCPT/GW Land
other
N
Kilometers
0 0.5 1 2 3 4
Kula Rd.
Piilani Hwy.
Papaka Rd.
765000
770000
775000
780000
2280000
2285000
2290000
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA

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.

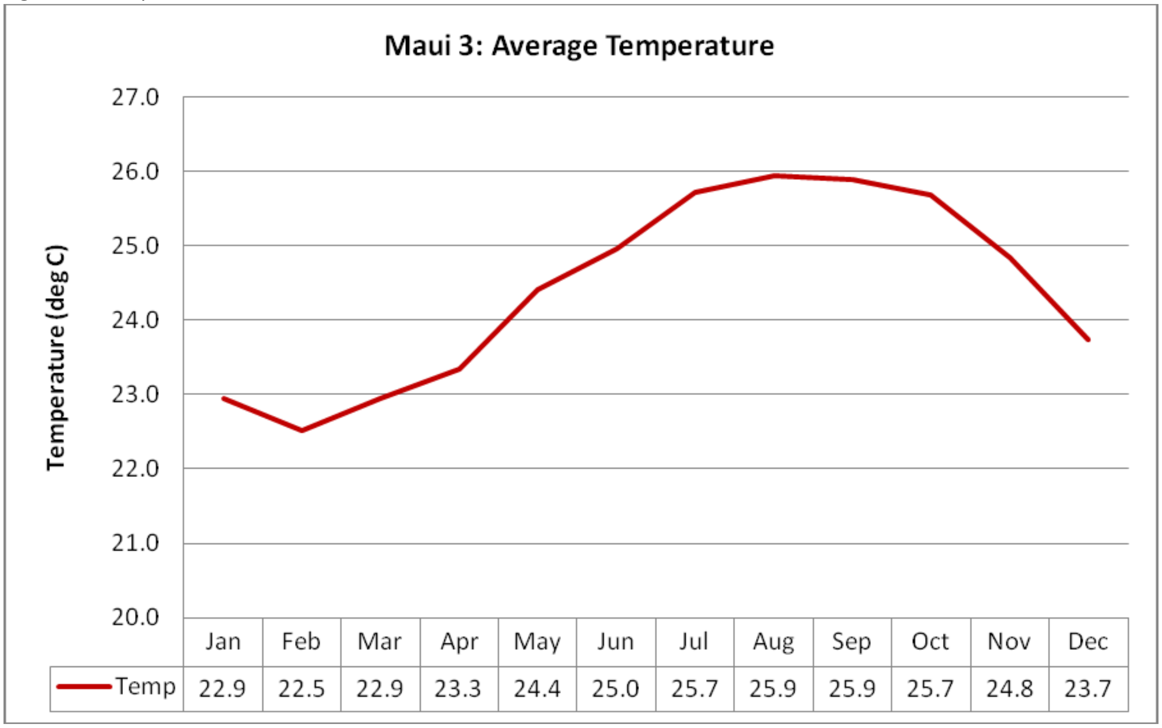


Figure 3. Wind rose for the wind farm site.

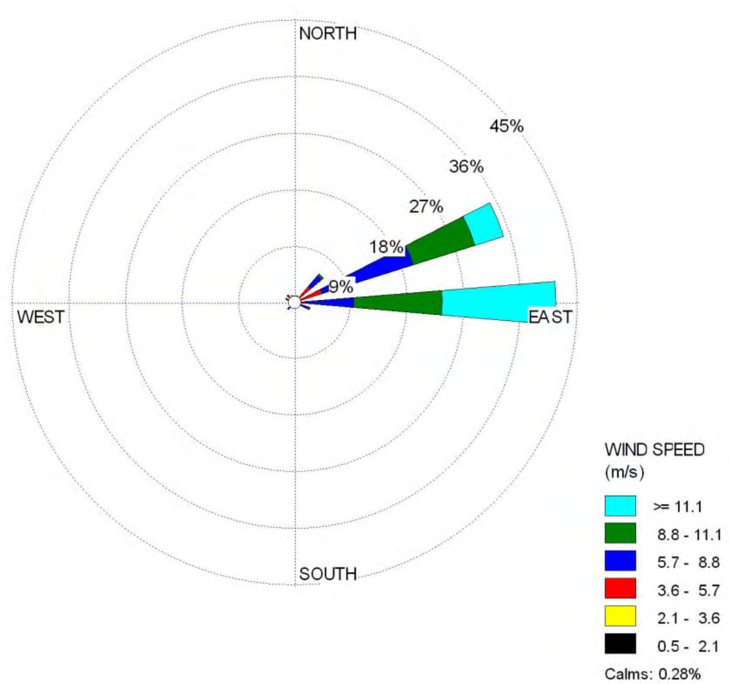
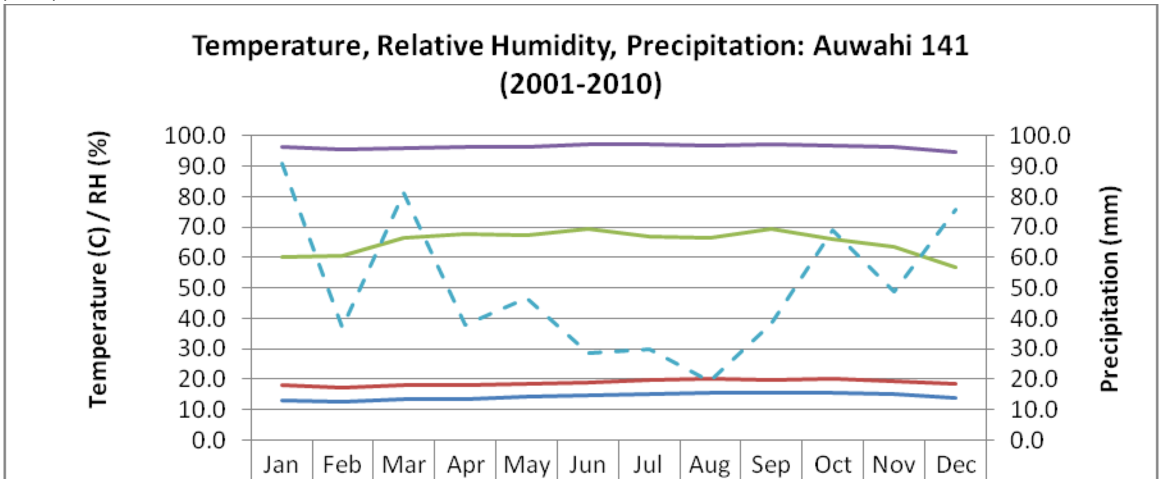
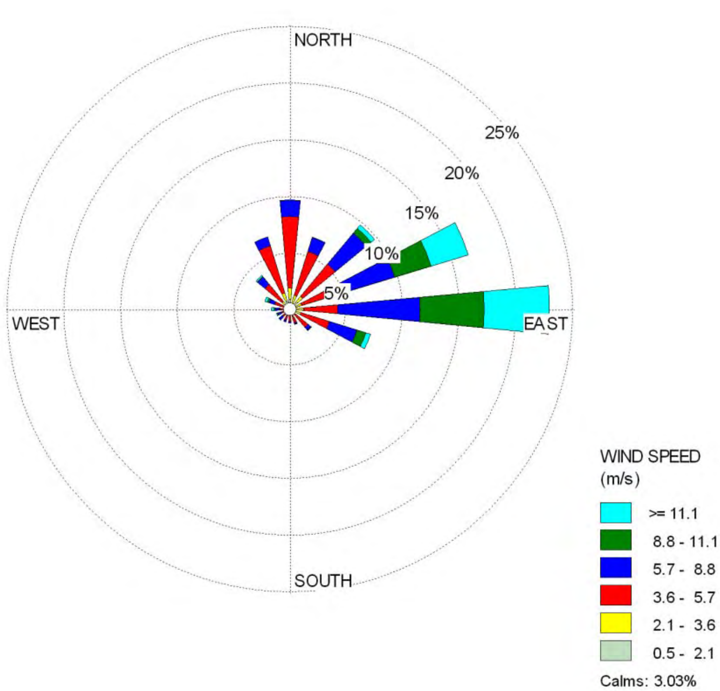


Figure 4. Monthly average maximum and minimum temperature, maximum and minimum relative humidity, and precipitation from the Auwahi 141 weather station.



	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.



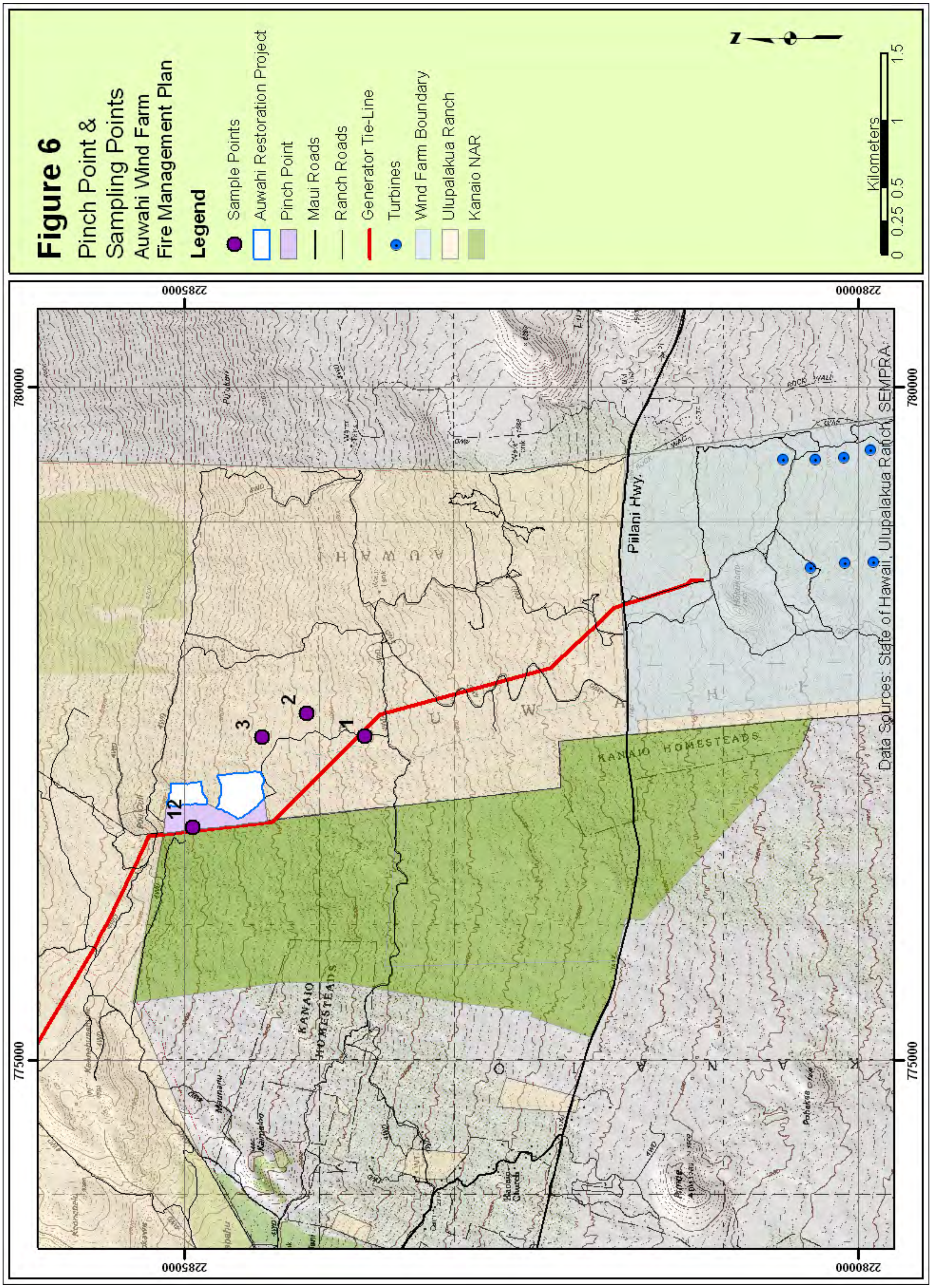


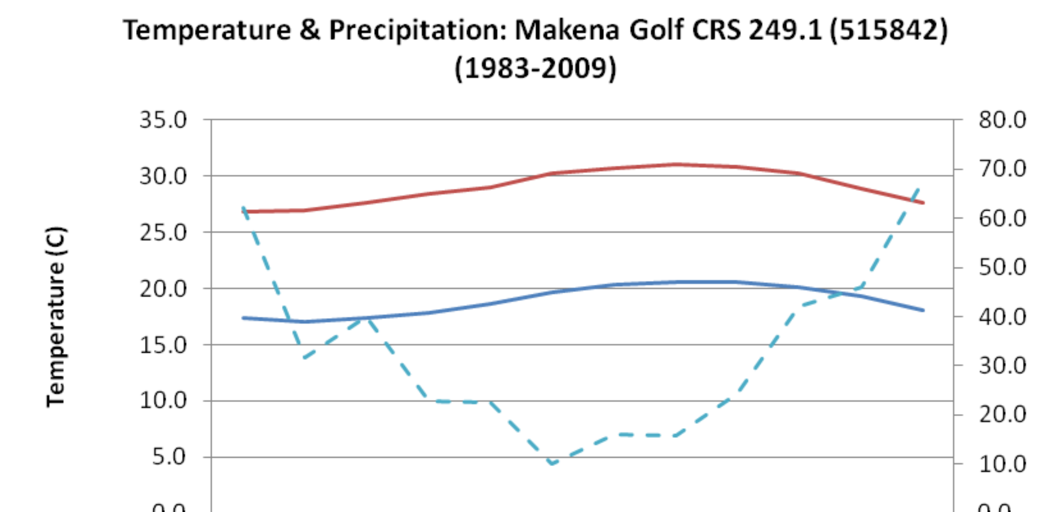
Figure 6
Pinch Point &
Sampling Points
Auwahi Wind Farm
Fire Management Plan
Legend
Sample Points
Auwahi Restoration Project
Pinch Point
Maui Roads
Ranch Roads
Generator Tie-Line
Turbines
Wind Farm Boundary
Ulupalakua Ranch
Kanaio NAR
N
Kilometers
0 0.25 0.5 1 1.5
2285000
2280000
780000
775000
1
2
3
12
Piilani Hwy.
KANAIO HOMESTEADS
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

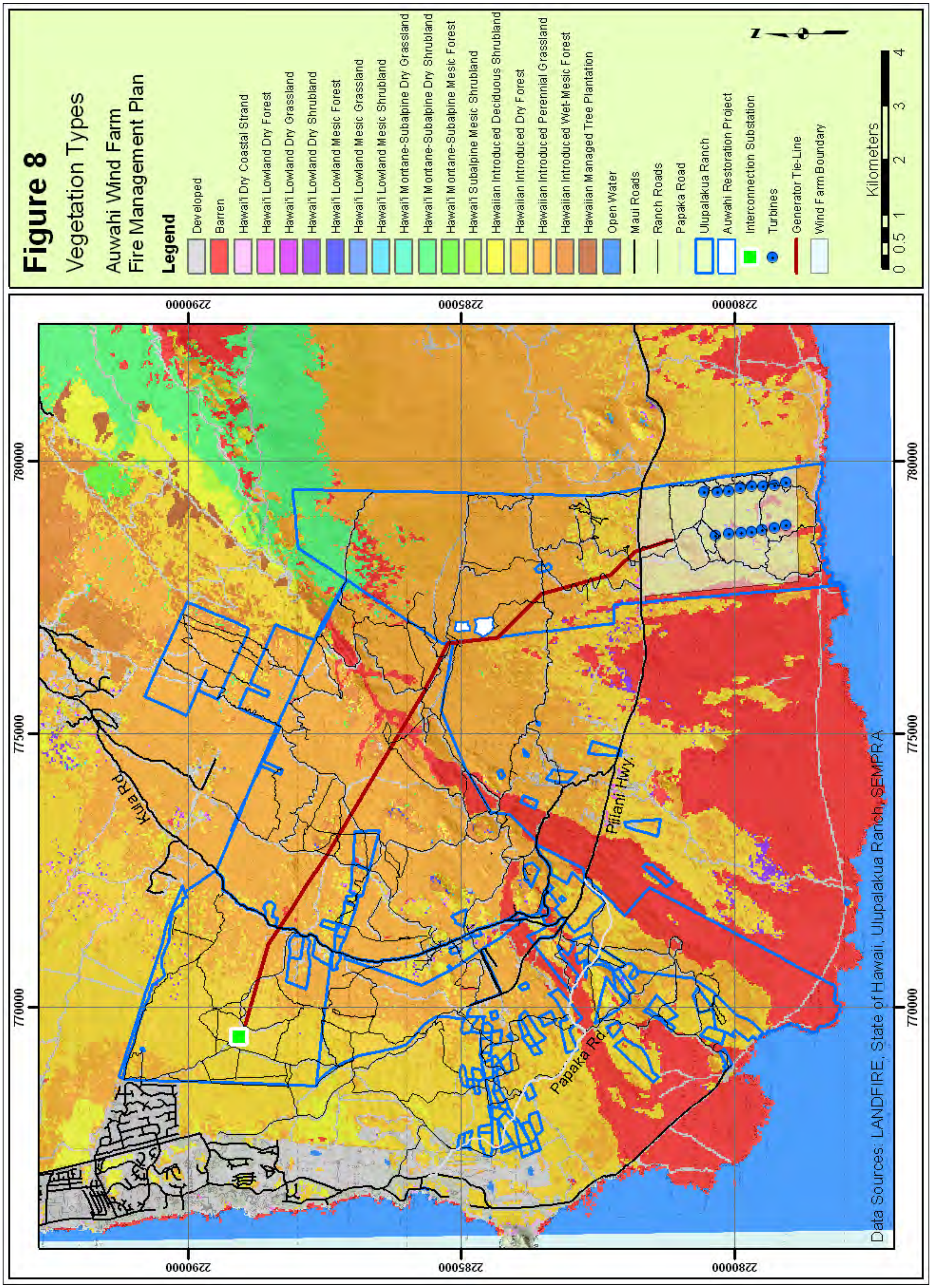


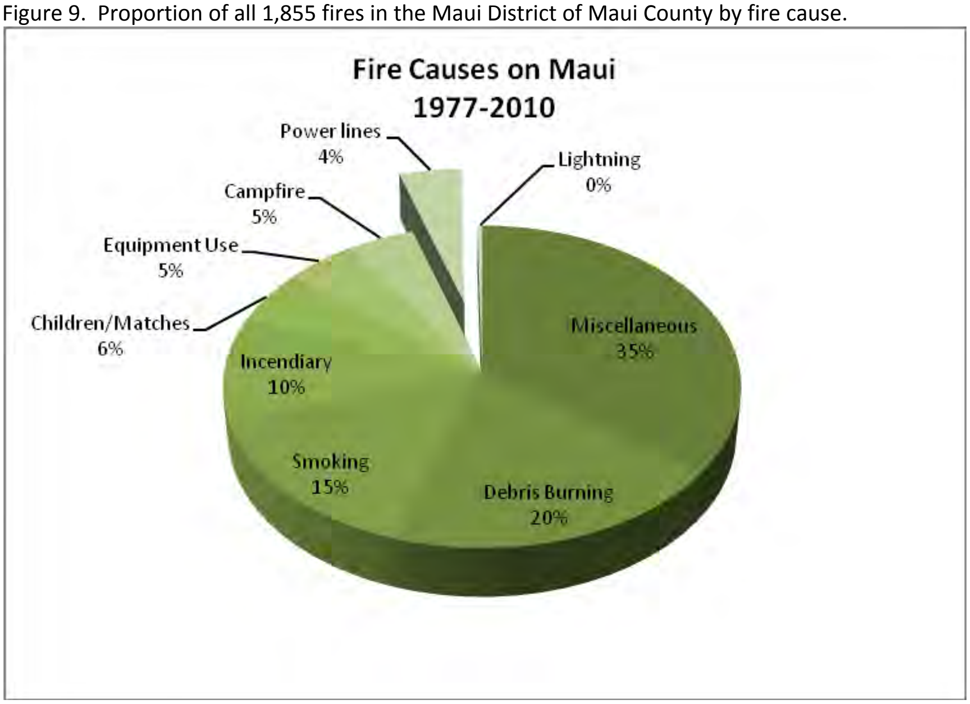
Figure 8
Vegetation Types
Auwahi Wind Farm
Fire Management Plan
Legend
Developed
Barren
Hawai'i Dry Coastal Strand
Hawai'i Lowland Dry Forest
Hawai'i Lowland Dry Grassland
Hawai'i Lowland Dry Shrubland
Hawai'i Lowland Mesic Forest
Hawai'i Lowland Mesic Grassland
Hawai'i Lowland Mesic Shrubland
Hawai'i 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
N
0 0.5 1 2 3 4
Kilometers
2290000
2285000
2280000
770000
775000
780000
Kula Rd.
Piilani 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 Hawaiʻi 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 Hawai‘i 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 Piʻilani 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 Piʻilani 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 0.5%. This figure is calculated from the fire history in section 2.3 and figures provided by the Maui Electric Company (MECO). 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 Hawaiʻi 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.

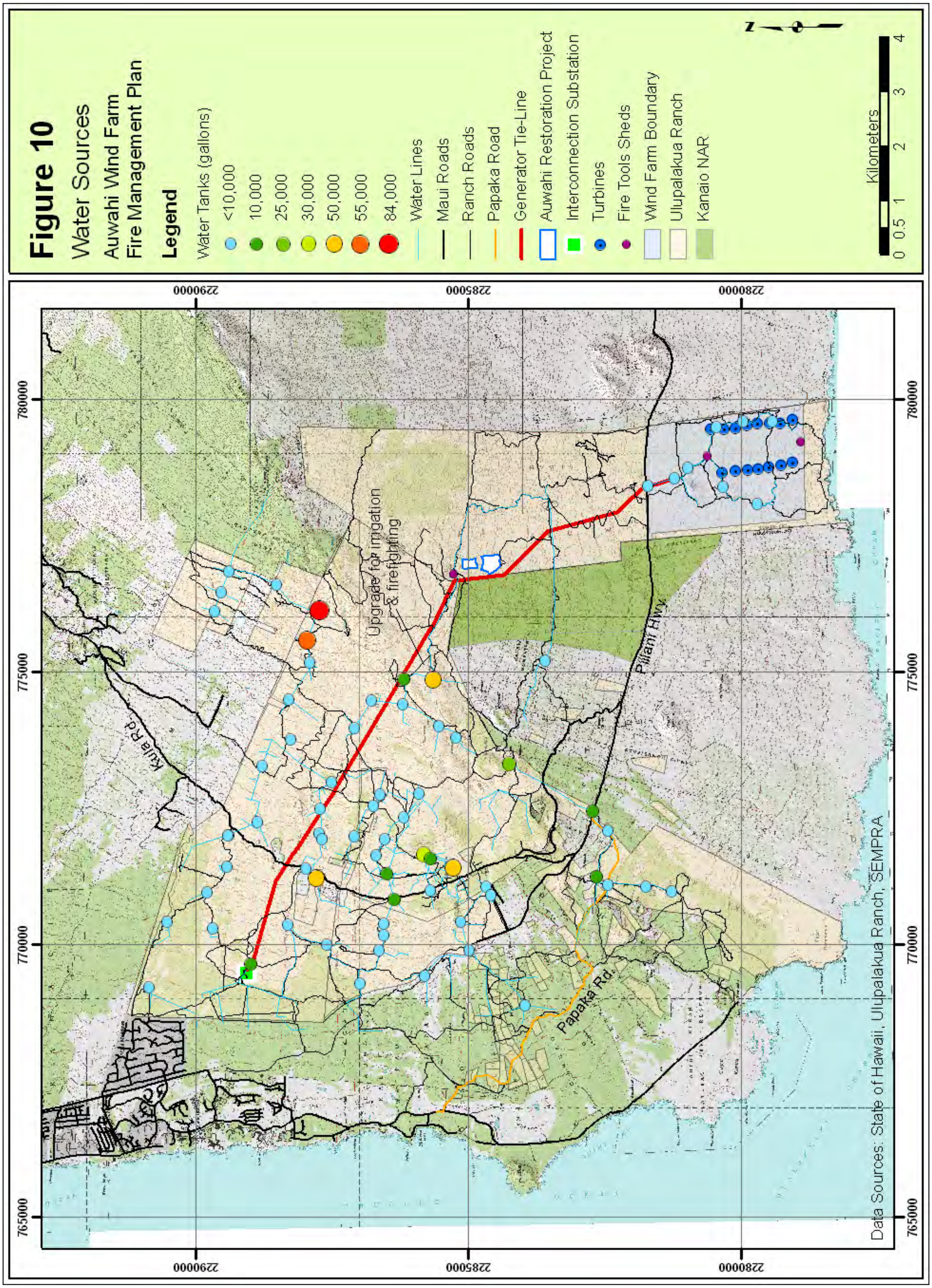


Figure 10
Water Sources
Auwahi Wind Farm
Fire Management Plan
Legend
Water Tanks (gallons)
<10,000
10,000
25,000
30,000
50,000
55,000
84,000
Water Lines
Maui Roads
Ranch Roads
Papaka Road
Generator Tie-Line
Auwahi Restoration Project
Interconnection Substation
Turbines
Fire Tools Sheds
Wind Farm Boundary
Ulupalakua Ranch
Kanaio NAR
N
Kilometers
0 0.5 1 2 3 4
765000
770000
775000
780000
2290000
2285000
2280000
Kula Rd.
Pillani Hwy.
Papaka Rd.
Upgrade for irrigation & firefighting
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA

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 electrical fires over 29 years.
The maximum number of fires in a given year is 7 electrical fires in 2010

***Miles of electrical line from MECO*.**
MECO has approximately 240 circuit miles of transmission lines (23 kV and above) and 1500 circuit miles of distribution lines (below 23 kV).

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.

Probability of a fire somewhere within the MECO transmission/distribution system over the lifetime of the Auwahi Wind Farm project, assumed here to be 50 years:

In 50 year lifetime of the project: 1 - (prob of no fire)^50 = 1 - (.1034^50) = ~1 (e.g. nearly 100%).

In any 2 year period: 1 - (prob of no fire)^2 = 1 - (.1034^2) = ~1 (e.g. nearly 99%).

Probability of a fire along the 9 miles of generator tie 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 generator tie line / total number of miles of electrical line):

1 * (9/1749) = 0.00515 (e.g. 0.5%)

Assumptions

1. This accounts for fires started during the operation of the generator tie line **only.** Other potential fire sources are construction activities and operation of the wind turbines.
2. 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.
3. There is no difference in the probability of a fire start from a generator tie line as compared to a distribution line (there is anecdotal evidence that distribution lines produce more fires).
4. There is no trend in fire occurrence in the historical record.
5. There will be no increase in fire occurrence in the future as a result of climate change.

Appendix D
Auwahi Wind Farm Project Post-construction Monitoring Plan

AUWAHI WIND FARM PROJECT

POST-CONSTRUCTION MONITORING PLAN

Prepared for

Auwahi Wind Energy, LLC

Prepared by

TETRA TECH EC, INC.

June 2011

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND AND PURPOSE OF THE POST-CONSTRUCTION MONITORING PLAN

Species listed under the federal Endangered Species Act (ESA) of 1973, as amended, and the State of Hawaii endangered species statutes, have the potential to occur in the vicinity of the Auwahi Wind Farm Project (Project), including the Hawaiian petrel, nēnē, and Hawaiian hoary bat. Individuals of these species could be killed or injured if they collide with wind turbine generators (WTG), or when bats fly close enough to experience barotrauma. Barotrauma is the tissue damage to air-containing structures (lungs) that results from the rapid air-pressure reduction near moving WTG blades (Baerwald et al. 2008).

Due to the potential for incidental take of these species, Auwahi Wind Energy LLC (Auwahi Wind) has consulted with the U.S. Fish and Wildlife Service (USFWS) and the Hawaii Department of Land and Natural Resources (DLNR) to acquire an Incidental Take Permit (ITP) and an Incidental Take License (ITL) issued by these agencies, respectively. These permits issued in accordance with Section 10(a) (1) (B) of the ESA and Section 195 D of the Hawaii Revised Statues, respectively, require the preparation of a Habitat Conservation Plan (HCP).

This post-construction monitoring plan (PCMP) has been developed as a means to document impacts or lack thereof to the Covered Species as a result of operation of the Project, and to ensure compliance with the authorized provisions and take limitations of the HCP and the associated ITP/ITL. Based on the results of post-construction monitoring, avoidance and minimization measures as outlined in the HCP adaptive management strategy could be modified, or additional measures implemented, as necessary, should Project effects differ substantially from what was anticipated.

Although the PCMP is implemented to document any potential incidental take of threatened or endangered species, impacts to non-listed species will be recorded for informational purposes. Additionally, although survey efforts will focus on documenting mortality through standardized searches, all injuries and mortality associated with the project (e.g., vehicle strikes) will be documented.

1.2 COMPONENTS OF THE PCMP

Wind farm-related fatality estimation is based on the number of carcasses found during carcass searches conducted under operating WTGs. Both the length of time carcasses remain on site before being removed by scavengers (carcass removal rate) and the ability of searchers to locate carcasses (searcher efficiency) can bias the number of carcasses located during standardized searches. Therefore, this PCMP includes 1) methods for conducting standardized carcass searches to monitor potential injuries or fatalities associated with Project operation, 2) carcass removal trials to assess seasonal, site-specific carcass removal rates by scavengers or other means, and 3) searcher efficiency trials to assess observer efficiency in finding carcasses. Vegetation conditions will be assessed and documented as part of the monitoring protocol to consider when conducting carcass searches and carcass removal and searcher efficiency trials. The field and analytical methods proposed below are consistent with post-construction monitoring being conducted, or proposed, for other wind projects in Hawaii and other U.S. locations (Johnson et al. 2000; Kerns and Kerlinger 2004; Fiedler et al. 2007; NWC and West 2007; Tetra Tech 2008; KWP 2006, 2011; Erickson 2009; Arnett et al. 2009a;

SWCA 2010; Poulton and Erikson 2010), but have been adapted to the specific characteristics of the Project.

The PCMP protocol outlines the surveys and trials to be conducted and provides an adaptive management approach to post-construction monitoring. Methods and timing outlined in this protocol may be modified over time as project-specific information is obtained to maximize the effectiveness and efficiency of the monitoring program (e.g., search interval, the number of WTGs searched, plot size). Additionally, recent advancements in the science of post-construction monitoring have resulted in variations in the standard monitoring protocol based on site-specific conditions at individual wind farms, species of interest, study objectives, and statistical developments in the quantification of bias correction factors and mortality rates (Shoenfeld 2004; Jain et al. 2007, Arnett et al. 2009a; Huso 2010). It can be assumed that post-construction monitoring techniques will continue to be refined over the 25-year life of the ITP and ITL. Therefore, the intent of this protocol is to provide a sound framework that can apply the best available science over the long term. Any recommended changes to the protocol from the baseline provided herein would require review and approval by USFWS, DLNR/Division of Forestry and Wildlife (DOFAW), and the Endangered Species Recovery Committee (ESRC).

1.3 Other Necessary Permits

Prior to initiating surveys, permits required to implement the monitoring program will be obtained, including the USFWS Special Purpose Permit and the DOFAW Protected Wildlife Permit. These permits grant permission and include provisions for handling wildlife and carcasses. They will be required for handling any dead or live native wildlife used in the searcher efficiency and carcass removal trials described below, unless other legal species, such as chickens are used.

2.0 STANDARDIZED CARCASS SEARCHES

The objective of the standardized carcass searches is to systematically search WTG locations for avian and bat casualties that are attributable to collision with Project facilities or barotrauma. For purposes of this PCMP, the casualties will be referred to as collision-related fatalities.

2.1 SAMPLING DURATION AND INTENSITY

The post-construction monitoring carcass searches to document avian and bat fatalities will begin once all WTGs are constructed and commissioning activities are complete. Some level of monitoring may be required throughout the operational period of the Project, but the monitoring effort may be reduced after the first 2 years upon approval by DOFAW, USFWS, and the ESRC. During the first 2 years of operation, post-construction monitoring consisting of systematic searches beneath each of the 8 WTG will be conducted approximately every one to two weeks from March through September each of the first 2 years and twice a week during the fledgling period for seabirds (8 weeks from October to the end of November). This timeframe will encompass movements of the Hawaiian petrel between nesting areas in Haleakala National Park (HNP) and the ocean during pre-nesting, nesting, and fledging (March through November; Simons and Hodges 1998). This also encompasses the period when Hawaiian hoary bats are thought to breed in Hawai‘i (April through August), although this has not been verified on Maui, and have the highest potential to be present in the Project area (Menard 2001). Hawaiian hoary bats appear to exhibit a seasonal, altitudinal migration from highland areas (roughly above 4,200 feet [ft] or 1,280 meters [m] above sea level [asl]) that are used during the pre-pregnancy period (January though March; Menard 2001) to lowland areas (roughly below 4,200 ft or 1,280 masl) that are used during the breeding period (April through August). Thus, bats are most likely to be in the Project site, which ranges from 200 ft to 1,600 ft (61 m to 487 m) asl, outside of the pre-pregnancy period. Regularly scheduled surveys (see search interval discussion below) will be conducted monthly from December through late February when seabirds are not present on Maui and when bat use of the Project site is likely very low (Bonaccorso 2011, Tetra Tech 2011). Depending on the results of the first year of monitoring, survey intensity may be modified in coordination with the USFWS, DOFAW, and ESRC.

Seasons will be defined based on the following annual dry and wet seasons experienced in Hawaii:

- Dry season (May through October); and
- Wet season (November through April).

Given that carcass persistence times are currently unknown in the Project site, an initial carcass removal trial will be conducted for seabirds and bats after the Project is operational and just prior to the initiation of the PCMP to determine an initial carcass persistence rate. Searches will be conducted at regular intervals to be determined based on the results of the pilot carcass removal study. If the mean persistence rate of seabird carcasses is equal to or less than 7 days, the carcass searches will be conducted weekly. If the mean persistence rate is greater than 7 days, the searches will be conducted every 10 to 14 days. Subsequent search intervals during years 1 and 2 will be based on project-specific seasonal carcass removal rates for birds to ensure that, on average, the search interval will offset scavenging losses (Section 3.0). Carcass removal trials will be conducted for bats and the resulting data used during estimation of Project-wide bat mortality.

Should the minimum search frequency not be met at any time due to reasons other than weather, health, or safety, Auwahi Wind will inform the agencies to discuss a course of action. These occurrences will be documented in annual monitoring reports.

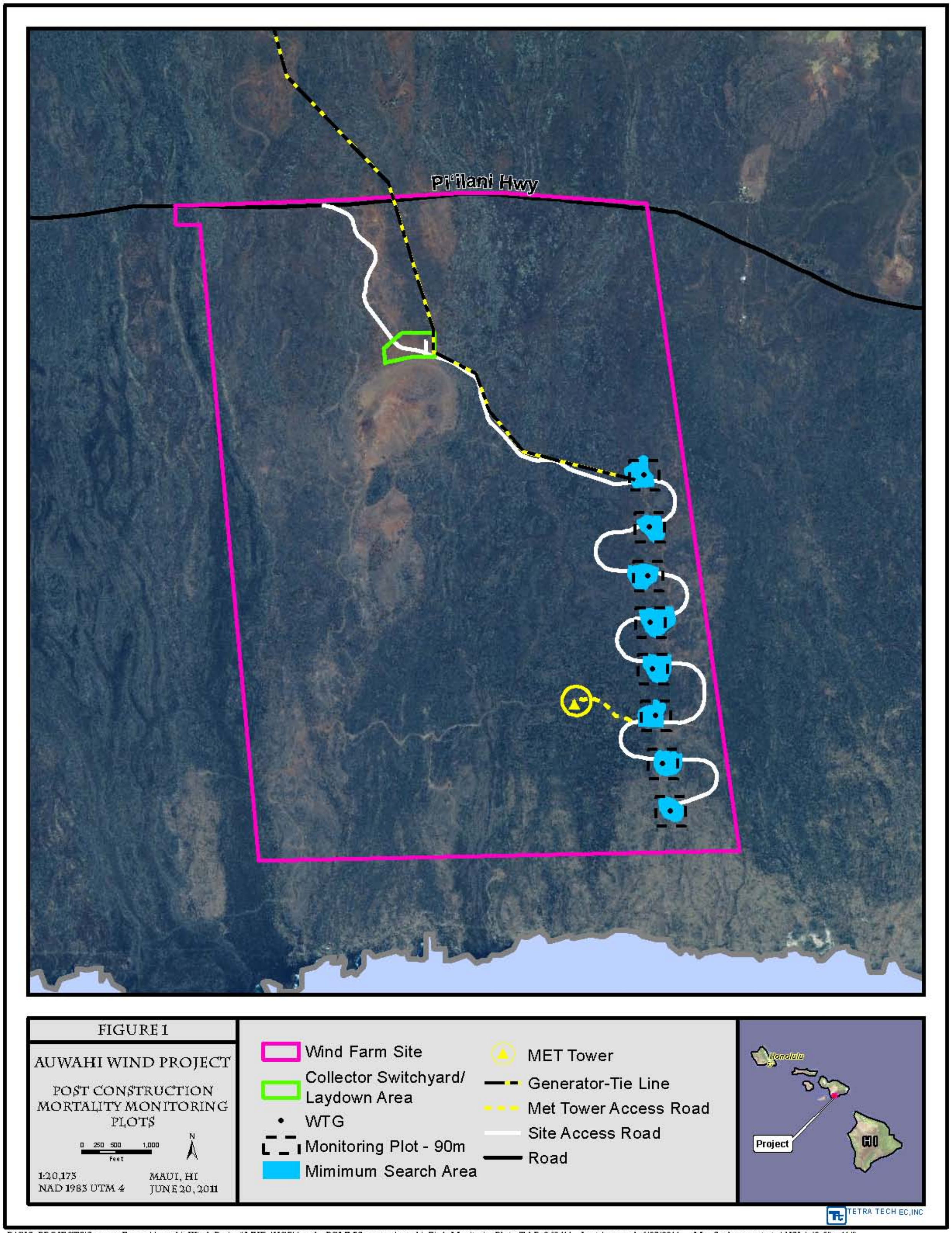
2.2 SAMPLING DESIGN

Search Plot Size and Configuration

Based on publicly available results from other post-construction monitoring programs at wind farms in Hawaii and the mainland, the majority of carcasses found during standardized carcass searches around individual WTGs have been found within a distance equal to 50 to 67 percent of WTG height. At the High Winds Wind Power Project, 96 percent of carcasses were found within two-thirds (67 percent) of WTG height (Kerlinger et al. 2005). At the operating Kaheawa I project, 75 percent of carcasses attributed to WTG collisions found to date (one Hawaiian petrel, four nēnē, and one Hawaiian hoary bat) were found within a distance less than 50 percent of the maximum time height of the WTGs where the area searched was 100 percent of WTG height (Hufana, S. pers. com. 2010). Studies conducted at other wind energy facilities indicate that nearly all fatalities are found well within the WTG maximum tip height with over 80 percent of bat carcasses within a distance equal to 50 percent of the maximum distance from the tip height to the ground (Johnson et al. 2003; Young et al. 2003; Erickson et al. 2004; Arnett 2005; Kerns et al. 2005; Jain et al. 2007).

The search area of 97.5 m will include the area that is up to 75 percent of the WTG height of the Siemens 3.0 MW WTG (Figure 1) . The WTG has a hub height of approximately 262.5 ft (80 m) and blade lengths of 165.6 ft (50.5 m), resulting in a maximum tip height of 428.2 ft (130.5 m) agl. The cleared and maintained turbine pad areas are not uniform among turbines, but are primarily rectangular in shape with sides between 295 ft and 492 ft (90 m and 150 m) in length (Figure 2-1). Therefore, a portion of each search area will be cleared as a result of construction activity, but a portion of each search area will remain rugged terrain. However, if the full area within the plot is determined not to be searchable based on low searcher efficiency or impassible terrain (depending on existing vegetation), the plot size will be reduced to the searchable area. Search areas will encompass maintained turbine pads and access roads, as well as adjacent unmaintained searchable areas. The actual area searched will be dependent on the configuration of the maintained areas, as well as the portion of the unmaintained area that can be realistically searched as determined during initial surveys (see Search Plot Mapping). Prior to conducting the first survey, a sweep survey will be completed within all search plots to clear all pre-existing carcasses from the search area. Ultimately, the monitoring plot sizes may not be consistent across WTGs or uniform in size in order to maximize search area and searcher efficiency.

Some of the terrain where WTGs are proposed is rugged and densely vegetated, which may in some instances make locating carcasses very difficult. Much effort would be spent searching these areas with an anticipated low searcher efficiency rate. Vegetation management would not be cost effective for this site; however, once the WTGs are operational and if it is determined that some vegetation can be managed for a reasonable cost, Auwahi Wind will consider this in order to increase the



P:\GIS_PROJECTS\Sempra_Energy\Auwahi_Wind_Project\MXDs\HCP\Apndx_PCMM\Sempra_Auwahi_Fig1_MonitoringPlots_TabP_062411 - Last Accessed: 6/27/2011 - Map Scale correct at: ANSI A (8.5" x 11") searchable area and searcher efficiency. Therefore, to maximize the potential for locating carcasses and use of resources, areas will be deemed realistically searchable if they consist of terrain that is safe for searchers to traverse and/or have a searcher efficiency rate of at least 70 percent for seabirds. The total search area for each WTG will be measured post-construction.

Transects will be established within search plots approximately 20 ft (6 m) apart, adjusted as necessary for vegetation type and visibility, and the searcher will walk along each transect searching both sides out to 10 ft (3 m) for fatalities. Personnel trained in proper search techniques will conduct the carcass searches. Protocol for documenting any fatalities or injuries is provided in Section 2.3.

The likelihood of collisions with the one met tower on site is low. However, standardized searches will be conducted at the same search interval under the met tower within a plot extending 33 ft (10 m) from the base of the guy wires. Transects will be spaced approximately 20 ft (6 m) apart, but will be adjusted for vegetation type and visibility.

Search Plot Mapping

The Project site is topographically diverse with some proposed WTG locations in areas where safety issues may render portions of search plots unsearchable and vegetation management not feasible. This search area restriction influences the proportion of the actual fatalities that can possibly be detected (Huso 2010). To better estimate this potential influence, a global positioning system (GPS) will be used to map the actual area searched at each WTG. A correction factor, based on this percentage of area searched, will be subsequently applied to the fatality estimate to account for the area under each WTG actually searched (e.g., Arnett 2005). The proposed mortality estimator accounts for unequal searchable area across searched WTGs (Section 5.0).

Once the plot size is determined, vegetation types outside the maintained WTG pad within search plots will be mapped and classified according to varying levels of visibility (e.g., Arnett et al. 2009a,b). However, as previously discussed, search plot size and visibility may differ between WTGs. Therefore, it may be appropriate to group WTGs according to plot size and visibility and calculate fatality rates accordingly.

2.3 FATALITY DOCUMENTATION

2.3.1 Documentation of Turbine-related Fatalities

All carcasses found during standardized carcass searches will be labeled with a unique number, and searchers will record: species, sex, and age when possible; date and time collected; location (GPS coordinate and distance/direction from the WTG); condition (intact, scavenged, feather spot); and any comments that may indicate cause of death. If a carcass of a listed species is found, searchers will follow the project Downed Wildlife Protocol (Attachment 1).

The condition of each carcass found will be recorded using the following categories:

- Intact/Complete—a carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.
- Scavenged/Dismembered—an entire carcass or a majority of a carcass which shows signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, portion of a carcass, etc.), or a carcass that has been heavily infested by insects.
- Feather Spot—ten or more feathers at one location indicating predation or scavenging.

All casualties located will be photographed as found and plotted on a detailed map of the study area showing the location of the WTGs and associated facilities such as overhead power lines and met towers. A copy of the field forms for each carcass will be kept with the carcass at all times in a separate bag, if the carcass is removed from the field (Attachments 2 and 3).

Carcasses will be double-bagged and frozen for future reference and possible necropsy or as otherwise directed by USFWS or DOFAW. Carcasses of non-listed species will be left in place or kept for searcher efficiency and/or carcass removal trials, or disposed of at an approved location as appropriate.

Searchers may discover carcasses incidental to formal carcass searches (e.g., while driving within the Project site). For each incidentally discovered carcass, the searcher will identify, photograph, and record data for the carcass as would be done for carcasses found during formal scheduled searches, but will code these carcasses as incidental discoveries.

Any injured native birds or bats found on the Project site will be carefully captured by a trained project biologist or technician and transported to a local USFWS- and DOFAW-approved wildlife rehabilitator (e.g., Maui Animal Rescue and Sanctuary located approximately 30 miles [48 kilometers] from the Project). Auwahi Wind staff conducting the surveys will be trained on how to handle any downed wildlife or carcasses found anywhere within the project area. Furthermore, a Downed Wildlife Incident Report (Attachment 3) will be completed for any injured animal or fatality.

2.3.2 Reporting Procedures

If a carcass of a listed species is found, searchers will follow the project Downed Wildlife Protocol (Attachment 1). This protocol includes agency contact information for reporting project-related incidental takes and from standardized surveys. Searchers will either provide the carcasses to the appropriate entity or store the carcass in the freezer for possible necropsy or take other action as directed by the USFWS and DOFAW. During the first 2 years of monitoring, all carcasses found attributed to incidental or during standardized surveys will be reported to USFWS and DOFAW.

3.0 CARCASS REMOVAL TRIALS

Carcass removal is the disappearance of a carcass from the search area due to scavenging, predation, or other means (e.g., wind, rain, decomposition beyond recognition). As previously discussed, the intensity of fatality searches should be conducted at a frequency that minimizes the amount of extrapolation that would be required in estimating mortality. Seasonal differences in carcass removal rates (e.g., changes in scavenger population density or type) and possible differences in the size of the animal being scavenged are typically taken into account when evaluating carcass removal rates.

The objective of the carcass removal trials is to document the length of time carcasses remain in the search area, and thus are available to be found by searchers, and, subsequently, to determine the frequency of carcass searches within the search plots. Carcass removal trials will be conducted during each season the first 2 years and will be used to adjust carcass surveys for removal bias.

Carcasses used in the trials will be selected to best represent the size, mass, coloration, and will have similar proportions to the Covered Species. For petrels and shearwaters, carcasses may include legally obtained wedge-tailed shearwaters, a close taxonomic relative to Hawaiian petrels, if available; otherwise, commercially available adult game birds or cryptically colored chickens will be used to simulate seabirds. Auwahi Wind will coordinate with DOFAW and USFWS on availability of carcasses to be used during carcass removal trials. Bat carcasses will most likely not be available for scavenging trials, so a surrogate will be used. Carcasses of dark-colored mammals (e.g., small rats or mice) may be used to simulate bats. Legally obtained small passerines (e.g., house sparrows) or commercially available game bird chicks may be considered to simulate bats, although they are not ideal because of their differences in appearance and decomposition rates. Non-listed bird carcasses found during the surveys may be used for these trials.

3.1 SAMPLING INTENSITY

Assuming adequate carcass availability, at least two trials will be conducted per season with up to eight carcasses of each size class (bat and bird) placed per trial, resulting in a total of up to 64 trial carcasses used in carcass removal studies for the entire year for the Project. The trials will be spread throughout sampling period to incorporate the effects of varying weather, climatic conditions, and scavenger densities. The first trial will be conducted prior to initiating the monitoring program to establish the initial appropriate search interval.

3.2 CONDUCTING THE TRIAL

Each carcass used for the carcass removal trial will be placed at stratified random locations within the Project site near or within the search plots. Prior to initiating the trial, a set of random locations will be generated to determine the location of trial carcasses. These locations will subsequently be loaded into a GPS as waypoints to allow the accurate placement of the carcasses by field personnel. Carcasses will be dropped from waist high and allowed to land in a random posture. Each trial carcass will be discreetly marked (e.g., small tag or wire wrapped around one leg) prior to dropping so that it can be identified as a study carcass if it is found by other searchers or Project personnel.

Personnel conducting carcass searches will monitor the trial birds every day over a 21-day period during the first year of post-construction monitoring. By doing daily checks, Auwahi Wind will know the exact 24-hour period when the carcass is removed. Experimental carcasses will be left at the location until the end of the carcass removal trial.

When checking the carcass, searchers will record the condition as intact (normal stages of decomposition), scavenged (feathers pulled out, chewed on, or parts missing), feather spot (only feathers left), or completely gone. Changes in carcasses condition will be cataloged with pictures and detailed notes; photographs will be taken at placement and any time major changes have occurred. At the end of the 21-day period any evidence of the carcasses that remain will be removed.

3.3 CARCASS REMOVAL RATE ESTIMATION

Estimates of carcass removal rates or the time (measured in days) that carcasses remain on site and are available to be found by searchers are used to adjust carcass counts for removal bias. Mean carcass removal time ($\bar{t}$) is the average length of time a carcass remains in the study area before it is removed:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

where t_i is the time (in days) a carcass remains in the study area before it is removed, s is the number of carcasses used in the trial, and s_c is the number of carcasses in removal trials that remain in the study area at the end of the trial period.

4.0 SEARCHER EFFICIENCY TRIALS

The ability of searchers to detect carcasses is influenced by a number of factors including the skill of an individual searcher in finding the carcasses, the vegetation composition within the search area, and the characteristics of individual carcasses (e.g., body size, color). The objective of searcher efficiency trials is to estimate the percentage of bird and bat fatalities that searchers are able to find. Estimates of searcher efficiency are then used to adjust carcass counts for detection bias. Searcher efficiency trials will be conducted during each season of the survey period during the first 2 years of monitoring to account for seasonal differences in searcher efficiency. Carcass acquisition for searcher efficiency trials will be the same as that described for carcass removal trials.

4.1 SAMPLING INTENSITY

Searcher efficiency trials will begin when WTGs are placed into operation and standardized carcass searches start. Personnel conducting the searches will not know when trials are conducted or the location of the detection carcasses. Trials will be conducted at least two times per season and will incorporate testing of each member of the field crew. Carcasses from both size classes (seabird and bat) will be included in the trials. A minimum of five carcasses per size class will be used in each trial. The number of trials conducted per season will be dependent upon carcass availability.

4.2 CONDUCTING THE TRIAL

All carcasses will be placed at stratified random locations within areas being searched prior to the carcass search on the same day so that searchers are not aware they are being tested. Carcasses will be dropped from waist high or higher and allowed to land in a random posture. Each trial carcass will be discreetly marked (e.g., small tag or wire wrapped around one leg) prior to dropping so that it can be identified as a study carcass after it is found. The number and location of the detection carcasses found during the carcass search will be recorded. The number of carcasses available for detection during each trial will be verified immediately after the trial by the person responsible for distributing the carcasses.

4.3 SEARCHER EFFICIENCY RATE ESTIMATION

Searcher efficiency rates will be estimated by searcher, carcass size and types, WTG, and season. These rates are expressed as p, the proportion of trial carcasses that are detected by searchers in the searcher efficiency trials, as provided in the fatality rate calculation discussion in Section 5.0.

5.0 FATALITY RATE CALCULATION

The estimate of total direct take will incorporate observed mortality, documented during standardized carcass searches, as well as unobserved mortality, or individuals that may have been killed by interactions with Project components but are not found by searchers for various reasons.

Specifically, fatality estimates will be calculated for seabirds and will take into account:

- search interval;
- searchable area around each searched turbine;
- observed number of carcasses found during standardized searches during the monitoring year for which the cause of death can be attributed to facility operation;
- carcass removal rates, expressed as the estimated average number of days a carcass is expected to remain in the study area and be available for detection by the searchers during removal trials; and
- searcher efficiency, expressed as the weighted average proportion of planted carcasses found by searchers during searcher efficiency trials.

There have been many recent advances in post-construction monitoring techniques and fatality rate estimates, and there are a number of estimators available for calculating fatality rates. These estimators provide different methods to account for unobserved mortality, with some estimators treating searcher efficiency and carcass removal as separate factors and others treating them as interrelated (e.g., Shoenfeld 2004; Jain et al. 2007; Huso 2010). However, the most recent estimator developed by Huso (2010) is expected to be used until improvements to estimating fatality rates are available. Huso's estimator will improve the potential for reducing the inherent biases in the data and provide the ability to account for variable search ability (e.g., based on vegetation types or unsearchable areas) within the search plot. Take can also be calculated per turbine and per interval while adjusting for variables such as actual area searched or visibility class. The Huso (2010) estimator can be expressed as:

$$\hat{M} = \frac{c}{\hat{a}\ \hat{r}\ \hat{p}\ \hat{e}}$$

Where:

M = estimated total direct mortality
c = observed number of carcasses
a = the estimated density-weighted proportion of the plot searched
r = estimate of proportion of carcasses remaining after scavenging (scavenger efficiency)
p = estimated searcher efficiency (proportion of carcasses found)
e = effective search interval (days) calculated as the ratio of (days before 99 percent of carcasses can be expected to be removed/search interval) or 1, whichever is less

As unobserved take has been incorporated into the requested take numbers for bats, this estimator will not be used in estimating total adjusted bat take. At the time of Project implementation, Auwahi Wind will assess the most recent advances in fatality rate estimation and will select the most appropriate estimator in collaboration with USFWS and DOFAW based on the best available science.

6.0 WILDLIFE EDUCATION AND INCIDENTAL REPORTING PROGRAM

Auwahi Wind will implement a Wildlife Education and Incidental Reporting program for contractors, Project staff members, and other ‘Ulupalakua Ranch staff who are on site on a regular basis. This training enables staff to identify the Covered Species that may occur in the Project area, record observations of these species, and take appropriate steps for documentation and reporting when any Covered Species is encountered during construction or operation of the Project including when downed birds or bats are found. The Wildlife Education and Incidental Reporting program will facilitate incidental reporting of observations within the Project site, as well as within the generator-tie line corridor where Auwahi Wind staff and ‘Ulupalakua Ranch are regularly present during the course of normal Project and ranch operations. Incidental reporting will inform the Project post-construction monitoring program of any wildlife fatalities that occur outside of standardized fatality surveys within the Project, as well as providing supplementary information on impacts associated with the generator-tie line where standardized post-construction monitoring will not occur. The program will be prepared by a qualified biologist and will be approved in advance by the USFWS and DOFAW. Over the term of this HCP, the program will be updated as necessary.

The program will include wildlife education briefings to be attended by new Project staff and other contractors or ranch staff as appropriate. Staff members will be provided with printed reference materials that include photographs of each of the Covered Species and information on their biology and habitat requirements; threats to the species on site; and measures being taken for their protection under this HCP. The Project Biologist, who will coordinate the post-construction monitoring on site, shall coordinate with the Construction Foreman and the Project Operations Manager to ensure that personnel receive the appropriate written material.

Staff members will be responsible for responding to and treating wildlife appropriately under all circumstances, including avoiding approaching any wildlife other than downed wildlife and avoiding any behavior that would harm or harass wildlife (including feeding). In conjunction with regular assigned duties, personnel will be responsible for:

- recording any project-related wildlife incidents;
- adhering to Project area road speed limits;
- identifying Covered Species when possible (Hawaiian petrel, nēnē, Hawaiian hoary bat, and Blackburn’s sphinx moth) and documenting observations by filing a Wildlife Observation Form; and
- identifying, reporting, and handling any downed wildlife in accordance with the Downed Wildlife Protocol, including filing a Downed Wildlife Incidence Report form (Attachment 3).

7.0 SAMPLING BEYOND THE INITIAL TWO-YEAR PERIOD

Sampling duration, plot size, and survey intensity may be modified upon completion of the initial 2 years of monitoring or sooner, subject to approval by USFWS, DOFAW, and the ESRC. It is anticipated that surveys conducted during the first two-year period will provide sufficient data to adequately describe carcass distribution, as well as spatial and temporal trends in fatalities within the Project area. Depending on the results, these data may provide justification for modifying search plot size, search frequency, or the number of WTGs searched, or for concentrating sampling efforts at specific WTGs or during certain times of year during subsequent years of monitoring. These data will also illustrate trends in searcher efficiency and carcass removal over time.

Auwahi Wind proposes a long-term monitoring approach consisting of periodic comprehensive monitoring followed by interim years of less intensive monitoring. Comprehensive monitoring would occur every 5 years after the initial 2-year intensive sampling period (i.e., years 7, 12, 17, and 22), resulting in a total of 6 years of comprehensive monitoring during the life of the Project (Table 7-1). During comprehensive monitoring years, searcher efficiency trials and carcass removal trials would be conducted to determine if any variables have changed over time and if any modifications to search frequency are required (Table 7-1). During interim years, assuming trends in the monitoring data provide confidence in the estimate of take, the monitoring effort would be reduced to conducting systematic carcass surveys on a monthly or other less frequent basis. The frequency at which the surveys take place during interim years will be determined at the conclusion of the carcass removal trials for that 5-year period. It is assumed that searcher efficiency trials may have to be conducted more frequently depending on changes in staff. All adjustments to direct take during interim years would use the most recent estimates from the searcher efficiency and carcass removal trials. Revised methods will be evaluated in cooperation with UFWS, DOFAW, and the ESRC.

Table 7-1. Schedule of Post-Construction Monitoring over the ITP/ITL Term

Year of Permit Term	Standardized Carcass Searches	Searcher Efficiency and Carcass Removal Trials
1	Intensive Monitoring	X
2	Intensive Monitoring	X
3-6	Systematic Monitoring	--
7	Comprehensive Monitoring	X
8-11	Systematic Monitoring	--
12	Comprehensive Monitoring	X
13-16	Systematic Monitoring	--
17	Comprehensive Monitoring	X
18-21	Systematic Monitoring	---
22	Comprehensive Monitoring	X
23-25	Systematic Monitoring	--

This approach is designed to inform Auwahi Wind where take levels are in relation to the established tiers outlined in the HCP and to provide a mechanism for continually assessing and adjusting the sampling scheme to ensure data accuracy. Continuous standardized monitoring will provide shorter-term benchmarks for evaluating whether take is higher or lower than anticipated over a several-year period, recognizing that take may fluctuate during years of operation. Thus, Auwahi Wind will be able to gauge easily when a given tier of take is being approached, signaling the need to engage the USFWS and DOFAW in additional discussions regarding Project status and to begin preparation for implementation of additional mitigation. This information will be used to inform any other decisions related to adaptive management as described in the HCP.

8.0 REPORTING

An annual report for the Project will be submitted to USFWS, DOFAW, and ESRC. The report will include the following:

- a summary of the results of the post-construction monitoring surveys over each of the 2 years of intensive monitoring, including a list of all detected carcasses;
- results of the carcass removal trials and searcher efficiency trials;
- documented take, if any, of each covered listed species;
- the identification of any recommended changes to the monitoring protocols, and
- results of surveys conducted after the 2 years of intense monitoring and associated modified protocols.

The reporting schedule is outlined in the Monitoring section of the HCP.

A Downed Wildlife Incident Report will be filed with the USFWS and DOFAW within 3 business days (Attachment 3) of the discovery of a federally and state-listed species and cumulative adjusted take will be reported to the agencies within 3 weeks. Auwahi Wind will consult with the USFWS and DOFAW to review take limits and will discuss changed circumstances or adaptive management measures as necessary. Carcasses of non-listed species will be reported to DOFAW and USFWS on a monthly basis.

9.0 REFERENCES

Arnett, E.B. (ed). 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX.

Arnett, E.B., M.R. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009a. Patterns of bat fatality at the Casselman Wind Project in south-central Pennsylvania. An annual report submitted to the Bats and Wind Energy Cooperative and the Pennsylvania Game Commission. Bat Conservation International. Austin, TX.

Arnett, E.B., M.R. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009b. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX.

Baerwald, E.F., G.H. D'Amours, B.J. Klug, and R.M.R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18:695-696.

Bonaccorso, F. 2011. Research progress on bat occupancy on the Big Island and Kauai. Hawaiian Hoary Bat Cooperative Meeting, Volcano National Park, June 23, 2011.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project wildlife monitoring annual report, results for the period July 2001 - December 2003. Technical report prepared by WEST, Inc. and submitted to FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee.

Erickson, W.P. 2009. Draft avian and bat monitoring plan for the Martinsdale wind farm, Wheatland County, MT.

Fiedler, J.K., T.H. Henry, C.P. Nicholson, and R.D. Tankersley. 2007. Results of bat and bird mortality monitoring at the expanded Buffalo Mountain windfarm, 2005. Tennessee Valley Authority, Knoxville, TN.

Huso, M. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics. DOI: 10.1002/env.1052.

Hufana, S. 2010. Personal communication. Fatalities documented at the Kaheawa Wind Farm.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study – 2006. Annual report prepared for PPM Energy and Horizon Energy, Curry and Kerlinger LLC, Cape May Point, NJ.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, and D.A. Shepherd. 2000. Avian monitoring studies at the Buffalo Ridge Wind Resource Area, Minnesota: results of a 4-year study. Technical Report prepared by WEST, Inc. for Northern States Power Co., Minneapolis, MN.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2003. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. The American Midland Naturalist 150:332-342.

KWP (Kaheawa Wind Power, LLC). 2006. Kaheawa Wind Power wind energy generation facility habitat conservation plan. Ukumehame, Maui, HI.

KWP. 2008. Kaheawa Pastures Wind Energy Generation Facility habitat conservation plan year 2 HCP implementation.

KWP. 2011. Kaheawa Wind Power II wind energy generation facility habitat conservation plan. Ukumehame, Maui, HI.

Kerlinger, P., L. Culp, and R. Curry. 2005. Post-construction avian monitoring study for the High Winds Wind Power Project, Solano County, California. Year one report prepared for High Winds, LLC, and FPL Energy.

Kerns, J., W.P. Erickson, and E.B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24–95 in E.B. Arnett, (ed), Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, TX.

Kerns, J., and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the MWEC Wind Energy Center, Tucker County, West Virginia: annual report for 2003. Technical report prepared by Curry and Kerlinger, LLC, for FPL Energy and MWEC Wind Energy Center Technical Review Committee.

Menard, T. 2001. Activity Patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) in Relation to Reproductive Time Periods. M.S Thesis. University of Hawaiʻi.

NWC (Northwest Wildlife Consultants, Inc.) and WEST, Inc. 2007. Avian and bat monitoring report for the Klondike II Wind Power Project, Sherman County, Oregon. Prepared for PPM Energy, Portland, OR.

Poulton, V., and W.P. Erickson. 2010. Post-construction bat and bird fatality study Judith Gap wind farm, Wheatland County, Montana. Technical report prepared by WEST, Inc., for Invenergy.

Simons, T.R., and C.N. Hodges. 1998. Dark-rumped Petrel (*Pterodroma pheaopygia*) In A. Poole and F. Gill (eds.). The birds of North America, No. 345. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

Shoenfeld, P. 2004. Suggestions Regarding Avian Mortality Extrapolation. Technical memo provided to FPL Energy. West Virginia Highlands Conservancy, HC70, Box 553, Davis, WV.

SWCA (SWCA Environmental Consultants). 2010. Kahuku Wind Power habitat conservation plan. Kahului, Hawaii.

Tetra Tech (Tetra Tech EC, Inc.). 2008. Final habitat conservation plan for the construction and operation of Lanai meteorological towers, Lanai, Hawaii. Prepared for Castle & Cooke Resorts, LLC.

Tetra Tech. 2011. Auwahi bat monitoring field report. Interim report submitted to Sempra Energy 2-24-2011.

Young, D.P. Jr., Johnson, G. D., W. P. Erickson, M. D. Strickland, R. E. Good and P. Becker. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Wind Power Project, Carbon County, Wyoming: November 1998 – June 2002. Tech. Report prepared by WEST, Inc. for Pacific Corp, Inc., SeaWest Windpower Inc., and Bureau of Land Management.

Attachment 1

Downed Wildlife Protocol

DOWNED WILDLIFE PROTOCOL

Downed birds or Hawaiian hoary bats may be dead or injured at discovery. Birds or bats will be labeled with a unique number, and searchers will record species, sex and age when possible, date and time collected, location (GPS coordinate, and distance/direction from the turbine), condition (injured or carcass that is either intact, scavenged, feather spot) and any comments that may indicate cause of death. After the downed bird or bat is photographed, USFWS or DOFAW Staff will be contacted if it is a threatened or endangered species.

DEAD BIRD OR HAWAIIAN HOARY BAT:

- After the appropriate documentation has been completed, leave the carcass in place for DOFAW or USFWS to inspect and collect or bag and freeze as directed by DOFAW or USFWS.

- Contact DOFAW or USFWS staff about find:
  1. Fern Duvall, DOFAW 808-264-0922
  2. Sandee Hufana, DOFAW 808- 587-4148
  3. Dawn Greenlee, USFWS 808-792-9469

INJURED BIRD OR HAWAIIAN HOARY BAT:

Procedure

1. Gently pick up and place bird or bat into carrier equipped with turf/carpet.
2. Mark exact spot of find(s) with stake(s)
3. Call DOFAW or USFWS - as above if listed species.
4. Move or transport bird/bat from site subsequent to notification or instruction of DOFAW or USFWS staff.

Attachment 2

Carcass Survey Field Forms

Auwahi Wind Farm Project Post-construction Monitoring Field Form

Date (MM/DD/YYYY) ____________ **Surveyors** ________________

Precipitation ______ (L) light rain (R) rain (D) dry (F) fog **Cloud Cover** _____ (C) clear (P) partly cloudy-25% (L) light-50% (M) moderate-75% (H) high-100%

Wind _____ (0) <0 mph (1) leaves barely move (2) leaves rustle/sm. twigs move (3) sm. twigs move (4) sm. branches move (5) lg. branches move/trees sway (6) variable

Standardized Carcass Searches

Tower No./Met tower[1]	Search Plot (50 or 75 %)	Start Time	End Time	Total Minutes	Fatalities Detected[2]	Other Observations (other wildlife, tracks, sign)
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			

[1] If a scheduled carcass search cannot be conducted due to weather or other safety concerns note the tower number and provide justification.

[2] List unique identifying number to correspond with casualty form: mmddyyyy_ turbine#_species code_ # (optional if more than one carcass of the same species is found)

Attachment 3

Downed Wildlife Incident Report

Auwahi Wind Farm Project Downed Wildlife Incident Report

CASUALTY INFORMATION

Date ______________ **Time**___________ **Observer**________________________

Type of Find (check one): Scheduled Carcass Search_____ Incidental Find_____

Identification number _____________________________ **Photo No.**_____________________
(mmddyyyy_ turbine#_species code_# (optional if more than one carcass of the same species is found))

Species ______________ **Sex (circle):** male female unknown **Age (circle):** adult juvenile unknown

Condition (circle one): injured intact scavenged dismembered feather spot other

Estimated Time Since Death/Injury____________

Comments: (e.g., behavior observed in bird/bat is injured; detail of carcass—body parts missing, injuries, number of feathers in feather spot; indications of cause of death)

LOCATION

Plot Type (circle): turbine met tower other **Turbine No.** _______

Location if not on plot ________________

Habitat ______________________________

Location Relative to Nearest Turbine/Tower:

Description	Distance (meters)	Bearing (degrees)
Part 1 ______________	___________	______________
Part 2 ______________	___________	______________
Part 3 ______________	___________	______________

Comments: (if carcass is estimated to be less than a week old, note weather conditions that occurred at or before the estimated time of death/incident)

AGENCY CONTACT

USFWS Contact: Date _______ **Time** _____ **Contact Person(s)** ___________________________
Comments:

DOFAW Contact: Date _______ **Time** ______ **Contact Person(s)** ___________________________
Comments:

Disposition of Find _________________________

Transport to Freezer (circle): yes no **Date** _______________ **Time** ________________

Appendix E
Avian Risk of Collision Analysis for the South Auwahi Wind Resource Area, Maui, Hawaiʻi

AVIAN RISK OF COLLISION ANALYSIS
FOR THE
SOUTH AUWAHI WIND RESOURCE AREA
MAUI, HAWAII

PREPARED FOR:

Sempra Generation
101 Ash Street
San Diego, CA 92101-3017

PREPARED BY:

Hamer Environmental L.P.,
P.O. Box 2561
Mount Vernon, WA, 98273

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EXECUTIVE SUMMARY

- We utilized ornithological radar and audiovisual survey methods to record movement rates and flight heights of the Hawaiian Petrel (*'Ua'u*) (*Pterodroma sandwichensis*) at the proposed Auwahi Wind Resource Area (AWRA) from 25-30 May 2010 (nesting season) and 11-18 October 2006 (fledging season) for a total sampling time of 41.5 hours.

- Study objectives were to: 1) use surveillance (horizontal) and vertically oriented radars to measure movement rates (birds/hr) and flight heights of Hawaiian Petrels and Newells Shearwaters during nesting and fledging seasons at the AWRA, 2) estimate an annual passage rate of birds that would pass through the AWRA, and 3) estimate annual collision and fatality rates for Hawaiian Petrels for each of the three wind turbine configurations. Newell's Shearwaters were excluded from this collision risk analysis due to low likelihood of shearwater presence in south Maui.

- Petrel flights recorded during spring 2010 and fall 2006 radar surveys were 164 petrel flights in spring and 229 petrel flights in the fall.

- The peak hourly movement rate for nesting and fledging season was 9.45 petrel flights per hour. We adjusted the movement rate for portions of the turbine array not sampled by radar, portion of the night not sampled, and mean flock size of petrels. The mean movement rate was 43.67 petrel flights per day.

- We calculated the yearly passage rate for Hawaiian Petrels based on their breeding period of 231 days. We estimated 11,642 Hawaiian Petrel flights passing over the AWRA 1.5 km radius study area annually. This estimate is likely based on birds passing through the AWRA multiple times during the entire survey period rather than individual birds passing through the AWRA only once. Hence, this annual estimate does not represent a population size.

- To estimate collision risk for petrels at the proposed AWRA, we used a site-specific adjusted avian passage rate, flight altitudes and wind data as model inputs. In addition, we used wind turbine characteristics and Hawaiian Petrel body dimensions to run the Hamer Risk of Collision Model for 36 different model configurations. The Monte Carlo sampling method used in the Hamer Model simulated 1,000,000 "typical" flight paths for each of the 36 model configurations in order to generate an estimate of mean collision probability.

- We selected a range of avian avoidance rates for Hamer Risk of Collision Model simulations, assuming 90, 95 and 99% of Hawaiian Petrels will avoid collisions with moving portions of wind turbines in the AWRA. We assumed 99% of petrels will avoid fixed portions of wind turbines.

- We estimate that between 0.662 to 3.450 Hawaiian Petrels may be at risk of collision annually with turbine structures at the AWRA, depending on the turbine configuration and a collision avoidance rate between 99% to 95%. Similarly, we estimate between 0.067

to 0.312 Hawaiian Petrels may be at risk of collision annually per turbine, depending on the turbine configuration and a collision avoidance rate between 99% to 95%. We assume that all avian collisions with structures will result in mortality, so these collision estimates are also annual mortality estimates.

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INTRODUCTION

Sempra Generation (Sempra) is proposing to construct a wind energy development on the Auwahi parcel of Ulupalakua Ranch, located on the southern coast of East Maui. The project was recently purchased by Sempra from Shell WindEnergy, Incorporated (Shell) of Houston, Texas. As part of the assessment of environmental impacts for the project, ornithological radar surveys were conducted to determine the relative use of the Auwahi Wind Resource Area (AWRA) by a state and federally listed avian species, the endangered Hawaiian Petrel (‘*Ua‘u*) (*Pterodroma sandwichensis*).

Based on the previous success of using modified marine radar to study these species in the Hawaiian Islands (Cooper and Day 1994, 1995, 1998, 2003, Day et al. 2003a,b, Reynolds et al. 1997), the use of ornithological radar was chosen as the primary survey method, with supplemental assistance from an audio-visual observer. Upon review of 2006 avian radar surveys conducted by Shell, Sempra determined spring/summer nesting season surveys should be redone in 2010 for two reasons:

1) the radar location in summer 2006 was located close to the Pi‘ilani Highway due to limited road access and coverage designed for a previously proposed turbine configuration. This resulted in poor radar coverage (41-49% coverage depending on the turbine configuration) of the current proposed AWRA. The location of the spring 2010 radar surveys is the same as fall 2006 to attain the most complete coverage of the proposed wind development and to ensure maximal cross-season comparisons.
2) summer 2006 surveys were conducted in mid-July, which may have been too late to capture peak nesting activity of the target bird species. Surveys were conducted May 25-30, 2010 to replace the 2006 summer surveys. The timing of the 2010 spring survey effort captured peak movement rates of birds passing through the proposed AWRA.

Data collected by avian radar surveys was utilized to model potential avian collision risk for Hawaiian Petrels transiting through the proposed AWRA study area (1.5 km radius). The Hamer Risk of Collision Model (Hamer Model), an improved extension of the industry standard Tucker Model (Tucker 1996), was utilized to model avian collision risk. The Hamer Model incorporates site specific wind turbine design and configurations, wind data (from a meteorological tower), petrel passage rates, flight directions, flight speeds, and flight heights (from radar data), and also accounts for collision risk of stationary portions of the wind turbine to determine the risk of collision at the AWRA.

Three different turbine models are being considered for the AWRA (GE 1.5 xleWE, Siemens SWT 2.3-101 and Siemens SWT 3.0-101). The number of wind turbines proposed, their configuration on the landscape, and the turbine dimensions/specifications are different for each turbine model. Therefore, avian collision risk was modeled independently for each of the three turbine models. In this report, we will summarize the avian passage rates determined by radar surveys conducted at the AWRA study area (fall 2006 and spring 2010), and review the height distribution of Hawaiian Petrel targets. Using this data and the Hamer Model, we then provide an estimate of the mean collision risk and annual fatality of Hawaiian Petrels for each of the three possible wind turbine configurations.

BACKGROUND

Species Composition

Based on known seabird populations nesting on Haleakala, we assumed that all birds transiting the AWRA were Hawaiian Petrels but Newell's Shearwaters were potentially present in extremely small numbers. Newell's Shearwaters were not detected during avian radar and audio-visual surveys conducted at the AWRA study area in spring 2010 and fall 2006. Additionally, a study conducted at multiple sites on Maui in 2003 detected only Hawaiian Petrels and no Newell's Shearwaters at the Nuʽu Bay site closest to the AWRA (Cooper and Day 2004). Fern Duvall (DOFAW biologist, pers. comm.) concured that over 99% of seabirds transiting the AWRA would be Hawaiian Petrels (Fern Duvall, pers. comm.). Hawaiian Petrel were the only species assessed in the following risk of collision analyses.

Hawaiian Petrel

The Hawaiian Petrel is a large, nocturnal gadfly petrel endemic to Hawaiʻi. Prior to the arrival of Polynesians, sub-fossil evidence indicates the Hawaiian Petrel was common throughout the main Hawaiian Islands (Olson and James 1982). The species was federally listed as endangered in 1967 (USFWS 2005a). It is also listed as endangered under the State of Hawaiʻi endangered species statutes (DLNR 1998).

Hawaiian Petrel nesting colonies have been documented on Maui, Hawaiʻi, Lanaʻi and Kauaʻi (Figure 1). The islands of Kauaʻi and Maui are estimated to support the majority of the nesting adults. Based on calls heard during the breeding season the Hawaiian Petrel is also suspected to breed on the island of Molokaʻi (Simons and Hodges 1998).

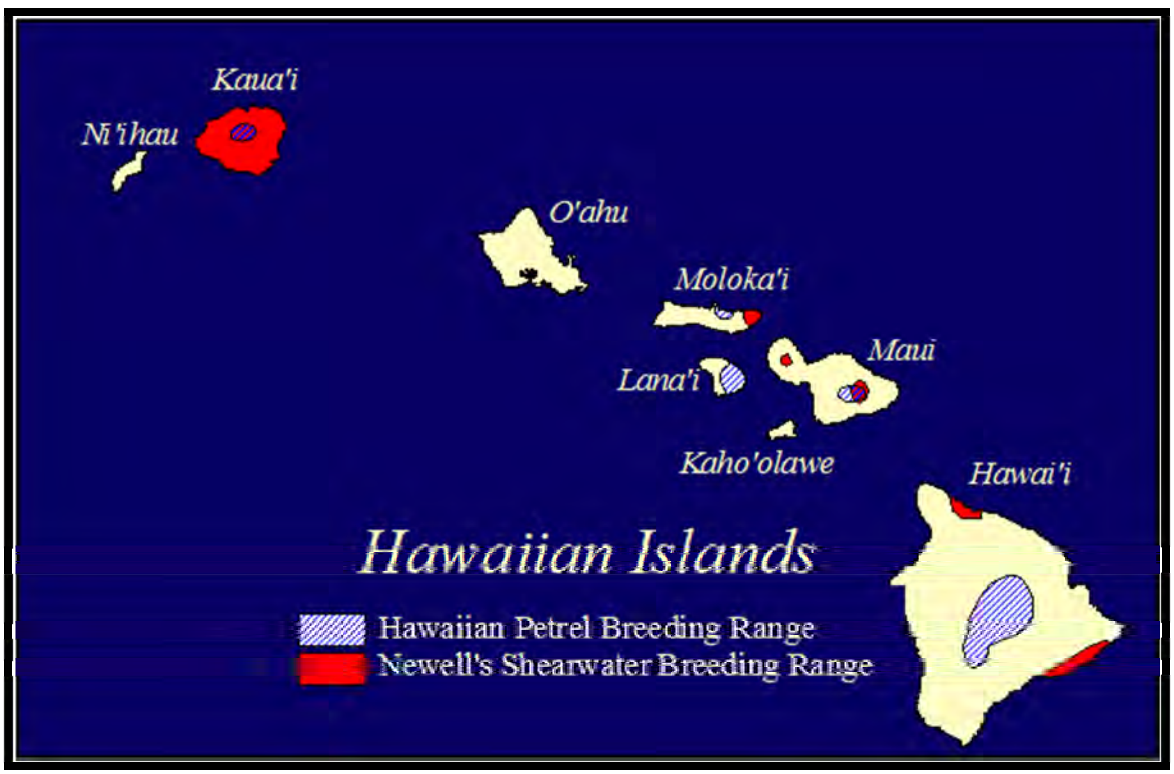

Figure 1. Breeding distribution of Newell's Shearwaters and Hawaiian Petrels in the Hawaiian Islands. (Source: Birds of North America [Ainley et. al. 1997]).

On Maui, most of the known Hawaiian Petrel nest sites can be found in and around Haleakala National Park. Vegetation associated with nesting areas is characterized primarily as subhumid and subalpine. In these dry habitats, vegetative cover is generally low and plant community is dominated by several shrub species. In more humid areas at lower elevations, petrels burrow extensively along soil-covered slopes. Natividad Bailey (2009) states that Hawaiian Petrels in Haleakala National Park nest in burrows, most of which are located along the steep cliffs of the western rim of Haleakala Crater.

There are currently more than 1,000 known burrows, of which about 60% are occupied by Hawaiian Petrels each year. Hawaiian Petrels are present at Haleakala from February through October and are absent from November through January. Haleakala National Park staff search for new burrows and check existing burrows at least once a month while the petrels are present. Petrels fly over land only at night and can be detected by distinctive calls. Calls are commonly heard throughout Haleakala Crater from March through September each year. The population of Hawaiian Petrels on Haleakala is estimated at 900-1,300 individuals, (450-650 breeding pairs) (Simons 1984, 1985, Simons and Hodges 1998). A small sub-colony has also been located along the more densely vegetated south rim of the crater (Simons and Hodges 1998).

Typical summer flight patterns for the Hawaiian Petrel includes flights landward at dusk and seaward at dawn. Collisions with human-made objects on Maui (Hodges 1994) and Kaua'i (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998) have caused documented mortality. Hawaiian Petrels occasionally become grounded after being disoriented by lights in urban areas. Although only 15–20 petrels are reported grounded on Maui and Kaua'i in an average year, the maximum number of reported groundings has been as high as 20 birds on Maui, and 29 on Kaua'i (Simons 1983, Hodges and Nagata 2001, Reggie David pers. comm.). Groundings on Maui are concentrated in urban areas, as on Kaua'i, and are more likely to occur on overcast or moonless nights (Telfer et al. 1987).

Newell's Shearwater

The Newell's Shearwater is the Hawaiian endemic sub-species of the Townsend's Shearwater (*Puffinus auricularis auricularis*), a medium sized "Manx-type shearwater". Due to low overall population numbers and restricted breeding distribution, the sub-species was federally listed as threatened in 1975 (USFWS 2005b). It is also listed as threatened under the State of Hawai'i endangered species statutes (DLNR 1998). Newell's Shearwater were once widespread in the main Hawaiian Islands; they are now known to breed mainly on Kaua'i, Hawaiʻi, and Molokaʻi with possible small numbers on Oʻahu, Maui and Lanaʻi, (Ainley et al. 1997, Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a, b) (Figure 1). On Maui, injured, dead or grounded Newell's Shearwater adults in summer (Pyle 1983), and juveniles in autumn have been confirmed, though it is believed that fledgling specimens probably were individuals attracted to shore from elsewhere by coastal lights (Ainley et al. 1997). Wood and Bily (2008) reported possible nesting grounds on the east side of Maui (see below), though this report is unconfirmed since their detection of nocturnal, terrestrial-based vocalizations on a single night did not visually confirm species identity or breeding activity. Thus, if they do nest on Maui, their nesting distribution and habitat use are still unknown and unpublished. Due to their nocturnal habits (Day and Cooper 1995) and inaccessible and remote mountainous terrain where most nesting colonies are located, obtaining accurate information on their distribution, abundance, and population trends has proven difficult.

Nesting sites have been observed within steep mountainous terrain where they burrow under matting fern species such as *Dicranopteris linearis*, *Diplopterygium pinnatum* and *Sticherus owhyhensis*, and are frequently associated with sparse *Metrosideros* and *Cheirodendron* tree cover with a varying presence of understory native shrubs. Substantial numbers of Newell's are also known to nest on sparsely vegetated cliffs in remote valleys such as the dry leeward side of Kauaʻi (Wood et al. 2001). Wood and Bily (2008) suggest that Newell's Shearwater utilize the *Sadleria* (ʻamaʻu) mixed shrubland community found on East Maui for at least one nesting site, based on the aforementioned aural records and their impression of potential suitable habitat. This fern community is found within the upper Piʻinaʻau headwater region situated within the Koʻolau Forest Reserve and just above the western wall of Ainahou Bowl of Koʻolau Gap.

STUDY AREA

The AWRA is located on the lower southern slopes of a ridge system that runs northeast toward Red Hill and the Haleakala Crater. Sheltered on the leeward side of Mount Haleakala, the vegetation in this area is characteristic of dry coastal shrublands and volcanic landscapes. The AWRA is on the Ulupalakua Ranch; bordered by the Pacific Ocean to the south, the Kanaiʻo parcel to the west, and the Lualailua parcel to the east (Figure 2).

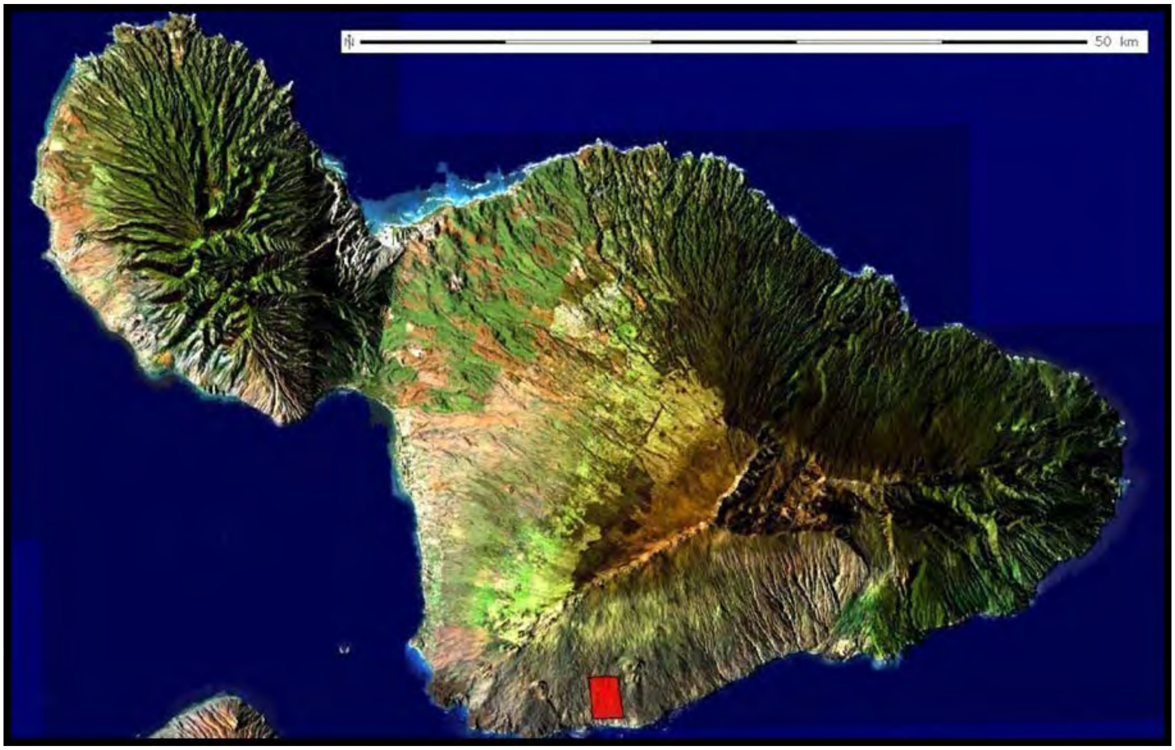

Figure 2. Location of proposed AWRA on the island of Maui, Hawaiʻi.

The Auwahi parcel is bisected into a northern and southern section by Piʻilani Highway, with the proposed AWRA located south of Piʻilani Highway. The spring 2010 and fall 2006 radar survey station was located at 20.60322 lat, -156.32518 long, at an elevation of 330 m above sea level (ASL) (Figure 3). The proposed AWRA encompasses the area south of Piʻilani Highway and is approximately 3 km long and 2.5 km wide (Figure 3).

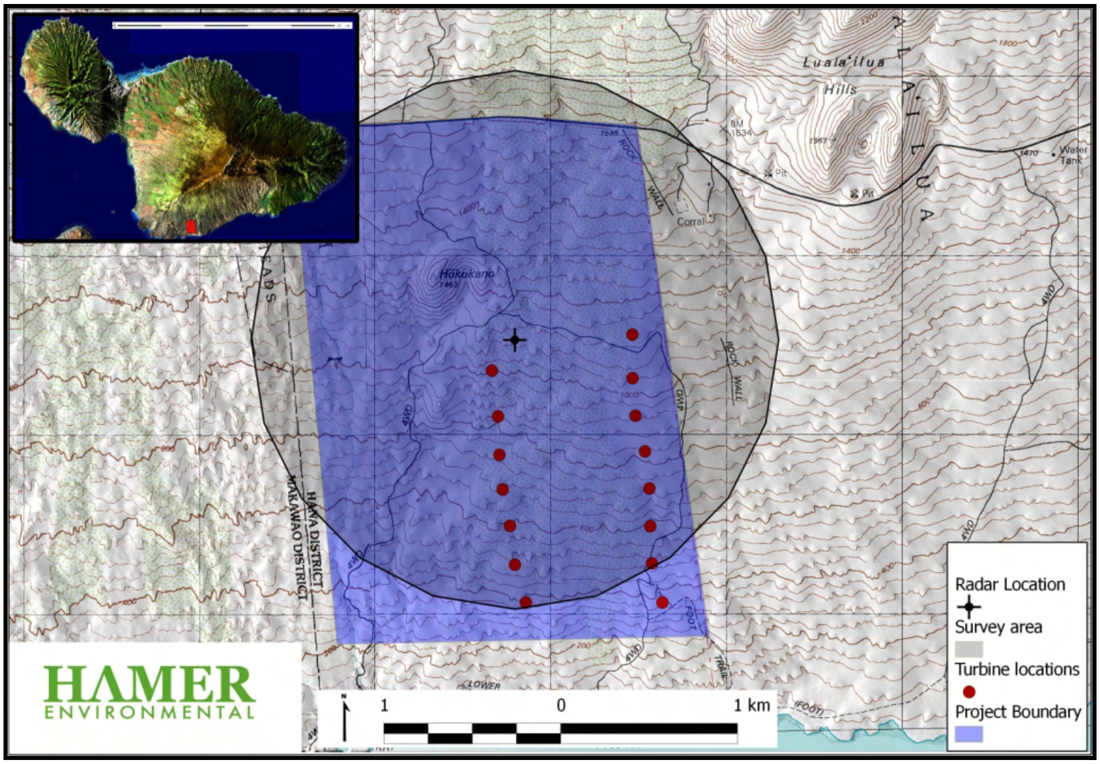

Figure 3. Location of the AWRA (blue), GE turbine configuration, with radar survey coverage (gray circle), Ulupalakua Ranch, Maui, Hawai'i.

METHODS

Radar Surveys

We used standard marine radar systems which we modified to enable their use for terrestrial ornithological studies. Our systems consisted of Furuno Model FR-1510 Mark 3 X-band marine radars transmitting at 9,410 MHz with a peak power output of 12 kW. The radars were operated at the 1.5 km scale and a pulse length of 0.07 µsecond. We tilted the horizontal radar scanners up 30° to reduce ground clutter. Because of these modifications and the selection of optimal survey sites, the amount of ground clutter at this site was less than 10%, and likely did not affect our ability to detect birds within the range of the radar.

We conducted radar observations of bird activity from 25 to 30 May 2010 and from 11 to 18 October 2006. The spring 2010 and fall 2006 studies were scheduled to correspond with the peak nesting and fledging periods, respectively, of both the Hawaiian Petrel and Newell's Shearwater. We sampled the site for five consecutive days each season during both the peak dusk movement (~1830-2130) and the peak dawn period (~400-600).

Data collected by horizontal radar included: the event number, time, direction of flight and tangential range. We recorded the flight behavior, flight speed, and number of birds. We also recorded the flight direction of each bird and whether the targets were heading landward, seaward or other directions. We used the surveillance (horizontal) radar and vertical radar systems for both the spring and fall seasons. The vertical radar system enabled us to collect information on bird flight heights. On the vertical radar, we recorded only the birds that were confirmed by the surveillance radar as likely petrel targets. For every bird detected on the vertical radar, we recorded the closest distance to the ground along with the bearing from the radar, enabling us to calculate the height above ground level and horizontal distance from the radar to each bird.

We used Microsoft Excel 2007 to enter all radar and outside data collected. We then generated counts of birds during each sample session. These counts were converted to estimates of movement rates (bird flights/hr for the entire 3 km diameter radar sampling area), based on the number of minutes sampled.

Passage Rate Calculations

Some assumptions were implicit to create an annual adjusted passage rate of Hawaiian Petrels transiting across the AWRA study area. The total passage rate is not necessarily equivalent to the number of individuals that pass through the AWRA, since a single bird may pass through the AWRA multiple times throughout the year. Furthermore, a single bird could fly over the AWRA as often as twice in one day during the morning foraging (seaward) flight and the evening (landward) flight to the nest. Our modeling approach assumes the population of Hawaiian Petrels remains constant throughout the year, even if there is a chance of mortality due to avian/turbine collision (sampling with replacement). This approach can be justified if the estimated number of annual collisions is significantly less than the daily passage rate.

<u>Survey Hours and Peak Activity Period</u>

Radar observations of bird activity were conducted during nesting (spring) and fledging (fall) periods of Hawaiian Petrel. Radar sampling of the AWRA study area was conducted for five consecutive days each season during both the peak dusk and dawn activity periods for a total of 41.5 sampled hours. One day was rained-out in the fall and could not be repeated due to record rainfall and flooding of the area.

Hence, a total of 9 days were successfully sampled for both survey visits with only 99 minutes when the radar sessions were affected by periods of rain causing clutter on the radar screens. During periods of light rain, rain clutter on the screen is often somewhat transparent, and echoes of birds can often be tracked and measured through the clutter. We could not collect horizontal or vertical radar data during periods of moderate to heavy rain because the electronic filtering required to remove the echoes of the precipitation from the display screen also removed bird targets. As a result, we recorded the number of minutes of each survey where ≥50 percent of the radar monitor contained clutter due to rain. During these portions of the survey period the radar scan was compromised by rain to the point where we could no longer reliably detect petrel type targets. Therefore, these compromised survey minutes were excluded from mean passage rate calculations. The numbers of petrel type targets detected during the sampling periods were divided by the total sampled hours unaffected by rain to determine a mean hourly passage rate. The daily movement rate was determined by dividing the total numbers of petrel type targets detected by the total number of days sampled.

Hawaiian Petrel peak flight periods occur around dawn and dusk when most birds are transiting between inland nest sites and open ocean. Thus, radar and audio-visual surveys were conducted during peak dusk and dawn periods. Peak dusk movement (when birds would be expected to be flying landward toward their nesting colonies) occurred just after sunset (~1845-2115). Peak dawn movement (when birds would be expected to be flying toward the ocean away from nesting colonies) occurred before sunrise (~0345-0545). The peak hourly movement rate was calculated by dividing the total number of Hawaiian Petrel flights detected by radar by the total number of radar survey hours.

To calculate a daily passage rate, we combined dusk and dawn sessions into one survey "day" by defining each survey day to begin near sunset (e.g., 1845) and end the next day at sunrise (e.g., 0545). Though most petrels fly during peak dusk and dawn periods, smaller portions of birds are known to fly throughout the night (Day and Cooper 1995, Sanzenbacher and Cooper 2009). To estimate the proportion of birds expected to pass over during the portions of the night when we did not sample, we used an adjustment derived by comparing peak and all night sampling passage rates from data collected on Kaua'i in 1993 (Day and Cooper 1995). The adjustment for the proportion of flights occurring during the un-sampled nocturnal period was 12.6% of the total nightly passage rate (Cooper and Day 2004). Therefore, our total nightly passage rate was calculated by multiplying our mean movement rate from our peak sampling periods (targets/day) by 1.126.

Flock Size

Radar detections of multiple birds flying close together may sometimes appear as a single echo on the radar screen and thus be recorded as a single target. For that reason the nightly passage rate was adjusted by the expected mean number of birds per radar target (flock size) following the methods of Cooper and Day (2004). Their estimate of 1.025 birds/flock was derived by taking the mean flock size of petrel and shearwater targets from data they collected on Kaua'i (Day and Cooper, unpubl. data). Therefore, our mean nightly passage rate was multiplied by 1.025.

Breeding Season

We determined the total number of days Hawaiian Petrels are expected to be on land for the breeding season, which includes nesting and incubation in the spring and summer months through young fledging in the fall. Adults and sub-adults are at-sea and not transiting across the island outside of the breeding season. To account for this activity pattern, we multiplied our daily passage rate by the length of the breeding season (231 days for Hawaiian Petrels), to estimate the total number of petrel flights per year passing through the AWRA.

The Hawaiian Petrel breeding season was calculated based on detailed breeding phenologies augmented with local records of species observations at nesting colonies (Simons 1985, Simons and Hodges 1998). According to breeding phenology literature, Hawaiian Petrels arrive at nesting colonies in mid-April and the young fledge in October and November for a breeding season of 230 days (Simons and Hodges 1998). On Haleakala, however, Hawaiian Petrels are observed returning to nesting burrows as early as the last week of February (Simons 1985) (+52 days = 282 maximum breeding days) and fledging is over before the month of November (Simons 1985) (282 max. breeding days -30 days of November = 252 breeding days). Additionally, Hawaiian Petrel adults exhibit a pre-laying absence from the colony and nest site for three weeks (21 days) immediately prior to egg laying (Simons 1985, Warham 1990). This pre-laying absence (also known as pre-laying exodus) is exhibited by many species in the Procellariiformes group, which includes petrels, shearwaters, albatrosses and other seabirds (Warham 1990). The pre-laying absence occurs at the time females develop their eggs and allows males time to store up fat reserves for the first egg incubation shift (Warham 1990). To determine the Hawaiian Petrel breeding period we subtracted the pre-laying absence period from the number of breeding days, for a total annual breeding period of 231 days (252 breeding days – 21 day pre-laying absence = 231 breeding days). Hawaiian Petrels on Maui follow the same general breeding patterns as other Hawaiian Petrels (i.e., same general length of nest building, egg laying, incubation and fledging). Although petrels may arrive at nest sites on Maui earlier than petrels on other Hawaiian Islands, we have no evidence of longer incubation, fledging, or other breeding periods. For this reason we would not expect the entire breeding season for Hawaiian Petrels on Maui to be greater than for other Hawaiian Petrels. The calculated breeding period of 231 days is very close to the 230-day breeding period listed for Hawaiian Petrels by Simons and Hodges (1998).

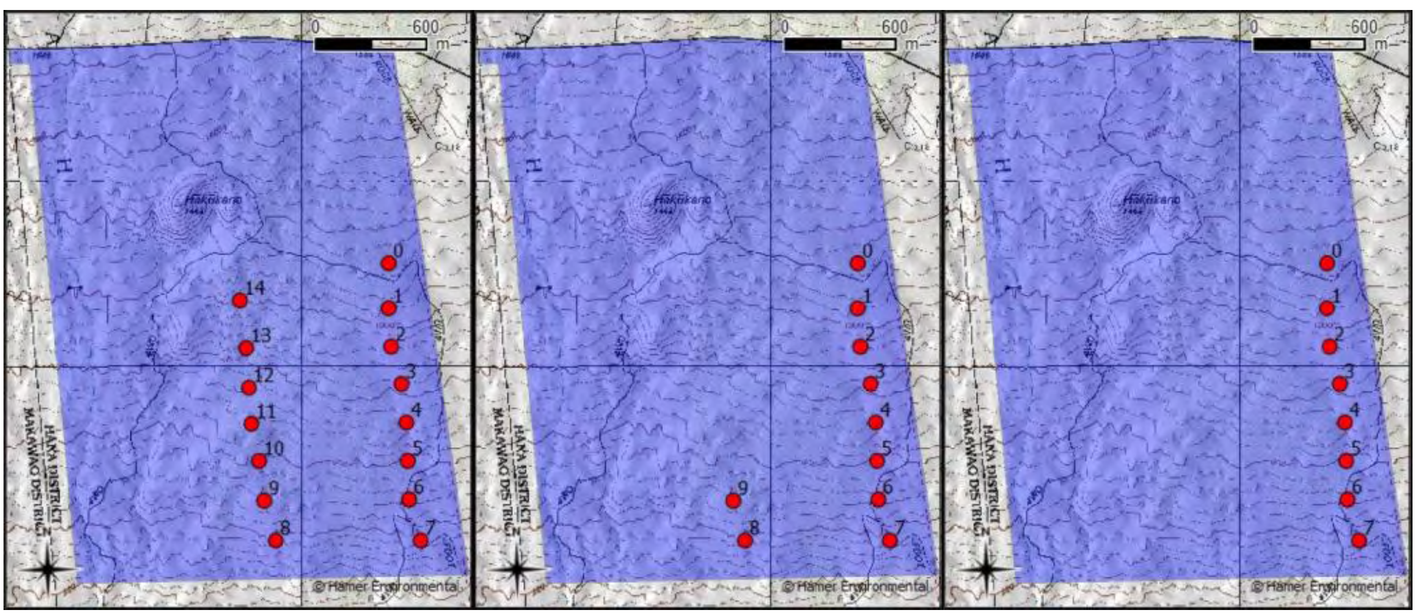

Figure 4. Three possible wind turbine configurations for the AWRA, GE 1.5xleWE (15 turbines, left), Siemens SWT 2.3-101 (10 turbines, center) and Siemens SWT 3.0-101 (8 turbines, right), Ulupalakua, Maui, Hawaii.

Modeling of Collision Risk

The Hamer Avian Risk of Collision Model was used for the estimation of collision risk at the AWRA. The goal of the modeling process was to estimate the expected number of annual avian/turbine collisions for Hawaiian Petrels under three proposed wind turbine configurations (Figure 4). Because the collision risk and passage rate are dependent on the time of day, time of year, turbine configuration, and avoidance rate, a number of different model configurations were used to arrive at our final annual collision estimates. Each model configuration was specified by a permutation of the following variables, resulting in 36 total configurations:

Turbine Type: GE 1.5xleWE (15 turbines), Siemens SWT 2.3-101 (10 turbines), Siemens SWT 3.0-101 (8 turbines)

Time of Year: Spring, Fall

Time of Day: Dawn, Dusk

Bird Avoidance Rates: 90%, 95%, 99%

The modeling process (Figure 5) consists of 4 primary phases: 1) the collection of model inputs, 2) estimation of the probability distribution functions (PDFs), 3) running the Monte Carlo simulations and, 4) estimation of the annual collision rates from the different model outputs.

Model Inputs

The Hamer Model is designed to account for a number of inputs that may have a significant effect on bird mortality. Some of these inputs are not dependent on observed field data, and include turbine locations, turbine characteristics (Table 1), and Hawaiian Petrel body dimensions (average body length and wingspan). Comparable studies and available data of bird behavior were used to estimate avian avoidance rates (see Discussion). Other inputs are site-specific and were determined by observed bird flight behavior and meteorological data at the AWRA. Bird flight inputs included flight path direction, speed, passage rates and flight height. Meteorological data was obtained from on-site meteorological towers and included time dependent wind directions and speeds.

Probability Distribution Functions

In order to simulate “typical”, or probable, wind conditions and petrel flight paths through the AWRA study area for different turbine configurations and peak flight periods, it was necessary to estimate the distributions of flight and wind parameters under these conditions. This estimation process was driven by observed, site-specific data and resulted in a set of probability distribution functions (PDFs) for each variable (e.g., flight height). If these data were a good fit for a parametric distribution function (e.g., Gaussian or gamma) then the parametric distribution was estimated using a maximum likelihood algorithm. Otherwise, kernel smoothing methods were used to estimate the PDFs.

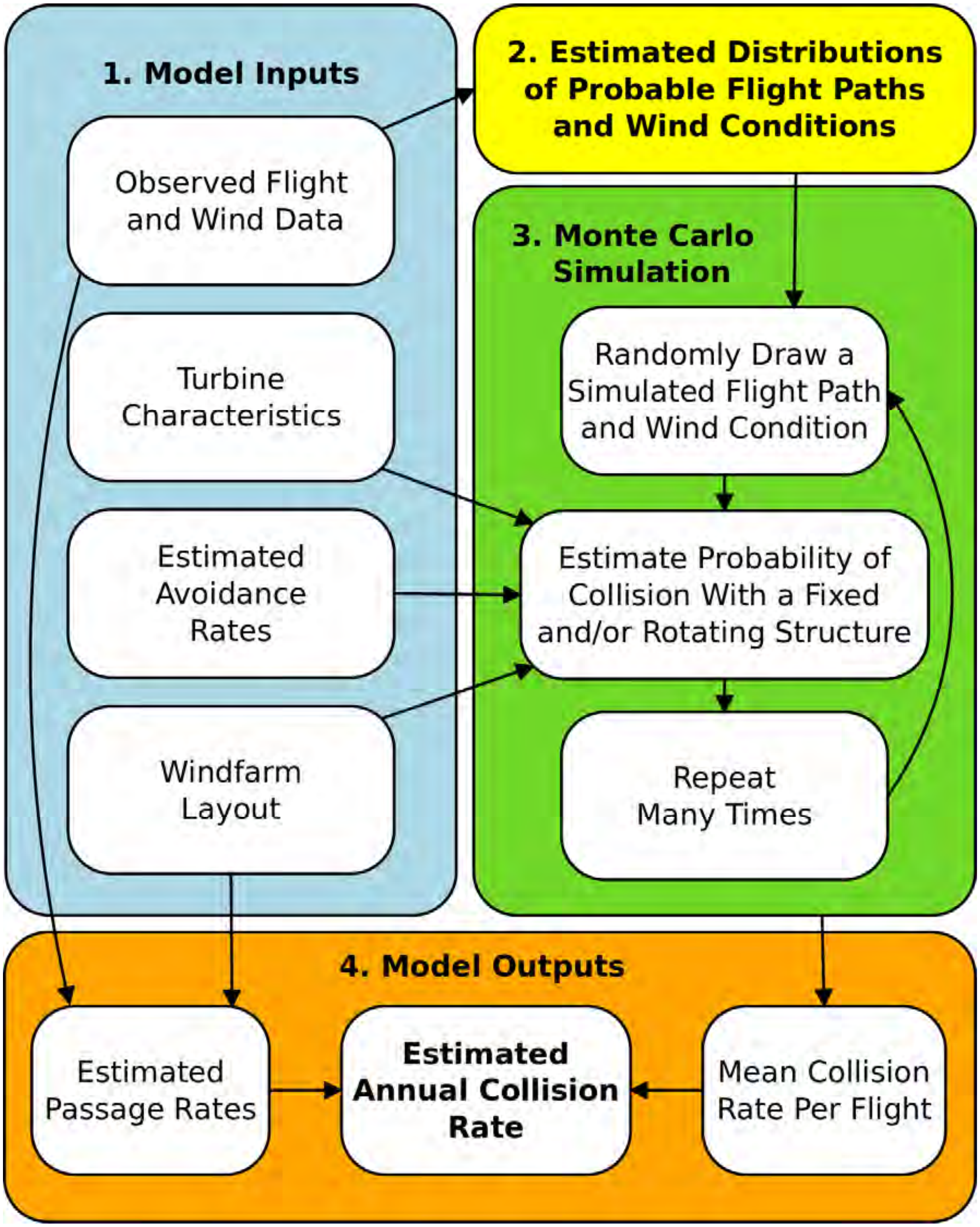

Figure 5. Workflow for the Monte Carlo simulation based Hamer Model.

Table 1. Wind turbine characteristics used for the Hamer Model.

Turbine Manufacturer	GE	Siemens	Siemens
Turbine Model	GE 1.5 xleWE	SWT 2.3-101	SWT 3.0-101
Turbine MW	1.5	2.3	3.0
Height to top of blade (m)	121.25	130.5	130.5
Lowest rotor swept height (hub height- rotor radius) (m)	38.75	29.5	29.5
Rotor height (Zone of Risk) (m)	45 – 121	30 – 131	30 – 131
RPM	9 – 20	6 – 16	6 – 16
Cut in wind speed (m/s)	3.5	4	4
Cut out wind speed (m/s)	25	25	25
Rotor Radius (m)	41.25	50.5	50.5
Blade Width at Hub (m)	1.9	2.4	2.4
Blade Width at Widest Point [Chord Root] (m)	3.2	3.5	3.5
Radius at Widest Point on Rotor (m)	8	16	16
Blade Width at Tip [Chord Tip] (m)	1	1	1
Number of Rotor Blades	3	3	3
Monopole Diameter at Ground Level (m)	4.3	4.2	4.2
Monopole Diameter at Widest Point (m)	4.3	4.2	4.2
Elevation at Widest Point on Monopole (m)	0	0	0
Monopole Diameter at Hub (m)	2.6	2.4	2.4
Elevation at Hub (m)	80	80	80
Nacelle Height (m)	4	3.8	-
Nacelle Width (m)	3.6	3.5	-
Total Number of Turbines	15	10	8

Monte Carlo Simulation

Monte Carlo simulation was used to estimate the mean collision risk per "typical" flight through the AWRA study area for each model configuration. For each turbine type, bird species, and peak flight period, we were able to generate any number of probable bird flight paths through the AWRA study area by random sampling of the PDFs calculated from the observed data. The 1.5 km radius AWRA study area circle was centered over each of the proposed turbine configurations for model simulations (Figure 6). Each individual flight path was then analyzed for collision risk by checking to see if it intersected with any fixed wind turbine structures (towers, nacelles) and/or areas swept by rotor blades (Figure 6). Avoidance rates were applied to each interaction with fixed or rotating turbine components. Flight paths that intersected multiple turbines incurred an accumulation of collision risk.

For flight paths at risk of collision with rotor blades, the Hamer Rotor Sub-Model was used to estimate the probability of collision. This kinematic model accounts for numerous parameters, including wind speed, wind direction, bird flight speed, bird flight direction, bird body and wing dimensions, turbine dimensions, rotational speed of the turbine in relation to wind speed, and the precise point of entry into the rotor plane. The Hamer Rotor Sub-Model is an extension of the Tucker Model (Tucker 1996). Where the Tucker Model addresses rotor collision probability for cases where the bird's air speed is either parallel or perpendicular to the wind direction, our model handles the more general and common case of oblique angles of approach. Accounting for the angle of approach can significantly impact collision risk, and is an important feature enabling us to more accurately model risk with our simulation based approach.

By averaging the collision risks associated with the simulated flight paths and wind conditions for each model configuration, we calculated the mean, per flight collision risk:

$$Risk_{\text{turbine type, season, time of day}}$$

As the number of simulation iterations increases, so does the accuracy of these estimates. We performed 1,000,000 simulations for each of the 36 model configurations.

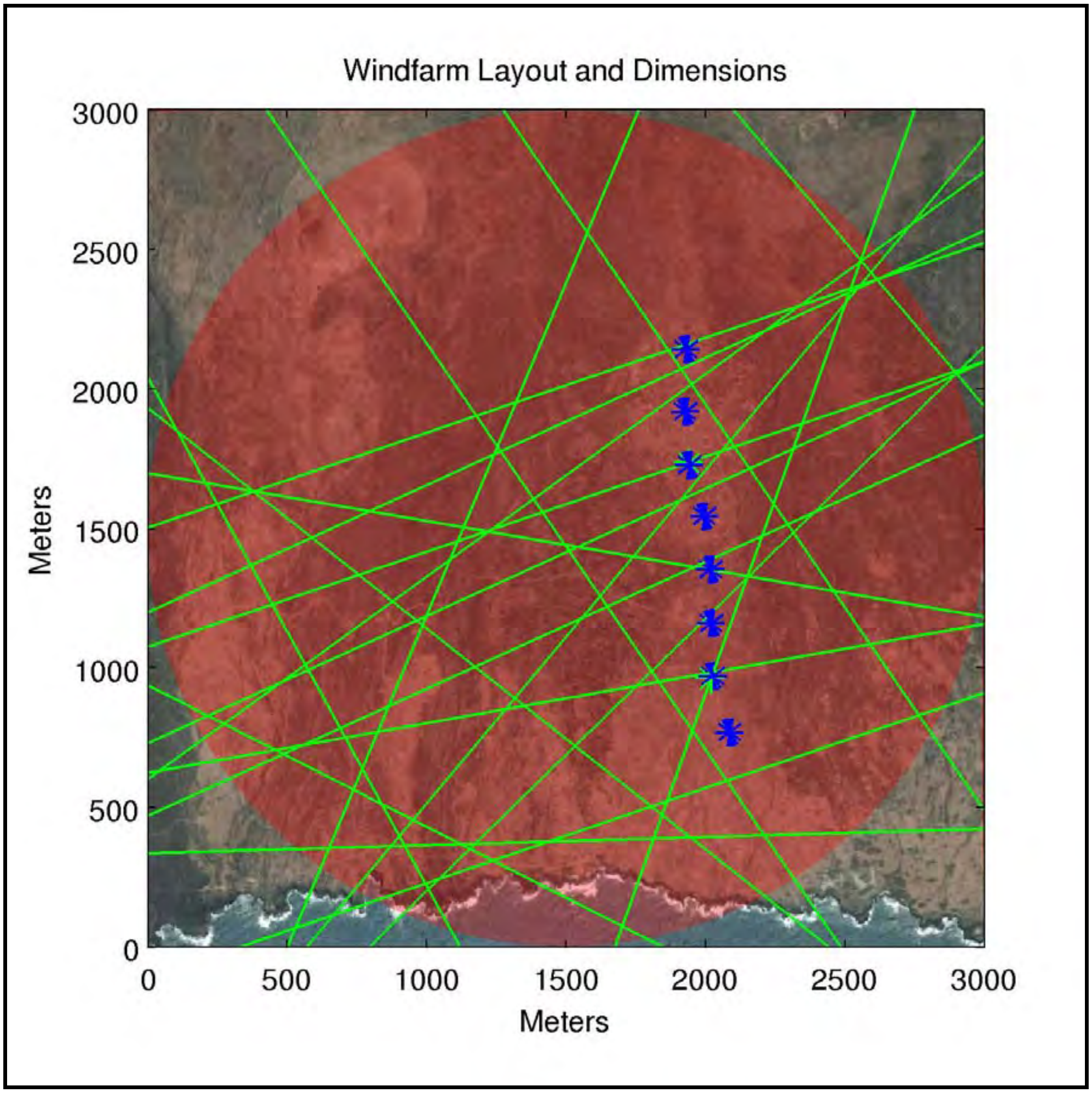

Figure 6. Visualization of a model run for the Siemens SWT 3.0-101 turbine configuration showing 20 randomly generated, but probable flight paths (green lines). All simulated flight paths are ensured to cross over the shaded polygon defined as the AWRA study area (1.5 km radius, red shaded region). Turbines always face upwind, creating the distribution of rotor orientations (blue). Collision is possible when the flight paths intersect solid structures (towers, nacelles) and/or the areas swept by rotor blades. For these flight paths, the Hamer Rotor Sub-Model is used to determine the probability of collision with a component of the turbine (possible rotor collisions are denoted by green asterisks).

<u>Model Outputs</u>

The Monte Carlo simulations resulted in different mean per passage collision risk estimates for each model configuration:

$$Risk_{\text{turbine type, season, time of day}}$$

We also estimated the total number of avian passages through the AWRA study area during peak flight periods (see Passage Rate Estimation):

$$Passage_{\text{season, time of day}}$$

To determine the estimated number of collisions for each turbine configuration, and peak flight period, the per passage collision probability is simply multiplied by the number of passages. For example, the estimated number of Hawaiian Petrel collisions at dusk during the fall for the GE configuration is:

$$Collisions_{\text{GE, fall, dusk}} = Risk_{\text{GE, fall, dusk}} \cdot Passage_{\text{fall, dusk}}$$

For each tower configuration, the annual collision rate was therefore calculated by summing the estimated number of collisions for each peak flight period:

$$Collisions_{\text{turbine type}} = \sum_{i=\{\text{spring, fall}\}} \sum_{j=\{\text{dawn, dusk}\}} Risk_{\text{turbine type}, i, j} \cdot Passage_{i, j}$$

Model Inputs

<u>Wind Turbines and Turbine Configurations</u>

Three different turbine models and spatial configurations: GE 1.5 xleWE (15 turbines with 1.5-MW output), Siemens SWT 2.3-101 (10 turbines with 2.3-MW output) and Siemens SWT 3.0-101 (8 turbines with 3.0-MW output) are being considered for the AWRA (Table

1). Proposed turbine configurations consist of one to two parallel rows of turbines running south to north and result in a 22.5 - 24-MW wind resource development (Figure 4).

The GE 1.5 xleWE is the smallest of the proposed turbines at 121.25 m height to top of rotor sweep, with a rotor radius of 41.25 m (Table 1). The Siemens SWT 2.3-101 turbine is the largest turbine at 130.5 m to the top of the rotor sweep and a rotor radius of 50.5 m. The Siemens SWT 3.0-101 has the same dimensions as the other Siemens turbine, but uses direct-drive instead of a gearbox and is therefore more efficient. Turbine dimensions and characteristics used in the Hamer Model were based on manufacturer specifications (Table 1).

Because rotor speed and blade characteristics have a large impact on collision probability, we modeled the angular rotor speed and rotor pitch as a function of the wind speed to match operational data. For wind speeds below the turbine's cut in wind speed, the rotors are assumed to be fixed and the rotor pitch equal to 0 degrees. As the wind increases from the cut in wind speed to the cut out wind speed, the angular rotor speed and pitch both increase to their maximum values. For wind speeds above the turbine's cut out speed, the rotors are again fixed and the pitch equal to 90 degrees. Operational data was obtained which described the relationship between wind speed and the angular rotor speed and rotor pitch for each the Siemens SWT 2.3-101 (Figure 7), Siemens SWT 3.0-101 (not pictured) and GE 1.5 xleWE (not pictured) turbines.

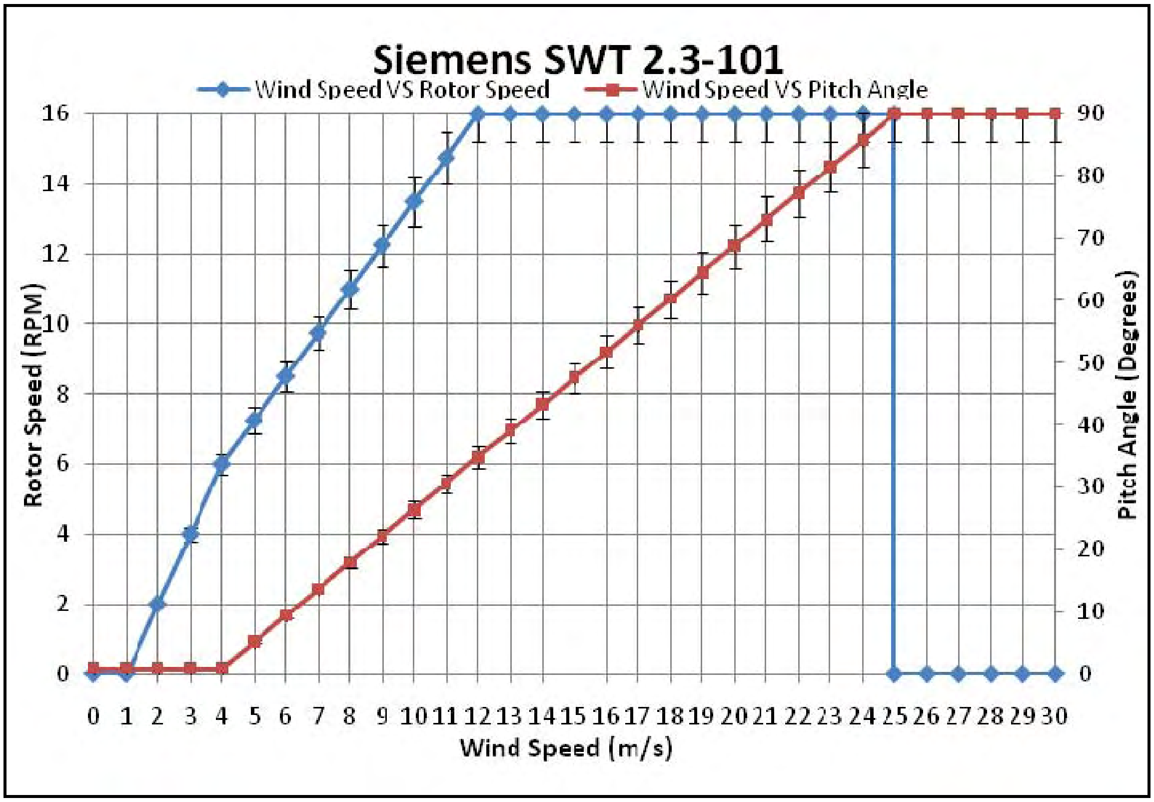

Figure 7. Rotor speed and blade pitch angle by associated wind speed for the Siemens SWT 2.3-101 wind turbine. Data provided by manufacturer.

<u>Wind Characteristics</u>

Wind data were available from two different meteorological towers (636, 637) in the AWRA, but were utilized from the tower located closest to the proposed wind turbines (tower 637) to match conditions most representative of those encountered by birds flying through the wind development. Meteorological tower 637 is located 42 m south of proposed turbine 13. Meteorological tower 637 stands 50 m tall and has anemometers to collect wind data set at 30.5 and 48.5 m. Wind experts at AWS Truewind used wind shear algorithms to extrapolate wind speeds to 80 m agl (above ground level) (Elliot et al. 1986). Wind speeds at 80 m agl were utilized for the Hamer Model as they represented wind conditions encountered by both turbine rotors and petrels facing collision risk.

Wind data collection at meteorological towers began December 2006 with data collection ongoing at time of report writing. Wind data were collected every minute and averaged over each hour, day, and month. We used wind speeds and directions for nesting and fledging seasons from 2007-2009 to best replicate wind conditions likely encountered by petrels. From the nesting and fledging months, hourly wind data from dawn (400-1000) and dusk (1800-2200) periods was utilized to best represent wind conditions encountered by petrels during peak daily movement periods.

The distribution of wind speeds was consistently bimodal, with a small peak around 4 m/s and a larger one around 12 m/s. Because of the non-parametric nature of this distribution, kernel smoothing was used to estimate this PDF (Gaussian kernel, automatic bandwidth selection).

Monthly averages of wind direction data were used to estimate the wind direction PDF. On average the wind was blowing either east-northeast or east 85% of the time (40% ENE and 45% E). However, the wind directions for wind speeds less than 4 m/s were not reported, so a uniform distribution of wind directions was assumed in these cases. Due to this dependence between wind speed and wind direction, wind characteristics were modeled as a 2-dimensional joint-PDF. These PDFs were estimated separately for spring/summer breeding and fall fledging seasons and for dawn and dusk peak activity periods.

<u>Hawaiian Petrel Characteristics</u>

Size

Hawaiian Petrel body dimensions were modeled using an average body length of 0.43 m and a wingspan of 0.91 m (Simons and Hodges 1998). Body dimensions of the seabird were held constant for model simulations.

Flight Speed and Direction

Flight speeds and directions were determined from flights of petrel type targets detected during fall 2006 and spring 2010 radar surveys. Due to the strong dependence of flight patterns on the time of day, different probability distribution functions were estimated for dawn and dusk targets. The distribution of dawn and dusk flight speeds were bimodal, with peaks near 16 and 25 m/s, respectively (Figure 9). These peaks were not as pronounced, however, for the dusk survey period. Dawn and dusk distributions of flight directions tended to be unimodal but had their peaks in different directions (200 vs. 300 degrees clockwise from north for the dawn and dusk flights, respectively) (Figure 8). None of these distributions were well described by normal distributions, so kernel smoothing was again used to estimate these PDFs (Gaussian kernel, automatic bandwidth selection). As opposed to wind speed and direction, no significant dependence was evident between bird speed and direction and each PDF was modeled independently.

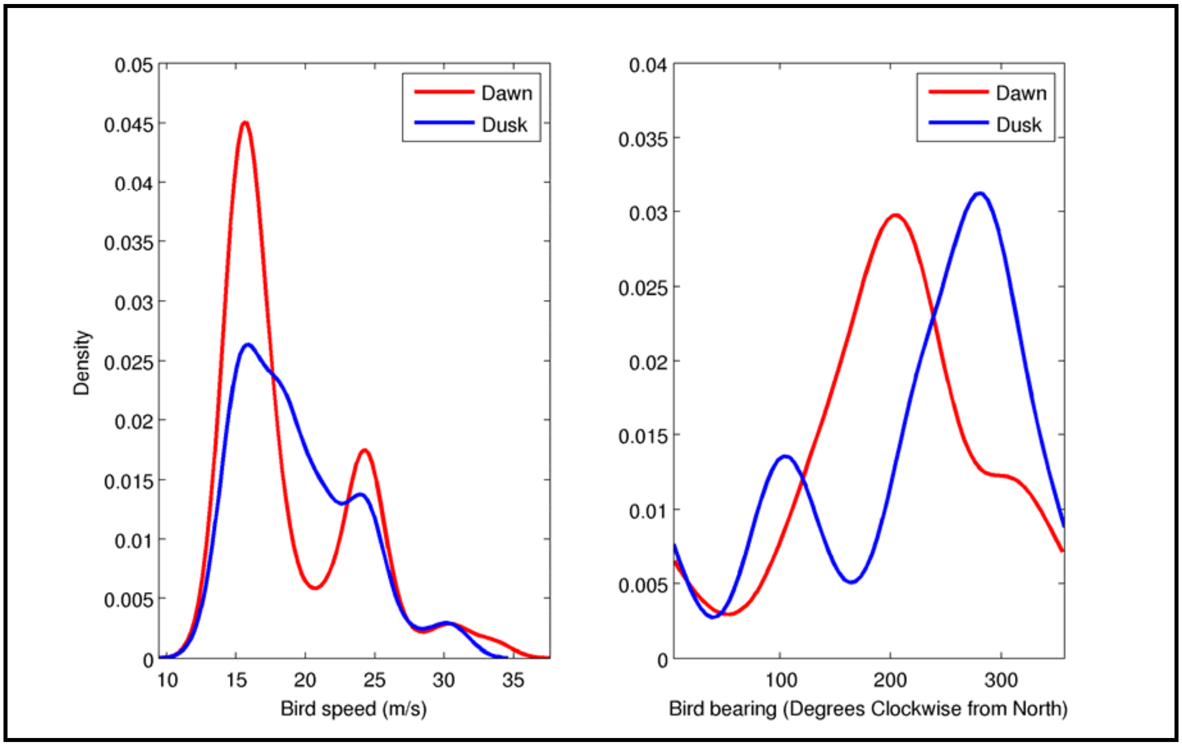

Figure 8. Probability Distribution Functions (PDFs) for petrel speed and bearing estimated from observed data. Dawn and dusk flight patterns were distributed differently, motivating separate model runs for each of these cases.

Flight Heights

We utilized vertical radar to collect minimum flight heights of birds transiting the AWRA study area. All flight heights collected by radar were utilized to create a flight height distribution for model simulations. Flight heights were fit to a gamma distribution for PDF estimation (Figure 9). This gamma distribution passed the Kolmogorov-Smirnov goodness of fit test (α=0.05).

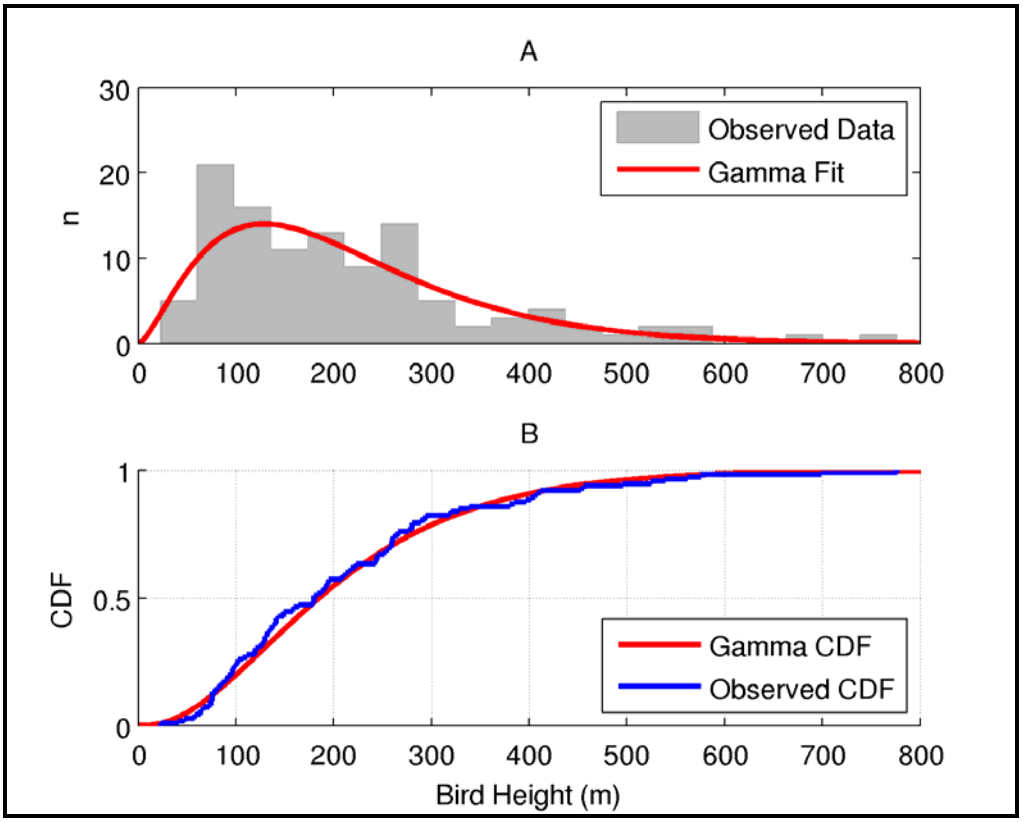

Figure 9. (A) Observed flight heights from spring 2010 and fall 2006 radar data (n=112) fit to a gamma distribution. **(B)** A comparison of the cumulative distribution functions (CDFs) of the observed data and the gamma distribution. Using these CDFs, the gamma distribution passed the Kolmogorov-Smirnov goodness of fit test (α=0.05).

Avoidance and Fatality Rates

For possible collisions with the moving components of the wind turbines, we modeled expected avian avoidance at 90%, 95% and 99%. The assumption of 90% and higher avian avoidance for Hawaiian Petrels is supported by post-construction mortality studies at the Kaheawa Pastures Wind Energy Facility on Maui (Sanzenbacher and Cooper 2009, Brian Cooper pers. comm. found 99% avoidance) and other avian avoidance studies at wind developments (Cooper, Day and Plissner 2007, Desholm 2006, Desholm and Kahlert 2005, Dirksen et al. 1998), which show that the majority of birds see wind turbines and avoid them. For portions of the turbine that are static (tower and nacelle) we assumed 99% avoidance by petrels.

We assumed that any petrel collision with a wind turbine (tower, nacelle or rotor) will result in a fatality. This assumption of 100% fatality is in line with Endangered Species Act's definition of "take". Though not all collisions with wind turbines may result in mortality, this 100% fatality assumption allows for a conservative estimate of collision and fatality risk.

RESULTS

Passage Rate Estimation

The peak hourly movement rate for nesting and fledging season is 9.45 petrel passes per hour (Table 2). We adjusted the movement rate for portion of the night not sampled and the mean flock size of petrel type targets. Explanations for the passage rate adjustments are described in the passage rate calculation section (see Methods, page 12). The final mean movement rate is 43.67 petrel passages per day (Table 2).

We calculated the yearly passage rate for petrels based on a 231-day (7.7-month) Hawaiian Petrel breeding period. We estimate 11,642 Hawaiian Petrel passages over the AWRA study area annually (Table 2). This adjusted rate was approximately 1.2 times higher than the unadjusted annual passage rate of 10,087 bird passages/yr (Table 2).

Table 2. Annual passage rate calculation for the AWRA.

PASSAGE RATE CALCULATION	
(A) Bird Targets within the AWRA in Spring	164.00
(B) Bird Targets Detected within the AWRA in Fall	229.00
(C) Total Number of Bird Flights Detected within the AWRA =A + B	393.00
(D) Total Hours Sampled by Radar (adjusted for lost survey time due to rain)	41.57
(E) Total Days Sampled by Radar	9.00
(F) Mean Rate During Daily Peak Movement Period (targets/hour) = C/D	9.45
(G) Mean Rate of Movement/Day (targets/day) = C/E	43.67
(H) Mean Proportion of Bird Flights During Off-peak Hours of the Night	0.126
(I) Mean Daily Movement Adjusted for Portion of Night Not Sampled (targets/day) = (G xH)+ G	49.17
(J) Number of Bird Flights/Radar Target (average flock size)	1.025
(K) Mean Movement Rate Adjusted for Flock Size (targets/day) =I x J	50.40
(L) Length of Breeding Season for Hawaiian Petrel (days)	231.00
(M) Unadjusted Annual Bird Passage Rate = ((A+B)/E) x L	10087.00
(N) Mean Hawaiian Petrel Flights/Year (adjusted annual passage rate) = K x L	**11642**

Collision Rate Estimates for the AWRA

Model simulations were summarized for each combination of model runs: wind turbine design, season, time of day (dawn/dusk), and avoidance rate (Tables 3, 4). The Hamer Model results represent the collision risk for one bird transiting the wind turbine configuration (Tables 3, 4). For the 90% avoidance rate, the model scenario that resulted in the highest risk of collision estimate was for a Hawaiian Petrel flying during dawn and spring breeding season through the GE turbine configuration of the AWRA, with a collision risk of 0.000574 (Table 3). The model scenario for the 90% avoidance rate resulting in the lowest collision risk estimate was for a Hawaiian Petrel flying during the dusk in the fall through the Siemens 3.0 turbine configuration, with a collision risk of 0.000401 (Table 3). In general, collision risk was highest for petrels under the GE turbine configuration.

Table 3. Estimated risk of collision for one bird transiting the AWRA study area, based on 1,000,000 flight simulations for each of 36 model combinations.

Turbine Type	Time of Year	Time of Day	Avoidance Rate		
			90%	95%	99%
GE	spring	dawn	0.000574	0.000304	0.000088
GE	spring	dusk	0.000554	0.000294	0.000086
GE	fall	dawn	0.000564	0.000299	0.000087
GE	fall	dusk	0.000549	0.000292	0.000086
Siemens 2.3	spring	dawn	0.000531	0.000277	0.000074
Siemens 2.3	spring	dusk	0.00051	0.000267	0.000071
Siemens 2.3	fall	dawn	0.000517	0.00027	0.000072
Siemens 2.3	fall	dusk	0.000501	0.000262	0.00007
Siemens 3.0	spring	dawn	0.000424	0.000221	0.000059
Siemens 3.0	spring	dusk	0.000404	0.000211	0.000056
Siemens 3.0	fall	dawn	0.000412	0.000215	0.000057
Siemens 3.0	fall	dusk	0.000401	0.00021	0.000056

We estimate that annually, 0.662-3.450 Hawaiian Petrels may be at risk of collision with turbine structures at the AWRA depending on the turbine configuration (95% and 99% avoidance, Table 4). Similarly, per turbine, we estimate 0.067-0.312 Hawaiian Petrels may be at risk of collision annually, depending on the turbine configuration (95% and 99% avoidance, Table 4). As a conservative measure, we assume all avian collisions with structures will result in mortality, so these collision estimates are also annual mortality estimates.

Table 4. Annual and per turbine avian collision estimates by turbine type and avoidance rate. Assumes 99% avoidance rate for all fixed portions of the wind turbine (nacelle and tower).

Turbine Type	Annual Collision Risk Avoidance Rate			Annual Per Turbine Collision Risk Avoidance Rate		
	90%	**95%**	**99%**	**90%**	**95%**	**99%**
GE						
Hawaiian Petrel	6.501	3.450	1.008	0.433	0.230	0.067
Siemens 2.3						
Hawaiian Petrel	5.973	3.122	0.833	0.597	0.312	0.083
Siemens 3.0						
Hawaiian Petrel	4.761	2.487	0.662	0.595	0.311	0.083

DISCUSSION

Passage Rate Estimate

The passage rate estimate in this report was derived from spring 2010 and fall 2006 radar detections of petrel targets. Spring 2010 surveys had better coverage of the AWRA than the summer 2006 radar study, and were conducted earlier in the season to capture peak flight activity of the target species during the breeding (nesting) season.

We estimated 11,642 petrel flights passed through the AWRA study area annually (Table 2). We believe this annual passage rate estimate to be conservative (estimated high) based on positive adjustments to account for flock size and nocturnal activity outside of peak movement times.

We assumed that the passage rate estimate represents target bird flights and not necessarily individual birds, as petrels may pass through the AWRA more than one time per year. Furthermore, the population estimate for Hawaiian Petrels nesting on Haleakala is 900-1,300 individuals, which represent significantly fewer birds than our passage rate estimate of 11,642 petrel flights (Simons 1984, 1985, Simons and Hodges 1998). If we had assumed that the passage rate represented individual birds, this would result in more than the entire petrel population on Haleakala flying over the AWRA annually.

Within the AWRA study area, the hourly peak passage rate was 9.45 petrel flights per hour (Table 2). This hourly passage rate was much lower than hourly petrel passage rates collected at three coastal sites in South Maui, which ranged from 68-93 petrel type targets per hour (Kaupo, Nu'u Bay and Mokuia Point, Cooper and Day 2003, Figure 10). Additionally, a study of petrels for a proposed tower near the Haleakala summit reported an average passage rate of 15.6 petrels per hour, with a range of 7.2- 26.8 petrels per hour depending on the site (Day and Cooper 2004).

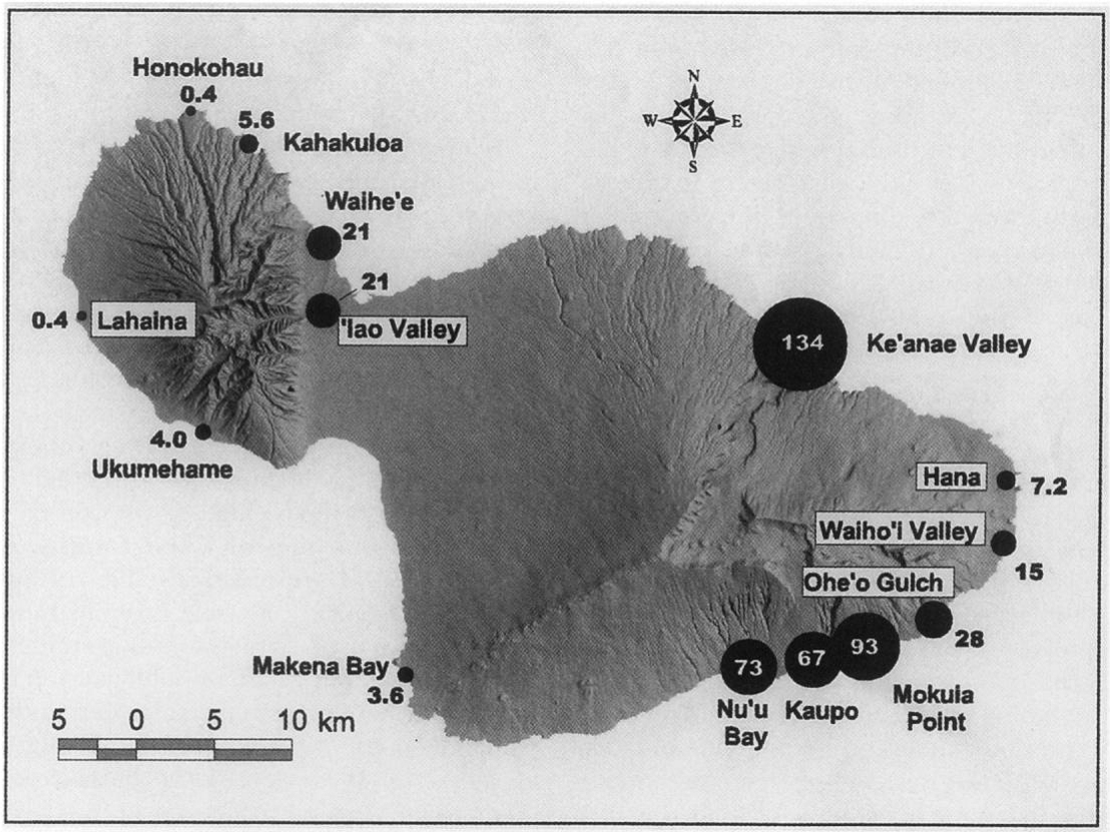

Figure 10. Geographic variation in mean movement rates (targets/hr) of petrels and shearwaters observed during 1900-2200 hours on radar around Maui Island, Hawaii, June 2001. Sizes of circles are proportional to the mean movement rate; numbers in/near circles are actual mean movement rates (targets/hr) (figure from Day and Cooper 2004).

Non-target Species

The radar passage rate was higher in fall 2006 than in spring 2010. Typically, fall passage rates at a given site are lower than the spring breeding season, as non-breeding adults have stopped visiting inland nesting colonies and breeding adults are making fewer trips inland to feed their young. This higher fall passage rate may indicate that non-target species such as Sooty Terns, were included as Hawaiian Petrel radar detections. During the fall 2006 sampling, the outside observer detected only a few Sooty Terns because the outside conditions were not ideal for bird observations (low clouds, light rain, dark skies). The Sooty Terns have a similar body size and flight speed to Hawaiian Petrels and Newell's Shearwaters and thus look similar on the radar. Additionally, many of the radar targets were flying at high altitudes over the AWRA study area, as confirmed by our vertical radar, thus the outside observer often had little chance of detecting them and confirming their identification.

Therefore, it is possible that some of the birds we recorded and analyzed as petrel type targets were actually Sooty Terns. The Sooty Tern is the most abundant seabird in the tropics, numbering about 60 million – 80 million birds (Schreiber et al. 2002) with stable populations in the Hawaiian Islands.

Hawaiian Petrels generally move during crepuscular periods (Day and Cooper 1995). However, some birds we recorded as petrel may have been Sooty Terns since they would also be expected to be active even after sunset or before sunrise. Sooty terns are known to be active during the day and night, especially at, or near, nesting colonies. Even with our attempts at filtering out non-petrel targets by focusing our survey efforts during crepuscular periods during the fall, likely similarities in body size, flight speed, flight behavior, and flight altitudes between birds we recorded as Hawaiian Petrel and Sooty Terns indicate that some proportion of the birds recorded on radar could be Sooty Terns.

Avoidance Rates

We selected a range of avian avoidance rates (90%, 95%, and 99%), but feel that the 95% avoidance rate likely best represents what current literature on avian avoidance of wind turbines suggests (Day et al. 2005, Desholm 2006, Desholm and Kahlert 2005, Madders 2004, Percival 2004). Avian avoidance behavior is the least understood parameter in all avian risk of collision models, while being one of the most important to resulting estimates of collision risk. Species specific studies on avian avoidance of man-made structures are needed to make better estimations of collision risk (Chamberlain et al. 2006, Desholm 2006, Fox et al. 2006).

However, in absence of species specific information, the high sensitivity to bird avoidance of turbines does not warrant the abandonment of risk of collision models (Chamberlain et al. 2006, Madders and Whitfield 2006). Avoidance data can be incorporated after calculating the mathematical turbine collision risk as they become available for species and site specific scenarios, but it is important that the base collision model be as accurate as possible. In the absence of detailed avoidance data, the results of the risk of collision model still proves useful in comparing relative collision risk between different wind park locations, wind turbine configurations, turbine models, and other factors, which is increasingly a common practice when siting wind power projects.

Very little is known about Hawaiian Petrel avoidance behaviors, but a few studies in Hawai'i have been conducted where Hawaiian Petrel avoidance behaviors were documented or can be inferred. A study for meteorological towers on Lana'i documented avoidance behaviors exhibited by 20 Hawaiian Petrels observed altering their flight paths to avoid collision with communication towers, with 100% successful avoidance of the structures (Cooper, Day and Plissner 2007, cited in Sanzenbacher and Cooper 2009). Post-mortality studies at the Kaheawa Pastures Wind Energy Facility in West Maui report an annual average of 1.2 Hawaiian Petrel and 0.0 Newell's Shearwater mortalities annually (Greg Spencer pers. comm., Sanzenbacher and Cooper 2009). This mortality rate corresponded to a 97.5% avoidance rate estimated by risk of collision modeling of the Kaheawa Pastures Wind Energy Facility prior to construction (Cooper and Day 2004). Based on the inclusion of 2010 data, the mortality rate at Kaheawa Pastures Wind Energy Facility corresponds to a 99% avoidance rate estimated by risk of collision modeling (Brian Cooper pers. comm.).

Avian Avoidance of Wind Developments

Our Hamer Model addresses behavioral avoidance by birds of individual wind turbines, but assumes no avian avoidance of the entire wind development. In the studies where wind park avoidance has been examined, the rate of avoidance has been high (Barrios and Rodriguez 2004, Desholm 2006, Dirksen et al. 1998, Masden et al. 2009, Smallwood and Thelander 2004, 2005). Particularly at wind developments with multiple turbine strings (rows of turbines), most birds alter flight paths to avoid the developments (Barrios and Rodriguez 2004, Desholm 2006). A study of migrating Common Eiders at Nysted offshore wind development SE of Denmark found that birds were more likely to avoid the entire wind development (by a factor of 4.5) than to fly through it (Desholm 2006). Although we believe some proportion of Hawaiian Petrels would be likely to alter flight paths to avoid the entire AWRA, this was not studied and is not possible to assess during the pre-construction phase. Therefore, we have assumed no avoidance of the entire wind development.

Risk of Collision Estimates

At the 95% avoidance rate, annual collision estimates for the proposed wind development were highest for the GE turbine configuration with an estimated 3.450 collisions between Hawaiian Petrels and turbines annually (Table 4). At the 99% avoidance rate, annual collision estimates for the proposed wind development were 0.662-1.008 depending on turbine configuration (Table 4). At the 99% avoidance rate, the GE configuration for the wind development poses the highest risk of collision to petrels, 18 to 34% higher avian collision risk than the Siemens 2.3 and Siemens 3.0 configurations, respectively (Table 4). Although the smallest of the three wind turbines proposed, the GE turbine configuration poses the highest risk of collision to petrels because it consists of the largest number of turbines (15 turbines, versus 10 turbines for Siemens 2.3 and 8 turbines for Siemens 3.0 configurations).

When assessed per turbine, the Siemens 2.3 model has the highest risk of collision at 0.312 Hawaiian Petrels per turbine per year (95% avoidance rate) or at 0.083 Hawaiian Petrels per turbine per year (99% avoidance rate, Table 4). The Siemens 2.3 model is 9.0 m taller than the GE model, and has significantly larger and wider turbine blades, which accounts for the higher collision risk to birds (Table 2). The Siemens 2.3 and Siemens 3.0 turbines are essentially identical, so the per turbine collision estimates are similar, (within 4% of each other, Table 4). The discrepancy between the Siemens 2.3 and Siemens 3.0 arises because the per turbine collision risk estimate takes into account the specific turbine configuration and the locations of the turbines relative to each other on the landscape.

Calculating the annual collision rate as a product of the collision risk per passage and the number of passages implicitly assumes that each passage represents a unique bird. Otherwise, the occurrence of a collision should reduce the passage rate for the remainder of the year and therefore reduce the estimated number of annual collisions. Because the annual passage rates we calculate may include multiple passages by individual birds, we are, in effect, sampling with replacement and assume that the occurrence of a collision does not have any effect on the annual passage rate. This approach can be justified if the estimated number of annual collisions is significantly less than the daily passage rate. This condition, which was found to be true at the AWRA, indicates that it is unlikely that collisions will significantly impact the annual passage rate. Therefore, sampling with replacement was justified for this study.

LITERATURE CITED

Ainley, D. G., T. C. Telfer, and M. H. Reynolds. 1997. Townsend's and Newell's Shearwater (*Puffins auricularis*). *In* A. Poole and F. Gill (eds.). The birds of North America, No. 297. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC. 20 pp.

Barrios, L. & A. Rodriguez. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. Journal of Applied Ecology 41:72–81.

Chamberlain, D. E., M. R. Rehfisch, A. D. Fox, M. Desholm, and S. J. Anthony. 2006. The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. Ibis 148: 198–202.

Cooper, Brian A. 2010. Wildlife Biologist, ABR, Inc. Personal communication with Alicia Oller of Tetra Tech EC.

Cooper, B. A., and R. H. Day. 1994. Interactions of Dark-rumped Petrels and Newell's Shearwaters with utility structures on Kaua'i, Hawai'i: Results of 1993 studies. Final report prepared for Electric Power Research Institute, Palo Alto, California, by Alaska Biological Research, Inc., Fairbanks, Alaska.

Cooper, B. A. and R. H. Day. 1995. Kauai Endangered Seabird Study, Vol. 1: Interactions of Dark-rumped Petrels and Newell's Shearwaters with utility structures on Kauai, Hawaii. Electric Power Research Institute, Palo Alto, CA, Final Report No. TR-105847-V1. 170 pp.

Cooper, B. A. and R. H. Day. 1995. Unpublished data of Hawaiian Petrel and Newell's Shearwater flock size from radar and audiovisual surveys conducted on Kauai, by Alaska Biological Research, Inc., Fairbanks, Alaska.

Cooper, B. A. and R. H. Day. 1998. Summer behavior and mortality of Dark-rumped Petrels and Newell's Shearwaters at power lines on Kauai. Colonial Waterbirds 21:11-19.

Cooper, B. A. and R. H. Day. 2003. Movement of Hawaiian Petrels to inland breeding sites on Maui Island, Hawaii. Waterbirds 26:62-71.

Cooper, B.A. and R.H. Day. 2004. Results of Endangered Bird and Bat Surveys at the Proposed Kaheawa Pastures Wind Energy Facility on Maui Island, Hawaii, Fall 2004. Unpublished report prepared for Kaheawa Windpower LLC, Makawak, HI by ABR, Inc. Forest Grove, OR. 16pp.

David, Reggie. Rana Productions. 2006-2009. Personal communication by phone and email with Nathalie Denis, Erin Colclazier and Thomas Hamer of Hamer Environmental.

Day, R. H. and B. A. Cooper. 1995. Patterns of movement of Dark-rumped Petrels and Newell's Shearwaters on Kauai. Condor 97: 1011-1027.

Day, R. H. and B. A. Cooper. 2004. Estimated mortality of Hawaiian Petrels at a proposed USCG tower on Haleakala, Maui Island. Unpublished report prepared for US Coast Guard, Civil Engineering Unit, Honolulu, HI by ABR, Inc., Fairbanks, AK, and Forest Grove, OR. 17 pp.

Day, R. H., A. K. Prichard, and J. R. Rose. 2005. Migration and collision avoidance of eiders and other birds at Northstar Island, Alaska, 2001–2004. Unpublished final report prepared for BP Exploration (Alaska), Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 142 pp.

Day, R. H., B. A. Cooper, and R. J. Blaha. 2003a. Movement patterns of Hawaiian Petrels and Newell's Shearwaters on the island of Hawaii. Pacific Science 57:147-159.

Day, R. H., B. A. Cooper, and T. C. Telfer. 2003b. Decline of Newell's Shearwaters on Kauai, Hawaii. Auk 120:669-679.

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.

Desholm, M. 2006: Wind farm related mortality among avian migrants – a remote sensing study and model analysis. PhD thesis. Dept. of Wildlife Ecology and Biodiversity, NERI, and Dept. of Population Biology, University of Copenhagen. National Environmental Research Institute, Denmark. 128 pp.

Desholm, M. & Kahlert, J. 2005. Avian collision risk at an offshore wind farm. Biology Letters 1: 296-298.

Dirksen, S. E., A. L. Spaans, and J. Winden. 1998. Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. Pp. 99–108 *In* Proceedings of International Workshop on Wind Energy and Landscape, Genua, 26–27 July 1997. Balkema, Rotterdam, The Netherlands.

Dunn, J.L. and J. Alderfer. 2006. National Geographic Guide to Birds of North America; 5th Edition. National Geographic Society, Washington D.C.

Duvall, Fern. Wildlife Biologist, Division of Forestry and Wildlife (DOFAW), State of Hawaii. 2010. Personal communication with Alicia Oller of Tetra Tech EC and Joan Heredia of Sempra Global.

Elliot, D.L., C.G. Holladay, W.R. Barchet, H.P. Foote, W.F. Sandusky. 1986. Wind Energy Resource Atlas of the United States. Pacific Northwest Laboratory, Richland, Washington. Prepared for: U.S. Department of Energy.

Erickson, W. P., Johnson, G. D., and Young, D. P. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. US Forest Service General Technical Report, PSW, 191: 1029–1042.

Fox, A. D., M. Desholm, J. Kahlert, T. K. Christensen, and I. K. Petersen. 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis 148: 129–144.

Hamer Environmental. 2010. Endangered bird and bat surveys at the South Auwahi Wind Resource Area Report, Unpubl. report for Sempra Generation, Mt. Vernon, WA. 33 pp.

Hodges, C. S. N. 1994. 'Ua'u observation at proposed site for antenna farm. Unpublished memorandum by Haleakalā National Park, Makawao, HI, 2pp.

Hodges, C. S. N, and R. J. Nagata. 2001. Effects of predator control on the survival and breeding success of the endangered Hawaiian Dark-rumped Petrel. Pages 308-318 *in* J.M. Scott, S. Conant, and C. van Riper III, eds. Ecology, conservation and management of endemic Hawaiian birds: A vanishing avifauna. Stud. Avian Biol. 22.

Madders, M. 2004. Proposed Wind Farms at Ben Aketil Edinbane, a Quantitative Collision Risk Model for Golden Eagle. Unpublished NRL Report. Natural Research Ltd. Isle of Islay, UK.

Madders,M. & D.P. Whitfield. 2006. Upland raptors and the assessment of wind farm impacts. *Ibis* **148**(Suppl. 1): 43–56.

Masden, E. A., Haydon, D. T., Fox, A. D., Furness, R. W., Bullman, R., and Desholm, M. 2009. Barriers to movement: impacts of wind farms on migrating birds. ICES Journal of Marine Science, 66: 746–753.

Natividad Bailey, C. S. 2009. Seabird Inventory at Haleakala National Park, Maui, Hawai`i. Pacific Cooperative Studies Unit Technical Report 164, University of Hawai`i at Mānoa, Department of Botany, Honolulu, HI.

Olson, S.L. and H.F. James. 1982. Fossil birds from the Hawaiian Islands: Evidence for wholesale extinction by man before western contact. Science 217:633-635.

Percival, S.M. 2004. On nature conservation issues. Main Appendices. NRL5/3. *In:* Application to the Secretary of State for Trade and Industry for consent & deemed planning permission for a 78M.W. wind farm on land at Little Cheyne Court, Lydd, Kent, UK.

Planning Solutions Inc and Rana Productions. 2004. Habitat Conservation Plan: Kaua'i

Island Utility Cooperative: Data Report and Analysis: Save Our Shearwaters Program 2003 Update. Prepared for: Kaua'i Island Utility Cooperative.

Podolsky, R., D. G. Ainley, G. DeForest, and N. Nur. 1998. Mortality of Newell's Shearwaters caused by collisions with urban structures on Kauai. Colonial Waterbirds 21:20-34.

Pyle, R. L. 1983. Hawaiian Islands Region (1 June–31 July 1983). American Birds 37: 1028–1029.

Reynolds, M. H., and G. L. Richotte. 1997. Evidence of Newell's Shearwater breeding in the Puna District, Hawaii. Journal of Field Ornithology 68:26-32.

Reynolds, M. H., B. A. Cooper, and R. H. Day. 1997. Radar study of seabirds and bats on windward Hawaii. Pacific Science 51: 97-106.

Save our Shearwaters (SOS). 2007. Planning Solutions Inc. and Rana Productions, Ltd. Unpubl. Data, 2004-2007.

Sanzenbacher, P.M. and B.A. Cooper. 2009. Radar and visual studies of seabirds at the proposed KWP II wind energy facility, Maui Island, Hawaii: Use of 2008 data to model annual collision fatalities at proposed wind turbines. Final report for First Wind, Newton, MA, by ABR, Inc, Forest Grove, OR and Fairbanks, AK.

Simons, T. R. 1983. Biology and Conservation of the endangered Hawaiian dark-rumped petrel (*Pterodroma sandwichenesis*). Nat. Park Serv., CPSU, Univ. Washington, CPSU/UW83-2, Seattle.

Simons, T. R. 1984. A population model of the endangered Hawaiian Dark-rumped Petrel. Journal of Wildlife Management 48: 1065-1076.

Simons, T. R. 1985. Biology and behavior of the endangered Hawaiian Dark-rumped Petrel. Condor 87: 229-245.

Simons, T. R. and C. N. Hodges. 1998. Dark-rumped Petrel (*Pterodromapheaopygia*) *In* A. Poole and F. Gill (eds.). The Birds of North America, No. 345. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC. 24 pp.

Smallwood, K. S. and C. Thelander. 2004. Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. 500-01-019. Sacramento, California.

Smallwood, K. S. and C. Thelander. 2005. Bird mortality at the Altamont Pass Wind Resource Area, March 1998 – September 2001 Final Report. National Renewable Energy Laboratory, NREL/SR-500-36973. Golden, Colorado.

Spencer, G. 2010. First Wind Biologist, personal communication on 1-17-2010 with Erin Colclazier of Hamer Environmental via email.

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.

TetraTech EC. 2008. DRAFT Habitat Conservation Plan for the construction and operation of Lanai met towers, Lanai, Hawaii (Revised February 8, 2008, TTEC-PTLD-2008-080). Unpubl. report by Tetratech EC, Honolulu, HI for Castle and Cooke LLC, Lanai City, HI. 52 pp. + appendices.

Tucker, V.A. 1996. A mathematical model of bird collisions with wind turbine rotors. Journal of Solar Energy Engineering 118:253-262.

US Fish & Wildlife Service (USFWS). 2005a. Endangered and Threatened Wildlife and Plants. 50CFR 17:11 and 17:12 (Tuesday, November 1, 2005).

US Fish and Wildlife Service. 2005b. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Warham, J. 1990. The petrels: their ecology and breeding systems. Academic Press, Orlando, Florida.

Wood, K. R., M. Legrande, and D. Boynton. 2001. Kaua'i diverse mesic cliff and forest, Pohakuao Valley, Kaua'i, Hawai'i. Report to U.S. Fish and Wildlife Service. National Tropical Botanical Garden Technical Report.

Wood K.R. and P. Bily. 2008. Vegetation description of a nesting site for Newell's Shearwater (*Puffinus Auricularis Newelli*), Pi'ina'au Stream, East Maui, Hawai'i. 'Elepaio, Volume 68, Number 68.