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August 11, 2014

VIA EMAIL

Sina Pruder, P.E.
Chief
Wastewater Branch
Environmental Management Division
Department of Health
919 Ala Moana Blvd., Room 309
Honolulu, HI 96814

Re: Comments re Hawaii Dairy Farms' Waste Management Plan, dated July 23, 2014

Dear Ms. Pruder:

I am writing on behalf of Kawailoa Development LLP ("Kawailoa") regarding Hawai'i Dairy Farms' Waste Management Plan ("Plan"), dated July 23, 2014, for its proposed dairy farm ("Dairy") in Māhā'ulepū, Kaua'i.

Kawailoa is the owner of the Grand Hyatt Kaua'i and the Poipu Bay Golf Course. Kawailoa has a substantial interest in the Plan as both the Grand Hyatt Kaua'i and the Poipu Bay Golf Course will be directly affected by the operations of the Dairy. The project boundary of the Dairy will be less than a mile from the boundary of the Poipu Bay Golf Course and a mere mile and a half from the boundary of the Grand Hyatt Kaua'i.

A. **Overview**. This project will be of significant public interest. Not only will the project affect the over 1,000 employees at the Grand Hyatt Kaua'i and Poipu Bay Golf Course, but adverse consequences resulting from the Dairy's operations will be a concern for all who visit, live or work in the Poipu and Koloa area. The operations of the Dairy have already been acknowledged by the Dairy to be a Concentrated Animal Feeding Operation ("CAFO"), and at 2,000 cows, or even 699 cows (Hawai'i Dairy Farms' purported first phase), the Dairy will be one of the largest and most concentrated in the State. As the U.S. Environmental Protection Agency ("EPA") has stated, "The concentrations of waste from these animals increase the potential to impact air, water, and land quality." Each cow, it should be noted, "produces an average of 143 lbs. of manure per day." *See*, page 42 of the Plan. The 2,000 cows will therefore

produce a total of 286,000 lbs. of manure per day. Given such potential impacts, a careful and deliberate review of the Plan is imperative.

Kawailoa offers its comments in two parts. First, preliminary comments and observations by industry experts as to specific sections of the Plan are attached to this letter. Second, general comments relating to the processes and the overall scope of review are included in the body of this letter. We hope that the comments, both general and specific, will be helpful and will assist the Department of Health ("Department").

B. Comments by Experts. Preliminary comments of Dr. Deanne Meyer are attached.

Dr. Meyer is a Research Scientist and Cooperative Extension Specialist in the Department of Animal Science at the University of California, Davis (UC Davis). She holds a B.S. in Animal Science and an M.S. in Dairy Science from UC Davis and a Ph.D. in Animal Science from the University of Florida, Gainesville. Dr. Meyer's research analyzes production, collection, storage, transportation, and utilization of manure management waste stream(s) on livestock facilities with an emphasis on commercial dairies. She consults with both dairy operators and with agency regulators. Her CV is attached to her comments.

Because of the shortness of time to provide comments, Kawailoa expressly reserves the right to supplement the comments of Dr. Meyer. We must emphasize that the comments of Dr. Meyer are preliminary and may be supplemented. Furthermore, comments from additional experts are anticipated.

By way of background, a copy of the Plan was received on July 25, 2014.[1] Since then, there have been only ten business days for the experts to review the lengthy Plan. (Although prior versions of the Plan have existed, those prior versions have not been helpful in the review of this Plan. The prior versions have not been made publicly available except with wholesale and substantial redactions of material sections. Moreover, the Plan released on July 25, 2014 appears to be significantly revised from prior versions.)

Until Wednesday, August 6, 2014, Kawailoa did not realize that a due date of August 11, 2014 had been established for comments.[2] The experts submitting comments have worked diligently, but have been on previously scheduled travel in addition to facing the time challenges related to the scope of this review. Some experts have simply not been available and will not available for several more weeks. We intend to send the Department complete comments as soon as they are received from our experts. We request that the Department consider these comments, in their entirety.

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[1] Hawai'i Dairy Farms' project was first announced over a half year ago. The Dairy has had at least that long of a period to develop the Plan and to consider its impacts.

[2] Although Kawailoa understood that the due date for comments initially was set for Friday, August 8, 2014, State offices were closed on such date.

C. **General Comments**.

1. **Chapter 343**. This project is subject to Hawai'i Revised Statutes ("HRS") Chapter 343. HRS Chapter 343 requires that when a project proposes any "wastewater treatment unit," an environmental assessment must be prepared "at the earliest practicable time to determine whether an environmental impact statement shall be required." HRS § 343-5(a)-(b). There is no agricultural exemption applicable to the Dairy. The term "wastewater treatment unit" is defined in Hawai'i Administrative Rules ("HAR") Chapter 11-62 and does not exempt animal waste. Hawai'i Dairy Farms ("HDF") will operate a wastewater treatment facility in order to treat the cow manure generated by its milking cows.

HDF has not prepared an environmental assessment for its proposed wastewater treatment unit and its dairy farm and therefore may not proceed with its project until it does so. The Department should likewise not proceed with decision-making on a project that has not complied with Chapter 343.

2. **Storm Water Permit**. Construction of the Dairy has already commenced without a storm water permit for such construction activities. HAR § 11-55-04 requires that before beginning construction activities that disturb one or more acres of land, a person shall submit a complete National Pollutant Discharge Elimination System ("NPDES") permit application and provide notice of intent at least 180 days before construction begins. Since the construction activities have involved far in excess of one acre of property and since a storm water permit has not been obtained, all construction activities must cease immediately.

3. **Kaua'i County Board of Water Supply**. It would be appropriate that the Department exercise its discretion to require that the Dairy's wastewater system be approved in writing by the Kaua'i Board of Water Supply, pursuant to HAR § 11-62-6(k). The Kaua'i Board of Water Supply is not only suited to evaluate the impacts to Kauai's drinking water sources, but is the agency most directly interested in assuring that the drinking water sources on Kauai not be impacted by the Dairy. The entire island of Kaua'i is a critical wastewater disposal area, HAR § 11-62 Appendix E, and the dairy farm is proposing a unique, highly intensive agricultural use.

4. **Wastewater Treatment Permits**. Under a number of existing administrative rules of the Department, permits are necessary and should be required for the Dairy's wastewater treatment works. *See*, HAR § 11-62-50(a)(5), HAR § 11-62-50(b)(5), HAR § 11-62-50(d)(6) and/or HAR § 11-62-50(c).

5. **Public Meeting**. The Department has the authority to hold, and Kawailoa requests a public meeting prior to its decision regarding the Plan. HAR § 11-62-10. There are numerous reasons for a public meeting, which individually, as well as collectively, are compelling.

The primary and overarching reason for the public forum is that the dairy farm is in a location of great public importance. The Māhā'ulepū area holds such natural and cultural

significance that the National Park Service ("NPS") conducted a reconnaissance survey for potential inclusion in the national park system. *See* NPS Reconnaissance Survey, attached as Exhibit B. Impacts from the dairy to the natural and cultural resources have caused extensive public debate. It would be ironic that such a major use by the Dairy of an area that is worth preserving and protecting, so much so as to be potentially included in the National Park System, not be the subject of at least a public meeting by the Department.

The Dairy will discharge its effluent directly to waters of the United States. Māhā'ulepū valley contains "waters of the United States" as defined under the Clean Water Act ("CWA"), 33 U.S.C. § 1251 *et seq.*, and discharge into these waters is prohibited. According to the Hawai'i Clean Water Branch Water Quality Map, two streams run through the middle of Māhā'ulepū valley and discharge into the ocean. *See* Water Quality Map, attached as Exhibit C.

The NPS reconnaissance survey (Exhibit B) notes that landowner Grove Farm "operates a water system that includes wells, ditches, tunnels and reservoirs." Exhibit B at 29. Māhā'ulepū Reservoir, at the back of the valley, is part of that system. *Id.* Although Māhā'ulepū valley's streams and wetlands have been modified, their remnants remain and visibly expand during wetter periods. *Id.* The valley's water bodies provide habitat for endangered species, such as koloa and nēnē. *Id.* at 19.

The former Wai'ōpili stream—largely subsumed by the ditch system within the cultivated area at Māhā'ulepū —emerges in a more natural form near Makauwahi Cave, where it joins forces with a natural spring and Kapunakea pond. *Id.* at 29. This wetland juncture attracts waterbirds and serves as nursery habitat for native fish. *Id.* It is also linked hydrologically to the Makauwahi Cave complex, a critical habitat for endangered anthropods. *Id.*

Research and restoration have been ongoing in the Wai'ōpili stream/Kapunakea pond area since 1992. *Id.* at 30. On 15 acres leased from Grove Farm, volunteers have been restoring native grassland and riparian areas. *Id.* A statewide wetland strategy calls for continuation of these efforts, and protection of "this unique area in perpetuity through conservation easements, cooperative agreements with the landowner, and/or direct acquisition." *Id.* (quoting Pacific Coast Joint Venture, Strategic Plan for Wetland Conservation in Hawai'i (March 2005)). Whether the result of streams, wetlands or ponds, it is clear that Māhā'ulepū valley contains "waters of the United States" pursuant to 40 CFR §122.2.

State water quality data designates the two streams in Māhā'ulepū valley as Class 2. *See* Exhibit C.

> The objective of class 2 waters is to protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation. The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. <u>These</u>

> waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class. No new treated sewage discharges shall be permitted within estuaries.

HAR § 11-54-3(b)(2) (emphasis added). Underscoring the above, no new industrial discharges within estuaries are permitted, with the exception of: (1) discharges covered by an NPDES general permit in accordance with 40 CFR § 122.28 and HAR § 11-55; and (2) stormwater discharges associated with industrial activities which meet water quality criteria as specified in HAR §§ 11-54-4(a) and 11-55. *Id.*

The two streams in Māhā'ulepū valley converge and flow through a Class 1 Critical Habitat, the Māhā'ulepū Coast, before discharging into the ocean. *See* Exhibit C.

> It is the objective of class 1 waters that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character of these areas shall be protected. Waste discharge into these waters is prohibited, except as provided in section 11-54-4(e). Any conduct which results in a demonstrable increase in levels of point or nonpoint source contamination in class 1 waters is prohibited.

HAR 11-54-3(b)(1) (emphasis added).

D. Conclusion.

It is not enough for the Dairy to simply assert without more that there will be no discharge. The Māhā'ulepū area, including the ground water and nearby Class 1 waters, are pristine and irreplaceable, and any discharge will cause irreparable damage. After-the-fact remedies will be wholly lacking and unsatisfactory.

It is HDF that proposes a highly intensive use of the land. The operations and condition of the Dairy alone will directly affect both the quality and quantity of runoff water that inevitably will find its way into the streams, wetlands and ocean or seep into the groundwater table. It is therefore highly appropriate that HDF bear the burden to demonstrate in detail that there is no risk of polluting the area. HDF has not so demonstrated. Its Plan is not adequate and should be rejected by the Department.

Thank you for your attention to this matter. Please do not hesitate to contact me with any questions regarding these comments.

Sincerely,

Lisa Woods Munger

LWM

cc: Edward Bohlen, Esq.
Becky Mitschele, EPA Region 9, NPDES Permits Office
Jun Fukada, Kawailoa Development LLP

Enclosures:
Exhibit A, Expert's CV and Comments on Hawai'i Dairy Farms' Waste Management Plan
Exhibit B, National Park Service Reconnaissance Survey
Exhibit C, Hawai'i State Water Quality Map and Key

Exhibit A

Meyer, Deanne

University of California, Davis

Dr. Deanne Meyer is a Research Scientist and Cooperative Extension Specialist in the Department of Animal Science at the University of California, Davis (UC Davis). She holds a B.S. in Animal Science from UC Davis (1983) and an M.S .in Dairy Science (1986) and a Ph.D. (1989) in Animal Science from the University of Florida, Gainesville. She minored in Food and Resources Economics (M.S.) and Farming Systems and Agricultural and Extension Education (Ph.D.). Dr. Meyer's research analyzes production, collection, storage, transportation, and utilization of manure management waste stream(s) on livestock facilities with an emphasis on commercial dairies. Research has focused on nutrient flows into, through and out of dairy operations including: content of manure solids and liquids, water use, efficiency of mechanical and gravity flow separator devices, analyses of other treatment technologies, nutrient distribution during land applications, and ammonia volatilization and PM10 emissions. Based on her experiences in research and policy development related to atmospheric emissions she has served twice as panel manager for USDA NIFA Air Quality grant review process. She maintains an active collaboration with San Joaquin Air District Staff since initial development of Volatile Organic Compound (VOC) dairy cattle emission rates (2005) to assist with understanding mitigation measures for implementation by dairy operators. Dr. Meyer worked with colleagues to reformat Table D384.1 Manure Characteristics Standard for the American Society of Agricultural and Biological Engineers. These landmark modifications (2005) allowed an end user to include biological input (dietary parameters) to estimate manure and nutrient excretion and not solely rely on body weight. This was the first major revision to the Table D384.1 since its inception. Dr. Meyer has served on numerous advisory committees working with Federal, State, and Regional regulatory agencies to better understand potential for nutrients from dairy production operations to be emitted to soil, ground or surface water, or air. Dr. Meyer was a primary contributor to Livestock and Poultry subcommittee responsible for white paper for USDA NRCS Agricultural Air Quality Task Force, Recommended Units and Supporting Data for Standardized Reporting of Air Emissions from Animal Agriculture (2010) and is currently serving on US EPA Scientific Advisory Board Animal Feeding Operation Emissions Panel. Dr. Meyer maintains an active outreach program to educate dairy operators and professionals in water and air regulatory compliance requirements. Through this process she regularly interacts with stakeholders and regulatory staff to provide scientific input and better understand needs of each agency.

August 11, 2014
Dr. Deanne Meyer

Comments on Hawai‘i Dairy Farms’ Waste Management Plan

Hawai‘i Dairy Farms’ Waste Management Plan (“Plan”), dated July 23, 2014, contains incomplete and/or contradictory information. Significantly, the Plan fails to address herd size and composition, average expected milk production, potential nutrients available for land application, reasonable expectation for crop yields in the early years, stocking rate, confirmation that the settling pond will or won’t be aerated, reasonable recovery of estimated nitrogen excretion, reasonable initial frequency and protocols for manure sampling, the need to import more than 80% of nitrogen applied to pasture, the high fertilization rates compared to sugar cane production, the minimum feedback analysis to determine if nutrient applications met or exceeded crop needs and how to modify accordingly to be protective of water resources. The Plan also contains numerous inconsistencies and contradictory information, such as herd size (both number of animals and weight of cows), use of terminology (effluent, solids, manure), and that storage ponds will have next to no odor then describe odor mitigations for the storage pond. The Plan, as it currently stands, is highly problematic because insufficient information is provided to determine if nutrient management of effluent, solids and manure will be consistent with pasture needs and production and protective of water resources and how long term importation of nutrients to the facility (fertilizer and feed) will impact existing natural resources and surrounding landscape. The Plan identifies that all facilities and infrastructure presented in the application are for 2000 cows. Yet, it is unclear when the base number of 699 or 2000 cows is used. The Hawai‘i Department of Health (“Department”) should reject the Plan because it cannot properly form a decision on the Plan’s sufficiency until all of these issues are resolved. My comments on the Plan are as follows:

1. The Plan does not properly count the number of animals. The Plan cannot be approved if the number of animals is unknown.
    a. First, the Plan does not identify exactly how many animals will fall into each category: (1) dry cows (pregnant, not lactating); (2) lactating cows; (3) bulls; or (4) replacement heifers. How many total animals will be at the property?
    b. Second, there is a discrepancy between the number of milking cows and the number of mature cows. They are not interchangeable; from a regulatory perspective, mature cows consist of all cows that have calved at least once.
    c. Third, the Plan also fails to describe consistently how many cows will be in a mob. This will determine how many mobs are present and how much time is needed to get each mob to and from the milking parlor twice each day. If there are too many mobs the animals will not be able to be milking even if capacity is present in the parlor. It may take up to 30 minutes per mob for animals to commute to or from the milking parlor for the distant mobs.

    It is unclear if the dairy will have 699 milking cows, or 699 milking and dry cows. Unless seasonal calving occurs, approximately 85% of cows are lactating and 15% are dry (pregnant and not lactating). Anticipated number and age of support stock (day old calves through first calving) must be defined. Animals are responsible for excreting

manure and associated nutrients that must be accounted for/included in the Plan as well as generating process water from the milking parlor or calf shed.

2. The Plan fails to identify the estimated milk production and nutrient loading per day from one cow or from the anticipated number of animals. This is important because milk production drives feed intake. Nutrients consumed in feed that are not incorporated into milk, body growth (during the first and second lactations) or the growing fetus (when cows are pregnant) will be excreted. These excreted nutrients will be the basis for the nutrients excreted by lactating cows that must be accounted for/included in the Plan.

3. The Plan fails to address the stocking rate. This is critical information because the ratio of animals per unit surface area will impact soil compaction and therefore impact water infiltration rate and water runoff. Additionally, stocking rate should be determined based on forage productivity and quality. Estimated yields and forage composition should be used to determine stocking rate. The historic use of the land indicates soils are of low fertility and maximum or average forage production should not be planned for during the early stages of use. Recommendations for nitrogen fertilization on sandy soils growing sugarcane are near 180 pounds. The plant biomass grown will be much greater in this project with suggested nitrogen fertilization rates above 700 lbs per acre (requiring large importation of nitrogen into the watershed).

4. The Plan does not address what happens to the daily wash water used to wash down the feed area of the calf shed. This water and associated nutrients must be accounted for in pond storage and effluent irrigation uses.

5. The Plan does not address what happens to calves once they leave the calf shed. This is significant because once calves are moved to open paddocks, those paddocks are not available for grazing for the milk herd. The excrement from calves must be accounted for in nutrient management calculations.

6. The Plan does not identify a maximum distance for cattle walking in a day. It indicates that a mob will graze in an individual paddock for a day. For the outlying paddocks this is considerable distance to walk to and from twice a day. Additionally, many of the perimeter paddocks have greater slope which will require more energy for animals to graze. This is significant because the greater walking distance and slope will affect the efficiency of energy utilization by animals in a mob.

7. The Plan does not provide information on the water holding capacity of various soils. This information is required in order to properly evaluate the Plan because water holding capacity of soil and soil porosity impact how fast water will infiltrate through the soil profile to the underlying water table. Irrigation or rainfall on porous soil will result in water leaching through the soil profile (moving from the surface of the soil through the soil). The moving front of leaching water will carry nitrate nitrogen (nitrate does not stick to soil particles) with it. This nitrogen will ultimately reach groundwater if it is not denitrified by microbial processes during transit.

8. The Plan does not give a description (slope) for the "Ke" Kalihi soil type. Steeper slopes require more energy for animals to graze. Steeper slopes will likely have increased runoff during intense rain events.

9. The animal cemetery is located in soil with 6 to 12% slope. Run-on will need to be diverted to not inundate the cemetery and result in leaching to groundwater. A riverine is adjacent to the paddock with the cemetery. Management of the riverine to be sure it doesn't flow onto the cemetery is important. Physically digging the defined trenches for mortality may be challenging in sloping soils. Managing rainfall will be critical to minimize ponding of rain water and prevent deep percolation.

10. According to the Plan, the perimeter of the property has greater slopes. This is problematic because runoff will likely be greater from these areas and the runoff will be directed through other paddocks. Intense rain events resulting in runoff that goes through the paddocks will collect freshly excreted feces and relocate it. Manure will likely be discharged with runoff off-site. The Plan does not address where this runoff will flow. However, according to the Department of Health, Clean Water Branch's water quality map, there is a ditch that flows next to the taro farm, which connects to a water body that flows directly to the ocean.

11. The Figure 9 farm map legend does not provide definitions for the following: truck turn around, cow walkways/races, concrete holding yards and gravel farm races, calf sheds, effluent and sludge pumps and distribution system, irrigation water storage and distribution system, potable well and transmission main to milking parlor, potable water tank for milking parlor and livestock consumption, livestock water distribution system, feed silos or individual wastewater system. In particular, the dairy calf shed is going to be problematic because there is wash water generated from daily cleaning of the feeding area and this does not appear to be accounted for in pond design calculations. Also, there is no discussion on how the bedding area of the calf shed will be cleaned and sanitized between animals. Additionally, it is not clear if two sheds would be sufficient space for the maximum build out of 2000 cows.

12. In-parlor feeding by definition will result in dust presence and accumulation. In-parlor or supplemental feeding is done to provide needed nutrients that are not provided by pasture consumption. Accumulated dust feed particles will provide substrate for flies and require labor and water to remove. Fly management is important to minimize nuisance issues for employees and minimize health issues for cows. Perhaps use of water to remove dust is accounted for in the 30,000 gallons a day identified as dairy facility water (primarily for wash water). However, only 10,667 gallons of process water from machine wash, yard wash, and water usage appear to be in the calculation for the settling and storage pond system.

13. The amount of time devoted to milking cannot be determined as described. If only one mob is in the holding area/parlor at a time, there must be considerable down time as described between mobs for one mob to return and another mob to come up to be milked. Paddock rotation must be known to determine if all mobs will be milked successfully.

The long transit times may translate to more manure deposited on cow runs (where no plants are growing) versus in pasture (where nutrients may be used by growing plants).

14. The information given regarding the potable water systems is incomplete because it is not clear if the potable water is used as drinking water for all the animals on the farm, including the non-milking cows and replacement animals. This is significant because potable water must be available daily for all animals and to clean milk harvesting equipment. The water use budget must be calculated with all categories and number of animals considered.

15. The discussion on irrigation setbacks is incomplete because it does not address such significant issues as whether the GPS will correct for wind speeds and directions during irrigations. This information is required to properly evaluate the Plan because during irrigation, with effluent, if no correction is made for wind speed and direction, drift of applied water a conduit to US Waters or directly to US Waters could occur and is not legal. Drift is the unintentional off-target application due in this case to wind movement.

16. The Plan's effluent pond calculations are highly problematic and contradictory because it indicates the dairy facility including the wastewater treatment ponds and other infrastructure will be sized and constructed for the Phase 2 capacity of 2,000 cows. However, the calculations in this report are based on the Phase 1 capacity of 699 cows. The facility cannot be sized for 2000 cows if the calculations are based on 699 cows. Is the 2000 number referring to all the cows on the farm or just milking cows?

17. The values given for the total wastewater volume and potable water demand for the dairy facility are inconsistent because the total wastewater volume for 699 cows from the machine wash, yard wash, and other milking activity is 10,667 gallons per day ("gpd") plus other farm uses. See Figure 18, Water Flow Schematic. This value does not agree with "Total potable water demand for the dairy facility (primarily for wash water) is approximately 0.03 millions of gallons per day (MGD)." Located on page 25, Paragraph 1. If other farm uses are an additional 20,000 gpd of water they should be used in the calculations. Figure 18 identifies there are other farm uses and only indicated the estimated volume of water and estimated manure generated during milking to in the flow schematic. Further clarification regarding all material entering the settling or effluent ponds is necessary in order to adequately determine if pond size is sufficient for holding and required storage for storm events.

18. The description of the settling pond is problematic because the intent of a settling pond is to settle larger and/or denser particles. Yet, the description includes use of a stirrer to break up the solids. The larger sized particles are retained in the settled solids, along with some smaller trapped particles. However, solids (what remains after moisture is removed; solubles and very fine suspended solids, as well as other solids) will transfer to the storage pond.

19. The description of the secondary containment area for overflow from the storage pond is problematic because by definition it would allow dumping or emptying of the storage

pond to land without implementing the nutrient budget. This dumping of waste into an area that will likely not support crop growth is against the intent of the EPA's CAFO Rule. The Plan fails to describe how the water will be managed if the secondary containment area is utilized. Additionally, the Plan fails to address whether a portable pump will be used after an extreme rain event to relocate water back to the storage pond. If not, the Plan needs to address how the material will be handled in order to prevent leaching or runoff of nutrients. A contingency plan is needed so if the secondary containment area is utilized environmental impact will be minimized. The secondary containment would need to hold the discharged material, rainfall, and be managed to withstand intense weather conditions for an unknown duration. It would likely have to have freeboard similar to the storage pond.

20. The Plan fails to address how weeds and plant material will be managed around the fence that surrounds the settling and effluent storage ponds. Weed management is critical to maintain structural integrity of ponds and minimize windblown weed seeds from entering the effluent and subsequently be applied to paddocks during irrigations. As weeds die, they may become debris on the surface of the pond and interfere with pump function.

21. The Plan inadequately discusses how the farm's structures will ensure human and livestock safety. Many manure storage ponds/structures are deemed confined spaces and must meet appropriate safety requirements to fulfill OSHA. The description of the pond lining is highly problematic because there is nothing to assure joint integrity. The Plan fails to address the expected life of the lining. The expected life of storage ponds is 20 years, as identified in the operation and maintenance worksheet on page 94. Maintaining joint integrity is essential to keep the pond from leaking into underlying area. More information must be provided in the Plan before decisions can be made on this application.

22. The Plan's description on pond sealing, lining and flexible membrane is incomplete because there is no concise discussion regarding prevention of whaling. In soils prone to gaseous release whaling can occur. This is when the liner traps gas between the soil and the liner. The liner inflates (stretches out of shape) and displaces capacity for storage. Releasing the gas without puncturing the liner is a challenge. Even if gas is removed the liner will not return to its proper location, since it is stretched. In other instances, when liners aren't installed properly they can slough resulting in the liner sagging into the structure (pulling away from the anchor). Any reconfiguration of the liner shape will make pond clean-out difficult.

23. The Plan fails to include calculations to identify how much irrigation land will be reduced when setbacks are taken into account. That is, calculations should be provided to identify how many acres will not be irrigated as a result of the various setbacks in each of the irrigation units. The 378 acres at the farm is equal to 7 areas*54 acres/area. The calculation to identify reduction of irrigation land by setback acreage needs to be shown. Summary information is provided in Table 6. Paddocks are identified in Table 7 (page 18). They add up to 517.29 acres. Table 9 identifies 378 acres are irrigated through pivot

systems; 82 acres irrigated through drip; 57 acres not irrigated (perimeter lands with greater slopes; beyond the reach of the pivot and not uniformly shaped).

a. In addition, Table 6 currently lists total non-irrigated land within the irrigation area. It appears that this number was subtracted from the size of the area. The final value was divided by 7 sections, resulting in 54 acres each. The amount of water and fertilizer needed by each area is a function of the area size. If one area is larger or smaller than another nutrient and water applications must be modified appropriately.

24. The Plan fails to properly prepare for upcoming storm events. EPA will not condone emptying ponds due to upcoming storm events. If material is emptied on land, there will be a higher probability of effluent contaminated runoff. The CAFO Rule does not acknowledge cataclysmic storm events. Were a 25-yr, 24-hr storm event to hit, the only legal discharge for NPDES permit holders is the water collected beyond the 25-yr 24-hr storm event rainfall. 10.4 inches is the estimated storm event. Clearly, given the topography, animals will need to be moved to higher ground and anything in the way at lower elevations may not exist after the storm event.

25. The Plan does not include an adequate description of the laboratory that will provide soil fertility recommendations to support the farm's nutrient applications. In particular, the Plan fails to provide the types of certifications performed at the laboratory. This is problematic because analytic methods used for various types of waste streams may or may not be sufficient for dairy manure slurry or effluent or plant tissue testing.

26. The Plan fails to adequately ensure that the recommended nutrient application rates are protective of ground and surface water resources. Comparing planned nutrient applications to a Standard does not insure anything. In addition, it is not clear why there is a reference to the Standard for purposes of Phosphorus indexing. The phosphorus index is an index value that identifies if there are sufficient or insufficient amounts of phosphorus in soil (is it ok to apply phosphorus—yes or no; not how much phosphorus should be applied). This is inconsistent because having a Plan and implementing the Plan are two separate concepts. It is important to have a feedback mechanism to evaluate if the targets of the Plan were achieved and if they were not, what modification(s) need to occur and what potential environmental ramifications may occur as a result of the Plan.

27. The Plan contains unrealistic yield expectations certainly for the early years of implementation. The Plan thus cannot be properly evaluated because Plan evaluation relies on reasonable estimates of yield expectations (how much nutrient is removed) and that allows the application of nutrients based on removal rates. If, as the Plan states, the historical uses of the farm have left the soils depleted of the essential nutrients required for crop growth, it is highly unlikely that such poor soil will begin Kikuyu production at 20 ton of dry matter per year. Reasonable estimates of yield must be used. For every ton of dry matter at 22% crude protein (crude protein is approximately 6.25% nitrogen) an additional 70.4 pounds of nitrogen is removed per acre [2,000 lbs x 22 lbs crude protein per 100 lbs of dry matter x 6.25 lbs nitrogen/ 100 lbs of Crude Protein]. This extra removal justifies the application of more nitrogen to the field. There is **no** compelling

evidence in the document to believe 20 tons of dry matter would be reasonable early on, even with heavy fertilization rates. This is especially true for the perimeter paddocks that are not irrigated as well as Block F that is subject to flooding. As identified previously, it is imperative to have reasonable yield goals. When excess nitrogen is applied to land it may be emitted as ammonium (atmospheric), or the organic form may be allowed to mineralize to ammonium. Ammonium may adsorb to negatively charged soil particles or if conditions are favorable, it may be nitrified to nitrate, a very mobile form of nitrogen. It is important to maintain reasonable yield goals. To begin with a 20 dry ton/acre yield goal is unusual given the stated poor quality of the soil. When nitrogen is applied to meet higher yield expectations and these yields are not achieved the excess nitrogen is likely lost to the environment. The difference of applying nitrogen for a yield that doesn't occur, results in potentially huge imports of nitrogen fertilizer that will be lost to the environment. Ammonium volatilized into the atmosphere will be deposited to earth downwind (on soil or surface water). This increases the amount of nitrogen quantity in the landscape. Significant amount of greenhouse gases are released during the production of fertilizer.

28. The Plan is misleading and contains many inconsistencies which make it impossible for the Department to thoroughly evaluate it.
    a. For example, the inconsistency in use of effluent and sludge adds considerable and unnecessary confusion. Effluent as described is only the material leaving the storage pond (second stage pond) for irrigation purposes. Sludge refers to material from within the settling pond. Manure is the excrement from cattle (feces and urine).
    b. Another example is found in Section 8, Nutrient Management with subsection 8.2 Pasture-Based Dairy. The following is on page 57 in paragraph 3: *The effluent is highly diluted, to the extent that it will have next to no odor in the storage pond and certainly no odor at the farm boundary. The settling pond will also be aerated to help mitigate odor. To help further mitigate any odors arising from the facility a Windbreak/Shelterbelt (i.e. a multiple row planting of trees) will be established along the prevailing wind pattern of the pond. This design will follow the guidance of NRCS Conservation Plan Standard 380 Windbreak/Shelterbelt Establishment.* These sentences do not belong under a heading of Nutrient Management. Having 1% solids concentration in a storage pond does not guarantee no odor. This is the first mention that the settling pond will be aerated. There is no further discussion of aeration, aside from it occurring in NRCS Standard. Neither Figure 21 nor 22 have any indication of aeration mechanism. There is no mention in Section 7.2 Effluent Ponds about aeration. Figure 17 "Dairy Facility Site Plan" has no indication of windbreak/shelterbelt location. There is virtually no space west of the settling pond for a shelterbelt. This information should be under an independent heading of odor management in Section 7.2. If aeration is going to be used, more detailed information is needed to determine if it will be sufficient. Keep in mind that depending on the type of aeration technique used, ammonia may be volatilized to the atmosphere (with subsequent return to ground uncontrolled). This may not be desirable of it returns into a pristine waterway where very small concentrations of added ammonium may make an impact on aquatic habitat.

c. Another example is on Page 59. The Plan states: *As the cattle excrete on the Kikuyu thatch, it is incorporated into what is effectively an organic net. Due to the high moisture and moderate temperatures, the microbial activity in the thatch is very high and the effluent will be largely broken down by microbial activity within 24 hours. The effluent is less than 20% of the daily nutrient needs, and therefore readily absorbed in Kikuyu.* Fecal matter (organic nitrogen) will likely remain on the plant or thatch until sufficient rainfall or irrigation water washes it to the ground. Organic nitrogen will not be readily absorbed in Kikuyu. The ammonium fraction of the waste stream may be adsorbed into the plant. Organic nitrogen has a much slower release (mineralization) time and although it may not be readily available for plant growth, if discharged off site it may have import on mineralization near aquatic species (ammonium toxicity).
d. Generalities lacking specific detail provide no insight to farm oversight and management. Page 59 states: *Site specific soil moisture will be monitored, in real time, to ensure irrigation water, liquid effluent and cattle are not applied to soils when conditions are suboptimal.* Cattle are not applied to soil. They are given access to a paddock. No definition is provided for suboptimal. What happens if cattle were supposed to go onto a paddock that has suboptimal conditions? Where should the cattle go (need a contingency plan). What happens to the quality of the pasture that isn't consumed? What criteria will be used to identify when suboptimal conditions no longer exist?
e. In Table 9, the drip irrigation area is 82 acres. However, in Figure 23 Nutrient Management Map Block H, the drip irrigation area is 81 acres.
f. Another inconsistency relates to body size of the cows. Page 42 identifies that *the kiwi-cross cow's weight is about 1,210 lbs.* Page 90 under 8.10.1 Nutritional Requirements states: *The nutritional requirements are based on an approximately 1,000 lb animal producing 5.3 gal of milk per day.* The amount of potable water required for 699 livestock animals is 20,000 gallons per day. It's not clear how many animals drink this water or their stage of production. Hence, it's not possible to estimate milk production by using average water intake. Closely identifying body weight and milk production are critical. Milk production and body weight drive feed intake, and therefore quantity of manure excreted daily as well as total quantity of nutrients excreted daily.
g. Another example is the amount of dry matter consumed from pasture per day. A mob of animals (105 to 150 cows when there are 699 cows in residence; 300 when there are 2000 cows) will graze one paddock in one day. According to the Plan, the paddock size ranges from 4 to 5 acres. If 115 cows graze a 5 acre paddock the amount of space available for 1 cow to graze is 5 ac/paddock ÷ 115 cows/paddock=.04 ac/cow. At a yield expectation of 20 tons of dry matter per acre per year this amounts to .04 ac/cow x 20 tons dry matter/ac/yr x 2000 lbs/ton ÷ 365 days/year = 4.4 lbs dry matter per cow per day. Page 90 identified the Kikuyu intake as 14 kg dry matter a day (14 kg x 2.2 lbs/kg=30.8 lbs dry matter per day). According to the Plan, cows will consume pasture from .04 acres and consume far less than recommended nutrient requirements identified as 30.8 lbs dry matter per day.

h. According to calculations on page 82, the Kikuyu growth rate of 120.5 lbs dry matter/ac/day x 365 days a year is an annual yield of 22 tons (not the previously defined 20 tons). Protein listed here is 22 to 23%. This is inconsistent with 20% identified on page 90. The assumption is that one only applies the nitrogen needed by the plant for growth. This is not the standard method for making fertilizer recommendations. Nitrogen is a leaky system. For many fertilizer applications more than 100% of the nitrogen needed by the plant is applied. The 'leaky' part of nitrogen is unmanaged and unaccounted for and may enter the environment as N2 gas, nitrate (leached), ammonia (atmospheric emissions), or other forms of nitrogen.

i. The tables on pages 85 to 86 representing phosphorus and potassium appear to be in the elemental form not at P2O5 or K2O. This is inconsistent with tables on pages 72 and 73. One standard method of discussion should be used. Likely this would be the elemental forms as the analysis for phosphorous and potassium excretion will yield elemental forms.

j. The manure analysis on page 88 demonstrates the inconsistent use of nomenclature. As discussed previously, manure is the feces and urine as excreted. Yet, the material may include other wastes. Manure in the general sense may include bedding and is referred to as solid manure. Manure diluted with water is referred to as liquid manure. In this document the term effluent (indicating material from the storage pond) is used. The term "solids" is used for the pumpable material removed from the settling pond. Use of definitions in ASAE Standard S292.5 Uniform Terminology for Rural Waste Management should help reduce confusion in terminology used in the Plan.

29. The Plan fails to account for nitrogen ("N"). This is unacceptable because N lost to the environments in undesirable forms may result in environmental impact. According to the Plan, the total N applied from animals is 81,224.8 (40.6 tons). Assuming this comes from 699 milking cows the value is low. If any manure from any other age group is allegedly in the liquid effluent, sludge or excreted on pasture, the recovered value is extremely low. Logically, one would compare application values to potential excretion values to ground truth the applied values. Information in "8.10.1 Nutritional requirements" was used to estimate excretion. The protein daily requirement of 18% for 5.3 gallons of milk is very high. The US National Research Council Nutrient Requirements for Dairy Cattle recommends concentrations closer to 14 or 15% for the given average daily milk production. At 18% protein concentration 3240 g of protein are identified as required. Divide this number by 6.25 (composition of N in crude protein) to estimate 518 g of N intake per day. N in milk is estimated 5.3 gal x 8.6 lb/gal x 3.2% protein /6.25 *454 = 106 g of N in milk per day**.** Intake – product is a rough estimate of excretion. 518-106= 412 grams per head per day (g/hd/day) excreted. Estimated N excretion rate for the herd is 412 g/hd/d x 365 d/yr x 699 hd ÷ 1000 g/kg x 2.2 lb / kg ÷ 2000 lbs/ton = 115.6 tons of N excreted/yr (for 699 cows; 330.8 tons of N excreted/year for 2000 cows). **Only 35.1% of the estimated excreted N is accounted for in the nutrient mass balance (unnumbered table on page 73).** This is quite low for a pasture based system. Biological processes involved in the N cycle make it unlikely that recovery of 100% of excreted N occur on an animal operation. In a pasture based facility, one expects much of the N to be land applied by animals as very small losses of N occur between defecation

or urination by the animal and contact of feces or urine on the soil surface. Much more than one-half of the excreted N would be land applied directly. There are calves in the calf shed and it is unknown if/where replacement heifers and bulls reside. The numerator of applied nutrients would not change. However, the denominator of how much N was excreted would change. Therefore recovery, already low, would actually be lower. Unaccounted for N is escaping into the environment in an unmanaged fashion. According to the Table on page 73 only 20.8% of the N needs of the crop will come from manure. Therefore 79.2% will come from commercial fertilizer. **A minimum of 154 tons of fertilizer will be imported into the watershed. More is likely imported as nitrogen application is seldom equal to nitrogen removal given the leaky nature of the N cycle.**

a. An alternative method to estimate excretion is by use of the American Society of Agricultural and Biological Engineers Standard D384.2. Data from cattle in the US fed within 113% of daily requirements were used to develop regression equations to estimate manure and nutrient excretion. Equation 16 is one method to estimate nitrogen excretion: Nitrogen excreted (g)/hd/d= (milk (kg) x 4.204) +283.300. For this example, 20.7 kg (calculated as 5.3 gal/hd/d x 8.6 lb/gal ÷ 2.2 lbs/kg) x 4.204) +283.3 = **374 g/hd/day.** This 374 g/hd/day value is less than the 412 g/hd/day value because the equation is based off results from diets that were formulated closer to recommended concentrations**. The difference of 38 g/hd/day over 699 or 2000 animals in one year 10.6 to 30.5 tons per year of additional estimated nitrogen excreted.** The fate of this extra nitrogen excreted in the environment is unknown.
b. In addition, an analysis of the effluent needs to be done to determine if the nitrogen form can be absorbed by the plant leaves. Organic N will not absorb into the plant (the fraction responsible for the coloration of the effluent). Ammonium may absorb into the plant. It is likely that organic nitrogen (manure solids) that sticks to plant tissue will be washed off during a rain event or subsequent irrigation event.

30. The discussion of Block F (paddocks 215 to 226) is inadequate. The short and long term ability to apply nutrients to this block and mob graze is questionable given its predisposition to flooding (and subsequent movement of nutrients off site). This will include excretion by cattle, unless they cease grazing on these paddocks.

31. The Plan cannot be evaluated where it is missing vital information in its data presentation. On page 73 of the Plan, the column heading units for N, P2O5, and K2O of applied/ac/yr are misleading. The units appear to be pounds per acre per year or total pounds per acre (for the subtotal rows).
    a. Neither the Table nor the Figure on pages 74 through 76 has titles. Additionally there are no units in the table or the figure on pages 74 and 75.
    b. Table 15 needs to identify that the letters represent Blocks. The table in the middle of the page needs a number and title. It contradicts the information presented in the table that precedes it.
    c. The values in the table on page 84 need to be defined.

32. The discussion of the effluent application schedule in light of rain is inadequate because if 5 application events are delivered to one block at one application event, then the quantity of nutrients delivered will be 400% of a normal irrigation. What changes will occur in subsequent nutrient applications? If this occurs, then subsequent application events of effluent or fertilizer need to be modified to some extent.

33. The manure sampling frequency is insufficient for initial analyses for year round applications. Initial sampling for a facility with no data should be far more frequent than annually to determine the variability in nutrient concentration. If samples come back consistent then an annual sample is appropriate. If variability is present (most likely) then more frequent sampling is needed and data should be incorporated into nutrient management.

34. In addition, the Plan cannot be approved when the sampling procedures are inadequate. The Operations and Management Worksheet for Manure Sampling Protocol represents what was presented in the Plan and is insufficient to obtain representative samples and incomplete in that it does not define analytes for analyses. Regarding liquid effluent manure sampling, taking multiple grab samples from an existing storage structure may or may not represent the actual material applied during land application. If material is agitated prior to application then the sample should be taken while agitation is occurring. Taking grab samples from the same depth serves no purpose as they are composited. However, if the grab sample is taken with a dipper tool, the contents of any sample container may or may not represent the actual material going to the field. When a dipper is inserted below the water surface and material fills the container, retrieval of the dipper from the water may displace contents (leaving behind more dense particles). This is not a recommended sampling method and may not yield a representative sample. The term sub-sample should be replaced with grab sample. Multiple grab samples may be composited. A sub-sample of that may be extracted. It is unclear why grab samples will be mixed and what analysis will be conducted in the field under swirling conditions. Analytical needs should be identified.
    a. Regarding “solid” (sludge) manure sampling, the material in the settling pond does not dewater. This material does not have characteristics of solid manure (it will not stack). It will behave as a liquid or a slurry. The method of sampling should be consistent with effluent sampling. The sampling protocol described in the Plan is inconsistent with the Effluent sludge management Operation and Maintenance Worksheet that suggests individuals go on a boat onto the pond to retrieve sludge samples. Freezer bags are not unbreakable and should not be used for something that has high moisture. Analytical needs should be identified.

35. The Plan’s description of feed management is inadequate because it relies on very high intake of dry matter from pasture, long walking distances (when in distant paddocks), and high protein composition. There is no question that regular analysis of feeds is valuable to incorporate into diet formulation when feeds with high variability are used. However, in a pasture based system it is unclear what reformulation will occur. More grain can be provided to a point to increase energy content of the diet. Nutrient composition of pasture will not be modified when only one species of forage is intended to be grown.

The animals will eat what is present. The primary way to modify intake of nutrients is to reduce time exposed to pasture. However, as currently defined, it appears that the cows will have insufficient intake of pasture [the identified 30.8 lbs of dry matter intake daily is well above calculated dry matter intake given the number of animals in a mob, average acres per paddock, and the annual dry matter yield per acre]. If the nutrient ratios of the pasture are not what is needed for the animals (excess nutrients provided) the animals will excrete more nutrients than desired. If the pasture nutrient content is deficient then potentially mineral supplement may be provided to animals.

36. The Animal Mortality Management Plan (in appendices) should include an estimate of normal mortality (percent of herd per month) and episodic mortality (in case of disease outbreak). The worksheet has some unusual language: "The burial pit will be a minimum of 2 feet wide with length necessary to accomplish mortality." It is unclear what is being accomplished. How many animals can be accommodated in 4,400 ft sq area? If a pit is only2' wide and 3' separation is needed between pits, a double line of pits with a single 3' separation would be 628' long if only 4,400 ft sq of land is used for the cemetery. How long will it take to fill the cemetery to capacity? What is the burial plan after the cemetery is filled? How many animals can be accommodated in this area? Is a separation required between carcasses? What happens when catastrophic losses occur (during flood, hurricane, disease outbreak, bad feed)? The cemetery is proposed in an area of greater slope than many of the paddocks. Extreme care will need to occur to divert runoff from the neighboring landscape around the cemetery (so it doesn't run-on to the area of the cemetery) and minimize infiltration in the area of the cemetery. How accessible will this area be given the frequency of rainfall? What contingency plans will be in place to handle mortality during wet, rainy conditions, when it may not be possible to excavate and bury animals?

Conclusion

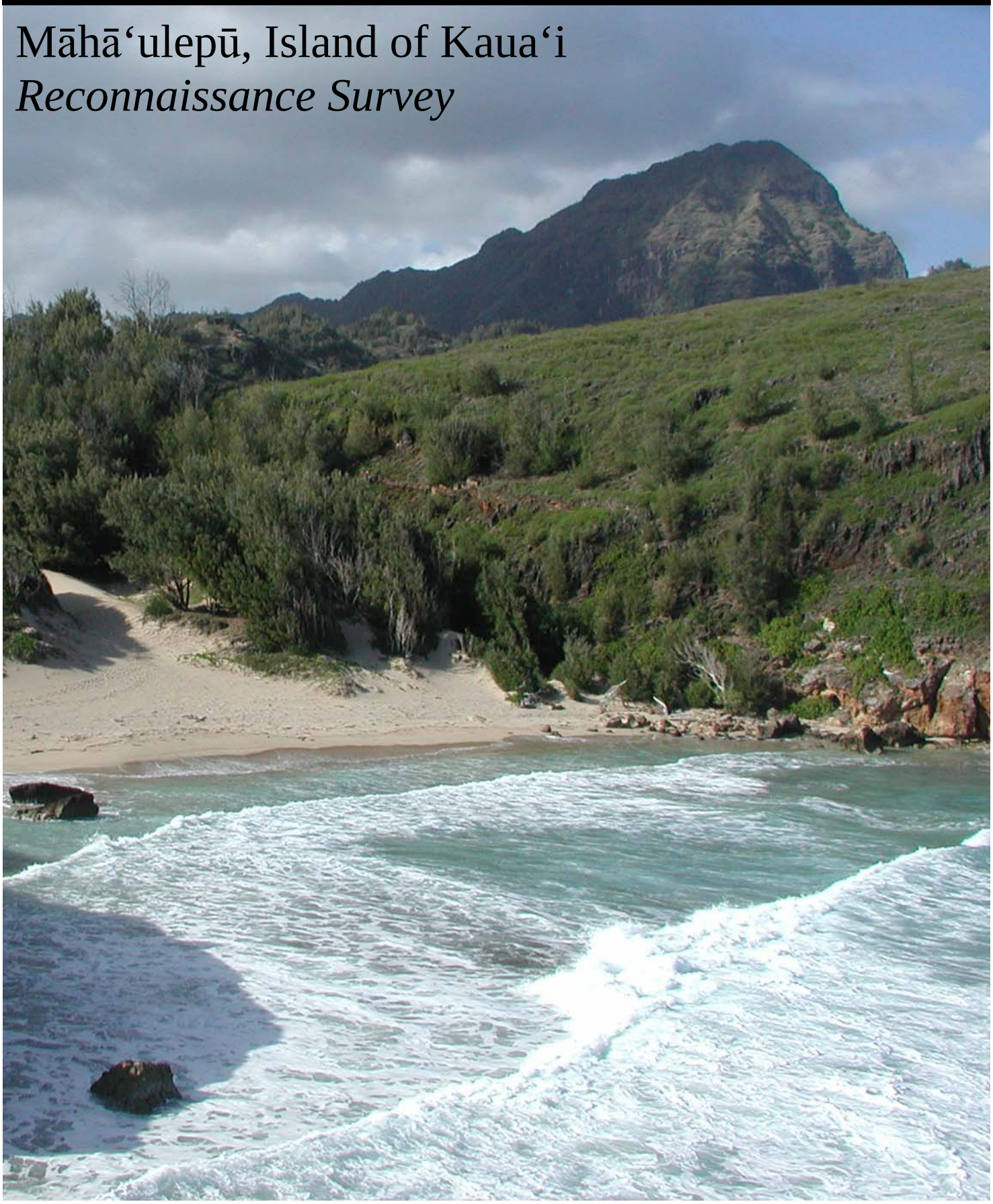
The Plan, as it currently stands, cannot be approved by the Department because it is incomplete and inconsistent, and lacks necessary nutrient and water accumulation calculations to determine if it is appropriate. It is in my professional opinion that such vital components are lacking in sufficiency and specificity to determine if adequate waste and nutrient management may occur. At a minimum these include: actual animal population (including weight of each population category, average daily milk production, estimated excretions, estimates of mortality by population category), process waters contributing to the waste stream (from calf sheds, milking parlor, and any other location), consistent use of terminology, proposed nutrient budgets for paddocks of differing slopes and field conditions (with and without irrigation; with flooding), explanation for unreasonably low recovery of nitrogen from manure, detailed management of settling pond (aerated?, stirred daily even if not pumped?), potential impact to the watershed of markedly higher fertilization requirements for Kikuyu compared to the previous crop (sugarcane) and a check and balance system in place to evaluate nutrient applications and removals and modify as needed.

Exhibit B

National Park Service
U.S. Department of the Interior

Pacific West Region, Honolulu Office
February 2008

Māhāʻulepū, Island of Kauaʻi
Reconnaissance Survey



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1 SUMMARY

At the request of Senator Daniel K. Inouye, in 2006 the National Park Service agreed to conduct a reconnaissance survey of Māhāʻulepū and nearby areas on the island of Kauaʻi, the oldest major inhabited island in the state of Hawaiʻi.

Māhāʻulepū is an ahupuaʻa (historic Hawaiian land division) and watershed running from the Hāʻupu mountain range to the shoreline on Kauaʻi's southeast coast. It sits at the heart of a larger undeveloped 9-mile coastal span that separates the county seat of Līhuʻe from the resort town of Poʻipū. Natural and cultural resources in this area provide respite and recreation for residents and visitors, and are the focus of this study.

Resources of particular interest in this locale include the undeveloped shoreline corridor from Makawehi northeastward through Māhāʻulepū and Kīpū Kai to Nāwiliwili Bay; the Hulēʻia National Wildlife Refuge and historic Alekoko Fishpond along Hulēʻia Stream; and parts of the Hāʻupu mountain range overlooking these areas. These natural and cultural assets are mostly privately owned, and are mostly designated as conservation district by the state of Hawaiʻi. They exist within a broader landscape of vast, private agricultural lands currently used for farming and ranching.

In accord with established NPS planning criteria, this report examines these natural and cultural resources to provide a preliminary evaluation of their significance, and a preliminary evaluation of the suitability and feasibility of helping to protect them within the framework of the national park system. These evaluations are based on limited site visits, research and consultations conducted by staff of the NPS Pacific West Region Honolulu Office in 2007, and are neither final nor definitive. They serve as background material for Senator Inouye as he considers whether to seek Congressional authorization for a full-fledged study of resource protection alternatives for Māhāʻulepū and surrounding areas.

This reconnaissance survey report provides the following preliminary evaluations of the study area:

- The study area shoreline corridor, Hāʻupu mountain range and Hulēʻia Stream are deemed nationally significant on the basis of natural and cultural resources including geologic landforms, rare species and habitats, and features central to stories of native Hawaiian and United States history. Collectively these areas comprise a relatively unspoiled and increasingly threatened coastal landscape that provides unique opportunities for public enjoyment, interpretation and scientific study.
- Resources in these areas represent themes and types suitable for protection within the framework of the national park system, and not otherwise adequately protected in the state or nation. Volcanic features of the study area represent a stage and range of geologic development of the Hawaiian high islands that is not featured at other Hawaiʻi parks. Landforms and fossils of the Māhāʻulepū coast illustrate the reality of global climate and sea level change, as well as the impacts of human settlement on native ecosystems. An extensive and undeveloped Hawaiʻi shoreline within easy reach of population centers, such as that found in the study area, is a rare and rapidly vanishing

type of recreational resource prized by U.S. citizens and international visitors as well as Hawai‘i residents. Protection and management of this resource type is currently inadequate at federal, state and local levels.

- The study area’s significant natural and cultural resources are of a collective size and configuration to be feasibly managed for resource protection and public enjoyment at reasonable cost, provided that NPS, affected landowners, and interested state and local entities work in ongoing partnership to identify and reduce resource threats, manage access, and ensure long-term protection of the area’s overall scenic quality.

Based on these preliminary evaluations, the National Park Service Pacific West Region recommends that a Special Resource Study be authorized under the stipulations of Public Law 105-391, so long as it focuses on non-traditional management alternatives that a) involve local partners and b) include options for continued farm and ranch operations on private agricultural lands.

2 BACKGROUND OF THE STUDY

In 2006, Senator Daniel K. Inouye asked the National Park Service (NPS) to conduct a reconnaissance survey on the Hawaiian island of Kauaʻi, in order to provide a preliminary evaluation of the resources of Māhāʻulepū and surrounding areas for potential inclusion in the national park system. NPS agreed to conduct the study in the next fiscal year, and began its work in February 2007.

A team of NPS staff conducted a field visit to the study area March 19-21, 2007. The team included Frank Hayes, Pacific Area Director; Keith Dunbar, Chief of Planning for the Pacific West Region; Dr. Larry Basch, Marine Biologist/Science Advisor; Darcy Hu, Ecologist; and Helen Felsing, Planner.

The visit included guided tours of the Makawehi-Pāʻā dunes trail, Māhāʻulepū shoreline, Māhāʻulepū Valley, Makauwahi Cave Reserve, and Kīpū Kai, plus a brief stop at Alekoko Fishpond and Hulēʻia National Wildlife Refuge. NPS held off-site meetings with the state's Kauaʻi District archeologist and wildlife manager, the board of directors of nonprofit Mālama Māhāʻulepū, and the managers of Makauwahi Cave Reserve. Field notes and photographs from the visit were combined with follow-up research and consultations to prepare this report.

For sharing their knowledge of the study area and facilitating access to it, we thank representatives of Grove Farm, National Tropical Botanical Garden, Grand Hyatt Kauaʻi, Mālama Māhāʻulepū, TEOK Investigations, Hulēʻia National Wildlife Refuge, and Kīpū Ranch (Waterhouse Trust and caretakers). Mahalo also to Thomas Kaiakapu and Nancy McMahon of the Kauaʻi District office of the Hawaiʻi Department of Land and Natural Resources for sharing their valuable time and information.

2.1 Purpose and Scope of an NPS Reconnaissance Survey

Special Resource Studies for potential new units of the national park system may be conducted by the NPS only with specific authorization of Congress. However, Congress does permit the NPS to conduct preliminary resource assessments and gather data on potential study areas or sites. The term "reconnaissance survey" has been used to describe this type of assessment.

A reconnaissance survey examines the natural and cultural resources in a study area to provide a preliminary evaluation of their significance, and a preliminary evaluation of the suitability and feasibility of helping to protect them within the framework of the national park system. Unlike a Special Resource Study, the reconnaissance survey does not explore management alternatives. Its findings and recommendations are centered on whether or not a full Special Resource Study is warranted.

If according to the reconnaissance survey a study area appears potentially eligible for inclusion in the NPS system, then NPS may recommend that a full-scale Special Resource Study be authorized by Congress. The Special Resource Study process is an extensive one,

designed to involve the public and affected parties; further examine significance, suitability, and feasibility; and identify and evaluate potential resource protection strategies, boundaries, and management alternatives.

2.2 NPS Evaluation Criteria

To be eligible for favorable consideration as a unit of the national park system, a study area must possess nationally significant natural or cultural resources. It must be a suitable and feasible addition to the system, and should be shown to require direct NPS management instead of protection by some other governmental agency or the private sector. These criteria are further described below.

2.2.1 Criterion 1: National Significance

Significance evaluation is based on the qualities of the natural and cultural resources present in the study area. Recreational resources, while an important component of most NPS units, are not evaluated independently for their significance. NPS considers a natural or cultural resource nationally significant if it meets four standards: 1) It is an outstanding example of a particular type of resource; 2) it possesses exceptional value or quality illustrating or interpreting the natural or cultural themes of our nation's heritage, 3) it offers superlative opportunities public enjoyment or scientific study; and 4) it retains a high degree of integrity as a true, accurate, and relatively unspoiled example of the resource. Appendix 6.1 provides examples of types of natural and cultural resources NPS may consider significant.

2.2.2 Criterion 2: Suitability

To be considered suitable, an area must represent a type of recreational resource or natural or cultural theme that is not already adequately represented in the National Park System, and not comparably represented and protected for public enjoyment by another land-managing entity. Adequacy of representation is determined on a case-by-case basis by comparing the proposed area to other units in the National Park System for differences or similarities in the opportunities for public enjoyment, and in the type, quality, quantity, or combination of resources present.

2.2.3 Criterion 3: Feasibility

To be considered feasible, an area's natural systems and/or historic settings must be of sufficient size and appropriate configuration to ensure long-term protection of the resources and to accommodate public use. The area must have potential for efficient administration at a reasonable cost. Other important feasibility factors include landownership, acquisition costs, access, threats to the resource, and staff or development requirements.

2.2.4 Criterion 4: Management Options

Even if a study area's resources are deemed significant, feasible and suitable for addition to the National Park System, management by the NPS will not usually be recommended if

other entities—such as state or local government or the private sector—can provide adequate protection and management. As a preliminary document, a reconnaissance survey does not address potential management options, however; these are explored only if and when a Special Resource Study is conducted.

3 OVERVIEW OF THE STUDY AREA

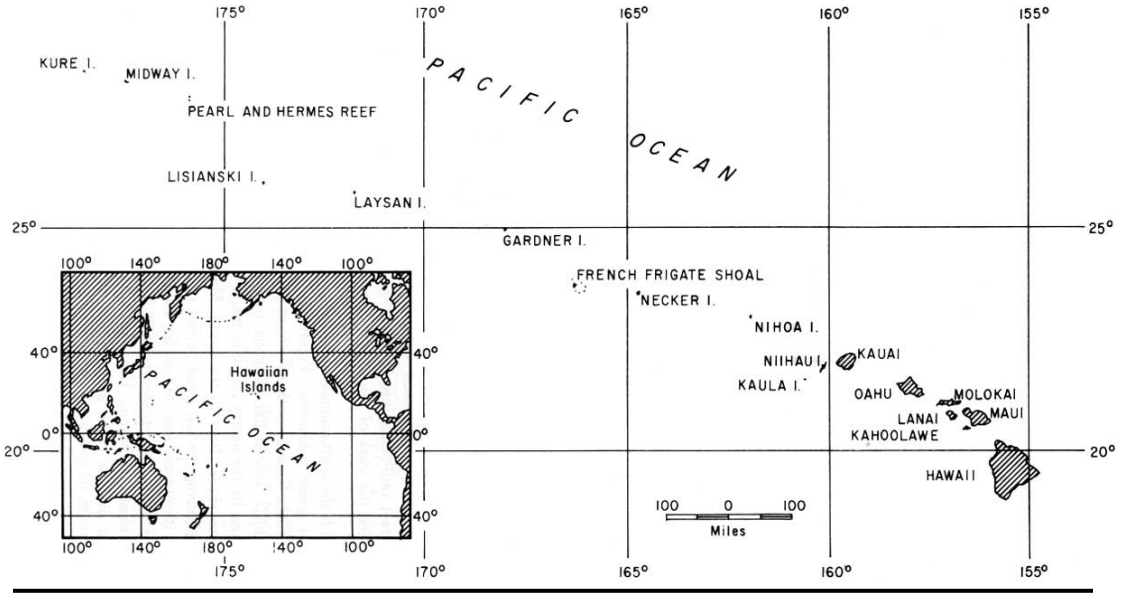
3.1 Regional Context

Hawai‘i is unique in our nation—it is the only state that is not part of the North American continent, and the only one made up of volcanic islands. Situated midway between the American and Asian continents, it spans 1500 miles of sea and encompasses nearly as much ocean as land within its boundaries. The isolated Hawaiian archipelago was one of the last places on earth to be occupied by people.

Entirely volcanic in origin, the state’s 132 isles range from the tiny reefs and shoals of the Northwestern Hawaiian Islands to the 4,038-square-mile “Big Island” of Hawai‘i at the southeastern end of the chain. Their varying sizes reflect different stages in a shared and ongoing volcanic process.

For each island that process begins by eruption over the Hawaiian magmatic hot spot (located today beneath the ocean just east of Hawai‘i). Through buildup from successive eruptions, an island emerges from the sea. At the same time it drifts slowly westward—away from the hot spot—along with the underlying Pacific Tectonic Plate. As an island’s distance from the hot spot increases, eruptions cease, and it slowly subsides into the sea.

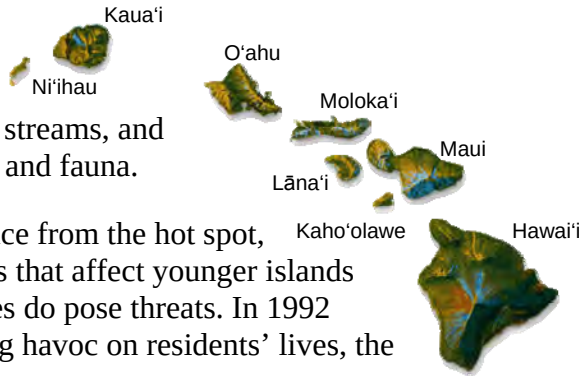
Drifting west at about 3.5 inches per year, all the islands of Hawai‘i will eventually—in millions of years—be drawn back into the earth at the subduction zone where the Pacific plate collides with the plate of the Asian continent.



HAWAIIAN ARCHIPELAGO

Hawai‘i’s human population concentrates on the eight main islands that were most recently formed. Lined up in just a 350-mile stretch at the southeastern end of the archipelago, these populated high islands make up all but three square miles of the state’s 6400 square miles of land.

The Māhā‘ulepū study area is located on Kaua‘i, the oldest and westernmost of the main high islands. At 5 million years of age, Kaua‘i’s volcanic slopes are deeply carved by streams, and its forests host Hawai‘i’s richest array of flora and fauna.



Because of its Kaua‘i’s relative age and distance from the hot spot, it escapes the seismic activity and lava hazards that affect younger islands in the chain. However, tsunamis and hurricanes do pose threats. In 1992 Hurricane Iniki devastated the island, wreaking havoc on residents’ lives, the local economy, and fragile native ecosystems.

Historically, Kaua‘i’s economy was based in agriculture, and its lifestyle today remains rural and relaxed. As development escalates throughout the state, however, visitors increasingly seek the haven of Kaua‘i’s lush environment, scenic beauty and tranquility. The island’s 63,000 residents coexist with a daily visitor population of about 21,000. From 2005 to 2006, Kaua‘i’s annual visitor count rose 10.4%, to over 1.2 million people (DBEDT 2007b). Today new commercial and residential developments are changing both the landscape and the people. These provide needed jobs, but also generate tension about the pace and direction of change on the island.

Of the larger main islands (Kaua‘i, Hawai‘i, Maui, Moloka‘i and O‘ahu), Kaua‘i is the only one that is not home to a unit of the national park system. In the 1960s an NPS study for a national park on the island’s rugged northwest Nā Pali coast and Waimea Canyon met intense local resistance; no NPS designation was pursued.

Māhā‘ulepū, a focus area for this reconnaissance survey, was evaluated in an NPS Natural Landmarks Survey of the Hawaiian Islands in 1981. That survey concluded that “the lands of Māhā‘ulepū are among the most interesting areas in the State both geologically and biologically.” It gave the area a priority ranking of 1, applied to areas that “include outstanding and/or unique examples of geological and ecosystem features characteristic of the Hawaiian Islands and which encompass several such features.” (NPS 1981)

3.2 Geography and Climate

The study area encompasses approximately 12 square miles on Kaua‘i’s southeast coast (see Study Area map). Its *makai* or seaward side spans the 9-mile coastal corridor between the county seat of Līhu‘e and the resort town of Po‘ipū, and is bracketed by the bays of Keoneloa and Nāwiliwili. Its inland edge arcs around Māhā‘ulepū valley, across Hā‘upu Ridge and through Kīpu to include Hulē‘ia National Wildlife Refuge and Alekoko Fishpond at Hulē‘ia Stream. These boundaries are tentative ones established only for

purposes of this report and should be reconsidered in consultation with local landowners if and when a more detailed study is authorized by Congress.

The Hā‘upu (Hoary Head) mountain ridge runs east-west across the study area. Land south of the ridge is part of the county's Hanamā‘ulu-Po‘ipū planning district, which extends from the ridgeline across forests, fields, and old plantation towns to the fast-growing resort area of Po‘ipū. Study area land north of the ridge lies in the planning district of Līhu‘e; this district includes Līhu‘e town—Kaua‘i's county seat, population center and business hub—and adjacent Nāwiliwili Harbor, a deepwater port for cargo and cruise ships.

Weather and climate in the study area typify the mild and locally variable conditions for which Hawai‘i is famous. At Māhā‘ulepū, in the lee of the Hā‘upu mountains, rainfall averages 53 inches a year. Average temperatures range from 72-86°F in the hottest months (August and September) and 64-80°F in cool January and February (WRCC 2007). Wetter and cooler conditions prevail north of Hā‘upu ridge, where moisture-laden northeast trade winds are slowed by the nearly 3,000-ft mountain before sweeping over and around to Māhā‘ulepū. Along the coast the trade winds run roughly parallel to the shore, shaping the dunes from Kīpū Kai to Makawehi.

Resources of particular interest in the study area lie along the entire shoreline corridor, Hulē‘ia Stream, and the Hā‘upu mountain range. While large open agricultural areas at Māhā‘ulepū and Kīpū are encompassed by the study area boundary and may contain relevant natural and cultural resources, their primary importance to this study lies in their potential impact upon adjacent natural areas.

The shoreline corridor begins at Makawehi Point, where a trail across the Pā‘ā dunes affords pedestrian access from the Po‘ipu resort area to Punahoa Point and Māhā‘ulepū Beach. From there the accessible shoreline continues north to Ha‘ula at the foot of the Hā‘upu range. Known as the **Māhā‘ulepū coast**, this popular recreation area features crescents of sandy beach, a variety of coastal vegetation, windblown modern dunes, and a fossil-rich lithified dune system that forms fantastic cliffs, points and pinnacles overlooking the water. A privately-owned rutted dirt road affords daytime vehicular access to the Māhā‘ulepū coast from Punahoa Point north to Hā‘ula Bay.

Beyond Hā‘ula is the private coastal property of **Kīpū Kai**, a spectacular and secluded valley isolated from its surroundings by the eastern arms of the Hā‘upu range. Kīpū Kai's two-mile shoreline consists of four beaches separated by low rocky points, set against a backdrop of coastal wetland, green pastures, a perennial stream and soaring cliffs. Public access by land is not allowed. Kīpū Kai teems with birdlife, including many native species, and the coastal marine resources appear to be in pristine condition.

Towering above Kīpū Kai valley is the **Hā‘upu** mountain range, which runs inland nearly eleven miles to Knudsen Gap. The eastern half of the range, dominated by the ancient volcanic caldera of Mt. Hā‘upu, lies within the study area. Rising dramatically between the Kōloa and Līhu‘e basins, Mt. Hā‘upu serves as an orientation point from land and sea, and plays a key role in native Hawaiian myths and legends. Native plant communities high on

Hā‘upu ridge provide nesting areas for endangered birds, and serve as critical habitat for some of the last remaining specimens of endemic Hawaiian flora.

The seaward end of the Hā‘upu mountain range at **Niumalu**, north of Kīpū Kai, terminates in headlands by Nāwiliwili Bay. It includes three ancient volcanic cones—Kalanipu‘u, Keōpāweo, and Hōkūnui—with elevations up to over 1600 feet. Its makai face is a broad and steep sea cliff indented by small valleys, and its inland face descends to Hulē‘ia Stream. This undeveloped land lacks public access, is mostly zoned for conservation, and is privately owned except for a small state-owned strip above Nāwiliwili Harbor. It includes dense forest along the Hulē‘ia Stream corridor; freshwater springs and streams; designated Critical Habitat for endangered plant species; and expansive open areas of non-native scrub and grassland. In the evening, large numbers of seabirds stream into this area.

The verdant **Hulē‘ia Stream corridor** at Hulē‘ia National Wildlife Refuge and Alekoko Fishpond marks the northern extent of the study area. Flat valley land by the stream was historically used for growing taro, rice and other foods; today it is regrown with natural vegetation and provides important habitat for endangered birds. Hulē‘ia Stream waters and adjacent private forests serve as settings for kayaking and hiking tours, and afford awe-inspiring views of the Hā‘upu mountain range that forms the backbone of the study area.

3.3 Land Use and Ownership

Hawai‘i’s State Land Use Commission classifies all real estate into one of four land use designations: Conservation, Agricultural, Rural and Urban. Counties establish more detailed designations and zonings, but these conform to the range of allowable uses under each designation by the state.

In Hawai‘i, conservation lands are further designated into subzones according to environmental sensitivity; all subzones place strong limits on use, and most uses must be approved by a permit from the state’s Board of Land and Natural Resources. Most of the conservation lands in the study area fall into the two strongest subzones.

All of the land in the study area is designated and zoned for agriculture or conservation, and except for a few homes and farm or ranch structures, it remains undeveloped. The conservation lands are found in a narrow strip along the Māhā‘ulepū coast, across most of Hā‘upu ridge, and around part of Hulē‘ia Stream. Broad agricultural lands occur on both sides of the Hā‘upu range and at Kīpū Kai. (See Regional Land Use map).

The vast majority of the study area is privately owned (see Study Area Landowners map). Grove Farm, one of the oldest and largest landowners in the state, holds all of the parcels that comprise Māhā‘ulepū valley and coast (except for a small home lot at Māhā‘ulepū Beach and a county-owned water reservoir just inland of Makawehi). Grove Farm was founded in 1864 by George N. Wilcox. Historically a sugar plantation, during the late 20th century it transitioned into real estate development, and ceased sugar production in the 1990s. Around the same time, Grove Farm unsuccessfully sought development permits for coastal land at Māhā‘ulepū.

In 2000, the Wilcox family sold Grove Farm to Steve Case of America Online. Today the corporation is involved in major residential and commercial developments in Līhu‘e. In recent years it has leased portions of its Māhā‘ulepū land for various individual and business purposes, including crops, pasturage, a commercial stable, a sand quarry, and a nonprofit research and restoration project at Makauwahi cave. Grove Farm allows daytime vehicle access through the valley to a dirt road that skirts the shoreline, with a gated entry that is locked at night. This beach access is used by both residents and visitors.

While acknowledging the potential development value of the Māhā‘ulepū valley and shoreline, Grove Farm managers say they intend to utilize the valley as an agricultural park with its own branding, and that they have no current plans for resort or residential development there, or along the shoreline. Cultivation of taro has already begun. The long-term conceptual plans for the agricultural park include a possible interpretive pedestrian path around the valley, where hundreds of acres will be dedicated to traditional Hawaiian taro-growing, native Hawaiian healing plants, organic greens, fruit orchards, and other 'grow what you eat' crops.

A second major private property is Kīpū Kai, a 1,117-acre coastal valley owned by the long-time heirs of Jack Waterhouse, and legally slated to be turned over to the state as a wilderness park upon their passing. Its scenic setting has served as a movie location, and until 2006, a cattle ranch. Today resident caretakers live on site, and Waterhouse family and friends vacation in the old Waterhouse home. Residents and commercial tour operators approach this scenic hideaway by boat to play, fish and gather *limu* (edible seaweed) in the nearshore waters; foot traffic is not allowed above the high tide line. It is unclear how the family will sustain the land in the near term under a growing tax burden, and details remain unsettled as to how the state will protect Kīpū Kai’s resources in the long term.

North of Kīpū Kai, in the area known as Niumalu, is a nearly 1400-acre private property that overlooks the ocean, Nāwiliwili Bay and Hulē‘ia Stream. Owned by California resident Donn R. Campion, this land remains undeveloped and unused. Though its conservation zoning allows for construction of a single residence, none has been built. The owner placed the property on the real estate market in 2004; no sale occurred. Access to the Niumalu tract is afforded through the adjacent private Kīpū Ranch.

Kīpū Ranch was purchased by William Hyde Rice in 1881 and has remained in the Rice family, operated first as sugar plantation and then as cattle ranch. The Kīpū property ascends from Hulē‘ia to the Hā‘upu ridge above Kīpū Kai and Māhā‘ulepū, and is zoned for agriculture except on upper portions of the ridge. Uses of the land today include not only cattle ranching, but also ecotourism. Tour operators offer kayak and hiking trips that begin at Hulē‘ia and then venture inland to Kīpū’s pastures and forested slopes. The ranch is home to a variety of non-native wildlife introduced by the Rice family. An ATV operation on site provides guided adventures throughout the Kīpū property. Approximately three-fourths of the ranch lies within our reconnaissance survey study area.

The final major private property in the study area is made up of the Alekoko Fishpond and an adjacent segment of Hulē‘ia Stream. These two parcels totaling just over 100 acres

belong to the O`ahu-based Okada Trucking firm. The pond is designated as conservation land and is listed on the State and National Register of Historic Places. Although public access is prohibited, stream users occasionally enter the pond by kayak. In 2005, the owners attempted unsuccessfully to sell this property.

Adjacent and upstream to the fishpond is the only major public land in the study area, the U.S. Fish and Wildlife Service's Hulē'ia National Wildlife Refuge. The refuge was established in 1973 as a managed wetland to provide habitat for Hawai'i's endangered waterfowl. It occupies four parcels including both conservation and agricultural land. Like the fishpond, the refuge prohibits public access, but in the absence of on-site enforcement some informal recreation use occurs. A state-owned roadside overlook affords a scenic view of the fishpond and wildlife refuge against the backdrop of the Hā'upu mountain range.

Owner	**Parcels**	**GIS Acres**
Grove Farm	6	3477
W.H. Rice	2	1476
D.R. Campion	3	1400
Waterhouse Trust	1	1117
U.S. Fish and Wildlife Service	4	237
Okada	2	102
Small privately owned parcels	13	17
Total acreage		*7826*

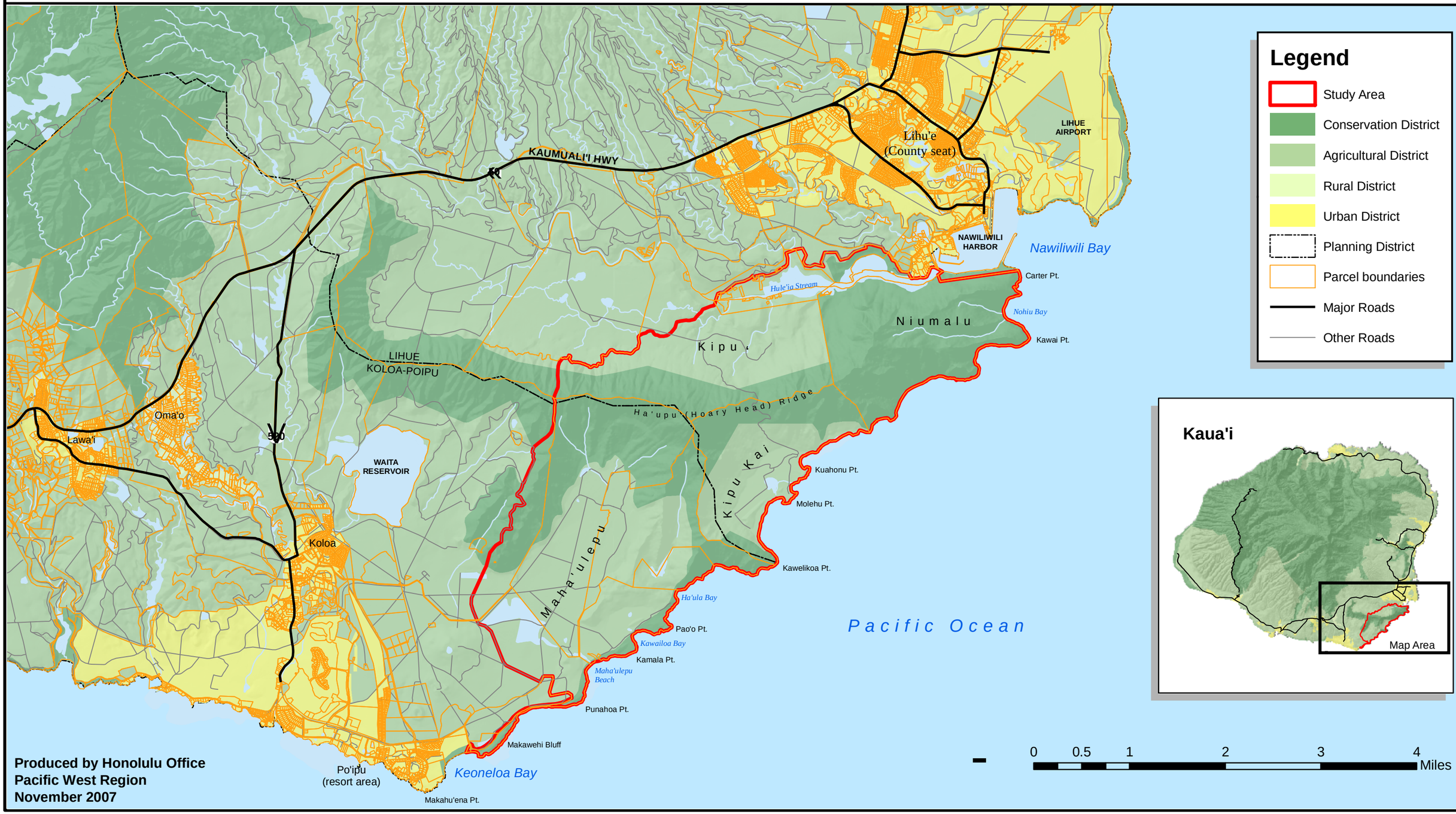
3.4 Maps

Study area maps follow.

Maha'ulepu Reconnaissance Survey, Isle of Kaua'i
Hawai'i

National Park Service
U.S. Department of the Interior

Regional Land Use



Legend

- Study Area
- Conservation District
- Agricultural District
- Rural District
- Urban District
- Planning District
- Parcel boundaries
- Major Roads
- Other Roads

Kaua'i

0 0.5 1 2 3 4 Miles

Produced by Honolulu Office
Pacific West Region
November 2007

Maha'ulepu Reconnaissance Survey, Isle of Kaua'i
Hawai'i

National Park Service
U.S. Department of the Interior

Study Area Landowners

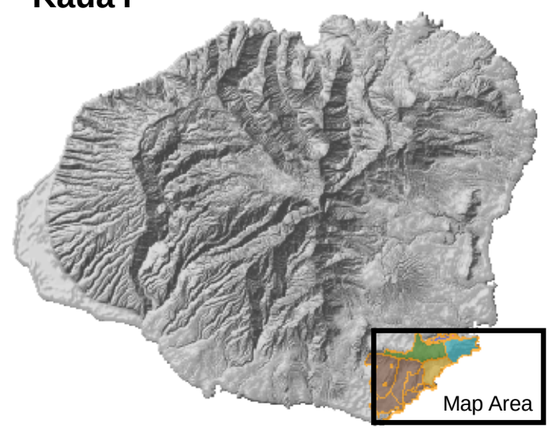
Nawiliwili Bay
Carter Pt.
Nohiu Bay
Kawai Pt.
Kuahonu Pt.
Molehu Pt.
Kawelikoa Pt.
Ha'ula Bay
Pao'o Pt.
Kawailoa Bay
Kamala Pt.
Maha'ulepu Beach
Punahoa Pt.
Makawehi Bluff
Keoneloa Bay
Pacific Ocean

0 0.5 1 2 3 4 Miles

Legend

- Study Area
- Parcel boundaries
- Grove Farm
- W.H. Rice
- D.R. Campion
- U.S. Fish & Wildlife Service
- J. Waterhouse heirs
- Okada
- Other private

Kaua'i



Produced by Honolulu Office, Pacific West Region, November 2007

Maha'ulepu Reconnaissance Survey, Isle of Kaua'i
Hawai'i

National Park Service
U.S. Department of the Interior

Study Area Features

Nawiliwili Bay
Alekoko Fishpond
Huleia Nat'l Wildlife Refuge
Carter Pt.
Kalanipuu 779
Nohiu Bay
Niumalu
undeveloped conservation land
Kawai Pt.
Kipu Ranch
cattle, introduced wildlife, ecotours
Hokunui 1608
Hokulei 1666
Ha'upu Ridge
Mt. Haupu 2297
Naluakeina 1321
Shell Beach
Seal Beach
Bathtub Bay
Kuahonu Pt.
Mahaulepu Reservoir
Kipu Kai
future state wilderness preserve
Wild Beach
Molehu Pt.
Long Beach
Puu Pihakapu 733
Awaowao Valley
Mahaulepu Valley
agricultural park
Kawelikoa Pt.
Haula dunes
Naakea Pt.
Ha'ula Bay
Kapunakea Pond (relictual)
Puu Keke
Paoo Pt.
Waiopili Stream
Makauwahi Sinkhole
Kawailoa Bay
Kamala Pt.
Puu Hi
Quarry
Maha'ulepu Beach
Puu Hunihuni
golf course
Punahoa Pt.
Mahaulepu Coast
recreation, subsistence, scenic views, lithified & modern dunes, native coastal vegetation, seabird nesting, fossils, coastal trail
resort hotel
Paa dunes
Makawehi Bluff
Keoneloa Bay

Pacific Ocean

Kaua'i
Map Area

Legend

- Study Area
- Roads
- Critical Plant Habitat
- Critical Cave Habitat

0 0.5 1 2 3 4 Miles

Produced by Honolulu Office, Pacific West Region, November 2007

4 STUDY AREA RESOURCES

4.1 Geological Resources

As the oldest of the state's main islands, Kauaʻi features the widest age range of geologic landforms that illustrate the birth of the Hawaiian archipelago. Within the study area, this full age span of high-island volcanics can be seen at one time. The study area also displays a visible geologic record of global sea level changes over the last 300,000 years, and a 10,000-year fossil trove of Hawaiʻi lifeforms.

Waimea Basalts

The Hāʻupu mountains that cross the the study area are made up of the most ancient volcanic series in the high islands, the Waimea Canyon Basalts. These formed during the shield-building stage of the Kauaʻi volcano, as eruptions gradually built up its sides and widened its base. Most of the Hāʻupu range is part of the ancient Nāpali member of the Waimea series, dating from 4.35 to 5.1 million years old. The caldera of Mt. Hāʻupu is the separate Hāʻupu member, which remains undated. (Blay & Siemens 2004)

Waimea basalts comprise most of the Hāʻupu mountain range, and can be readily seen in the slopes and sea cliffs of Kawelikoa Point, at the northeast end of the Māhāʻulepū coast near Hāʻula Bay.

Kōloa Volcanics

Māhāʻulepū lands below Hāʻupu ridge are part of the Kōloa series that cloaks most of the east half of Kauaʻi. It formed as the Kauaʻi volcano ceased major eruption and began to erode, with occasional small eruptions at lava domes, cinder cones and spatter cones. These produced a layer of lava that, though not large in mass, nevertheless covered a large area. Kōloa volcanics within the study area at Māhāʻulepū include both underlying lava and visible vents, ranging from .5 to 2.0 million years in age (Blay & Siemens 2004).

Lithified Dunes

The Māhāʻulepū coast features a remarkable array of lithified dune features that lie atop the much older Kōloa and Waimea Canyon lavas. First formed when sea level was about 60 feet lower than today, they accumulated over the last 350,000 years, and are still dynamically changing. Extending from below sea level to as high as 500 feet above it, their layers reflect global cycles of glaciation and sea level change. Transitions between layers are marked by depositional and erosional soils that settled there during glacial periods, when sea level dropped and the shoreline lay as much as a mile farther out than it does today. The dunes contain plant and animal fossils that tell the stories of their time.

The dunes vary in their degree of consolidation and weathering according to age. The oldest and most thoroughly cemented layer, the Punahoa member, occurs near Hāʻula and Papamōʻi and covers most of Punahoa Point. It is laced by caves and contains fossils of land snails and plant roots. Mid-range layers (Pāoʻo and Makawehi members) are moderately or well cemented, with fossils of land crab burrows and plant roots. The loosely cemented Pāʻā dunes that run northeast from Makawehi Pt. toward Punahoa comprise the youngest Māhāʻulepū member. Formed 4,000-6,000 years ago, they contain numerous fossils including land crabs, crab burrows, plant roots, land snails and birds. (Blay & Siemens 2004)

Caliche limestone dunes at Pāoʻo Point

The Māhāʻulepū formation is an exceptionally rich ground for avian and other fossils. According to Smithsonian Institute researchers, the majority of significant avifauna fossils found in Hawaiʻi were collected along this coast. Many were documented in the 1970s and 1980s, a period when the dunes were active and shifting, exposing pockets of fossils, including bones from three species of goose, a long-legged owl, and a flightless rail. Though vegetation has since partially stabilized the dunes, portions of loose limestone still sometimes break off to reveal new and startling fossil finds. (James 2007)

An adjacent limestone cave/sinkhole that is part of the lithified dune system lies just inland of Punahoa Point. Paleoecologists excavating there have discovered an unparalleled array of plant and animal fossils and human remains from both pre- and post-contact Hawai‘i; these are described later in this section (see Makauwahi Cave, below and in Section 4.6) Fossils were also found at a sand quarry site next to the cave.

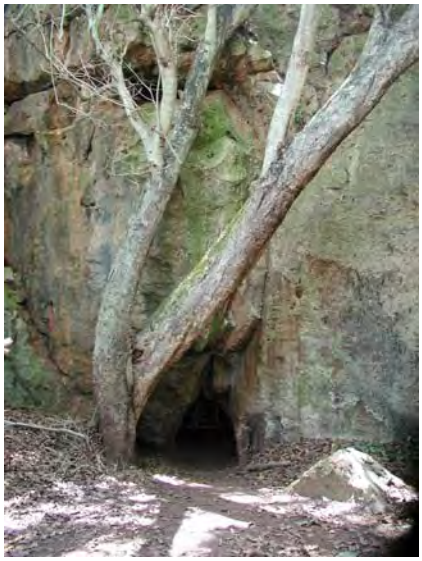
Modern Dunes and Recent Sedimentary Deposits

Loose sand deposited during the last 2000 years overlies all the geologic units in the Māhā‘ulepū Formation. Modern dunes of up to 50 ft occur at Hā’ula, Papamoi, and Kāmala, as well as farther up the coast at Kīpū Kai. They are partially stabilized by vegetation, but continue to be reshaped by the trade winds that sweep the coast. ‘Āweoweo, a tall fossil sand dune atop basement rock north of Hā‘ula, is reported to be the longest, largest burial dune in the Pacific. It consists of partly lithified gray hydromorphic soils that were transported from the Yangtse River valley, China by high altitude winds (Blay 2007).

Beaches along the study area are comprised of recent sedimentary deposits, either in the form of loose sand or bedded calcareous sandstone (beachrock). Geologically recent deposits also formed the alluvial soils in the study area at Hulē‘ia river valley, and around the base of the Hā‘upu range at Kīpū Ranch, Māhā‘ulepū valley, and Kīpū Kai.

Makauwahi Cave and Sinkhole

A large limestone cave system, hollowed out by groundwater, permeates the dunes of the Māhā‘ulepū Formation. The best known part of this cave system is the Makauwahi cave and sinkhole, located on Grove Farm property just inland of Punahoa Point. It is the state’s only solution limestone cave (OSP 1992), and has been described as “the largest limestone cave complex, the richest fossil site and the oldest dated ecological site in the Hawaiian Islands.” (Hoopaja 2006). Discoveries at Makauwahi were featured in public television’s 2001 NOVA series on worldwide species extinction.



A small opening in a limestone bluff affords entrance to the sinkhole.

In the early Holocene, the Makauwahi Cave was entirely roofed and had a dry floor. But as sea levels rose the nearby ocean increasingly breached the cave. About 7,000 years ago the roof at the center of the cave collapsed, forming a sinkhole open to the sky, and internal collapses sealed the cave off from the sea. Groundwater filled the cave and created a lake. During the millennia that followed, natural soils, sand, bones, plant remains, shells, and human artifacts and debris from the surrounding area swept into the sinkhole lake, building up thick layers of a peat-like substance that eventually turned the lake into a swamp. (Burney & Kikuchi 2006)

Today the sediments are 10 meters deep at the sinkhole's center, and the sinkhole floor sits 1-2 meters above sea level. A coating of silty clay—deposited mostly during the 20th century—cloaks the earlier peat-like strata. The water table, fed by underground springs, sits just below the clay surface. The sinkhole's sheer walls range in height from 6 to 25 meters, forming an irregular opening to the sky that measures 30-35 meters across. (Burney *et al.* 2001)

Cave passages connect to the north and south ends of the sinkhole. The south passage leads to culturally sensitive areas and is protected from public access. The north passage, where researchers and visitors enter the cave, has a crawl-in entrance through a sheer limestone bluff bordering Waiʻōpili Stream.

The sinkhole walls range in height from 6 to 25 meters.

Sediment layers in the cave chronicle Hawaiʻi environment, lifeforms and geological events from 10,000 years ago up to the present. The site is exceptional partly because of its excellent stratification, and also because of its unusual degree of preservation of materials that normally perish. The peat's neutral pH, created by the combination of fresh water and limestone, allows for preservation of minute pollen grains as well as bones and shells; one fossilized but intact yam was even uncovered. "This is like a giant pickling jar. Leaves,

whole tree trunks, extinct land snail shells, bird bones, seeds, fish with scales still on—they're all remarkably preserved" (Burney D, quoted in Hoopaja 2006)

To protect this unique resource and make it available for research, the private landowner leases the sinkhole and 17 acres around it to the nonprofit Makauwahi Cave Reserve. Research at the site began in 1992 and first received federal funding in 1996. Sponsors have included National Science Foundation, NOAA, National Tropical Botanical Garden, Fordham University, the Smithsonian Institution, USDA, Kaua'i Community College, and the National Geographic Society.

Researchers have collected cores throughout the site; described ten stratigraphic units based on age, sediment, and the fossils and artifacts found; and excavated in three pits to depths as much as 5 meters below the water table. To date, they have documented findings from over 200 cubic meters of sediment. According to the lead researchers on site, "Nearly 10,000 years of sedimentary record … has been analyzed for vertebrate bones, invertebrate shells, plant macrofossils, pollen, diatoms, sedimentology, and in the upper layers, human artifacts." Their finds, often cited in journals and featured in public media, are documented in Burney and Kikuchi (2001) and Burney *et al.* (2001), and are summarized below.

Fossil bird bones from Makauwahi cave and sinkhole.

Excavations at Makauwahi have uncovered fossils of 45 species of birds. Fully half of these are extinct, and seven or eight are species not previously documented by science. They include a long-legged owl that ate fellow birds; a newly discovered extinct species of bat; flightless grazing birds the size of turkeys; a moa nalo (lost fowl) with a jaw like a turtle; and a tiny duck that fed at night and had eyes set unusually far back on its head. Other finds are nesting boobies, gulls, several forest birds, and the endangered Laysan duck, which still exists elsewhere in the Hawaiian archipelago but was not previously known to inhabit Kaua'i.

Plant fossils uncovered at Makauwahi are equally surprising. The cave strata yield seeds and pollen of many plant species which today are rare and seen only at higher elevations, and which were previously assumed to be suited only to Hawai'i's cooler, wetter upland and mountain areas. Their appearance in significant numbers in core samples from Makauwahi is leading scientists to reconsider these assumptions, and to examine the possibility for extensive native plant restoration efforts in coastal areas.

Other finds include 14 species of extinct land snails, seen in large numbers in lower cave layers but entirely absent in later strata. Their disappearance correlates with the arrival of the Pacific rat, which is believed to have landed in the islands with the first Polynesians. Earliest evidence of rats in the cave layers is dated at 1039-1241 A.D.

Hawai‘i’s native species disappear from Makauwahi’s successive sediment layers in stages that reveal much about human interaction with the island environment. Arrival of people, rats and pigs corresponds with rapid disappearance of large snails, large flightless birds, and certain plants. A second stage of species loss ensues as Polynesian settlers alter the landscape, eat some native species, and introduce new ones. Extinction proceeds apace when Europeans arrive: they introduce goats and cattle, import new species for agriculture, rapidly use forest resources, and alter the landscape in ways that dramatically contribute to erosion and lowland sedimentation.

Even today, a drama of potential extinction is playing out at Makauwahi and other caves in the Māhā‘ulepū Formation. The cave system is designated Critical Habitat for the Kaua‘i cave wolf spider (*Adelocosa anops*) and the Kaua‘i cave amphipod (*Spelaeorchestia Hanamā‘uluna*). Only a few known populations of these species remain; all are small, and all occur in Makauwahi or its immediate vicinity. The U.S. Fish and Wildlife Service is helping to fund plant restorations atop the cave area, in order to foster the native plants whose roots extend downward to the cave ceilings, potentially serving as food for the endangered arthropods (Henry 2007).

4.2 Vegetation

Hawai‘i’s geographic isolation and varied volcanic habitats combined to support evolution of unique flora. Nine-tenths of the state’s approximately 1500 indigenous plants grow nowhere else in the world. Because they are adapted to such localized conditions, Hawai‘i’s endemic plants are especially vulnerable to extinction as human population expands, development encroaches, and competition from introduced species increases.

Within the study area, both the undeveloped shoreline and the upper reaches of Hā‘upu ridge provide haven for a variety of native Hawaiian flora, including many rare and endemic species that have been identified as Species of Greatest Conservation Need by the state of Hawai‘i. Extensive portions of ridge and shoreline are designated as Critical Habitat for federally-listed endangered species (see Study Area Features map). In the valleys and on the lower slopes of the Hā‘upu range, non-native species dominate.

4.2.1 Coastal Vegetation

Hawai‘i’s native coastal strand vegetation—an array of plants unique in the world—has been destroyed or seriously degraded on beaches throughout the state’s inhabited islands. Along the shoreline of the study area, the fact that public access is relatively limited and adjacent land remains undeveloped provides some protection for this plant community. A wide variety of native coastal flora still grows here, despite the extensive presence of non-natives such as ironwood and koa haole.

Ma‘o, Hawaiian cotton (Gossypium tomentosum)

NPS staff noted coastal strand vegetation from Makawehi to

Hā'ula and at Kīpū Kai, with the greatest concentration of native species seen from Pā'o'o Point northward. U.S. Fish and Wildlife Service has designated Critical Habitat along the entire Māhā'ulepū shoreline for the endangered 'ohai *(Sesbania tomentosa).*

Other endemics (species found only in Hawai'i) include Hawaiian cotton *(Gossypium tomentosum)*; beach spurge *(Chamaesyce degeneri)*; pa'uohi'iaka *(Jacquemontia ovalifolia)*; koki'o *(Kokia Kaua'iensis)*; nehe *(Lipochaeta integrifolia)*; ma'oli'oli *(Schiedea* sp.*)*; noni tree *(Morinda citrifolia);* the tree *Munroidendron racemosum*; two species of loulu *(Pritchardia* cf *minor, Pritchardia elmerrobinsoni)*; and the Hawaiian caper *(Capparus sandwichiana)* and hinahina kahakai *(Nama sandwicensis)*, both designated as USFWS Species of Concern.

Pohuehue, beach morning-glory (Ipomea pes-caprae)

Indigenous species (native to Hawai'i but also found elsewhere) include two species of pohuehue (morning-glory); naio (false sandalwood); hala (screwpine); 'akulikuli (sea purslane); 'ilima; milo (portia tree); and 'uhaloa. Common non-natives near the shoreline are beach pea, tree heliotrope, and niu (coconut palm).

Koko, beach spurge (Chamaesyce degeneri)

One item of special note is *Ruppia martima,* an indigenous seagrass recorded in the north end of the study area. Although not seen by NPS, according to staff of the National Tropical Botanical Garden, this is one of three previously known Kaua'i populations of this species, and it is likely that is the only one still persisting. It is characterized by NTBG staff as the "nicest presentation of [the species]" (Burney and Flynn 2007).

Coastal strand species sighted or reliably reported during the survey appear in Appendix 6.2.1. One non-coastal tree, the native leguminous wiliwili, appears in the list. While not a coastal strand species, it was found quite near the beach in a remote spot. This merits attention due to the recently introduced Erythrina gall wasp that has attacked most wild wiliwili in the state.

'*Ilima* (Sida fallax)

4.2.2 Upper Elevation

NPS staff did not visit upland sites during the reconnaissance survey visit, but botanist Ken Wood, a conservation biologist for the National Tropical Botanical Garden, compiled records of native flora and fauna on and around the summit region of Mt. Hā'upu (1800-2300 ft elevation) during a recent research trip. He describes an impressive inventory of native vascular plant species in this isolated ecosystem (Wood 2005).

*Matting ferns such as uluhe (*Dicranopteris linearis*) and uluhe lau nui (*Diplopterygium pinnatum*) mix with a scattering of trees, primarily ʻōhiʻa (*Metrosideros polymorpha*), on Hāʻupu's east slope and upper summit.*

Throughout the Mt. Hāʻupu summit area, native vegetation still dominates in a mostly open landscape of shrubs, ferns, and scattered trees. The estimated amount of native vegetation varies by location—from 60% on the summit and east slopes to as much as 85% on the precipitous north face. (Wood 2005).

The summit hosts at least 112 native plant species (Wood 2005). Of these, nearly ninety are endemic to Hawaiʻi. Over two dozen are endemic to Kauaʻi only, and some are restricted to just Mt. Hāʻupu.

Wood singled out seventeen endemic vascular plants on Mt. Hāʻupu that merit especially urgent conservation efforts due to their rarity (Appendix 6.2.2). Among them are three of Hawaiʻi's Genetic Safety Net species—those of which fewer than fifty individuals are known to remain alive in the wild. They include *Schiedea perlmanii*, *Tetraplasandra bisattenuata* (ʻohe ʻohe), and *Delissea rhytidosperma.* The thirteen Schiedea on Hāʻupu are the only known living examples of their species. A group of thirty ʻohe ʻohe trees found by Wood provides cause for celebration: until recently, only two individuals of this single-island endemic were known to exist.

Delissea rhytidosperma, a Genetic Safety Net species.

Three of the plants identified by Wood on Hāʻupu may be previously unknown species. Another, *Pittosporum gayanum,* is a unique Hāʻupu form of the hōʻawa tree that appears to hold horticultural promise (Wood 2005). USFWS has designated six species known on Hāʻupu as endangered, one as threatened and six as Species of Concern. Parts of Hāʻupu ridge are designated Critical Habitat for eleven endemic plant species.

4.3 Terrestrial Wildlife

4.3.1 Birds

NPS staff recorded nine native bird species while on the reconnaissance and documented another seven via research or by interviews with local biologists. Of the total, seven are endemic at the species or sub specific level, five are indigenous, and the remaining four are migratory birds that winter in Hawai‘i. Five of the seven endemic species are designated by USFWS as Endangered, and one as Threatened.

Nēnē, Hawaiian goose

The endemic Endangered birds known in the study area are the Hawaiian coot (‘alae ke‘oke‘o), common moorhen (‘alae ‘ula), Hawaiian duck (koloa); Hawaiian stilt (ae‘o); and Hawaiian goose (nēnē). All but the coot and the nēnē were observed by NPS during the site visit.

Koloa maoli, Hawaiian duck

Habitat for these species is scattered throughout the study area. Manmade reservoirs at Waitā, Pu‘u Hi and Māhā‘ulepū provide a year-round attraction, as do the golf course ponds at the adjacent Grand Hyatt resort. Intermittent streams and wetlands at Māhā‘ulepū and Kīpū Kai also provide habitat. Bottomlands at Kīpū Kai were the site of a deliberate reintroduction of nēnē several decades ago; the increasing numbers of nēnē now seen on south Kaua‘i outside Kīpū Kai are believed to be descendent populations from that group. According to a state source, nēnē, koloa and other waterfowl frequent the taro lease land in Māhā‘ulepū valley, and a broad natural depression in the valley that fills with water after heavy rain draws many waterbirds. Sixty koloa individuals were counted during one such event (Kaiakapu 2007).

The most extensive habitat for waterbirds in the study area is at the Hulē‘ia National Wildlife Refuge. Hulē‘ia was established in 1973 to provide open, productive wetland and is considered a Core Wetland in the USFWS Recovery Plan for Hawai‘i’s Endangered coot, moorhen, duck and stilt (USFWS 2005). It provides breeding habitat to all four of these Hawaiian waterbirds plus the indigenous black-crowned night-heron. Two endemic birds characteristic of open country also nest on the refuge: the endangered nēnē and the pueo. Migratory water fowl and shorebirds are common seasonal inhabitants.

Newell’s shearwater, a Threatened endemic species, nests in the study area on Hā‘upu ridge. A known nesting site recognized in the USFWS Recovery Plan for the Newell’s

Shearwater is at Kaluahonu, northeast of Waitā Reservoir (USFWS 1983) by the west edge of the study area. Biologists who spend research time on Mt. Hā‘upu report hearing approximately 100-120 individuals arriving in summit areas around 8pm and departing back to sea in the early mornings between 3 and 5 am. Based on audial observations they believe that most of these birds were headed to the Kaluahonu area, but that perhaps 15-20 pairs were nesting nearer their summit camp (Wood 2005).

‘A‘o, Newell’s shearwater

The endemic short-eared or Hawaiian owl (pueo) was reported by a biologist and seen by NPS during the survey; both sightings occurred on or near the east end of the Hā‘upu ridge (Wood 2005).

Pueo, Hawaiian owl

Five indigenous species are known by NPS to frequent the study area: the black-crowned night heron, white-tailed tropicbird, great frigatebird, wedge-tailed shearwater, and red-tailed tropicbird. The black-crowned night heron finds breeding habitat at Hulē‘ia NWR and was spotted during the survey. Biologists describe frigatebird sightings at Māhā‘ulepū and on Mt. Hā‘upu, where seven individuals were seen flying together (Wood 2005). Researchers at the Makauwahi Cave Reserve and on Mt. Hā‘upu report repeated sightings of white-tailed tropic birds (Burney 2007, Wood 2005) and NPS staff saw several during the reconnaissance survey.

Koa‘e kea, white-tailed tropicbird

Wedge-tailed shearwaters regularly nest in the nooks and crannies of the Māhā‘ulepū coast, and red-tailed tropicbirds are also known to nest there. However, in recent years feral and domestic dogs wreaked havoc on accessible nests in this popular area (Kaiakapu 2007, Zaun 2007). Presumably successful nesting still occurs along sea cliffs in the northeastern part of the study area where access is limited.

Four migratory species that winter in Hawai‘i and return to the arctic to breed were noted in the study area. We observed three of these: the Pacific golden plover, ruddy turnstone, and wandering tattler. The fourth migrant, the sanderling, has been reported by residents (MM 2004). Additional migratory shorebirds probably frequent the coastline occasionally,

and other seabird species likely transit the coast. A state study notes that seabirds use the coastal sea cliffs and foothills for nesting and loafing (OSP 1992).

We neither observed nor learned of any native passerines in the study area. In a 2005 record of birds seen on the summit of Mt. Hā‘upu during botanical research, biologists reported two introduced passerine species (hwamei and Japanese white-eye), but no native ones (Wood 2005). As is common on all the main Hawaiian islands, songbird habitat along this coast has been severely altered or eliminated, and disease-bearing alien mosquitoes that infect the passerines are presumably present at least seasonally at all elevations.

The extensive limestone formations of the Māhā‘ulepū coast are an exceptionally rich ground for avian fossils. Fossilized bird bones from three species of goose, a long-legged owl, and a flightless rail were recovered from the lithified dunes, and fossilized bird prints from an extinct bird, possibly one of the moa nalo species, were recently found. Nesting boobies (possibly shrub-nesting red-footed boobies) are known from fossil remains recovered from the Makauwahi Cave Reserve.

The seldom-accessed Niumalu portion of the study area, which was not visited by NPS, is a potential location for seabird sightings and research. A website for Hawai‘i birders describes Ninini Point—outside the study area but directly across Hulē‘ia Stream from Niumalu—as “probably the best seawatching site in Hawai‘i,” with thousands of birds observable under good conditions (e.g., mornings in spring through fall, with northeast tradewinds):

> Most of the birds offshore will be Wedge-tailed Shearwaters and Red-footed Boobies, but large gatherings of Newell's Shearwaters and smaller groups of Hawaiian Petrels can also be seen. Brown Boobies (below) are regularly seen as are Sooty Terns, Black and Brown Noddies, Laysan and Black-footed Albatross and less frequently Tropicbirds and Frigatebirds. Groups of 100 or more Newell's Shearwaters and 50+ Hawaiian Petrels have been recorded as well as many other migrant seabirds. Sooty Shearwater is regular in the Spring, usually in small numbers but over 500 were recorded in one evening in 1999. Other migrants and vagrant seabirds recorded here have included Masked Booby, Mottled Petrel, Short-tailed Shearwater, Ring-billed and Laughing Gulls, Grey-backed Tern, Common Tern and White Tern. Bristle-thighed Curlews have been reported several times passing the Point during the spring and fall and are always worth keeping an eye, and ear, out for. Ruddy Turnstone and Sanderling are sometimes seen on the rocks here and a Dunlin was seen nearby in 1997. Barn Owls regularly hunt the nearby airfield and often fly low over the Point whilst searching for prey, such as mice and rats. Short-eared Owls (or Pueo) are less regular at the Point but are seen occasionally…(Birding Hawai‘i 2007).

Appendix 6.2.3 provides a species list of native birds identified by NPS in the study area. It includes nine species seen on the March 2007 site visit and seven noted during interviews or by research.

4.3.2 Terrestrial Invertebrates

The study area hosts two notable and extremely rare terrestrial invertebrates: the Kauaʻi cave wolf spider (*Adelocosa anops*) and the Kauaʻi cave amphipod (*Spelaeorchestia Hanamāʻuluna*). In 2000, both the spider and the amphipod were federally listed by USFWS as endangered species. All known populations occur in the Kōloa basin on Kauaʻi, within a 4-square-mile area (CBD 2007) that lies partly within the study area.

Kauaʻi cave wolf spider

The Kauaʻi cave wolf spider—sometimes called the "no-eyed, big-eyed wolf spider"—grows to about 1.5 inches. It has so completely adapted to deep, dark moist caves that it has no eyes. The spider uses venom to capture small prey—including the Kauaʻi cave amphipod—but is harmless to humans. The Kauaʻi cave amphipod, also sightless, is a smaller shrimp-like creature (~.4 inch). It eats decomposing matter, mostly plant parts and roots, found in the caves.

At least three-fourths of the historic habitat for these two species has been “rendered uninhabitable by development projects” (CBD 2007). Both species have been reduced to a few small populations; exact numbers remain unknown. Researchers say the spider is seen regularly in only one cave with a population of 16 to 28 individuals (USFWS 2005).

The cave-laced corridor along the Māhāʻulepū coast of the study area, from Makawehi Point to Kawelikoa Point, is designated by USFWS as Critical Habitat for both of these endangered species. At Makauwahi cave and sinkhole, located within the study area near Punahoa Point, the USFWS is funding plant restoration atop the cave system in order to foster the native plants whose roots extend downward to the cave ceilings and serve as food for the endangered arthropods (Henry 2007).

NPS uncovered little additional information on terrestrial invertebrates in the study area. Results are pending from a recent study (Wood 2005)in which botanists from the National Tropical Botanical Garden observed, recorded and collected specimens of arthropods and molluscs on and around the summit of Mt. Hāʻupu. Specimens were sent to Bishop Museum for further identification. Results will provide a window into species distribution and diversity within Hāʻupu’s native plant communities.

4.4 Marine Resources

This section summarizes the large marine vertebrates, fishes, algae, and marine invertebrates in the study area that were noted by NPS during the survey and reported by reliable sources. The NPS site visit included hiking and observations along the entire shoreline from Makawehi to Hā'ula, and a separate excursion to Kīpū Kai. We were unable to access the steep coastal cliffs of Niumalu on the private property that extends from Kīpū Kai north to Nāwiliwili Harbor. Observations were necessarily limited by time, as well as by rough ocean conditions. Staff took notes, GPS points, and photographs; no specimens were collected. We recorded about 80 marine species across all taxonomic groups.

The study area coast is exposed to strong tradewinds and turbulent surf, and lacks any major well-protected bays. The geomorphology of its undulating shoreline offers a variety of habitats for hardy marine life. Above Hā'ula, around Kīpū Kai, and northward to Nāwiliwili Harbor the stratified basalts of the Hā'upu mountain range terminate in cliffs and headlands that drop precipitously to the sea. Below Hā'ula along the Māhā'ulepū coast, the ancient lithified dunes that overlay basalt bedrock are eroded into elaborate cliffs, caves and pinnacles angled over the water.

The cliffs and headlands are separated by small bays, coves or shelves, often with nearshore rock reef benches or boulders that partly protect the shallow waters. White carbonate sand or cobble beaches and basalt benches occupy the intertidal zones (olivine sand occurs in one location). Modern loose sand dunes back many of the beaches and storm-deposited colonies of aged coral rubble are occasionally found high up on shore.

Tidepools in the basalt benches serve as important nursery habitats for marine invertebrates and fishes. The most extensive tidepool complexes we saw during the site visit are at Makawehi and Kīpū Kai. NPS staff observed juveniles of several marine species at both locations, with the greatest diversity occurring at Kīpū Kai.

Limited information is available on the study area's subtidal composition and bathymetry, except for a few sample sites. Below the cliffs by Hā'ula Bay, the nearshore bottom is consolidated reef and beachrock with some sediment, and the offshore bottom is sand; depth drops to 50 feet within 0.3 miles. At Makawehi, the bottom is basalt with a thin veneer of non-reefal marine life, and depth drops to 50 feet within 0.2 miles.

Compared to other Hawai'i shorelines near population areas, the coastal marine habitats of the study area appear relatively unmodified and undisturbed by humans. To date these habitats—and the species they harbor—remain largely unstudied, probably because of rough ocean conditions combined with restricted access.

4.4.1 Large Marine Vertebrates

The beaches and nearshore waters of the study area are home to three important large marine vertebrates: the endangered Hawaiian monk seal, known in Hawaiian as 'īlio holo i ka uaua (*Monachus schauinslandi*); the endangered humpback whale or kohala (*Megaptera*

novaeangliae); and the threatened green sea turtle or honu (*Chelonia mydas*). All three were sighted during NPS's March 2007 visit.

Hawaiian Monk Seal

Endangered Hawaiian monk seals regularly haul out on the beaches of the study area to bask. During the brief NPS field reconnaissance we observed adult seals resting onshore at Kawailoa Beach and at Kīpū Kai. Successful monk seal puppings occurred at Māhāʻulepū in 2000 and 2007, at nearby Poʻipu Beach in 2000 and 2001, and at Kīpū Kai in 2006.

The Hawaiian monk seal is one of only two mammals endemic to Hawaiʻi, and the most endangered marine mammal unique to U.S. waters (KMSWP 2007). In 1976 it was declared depleted under the Marine Mammal Protection Act, and endangered under the Endangered Species Act. Despite these protections, seal populations plummeted. An estimated 1200 Hawaiian monk seals remain alive today; experts predict there will be fewer than 1000 within five years (NOAA 2007b).

Ninety percent of the surviving Hawaiian monk seals live around the tiny unoccupied islets of the northwestern Hawaiian archipelago. However, within this group few juveniles are living to reproductive age. By contrast, the much smaller group of seals that inhabits the main islands is slowly growing.

Hawaiian monk seal seen basking during March 2007 NPS site visit.

About 25 seals are known to live around Kauaʻi (KMSWP 2007). They feed on fish, eels, lobsters and octopi in the nearshore waters, and haul onto shore to bask. Females look for safe, gently sloping beaches by shallow water where they can give birth. They stay onshore to nurse their young for about six weeks, and the pup generally lingers at the birth beach for another month or two after weaning. Kauaʻi is considered the hot spot for seals in the main islands (Eagle 2007).

Monk seals in the study area and elsewhere attract crowds: a healthy adult seal weighs in at an impressive 400 to 600 pounds, and a pup grows from 25 to 200 pounds or so during its six weeks of nursing. The Kauaʻi Monk Seal Watch Program monitors seal use of island

beaches. Its volunteers establish cordons and round-the-clock watches to protect ill seals or mothers and pups from disturbance. (KSMWP 2007)

Monk seal occurrences within the study area take on increasing significance as the overall population continues declining at about 4 percent each year. The updated Recovery Plan for the Hawaiian Monk Seal, released in August 2007, states that the species "is headed to extinction if urgent action is not taken." Its recovery strategy calls for actions to ensure continued growth of the seal population in the main Hawaiian Islands. (NOAA 2007b)

Green Sea Turtles

Residents report green sea turtles basking and nesting on sandy beaches in the study area and foraging in nearshore waters. During the site visit NPS staff spotted green sea turtles swimming at Kīpū Kai.

Green sea turtles swim in warm seas around the world, but the undisturbed environments they require as major breeding sites and the untrammeled sandy beaches they need as nesting areas are becoming increasingly rare. In 1978, the species was listed as Threatened under the Endangered Species Act in all areas under U.S. jurisdiction. Despite this protection the Pacific population is continuing to decline overall. No major breeding sites remain in the Pacific. (NOAA 1998)

Nine out of ten green sea turtle nests in Hawai‘i occur in the remote northwestern end of the archipelago. Growing turtles range hundreds of miles, however, to find foraging grounds. They feed in shallow waters, mainly on algae and sea grasses, and bask on open beaches. To nest and give birth, they return to the beach where they were born.

Increasingly, green sea turtles frequent the waters and beaches of Hawai‘i's main islands, including Kaua‘i. Within the state the species appears to be making a comeback. At the same time, these Hawai‘i turtles are plagued by fibropapilloma tumors. Because of this affliction, plus mortality from poaching and gillnet capture throughout the Pacific, officials say the conservation future for the species is "seriously compromised." (NOAA 1998)

Humpback Whale

According to a summary of humpback whale sightings recorded in 2002-2005, the Māhā‘ulepū coast featured Kaua‘i's best spot for whale-watching (NOAA 2006). On the March 2007 site visit, late in whale season, NPS noted three humpback whales in waters offshore of the study area.

Each winter about 5,000 humpback whales migrate to Hawai‘i from their Alaska feeding grounds to mate, calve and nurse their young. After centuries of population decline by whaling, in the 1970s this massive marine mammal—adults reach over 40 tons—was declared endangered under the Endangered Species Act and depleted under the Marine Mammal Protection Act. Today the species is slowly making a comeback. Hawai‘i is the only state in the nation where humpbacks reproduce.

During annual whale counts—an extensive volunteer effort coordinated by NOAA—observers record whale presence and surface activity at sites around the islands. Four sites in or immediately adjacent to the study area coast are included in the annual count: Ninini Lighthouse at Nāwiliwili Bay, Hā'ula Bay and Makawehi dunes at Māhāʻulepū, and Makahūena Point just south of Māhāʻulepū (NOAA 2006).

Preliminary results for 2007 show the Māhāʻulepū coast area (Hā'ula, Makawehi and Makahūena sites) with the three highest whale sighting counts on Kauaʻi (NOAA 2007).

4.4.2 Fishes

Kauaʻi residents describe the nearshore waters of the study area as a "prime fishing area." Telltale pipes for holding fishing poles are embedded at favored sites along the shoreline. Fish abundance is also implied by the presence of monk seals—the seals feed on reef fish as well as octopus, lobster, and eel.

Fish fauna offshore of the study area appear similar to those seen at other shallow water sites throughout the Hawaiian archipelago. Snorkel fish surveys by trained volunteers for the Reef Environmental Education Foundation recorded 24 species of fish at Kawailoa Bay (Māhāʻulepū), and 43 species at Kīpū Kai. During the site visit NPS noted eight marine species, and an additional eight appeared in records kept by proprietors at Kīpū Kai.

In study area tidepools we saw the zebra rockskipper blenny, as well as juveniles of several families found commonly in Hawaiian intertidal pools and shallow nearshore rock reefs. One brackish-water fish, the Western mosquitofish (*Gambusia affinis*) was seen in the *mulivai* (brackish water wetland) at Kīpū Kai.

A species list of fishes seen by NPS or reliably reported by others appears in Appendix 6.2.4. It should be noted that we were not able to observe or reliably confirm fish species of Hulēʻia Stream or Nāwiliwili Bay during the reconnaissance survey.

4.4.3 Algae

NPS observed and identified 23 algal taxa from shore and at wading depth during our brief site visit. Based on the locations we saw, algal and benthic invertebrate cover appear to be in equilibrium throughout the study area. We saw no invasive or alien algae. A 2007 limu inventory along the Māhāʻulepū coast by a local biologist reportedly noted small amounts of invasive hypnea but an otherwise diverse and healthy array of species.

The only indication of algal overgrowth observed by NPS is on shallow, gently sloping rocky intertidal benches, where cover is dominated by limu kala (*Sargassum echino-carpum)* or a diverse assemblage of foliose and turf algae. Where limu kala dominates, other algal species present include *Asparagopsis taxiformis*, *Dictyota sandvicensis*, *Dictyosphaeria cavernosa*, *Laurencia* sp., *Padina* sp., *Turbinaria ornata*, *Ahnfeltiopsis coccinea*, and *Wrangelia elegantissima*. On large boulders exposed to strong waves, crustose coralline red algae are particularly abundant.

Limu is a valued food source in Hawai‘i. Caretakers of Kīpū Kai report that during low tides Kaua‘i residents arrive by boat to glean for limu kohu (*Asparagopsis taxiformis*) and other edible algae. Evidence of excessive harvesting and poor harvesting of limu kohu is reported along the Māhā‘ulepū coast.

A species list of algae sighted by NPS during the survey appears below in Appendix 6.2.5. The list reflects the survey's limited scope and should not be considered comprehensive.

4.4.4 Marine Invertebrates

Marine invertebrates noted by NPS during the site visit included nine corals, a relatively rare sea anemone, and 29 other macroinvertebrates.

Occurring as widely scattered colonies on basalt, all corals observed had the encrusting, mound, or robust branching morphologies characteristic of species adapted for life on high energy exposed coasts. Corals seen in the study area's wave-protected embayments reflect good water quality, and presumably low levels of runoff and sedimentation from adjacent undeveloped lands. While the number of coral species we saw is fairly low for shallow coastal areas in the Hawaiian Islands, we believe this reflects more the limits on observation (time, sea conditions) than a depauperate coral fauna.

We recorded eight species of stony coral, one zoanthid soft coral, and the relatively rare Mann's anemone (*Cladactella manni),* the largest intertidal sea anemone in Hawai'i. The most commonly encountered corals across all sites were encrusting *Porites lobata.* More protected areas like Long Beach and Mōlehu Point at Kīpū Kai hosted a slightly broader range of species: *Porites lobata*, *Pocillopora meandrina*, *Montipora flabellata* and the zoanthid soft coral *Palythoa caesia*. Small recruits of *Pocillopora meandrina* were common on the tidal bench at Long Beach.

Mann's anemone (cladactella manni), *Hawai'i's largest intertidal sea anemone.*

Similar patterns of coral colonization may occur in nearshore subtidal depths, but we were not able to confirm this. It has been reported that a small fringing reef exists off Kuahonu Point (Fletcher et al. 2002), and that an intact reef of *Porites compressa* is located off Kawailoa Point (OSP 1992).

Towed-diver surveys conducted offshore of the study area by NOAA in 2005/2006 recorded relatively low coral cover, seldom over 10%. The notable exception was at depths of 20-30 feet between Pāoʻo Point and Kamala Point, where they noted cover of 20-30% with medium to high habitat complexity. (Asher 2007)

Non-coral macroinvertebrates noted during the NPS site visit were typical for rocky intertidal waters in Hawaiʻi. Molluscs were most prevalent: we saw ʻopihi (*Cellana exarata)*, false ʻopihi (*Siphonaria normalis)*, reticulated clam (*Periglypta reticulate*), and 15 species of snails including cone shells, cowries, tube snails, nerites, periwinkles, Hawaiian turbans and others. At Makawehi Point, nearest to populated areas, evidence of ʻopihi appeared as old middens containing small shells. In the remoter northeast coast of the study area we saw abundant live ʻopihi up to 7 cm in size.

After molluscs, the next most abundant marine invertebrates sighted by NPS were echinoderms: we identified four species of urchins and two sea cucumbers. Other species noted were the spaghetti worm (*Loimia medusa*), spiny lobster (*Panulirus* sp. [molt]) and three types of crab. Shingle urchins (*Colobocentrotus atratus*) and a'ama crabs (*Grapsus tenuicrustatus*) are abundant at some places, especially Pakamoi and Kīpū Kai. A full list of marine invertebrates recorded during the site visit appears in Appendix 6.2.6.

4.5 Hydrological Resources

The study area lands encompass portions of five Kauaʻi watersheds: Hulēʻia, Puali, and Nāwiliwili in the area north of the Hāʻupu ridge; Kīpū Kai at the ridge's east end; and Māhāʻulepū from the ridgeline southeast to the coast. Collectively these watersheds feature one perennial stream at Hulēʻia; intermittent streams at Māhāʻulepū, Kīpū Kai, and Niumalu; a mosaic of varied wetland habitats; and two major freshwater aquifers.

Hulēʻia

Lowlands of the Hulēʻia, Pūʻali and Nāwiliwili watersheds converge at Hulēʻia Stream, the only perennial stream within the study area. The Hawaiʻi Stream Assessment (DLNR 1990) identifies it as one of eight "Outstanding Riparian Resources" on the island of Kauaʻi, noting the presence of recovery habitat, four species of threatened or endangered birds, and a significant amount of palustrine wetland. The stream's aquatic resources are also rated outstanding: a native indicator species, ʻoʻopu nākea (awaous stamineus), and six other native aquatic species were observed during the 1990 survey. Threats identified during the assessment included invasive hau, California grass, and pigs.

Hulēʻia is partially protected due to the presence of the National Wildlife Refuge, which was established in 1973 to provide wetland habitats for Hawaiian waterbirds. The refuge is designated a Core Wetland by the USFWS. Currently it is managed to control invasive vegetation species through disking and water-level manipulation. Proposed future activities include improved water delivery, mangrove removal at the adjacent fishpond (PCJV 2005) and wetland restoration (FWS/DU 2005). However, limits on funding and staff appear to have curtailed any active planning for such improvements.

The lower reach of Hulēʻia Stream leading into Nāwiliwili Bay is listed as impaired due to turbidity and nitrite/nitrate levels. This area—rated in the 1990 stream assessment as an "Outstanding" recreational resource—is heavily used by residents and tourist for water-based recreation, and is now the target of state and local monitoring and restoration efforts (UH Manoa 2007).

Kīpū Kai

Kīpū Kai watershed descends from the eastern ridges of the Hāʻupu mountain range to the ocean. During periods of heavy rain, waterfalls course down the steep coastal pali. A freshwater spring surfaces near the ridge and an intermittent stream flows through the valley. The Hawaiʻi Stream Assessment recognizes Kīpū Kai stream for its "Substantial" riparian and recreational resources, and documents the presence of four species of threatened and endangered birds.

Since access to this watershed is tightly controlled, its water resources have not been well-studied. NPS staff who visited the site report a brackish water wetland or muliwai behind the beach at Kīpū Kai. With sufficient rain it flows directly to the ocean by a channel and concrete mākāhā, and also joins with the nearby intermittent stream. The muliwai contains the aquatic grass *Ruppia maritima* and the introduced Western mosquitofish, and provides a secluded and protected habitat for Hawaiʻi's threatened and endangered waterfowl.

Māhāʻulepū

The portion of Māhāʻulepū watershed that lies within the study area stretches from the Hāʻupu ridgeline southward through Māhāʻulepū valley and eastward to the coast.

Agricultural operations began in the mid-1800s in Māhāʻulepū valley; its intermittent streams and wetlands were long ago modified for irrigation purposes. The landowner Grove Farm operates a water system that includes wells, ditches, tunnels and reservoirs. Māhāʻulepū Reservoir, at the back of the valley, is part of that system. Both it and the County-owned Puʻu Hi reservoir (at the very southern end of the study area) serve as important attractors for Hawaiʻi waterfowl. Irrigated taro loʻi in the valley provide additional waterbird habitat. A broad natural depression in the valley also fills with water after heavy rains and temporarily draws waterbirds in large numbers.

Though Māhāʻulepū valley's streams and wetlands were modified, their remnants remain; these expand and become especially visible during wetter periods. The former Waiʻōpili stream—largely subsumed by the ditch system within the cultivated area at Māhāʻulepū—emerges in more natural form near Makauwahi Cave at the south end of the study area, where it joins forces with a natural spring and a remnant of the once much larger Kapunakea Pond. This wetland juncture attracts waterbirds and serves as nursery habitat for native fish. It is linked hydrologically to the important Makauwahi Cave complex, a critical habitat for endangered arthropods that rely on seepage of nutrient-rich water.

Wai‘ōpili Stream at Māhā‘ulepū Beach

Research and restoration have been ongoing in Wai‘ōpili Stream/Kapunakea Pond area since 1992. On fifteen acres leased from Grove Farm, volunteers are restoring native grassland and riparian areas. A statewide wetland strategy calls for continuation of these efforts, and protection of “this unique area in perpetuity through conservation easements, cooperative agreements with the landowner, and/or direct acquisition.” (PCJV 2005).

Along the Māhā‘ulepū watershed coastline, other small wetland ecosystems fed by rain and groundwater lie just inland of the dunes. These, too, attract native waterfowl; biologists believe they once supported larger populations, and have excellent restoration potential.

Resource specialists told NPS that Māhā‘ulepū and Kīpū Kai, in combination with Hulē‘ia, provide a much-needed mosaic of varied wetland habitats that should be protected and restored to be reliably available for endangered Hawaiian waterbirds.

Groundwater

Rain is Kaua‘i’s sole source of water. Rainfall not lost to runoff or evaporation seeps into the lava flows that make up the island, forming freshwater aquifers. In the study area this seepage is generally slow, since the types of lava found here are relatively impermeable overall. However, they do contain some spaces where water collects to form underground

aquifers. Large amounts of fresh water perch in the Kōloa volcanics atop denser layers of soil, ash or lava. Fresh basal groundwater occurs in the basalt lavas that comprise most of Hāʻupu ridge, and scattered springs emerge around the base of the mountain range. County of Kauaʻi and major landowners, including Grove Farm, collect and distribute fresh water from area streams and basal sources through ditches, wells, tunnels and reservoirs. Two separate aquifers—Kōloa and Hanamāʻulu—supply the water system in the study area.

Because of the limited permeability of lavas in the study area, few freshwater springs discharge into the ocean. In the permeable limestone dunes along the coast, the basal water is brackish.

4.6 Cultural Resources

Scholars say Polynesians seafarers in canoes discovered Hawaiʻi over a millennium ago, possibly as early as 300 AD. Cultural resources in the study area tell the story of Hawaiʻi's subsequent transformation by human settlement—from the first Polynesian settlers, to the wave of later immigrants who launched the ranching and plantation era, to the mixed communities and modern agriculture and tourism operations in place today.

The whole coast of the study area was populated by native Hawaiians when the first westerner, explorer Captain James Cook, sailed through Kauaʻi waters to land in Waimea in 1778 (McMahon 2007). At that time Hawaiians distributed their settlements and shared land and resources through a system of land divisions known as *ahupuaʻa*. Boundaries of ahupuaʻa were delineated to maximize occupants' access to a range of natural resources needed for sustenance—from nearshore reefs to upland forests.

Cook's arrival set the stage for an influx of newcomers from around the world and catalyzed a dramatic transformation of Hawaiʻi's land use and demographics. Cook introduced cattle to the islands; a gift to the government, they quickly multiplied and spread across the landscape. Whaling ships, traders and missionary expeditions soon brought new immigrants from America, Asia and Europe. In the decades from the 1830s to 1870s the native Hawaiian population declined by over half, largely due to introduced diseases. An American land ownership framework replaced Hawaiian ways of managing resources and a western-style economy rapidly took hold, enabling ambitious immigrants to acquire major landholdings.

By 1850, American entrepreneurs launched large-scale sugar plantations in southeast Kauaʻi. Their efforts heralded the beginning of Hawaiʻi's plantation era, which lasted into the late 20th century. Over that same period, the Hawaiian kingdom fell to United States political interests. With the 1893 overthrow of Queen Liliʻuokalani, the islands were claimed as a United States Territory; in 1959, Hawaiʻi became our nation's fiftieth state.

In the study area today, a range of natural and cultural resources reflect the state's evolution through the periods of Hawaiian settlement and expansion, Western contact, and plantation life.

4.6.1 Hawaiian Settlement and Expansion

The lands examined in this reconnaissance study encompass portions of five different traditional Hawaiian ahupua‘a: Haiku, Kīpū , Niumalu, Kīpū Kai, and Māhā‘ulepū. Changes in these ahupua‘a as a result of modern agriculture, ranching or natural events buried many sites and features from the period of native Hawaiian settlement and expansion. Most which remain are on private land, where archeological investigation is likely to occur only if the owner seeks development permits.

According to the state’s archeologist, basic sites in the region are known and some burial reinterments have occurred, but generally speaking, researchers have not done extensive fieldwork in the study area (McMahon 2007). Notable documented cultural resources which are rooted in the period of native Hawaiian settlement and expansion—and which remain visible today—are described below.

Hulē‘ia Valley

Hulē‘ia Valley—the land designated today as Hulē‘ia National Wildlife Refuge—was natural breadbasket for early Hawaiians on Kaua‘i. Rich in the resources that sustained native settlers, its lands formed the lowland junction of three ahupua‘a: Kīpū, Niumalu, and Haiku.

In the drier portions of the valley, people grew *‘ulu* (breadfruit), *wauke* (mulberry, for making tapa cloth),*‘awa* (for ceremonial drink), and other crops. In wetter areas near streams, they shaped *lo‘i* (irrigated pond fields) for cultivating the staple *kalo* (taro). Records indicate that by the early 1800s, and probably well before, the valley hosted a healthy agricultural community with native Hawaiian homes, fields, and at least 113 separate taro lo‘i. (FWS 2005)

With the changes in land use laws and demographics in the mid-19th century, however, taro patches soon became “a rarity among the profusion of rice fields.” Westerners purchased large agricultural acreages, and Grove Farm—still a major landowner in the study area today—began cultivating sugar in Hulē‘ia valley. (FWS 2005)

Archeologists have documented an entire lo‘i and *‘auwai* (ditch) system on the valley floor; agricultural terraces delineated by boulders in the valley’s western end; conical depressions in rock that appear to be prehistoric native Hawaiian bait cups (for preparing fish bait); and two *lo‘i* (taro paddy) complexes created within the last decade by FWS lessees. In site investigations they also identified or recovered Hawaiian artifacts including basalt flakes and a polished basalt scraper. Researchers recommend studies of exposed soil profiles if excavation is undertaken as part of future wetland restoration at the Hulē‘ia National Wildlife Refuge.

Alekoko Fishpond

Makai of the Hulē‘ia National Wildlife Refuge is Alekoko Fishpond, a native Hawaiian aquaculture site that dates to approximately 1200 AD. Alekoko—sometimes known as

Menehune Fishpond— is listed on the National Register of Historic Places and widely recognized as one of the most important cultural features on Kaua‘i.

While aquaculture existed in other island cultures, prehistoric Hawai‘i’s aquaculture endeavors were far more extensive and innovative than elsewhere in the Pacific. In hundreds of ponds throughout the islands Hawaiians raised and harvested fish—mainly *awa* (milkfish) and *‘anae* (mullet)—and other products. Though usually ponds were built along the ocean shoreline, in some places they were located inland to take advantage of stream waters. Of the 65 fishponds known on Kaua’i, at least nine were located on Hulē‘ia Stream (Cockett 2001). Inland freshwater ponds were known as *loko wai.*

Some ponds were simply natural enclosures, but most were constructed laboriously from rocks. A unique feature of many Hawai‘i ponds was the *mākāhā*, or sluice grate, which improved the pond from a tide-dependent fishtrap into an aquatic arena that could be controlled, regardless of tide, to manage movement of fish between the pond and adjacent stream or ocean waters.

The success of Hawai‘i ponds made them a treasured resource for Hawai‘i’s royalty:

> By the end of the 18th century, more than 300 fishponds were conspicuously owned by the high chiefs. Accessibility to these ponds and their products was limited to the elite minority of the native population—the chiefs and priests. Ownership of one or more fishponds was one of the ultimate, high-status symbols in the status-conscious Hawaiian culture…

Hulē‘ia Stream and Alekoko Fishpond

Alekoko is a royal fishpond of the *loko wai* type. It is the largest manmade inland fishpond in the state (McMahon 2007), and was built using cut stones, a technique rarely employed by ancient Hawaiians. Its extensive rock wall embankments remain, hidden by mangrove, and the mākāhā openings still exist. Although listed on the National Register, the pond has not been fully studied; it is privately owned and access is restricted to viewing from a nearby state-owned overlook. Alekoko is not used today for fish production: water diversion upstream and breakwater jetties downstream altered the rate of flow, and sediments have increased the water turbidity.

A statewide study of Hawaiian fishponds for NPS in 1975 identified remnant Hawaiian fishponds "worthy of preservation as part of the cultural heritage of the State of Hawai‘i and the United States of America." Highest value was given to ponds "judged to have deviated least from their conditions when in operation." The study authors rated Alekoko fifth out of 56 extant royal Hawaiian fishponds for its potential restorability. The state's aquatic resources biologist on Kaua‘i says the pond could serve as a research site and be restored as "an incredible teaching and demonstration resource for Hawaiian aquaculture."

Since the NPS study, mangrove has overgrown and interpenetrated the fishpond walls, posing an increased challenge for restoration. Study authors noted in 1975 that the extent of mangrove invasion strongly affects a pond's potential, since "mangrove removal may involve cranes and underwater sawing. In removing mangrove roots grown into man-made pond walls, the walls would have to be wrecked and rebuilt." Recently more sophisticated mangrove-removal machinery has become available, however. Opinions of experts we spoke with vary widely as to whether restoration of Alekoko is feasible.

Makauwahi Cave and Sinkhole

Makauwahi cave and sinkhole, discussed in section 4.1 for its paleoecological importance, is equally important for the light it sheds on Hawai‘i's human story. According to scientists working at the site, it contains "in a single stratigraphic sequence an encapsulated view of the full span of human occupation, including the millennia preceding human arrival, earliest human evidence, subsequent population increase and cultural change, European contact, and modern transformation" (Burney and Kikuchi 2006).

Due to its neutral pH environment, Makauwahi's fossil and artifact finds are exceptionally well preserved. Its sinkhole walls surround an ordered column of sediment layers that tell a nearly unbroken tale of conditions on Kaua‘i, from before the arrival of people through the changes wrought by a millennium of human activity. Researchers are piecing together new and detailed views of Kaua‘i's past based on analysis of the cave's sediments, combined with oral and archival sources.

They have identified consistencies between local oral traditions dating back to the 1300s and data retrieved from the cave's hidden layers. In sediments from the historic period over the last two centuries, their finds show consistency not only with oral accounts, but also with historic maps, drawings, photographs, and Land Court Award records (Burney and Kikuchi 2006).

Bones of the Pacific rat, believed to have arrived in Hawai‘i with Polynesian voyagers, are dated at 1039-1241 A.D. in the cave and provide the earliest evidence of people in its immediate vicinity. Sediment layers above the first rat bones show an increasing abundance and diversity of whole or partial human artifacts. Documented by Burney and Kikuchi (2006), they include:

- tools such as files, picks, scrapers, and adzes
- fishing gear including hooks, octopus lures, and stone weights
- game stones, sling stones, and hammerstones
- gourds and a wide range of food remnants
- fiber cordage
- wooden fragments of canoes, paddles and tool handles
- a stone stool and evidence of a platform
- ornaments, including drilled shells and a drilled, polished basalt mirror pendant.

The increase in human artifacts through successive layers corresponds with a decrease in native flora and fauna. Some species abruptly vanish when humans arrive, while others gradually decline in size over the centuries and eventually disappear, especially after European contact. In the 1800s and 1900s, as feral animals and agriculture strip nearby land, the number of native plants and birds drops dramatically.

Discoveries at Makauwahi lend weight to an ongoing discussion among scholars about the ways in which Polynesian settlers may have significantly altered the landscape and native biota of Hawai‘i, even prior to European arrival.

Archeological finds at Makauwahi cave and sinkhole to date are from only three excavation pits; presumably many future discoveries remain hidden in the cave sediments. Burney and Kikuchi (2006) note that the cave strata “provide an ongoing record of human activity near the site [that] can be thought of as not just an ‘album of snapshots’ of past life, but perhaps, in combination with the oral histories and early documents, maps, and pictures … a sort of epic movie of human ecology stretching over a thousand years.”

Mt. Hā‘upu

A notable landmark in the study area, Mt. Hā‘upu, is of special meaning to native Hawaiians. In 1998, proposals to build a communications tower on Hā‘upu Ridge prompted the state’s Office of Hawaiian Affairs to document the cultural importance of Mt. Hā‘upu. In a 3-week period they collected information from elders, traditional religious practitioners, teachers of hula and chant, and historians. Their results were summarized in a written appeal to the Federal Communications Commission (OHA 1998) that successfully stopped plans to erect the tower. Points they outlined in the appeal are noted and quoted below.

In Hawaiian culture, a “sacred familial union” joins people to the land.

> “If a time arises when the ‘āina is threatened, we, as Hawaiians, will be there, not by choice, but by our deep aloha to protect our fellow family

> member. No amount of Western influence, cultural assimilation, or persuasion can sever this relationship between Hawaiians and the land, for the land is our kin." (OHA 1998)

In this reality, Hā‘upu ridge is a *wahi kapu* (sacred place).

> "Hā‘upu is our kin, descendant of Papa [Earth mother] and Wakea [Sky father], and older sibling of the Hawaiian people. This is the main underlying reason why we, as Hawaiians, hold Hā‘upu sacred in our hearts." (OHA 1998)

Hā‘upu is said to be named after a warrior demi-god who tore a large rock (*pohaku*) from Kaua‘i and threw it across the channel to kill an enemy chief on O‘ahu, forming the islet there known as Pohaku o Kaua‘i. Hā‘upu in the Hawaiian language means a sudden recollection; the mountain is known for its ability to jolt a memory, or alternatively, open a view to the future. A small heiau atop Mt. Hā‘upu is dedicated to Laka, the goddess of hula, whose *kinolau* (embodied form) lives in the wild and sacred plants of the upland forest that are used by hula practitioners. Both the heiau and the wooded area at Hā‘upu's summit are known by the place name Keolewa, which appears in a variety of prayers, chants and oral traditions. (OHA 1998)

Hā‘upu Ridge is revered as a meeting place where the powerful fire-goddess Pele made passionate love with the demi-god Kamapua‘a. The Kōloa region south of the ridge was controlled by Pele; its dry and rocky landscape reflects her harsh, impatient and dominant personality. The lusher Līhu‘e side of the ridge was home to the pig god Kamapua‘a, who is associated with "taro, fertility and the creation of fertile springs necessary to sustain life," and who is known to excel as a lover. According to tradition,

> "Pele and Kamapuaʻa are believed to have been involved in a tumultuous love affair with each other in the vicinity of Hāʻupu and the topography of the area is believed to have been shaped by the fury of their love-making…Hāʻupu Ridge is the dividing line between the two areas controlled by Pele and Kamapuaʻa and Hawaiian religious practitioners believe these gods continue to dwell there. In times of drought, the fertile and lush domain of Kamapuaʻa is said to be inhabited by Pele, whereas in times of heavy rains the dry and arid domain of Pele is said to be inhabited by Kamapuaʻa. It is at these times that their love affairs are believed to continue." (OHA 1998)

Ku and Hina, the earliest Hawaiian god and goddess, reside on Hāʻupu Ridge. They are patron gods of fishermen and "the special protectors of all the generations of Hawaiians whose ancestors came from Kahiki [Tahiti]." Ku and Hina also represent the male and female procreative powers; their images, seen in rock formations atop the mountain, are a focal point for Hawaiian cultural and religious practitioners. (OHA 1998)

Hawaiian proverbs and poetical sayings reflect Hāʻupu's cultural importance. The phrase *Hāʻupu mauna kilohana i ka laʻi* (Hāʻupu, a mountain outstanding in the calm) honors the mountain itself, and is also a description for someone who achieves outstanding things. Mary Kawena Pukui's *Olelo No Eau* includes seven sayings centered on Hāʻupu, a relatively large number for a place that is not a habitation site. (OHA 1998)

Visible from as far as sixty miles at sea, Mt. Hāʻupu was an important navigational landmark for traditional Hawaiian fishermen in canoes. Hawaiian fishermen today use modern navigation technology, but continue to look to the mountain as both a physical and spiritual guide. (OHA 1998)

Waiʻōpili Heiau

Waiʻōpili Heiau is located near Makauwahi cave, on the land leased from Grove Farm for a sand quarry operation. In a 1974 surface survey archeologists recognized the heiau as "undoubtedly the most important site" known at that time along the southeast Kauaʻi coast, and rated it in the state's "Valuable" category—i.e., significant sites in excellent condition that are good examples of a feature type. They recommended the heiau be "stabilized and/or restored" and described its unique qualities:

> This temple is only one of 4 major heiau, in good condition, which still exist between Hanapepe and Māhāʻulepū (in fact, if one were to continue up the east coast of the island of Kauaʻi the next comparable temple would be those in and around the State Park at Wailua)…The large pahoehoe slabs used in the construction of the south wall is unique as is the stone "tower" near the corner of the south and west walls. Waiʻōpili is also the only remaining temple in the ahupuaʻa of Māhāʻulepū. (Ching et al 1974)

Quarry operations were already underway when the site was examined in 1974. The walls and interior of the heiau were readily seen, but the unique tower formation, noted as substantial by previous archeologists 40 years earlier, had been reduced to "a pile of lava," apparently as a result of quarry operations pushing against the heiau (Ching et al 1974).

Twenty years later conditions had worsened: a 1992 state study noted commented that the heiau was "sitting directly underneath the rock crusher" (OSP 1992). Archeologists and residents who have visited the quarry recently say the heiau is difficult to see but appears to have been further degraded.

Several local sources told NPS that the quarry operator is preparing to close the current site in the near future and move operations to a second permitted site above Hā'ula Bay. According to the state's archeologist on Kaua'i, quarry permit conditions require the operator to revegetate the existing site and restore Wai'ōpili Heiau upon shifting locations.

Burials

The coastal sand dunes of the study area are all known to contain Hawaiian burials. 'Āweoweo, a tall dune north of Hā'ula, is reported to be the longest, largest burial dune in the Pacific. Excavation and grading for the Hyatt hotel, adjacent to the study area, uncovered human remains in the Makawehi dunes. Burials occasionally erode out of other coastal dunes in the study area, and some have been found in study area caves. Newly discovered burials are protected and reinterred through protocols established by the local Native Hawaiian Burial Council.

Little is definitively known about the numerous dune burials. From the early to late 1800s, written accounts refer to great numbers of bones visible in the dunes of Pā'ā and Māhā'ulepū. In 1867, entrepreneur Sanford Dole wrote a letter describing the scene:

> Over this whole extent of sand beaches and hills, human bones are thickly scattered….Ten years ago they were much more numerous than now. The wind is constantly uncovering the skeletons, and when exposed, they are quickly destroyed by the weather and the feet of cattle…[Formerly] it was easy to find perfect skeletons in the exact position in which they were buried. This is now impossible and even perfect crania are becoming more scarce with every year. In olden times the natives often made use of the soft sand beaches for sepulture, but the immense number that is buried here forbids the idea that it was any common burying place. The present generation of natives know nothing definite on the subject. (Ching et al 1974, citing Wyman 1868)

Some 19th century Hawaiians told questioners that the dunes were simply easy places to accomplish common burials. Others said the burials were the result of a great battle in which Kaua'i warriors defeated invading forces. One version placed the battle in the 13th century; the best-known versions—still popular today—describe it as a 1796 battle in which the warriors of Kaua'i's chief, Kamuali'i, defeated Kamehameha's warriors from O'ahu (Ching 1974). To date, none of these battle legends have been confirmed archeologically (McMahon 2007).

Petroglyphs

Known petroglyphs in the study area occur on Māhā'ulepū beach; on privately-owned coastal lands between Hā'ula and Nāwiliwili Bay; and on Grove Farm agricultural lands in Māhā'ulepū valley.

Petroglyphs on rock ledges underlying Māhā‘ulepū beach are occasionally exposed by high tide and waves.

At Māhā‘ulepū beach and at Keoneloa Bay just outside the study area, dozens of petroglyphs and carvings decorate expanses of rock that are usually buried deep in sand, but occasionally exposed by high tides and waves. The markings range up to six feet in length and show historic influences mixed with ancient designs (Clark 1990). Their origin is unknown. In the late 1800s, elders from the area reported the petroglyphs had “always” been there (Ching et al 1974). Rocks in the shallow water at Māhā‘ulepū Beach exhibit grooves made by the sharpening of adzes. Underwater archeology may reveal additional features of interest.

Inland, in the upper reaches of Māhā‘ulepū Valley, is a mystifying petroglyph boulder measuring nearly 4 meters across. It features approximately twenty carved figures, and on its top are two cup-like carved holes; the larger of the two is 4” deep and 1 ft in diameter, and is connected to the edge of the boulder by a shallow carved groove. Researchers have speculated on the meaning and purpose of this configuration—some think it may symbolize or even map a stream and/or spring, and others suggest that it might have served a sacrificial purpose. The actual function and meaning are entirely unknown. (Ching et al 1974; McMahon 2007; KCC 1973)

Other Archeological features

Through ship’s logs and drawings, historians know that Kaua‘i’s southeast coast was well populated by Hawaiians when Captain Cook arrived in 1778. Unfortunately, the village complexes he saw did not survive the two centuries of social and physical upheaval that

followed. An archeological surface survey in coastal portions of Māhāʻulepū in 1974 noted "…many of the sites within the study area were destroyed, otherwise obliterated, or in an advanced stage of deterioration…a reflection of the changing land use patterns of the region" (Ching et al 1974).

Surface sites and features that do remain are mostly scattered and isolated. They include shelter caves, remnants of rock walls and house sites. Three heiau are preserved on the Hyatt hotel property abutting the south end of the study area. An 1896 map by Monsarratt shows house lots and salt ponds near Waiʻōpili Stream and Kapunakea Pond, but evidence of these has been destroyed or obscured, and even the stream and pond have been drastically altered by agricultural operations.

On private properties in the north end of the study area a range of sites and features are reported to exist. These include burials, village and house sites, heiau, rock walls, middens, agricultural terraces, taro loʻi, a clay-mining cave, and a fishpond site. Hunters tell of a place in Niumalu that is said to be the house and burial site of a princess from the island of Hawaiʻi.

Some of these have been documented and a few were viewed by NPS staff during the site visit, but overall the documentation to date has not been thorough. Given the habitation dates revealed at Makauwahi Cave, and the known existence of coastal villages in the study area through the 18th century, a more thorough survey and excavation would likely yield new finds and insights.

4.6.2 First Western Contact

The ocean off Māhāʻulepū was the location of the first documented contact between native Hawaiians and people of the Western world on January 19, 1778. Captain James Cook recorded the rendezvous in his diary (as cited in MM 2004):

> January 19, 1778…I stood for the East end of the second island [Kauaʻi] …the nearest part about two leagues distant. At this time we were in some doubt whether or not the land was inhabited, this doubt was soon cleared up, by seeing some canoes coming off from shore towards the Ships, I immediately brought about to give them time to come up, there were three and four men in each and we were agreeably surprised to find them of the same nation as the people of Otahiete [Tahiti] and the other islands we had lately visited…

This fateful meeting marked the first economic encounter between two vastly different cultures. A brief flurry of trade between the Hawaiians in canoes and the Westerners in ships marked the first exchange in the series of economic transactions that would eventually transform Hawaiʻi's people, laws, and landscape:

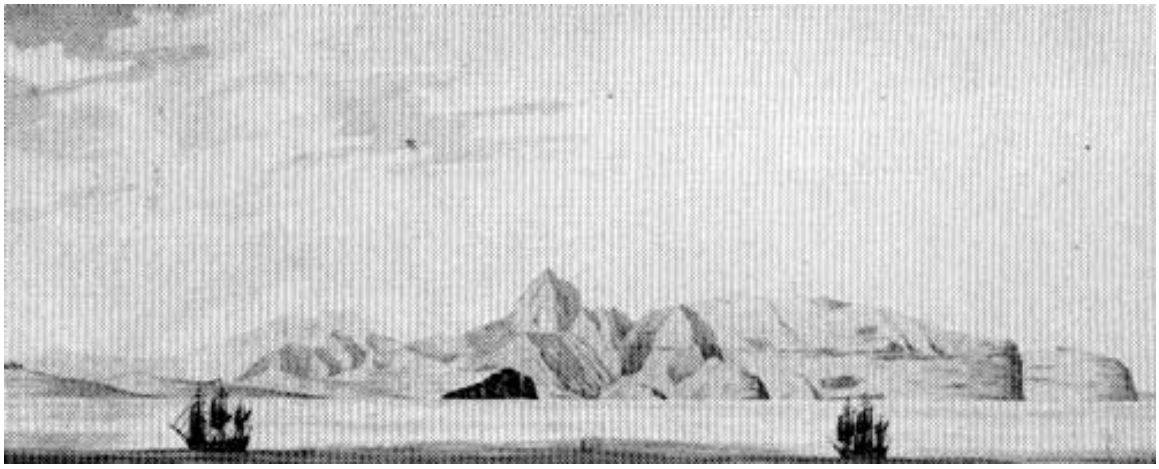
> …It required but little address to get them to come along side, but we could not prevail upon any one to come on board; they exchanged a few fish they had in the Canoes for any thing we offered them, but valued nails, or iron above every other thing; they only weapons they had were a few stones in

> some of the Canoes and these they threw overboard when they found they were not wanted.

Lack of a good anchorage led Cook to proceed around the island to Waimea, but as he skirted Kaua‘i’s southeast coast, he described the view across Kōloa and Māhā‘ulepū to the Hā‘upu Ridge, with its steep stratified basalt headlands at Kīpū Kai and Niumalu:

> …The land on this side of the island rises in a gentle slope from the sea shore to the foot of the Mountains that are in the middle of the island, except in one place, near the East end where they rise directly from the sea; here they seemed to be formed of nothing but stone which lay in horizontal stratus.

The first drawing of Hawai‘i by a European is William Ellis’ depiction of the Māhā‘ulepū Coast, with Mt. Hā‘upu as its focal point (Ainakumuwai 2001).



4.6.3 Plantation and Ranching Era

Scattered physical remnants of plantation life are visible in and around the study area. Kōloa Plantation—the 19th century owner of Māhā‘ulepū lands that now belong to Grove Farm—gave birth to Hawai‘i’s commercial sugar industry. Remnants of the company’s first mill are in nearby Kōloa town, and a second mill constructed in 1912 stands on Grove Farm property just outside Māhā‘ulepū Valley.

Kīpū Ranch and Grove Farm—two agricultural entities that shaped Hawai‘i’s historic plantation and ranching era—still manage active operations on lands within the study area, with some historic facilities remaining in use. At Kīpū Kai, cattle operations ended just two years ago.

The histories of these properties illustrate Hawai‘i’s transformation since the early 1800s—the troubled transition to a Western-style land ownership system; the acquisition of vast acreages by American missionary families; the diversion of water to support commercial sugar crops; the tide of imported laborers needed to maintain production; and the mid-20th century decline of plantation life as laborers left the fields for other work opportunities.

They stop just short of the modern chapter in the story—the wave of subdivision and development that has recently broken up many of the state's vast and historic agricultural holdings.

Kipu Ranch abandoned sugar in 1942 and narrowed its focus to cattle ranching. The Rice family, owner of the land since 1872, continues cattle operations today. In recent years the ranch trimmed staff, replaced horses with ATVs, launched an ecotour operation, and served as a location for Hollywood movies. (Yamanaka and Rice 1998)

Grove Farm stopped actively cultivating sugar in the 1970s. A lessee grew sugar on Grove's Koloa lands for twenty more years—1996 marked their final harvest and the closure of the historic Koloa Mill just outside Māhāʻulepū Valley (Yamanaka 2000). Over the last two decades, Grove Farm engaged in extensive real estate development outside the study area, but its Māhāʻulepū valley land remained in crops and pasture.

In their current state, both Kīpū Ranch and Grove Farm offer windows into Hawaiʻi's past. Interestingly, both are invested in business strategies that highlight that past. Kipu Ranch offers ecotours emphasizing the ranch's history, while Grove Farm plans interpretive features focused on local agriculture.

4.7 Recreation and Community Use

Despite the study area's location between the population centers of Līhuʻe and Poʻipū, no public lands within it are managed for recreation purposes. However, residents and tourists enjoy both informal and commercial recreation along the study area shoreline, in the adjacent ocean, on Hulēʻia Stream, and on some of the privately-owned lands. Community uses include traditional cultural activities such as fishing, hunting and gathering.

Shoreline

The Māhāʻulepū and Kīpū Kai shorelines have long served as secluded recreation places for local residents. Lately a growing tourist presence has added to the mix; over one-third of the petition-signers in a community initiative to protect Māhāʻulepū's shoreline resources identified themselves as visitors to the island (MM 2007).

The study area shoreline is accessible at its south end via a footpath leading from Keoneloa Bay and the Hyatt hotel along the Makawehi/Pāʻā dunes. Businesses and community groups jointly prepared an interpretive guide for this trail and sponsor occasional guided walks from the hotel to Punahoa Point.

Grove Farm allows daytime vehicle access through its property to a rutted road that parallels the Māhāʻulepū coast from Punahoa Point to Hā'ula Bay. Punahoa Point is a popular place to fish for ulua, pāpio, and ʻōʻio; pipes for holding poles are permanently anchored into the rock here and at other high points along the shoreline. Māhāʻulepū Beach is favored for windsurfing and kite surfing, and its long white stretch of sand appeals to sunbathers and walkers. Kāmala Point Beach, Kawailoa Bay and Hāʻula Beach are all

popular swimming spots. A commercial stable just inland of Punahoa Point provides horseback riding tours along the shoreline.

The Māhā‘ulepū coast offers varied and readily accessible recreation opportunities in a wilderness type atmosphere.

The entire four-mile stretch from Makawehi Point to Hā’ula offers a scenic hike in a wilderness atmosphere with no visible development except a single house at Māhā‘ulepū Beach. A narrow and rutted dirt road reaches most of the way to Hā‘ula; at favored spots it can be packed with vehicles on weekends and holidays, when local families converge for daytime and overnight fishing, spearfishing and camping.

Kīpū Kai encompasses five separately named beach areas, but these are not accessible to the public by land, and foot travel is allowed only below the high tide line. The single road that leads over the ridges of the Ha’upu Range into Kīpū Kai is private property and blocked by gates. Most visitors arrive by boat or kayak.

Most of the public recreation at Kīpū Kai occurs at Long Beach, which is suitable for swimming, snorkeling, bodysurfing, bodyboarding, surfing, fishing, and beachcombing. A small cove in the arc of Mōlehu Point at the north end of Long Beach is a popular snorkel site for tour boats. By agreement between commercial boat operators and Kīpū Kai landowners, onshore tour activities are confined to the adjacent beach area, below the high tide line (Clark 1990). On the smaller and rockier beaches beyond Long Beach, residents often arrive by boat to harvest edible algae (e.g. limu kohu) and capture shallow reef fish and octopus (he’e or tako).

The study area coast lacks well-sheltered harbors and is exposed to strong waves, currents and tradewinds, so boat-based ocean uses are often limited by rough sea conditions. During calm periods, however, small vessels from nearby Nāwiliwili Bay or Kukui‘ula Bay (west of Po’ipū) fish offshore. Charter boats and commercial kayak, dive, snorkeling and sightseeing craft skirt the study area shoreline and enter coves along the way when conditions allow, particularly in winter when high surf precludes tours along the Nā Pali coast. Ocean-based tours to Kīpū Kai—where public access by land is not allowed—are increasingly popular.

Hulēʻia Stream and Kīpū Ranch

The waters of Hulēʻia Stream are a peaceful kayaking spot for local residents and independent tourists. Local outfitters also offer guided kayak tours along two miles of the sheltered Hulēʻia waterway, through scenic forests that are often used as film locations for adventure movies. Paddlers glide past Alekoko Fishpond and through the Hulēʻia National Wildlife Refuge, then hike through the forest to waterfalls and swimming holes. One kayak tour operator, by agreement with the landowner, leads hikes into Kīpū Ranch that feature a covered wagon tour, a treehouse picnic, and a zipline ride across a waterfall.

Kīpū Ranch is also the site of commercial ATV tours. Sponsors tout the varied terrain through forests and along Hulēʻia Stream; opportunities to learn about Hawaiian culture; stops at Hollywood movie locations; encounters with cattle, wild pigs, and game birds; and spectacular "ocean, mountain and jungle" views, including a look at the private and inaccessible valley of Kīpū Kai.

Hāʻupu Ridge

Hāʻupu Ridge was formerly a popular hunting area accessible to the public. Due to growing vandalism, poaching, and risk of fire on the ridge and adjacent land, owners now allow access only by permission.

4.8 Resource Threats

Human Land Use and Activities

Changing land uses and activities pose current and potential threats to important natural and cultural resources within the study area.

An active sand quarry excavation operates adjacent to Makauwahi cave and sinkhole—so close that one small cave opening in the west sinkhole wall rises diagonally only about 50 feet before it ends in a surface collapse at the edge of the quarry (Burney and Kikuchi 2006). Heavy equipment in use at the quarry can sometimes be felt within the cave environment, causing fear of potential rockfall or collapse. A heiau on the quarry site has already suffered significant damage. A future quarry site farther north at ʻĀweoweo may potentially impact dune burials.

Kauaʻi's endangered arthropods in the study area are especially vulnerable to impacts from quarrying and other activity on the marginal agricultural soils overlying their cave habitats. Grading, fill, and excavation result in disturbance, compaction or blockage of the subterranean cracks where these species find refuge during drought. Blocked areas break up the cave system into separate areas, isolating the already small populations and increasing their risk of extinction.

Endangered birds rely on a mix of natural and manmade resources in the study area that are readily subject to change. At Kīpū Kai—the release site for a small population of nēnē that grew and catalyzed resurgence of nēne on Kauaʻi—the mowed and grazed grassy areas favored by nēne have been substantially reduced since the cessation of cattle operations in the valley. On Hāʻupu ridge, pig predation and fire risk are ongoing threats to the Newell's shearwater nesting habitat. Potential development in the shearwater's land-sea flight path also poses a threat if it results in increased lighting, which disorients and downs birds in transit.

Recreational use of the study area shoreline is growing in tandem with Kauaʻi's resident and visitor populations. Along the accessible Māhāʻulepū coast, user conflicts are common; and at relatively inaccessible Kīpū Kai, trustees express concerns about the increasing arrivals by boat. Neither site is currently managed to assess and monitor coastal-marine resources or actively manage use. Without active management, shoreline cultural and natural assets run the risk of damage from overuse before they have even been well studied. If activities get out of hand at Māhāʻulepū, Grove Farm could choose to block access through its property, effectively limiting public use of an important recreational resource.

A potential threat to resources is future development on the private lands that are now designated for agriculture, and that are intertwined with important natural and cultural elements in the study area. Past proposals by Grove Farm, for example, included luxury resorts, large home sites, businesses, and a marina along the Māhāʻulepū coast. Kīpū Ranch lands hold obvious value for potential development. A 2004 sales brochure for the Campion property at Niumalu suggests the buyer could apply to "change zoning for a commercial type development" and notes that "when this application was approved obviously the value would multiply."

Despite current owner intentions to keep lands in agriculture, without permanent legal protection, their redesignation and development remain possible. Such development would destroy the scenic integrity of the study area, exacerbate competition for shoreline use, and potentially cause unacceptable impacts on adjacent natural areas.

Invasive Alien Plant Species

Non-native species dominate parts of the study area, and threaten or encroach on significant resources on the shoreline, at Hulēʻia, and on Hāʻupu ridge. Once established, some of these aliens are difficult to remove.

At Alekoko Fishpond, red mangrove completely covers the pond's rock walls. Study area coastal lands are invaded by ironwood, Christmas berry, koa haole, kiawe, false kamani and prickly pear. At Kīpū Kai, NPS staff noted one small patch of a *Canavalia*, or beach pea; fruit or flowers are needed to confirm the identification. This species was not recorded from Kaua'i in the *Manual of the Flowering Plants of Hawai'i* (Wagner et al. 1990), and thus has likely been introduced in the past decade (L. Pratt, pers. comm.).

Albizia, guinea grass and java plum are major invasives on parts of Hā‘upu Ridge. Non-natives such as rose myrtle, passion flower, cat’s claw, and thimbleberry have also gained a foothold; some of these are able to spread quickly through the forest understory, competing for habitat with Hā‘upu’s rare native species (Wood 2005). In the absence of active management, alien invasives can eventually destroy native plant communities within the study area.

A species list of introduced plant and animal threats identified during the reconnaissance survey appears in Appendix 6.3.

Grazers and Predators

Pigs and goats seriously threaten native habitat in the study area. After Grove Farm ceased sugar operations and began leasing out crop and pasture at Māhā‘ulepū, they closed hunters’ access to Hā‘upu ridge through their property. Habitat degradation and destruction by feral pigs, always a problem, has since grown unchecked. Large numbers of feral goats also clamber across the slopes of the Hā‘upu range. During the reconnaissance survey site visit, NPS staff counted 89 goats on the ridge between Kīpū Kai and Niumalu.

Ungulate disturbance destroys native vegetation, increases erosion, and provides fertile ground for invasive species. Throughout Hawai‘i, feral ungulates are ravaging native ecosystems. The study area is no exception. Ungulate control on Hā‘upu ridge is a critical need.

Dogs, both domestic and feral, threaten populations of native seabirds on the study area coast. Dogs are blamed for killing remnant or nascent Wedge-tailed Shearwater colonies along the coast (Kaiakapu 2007, Blaich 2007). Dogs have killed nesting albatrosses and nēnē elsewhere and threaten all ground-nesting birds. Feral dog removal and domestic dog control are sensitive social issues—ones that demand attention if native species in the study area are to be protected.

Rats pose a special threat in the forests of Hā‘upu, where they can wreak havoc on small and vulnerable populations of endemic plants by eating precious seeds. Rats are a persistent pest in agricultural areas and a threat to nesting birds.

Non-native predatory birds in the study area include the barn owl, which has been recorded preying on both Newell’s shearwaters (Ainley et al. 1997) and Hawaiian stilts; and the cattle egret, which may take young of endemic waterbirds (USFWS 2005) and compete with native waterbirds for food (Hawaii Audubon Society 2005).

Of particular positive note, Kaua’i is the largest island in the state that appears free of the mongoose, a voracious eater of bird eggs and chicks. Likely in part because of its absence, Kaua’i remains the stronghold of the threatened Newell’s ahearwater (‘a’o) and is home of a growing nēnē population, especially in and around the study area. Isolated individual mongoose sightings have been reported on the island; an established mongoose population would be a serious threat to the study area and all of Kaua‘i.

Environmental Events

Environmental events such as hurricanes, fires, tsunamis and landslides are potential study area threats that can not only wreak direct havoc, but also set into motion long-term landscape changes—such as erosion and alien plant invasion—that gradually degrade and destroy native habitats. State officials report that two hurricanes in recent decades damaged Newell's Shearwater habitat on Hā‘upu ridge, and allowed invasives to spread across newly-eroded slopes. Kīpū Kai representatives say the mountainsides above their valley were lushly vegetated before the hurricanes. By the time of the NPS site visit, the slopes were bare and roamed by goats, and a small recent landslide was apparent on the upper part of the access road.

The entire study area shoreline is highly vulnerable to storms and hurricanes. Long-term coastal erosion hazard is high at Māhā‘ulepū Beach and moderately high at Kawailoa Bay, Hā‘ula, Kīpū Kai beaches, and the southern portion of Niumalu. (KC 2003)

Located far from the Hawai‘i magmatic hot spot, the study area is not at direct risk from volcanic or seismic events. However, potential tsunami hazard intensity is considered high along the Māhā‘ulepū coast between Punahoa Point and Hā‘upu Bay, and at Long Beach in Kīpū Kai. These moderately sloped areas are also vulnerable to coastal stream flooding from seasonal rainfall (KC 2003).

4.9 Resource Protections

Besides the National Wildlife Refuge designation at Hulē‘ia, the strongest existing resource protection mechanism applied in the study area is state designation of Conservation lands along the shoreline corridor and much of Hā‘upu ridge (See Regional Land Use Map). Most of these lands fall into the state's two strongest Conservation subzones, which place strong limits on use, and which require state permits for most uses (DLNR 2005b).

Federal Critical Habitat designations along the Māhā‘ulepū shoreline and portions of Hā‘upu ridge provide minimal protection. A Critical Habitat designation does not affect situations where a federal agency is not involved—for example, a landowner project on private land that involves no federal funding or permit. Similarly, Alekoko Fishpond's listing on the National Register of Historic Places only modestly assists in its protection: under federal law, private property owners can do anything they wish with their National Register-listed property provided that no federal license, permit, or funding is involved.

Several state planning documents related to tourism, recreation, and historic trails emphasize the importance of recreational access and resource protection along this coast, especially in light of increasing public use (OSP 1992). These documents establish ideals and goals that are not reflected in enforceable policy. They do not necessarily result in actual resource protection or maintenance of existing public access.

In 1992, Hawai‘i 's Office of State Planning conducted a land use review that recognized Māhā‘ulepū's "combination of outstanding coastal recreational areas, native coastal strand

vegetation and significant physiographic, archaeologic and scenic resources." Anticipating future development pressure, it said "measures will need to be taken to assure that the sensitive resources here will be protected." Suggested ways to achieve that protection included transfer of development rights and purchase of easements (OSP 1992).

The 2000 update of the Kauaʻi County General Plan—a direction-setting policy document that precedes and guides zoning regulations—discusses important resources in the study area (KC 2000). In Section 6.3, Līhuʻe, it notes the value of the Hāʻupu mountains, Alekoko Fishpond, Hulēʻia, Kīpū Kai, and the Niumalu coastline; establishes policy to ensure that future urban development on bluffs above the fishpond is placed out of sight from the fishpond overlook; and envisions a future in which Hulēʻia Stream and valley are well-managed, and the scenic qualities of Hāʻupu ridge are preserved.

General Plan policy statements in Section 6.4, Hanamāʻulu-Poʻipū, promote a community-based approach to protecting Māhāʻulepū resources:

> Involve the community in planning for the future of Māhāʻulepū. Planning should take into consideration various interests and factors, including but not limited to: the long-term need for managing Māhāʻulepū lands to preserve their significant natural and cultural features; the owner's desire to develop revenue-producing uses in a way that is sensitive to the area's unique qualities; the need to secure permanent public access to the shoreline; and the potential to create a coastal park.
>
> …This area needs a community-based planning effort that engages the landowner and local community interests, drawing upon the County government, the State DLNR, and various professional experts, as needed. Options for the area include some development in exchange for a park and/or preservation areas; or purchase of the land for a State park.

In 2001 the Kauaʻi County Council approved a resolution to work with the state to preserve the entire Māhāʻulepū ahupuaʻa (Sommer 2001a), and the State Legislature passed a concurrent resolution saying "This body supports a collaborative planning effort to explore options that would make it possible to preserve the irreplaceable natural and cultural resources of Māhāʻulepū, and to sustain the special experience of this place" (HI 2001). Hawaiʻi's Governor declared his intent to add Māhāʻulepū to an envisioned statewide "string of pearls", made up of wilderness parks with minimal infrastructure and no commercial activity (TenBruggencate 2001). The Governor met with Grove Farm owners, but could not strike a satisfactory deal to acquire the land.

Kauaʻi County's Open Space Commission, an advisory group that gathers public input and recommends priorities for allocation of the county's Open Space Fund, names Māhāʻulepū as one of the island's ten "Priority Sites for Acquisition." Since little money is allocated to the fund—coffers amounted to $1.2 million at the beginning of 2007—actual acquisition in the near future via this funding source appears unlikely. (KC 2006)

5 CONCLUSIONS OF THE STUDY

5.1 Preliminary Evaluations Based on NPS Criteria

Based on the reconnaissance survey site visit, research and consultations in 2007, the NPS Pacific West Region Honolulu Office provides the following preliminary evaluations of the national significance of the study area resources, and the suitability and feasibility of helping to protect them within the framework of the national park system.

5.1.1 Significance

> *A natural or cultural resource is considered nationally significant if it is an outstanding example of a particular type of resource; possesses exceptional value or quality illustrating or interpreting the natural or cultural themes of our nation's heritage; offers superlative opportunities public enjoyment or scientific study; and retains a high degree of integrity as a true, accurate, and relatively unspoiled example of the resource.*

Within the Māhāʻulepū reconnaissance survey study area, the resources of the Māhāʻulepū coast, Makauwahi Cave, Kīpū Kai, Hāʻupu range, and Hulēʻia Stream are deemed nationally significant. These areas encompass unique geologic landforms and fossils, rare species and habitats, and storied sites important to native Hawaiian and United States history. Together they comprise a relatively unspoiled landscape that affords exceptional opportunities for interpretation, enjoyment and study.

The lithified dune system of the Māhāʻulepū coast is a rare remnant of a landscape type that has almost vanished in Hawaiʻi due to human settlement and development. Its visible layers reveal the story of global sea level changes—and accompanying changes in landscape—over the last 300,000 years. The dunes and Makauwahi cave harbor an abundance of rare and extinct plant and animal fossils including 45 species of extinct birds. Sediment layers sealed within Makauwahi sinkhole afford a unique sequential look at Hawaiʻi biota over a span of 10,000 years. Māhāʻulepū dunes and underlying caves, especially Makauwahi, have been the site of significant natural resource discoveries over the last two decades, and are the ongoing focus of international scientific interest.

The volcanic vents of the Kōloa plain, ancient layered basalts of Hāʻupu Ridge, and dunes of Māhāʻulepū are manifestations of geologic processes dating from the birth of the high Hawaiian islands to the present—an observable age range available only on Kauaʻi, the state's geologically oldest high island.

Habitats of the study area provide critical refuge for endemic Hawaiian plant and animal species whose survival is in jeopardy.

- The only known living examples of two endangered arthropods—the Kauaʻi cave wolf spider and the Kauaʻi cave amphipod —cling to life in the confines of caves on the Māhāʻulepū coast.

- Mt. Hāʻupu's summit hosts nearly ninety plant species endemic to Hawaiʻi, including more than two dozen endemic to Kauaʻi only, and some restricted to just Mt. Hāʻupu. USFWS has designated six species as endangered, one as threatened and six as Species of Concern. Parts of Hāʻupu ridge are designated Critical Habitat for eleven endemic plant species.
- The endangered and nearly extinct Hawaiian monk seal rests and nurses its pups on study area beaches.
- Hawaiʻi's four endemic endangered waterfowl—the Hawaiian duck, stilt, coot and moorhen—breed at Hulēʻia and other protected sites, and feed at remnant wetlands and manmade water features throughout the study area.
- The endemic endangered nēnē, or Hawaiian goose, is making a comeback on Kauaʻi thanks in part to breeding habitat at Kīpū Kai and foraging opportunities at study area sites.
- Newell's shearwater, a Threatened endemic species, nests on Hāʻupu ridge.
- Native coastal strand vegetation includes thirteen endemic plant species at increasing risk of disappearance due to continuing shoreline development throughout Hawaiʻi. The Māhāʻulepū coastal corridor is designated Critical Habitat for the endangered ʻohai (*Sesbania tomentosa).*

By definition, these endemic species—found in Hawaiʻi and nowhere else—have always been uncommon. Today, they depend on habitats in the study area for their continued survival on earth.

Relatively intact native plant communities, made up mostly of endemic and indigenous species, persist in the coastal strand vegetation and on the upper reaches of Hāʻupu ridge. Indigenous and migrant birds roost and nest at Hulēʻia, Niumalu, Kīpū Kai, and undisturbed sites along the Māhāʻulepū coast.

Dramatic topography and unusual contrasts in form create a study area landscape with outstanding scenic qualities. Mt. Hāʻupu and its arms rise majestically out of the Kōloa plain, a green beacon visible from all directions. Along the Māhāʻulepū shoreline, the weathered seacliffs, dunes and limestone crannies offer an intriguing window into the past, and the lateral coastal vista remains entirely undeveloped. Untrammeled beaches and a backdrop of green help establish the feeling of a remote wilderness, despite the study area's accessible location between two population centers

Nationally significant cultural resources within the study area are Mt. Hāʻupu, Makauwahi Cave, and Alekoko Fishpond; other sites may prove significant upon further investigation. Mt. Hāʻupu is a revered *wahi kapu*, or sacred place, within native Hawaiian culture. Ku and Hina—the earliest Hawaiian god and goddess, the patron gods of fishermen, and the embodiments of procreative power—reside on Hāʻupu Ridge. A notable landmark and navigation aid for seafarers, Hāʻupu features in the first documented sighting of Hawaiʻi by a westerner, Captain James Cook. The first European drawing of Hawaiʻi is of the Māhāʻulepū Coast, with Mt. Hāʻupu as its focal point.

Makauwahi cave's uniquely well-preserved fossils and artifacts tell a nearly continuous tale of Hawaiʻi people on the land over the last millennium. Remnants of tools, ornaments,

food, craft supplies and fishing gear provide a record of human activity; fossilized seeds, shells, bones and organic debris reveal a changing mix of native and nonnative plants and animals; and sediment strata speak of environmental events that shaped both land and people. In combination with oral and archival sources, the finds at Makauwahi Cave shed new light on Hawai‘i’s human story, and chronicle the transformation of Hawai‘i’s landscape and biota through a thousand years of dynamic cultural change.

Alekoko Fishpond, an aquaculture site built by early Hawaiians around 1200 A.D., was recognized by NPS over thirty years ago as “worthy of preservation as part of the cultural heritage of the State of Hawai‘i and the United States of America.” Hawai‘i’s prehistoric manmade ponds were the most extensive and innovative in the Pacific; the best ones were held by royalty as both a symbol of status and a source of food. Among the examples that survive today, Alekoko is a rare example of a royal pond located on a stream, rather than at the ocean, and it is the largest inland manmade historic fishpond in Hawai‘i. Alekoko remains worthy of preservation as part of the state and national heritage, provided that overgrown mangrove can be removed from its rock walls without undue damage.

Bracketed between two population centers, the study area nevertheless still embraces significant places with relative resource integrity, against a backdrop of current and historic agricultural lands. Poised at the brink of the 21st century but not yet urbanized, this span of undeveloped coast offers unique opportunities for understanding the dynamic forces that shaped Hawai‘i—volcanic birth, sea level changes, human settlement and expansion, and native ecosystems struggling to survive the impacts of people and natural events. The Māhā‘ulepū coast in particular affords excellent venues not only for interpretation and education, but also for outdoor recreation. Other significant sites such as Alekoko Fishpond, Kīpū Kai, Hā‘upu ridge, and Makauwahi cave merit extensive further scientific study, and careful management to assure appropriate use.

5.1.2 Suitability

> *To be considered suitable, an area must represent a natural or cultural theme or type of recreational resource that is not already adequately represented in the National Park System or is not comparably represented and protected for public enjoyment by another land-managing entity. Adequacy of representation is determined on a case-by-case basis by comparing the proposed area to other units in the National Park System for differences or similarities in the character, quality, quantity, or combination of resources, and opportunities for public enjoyment.*

Significant resources in the study area represent themes and types that are suitable for protection within the framework of the national park system, and are not otherwise adequately protected in the state or nation. Volcanic features of the study area represent a stage and range of geologic development of the Hawaiian high islands not available at other Hawai‘i parks. Landforms and fossils of the Māhā‘ulepū coast illustrate the reality of global climate and sea level change, as well as the impacts of human settlement on native ecosystems. An extensive and undeveloped Hawai‘i shoreline within easy reach of population centers, such as that found in the study area, is a rare and rapidly vanishing type

of recreational resource prized by U.S. citizens and international visitors as well as Hawai‘i residents. Protection and management of this resource type is currently inadequate at federal, state and local levels.

5.1.3 Feasibility

> *To be considered feasible, an area's natural systems and/or historic settings must be of sufficient size and appropriate configuration to ensure long-term protection of the resources and to accommodate public use. The area must have potential for efficient administration at a reasonable cost. Other important feasibility factors include landownership, acquisition costs, access, threats to the resource, and staff or development requirements.*

The study area’s significant resources are of a collective size and configuration that would be feasible to manage for protection and public enjoyment, provided that NPS, affected landowners, and local and state stakeholders collaborate to identify and reduce threats, manage access, and ensure long-term protection of the area’s overall scenic quality. To manage costs, NPS would need to emphasize partnerships and minimize outright land acquisition.

Because sensitive conservation areas are mingled with active agricultural land throughout the study area, future activities on agricultural land could cause major impacts on significant resources. In addition, vehicular public access to the Māhā‘ulepū coast—the portion of the study area best suited for public recreation—depends on roadways through private land. Successful resource protection and management will depend on willing cooperation by all parties.

The National Park Service manages a variety of designated units including parks, recreation areas, seashores, national historic sites, monuments, reserves and preserves. In some cases, enabling legislation for a designated NPS unit provides for continued private land ownership, ongoing community uses, and sharing of management costs and responsibilities via agency or community partnerships.

For example, Ebey’s Landing National Historic Reserve includes extensive private land, with NPS holding some 3500 acres in easement to retain historic agricultural lands and exclude rural subdivisions. Craters of the Moon National Monument and Preserve allows for hunting and grazing on Preserve acreage. City of Rocks National Reserve encompasses private land within its boundary, where NPS holds conservation easements and grazing is permitted. In potential units where nonprofit land trusts can secure conservation easements on agricultural lands and/or certain significant natural and cultural resources, NPS can focus on the remaining significant resources that would benefit most from NPS management.

Scrutiny of such options and how they might apply to the current study area is beyond the scope of this reconnaissance survey. If a Special Resource Study is conducted, it would identify, examine and compare alternatives that appear to hold promise.

5.2 Other Findings

Notable partners have been involved in research, management, or resource protection within the study area, or have expressed interest in involvement. Besides the landowners, they include local land trusts, Trust for Public Land, The Nature Conservancy, National Tropical Botanical Garden, Mālama Māhāʻulepū, Sierra Club, Smithsonian Institution, National Geographic Society, Bishop Museum, County of Kauaʻi, Kauaʻi Community College, and State of Hawaiʻi Department of Land and Natural Resources.

Since the development of the Hyatt Resort by the south end of the study area in the 1980s, residents and government officials have expressed ongoing concern about the potential for further development that would impact resources and affect public use of the Māhāʻulepū coast. To some extent discussion has become polarized, with preservation advocates and landowners viewing each other through a cloud of mutual suspicion and wariness, and shaping their communications with each other based on that view. Great potential exists for creative management of resources within the study area, but a constructive framework for stakeholder discussion is needed.

It is also worth noting that since 2002, Hawaiʻi Congressional officials on behalf of Hawaiʻi residents asked the National Park Service to conduct reconnaissance surveys on three southeast shores of Hawaiian islands: at Keoneʻōʻio on Maui, Kaʻū on Hawaiʻi, and Māhāʻulepū on Kauaʻi. In general, these coasts are relatively dry, traditionally rural and lacking in infrastructure; they are the last major bastions of undeveloped, unmanaged accessible shoreline in Hawaiʻi.

In all three instances, residents unsuccessfully sought state and local protections, and then expressed interest in the concept of a National Seashore, in the hope that such a designation would protect the resources in perpetuity and allow for continued community uses. The request for federal protection is an index of fear that Hawaiʻi residents express about growing tourism, population and development, and a concomitant loss of access to coastal wilderness.

Hawaiʻi serves as a multi-island playground for the nation and the world, hosting nearly 7.6 million visitors per year, but its tax base depends on a statewide resident population of only 1.3 million people (USC 2007). Local and state financial resources may be insufficient to protect sensitive Hawaii seashores from development.

5.3 Recommendation

The National Park Service Pacific West Region recommends that a Special Resource Study be authorized under the stipulations of Public Law 105-391, so long as it focuses on non-traditional management alternatives that a) involve local partners and b) include options for continued farm and ranch operations on private agricultural lands.

6 APPENDICES

6.1 How NPS Evaluates Significance of Resources

Natural resource significance may be associated with the following types of sites:

- an outstanding site that illustrates the characteristics of a landform or biotic area that is still widespread;
- a rare remnant natural landscape or biotic area of a type that was once widespread but is now vanishing due to human settlement and development;
- a landform or biotic area that has always been extremely uncommon in the region or nation;
- a site that possesses exceptional diversity of ecological components (species, communities, or habitats) or geological features (landforms, observable manifestations of geologic processes);
- a site that contains biotic species or communities whose natural distribution at that location makes them unusual (for example, a relatively large population at the limit of its range or an isolated population);
- a site that harbors a concentrated population of a rare plant or animal species, particularly one officially recognized as threatened or endangered;
- a critical refuge that is necessary for the continued survival of a species;
- a site that contains rare or unusually abundant fossil deposits;
- an area that has outstanding scenic qualities such as dramatic topographic features, unusual contrasts in landforms or vegetation, spectacular vistas, or other special landscape features;
- a site that is an invaluable ecological or geological benchmark due to an extensive and long-term record of research and scientific discovery.

Cultural resource significance may be attributed to districts, sites, structures, or objects that possess exceptional value or quality in illustrating or interpreting our heritage and that possess a high degree of integrity of location, design, setting, materials, workmanship, feeling, and association. Specific examples include:

- a resource that is associated with events that have made a significant contribution to and are identified with, or that outstandingly represent the broad national patterns of United States history and from which an understanding and appreciation of those patterns may be gained;
- a resource that is importantly associated with the lives of persons nationally significant in the history of the United States;
- a resource that embodies distinguishing characteristics of an architectural type specimen, exceptionally valuable for study of a period, style, or method of construction, or represents a significant, distinctive and exceptional entity whose components may lack individual distinction;
- a resource that is composed of integral parts of the environment not sufficiently significant by reason of historical association or artistic merit to warrant individual

recognition but collectively composes an entity of exceptional historical or artistic significance, or outstandingly commemorates or illustrates a way of life or culture;
- a resource that has yielded or may be likely to yield information of major scientific importance by revealing new cultures, or by shedding light upon periods of occupation over large areas of the United States.

Many units of the national park system have been established to recognize their important role in providing recreational opportunities. The potential for public use and enjoyment is an important consideration in evaluating potential new additions to the National Park System. However, recreational values are not evaluated independently from the natural and cultural resources that provide the settings for recreational activities.

6.2 Study Area Species Lists

The species lists shown below are based on NPS observations, limited research, and reliable reports from local researchers, government officials, and residents. Locations of specific sightings are intentionally omitted.

6.2.1 Coastal Vegetation

Since staff had limited time to explore or botanize, this list should not be considered to cover all species present or their full range of distribution.

E=Endemic (found in Hawaii and nowhere else); I=Indigenous (native to Hawai‘i but not endemic); A=Alien; SOC= federal Species of Concern (USFWS); END=federally listed Endangered Species; GCN=State of Hawai‘i Species of Greatest Conservation Need.

Scientific Name	Common / Hawaiian Name	Family	Status
Boerhavia repens?	Alena, anena, nena	Nyctaginaceae	I
Capparis sandwichiana	Hawaiian caper, maiapilo	Capparaceae	E, SOC, GCN
Chamaesyce degeneri	beach spurge, koko, 'akoko	Euphorbiaceae	E
Cocos nucifera	coconut palm, niu	Arecaceae	A
Cordia subcordata	kou	Boraginaceae	I
Dodonaea viscosa	'a'ali'i	Sapindaceae	I, GCN
Erythrina sandwicensis	Wiliwili	Fabaceae	E, GCN
Gossypium tomentosum	Hawaiian cotton, ma'o, uluhulu	Malvaceae	E, GCN
Heliotropium anomalum var. *argenteum*	Beach heliotrope, hinahina, hinahina ku kahakai	Boraginaceae	I , GCN
Ipomea indica	Morning glory koali ‘awa	Convolvulaceae	I
Ipomea pes-caprae	Beach morning glory, pohuehue	Convolvulaceae	I, GCN
Jacquemontia ovalifolia subsp. *Sandwicensis*	Pa’u o Hi’iaka	Convolvulaceae	E
Kokia Kaua‘iensis	koki'o	Malvaceae	E, GCN
?*Lipochaeta integrifolia*	nehe, ko'oko'olau	Asteraceae	E, GCN
Morinda citrifolia	noni tree, noni kuahiwi	Rubiaceae	E
Munroidendron racemosum	tree	Araliaceae	E, GCN
Myoporum sandwicense	false sandalwood, naio	Myoporaceae	I, GCN
Osteomeles anthyllidifolia	u‘ulei	Rosaceae	I, GCN

Pandanus tectorius	screwpine, hala	Pandanaceae	I, GCN
Pritchardia cf *minor*	loulu	Arecaceae	E
Pritchardia elmerrobinsoni	Ni'ihau lolou palm, loulu	Arecaceae	E
Ruppia martima	ditchgrass, widgeon grass	Potamogetonaceae	I
Scaevola taccada	Beach naupaka, naupaka kahakai	Goodeniacea	I
Schiedea sp.	ma'oli'oli	Caryophyllaceae	E
**Sesbania tomentosa*	'ohai	Fabaceae	E , END, GCN
Sesuvium portulacastrum	Sea purslane, 'akulikuli	Aizoaceae	I, GCN
Sida fallax	'Ilima, 'ilima ku kahakai, 'ilima papa	Malvaceae	I, GCN
Thespesia populnea	portia tree, milo	Malvaceae	I
Tournefortia argentea	tree heliotrope	Boraginaceae	A
Waltheria indica	'uhaloa	Sterculiaceae	I

* Federally designated Critical Habitat along Māhā'ulepū coastal corridor. Not seen during survey.

6.2.2 Notable Rare Plants of Hā'upu

Of 112 native plant species identified on the summit of Mt. Hā'upu during research in 2005, botanist Ken Wood identified a subset of endemic vascular plants which urgently need action to carry out conservation collections, due to their rarity. Shown below, they are taken from Wood's *Summary Report of Botanical Research, Hā'upu Summit, Kaua`i, Hawai'i (550—700 m [1800—2297 ft] elevation), August 2005.*

E=Endemic (found in Hawaii and nowhere else); I=Indigenous (native to Hawai'i but not endemic); A=Alien; SOC= federal Species of Concern (USFWS); END=federally listed Endangered Species; GCN=State of Hawai'i Species of Greatest Conservation Need; GSN=State of Hawai'i Genetic Safety Net species.

Species	Common / Hawaiian Name	Family	Status
Bonamia menziesii		Convolvulaceae	E, END, GCN
Delissea rhytidosperma		Campanulaceae	E, SIE, END, GCN, GSN
Dubautia laxa subsp *pseudoplantaginea* [New sp.?]	na'ena'e, pua melemele	Asteraceae	E [New sp.?]
Hedyotis fluviatilis	kamapua'a, pilo	Rubiaceae	E, SOC
Hedyotis sp. nov. [unnamed]		Rubiaceae	?
Hibiscus kokio	koki'o 'ula, mākū	Malvaceae	E, SOC
Isodendrion longifolium	aupaka	Violaceae	E,T, GCN
Lepidium orbiculare	'ānaunau	Brassicaceae	E,SIE
Lipochaeta micrantha var. *exigua*	nehe	Asteraceae	E,SIE,END
Lobelia Ni'ihauensis		Campanulaceae	E,END
Lobelia sp. [new sp.?]		Campanulaceae	E [new sp.?]
Munroidendron racemosum		Araliaceae	SIE, GCN
Myrsine linearifolia	kōlea	Myrsinaceae	E,V,SIE, GCN
Peucedanum sandwicense	makou.	Apiaceae	E,T, GCN
Pittosporum gayanum	hō'awa	Pittosporaceae	E, SIE
Schiedea perlmanii		Caryophyllaceae	E,SIE, END, GCN
Tetraplasandra bisattenuata	'ohe mauka	Araliaceae	E, SIE,SOC, GCN, GSN

6.2.3 Native Birds

This list includes nine native bird species noted on the March 2007 NPS site visit, plus seven others documented during interviews or from research. It should not be considered a definitive list of all native bird species in the study area.

E = endemic at the species or subspecific level; I = indigenous; M = migrant; T = federally listed Threatened Species; END = federally listed Endangered Species.

Species	Common / Hawaiian Name	Family	Status
Anas wyvilliana	Hawaiian Duck, Hanamā‘ulu	Anatidae	E, END
Arenaria interpres	Ruddy Turnstone, ‘Akekeke	Scolopacidae	M
Asio flammeus sandwichensis	Short-eared or Hawaiian Owl	Strigidae	E
Branta sandvicensis	Hawaiian Goose, Nēnē	Anatidae	E, END
Calidris alba	Sanderling, Hunakai	Scolopacidae	M
Fregeta minor palmerstoni	Great Frigatebird, ‘Iwa	Fregatidae	I
Fulica alai	Hawaiian Coot, ‘Alae keo’keo	Rallidae	E, END
Gallinula chloropus sandvicensis	Common Moorhen, ‘Alae ‘ula		E, END
Heteroscelus incanus	Wandering Tattler, ‘Ulili	Scolopacidae	M
Himantopus mexicanus knudseni	Hawaiian Stilt, Ae’o	Recurvirostridae	E, END
Nycticorax nycticorax hoactli	Black-crowned Night-heron, ‘Auku’u	Ardeiidae	I
Phaethon lepturus dorotheae	White-tailed Tropicbird, Koa’e kea	Phaethontidae	I
Phaethon rubricauda melanorhynchos	Red-tailed Tropicbird, Koa’e ‘ula	Phaethontidae	I
Pluvialis fulva	Pacific Golden Plover, Kolea	Charadridae	M
Puffinus auricularis newelli	Newell’s Shearwater, ‘A’o	Procellidae	E, T
Puffinus pacificus	Wedge-tailed Shearwater, ‘Ua’u kani	Procellidae	I

6.2.4 Marine Fishes

Fishes shown here are taken from three sources: NPS observations during the site visit; recorded observations at Kipu Kai and Māhā‘ulepū by trained volunteers for Reef Environmental Education Foundation (REEF); and information from David Waterhouse of Kipu Kai, based on fish catches noted in Kipu Kai guestbooks.

Species	Common / Hawaiian Name	Family
Abudefduf abdominalis	Hawaiian Sergeant, mamo	Pomacentridae
Abudefduf sordidus	Blackspot Sergeant, kupipi	Pomacentridae
Acanthurus achilles	Achilles Tang, paku‘iku‘i	Acanthuridae
Acanthurus nigrofuscus	brown surgeonfish, ma’i’i’i	Acanthuridae
Acanthurus nigroris	Bluelined Surgeonfish, maiko	Acanthuridae
Acanthurus olivaceus	Orangeband Surgeonfish, na‘ena‘e	Acanthuridae
Acanthurus triostegus	convict tang, manini	Acanthuridae
Aetobatus narinari	Spotted Eagle Ray, hihimanu	Myliobatidae
Arothron meleagris	Guineafowl Puffer, moa	Tetraodontidae
Aulostomus chinensis	Trumpetfish, nunu	Aulostomidae
Cantherhines sandwichiensis	Squaretail Filefish, o‘ili lepa	Monacanthidae
Canthigaster jactator	Hawaiian Whitespotted Toby	Tetraodontidae
Caranx ignobilis	giant trevally, ulua aukea	Carangidae

Caranx melampygus	bluefin trevally, omilu	Carangidae
Caranx ignobilis	juvenile giant trevally, papio	Carangidae
Chaetodon sp.	butterfly fish, kikakapu	Chaetodontidae
Chaetodon auriga	Threadfin Butterflyfish, kikakapu	Chaetodontidae
Chaetodon fremblii	Bluestripe Butterflyfish kikakapu,	Chaetodontidae
Chaetodon lunula	Raccoon Butterflyfish, kikakapu	Chaetodontidae
Chaetodon miliaris	Milletseed Butterflyfish, lau wiliwili	Chaetodontidae
Chaetodon multicinctus	Multiband Butterflyfish, kikakapu	Chaetodontidae
Chaetodon quadrimaculatus	Fourspot Butterflyfish, lauhau	Chaetodontidae
Chaetodon unimaculatus	Teardrop Butterflyfish, kikakapu	Chaetodontidae
Chlorurus sordidus	Bullethead Parrotfish, uhu	Scaridae
Chromis vanderbilti	Blackfin Chomis	Pomacetridae
Cirrhitops fasciatus	Redbarred Hawkfish, pilikoa	Cirrhitidae
Coris gaimardi	Yellowtail Coris, hinalea ʻakilolo	Labridae
Dascyllus albisella	Hawaiian Dascyllus	Pomacetridae
Echidna nebulosa (juvenile)	snowflake eel, puhi kappa	Muraenidae
Gambusia affinis	Western mosquitofish (Introduced)	Poeciliidae
Gomphosus varius	Bird Wrasse, hinalea iʻiwi	Labridae
Gymnothorax undulatus	undulated moray, puhi	Muraenidae
Holacanthus arcuatus	Bandit Angelfish	Pomacanthidae
Istiblennius zebra	zebra rockskipper, pao'o	Blenniidae
Kuhlia sandvicensis	Hawaiian flagtail, aholehole	Kuhliidae
Kyphosus sp.	Gray/Highfin/Lowfin Chub, nenue	Kyphosidae
Labroides phthirophagus	Hawaiian Cleaner Wrasse	Labridae
Lutjanus fulvus	Blacktail Snapper, toʻao	Lutjanidae
Lutjanus kasmira	Bluestripe Snapper, taʻape	Lutjanidae
Melichthys niger	Black Durgonm humuhumu ele ele	Balistidae
Melichthys vidua	Pinktail Durgon, humuhumuhiʻukole	Balistidae
Monotaxis grandoculis	Bigeye Emperor, mu	Lethrinidae
Mugil cephalis	mullet (juvenile), ʻamaʻama	Mugilidae
Mulloidichthys flavolineatus	Yellowstripe Goatfish, wekeʻa	Mullidae
Mulloidichthys vanicolensis	Yellowfin Goatfish, wele ʻula	Mullidae
Myripristis berndti	Bigscale Soldierfish, ʻuʻu	Holocentridae
Naso lituratus	Orangespine Unicornfish, umaumalei	Acanthuridae
Naso unicornis	bluespine unicornfish, kala	Acanthuridae
Oplegnathus punctatus	Spotted Knifejaw	Oplegnathidae
Ostracion meleagris	Spotted Boxfish, moa	Ostraciidae
Paracirrhites arcatus	Arc-Eye Hawkfish, pilikoʻa	Cirrhitidae
Paracirrhites forsteri	Blackside Hawkfish, hilu pilikoʻa	Cirrhitidae
Parupeneus bifasciatus	Doublebar Goatfish	Mullidae
Parupeneus multifasciatus	Manybar Goatfish, moano	Mullidae
Plectroglyphidodon johnstonianus	Blue-eye Damselfish	Pomacetridae
Polydactylus sexfilis	6-fingered threadfin, moi	Polynemidae
Priacanthus meeki	Hawaiian Bigeye, ʻʻĀweoweo	
Pseudocheilinus octotaenia	Eightstripe Wrasse	Labridae
Rhinecanthus rectangulus	Reef Triggerfish, humuhumu nukunuku apuaʻa	Balistidae
Selar crumenopthalmus	bigeye scad, akule	Carangidae
Seriola dumerili	greater amberjack, kahala	Carangidae
Stegastes fasciolatus	South Pacific Gregory	Pomacetridae
Sufflamen bursa	Lei Triggerfish, humuhumu lei	Balistidae
Thalassoma duperrey	Saddle Wrasse, hinalea lauwili	Labridae
Thalassoma trilobatum	Christmas Wrasse, ʻawela	Labridae
Zanclus cornutus	Moorish Idol, kihikihi	Zanclidae

6.2.5 Algae

Species	Common / Hawaiian Name	Family
Asparagopsis taxiformis	limu kohu, limu lipehe	Bonnemaisoniaceae
?*Centroceras* cf. *clavulatum*		Ceramiaceae
Cladophora sp.	green filamentous algae	Cladophoraceae
Codium arabicum	limu 'a 'ala'ula	Codiaceae
Dasya iridescens	iridescent red algae	Dasyaceae
Dictyota sp.		Dictyotaceae
Dictyota sandvicensis		Dictyotaceae
Halimeda discoidea	green calcareous algae	Halimedaceae
Dictyosphaeria cavernosa	green bubble algae	Siphonocladaceae
Colpomenia sinuosa	brown bubble algae	Scytosiphonaceae
Laurencia cf. *mcdermidiae*		Rhodomelaceae
Martensia fragilis	fragile red algae	Delessariaceae
Asteronema breviarticulatum	intertidal brown filimentous algae	Scytothamnaceae
Padina sp.		Dictyotaceae
Peysonnellia sp.	crustose red algae	Peysonneliaceae
Galaxaura sp.		Galaxauraceae
Sargassum echinocarpum	limu kala	Sargassaceae
Turbinaria ornata		Sargassaceae
Ahnfeltiopsis coccinea	limu 'aki'aki	Phyllophoraceae
Wrangelia elegantissima		Ceramiaceae
?*Haliptilon subulatum*		Corallinaceae
?*Stenopeltis gracilis*	red calcareous algae	Liagoraceae
Lithophyllum sp.	red coralline algae, crustose coralline algae	Corallinaceae

6.2.6 Marine Invertebrates

Species	Common / Hawaiian Name	Family
Corals (Cnidaria)		
Cladactella manni	Mann's anemone	Actiniidae
Palythoa caesia	soft coral, limu make o Hana	Zoantharia
Fungia sp. skeleton juveniless	solitary coral, ‘ako’ako’a kohe	Fungiidae
Montipora capitata	rice coral, ‘ako’ako’a, ko’a	Acroporidae
Montipora cf. *flabellata*	blue rice coral, ako’ako’a, ko’a	Acroporidae
Pocillopora sp.	'ako'ako'a, ko'a, puna kea	Pocilloporidae
Pocillopora meandrina	cauliflower coral, ‘ako’ako’a, ko’a	Pocilloporidae
Pocillopora edouxi	cauliflower coral, ako’ako’a, ko’a	Pocilloporidae
Porites evermanni	mound coral, pohaku puna	Poritidae
Porites lobata	mound coral, pohaku puna	Poritidae
Worms (Annelida)		
Loimia medusa	spaghetti worm	
Molluscs (Mollusca):		
Cassis cornutus	conch snail, pu puhi	Cassididae
Cellana exarata	black-foot limpet, 'opihi makaiauli	Patellidae
Conus sp.	cone snail, pupu ‘ala	Conidae
Cypraea spp,	cowry, leho	Cypraeidae
Cypraea granulata	cowry, leho ‘okala, leho opu ‘upu’u	Cypraeidae
Dendropoma gregaria	tube snail, kauna'oa	Vermetidae

Drupa morum	snail, makaloa	Thaididae
Drupa ricina	snail, makaloa	Thaididae
Hipponix foliaceus	hoof snail	Hipponicidae
Littoraria pintado	periwinkle snail, pipipi kolea	Littorinidae
Nerita picea	black nerite snail, pipipi	Neritidae
Nerita polita	polished nerite, kupe'e	Neritidae
Periglypta reticulata	reticulated clam	Veneridae
Purpura aperta	snail	Muricidae
Serpulorbis sp.	tube snail, kauna'oa	Vermetidae
Serpulorbis variabilis	tube snail, kauna'oa	Vermetidae
Siphonaria normalis	false 'opihi, 'opihi-'awa	Siphonariidae
Turbo sandwicensis	Hawaiian turban, 'alilea, pupu mahina	Turbinidae
Crustaceans (Arthropoda)		
Calcinus sp.	hermit crab, unauna	Diogenidae
Grapsus tenuicrustatus	rock crab, 'a'ama	Grapsidae
Ocypode pallidula	pallid ghost crab, 'ohiki	Ocypodidae
Panulirus sp. (molt)	spiny lobster, ula	Palinuridae
Echinoderms (Echinodermata)		
Brissus latecarinatus	keeled heart urchin, ha'uke'uke kaupali	Brissidae
Colobocentrotus atratus	shield urchin,	Echinometridae
Echinometra sp.	boring sea urchin, 'ina kea	Echinometridae
Heterocentrotus mammillatus	pencil urchin, ha'uke'uke 'ula'ula	Echinometridae
Actinopyga mauritiana	white-spotted sea cucumber, loli	Holothuriidae
Holothuria atra	black sea cucumber, loli okuhi kuhi	Holothuriidae

6.2.7 Introduced Plant and Animal Threats

Threats as observed by NPS staff or reported by researchers or state wildlife officials.

Scientific Name	Common / Hawaiian Name	Family
?Canavaliea sericea	Beach pea, silky jackbean	Fabaceae
?Verbesina enceloides	golden crown-beard	
Albizia sp.	Albizia	Fabaceae
Caesalpinia decapetala	Cat's claw, Puakelekino	Fabaceae
Casuarina equisetifolia	Ironwood, p'āina	Casuarinaceae
Leucaena leucocephala	Koa haole, ekoa	Fabaceae
Opuntia sp	prickly pear cactus, panini, papipi	Cactaceae
Paederia foetida (*P. scandens*)	(coffee family), Maile pilau	Rubiaceae
Panicum maximum	Guinea grass	Poaceae
Passiflora laurifolia	Yellow water lemon, passion flower	Passifloraceae
Prosopis sp. Prosopis pallida	mesquite, Kiawe	Fabaceae
Psidium cattleianu	Strawberry guava, Waiawi, 'ula'ula	Myrtaceae
Psidium guajava	Guava, Kuawa	Myrtaceae
Rhizophora mangle	Red mangrove	Rhizophoraceae
Rhodomyrtus tomentosa	Downy rose myrtle	Myrtaceae
Rubus rosifolius	Thimbleberry, Olaa	Rosaceae
Schinus terebinthifolius	Christmas berry, naniohilo, wilelaiki	Anacardiaceae
Syzygium cumini	Java plum	Myrtaceae
Terminalia catappa	false kamani tree, kamani haole	Combretaceae
Capra hircus	Feral goats	Bovidae
Rattus sp.	Rats	Muridae
Sus scrofa	Feral pigs	Suidae

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4.1	12	Lithified dunes (2)	NPS – Larry Basch
4.1	13	Cave opening	NPS – Larry Basch
4.1	14	Sinkhole walls	NPS – Larry Basch
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4.2.1	16	Hawaiian cotton	NPS – Larry Basch
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4.2.2	18	Uluhe, uluhe lau nui, ‘ōhi‘a (3)	Forest & Kim Starr
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4.3.1	19	Nēnē	Forest & Kim Starr
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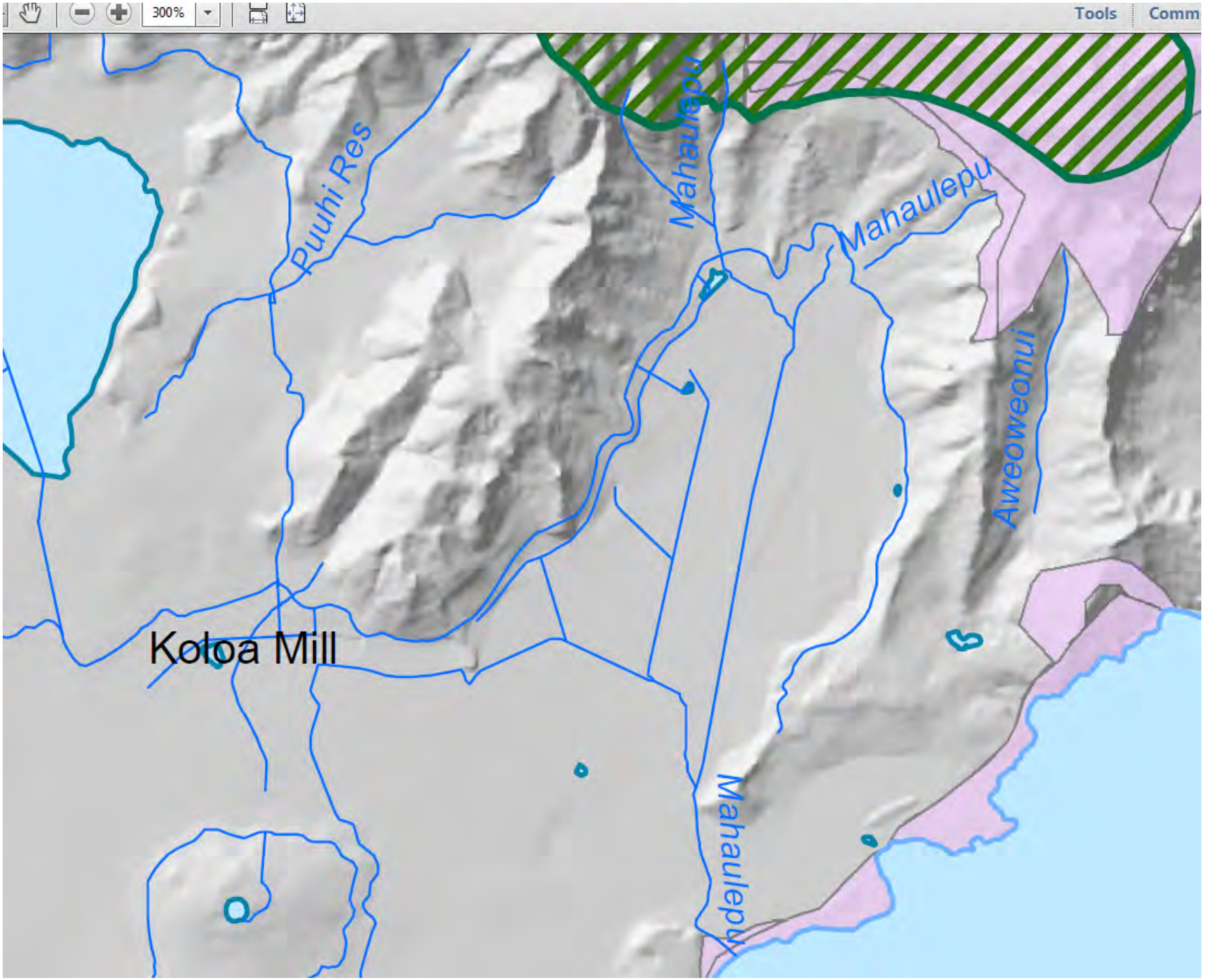
Exhibit C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Mahaulepu
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Koloa Mill
Mahaulepu

Explanation

Quality Standards Classification

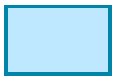
Inland Classification

Class 1

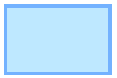
Critical Habitats (Class 1)

Class 2

NHD Streams


NHD Waterbodies

Marine Classification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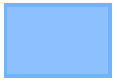
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