Instream Flow Standard Assessment Report

Island of Maui
Hydrologic Unit 6055
Waiokamilo

September 2008 **PR-2008-04**

State of Hawaii
Department of Land and Natural Resources
Commission on Water Resource Management

COVER
Waiokamilo Stream meets the Pacific Ocean in the terminal Waiokilo Falls in the lower section of the photo. The hydrologic unit spans from Pauwalu Point (top center), with Mokumana Islet just offshore, to the midway point between Waiokilo Falls and the mouth of Wailuanui Stream (not shown) [Google Earth, 2008].

Note: This report is intended for both print and electronic dissemination and does not include diacritical marks in spelling of Hawaiian words, names, and place names due to problems associated with its use electronically. However, Commission staff has made attempts to include diacritical marks in direct quotations to preserve accuracy.

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Acronyms and Abbreviations

A&B	Alexander & Baldwin
AG	agricultural
ALISH	Agricultural Lands of Importance to the State of Hawaii
ALUM	agricultural land use maps [prepared by HDOA]
BFQ	base flow statistics
BLNR	Board of Land and Natural Resources (State of Hawaii)
C-CAP	Coastal Change Analysis Program
cfs	cubic feet per second
Code	State Water Code (State of Hawaii)
COM	commercial
Commission	Commission on Water Resource Management (DLNR)
CPRC	Compilation of Public Review Comments (PR-2008-07, CWRM)
CWA	Clean Water Act (EPA)
CWRM	Commission on Water Resource Management (State of Hawaii)
DAR	Division of Aquatic Resources (State of Hawaii)
DBEDT	Department of Business, Economic Development and Tourism (State of Hawaii)
DLNR	Department of Land and Natural Resources (State of Hawaii)
DHHL	Department of Hawaiian Home Lands (State of Hawaii)
DOH	Department of Health (State of Hawaii)
DWS	Department of Water Supply (County of Maui)
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMI	East Maui Irrigation Company
EMWP	East Maui Watershed Partnership
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency (Department of Homeland Security)
FILEREF	File Reference [in the Commission's records of registered diversions]
ft	feet
gad	gallons per acre per day
GIS	Geographic Information Systems
G.L.	Government Lease
GOV	government
gpm	gallons per minute
Gr.	Grant
HAR	Hawaii Administrative Rules
HC&S	Hawaiian Commercial and Sugar Company
HDOA	State Department of Agriculture (State of Hawaii)
HI-GAP	Hawaii Gap Analysis Program
HOT	hotel
HRS	Hawaii Revised Statutes
HSA	Hawaii Stream Assessment
IFS	instream flow standard
IFSAR	Instream Flow Standard Assessment Report
IND	industry
IRR	irrigation requirements
IWREDSS	Irrigation Water Requirement Estimation Decision Support System
LCA	Land Commission Award
LCL	lower confidence level
LUC	Land Use Commission (State of Hawaii)
MECO	Maui Electric Company
MF	multi-family residential
mgd	million gallons per day

mi	mile
MLP	Maui Land and Pineapple Company, Inc.
MOU	Memorandum of Understanding
na	not available
NAWQA	National Water Quality Assessment (USGS)
NHLC	Native Hawaiian Legal Corporation
NIR	net irrigation requirements
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NRCS	Natural Resource Conservation Service (USDA)
NVCS	National Vegetation Classification System
REL	religious
RMT	R.M. Towill Corporation
SCS	Soil Conservation Service (United States Department of Agriculture)
	Note: The SCS is now called the Natural Resources Conservation Service (NRCS)
SF	single family residential
SPI	Standardized Precipitation Index
sq mi	square miles
TFQ	total flow statistics
TFQ_{50}	50 percent exceedence probability
TFQ_{90}	90 percent exceedence probability
TMDL	Total Maximum Daily Load
TMK	Tax Map Key
UCL	upper confidence level
UHERO	University of Hawaii's Economic Research Organization
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service (Department of the Interior)
USGS	United States Geological Survey (Department of the Interior)
WQS	Water Quality Standards
WRPP	Water Resource Protection Plan (Commission on Water Resource Management)
WTF	water treatment facility

1.0 Introduction

General Overview

The hydrologic unit of Waiokamilo is located on the northeast slope of the East Maui Volcano (Haleakala), which forms the eastern part of the Hawaiian island of Maui (Figure 1-3). It covers an area of 2.45 square miles from the slopes of Haleakala at 4,891 feet elevation to the sea. The topography is gently sloping except for the steep sides of the Keanae Valley walls that are nearly 1,000 feet high (Gingerich, 2005). Waiokamilo Stream is 4.4 miles in length, traversing in a northeasterly direction from its headwaters originating in the Koolau Forest Reserve to Waiokilo Falls before entering the ocean. Tributary to the Waiokamilo Stream is Kualani Stream, which is 2.1 miles in length. Most of the hydrologic unit is made up of forest reserves that cover slopes down to about 700 feet. The lower elevations are occupied by grasses and shrubs with very few cultivated lands. There is no major village within the unit, making population relatively small – about 181 people (Coral Reef Assessment and Monitoring Program, 2007).

Current Instream Flow Standard

The current interim instream flow standard (IFS) for Waiokamilo Stream was established by way of Hawaii Administrative Rules (HAR) §13-169-44, which, in pertinent part, read as follows:

> Interim instream flow standard for East Maui. The Interim Instream Flow Standard for all streams on East Maui, as adopted by the commission on water resource management on June 15, 1988, shall be that amount of water flowing in each stream on the effective date of this standard, and as that flow may naturally vary throughout the year and from year to year without further amounts of water being diverted offstream through new or expanded diversions, and under the stream conditions existing on the effective date of the standard.

The current interim IFS became effective on October 8, 1988. Streamflow was not measured on that date; therefore, the current interim IFS is not a measurable value.

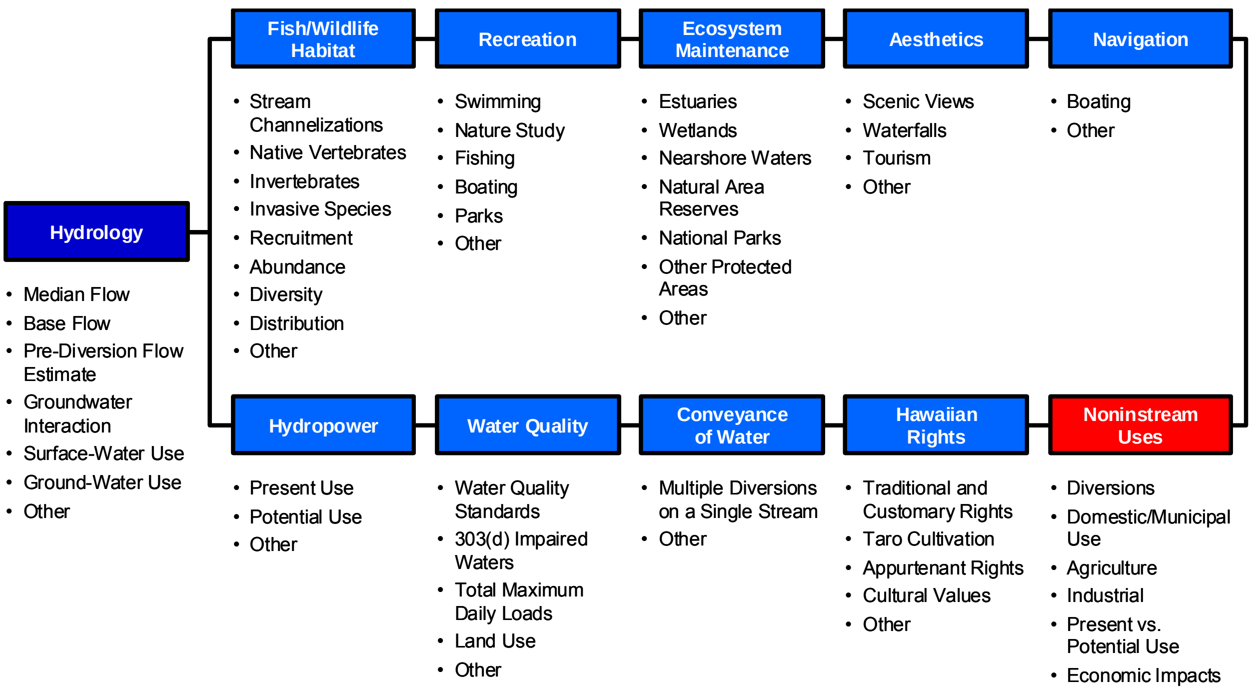
Instream Flow Standards

Under the State Water Code (Code), Chapter 174C, Hawaii Revised Statutes (HRS), the Commission on Water Resource Management (Commission) has the responsibility of establishing IFS on a stream-by-stream basis whenever necessary to protect the public interest in the waters of the State. Early in its history, the Commission recognized the complexity of establishing IFS for the State's estimated 376 perennial streams and instead set interim IFS at "status quo" levels. These interim IFS were defined as the amount of water flowing in each stream (with consideration for the natural variability in stream flow and conditions) at the time the administrative rules governing them were adopted in 1988 and 1989.

The Hawaii Supreme Court, upon reviewing the Waiahole Ditch Contested Case Decision and Order, held that such "status quo" interim IFS were not adequate to protect streams and required the Commission to take immediate steps to assess stream flow characteristics and develop quantitative interim IFS for affected windward Oahu streams, as well as other streams statewide. The Hawaii Supreme Court also emphasized that "instream flow standards serve as the primary mechanism by which the Commission is to discharge its duty to protect and promote the entire range of public trust purposes dependent upon instream flows."

To the casual observer, IFS may appear relatively simple to establish upon a basic review of the Code provisions. However, the complex nature of IFS becomes apparent upon further review of the individual components that comprise surface water hydrology, instream uses, noninstream uses, and their interrelationships. The Commission has the distinct responsibility of weighing competing uses for a limited resource in a legal realm that is continuing to evolve. The following illustration (Figure 1-1) was developed to illustrate the wide range of information, in relation to hydrology, instream uses, and noninstream uses that should be addressed in conducting a comprehensive IFS assessment.

Figure 1-1. Information to consider in setting measurable instream flow standards.

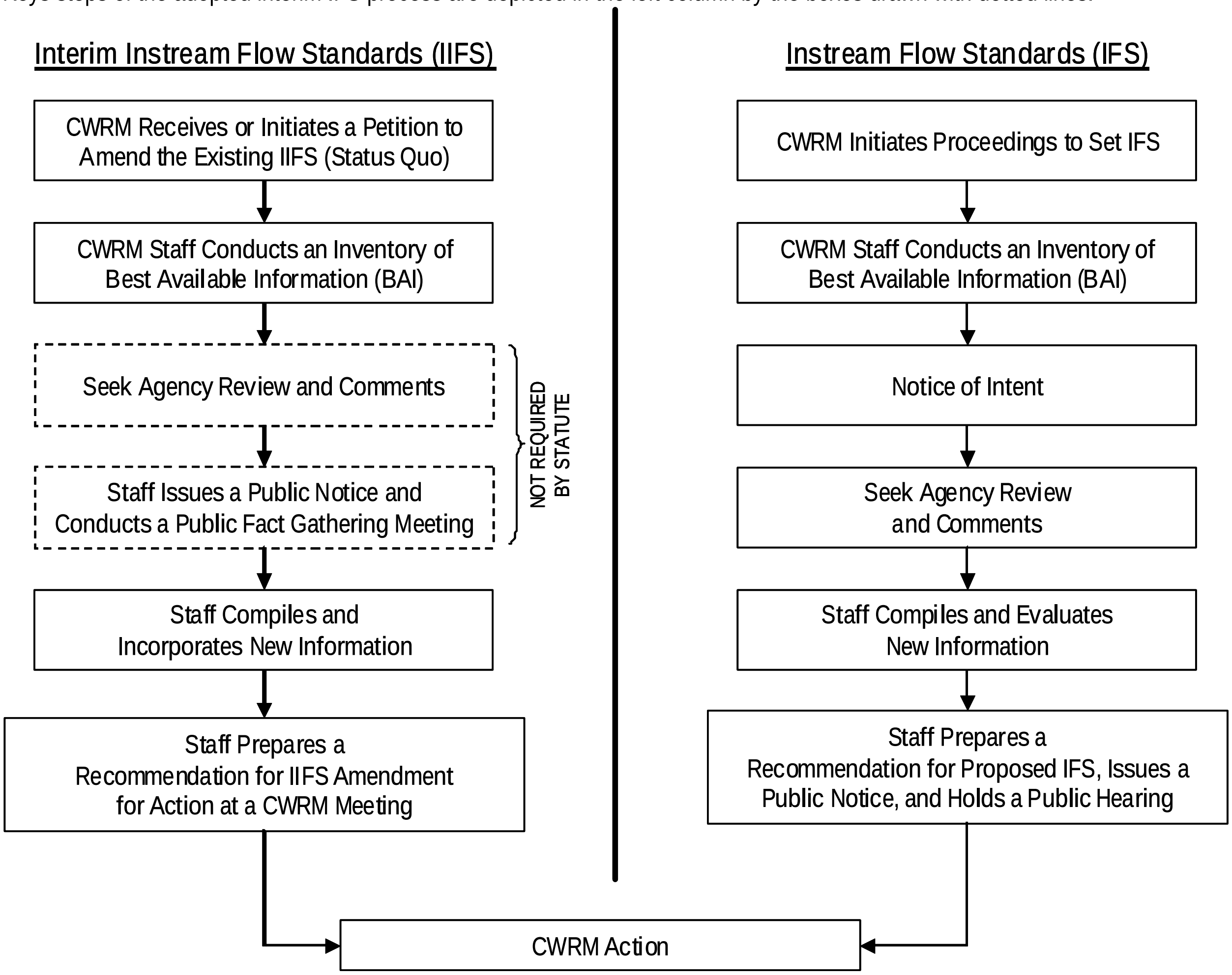


Interim Instream Flow Standard Process

The Code provides for a process to amend an interim IFS in order to protect the public interest pending the establishment of a permanent IFS. The Code, at §174C-71(2), describes this process including the role of the Commission to "weigh the importance of the present or potential instream values with the importance of the present or potential uses of water for noninstream purposes, including the economic impact of restricting such uses."

Recognizing the complexity of establishing measurable IFS, while cognizant of the Hawaii Supreme Court's mandate to designate interim IFS based on best available information under the Waiahole Combined Contested Case, the Commission at its December 13, 2006 meeting authorized staff to initiate and conduct public fact gathering. Under this adopted process (reflected in the left column of Figure 1-2), the Commission staff will conduct a preliminary inventory of best available information upon receipt of a petition to amend an existing interim IFS. The Commission staff shall then seek agency review and comments on the compiled information (compiled in an Instream Flow Standard Assessment Report) in conjunction with issuing a public notice for a public fact gathering meeting. Shortly thereafter (generally within 30 days), the Commission staff will conduct a public fact gathering meeting in, or near, the hydrologic unit of interest.

Figure 1-2. Simplified representation of the interim instream flow standard and permanent instream flow standard processes. Keys steps of the adopted interim IFS process are depicted in the left column by the boxes drawn with dotted lines.



Instream Flow Standard Assessment Report

The Instream Flow Standard Assessment Report (IFSAR) is a compilation of the hydrology, instream uses, and noninstream uses related to a specific stream and its respective surface water hydrologic unit. The report is organized in much the same way as the elements of IFS are depicted in Figure 1-1. The purpose of the IFSAR is to present the best available information for a given hydrologic unit. This information is used to determine the interim IFS recommendations, which is compiled as a separate report. The IFSAR is intended to act as a living document that should be updated and revised as necessary, thus also serving as a stand-alone document in the event that the Commission receives a subsequent petition solely for the respective hydrologic unit.

Each report begins with an introduction of the subject hydrologic unit and the current IFS status. Section 2.0 is comprised of the various hydrologic unit characteristics that, both directly and indirectly, impact surface water resources. Section 3.0 contains a summary of available hydrologic information, while Sections 4.0 through 12.0 summarize the best available information for the nine instream uses as defined by the Code. Noninstream uses are summarized in Section 13.0. Maps are provided at the end of each section to help illustrate information presented within the section's text or tables. Finally, Section 14.0 provides a comprehensive listing of cited references and is intended to offer readers the opportunity to review IFSAR references in further detail.

An important component of the IFSAR and the interim IFS process is the Compilation of Public Review Comments (CPRC). The CPRC serves as a supporting document containing the oral and written comments that are submitted as part of the initial public review process. This report refers specifically to PR-2008-07, Compilation of Public Review Comments for the Hydrologic Units of Honopou (6034), Hanehoi (6037), Piinaau (6053), Waiokamilo (6055), and Wailuanui (6056), Island of Maui, September 2008. Comments referred to within the IFSAR will identify both the section and page number where the original comment can be located in the CPRC. For example, a reference to "8.0-3" indicates the third page of comments in Section 8.0 of the CPRC.

Following the preparation of the IFSAR and initial agency and public review, information may be added to the IFSAR at any time. Dates of revision will be reflected as such. Future review of the IFSAR, by agencies and the public, will only be sought when a new petition to amend the interim (or permanent) instream flow standard is pending. Recommendations for IFS amendments are prepared separately as a stand-alone document. Thus, the IFSAR acts solely as a compendium of best available information and may be revised further without the need for subsequent public review following its initial preparation.

Surface Water Hydrologic Units

Early efforts to update the Commission's Water Resource Protection Plan (WRPP) highlighted the need for surface water hydrologic units to delineate and codify Hawaii's surface water resources. Surface water hydrologic units served as an important first-step towards improving the organization and management of surface water information that the Commission collects and maintains, including diversions, stream channel alterations, and water use.

In developing the surface water hydrologic units, the Commission staff reviewed various reports to arrive at a coding system that could meet the requirements for organizing and managing surface water information in a database environment, and could be easily understood by the general public and other agencies. For all intents and purposes, surface water hydrologic units are synonymous with watershed areas. Though Commission staff recognized that while instream uses may generally fall within a true surface drainage area, noninstream uses tend to be land-based and therefore may not always fall within the same drainage area.

In June 2005, the Commission adopted the report on surface water hydrologic units and authorized staff to implement its use in the development of information databases in support of establishing IFS (State of Hawaii, Commission on Water Resource Management, 2005a). The result is a surface water hydrologic unit code that is a unique combination of four digits. This code appears on the cover of each IFSAR above the hydrologic unit name.

Surface Water Definitions

Listed below are the most commonly referenced surface water terms as defined by the Code.

Agricultural use. The use of water for the growing, processing, and treating of crops, livestock, aquatic plants and animals, and ornamental flowers and similar foliage.

Channel alteration. (1) To obstruct, diminish, destroy, modify, or relocate a stream channel; (2) To change the direction of flow of water in a stream channel; (3) To place any material or structures in a stream channel; and (4) To remove any material or structures from a stream channel.

Continuous flowing water. A sufficient flow of water that could provide for migration and movement of fish, and includes those reaches of streams which, in their natural state, normally go dry seasonally at the location of the proposed alteration.

Domestic use. Any use of water for individual personal needs and for household purposes such as drinking, bathing, heating, cooking, noncommercial gardening, and sanitation.

Ground water. Any water found beneath the surface of the earth, whether in perched supply, dike-confined, flowing, or percolating in underground channels or streams, under artesian pressure or not, or otherwise.

Hydrologic unit. A surface drainage area or a ground water basin or a combination of the two.

Impoundment. Any lake, reservoir, pond, or other containment of surface water occupying a bed or depression in the earth's surface and having a discernible shoreline.

Instream Flow Standard. A quantity of flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses.

Instream use. Beneficial uses of stream water for significant purposes which are located in the stream and which are achieved by leaving the water in the stream. Instream uses include, but are not limited to:

(1) Maintenance of fish and wildlife habitats;
(2) Outdoor recreational activities;
(3) Maintenance of ecosystems such as estuaries, wetlands, and stream vegetation;
(4) Aesthetic values such as waterfalls and scenic waterways;
(5) Navigation;
(6) Instream hydropower generation;
(7) Maintenance of water quality;
(8) The conveyance of irrigation and domestic water supplies to downstream points of diversion; and
(9) The protection of traditional and customary Hawaiian rights.

Interim instream flow standard. A temporary instream flow standard of immediate applicability, adopted by the Commission without the necessity of a public hearing, and terminating upon the establishment of an instream flow standard.

Municipal use. The domestic, industrial, and commercial use of water through public services available to persons of a county for the promotion and protection of their health, comfort, and safety, for the protection of property from fire, and for the purposes listed under the term "domestic use."

Noninstream use. The use of stream water that is diverted or removed from its stream channel and includes the use of stream water outside of the channel for domestic, agricultural, and industrial purposes.

Reasonable-beneficial use. The use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the state and county land use plans and the public interest.

Stream. Any river, creek, slough, or natural watercourse in which water usually flows in a defined bed or channel. It is not essential that the flowing be uniform or uninterrupted. The fact that some parts of the bed or channel have been dredged or improved does not prevent the watercourse from being a stream.

Stream channel. A natural or artificial watercourse with a definite bed and banks which periodically or continuously contains flowing water. The channel referred to is that which exists at the present time, regardless of where the channel may have been located at any time in the past.

Stream diversion. The act of removing water from a stream into a channel, pipeline, or other conduit.

Stream reach. A segment of a stream channel having a defined upstream and downstream point.

Stream system. The aggregate of water features comprising or associated with a stream, including the stream itself and its tributaries, headwaters, ponds, wetlands, and estuary.

Surface water. Both contained surface water--that is, water upon the surface of the earth in bounds created naturally or artificially including, but not limited to, streams, other watercourses, lakes, reservoirs, and coastal waters subject to state jurisdiction--and diffused surface water--that is, water occurring upon the surface of the ground other than in contained water bodies. Water from natural springs is surface water when it exits from the spring onto the earth's surface.

Sustainable yield. The maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the Commission.

Time of withdrawal or diversion. In view of the nature, manner, and purposes of a reasonable and beneficial use of water, the most accurate method of describing the time when the water is withdrawn or diverted, including description in terms of hours, days, weeks, months, or physical, operational, or other conditions.

Watercourse. A stream and any canal, ditch, or other artificial watercourse in which water usually flows in a defined bed or channel. It is not essential that the flowing be uniform or uninterrupted.

Figure 1-3. Topographic map of the Waiokamilo hydrologic unit in east Maui, Hawaii (Source: U.S. Geological Survey, 1996).

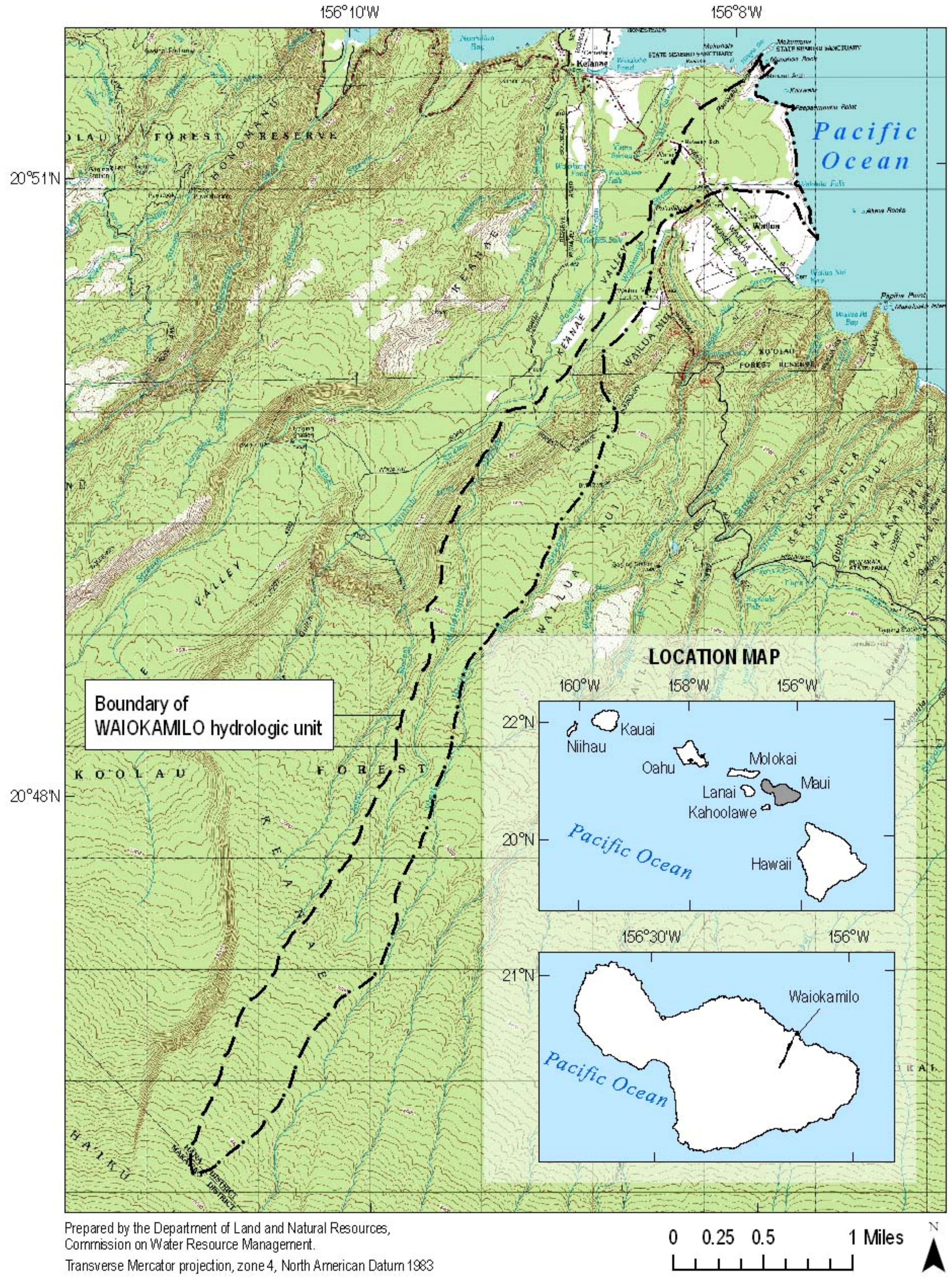


Figure 1-4. Elevation range and the location of Waiokamilo hydrologic unit. (Source: State of Hawaii, Office of Planning, 1983).

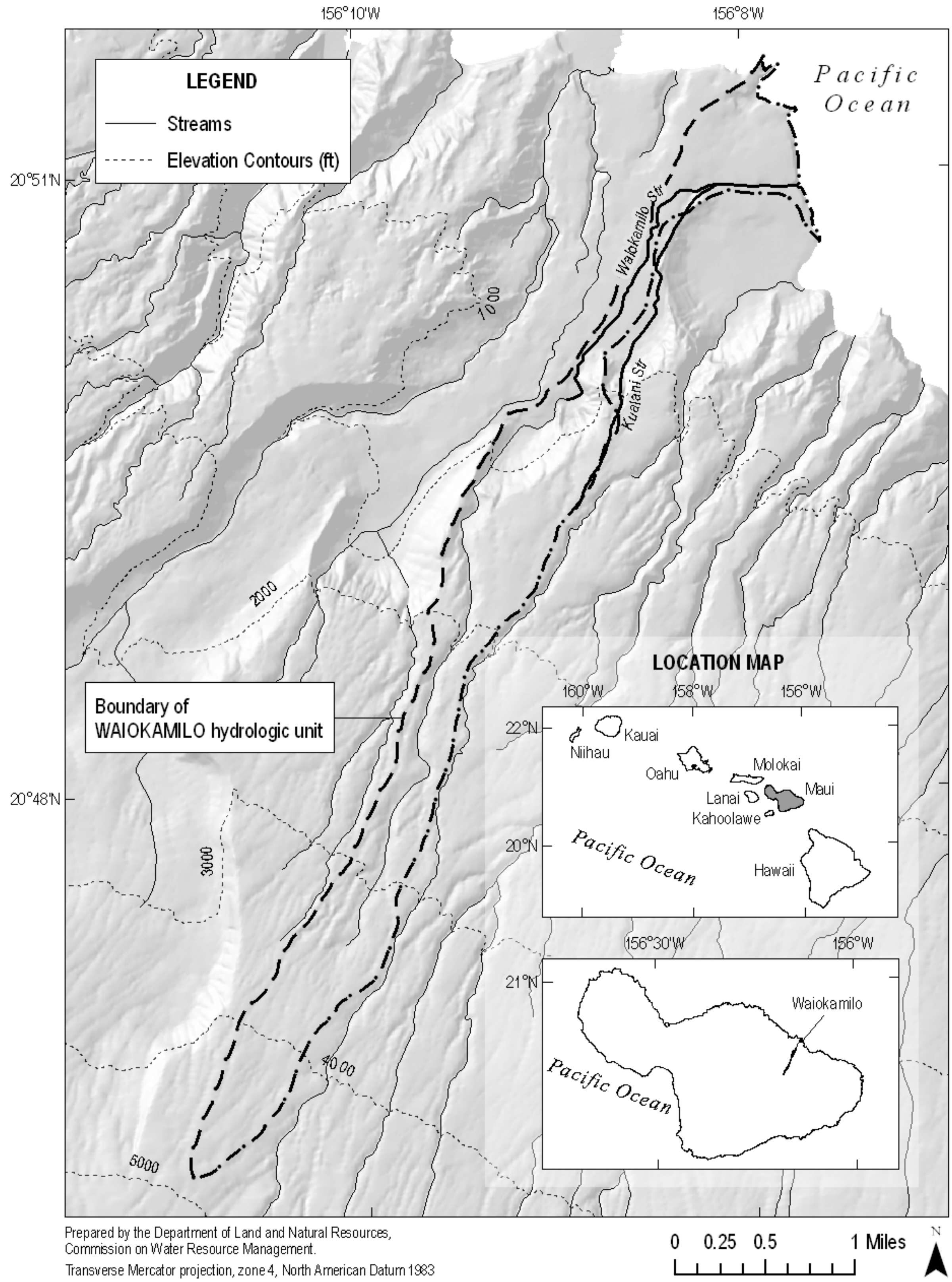


Figure 1-5. Major and minor roads and Tax Map Key (TMK) parcel boundaries for Waiokamilo hydrologic unit (Source: County of Maui, 2006; County of Maui, Geographic Information Systems [GIS] Division, Department of Management, 2006).

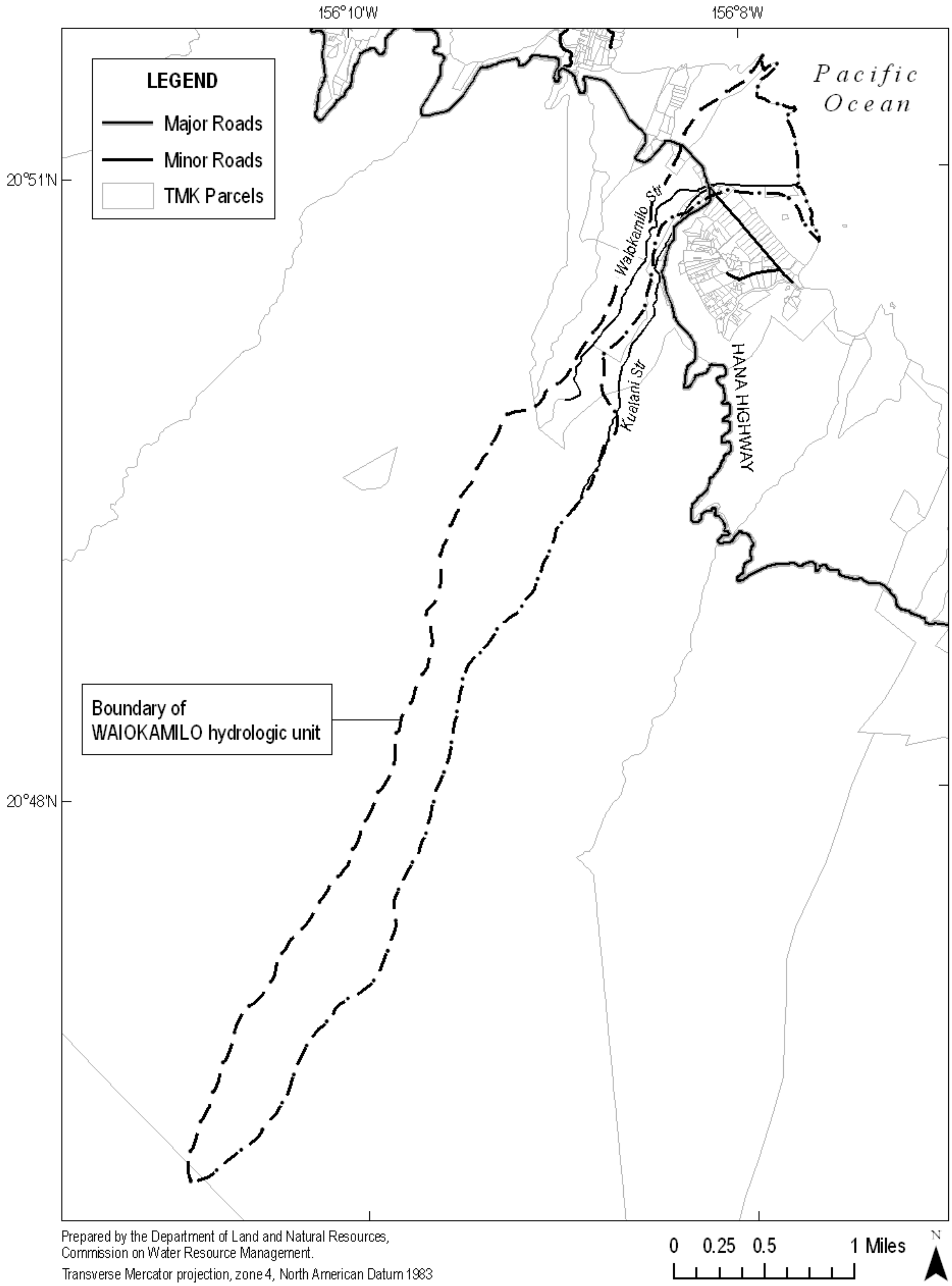
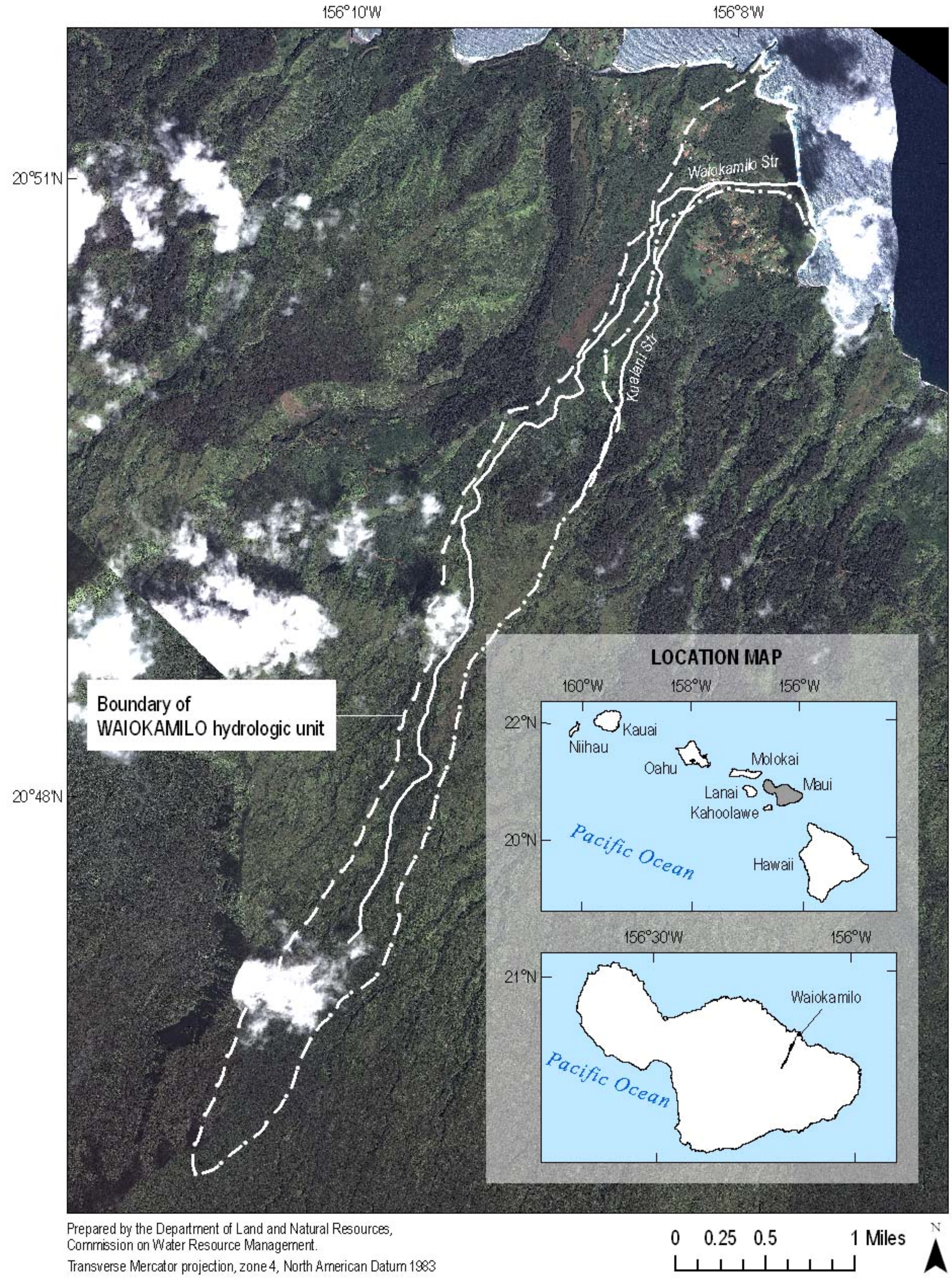


Figure 1-6. Quickbird satellite imagery of Waiokamilo hydrologic unit (Source: County of Maui, Planning Department, 2004).



2.0 Unit Characteristics

Geology

Most of the Waiokamilo hydrologic unit's surface geology consists of fairly permeable[1] to very permeable basalts, meaning that water moves easily through the rock. Thus, once rainwater penetrates the groundcover and passes through the soil into the rock below, it will flow quickly into streams and into the ground water aquifer. The older, Kula volcanics are fairly permeable and may contain perched[2] water if there are layers that the water cannot penetrate. Nearly 42 percent of the surface geology of the hydrologic unit consists of Kula volcanics. A small area of the hydrologic unit – just under 5 percent – is made up of exposed Honomanu basalt. The Honomanu volcanic series, which predates the Kula volcanics, is believed to form the basement of the entire Haleakala mountain to an unknown depth below sea level. The Honomanu volcanics are predominantly pahoehoe (lava characterized by a smooth or ropy surface with variable interior, including lava tubes and other voids), in flows ranging from 10 to 75 feet thick and are very vesicular. The Honomanu basalts are extremely permeable and yield water freely. Almost half the hydrologic unit consists of Hana volcanics. Younger than the other basalts, the Hana volcanics are so permeable that most of the rain that sinks into them continues downward to the older rocks below. The lowland section of the hydrologic unit includes younger flows of the Hana volcanic series; most of these are highly permeable as well, and springs may issue from them. There are some alluvial deposits (soil, gravel, etc.), particularly along streams and at the coastal part of the hydrologic unit (Stearns and MacDonald, 1942; and U.S. Geological Survey, 2007). These make up close to 5 percent of the hydrologic unit. The more seaward of these is not highly permeable. The generalized geology of the Waiokamilo hydrologic unit is depicted in Figure 2-2.

Table 2-1. Area and percentage of surface geologic features for Waiokamilo hydrologic unit.

Symbol	Name	Rock Type	Lithology	Area (mi^2)	Percent of Unit
Qa	Alluvium	Sand and gravel	Cobble to sand, moderately sorted	0.02	1.0
Qbd	Beach deposits	Sand and gravel		0.00	0.1
Qhn0	Hana Volcanics	Lava flows	Aa	0.23	9.3
Qhn1	Hana Volcanics	Lava flows	Aa	0.37	15.2
Qhn6	Hana Volcanics	Lava flows	Aa	0.59	24
Qmnl	Honomanu Basalt	Lava flows	Pahoehoe and aa	0.12	4.9
Qkul	Kula Volcanics	Lava flows	Aa and pahoehoe	0.01	0.4
Qkul	Kula Volcanics	Lava flows	Aa and pahoehoe	1.01	41.4
QTao	Older alluvium	Sand and gravel, lithified		0.08	3.4

Soils

The soils of the Waiokamilo hydrologic unit are generally good for water supply as they are mostly well-drained, permeable soils. The uplands of the hydrologic unit consist of soils developed in volcanic ash and material weathered from cinders and basic igneous rock. They absorb water and transmit it rapidly. These soils are not good for engineering or agricultural uses.

[1] Permeability is the ease with which water passes through material. It is a factor in determining whether precipitation runs off on the surface or descends into the ground.
[2] Perched water is water confined by an impermeable or slowly permeable barrier.

Soils in the central section of the hydrologic unit consist of silty clay and rock land, and are fairly steep and well-drained (i.e. water drains through it easily). Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight.

Much of the lowlands of the hydrologic unit consist of stones, boulders, and soil deposited by streams along the bottoms of gulches and on alluvial fans (fan-shaped deposits of sediment at the mouth of a valley). There are small areas of a well-drained clay with moderately rapid permeability, slow to medium runoff, and a slight to moderate erosion hazard. There is a small area of poorly drained soils (i.e. soil that is wet for long periods) that are periodically flooded by irrigation in order to grow crops that thrive in water (e.g. taro and rice) (U.S. Department of Agriculture, Soil Conservation Service, 1972).

The U.S. Department of Agriculture's Natural Resources Conservation Service (formerly known as the Soil Conservation Service) divides soils into hydrologic soil groups (A, B, C, and D) according to the rate at which infiltration (intake of water) occurs when the soil is wet. The higher the infiltration rate, the faster the water is absorbed into the ground and the less there is to flow as surface runoff. Group A soils have the highest infiltration rates; group D soils have the lowest. In the Waiokamilo hydrologic unit, 32.1 percent of soils are group A; 51.1 percent group B; and 15.7 percent group D (U. S. Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division, 1986). This means that more than three-fourths of the hydrologic unit's soils have moderate or high infiltration rates.

During the field investigation for a study published by Gingerich (1999b), the section of Waiokamilo Stream below the Koolau Ditch was dry until just below the Akeke spring. The spring then feeds the stream, but much of the remainder of the stream is losing water by seepage into the ground. The study did not determine if the reach upstream of the ditch is gaining (the flow increases from ground water seepage or springs in or alongside the channel) or losing. The losing reaches are mostly in an area where the soil is classified as group A, i.e. having a high infiltration rate (Figure 2-3). Waiokamilo Stream's hydrology is discussed in further detail in Section 3.0, Hydrology.

Table 2-2. Area and percentage of soil types for the Waiokamilo hydrologic unit.

Map Unit	Description	Area (mi^2)	Percent of Unit
HwC	Honolua silty clay, 7 to 15 percent slopes	0.04	1.5
KBID	Kailua silty clay, 3 to 25 percent slopes	0.03	1.4
TR	Tropaquepts	0.03	1.3
rHOD	Honomanu silty clay, 5 to 25 percent slopes	0.28	11.6
rHT	Hydrandepts-Tropaquods association	1.21	49.6
rRT	Rough mountainous land	0.35	14.4
rSM	Stony alluvial land	0.47	19.1

Rainfall

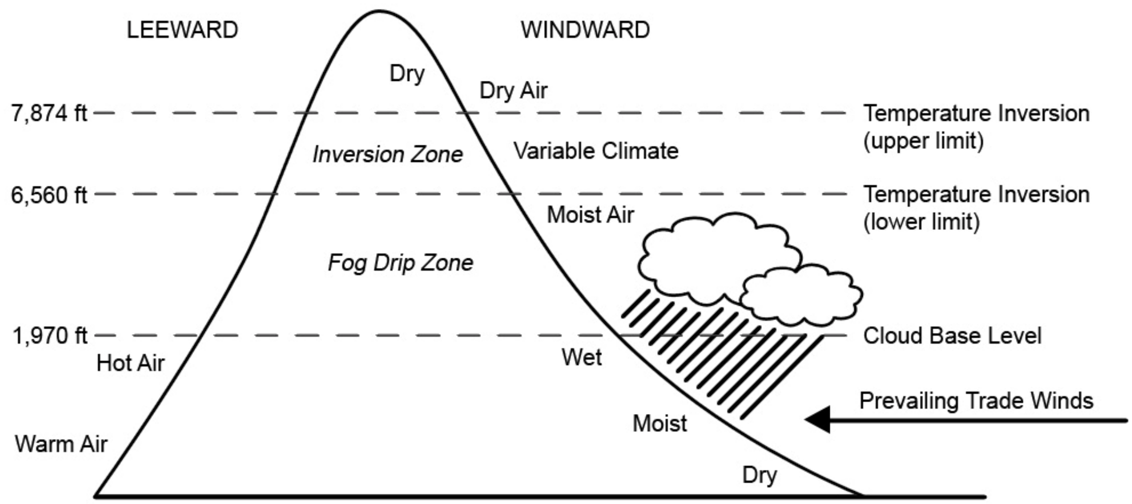
Rainfall distribution in Waiokamilo is governed by the orographic[3] effect (Figure 2-1). Orographic precipitation occurs when the prevailing northeasterly trade winds lift warm air up the windward side of the mountains into higher elevations where cooler temperatures persist. As a result, frequent and heavy rainfall is observed at the windward mountain slopes. Once the moist air reaches the fog drip zone, cloud height is restricted by the temperature inversion, where temperature increases with elevation, thus favoring fog drip over rain-drop formation (Shade, 1999). Fog drip is a result of cloud-water droplets impacting vegetation (Scholl et al., 2002) and it can contribute significantly to ground water recharge.

[3] Orographic refers to influences of mountains and mountain ranges on airflow, but also used to describe effects on other meteorological quantities such as temperature, humidity, or precipitation distribution.

The fog drip zone on the windward side of East Maui Volcano (Haleakala) extends from the cloud base level at 1,970 feet to the lower limit of the most frequent temperature inversion base height at 6,560 feet (Giambelluca and Nullet, 1992).

A majority of the mountains in Hawaii peak in the fog drip zone. In such cases, air passes over the mountains, warming and drying while descending the leeward mountain slopes. When the mountains are at elevations higher than 6,000 feet (e.g. Haleakala), climate is affected by the presence and movement of the inversion. The temperature inversion zone typically extends from 6,560 feet to 7,874 feet. This region is influenced by a layer of moist air below and dry air above, making climate extremely variable (Giambelluca and Nullet, 1992). Above the inversion zone, the air is dry and sky is frequently clear (absence of clouds) with high solar radiation, creating an arid atmosphere with little rainfall.

Figure 2-1. Orographic precipitation in the presence of mountains higher than 6,000 feet.



The hydrologic unit of Waiokamilo is situated on the windward flank of the East Maui Volcano. The hydrologic unit receives near-daily orographic rainfall ranging from 118 inches per year at the coast to 280 inches per year near the center of the hydrologic unit. This rainfall drops down to 130-150 inches per year in the upper slopes where fog contribution to total rainfall may exceed rain-drop formation (Giambelluca et al, 1986). The high spatial variability in rainfall is evident where the mean annual rainfall decreases by about 34 inches with an average 500-foot drop in elevation in the lower half of the hydrologic unit. Rainfall is highest during the months of March, April, November, and December during which the mean monthly rainfall across the hydrologic unit is approximately 21-24 inches. In March, rainfall can reach as high as 35 inches in the mountains. For the rest of the year, the mean monthly rainfall ranges from 12 inches to 19 inches. The driest months are May, June, and September during which only 4-6 inches of rain fall at the coast.

Currently, fog drip data for east Maui are very limited. Shade (1999) used the monthly fog drip to rainfall ratios for the windward slopes of Mauna Loa on the island of Hawaii (Table 2-3) to calculate fog drip contribution to the water-budget in windward east Maui. The fog drip to rainfall ratios were estimated using 1) the fog drip zone boundaries for east Maui (Giambelluca and Nullet, 1992), and 2) an illustration that shows the relationship between fog drip and rainfall for the windward slopes of Mauna Loa, island of Hawaii (Juvik and Nullet, 1995). This method was used to determine the contribution of fog drip in the Waiokamilo hydrologic unit, which is calculated by multiplying the ratios with the monthly rainfall values (Giambelluca et al., 1986). Calculations show that approximately 47 percent of Waiokamilo lies in the fog drip zone (Figure 2-4) with an estimated average annual fog drip rate of 76 inches per year. Since a relatively large portion of the Waiokamilo hydrologic unit lies in the fog drip zone, the contribution of fog to total rainfall is significant.

Table 2-3. Fog drip to rainfall ratios for the windward slopes of Mauna Loa on the island of Hawaii.

Month	Ratio (%)
January-March	13
April-June	27
July-September	67
October-November	40
December	27

Solar Radiation

Solar radiation is the sun's energy that arrives at the Earth's surface after considerable amounts have been absorbed by water vapor and gases in the Earth's atmosphere. The amount of solar radiation to reach the surface in a given area is dependent upon latitude and the sun's declination angle (angle from the sun to the equator), which is a function of the time of year. Hawaii's trade winds and the temperature inversion layer greatly affect solar radiation levels, the primary heat source for evaporation. High mountain ranges block moist trade-wind air flow and keep moisture beneath the inversion layer (Lau and Mink, 2006). As a result, windward slopes tend to be shaded by clouds and protected from solar radiation, while dry leeward areas receive a greater amount of solar radiation and thus have higher levels of evaporation.

In the Waiokamilo hydrologic unit, estimated daily solar radiation ranges from 0 to 300 calories per square centimeter per day. Solar radiation decreases from the coast toward the mountains, where there is a zone with very low solar radiation and high rainfall. Upslope of that zone, solar radiation increases (and rainfall decreases) with elevation (Figure 2-4).

Evaporation

Evaporation is the loss of water to the atmosphere from soil surfaces and open water bodies (e.g. streams and lakes). Evaporation from plant surfaces (e.g. leaves, stems, flowers) is termed transpiration. Together, these two processes are commonly referred to as evapotranspiration, and it can significantly affect water yield because it determines the amount of rainfall that becomes streamflow. On a global scale, the amount of water that evaporates is about the same as the amount of water that falls on Earth as precipitation. However, more water evaporates from the ocean whereas on land, rainfall often exceeds evaporation. The rate of evaporation is dependent on many climatic factors including solar radiation, albedo[4], rainfall, humidity, wind speed, surface temperature, and sensible heat advection[5]. Higher evaporation rates are generally associated with greater net radiation, high wind speed and surface temperature, and lower humidity.

A common approach to estimating evaporation is to employ a relationship between potential evaporation and the available water in the watershed. Potential evaporation is the maximum rate of evaporation if water is not a limiting factor, and it is often measured with evaporation pans. In Hawaii, pan evaporation measurements were generally made in the lower elevations of the drier leeward slopes where sugarcane

[4] Albedo is the proportion of solar radiation that is reflected from the Earth, clouds, and atmosphere without heating the receiving surface.
[5] Sensible heat advection refers to the transfer of heat energy that causes the rise and fall in the air temperature.

was grown. These data have been compiled and mapped by Ekern and Chang (1985). Unfortunately, pan evaporation data are available only for the lower slopes of west and central Maui. This makes estimating the evaporative demand on the watersheds in windward east Maui challenging.

Most of the drainage basins in Hawaii are characterized by a relatively large portion of the rainfall leaving the basin as evaporation and the rest as streamflow (Ekern and Chang, 1985). Based on the available pan evaporation data for Hawaii, evaporation generally decreases with increasing elevation below the temperature inversion[6] and the cloud layer (Figure 2-1). At low elevations near the coast, pan evaporation rates are influenced by sensible heat advection from the ocean (Nullet, 1987). Pan evaporation rates are enhanced in the winter by positive heat advection from the ocean, and the opposite occurs in the summer when pan evaporation rates are diminished by negative heat advection (Giambelluca and Nullet, 1992). With increasing distance from the windward coasts, positive heat advection from dry land surfaces becomes an important factor in determining the evaporative demand at the slopes (Nullet, 1987). Shade (1999, Fig. 9) estimated pan evaporation rates of 30 inches per year below 2,000 feet elevation to 80 inches per year near the coast. Within the cloud layer, evaporation rates are particularly low due to the low radiation and high humidity caused by fog drip. Pan evaporation rates dropped below 30 inches per year in this area as reported in Shade (1999, Fig. 9). Near the average height of the temperature inversion, evaporation rates are highly variable as they are mainly influenced by the movement of dry air from above and moist air from below (Nullet and Giambelluca, 1990). Above the inversion, clear sky and high solar radiation at the summits cause increased evaporation, with pan evaporation rates of about 50 to 70 inches per year (Shade, 1999, Fig. 9). Ekern and Chang (1985) reported evaporation increased to 50 percent more than surface oceanic rates near the Mauna Kea crest on the island of Hawaii.

Land Use

The Hawaii Land Use Commission (LUC) was established under the State Land Use Law (Chapter 205, Hawaii Revised Statutes) enacted in 1961. Prior to the LUC, the development of scattered subdivisions resulted in the loss of prime agricultural land that was being converted for residential use, while creating problems for public services trying to meet the demands of dispersed communities. The purpose of the law and the LUC is to preserve and protect Hawaii's lands while ensuring that lands are used for the purposes they are best suited. Land use is classified into four broad categories: 1) agricultural; 2) conservation; 3) rural; and 4) urban.

Land use classification is an important component of examining the benefits of protecting instream uses and the appropriateness of surface water use for noninstream uses. While some may argue that land use, in general, should be based upon the availability of surface and ground water resources, land use classification continues to serve as a valuable tool for long-range planning purposes.

As of 2006, the LUC designated 79 percent of the land in the Waiokamilo hydrologic unit as conservation district and 21 percent as agricultural district (State of Hawaii, Office of Planning, 2006d). No lands were designated as rural or urban districts. The conservation district is located in the upper part of the hydrologic unit and along the coast, whereas the agricultural district lies is in the lower part of the hydrologic unit (Figure 2-5).

Land Cover

Land cover for the hydrologic unit of Waiokamilo is represented by two separate 30-meter Landsat satellite images. One of the datasets, developed by the Coastal Change Analysis Program (C-CAP),

[6] Temperature inversion is when temperature increases with elevation.

provides a general overview of the land cover types in Waiokamilo, e.g. forest, shrub land, grassland, developed areas, cultivated areas, and bare land (Table 2-4, Figure 2-6). The second is developed by the Hawaii Gap Analysis Program (HI-GAP), which mapped the National Vegetation Classification System (NVCS) associations for each type of vegetation, creating a more comprehensive land cover dataset (Table 2-5, Figure 2-7).

Based on the two land cover classification systems, the land cover of Waiokamilo consists mainly of forested areas. A majority of the hydrologic unit is made up of native Ohia forests that spread throughout the upper slopes as part of the Koolau Forest Reserve. Alien forests with a mixture of alien grasslands can be found at intermediate and lower elevations with very little urban or industrial developments.

The land cover maps (Figures 2-6, 2-7) provide a general representation of the land cover types in Waiokamilo. Given that the scale of the maps is relatively large, they may not capture the smaller cultivated lands or other vegetation occupying smaller parcels of land. Land cover types may also have changed slightly since the maps were published.

Table 2-4. C-CAP land cover classes and area distribution in Waiokamilo hydrologic unit (Source: National Oceanographic and Atmospheric Agency, 2000).

Land Cover	Description	Area (mi^2)	Percent of Unit
Evergreen Forest	Areas where more than 67 percent of the trees remain green throughout the year	1.80	73.5
Scrub/Shrub	Areas dominated by woody vegetation less than 6 meters in height	0.45	18.6
Grassland	Natural and managed herbaceous cover	0.16	6.7
Bare Land	Bare soil, gravel, or other earthen material with little or no vegetation	0.01	0.5
Water	Open water	0.01	0.37
Low Intensity Developed	Constructed surface with substantial amounts of vegetated surface	0.01	0.2
Unconsolidated Shoreline	Material such as silt, sand, or gravel that is subject to inundation and redistribution by water	< 0.01	0.1

Table 2-5. HI-GAP land cover classes and area distribution in Waiokamilo hydrologic unit (Source: HI-GAP, 2005).

Land Cover	Area (mi^2)	Percent of Unit
Open Ohia Forest (uluhe)	0.84	34.2
Closed Ohia Forest (native shrubs)	0.64	26.0
Alien Forest	0.59	23.9
Uncharacterized Open-Sparse Vegetation	0.12	5.0
Uncharacterized Shrubland	0.09	3.5
Closed Ohia Forest (uluhe)	0.06	2.6
Alien Grassland	0.05	2.1
Very Sparse Vegetation to Unvegetated	0.04	1.5
Open Ohia Forest (native shrubs)	0.01	0.3
Uluhe Shrubland	0.01	0.2
Low Intensity Developed	< 0.01	0.2
Native Wet Cliff Vegetation	< 0.01	0.2
Uncharacterized Forest	< 0.01	0.1
Undefined	< 0.01	0.1

Flood

Floods usually occur following prolonged or heavy rainfall associated with tropical storms or hurricanes. The magnitude of a flood depends on topography, ground cover, and soil conditions. Rain falling on areas with steep slopes and soil saturated from previous rainfall events tends to produce severe floods in low-lying areas. Four types of floods exist in Hawaii. Stream or river flooding occurs when the water level in a stream rises into the flood plain. A 100-year flood refers to the probability of the flood happening once in a hundred years, or 1 percent chance of happening in a given year. Flash floods occur within a few hours after a rainfall event, or they can be caused by breaching of a flood safety structure such as a dam. Flash flooding is common in Hawaii because the small drainage basins often have a short response time, typically less than an hour, from peak rainfall to peak streamflow. They are powerful and dangerous in that they can develop quickly and carry rocks, mud, and all the debris in their path down to the coast, causing water quality problems in the near-shore waters. Some floods can even trigger massive landslides, blocking off an entire stream channel. One of the major historic flash flooding events occurred on December 5-6, 1988, when rainfall was at the average annual maximum, causing significant flash flooding in many parts of Maui (Fletcher III et al., 2002). Sheet flooding occurs when runoff builds up on previously saturated ground, flowing from the high mountain slopes to the sea in a shallow sheet (Pacific Disaster Center, 2007). Coastal flooding is the inundation of coastal land areas from excessive sea level rise associated with strong winds or a tsunami.

The Federal Emergency Management Agency (FEMA) developed maps that identify the flood-risk areas in an effort to mitigate life and property losses associated with flooding events. Based on these maps, FEMA did not identify any flood-risk zones in the hydrologic unit of Waiokamilo.

Drought

Drought is generally defined as a shortage of water supply that usually results from lower than normal rainfall over an extended period of time, though it can also result from human activities that increase water demand (Giambelluca et al., 1991). The National Drought Mitigation Center (State of Hawaii, Commission on Water Resource Management, 2005b) uses two types of drought definitions — conceptual and operational. Conceptual definitions help people understand the general concept of drought. Operational definitions describe the onset and severity of a drought, and they are helpful in planning for drought mitigation efforts. The four operational definitions of drought are meteorological, agricultural, hydrological, and socioeconomic. Meteorological drought describes the departure of rainfall from normal based on meteorological measurements and understanding of the regional climatology. Agricultural drought occurs when not enough water is available to meet the water demands of a crop. Hydrological drought refers to declining surface and ground water levels. Lastly, socioeconomic drought occurs when water shortage affects the general public.

Impacts of drought are complex and can be categorized into three sectors: water supply; agriculture and commerce; and environment, public health, and safety sectors (State of Hawaii, Commission on Water Resource Management, 2005b). The water supply sector encompasses urban and rural drinking water systems that are affected when a drought depletes ground water supplies due to reduced recharge from rainfall. The agriculture and commerce sector includes the reduction of crop yield and livestock sizes due to insufficient water supply for crop irrigation and maintenance of ground cover for grazing. The environmental, public health, and safety sector focuses on wildfires that are both detrimental to the forest ecosystem and hazardous to the public. It also includes the impact of desiccating streams, such as the reduction of instream habitats for native species.

Droughts have affected the islands throughout Hawaii's recorded history. The most severe events of the past 15 years are associated with the El Niño phenomenon. In January 1998, the National Weather Service's network of 73 rain gauges throughout the State did not record a single above-normal rainfall, with 36 rain gauges recording less than 25 percent of normal rainfall (State of Hawaii, Commission on Water Resource Management, 2005b). The most recent drought occurred in 2000-2002, affecting all islands, especially the southeastern end of the State. During that period, east Maui streams were at record low levels and cattle losses projected at 9 million dollars (State of Hawaii, Commission on Water Resource Management, 2005b).

With Hawaii's limited water resources and growing water demands, droughts will continue to adversely affect the environment, economy, and the residents of the State. Aggressive planning is necessary to make wise decisions regarding the allocation of water at the present time, and conserving water resources for generations to come. The Hawaii Drought Plan was established in 2000 in an effort to mitigate the long-term effects of drought. One of the projects that supplemented the plan was a drought risk and vulnerability assessment of the State, conducted by researchers at the University of Hawaii (2003). In this project, drought risk areas were determined based on rainfall variation in relation to water source, irrigated area, ground water yield, stream density, land form, drainage condition, and land use. Fifteen years of historical rainfall data were used. The Standardized Precipitation Index (SPI) was used as the drought index because of its ability to assess a range of rainfall conditions in Hawaii. It quantifies rainfall deficit for different time periods, i.e. 3 months and 12 months. Results of the study for Maui are summarized in Table 2-6. Based on the 12-month SPI, the Kula region has the greatest risk to drought impact of the Maui regions because of its dependence on surface water sources, which is limited by low rainfall. The growing population in the already densely populated area further stresses the water supply.

Table 2-6. Drought risk areas for Maui (Source: University of Hawaii, 2003).

[Drought classifications of moderate, severe, and extreme have SPI values -1.00 to -1.49, -1.50 to -1.99, and -2.00 or less, respectively]

Sector	Drought Classification (based on 12-month SPI)		
	Moderate	Severe	Extreme
Water Supply	Kula, Kahului, Wailuku, Hana, Lahaina	Kula, Hana	Kula
Agriculture and Commerce	--	--	--
Environment, Public Health and Safety	Kula	Kula	Kula

Figure 2-2. Generalized geology of Waiokamilo hydrologic unit (Source: Sherrod et al., 2007; State of Hawaii, Office of Planning, 2006a; and State of Hawaii, Commission on Water Resource Management, 2008c).

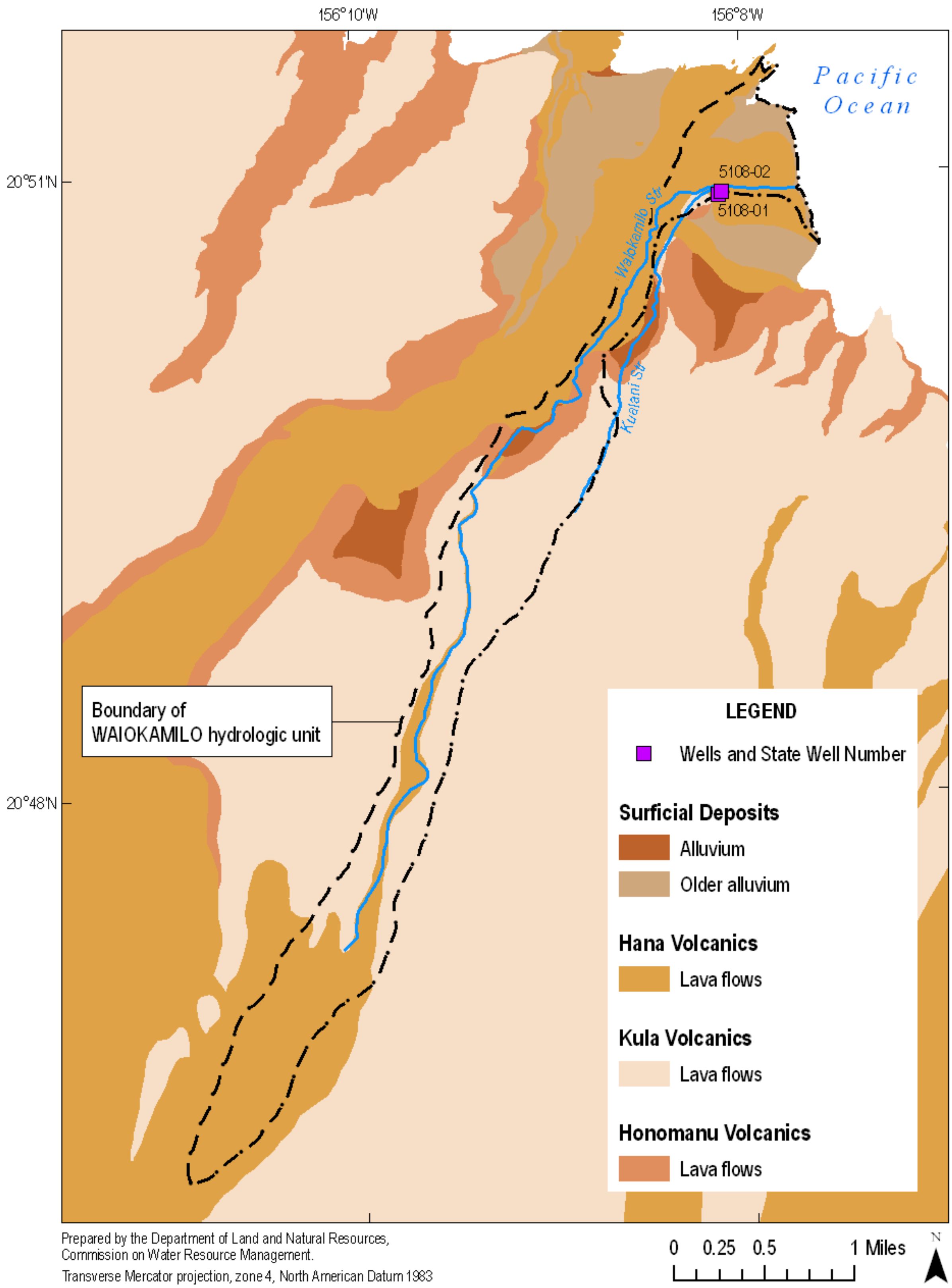


Figure 2-3. Soil classification in Waiokamilo hydrologic unit (Source: State of Hawaii, Office of Planning, 2007c).

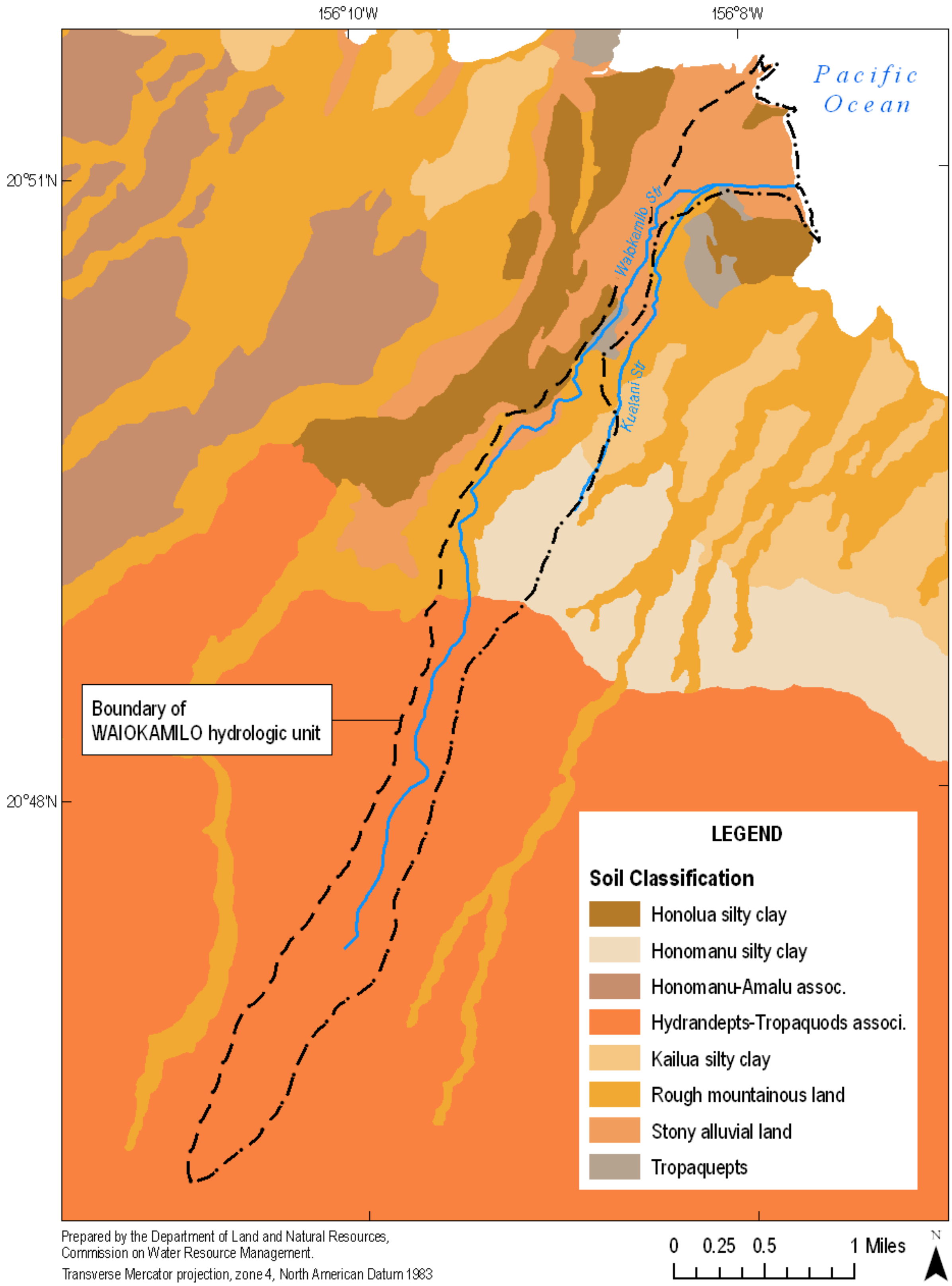


Figure 2-4. Mean annual rainfall and fog area in Waiokamilo; and solar radiation for Waiokamilo and the island of Maui, Hawaii (Source: Giambelluca et al., 1986; State of Hawaii, Office of Planning, 2006b; 2006c).

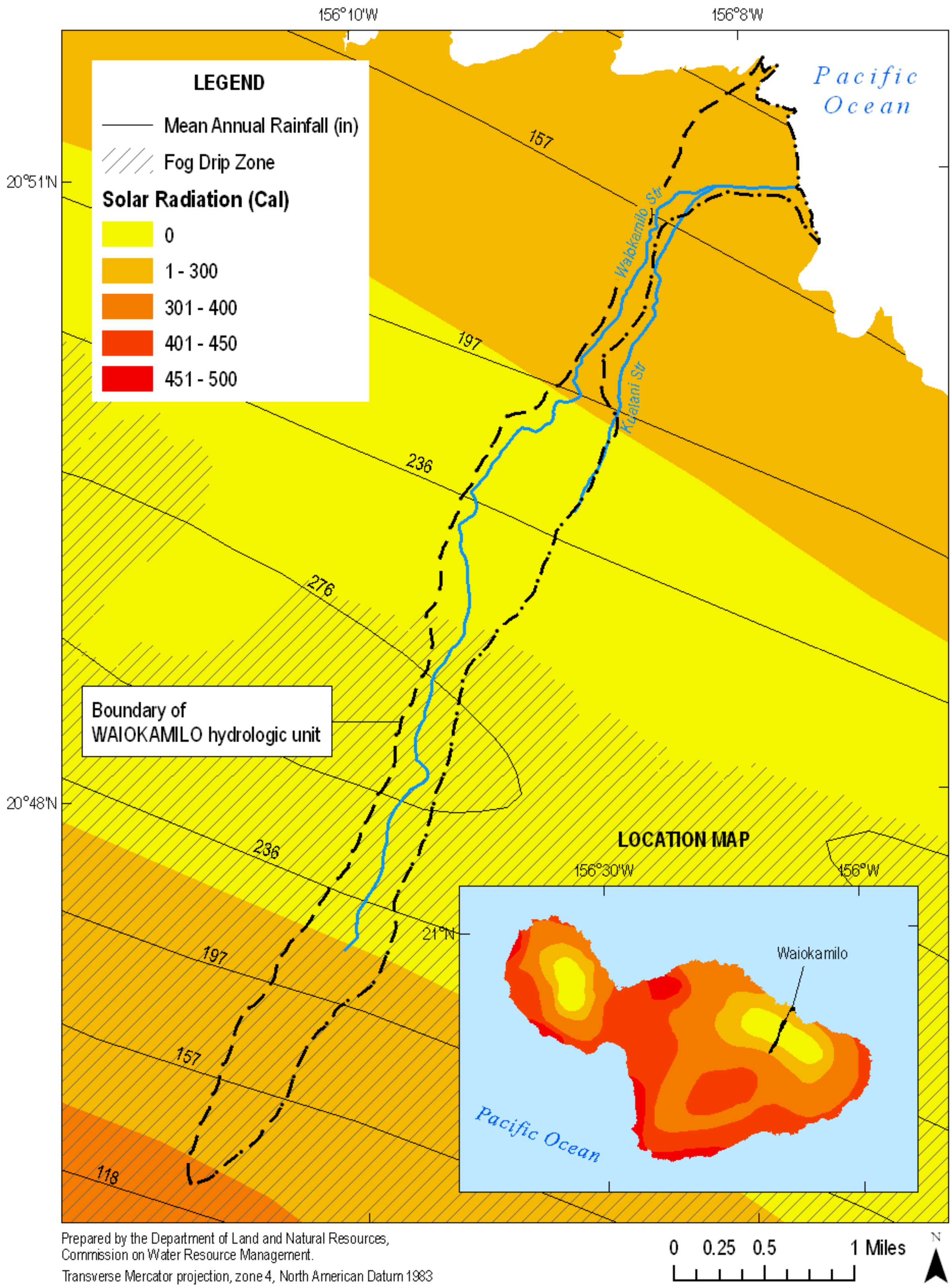


Figure 2-5. State land use district boundaries in Waiokamilo hydrologic unit (Source: State of Hawaii, Office of Planning, 2006d).

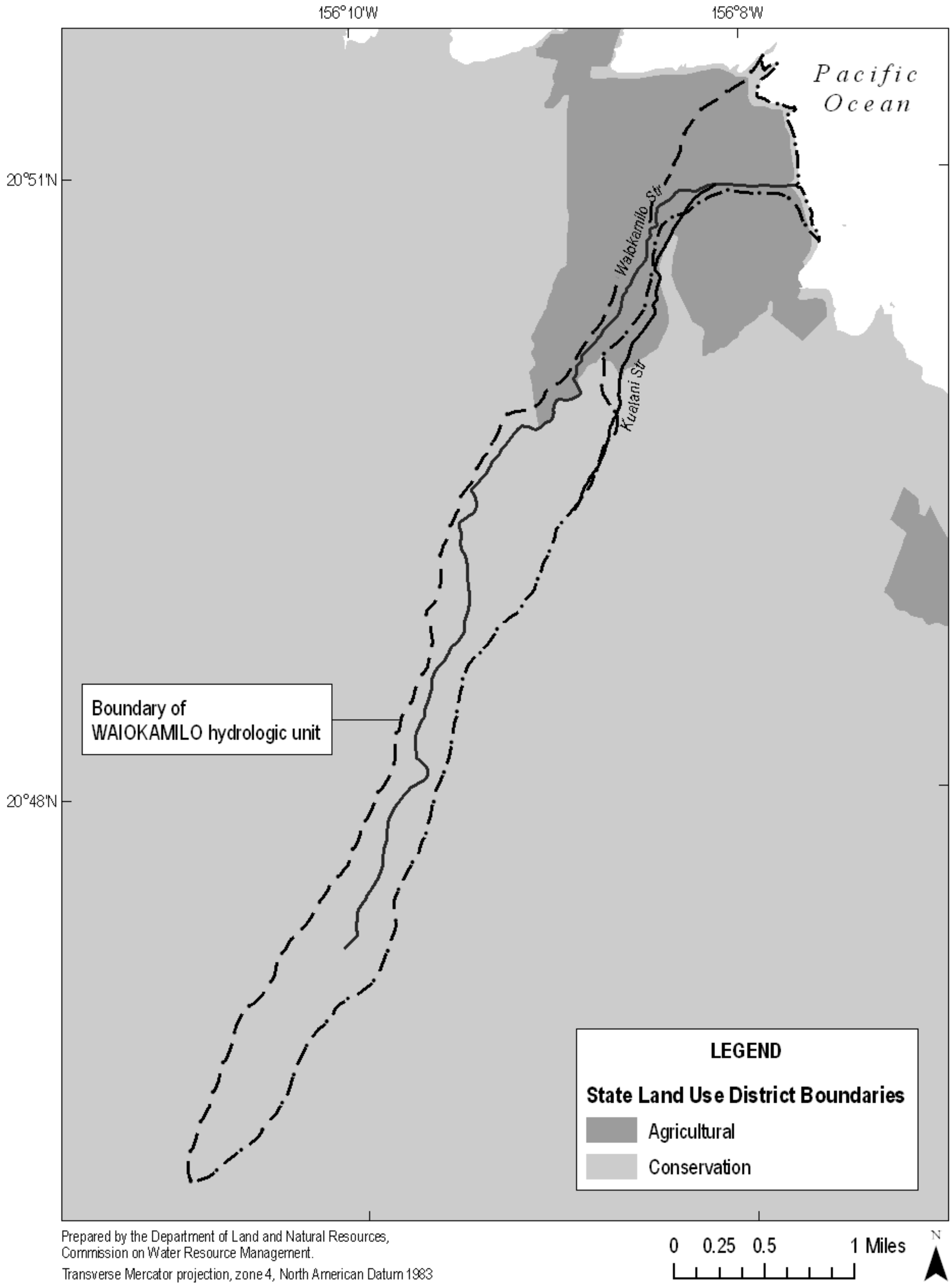


Figure 2-6. C-CAP land cover in Waiokamilo hydrologic unit (Source: National Oceanic and Atmospheric Administration, Coastal Services Center, 2000).

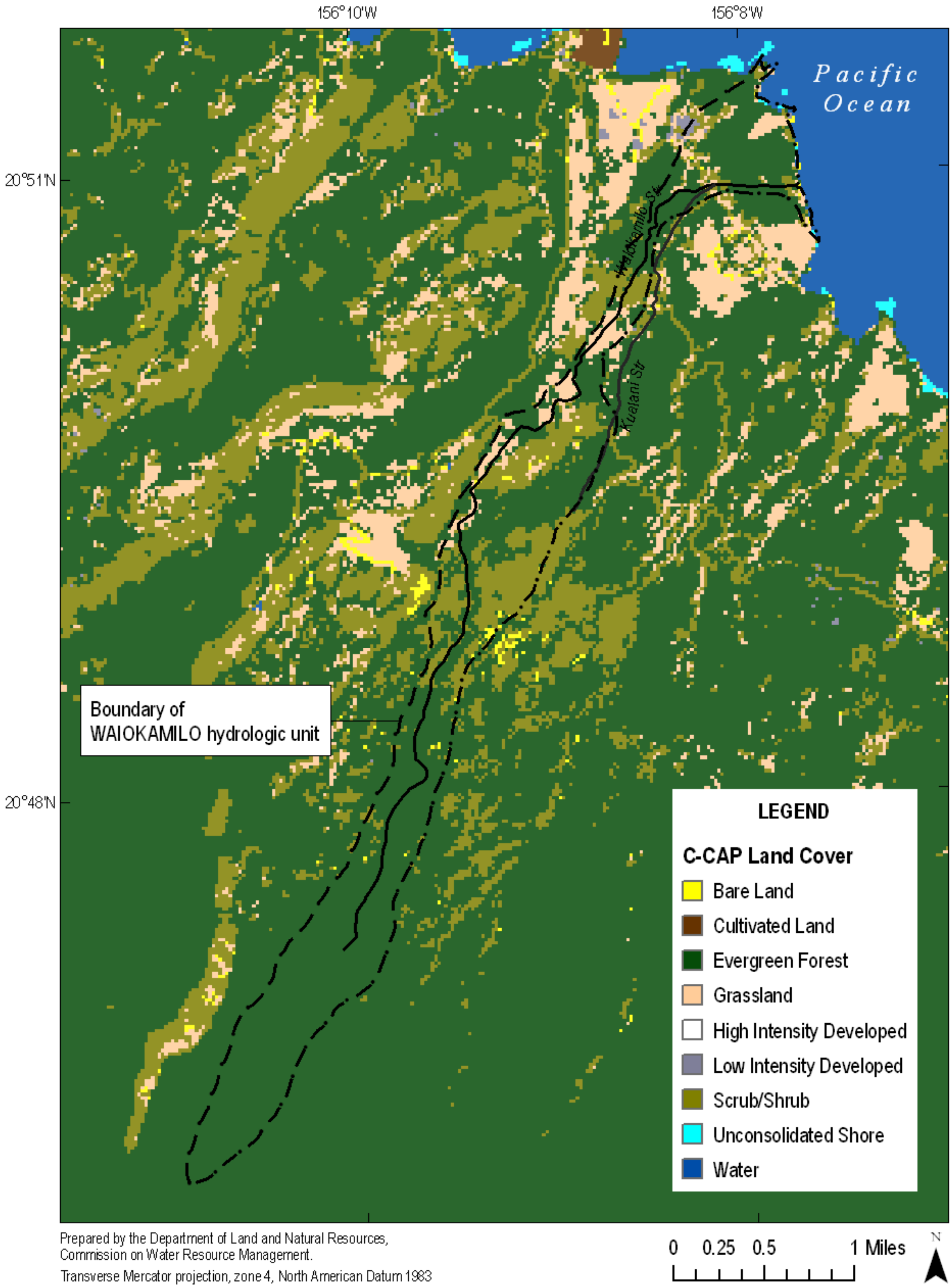
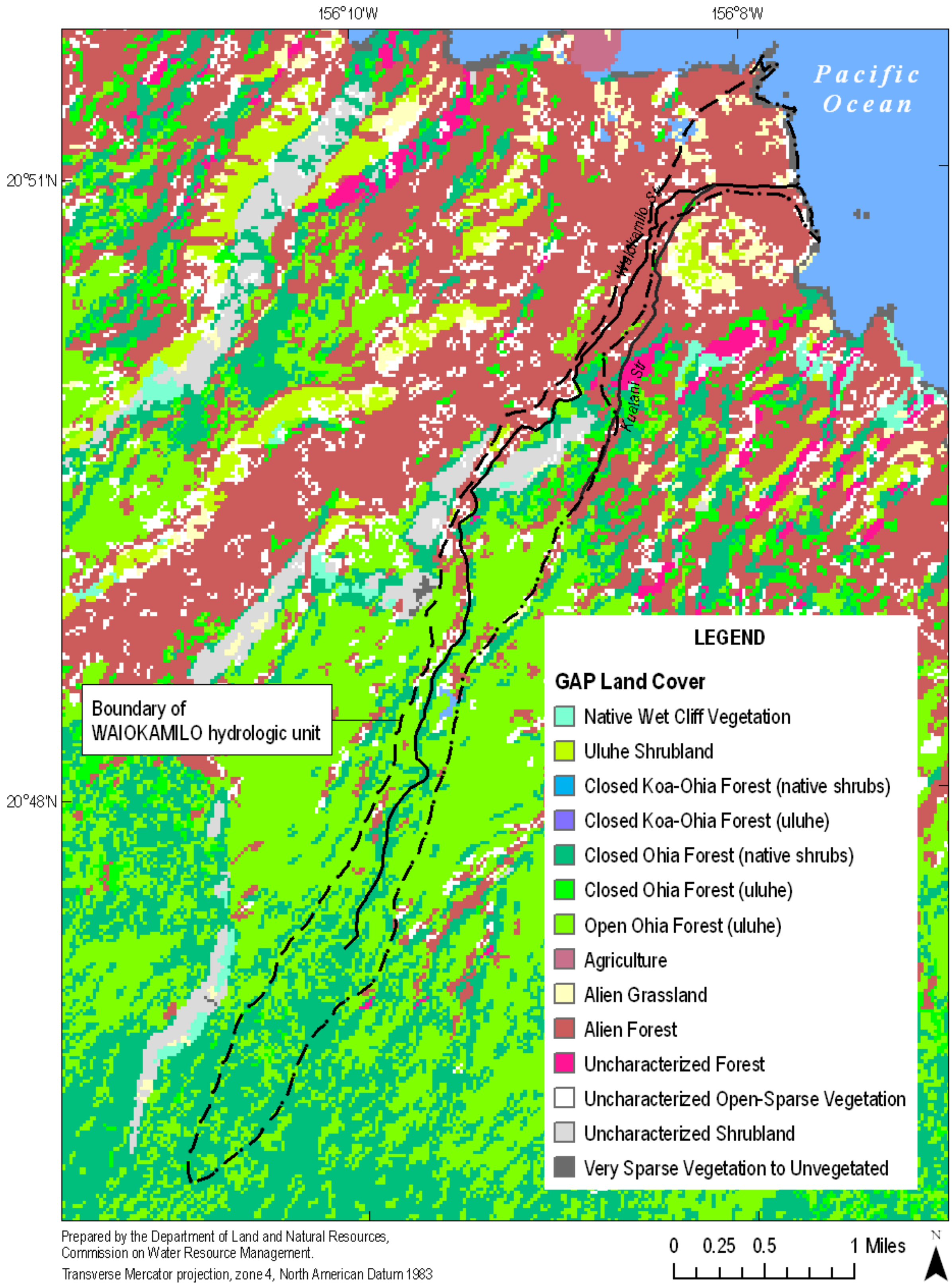


Figure 2-7. Hawaii GAP land cover classes in Waiokamilo hydrologic unit (Source: Hawaii GAP Analysis Program, 2005).



3.0 Hydrology

The Commission, under the State Water Code, is tasked with establishing instream flow standards by weighing "the importance of the present or potential instream values with the importance of the present or potential uses of water for noninstream purposes, including the economic impact of restricting such uses." While the Code outlines the instream and offstream uses to be weighed, it assumes that hydrological conditions will also be weighed as part of this equation. The complexity lies in the variability of local surface water conditions that are dependent upon a wide range of factors, including rainfall, geology, and human impacts, as well as the availability of such information. The following is a summary of general hydrology and specific hydrologic characteristics for Waiokamilo Stream.

Streams in Hawaii

Streamflow consists of: 1) direct surface runoff in the form of overland flow and subsurface flow that rapidly returns infiltrated water to the stream; 2) ground water discharge in the form of base flow; 3) water returned from streambank storage; 4) rain that falls directly on streams; and 5) additional water, including excess irrigation water discharged into streams by humans (Oki, 2003). The amount of runoff and ground water that contribute to total streamflow is dependent on the different components of the hydrologic cycle, as well as man-made structures such as diversions and other stream channel alterations (e.g. channelizations and dams).

Streams in Hawaii can either gain or lose water at different locations depending on the geohydrologic conditions. A stream gains water when the ground water table is above the streambed. When the water table is below the streambed, the stream can lose water. Where the streambed is lined with concrete or other low-permeability or impermeable material, interaction between surface water and ground water is unlikely. Another way that ground water influences streamflow is through springs. A spring is formed when a geologic structure (e.g., fault or fracture) or a topographic feature (e.g., side of a hill or a valley) intersects ground water either at or below the water table. It can discharge ground water onto the land surface, directly into the stream, or into the ocean. Figure 3-2 illustrates a valley that has been incised into a high-level water table, resulting in ground water discharges that contribute directly to streamflow and springs that contribute to streamflow. At places where erosion has removed the caprock, ground water discharges either as springs or into the ocean as seeps.

According to Gingerich (2005), streamflow measurements made on May 11, 1999 show that the 0.4 mile reach of Waiokamilo Stream immediately downstream from the Koolau Ditch to Akeke Spring was dry (no flow) from water being diverted at the ditch (Table 3-5). The stream gained about 3.8 million gallons per day (5.88 cubic feet per second) from the spring, which discharges from the Honomanu Basalt (Gingerich, 1999b). Downstream from the spring to the coast, Waiokamilo Stream loses flow to ground water and to various diversions. One of the written comments to the draft version of this IFSAR stated that in only 4 of the past 24 years, Waiokamilo Stream has run continuously from the springs below the ditch to the ocean; the last year was 1994 (see CPRC 41.0-3). The upper reaches were unclassified (i.e. it is not known if they are gaining or losing), probably due to inaccessibility of the stream.

On August 13, 2008, staff from the Commission and the East Maui Irrigation Company (EMI), including Manager Garret Hew, visited dams #2 and #3 on Waiokamilo Stream. As illustrated in Figure 3-4, the two dams are located in close proximity to one another at approximately 400 feet elevation, with dam #3 slightly upstream of dam #2. Dam #2 was constructed to divert water for taro cultivation in Wailuanui Valley. Information on taro cultivation in Wailua Valley is detailed in section 12.0, Protection of Traditional and Customary Hawaiian Rights. Dam #3 (Figure 3-1a) was constructed and maintained by

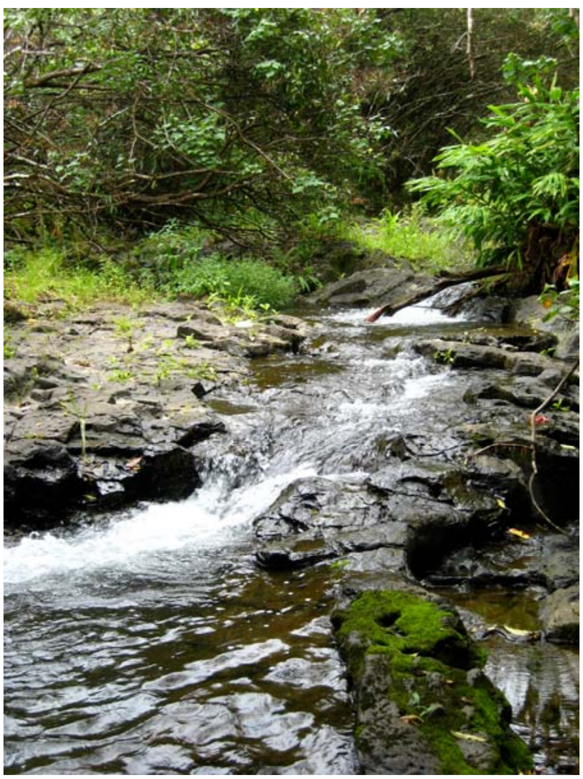
EMI to divert water away from the losing reach (Figure 3-1b) located immediately downstream of the dam. Staff also noted the presence of a second losing reach that is located upstream of the dam (Figure 3-1d). Currently, there is no information on where the stream water reappears when the water reaches the two losing sections of the stream, or if the water even reappears in downstream reaches. Flow may be decreased in the downstream reaches due to the presence of these losing sections of the stream.

Figure 3-1. a) Dam #3 on Waiokamilo Stream; b) losing reach immediately downstream of dam #3 on Waiokamilo Stream; c) Waiokamilo Stream upstream of dam #3; and d) losing reach upstream of dam #3.

a)

b)

c)



d)

Ground Water

Ground water is an important component of streamflow as it constitutes the base flow[7] of Hawaiian streams. When ground water is withdrawn from a well, the water level in the surrounding area is lowered. Nearby wetlands or ponds may shrink or even dry up if the pumping rate is sufficiently high (Gingerich and Oki, 2000). The long-term effects of ground water withdrawal can include the reduction of streamflow, which may cause a decrease in stream habitats for native species and a reduction in the amount of water available for irrigation. The interaction between surface water and ground water warrants a close look at the ground water recharge and demand within the State as well as the individual hydrologic units.

In Hawaii, ground water is replenished by recharge from rainfall, fog drip, and irrigation water that percolate through the plant root zone to the subsurface rock. Recharge can be captured in three major fresh ground water systems: 1) fresh water-lens system; 2) dike-impounded system; and 3) perched system. The fresh water-lens system provides the most important sources of ground water. It includes a lens-shaped layer of fresh water, an intermediate transition zone of brackish water, and underlying salt water. In northeast Maui, a vertically extensive fresh water-lens system can extend several hundreds or even thousands of feet below mean sea level. A dike-impounded system is found in rift zones and caldera of a volcano where low-permeability dikes compartmentalize areas of permeable volcanic rocks, forming high-level water bodies. On Maui, dikes impound water to as high as 3,300 feet above mean sea level. A perched system is found in areas where low-permeability rocks impede the downward movement of percolated water sufficiently to allow a water body to form in the unsaturated zone above the lowest water table (Gingerich and Oki, 2000).

The hydrologic unit of Waiokamilo lies within the Keanae aquifer system that has an area of 55.6 square miles. A general overview of the ground water occurrence and movement in this area is described by Gingerich (1999) and illustrated in Figure 3-2. The fresh water-lens system is vertically extensive, in which the saturated zone extends from the Honomanu Basalt at sea level through the Kula Volcanics and into the Hana Volcanics. Streams that intersect the water table continue to gain water as they descend to sea level. Ground water withdrawals from wells open to any part of the aquifer will reduce streamflow and discharge to the ocean. One of the two production wells (well numbers 5108-01 and 5108-02) located at the boundary of the Waiokamilo and Wailuanui hydrologic units taps into the aquifer for municipal use (Figure 3-3). Detailed information for each well is specified in Table 3-1. As of July 2005, the ground water demand of the Keanae aquifer system is only 0.162 million gallons per day, which is well below the aquifer's current sustainable yield of 96 million gallons per day (State of Hawaii, Commission on Water Resource Management, 2007). Estimated total ground water recharge without accounting for fog drip contribution is 171 million gallons per day, which represents 37 percent of total rainfall (Shade, 1999).

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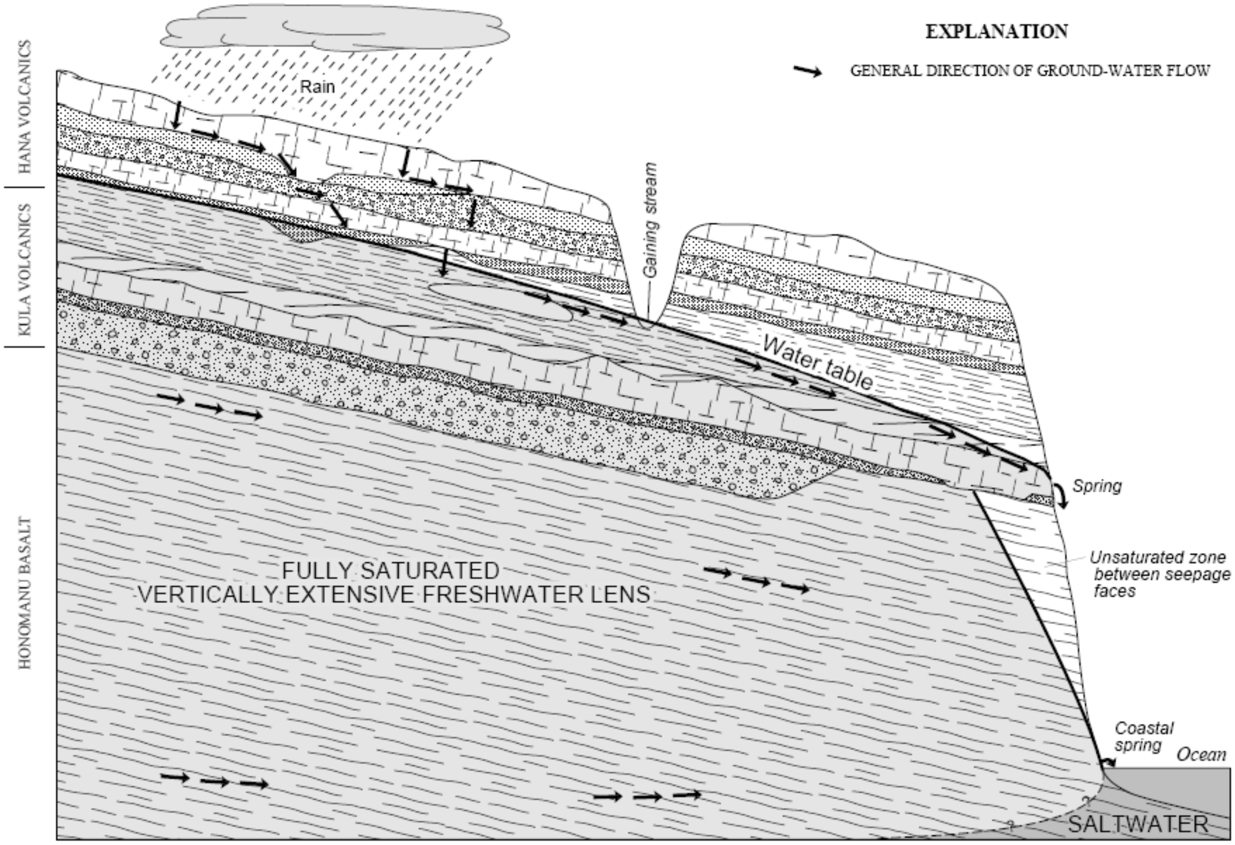
[7] Base flow is the water that enters a stream from persistent, slowly varying sources (such as the seepage of ground water), and maintains stream flow between water-input events (i.e., it is the flow that remains in a stream in times of little or no rainfall).

Figure 3-2. Diagram illustrating the ground water system east of Keanae Valley, northeast Maui, Hawaii. Arrows indicate general direction of ground water flow (Source: Gingerich, 1999b).



Ground water use information is only available by island. Among the major Hawaiian islands, Maui has the second highest number of production wells following Oahu. Of the 450 productions wells in Maui, 259 are low-capacity wells with a pumping rate of less than 25 gallons per minute. Assuming all the low-capacity production wells in Maui are pumping at 1,700 gallons per day, the island-wide withdrawal rate would be 0.44 million gallons per day. The cumulative impacts of small, domestic wells become particularly important when assessing areas where municipal water is unavailable (State of Hawaii, Commission on Water Resource Management, 2007). A majority of the reported ground water use in Maui is for agriculture (54 percent) and irrigation (34 percent) (Table 3-2).

Table 3-1. Information of wells located in Waiokamilo hydrologic unit (Source: State of Hawaii, 2008d).

[Negative elevation values indicate feet below mean sea level; positive elevation values indicate feet above mean sea level. Pump rate measured in gallons per minute (gpm); -- indicates value is unknown.]

Well number	Well Name	Year drilled	Use	Ground elevation (feet)	Well depth (feet)	Pump elevation (feet)	Pump depth (feet)	Pump rate (gpm)
5108-01	Keanae	1984	Municipal	214	330	--	--	100
5108-02	Keanae 2	2000	Unused	215	330	None	None	0

Table 3-2. Summary of ground water use reporting in the island of Maui (Source: State of Hawaii, Commission on Water Resource Management, 2007).

[Agriculture category includes water use for crops, livestock, and nursery plants; irrigation category includes water use for golf courses, landscape features, and other infrastructures. Mgd equals million gallons per day.]

Use Category	Use Rate (mgd)	Percent of Total (%)
Agriculture	48.134	53.7
Domestic	0.001	0
Industrial	1.683	1.9
Irrigation	9.611	10.7
Military	0	0
Municipal	30.172	33.7
Total	89.601	100

Streamflow Characteristics

One of the most common statistics used to characterize streamflow is the median value of flow in a particular time period. This statistic is also referred to as the flow at 50 percent exceedence probability, or the flow that is equaled or exceeded 50 percent of the time (TFQ_{50}). The longer the time period that is used to determine the median flow value, the more representative the value is of the average flow conditions in the stream. Median flow is typically lower than the mean or average flow because of the bias in higher flows, especially during floods, present when calculating the mean flow. The flow at the 90 percent exceedence probability (TFQ_{90}) is commonly used to characterize low flows in a stream. In Hawaii, the base flow is usually exceeded less than 90 percent of the time, and in many cases less than 70 percent of the time (Oki, 2003).

In cooperation with the Commission on Water Resource Management, the USGS conducted a study (Gingerich, 2005) to assist in determining reasonable and beneficial noninstream and instream uses of water in northeast Maui. The purpose of the study was to develop methods of estimating natural (undiverted) median streamflow, total flow statistics (TFQ), and base flow statistics (BFQ) at ungaged sites where observed data are unavailable. The study area lies between the drainage basins of Kolea Stream to the west and Makapipi Stream to the east. Basin characteristics and hydrologic data for the study area were collected and analyzed. One of the products of the study is a set of regression equations that can be used to estimate natural (undiverted) TFQ_{50}, BFQ_{50}, TFQ_{95}, and BFQ_{95} at gaged and ungaged sites. The subscripts indicate the percentage of time the flow, either total or base flow, is equaled or exceeded.

Since there is no USGS continuous-record stream gaging station in Waiokamilo, streamflow statistics were estimated at selected ungaged sites using the regression equations developed from the study. Three sites were selected along Waiokamilo Stream (Figure 3-4): 1) station WoL is located at about 200 feet elevation in the lower reach, in which the coastal waterfall is about 200 feet high; 2) station WoM is at 506 feet elevation in the middle reach; and 3) station WoU is at 1,375 feet elevation in the upper reach. The estimated streamflow statistics at each ungaged site are presented in Table 3-3.

Based on the estimates, the median total flows (TFQ_{50}) at stations WoL, WoM, and WoU are 14, 10, and 7 cubic feet per second, respectively. The median base flows (BFQ_{50}) are 8.7, 6.1, 3.9 cubic feet per second, respectively. The TFQ_{95} and BFQ_{95} at the middle and lower sites were adjusted based on low-flow measurements made by USGS and measurements made by the EMI in 1928. These statistics are different from those in Table 3-4, which shows the natural (undiverted) flow statistics. The middle site

TFQ_{95} estimate is a combination of the measured net gains of about 4.1 cubic feet per second (Gingerich, 1999), probably from the spring, and the upper site estimate (1.3 cubic feet per second) from regression equations. At the lower site, additional gains of 0.12 cubic feet per second and a tributary inflow of 1.3 cubic feet per second increase the undiverted flow estimate to 6.8 cubic feet per second (Gingerich, 2005).

Table 3-3. Stream flow statistics estimated using regression equations, lower and upper confidence intervals, standard errors, measured flow, and relative errors for ungaged sites in Waiokamilo (Source: Gingerich, 2005).

[Flows are in cubic feet per second (cfs); 90% LCL and 90% UCL is 90-percent lower and upper confidence level; Standard error is in percent; Relative error is the percent difference between the measured statistic and the estimated statistic; Measured flows in ***bold italic*** fall within the lower and upper 90-percent confidence interval; East Maui Irrigation Co., Ltd (EMI) 1928 measurements from March 16-20 when index station had a Q_{90} flow (reported in Gingerich, 1999)]

Stream location	Statistic	TFQ_{50}	BFQ_{50}	TFQ_{95}	BFQ_{95}	Source of measured flow estimates
Waiokamilo lower (WoL)	Estimated flow	14	8.7	2.8	2.4	**TFQ_{95}**: 1999 USGS low-flow measurement (Gingerich, 1999)
	90% LCL	12	6.8	2.2	1.8	
	90% UCL	17	11	3.6	3.2	
	Standard error	9.8	14.4	14.2	15.9	
	Measured flow	--	--	5.7	--	
	Relative error	--	--	-51	--	
Waiokamilo middle (WoM)	Estimated flow	10	6.1	2.2	1.8	**TFQ_{95}**: Average of EMI 1928 measurement and 1999 USGS low-flow measurement (Gingerich, 1999)
	90% LCL	9.0	5.0	1.8	1.4	
	90% UCL	12	7.4	2.6	2.3	
	Standard error	7.3	10.7	11.4	12.8	
	Measured flow	--	--	4.9	--	
	Relative error	--	--	-55	--	
Waiokamilo upper (WoU)	Estimated flow	7.0	3.9	1.3	1.1	No data available
	90% LCL	6.1	3.3	1.1	0.90	
	90% UCL	7.8	4.7	1.6	1.3	
	Standard error	6.9	10.2	9.1	10.1	
	Measured flow	--	--	--	--	
	Relative error	--	--	--	--	

Table 3-4. Estimates of natural (undiverted) streamflow statistics for ungaged sites in Waiokamilo (Source: Gingerich, 2005).

[Flows are in cubic feet per second (cfs); Numbers in ***bold italic*** are considered maximums at sites downstream of unquantified but known losing reaches]

Stream location	TFQ_{50}	BFQ_{50}	TFQ_{95}	BFQ_{95}	Source of estimate
Waiokamilo lower (WoL)	14	8.7	6.8	6.8	Regression equation; **TFQ_{95}**: measurement plus upper site estimate
Waiokamilo middle (WoM)	10	6.1	5.4	5.4	Regression equation; **TFQ_{95}**: measurement plus upper site estimate
Waiokamilo upper (WoU)	7.0	3.9	1.3	1.1	Regression equation

Measurements made on May 11, 1999 (Table 3-5) show that diversion at Koolau Ditch diverts all flows upstream from Akeke Spring, below which the stream gains 5.9 cubic feet of flow per second from the spring. Then the stream flows past a taro patch diversion, which takes water at a constant rate of 0.4 cubic feet per second. Another diversion at 440 feet elevation takes nearly all flow at 3.7 cubic feet per second. At approximately 400 feet elevation, the stream flows pass a losing reach (Figure 3-1d), dam #3 (Figure 3-1a), another losing reach (Figure 3-1b), and then dam #2. The flow increase between the upper and the middle sites can be attributed to flow gains at around 250 feet elevation from tributary Hamau Stream of 1.3 cubic feet per second, and an unnamed spring of 0.36 cubic feet per second. At the lower site, flow is decreased by a taro-patch diversion at 220 feet elevation, taking water at 1.1 cubic feet per second.

Effects of diversions can be assessed by comparing the flow statistics under natural conditions (Table 3-4) and those under diverted conditions (Tables 3-3, 3-5). A number of diversions are located along Waiokamilo Stream, with three being taro diversions and one other private diversion. Flow at the middle site (WoM) is affected by one diversion that is taking water at a known constant volume of 0.40 cubic feet per second. Median base flow (BFQ_{50}) decreased 39 percent from 6.1 (undiverted flow) to 3.7 cubic feet per second (diverted flow) (Gingerich, 2005). Flow at the lower site is reduced by three diversions, one at 440 feet elevation diverting at least 3.7 cubic feet per second and oftentimes all low flows (Gingerich, 1999), the second at 220 feet elevation diverting 1.1 cubic feet per second, and the third private diversion at 250 feet elevation diverting an unknown amount of water (Gingerich, 2005). Median base flow (BFQ_{50}) decreased 70 percent from 8.7 (undiverted flow) to 2.6 cubic feet per second (diverted flow) (Gingerich, 2005).

Table 3-5. Streamflow in Waiokamilo Stream, May 11, 1999, northeast Maui, Hawaii (Source: Gingerich, 1999, Table 15).

[mgd is million gallons per day; cfs is cubic feet per second]

Station number	Stream name	Altitude (ft)	Streamflow (mgd)	Streamflow (cfs)	Comments
Waiokamilo 1	Waiokamilo	80	0.47	0.73	
Waiokamilo 2	Waiokamilo	110	0.52	0.80	Includes some return flow from taro patch
Waiokamilo 3.1	Waiokamilo	220	0.36	0.56	
Waiokamilo 3.2	Diversion	220	0.70	1.08	Taro-patch diversion
Waiokamilo 4.1	Waiokamilo	240	0.23	0.36	Includes flow from unnamed spring
Waiokamilo 4.2	Hamau	250	0.83	1.28	Tributary to Waiokamilo Stream
Waiokamilo 5	Waiokamilo	440	2.40	3.71	Diversion takes nearly all flow
Waiokamilo 6	Waiokamilo	560	3.66	5.66	Upstream from taro-patch diversion
Waiokamilo 7	Diversion	540	0.25	0.39	Diversion to taro patch
Waiokamilo 8	Waiokamilo	720	3.80	5.88	Downstream from Akeke Spring
Waiokamilo 9	Waiokamilo	750	0.00	0.00	Upstream from Akeke Spring

Mathematical models and equations are commonly used to represent hydrologic occurrences in the real world; though, they are typically based on a set of assumptions that oftentimes render their estimates questionable in terms of accuracy and precision. This does not mean the public should entirely discount the estimates produced by these mathematical tools because they do provide quantitative and qualitative relative comparisons that are useful when making management decisions. Objections have been raised by several agencies in regards to the use of regression equations to estimate flow statistics. While the estimated statistics are presented to fulfill the purpose of compiling the best available information that will be considered in determining the interim IFS recommendations, the Commission staff does not intend to rely exclusively on the regression equations to make such important management decisions. The limitations and potential errors of the regression equations must also be considered.

One of the limitations of the regression equations is that they do not account for variable subsurface geology, such as those of intermittent streams and where springs discharge high flow to streams. The equations may overestimate flow statistics in intermittent streams as they do not account for losing reaches. On the other hand, the equations may underestimate the additional streamflow gained from springs. The equations tend to predict more accurately the higher flow statistics, TFQ_{50} and BFQ_{50}, rather than the lower flow statistics, TFQ_{95} and BFQ_{95}. The relative errors between observed and estimated flows ranged from 11 to 20 percent for TFQ_{50} and from 29 to 56 percent for TFQ_{95} and BFQ_{95}. According to Gingerich (2005), the most reliable estimates of natural and diverted streamflow duration statistics at gaged and ungaged sites in the study area were made using a combination of continuous-record gaging station data, low-flow measurements, and values determined from the regression equations. The study found that the average reduction in the low flow of streams due to diversions ranges from 55 to 60 percent.

Long-Term Trends in Flow

In a different study, the USGS examined the long-term trends and variations in streamflow on the islands of Hawaii, Maui, Molokai, Oahu, and Kauai, where long-term stream gaging stations exist (Oki, 2004). The study analyzed both total flow and estimated base flow at 16 long-term gaging stations. Figure 3-5 illustrates the results of the study for seven long-term gaging stations around the island. According to the analyses, low flows generally decreased from 1913 to 2002, which is consistent with the long-term downward trends in rainfall observed throughout the islands during that period. Monthly mean base flows decreased from early 1940s to 2002, which is consistent with the measured downward trend of low flows from 1913 to 2002. This long-term downward trend in base flow may imply a reduction of ground water contribution to streams. Changing streamflow characteristics could pose a negative effect on the availability of drinking water and habitat for native stream fauna (Oki, 2004).

Figure 3-3. Aquifer system area and well locations in Waiokamilo hydrologic unit (Source: State of Hawaii, Office of Planning, 2006b; State of Hawaii, Commission on Water Resource Management, 2004).

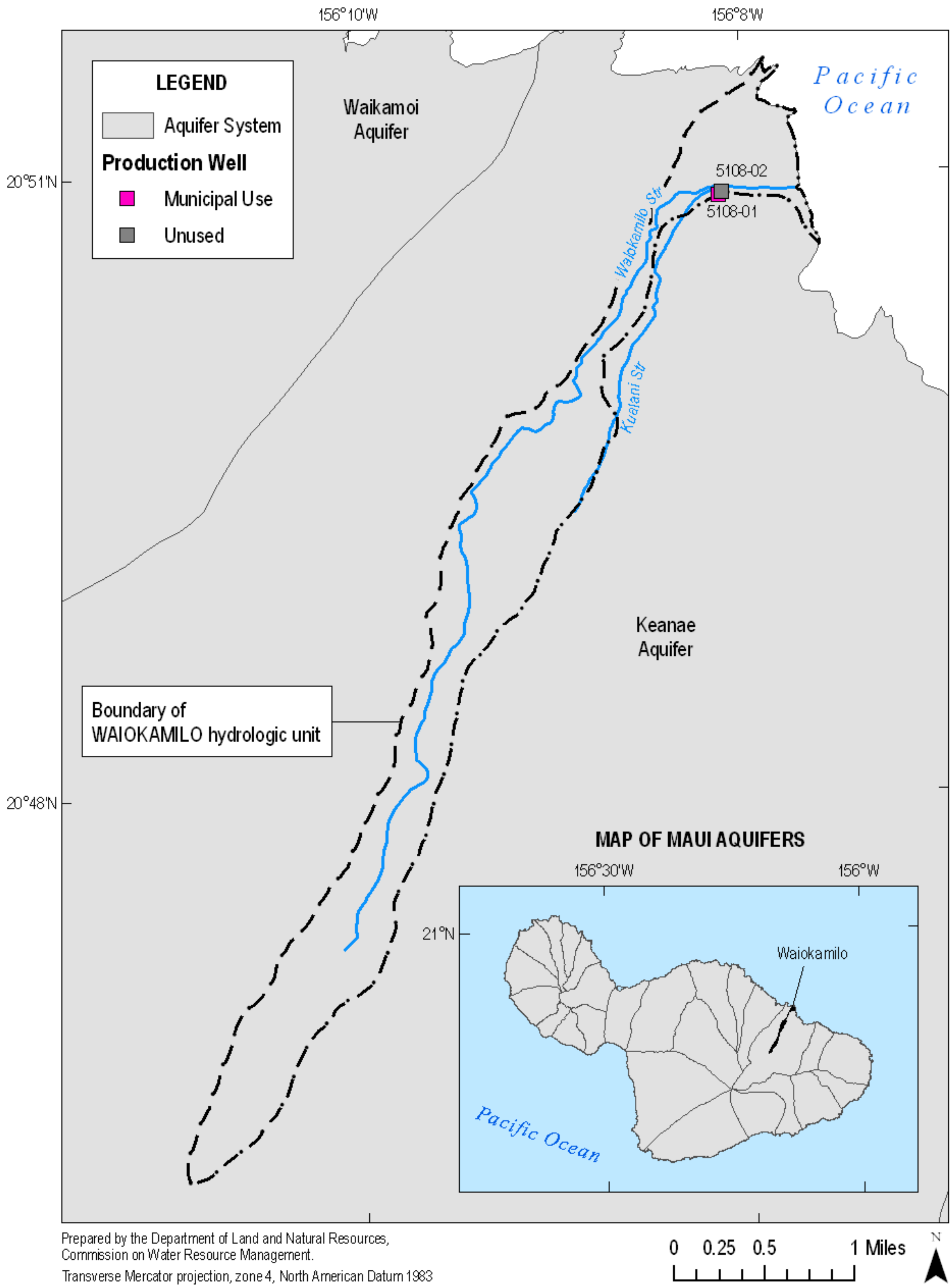
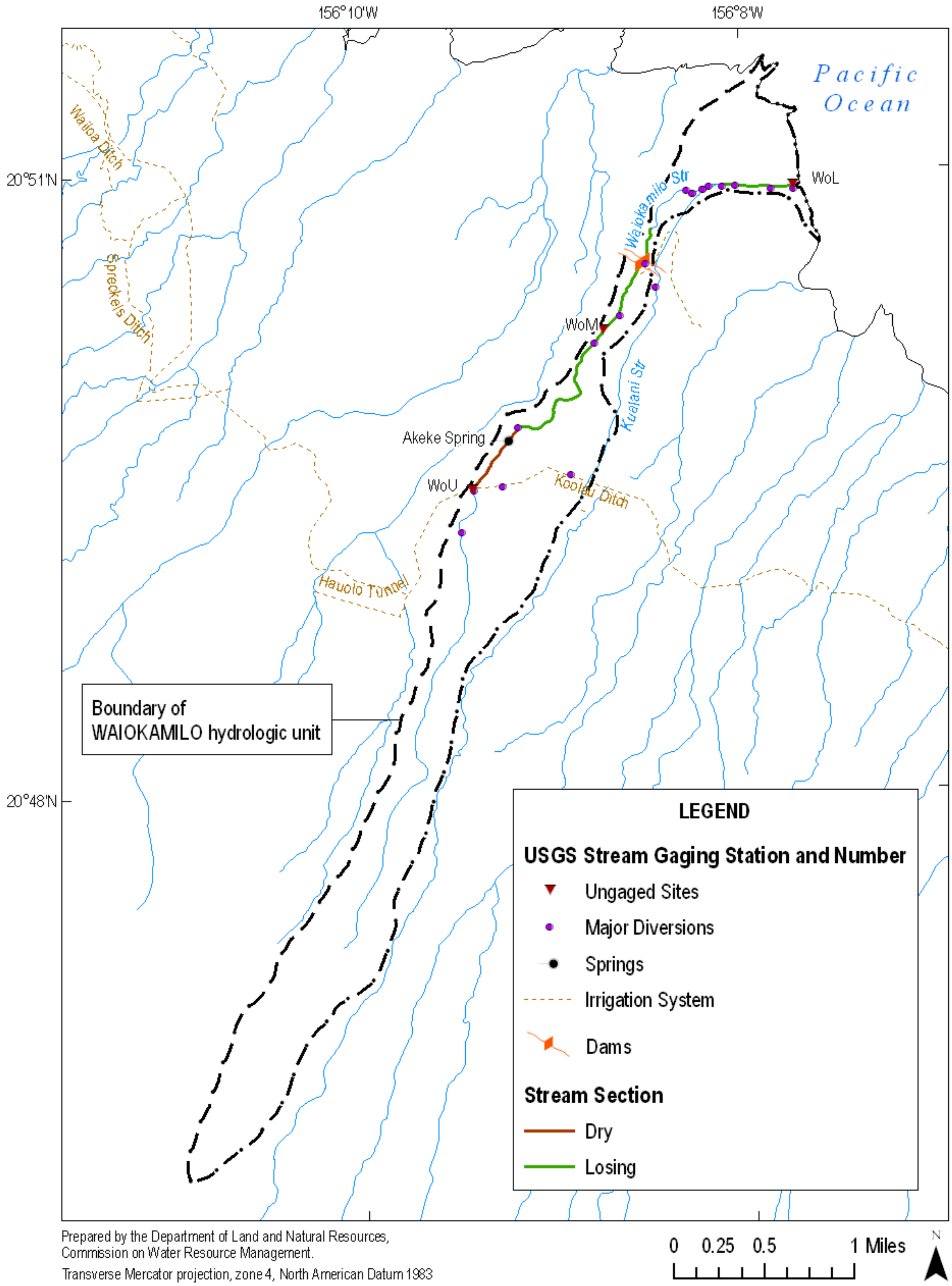


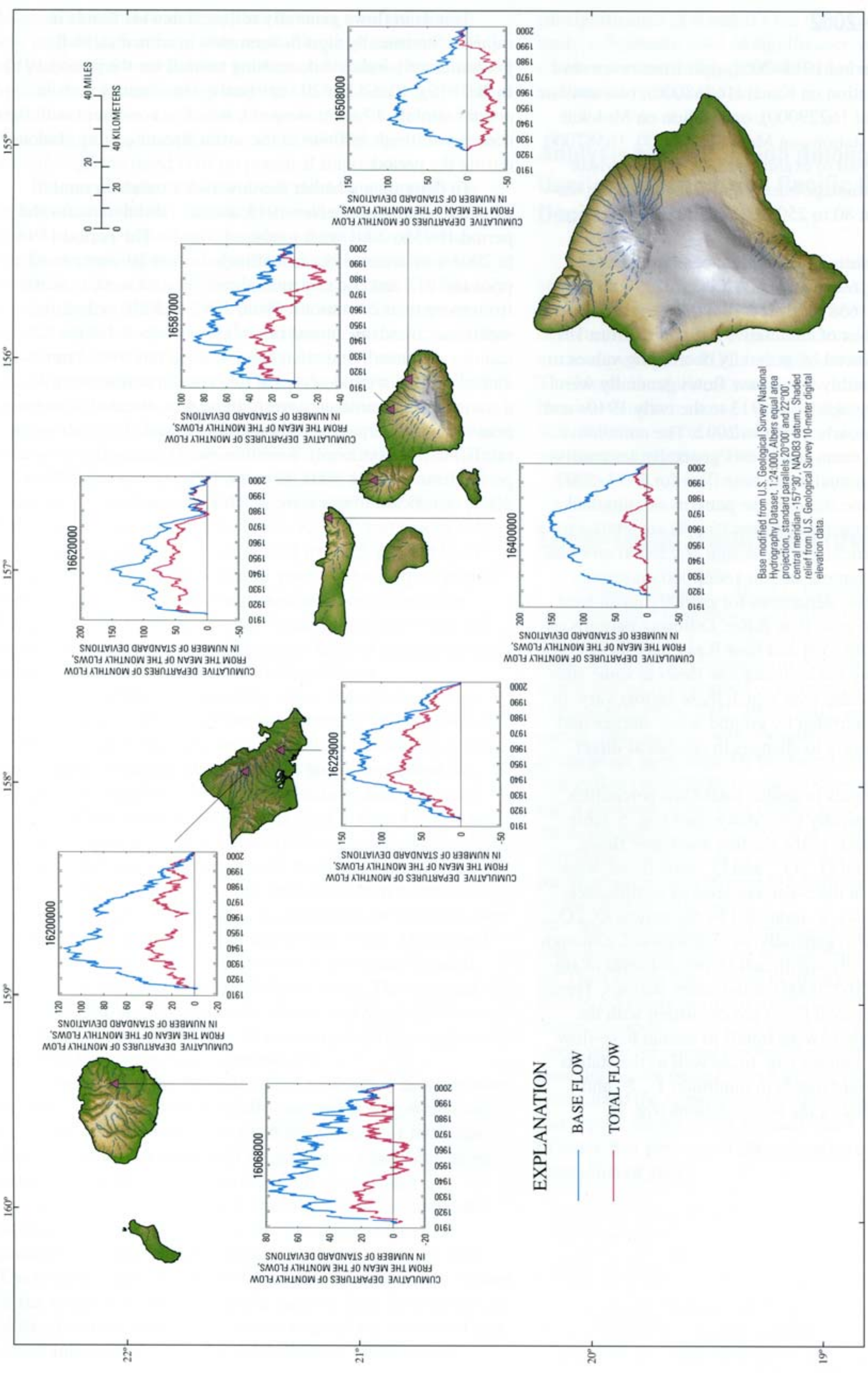
Figure 3-4. Location of diversions, irrigation systems, and selected ungaged sites in Waiokamilo hydrologic unit (Source: Gingerich, 2005; State of Hawaii, Office of Planning, n.d.; 1996, 2004c; 2005).



Prepared by the Department of Land and Natural Resources, Commission on Water Resource Management.

Transverse Mercator projection, zone 4, North American Datum 1983

Figure 3-5. Cumulative departures of monthly mean flow from the mean of the monthly flows, Hawaii. This data is based on complete water years from 1913 through 2002. (Oki, 2004, Figure 4).



4.0 Maintenance of Fish and Wildlife Habitat

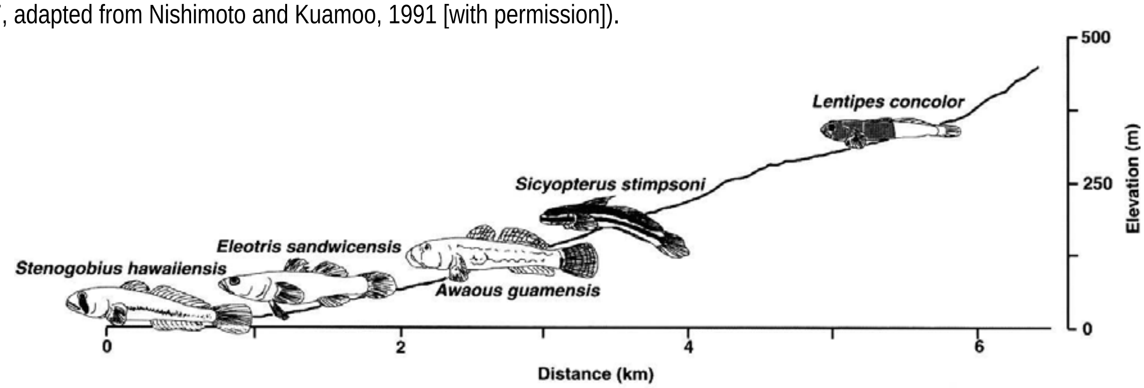
When people in Hawaii consider the protection of instream flows for the maintenance of fish habitat, their thoughts generally focus on just a handful of native species including five native fishes (four gobies and one eleotrid), two snails, one shrimp, and one prawn. Table 4-1 identifies commonly mentioned native stream animals of Hawaii.

Table 4-1. List of commonly mentioned native stream organisms. (Source: State of Hawaii, Division of Aquatic Resources, 1993).

Scientific Name	Hawaiian Name	Type
Awaous guamensis	ʻOʻopu nakea	Goby
Lentipes concolor	ʻOʻopu hiʻukole (alamoʻo)	Goby
Sicyopterus stimpsoni	ʻOʻopu nopili	Goby
Stenogobius hawaiiensis	ʻOʻopu naniha	Goby
Eleotris sandwicensis	ʻOʻopu akupa (okuhe)	Eleotrid
Atyoida bisulcata	ʻOpae kalaʻole	Shrimp
Macrobrachium grandimanus	ʻOpae ʻoehaʻa	Prawn
Neritina granosa	Hihiwai	Snail
Neritina vespertina	Hapawai	Snail

Hawaii's native stream animals have amphidromous life cycles (Ego, 1956) meaning that they spend their larval stages in the ocean (salt water), then return to fresh water streams to spend their adult stage and reproduce. Newly hatched fish larvae are carried downstream to the ocean where they become part of the planktonic pool in the open ocean. The larvae remain at sea from a few weeks to a few months, eventually migrating back into a fresh water stream as juvenile *hinana*, or postlarvae (Radtke et al., 1988). Once back in the stream, the distribution of the five native fish species are largely dictated by their climbing ability (Nishimoto and Kuamoo, 1991) along the stream's longitudinal gradient. This ability to climb is made possible by a fused pelvic fin which forms a suction disk. *Eleotris sandwicensis* lacks fused pelvic fins and is mostly found in lower stream reaches. *Stenogobius hawaiiensis* has fused pelvic fins, but lacks the musculature necessary for climbing (Nishimoto and Kuamoo, 1997). *Awaous guamensis* and *Sicyopterus stimpsoni* are able to ascend moderately high waterfalls (less than ~20 meters) (Fitzsimons and Nishimoto, 1990), while *Lentipes concolor* has the greatest climbing ability and has been observed at elevations higher than 3,000 feet (Fitzsimons and Nishimoto, 1990) and above waterfalls more than 900 feet in vertical height (Englund and Filbert, 1997). Figure 4-1 illustrates the elevational profile of these native fresh water fishes.

Figure 4-1. Elevational profile of a terminal-estuary stream on the Big Island of Hawaii (Hakalau Stream). (Source: McRae, 2007, adapted from Nishimoto and Kuamoo, 1991 [with permission]).



The maintenance, or restoration, of stream habitat requires an understanding of and the relationships among the various components that impact fish and wildlife habitat, and ultimately, the overall viability of a desired set of species. These components include, but are not limited to, species distribution and diversity, species abundance, predation and competition among native species, similar impacts by alien species, obstacles to migration, water quality, and streamflow. The Commission does not intend to delve into the biological complexities of Hawaiian streams, but rather to present basic evidence that conveys the general health of the subject stream. The biological aspects of Hawaii's streams have an extensive history, and there is a wealth of knowledge, which continues to grow and improve.

One of the earliest statewide stream assessments was undertaken by the Commission in cooperation with the National Park Service's Hawaii Cooperative Park Service Unit. The 1990 Hawaii Stream Assessment (HSA) brought together a wide range of stakeholders to research and evaluate numerous stream-related attributes (e.g., hydrology, diversions, gaging, channelizations, hydroelectric uses, special areas, etc.). The HSA specifically focused on the inventory and assessment of four resource categories: 1) aquatic; 2) riparian; 3) cultural; and 4) recreational. Though no fieldwork was conducted in its preparation, the HSA involved considerable research and analysis of existing studies and reports. The data were evaluated according to predefined criteria and each stream received one of five ranks (outstanding, substantial, moderate, limited, and unknown). Based on the stream rankings, the HSA offered six different approaches to identifying candidate streams for protection.

Due to the broad scope of the HSA inventory and assessment, it continues to provide a valuable information base for the Commission's Stream Protection and Management Program and will continue to be referred to in various sections throughout this report. Unfortunately, the aquatic resources of Waiokamilo Stream were classified as "unknown." The HSA classification was based on two surveys, with the last one conducted in 1963.

The HSA inventory was general in nature, resulting in major data gaps, especially those related to the distribution and abundance of aquatic organisms – native and introduced – inhabiting the streams. The State of Hawaii Division of Aquatic Resources (DAR) has since continued to expand the knowledge of aquatic biota in Hawaiian streams. Products from their efforts include the compilation and publication of an *Atlas of Hawaiian Watersheds and Their Aquatic Resources* for each of five major islands in the state (Kauai, Hawaii, Oahu, Molokai, and Maui). Each atlas describes watershed and stream features, distribution and abundance of stream animals and insect species, and stream habitat use and availability. Based on these data, a watershed and biological rating is assigned to each stream to allow easy comparison with other streams on the same island and across the state. The data presented in the atlases are collected from various sources, and much of the stream biota data are from stream surveys conducted by DAR. Currently, efforts have been focused on updating the atlases with more recent stream survey data collected statewide, and developing up-to-date reports for Commission use in interim IFS recommendations for east Maui. A copy of the updated inventory report for Waiokamilo Stream is in Appendix A. The following is a brief summary of findings. (See Figure 4-4 for survey points.)

- **Point Quadrat Survey.** Native species of fish (*Awaous guamensis*) and crustaceans (*Atyoida bisulcata*) were observed in the middle reaches (downstream of Koolau Ditch) of Waiokamilo Stream and most of them were present in deeper waters. The headwaters and upper reaches of the stream (upstream of Koolau Ditch) were not surveyed. Larval recruitment of native fish was not observed near the terminal section of this stream as there was little or no flow in the stream mouth. Postlarval recruitment may be limited to periods of high flow when the lower stream channel is completely watered. Introduced species such as mosquitofish (*Gambusia affinis*), crayfish (*Procambarus clarkii*), and poeciliid fish (*Poecilia sp.*) were observed in the middle reaches. Mosquitofish and other poeciliids are known to transmit parasites to native fishes. High flows may reduce the population of these introduced species; however, they are likely to be reintroduced if ditch water is released back into the stream.

- **Insect Survey.** No aquatic insect surveys were conducted on Waiokamilo Stream. Since native damselflies were observed in adjacent streams, it is possible that native damselflies are present in the upper reaches of this stream.

- **Analysis of Depth Use versus Availability.** Waiokamilo Stream is generally shallower downstream of diversions than would be expected of a typical Hawaiian stream. The frequency of sampling a dry site was 14 percent higher than statewide. Native animals were restricted to disconnected deep pools formed by dry or shallow sections associated with stream diversions. The average site depth where native stream animals were observed was 20 inches, suggesting that a depth of 20 inches or deeper was suitable for most species. However, many sites with adequate water depth were uninhabited, which indicated that the terminal waterfall at the stream mouth and the dry sections of the lower reaches may be restricting upstream migration of native amphidromous animals. Water quality may also be a factor that was not tested in the stream surveys. Return of water into the stream would likely have a beneficial effect on the availability of suitable depths for native species in the currently dry or shallow stream sections dewatered by diversions.

- **Watershed and Biological Rating.** Waiokamilo Stream and watershed have a moderately high rating for total watershed rating and low total biological rating when compared across Maui and statewide. The low native- to alien- species population ratio contributes to the low biological rating of this stream. Based on the rating, Waiokamilo Stream may have the potential to sustain larger populations of native species than observed if flow is restored to the stream. When restoring flow from ditch waters, steps must be taken to prevent the introduction of invasive species (i.e., poeciliid fishes) from the ditch into the stream.

In addition to the presence of a terminal waterfall at its mouth, the ditch diversions in Waiokamilo Stream block upstream migration of native amphidromous animals with the use of pipes. At high flows, stream diversions are overtopped and streamflow is continuous from the upper reaches to the sea. When flow returns to normal level, diversions could quickly remove water from the stream, leaving sections dry. This prevents the upstream migration of native stream animals, restricts surviving adult animals to the disconnected deep pools, and causes postlarvae recruits to be stranded at the stream mouth. The diversions also have significantly reduced baseflows in the stream, limiting overall habitat for native species. Restoration of streamflow and increased connectivity could lead to the development of a richer and more native-dominated community in the stream. The potential for introducing species from invasive-dominated terminal reaches to native-dominated mid- and headwater reaches is not a major problem in east Maui due to the presence of large waterfalls. However, care must be taken to not introduce invasive species via release of water from ditches. This could be accomplished through ditch bypasses.

Surface water diversion systems can have profound effects on the availability of instream habitats for native stream fauna (fish, shrimp, and snails). The major diversion systems in northeast Maui are operated by East Maui Irrigation Co, Ltd. With a few exceptions, the diversions capture all base flow and an unknown amount of total streamflow in each stream, decreasing flow downstream of the diversion and sometimes causing streams to go dry (Gingerich and Wolf, 2005). Changes in flow volume may influence the physical and chemical characteristics of stream water and flow (e.g. temperature, pH, velocity), hence altering the stream ecosystem.

In cooperation with the Commission on Water Resource Management, the USGS conducted a study to assess the effects of surface water diversion systems on habitat availability for native stream species in northeast Maui, Hawaii. The goal was to determine a relationship between streamflow and habitat availability using a habitat selection model. By incorporating hydrology, stream morphology, and habitat characteristics, the model simulated habitat and streamflow relations for various species and life stages (Gingerich, 2005). The end product of the study was a set of equations that can estimate the relative amount of usable streambed habitat at diverted conditions when compared with the undiverted condition, as a percentage of the habitats available under undiverted conditions.

The study focused on certain native fish, snail and shrimp species found in Hawaiian streams. Three fish species of the Gobiidae family, also known as gobies, were considered: 1) alamoo (*Lentipes concolor* (Gill)); 2) nopili (*Sicyopterus stimpsoni* (Gill)); and 3) goby nakea (*Awaous guamensis* (Valenciennes)). In addition, one of the freshwater snail species, *Neritina granosa* (Sowerby), commonly referred to as hihiwai, and the mountain shrimp, *Atyoida bisulcata* (Randall), also known as opae kalaole or mountain opae, were also considered in the study. All the species are amphidromous, in which individuals migrate between a fresh water stream and the saltwater ocean, and then return to the freshwater environment once in their lifetime. The gobies of interest have a fused pelvic fin, allowing them to climb upstream.

Stream morphology data were collected at five streams (excluding Waiokamilo) in northeast Maui at three locations along each study stream: 1) directly upstream of the diversions at about 1,400-1,700 feet elevation (upper site); 2) midway to the coast at about 500-600 feet (middle site); and 3) near the coast at 10-40 feet elevation (lower site). Estimated natural and diverted median total and base flows were compiled from Gingerich (2005). Habitat availability and species abundance were quantified using snorkel surveys made during daylight hours. The lower sites were evaluated for adult and juvenile nopili, adult nakea, and hihiwai. Since the adult and juvenile alamoo, and opae do not typically live in the lower reaches, they were evaluated only in the middle and upper sites. Hydrologic data were entered into the habitat selection model to develop a set of equations that estimate the area of usable streambed habitat over a range of streamflow values.

These equations were applied to two sites in Waiokamilo Stream, middle (WoM) and lower (WoL), to estimate the relative amount of available habitats under diverted and natural conditions. Results were plotted against those of the five studied streams as represented by the green band in Figure 4-2. The general relation shows that as streamflow increases, the area of estimated usable streambed habitat for all interested species also increases. Since the lower site is downstream from multiple diversions, only 59-70 percent of the expected habitat for the gobies and hihiwai, and 73-77 percent of the expected habitat for the opae are available if 30 percent of the median base flow is present under diverted conditions (Table 4-2). When median base flow is at 61 percent of the natural conditions (middle site), 83-93 percent of the expected habitat for the gobies and hihiwai, and 90-93 percent of the expected habitat for the opae are available (Table 4-2). Thus, the addition of even a small amount of water to a relatively dry stream can have a significant effect on the amount of habitat available (Gingerich, 2005). Estimates of expected habitat availability are not representative of stream reaches within close proximity to large waterfalls since they generally prevent all species of interest, except for the opae and alamoo, from migrating upstream.

Figure 4-2. Relative habitat available for given relative base flow at studied streams. Relative change is the difference between natural and diverted conditions divided by natural conditions (Gingerich and Wolff, 2005).

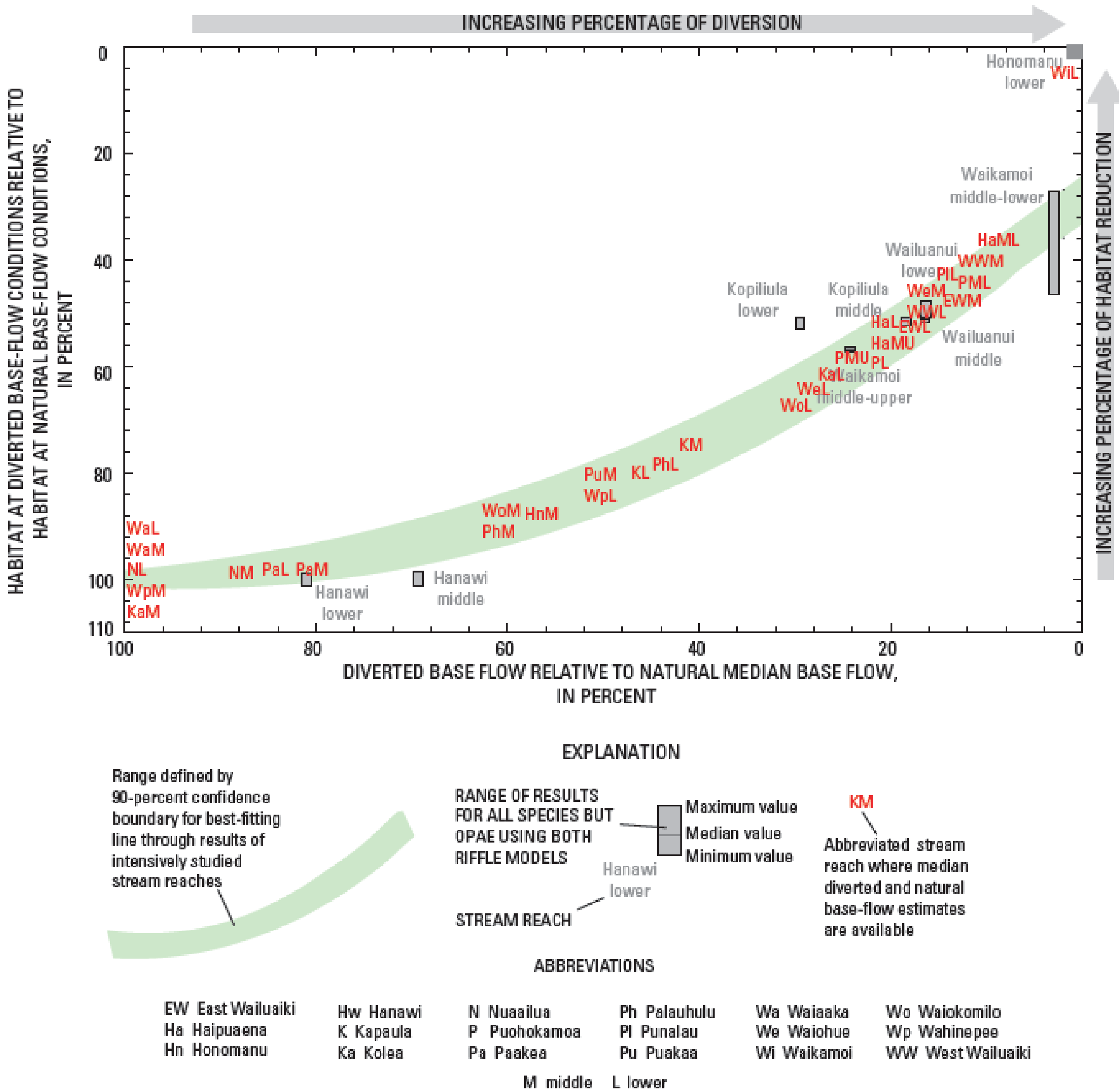


Table 4-2. Summary of relative base flow and available habitat in Waiokamilo Stream (Source: Gingerich and Wolff, 2005).

[ft^3/s is cubic foot per second; Numbers in ***bold italic*** are considered maximums at sites downstream of unquantified but known losing reaches]

Stream site	Median base flow remaining in stream (ft^3/s)		Median base flow at diverted conditions relative to median base flow at natural conditions (% of natural conditions)	Habitat available at diverted conditions (excluding opae) relative to habitat available at natural conditions (% of natural conditions)	Habitat available for opae at diverted conditions relative to habitat available at natural conditions (% of natural conditions)
	Diverted	Natural			
lower (WoL)	2.6	8.7	30	70 - 59	77 - 73
middle (WoM)	***3.7***	6.1	61	93 - 83	93 - 90

Another important consideration of fish and wildlife habitat is the presence of critical habitat. Under the Endangered Species Act, the U.S. Fish and Wildlife Service is responsible for designating critical habitat for threatened and endangered species. Though there are very few threatened or endangered Hawaiian species that are directly impacted by streamflow (e.g., Newcomb's snail), the availability of surface water may still have indirect consequences for other species. Based upon current designations, there are no known critical habitat areas for fish and wildlife associated with Waiokamilo Stream.

In addition to critical habitat, the presence of native bird habitat should not be overlooked. Bird habitat ranges from urban environments and grasslands, to wetlands and native rainforests. Within these habitat ranges, streams provide an important source of food and water for native birds. Springs flow into loi and fishponds where native waterbirds, such as the *aukuu* (black-crowned night-heron) and the *koloa* (Hawaiian duck), search for food and locations to build a nest for their young. Streams are also valuable indicators of forest health. Since the headwaters of streams typically originate from forested areas, a forest with dense vegetation, especially along the stream bank would help prevent erosion, thus yielding cleaner fresh water for fish and wildlife as well as water demands in the lowland areas.

A diversity of native birds can be found in east Maui. Some of the notable species found in Haleakala National Park include the Hawaii (Dark-rumped) Petrel, *Nene* (Hawaiian Goose), and Common *Amakihi* (Pratt, 1993). Within Waikamoi Preserve and the northeast slope of Haleakala above 4,000 feet, the species found are the Maui Parrotbill, Maui Creeper, and *Akohekohe* (Crested Honeycreeper). The *Iiwi*, Red-billed Leiothrix, and *Apapane* are more common in Waikamoi Preserve. The U.S. Fish and Wildlife Service (n.d.) estimated the habitat ranges for native Hawaiian forest birds based on vegetation boundaries. In Waiokamilo, the native forest bird habitat spans 0.4 square miles across the upper slopes of the hydrologic unit where there is an abundance of forested wetlands (Figure 4-5).

Figure 4-3. Relative habitat available for given relative base flow at studied streams. Relative change is the difference between natural and diverted conditions divided by natural conditions (Source: Gingerich and Wolff, 2005).

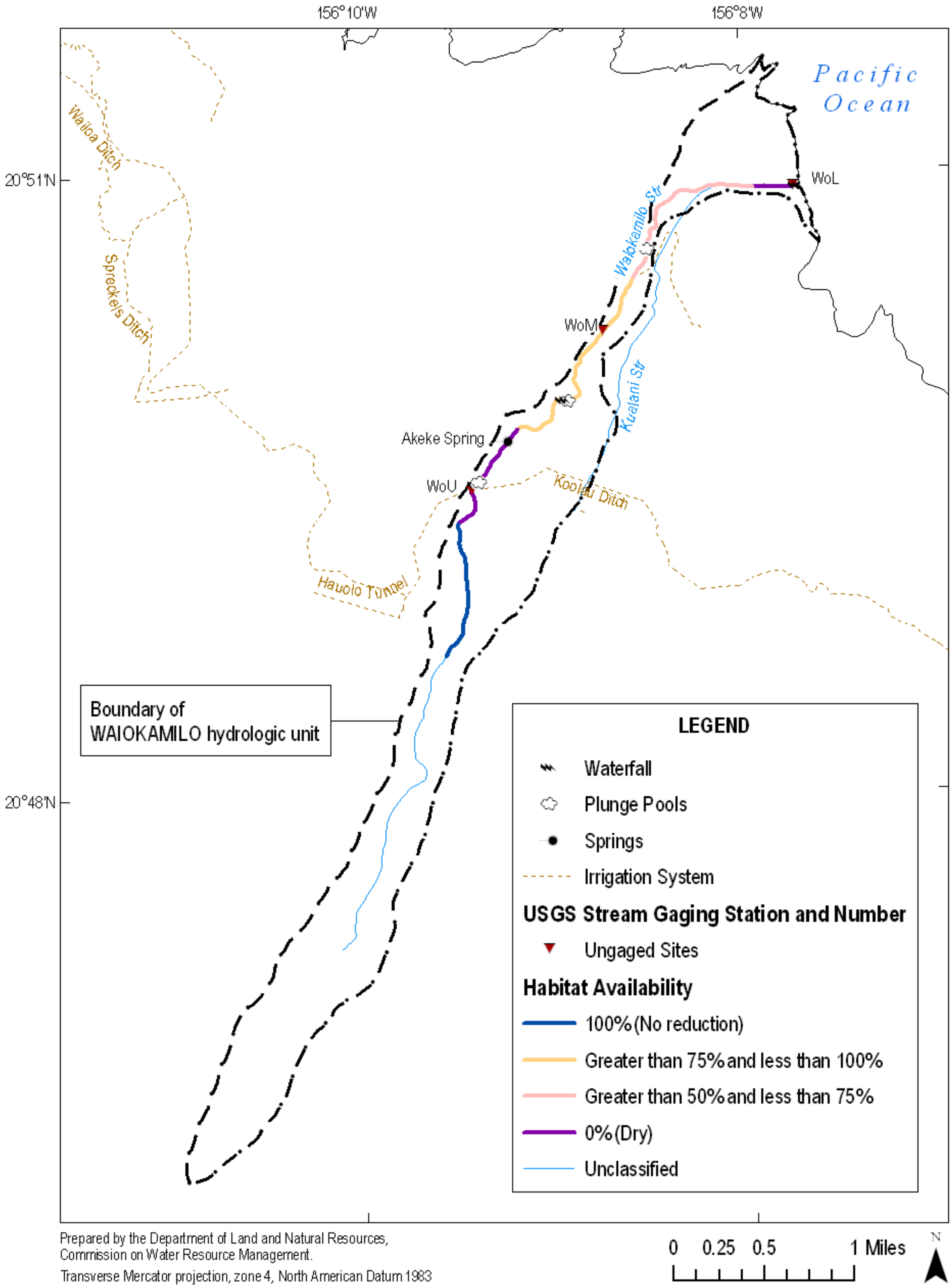


Figure 4-4. State Division of Aquatic Resources stream survey points for Waiokamilo hydrologic unit.

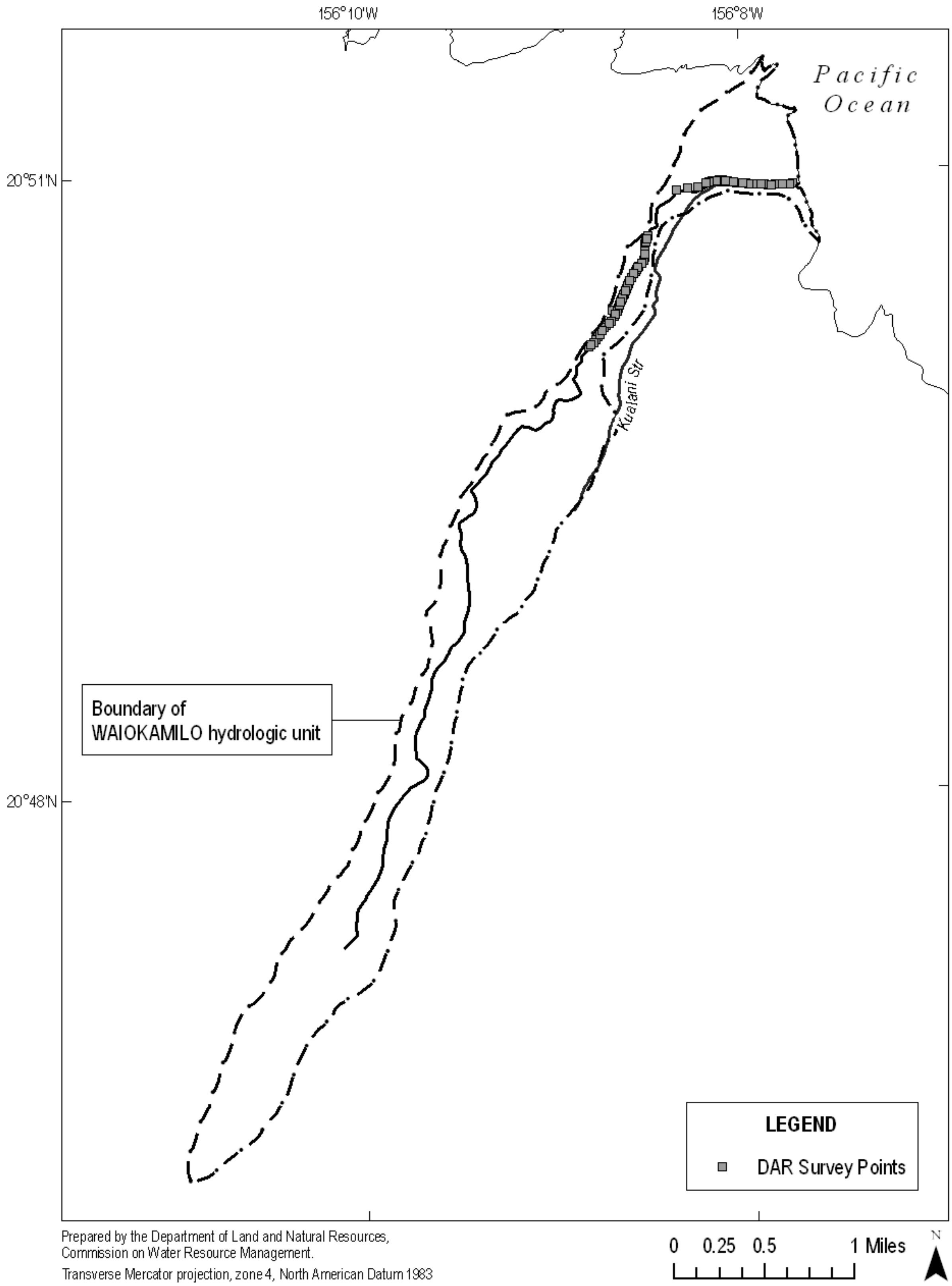
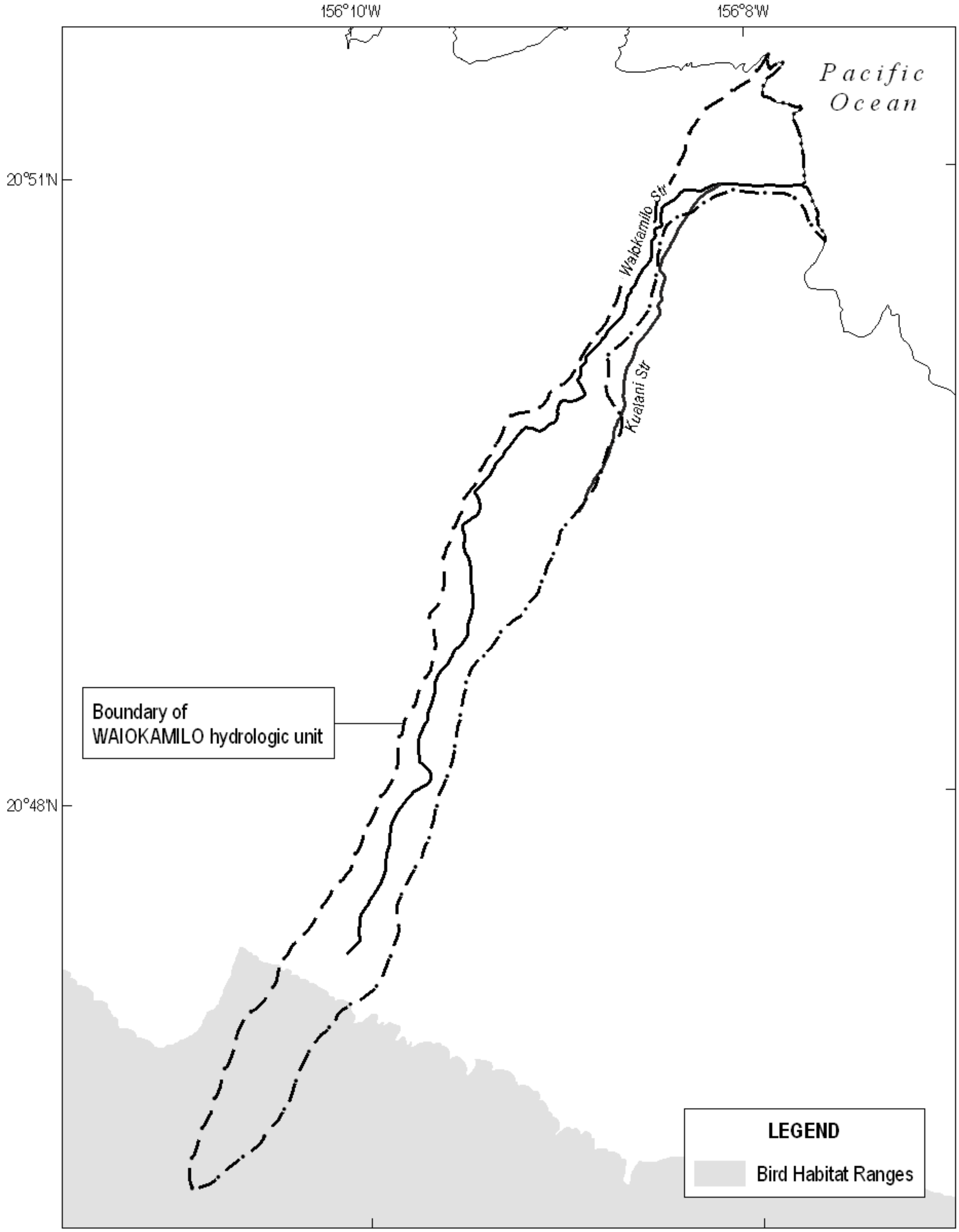


Figure 4-5. Bird habitat ranges, critical habitats, and density distribution of threatened and endangered plant species in the Waiokamilo hydrologic unit (Source: Jacobi, 1989; Scott et al., 1986; State of Hawaii, Office of Planning, 1992, 2004).



Prepared by the Department of Land and Natural Resources, Commission on Water Resource Management.
Transverse Mercator projection, zone 4, North American Datum 1983

5.0 Outdoor Recreational Activities

Water-related recreation is an integral part of life in Hawaii. Though beaches may attract more users, the value of maintaining streamflow is important to sustaining recreational opportunities for residents and tourists alike. Streams are often utilized for water-based activities, such as boating, fishing, and swimming, while offering added value to land-based activities such as camping, hiking, and hunting. Growing attention to environmental issues worldwide has increased awareness of stream and watershed protection and expanded opportunities for the study of nature; however, this must be weighed in conjunction with the growth of the eco-tourism industry and the burdens that are placed on Hawaii's natural resources.

The State of Hawaii Department of Health (DOH) maintains water quality standards (HAR 11-54) for recreational areas in inland recreational waters based on the geo-mean of *Enterococcus*, a fecal indicator: 33 colony-forming units per 100 mL of water or a single-sample maximum of 89 colonies per 100 mL. This is for full-body contact (swimming, jumping off cliffs, etc.). If *Enterococcus* exceeds those values, the water body is considered to be impaired. DOH also has a standing advisory for *Leptospirosis* in all freshwater streams. The marine recreational zone, which extends from the shoreline seaward to 1,000 feet from shore, requires an *Enterococci* geo-mean of less than 7 colony-forming units per 100 mL of water, to protect human health.

The recreational resources of Waiokamilo Stream were classified as "outstanding" by the HSA's regional recreation committee; however, it was not ranked as one of the outstanding streams statewide. The HSA identified opportunities for fishing, hunting, swimming, and scenic views related to Waiokamilo . Of a total of nine experiences (opportunities categorized by a recreational opportunity spectrum), three were defined as high-quality experiences (National Park Service, Hawaii Cooperative Park Service Unit, 1990) (Table 5-1).

Table 5-1. Hawaii Stream Assessment survey of recreational opportunities by type of experience.

	Urban		Country		Semi-Natural		Natural	
	Norm	High	Norm	High	Norm	High	Norm	High
Camping								
Hiking								
Fishing			■		■		■	
Hunting						■		
Swimming			■		■		■	
Boating								
Parks								
	Trail		Road		Ocean		Air	
Scenic Views						■		■
	Educational		Botanical					
Nature Study								

According to public hunting data, Hunting Unit B on the island of Maui consists of portions of the Koolau Forest Reserve. The portion of the hunting area unit within the Waiokamilo hydrologic unit is approximately 1.83 square miles or 74.7 percent of the hydrologic unit (Figure 5-1). A permit is required for the hunting of wild pigs and goats, using rifles, shotguns, bows and arrows, and dogs. Bag limits are two pigs and two goats of either sex per day, while the hunting season is open year-round on Saturdays, Sundays, and State holidays. Handguns are allowed for the hunting of pigs with or without dogs.

Since changes to streamflow and stream configurations have raised concerns regarding their impact to on-shore and near-shore activities, the Commission attempted to identify these various activities in relation to Waiokamilo Stream. A 1981 Maui Resource Atlas, prepared by the State of Hawaii Department of Transportation's Harbors Division, inventoried coral reefs and coastal recreational activities. Looking at available GIS data, the Commission identified the following activities that were known to occur or observed at or near Waiokamilo: pole and line fishing, trolling/bottom fishing, and some specialized fisheries. There are no opportunities for beach swimming related to Waiokamilo since the stream enters the ocean at a terminal waterfall known as Waiokilo Falls (Figure 5-2).

Oral testimony at the Public Fact Gathering Meeting held by the Commission on April 10, 2008 included comments about low flows in Waiokamilo Stream resulting in impaired recreational opportunities. One resident testified that because of the lack of flow, there are lots of mosquitoes in the area; the river is black and dirty and no longer suitable for children to swim in it; and a family dog has a skin disease from the stream water (See CPRC 1.0-32).

Another facet of recreation is the unique educational opportunities that streams provide for nature study. One way to approach this is to identify established study sites or nature centers that offer structured learning programs. In lieu of that, the Commission considered available GIS data to identify schools in proximity to Waiokamilo Stream that may utilize the stream as part of its curriculum. Keanae Elementary School, established in 1915, is the only public education facility in the area and is less than a 0.25 miles from Waiokamilo Stream. However, Keanae Elementary was closed in 2005, for the time being, due to a lack of students. Local area students must now attend Hana High and Elementary (San Nichols, 2005).

Figure 5-1. Public hunting areas for game mammals in Waiokamilo hydrologic unit (Source: State of Hawaii, Office of Planning, 2002b).

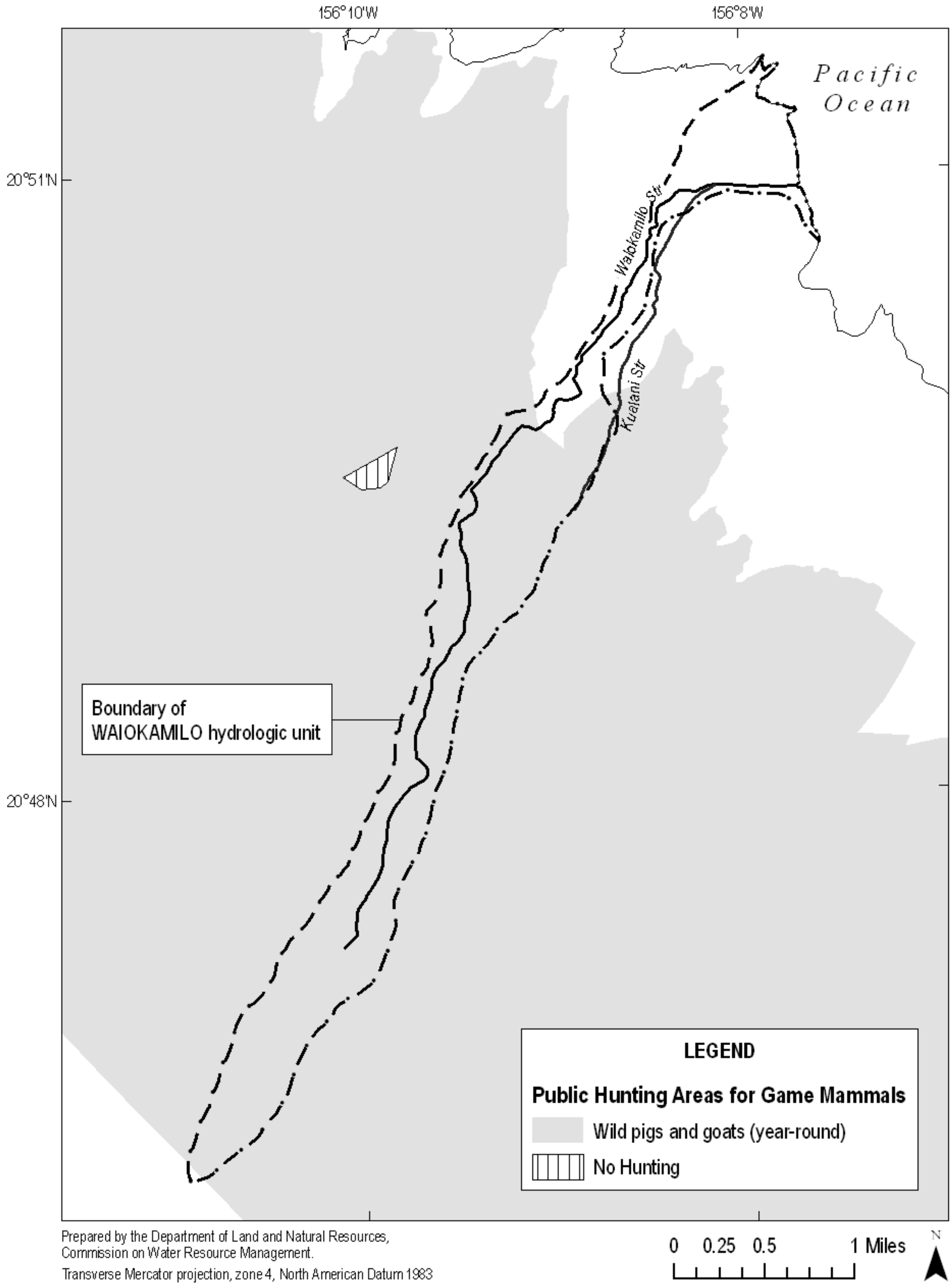
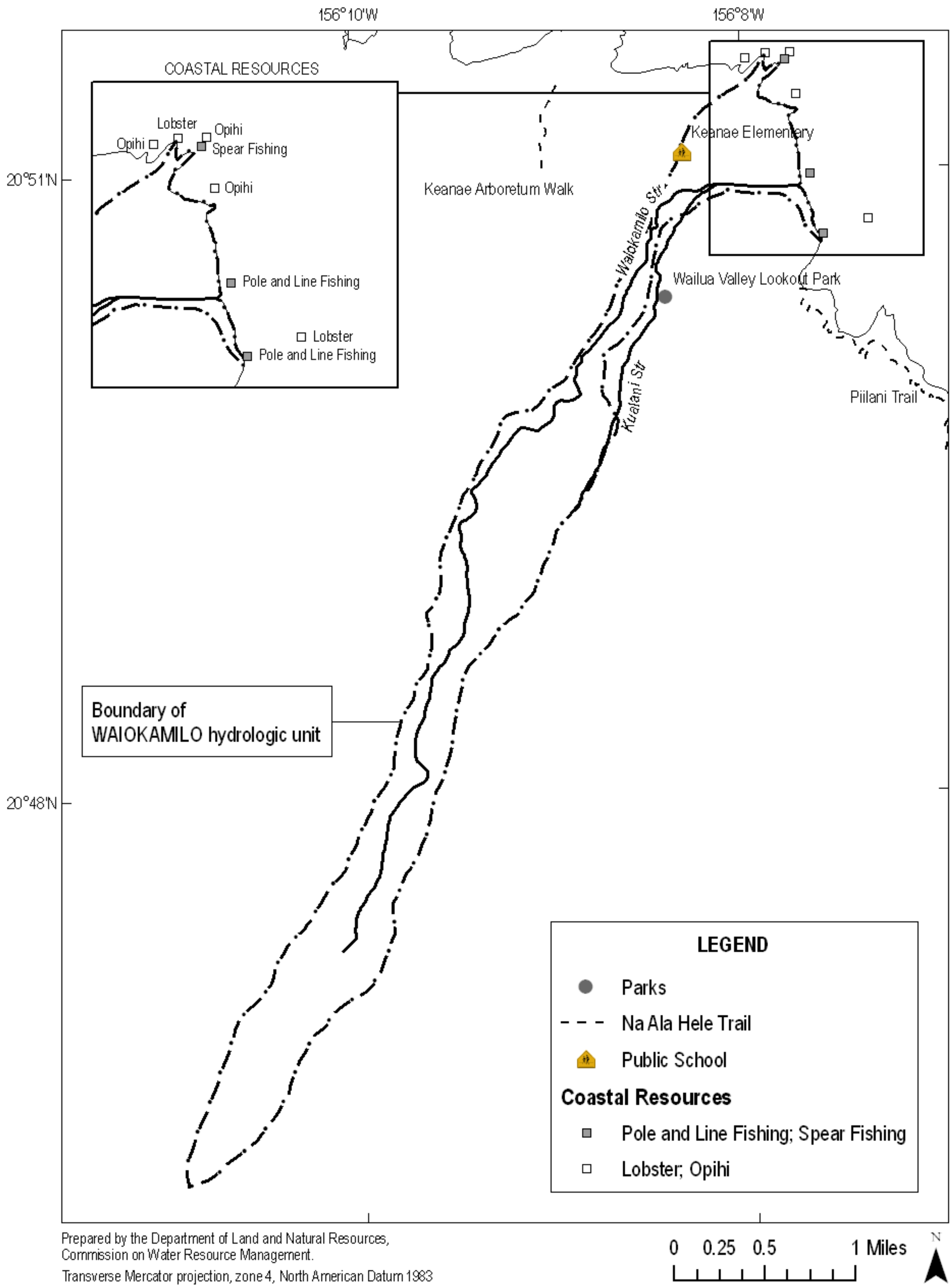


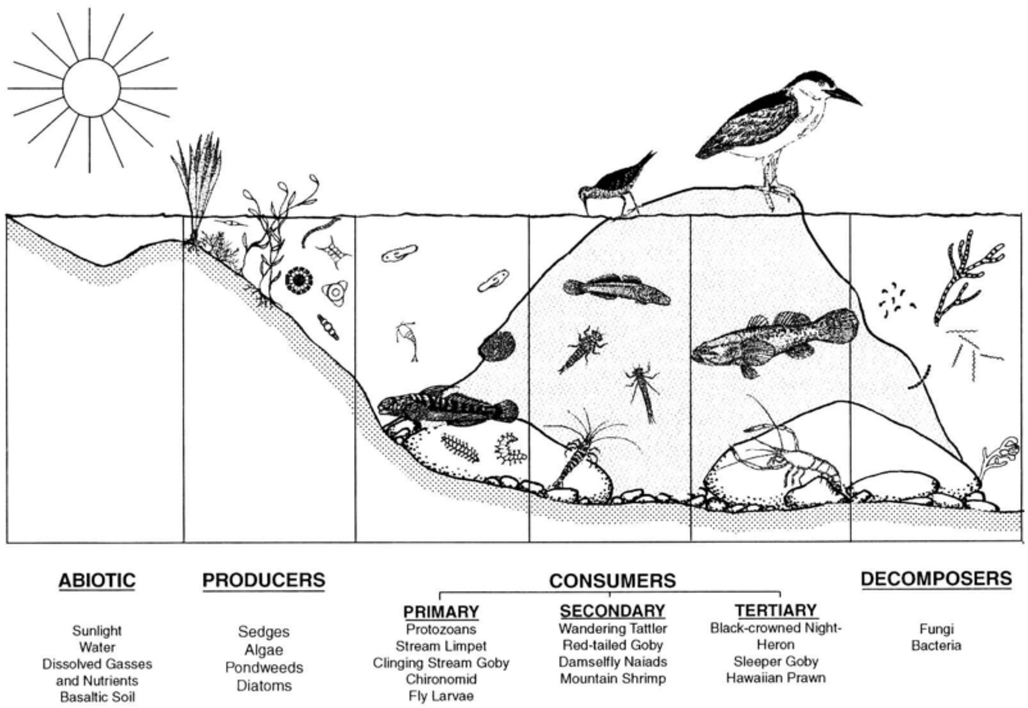
Figure 5-2. Recreational points of interest for Waiokamilo hydrologic unit (Source: State of Hawaii, Office of Planning, 1999, 2002a; 2002c; 2002d; 2004a).



6.0 Maintenance of Ecosystems

An ecosystem can be generally defined as the complex interrelationships of living (biotic) organisms and nonliving (abiotic) environmental components functioning as a particular ecological unit. Depending upon consideration of scale, there may be a number of ecosystem types that occur along a given stream such as estuaries, wetlands, and stream vegetation, according to the State Water Code. Figure 6-1 provides a simplified ecosystem represented in a Hawaiian stream. The entire hydrologic unit, as it relates to hydrologic functions of the stream, could also be considered an ecosystem in a very broad context.

Figure 6-1. Simplified ecosystem illustrated in a Hawaiian stream. (Source: Ziegler, 2002, illustration by Keith Kruger)



The Hawaiian resource-use concept of ahupuaa is closely related to the Western concepts of ecosystem maintenance. Native Hawaiians generally utilized natural resources within the limits of their ahupuaa; therefore, it was important to manage and conserve the resources within their living unit. Likewise, watershed resources must be properly managed and conserved to sustain the health of the stream and the instream uses that are dependent upon it.

The riparian resources of Waiokamilo Stream were not classified by the HSA (National Park Service, Hawaii Cooperative Park Service Unit, 1990). The HSA ranked the streams according to a scoring system using six of the seven variables presented in Table 6-1. Detrimental organisms were not considered in the final ranking; however, their presence and abundance are considerable ecosystem variables.

Table 6-1. Hawaii Stream Assessment indicators of riparian resources for Waiokamilo Stream.

Category	Value
Listed threatened and endangered species: These species are generally dependent upon undisturbed habitat. Their presence is, therefore an indication of the integrity of the native vegetation. The presence of these species along a stream course was considered to be a positive attribute; with the more types of threatened and endangered species associated with a stream the higher the value of the resource. Only federally listed threatened or endangered forest or water birds that have been extensively documented within the last 15 years were included.	None
Recovery habitat: Recovery habitat consists of those areas identified by the USFWS and DLNR as essential habitat for the recovery of threatened and endangered species. Streams that have recovery habitat anywhere along their length were included.	None
Other rare organisms and communities: Many species that are candidates for endangered or threatened status have not been processed through all of the requirements of the Endangered Species Act. Also a number of plant communities associated with streams have become extremely rare. These rare organisms and communities were considered to be as indicative of natural Hawaiian biological processes as are listed threatened and endangered species.	None
Protected areas: The riparian resources of streams that pass through natural area reserves, refuges and other protected areas are accorded special protection from degradation. Protected areas were so designated because of features other than their riparian resources. The presence of these areas along a stream, however, indicates that native processes are promoted and alien influences controlled.	None
Wetlands: Wetlands are important riparian resources. They provide habitat for many species and are often important nursery areas. Because they are often extensive areas of flat land generally with deep soil, many have been drained and converted to agricultural or urban uses. Those that remain are, therefore, invaluable as well as being indicators of lack of disturbance.	None
Native forest: The proportion of a stream course flowing through native forest provides an indication of the potential "naturalness" of the quality of a stream's watershed; the greater the percentage of a stream flowing through native forest most of which is protected in forest reserves the more significant the resource. Only the length of the main course of a stream (to the nearest 10 percent) that passes through native forest was recorded.	40%
Detrimental organisms: Some animals and plants have a negative influence on streams. Wild animals (e.g., pigs, goats, deer) destroy vegetation, open forests, accelerate soil erosion, and contaminate the water with fecal material. Weedy plants can dramatically alter the nature of a stream generally by impeding water flow. Three species, California grass, hau, and red mangrove, are considered to have the greatest influence. The presence of any of these animals or plants along a stream course was considered a potentially negative factor, while the degree of detriment is dependent on the number of species present.	2 (Hau, Pigs)

For the purpose of this section, management areas are those locales that have been identified by federal, state, county, or private entities as having natural or cultural resources of particular value. The result of various government programs and privately-funded initiatives has been a wide assortment of management areas with often common goals. Such designated areas include forest reserves, private preserves, natural area reserves, wildlife sanctuaries, national parks, historic landmarks, and so on. In Waiokamilo, nearly 75 percent of the hydrologic unit falls within the Koolau Forest Reserve (Table 6-2).

Table 6-2. Management areas located within Waiokamilo hydrologic unit. (Source: State of Hawaii, Division of Forestry and Wildlife, 2008a; State of Hawaii, Office of Planning, 2007b).

Management Area	Managed by	Area (mi^2)	Percent of Unit
Koolau Forest Reserve	State Division of Forestry and Wildlife	1.83	74.7
The Koolau Forest Reserve, consisting of over 31,000 acres (48.45 sq. mi.) is one of eight reserves on the Island of Maui that are managed by the State of Hawaii Department of Land and Natural Resources (DLNR)'s Division of Forestry and Wildlife. These reserves are established as multi-use land areas that incorporate various, and often competing, public uses and benefits. The management goals of the Forest Reserve System include: 1) Protect and manage forested watersheds for production of fresh water supply for public uses now and into the future; 2) Maintain biological integrity of native ecosystems; 3) Provide public recreational opportunities; and 4) Strengthen the economy by assisting in the production of high quality forest products in support of a sustainable forest industry.			
Pauwalu Point Wildlife Sanctuary	State Division of Forestry and Wildlife	0.01	0.5
The Pauwalu Point Wildlife Sanctuary, managed by DLNR's Division of Forestry and Wildlife, encompasses nearly 11 acres (0.02 sq. mi.) and includes Pauwalu Point and the offshore islets of Mokuhala, Mokumana, and Manahoa (Rock). This sanctuary has been identified by the USFWS as an area for waterbird recovery			

In addition to the individual management areas outlined above, Watershed Partnerships are another valuable component of ecosystem maintenance. Watershed Partnerships are voluntary alliances between public and private landowners who are committed to responsible management, protection, and enhancement of their forested watershed lands. There are currently nine partnerships established statewide, three of which are on Maui. Table 6-3 provides a summary of the partnership area, partners, and management goals of the East Maui Watershed Partnership.

Table 6-3. Watershed partnerships associated with Waiokamilo hydrologic unit. (Source: State of Hawaii, Division of Forestry and Wildlife, 2008b; East Maui Watershed Partnership, 1993).

Management Area	Year Established	Total Area (mi^2)	Area (mi^2)	Percent of Unit
East Maui Watershed Partnership	1991	186.73	1.88	76.7
The East Maui Watershed Partnership (EMWP) is comprised of the County of Maui, State Department of Land and Natural Resources, East Maui Irrigation Co. Ltd., Haleakala National Park, Haleakala Ranch Company, Keola Hana Maui, Inc. (Hana Ranch Company), and The Nature Conservancy. The management priorities of the EMWP include: 1) Watershed resource monitoring; 2) Animal control; 3) Weed control; 4) Management infrastructure; and 5) Public education and awareness programs. The EMWP has conducted various projects including the construction of over seven miles of fence construction and on-going fence maintenance, the survey and removal of invasive plant species, eradication of animal species through an expanded hunting program, implementation of runoff and stream protection measures, water quality monitoring, and extensive public education and outreach campaigns.				

In 1974, the U.S. Fish and Wildlife Service (USFWS) initiated a National Wetlands Inventory that was considerably broader in scope than an earlier 1954 inventory that had focused solely on valuable waterfowl habitat. The inventory for Hawaii was completed in 1978 and utilized a hierarchical structure in the classification of various lands. The USFWS defines wetlands as "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Cowardin et al., 1979). Nearly 46 percent of Waiokamilo is classified as seasonal, non-tidal palustrine wetlands occurring in the headwaters of the hydrologic unit (Table 6-4 and Figure 6-2). Palustrine wetlands are nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, or wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 percent.

Table 6-4. Wetland classifications for Waiokamilo hydrologic unit (Source: U.S. Fish and Wildlife Service, 1978).

System Type	Class	Regime	Area (mi^2)	Percent of Unit
Palustrine	Emergent, persistent	Seasonal non-tidal	< 0.01	0.1
Palustrine	Forested, broad-leaved evergreen	Seasonal non-tidal	0.78	31.7
Palustrine	Scrub/shrub, broad-leaved evergreen	Seasonal non-tidal	0.34	14.1

A series of vegetation maps describing upland plant communities was prepared as part of a USFWS survey in 1976 to 1981 to determine the current status of native forest birds and their associated habitats. Table 6-5 and Figure 6-3 present the portion of the hydrologic unit (approximately 1,000 feet above mean sea level) that was surveyed and the degree of disturbance of native forest. Nearly two-thirds of the unit above 1,500 feet is predominantly native species with little or no alien species.

Table 6-5. Distribution of native and alien plant species for Waiokamilo hydrologic unit. (Source: Jacobi, 1989).

Canopy Type	Area (mi^2)	Percent of Unit
Communities totally dominated by native species of plants	1.55	63.2
Communities dominated by introduced species but contain remnant populations of native species; no native community structure remaining	0.02	1.0

The density of threatened and endangered plant species is low at elevations below 1,600 feet, while the majority of the hydrologic unit, roughly 62 percent, has a high concentration of threatened and endangered plant species at higher elevations (Table 6-6 and Figure 6-4).

Table 6-6. Density of threatened and endangered plants for Waiokamilo hydrologic unit. (Source: State of Hawaii, Office of Planning, 1992).

Density	Area (mi^2)	Percent of Unit
High concentration of threatened and endangered species	1.51	61.5
Low concentration of threatened and endangered species	0.94	38.5

A current working paper is being developed by the University of Hawaii's Economic Research Organization (UHERO), entitled *Environmental Valuation and the Hawaiian Economy*, which discusses the use of existing measures of economic performance and alternative statistical devices to provide an economic valuation of threatened environmental resources. The paper focuses on the Koolau, Oahu watershed and illustrates three categories of positive natural capital (forest resources, shoreline resources, and water resources) against a fourth category (alien species) that degrades natural capital. In the case of the Oahu Koolau forests, a benchmark level of degradation is first defined for comparison against the current value of the Oahu Koolau system. The Oahu Koolau case study considers a hypothetical major disturbance caused by a substantial increased population of pigs with a major forest conversion from native trees to the non-indigenous Miconia (*Miconia calvescens*), along with the continued "creep" of urban areas into the upper watershed (Kaiser, B. et al., n.d.).

Recognizing that in the United States, the incorporation of environmental and natural resource considerations into economic measures is still very limited, the paper provides the estimated Net Present Value (NPV) for "Koolau [Oahu] Forest Amenities." These values are presented in Table 6-7.

Table 6-7. Estimated Net Present Value (NPV) for Koolau [Oahu] Forest Amenities (Source: Kaiser, B. et al., n.d.).

Amenity	Estimated Net Present Value (NPV)	Important limitations
Ground water quantity	$4.57 to $8.52 billion NPV	Optimal extraction assumed.
Water quality	$83.7 to $394 million NPV	Using averted dredging cost estimates.
In-stream uses	$82.4 to $242.4 million NPV	Contingent valuation estimate for a single small fish species.
Species habitat	$487 to $1,434 million NPV	Contingent valuation estimate for a single small bird species.
Biodiversity	$660,000 to $5.5 million NPV	Average cost of listing 11 species in Koolaus.
Subsistence	$34.7 to $131 million NPV	Based on replacement value of pigs hunted.
Hunting	$62.8 to $237 million NPV	Based on fraction of hunting expenditures in state. Does not include damages from pigs to the other amenities.
Aesthetic values	$1.04 to $3.07 million NPV	Contingent valuation; Households value open space for aesthetic reasons.
Commercial harvests	$600,000 to $2.4 million NPV	Based on small sustainable extraction of koa.
Ecotourism	$1.0 to $2.98 billion NPV	Based on fraction of direct revenues to ecotourism activities.
Climate control	$82.2 million	Based on replacement costs of contribution of all tropical forests to carbon sequestration.
Estimated value of joint services:	**$7.444 to $14.032 billion**	

Following upon the results of the Oahu Koolau case study, the paper provides a brief comparison with the east Maui forests, noting the particular importance of the east Maui watershed as the single largest source of surface water in the state, home to some of the most intact and extensive native forests left in Hawaii, along with having the State's largest concentration of endangered forest birds. In both cases, the Oahu Koolaus and east Maui, the most valuable aspects of the forested areas are believed to be ecotourism, aesthetic pleasure, species habitat, water quality, and water quantity. Both regions are roughly the same size; however, the east Maui forests may have greater value due to greater species diversity and native habitat, and the County of Maui's dependence upon surface water as a drinking water source (water quality) (Kaiser, B. et al., n.d.).

Figure 6-2. Reserves and wetlands for the Waiokamilo hydrologic unit (Source: State of Hawaii, Office of Planning, 2003; 2007b).

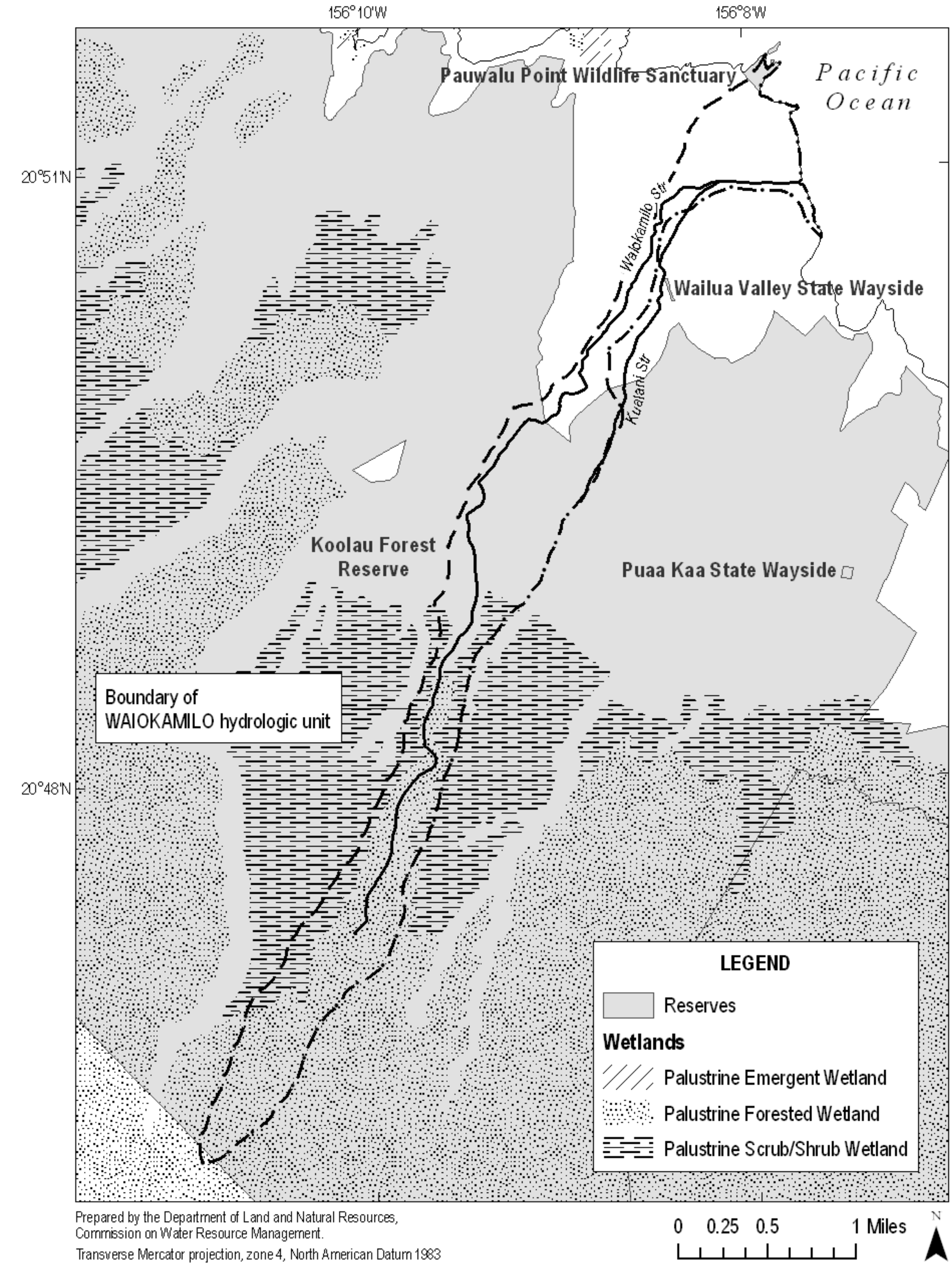


Figure 6-3. Distribution of native and alien plant species for Waiokamilo hydrologic unit (Source: Jacobi, 1989; Scott et al., 1986; State of Hawaii, Office of Planning, 1992, 2004b; 2004d).

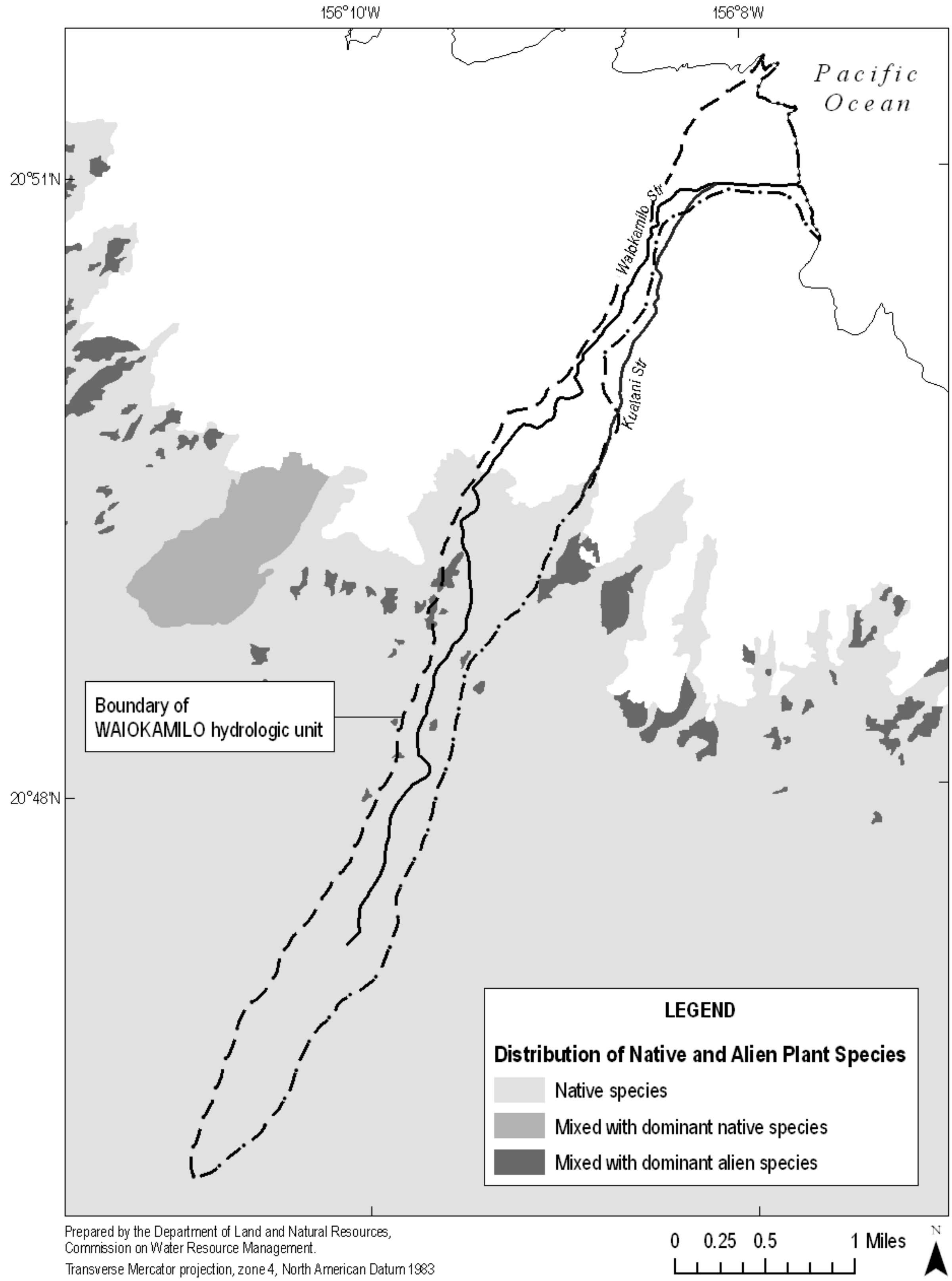
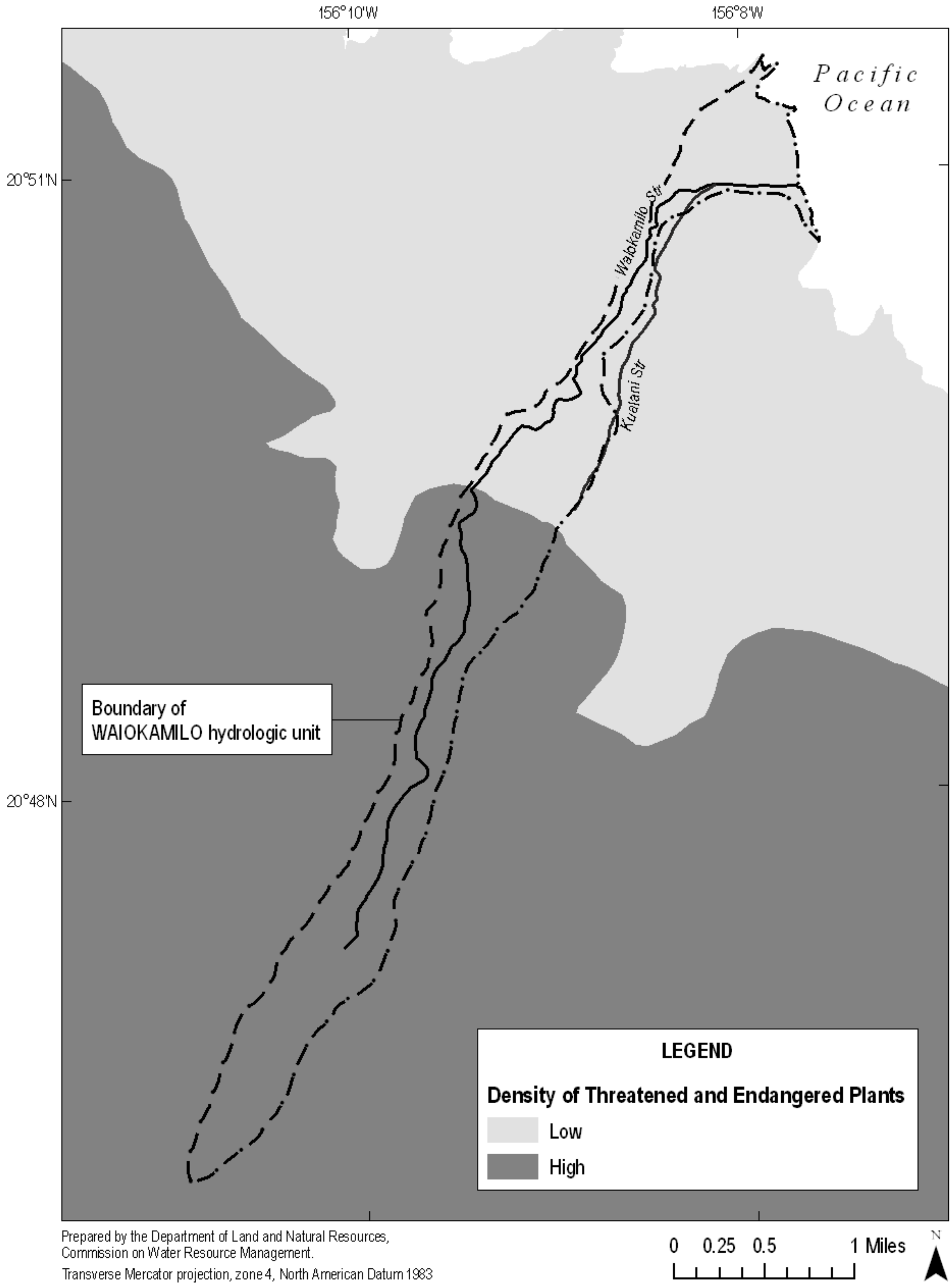


Figure 6-4. Density of threatened and endangered plant species for Waiokamilo hydrologic unit (Source: Jacobi, 1989; Scott et al., 1986; State of Hawaii, Office of Planning, 1992; 2004b; 2004d).



7.0 Aesthetic Values

Aesthetics is a multi-sensory experience related to an individual's perception of beauty. Since aesthetics by definition is a subjective observation, a stream's aesthetic value cannot be determined quantitatively (Wilson Okamoto & Associates, Inc., 1983). However, there are certain elements, either within or surrounding a stream, which appeal to an observer's visual and auditory senses, such as waterfalls and cascading plunge pools. Several assumptions were made in identifying the elements that give Waiokamilo Stream a particular aesthetic quality.

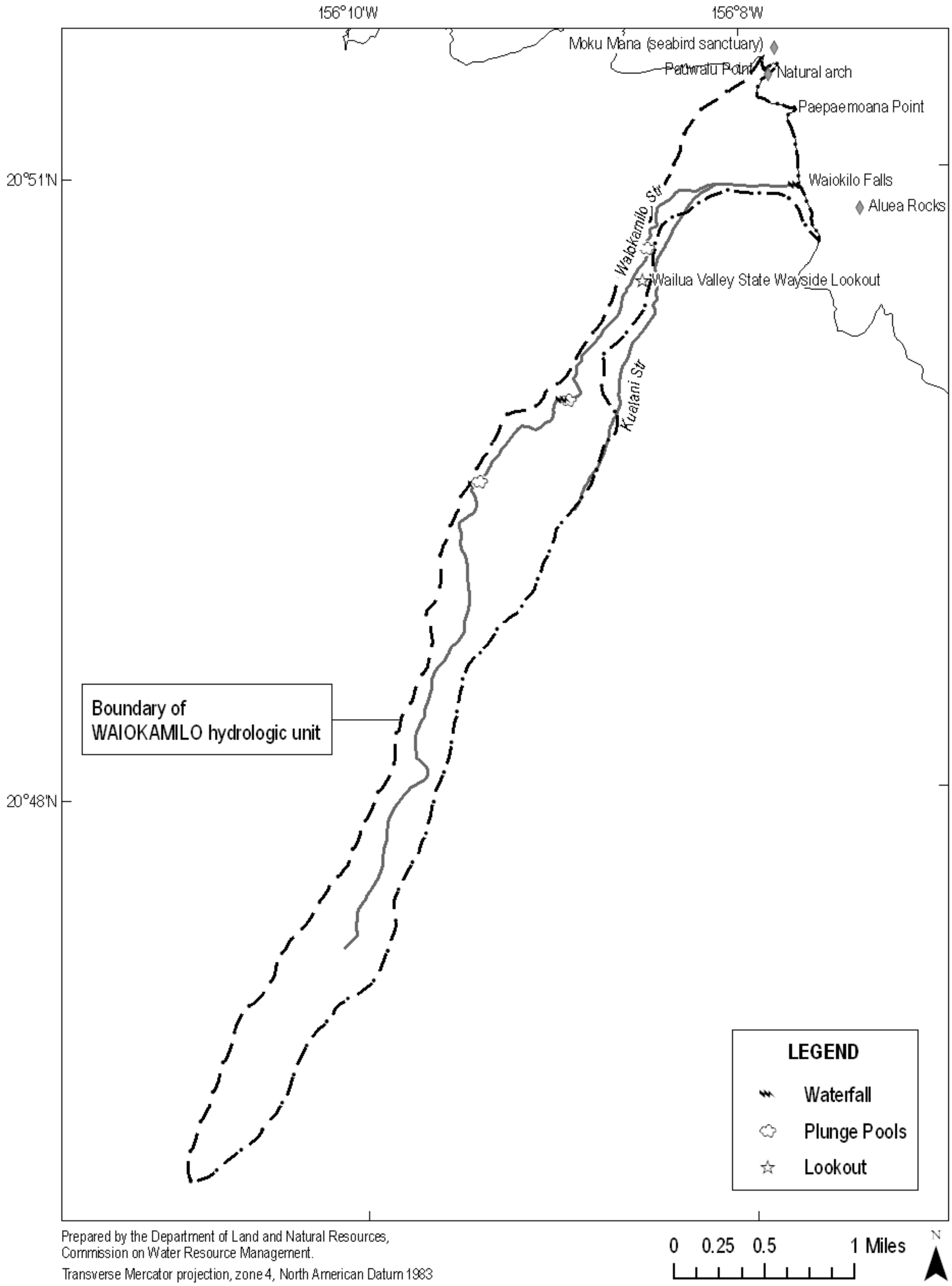
The headwaters of Waiokamilo Stream originate in the lush tropical forests of the Koolau Forest Reserve. Along with its tributary Kualani Stream, it flows northeasterly through the evergreen forests that cover a majority of the drainage basin. Of the two waterfalls along Waiokamilo Stream, Waiokilo Falls is situated near the coast. Wailua Valley State Wayside Lookout is situated at about 430 feet elevation and, while actually situated in the Wailuanui hydrologic unit, it provides a picturesque view of the upper basin as well as the lower basin where Waiokamilo Stream empties into the ocean. (Figure 7-1).

In a 2007 Hawaii State Parks Survey, released by the Hawaii Tourism Authority (OmniTrak Group, Inc., 2007), scenic views accounted for 21 percent of the park visits statewide, though that was a decrease from 25 percent in a 2003 survey. Other aesthetic-related motivations include viewing famous landmarks (9 percent), hiking trails and walks (7 percent), guided tour stops (6 percent), and viewing of flora and fauna (2 percent). On the island of Maui, visitors' preference to visit state parks for scenic views (26 percent) was second only to uses for outings with family and friends (29 percent). In comparison, residents primarily used state parks for ocean/water activities (30 percent), followed by outings with friends and family (28 percent), and then scenic views (9 percent). Overall, Maui residents were very satisfied with scenic views giving a score of 9.7 (on a scale of 1 to 10, with 10 being outstanding), with out-of-state visitors giving a score of 9.3.

Specifically for the Wailua Valley State Wayside, which is managed by DLNR's Division of State Parks, the Hawaii State Parks Survey identified a reduction from 95,400 visitors in 2003 to 30,900 visitors in 2007. Of those utilizing the wayside in 2007, 25,000 were visitors (78,800 in 2003) and 5,900 were residents (16,600 in 2003). The large gap between use of the wayside by visitors and residents is generally attributed to preference of activities by the two groups. With the exception of hiking, residents tend to engage in more active or social activities at parks, while visitors prefer to enjoy the scenery.

In addition to the Wailua Valley State Wayside Lookout, it is assumed that where Waiokamilo Stream crosses Hana Highway there may be opportunities for scenic enjoyment.

Figure 7-1. Aesthetic points of interest for the Waiokamilo hydrologic unit (Source: Gingerich and Wolff, 2005, Plate 1; U.S. Geological Survey, 1996).



8.0 Navigation

The State Water Code, Chapter 174C, HRS, includes navigation as one of nine identified instream uses; however, it fails to further define navigation. Navigational water use is largely defined as water utilized for commercial, and sometimes recreational, transportation. In the continental United States, this includes water used to lift a vessel in a lock or to maintain a navigable channel level. Under the provisions of the Clean Water Act, navigable waters also include wetlands (State of Nevada, Department of Conservation and Natural Resources, Division of Water Resources, n.d.).

Hawaii streams are generally too short and steep to support navigable uses. If recreational boating (primarily kayaks and small boats) is included under the definition of navigation, then there are only a handful of streams statewide that actually support recreational boating and even fewer that support commercial boating operations. Kauai's Wailua River is the only fresh water waterway where large boat commercial operations exist, and no streams are believed to serve as a means for the commercial transportation of goods.

The hydrologic unit of Waiokamilo is not known to support any instream uses of navigation.

9.0 Instream Hydropower Generation

The generation of hydropower is typically accomplished through instream dams and power generators; however, the relatively short lengths and flashy nature of Hawaii's streams often require water to be diverted to offstream power generators. In these "run-of-river" (i.e., utilizes water flow without dams or reservoirs) designs, water is diverted through a series of ditches, pipes, and penstocks to the powerplant, and then returned to the stream. Some designs call for the powerplant to be situated such that the drop of water level (head) exiting the plant can be sent to fields for crop irrigation.

Considering the definition of instream hydropower generation, there are no known true instream hydropower systems located on Waiokamilo or Kualani Streams, nor has the potential for hydropower generation been identified in previous reports (W.A. Hirai & Associates, Inc., 1981).

While the following information should perhaps be a part of Section 13.0, Noninstream uses, it has been included here for further consideration. Carol Wilcox, in her book *Sugar Water: Hawaii's Plantation Ditches* (1996), describes the use of surface water for generating hydroelectricity by Hawaiian Commercial and Sugar Company as follows:

> On Maui, Hawaiian Commercial and Sugar Company (HC&S) had three hydroelectric plants, all utilizing water collected by the East Maui Irrigation Company (EMI) irrigation system. The earliest, Paia Hydro, was built by Maui Agricultural Company in 1912 with an 800-kilowatt capacity. In 1923, the penstock was extended to a higher elevation, thus increasing the capacity to 1000 kilowatts. HC&S built a 4000-kilowatt hydroplant at Kaheka in 1924. In 1982, a 500-kilowatt hydroelectric powerplant was installed at the Hamakua Ditch above Paia. Located only 50 feet below the Wailoa Forebay, this "low-head" hydroplant takes water through a 36-inch pipe and discharges it into the Hamakua Ditch.
>
> Besides these three hydros, HC&S has a bagasse-powered steam powerplant at the Paia factory, and the Central Powerplant, built in 1918, located at Kahului. In 1921, electric lighting was brought to the camp houses. By the 1930s this was the largest plantation power system in Hawaii, with a 12,000-kilowatt capacity. The largest consumer was the water pumps (6000 kilowatts), then the factory (1500 kilowatts), and general uses such as lighting, feed mill, dairy, carpentry shop, refrigerator plants, machine shops, and "talkie movie houses" (400 kilowatts). Surplus power (900 kilowatts) was sold to Kahului Railroad Company and to Maui Electric Company. The Central Powerplant supplied power for all of central Maui until after World War II. In 1984, the combined total capacity of all HC&S power-generating systems was rated at 37,300 kilowatts.

While the hydrologic unit of Waiokamilo is not known to support any instream or noninstream generation of hydroelectricity, HC&S continues to provide Maui Electric Company (MECO) with hydroelectric power generated from water flowing through the ditch system. An "Amended and Restated Power Purchase Agreement" between the two, dated 1989, details the terms. "Force Majeure" events are listed in the agreement, releasing HC&S from their obligation to provide the agreed-upon amount of power to MECO if events beyond their control prevent them from delivering energy (Alexander and Baldwin [A&B] Hawaii and Maui Electric Company, Limited, 1989). Therefore, an order to reduce ditch flow may release HC&S and MECO from this agreement, thereby reducing the amount of power that MECO can provide to its customers.

10.0 Maintenance of Water Quality

The maintenance of water quality is important due to its direct impact upon the maintenance of other instream uses such as fish and wildlife habitat, outdoor recreation, ecosystems, aesthetics, and traditional and customary Hawaiian rights. There are several factors that affect a stream's water quality, including physical, chemical, and biological attributes. The State of Hawaii Department of Health (DOH) is responsible for water quality management duties statewide. The DOH Environmental Health Administration oversees the collection, assessment, and reporting of numerous water quality parameters in three high-priority categories:

- Possible presence of water-borne human pathogens;
- Long-term physical, chemical and biological components of inland, coastal, and oceanic waters; and
- Watershed use-attainment assessments, identification of sources of contamination, allocation of those contributing sources, and implementation of pollution control actions.

The Environmental Health Administration is also responsible for regulating discharges into State waters, through permits and enforcement actions. Examples include federal National Pollutant Discharge Elimination System (NPDES) permits for storm water, and discharge of treated effluent from wastewater treatment plants into the ocean or injection wells.

Sediment and temperature are among the primary physical constituents of water quality evaluations. They are directly impacted by the amount of water in a stream. The reduction of streamflow often results in increased water temperatures, whereas higher flows can aid in quickly diluting stream contamination events. According to a book published by the Instream Flow Council, "[w]ater temperature is one of the most important environmental factors in flowing water, affecting all forms of aquatic life (Amear et al, 2004)." While this statement is true for continental rivers, fish in Hawaii are similar, but their main requirement is flowing water. Surface water temperatures may fluctuate in response to seasonal and diurnal variations, but only a few degrees Celsius in natural streams, mainly because streams in Hawaii are so short. However, temperatures in streams with concrete-lined channels, and dewatered streams, may fluctuate widely due to the vertical solar contact. Surface water temperatures may also fluctuate widely due to water column depth, channel substrate, presence of riparian vegetation, and ground water influx. Surface water also differs considerably from ground water, generally exhibiting lower concentrations of total dissolved solids, chlorides, and other major ions, along with higher concentrations of suspended solids, turbidity, microorganisms, and organic forms of nutrients (Lau and Mink, 2006). Findings of a 2004 USGS National Water Quality Assessment (NAWQA) Program report identified land use, storm-related runoff, and ground water inflow as major contributors of surface water contaminants (Anthony, S.S. et al., 2004).

Water body types can be freshwater, marine, or brackish. They can be further delineated as inland fresh waters, estuaries, embayments, open coastal waters, and oceanic waters (HAR 11-54-5 to 11-54-6). Each water body type has its own numeric criteria for State of Hawaii Water Quality Standards (WQS).

Fresh waters are classified for regulatory purposes, according to the adjacent land's conservation zoning. There are two classes for the inland fresh waters. Class 1 inland waters are protected to "remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source." These waters are used for a number of purposes including domestic water supply, protection of native breeding stock, and baseline references from which human-caused changes can be measured.

Class 2 inland waters are protected for uses such as recreational purposes, support of aquatic life, and agricultural water supplies.

Class 1 waters are further separated into Classes 1a and 1b. Class 1a waters are protected for the following uses: scientific and educational purposes, protection of native breeding stock, baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other non-degrading uses which are compatible with the protection of the ecosystems associated with waters of this class. Streams that run through natural reserves, preserves, sanctuaries, refuges, national and state parks, and state or federal fish and wildlife refuges are Class 1a. Streams adjacent to the most environmentally sensitive conservation subzone, "protective," are Class 1b, and are protected for the same uses as Class 1a waters, with the addition of domestic water supplies, food processing, and the support and propagation of aquatic life (HAR 11-54-3). These classifications are used for regulatory purposes, restricting what is permitted on the land around receiving waters. For example, public access to Class 1b waters may be restricted to protect drinking water supplies.

Land use affects water quality because direct runoff (rainfall that flows overland into the stream) can transport sediment and its chemical contaminants into the stream. According to the U.S. Environmental Protection Agency (EPA), "[a] TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing as well as ecological health), and the scientific criteria required to support those uses. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs (EPA, 2008)."

The DOH, Environmental Health Administration maintains the State of Hawaii Water Quality Standards (WQS), a requirement under the Federal Clean Water Act (CWA) regulated by the EPA. The CWA aims to keep waters safe for plants and animals to live and people to wade, swim, and fish. Water Quality Standards are the measures that states use to ensure protection of the physical, chemical, and biological health of their waters. "A water quality standard defines the water quality goals of a water body, or portion thereof, by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses (CWA §131.2)." Each state specifies its own water uses to be achieved and protected ("designated uses"), but CWA §131.10 specifically protects "existing uses", which it defines as "…those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards (CWA §131.3)."[1] Although the State WQS do not specify any designated uses in terms of traditional and customary Hawaiian rights, the "protection of native breeding stock," "aesthetic enjoyment," and "compatible recreation" are among the designated uses of Class 1 inland

[1] Existing uses as defined in the CWA should not be confused with existing uses as defined in the State Water Code, although there is some overlap and linkage between the two. Under the Water Code, if there are serious threats to or disputes over water resources, the Commission may designate a "water management area." Water quality impairments, including threats to CWA existing uses, are factors that the Commission may consider in its designation decisions. Once such a management area is designated, people who are already diverting water at the time of designation may apply for water use permits for their "existing uses." The Commission then must weigh if the existing use is "reasonable and beneficial." The Water Code defines "reasonable-beneficial use" as "the use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the state and county land use plans and the public interest." The relationships between a Commission existing use and a CWA existing use can help determine the appropriateness of the use and its consistency with the public interest.

waters, and "recreational purposes, the support and propagation of aquatic life, and agricultural and industrial water supplies" are among the designated uses of Class 2 inland waters. This means that uses tied to the exercise of traditional and customary Hawaiian rights that are protected by the State Constitution and the State Water Code (Section 12.0, Protection of Traditional and Customary Hawaiian Rights), including but not limited to gathering, recreation, healing, and religious practices are also protected under the CWA and the WQS as designated and/or existing uses. Therefore, the Commission's interim IFS recommendation may impact the attainment of designated and existing uses, water quality criteria, and the DOH antidegradation policy, which together define the WQS and are part of the joint Commission and DOH obligation to assure sufficient water quality for instream and noninstream uses.

State of Hawaii WQS define: 1) the classification system for State surface waters, which assigns different protected uses to different water classes; 2) the specific numeric or narrative water quality criteria needed to protect that use; and 3) a general antidegradation policy, which maintains and protects water quality for the uses defined for a class. Quantitative and qualitative data are utilized. Numeric water quality criteria have specific concentrations (levels of pollutants) that must be attained based on water body type, e.g. fresh water stream. Qualitative standards are general narrative statements that are applicable to all State waters, such as "all waters shall be free of substances attributable to domestic, industrial, or other controllable sources of pollutants (State of Hawaii, Department of Health, 2004)." Conventional pollutants include nutrients and sediments. Toxic pollutants include pesticides and heavy metals. Indicator bacteria are utilized to assess bacterial levels. Biological assessments of aquatic communities are also included in the data collected.

Once data are gathered and evaluated for quality and deemed to be representative of the waterbody segment, a decision is made as to whether the appropriate designated uses are being attained. This set of decisions are then tabulated into a report to the EPA that integrates two CWA sections; (§) 305(b) and §303(d). This Integrated Report is federally required every even-numbered year. CWA §305(b) requires states to describe the overall water quality statewide. They must also describe the extent to which water quality provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water. Additionally, they determine whether the designated uses of a water body segment are being attained, and if not, what are the potential causes and sources of pollution. The CWA §303(d) requires states to submit a list of Water-Quality Limited Segments, which are waters that do not meet state water quality standards and those waters' associated uses. States must also provide a priority ranking of waters listed for implementation of pollution controls, which are prioritized based on the severity of pollution and the uses of the waters. In sum, the §303(d) list leads to action.

The sources for the 2006 Integrated Report are Hawaii's 2004 §303(d) list, plus readily-available data collected from any State water bodies over the preceding 6 years (State of Hawaii, Department of Health, 2007). Per §303(d), impaired waters are listed after review of "'all existing and readily available water quality-related data and information' from a broad set of data sources" (State of Hawaii, Department of Health, 2004, p.57). However, available data are not comprehensive of all the streams in the State. According to the Hawaii Administrative Rules Title 11 Chapter 54 (HAR 11-54) all State waters are subject to monitoring; however, in the most recent list published (from the 2006 list that was published in 2007), only 74 streams statewide had sufficient data for evaluation of whether exceedence of WQS occurred. Neither Waiokamilo Stream nor Kualani Stream appears on the 2006 List of Impaired Waters in Hawaii, Clean Water Act §303(d). While some data exist for Waiokamilo Stream (and its "entire network"), there were not sufficient data for decision-making; therefore, no decision was made pertaining to the attainment of WQS or the applicable designated uses.

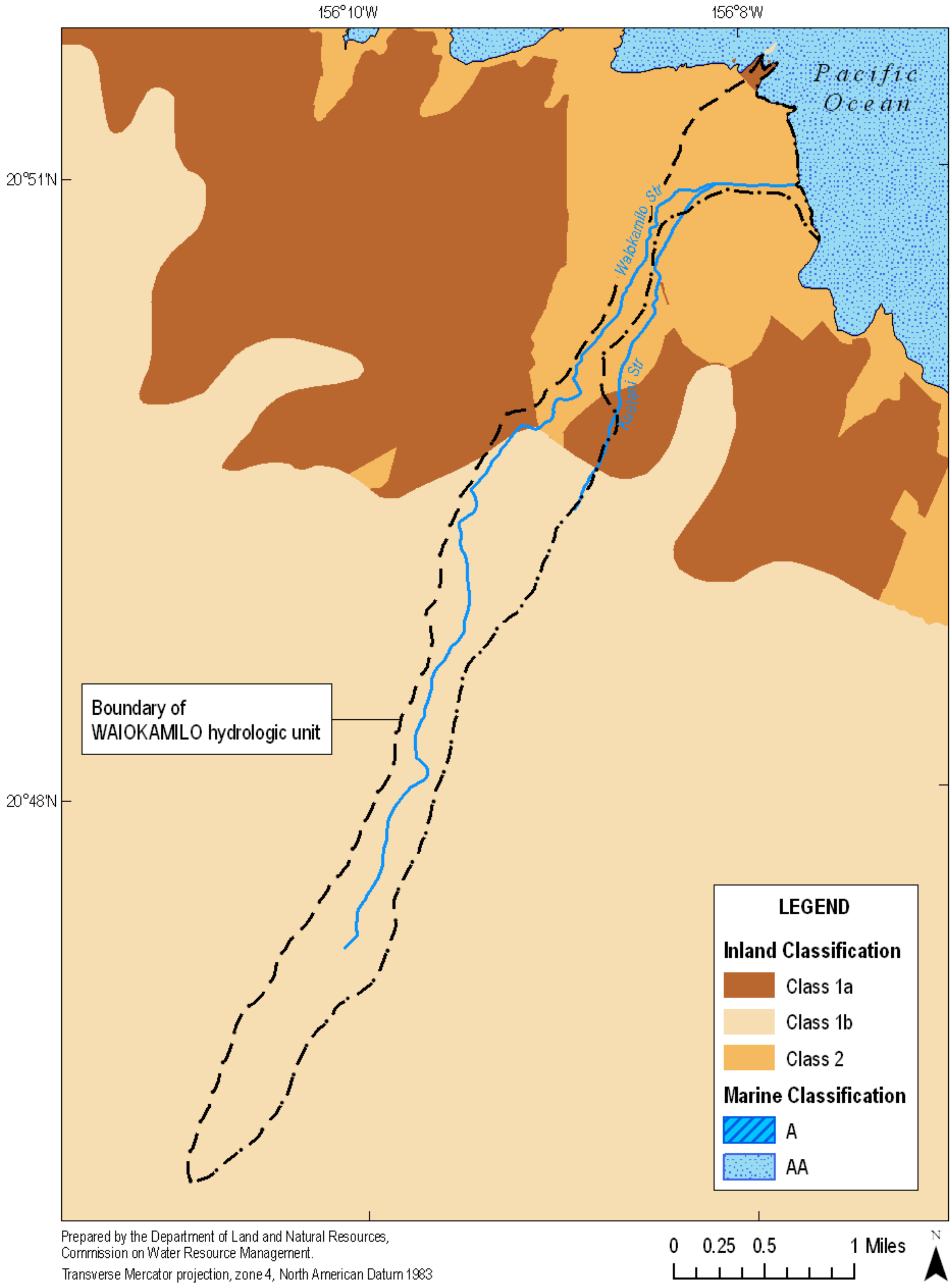
The 2006 Integrated Report indicates that the current WQS require the use of *Enterococci* as the indicator bacteria for evaluating public health risks in the waters of the State; however, no new data were available for this parameter in inland waters. As mentioned in Section 5.0, Outdoor Recreational Activities, DOH maintains WQS for inland recreational waters based on the geo-mean statistic of *Enterococci*: 33 colony-forming units per 100 mL of water or a single-sample maximum of 89 colonies per 100 mL. This is for full-body contact (swimming, jumping off cliffs into waterfall pools, etc.). If *Enterococci* count exceeds those values, the water body is considered to be impaired. DOH Clean Water Branch efforts have been focused on coastal areas (State of Hawaii, Department of Health, 2006, Chapter II, p.20). The marine recreational zone, which extends from the shoreline seaward to 1,000 feet from shore, requires an *Enterococci* geo-mean of less than 7 colony-forming units per 100 mL of water to protect human health (HAR 11-54-8.)

The 2006 Integrated Report also states: "Public health concerns may be underreported. *Leptospirosis* is not included as a specific water quality standard parameter. However, all fresh waters within the state are considered potential sources of *Leptospirosis* infection by the epidemiology section of the Hawaii State Department of Health. No direct tests have been approved or utilized to ascertain the extent of the public health threat through water sampling. Epidemiologic evidence has linked several illness outbreaks to contact with fresh water, leading authorities to issue blanket advisories for all fresh waters of the state (State of Hawaii, Department of Health, 2006, Chapter II, p.3)."

Waiokamilo Stream is classified as Class 1b inland waters from its headwaters down to approximately 650 foot elevation, as the surrounding land is in the conservation subzone "protective." It is Class 2 from there to the coast. Kualani Stream is classified as Class 1b inland waters from its headwaters down to approximately 1,400 foot elevation. From there to about 1,000 foot elevation it is classified as Class 1b inland waters, as it is not in the "protective" subzone but is within the Koolau Forest Reserve. From there to the sea, it is Class 2. It should be noted that the conservation subzone map utilized for this interpretation is general and elevations are not exact. It should also be noted that there is no direct relationship between elevation and attainment of water quality standards.

Marine water body types are delineated by depth and coastal topography. Open coastal waters are classified for protection purposes from the shoreline at mean sea level laterally to where the depth reaches 100 fathoms (600 feet). Marine water classifications are based on marine conservation areas. The objective of Class AA waters is that they "remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions." Class A waters are protected for recreational purposes and aesthetic enjoyment; and protection of fish, shellfish, and wildlife. The marine waters at the mouth of the entire Waiokamilo hydrologic unit are Class AA waters. Figure 10-1 shows the Waiokamilo hydrologic unit, including inland and marine (coastal) water classifications.

Figure 10-1. Water quality standards for the Waiokamilo hydrologic unit. (Source: State of Hawaii, Office of Planning, 2002e; 2008). The classifications are general in nature and should be used in conjunction with Hawaii Administrative Rules, Chapter 11-54, Water Quality Standards.



11.0 Conveyance of Irrigation and Domestic Water Supplies

Under the State Water Code, the conveyance of irrigation and domestic water supplies to downstream points of diversion is included as one of nine listed instream uses. The thought of the stream as a conveyance mechanism for noninstream purposes almost seems contrary to the concept of instream flow standards. However, the inclusion of this instream use is intended to ensure the availability of water to all those who may have a legally protected right to the water flowing in a stream. Of particular importance in this section is the diversion of surface water for domestic purposes. In its August 2000 decision on the Waiahole Ditch Combined Contested Case Hearing, the Hawaii Supreme Court identified domestic water use of the general public, particularly drinking water, as one of, ultimately, four trust purposes.

Neither the State nor the County keeps a comprehensive database of households whose domestic water supply is not part of a municipal system (i.e. who use stream and / or catchment water). The County of Maui Department of Water Supply does not have data for water users who are not on the county system and may be using catchment or surface water for domestic use (Ellen Kraftsow, personal communication, June 23, 2008). The State of Hawaii Department of Health Safe Drinking Water Branch administers Federal and State safe drinking water regulations to public water systems in the State of Hawaii to assure that the water served by these systems meets State and Federal standards. Any system which services 25 or more people for a minimum of 60 days per year or has at least 15 service connections is subject to these standards and regulations. Once a system is regulated by the Safe Drinking Water Branch, the water must undergo an approved filtration and disinfection process when it has been removed from the stream. It would also be subject to regulatory monitoring. According to DOH, the Safe Drinking Water Branch does not currently regulate any private water systems in the Waiokamilo hydrologic unit (Mike Miyahira, personal communication, August 1, 2008).

The Commission's records for the hydrologic unit of Waiokamilo indicate that there are a total of 19 registered diversions, of which four are East Maui Irrigation Company (EMI) diversions. Since EMI diversions transport water to locations outside of this hydrologic unit, the information is not discussed in this section; rather, it is included in Section 13.0, Noninstream Uses. Of the remaining 15 diversions, 11 were declared for domestic purposes, in part, with a total of eight service connections. All 15 diversions are utilized for irrigation of various crops and livestock, including the cultivation of taro.

This information is derived from original registration documents, much of which has not been field verified and may have changed. In 2007, the Commission contracted R.M. Towill Corporation to conduct a statewide diversion verification inventory starting with priority areas across the island of Maui. Data from this study, along with information collected from Commission staff site visits, and information extracted from the original registration files regarding the registered diversions may be found in Table 13-1 of Section 13.0, Noninstream Uses.

Keanae Well No. 1 (5108-01), whose location is depicted in Figure 3-3, was drilled in 1984 to replace an existing surface water source that did not meet Safe Drinking Water Standards (County of Maui, 1998). The surface water system was abandoned (C. Takumi Engineering, Inc., 2001). In 1998, an Environmental Assessment was prepared for the potential installation of a second County of Maui Department of Water Supply drinking water well. At the time, Well No. 1 was the only source of drinking water for the Keanae Water System. The Department of Water Supply considered several alternatives to a second well, including surface water treatment. The impact of taking surface water as a drinking water source includes construction and treatment costs, as well as impacts to other surface water users including taro and other agricultural uses (County of Maui, 1998). Though the exact service area is unknown, the Keanae Water System serves the communities of Keanae and Wailuanui.

Keanae Well No. 2 (5108-02), whose location is depicted in Figure 3-3, was designed as a back-up to Keanae Well No. 1 and was drilled in 2000 (C. Takumi Engineering, Inc., 2001). The well was approved by the Department of Health as a potable water source in March 2002. The well has not been used. In March 2008, the Commission on Water Resource Management approved a Pump Installation Permit that authorizes permanent pump installation work for Keanae Well No. 2. Other such permits had previously been issued, but the pump was not installed. The new permit does not indicate any changes to the original plans (State of Hawaii, Commission on Water Resource Management, 2008).

12.0 Protection of Traditional and Customary Hawaiian Rights

The maintenance of instream flows is important to the protection of traditional and customary Hawaiian rights, as they relate to the maintenance of stream resources (e.g., hihiwai, opae, oopu) for gathering, recreation, and the cultivation of taro. Article XII, Section 7 of the State Constitution addresses traditional and customary rights: "The State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupua'a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights." Case notes listed in this section indicate, "Native Hawaiian rights protected by this section may extend beyond the ahupua'a in which a native Hawaiian resides where such rights have been customarily and traditionally exercised in this manner. 73 H.578, 837 P.2d 1247."

It is difficult to fully represent in words the depth of the cultural aspects of streamflow, including traditions handed down through the generations regarding gathering, ceremonial and religious rites, and the ties to water that are pronounced in Hawaiian legend and lore. "There is a great traditional significance of water in Hawaiian beliefs and cultural practices…The flow of water from mountain to sea is integral to the health of the land. A healthy land makes for healthy people, and healthy people have the ability to sustain themselves (Kumu Pono Associates, 2001b, p.II:8)."

Taro cultivation is addressed in this section of the report as well as the next section, 13.0 Noninstream Uses. This is because instream flow standards take into account both social and scientific information. For sociological and cultural purposes, taro cultivation can be considered an instream use as part of the "protection of traditional and customary Hawaiian rights," that is specifically listed as an instream use in the Water Code. Taro cultivation can also be considered a noninstream use since it removes water from a stream (even if water from taro loi is later returned to the stream). It could be argued that for scientific analysis, taro cultivation is an instream use since taro loi provide habitat for stream biota, but because the water is physically taken out of the stream, it is also a noninstream use. Another way to look at the approach of indentifying taro cultivation as both instream and noninstream uses is that when the Commission addresses taro cultivation as an instream use, it is generally in the context of traditional and customary Hawaiian rights; whereas when the Commission addresses taro cultivation as a noninstream use, it is approaching the issue from the aspects of agriculture and water use.

In ancient Hawaii, the islands (*moku*) were subdivided into political subdivisions, or ahupuaa, for the purposes of taxation. The term ahupuaa in fact comes from the altar (*ahu*) that marked the seaward boundary of each subdivision upon which a wooden head of a pig (*puaa*) was placed at the time of the *Makahiki* festival when harvest offerings were collected for the rain god and his earthly representative (Handy et al., 1972). Each ahupuaa had fixed boundaries that were usually delineated by natural features of the land, such as mountain ridges, and typically ran like a wedge from the mountains to the ocean thus providing its inhabitants with access to all the natural resources necessary for sustenance. The beach, with its fishing rights, were referred to as *ipu kai* (meat bowl), while the upland areas for cultivation were called *umeke ai* (poi container hung in a net) (Handy et al., 1972). As noted earlier in Section 6.0, Maintenance of Ecosystems, Western concepts of ecosystem maintenance and watersheds are similar to the Hawaiian concept of ahupuaa, and so the Commission's surface water hydrologic units often coincide with or overlap ahupuaa boundaries. The hydrologic unit of Waiokamilo includes parts of the ahupuaa of Wailua Nui, Keanae, and Haiku Uka as shown in Figure 12-4.

An appurtenant water right is a legally recognized right to a specific amount of surface freshwater – usually from a stream – on the specific property that has that right. This right traces back to the use of water on a given parcel of land at the time of its original conversion into fee simple lands: When the land allotted during the 1848 Mahele was confirmed to the awardee by the Land Commission and/or when the Royal Patent was issued based on such award, the conveyance of the parcel of land carried with it the appurtenant right to water if water was being used on that land at or shortly before the time of the Mahele (State of Hawaii, Commission on Water Resource Management, 2007).

An appurtenant right is different from a riparian right, but they are not mutually exclusive. Riparian rights are held by owners of land adjacent to a stream. They and other riparian landowners have the right to reasonable use of the stream's waters on those lands. Unlike riparian lands, the lands to which appurtenant rights attach are not necessarily adjacent to the freshwater source (i.e., the water may be carried to the lands via auwai or ditches), but some pieces of land could have both appurtenant and riparian rights.

Appurtenant rights are provided for under the State Water Code, HRS §174C-101, Sections (c) and (d), as follows:

- Section (c). Traditional and customary rights of ahupuaa tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778 shall not be abridged or denied by this chapter. Such traditional and customary rights shall include, but not be limited to, the cultivation or propagation of taro on one's own kuleana and the gathering of hihiwai, opae, oopu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes.

- Section (d). The appurtenant water rights of kuleana and taro lands, along with those traditional and customary rights assured by this section, shall not be diminished or extinguished by a failure to apply for or to receive a permit under this chapter.

The exercise of an appurtenant water right is still subject to the water use permit requirements of the Water Code, but there is no deadline to exercise that right without losing it, as is the case for correlative and riparian rights, which must have been exercised before designation of a water management area.

In August 2000, the Hawaii Supreme Court issued its decision in the Waiahole Ditch Combined Contested Case Hearing, upholding the exercise of Native Hawaiian and traditional and customary rights as a public trust purpose. These rights are described in the Commission's 2007 *Water Resource Protection Plan – Public Review Draft*, incorporating a later revision[1] as follows:

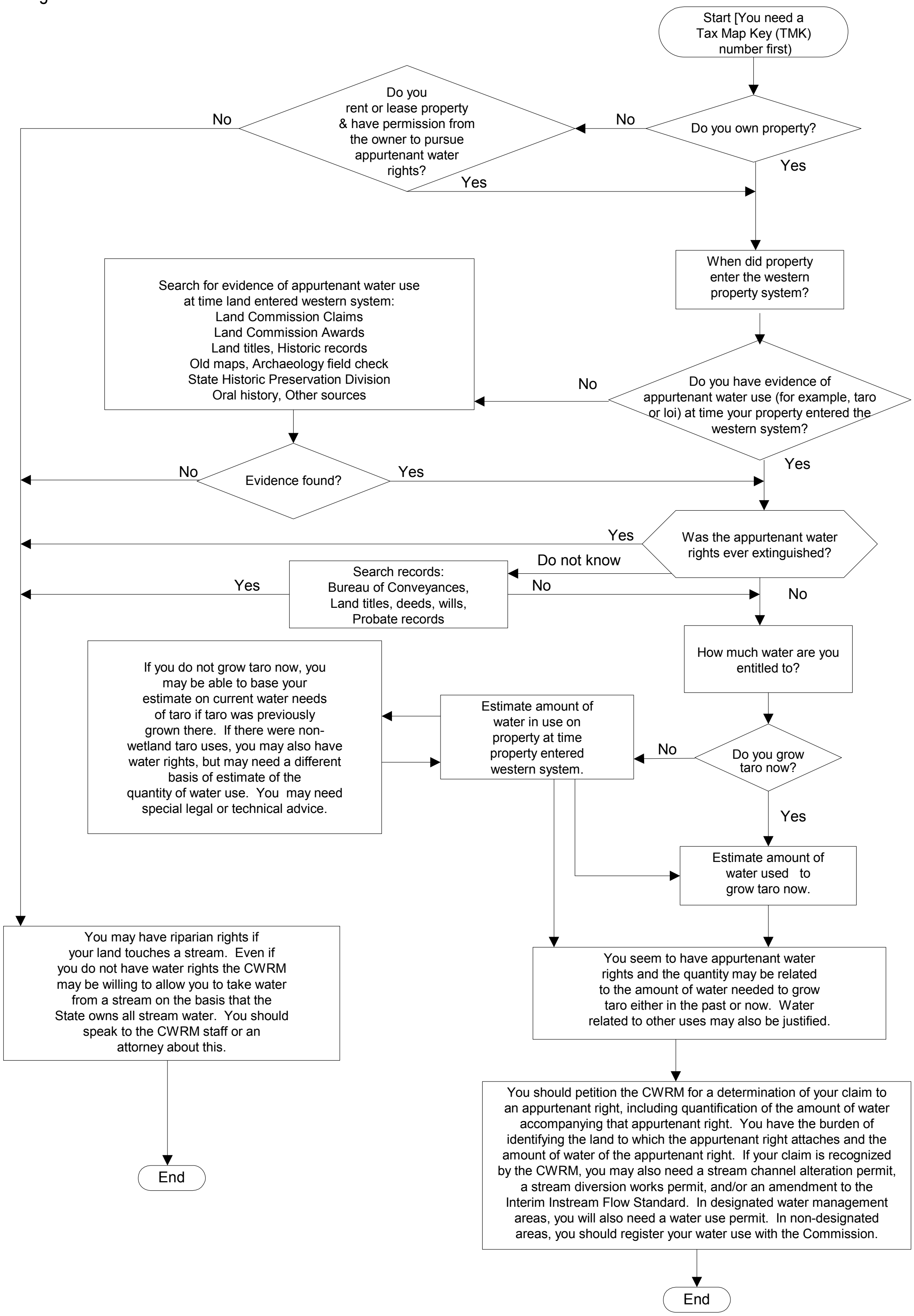
> Appurtenant water rights are rights to the use of water utilized by parcels of land at the time of their original conversion into fee simple lands i.e., when land allotted by the 1848 Mahele was confirmed to the awardee by the Land Commission and/or when the Royal Patent was issued based on such award, the conveyance of the parcel of land carried with it the appurtenant right to water.[2] The amount of water under an appurtenant right is the amount that was being used at the time of the Land Commission award and is established by cultivation methods that approximate the methods utilized at the time of the Mahele, for example, growing wetland taro.[3] Once established, future uses are not limited to the cultivation of traditional products approximating those utilized at the time of the Mahele[4], as long as those uses are reasonable, and if in a water management area, meets the State Water Code's test of reasonable and beneficial use ("the use of

[1] Although the final Water Resource Protection Plan had not been printed as of the date of this report, most edits had already been incorporated into the latest version, which the Commission utilized for this report.
[2] 54 Haw. 174, at 188; 504 .2d 1330, at 1339.
[3] 65 Haw. 531, at 554; 656 P.2d 57, at 72.
[4] *Peck v Bailey*, 8 Haw. 658, at 665 (1867).

water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the State and county land use plans and the public interest"). As mentioned earlier, appurtenant rights are preserved under the State Water Code, so even in designated water management areas, an unexercised appurtenant right is not extinguished and must be issued a water use permit when applied for, as long as the water use permit requirements are met [Figure 12-1].

The Hawaii Legislative Session of 2002 clarified that the Commission is empowered to "determine appurtenant rights, including quantification of the amount of water entitled to by that right," (HRS §174C-5(15)). In those cases where a Commission decision may affect an appurtenant right, it is the claimant's duty to assert the appurtenant right and to gather the information required by the Commission to rule on the claim. The Commission is currently in the process of developing a procedural manual to aid in the understanding and assembling of information to substantiate an appurtenant rights claim.

Figure 12-1. Generalized process for determining appurtenant water rights. This process is generalized and may not fully explain all possible situations. It does not apply to Hawaiian Homes Lands. If you are Native Hawaiian you may have other water rights.



The Commission conducted a cursory assessment of tax map key parcels to identify their associated Land Commission Awards, in an attempt to identify the potential for future appurtenant rights claims within the hydrologic unit of Waiokamilo. In addition to the original reference documents, a 2001 inventory conducted by Kumu Pono Associates, under contract by East Maui Irrigation Company, serves as a valuable reference of historical accounts of the lands of Hamakua Poko, Hamakua Loa and Koolau, Maui Hikina (east Maui). Table 12-1 presents the results of the Commission's assessment.

Table 12-1. Tax map key parcels with associated Land Commission Awards for the Waiokamilo hydrologic unit.

[LCA is Land Commission Award; Gr. is Grant; and G.L. is Government Lease.]

TMK	Landowner	LCA	Grants/Leases	Notes
(2)1-1-004:006	State Of Hawaii	none	G.L. S-4192	
(2)1-1-007:020	Ah You,Abel Jr /Etal	none	Gr. 2091:2	
(2)1-1-008:004	Acain,Lucy Ellen Akiona /Etal	3472	Gr. 3117	Gr. 3117 applies to parcels 4 and 23.
(2)1-1-008:005	State Of Hawaii	none	G.L. S-4328	
(2)1-1-008:006	Tam,Anne Vivienne W Y	none	Gr. 4866	
(2)1-1-008:007	Chong Kee Family Trust /Etal	none	Gr. 3223	
(2)1-1-008:010	Akina,Andrew /Etal	none	Gr. 1899	
(2)1-1-008:011	Algasca,Miulan /Etal	none	Gr. 2949	
(2)1-1-008:012	East Maui Irrigation Co. Ltd.	10828B:4	none	
(2)1-1-008:014	State Dept. Of Hawaiian Home Lands	none	Gr. S-15845	
(2)1-1-008:023	Sexton,Anne Lenhart /Etal	none	Gr. 3117	Gr. 3117 applies to parcels 4 and 23.
(2)2-4-016:004	East Maui Irrigation Co. Ltd.	none	Gr. 182	

In accordance with the State Water Code and the Supreme Court's decision in the Waiahole Ditch Combined Contested Case Hearing, the Commission is focused on the assertion and exercise of appurtenant rights as it largely relates to the cultivation of taro. Wetland kalo or taro (*Colocasia esculenta* (L.) Schott) is an integral part of Hawaiian culture and agricultural tradition. The preferred method of wetland taro cultivation, where terrain and access to water permitted, was the construction of loi (flooded terraces) and loi complexes. These terraces traditionally received stream water via carefully engineered open channels called auwai. The auwai carried water, sometimes great distances, from the stream to the loi via gravity flow. In a system of multiple loi, water may either be fed to individual loi through separate little ditches if possible, or in the case of steeper slopes, water would overflow and drain from one loi to the next. Outflow from the loi may eventually be returned to the stream.

The loi also served other needs including the farming of subsidiary crops such as banana, sugar cane, and ti plants that were planted on its banks, and the raising of fish such as oopu, awa, and aholehole within the waters of the loi itself. At least 85 varieties of taro were collected in 1931, each of which varied in color, locale, and growing conditions. The water needs of taro under wet conditions depend upon: 1) climate; 2) location and season (weather); 3) evaporation rate; 4) soil type; 5) ground water hydrology; 5) water temperature; and 6) agronomic conditions (crop stage; planting density and arrangement; taro variety; soil amendment and fertilization regime; loi drainage scheme; irrigation system management; and weed, pest, and disease prevalence and management).

Among its comments to the draft version of this and the other concurrent IFSARs, Native Hawaiian Legal Corporation (NHLC) submitted testimony from 2001 relating to taro cultivation and gathering practices in east Maui streams. The pre-printed forms were completed by several east Maui residents. The information relating to taro cultivation is collected in Table 12-2 (See CPRC 29.2-1 through 29.2-56).

Table 12-2. Summary of the 2001 testimonies submitted by NHLC related to taro cultivation.

Declarant (CPRC Reference)	Stream Adjacent To Property	Stream Adjacent To Property Where Kalo Is Grown	Stream Source For Auwai Adjacent To Property	Stream Source For Auwai Adjacent To Property Where Kalo Is Grown	Streams Where Kalo Would Be Grown If Water Were Available
Charles L. Barclay (CPRC 29.2-3)	Wailuanui	Lakini	Lakini	Kualani, Waiokamilo (Kamilo)	Makapipi
	<u>Problem Statement (Kalo):</u> "No constant water flow. Also because of lack of water flow at Lakini we are unable to open all of our patches at Wailua-Nui."				
Awapuhi Carmichael (CPRC 29.2-55)					
Daniel Carmichael (CPRC 29.2-33)					
Puanani Holokai (CPRC 29.2-17)	(lease) Piinaau & Palahulu	(lease) Piinaau & Palahulu	(lease) Piinaau & Palahulu	(lease) Piinaau & Palahulu	
Cindy Ku'uipo Ka'auamo (CPRC 29.2-21)	Waiokamilo			Waiokamilo, Kulani, Wailuanui, Palauhulu, Piinaau	
Darlene Kaauamo (CPRC 29.2-19)	Waiokamilo			Waiokamilo, Kulani, Wailuanui, Palauhulu, Piinaau	
Frances Kaauamo (CPRC 29.2-45)			Waikani		
Hannah K. Kaauamo (CPRC 29.2-27)	Ka'amilo (Wai O'Ka Milo)	La'Kine, Wai O'Ka Milo, Kulani	Wai'Lua'Nui, Wai'O'Kamilo	La'Kine, Wai'Lua'Nui, Kulani, Wai Kani, Wai O'Ka Milo,	Wai'Lua'Nui
	<u>Problem Statement (Kalo):</u> "There is not enough water flowing through the streams, - That is one of the reason why we have a lot diseases destroying our taro - We have to depend on the rain to get more water flow - In the above streams but some of the stream have no life (note enough flow)."				
Leolani R. Kaauamo (CPRC 29.2-41)	Ka'a Hiio (?)	Laikaine-moii (?, illegible)	Wailuanui, Waiokamoii	Wailuanui, Waiokamoii, Lakai, Waiokani	Wailuanui
	<u>Problem Statement (Kalo):</u> "Water was constructed by the State of HI but insufficient water to feed way water has diminished since not enough water to fill 8" of pipe on a continuous flow."				
Mary Kaauamo (CPRC 29.2-43)			Wailuanui and Waiokamilo	Wailuanui and Waiokamilo	
Samuel E. Kaauamo (CPRC 29.2-25)	Lakini, Kaamilo	Lakini, Kaamilo	Lakini, Kaamilo	Lakini, Kaamilo	Lakin, Kamilo

Table 12-2. Continued. Summary of the 2001 testimonies submitted by NHLC related to taro cultivation.

Declarant (CPRC Reference)	Stream Adjacent To Property	Stream Adjacent To Property Where Kalo Is Grown	Stream Source For Auwai Adjacent To Property	Stream Source For Auwai Adjacent To Property Where Kalo Is Grown	Streams Where Kalo Would Be Grown If Water Were Available
Solomon Kaauamo Jr. (CPRC 29.2-29)	Kaamilo (Waiokamilo)	Lakini, Kulani, Waiokamilo, Wailuanui	Wailuanui, Waiokamilo	Wailuanui, Waiokamilo, Lakini, Kulani	Wailuanui
	<u>Problem Statement (Kalo):</u> "Water way was constructed by the State of HI, but insufficient water to feed water way. Water has diminished since. Not enough water to fill 8" of pipe, on a continuous flow."				
Gladys Kanoa (CPRC 29.2-31)	Waiokamilo, Piinaau, Palauhulu, Kulani	Waiokamilo, Piinaau, Palauhulu, Kulani	Waiokamilo, Piinaau, Palauhulu, Kulani	Lakini, Makilo, Waiokamilo, Palauhulu, Kualani	
Jerome Kekiwi, Jr. (CPRC 29.2-49)	Lakini, Kulani, Kamilo	Wai O Kamilo, Lakini, Kulani	Wai O Kamilo, Lakini, Kulani		Waikau, Wailua
	<u>Problem Statement (Kalo):</u> "The water is unable to reach the land because there is no access or irrigation to go to the kalo patch."				
Puaala Kekiwi (CPRC 29.2-47)			(lease) Kulani, Waiokamilo	Kulani, Waiokamilo	
Chauncey K. Kimokeo (CPRC 29.2-5)			Palahulu	Keanae Flume	
Ihe Kimokeo (CPRC 29.2-11)			Palahulu	Keanae Flume	
Lincoln A. Kimokeo (CPRC 29.2-9)			Palahulu	Palahulu	Kolea to Makapipi
	<u>Problem Statement (Kalo):</u> "Because of low water pressure water is unable to reach loi furthest from flume catchments and production is minimal and could be of higher quality. This prevents all kalo farmers & residents of this ahupua'a from utilizing all of the resources in this ahupua'a and making higher productivity depending on the streams."				
Pualani Kimokeo (CPRC 29.2-7)			Palahulu	Palahulu	Any property next to me
	<u>Problem Statement (Kalo):</u> "We need constant flowing water at all times. Patches next to the flume catch is more likely to have a better growth than the patches at the end cause the water pressure gets smaller and warmer."				
Willie K. Kimokeo (CPRC 29.2-13)	Palahulu	Keanae Flume	Keanae Flume	Keanae Flume	
Norman D. Martin Jr. (CPRC 29.2-15)	Waikane, Kulani, Waiokamilo	Waikane, Kulani, Waiokamilo	Waikane, Kulani, Waiokamilo	Waikane, Kulani, Waiokamilo	Waikane
	<u>Problem Statement (Kalo):</u> "Lack of water."				

Table 12-2. Continued. Summary of the 2001 testimonies submitted by NHLC related to taro cultivation.

Declarant (CPRC Reference)	Stream Adjacent To Property	Stream Adjacent To Property Where Kalo Is Grown	Stream Source For Auwai Adjacent To Property	Stream Source For Auwai Adjacent To Property Where Kalo Is Grown	Streams Where Kalo Would Be Grown If Water Were Available
B. Tau-a M. Pahukoa (CPRC 29.2-51)	Waiakamilo (sic), Piinaua (sic)	Palauhulu, Waiakamilo & Piinaua But [illegible] water from flume that comes from Palauhulu also.	Waiakamilo, Palauhulu, Piinaua & also Waipio	Waiokamilo & Piinaau	Waipio
	<u>Problem Statement (Kalo):</u> "There is lack of water to even push (?) the stream."				
Benjamin Smith Sr. (CPRC 29.2-37)	Wailua Nui		Wailua Nui, Ka Milo		
	<u>Problem Statement (Kalo):</u> "We subsist on whatever water that is not diverted. Since 1985 our streams are dry. We need more water that we are accustomed to before Hawaii became a state."				
Lucille L. Smith (CPRC 29.2-39)	Wailua Nui		Wailua Nui, Kamilo		
Edward Wendt (CPRC 29.2-53)	Lakini and Waiokamilo, Kulani	Lakini and Waiokamilo, Kulani	Lakini, Kulani, Waiokamilo	Lakini, Kulani, Waiokamilo	

In 2002, the State Office of Hawaiian Affairs cosponsored a "No Ka Lo'i Conference", in the hopes of bringing together taro farmers from around the state to share knowledge on the cultivation of taro. An outcome of the conference was an acknowledgement that farmers needed to better understand the water requirements of their taro crops to ensure and protect their water resource interests. The result of this effort was a 2007 USGS wetland kalo water use study, prepared in cooperation with the State Office of Hawaiian Affairs, which specifically examined flow and water temperature data in a total of 10 cultivation areas on four islands in Hawaii. Two of the loi (flooded terrace) complexes are located in east Maui (Wailua and Keanae).

The study reiterated the importance of water temperature in preventing root rot. Typically, the water in the taro loi is warmer than water in the stream because of solar heating. Consequently, a taro loi needs continuous flow of water to maintain the water temperature at an optimum level. Multiple studies cited in Gingerich, et al., 2007, suggest that water temperature should not exceed 77ºF (25ºC). Low water temperatures slow taro growth, while high temperatures may result in root rot (Penn, 1997). When the flow of water in the stream is low, possibly as a result of diversions or losing reaches, the warmer water in the taro loi is not replaced with the cooler water from the stream at a quick enough rate to maintain a constant water temperature. As a result, the temperature of the water in the taro loi rises, triggering root rot.

The USGS 2007 study noted that "although irrigation flows for kalo cultivation have been measured with varying degrees of scientific accuracy, there is disagreement regarding the amount of water used and needed for successful kalo cultivation, with water temperature recognized as a critical factor. Most studies have focused on the amount of water consumed rather than the amount needed to flow through the irrigation system for successful kalo cultivation (Gingerich, et al., 2007)." As a result, the study was designed to measure the throughflow of water in commercially viable loi complexes, rather than measuring the consumption of water during taro growth.

Because water requirements for taro vary with the stage of maturity of the plants, all the cultivation areas selected for the study were at approximately the same stage (i.e. near harvesting, when continuous flooding is required). Temperature measurements were made every 15 minutes for approximately 2 months. Flow measurements were collected at the beginning and the end of that period. Data were collected during the dry season (June – October), when water requirements for cooling kalo are higher. Surface water temperatures generally begin to rise in April and remain elevated through September, due to increased solar heating. Water inflow temperature was measured in 17 loi complexes, and only three had inflow temperatures rising above 27ºC (the threshold temperature above which wetland kalo is more susceptible to fungi and associated rotting diseases).

The average and median inflows from all 10 cultivation areas studied are listed in Table 12-3. The study indicated that the "values are consistent with previously reported inflow and are significantly higher than values generally estimated for consumption during kalo cultivation." It should also be noted that farmers were interviewed during field visits; most "believed that their supply of irrigation water was insufficient for proper kalo cultivation."

Table 12-3. Summary of water use calculated from loi and loi complexes by island, State of Hawaii (Source: Gingerich et al., 2007, Table 10).

[gad = gallons per acre per day; na = not available]

Island	Complex				Loi			
	Number	Average water use (gad)	Average windward water use (gad)	Average leeward water use (gad)	Number	Average water use (gad)	Average windward water use (gad)	Average leeward water use (gad)
Kauai	6	120,000	97,000	260,000	2	220,000	220,000	na
Oahu	5	310,000	380,000	44,000	4	400,000	460,000	210,000
Maui	6	230,000	230,000	na	na	na	na	na
Hawaii	2	710,000	710,000	na	na	na	na	na
Average of all measurements		260,000	270,000	150,000		350,000	370,000	210,000
Median of all measurements		150,000	150,000	150,000		270,000	320,000	210,000

The windward Maui areas chosen for the study were Waihee, Wailua, and Keanae. Wailua and Keanae each have numerous individual loi and loi complexes. Three of the Wailua area complexes were available for study: 1) Lakini complex, supplied through an auwai with water diverted from Hamau Stream, which in turn receives diverted water from Waiokamilo Stream; 2) Wailua complex, supplied through an auwai with water diverted from Waiokamilo Stream; and 3) Waikani complex, supplied through an auwai with water diverted from Wailuanui Stream. The loi in Keanae were treated as a single complex supplied by the Keanae Flume, which diverts water from Palauhulu Stream.

The study results are presented below in Table 12-4 (discharge measurements) and Table 12-5 (water-temperature statistics).

Table 12-4. Summary of discharge measurements and areas for selected loi complexes, Island of Maui (Source: Gingerich et al., 2007, Table 6).

[mgd = million gallons per day; gad = gallons per acre per day; na = not applicable; average water use is determined by summing the averages of each complex or loi and dividing by the number of complexes or loi.]

Area	Complex						
	Station	Irrigation area (acre)	Date	Measurement time	Discharge (mgd)	Water use (gad)	Remarks
Waihee	Ma08A-CI	2.3	7/29/2006	1501	0.34	150,000	total flow for upper and lower complexes
			9/22/2006	1158	0.30	130,000	total flow for upper and lower complexes
	Ma08B-CIR	na	7/29/2006	1500	0.025		
	Ma08B-CIL	na			0.06		
		0.76		na	0.085	110,000	combined right and left complex inflows
	Ma08B-CIR	na	9/22/2006	1150	0.058		
	Ma08B-CIL	na		1055	0.067		
		0.76		na	0.13	160,000	combined right and left complex inflows
Wailua (Lakini)	Ma09-CIR	na	7/30/2006	1004	0.26		
	Ma09-CIL	na		947	0.30		
		0.74		na	0.56	750,000	combined right and left complex inflows
	Ma09-CIR	na	9/21/2006	1015	0.16		
	Ma09-CIL	na		1049	0.06		
	Ma09-CIM	na		1206	0.19		
		0.74		na	0.41	550,000	combined right, left, and middle complex inflows
Wailua	Ma10-CI	3.32	7/30/2006	1136	0.59	180,000	
			9/21/2006	845	0.46	140,000	
Wailua (Waikani)	Ma11-CI	2.80	7/30/2006	1236	0.54	190,000	
			9/21/2006	1608	0.26	93,000	
Keanae	Ma12-CI	10.53	7/31/2006	836	1.90	180,000	former USGS streamflow-gaging station
			9/21/2006	1415	1.60	150,000	
number		6.00				6	
minimum		0.74				93,000	
maximum		10.53				750,000	
average		3.41				230,000	

Table 12-5. Water-temperature statistics based on measurements collected at 15-minute intervals for loi complexes on the Island of Maui (Source: Gingerich et al., 2007, Table 7).

[ºC = degrees Celsius; na = not applicable]

Geographic designation	Area	Station	Period of record	Temperature (ºC) Mean	Range	Mean daily range	Temperature measurements greater that 27ºC (percent)
Windward	Waihee	Ma08A-CI	7/29/2006 - 9/22/2006	21.6	19.9 - 24.0	2.0	0.0
		Ma08B-CIL	7/29/2006 - 9/22/2006	24.9	20.3 - 34.0	7.6	25.4
		Ma08B-CO	7/29/2006 - 9/22/2006	25.5	20.0 - 35.5	5.7	27.0
Windward	Wailua (Lakini)	Ma09-CIT	7/30/2006 - 9/21/2006	20.7	18.5 - 23.4	2.3	0.0
		Ma09-CO	7/30/2006 - 9/21/2006	23.2	18.4 - 31.7	7.4	16.9
Windward	Wailua	Ma10-CI	7/30/2006 - 9/21/2006	22.5	20.5 - 25.9	1.9	0.0
Windward	Wailua (Waikani)	Ma11-CI	7/30/2006 - 9/21/2006	22.2	21.0 - 24.0	0.7	0.0
		Ma11-CO	7/30/2006 - 9/21/2006	26.1	22.1 - 31.8	3.3	29.1
Windward	Keanae	Ma12-CI	7/31/2006 - 9/21/2006	20.0	19.0 - 21.9	1.0	0.0
		Ma12-CO	equipment malfunction	na	na	na	na

On August 12, 2008, Commission staff met with a group of Wailuanui taro farmers, including Kimo Day, Steven and Pauahi Hookano, Bush Martin, Edward Wendt, and Charles Barclay, to learn more about the taro cultivation practices in Wailua Valley. During this site visit, the taro farmers submitted photos that illustrate the effects of an insufficient supply of water on taro growth. In particular, Steven Hookano provided photos of taro root rot occurring to his harvest in September of 2006 (Figure 12-2). Kimo Day's photos (Figure 12-3) illustrate his attempt to start a taro loi in April of 2007 that failed due to a lack of water in the stream. The last photo in Figure 12-3 (lower right corner) shows his dried up taro loi.

Figure 12-2. Photos submitted by Steven Hookano illustrating taro root rot, taken September 2006.

Figure 12-3. Photos submitted by Kimo Day illustrating his failed attempt to start a taro loi, taken April 2007.

According to a 1995 cultural landscape study prepared by Group 70 International, Inc. et al., for the County of Maui Planning Department, there are three complexes of taro loi in cultivation with sources attributed to Waiokamilo Stream, two of which are considered part of the larger Wailuanui loi complex. The first complex is the Lakini loi located mauka of Hana Highway. Although Lakini is considered part of the Wailua complex and occurs within the Wailuanui hydrologic unit, the source of water is from an auwai conveying water from Kualani Stream (USGS referred to this as Hamau Stream in Gingerich, S.B. *et al*, 2007). Though Kualani Stream appears to be a tributary of Waiokamilo, Gingerich et al. (2007) indicates that Kualani "receives diverted water from Waiokamilo Stream further upstream." Water is diverted from Waiokamilo Stream and flows via an auwai to feed the Lakini loi. The outflow from the Lakini complex continues in the auwai under the highway to feed the central portion of the larger Wailuanui complex. Group 70 International, Inc. et al. (1995) also noted that the ridge line at Lakini had been cut to allow for the construction of the auwai to carry water from Waiokamilo to Wailuanui, a testament to the engineering skill of the early Hawaiian planters.

The second complex, referred to as the Wailua loi complex by Gingerich et al. (2007), comprises the northwest portion of the larger Wailuanui loi complex and is primarily fed by an auwai that takes water directly from Waiokamilo Stream. The Wailua complex is approximately 3.32 acres and consists of roughly 55 individual loi. Group 70 International, Inc. et al. (1995) noted the complexity of the entire Wailuanui complex, having identified 339 individual loi from a 1982 aerial photograph and also indicated that portions of the complex had been converted to rice cultivation by the early 1900s.

The smallest of the three complexes associated with Waiokamilo Stream is located on both sides of the stream just makai of Hana Highway. Group 70 International, Inc. et al. (1995) indicated that the loi was located "a short distance behind the Harry K. Mitchell family compound," and "is cultivated by two separate families." A cursory examination of recent aerial imagery reveals that additional taro loi may have been opened/reopened in other areas of the Waiokamilo hydrologic unit, warranting further analysis related to potentially increased water requirements for the area.

The Commission's records for the hydrologic unit of Waiokamilo indicate that there are a total of 19 registered diversions, of which four are EMI diversions. Of the 15 non-EMI diversions, 11 registrants declared water use for taro cultivation with an estimated cultivable area of 514.71 acres (0.80 square miles). This estimation of taro acreage includes a collective registration by the Keanae/Wailuanui Native Hawaiian Land Association (File reference: EAST MAUI TARO) which declared water use for approximately 350 acres of taro from both Waiokamilo and Wailuanui Streams. In addition, six of the registrants claimed water use for other irrigation purposes including the watering of livestock, aquaculture, and the cultivation of fruits, vegetables, flowers, and other plants. Data from the statewide diversion verification study conducted by R.M. Towill Corporation, along with information collected from Commission staff site visits, and information extracted from the original registration files regarding the registered diversions may be found in Table 13-1 of Section 13.0, Noninstream Uses.

Commission staff held a Public Fact Gathering Meeting on April 10, 2008 in east Maui to gather comments on the draft version of this and the other four IFSARs published simultaneously. Written comments were also accepted over a 2-month period. A great deal of the oral and written testimony addressed traditional and customary rights, including taro cultivation and gathering practices. Dozens of east Maui residents testified that insufficient water in the streams to cultivate as much taro as desired; and that often the water that does flow is too warm, resulting in root rot.

Further, testimony indicated that there is insufficient native fauna for gathering, and the water is also not sufficient for recreation. Testimony before the Board of Land and Natural Resources from May 2001 was also provided, with six long-time east Maui residents all stating that the streamflow in east Maui has diminished within their lifetimes (See CPRC 29.3-1 through 29.3-12). Some of the same six residents also provided oral testimony on April 10, 2008 and/or in writing. They, and others, state that the reduction in streamflow has impacted their ability to survive off the land and to perpetuate the Hawaiian culture (See CPRC).

As part of their written comments, Native Hawaii Legal Corporation also submitted testimony dated 2001, related to taro cultivation and gathering in east Maui streams. The testimony consisted of a form in which people completed pre-designated sections. The information in these forms, as it relates to gathering, is collected in Table 12-6 (See CPRC 29.2-1 through 29.2-56).

Table 12-6. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Charles L. Barclay (CPRC 29.2-3)	opae, hihiwai, o'opu	Honomanu to Makapipi	opae, hihiwai, o'opu	Honomanu, Waiokamilo
	<u>Problem Statement (Gathering):</u> "Not enough free-flowing water to maintain the kalo, opae, hihiwai & o'opu."			
Awapuhi Carmichael (CPRC 29.2-55)	opae, hi hi wais, oopu	from Honomanu to Makapipi	opai (?)	Palauhulu, West Wailuaiki
	<u>Problem Statement (Gathering):</u> "As a child we had all the water we needed to gather & grow healthy taro. When Hawaii became a state, our ahupua'a is left with little or no water to grow healthy taro and gather. Our fishing areas are depleted. We need the water for this native (Kanaka maoli) ahupuaa whose people have existed here since time immemorial."			

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Daniel Carmichael (CPRC 29.2-33)	opaes, hihiwais, oopu, and a variety of fishes in the ocean	Hanawi - Palauhulu, Piinaau Haepuaena - Wailuanui Stream - Waioka Milo aka Kamilo - Kapa'akea - Waiohue, Kapiliula, Wailuaiki East and West, Makapipi	a variety of species	all streams between Kolea & Kuahiwi
	<u>Problem Statement (Gathering):</u> "We do not have enough water in all streams from Kolea to Kuahiwi Nahiku for us to gather from mountain to ocean and from boundary in the ahupua'a of Keanae - Wailuanui within the Koolau District."			
Puanani Holokai (CPRC 29.2-17)	hihiwai, opae	Makapipi - Honomanu	opae, hihiwai	Palahulu
	<u>Problem Statement (Gathering):</u> "Can not gather opae in Palahulu stream because no water flow."			
Cindy Ku'uipo Ka'auamo (CPRC 29.2-21)	opae, hi'iwai, prawns, o'opu, gold fish, haha	Makapipi to Honomanu	opae, hi'iwai	Wailuanui, Waiokamilo, Kulani, Palauhulu, Piinaau, Honomanu
	<u>Problem Statement (Gathering):</u> "Water is a source of life to land and man. It is not for man to possess, but simply for man to use. However, the right to use water depends entirely upon the use of it. The people of Keanae-Wailuanui Ahupua'a have respected the rights of water use for many generations. Our ancestors have taught us that water is of great value. Without it there is no life. "The decrease of water flow affects all life in, around and on this land. It prevents spawning of 'opae & 'o'opu, disrupting the natural process of reproduction resulting in decrease food supply. In addition, making it harder for people to gather. "Insufficient water flow decreases water temperature causing stagnation, allowing small ponds to become host of bacteria, spreading disease among striving creatures, plant life and even man. "Finally, the interruption of natural water flow affects taro. Diseases, foreign pest, decrease in production, frustration among farmers and a threat to our Hawaiian Culture as well as our way of life. "Like our ancestors, the people of Keanae-Wailuanui Ahupua'a understand the importance of water for all life. Because of this, we have inherited the rights of trusteeship over our natural resources. "Ad a trustee, I ask that you answer this question… Do you value the comfort of man or the life of man?... Think about it and do what is right. Restore our streams… Give life not death!"			
Darlene Kaauamo (CPRC 29.2-19)	opae, hihiwai, haha, prawn, gold fish, prawns	Makapipi to Honomanu	opae, hihiwai, haha, gold fish	Wailuanui, Waiokamilo, Kulani, Palauhulu, Piinaau, Honomanu
	<u>Problem Statement (Gathering):</u> "Insufficient water flow in our streams causes multiple problems. It decreases the production of food supply in our streams, causes an increase of bacteria in the water that remain in our streams causing hazard to the people & life that live in and around that area. Most importantly, it destroys the essence of out lifestyle of a taro farming community by causing damage to our taro."			

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Frances Kaauamo (CPRC 29.2-45)				
	Problem Statement (Gathering): "Water flow in streams at times are reduced to 0 which years back the same streams would flow continuously."			
Hannah K. Kaauamo (CPRC 29.2-27)	pohole, leko, polu (?), opai, o'opu, hihiwai, HaHa	Makapipi to Kolea		
Leolani R. Kaauamo (CPRC 29.2-41)	Po-ne (sic), leko, poiup (?), ooipi (?), opoe (opae?), oopu, hihiwai, haha, pula, leko, pohole	Makapip (sic) to Kolea		in most of these streams but not enough water to sustain life
	Problem Statement (Gathering): "Not enough water for oopu to move downstream to spawn. Today there is no oopu."			
Mary Kaauamo (CPRC 29.2-43)			opae, oopu, hihiwai	Wailuanui and Waiokamilo
Samuel E. Kaauamo (CPRC 29.2-25)	pupu, kalo, paholi [possibly means pohole?], haha, luau	Kuhiwa - Kolea		Kuhiwai Kolea
	Problem Statement (Gathering): "EMI is taking too much water."			
Solomon Kaauamo Jr. (CPRC 29.2-29)	opae, oopu, hihiwai, pulu, leko, pohole	Makapipi to Kolea		in most of these streams but not enough water to sustain life
	Problem Statement (Gathering): "Not enough water for oopu to move downstream to spawn. Today there is no oopu."			
Gladys Kanoa (CPRC 29.2-31)	hihiwai, opae, oopu, prawns, ahole, mullet	Honomanu to Makapipi	hihiwai, opae, oopu, prawns	Honomanu to Makapipi
	Problem Statement (Gathering): "Most years we have losses to our taro crops due to drought. Water temperatures cannot be maintained cold enough to keep taro healthy. Taro farmers shouldn't have to compete for use of limited water."			
Jerome Kekiwi, Jr. (CPRC 29.2-49)	opae, hihiwai, oopu	from Honomanu to Makapipi	opae, hihiwai, oopu	Kolea, Honomanu
	Problem Statement (Gathering): "When the rain stops, the water flow in Wailua streams drop to almost nothing. It is hard to grow kalo with no water in the patches."			
Puaala Kekiwi (CPRC 29.2-47)	opae, hihiwai, oopu	from Makapipi to Honomanu	opae	Palahulu in Keanae
	Problem Statement (Gathering): "Getting water to a few of our patches when my neighbor doesn't let any water down."			
Chauncey K. Kimokeo (CPRC 29.2-5)	opae, hihiwai, o'opu, ferns, plants	from Kolea to Makapipi		

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Ihe Kimokeo (CPRC 29.2-11)	oopu, hihiwai, opae, pig hunting, prons (sic)	Kolea to Makapipi		
Lincoln A. Kimokeo (CPRC 29.2-9)	opae, hihiwai, prawns, Hawaiian herbs, ferns shoots, ti leaves, flowers, plants to make leis	all streams (Kolea to Makapipi)	Everything of use	Kolea to Makapipi
	<u>Problem Statement (Gathering):</u> "Regular water flow once sustained the right environment for great populations of fish and other stream life, today disturbed water flow prevents stream life to increase population."			
Pualani Kimokeo (CPRC 29.2-7)	opae, hihiwai, o'opu, Hawaiian herbs, ferns shoots, ti leaves, flowers, lei making ferns	all streams of the Koolau	Everything	All (along the Koolau Valley)
	<u>Problem Statement (Gathering):</u> "Our kalo growth would be massive if the water was left alone. We would not have all these sickness in our loi. Worked the loi all my life and never did see all the problems on our kalo & water till the years of late 1960 through now."			
Willie K. Kimokeo (CPRC 29.2-13)	oopu, hihiwai, opae, water cress, mountain kalo, haha	Kolea to Makapipi	oopu, hihiwai, opae, water cress	Kolea to Makapipi
	<u>Problem Statement (Gathering):</u> "Lack of water."			
Norman D. Martin Jr. (CPRC 29.2-15)	oopu, hihiwai, opai, everything	Kolea to Makapipi	oopu, opai, hihiwai	Kolea to Makapipi
	<u>Problem Statement (Gathering):</u> "Lack of water."			
B. Tau-a M. Pahukoa (CPRC 29.2-51)	opae, hihiwai	from Kolea to Makapipi		from Makapipi to Kolea & Waipio, Honomanu, Wailuaiki & Waialohe which is the muluwai of Palauhulu & Piinaau
	<u>Problem Statement (Gathering):</u> "The problem is not all of the water in the streams meet the sea."			
Benjamin Smith Sr. (CPRC 29.2-37)	opai, hihiwai, oopu	Hanawi, Kapaula, Kopiliula, Kapa'akea, East and West Wailua Iki , Honomanu, Makapipi	opai, hihiwai, oopu	all streams between Kolea & Kuahiwa
Lucille L. Smith (CPRC 29.2-39)	opai, hihiwai & oopu	Hanawi, Makapipi, Kopiliula, Kapa'akea, East and West Wailua Iki , Kapahula, Waiohue, Honomanu	opai, hihiwai, oopu	streams between Kolea & Kuahiwa

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Edward Wendt (CPRC 29.2-53)	opae, hihiwai, oopu		opai, hihiwai, oopu	Waiokamilo - Wailua Stream
	Problem Statement (Gathering): "Cause not enough free flowing to enhance aquatic life and to assist in good taro growth."			

Historical uses of Waiokamilo Stream can also provide some insight into the protection of traditional and customary Hawaiian rights. Without delving into the extensive archive of literature (refer to Kumu Pono Associates, 2001a), Handy et al., in *Native Planters of Old Hawaii* (1972), provide a limited regional description as follows:

> Beyond Ke‘anae is a sizable bay formed by erosion where three streams flow into the ocean. Facing the bay on its west side is a pocket of land which slopes gently seaward from the base of a cliff which corresponds to that separating Ke‘anae Valley from the peninsula. This cliff probably represents an old shore line during a period of subsidence. About half the gently sloping land seaward of the cliff was terraced with lo‘i which were watered by Wailuanui (Big Wailua) Stream, the larger of the three that flow into the bay. The land beyond the terraced area, on the Ke‘anae side toward the sea, is too high for irrigation; here sweet potatoes were planted. And on high ground, there was a war temple. A road runs down to the bay between the terraced area and the higher ground, and along this road are the houses of the people, and the Roman Catholic Church.
>
> Wailua has been notable for its continued occupancy and cultivation by Hawaiian families. This has been due, we were told, to the influence of the Catholic mission. Land titles here are very complicated, too much so to be defined correctly by an outsider."
>
> There are several small stream between Ke‘anae and Wailuanui. They flow in deep small gorges, and the terrain is very rough, but there were a few small *lo‘i* developments. There are said to have been two springs of fresh water, which were opened by Kane and Kanaloa in their travels on Maui. From these springs, in a valley named ‘Ohi‘a, comes the water that irrigates the *lo‘i* in Wailua, so says the legend (*Ka Nupepa Ku‘oko‘a*, October 4, 1923). The Wailuanui Stream gushes down in a beautiful cascade in its gorge just before flowing into the *lo‘i* area. This cascade is called Wai-o-Kane (Water of Kane).

The cultural resources of Waiokamilo Stream were not classified by the HSA, likely due to a lack of archaeological survey coverage. The HSA collected data in three general areas of: 1) archaeological; 2) historical; and 3) modern practices. Archaeological data were originally compiled by the State Historic Preservation Division and are only current to 1990, the date of the HSA (Table 12-7).

Table 12-7. Cultural resource elements evaluated as part of the Hawaii Stream Assessment for Waiokamilo Stream.

Category	Value
Survey coverage: The extent of archaeological survey coverage was analyzed and recorded as complete, partial, very limited, and none. Few valleys are completely surveyed. Many have little or no survey coverage.	None
Predictability: The ability to predict what historic sites might be in unsurveyed areas was scored as high, medium, or low predictability or unable to predict. A high score was assigned if archaeologists were able to predict likely site patterns in a valley given historic documents, extensive archaeological surveys in nearby or similar valleys, and/or partial survey coverage. A low score was assigned if archaeologists were unable to predict site patterns in a valley because of a lack of historical or archaeological information. A medium score was assigned to all other cases.	Not assessed
Number of Sites: The actual number of historic sites known in each valley is straightforward yet very time consuming to count. Instead, archaeologists used survey information to estimate the number of sites in each valley. These figures, adequate for this broad-based assessment, are only rough estimates.	Not assessed
Valley significance as a Whole District: The overall evaluation of each valley's significance was made considering each valley a district. The significance criteria of the National and Hawaii Registers of Historic Places was used. Criterion A applies if the district is significant in addressing broad patterns of prehistory or early history. Criterion B applies if the district is associated with important people (rulers) or deities. Criterion C applies if the district contains excellent examples of site types. Criterion D applies if the district is significant for information contained in its sites. Finally, Criterion E applies if the district is culturally significant for traditionally known places or events or for sites such as burials, religious structures, trails, and other culturally noteworthy sites.	Not assessed
Site Density: The density patterns of historic sites make up a variable extremely important to planners. Three ranks were assigned: low for very few sites due either to normal site patterning or extensive land alteration, moderate for scattered clusters of sites, and high for continuous sites. Valleys with moderate or high density patterns are generally considered moderate or high sensitivity areas.	Not assessed
Site Specific Significance: The site specific significance variable was developed for valleys that had low densities of sites (very few sites) due either to normal site patterning or to extensive land alteration. An example of the first type might be a valley with housing sites on the side but too narrow for taro or housing sites on the valley floor. The second type might be a valley in which there had been sugar cane cultivation but a large heiau was left. The site specific significance of these valleys was categorized as either: 1) sites significant solely for information content which can undergo archaeological data recovery; or 2) sites significant for multiple criteria and merit preservation consideration. Those categorized as meriting preservation consideration would likely include large heiau, burial sites, and excellent examples of site types.	Not assessed
Overall Sensitivity: The overall sensitivity of a valley was ranked very high, high, moderate, low, or unknown. Very high sensitivity areas have moderate or high densities of sites with little or no land alteration. They are extremely important archaeological and/or cultural areas. High sensitivity areas have moderate or high densities of sites with little or no land alteration. Moderate sensitivity areas have very few sites with the sites meriting preservation consideration due to multiple criteria or moderate densities of sites with moderate land alteration. Low sensitivity areas have very few sites due to normal site patterning or due to extensive land alteration. The sites present are significant solely for their informational content, which enable mitigation through data recovery. Those valleys where no surveying had been undertaken and the ability to predict what might be found was low were ranked unknown.	Not assessed

Table 12-7. Continued. Cultural resource elements evaluated as part of the Hawaii Stream Assessment for Waiokamilo Stream
.

Category	Value
Historic Resources: Several types of sites were considered by inclusion in this section, particularly bridges, sugar mills and irrigation systems. Those that are listed on the State or National register were inventoried, but none of them assessed.	Waiokamilo Bridge
Taro Cultivation: Streams and stream water have been and continue to be an integral part of the Hawaiian lifestyle. The committee identified a number of factors important to current Hawaiian practices. These include current taro cultivation, the potential for taro cultivation, appurtenant rights, subsistence gathering areas, and stream-related mythology. The committee felt that a complete assessment of the cultural resources of Hawaii's streams should include these items but, due to limits of information, only the current cultivation of taro was included.	10 to 50 acres of taro

Fishponds are another integral part of traditional Hawaiian culture, which speaks volumes of Native Hawaiian skill and knowledge of aquaculture, which has also seen a resurgence of interest in recent years. Fishponds are found throughout the Hawaiian Islands and were either man-made or natural enclosures of water used for the raising and harvesting of fish and other aquatic organisms. Kikuchi (1973) identified six main types of fishponds, two of which are associated with streams (*loko wai*, *loko ia kalo*) and one type is associated with fresh water springs (*kaheka* or *hapunapuna*).

- Type III – *Loko Wai*: An inland fresh water fishpond which is usually either a natural lake or swamp, which can contain ditches connected to a river, stream, or the sea, and which can contain sluice grates. Although most frequently occurring inland, *loko wai* are also located along the coast near the outlet of a stream.
- Type IV – *Loko Ia Kalo*: A fishpond utilizing irrigated taro plots. *Loko ia kalo* are located inland along streams and on the coast in deltas and marshes.
- Type VI – *Kaheka* and *Hapunapuna*: A natural pool or holding pond. The majority, if not all of these types of ponds, are anchialine ponds with naturally occurring shrimp and mollusks.

According to a 1990 Hawaii Coastal Zone Management Program *Hawaiian Fishpond Study for the Islands of Hawaii, Maui, Lanai, and Kauai*, the Puu Polu fishpond exists towards the northern portion of the Waiokamilo hydrologic unit near the ocean (Table 12-8 and Figure 12-2) (DHM, Inc., 1990).

Table 12-8. Inventory and classification of fishpond in the Waiokamilo hydrologic unit (Source: DHM, Inc., 1990)

The classification of the fishpond for condition and significance. The condition or integrity of the fishpond was based on the criteria of wall condition, degree of siltation, and degree of encroachment by vegetation. Significance decisions were based on the National Register of Historic Places criteria A, B, C and D. The National Register Criteria, described below, were established for use in evaluating and determining the eligibility of properties for listing on the National Register of Historic Places.

Criterion A:	Specifies association with events or broad patterns important in the history of an area. As economic and political resources fishponds have played significant roles in events and patterns important to Hawaiian history.
Criterion B:	Specifies association with the lives or persons significant in our past. The literature search identified several fishponds which have direct associations to people significant in our past.
Criterion C:	Applies to sites that represent architectural achievements. Most fishponds contain structural remains representing considerable architectural achievement by prehistoric as well as historic period engineers.
Criterion D:	States that the property has yielded or has the potential to yield information significant for our understanding of traditional culture, history, prehistory, and foreign influences on traditional culture and history. All fishponds satisfy this criterion.

Fishpond Name:	Puu Polu
Ili/Ahupuaa:	Keanae
TMK Parcel:	(2) 1-1-008:011
Classification:	IIB: Wall in fair to poor condition; Heavy siltation or completely filled; Vegetation encroachment on most or all of fishpond; and Three (3) or less National Register criteria.
Pond Type:	III, Loko Wai: An inland fresh water fishpond which is usually either a natural lake or swamp, which can contain ditches connected to a river, stream, or the sea, and which can contain sluice grates. Although most frequently occurring inland, Loko Wai are also located along the coast near the outlet of a stream.
Ownership:	Private

Another component in the assessment of traditional and customary Hawaiian rights is the presence of Department of Hawaiian Home Lands (DHHL) parcels within the surface water hydrologic unit. The mission of DHHL is to effectively manage the Hawaiian Home Lands trust and to develop and deliver land to native Hawaiians (PBR Hawaii, 2004). In September 2004, DHHL published the Maui Island Plan which served to examine infrastructure needs, provide development cost estimates, and identify priority areas for homestead development. Of the more than 31,000 acres of DHHL land on the island of Maui, only a portion of TMK parcel (2) 1-1-008:014 (15.00 acres) occurs within the Waiokamilo hydrologic unit (Figure 12-5). The entire parcel is part of DHHL's Wailua Tract which constitutes a total area of 91.4 acres (PBR Hawaii, 2004).

According to a DHHL beneficiary survey, the East Maui region has a residential demand for 79 units and an agricultural demand of 204 lots. The DHHL Maui Island Plan identified two alternatives for the entire Wailua Tract. Alternative 1 proposes approximately 11 two- to three-acre lots on 28 acres for subsistence agricultural use, 52 acres of general agriculture, and 10 acres of conservation.

Alternative 2 proposes designating the Wailua Tract as a Special District. The proposed designation arises from concerns raised by Na Moku Aupuni o Koolau Hui (Na Moku). According to DHHL, Na Moku does not support the presence of the Hawaiian Home Lands program in Keanae and Wailua since these areas were never included in the original inventory when the Hawaiian Homes Commission Act was passed in 1920. Na Moku noted that settling DHHL beneficiaries who are unaccustomed to the traditional, subsistence lifestyle that has been preserved, protected, and carried on from ancient times in this area will severely disrupt and tear apart the fabric of the community. Na Moku also felt that it would be damaging to the community if DHHL beneficiaries on the wait list were to by-pass area residents who were attempting to gain leases to house lots for nearly 30 years prior to lands being transferred to DHHL.

In its final land use plan, DHHL selected Alternative 1 due to the high beneficiary demand for agriculture lots on Maui. However, the Wailua Tract is not part of the near-term implementation plans under DHHL's Maui Island Plan. The highest priority tracts selected for Phase One (one to six years) implementation occur within the West and Upcountry Regions of Maui. Phase Two, which is a longer-term, 7- to 20-year period, recommends development of the Wakiu Tract in East Maui. The Wakiu Tract is further east of the Keanae Tract towards Hana, and is outside of this assessment area.

Figure 12-4. Traditional ahupuaa boundaries in the vicinity of Waiokamilo hydrologic unit. This hydrologic unit spans three ahupuaa – Wailua Nui, Keanae, and Haiku Uka (Source: State of Hawaii, Office of Planning, 2007a).

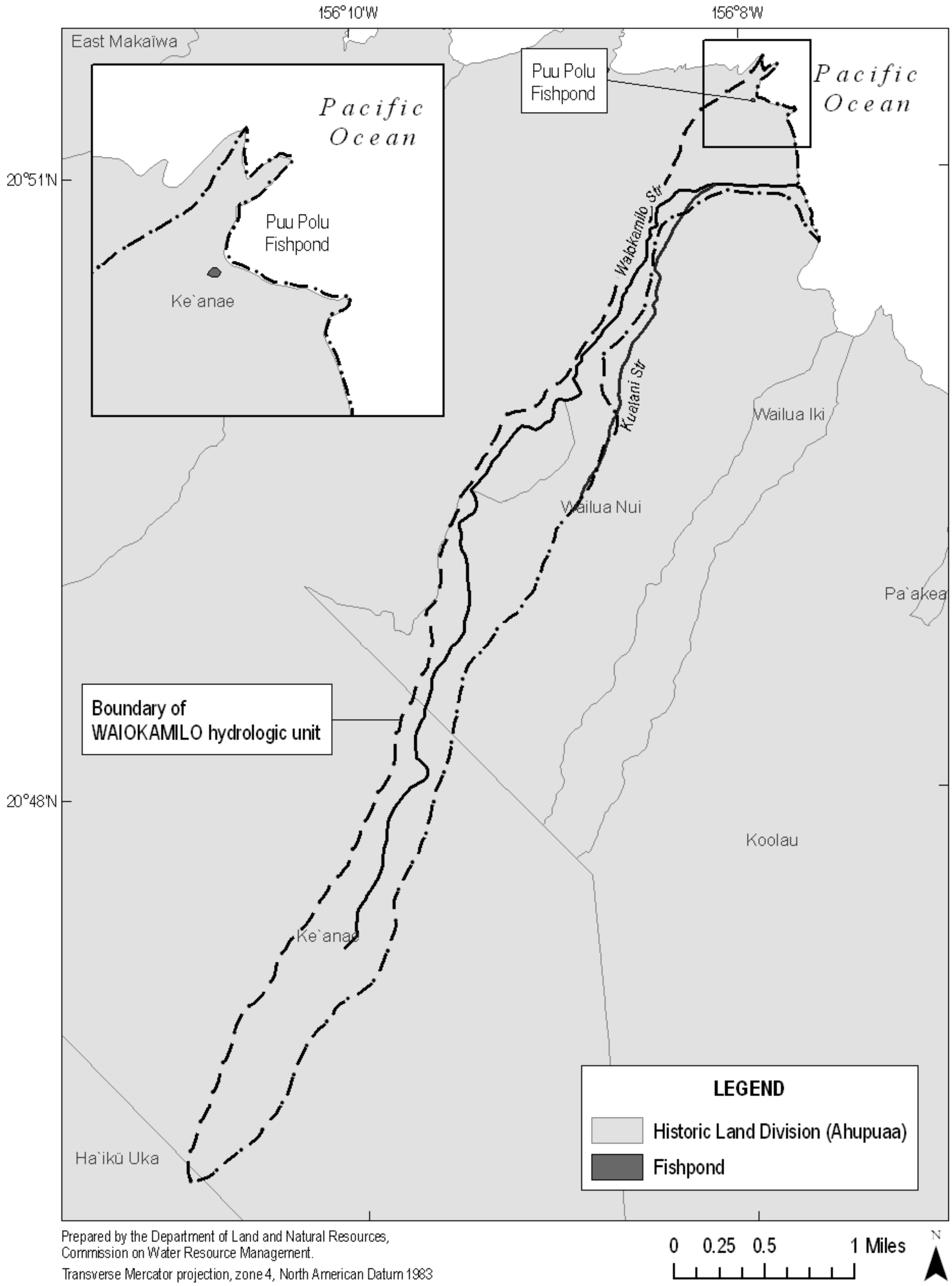
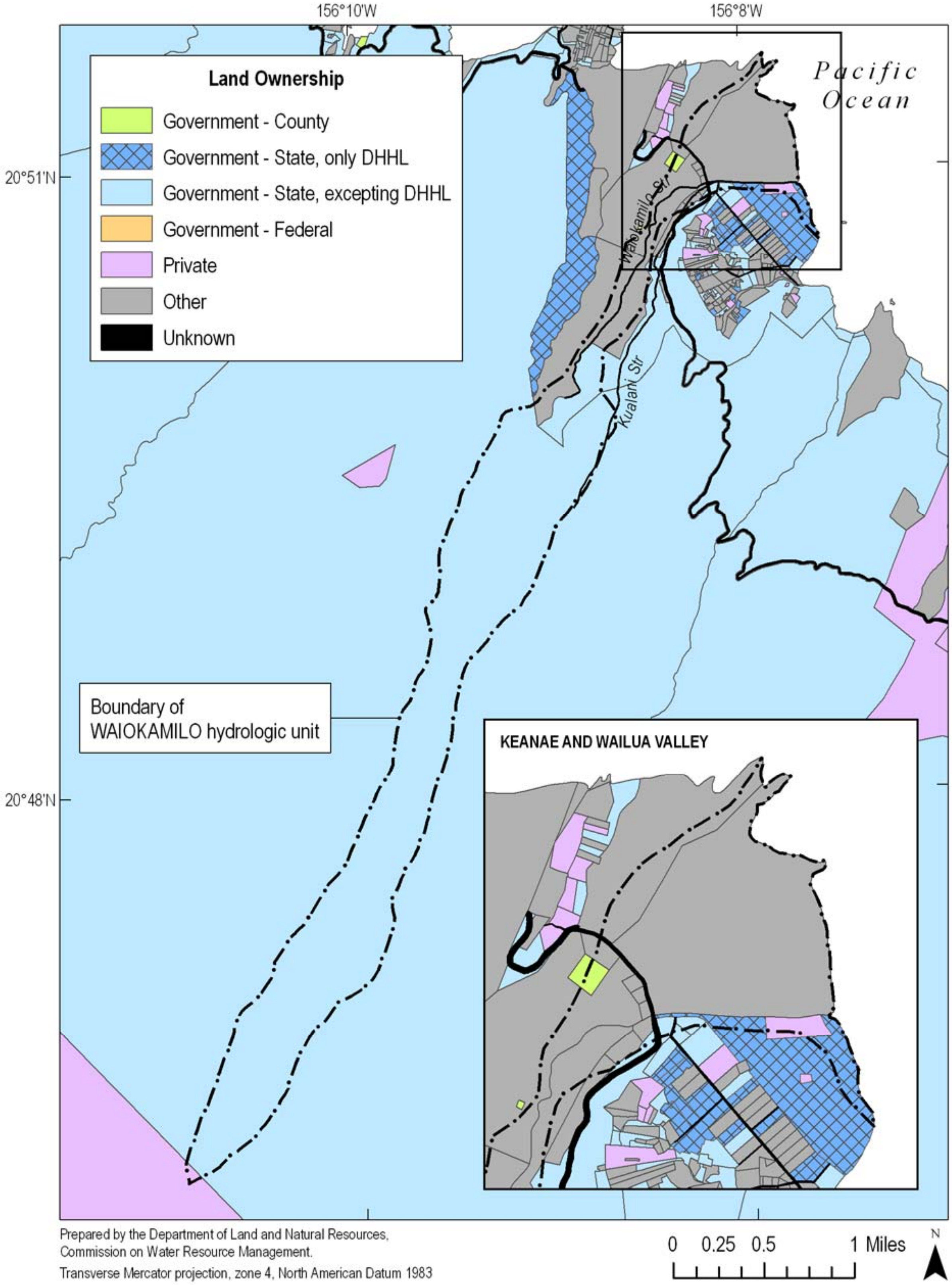


Figure 12-5. Land ownership in Waiokamilo hydrologic unit (Source: County of Maui, 2006).



13.0 Noninstream Uses

Under the State Water Code, noninstream uses are defined as "water that is diverted or removed from its stream channel…and includes the use of stream water outside of the channel for domestic, agricultural, and industrial purposes." Article XI, Section 3 of the State Constitution states: "The State shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally sustainable lands." Water is crucial to agriculture and agricultural sustainability. Article XI, Section 3 also states, "Lands identified by the State as important agricultural lands needed to fulfill the purposes above shall not be reclassified by the State or rezoned by its political subdivisions without meeting the standards and criteria established by the legislature and approved by a two-thirds vote of the body responsible for the reclassification or rezoning action. [Add Const Con 1978 and election Nov 7, 1978]." It is the availability of water that allows for the designation of Important Agricultural Lands. In its comments to the draft version of this and the other four IFSARs published concurrently, the Hawaii Farm Bureau Federation, Hawaii's largest advocacy organization for General Agriculture, states that agriculture is a public trust entity worthy of protection, as demonstrated in its inclusion in the State Constitution. They, along with the Maui County Farm Bureau on behalf of farmers and ranchers on Maui, point to the importance of large-scale agriculture to sustainability and self-sufficiency of our islands, particularly in times of catastrophe when imports are cut off (See CPRC 12.0 and 22.0).

In most cases, water is diverted from the stream channel via a physical diversion structure. Diversions take many forms, from small PVC pipes in the stream that remove relatively small amounts of water, to earthen auwai (ditches), hand-built rock walls, and concrete dams that remove relatively larger amounts of water. Water is most often used away from the stream channel and is not returned; however, as in the case of taro fields, water may be returned to the stream at some point downstream of its use. While the return of surface water to the stream would generally be considered a positive value, this introduces the need to consider water quality variables such as increased temperature, nutrients, and dissolved oxygen, which may impact other instream uses. Additionally, discharge of water from a ditch system into a stream may introduce invasive species.

In addition to the amount of water currently (or potentially) being diverted offstream, the Commission must consider the diversion structure and the type of use, all of which impact instream uses in different ways. The wide range of diversion structures, as noted above, is what makes regulation of surface water particularly difficult, since one standard method cannot be depended upon for monitoring and measuring flow. The ease of diverting streamflow, whether it be by gravity-flow PVC pipe, pump, or a dug channel, also plays a role in the convenience of diverting surface water and the abundance of illegal, non-permitted diversions.

Upon the enactment of the State Water Code and subsequent adoption of the Hawaii Administrative Rules, the Commission required the registration of all existing stream diversions statewide. The Commission categorized the diversions and filed registrations according to the registrant's last name or company name. While it is recognized that the ownership and/or lease of many of the properties with diversions has changed since then, the file reference (FILEREF) remains the name of the original registrant file (Table 13-1). Locations are depicted in Figure 13-9.

In 2007, the Commission initiated a contract for the purpose of conducting statewide field investigations to verify and inventory surface water uses and stream diversions, and update existing surface water information. Priority 1 Areas, under this contract, include all east Maui streams that are part of the pending Petition to Amend Interim Instream Flow Standards. Data from this study, along with information collected from Commission staff site visits, and information extracted from the original registration files are included in Table 13-1 and Table 13-2.

For the Waiokamilo hydrologic unit, East Maui Irrigation Co. (EMI) operates only the Koolau Ditch as part of the larger East Maui Irrigation System. Though EMI registered all of its "major" diversions (included in Table 13-1), the Commission did not require EMI to register their "minor" diversions and instead was provided with a map, lists, and photographs. These minor diversions may vary widely in construction. One example consists of a small concrete basin collecting ground water seepage, which then transports the collected water via a gravity-flow PVC pipe to a larger ditch, ultimately joining one of the primary systems. The contribution of these small seeps and springs to total streamflow is unknown. Information on EMI's minor diversions is listed in Table 13-2, and their locations depicted in Figure 13-9.

Since the enactment of HAR Title 13 Chapter 168, stream diversion works permits are required for the construction of new diversions or alteration of existing diversions, with the exception of routine maintenance. These permitted (as opposed to "registered") diversion works are not part of the Commission's verification effort, nor have any diversions been permitted in the Waiokamilo hydrologic unit.

Table 13-1. Registered diversions in the Waiokamilo hydrologic unit.

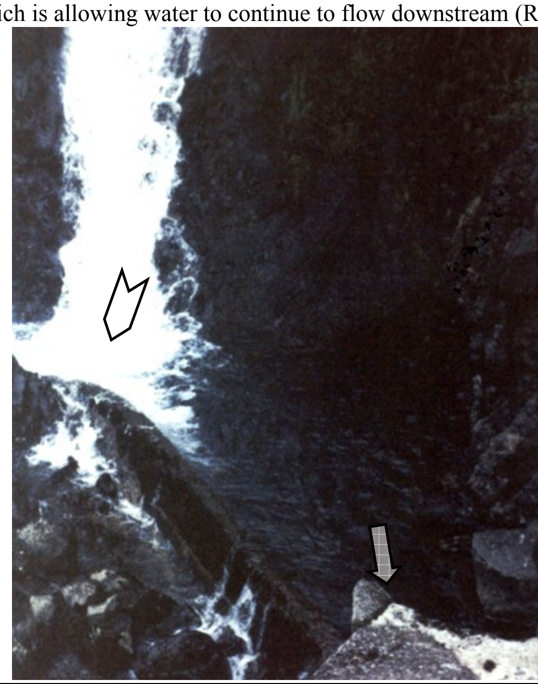
[Source of photos are denoted at the end of each description; CWRM, Commission on Water Resource Management; DAR, Division of Aquatic Resources; EMI, East Maui Irrigation Company, Inc.; RMT, R.M. Towill Cooperation (R.M. Towill conducted field verifications on the island of Maui under contract with the Commission on Water Resource Management in late 2007); Arrows (⇨) indicate general direction of water flow to, into, and through noninstream diversions; Chevrons (⪢) indicate general direction of natural surface water flow]

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.9.6	AKINA S	2-1-1-008:	unknown		No	No	No
Diversion consists of a 12-inch PVC pipe from Waiokamilo Stream. Use is for 2 acres of taro.							
REG.320.6	EAST MAUI IRR	2-1-1-002:			No	Yes	

Water is diverted from Waiokamilo Stream at Intake K-25 (Koolau Ditch intake on Waiokamilo Stream [Kikokiko Intake]) into the Koolau Ditch system. The diversion structure is concrete with a divertable capacity of 7 mgd, controlled by a wooden gate. Declarant stated that approx. 36,000 acres are irrigated from this source and all other HC&S and EMI sources. Uses include irrigation of sugar, pineapple, and a variety of other crops; cooling, manufacturing, and mill use; and hydroelectric; and livestock. Quantity of use taken at Wailoa @ Honopou gaging station (total declared Q for gage is 45943.000 MG).

Photos. a) The diversion intake structure captures water at the foot of the falls and directs it into the intake at bottom right (EMI, 05/1989); b) Photo is taken after intake was supposedly cemented shut in response to the Land Board's interim order, which is allowing water to continue to flow downstream (RMT, 12/2007).

a)



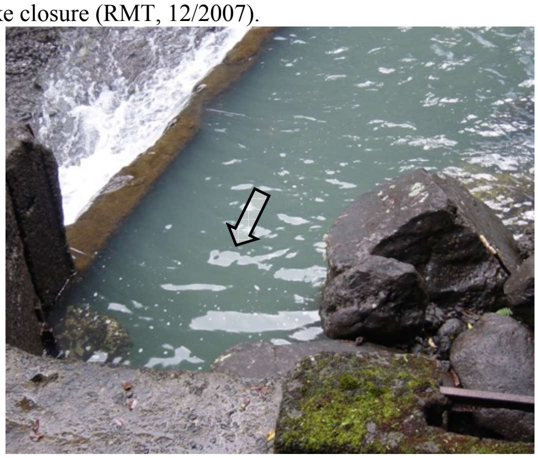
b)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.320.6 (Continued)	EAST MAUI IRR	2-1-1-002:		Yes	Yes	Yes	

Photos. c) Water would normally flow into the intake structure on the left bank below the falls (RMT, 12/2007); d) Water flows down a flume towards the Koolau Ditch (RMT, 12/2007); e) Water continues to flow downstream as a result of the intake closure (RMT, 12/2007).

d)



e)

f)

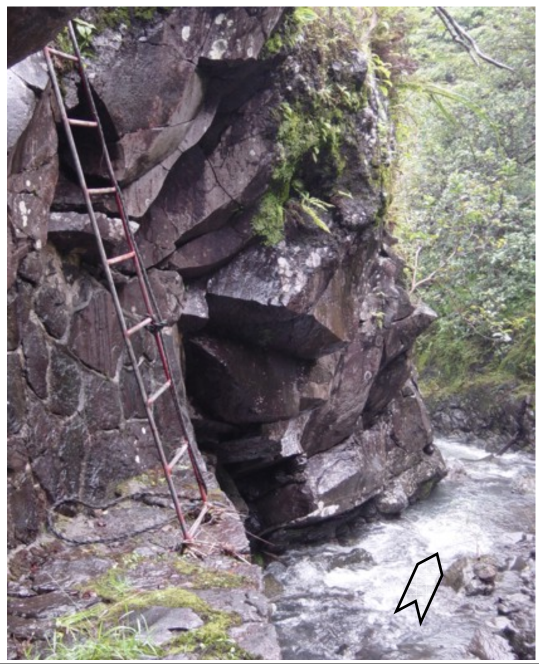


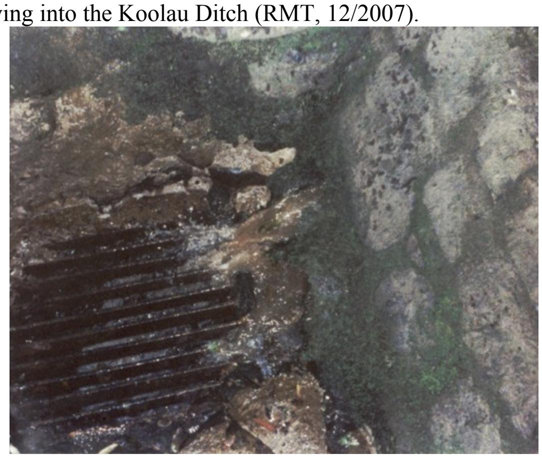
Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.326.6	EAST MAUI IRR	2-1-1-002:		Yes	Yes	Yes	

Water is diverted from Kualani Stream at Intake K-22 (Koolau Ditch intake on Kualani Stream) into the Koolau Ditch system. The diversion structure is concrete with a divertable capacity of 9 mgd, controlled by a 10-inch steel pipe. Declarant stated that approx. 36,000 acres are irrigated from this source and all other HC&S and EMI sources. Uses include irrigation of sugar, pineapple, and a variety of other crops; cooling, manufacturing, and mill use; and hydroelectric; and livestock. Quantity of use taken at Wailoa @ Honopou gaging station (total declared Q for gage is 45943.000 MG). Please note that the diversion capacity of 9 mgd far exceeds the estimated median flow of the stream (See CPRC 38.0-8).

Photos. a) Diversion intake structure at Intake K-22 (EMI, 05/1989); b) Water flow at the roadway adjacent to tunnel (RMT, 12/2007); c) Water flowing out of the access tunnel due to closure of tunnel with board gates to prevent water flowing into the Koolau Ditch (RMT, 12/2007).

a)



b)

c)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.328.6	EAST MAUI IRR	2-1-1-002:		Yes	Yes	Yes	

Water is diverted from Waiokamilo Stream at Intake K-24 (Koolau Ditch intake on Waiokamilo Stream [#12 intake]) into the Koolau Ditch system. The diversion structure is concrete with a divertable capacity of 9 mgd, controlled by the size of the opening. Declarant stated that approx. 36,000 acres are irrigated from this source and all other HC&S and EMI sources. Uses include irrigation of sugar, pineapple, and a variety of other crops; cooling, manufacturing, and mill use; and hydroelectric; and livestock. Quantity of use taken at Wailoa @ Honopou gaging station (total declared Q for gage is 45943.000 MG).

Photos. a) Diversion intake structure (EMI, 05/1989); b) Intake K-24 was supposedly cemented shut in response to the Land Board's interim order, which is allowing water to continue to flow downstream (RMT, 12/2007).

a)

b)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.329.6	EAST MAUI IRR	2-1-1-002:		Yes	Yes	Yes	

Water is diverted from Waiokamilo Stream at Intake K-23 (Koolau Ditch intake on Waiokamilo Stream [#11 intake]) into the Koolau Ditch system. The diversion structure is concrete with a divertable capacity of 20 mgd, controlled by the size of the opening. Declarant stated that approx. 36,000 acres are irrigated from this source and all other HC&S and EMI sources. Uses include irrigation of sugar, pineapple, and a variety of other crops; cooling, manufacturing, and mill use; and hydroelectric; and livestock. Quantity of use taken at Wailoa @ Honopou gaging station (total declared Q for gage is 45943.000 MG).

Photos. a) Diversion intake structure (EMI, 05/1989); b) Water flows from above the cliff and goes under the road (RMT, 12/2007).

a)

b)

REG.333.6	EAST MAUI TARO	2-1-1-002:		Yes	Yes	No	Yes

Diversion consists of a 2-foot driscoll pipe. Registration of diversion was made in conjunction with Diversion (Event ID) REG.332.6 on West Wailuanui Stream. Uncertain whether or not declared use is for combined sources of water. Declared use is for ~350 or more acres of wetland taro, watercress, ornamental flowers and foliage, and livestock. Declarant claims divertable capacity is 10 or more million gallons per day.

This diversion is believed to be the same diversion registered under HOKOANA BK (REG.499.6), which has been identified as the Lakini Ditch Intake and is sometimes referred to as the location at Dam #2.

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.335.6	ECHTERNACH S	2-1-1-008:007		Yes	Yes	Yes	No

Diversion consists of plastic pipe. Uses are domestic (one house, one service building); irrigation of vegetable garden, fruit trees, and landscaping; livestock; fish pond; and aquatic plants. Water use is approx. 500-700’ downstream of diversion.

Photos. a) Downstream view of Waiokamilo Stream with intake pipe with filter at center (EMI, 05/1989); b) Downstream view of stream below diversion intake (RMT, 12/2007).

a)

b)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

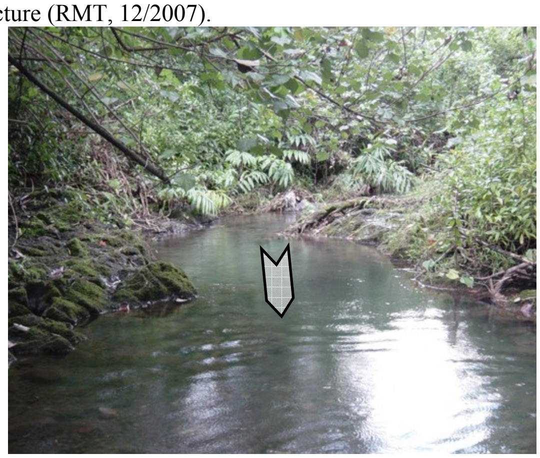
Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.499.6	HOKOANA BK	2-1-1-008:010		Yes	No	Yes	Yes

Diversion from Waiokamilo Stream to irrigate 2.09 acres of taro. Declarant claims riparian and appurtenant rights. Three sources (Waiokamilo Stream, Palauhulu Stream, and a spring (source of Waianu Stream) serve ~3 acres in taro production and ~ 10 acres in other uses, including watercress, ti plants, flowers for sale to florists, and domestic and landscaping uses for one dwelling. Declarant also asserts gathering rights.

This diversion has also been identified as the Lakini Ditch Intake and is sometimes referred to as the location at Dam #2.

Photos. a) Upstream view of Waiokamilo Stream just above Dam #2 (RMT, 12/2007); b) View at Dam #2 stretching from left bank, where water is diverted into Lakini Ditch to the right facing downstream (RMT, 12/2007); c) Downstream view from diversion intake (RMT, 12/2007); d) Downstream view in Lakini Ditch approximately 20-feet below diversion structure (RMT, 12/2007).

a)



b)

c)

d)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.553.6	KAINOA J	2-1-1-008:011		Yes	No	Yes	No

Diversion structure is a concrete intake, 18-inch x 14-inch x 6-inch deep with metal trash grate; user has 1-inch diameter black polyethelene pipe. Diversion is from Kaleipelehua Stream, a tributary to Waiokamilo Stream. Declarant claims that average flow before diversion was 200 gpm; divertable capacity is 10gpm (measured with 5 gal container and stopwatch). Uses are domestic and irrigation of diverse fruits and landscaping. Note: declaration is in Needham file.

RMT field notes indicate that this is the highest pipe intake on the right branch of Waiokamilo Stream. At the time of the RMT site visit, the diversion was not functioning due to a recent storm, but the diversion is active. Water is used for residential and agricultural use for taro, orchards, and crops.

Photos. a) View of diversion intake pipe submersed in stream channel (RMT, 12/2007); b) Upstream view of stream channel (RMT, 12/2007); c) Downstream view with pipe running from the left bank, across the channel, then down the right bank(RMT, 12/2007).

a)

b)

c)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

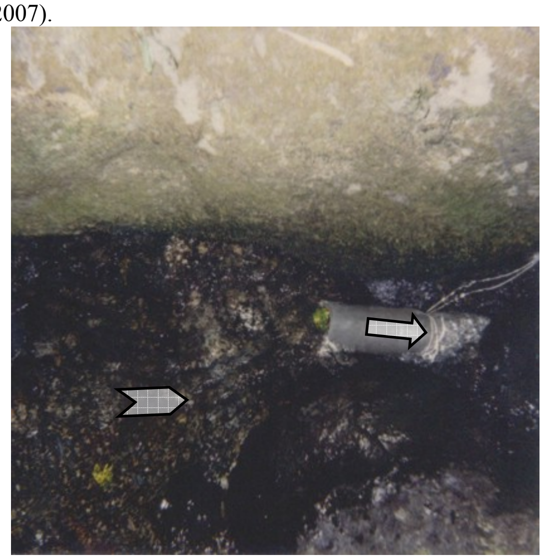
Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.569.6	KANOA I	2-1-1-008:010		Yes	Yes	Yes	Yes

Diversion structure a 4-inch intake pipe in stream. (Declaration indicates concrete diversion but field notes do not so indicate.) Use is one domestic service connection; aquaculture; and irrigation of 6 acres of taro, haleconia, and vegetables. Declarant claims Kuleana appurtenant rights and traditional gathering rights (oopu, opae, hihiwai, prawns). Field verification indicates that pipe transports water to a portion of TMK 1-1-007:020 where it is used for irrigation of ~6 acres of heliconia and noni. Waiokamilo

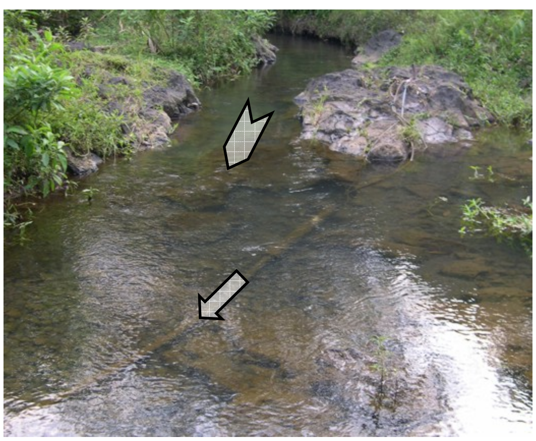
Field notes also indicate declarant leases 1-1-002:007, and Waiokamilo Stream runs through property. At the time (1994), the declarant plans to use water from the stream to farm (taro, bananas, and fern shoots).

Photos. a) Diversion intake structure on Waiokamilo Stream (CWRM, 10/1994); b) Upstream view of 4-inch diversion intake pipe submersed at center of channel (RMT, 12/2007); c) Downstream view from above diversion intake (RMT, 12/2007).

a)



b)



c)

REG.859.6	MITCHELL HO	2-1-1-008:010		No	Yes	Yes	Yes

Diversion is described as plastic pipe hose (from unmapped tributary to Waiokamilo Stream). Declared water use is 1 gal. every 5 min. Use is 6’ x 4’ fish pond. Declarant claims appurtenant, riparian, correlative (groundwater) and Hawaiian rights.

RMT field notes indicate that no pipe was found at this location.

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

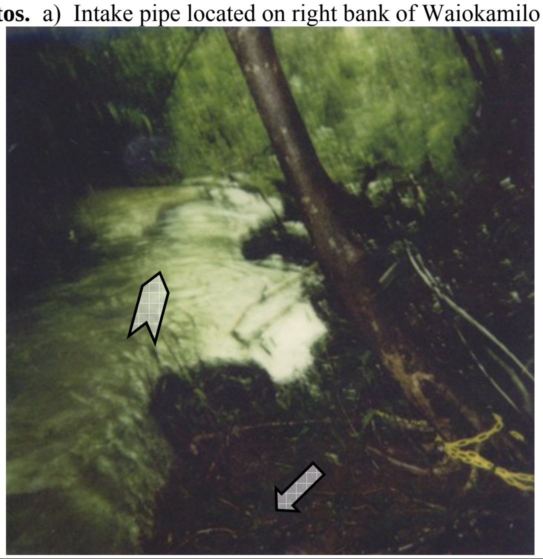
Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.891.6	NEEDHAM E	2-1-1-008:006	0.0	No	Yes	Yes	No

Diversion structure described as both concrete and pipe. Use is one domestic connection and irrigation of ~2,500 sq. ft. (100’ x 25’) for taro, and fire prevention. Annual water use estimated at 8,280,000 gallons; other users are all Wailua taro farmers. CWRM records indicate that the diversion is a 1.5-inch PVC with a 3-inch filer in Waiokamilo Stream. Estimate amount of diversion at time of registration was 0.0351 cfs.

RMT field notes indicate that no pipe was located in the stream adjacent to this property, however this property is served by diversion REG.891.6 (NEEDHAM E).

Photos. a) Intake pipe located on right bank of Waiokamilo stream (REG)

a)



b)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

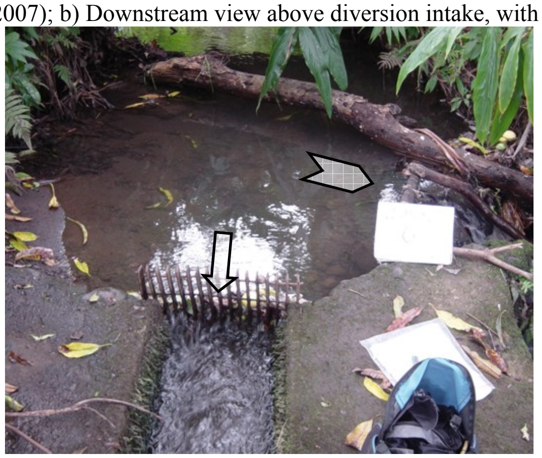
Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.970.6	PUU R	2-1-1-008:011		Yes	Yes	Yes	No

Diversion consists of concrete ditch with divertable capacity of 3 mgd. Uses are irrigation of ~2 acres for taro, and ornamentals, plus livestock. Water also used by others on TMK 1-1-04-6. Field verification indicates 3-inch filter with a 1.5-inch PVC pipe in Waiokamilo Stream on TMK 1-1-008:006. This line transports water to a 100 gal. holding tank on declarant's property for domestic and irrigation (taro) purposes.

RMT field notes indicate that the diversion is located on the right branch of Waiokamilo Stream, below the bridge on Hana Highway. The diversion is constructed of cement 1-foot high and 1.33-feet wide. Current end use of water is uncertain.

Photos. a) Upstream view from diversion intake structure with grate into cement ditch to right bank of stream (RMT, 12/2007); b) Downstream view above diversion intake, with water flowing nearest to left bank (RMT, 12/2007)

a)



b)

REG.1128.6	VILLALON C	2-1-1-008:011			No	Yes	Yes

Diversion consists of 8-inch pipe with daily use to irrigate ~3 1.2 acres of watercress, ti leaves, and haleconia / tropical plants. Declarant claims riparian rights.

RMT field notes indicate that no pipe was found to be serving this property. The only 8-inch pipe nearby is the County's domestic water line which parallels the bridge on Hana Highway next to Uncle Harry's Fruit Stand.

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.1203.6	WENDER ES	2-1-1-008:011		Yes	Yes	Yes	Yes

Diversion is a pipe from Waiokamilo Stream. Use is 50,000gpd (100,000 gpd combined from two pipes and one pump) for domestic use; to irrigate 151.64 acres of wetland taro, orchard, ti & other cultural plants, vegetables, etc; livestock; hydroelectric; aquaculture; recreation; and traditional gathering. Declarant claims riparian, appurtenant, and correlative water rights. . Field investigation indicates 3-inch filter and 1.5-inch PVC pipe not in use at present time (Nov. 1994). States that intakes are on TMK 1-1-008:004.

RMT field notes indicate that the diversion is a 2-inch white PVC pipe, however the pipe head was broken, and no water was in the pipe at the time of the site visit, like due to recent storm flow. The pipe runs down the right branch of Waiokamilo Stream and is the second highest on the branch.

Photos. a) Diversion pipe nearest to right bank of Waiokamilo Stream (REG, 11/1994); b)

a)

b)

c)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.1204.6	WENDER ES	2-1-1-008:011		Yes	Yes	Yes	Yes
Diversion is a pump from Waiokamilo Stream. Use is 50,000gpd (100,000 gpd combined from two pipes and one pump) for domestic use; to irrigate 151.64 acres of wetland taro, orchard, ti & other cultural plants, vegetables, etc; livestock; hydroelectric; aquaculture; recreation; and traditional gathering. Declarant claims riparian, appurtenant, and correlative water rights. RMT field notes indicate that no stream diversion works are located at or in the stream. Declarant uses a pump at this location as needed. The pump is located adjacent to a house on the property. No photos available.							
REG.1205.6	WENDER ES	2-1-1-008:010		No	Yes	Yes	Yes
Diversion is a pipe from Waiokamilo Stream. Use is 50,000gpd (100,000 gpd combined from two pipes and one pump) for domestic use; to irrigate 1511.65 acres of wetland taro, orchard, ti & other cultural plants, vegetables, etc; livestock; hydroelectric; aquaculture; recreation; and traditional gathering. Declarant claims riparian, appurtenant, and correlative water rights. Field investigation indicates 3-inch filter and 1 ½-inch PVC pipe are in use for domestic, irrigation (~1 acre taro, ~2 acres fruit trees and garden plants); and livestock. States that intakes are on TMK 1-1-008:004 and the second one is not in use. RMT field notes indicate that the area is currently inaccessible due to growth of hau. Declarant claims that the pipe is not currently working but is still an active declaration.							

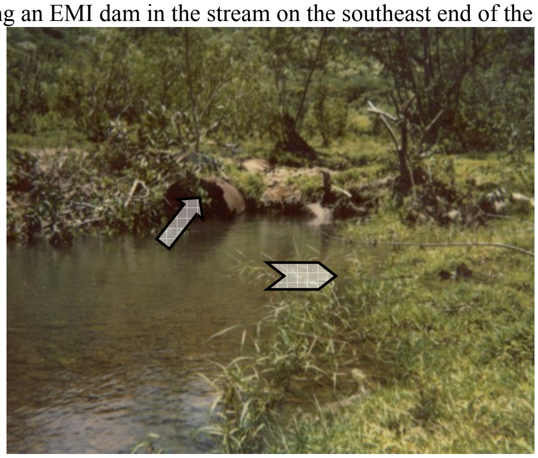
Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.1238.6	YOUNG A	2-1-1-008:006		No	Yes	No	Yes

Diversion consists of a 3-ft. metal pipe in the stream bank on unnamed tributary to Waiokamilo Stream. Uses include one domestic service connection, irrigation for taro, guava, lilikoi, breadfruit, kukui, coconut, flowers, and landscaping, also livestock and aquaculture. Declarant claims riparian and kuleana appurtenant rights.

Photos. a) Downstream view with 3-foot metal pipe on left bank of stream (REG, 05/1989); b) Declarant noted this as being an EMI dam in the stream on the southeast end of the property (REG, 05/1989).

a)



b)

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.1239.6	YOUNG A	2-1-1-008:006		No	Yes	Yes	Yes

Stream diversion, kuleana open ditches from Waiokamilo Stream. Diversion structure is stone and rock. Uses include one domestic service connection, irrigation for taro, guava, bananas, lilikoi, breadfruit, kukui, coconut, flowers, and landscaping, also livestock and aquaculture. Declarant claims riparian and kuleana appurtenant rights.

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
None	Non-Registered #1	2-1-1-008:006		Yes	Yes		

RMT field notes indicate that this diversion is owned by a K. Oliveira and is the only diversion that is located on the left branch of Waiokamilo Stream. The 2-inch PVC pipe was broken and very little water was flowing in the stream at the time of the site visit, but the diversion should still be considered active.

RMT field notes indicate that this diversion is owned by a K. Oliveira and is the only pipe diversion that goes down the left side of the left branch of Waiokamilo Stream. The 2-inch pipe was also disconnected and the pipe head is broken; however the diversion is still considered active.

Photos. a) View of disconnected pipes in stream channel (RMT, 12/2007); b) Upstream view of stream channel (RMT, 12/2007); c) Downstream view of stream channel (RMT, 12/2007).

a)

b)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
None	Non-Registered #2	2-1-1-008:005		No	Yes		

Diversion is located on State land and does not appear to be actively diverting water.

Photos. a) Dam spans entire stream with intake structure on the right bank of the stream, however is not actively diverting water off-stream (RMT, 11/2007); b) Upstream view from dam structure on left bank (RMT, 11/2007); c) Downstream view of stream channel from left bank(RMT, 11/2007).

a)

b)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
None	Non-Registered #3	2-1-1-008:006		No	Yes	Yes	

RMT field notes indicate that this diversion may have been declared by A. Young. Diversion consists of a pipe, but was in pieces in the stream. At the time of the site visit, there was no water in the pipe. Diversions may have been constructed by an S. Graham and was likely used for domestic use. Stream is referred to as Kupau Stream

Photos. a) View of white PVC piper in stream channel (RMT, 12/2007); b) Upstream view of stream channel (RMT, 12/2007); c) Downstream view of stream channel (RMT, 12/2007).

a)

b)

c)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
None	Non-Registered #4	2-1-1-008:005		No	Yes		

RMT field notes indicate that this diversion may have been declared by A. Young. Diversion consists of a pipe from a spring located on State land, however no water was in the pipe at the time. Diversions may have been constructed by an S. Graham.

Photos. a) Pipes located below spring source (RMT, 12/2007); b) Upstream view taken just above pipes (RMT, 12/2007); c) Downstream view from diversion pipes (RMT, 12/2007).

a)

b)

c)

Table 13-1. Continued. Registered diversions in the Waiokamilo hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
None	Non-Registered #5	2-1-1-008:010		Yes	Yes		

RMT field notes indicate that a 4-inch white PVC pipe is located in the stream and was installed by Na Moku Aupuni o Koolau Hui in the past 11 to 12 years. The diversion is considered active, but was damaged in a recent storm. The pipe feeds tanks and taro loi.

Photos. a) View of 4-inch white PVC pipe (RMT, 12/2007); b) Upstream view of stream channel (RMT, 12/2007); c) Downstream view of stream channel (RMT, 12/2007).

a)

b)

c)

Table 13-2. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

[Source of photos are denoted at the end of each description; CWRM, Commission on Water Resource Management; DAR, Division of Aquatic Resources; EMI, East Maui Irrigation Company, Inc.; RMT, R.M. Towill Cooperation (R.M. Towill conducted field verifications on the island of Maui under contract with the Commission on Water Resource Management in late 2007); Arrows (⇨)generally indicate direction of water flow to, into, and through noninstream diversions; Chevrons (⪢) generally indicated direction of natural surface water flow]

Diversion ID	EMI Ditch System	Description
K-22a	Koolau	6-inch Kulani aluminum pipe intake diverted to main Kulani intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via an aluminum pipe (EMI, 05/1989); b) Upstream view from below basin with PVC pipe at bottom center of photo (RMT, 12/2007); c) PVC pipe disconnected (RMT, 12/2007).

a)

b)

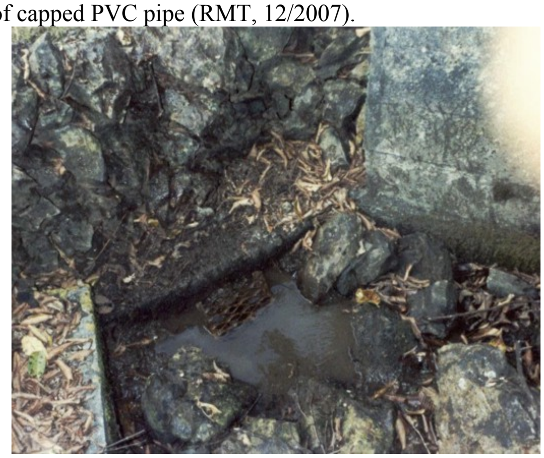
c)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-22b	Koolau	Koolau Ditch #10 crosscut intake #1. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Upstream view from below capture of seepage with PVC pipe at top center of photo (RMT, 12/2007); c) Close-up of capped PVC pipe (RMT, 12/2007).

a)



b)

c)

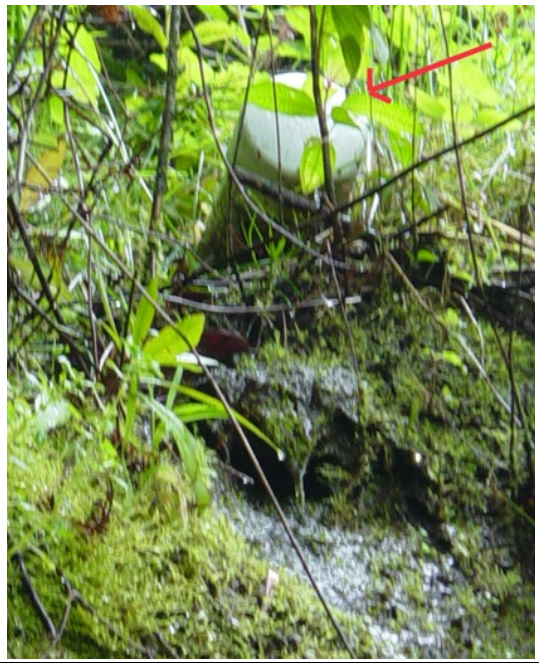


Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-22c	Koolau	Koolau Ditch #10 crosscut intake #2. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Upstream view from below capture of seepage with PVC pipe disconnected (RMT, 12/2007).

a)

b)

Diversion ID	EMI Ditch System	Description
K-22d	Koolau	Koolau Ditch #10 crosscut intake #3. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a pipe (EMI, 05/1989); b) Close-up of disconnected pipe below basin (RMT, 12/2007).

a)

b)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-22e	Koolau	Koolau Ditch #10 crosscut intake #4. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of PVC pipe outlet from catchment basin (RMT, 12/2007); c) According to EMI, the pipe intake in the catchment basin was capped, allowing water to overflow basin and flow downstream as depicted in photo (RMT, 12/2007).

a)

b)

c)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-22f	Koolau	Koolau Ditch #10 crosscut intake #5. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Water flowing downstream from catchment basin above (RMT, 12/2007).

a)

b)

Diversion ID	EMI Ditch System	Description
K-22g	Koolau	Koolau Ditch #10 crosscut intake #6. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of disconnected PVC pipe outlet from catchment basin (RMT, 12/2007).

a)

b)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-23a	Koolau	4-inch PVC pipe intake east of #11 intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of seepage from substrate (RMT, 12/2007).

a)

b)

Diversion ID	EMI Ditch System	Description
K-24a	Koolau	Koolau Ditch #12 crosscut intake #1. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989).

a)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-24b	Koolau	Koolau Ditch #12 crosscut intake #2. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989).

a)

Diversion ID	EMI Ditch System	Description
K-24c	Koolau	Koolau Ditch #12 crosscut intake #3. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989).

a)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-24d	Koolau	Koolau Ditch #12 crosscut intake #4. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989).

a)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-24e	Koolau	Koolau Ditch #12 crosscut intake #5. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) #12 intake window cemented with concrete (RMT, 12/2007); c) Koolau Ditch access tunnel at intake (RMT, 12/2007).

a)

b)

c)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-24f	Koolau	Small intake west of main #12 crosscut intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of seepage from substrate (RMT, 12/2007).

a)

b)

Diversion ID	EMI Ditch System	Description
K-24g	Koolau	Small intake west of main #12 crosscut intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989).

a)

b)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-24h	Koolau	Small intake west of main #12 crosscut intake. Stream tributary captured by ditch.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of seepage from substrate (RMT, 12/2007).

a)

b)

Diversion ID	EMI Ditch System	Description
K-24i	Koolau	Small intake west of main #12 crosscut intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of seepage from substrate and disconnected pipe at top center of photo (RMT, 12/2007).

a)

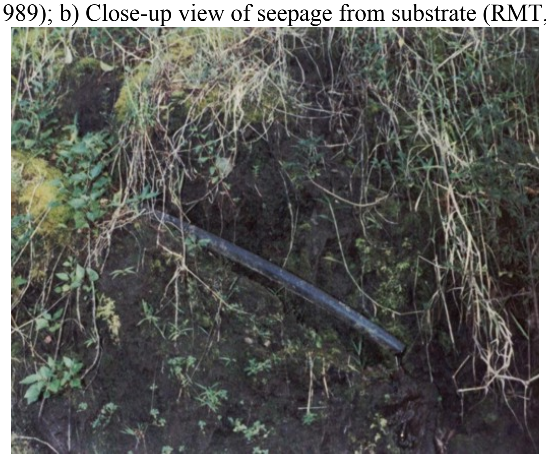
b)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-24j	Koolau	Small intake west of main #12 crosscut intake.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Close-up view of seepage from substrate (RMT, 12/2007).

a)



b)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-25a	Koolau	East Kikokiko 2-inch pipe intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Downstream view from diversion structure (RMT, 12/2007); c) Water dropping into concrete catchment basin below roadway (RMT, 12/2007).

a)

b)

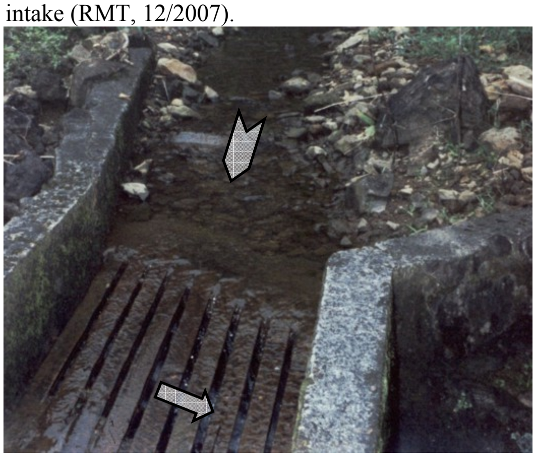
c)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-25b	Koolau	Kikokiko small intake. Concrete diversion structure with grate.

Photos. a) Concrete diversion structure with intake grate (EMI, 05/1989); b) Diversion intake structure from right bank with intake grate cemented shut (RMT, 12/2007); c) Upstream view from intake (RMT, 12/2007); d) Downstream view from intake (RMT, 12/2007).

a)



b)

c)

d)

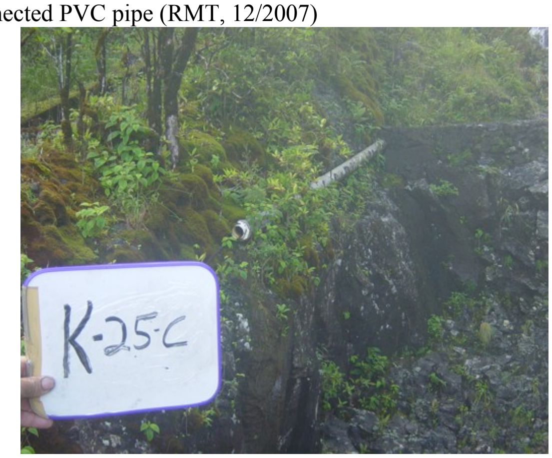
Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-25c	Koolau	Kikokiko 6-inch pipe intake mauka of bridge. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Upstream view from diversion structure with disconnected PVC pipe (RMT, 12/2007)

a)

b)



K-25d	Koolau	West Kikokiko 4-inch pipe intake.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Outflow from catchment basin (RMT, 12/2007)

a)

b)

Table 13-2. Continued. Minor diversions on the EMI System in the Waiokamilo hydrologic unit.

Diversion ID	EMI Ditch System	Description
K-25e	Koolau	West Kikokiko 3-inch pipe intake. Concrete catchment basin with pipe.

Photos. a) Concrete catchment basin captures seepage and transports water to Koolau Ditch below via a PVC pipe (EMI, 05/1989); b) Water flowing downstream below catchment basin from disconnected PVC pipes (RMT, 12/2007).

a)

b)

Diversion ID	EMI Ditch System	Description
K-25f	Koolau	Kikokiko 3-inch PVC pipe intake under bridge.

Photos. a) Downstream view of PVC pipe intake under roadway bridge (EMI, 05/1989); b) View from atop bridge of PVC pipe intake below (RMT, 12/2007).

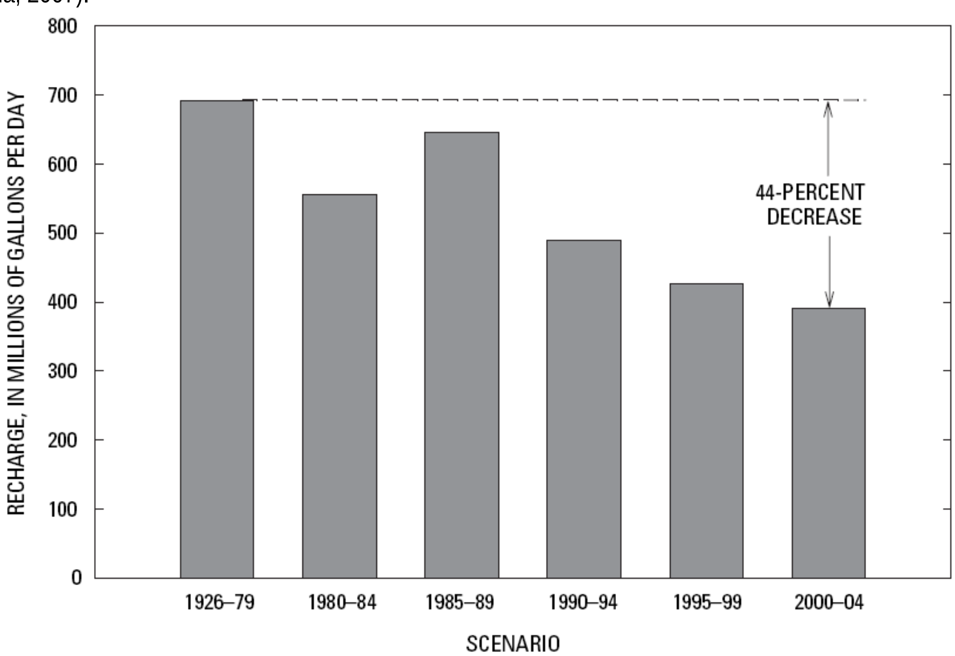
a)

b)

Following the establishment of instream flow standards, one of the proposed measures to increase streamflow may be to decrease the amount of water diverted from streams. Such a measure has important implications to ground water recharge because it affects the amount of water available for irrigation. Decreasing the amount of water diverted at the ditches located in east Maui affects the amount of water available for the irrigation of crops in west and central Maui. Since the early 20th century, about 100 billion gallons of water (274 million gallons per day) have been diverted each year from Maui streams for irrigation in west and central Maui. More than half of this diverted water, 59 billion gallons per year (162 million gallons per day), comes from east Maui (Engott and Vana, 2007).

The effects of irrigation water on ground water recharge can be analyzed using the water budget equation[5]. Engott and Vana (2007) at the USGS conducted a study that estimated each of the water budget components for west and central Maui using data from 1926 to 2004. Components of the water budget include rainfall, fog drip, irrigation, runoff, evapotranspiration, and recharge. Results of the study were separated into six historical periods: 1926-79, 1980-84, 1985-89, 1990-94, 1995-99, and 2000-04. From 1979 to 2004, ground water recharge decreased 44 percent from 693 million gallons per day to 391 million gallons per day (Figure 13-1). The low recharge rate in 2004 coincides with the lowest irrigation and rainfall rates that were 46 percent and 11 percent lower than those in 1979, respectively. During this period, agricultural lands decreased 21 percent from 112,657 acres in 1979 to 88,847 acres in 2004. Further analysis revealed that a 20 percent decrease in irrigation rate could result in a 9 percent reduction in recharge. A similar study by Izuka et al. (2005) reported that a 34 percent decrease in irrigation rate constituted a 7 percent reduction in recharge in the Lihue basin in Kauai, Hawaii. Since over half of the irrigation water for west and central Maui comes from east Maui, a 20 percent decrease in the amount of water diverted from streams in the east can potentially reduce recharge in the west and central parts of Maui by 5 percent.

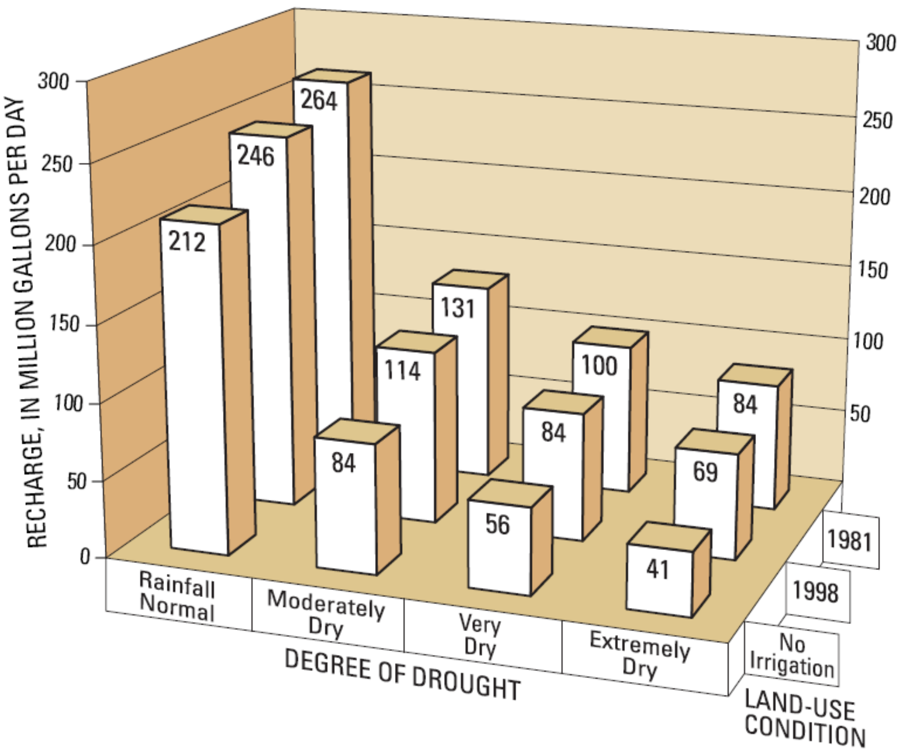
Figure 13-1. Estimated recharge for six historical periods between 1926 and 2004, central and west Maui, Hawaii (Source: Engott and Vana, 2007).



[5] Water-budget is a balance between the amount of water leaving, entering, and being stored in the plant-soil system. The water budget method/equation is often used to estimate ground water recharge.

Droughts, or periods of lower than average rainfall, have been shown to drastically decrease ground water recharge (Figure 13-2). The period of drought that occurred in 1998-2002, during which rainfall was at least 30 percent lower than the average annual rainfall, was estimated to reduce recharge by 27 percent in west and central Maui (Engott and Vana, 2007). For example, on the island of Kauai, the drought conditions reduced recharge in Lihue basin by 34-37 percent (Izuka et al., 2005). Even though droughts can have exacerbating effects on ground water recharge, these effects are transient and are usually mitigated by periods of higher than average rainfall (Engott and Vana, 2007). However, prolonged loss of irrigation water caused by a decrease in the amount of water diverted by irrigation ditches has greater effects on the long-term trends of ground water levels.

Figure 13-2. Summary of estimated recharge, in million gallons per day, for various land-use and rainfall conditions in the Lihue Basin, Kauai, Hawaii (Source: Izuka et. al., 2005).



The Agricultural Lands of Importance to the State of Hawaii (ALISH) were completed by the State Department of Agriculture (HDOA) in 1977, with the assistance of the Soil Conservation Service (SCS), U.S. Department of Agriculture, and the College of Tropical Agriculture, University of Hawaii. Three classes of agriculturally important lands were established for Hawaii in conjunction with the SCS in an effort to inventory prime agricultural lands nationwide. Hawaii's effort resulted in the classification system of lands as: 1) Prime agricultural land; 2) Unique agricultural land; and 3) Other important agricultural land. Each classification was based on specific criteria such as soil characteristics, slope, flood frequency, and water supply. ALISH was intended to serve as a long-term planning guidance for land use decisions related to important agricultural lands. HDOA is currently in the process of developing agricultural incentives based on classifications of Important Agricultural Lands. Waiokamilo does not contain any prime or unique agricultural land (Table 13-3).

Table 13-3. Agricultural Lands of Importance to the State of Hawaii and area distributions in the Waiokamilo hydrologic unit.

Density	Area (mi^2)	Percent of Unit
Other lands	0.10	4.1

From 1978 to 1980, HDOA prepared agricultural land use maps (ALUM) based on data from its Planning and Development Section and from SCS. The maps identified key commodity areas (with subclasses) consisting of: 1) Animal husbandry; 2) Field crops; 3) Orchards; 4) Pineapple; 5) Aquaculture; 6) Sugarcane; and Wetlands (Table 13-4).

Table 13-4. Agricultural land uses and area distributions in the Waiokamilo hydrologic unit.

Density	Area (mi^2)	Percent of Unit
Wetlands	< 0.01	< 0.01
Animal husbandry, grazing	0.28	11.6

Though both ALISH and ALUM datasets are considerably outdated, many of the same agricultural assumptions may still hold true. The information is presented here to provide the Commission with present or potential noninstream use information (Figure 13-10).

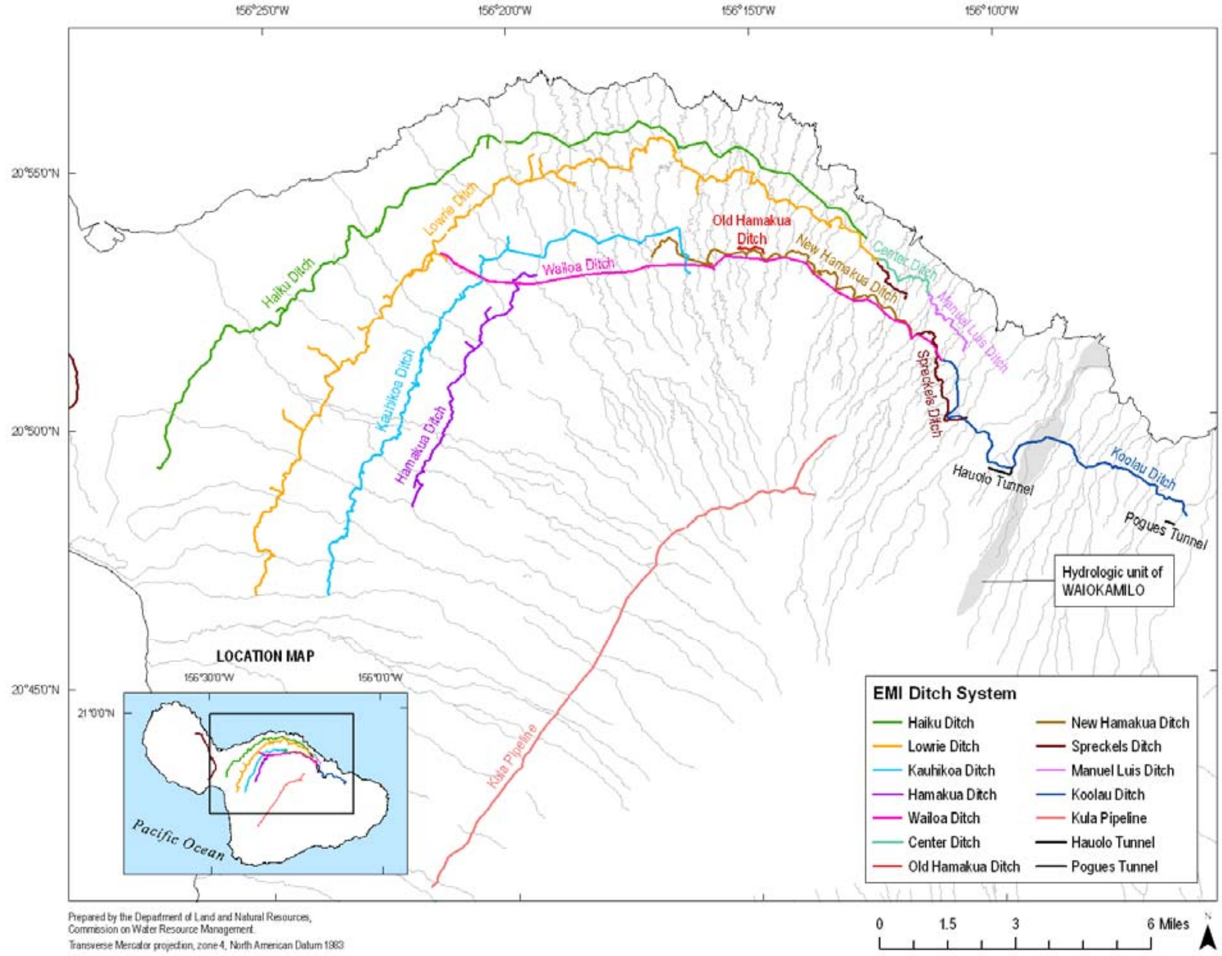
The presence of the EMI system adds considerable complexity to the Commission's role in weighing instream and noninstream uses. While this is largely due to the transfer of water from one hydrologic unit to another, the importance of the system to both agriculture and municipal water supply in Upcountry and Central Maui play a pivotal role in the consideration of economic impacts. The complexity of the EMI system is detailed in Table 13-5 and illustrated in Figure 13-3.

Table 13-5. Historic Timeline of the East Maui Irrigation System (Source: Wilcox, 1996)

1869 -	Samuel Alexander and Henry Baldwin partner to purchase 11.94 acres of Bush Ranch.
1876 -	Alexander and Baldwin form the Hamakua Ditch Company on Maui.
1878 -	Construction of the Hamakua Ditch is completed (not to be confused with the Upper and Lower Hamakua Ditches on the island of Hawaii).
1894 -	Alexander & Baldwin (A&B) is established as an agency.
1898 -	A&B gain control of Hawaiian Commercial & Sugar (HC&S), then become its agent shortly thereafter.
-	Construction of Lowrie Ditch is started about this time. The Lowrie Ditch emanates from the Kailua watershed in the Makawao District, and receives water from a reservoir in Papaaea and Kailua Stream where the diversion intercepts the source of the older Haiku Ditch.
1900 -	A&B is incorporated with accumulated assets of $1.5 million, compared with a net profit of just $2,627.20 in 1895
-	Lowrie Ditch is completed with a capacity of 60 million gallons per day and is able to irrigate 6,000 acres. The 22-mile system is 75 percent open ditch, but also includes 74 tunnels, 19 flumes, and a total of 4760 feet of siphons.
1904 -	Construction begins on Koolau Ditch, which extends the system 10 miles toward Hana.
1905 -	Koolau Ditch is completed with a capacity of 85 million gallons per day, and consists of 7.5 miles of tunnel and 2.5 miles of open ditch and flume.
1908 -	The East Maui Irrigation Company (EMI) is formed to develop and administer the surface water for all the plantations owned, controlled, or managed by A&B.
-	A&B gains control of Kihei Plantation.
1912 -	The old Haiku Ditch is abandoned between 1912 and 1929.
1914 -	New Haiku Ditch is completed with a capacity of 100 million gallons per day. The system is mostly tunnel, partially lined, with a length of 54,044 feet.
1915 -	Kauhikoa Ditch is completed with a capacity of 110 million gallons per day and a length of 29,910 feet.
1918 -	Construction of Wailoa Ditch is started.
1923 -	Wailoa Ditch is completed with a capacity of 160 million gallons per day. The system is mostly tunnel, completely lined, with a length of 51,256 feet. Capacity was later increased to 195 million gallons per day (date unknown).

In total, the EMI system consists of 388 separate intakes, 24 miles of ditch, 50 miles of tunnel, twelve inverted siphons, and numerous small feeders, dams, intakes, pipes, and flumes (Figure 13-3). Supporting infrastructure includes 62 miles of private roads and 15 miles of telephone lines. The system primarily captures surface water from multiple watersheds in East Maui with a combined area of approximately 56,000 acres, of which 18,000 acres are owned by EMI, and the rest by the State of Hawaii (Wilcox, 1996).

Figure 13-3. East Maui Irrigation System.



The EMI system has a delivery capacity of 450 million gallons per day, but delivers an average of 165 million gallons per day. However, the average water delivery can vary considerably due to variable climate conditions that affect surface water availability. Approximately 70 percent of the water delivered via the EMI system emanates from State lands, for which Alexander and Baldwin (A&B) and EMI currently hold revocable permits for the four license areas identified in Table 13-6.

Leases and water licenses have been granted in this area as early as 1876, immediately after the signing and ratification of a Reciprocity Treaty between the Kingdom of Hawaii and the United States (Kumu Pono Associates, 2001a, p.443), thus making sugar cultivation a more reliable economic prospect. At one point there were five licenses issued for this area. Two were subsequently combined, resulting in the four license areas. As the licenses expired, they were not reissued, instead, revocable permits were issued to the license holders. The intent was to eventually issue one license to cover all areas once the existing licenses had all expired. The licenses, and also the subsequent revocable permits, included clauses protecting the water rights of the native tenants for domestic use, including cultivation of taro. The licenses, and subsequent revocable permits, allow the taking of surface water and development of ground water via tunneling from state land. Commission staff reviewed 20 files pertaining to the water licenses/revocable permits that are housed in the Department of Land and Natural Resources' Land Division (State of Hawaii, Land Division, 2008). Documents in those files date from 1876 to present.

According to a collection of native traditions and historical accounts of east Maui, "While testimonies in some public hearings have expressed the sentiment that 'the waters were taken without permission'…, the initial development of the ditch system was authorized as a part of the Hawaiian Kingdom's program to promote prosperity for all the people of the Kingdom…Of importance to the native Hawaiian families of the land, each of the Water Licenses issued under the Kingdom included clauses which protected the pono wai (water rights) of native tenants of the respective lands through which the ditch system was developed (Kumu Pono Associates, 2001a, p.444)." Yet, as early as 1913, the USGS was reporting that "the present system of ditches takes practically the entire water supply of the region at times when the streams are low (Martin and Pierce, 1913, p.259).

In 1938, the "East Maui Water Agreement" was signed between the Territory of Hawaii and EMI, which by then had been incorporated (in 1908, through an Agreement between five agricultural companies) and which had consolidated the ditch system through leases of all ditches, water rights and easements, etc. (Kumu Pono Associates, 2001a, p.494). Under the terms of the East Maui Water Agreement, both parties granted to each other perpetual easements with a right to convey all waters, without charge, through any and all aqueducts owned respectively by EMI and the Territory, and over all lands owned by the two parties extending from Nahiku to Honopou inclusive. This agreement was made because the system traverses partly through government land and partly through EMI lands. Language in the Agreement allows for entities other than EMI to bid on the Water Licenses, but EMI has successfully bid on those licenses whenever they have been up for bid or renewal (State of Hawaii, Land Division, 2008).

The licenses were for different terms and with different covenants, and were renewed and changed from time to time. The final terms of the licenses follow; after which revocable permits were issued.

Table 13-6. Terms of last license, before they became revocable permits

License area	General Lease number	Term
Huelo	GL 3578	1960-1981
Honomanu	GL 3695	1962-1986
Keanae	GL 3349	1950-1971
Nahiku	GL 3505	1955-1976

When the first of the four licenses expired, the State commissioned an appraisal to recommend rates to be charged for the Keanae License. The resulting report, published in 1972, summarizes some of the results of the 1938 Agreement. Because of the perpetual easements, "each party is assured of being able to convey its water through the aqueduct, with each paying the operation and maintenance cost in proportion to their respective use of it. So long as [EMI] is the successful bidder for all four State water licenses, it pays all the operation and maintenance costs…Subsequent to the agreement, the question of how much water was owned by each party was in effect settled by means of a study made in 1949 by Luna B. Leopold, Meteorologist…This map was used by [EMI] to determine the percentage of the rainfall on the government and private lands that are mauka of and tributary to the collection system for each of the four watersheds. It was assumed that the yields of the water collected in the aqueduct system are in proportion to the amount of rainfall on the respective land ownerships (Hull, 1972)." In other words, the ditch system collected water from both State and private lands. Ditch flow measurements were only collected at certain points, and included water originating on government as well as on private lands. In order to determine the amount of money to charge EMI for the water licenses, the State had to calculate the percentage of water in the ditch that came from government land and the percentage that came from private land (Table 13-7), and they did this using rainfall isohyets and acreage of the license areas. Those numbers were still in use as of 1972, and presumably until the end of all four water license agreements, as the other three (besides the then-recently expired Keanae License) were still in place at the time the 1972 report was published (Hull, 1972).

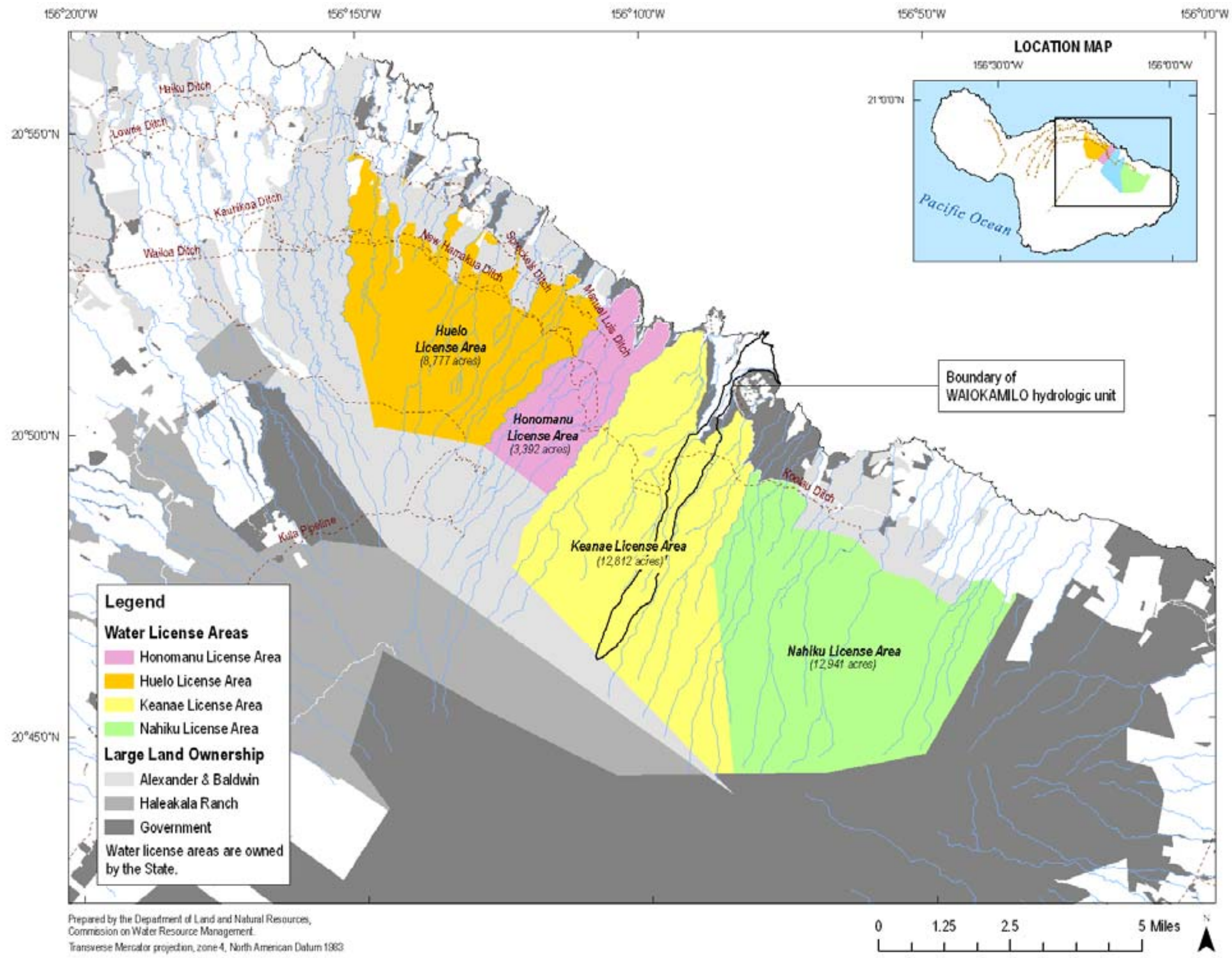
Table 13-7. Percentage of water yield from the four license areas (as of 1972).

Watershed	Government (%)	Private (%)
Huelo	64.49	35.53
Honomanu	47.39	52.61
Keanae	79.19	20.81
Nahiku	95.02	4.98

The correspondence and discussions over the course of many years indicate that the water was viewed as a commodity and that water permitted to flow into the ocean was considered waste. Originally the rates charged for the water licenses were low, to allow for construction costs. For many years after construction, lease amounts were determined according to the price of sugar, the annual quantity of water carried through the system, and the percentages of government and private lands from which the water contributed to the system (State of Hawaii, Land Division, 2008). Water yields were measured for each license area. Rate of the licenses fluctuated with the price of sugar, but the licenses included minimum and maximum sugar prices that could be used in the calculations, e.g. if the price of sugar exceeded the price ceiling in the license, the rental rate would be frozen for the remainder of the license period, using that maximum amount to calculate rent. The terms of the long-term licenses were renegotiated at the expiration of the license period, i.e. roughly every 20-35 years. Under the long-term lease, A&B was required to pay for a minimal take of water even if it was not available due to low flow, or not necessary due to high rainfall on the plantations (State of Hawaii, Land Division, 2008; and Hull, 1972).

Water yield is no longer measured per license area; flow for all four license areas is totaled at the Honopou Boundary. Total water supply is classified either as water runoff from EMI land or water runoff from State-owned land. The water license areas are shown in Figure 13-4, along with other large landowners.

Figure 13-4. East Maui Water License Areas.



In 1965, HRS 171-58, as amended, required water rights to be leased through public auction or permitted on a month-to-month basis up to one year. The existing leases were grandfathered until their expiration. As mentioned above, the last water license agreement expired in 1986, after which all four license areas were disposed of as month-to-month revocable permits that were renewed annually, alternating in issuance to EMI and A&B. A&B proposed the consolidation of the four leases into a single lease, and in 1985 the Land Board approved a public auction sale for a 30-year water license incorporating the four licenses into a single license. In 1986, Native Hawaiian Legal Corporation (NHLC) challenged the Department of Land and Natural Resources (DLNR)'s decision that an Environmental Impact Statement (EIS) was not required and an Environmental Assessment (EA) was sufficient for the issuance of the 30-year lease. The Circuit Court agreed that an EA was adequate, and NHLC appealed to the Supreme Court, who remanded back to Circuit Court to conduct a hearing pursuant to HRS section 343-7(b) on the matter. Further discussions resulted in several decisions, including that the Board of Land and Natural Resources (BLNR) and DLNR must work towards long-term resolution; and that interested parties work together to develop a watershed management plan for the water lease areas. The latter resulted in the creation of the East Maui Watershed Partnership and development of the East Maui Watershed Management Plan.

In 1987, the rate structure of the revocable permits was altered to a fixed flat fee independent of the amount of water diverted by A&B, and the rates were reduced by 25% to discount for the uncertainty that the annual permits would be renewed. However, the payments after 1987 were increased by 25% to remove the discount and convert the rates to long-term lease rentals. In 1988, the State performed an independent audit and set the benchmark rate based on the audit rate of five dollars per million gallons. In fiscal year 1999-2000, the permits were issued to A&B and EMI, with the fixed rates based on an assumed annual flow. The current revocable permits state that their rates are based on a staff appraisal dated May 7, 2001.

The revocable permits are currently regulated by the DLNR's Land Division, which collects fees for the permits. Those permits were most recently renewed in November 2007, with the following rental payments:

Table 13-8. Current revocable permits issued to A&B/EMI.

Revocable Permit No.	License Area	Area (acres)	Monthly Rent in 2008
S-7264	Huelo	8,752.69	$6,588
S-7263	Honomanu	3,381.00	$1,698
S-7265	Keanae	10,768.00	$3,477
S-7266	Nahiku	10,111.22	$1,427

In May 2001, A&B and EMI filed an Application for a Long Term Water License with the BLNR seeking a long-term 30-year lease rather than continue with year-to-year revocable permits. Shortly thereafter, Na Moku Aupuni O Koolau Hui, Inc. ("Na Moku") and Maui Tomorrow requested a contested case hearing, with NHLC filing on behalf of petitioners Na Moku, Elizabeth Lapenia, Beatrice Kekahuna, and Marjorie Wallett (In May 2007, Elizabeth Lapenia withdrew from the case and is no longer represented in it.). Concurrently, the Petitioners filed with the Commission a Petition to Amend the Interim Instream Flow Standard for 27 Streams in East Maui.

In May 2002 the BLNR deferred the reissuance of interim revocable permits and granted a holdover of the existing revocable permits on a month-to-month basis pending the results of the contested case hearing. A January 2003 BLNR "Findings of Fact and Conclusions of Law and Order" indicates that the "BLNR may enter into a lease of water emanating from State lands for transfer outside of the watershed of origin provided that such lease is issued in accordance with the procedures set forth in HRS Chapter 171 and provided that all diversions of stream water shall remain subject to the Interim Instream Flow Standards set by CWRM, and to any judgment of a court of competent jurisdiction establishing appurtenant or riparian rights in favor of downstream users (p.12)." This part of the Order was reversed by Circuit Court in October 2003 and the BLNR advised that if it does not believe it has the requisite expertise, it should wait until CWRM has acted or make its own application to establish instream flows. However, the Court Order goes on to state that the BLNR cannot "rubber-stamp" any Commission determination, meaning that at any BLNR contested case hearing, any party may challenge a Commission decision "if its methodology is wrong or some other error is committed." The Order also indicates legal precedent suggests that an EA should be required for issuance of a long-term lease, and perhaps an EIS depending upon the result of the EA.

In March 2005, the Petitioners filed Motions For Summary Relief contesting the "Holdover Decision" that allowed continued renewal of the revocable permits. The motions for summary relief were denied. However, in the Order denying the motions for summary relief, the Hearings Officer indicated that an evidentiary hearing could be held upon request to determine if interim releases of water were required in order for the Board to fulfill its public trust duties pending the completion of an environmental assessment and determination of amendments to interim IFS. At an early pre-hearing conference the parties agreed the streams in issue in the evidentiary hearing concerning interim relief were Honopou, Puolua, and Hanehoi Streams in the Huelo license area, and Wailuanui, Waiokamilo, and Palauhulu Streams in Keanae. Accordingly, the evidentiary hearing was held in October and November 2005.

The resulting “Findings of Fact, Conclusions of Law, and Decision and Order (‘Interim Order’)” was issued by the Board of Land and Natural Resources in March 2007. This was intended to provide interim relief based on evidence introduced in the 2005 evidentiary hearing, and is not intended to foreshadow the Board’s final decision in the case. The Interim Order concluded and ordered, among other things:

- That the DLNR “appoint an appropriate monitor… to ensure compliance with its order and to investigate and resolve if possible all complaints regarding stream flows by any of the parties to this proceeding.”
- That A&B/EMI be immediately ordered to decrease current diversions on Waiokamilo Stream such that the water flow can be measured below Dam #3 at the rate of 6,000,000 gallons per day based on a monthly moving average on an annual basis.
- In the event that Beatrice Kekahuna increases the amount of acreage that she has in cultivation as taro loi, A&B/EMI may be required to decrease diversions (from Honopou Stream) to allow her sufficient water to irrigate her loi.

In May 2008, NHLC on behalf of the petitioners filed a Motion to Enforce the March 2007 Interim Order. Though there has been release of water into Waiokamilo and Kualani Streams, NHLC contends that the Interim Order has not been fully implemented largely due to the ability of the monitor to perform certain actions. Additionally, NHLC claims that Beatrice Kekahuna, Marjorie Wallett, and others still do not have adequate water to cultivate their taro.

As mentioned above, it is not the intention of this IFSAR to enumerate all the details of the contested case; however, more detail, specifically contrasting claims by NHLC and HC&S, is provided in the recommendations to the Commissioners to amend the interim IFS.

There have been few changes to the EMI system since the Wailoa Ditch was completed in 1923. EMI continues to provide water to HC&S, which is the largest producer of raw sugar in Hawaii, and only one of two remaining sugar plantations in the state. In 2006, HC&S produced about 81 percent of the total raw sugar in Hawaii, or approximately 173,600 tons, amounting to about 3 percent of total U.S. sugar produced (A&B, 2007). HC&S also produces molasses, a by-product of sugar production, and specialty food-grade sugars sold under their Maui Brand® trademark. Table 13-9 summarizes the harvest and production yields for HC&S from 2000 through 2006.

Table 13-9. Summary of sugar-related harvests by HC&S for 2000-2006 (Source: A&B, 2002; 2003; 2005; 2007).

[* Data were not reported]

Year	Raw sugar produced (tons)	Percent of total raw sugar produced In Hawaii	Area harvested (acres)	Yield per acre (tons)	Average cost per ton (dollars)	Molasses produced (tons)	Specialty food-grade sugar produced (tons)
2006	173,600	81.0	16,950	10.2	*	55,900	15,500
2005	192,700	76.0	16,639	11.6	*	57,100	18,900
2004	198,800	77.0	16,890	11.8	435	65,100	15,500
2003	205,700	79.0	15,660	13.1	422	72,500	12,100
2002	215,900	79.0	16,557	13.0	332	74,300	11,000
2001	191,500	70.0	15,101	12.7	371	71,200	8,848
2000	210,269	*	17,266	12.2	331	70,551	*

The HC&S sugar plantation currently consists of approximately 43,300 acres of land. Sugar is cultivated on roughly 37,000 acres, while the balance is leased to third parties, is not suitable for cultivation, or is used for plantation purposes (A&B, 2007). Approximately 30,000 acres are irrigated with water delivered by EMI, with 5,000 acres irrigated solely with EMI water, and the remaining 25,000 acres are irrigated with a mix of EMI water and supplemental ground water pumped by HC&S.

According to the Board findings in the contested case hearing regarding the east Maui water license, the total amount of water HC&S needs from EMI varies largely with weather and seasonal conditions, but ranges from a low of 134 million gallons per day in the winter months to a high of 268 million gallons per day during peak usage in the months of May to October (Findings of Fact, Conclusions of Law, and Decision and Order, 2007). From 2002 to 2004, HC&S received 71 percent of its water supply from EMI (surface water), while the remaining 29 percent was supplemental ground water. The EMI system was designed and constructed to take full advantage of the gravity flow of water from higher to lower elevations, thus minimizing pumping and the additional consumption of electrical power. As a result, HC&S attempts to divert the maximum possible amount of water into the EMI system at the Wailoa Ditch, which has a capacity of 195 million gallons per day.

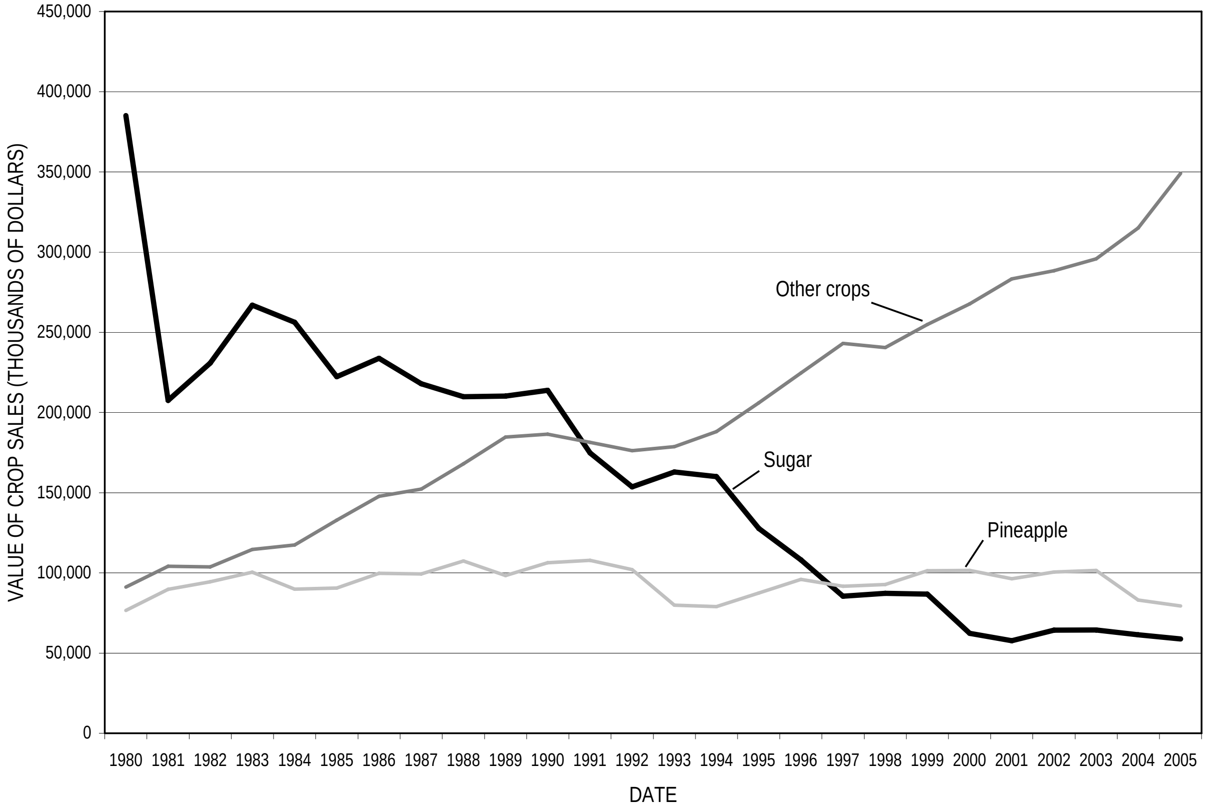
Of the estimated 1,750 agriculture-related jobs on Maui (Department of Business, Economic Development and Tourism [DBEDT], 2007), HC&S employs approximately 800 full-time workers, while EMI employs an additional 17 workers. The Agribusiness sector of HC&S saw a revenue increase of 3 percent, or $4.2 million, in 2006 over the previous year. This increase was attributed to higher revenues in repair services and trucking, higher-power sales, higher equipment rentals and soil sales, and higher specialty sugar and molasses sales. In comparison, lower revenues were reported in the bulk sugar sales (A&B, 2007). Table 13-10 provides a summary of HC&S' agribusiness revenues for 2000 to 2006.

Table 13-10. Summary of HC&S' agribusiness revenues for 2000 to 2006 (Source: A&B, 2002; 2005; 2007).

Year	Revenue (dollars)	Operating Profit (dollars)	Operating Profit Margin (percent)
2006	$ 127,400,000	$ 6,900,000	5.4
2005	$ 123,200,000	$ 11,200,000	9.1
2004	$ 112,800,000	$ 4,800,000	4.3
2003	$ 112,900,000	$ 5,100,000	4.5
2002	$ 112,700,000	$ 13,800,000	12.2
2001	$ 105,976,000	$ 5,660,000	5.3
2000	$ 107,510,000	$ 7,522,000	7.0

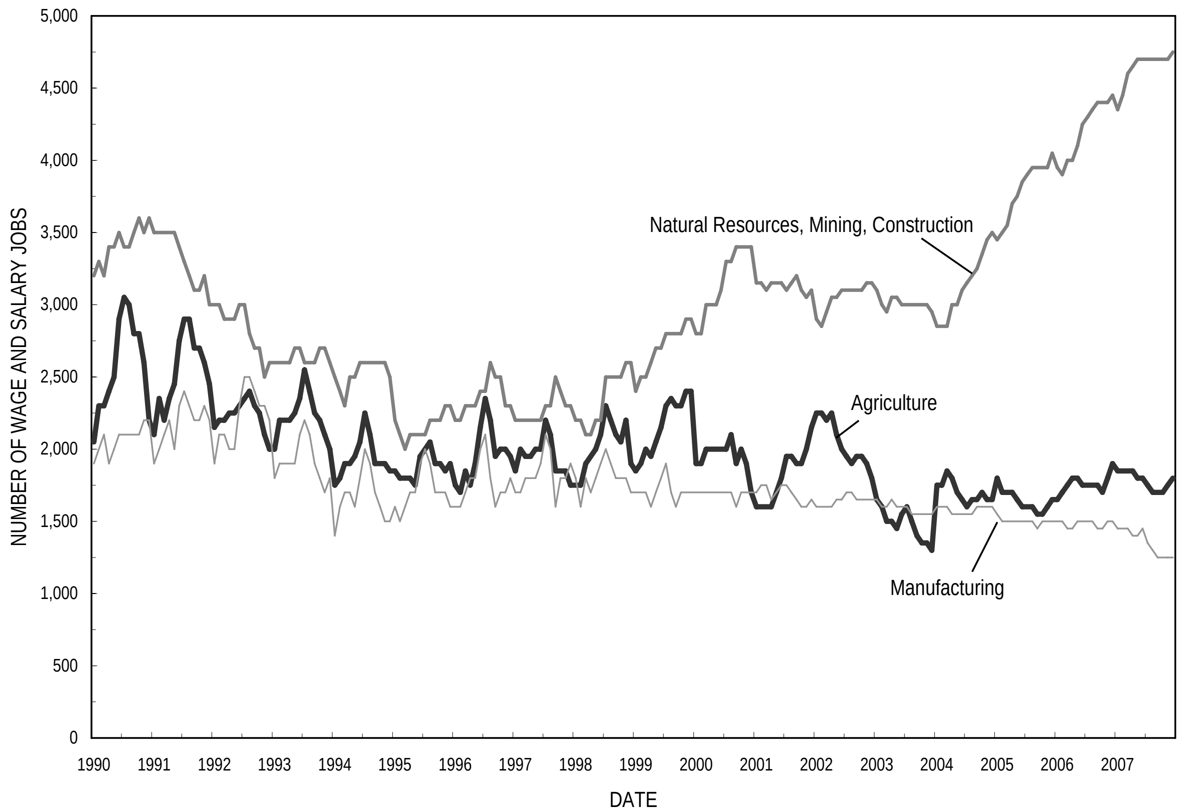
Overall, Hawaii sugar growers produce more sugar per acre than most other sugar-producing areas of the world; however, this advantage is offset by Hawaii's higher labor costs and higher transportation costs resulting from the longer distance to the U.S. mainland market. The DBEDT *State of Hawaii Data Book* shows the dramatic decline in sugar crop sales as plantations have closed over the last 25 years (DBEDT, 2006). Figure 13-5 illustrates the decline of sugar, the steady value of pineapple sales, and the increase of other crops generally considered as diversified agriculture.

Figure 13-5. Value of crop sales for sugar, pineapple and other crops from 1980 to 2005 (Source: DBEDT, 2006).



Examination of monthly economic indicators shows that, in general, agricultural jobs have slowly decreased on the island of Maui over the past 15 years. This trend is illustrated in Figure 13-6 along with trends for: 1) Natural resources, mining, and construction; and 2) Manufacturing.

Figure 13-6. Monthly number of wage and salary jobs, for three sectors including agriculture, for the island of Maui from 1990 to 2007 (Source: DBEDT, 2008).



In addition to sugar crops, HC&S receives revenue from its sale of electricity to Maui Electric Company (MECO). The HC&S Puunene Sugar Mill continues to provide a renewable energy alternative in the form of sugar cane bagasse, a fibrous byproduct of the sugar extraction process. Bagasse is the primary fuel used in boilers to generate steam, a requirement for sugar processing and for driving steam turbine generators to produce electricity. The electricity that is not used by the sugar mill is sold to MECO for distribution. HC&S is under contract with MECO to supply, at specified rates, 12 megawatts of power from 7:00 a.m. to 9:00 p.m. daily except Sunday and 8 megawatts at all other times. The contract provides for monetary penalties if these requirements are not met by HC&S. The approximate oil savings is 44,700 barrels per year (MECO, 2008).

HC&S also receives revenue from the delivery of water to the County of Maui Department of Water Supply's (DWS) Upcountry system, and to Maui Land and Pineapple Company, Inc. (MLP) for its east Maui pineapple fields. MLP cultivates roughly 6,000 acres of pineapple, of which over 2,800 acres are situated in east Maui and rely on the EMI system for water. While there are indications that MLP has leased, or is planning to lease, 400 additional acres in east Maui to expand their pineapple growing operations (Findings of Fact, Conclusions of Law, and Decision and Order, 2007), MLP has also expressed their intention of shifting plantings from Upcountry Maui to agricultural land in west Maui due to the susceptibility of their east Maui fields to drought conditions. MLP states that their west Maui lands are less susceptible to drought and irrigation storage capacity is being increased (MLP, 2007).

MLP estimates their water requirements from the EMI system at 4.5 million gallons per day from 2004 through 2009, and a reduction to approximately 4.4 million gallons per day from 2009 to 2016. Under a

License and Water Agreement between MLP and EMI, two "classes" of water are transported via the EMI system. The first class of water, which represents the majority of MLP's usage, is pumped by Maui Pineapple Co., Ltd. into the Koolau Ditch from Hanawi Stream at Nahiku near the start of the EMI system. The second class of water is what MLP is contractually allowed to withdraw, for a fee, from the EMI system when flow exceeds 100 million gallons per day.

According to MLP's Annual Reports to the U.S. Securities and Exchange Commission, the last year that MLP had an operating profit for their pineapple operations was in 1999. Table 13-11 provides a summary of revenue and operating losses from 1999 to 2006. Some of the revenue losses can be attributed to increased importation of oversees pineapple products (specifically from Thailand); though it appears that the U.S. had begun imposing antidumping duties, as canned pineapple imports had decreased in 2001. Regardless, in June 2007, MLP ceased pineapple canning operations on Maui, attributing the closure to increased imports of cheaper canned pineapple. MLP is instead choosing to focus on the production of pineapple juice and fresh fruit. The closure of Hawaii's last canned pineapple producer resulted in the loss of 120 jobs, or 27 percent of the company's workforce (Hao, 2007).

Table 13-11. Summary of MLP's revenues and operating losses for 1999 to 2006 (Source: MLP, 2002; 2004; 2005; 2007).

[Numbers in parentheses indicate operating losses; numbers not in parentheses are gains.]

Year	Revenue (dollars)	Operating Loss (dollars)
2006	$ 65,200,000	$ (18,600,000)
2005	$ 74,500,000	$ (11,400,000)
2004	$ 80,000,000	$ (10,800,000)
2003	$ 105,000,000	$ (921,000)
2002	$ 92,500,000	$ (8,500,000)
2001	$ 92,000,000	$ (3,000,000)
2000	$ 85,900,000	$ (2,900,000)
1999	$ 94,400,000	$ 6,100,000

The other major user of EMI surface water, Maui DWS, receives approximately 8.2 million gallons per day, a portion of which goes directly to the Kula Agricultural Park. Under a December 31, 1973 agreement between EMI, HC&S, and the County of Maui, EMI agreed to collect and deliver to the County 12 million gallons per 24-hour period for a term of 20 years, with an option for the County to receive an additional 4 million gallons after giving one year's written notice to EMI. Set to expire in 1993, this agreement was extended on several occasions, with the last extension expiring on April 30, 2000.

EMI currently delivers water to the County under a Memorandum of Understanding (MOU) that was executed on April 13, 2000, which provides for the County to continue to receive 12 million gallons per day from the Wailoa Ditch with an option to receive an additional 4 million gallons. However, the MOU also includes stipulations for periods of low flow, whereby the County will receive a minimum allotment of 8.2 million gallons per day while HC&S will also receive 8.2 millions gallons per day, or 9.4 million gallons per day should fire flow be required (Maui DWS, 2007b). The MOU has a term of 25 years and sets water delivery rates at $0.06 per thousand gallons. For the 2006 fiscal year, Maui DWS reported purchasing a total of 2,601 million gallons from EMI, at a cost of $156,848, which includes various other sources in addition to the Wailoa Ditch (Maui DWS, 2007a).

Of the five separate water systems operated by DWS, the Upcountry Maui (sometimes referred to as Makawao) system is the second largest system and is supported by Maui's largest surface water treatment facility (WTF), the Kamole Weir WTF. Surface water, for the most part, supplements the primary ground water sources (Haiku and Kuapakalua wells) for the region, but serves as backup in the event of pump failure or drought. The Kamole Weir WTF produces an average 3.6 million gallons per day, but is capable of producing 8 million gallons per day at maximum capacity. DWS also plans to increase capacity by 2.3 million gallons per day in 2015 (Findings of Fact, Conclusions of Law, and Decision and Order, 2007; Maui DWS, 2007e).

The Kamole Weir WTF receives water from the Wailoa Ditch and supplies water to approximately 6,571 water service connections and is capable of providing water to the entire Upcountry region (9,708 connections) if necessary (Maui DWS, 2007e). The EMI ditch system provides water to the Nahiku community, to Maui Land & Pine, and to the Maui County Board of Water Supply for use in upcountry Maui. There are three upcountry Maui County Department of Water Supply (DWS) water systems served by east Maui streams: Maui DWS Makawao is served by Wailoa Ditch, part of the EMI system; Maui DWS Upper Kula is served by Haipuaena and Waikamoi Streams; and Maui DWS Lower Kula by Honomanu, Haipuaena, and Waikamoi Streams. Maui DWS themselves divert the streams for the Upper and Lower Kula pipelines; it is only the Makawao system whose source is the EMI system (Mike Miyahira, DOH Safe Drinking Water Branch, personal communication, August 1, 2008.)

The Upcountry system includes the communities of Kula, Pukalani, Makawao, and Haiku, with an estimated population of 30,981 people (Findings of Fact, Conclusions of Law, and Decision and Order, 2007). Metered water usage in the Upcountry system has steadily climbed over the past 10 years, with the largest portion going towards potable water use (Table 13-12).

Table 13-12. Historical metered consumption for the Upcountry system, Maui (Source: Maui DWS, 2007d).

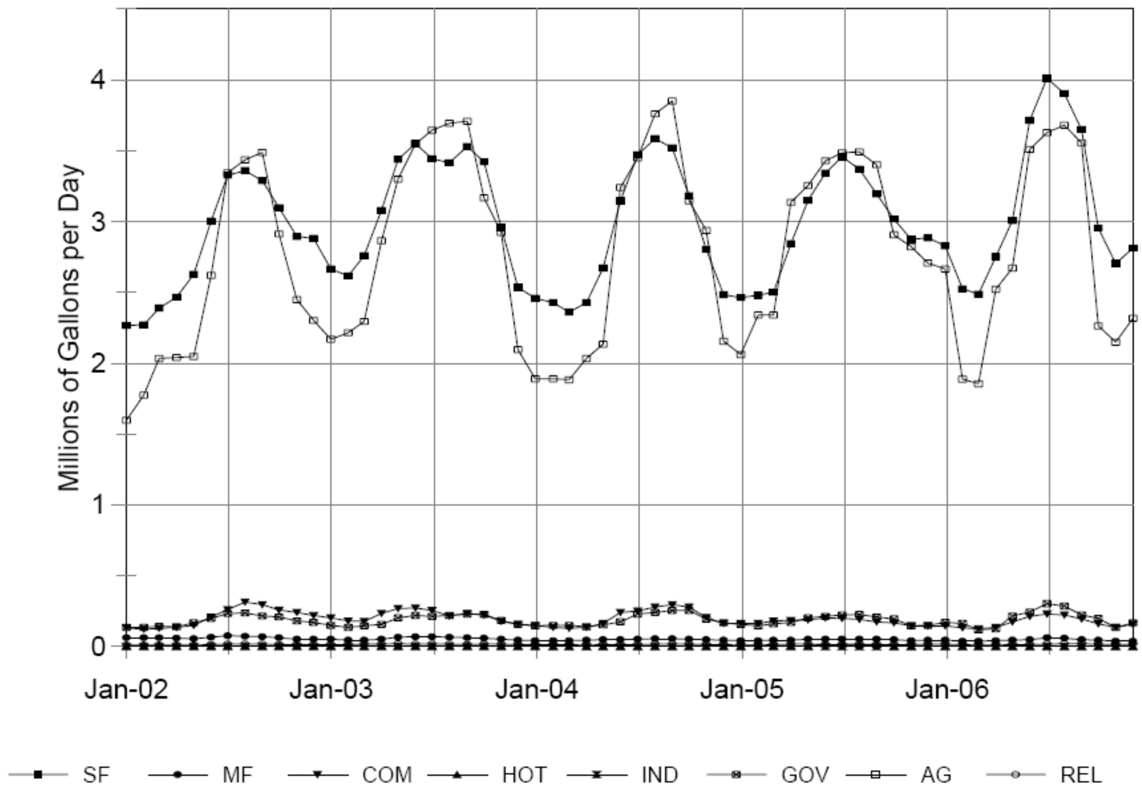
[Data reported in million gallons per day]

Year	General	Agriculture Potable	Total Potable	Agriculture Non-potable	Total
2005	4.441	2.378	6.820	0.571	7.391
2004	4.387	2.138	6.525	0.575	7.100
2003	4.778	2.320	7.098	0.582	7.680
2002	4.461	1.908	6.368	0.433	6.801
2001	4.823	2.563	7.387	0.690	8.077
2000	4.370	2.504	6.873	0.505	7.379
1999	4.146	2.474	6.620	0.555	7.175
1998	4.003	2.382	6.384	0.512	6.897
1997	3.693	1.829	5.521	0.374	5.895
1996	4.083	1.923	6.007	0.481	6.487
1995	4.382	2.300	6.682	0.634	7.317
1994	3.871	1.931	5.802	0.504	6.306

For the Makawao-Pukalani-Kula Community Plan District, water use for agriculture and single-family residences has been very similar over the past 5 years. The two uses also have strong annual patterns, with water use rising approximately 1.5 million gallons per day during summer months versus winter months (Figure 13-7). Other water uses within the district are relatively low (Maui DWS, 2007d).

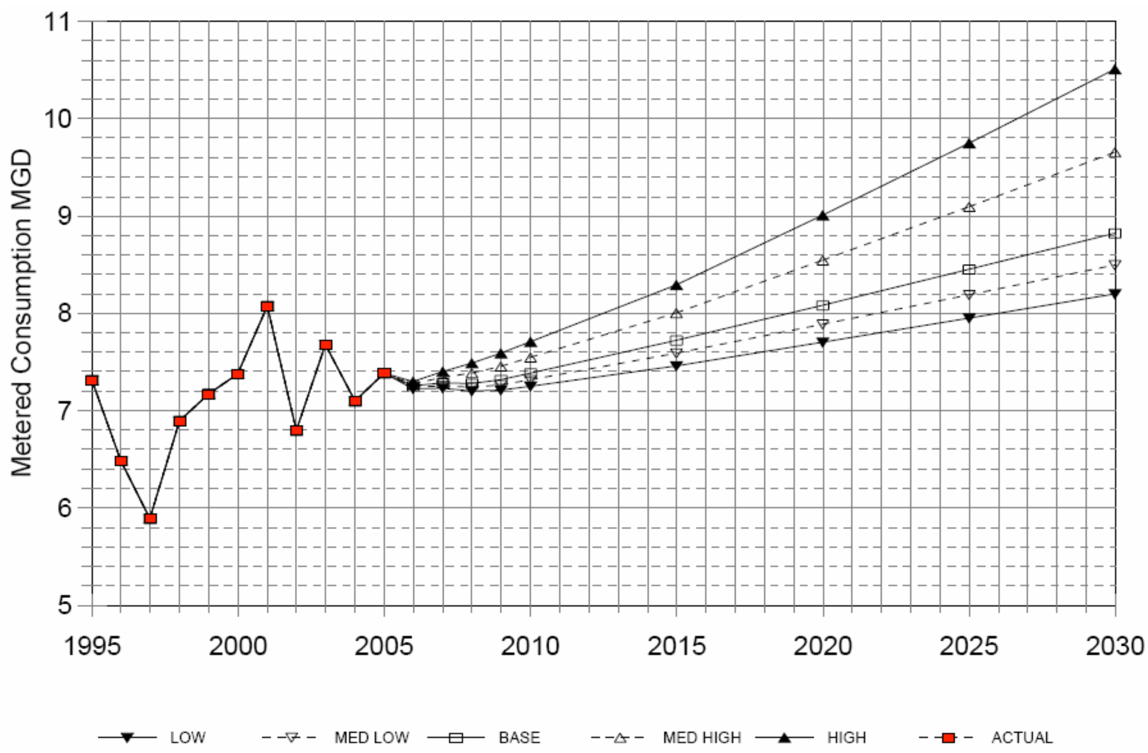
Figure 13-7. Historical monthly water consumption by use class code for the Makawao-Pukalani-Kula Community Plan District, Maui (Source: Maui DWS, 2007d).

[SF is single family residential; MF is multi-family residential; COM is commercial; HOT is hotel; IND is industry; GOV is government; AG is agricultural; REL is religious)



The County of Maui, as part of its current effort to update the Maui County Water Use and Development Plan, is examining various resource options to meet the forecasted water needs and planning objectives of the Upcountry district over a 25 year planning period. Expansion of the Kamole Weir WTF is the primary long-term option affecting water delivered via the Wailoa Ditch; however, other options for the entire district include developing additional ground water sources, expanding/upgrading interconnections (booster pumps) between systems, and increasing water storage capacity (Maui DWS, 2007c). Upcountry water demands are expected to increase, as depicted in Figure 13-8, based upon five water demand projections derived from varying growth scenarios (low, medium low, base, medium high, and high) to the year 2030.

Figure 13-8. Actual and projected water demands of all metered use classes for the Upcountry District, Maui (Source: Maui DWS, 2007d).



Hawaiian Commercial & Sugar Company has become the largest sugarcane plantation in Hawaii. With roughly 37,000 acres under cultivation, HC&S aims to produce 225,000 tons of raw sugar per year, accounting for 80 percent of the state's total production (see CPRC 13.20-80). The sugar industry in Hawaii is unique because more sugar is produced per acre than any other area in the world (Hawaiian Sugar Planters' Association, 1972). Hawaii is also the only area where sugarcane is grown on a two-year cycle from planting to the time of harvest.

Sugarcane is planted with seedcane, which are pieces of cane stalks obtained from special plots of cane. When sugarcane is harvested, it grows again from the old root system without replanting. This is the ratoon crop. The average age of the cane is 22 to 24 months at the time of harvest (Hawaiian Sugar Planters' Association, 1972). Sugarcane typically needs the most water during the initial stages of the crop cycle for vegetative growth, while less water is needed during the later stages of growth to bring the crop to maturity. The amount of water HC&S needs to irrigate its sugarcane fields varies largely with climate and rainfall. When the amount of rainfall does not meet the water demand of the sugarcane, especially during the summer season, HC&S depends on ditch water diverted from streams and brackish water pumped from ground water wells for irrigation. Since sugarcane cultivation uses a relatively significant amount of surface water for irrigation, determining the irrigation requirement with the changing weather conditions becomes important in weighing the noninstream and instream uses.

Irrigation Water Requirement Estimation Decision Support System, IWREDSS (State of Hawaii, Commission on Water Resource Management, 2008b), was developed by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa for the State of Hawaii. IWREDSS is an ArcGIS-based numerical simulation model that estimates irrigation requirements (IRR) and water budget components for different crops grown in the Hawaiian environment. The model accounts for different irrigation application systems (e.g., drip, sprinkler, flood), and water application practices (e.g., field capacity versus fixed depth). Model input parameters include rainfall, evaporation, soil water holding capacities, depth of water table, and various crop water management parameters including length of growing season, crop coefficient[6], rooting depth, and crop evapotranspiration.

Calibration and validation of the model was based on the crop water requirement data for different crops from the Hawaii region United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) Handbook 38 (NRCS-USDA, 1996). Relative errors between the net irrigation requirements (NIR) estimated by the model and those estimated by NRCS range from less than 1 percent to 26 percent overestimate. This difference may be attributed to the general nature of the technique NRCS used in estimating NIR. Results of the regression analysis indicate a good correlation ($R^2 = 0.97$) between the two techniques; however, the NIR calculations by NRCS were consistently 8 percent higher than those of the IWREDSS model. Overall, the model is an appropriate and practical tool that can be used to assess the IRR of crops in Hawaii.

The model was used to estimate the IRR of sugarcane grown on HC&S plantations. A GIS map of the sugarcane fields was provided by HC&S as part of their comment submission (see CPRC 13.1-20). Simulations were conducted on 188 fields with the following fixed input parameters: 1) drip irrigation with 85 percent efficiency; 2) irrigation water applied to field capacity; and 3) maximum leaf index of 5.5 by default. A number of scenarios were selected to determine an average range of IRR for sugarcane grown on all 188 fields. The first set of scenarios (Table 13-13) focuses on the effects of differing periods of water application on the IRR. All of the scenarios excluding No.1 assume that irrigation has stopped in the last two months of the crop cycle to initiate crop maturity. The second set of scenarios (Table 13-14) highlights the seasonal effects on the IRR.

According to the simulation results, the average IRR for sugarcane ranges from 1,400 to 6,000 gallons per acre per day. Applying irrigation water in the last two months of the crop cycle has insignificant effects on the IRR. As expected, IRR is lowest in the winter season when rainfall is high, and highest in the summer season when rainfall is low. The model calculates IRR based on long-term rainfall records available at the weather stations located nearest to the sugarcane fields. Thus, the estimated IRR represents an average value for average weather conditions as opposed to wet or dry year conditions. However, the estimated IRR for the winter and summer seasons could be extrapolated to represent the IRR for wet years and dry years, respectively.

Table 13-13. Scenarios modeled with IWREDSS that focuses on crop cycle changes, and average IRR in gallons per acre per day (gad) for sugarcane cultivated in all 188 fields for each scenario.

Scenario	Crop Cycle			Irrigation Period			IRR
	Total (months)	Planting (1st year)	Harvest (2nd year)	Total (days)	Start (1st year)	End (2nd year)	(gad)
1	24	Mar	Mar	730	Mar	Feb	4,711
2	24	Mar	Feb	671	Mar	Dec	4,957
3	24	May	May	669	May	Feb	4,443
4	22	May	Feb	610	May	Dec	4,771

Table 13-14. Scenarios modeled with IWREDSS that focuses on seasonal changes, and average IRR in gallons per acre per day (gad) for sugarcane cultivated in all 188 fields for each scenario.

Scenario	Season	Months	IRR (gad)
5	Fall	Sep-Nov	3,467
6	Winter	Dec-Feb	1,431
7	Spring	Mar-May	3,771
8	Summer	Jun-Aug	5,788

[6] Crop coefficient is an empirically derived dimensionless number that relates potential evapotranspiration to the crop evapotranspiration. The coefficient is crop-specific.

Figure 13-9. All registered diversions and EMI minor diversions identified in the Waiokamilo hydrologic unit (Source: East Maui Irrigation Company, 1970).

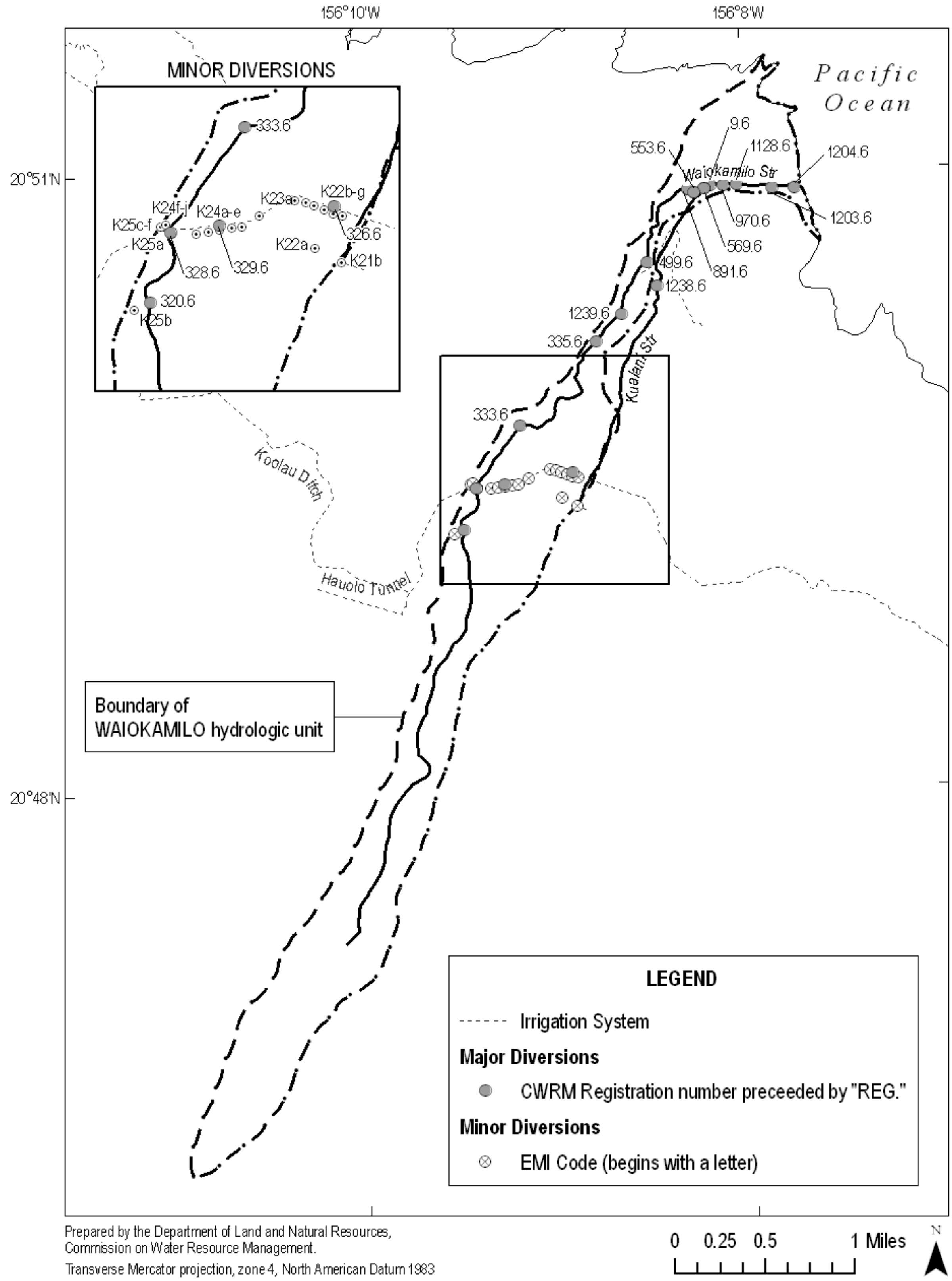
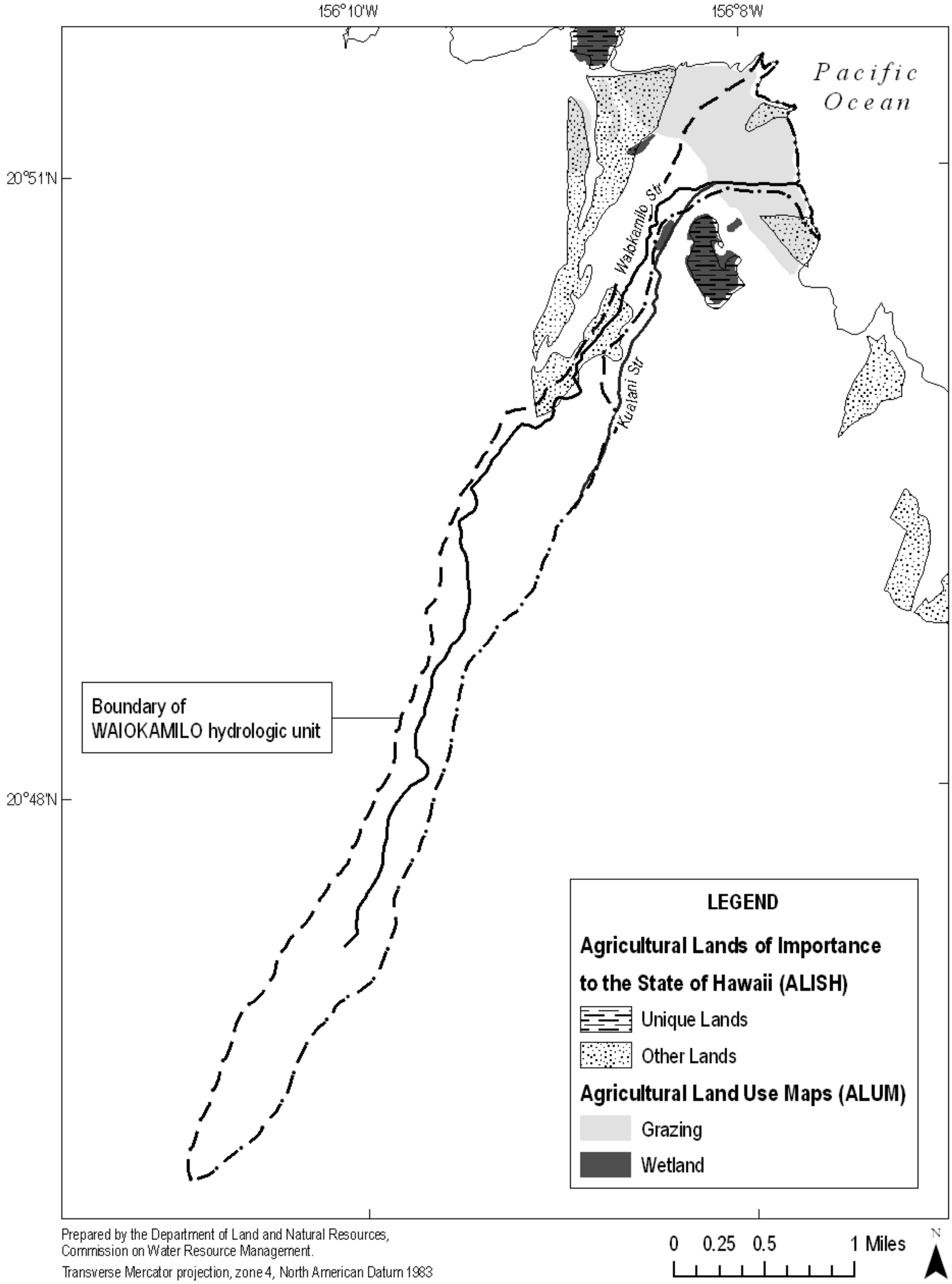


Figure 13-10. Potential agricultural land use for the Waiokamilo hydrologic unit based on the ALISH and ALUM classification systems (Source: State of Hawaii, Office of Planning, 1977; 1980).



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15.0 Appendices

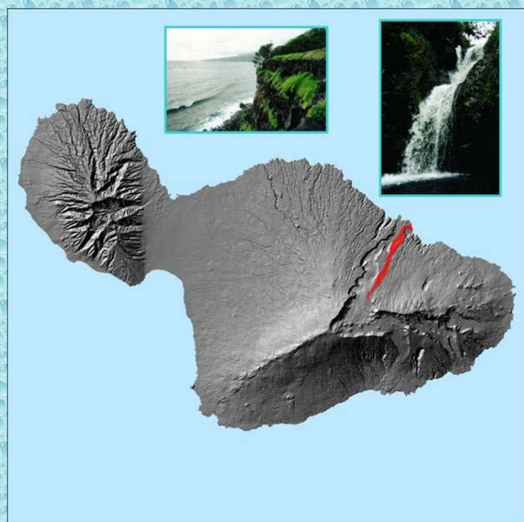
Appendix A Report on Waiokamilo Stream, Maui, Hawaii. June 2008.
State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources.

Appendix B Petition to Amend Interim Instream Flow Standards. Waiokamilo Stream, East Maui.
State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management.

Appendix C Petition to Amend Interim Instream Flow Standards. Kualani Stream, East Maui.
State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management.

Appendix A

Report on Waiokamilo Stream
Maui, Hawaii



June 2008

State of Hawai'i
Department of Land and Natural Resources
Division of Aquatic Resources

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Report on Waiokamilo Stream
Maui, Hawai‘i

June 2008

Prepared for
Commission on Water Resource Management
Department of Land and Natural Resources
State of Hawai‘i

Prepared by
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Section 1: Overview

Introduction:

This report is an accounting of the aquatic resources that have been observed in Waiokamilo Stream, Maui. The report was generated to provide some information to aid in the instream flow determination for the East Maui Streams at the request of the Commission on Water Resource Management (CWRM). The focus of this report is the animals that live in the stream and the data collected during surveys of the stream. The report covers six main sections, including:

- Overview
- Watershed Atlas Report
- DAR Point Quadrat Survey Report
- DAR Insect Survey Report
- An Analysis of Depth Use vs. Availability
- Photographs of stream taken during stream surveys

The overview provides the introduction for the purpose of this report, a summary of the findings on the stream and its animals, and a discussion of the importance of the findings and how stream conditions influence native species populations. The Watershed Atlas Report provides a description of the watershed and its aquatic resources from Division of Aquatic Resources (DAR) and other published and unpublished surveys as well as a rating of the condition of the stream compared to other streams on Maui as well as statewide. The DAR Point Quadrat Survey Report describes the distribution, habitats, and species observed during the standardized DAR stream surveys. The DAR Insect Survey Report describes the distribution, habitats, and species of insects observed in the stream. The analysis of depth use vs. availability looks at habitat use by native species and the availability of suitable depths in the stream. Finally, the photographs provide context to the conditions that the stream surveyors encountered in the stream.

This overview reports on the highlights of these findings and provides a discussion of the importance of the information presented. We hope that this format provides the reader with a simplified, general discussion and understanding of the condition of Waiokamilo Stream while also providing substantial evidence to support the conclusions presented.

Findings for Waiokamilo Stream, Maui:

Waiokamilo is a small (2.7 square miles), narrow watershed. It is mostly zoned conservation (83%) and agricultural (17%) and the land cover are mostly evergreen forest (76%), scrub (17%), and grassland (6%). Several stream surveys have been completed in Waiokamilo Stream beginning in 2002 to the present. This watershed rates average in comparison to other watersheds on Maui and statewide. It has a total watershed rating of 7 out of 10, a total biological rating of 3 out of 10, and a combined overall rating of 5 out of 10.

Native species observed in the stream include the following categories and species:

Fish - *Awaous guamensis*
Crustaceans - *Atyoida bisulcata*
Mollusks – No native mollusks

Introduced species observed in this stream includes the following categories and species:

Fish - *Poecilia reticulate, Poecilia sp., Gambusia affinis, Cyprinus carpio,* and *Misgurnus anguillicaudatus*
Crustaceans - *Macrobrachium lar* and *Procambarus clarkii*
Mollusks - *Pomacea canaliculata* and *Physidae*

No aquatic insect surveys were conducted on Waiokamilo Stream.

The native animals were observed using sites with deeper water. Suitable depths for all native species were approximately 20 inches or deeper. This is consistent with findings statewide. The diversions resulted in an increase frequency of dry sites as compared to streams statewide. The distribution of depths in comparison to elevation showed that the stream was shallower downstream of diversions than would be expected in a normal stream. This is likely restricting native adult animal habitat.

Photographs were only taken in the middle reach. There is no lower reach as a result of the terminal waterfall and the upper reaches and headwaters weren't surveyed.

Discussion for Waiokamilo Stream, Maui:

This is an intermittent stream with a terminal waterfall to the ocean. U.S. Geological Survey (USGS) reports that the lower end of the stream is a losing reach. Water is used for irrigation and taro. Water has been directed from this stream to taro patches (lo'i) in Wailua for over a hundred years. This watershed has a moderate total biological rating for Maui and statewide as a result of few native species in comparison to introduced species observed in the stream.

Fish and macroinvertebrates including *Awaous guamensis* and *Atyoida bisulcata*, were observed in the middle reach of this stream. No native mollusks were observed. The presence of *Awaous guamensis* and *Atyoida bisulcata*, both native amphidromous animals, in this stream is a positive sign that some habitat exists although the absence of *Lentipes concolor* suggests that overall habitat for fish in this stream is limited under current flow conditions. In contrast with other streams in the East Maui area, 66 of 93 sites had no animals of any type observed in them. Return of water into Waiokamilo Stream would likely have a beneficial effect on the availability of suitable depths for native species in the currently dewatered stream sections.

The lack of surveys or observations of insects in general and native damselflies in particular is an unknown for this stream. Given the presence of native damselflies in adjacent watersheds, it is possible that they exist in the upper reaches of this stream.

Larval recruitment has not been observed near the terminal section of this stream. Recruitment of postlarvae is likely restricted as there is little or no flow for much of the time at the mouth of this stream. The presence of *Awaous guamensis* and *Atyoida bisulcata* in this stream confirms that some recruitment is occurring. It is hypothesized that the recruitment is only happening during high flow events that completely water the lower stream channel. This stream is mainly diverted for taro irrigation.

Apple Snails were observed in the 1990's although they have not been observed recently. Guppies, mosquitofish, goldfish, and crayfish were observed in the middle reach. These poeciliid fishes have been known to carry and transmit parasites to native fishes. High flows alone are unlikely to remove all poeciliid fish populations as they can reestablish themselves from the ditch populations.

The lower stream reach is almost completely diverted and is directed to Wailua which drains into Wailuanui Stream. At most times there is ~~not~~ insufficient flow to connect to the ocean in its original stream channel. The lack of stream connectivity likely decreases the ~~observed~~ number of adult native amphidromous animals upstream. The combination of a losing stream and stream diversions resulted in decreased habitat and connectivity to the ocean in the lower section of this stream.

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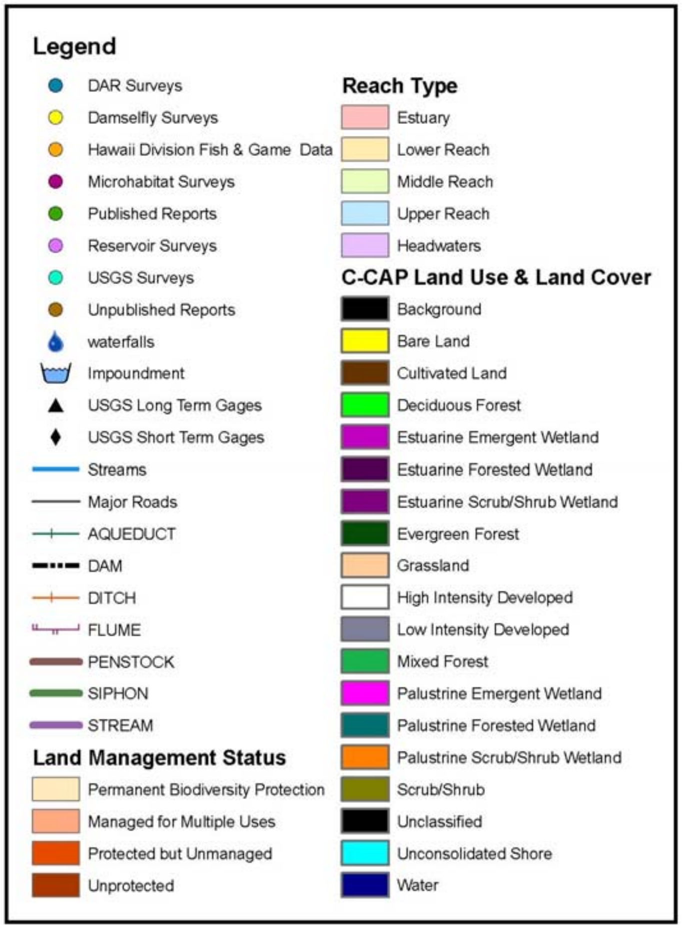
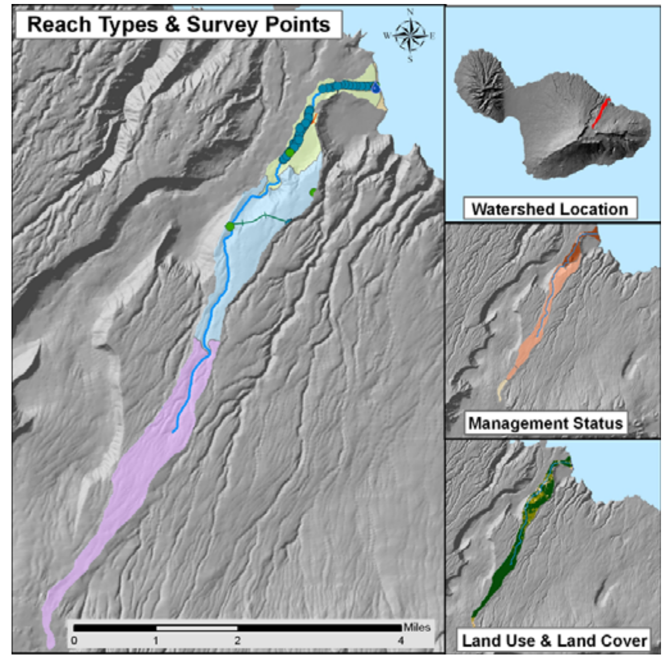


DAR Watershed Code: 64013

Waiokamilo, Maui



WATERSHED FEATURES

Waiokamilo watershed occurs on the island of Maui. The Hawaiian meaning of the name is unknown. The area of the watershed is 2.7 square mi (7.1 square km), with maximum elevation of 6486 ft (1977 m). The watershed's DAR cluster code is not yet determined. The percent of the watershed in the different land use districts is as follows: 17.4% agricultural, 82.6% conservation, 0% rural, and 0% urban.

Land Stewardship: Percentage of the land in the watershed managed or controlled by the corresponding agency or entity. Note that this is not necessarily ownership.

Military	Federal	State	OHA	County	Nature Conservancy	Other Private
0.0	0.0	75.9	0.0	0.0	4.3	19.8

Land Management Status: Percentage of the watershed in the categories of biodiversity protection and management created by the Hawaii GAP program.

Permanent Biodiversity Protection	Managed for Multiple Uses	Protected but Unmanaged	Unprotected
4.3	75.9	0.0	19.8

Land Use: Areas of the various categories of land use. These data are based on NOAA C-CAP remote sensing project.

	Percent	Square mi	Square km
High Intensity Developed	0.0	0.00	0.00
Low Intensity Developed	0.0	0.00	0.00
Cultivated	0.0	0.00	0.00
Grassland	6.3	0.17	0.45
Scrub/Shrub	16.7	0.46	1.19
Evergreen Forest	76.1	2.09	5.40
Palustrine Forested	0.0	0.00	0.00
Palustrine Scrub/Shrub	0.0	0.00	0.00
Palustrine Emergent	0.0	0.00	0.00
Estuarine Forested	0.0	0.00	0.00
Bare Land	0.4	0.01	0.03
Unconsolidated Shoreline	0.0	0.00	0.00
Water	0.3	0.01	0.02
Unclassified	0.0	0.00	0.00

STREAM FEATURES

Waiokamilo is a perennial stream. Total stream length is 5.8 mi (9.3 km). The terminal stream order is 1.

Reach Type Percentages: The percentage of the stream's channel length in each of the reach type categories.

Estuary	Lower	Middle	Upper	Headwaters
0.0	0.4	40.8	39.4	19.4

The following stream(s) occur in the watershed:
Waiokamilo

BIOTIC SAMPLING EFFORT

Biotic samples were gathered in the following year(s):
1979 2002 2003 2007

Distribution of Biotic Sampling: The number of survey locations that were sampled in the various reach types.

Survey type	Estuary	Lower	Middle	Upper	Headwaters
DAR Point Quadrat	0	0	98	0	0
DAR Rapid BioAssessment	0	1	10	0	0
Published Report	0	2	1	1	0

BIOTA INFORMATION

Species List

Native Species

Crustaceans *Atyoida bisulcata*
Fish *Awaous guamensis*
Lentipes concolor

Introduced Species

Amphibians *Bufo marinus*
Ranidae sp.
Crustaceans *Macrobrachium lar*
Procambarus clarkii
Fish *Carassius auratus*
Cyprinus carpio
Gambusia affinis
Misgurnus anguillicaudatus
Poecilia reticulata
Poeciliidae sp.
unidentified poeciliidae
Snails *Physidae sp.*
Pomacea canaliculata

Species Distributions: Presence (P) of species in different stream reaches.

Scientific Name	Status	Estuary	Lower	Middle	Upper	Headwaters
Atyoida bisulcata	Endemic			P	P	
Lentipes concolor	Endemic		P			
Awaous guamensis	Indigenous			P		
Bufo marinus	Introduced			P		
Ranidae sp.	Introduced			P		
Ranidae sp.	Introduced			P		
Ranidae sp.	Introduced			P		
Macrobrachium lar	Introduced			P		
Procambarus clarkii	Introduced			P		
Carassius auratus	Introduced			P		

Cyprinus carpio	Introduced	P	
Gambusia affinis	Introduced		P
Misgurnus anguillicaudatus	Introduced	P	
Poecilia reticulata	Introduced	P	P
Poeciliidae sp.	Introduced	P	
unidentified poeciliidae	Introduced		P
Physidae sp.	Introduced	P	P
Pomacea canaliculata	Introduced		P

HISTORIC RANKINGS

Historic Rankings: These are rankings of streams from historical studies. "Yes" means the stream was considered worthy of protection by that method. Some methods include non-biotic data in their determination. See Atlas Key for details.

Multi-Attribute Prioritization of Streams - Potential Heritage Streams (1998): No

Hawaii Stream Assessment Rank (1990): not ranked

U.S. Fish and Wildlife Service High Quality Stream (1988): No

The Nature Conservancy- Priority Aquatic Sites (1985): No

National Park Service - Nationwide Rivers Inventory (1982): No

Current DAR Decision Rule Status: The following criteria are used by DAR to consider the biotic importance of streams. "Yes" means that watershed has that quality.

Native Insect Diversity > 19 spp.	Native Macrofauna Diversity > 5 spp.	Absence of Priority 1 Introduced
No	No	No
Abundance of Any Native Species	**Presence of Candidate Endangered Species**	**Endangered Newcomb's Snail Habitat**
No	No	No

CURRENT WATERSHED AND STREAM RATINGS

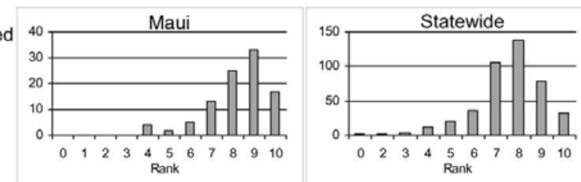
The current watershed and stream ratings are based on the data contained in the DAR Aquatic Surveys Database. The ratings provide the score for the individual watershed or stream, the distribution of ratings for that island, and the distribution of ratings statewide. This allows a better understanding of the meaning of a particular ranking and how it compares to other streams. The ratings are standardized to range from 0 to 10 (0 is lowest and 10 is highest rating) for each variable and the totals are also standardized so that the rating is not the average of each component rating. These ratings are subject to change as more data are entered into the DAR Aquatic Surveys Database and can be automatically recalculated as the data improve. In addition to the ratings, we have also provided an estimate of the confidence level of the ratings. This is called rating strength. The higher the rating strength the more likely the data and rankings represent the actual condition of the watershed, stream, and aquatic biota.

WATERSHED RATING: Waiokamilo, Maui

Land Cover Rating: Rating is based on a scoring sytem where in general forested lands score positively and developed lands score negatively.

Watershed Rating

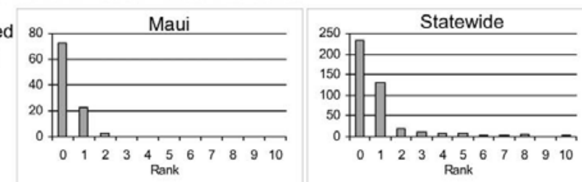
9



Shallow Waters Rating: Rating is based on a combination of the extent of estuarine and shallow marine areas associated with the watershed and stream.

Watershed Rating

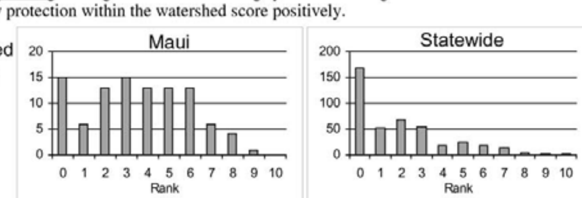
0



Stewardship Rating: Rating is based on a scoring system where higher levels of land and biodiversity protection within the watershed score positively.

Watershed Rating

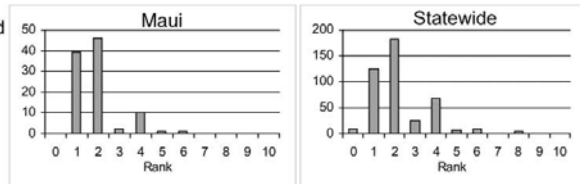
5



WATERSHED RATING (Cont): Waiokamilo, Maui

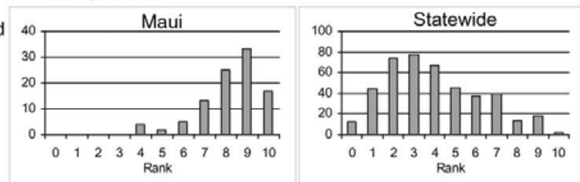
Size Rating: Rating is based on the watershed area and total stream length. Larger watersheds and streams score more positively.

Watershed Rating
1



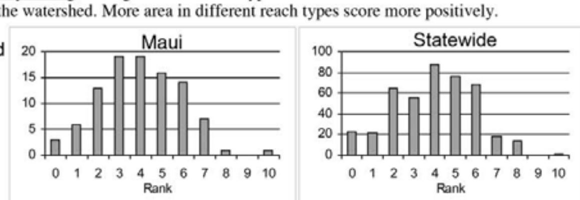
Wetness Rating: Rating is based on the average annual rainfall within the watershed. Higher rainfall totals score more positively.

Watershed Rating
8



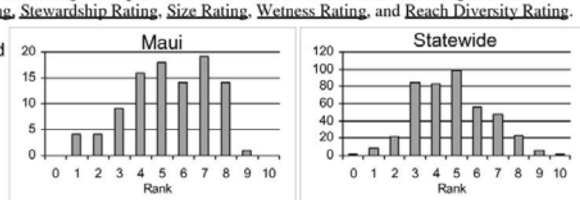
Reach Diversity Rating: Rating is based on the types and amounts of different stream reaches available in the watershed. More area in different reach types score more positively.

Watershed Rating
5



Total Watershed Rating: Rating is based on combination of Land Cover Rating, Shallow Waters Rating, Stewardship Rating, Size Rating, Wetness Rating, and Reach Diversity Rating.

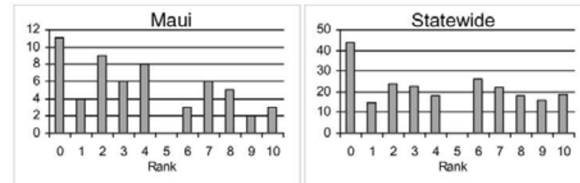
Watershed Rating
7



BIOLOGICAL RATING: Waiokamilo, Maui

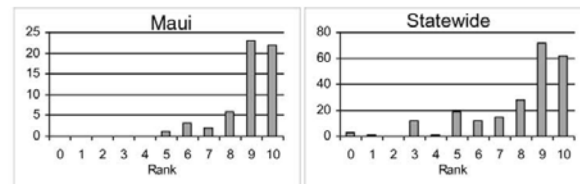
Native Species Rating: Rating is based on the number of native species observed in the watershed.

Stream Rating
2



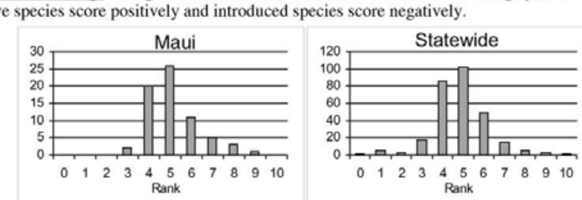
Introduced Genera Rating: Rating is based on the number of introduced genera observed in the watershed.

Stream Rating
8



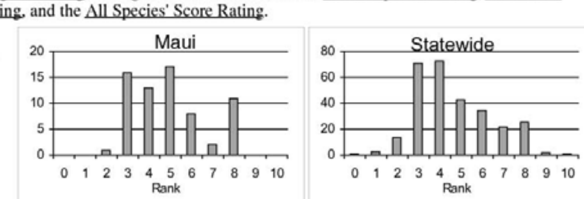
All Species' Score Rating: Rating is based on the Hawaii Stream Assessment scoring system where native species score positively and introduced species score negatively.

Stream Rating
3



Total Biological Rating: Rating is the combination of the Native Species Rating, Introduced Genera Rating, and the All Species' Score Rating.

Stream Rating
3

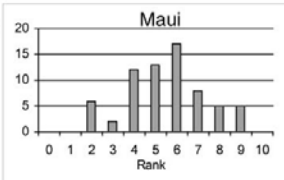


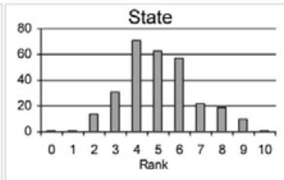
OVERALL RATING: Waiokamilo, Maui

Overall Rating: Rating is a combination of the Total Watershed Rating and the Total Biological Rating.

Watershed Rating

5



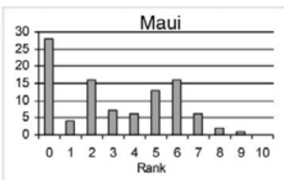


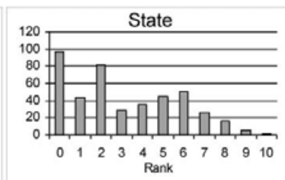
RATING STRENGTH: Waiokamilo, Maui

Rating Strength: Represents an estimate of the overall study effort in the stream and is a combination of the number of studies, number of different reaches surveyed, and the number of different survey types.

Information Rating

4





REFERENCES

2005. Gingerich, S.B. and R.H. Wolff. Effects of Surface-Water Diversions on Habitat Availability for Native Macrofauna, Northeast Maui, Hawai‘i.

2008. Hawai‘i Division of Aquatic Resources. DAR Point Quadrat Survey Data from the DAR Aquatic Surveys Database.

2008. Hawai‘i Division of Aquatic Resources. Rapid Assessment Surveys in DAR Aquatic Surveys Database.

Appendix 1: Scientific and Common Names

Appendix 1: Scientific and Common Names (continued)

CN = Common Name and HN = Hawaiian Name

Amphibian
Introduced
Bufo marinus
CN: marine toad; HN: none.
Ranidae
CN: none; HN: none.
Ranidae
CN: unidentified frog; HN: none.
Ranidae
CN: unidentified frog tadpole; HN: none.
Crustacean
Endemic
Atyoida bisulcata
CN: Mountain opae; HN: \`opae kala\`ole.
Introduced
Macrobrachium lar
CN: none; HN: none.
Procambarus clarkii
CN: red swamp crayfish; HN: none.
Fish
Endemic
Lentipes concolor
CN: \`O\`opu alamo\`o; HN: \`O\`opu alamo\`o.
Indigenous
Awaous guamensis
CN: none; HN: \`O\`opu nakea.
Introduced
Carassius auratus
CN: Goldfish; HN: none.
Cyprinus carpio
CN: Common carp (AFS), Carp (DLNR), Koi; HN: none.
Gambusia affinis
CN: Western mosquitofish; HN: none.
Misgurnus anguillicaudatus
CN: Oriental weatherfish (AFS), Dojo, Weather loach (Yamamoto & Tagawa, 2000; HN: none.
Poecilia reticulata
CN: Guppy (AFS), Rainbow fish (Yamamoto & Tagawa, 2000), Millions fish (Yamamoto & Tagawa, 2000); HN: none.

Appendix 1: Scientific and Common Names (continued)

CN = Common Name and HN = Hawaiian Name

Poeciliidae
CN: unidentified livebearers; HN: none.
unidentified poeciliidae
CN: unidentified molly; HN: .

Snail

Introduced

Physidae
CN: none; HN: none.
Pomacea canaliculata
CN: none; HN: none.

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Section 3: DAR Point Quadrat Survey Report

Results of DAR Point Quadrat Survey Report for Hanehoi Stream, Maui for Surveys from 5/2/2002 to 5/2/2002

This Division of Aquatic Resources (DAR) stream surveys report is produced using the Point Quadrat Methodology. Trained biologists and technicians survey a series of randomly located points in a stream to generate an assessment of composition of species and habitats in the stream. The Point Quadrat Methodology is only one of several different techniques that could be chosen for the surveys and is used to develop a statistically comparable stream survey. The following information represents an accounting of the observations that will be used in overall stream management efforts by DAR. All density measurements are in number of animals per square yard in the reach.

Table 1. The watersheds (and watershed ID), region, and island surveyed in this report are:

Waiokamilo (ID: 64013), Ke‘anae, Maui

Table 2. Survey Team Personnel:
- Hau, Skippy
- Higashi, Glenn
- Kuamoo, Darrell
- Leonard, Jason
- Nishimoto, Robert
- Young, Rodney

Table 3. The distribution of sites by reach during this survey effort.

	Reaches					
Survey Type	Estuary	Lower	Middle	Upper	Headwater	Total
Point Quadrat (random)			98			98

Middle Reach of Waiokamilo stream, Maui:

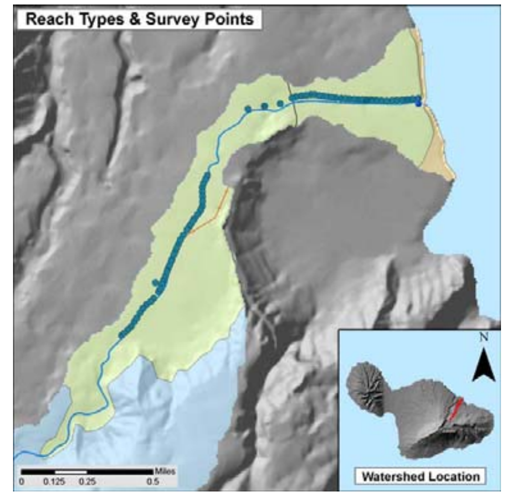

Figure 1. Location of the Point Quadrat Surveys done in the middle reach of Waiokamilo Stream. Green area is the middle reach delineation and blue dots are the surveys.

Habitat Types

Cascade	Riffle	Run	Pool	Plunge	Side pool	No water
3	4	37	27	4	5	13

Substrate Types in Surveys (%)

Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
5	3	6	13	17	12	44

Species Observed in the middle reach of Waiokamilo Stream

Category	Status	Scientific Name	Reach	Avg Density	Total # observed
Amphibian	Introduced	*Bufo marinus*	Middle	0.05	2
Amphibian	Introduced	*Ranidae*	Middle	0.26	10
Crustacean	Introduced	*Procambarus clarkii*	Middle	0.03	1
Crustacean	Introduced	*Macrobrachium lar*	Middle	0.41	16
Crustacean	Endemic	*Atyoida bisulcata*	Middle	1.05	41

Fish	Introduced	*Carassius auratus*	Middle	0.26	10
Fish	Introduced	*Gambusia affinis*	Middle	0.05	2
Fish	Introduced	*Poecilia reticulata*	Middle	0.31	12
Fish	Indigenous	*Awaous guamensis*	Middle	0.03	1
Snail	Introduced	*Physidae*	Middle	0.03	1
Snail	Introduced	*Pomacea canaliculata*	Middle	0.08	3

Section 4: DAR Aquatic Insect Report

No recent DAR aquatic insect surveys were performed in Waiokamilo Stream.

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Section 5: An Analysis of Depth Use vs. Availability

Introduction:

As part of an ongoing collaboration between the Division of Aquatic Resources and Bishop Museum, we have been analyzing the relationship between instream measures of habitat and the occurrence of native animals. The intention of this research is to better understand the habitat requirements of these animals to improve management of the stream environment. While this research effort is not complete, we have tried to provide some information to aid in the instream flow determination for the East Maui Streams given the deadlines for comment set by the Commission on Water Resource Management on these streams.

The amount of water in a stream is important to the fishes and macroinvertebrates that inhabit the stream. One measure of the amount of water needed in the stream to create suitable habitat is the depth of the water in a survey site. The deeper areas of a stream may be important to the animals to provide safety from predatory birds, a refuge from fluctuations in discharge, or as a buffer to changes in temperature as larger volumes of water heat or cool more slowly than smaller water volumes. Depth is also closely related to stream discharge. Given a specific streambed form, increased discharge results in increases in depth and velocity. Conversely, if water is diverted from a stream, the decrease in downstream discharge results in slower, shallower water. Surveyors record the quadrat depth when using the DAR Point Quadrat technique, but do not measure velocity; therefore we used the depth in this analysis.

In this report, we compared the depth measured for each site during the DAR Point Quadrat Surveys of Waiokamilo Stream, Maui to the depths where animals were observed. Additionally, we also compared the observations for Waiokamilo Stream to depth observations for all streams statewide surveyed using the Point Quadrat Surveys to see if the pattern for Waiokamilo Stream is consistent with other Hawaiian streams. Finally, the distribution of average site depth by elevation groups are provided.

Methods:

All data reflected in this report came from the DAR Aquatics Surveys Database. For each random survey site in Waiokamilo Stream, Maui (Watershed code: 64013) the depth and animals observed were queried from the database. Additionally, the same information was collected for all survey sites statewide.

To compare the depth suitability for the stream animals, availability, utilization, and suitability criteria were developed following standardized procedures (Bovee 1982). In general, this method based habitat utilization on the presence/absence data, and does not take into account site density. Depth availability is the frequency of each depth category based on the distribution of depths observed in the field survey. Percent availability is calculated by dividing the number of observations for a depth category by the total number of observations and multiplying by 100. Utilization is the frequency of occurrence for an individual species in each depth category. Percent utilization is calculated by dividing the number of sites with a species observed for a depth category

by the total number of sites with a species observed and multiplying by 100. Suitability is developed by dividing the percent utilization for each depth category with the percent availability for each depth category. The standardized suitability has the range adjusted so that the largest value for each species equals 1 (suitable) and the lowest value equals 0 (unsuitable).

To compare the site depths observed in the stream to the average site depths statewide, the percent frequency of occurrence for each depth bin was calculated from the data for Waiokamilo Stream and for all sites statewide in the DAR Point Quadrat Surveys. Additionally, the difference between the percent frequencies for each depth bin was plotted in a histogram to clearly show where the differences occurred.

To examine where in the stream changes in available depths occurred, the average depth was determined for a number of elevation bins. The determination of the distribution of the elevation bins was influenced by the number of samples in a depth bin. Where possible at least 5 samples were needed to create a depth bin.

Results:

There were insufficient observations for native amphidromous animals to develop depth suitability criteria. In the random point quadrats, 8 of 93 sites with *Atyoida bisulcata* were observed with an average depth of 16.5 inches, one site with *Awaous guamensis* were observed at a depth of 13 inches. In contrast with other streams in the East Maui area, 66 of 93 sites had no animals of any type observed and these sites averaged 11.6 inches in depth.

The pattern of the distribution of observed depths in Waiokamilo Stream in comparison to the statewide average depths reveals that dry sites are much more common in Waiokamilo than in most Hawaiian Streams (Figure 1). The sample size was 93 sites for Waikamilo Stream in comparison to 6084 sites statewide. There were approximately 14% more dry sites than observed in the statewide data set (Figure 2). In contrast to the increase in dry sites, there was a decrease in most depth bins 14 inches depth or deeper.

When observing the distribution of average depth as a function of elevation, the depths increased in the higher elevations and then decreased at lower elevations (Figure 3). The elevations bin between 70 and 120 m had an average site depth of almost 15 inches, while the elevation bin less then 40 m had an average site depth of 9 inches.

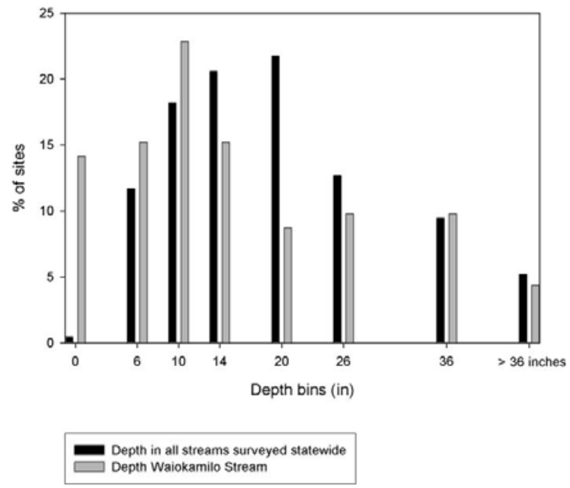

Figure 1. Comparison of percent availability for depth categories between Waiokamilo Stream, Maui and all streams statewide in the DAR Aquatics Surveys Database.

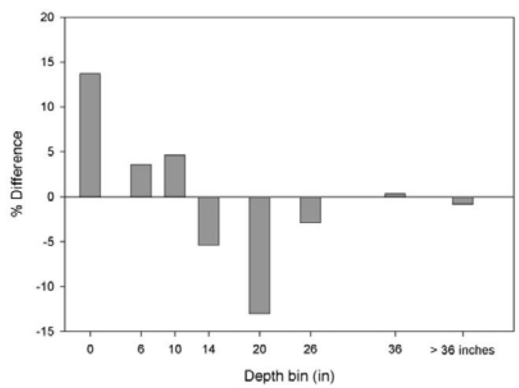

Figure 2. Percent difference in depth categories between Waiokamilo Stream, Maui and all streams statewide in DAR Aquatics Surveys Database. Positive values denote an increase in the percent frequency of a depth category in Waiokamilo Stream as compared to streams statewide. Negative values denote a decrease in the percent frequency of a depth category in Waiokamilo Stream as compared to streams statewide.

Analysis of Depth Use vs. Availability Waiokamilo, Maui

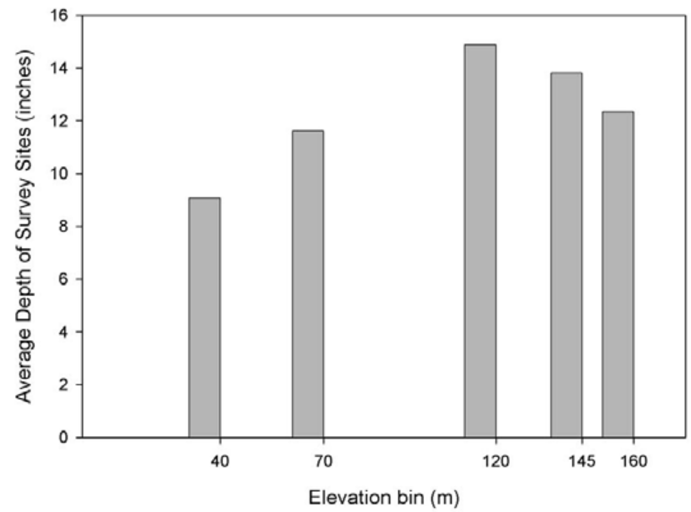

Figure 3. Average depth observed in Point Quadrat Survey Sites for different elevation bins. The elevation bins include all sites up to and including the elevation value. For example, the first bin would include all sites with elevations from 0 to and including 30 m, the second bin would include all sites greater than 30 m to and including 50 m, and so on.

Conclusions:

Native and introduced animals were not commonly observed in Waiokamilo Stream. *Atyoida bisulcata* were observed in sites with deeper then average water, but many sites with adequate water depth were uninhabited. This is different than the other streams in East Maui we surveyed, and may be an indication that the unconnected lower section of the stream is preventing most upstream migration, or maybe there are water quality issues in this stream that we did not test for.

The availability of suitable depths was quite different in Waiokamilo Stream than in other streams statewide. The frequency of sampling a dry site went from about 1 in 200 sites statewide to more then 1 in 7 sites in Waiokamilo. Field surveyors noted that the native animals were restricted to disconnected deep pools in an otherwise dry stream bed in the lower sections of the stream. In sections where water still flowed, the stream animals were observed in a wider range of habitats.

When the distribution of average depths was plotted as a function of elevation, a pattern of decreasing depths toward the downstream end of the stream was observed. While this pattern is not conclusive that all water lost from the stream as it flows downstream is associated with water diversions, it does suggest that large sections of stream are currently unsuitable for native animals.

Return of water into Waiokamilo Stream would likely have a beneficial effect on availability of suitable depths for native species in currently dewatered stream sections. Additionally, the return of water into Waiokamilo Stream would increase stream connectivity with the ocean aiding in the upstream migration of native animals.

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Section 6: Photographs taken during stream surveys

Estuary:

No estuary on this stream. Terminal waterfall goes into the ocean.

Lower Reach:

No aquatic insect or point quadrat surveys were performed. Lower reach is below terminal waterfall on the rocks.

View of cobble and boulder beach below the terminal waterfall.

View of cobble/boulder beach in the lower reach below the terminal waterfall which is the delineation for the middle reach. Note water seeping from the wall (yellow oval).

Middle Reach:

Waiokamilo Stream with its intermittent terminal waterfall next to ocean.

Downstream view Waiokamilo Stream just above terminal waterfall. Note standing pools.

Waiokamilo Stream above Hana Highway bridge.

Water partially diverted in stream for taro patch (lo’i) from Waiokamilo Stream.

Partial diversion of water from Waiokamilo Stream.

Run habitat in Waiokamilo Stream.

Waiokamilo Stream with vegetation canopy

Hau, *Hibiscus tiliaceus,* encroachment into flood channel of Waiokamilo Stream.

Waiokamilo Stream opens up where taro patches (lo'i) were previously established; Removal of hau, *Hibiscus tiliaceus,* from adjoining areas

Upstream view of concrete dam on Waiokamilo Stream showing areas where the hau, *Hibiscus tiliaceus*, are cut back.

Upper Reach:

No aquatic insect or point quadrat surveys were performed.

Headwaters:

No aquatic insect or point quadrat surveys were performed.

Appendix B

State of Hawaii
COMMISSION ON WATER RESOURCE MANAGEMENT
Department of Land and Natural Resources

P3:10

PETITION TO AMEND INTERIM INSTREAM FLOW STANDARDS

WAIOKAMILO STREAM, EAST MAUI

Instructions: Please print in ink or type and send completed petition with attachments to the Commission on Water Resource Management, P.O. Box 621, Honolulu, Hawaii 96809. Petition must be accompanied by a non-refundable filing fee of $25.00 payable to the Dept. of Land and Natural Resources. The Commission may not accept incomplete applications. For assistance, call the Regulation Branch at 587-0225.

1. **PETITIONER**

Firm/Name Na Moku 'Aupuni o Ko'olau Hui c/o Native Hawaiian Legal Corporation
Contact Person Alan Murakami, Attorney Ph: 521-2302
Address 1164 Bishop Street, Honolulu, Hawai'i 96813

2. **STREAMFLOW DATA**

USGS stream gaging station UNGAGED. Period of Record NONE.
Location/Reach SEE ATTACHED
(Attach a USGS map, scale 1"=2000', and a property tax map showing diversion location referenced to established property boundaries.)

TABLE 1. PERIOD OF RECORD AVERAGE MONTHLY STREAMFLOW WITHIN THE AFFECTED STREAM REACH, IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

CURRENT DATA UNAVAILABLE.

Annual Median flow in cfs =

TABLE 2. PROPOSED AVERAGE MONTHLY STREAMFLOW DIVERSION FROM AFFECTED STREAM REACH, IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

NONE. UNDETERMINED; SUFFICIENT FOR TARO FARMING AND/OR GATHERING.

Annual Median flow in cfs =

TABLE 3. AVERAGE MONTHLY STREAMFLOW IN AFFECTED STREAM REACH AFTER [redacted] RESTORATION (min release flow), IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

NATURAL STREAMFLOW EXCEPT FOR EXERCISE OF APPURTENANT WATER RIGHTS.

Annual Median flow in cfs =

3. **EXISTING INSTREAM AND OFFSTREAM WATER USES FOR ENTIRE STREAM REACH**

TMK	OWNER	USE
RESEARCH IN PROGRESS.		

(If more space is necessary, attach an extended list following above format)

4. **ANTICIPATED IMPACTS ON STREAM AND BASIS FOR SUCH IMPACTS:**

RESTORATION OF INSTREAM NATURAL HABITAT AND BIOTA, AND BENEFICIAL APPURTENANT AND GATHERING USES.

(Attach supporting documentation, plans, letters, etc.)

May 24, 2001
Date

Signature NATIVE HAWAIIAN LEGAL CORPORATION
Alan Murakami
Attorney for Na Moku 'Aupuni o Ko'olau Hui
Petitioner

For Official Use
Date Received
Date Accepted

Waiokamilo Stream

Waiokamilo Stream is headed at about 3,500 ft altitude about 5 mi inland on the upland surface east of Keanae Valley (plate 1). The stream has a flat gradient near the coast where it flows on Hana Volcanics that covered alluvium at the mouth of Keanae Valley (Stearns and Macdonald, 1942). At about 2.5 mi inland, at the east wall of Keanae Valley, the stream altitude abruptly increases from about 800 ft up to 1,200 ft along the next 2,000 ft of stream length. The stream lies on Hana Volcanics along its entire length (Stearns and Macdonald, 1942). All base flow is captured by the Koolau Ditch diversion system at about 1,300 ft altitude (table 4). Several other diversions capture water for taro cultivation in the Wailua area.

Streamflow measurements made on May 11, 1999 during low-flow conditions show that the stream was dry from the Koolau ditch diversion as far downstream as Akeke Spring. The stream gained about 3.8 Mgal/d from the spring which discharges from a ridge of Honomanu Basalt (table 15). Downstream from the spring all the way to the coast, the stream loses water to the subsurface and to at least three diversions. The stream flows on Hana Volcanics along the entire section of stream that is losing water. The vertically extensive freshwater-lens system appears to exist in the Honomanu Basalt, but below the floor of Waiokamilo Stream in the overlying Hana Volcanics. A water budget was not calculated for this stream basin.

Ground-Water Occurrence and Contribution to Streamflow, Northeast Maui, Hawaii, by Stephen B. Gingerich, U.S. Geological Survey, Water-Resources Investigations Report 99-4090 (1999) at page(s) 53 -54 .

Streamflow

Estimates of streamflow and base flow are based on streamflow records of varying length and from different times. The error associated with comparing these records is not considered significant because the average annual values used in the comparisons are expected to be within about 10 percent of the true value in most cases. A statistical analysis of five streamflow records, each with more than 60 years of record, shows that the average annual discharge for any 10-year period within that record has a standard error of 12 percent when compared with the whole record (Fontaine, 1996). When the length of the subset is increased to a 50-year period, the standard error only improves to 5 percent. Thirty nine of the streamflow records for the study area are equal to or greater than 10 years long.

For this study, the length of the period of record at each gaging station was determined to be unimportant by comparing each record to three reference records from the study area. The three longest streamflow records, 5080 (73 years), 5180 (76 years), and 5870 (85 years) were chosen as reference records. For each other individual record, a time period equal to the length of that record was chosen. A subset of a reference record was then selected from this same time period and the average flow during that time period was compared with the total reference record to estimate the ratio of flow during the subset period to the reference period. This analysis was made for all three reference records and the result was averaged to obtain a period-of-record scale factor for each of the other records. The scale factor ranged from 0.88 to 1.13 (table 2). This variability is consistent with the statistical analysis reported by Fontaine (1996). This range of accuracy is considered sufficient for the type of comparisons made in this study, and therefore, no corrections were made to any of the records to account for differences in length or period of record.

Table 15. Streamflow, temperature, and specific conductance in Waiokamilo Stream, May 11, 1999, northeast Maui, Hawaii
[ft, feet; Mgal/d, million gallons per day; °C, degrees Celsius; µS/cm, microsiemens per centimeter; --, not determined; all altitudes estimated from U.S. Geological Survey topographic map, Keanae and Nahiku quadrangles]

Station number	Stream name	Altitude (ft)	Stream-flow (Mgal/d)	Water temperature (°C)	Water specific conductance (µS/cm)	Comments
Waiokamilo 1	Waiokamilo	80	0.47	--	--	
Waiokamilo 2	Waiokamilo	110	0.52	--	--	Includes some return flow from taro patch
Waiokamilo 3.1	Waiokamilo	220	0.36	--	--	
Waiokamilo 3.2	diversion	220	0.70	--	--	Taro-patch diversion
Waiokamilo 4.1	Waiokamilo	240	0.23	19.9[a]	123[a]	Includes flow from unnamed spring
Waiokamilo 4.2	Hamau	250	0.83	20.3[a]	135[a]	Tributary to Waiokamilo Stream
Waiokamilo 5	Waiokamilo	440	2.40	19.1	139	Diversion takes nearly all flow
Waiokamilo 6	Waiokamilo	560	3.66	19.6	137	Upstream from taro-patch diversion
Waiokamilo 7	diversion	540	0.25	--	--	Diversion to taro patch
Waiokamilo 8	Waiokamilo	720	3.80	18.9	147	Downstream from Akeke Spring
Waiokamilo 9	Waiokamilo	750	0.00	--	--	Upstream from Akeke Spring

[a] Measured May 28, 1999

Appendix C

State of Hawaii
COMMISSION ON WATER RESOURCE MANAGEMENT
Department of Land and Natural Resources

PETITION TO AMEND INTERIM INSTREAM FLOW STANDARDS

KUALANI STREAM, EAST MAUI

Instructions: Please print in ink or type and send completed petition with attachments to the Commission on Water Resource Management, P.O. Box 621, Honolulu, Hawaii 96809. Petition must be accompanied by a non-refundable filing fee of $25.00 payable to the Dept. of Land and Natural Resources. The Commission may not accept incomplete applications. For assistance, call the Regulation Branch at 587-0225.

1. PETITIONER

Firm/Name: Na Moku 'Aupuni o Ko'olau Hui c/o Native Hawaiian Legal Corporation
Contact Person: Alan Murakami, Attorney Ph: 521-2302
Address: 1164 Bishop Street, Honolulu, Hawai'i 96813

2. STREAMFLOW DATA

USGS stream gaging station: UNGAGED. Period of Record: NONE.
Location/Reach: SEE ATTACHED
(Attach a USGS map, scale 1"=2000', and a property tax map showing diversion location referenced to established property boundaries.)

TABLE 1. PERIOD OF RECORD AVERAGE MONTHLY STREAMFLOW WITHIN THE AFFECTED STREAM REACH, IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

DATA UNAVAILABLE.

Annual Median flow in cfs =

TABLE 2. PROPOSED AVERAGE MONTHLY STREAMFLOW DIVERSION FROM AFFECTED STREAM REACH, IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

UNDETERMINED; SUFFICIENT FOR TARO FARMING AND/ OR GATHERING.

Annual Median flow in cfs =

TABLE 3. AVERAGE MONTHLY STREAMFLOW IN AFFECTED STREAM REACH AFTER RESTORATION [redacted] (min release flow), IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

NATURAL STREAMFLOW EXCEPT FOR EXERCISE OF APPURTENANT WATER RIGHTS.

Annual Median flow in cfs =

3. EXISTING INSTREAM AND OFFSTREAM WATER USES FOR ENTIRE STREAM REACH

TMK	OWNER	USE
RESEARCH IN PROGRESS.		

(If more space is necessary, attach an extended list following above format)

4. ANTICIPATED IMPACTS ON STREAM AND BASIS FOR SUCH IMPACTS:

RESTORATION OF INSTREAM NATURAL HABITAT AND BIOTA, AND BENEFICIAL APPURTENANT AND GATHERING USES.

(Attach supporting documentation, plans, letters, etc.)

May 24, 2001
Date

Signature: NATIVE HAWAIIAN LEGAL CORPORATION
Alan Murakami Petitioner
Attorney for Na Moku 'Aupuni o Ko'olau Hui

For Official Use
Date Received ______
Date Accepted