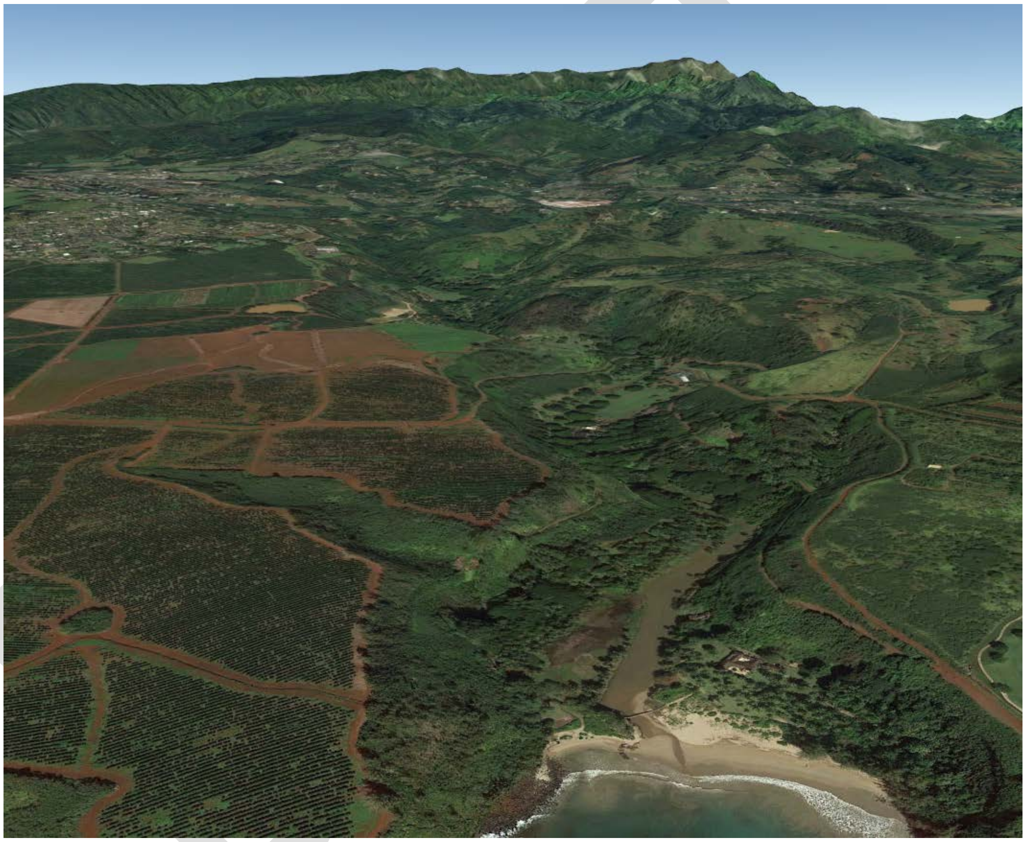
Instream Flow Standard Assessment Report

Island of Kauai
Hydrologic Unit 2050
Lawai

September 2019 **DRAFT PR-2019-05**



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

COVER

Satallite image of Lawai hydrologic unit with the Lawai Stream flowing into the Pacific Ocean, Southeast Kauai [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.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

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)
DHHL	Department of Hawaiian Home Lands (State of Hawaii)
DLNR	Department of Land and Natural Resources (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
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
HDOA	State Department of Agriculture (State of Hawaii)
HI-GAP	Hawaii Gap Analysis Program
HOT	hotel
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
KAA	Kekaha Agriculture Association
KIUC	Kauai Island Utility Cooperative
KLM	Kaanapali Land Management Company
LCA	Land Commission Award

LUC	Land Use Commission (State of Hawaii)
MECO	Maui Electric Company
MF	multi-family residential
mgd	million gallons per day
Mgal/d	million gallons per day
mi	mile
MLP	Maui Land & Pineapple
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
por.	Portion
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
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. Introduction

General Overview

The hydrologic unit of Lawai is located in Southeast Kauai, on the southern flank of Waialeale Mountain in the moku of Kona, which forms the southern part of the Hawaiian island of Kauai (Figure 1-3). It covers an area of 7.74 square miles from a maximum of 2370 feet elevation to the sea with a mean basin elevation of 879 feet and a mean basin slope of 78 percent (Figures 1-4 and 1-5). Sixty-two percent of the basin has a slope greater than 30 percent. The longest flow path in Lawai is 8.76 miles in length, traversing in a southernly direction from its headwaters to Lawai Bay. There are two branches of Lawai Stream with a number of short tributaries in the upper reaches. Baseflow in Lawai is supported by continuous groundwater discharge from perched water bodies in the Koloa Volcanics contributing to spring flow, supporting mauka to makai flow 100 percent of the time. The basin has a mean annual precipitation of 82.1 inches. Seepage-run measurements indicate spatially continuous flow downstream of the Lawai Ditch intake, although some reaches are losing and some gaining flow. The highest elevation sections of the hydrologic unit are made up of conservation land owned by the State of Hawaii and McBryde Resources Inc. The Eleele-Kalaheo (9,527) and Koloa-Poipu (6,208) region have a combined population of 15,735 people (U.S. Census Bureau Office of Planning 2011). Most of the watershed is dominated by alien vegetation. Throughout the middle and lower reaches along the stream, taro was extensively cultivated, although presently, few loi remain. The state highway provides the primary access through Lawai, with secondary roads continuing up and down the valley and a number of former agricultural roads providing limited access to some areas of the hydrologic unit (Figure 1-6). The Lawai Ditch was built by McBryde Sugar Company to bring water diverted from from Lawai Stream into drier lands of the Koloa and Poipu region to support sugarcane agriculture. Since the closure of McBryde Sugar Company, water has been diverted by the ditch to support non-potable needs of the Koloa and Poipu region (landscape irrigation, golf course irrigation). The stream supports habitat for native aquatic biota, although there are many non-native species as well. There is substantial recreational and aesthetic value in the lower reaches.

Current Instream Flow Standard

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

> Interim instream flow standard for Kaua‘i. The Interim Instream Flow Standard for all streams on Kaua‘i, 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 off stream 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 December 31, 1988. Streamflow was not measured on that date; therefore, the current interim IFS is not a quantifiable 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.

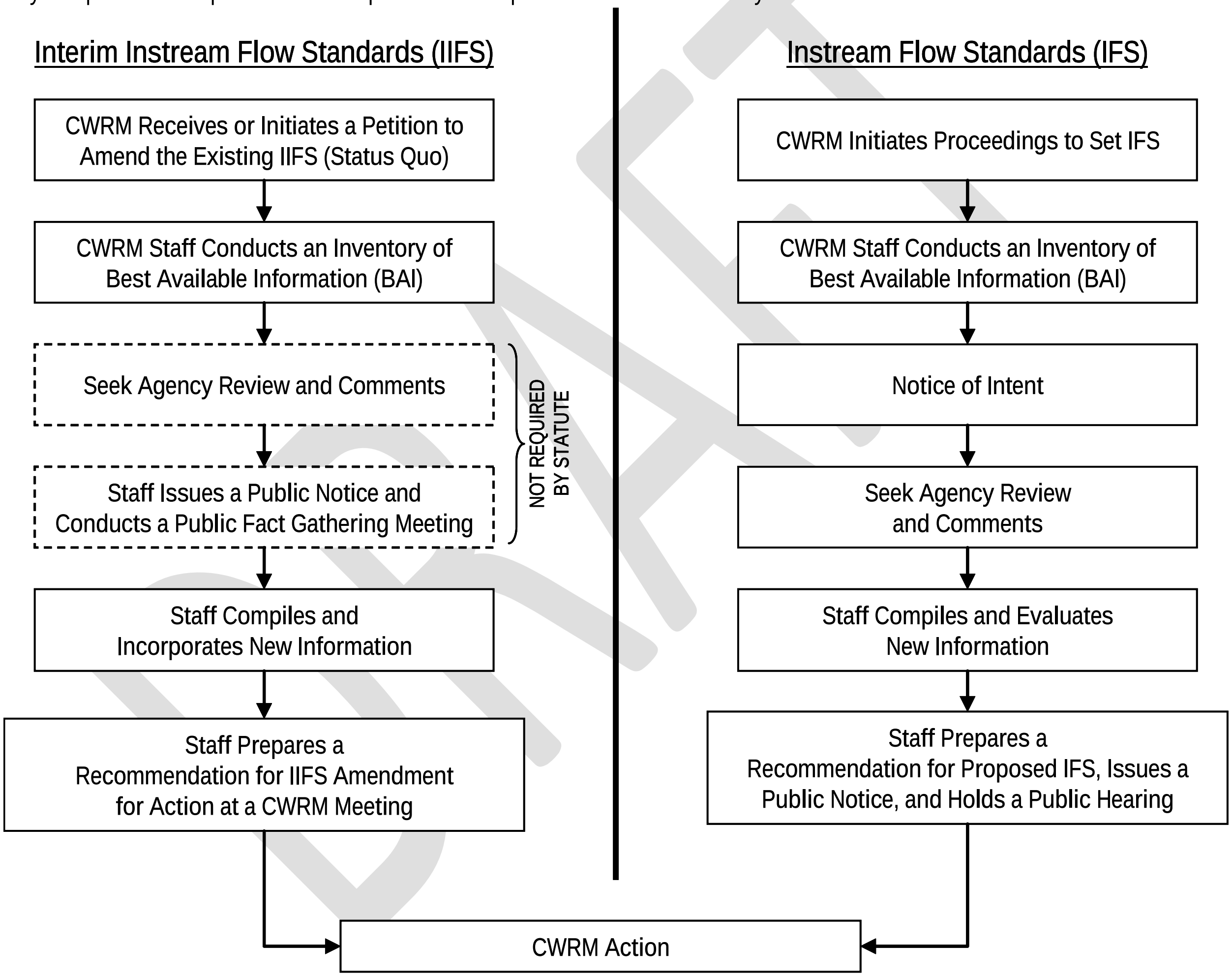
Figure 1-1. Information to consider in setting measurable instream flow standards.

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. Section 13.0 describes public trust uses of water not covered in other sections. Noninstream uses are summarized in Section 14.0. Maps are provided at the end of each section to help illustrate information presented within the section's text or tables. Finally, Section 15.0 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. 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. World View 2 satellite imagery of the Lawai hydrologic unit and streams in Southeast Kauai, Hawaii. (Source: State of Hawaii, Planning Department, 2004; State of Hawaii, Commission on Water Resource Management, 2015c; State of Hawaii, Office of Planning - Division of Aquatic Resources, 2005)

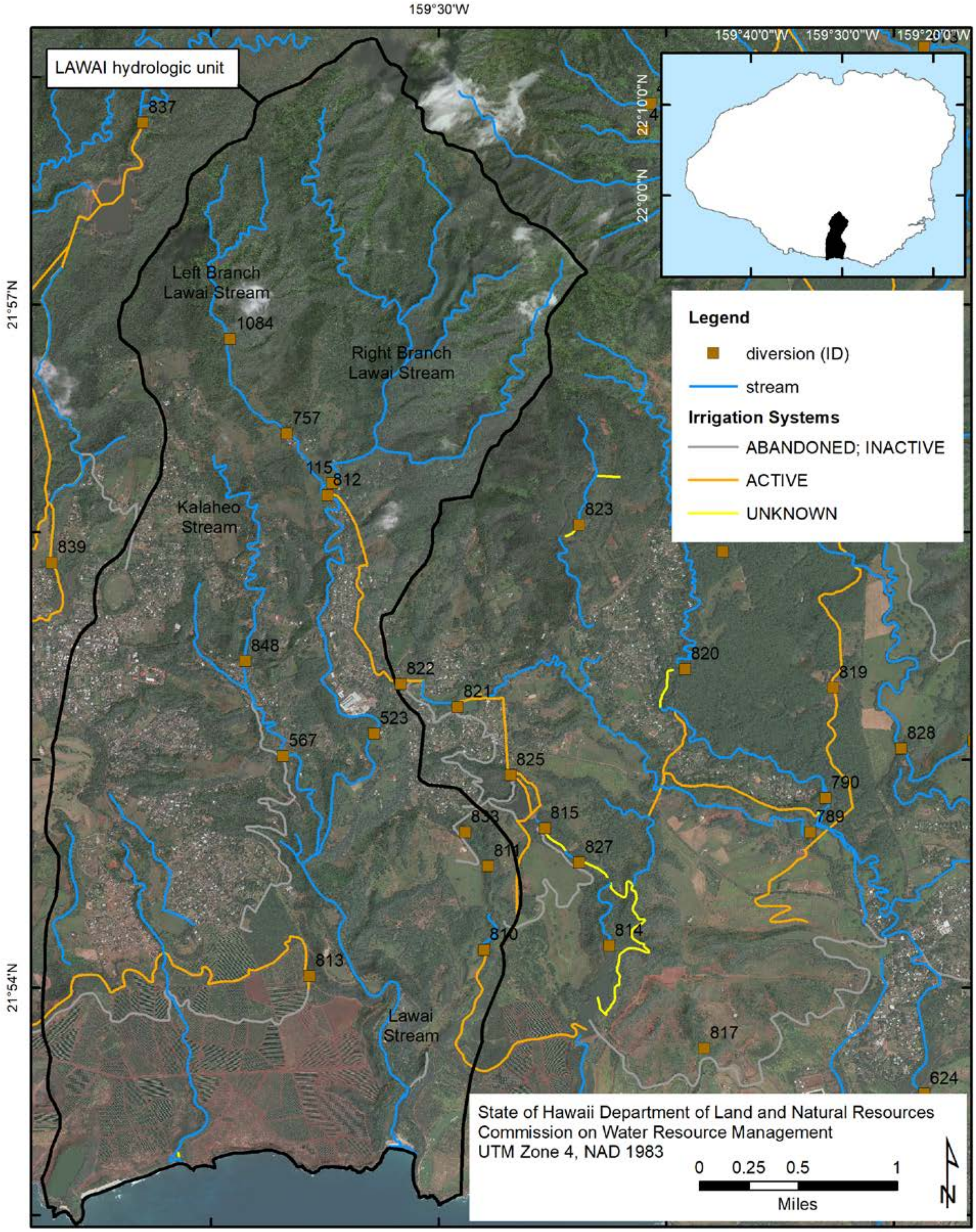


Figure 1-4. Elevation range of the Lawai hydrologic unit. (Source: State of Hawaii, Office of Planning, 2004e; U.S. Geological Survey, 2001)

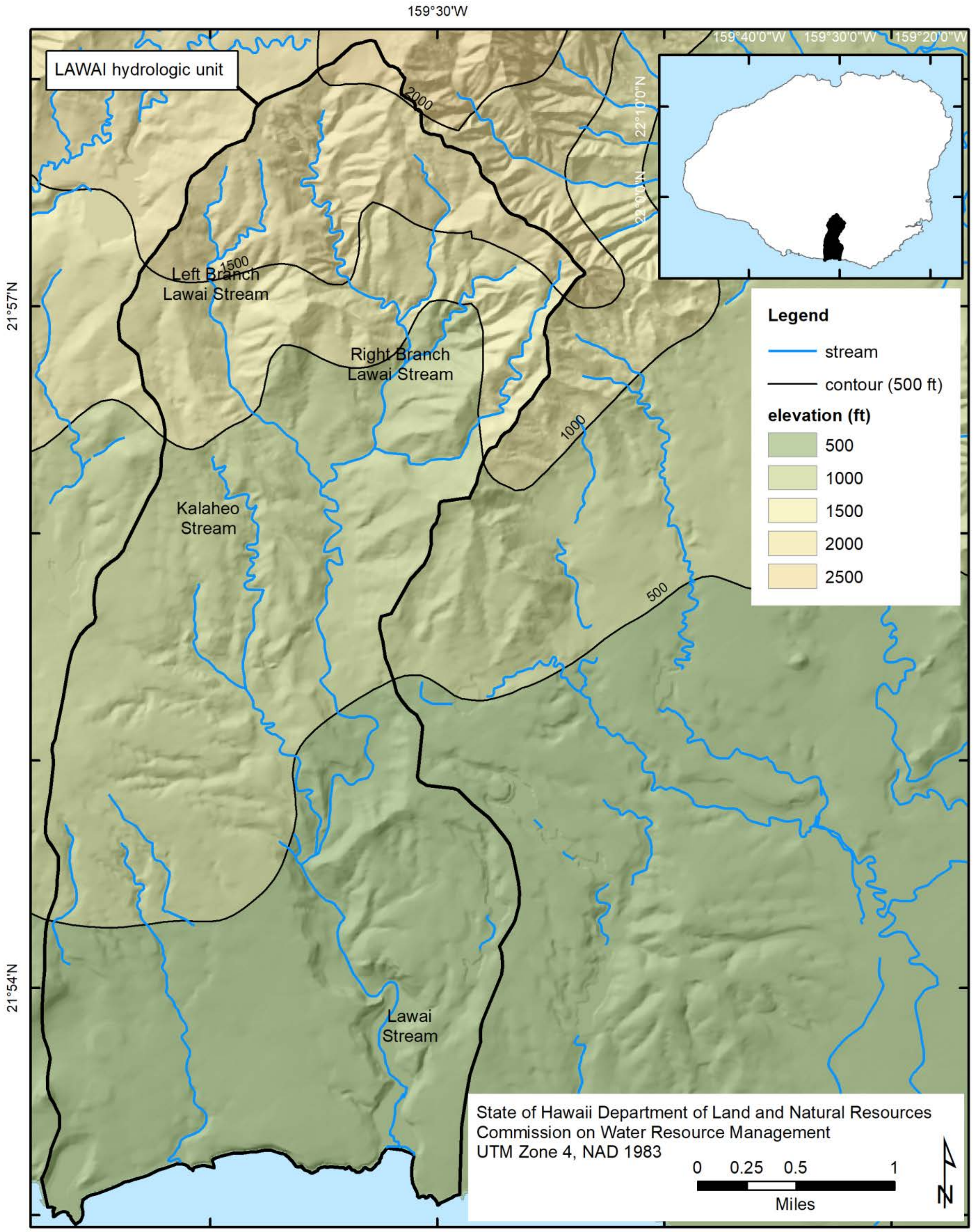


Figure 1-5. USGS topographic map of Lawai hydrologic unit. (Source: U.S. Geological Survey, 1996)

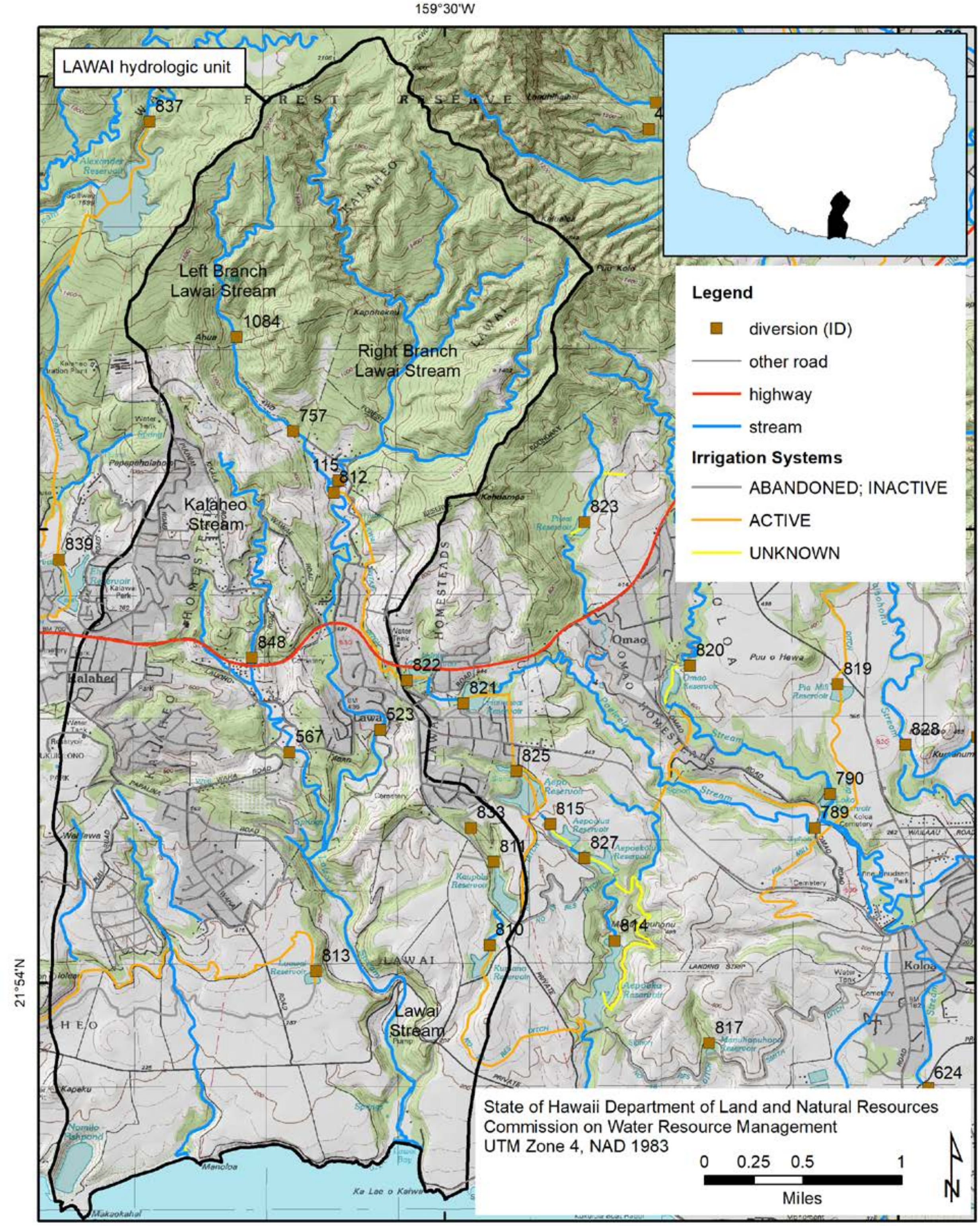
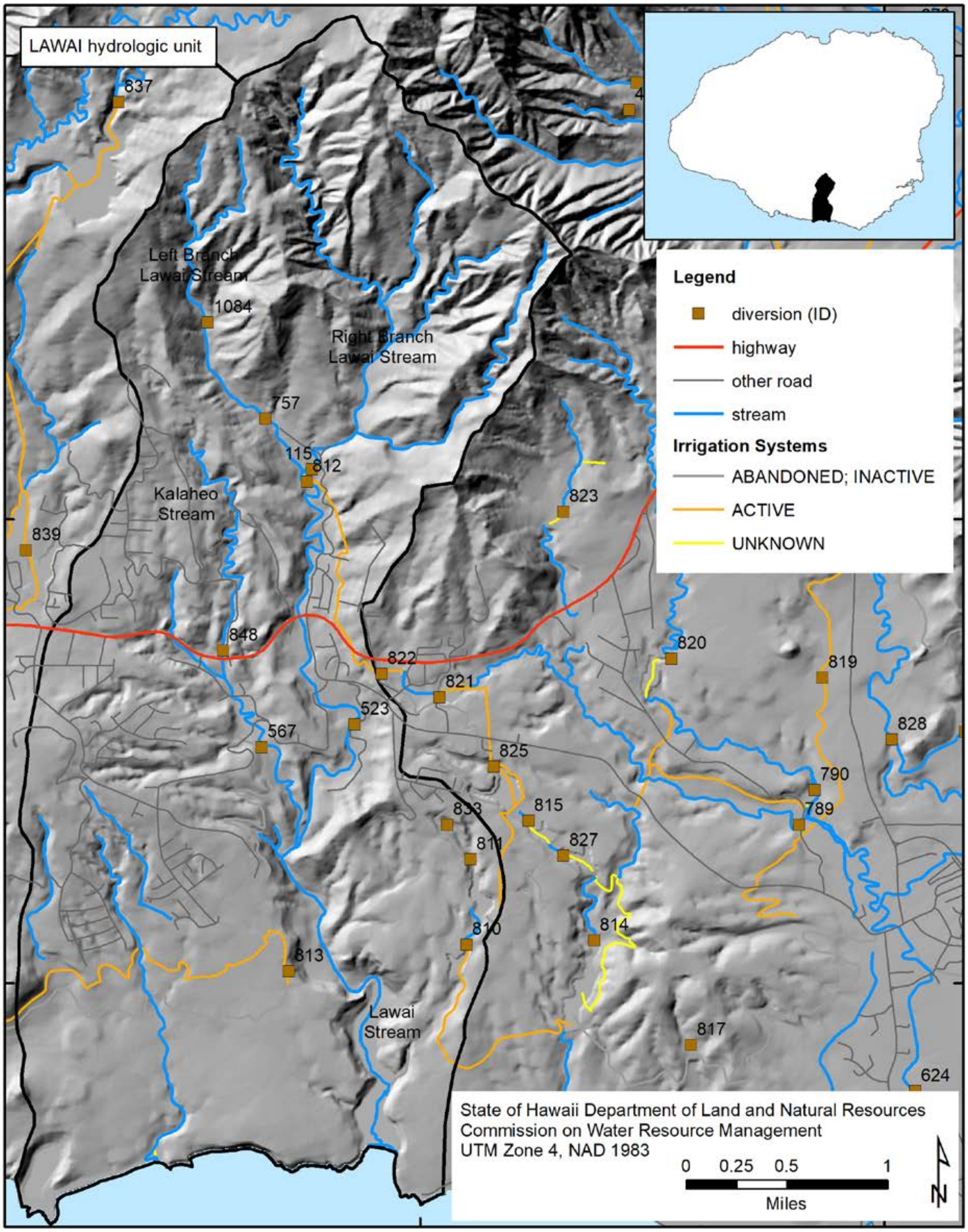


Figure 1-6. Major and minor roads for the Lawai hydrologic unit. (Source: State of Hawaii, Office of Planning 2015)



2. Watershed Characteristics

Geology

Kauai is the most geologically complex island of the main Hawaiian Islands, but subsurface geohydrologic information is not as well developed as in other areas of Hawaiʻi (USGS SIR 99-4066). The Lawai hydrologic unit is composed of two geologic formations: tholeiitic Waimea Canyon Basalt of the Napali Formation; and the heterogeneous Kōloa Volcanics composed of massive lava flows of highly alkali olivine basalt, nephelinite, melilitite, and basanite (Figure 3-2). The Napali Formation is a thick accumulation of many thin lava flows created during the shield-building phase of Kauaʻi and is highly permeable, but generally found in irregular north-south bands in Lawai (Macdonald et al., 1960). The basal aquifer occurs in this formation, although wells drilled below Kōloa Volcanics show head elevations ranging from 30-140 feet above sea level, suggesting mixed basal and high-level conditions. Deeply buried dikes are likely to influence transmissivity and submarine groundwater discharge. Kōloa Volcanics includes eroded sediment and weathered lava flows, ash, tuff, and cinder overlaying the Waimea Canyon Basalt, mainly along the coastal areas (Macdonald et al., 1960). The thick, dense lava flows and intercalated sediments of the Kōloa Volcanics are considered moderately permeable (Macdonald et al., 1960). The generalized geology of the Lawai hydrologic unit is depicted in Figure 3-2. Perched water bodies often occur in Kōloa Volcanics where impermeable ash layers are overlain with porous sediment and lava.

Soils

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 Lawai hydrologic unit, there is a large mix of soil types with 0.75% of soils in Group A, 48.57% of soils in Group B, 30.58% of soils in Group C, and 19.1% of soils in Group D, with 1.00% other (Table 2-1). The Lawai hydrologic unit consists largely of soils that are in hydrologic group B and C with generally moderate to good permeability (Table 2-2). The gently sloping regions between the interior mountains and the coastline are dominated by soils in the hydrologic group B composed of moderately deep to deep, well drained soils supporting moderate infiltration (Figure 2-3). The low elevation plateau regions and the gulch of the Lawai watershed are similarly composed of a variety of soils in groups A, B, and C. Soils in Group D tend to have a high clay content with the highest potential for runoff (low infiltration rate) and are often shallow soils on top of impervious lava (U.S. Department of Agriculture, Soil Conservation Service, 1972). The highest elevation regions are composed the rough broken land (4.00 mi^2, 20.8%) and rough mountainous land (3.16 mi^2, 16.4%) soil groups accounting for the largest percentage of the watershed.

Rainfall

Orographic[1] rainfall is the driving force affecting the distribution of rainfall in Hawaii (Figure 2-4). Precipitation occurs when the prevailing northeasterly trade winds lift warm air up the windward side of Waialeale into higher elevations where cooler temperatures persist. As moist air cools, water condenses and the air mass releases precipitation. As a result, frequent and heavy rainfall is observed on the

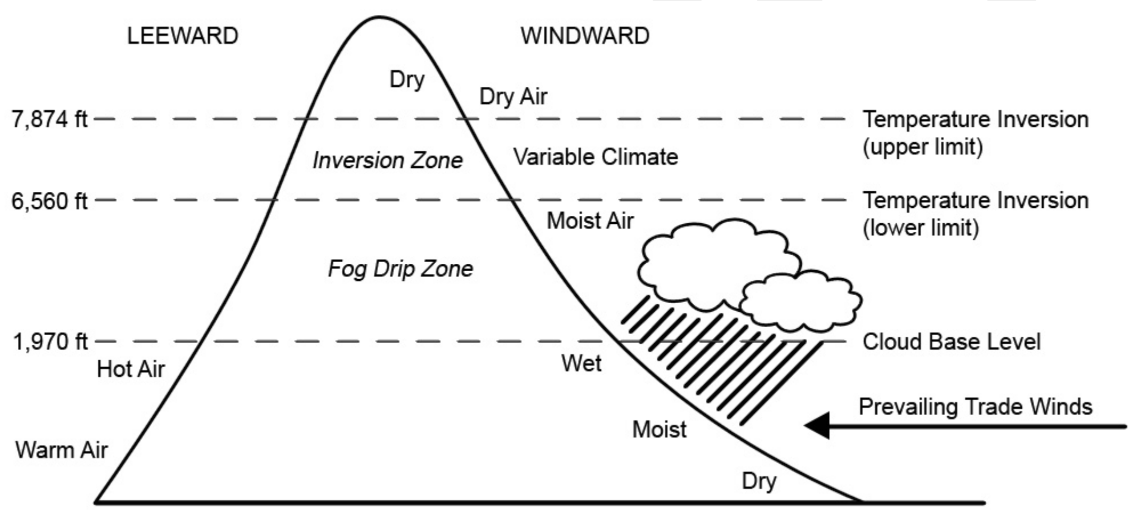
[1] Orographic refers to influences of mountains and mountain ranges on airflow, but also used to describe effects on other meteorological quantities such as temperature, humidity, or precipitation distribution.

windward mountain slopes. Fog drip is a result of cloud-water droplets impacting vegetation (Scholl et al, 2002) and can contribute significantly to ground water recharge. The fog drip zone occurs below the elevation where cloud height is restricted by the temperature inversion. The temperature inversion zone typically extends from 6,560 feet to 7,874 feet, and thus the Lawai hydrologic unit sits completely below the inversion zone.

A majority of the mountains in Hawaii peak in the fog drip zone, where cloud-water is intercepted by vegetation. In such cases, air passes over the mountains, warming and drying while descending on the leeward mountain slopes. Precipitation on Waialeale is influenced by its position relative to the trade winds. The steep gradient around the island forces moisture-laden air to rapidly rise in elevation (over 3,000 feet) in a short distance, resulting in a rapid release of rainfall. The relatively round, conical shape of the Waialeale exposes all sides of the peak to wind and moisture.

The Lawai hydrologic unit is situated on the leeward flank of Waialeale and as such receives less orographic rainfall than windward slopes (Figure 2-1). Near the coast, mean annual rainfall is only 40 inches but the interior-most ridges receive at least 135 inches per year. The high spatial variability in rainfall is evident by the 95 inch variation in mean annual rainfall across the hydrologic unit.

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



Fog drip is also expected to contribute substantially to the water budget of the hydrologic unit. Shade (1999) used the monthly fog drip to rainfall ratios for the windward slopes of Mauna Loa on the island of Hawaii to calculate fog drip contribution to the water budget in windward east Maui. None of the Lawai hydrologic unit lies in the fog drip zone based on elevation.

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 in part 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.

Figure 2-2. Generalized geology of the Lawai hydrologic unit, Kauai. (Source: Sherrod et al., 2007)

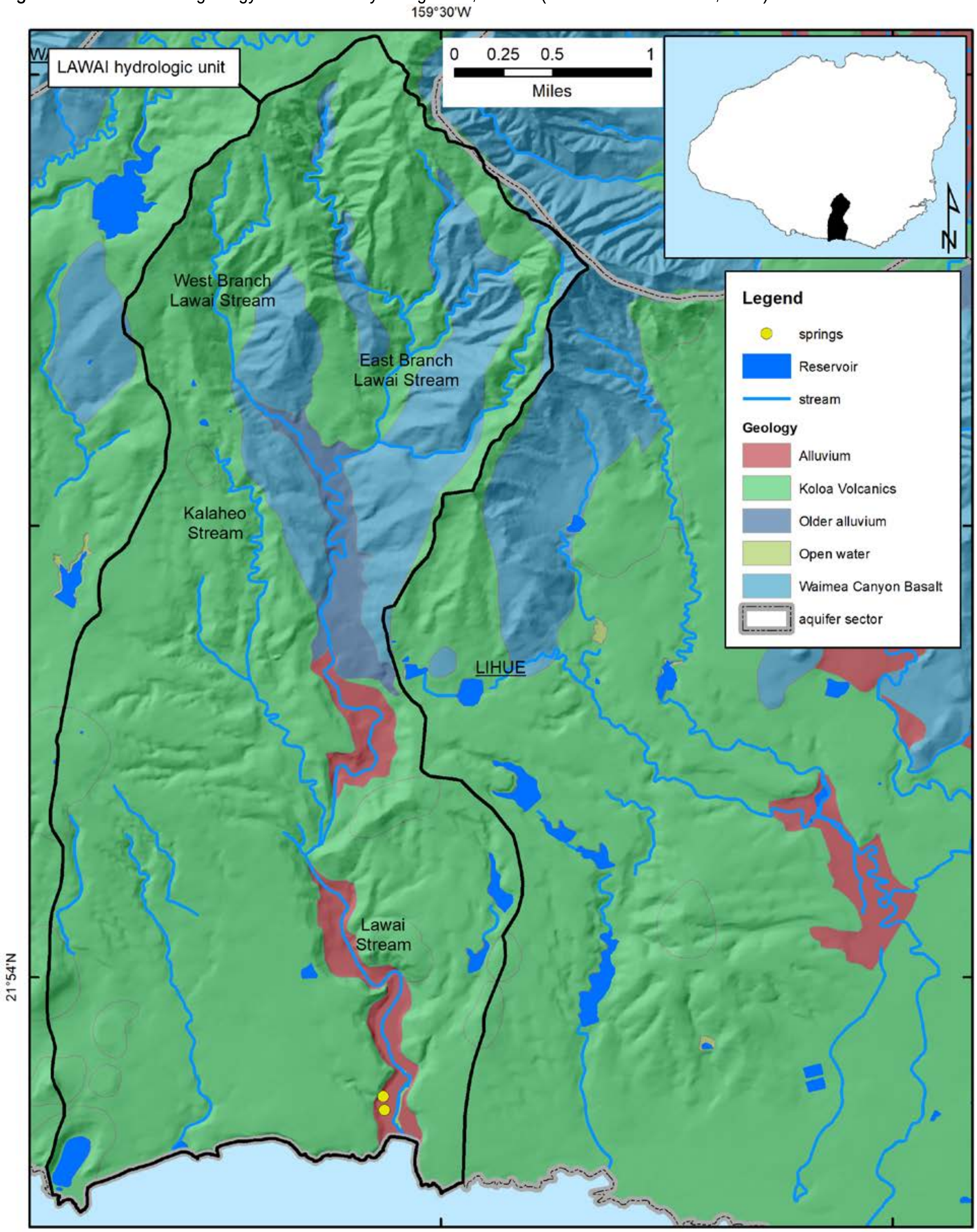


Figure 2-3. Soil classification of the Lawai hydrologic unit, Kauai. (Source: State of Hawaii, Office of Planning, 2015m)

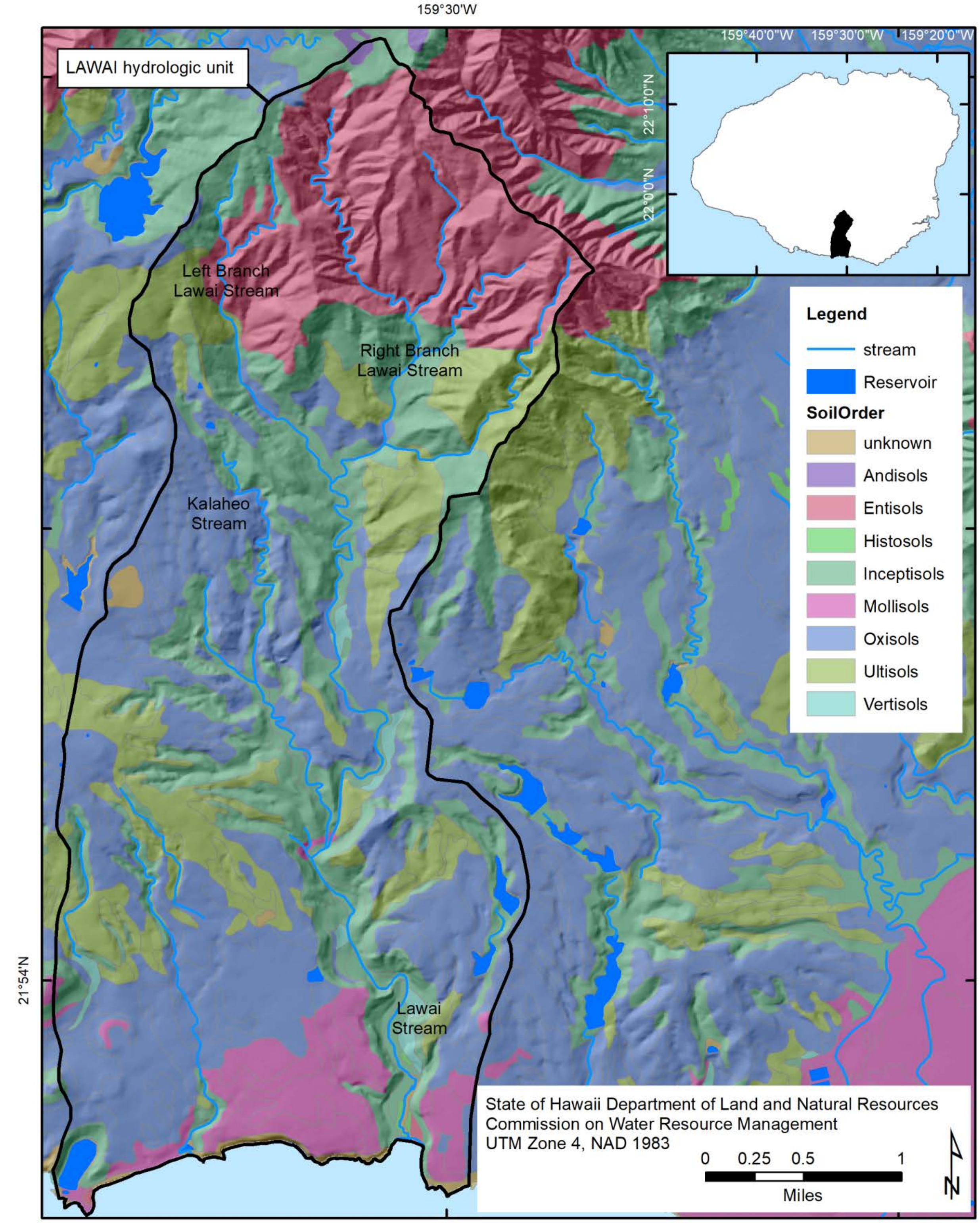
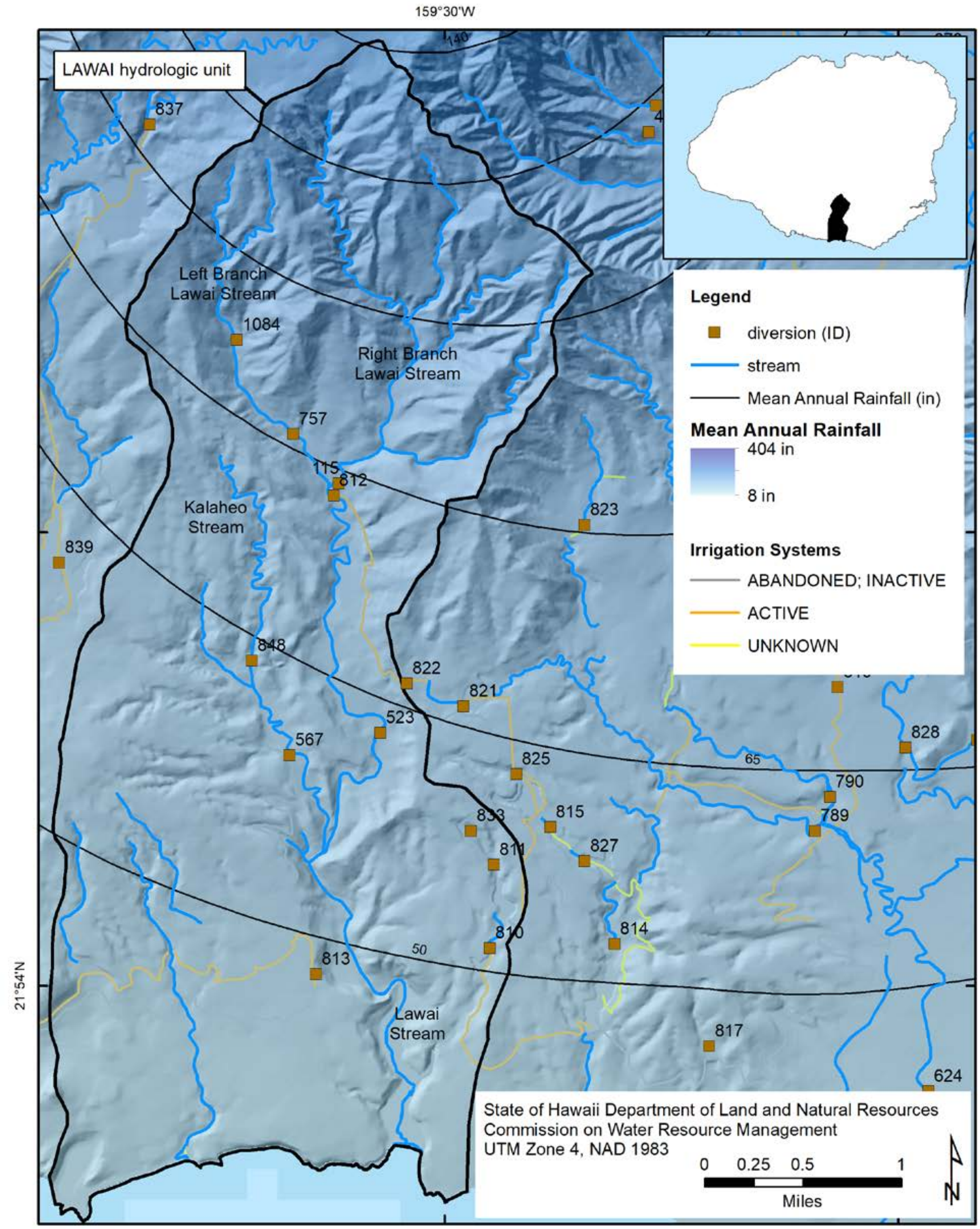


Figure 2-4. Mean annual rainfall isohyets (in) and rasterized mean annual rainfall for the Lawai hydrologic unit. (Source: Giambelluca et al., 2013)



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 Lawai, average annual solar radiation is 209.7 W/m^2 per day with a range of 178.2-230.8 W/m^2 per day (Figure 2-3). It is greatest at the coast and decreases toward the uplands, where cloud cover is more of an influence (Giambelluca et al. 2014).

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 lost to the atmosphere. 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[1], rainfall, humidity, wind speed, surface temperature, and sensible heat advection[2]. 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 was grown. These data have been compiled and mapped by Ekern and Chang (1985). 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[3] and the cloud layer (Figure 2-6). 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 90 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, Figure 2-4). Near the average height of the temperature inversion, evaporation rates are highly variable as they are mainly influenced by the movement of dry air

[1] Albedo is the proportion of solar radiation that is reflected from the Earth, clouds, and atmosphere without heating the receiving surface.
[2] Sensible heat advection refers to the transfer of heat energy that causes the rise and fall in the air temperature.
[3] Temperature inversion is when temperature increases with elevation.

Figure 2-5. Mean annual solar radiation for the Lawai hydrologic unit, Kauai. (Source: Giambelluca et al., 2014)

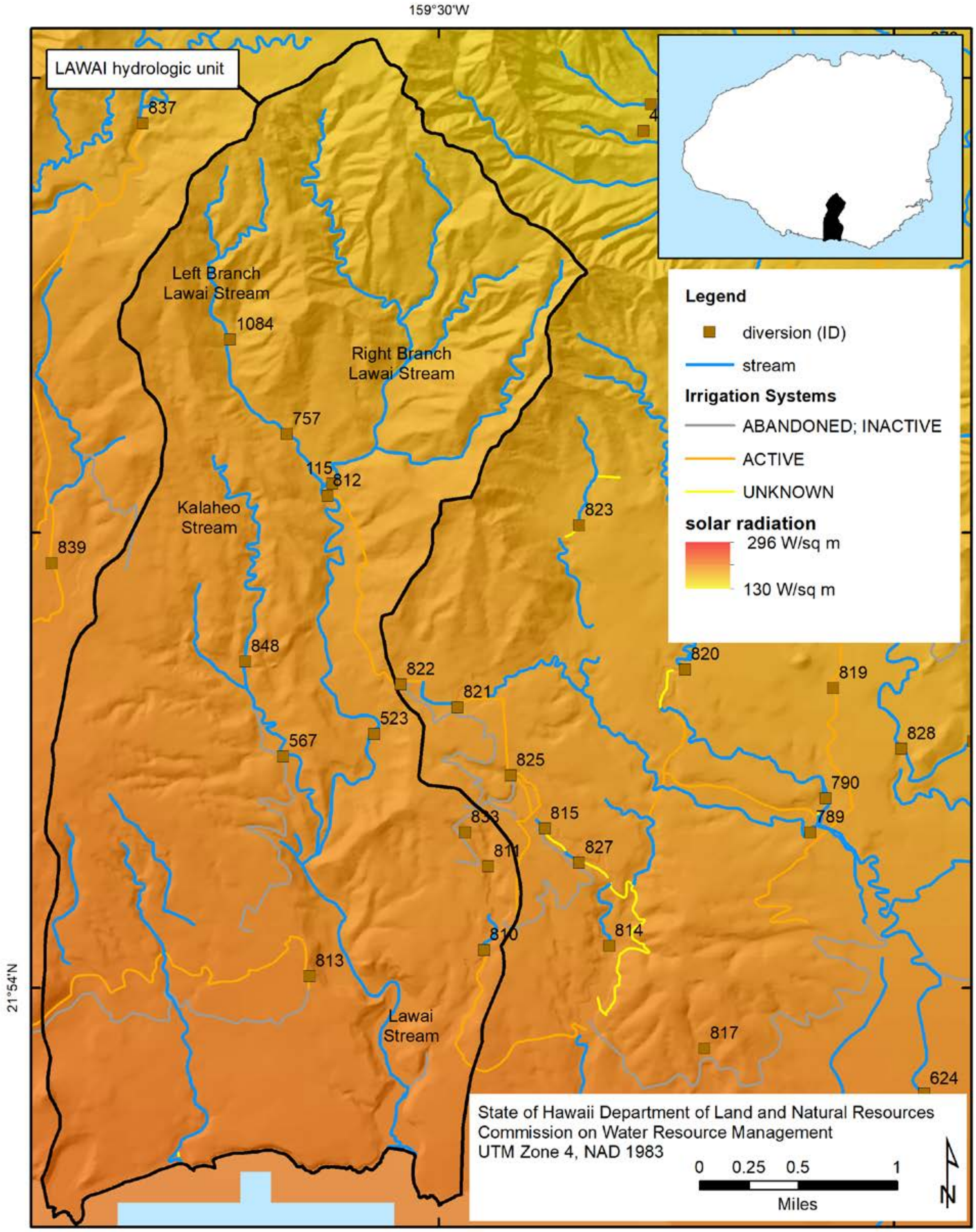
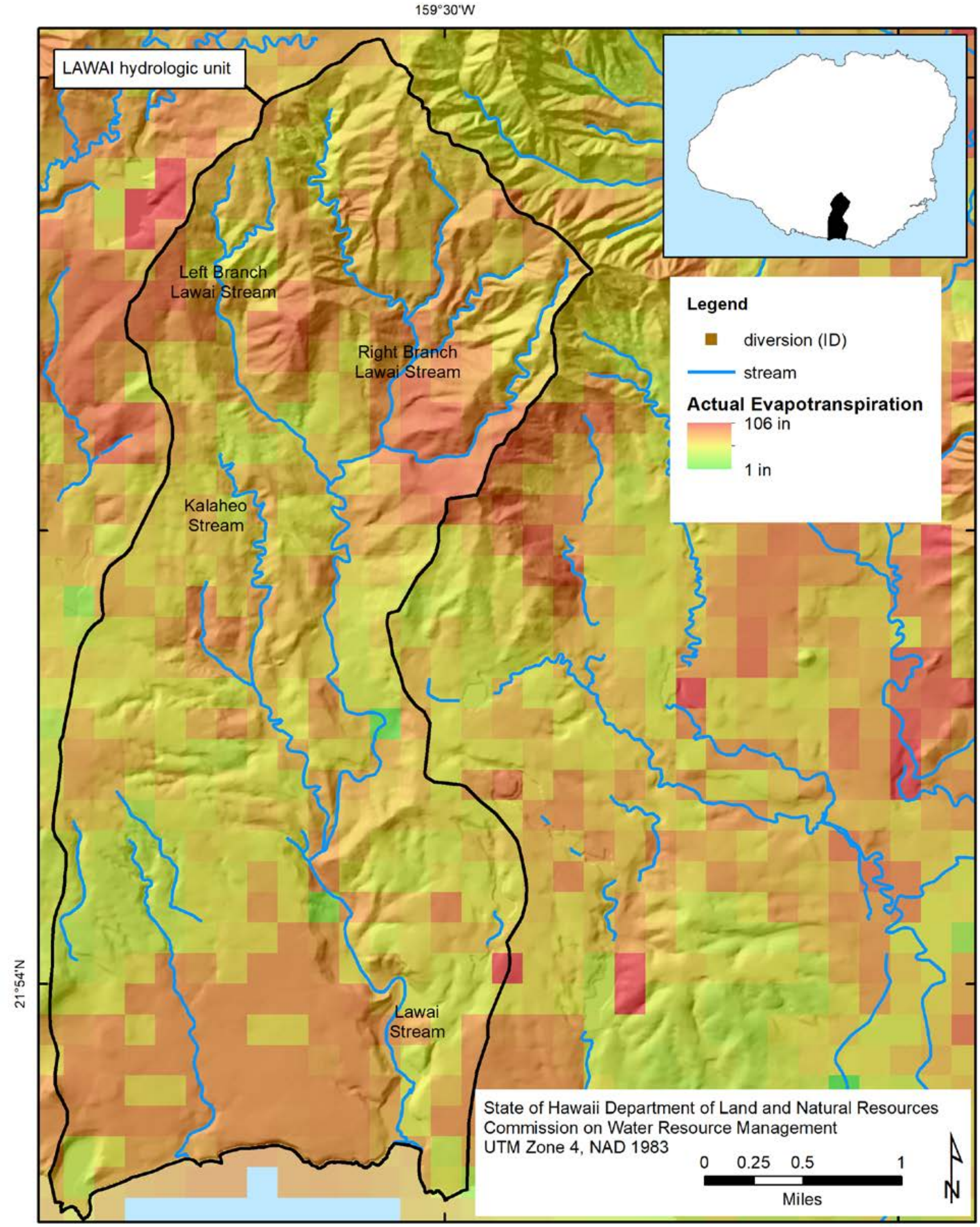


Figure 2-6. Mean annual actual evapotranspiration for the Lawai hydrologic unit, Kauai. (Source: Giambelluca et al., 2014)



from above and moist air from below (Nullet and Giambelluca, 1990). Above the inversion, clear sky and high solar radiation at the summit causes increased evaporation, with pan evaporation rates of about 50 to 70 inches per year (Shade, 1999, Figure 2-4). For example, 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. Actual annual evapotranspiration in the Lawai hydrologic unit (Figure 2-4) averages 39.9 inches and ranges from 6.61 inches to 80.6 inches per year (Giambelluca et al. 2014).

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 2014, the LUC designated 30.2 percent of the land in Lawai as conservation and 55.7 percent as agricultural with 1.3 percent as rural and 12.9 percent as urban (State of Hawaii, Office of Planning, 2015d). The conservation district is located in the upper part of the hydrologic unit, whereas the agricultural district lies in the lower part of the hydrologic unit (Figure 2-7).

Land Cover

Land cover for the hydrologic unit of Lawai is represented by two separate 30-meter Landsat satellite datasets. One of the datasets, developed by the Coastal Change Analysis Program (C-CAP), provides a general overview of the land cover types in Lawai, e.g. forest, grassland, shrub land, with minor developed areas, cultivated areas, and bare land (Figure 2-8). 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 (Figure 2-9).

Based on the two land cover classification systems, only a small portion of the Lawai hydrologic unit is composed of native open Ohia forest or native wet forest. Most of the region is composed of alien forest or scrubland species. Much of the lower elevation regions are in agriculture or grassland with high density urban or rural development.

Figure 2-7. Current land use zoning, current (2015) agricultural use, and golf courses in the Lawai-Poʻipū-Koloa region relative to the Lawai ditch and reservoir system, Kauai. (Source: State of Hawaii, Office of Planning, 2015d)

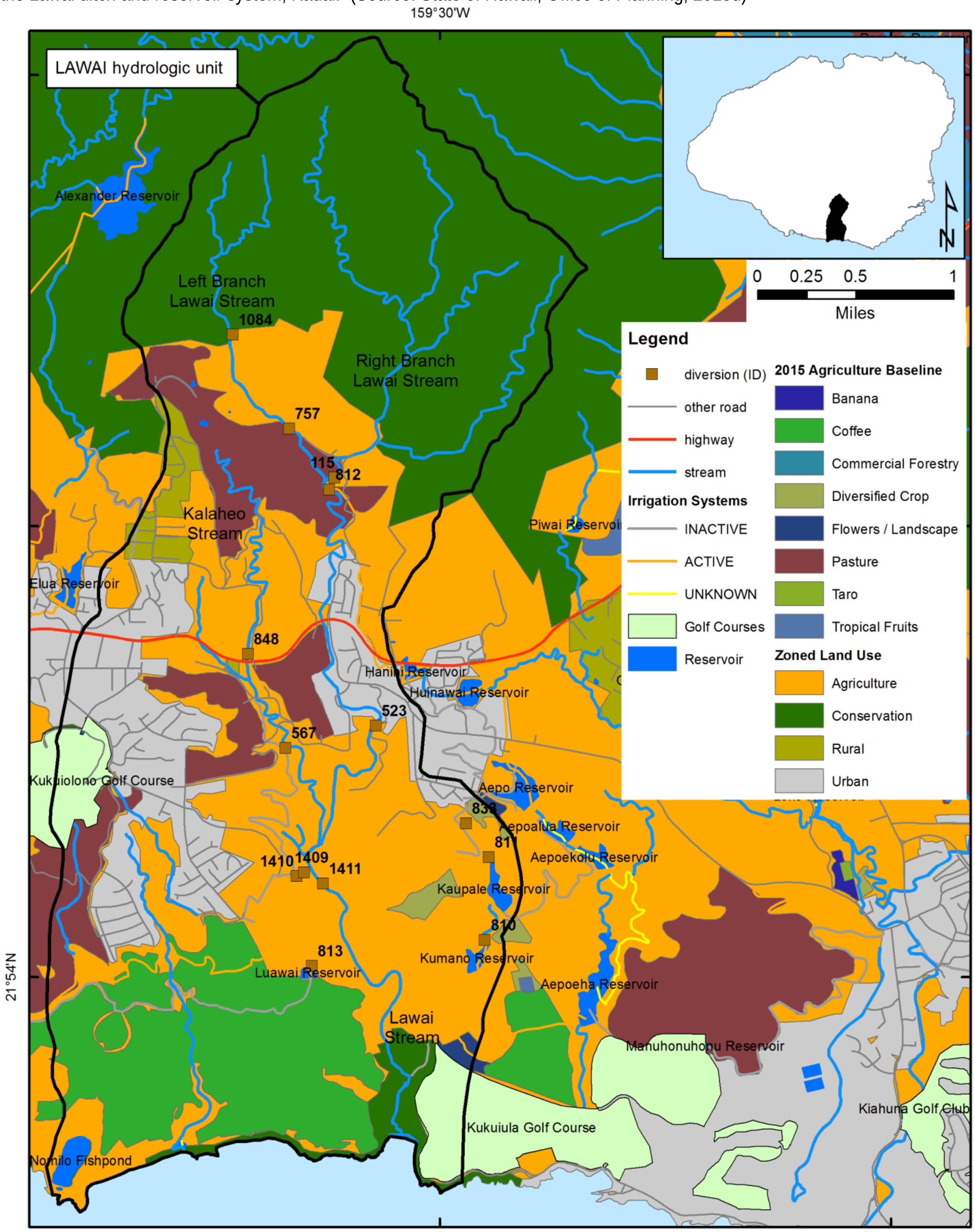


Figure 2-8. C-CAP landcover data for the Lawai hydrologic unit, Kauai. (Source: NOAA Coastal Change Analysis Program, State of Hawaii, Office of Planning 2015)

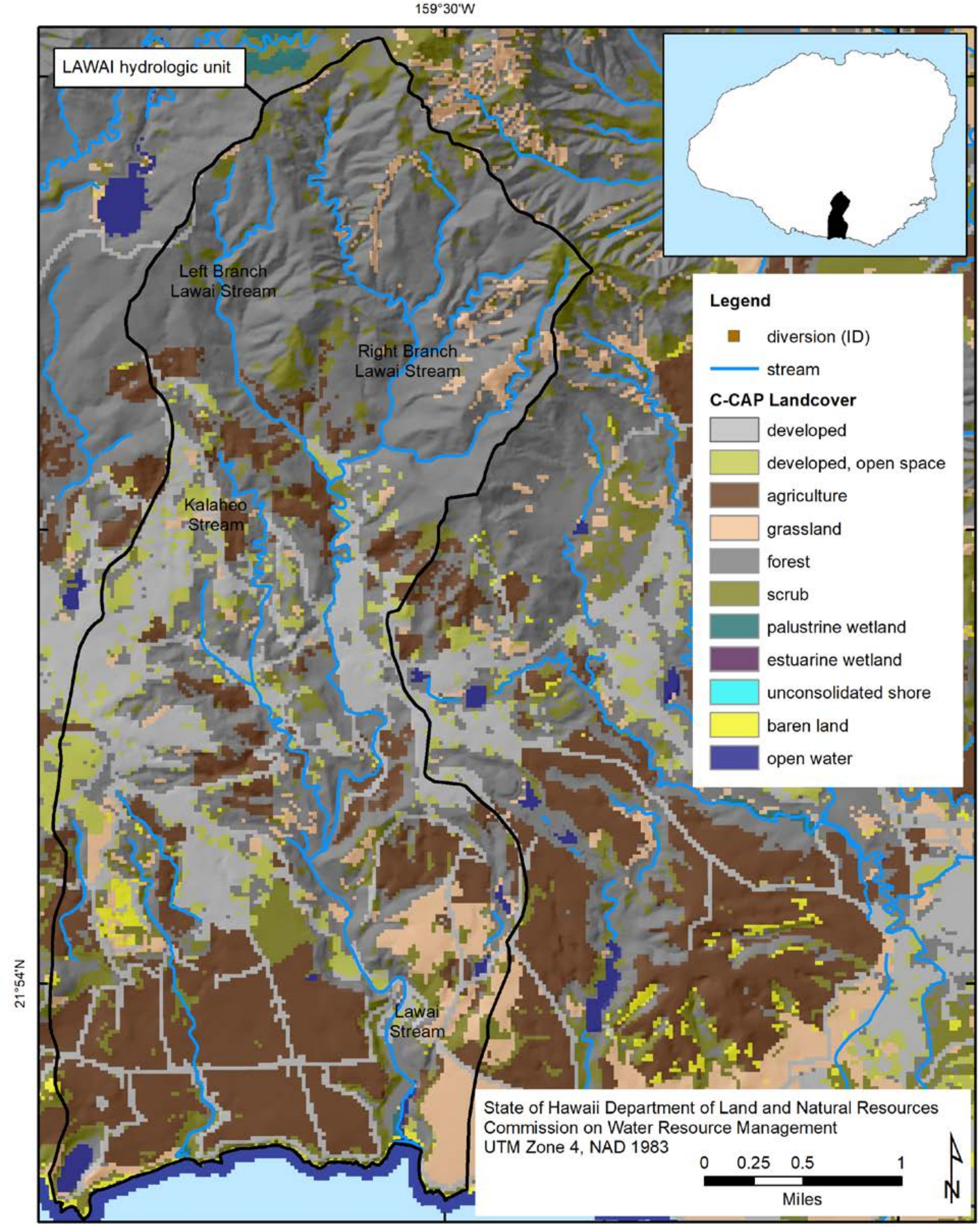
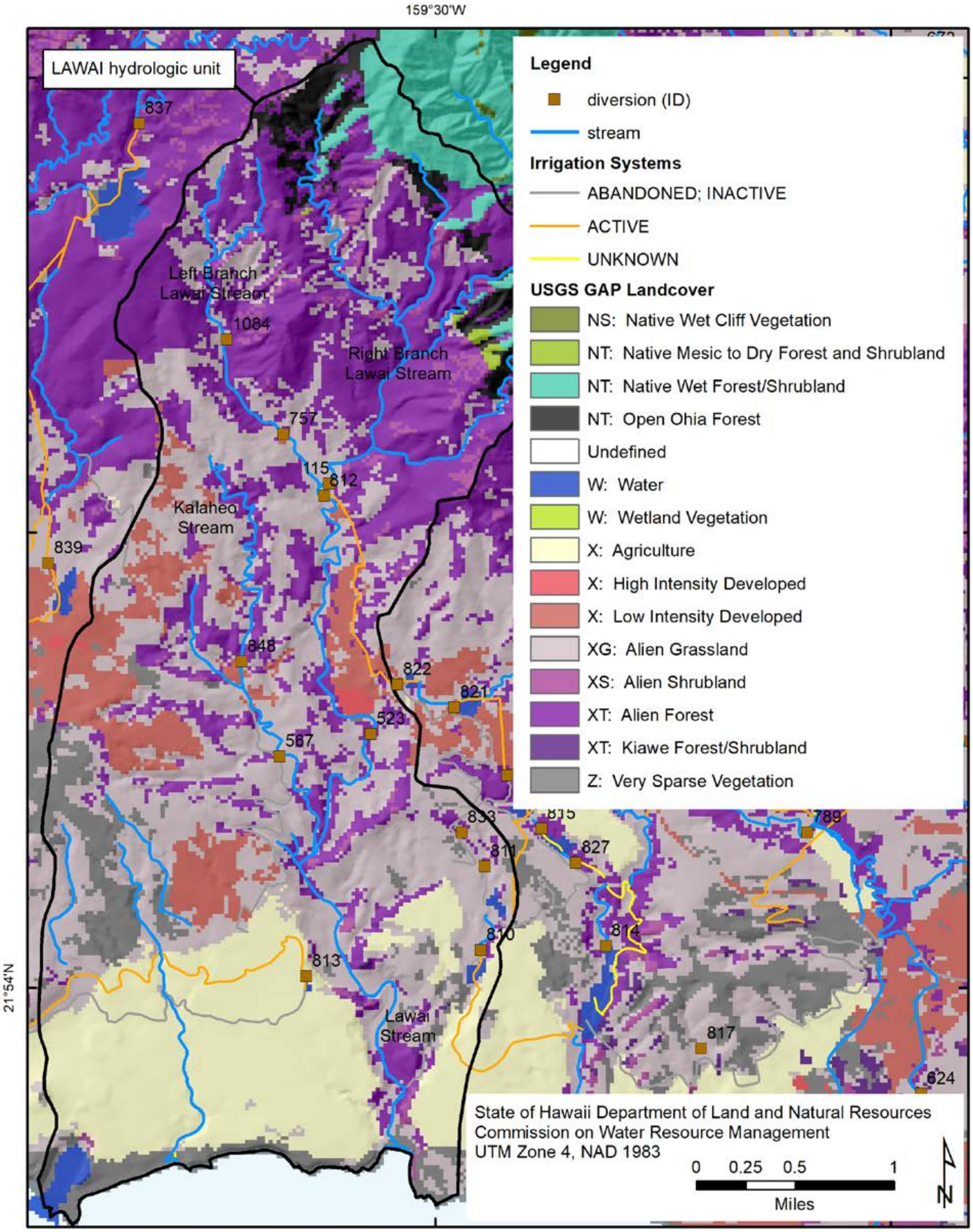


Figure 2-9. USGS GAP landcover analysis for the Lawai hydrologic unit, Kauai. (Source: USGS GAP Analysis, 2012)



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 the entire stream channel. 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.

Peak floods in Lawai have been monitored by USGS since 1962 on the Lawai Stream (USGS station 16052500). The estimated 2-, 5-, 10-, 50-, and 100-year flood magnitudes at these stations is listed in Table 2-1. 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 identified the lower reaches of the Lawai hydrologic unit along the stream channels as flood-risk zone A, (Figure 2-9).

Table 2-1. Estimated peak flood magnitudes (cubic feet per second) for selected recurrence intervals at USGS station 16052500 in Lawai hydrologic unit, Kauai. (Source: Oki et al. 2010)

station ID	station name	2-year	5-year	10-year	50-year	100-year
16052500	Lawai Str nr Koloa	1260	2770	4040	7370	8960

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 recent past 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. 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 Kauai are summarized in Table 2-2.

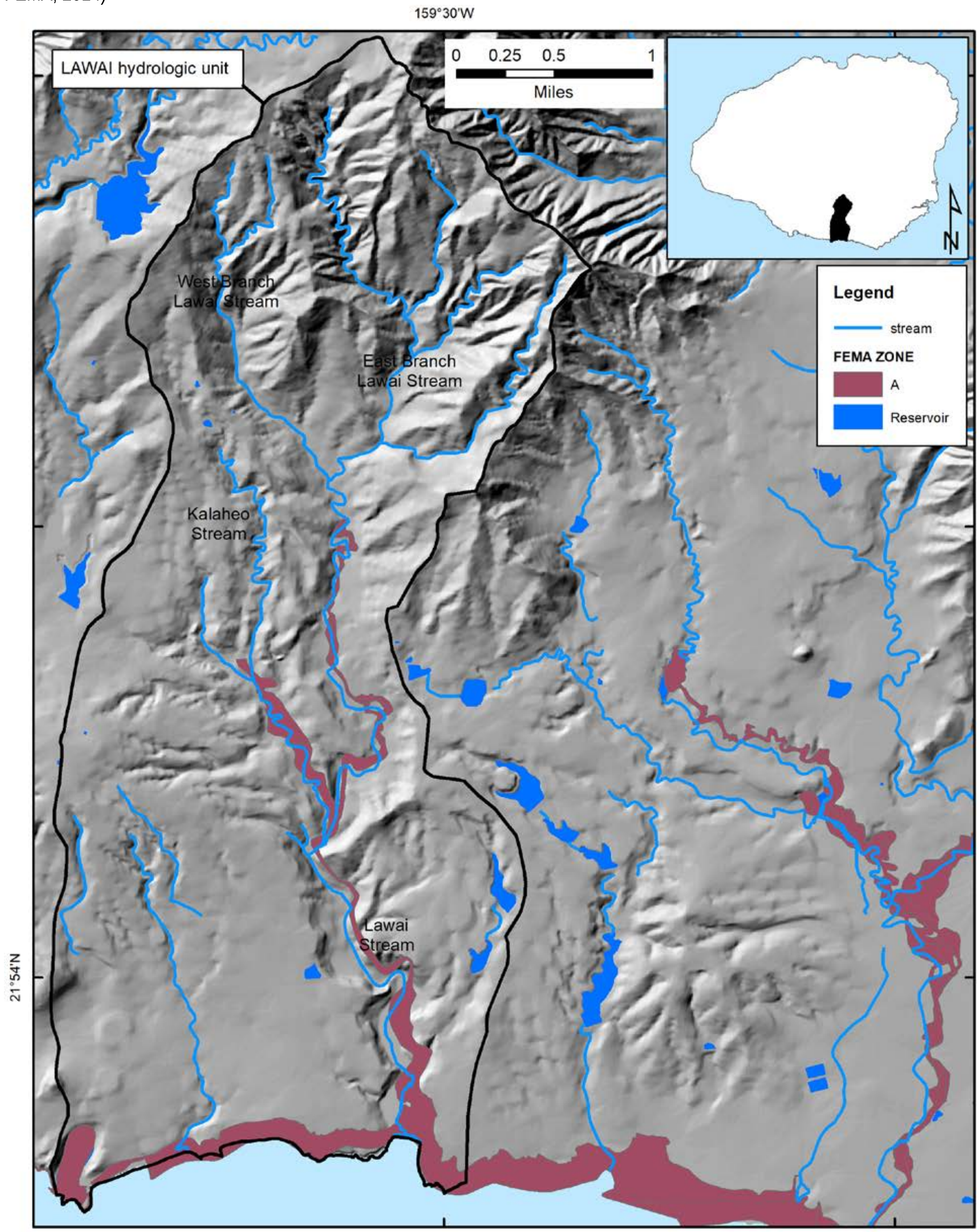
Table 2-2. Drought risk areas for Kauai. (Source: University of Hawaii, 2003)

[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	Hanalei to Alakai	Koloa, Kapaa, Wailua, Lihue, Poipu, Anahola	Kapaa, Wailua, Lihue, Poipu, Hanalei, Princeville, Kilauea, Anahola
Agriculture and Commerce	Waimea, Poipu, Lihue, Anahola, Kekeha/Mana	Lihue	Lihue
Environment, Public Health and Safety	Waimea	Lihue, Poipu, Wailua	Lihue, Poipu, Koloa

Based on the 12-month SPI, the Wailua, Lihue and Koloa regions have the greatest risk to drought impact on Kauai. The growing population in the already densely populated area further stresses the water supply. Water diverted from Lawai serves the Koloa and Poipu region, which are vulnerable to severe and extreme drought in the water supply sector as well as severe drought in the environment, public health and safety sectors.

Figure 2-10. Federal Emergency Management Agency (FEMA) flood risk zone for the Lawai hydrologic unit, Kauai. (Source: FEMA, 2014)



3. Hydrology

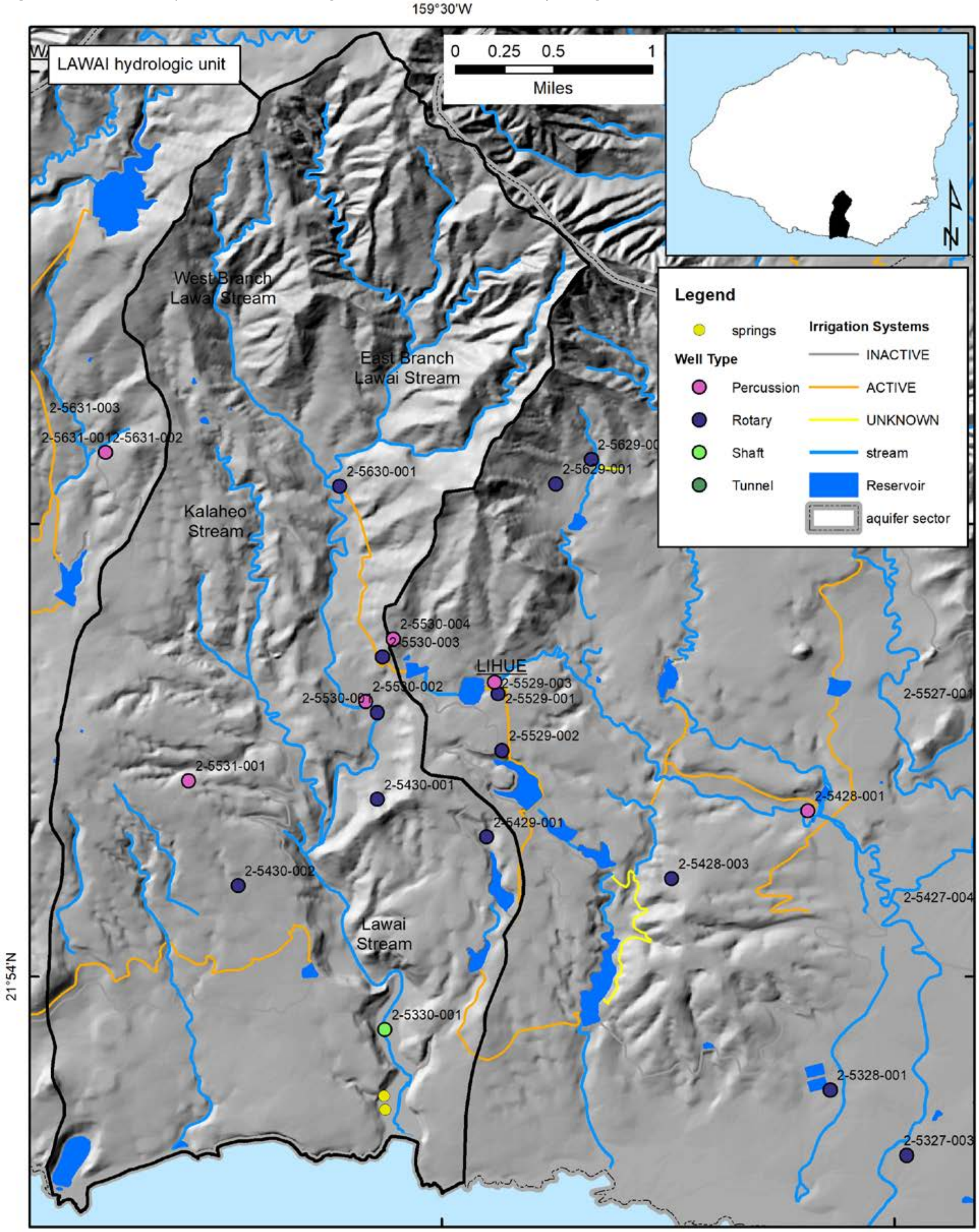
Ground water

Perched water bodies in thin, shallow Kōloa Volcanic series contribute numerous springs and seeps, especially where the rocks are incised by valleys. These are likely to contribute to surface flow of small streams. Many wells in the Kōloa Aquifer System are drilled into these perched bodies at lower elevations (Table 3-1). In a test hole (T-6) near Lawai, a perched water table in the Napali Formation was found standing 120 feet above sea level at a depth of 390 feet. Most wells in Southeast Kauai develop water from the Kōloa Volcanics, but permeability varies widely and high permeability is localized to only a few locations (USGS SIR 01-4200).

Table 3-1. Well number, name, owner, elevation, pump capacity (million gallons per day, mgd), and 10-year mean pumpage (mgd) for the Koloa Aquifer System, Kaua'i. [ABN = abandoned; AGR = Agriculture; UNU = unused; IRR = irrigation; MUNCO = municipal county; MUNPR = municipal private; DOM = domestic; NTBG = National Tropical Botanical Garden]

well number	well name	well owner	ground elevation (ft)	well depth (ft)	pump capacity (mgd)	2009-2018 pumpage (mgd)	water use
2-5226-001	Kaluahonu	Hyatt Regency	26	105	0.648	0.005	IRR
2-5226-002	Secondary Source	Hyatt Regency	11	60	2.880	0.000	UNU
2-5227-002	Waiohai	Marriott	7	27	0.072	0.000	IRR
2-5327-003	Makale'a	Timothy Beckman Trust	80	105	0.052	0.000	IRR
2-5330-001	Lawai Shaft 3 Pump 6	NTBG	26	41	0.194	0.102	AGR
2-5425-015	Koloa F	Kauai Dept of Water	130	377	1.728	0.478	MUNCO
2-5426-001	Koloa Mill A	Grove Farm Co	190	191	--	0.000	ABN
2-5426-003	Koloa	Grove Farm Co	222	576	--	0.000	IRR
2-5426-004	Koloa C	Kauai Dept of Water	157	393	1.728	0.352	MUNCO
2-5426-005	Koloa D	Kauai Dept of Water	222	420	1.728	0.485	MUNCO
2-5427-001	Koloa A	Kauai Dept of Water	245	455	1.728	0.570	MUNCO
2-5427-002	Koloa B	Kauai Dept of Water	245	503	0.806	0.000	MUNCO
2-5427-003	Koloa E	Kauai Dept of Water	244	511	1.008	0.436	MUNCO
2-5428-001	Omao Well	McBryde Resources Inc	249	970	--	0.000	UNU
2-5526-001	Kaluahonu	Grove Farm Co	355	1,010	5.710	0.000	AGR
2-5527-001	Kahoano	Grove Farm Co	358	1,030	5.360	0.000	AGR
2-5529-003	Poelele Pump	McBryde Resources Inc	464	719	5.000	0.827	AGR
2-5530-001	Lawai Cannery	McBryde Resources Inc	499	622	--	0.000	TH
2-5530-002	Kauai Pine Pump	McBryde Resources Inc	440	750	2.200	0.000	AGR
2-5530-003	Lawai 1	Kauai Dept of Water	594	695	0.612	0.181	MUNCO
2-5530-004	Lawai 2	Kauai Dept of Water	662	810	0.792	0.213	MUNCO
2-5531-001	Kalaheo	Kauai Dept of Water	630	952	--	0.000	UNU
2-5628-001	Koloa 610 K-55	Poipu Ranch LLC	439	910	5.360	0.000	IRR
2-5629-001	Piwai 2	Kauai Dept of Water	648	775	1.512	0.275	MUNCO
2-5629-002	Piwai 3	Kauai Dept of Water	656	770	1.512	0.161	MUNCO
2-5631-001	Kalaheo A	Kauai Dept of Water	887	1,125	1.440	0.296	MUNCO
2-5631-002	Kalaheo B	Kauai Dept of Water	892	1,030	1.440	0.338	MUNCO
2-5631-003	Brydeswood 1	A&B Properties, Inc	1,003	1,245	--	0.000	MUNPR

Figure 3-1. CWRM aquifer sectors and registered wells of the Lawai hydrologic unit, Kauai.

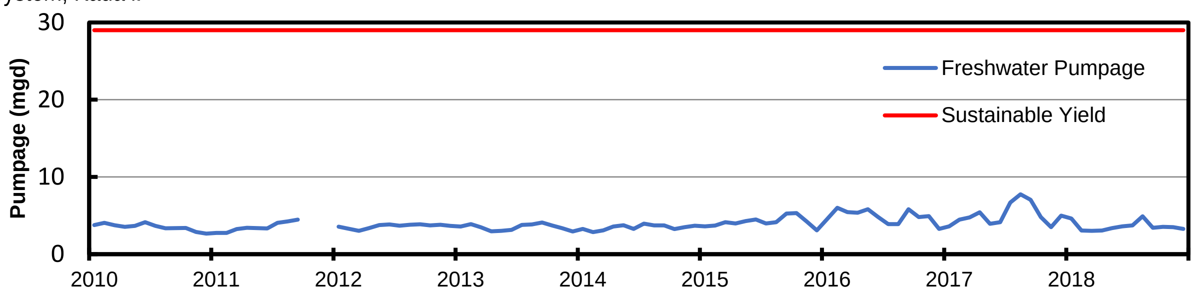


High-level water is not consistent due to the highly varied thickness and distribution of the lavas and do not make for a reliable source. Dike-impoundments may be present in the mountainous north part of the district but not in well-defined patterns.

In the vicinity of Lawai, basal water occurs 60 to 140 feet above sea level in the lava flows of the Napali Formation, but depending on the ground surface elevation, the depth to the basal aquifer could be 300 feet or more (Macdonald et al., 1960). The high basal head in the Napali Formation are the result of the impounding effects of the weathered coastal Kōloa Volcanics. MycBryde Sugar’s shaft 3 (well 2-5330-001) in Lawai Valley, for example, connected 31 drilled wells with tunnels 10 to 15 feet below sea level to a pump sump, averaging about 1.2 mgd. The tunnels also received surface water from Lawai Stream, and thus sediment has likely plugged many of the wells (Macdonald et al., 1960). NTBG continues to use this well.

Kauaʻi County operates 12 groundwater wells in the Kōloa Aquifer System with a total installed pump capacity of 16.034 mgd and a 10-year average pumpage of 3.785 mgd. Other users have current installed pump capacity of 21.344 mgd and a 10-year average freshwater pumpage of 0.929 mgd.

Figure 3-2. Mean daily pumpage (million gallons per day, mgd) and sustainable yield from 2010 to 2018 for the Kōloa Aquifer System, Kauaʻi.



Surface water

The hydrologic characteristics of a stream are critical to determining the interim IFS recommendation. These characteristics indicate the effects of geology, climate, and soils on the flow of water in the stream. Of great importance is the concept of a gaining and losing stream reach. A gaining reach is typically interpreted as where the streambed intersects the underlying water table and groundwater contributes to streamflow as seepage or springs. On Kaua‘i, streams are generally gaining from their headwater reaches at high elevations all the way to the lower elevation reaches. In Lawai, considerable groundwater gains occur from springs emanating from perched bodies. The USGS seepage run on Lawai Stream identified locations and quantities of gains in surface flow (Figure 3-7).

Continuous mauka to makai flow is estimated to naturally occur 100-percent of the time in the main stem of Lawai Stream. However, no long-term continuous gauging stations have existed in the watershed. From 1939 to 1940, USGS made nine low-flow stream measurements on Lawai Stream 0.2 miles upstream of Kaumuali‘i Highway during diverted conditions with a mean flow of 0.23 cfs (0.15 mgd), ranging from 0.14 cfs (0.09 mgd) to 0.38 cfs (0.25 mgd). This likely represents the seepage gain in the stream below diversion 812. USGS operated gage 16052500 on Lawai Stream at 37 ft above sea level from 1963-1972, monitoring regulated flow conditions. The magnitude of the median (Q_{50}) and low- (Q_{70} and Q_{90}) flows were 2.90 cfs (1.87 mgd), 1.88 cfs (1.22 mgd), and 0.81 cfs (0.52 mgd), respectively.

As part of the USGS Southeast Kaua‘i Low-Flow Study, a continuous low-flow monitoring station was installed on the right branch of Lawai Stream (station 16052400), just above the confluence with the left branch, to monitor natural flow. Using basin size estimates for the left branch, flow duration values can be estimated for this tributary. The sum of these two branches provides an estimate of total available water at Lawai Ditch Intake (Diversion 812) (Table 11-2).

Table 3-2. Estimated natural low-flow duration exceedance values for locations in the Lawai hydrologic unit for the current (1984-2013) climate period. [cubic feet per second (million gallons per day)]

USGS station ID	Station	Drainage Area (mi^2)	MAP (in)	Q_{30}	Q_{40}	Q_{50}	Q_{60}	Q_{70}	Q_{80}	Q_{90}
16052400	RB Lawai Stream	2.17	108	3.17 (2.05)	2.50 (1.62)	1.93 (1.25)	1.6 (1.03)	1.26 (0.81)	0.99 (0.64)	0.62 (0.40)
	LB Lawai Stream	0.91	94.7	1.33 (0.86)	1.05 (0.68)	0.81 (0.52)	0.67 (0.43)	0.53 (0.34)	0.42 (0.27)	0.26 (0.17)
	Lawai Stream at Lawai Ditch Intake	3.34	103	4.50 (2.91)	3.55 (2.29)	2.74 (1.77)	2.27 (1.47)	1.79 (1.15)	1.41 (0.91)	0.88 (0.57)

Historically (pre-plantation), Lawai Stream provided excellent habitat for native aquatic fauna. However, the introduction of non-native tilapia and Tahitian Prawn (in the estuary and lower elevation reaches, which prey upon *hinana* recruiting back to the middle and upper elevation stream reaches, suppresses the population of native species.

Another factor in the selection of an interim IFS site is appropriateness of the site selection for monitoring and regulation by Commission staff. For Lawai Stream, immediately below the Lawai Ditch Intake (Diversion 812) the stream channel is not suitable for monitoring. However, approximately 0.68 miles downstream at an old bridge, the channel is straight, with even banks, and a series of large, stable boulders define a gage pool suitable for monitoring streamflow. In July 2018, a staff plate was installed at this location (CWRM gage 2-194) and measurements made at this location are provided in Table 3-3. In August 2018, a real-time continuous monitoring station was installed at this location and mean daily flow for the most recent five months is provided in Figure 3-6. Mean daily flow at this station from April to August 2019 was 1.25 mgd.

Table 3-3. Stage and discharge measurement at CWRM gaging station 2-194 on the Lawai Stream below the Lawai Ditch intake. [cubic feet per second (million gallons per day)]

Date	Time	Stage (ft)	Discharge
7/24/2018	10:15	1.71	0.90 (0.58)
7/30/2018	15:41	2.29	4.41 (2.85)
9/11/2018	11:53	2.06	3.48 (2.25)
10/26/2018	10:30	1.55	0.03 (0.02)
12/5/2018	8:00	1.82	1.86 (1.20)
2/5/2019	15:15	1.92	1.73 (1.12)
3/1/2019	7:50	1.66	0.58 (0.37)
7/30/2019	11:14	1.88	1.19 (0.77)

Figure 3-3. Mean daily flow at the CWRM monitoring station Lawai Stream below Lawai Ditch Intake (2-194).

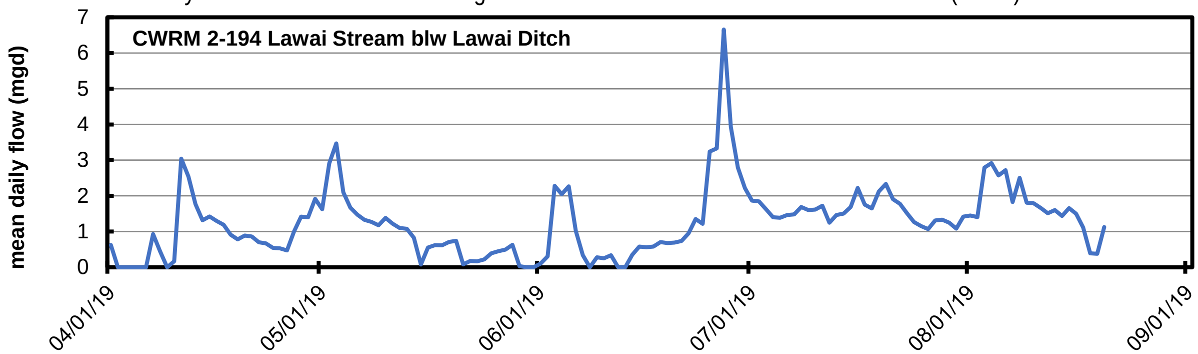


Figure 3-4. Seepage run results from USGS fieldwork August 26, 2019 on Lawai Stream, Kauaʻi.

4. Maintenance of Fish and Wildlife Habitat

Lawai stream would naturally provide mauka to makai streamflow year-round and as such, could provide habitat for freshwater fauna. Previous surveys (2017) by the Division of Aquatic Resources (DAR) found that several native species inhabit middle elevation reaches in Lawai, including ʻoʻopu nōpili (*Sicyopterus stimpsoni*), ʻoʻopu nākea (*Awaous guamensis*), ʻoʻopu akupa (*Eleotris sandwicensis*), āholehole (*Kuhlia xenura*), ʻoʻopu naniha (*Stenogobius hawaiiensis*), ʻōpae ʻoehaʻa (*Macrobrachium grandimanus*) and ʻōpae kalaʻole (*Atyoida bisulcata*). A more recent survey of the Lower Lawai Stream (Kido 2007) provided a comprehensive bioassessment, and rated Lawai's stream habitat as "poor" due to high sediment levels in the stream channel, chronic stream bank instability/erosion, and extreme variability in water flow regimes.

The lowest reaches of Lawai Stream are currently dominated by a variety of non-native aquatic species that were purposefully introduced for recreational fishing and consumption. Species such as the smallmouth (*Micropterus dolomieu*), tilapia (*Oreochromis* spp.), mosquitofish (*Gambusia affinis*), mexican molly (*Poecilia Mexicana*) and Tahitian prawn (*Macrobrachium lar*) are commonly found, preying upon recruiting post-larvae (*hinana*) ʻoʻopu and ʻōpae. Tahitian prawn (*Macrobrachium lar*) and African cichlids (*Oreocromis mossambicus*), are both common and extremely omnivorous, and competing with native aquatic species. A small population of alien atyid shrimp (*Neocardina denticulate sinensis*) is beginning to gain foothold at the lower reach. Native ʻoʻopu species (e.g., *Awaous stamineus*, *Eleotris sandwicensis*, *Sicyopterus stimpsoni*) can be found in a middle elevation reach above Stillwater dam (diversion 1411). While the maintenance and restoration of stream habitat improves with increased streamflow, the presence of non-native species can limit the improvement in habitat available to native species.

5. 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.

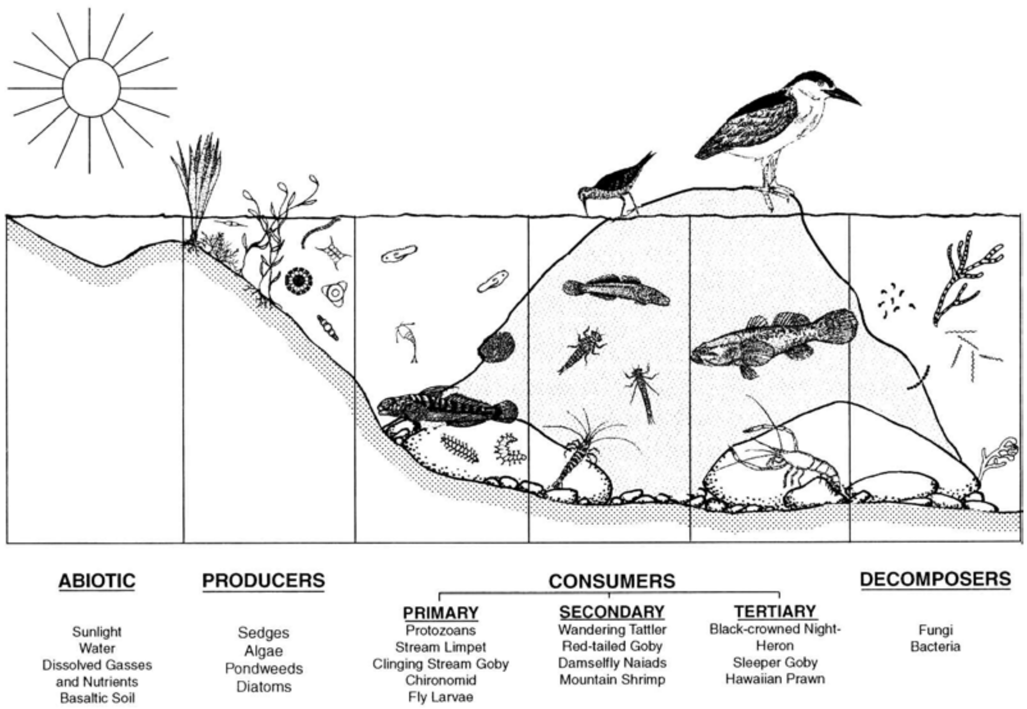
The Lawai hydrologic unit supports swimming, hiking, fishing, hunting, scenic views, and nature study activities. Swimming is common in larger pools in Lawai Stream and its tributaries. There are trails along the stream within the National Tropical Botanical Garden and tourists hike along the streams and banks. Hunting takes place in the upper reaches of the watershed. The Hawaii Stream Assessment identified nine recreational opportunities with four high quality experiences, giving it a regional ranking of outstanding for the Island of Kauai. Restoration of streamflow will increase the appeal of recreational opportunities. Coastal recreational features near the

Lawai hydrologic unit are depicted in Figure 10-1.

6. 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, riparian 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 these resources. 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 Hawaii Stream Assessment indicated the presence of a palustrine wetland with 20% of the overall Lawai watershed remaining in native forest. A more recent survey characterized Lawai Stream as a system that supports a deep estuarine reach and associated wetland features before entering into the ocean at Lawai Bay (Kido 2007). Stream restoration will benefit the estuarine habitat.

The valley is being invaded by hau bush (*hibiscus tiliaceus*) and California grass (*Uroshloa mutica*), with feral pigs feeding on groundcover and uprooting the soil. The valley supports three species of threatened and endangered birds and the National Tropical Botanical Garden maintains a collection of rare plants from Hawaii and across the tropical Pacific region.

7. Aesthetic Values

Lawai Stream supports aesthetic value throughout the watershed, both for the community which lives along its reaches and to hikers and tourists which visit the National Tropical Botanical Garden. Increasing the depth and width of streamflow through restoration will improve the aesthetic value of the stream.

8. Maintenance of Water Quality

Lawai stream is classified by the Department of Health (DO) as Class 1b inland waters in the upper elevations and Class 2 inland waters in the lower elevations. It does not appear on the 2014 List of Impaired Waters in Hawaiʻi, Clean Water Act §303(d), although there was insufficient data to support any conclusions. The abundance of cesspools and non-native mammals in the watershed are likely to contaminate the stream. Restoration of flow will have a small effect on stream temperature below the diversion, but will have little to no effect on microbiological water quality at the mouth of the river. Increased flow may improve the transport of sediment, thus reducing turbidity in some places. From 2001 to 2003, the DOH Clean Water Branch measured various water quality parameters in Lawai Stream (Table 8-1).

Table 8-1. Mean, standard deviation (SD), and sample size of various water quality parameters measured by the State of Hawaii Department of Health Clean Water branch from 2001 to 2003 at one lower (elevation 60 ft a.s.l.) and one upper elevation (1000 ft a.s.l.) site.

	Lower Lawai			Upper Lawai		
parameter	Mean	SD	n	Mean	SD	n
DO (%)	102.4	22.6	12	90.6	13.6	11
ORP (mg L^{-1})	336.0	42.4	8	343.6	24.9	7
pH	8.03	0.39	12	7.59	0.22	11
Salinity (mg L^{-1})	0.12	0.04	12	0.08	0.01	11
SpCond (µS cm^{-1})	0.262	0.078	12	0.166	0.025	11
Temp (°C)	23.66	2.66	12	21.89	2.12	11
Turbidity (mg L^{-1})	11.33	10.04	19	21.20	35.13	17

9. 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 a 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.

Lawai Stream is not used for the conveyance of irrigation or domestic water supplies.

10. 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 ahupuaʻa 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 ahupuaʻa 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, 2001, p.II:8)."

Appurtenant Water Rights

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, Section (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[5] 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.[6] 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.[7] Once established, future uses are not limited to the cultivation of traditional products approximating those utilized at the time of the Mahele[8], 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 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.

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 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 they largely relate 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,

---

[5] 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.
[6] 54 Haw. 174, at 188; 504 .2d 1330, at 1339.
[7] 65 Haw. 531, at 554; 656 P.2d 57, at 72.
[8] *Peck v Bailey*, 8 Haw. 658, at 665 (1867).

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).

Information relating to Pre-Contact Practices

Pre-contact Hawaiian communities cultivated taro along the Lawai Stream throughout the *ahupuaʻa* (Figure 10-1). Many locations have cultural significance and are labeled as such in Figure 10-1.

In *Native Planters in Old Hawaii*, Handy and Handy (1972) mention that…

> There were loi on flats above the sea and along Lawai Stream for a mile or more inland, and behond this were small loi in the narrow valley. In upper Lawai Valley there is no evidence of terracing.
>
> *p. 428*

Of more interest was the saltwater fish pond in Lawai which was famous for its salt pans.

The Hawaii Stream Assessment archeological summary identified six known archeological sites, but there was limited survey coverage and predictability. The National Register of Historic Places identifies the valley as having excellent examples of particular site types, sites that contain important information, and culturally noteworthy sites.

Land Commission Awards

Land Commission Awards (LCA) occurred during the Great Māhele (1848) or when the parcel was transitioned from royal ownership to the fee-simple system (1850s-1890s), when land was redistributed from being the sole property of the King to a division of three categorical types: land belonging to the mōʻī (monarch) as Hawaiian Crown Lands (one-third); land belonging to the aliʻi and konohiki (chiefs and managers of the ahupuaʻa) (one-third); and land belonging to the people (kuleana). During the Māhele, a total of approximately 75 acres of Wailua was awarded to 25 individuals, the most prominent being D. Kapule and Iosia Kauniua-lii, the wife and son of Kaumualaii, the last chief of Kauai (Folk 1990). These awards were all in the lowest reaches of the Wailua Ahupuaa. The large track of forest was kept as Crown Lands or private lands of Kamehameha III (Kauikeaouli).

Land Commission Award claimants may also have legal access to utilize surface water to practice traditional and customary uses of water. The claimants, their Land Commission Award, and one associated tax map key number are listed in (Table 10-1).

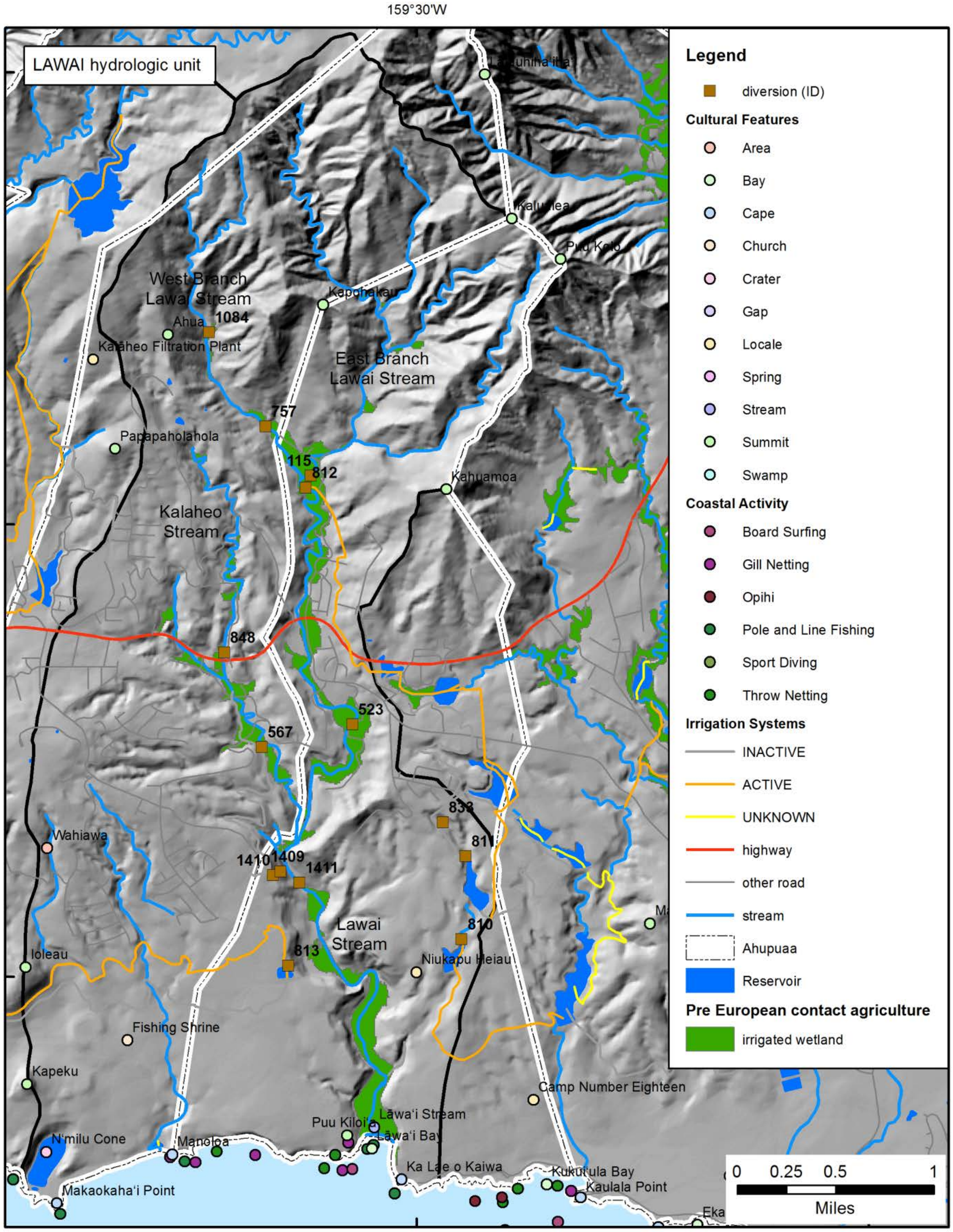
Table 10-1. Land Commission Award (Land Award), Tax Map Key (TMK), current landowner, and claimant in the Lawai Hydrologic Unit, Kauai (Source: www.kipukadatabase.com, 2019)

Land Award	TMK	Landowner	Claimant
43	426002001	Allerton Gardens Tr In HI	Kanehoa, John Young
3414:1	426002001	Allerton Gardens Tr In HI	Levi
3417:1	426002001	Allerton Gardens Tr In HI	Pehuiki
9188	426002001	Allerton Gardens Tr In HI	Kamakahookahi
43	426001010	Camara, Jason M	Kanehoa, John Young
7682	426001010	Camara, Jason M	William Aarona
7814	426001010	Camara, Jason M	Pako Gaia
10080	426001014	Camara Family Trust	Joe Gomes Companario
8054	426001015	McKnight, Aaron T	Ehu
6636	426001017	McKnight, Aaron T	Emma K. Kanehiwa
7806	426001006	Iwipoo Hillside Dream Condo	Manuel Brun
3612	426001020	Ventura, Valerie J Trust	Kahookahi
6829	426001019	Turville, Gay A	Francisco C. Sasules
6727	423009034	National Trop Bot Garden	Ai Imada
6745:2	423009011	National Trop Bot Garden	Ohule
6219	426001023	De La Pena, Ryan	Kioshi Yamamoto
6745:1	423009033	Kaneko, Toshio Trust	Ohule
5378	423001053	Yoshimori, Guy T	Joe Tavares
5666	423001012	Scales, Garrett P Jr	John Torres
5665	423001011	Ishiguro, Robert & Luz Rev Living Trust	Christina Gomes
6647:2	423002022	McCurley, Dallas L & Adair, William G Trust	Una
6145	423001042	Souza, Rolwand C Self-Trusteed Trust	Willie Souza
6570	425004002	Hop Hing Co	Palauhe
7038	423001046	Manu Corporation	Henry Dominici
10782	423001017	Unknown	Manuel and Augusta Andrade
6956	424001083	Na Hale Oʻkuli Condominium	Louis Dominici Rodrigues
6511	425003001	Silva, Joyce A Trust	Mary Silva
6322	424001079	Nitta, Keith	Cruciano Dominici
6534	425003029	Bukoski, Lynda C W	Seichi Yamamoto
6778	425003046	Shinagawa, Steven/Carol Trust	Kioshi Yamamoto
9930	425006019	Medeiros, Bernard & Charlene A	Manuel P. Medeiros
7371	425006024	Andrade, Manuel H & Phyllis J Living Trust	Whiston Kaulili
12070	425006009	Andrade, Mauel H Sr & Phyllis J Trust	Antone Andrade
7790	425003003	Factora, Debra F	Nicola Vegas
6544	424002028	Medeiros, Robert C Jr	Justo Perepena
7154	424001011	D A & S N Baby Angels LLC	Perico Rodrigues
7131	424001074	Liechty, George S Trust	Joe Martin
3396 B:1	424001010	Tausend, Peter C	Kihei, S.
6765	425002025	Lloyd Estates	John Silva
7638	425003035	Kaioli Condominium	Placido Perez
7922	425002047	Hoʻokaulana Kauai LLC	Joe Abreu
6766	425002026	Abreu, Kalani & Jolleen Rev Living Trust	John G. Abreu
6998	424002009	Wawae Road Kalaheo Real Estate LLC	Flora Vegas Toledo
6931	424001008	Landagora, Candida P	Frank Jordan
7257	425002035	Wendt, Mahealani P	Serafinea R. Borero
6693	424002008	Lawai Mauka	Ramon Feliciano
9866	425002062	Lawai Properties Ltd	Helen G. Barrero
6798	425002035	Wendt, Mahealani P	Manuel J. Martin
9141	424002007	Matias Condominium	Loui Matia
11868	425002012	Bodine, Carolyn J Trust	Keizo Kashiwabara
6223	425002042	H and H Kauai LLC	Kianiui Paris
10323	425006010	De Costa, Joseph J Jr	Louisa Hellum
12070	425006009	Andrade, Manuel H Sr & Phyllis J Trust	Antone Andrade
7715	425003043	Akemama Hale Estates	Mary E. Souza

Ahupuaa and Aha Moku Systems

In ancient Hawaii, the island regions (*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, 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 Lawai is fully within the ahupuaa of Lawai as shown in Figure 10-1. The ahupuaa boundaries are delineated based on the USGS Digital Line Graphs. These boundaries may be different from the information listed on legal documents such as deeds.

Figure 10-1. Cultural features, coastal activities, and distribution of pre-European contact agriculture in the Lawai Hydrologic Unit, Kaua'i.



11. Noninstream uses

The *ahupaʻa* of Lawai is west of Kōloa in the Moku of Kona in Southeast Kauaʻi. While historically, the region supported some of the oldest, and most productive sugarcane plantations, today, the region supports residential, small diversified agriculture, and resort facilities.

The McBryde Sugar Co., Ltd. (McBryde Sugar) operated from 1899 to 1996, with lands extending along the southern coast of Kauaʻi from Eleʻele to Kōloa. McBryde Sugar formed by the merging of Eleele Plantation, McBryde Estate, and Koloa Agricultural Company. From the beginning, the lack of water and extremely rocky terrain were clear limitations to the company's success. To increase water availability, pumps were used to bring surface water from Hanapepe Valley and basal ground water up to the plantation. Hydroelectric power plants were built on Wainiha and Wahiawa streams to meet the large electrical demands that these pumps required. Hanapepe, Wahiawa, and Lawai streams were all diverted for sugarcane irrigation. To attract European laborers, homestead lands in Lawai Valley and Kalaheo were developed, encouraging diversified agriculture.

On April 29, 2015, the Commission authorized the Chairperson to enter into a Joint Funding Agreement between the Commission and the United States Geological Survey (USGS) for a cooperative study to assess low-flow characteristics for streams in Southeast Kauaʻi, spanning watersheds from Wailua to Hanapepe (Cheng 2016). The agreement was then signed on May 5, 2015. The study is anticipated to be completed in the second quarter of calendar year 2020, with substantial fieldwork completed by the third quarter of calendar year 2019. This agreement is supporting fieldwork, data analysis, and documentation resulting in the production of a USGS Scientific Investigations Report. Because the fieldwork and analysis is ongoing, only point measurement data, continuous low-flow gaging data, and completed seepage run data that have been made available through the National Water Information System (https://waterdata.usgs.gov/nwis) as well as historical data, were compiled for this recommendation.

In 2015, Commission staff began to research the history of individual diversions and irrigation systems in Southeast Kauaʻi. The Lawai Ditch was used to bring water from Lawai Stream to Koloa- and McBryde Sugar-owned land to grow sugarcane.

In total, there are 14 diversions in the Lawai hydrologic unit; however, four are earthen reservoirs in dry gulches. With the passage of the Hawaiʻi State Water Code, these diversions were registered, with the instream flow standard adopted as status quo in 1988 (Table 11-1).

Table 11-1. Registered diversion ID, file reference name, registrant, tax map key (TMK) number, flow rate, and their registered primary use in or near the Lawai hydrologic unit. [-- = not available]

ID	File reference	Registrant	Year Built	TMK	flow rate (mgd)	Primary Use	type
115.2	COFFMAN R	Richard Coffman	1963	4-2-5-002:007	0.0072	diversified agriculture	pipe in Lawai Stream
523.2	HOP HING CO	David Chang	--	4-2-5-004:002	0.005	diversified agriculture	pump in Lawai Stream
567.2	KANEKO T	Rancho Kaneko	--	4-2-3-002:023	0.001	livestock pasture as needed	pump in Kalaheo Stream
757.2	MATIAS S	Kauai Stables	--	4-2-4-002:007	--	3 acres of diversified agriculture	dam in Lawai Stream at Margo's Pond
810.2	MCBRYDE SUGAR	Randy Hee	1902	4-2-6-003:028	storm water (49 mg)	Kumano Reservoir	Reservoir 20 in Kekee Gulch
811.2	MCBRYDE SUGAR	Randy Hee	1958	4-2-6-003:030	storm water (73 mg)	Kaupale Reservoir	Reservoir 21 in Kekee Gulch
812.2	MCBRYDE SUGAR	Randy Hee	1925	4-2-5-002:018	1.65	Irrigation	Lawai Ditch intake on Lawai Stream
813.2	MCBRYDE SUGAR	Randy Hee	1915	4-2-3-010:010	storm water (9 mg)	Lua wai Reservoir	Reservoir 15 from Pump 3 Ditch
822.2	MCBRYDE SUGAR	Randy Hee	1920	4-2-5-004:026	storm water (14 mg)	Hanini Reservoir	Reservoir 7 from Lawai Ditch
833.2	MCBRYDE SUGAR	Adam Killerman	--	4-2-6-003:030	1.00	diversified agriculture	504 Spring
848.2	MEDEIROS G	Gilbert Medeiros	1882	4-2-4-001:016	--	0.22 acres of *lo'i* kalo	Kalaheo auwai
1084.2	SWAIN AM&TP	Anna May N Palama Swain	--	4-2-4-003:019	--		unused
1409.2	NATL TROP BOT	Gregory Koob	1980	4-2-5-004:030	--	landscaping	Four-house Canyon Dam on tributary
1410.2	NATL TROP BOT	Gregory Koob	--	4-2-5-004:030	--	landscaping	Maidenhair Falls dam on tributary
1411.2	NATL TROP BOT	Gregory Koob	1920s	4-2-5-004:030	--	landscaping	Stillwater Dam

Towards the closure of McBryde Sugar in 1996, the operation of the Lawai Ditch and its diversion on Lawai Stream were transferred to McBryde Resources, Inc, (McBryde) a subsidiary of Alexander & Baldwin. Despite the cessation of sugarcane cultivation, streamflow has continued to be diverted by McBryde for irrigation of developments in the Kōloa region.

The McBryde Sugar and McBryde maintained continuous flow monitoring stations on the Lawai Ditch for extended periods of time: data at the ditch outlet into Hanini Reservoir was reported during the registration period; ditch flow just below the intake is currently reported monthly to the Commission (Table 11-2).

Table 11-2. Off-stream ditch gaging in million gallons per day (mgd) for the Lawai Ditch.

Station name	period of record	mean (±SD) flow (mgd)	median flow (mgd)
Lawai Ditch at Hanini Reservoir Flume	Jan 1983-Dec 1987	1.65 (± 1.25)	1.40
Lawai Ditch at Lawai Intake	Jan 2016-Jun 2019	0.56 (± 0.32)	0.49

Following a flood event in the fall of 2013, in which erosion cut a path around diversion 812 on the right bank, repairs were made to the concrete structure to maintain the original head behind the diversion dam. Commission staff has received a number of informal and formal complaints and inquiries (e.g., phone calls, letters, emails) regarding instream flow standards for this stream.

Diversion 115

Richard Coffman registered a diversion to irrigate 3.5 acres of diversified agriculture, specifically for nursery, banana, and citrus. His son-in-law, Keith Silva, now operates it for nursery, bananas, and hemp, using approximately 7200 gallons per day.

Diversion 523

Hop Ching Co. registered a diversion to irrigate 2 acres of land for landscaping and bananas. The diversion was estimated to draw 5,000 gallons of water each month. They also planned to have aquaculture (catfish) at the time. CWRM staff attempted to contact land owner for updated information but was unsuccessful.

Diversion 567

Toshio Kaneka registered a 3.5 hp pump from Kalaheo Stream via a 2" pipe for watering livestock and to irrigate 3 acres of pasture during summer months. CWRM staff attempted to contact land owner for updated information but was unsuccessful.

Diversion 757

Shyrl Matias registered “Margo’s Pond” on Lawai Stream, a diversion constructed of stone, to irrigate 3 acres of diversified agriculture and pasture using approximately 1000 gallons per day in the summer months as needed basis. CWRM staff attempted to contact land owner for updated information but was unsuccessful.

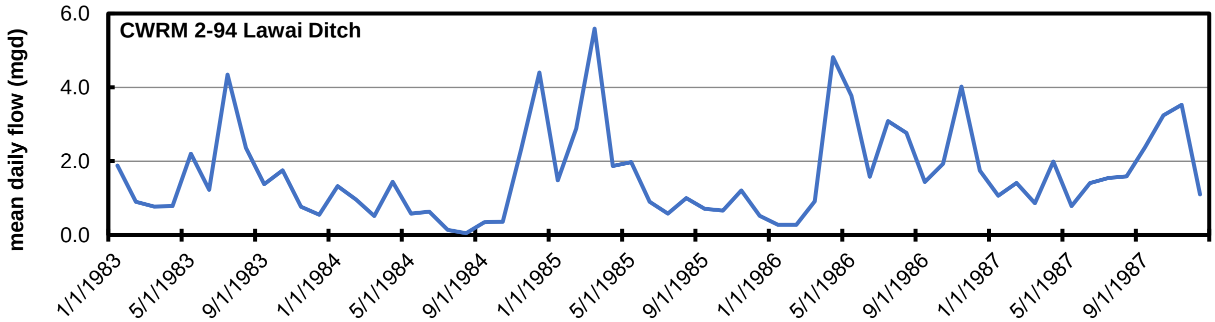
Diversions 810 (Kumano Reservoir), 811 (Kaupale Reservoir), 813 (Lua wai Reservoir), and 822 (Hanini Reservoir)

McBryde registered these four reservoirs since the dam captures runoff from storm water. Kumano Reservoir (49 million gallon capacity) and Kaupale Reservoir (73 million gallon capacity) receives water from Kekee Gulch; Lua wai Reservoir (9 million gallon capacity) from Pump 3 Ditch; and Hanini Reservoir (14 mg capacity) from Lawai Ditch.

Diversion 812

McBryde Sugar built this concrete and rock dam to supply water for sugarcane irrigation for their Kōloa fields. Registered mean and median water use in the 1980s was 1.65 mgd and 1.40 mgd, respectively (Table 11-2). McBryde currently uses this diversion for irrigation needs in the Kōloa and Poi‘pū region. A small amount of water is used for diversified agriculture. The Lawai Ditch is connected to multiple reservoirs which have the capacity to service non-potable water for a variety of uses, including agricultural irrigation, golf course and resort irrigation, and luxury home irrigation. The current land-use zoning identifies the agriculturally zone lands, golf courses, and urbanized areas of the Kōloa- Poi‘pū region, which are within the service area of the reservoirs fed by the Lawai Ditch (Figure 8).

Figure 11-1. Monthly mean daily flow in Lawai Ditch at Hanini Reservoir as registered by McBryde Sugar Co. (Source: REG.812.2)



Diversion 833

McBryde Resources registered 504 Spring as a diversion for the irrigation of watercress. It is currently listed as “abandoned.”

Diversion 848

Gilbert Medeiros registered the diversion and *auwai* water Kalahia Puukalulu Stream to irrigate approximately 0.22 acres of *lo‘i kalo*. CWRM staff attempted to contact land owner for updated information but was unsuccessful.

Diversion 1084

Anna May Palama Swain registered her rights claim for an *auwai* from Kaeahua Stream (left branch of Lawai Stream), although at the time of registration, there was no existing usage of water.

Diversion 1409 (Four-House Canyon Dam) and 1410 (Maidenhair Falls Dam)

The National Tropical Botanical Garden (NTBG) registered these two dams on a small tributary formed by spring flow and runoff along the eastern ridge of Lawai Valley. The springs emanate from perched water bodies in the thin Koloa Volcanic series and do not contribute much to the natural flow of Lawai Stream. The water is used for landscape irrigation of the NTBG.

Diversion 1411 (Stillwater Dam)

The NTBG used to pump water from Lawai Stream at this diversion to irrigation the botanical gardens. However, water is now gravity fed from Luawai Reservoir at the end of Pump 3 Ditch (from Hanapepe River) to meet this irrigation demand and no water is used from this diversion.

Figure 11-2. Agricultural land use and land use zoning for the Lawai-Koloa-Poipu area with major roads and irrigation systems.

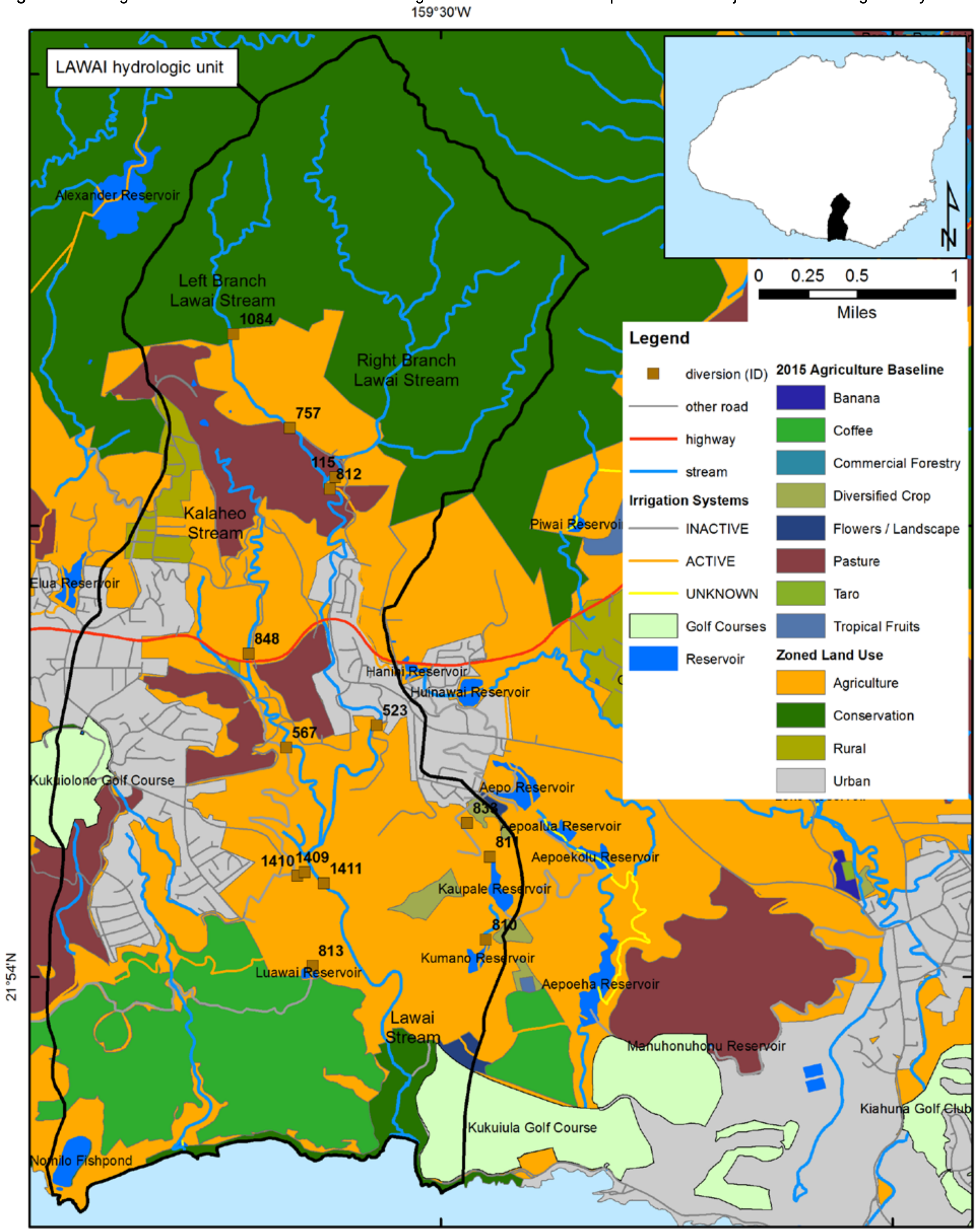
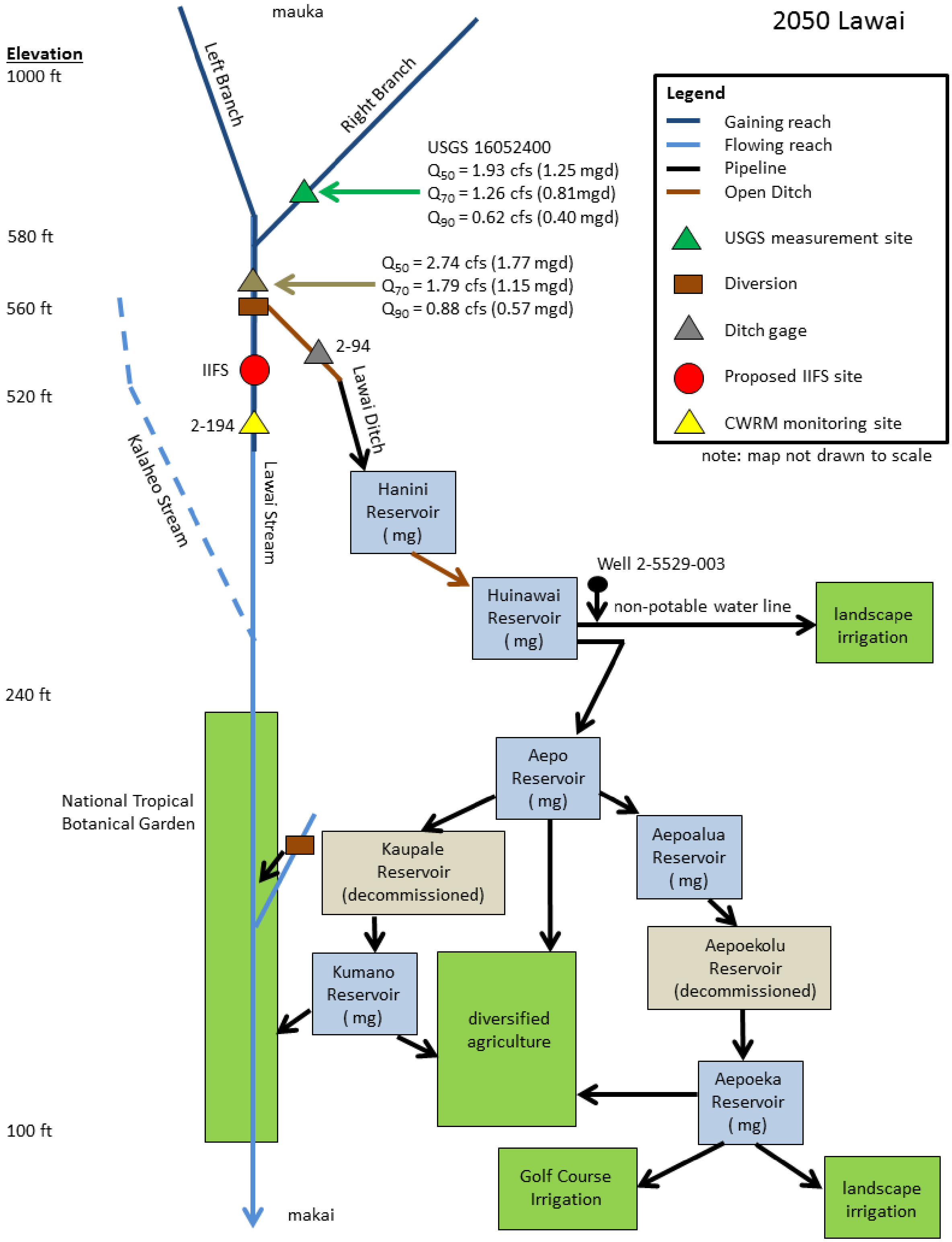


Figure 11-3. Simplified schematic diagram of the Lawai Stream, registered surface water diversions, ditches, pipelines, reservoirs, and proposed location of the interim IFS in the Lawai Hydrologic Unit, Kaua'i.



12. Other Public Trust Uses of Water

IMPACT TO HAWAIIAN HOME LANDS

The Department of Hawaiian Home Lands (DHHL) does not have any land holdings in or near Lawai which would benefit from either instream flow standards or the use of water through the Lawai Ditch.

IMPACT TO MUNICIPAL WATER SUPPLY

The Lawai Stream does not provide water for the County of Kaua‘i Department of Water Supply municipal system, nor does it provide water for any private drinking water systems.

13. AVAILABILITY OF ALTERNATIVE WATER SUPPLIES

While it is the Commission’s policy that water use should be matched to the quality of water needed, outside of water management areas, the Water code does not preclude non-potable water use for agriculture, landscape and golf course irrigation, or other non-potable needs. Currently, groundwater is used for many meet non-potable needs, especially where stream flow is not reliable due to seasonally varied rainfall patterns. The Poelele Pump (well # 5529-003) is located immediately next to Huniawai Reservoir on the Lawai Ditch and is currenlty used to supplement surface water to meet non-potable water needs in the Po‘ipū-Koloa region. The installed pump capacity for this well is 5.000 mgd and the 10-year average pumpage is 0.827 mgd. A number of irrigation wells along the coast pump brackish water for golf course irrigation.

It is the Commission’s policy to promote the viable and appropriate reuse of recycled water insofar as it does not compromise beneficial uses of existing water resources. While the Hawaii State Department of Health has jurisdiction and authority over wastewater reclamation and reuse in Hawai‘i, and the Commission does not have the authority to mandate recycled water use, the availability of recycled water as an alternative to surface water use is carefully considered. The Kōloa-Po‘ipū region is a rapidly growing tourist-centered development which supports golf-courses, resorts, and luxury home development. The region originally relied on decentralized wastewater treatment facilities and injection wells to treat resort wastewater, but in the last decade, the county has built the Kōloa-Po‘ipū regional wastewater reclamation facility (Regional WRF). The first phase of the regional WRF was completed in 2010 with a designed average daily flow (ADF) of 0.6 mgd; the second phase was competed in 2015 to expand the capacity to 1.1 mgd ADF; and the full buildout will have a capacity of 1.7 mgd ADF. The R-1 quality effluence generated by the Regional WRF is used to irrigate a variety of existing golf courses and resorts: Po‘ipū Bay Golf Course (0.1 mgd), Kiahuna Golf Club (0.36 mgd), Koloa Landing and the Po‘ipū Beach Wyndham Grand Resort Hotel (0.4 mgd), Kukui‘ula Resort and Residential Community, and Kukui‘ula Golf Course.

14. Bibliography

Cheng, C.L., 2016, Low-flow characteristics for streams on the Islands of Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i, State of Hawai‘i: U.S. Geological Survey Scientific Investigations Report 2016-5103, 36 p., http://dx.doi.org/10.3133/ sir20165103.

Ekern, P.C., and Chang, J-H. (1985). Pan evaporation: State of Hawaii, 1894-1983. Hawaii Department of Land and Natural Resources, Division of Water and Land Development, Report R74, p.1-3, 38-48.

Federal Emergency Management Agency. (2014). FEMA Flood Hazard Zones. Retrieved August 2015, from Hawaii State GIS Web site: http://hawaii.gov/dbedt/gis/data/dfirm_metadata.htm

Folk, W.H. (1990). A cultural Resources Reconnaissance for the Wailua River Hydropower Study. Addendum 6, Prepared for Ecosystem Research Institute.

Giambelluca, T.W., Nullet, M.A., Ridgley, M.A., Eyre, P.R., Moncur, J.E.T., and Price, P. (1991). Drought in Hawaii. State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, Report R88, 232 p.

Giambelluca, T.W., Shuai, X., Barnes, M.L., Alliss, R.J., Longman, R.J., Miura, T., Chen, Q., Frazier, A.G., Mudd, R.G., Cuo, L., Businger, A.D. (2014). Evapotranspiration of Hawai‘i. Final report submitted to the U.S. Army Corps of Engineers—Honolulu District, and the Commission on Water Resource Management, State of Hawai‘i.

Giambelluca, T.W., X. Shuai, M.L. Barnes, R.J. Alliss, R.J. Longman, T. Miura, Q. Chen, A.G. Frazier, R.G. Mudd, L. Cuo, and A.D. Businger. 2014. Evapotranspiration of Hawai‘i. Final report submitted to the U.S. Army Corps of Engineers—Honolulu District, and the Commission on Water Resource Management, State of Hawai‘i.

Giambelluca, T.W., and Nullet, D. (1992). Influence of the trade-wind inversion on the climate of a leeward mountain slope in Hawaii. Climate Research, 1, p. 207-2126.

Handy, E.S.C., Handy, E.G., and Pukui, M.K. (1972). Native Planters in Old Hawaii: Their Life, Lore, and Environment. Bishop Museum Press, Honolulu, Hawaii: Bernice P. Bishop Museum Bulletin 233, 676 p.

Kido, M. 2007. A biological and habitat assessment of Lower Lawai Stream, Kauai. Final technical report to The National Tropical Botanical Garden, June 2007. Hawai‘i Stream Research Center, Univ. Hawai‘i. 17 pp.

Kumu Pono Associates. (2001). Wai o ke ola: He wahi mo‘olelo no Maui Hikina, Oral history interviews with families of Hāmākua Poko, Hāmākua Loa and Ko‘olau, East Maui: Prepared for East Maui Irrigation Company, 512 p.

Lau, L. S. and Mink, J. F. (2006). Hydrology of the Hawaiian Islands. Honolulu: University of Hawaii Press, 274 p.

Macdonald, G. A., Davis, D. A. and Cox, D. C. (1960). Geology and groundwater resources of the island of Kauai, Hawaii. Haw. Div. Hydrog. Bull. 13, 212 p.

Nullet, D. (1987). Energy sources for evaporation on tropical islands. Physical Geography, 8: p. 36-45.

Nullet, D., and Giambelluca, T.W. (1990). Winter evaporation on a mountain slope, Hawaii. Journal of Hydrology: 112, p. 257-265.

Shade, P.J. (1999). Water budget of East Maui, Hawaii, U.S. Geological Survey Water Resources Investigations Report 98-4159, p. 36.

Sherrod, D.R., Sinton, J.M., Watkins, S. E., and Brunt, K.M. (2007). Geological Map of the State of Hawaii: U.S. Geological Survey Open-File Report 2007-1089, 83 p., 8 plates, scales 1:100,000 and 1:250,000, with GIS database. U.S. Geological Survey.

Scholl, M.A., Gingerich, S.B., and Tribble, G.W. (2002). The influence of microclimates and fog on stable isotope signatures used in interpretation of regional hydrology: East Maui, Hawaii. Journal of Hydrology, 264 (2002), p. 170-184.

State of Hawaii, Commission on Water Resource Management. (2005a). Commission on Water Resource Management surface-water hydrologic units: A management tool for instream flow standards. Department of Land and Natural Resources, Commission on Water Resource Management, Report PR-2005-01, 111 p.

State of Hawaii, Commission on Water Resource Management. (2005b). Hawaii Drought Plan 2005 Update. State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, p. 1-1 to 5-4.

State of Hawaii, Commission on Water Resource Management. (2007). Hawaii Water Plan: Water Resource Protection Plan, Public review draft. Department of Land and Natural Resources, Commission on Water Resource Management, 557 p.

State of Hawaii, Commission on Water Resource Management. (2015a). Irrigation Ditch GIS Layer [Database file]. Retrieved July 2015.

State of Hawaii, Commission on Water Resource Management. (2015b). Water Management Software to Estimate Crop Irrigation Requirement for Consumptive Use Permitting In Hawaii. Department of Land and Natural Resources, 61 p.

State of Hawaii, Commission on Water Resource Management. (2015c). Surface-water hydrologic unit GIS data layer. Department of Land and Natural Resources, Commission on Water Resource Management. Retrieved July 2015.

State of Hawaii, Division of Aquatic Resources. (2017). Point-quadrat survey and other resources database. Accessed February 2017.

State of Hawaii, Office of Planning. (2004). Coastal resources [GIS data file]. Retrieved December 2007, from Hawaii Statewide GIS Program Web site: http://hawaii.gov/dbedt/gis/cstrsrc.htm

State of Hawaii, Office of Planning. (2004). Critical habitat [GIS data file]. Retrieved December 2007, from Hawaii Statewide GIS Program Web site: http://hawaii.gov/dbedt/gis/criticalhab.htm

State of Hawaii, Office of Planning. (2004). Ditches [GIS data file]. Retrieved December 2007, from Hawaii Statewide GIS Program Web site: http://hawaii.gov/dbedt/gis/ditches.htm

State of Hawaii, Office of Planning. (2005). Division of Aquatic Resources (DAR) stream [GIS data file]. Retrieved July 2015, from Hawaii Statewide GIS Program Web site: http://hawaii.gov/dbedt/gis/streams.htm

State of Hawaii, Office of Planning. (2004). Vegetation [GIS data file]. Retrieved December 2007, from Hawaii Statewide GIS Program Web site: http://hawaii.gov/dbedt/gis/veg.htm

State of Hawaii, Office of Planning. (2015). C-CAP Land Cover Analysis: Impervious Surface and Land Cover Data [GIS data file]. National Oceanic and Atmospheric Administration, Coastal Services Center. Retrieved July 2015, from Hawaii Statewide GIS Program Web site: ftp://ftp.gap.uidaho.edu/products/Hawaii.zip

State of Hawaii, Office of Planning. (2015). census blocks [GIS data file]. Retrieved July 2015, from Hawaii Statewide GIS Program Web site: http://files.hawaii.gov/dbedt/op/gis/data/blocks10.htm

State of Hawaii, Office of Planning. (2015). Natural Resource Conservation Service Soils [GIS data file]. Retrieved July 2015, from Hawaii Statewide GIS Program Web site: http://hawaii.gov/dbedt/gis/soils.htm

University of Hawaii. (2003). Drought Risk and Vulnerability Assessment and GIS Mapping Project. State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, 157 p.

U.S. Department of Agriculture, Soils Conservation Service. [In cooperation with The University of Hawaii Agriculture Experiment Station.] (1972). Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. Washington, DC: U.S. Government Printing Office.

U.S. Geological Survey (1996). Digital raster graphics (DRG) data. Retrieved December 2007, from http://data.geocomm.com/drg/index.html

U.S. Geological Survey (2001). Digital elevation model (DEM) – 10 meter. Retrieved December 2007, from http://data.geocomm.com/dem/

U.S. Geological Survey (2012). GAP Analysis. https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap

Ziegler, A.C. (2002). Hawaiian natural history, ecology, and evolution. Honolulu: University of Hawaii Press, 477 p.