Final

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems

Waimea, Kaua‘i, Hawai‘i

October 2016

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

Contract Number 62944

Final

Investigation of Kōkeʻe and Kekaha Ditch Irrigation Systems

Waimea, Kauaʻi, Hawaiʻi

October 2016

Prepared for:

State of Hawaiʻi
Commission on Water Resource Management
P.O. Box 621
Honolulu, Hawaiʻi 96809

Prepared by:

Element Environmental, LLC
98-030 Hekaha Street, Unit 9
Aiea, Hawaiʻi 96701

Prepared under:

Professional Services Contract Number 62944

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms and Abbreviations

ADC	Agribusiness Development Corporation
AWUDP	Agricultural Water Use and Development Plan
bgs	below ground surface
BMDI	Bhalme and Mooley Drought Index
cfs	cubic feet per second
CWRM	Commission on Water Resource Management
DBEDT	Department of Business, Economic Development, and Tourism
DHHL	Department of Hawaiian Home Lands
DLNR	Department of Land and Natural Resources
DOA	Department of Agriculture
DOFAW	Division of Forestry and Wildlife
E2	Element Environmental, LLC
^{o}F	degrees Fahrenheit
HCS	hunting check-in station
HDPE	high-density polyethylene
hp	horsepower
IIFS	Interim Instream Flow Standards
KAA	Kekaha Agricultural Association
KEDIS	Kekaha Ditch Irrigation System
KIUC	Kauaʻi Island Utility Cooperative
KODIS	Kōkeʻe Ditch Irrigation System
KSC	Kekaha Sugar Company
kW	kilowatt
kWh	kilowatt-hours
LLC	Limited Liability Company
Ma	million years ago
mgd	million gallons per day
mgm	million gallons per month
MOA	Memorandum of Agreement
msl	mean sea level
NPDES	National Pollutant Discharge Elimination System
PDO	Pacific Decadal Oscillation
PMRF	Pacific Missile Range Facility
UH	University of Hawaiʻi
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
WSMC	Waimea Sugar Mill Company
WWTP	Wastewater Treatment Plant

Executive Summary

The surface water resources in the Waimea River watershed on Kauaʻi were diverted at the beginning of the twentieth century by the Kekaha Sugar Company (KSC) into miles of transmission ditches, tunnels, flumes, and siphons of the Kekaha Ditch Irrigation System (KEDIS) and the Kōkeʻe Ditch Irrigation System (KODIS). These ditch systems were constructed to transport water to the arid, fertile lands of the Mānā Plain that required irrigation water to grow sugarcane. Since the demise of large-scale sugarcane production in the late 1990s, the conditions have been set for a re-evaluation of the balance between historic off-stream uses (agriculture and hydroelectric power production) and instream uses of this water, including maintenance and restoration of stream and riparian habitat and ecosystems as well as protection of traditional and customary Hawaiian rights.

On July 24, 2013, two community groups, Poʻai Wai Ola and the West Kauaʻi Watershed Alliance, submitted a complaint and petition for a declaratory order through their attorneys (Earthjustice) against the waste of water diverted from the Waimea River watershed by the state Agribusiness Development Corporation (ADC) and its land manager, the tenant association, Kekaha Agriculture Association (KAA). The complaint alleged that despite the dramatic decline in cultivation and actual water demands following the closure of the KSC, the large-scale diversion of water into the KEDIS and KODIS continued in amounts comparable to volumes diverted during operation of the former plantation. This legal action included a petition requesting that the State of Hawaiʻi Commission on Water Resource Management (CWRM, the Commission) restore stream flow and amend interim instream flow standards (IIFSs) for the Waimea River and its headwater and tributaries. The Plaintiffs requested additional monitoring and reporting on the two ditch systems, including determination of average daily water usage by the various end users, breakdowns of acreages and crops cultivated, reservoir volumes, and determination of losses within the ditch systems.

The Commission executed a Contract for Professional Services with Element Environmental, LLC (E2) on May 27, 2014 to collect information that would assist the Commission in the matter of the Earthjustice complaint. The investigation and fact gathering work conducted by E2 involved meeting with the parties pertinent to the complaint, conducting an inventory and assessment of the existing infrastructure of KEDIS and KODIS, monitoring the current flow within the two ditch systems, and preparing a comprehensive report describing the findings from these assessments and monitoring to the Commission.

E2 found that the 28-mile long KEDIS is currently operated by KAA in a manner that focuses on production of electricity at the two hydroelectric plants (Mauka and Waiawa) on the ditch while still providing sufficient amounts of irrigation water to their members. The upper Kekaha ditch intake, located just above the convergence of the Waiahulu and Koaie Streams, routes the majority of water in these two streams into the ditch at the Waiahulu dam at an elevation of 780 feet under low to moderate flow conditions within these streams. The Mauka Hydroelectric Plant, located at an elevation of around 530 feet, is operated at a maximum rate of 1,100 kilowatts (kW) according to Landis Ignacio, the Manager of KAA. Water is routed to this upper hydroelectric plant via a 42-inch diameter steel penstock that starts at an elevation of around 730 feet. Approximately 32 million gallons per day (mgd) of water is required to produce 1,100 kW of energy at the Mauka plant according to Mr. Ignacio. The Waiawa Hydroelectric Plant is located in Waiawa gulch, approximately 1.5 miles west of Kekaha town. A steel penstock drops 280 feet (400 to 120 feet above mean sea level [msl]) into this 500 kW capacity hydroelectric plant. The KAA ditch operators attempt to route 21 mgd of water through this plant to produce 425 kW of energy.

The condition survey of KEDIS conducted during this study found that most of the recent upgrades and repairs made by KAA to the Kekaha ditch were performed on the approximately 20 miles of ditches, tunnels, and flumes located between the upper intake at Waiahulu dam and the lower Waiawa hydroelectric plant. The greatest amount of leakage from KEDIS was observed in the roughly 7.5-mile section of ditch located between the Waiawa hydroelectric plant and the terminal reservoir at Polihale.

The KODIS consists of a system of small dams that intercept flow from Waikoali, Kawaikōī, Kauaʻikananā, and Kōkeʻe Streams at elevations between 3,300 and 3,400 feet above sea level. The diverted stream water is then conveyed through 21 miles of ditches, tunnels, flumes, and reservoirs. The diverted water in the Kōkeʻe ditch was historically used to irrigate highland sugarcane fields located east of Kōkeʻe Road and below Puʻu ʻŌpae Reservoir during the plantation era. Since July 2013, the flow of water from the Kōkeʻe ditch into Puʻu Lua Reservoir has been controlled to prevent the water level from rising above a level of 60 feet within this 262-million-gallon capacity (when full) reservoir. As a result of the current storage limitations within Puʻu Lua Reservoir, the flow of water in the lower parts of KODIS is currently regulated by dumping the majority of water that is diverted from Waikoali and Kawaikōī Streams into Kauaʻikananā and Kōkeʻe Streams, thus retaining much of the diverted water within the Waimea River watershed.

E2 installed pressure transducers within KODIS and KEDIS between June 22, 2015 and June 10, 2016 to continuously monitor the flow of water within these two ditches at ten-minute intervals. The mean and median ditch flows determined using the continuous flow records during this period were similar to the monthly average values reported for both ditch systems by KAA to the Commission. The average measured velocity of water within these two ditch systems is between 1 to 2 miles per hour, under normal flow conditions.

The median flow of water currently exiting the Waimea Valley watershed via KEDIS and KODIS (about 14.4 mgd) is significantly lower than historic median flows measured during the plantation era (about 48.5 mgd, 1908-1968) and the post-plantation period under KAA management (32.9 mgd, January 2010 to June 2013). The major causes of the observed reduction in water exiting the watershed via KEDIS and KODIS are: 1) the reduction of water levels within Puʻu Lua Reservoir to 60 feet or less in June 2013; and 2) the reduction of the interior diameter of the black pipe siphon in the summer of 2015. During the post-plantation era, the ditch operators have returned greater amounts of water (compared to the plantation era) from KEDIS to the Waimea River at two diversions located just below the Mauka hydroelectric plant and seldom captured additional streamflow at the Waimea diversion located just above the Mauka plant. The amount of water removed from the Waimea River watershed via the Kekaha ditch was recently further reduced as a result of modification and relining work conducted on the interior of the black pipe siphon between August and October 2015. The narrowing of the pipe size within the siphon led to a decrease in monitored median ditch flow at the Huikipo Flume from 20.37 mgd between June 22, 2015 and August 12, 2015 (pre-siphon modification) to 12.51 mgd from November 9, 2015 to June 10, 2016 (post-siphon modification) based on the continuous flow measurements made during this study.

The median monitored flow in KODIS just above Puʻu Lua Reservoir between June 2015 and December 2016 was 1.9 mgd, compared to historic median flows of 12.3 mgd measured by the United States Geological Survey (USGS) just upstream at the Kauhao diversion during the plantation era (1927-1997) and a median value of 8 mgd reported by KAA during the post-plantation era (January 2010 to June 2013), before water levels in Puʻu Lua Reservoir were regulated to not exceed 60 feet depth. The water that currently exits the Waimea River watershed via KODIS is currently used to: 1) oxygenate and provide evaporative replacement water at Puʻu Lua Reservoir; 2) provide roughly 0.25 mgd of water to Department of Hawaiian Homeland

(DHHL) lands, which are currently used to raise cattle and cultivate taro; 3) provide water to a small upland farm located just west of the ditch (Wines of Kauaʻi, LLC); and 4) provide back-up water to the Menehune Ditch during periods when the Kekaha ditch is closed (such as when the black pipe siphon was repaired during the summer and fall of 2015).

KEDIS and KODIS currently supply irrigation water for agricultural activities by KAA members (BASF, Pioneer, Syngenta, and Wines of Kauaʻi), for taro cultivation by farmers using the Menehune ditch system and DHHL lands, water for cattle grazing on DHHL lands, for fire fighting purposes, and recreational uses (i.e., trout fishing at Puʻu Lua Reservoir). The ditch water is used to irrigate corn, soy, sunflower, canola, rice, grapes, taro, and cover crops grown on roughly 4,225-acres of land leased by KAA members as well as on additional lands farmed by non-KAA members. The estimated average daily water demand between 2010 and 2014 self-reported by the major KAA tenants averaged approximately 5.8 mgd during this five-year period.

The groundwater component of streamflow within the lower reaches of the Waimea River watershed was estimated using historic streamflow measurements made at monitoring stations during the most severe historic drought to occur on Kauaʻi between April and November 1953. Based on the stream measurements made during this intense drought, it is estimated that approximately 20 mgd of groundwater enters Poʻomau Stream, the upper section of the main Waimea River along with the lower sections of the main tributaries (Koaie and Waiʻalae) to the Waimea River as base flow from daylighting of dike-impounded groundwater from the marginal dike zone of the Waimea Canyon Volcanics, along with additional contribution from seepage of groundwater from rocks associated with the Olokele Volcanics.

The median streamflow at the USGS Waimea River stream monitoring station (Station Number 1603100), which is located approximately 7,600 feet upstream of the confluence between the Waimea and Olokele Rivers, is estimated to have increased from the Plantation era (1910-1997) value of 10.3 mgd to a current median value of around 42.5 mgd. The USGS recently (August 2016) restored this river monitoring station, which had been discontinued in 1997. The future stream monitoring data collected by the USGS from this restored gaging station will be useful in evaluating this projected increase in median river flow in the lower half of the Waimea River due to recent changes in operation of KEDIS and KODIS.

A biological survey of the sections of the stream system that are subjected to near complete diversion of surface water is recommended to evaluate the impact to the river ecosystem in these areas. In particular, a biologic assessment is recommended of the roughly 2,750- and 2,150-foot long sections of streambed between the diversion structures on the Waikoali and Kawaikōī Streams and the first large waterfall that conveys water in these streams to Poʻomau Canyon. In addition, a biologic assessment of the roughly 8,000-foot long section of the Waimea River, located between the diversions on the Koaie and Waiahulu Streams and the confluence of the Waimea River and Waiʻalae Stream, is recommended

This page intentionally left blank.

1 Introduction

This report describes monitoring work conducted by Element Environmental, LLC (E2) on the Kōke‘e and Kekaha Ditch Irrigation Systems (KODIS and KEDIS, respectively) at the behest of the State of Hawai‘i Commission on Water Resource Management (CWRM, the Commission). The Scope of Services were detailed in the June 17, 2014 Contract for Professional Services (Contract Number 62944) between the State of Hawai‘i and E2. The purpose of the monitoring work was to collect information to assist the Commission in the matter of the Complaint for Dispute Resolution and Complaint for Declaratory Order against Waste in the Waimea River and its Tributaries, Waimea, Hawai‘i filed by Earthjustice on behalf of Po‘ai Wai Ola and the West Kaua‘i Watershed Alliance.

The focus of the Earthjustice complaint is that due to the decline in acreage under cultivation and associated demands for irrigation water resulting from the demise of the former Plantation in the area (Kekaha Sugar Company [KSC]), a portion of the water currently being diverted by the KODIS and KEDIS is not being put to reasonable-beneficial use and is in effect being unlawfully wasted. The complaint tests the balance between historic and current off-stream uses (agriculture and hydroelectric power production) of water diverted from within the Waimea River watershed with instream uses. Figure 1-1 shows the location of these two ditch systems in southwestern Kaua‘i.

The different perspectives of the proponents of instream and off-stream use of river water in the western United States were discussed in John McPhee’s book titled “Encounters with the Archdruid.” In this book, McPhee describes a rafting trip he took down the Colorado River in the late 1960s with Floyd Dominy, Commissioner for the Bureau of Reclamation, and David Brower, the executive director of the Sierra Club, who at the time was widely regarded as one of the most articulate and powerful conservationists of the 20th century. During the trip, the men continually wrangle about whether remote stretches of the Colorado River were valuable because they were untouched, or wasted because they were not being used for off-stream purposes.

> “*Reclamation is the father of putting water to work for man-irrigation, hydropower, flood control, and recreation.” Dominy said as he turned on the lights. “Let’s use our environment. Nature changes the environment every day of our lives-why shouldn’t we change it? We’re part of nature……the challenge to man is to do and save what is good but to permit man to progress in civilization. Hydroelectric power doesn’t pollute water and it doesn’t pollute air. You don’t get any pollution out of my dams. The unregulated Colorado was a son of a bitch. It wasn’t any good. It was either in flood or in trickle. In addition to creating economic benefits with our dams, we regulate the river and we have created the sort of river Dave Brower dreams about. Who are the best conservationists-doers or preservationists?*”

Brower presents a confrontational, but more holistic perspective:

> “*I hate all dams, large and small*,” David Brower informs an audience.

A voice from the back of the room asks, “*Why are you conservationists always against things?*”

> “*If you are against something, you are for something*,” Brower answers, “*If you are against a dam, you are for a river.*”

Over fifty years later, a similar debate between proponents of instream and off-stream use exists in Hawai‘i over water diverted into irrigation systems developed during the former plantation era. This report was prepared to provide information about the historic operation of the two ditch systems (KEDIS and KODIS), the current physical condition of these ditch systems, the current volume of water being diverted into both ditch systems, and the current uses of the water captured by the ditch systems. This information will be used by the Commission, their staff, and the Petitioner (Earthjustice) to develop an equitable agreement that satisfies both future off-stream and instream uses of the water that flows through the Waimea River watershed.

1.1 Project Scope of Work

On May 27, 2014, the Commission executed a Contract for Professional Services with E2 that included providing the following services: 1) Project management, coordination, and meetings; 2) Literature research and base map preparation; 3) Physical conditions survey (field work); 4) Water budget analyses; and 5) Report of findings. It was subsequently decided that E2 would conduct continuous ditch flow monitoring of the Kōkeʻe and Kekaha ditch systems and a synoptic set of ditch flow measurements in lieu of conducting a detailed water budget analysis of the current water use by the active lessees to the Kekaha Agricultural Association (KAA) due to the proprietary nature of their farming operations. Instead, the major users of water provided by the two ditch systems provided information on their estimated water usage between 2010 and 2014 in letters dated July 10 and July 17, 2015, which are included in Appendix A. The fieldwork portion of this project began on November 25, 2014 when the Commission staff, serving as intermediary, forwarded a fully executed copy of a right-of-entry agreement for E2 on behalf of the Commission, to conduct an assessment and investigation of the KEDIS and KODIS.

The following list summarizes the inventory work conducted by E2 during this project:

- ✓ Conducted condition inventory surveys of all accessible portions of KEDIS and KODIS in July, November, and December 2014.
- ✓ Located and attempted to quantify the amount of leakage from the ditch systems observed during the inventory surveys.
- ✓ Used pressure transducers to synoptically monitor stage levels within the two ditch systems and the Waimea River during a five-day period in November and December 2014.
- ✓ Made a series of synoptic ditch flow measurements in both ditch systems on December 2, 2014.
- ✓ Continuously monitored ditch flow in both ditches between June 2015 and June 2016.
- ✓ Attended various meetings and field trips during the course of this project.

1.2 Summary of Earth Justice Complaint

In July 2013, Poʻai Wai Ola and West Kauaʻi Watershed Alliance, through their attorneys Earthjustice, filed a complaint and petition for a declaratory order against the waste of water diverted from the Waimea River system by the state Agribusiness Development Corporation (ADC) and its land manager, the tenant association called Kekaha Agriculture Association (KAA). This legal filing claimed that despite the closure of the Kekaha Sugar Plantation in 2001, ADC/KAA continued large-scale diversions into the Kekaha and Kōkeʻe Ditches and committed unlawful waste, including outright dumping of diverted river water. Some of the specific allegations listed in the complaint as well as the page on which the allegation appears are summarized below:

- Further, Poʻai Wai Ola and its members believe that inadequate stream flow is causing heavy siltation buildup within the Waimea River, creating a flood hazard for area residents, including Poʻai Wai Ola's members (page 6).

- In contrast to the sugarcane plantation operations, the current agricultural tenants under ADC/KAA cultivate only a fraction of Kekaha Sugar's former lands, in far less land- and water-intensive crops. The glaring discrepancy between the ongoing diversions and the radically reduced water demands indicate that the diverted river flows are not being put to maximum reasonable-beneficial use, but rather are being wasted, contrary to law. Indeed, Poʻai Wai Ola documents below several examples of dumping of water from the ditch systems. Further, much of the ditch infrastructure is inefficient and unlined, which causes an unknown amount of waste (page 26).
- From 1946 to 1996, the average flow in the Kekaha Ditch was 1,015 million gallons per month (mgm), or around 33.4 million gallons per day (mgd). The average flow in the Kōkeʻe Ditch during that same period was 438 mgm, or around 14.4 mgd (page 27).
- According to ADC's ditch flow reports to this Commission from 2010 through May 2013, Kekaha Ditch took an average of 31.3 mgd, and Kōkeʻe Ditch took an average of 7.6 mgd (page 30).
- Despite this dramatic decline in cultivation and actual water demands due to Kekaha Sugar's closure, ADC/KAA continue to divert Waimea River flows in amounts comparable to those utilized during sugarcane cultivation (page 30).
- While some reduction in reported ditch flows appears to have occurred over the years, there has not been a change in ditch operations or design commensurate to the collapse of water demand from the demise of sugarcane cultivation (page 30).
- Poʻai Wai Ola, in fact, is aware of the following examples of outright dumping of diverted water:
  1) From the Kōkeʻe Ditch, water is continually being dumped down the Kauhao gulch, at a point before the ditch reaches the Puʻu Lua Reservoir (page 31)
  2) Until earlier this year, Kōkeʻe Ditch water was also being continually dumped at a spot on the side of Waimea Canyon Road, where it flowed under the road and down the side of the canyon, many miles downstream from where it was originally diverted. More recently, this dumping has been modified to be less conspicuous, with the ditch water dumped into a newly constructed trench in an empty field, where the water flows away from the Waimea River and in a makai direction, to nowhere (page 31)
  3) As for the Kekaha Ditch, a visit to the Kekaha-Mānā Plain revealed dumping from an irrigation ditch directly into a low-elevation drainage canal flowing to the ocean (page 32)
- Long-time kamaʻaina community members attest that their ability to recreate in the river has deteriorated or vanished as the weak river flows continue and cause more and more silt to fill the river bed. As recent as the 1980s to 1990s, community members would frequent a popular swimming hole under the swinging bridge near the Waimea-Makaweli fork. The water was around fifteen-feet deep at the time, deep enough for people to dive in from the bridge. Today, the swimming hole is buried, and only a thin layer of water covers the silt-laden riverbed (page 39).
- Native Hawaiians are limited in their rights to gather stream life such as ʻoʻopu, ʻōpae, and hihiwai. As explained above, the Waimea River system was legendary for the abundance

of its native stream life, including ‘o‘opu. See Part IV.A.2, supra. These resources, however, have markedly declined with the continued long-term diversion of the river and cannot support the traditionally practiced and currently desired levels of gathering (page 41).

- Po‘ai Wai Ola anticipates that increased instream flow will have a direct, positive impact on the river ecosystem from mauka to makai (page 45).
- Recreational opportunities will increase as river flow rises and scours accumulated sediment (page 45).
- As part of its mandated investigation, the Commission should require essential monitoring and reporting, including average daily water usage by end user, breakdowns of acreages and crops cultivated, reservoir volumes or stages, and system losses (page 47).
- Moreover, the flows immediately returned to the Waimea River system to prevent waste must be incorporated into amended interim instream flow standards (IIFSs). “Interim standards must respond to interim circumstances.” Id. at 151, 9 P.3d at 463. “[A]t least for the time being,” the IIFSs should reflect the amount of instream flow that reflects current, actual reasonable-beneficial off-stream use and the absence of waste. Id. at 157, 9 P.3d at 469. If necessary, the Commission may further amend the IIFSs as it obtains more detailed information and analysis of instream and off-stream uses (page 47).

1.3 Project Meetings and Field Activities

A series of project meetings and field trips were conducted on the islands of O‘ahu and Kaua‘i during the course of this investigation. Two separate field visits conducted on April 28, 2015 and October 21-22, 2015 were designed to give interested parties a better understanding of the ditch systems. Table 1-1 summarizes the meetings and major field tasks conducted during this project.

Table 1-1: Summary of Meetings

Date	Time	Meeting Location	Meeting Description
7/1/2014	All Day	Waimea, Kaua‘i	Reconnaissance site visit up Waimea River by E2.
7/22/2014	All Day	Waimea, Kaua‘i	Reconnaissance site visit to KODIS and KEDIS by E2 and CWRM staff.
7/23/2014	All Day	Waimea, Kaua‘i	Reconnaissance site visit to KODIS and KEDIS by E2 and CWRM staff.
11/2015 – 12/2015	Various	Waimea, Kaua‘i	Ditch inventory and monitoring field work by E2.
2/18/2015	9:00 – 11:00	Honolulu, Oah‘u	Commission Meeting. An overview presentation of KEDIS and KODIS and initial surface water flow measurements made on both systems was provided by E2.
3/20/2015	9:00 – 14:00	Waimea, Kaua‘i	Visit State of Hawai‘i Department of Hawaiian Home Lands (DHHL) lands by CWRM staff, DHHL staff, and members of the public (about 15 people).
4/28/2015	9:30 – 20:00	Waimea and Līhu‘e, Kaua‘i	Field Trip to portions of KODIS and KEDIS by CWRM Commissioners and staff, and members of the public (about 40 people). Public Meetings at the Waimea (morning and afternoon) and Līhu‘e (evening, about 30 attendees) Community Centers.

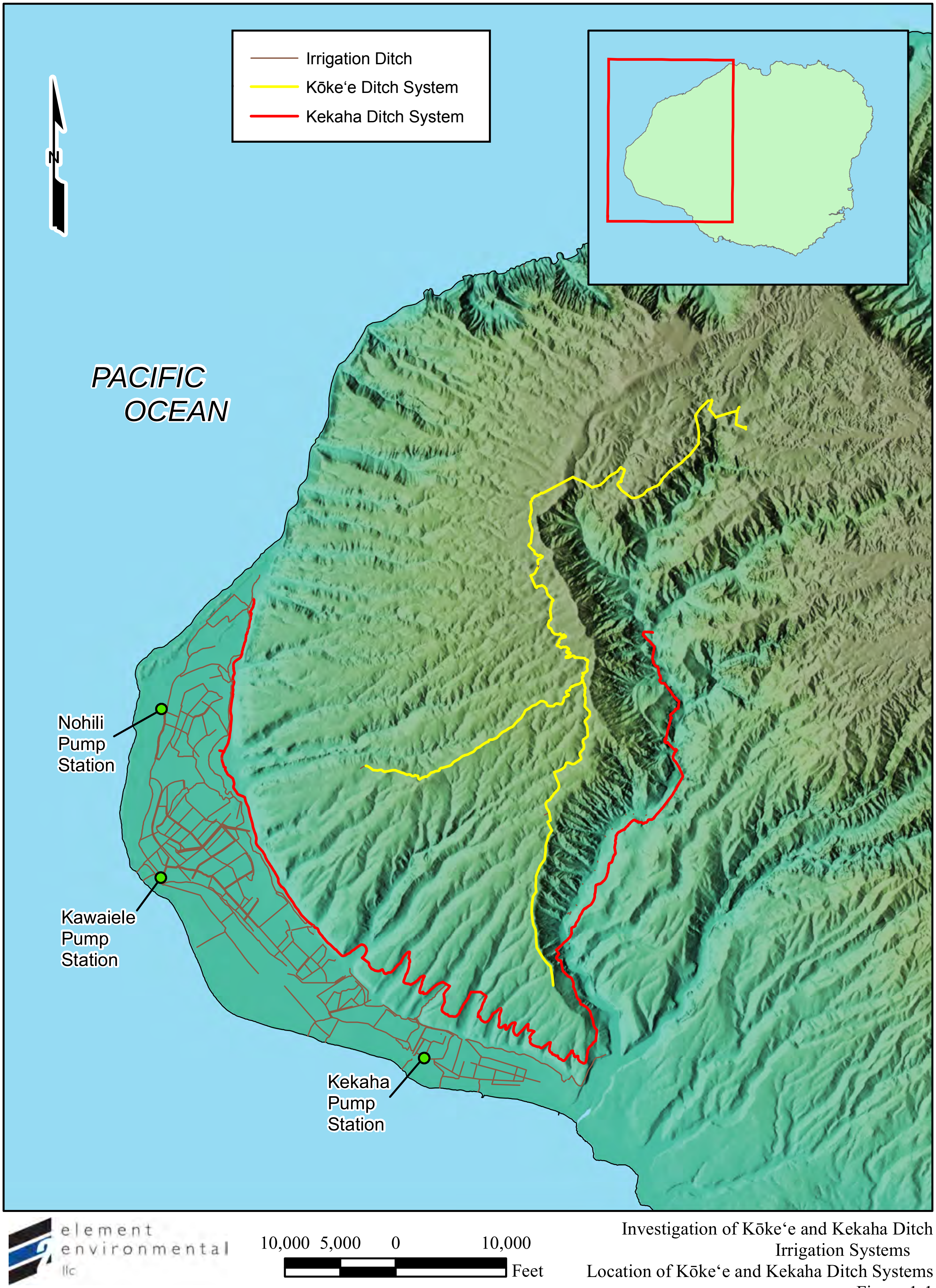
Table 1-1: Summary of Meetings

Date	Time	Meeting Location	Meeting Description
4/29/2015	9:30 – 18:00	Līhuʻe, Kauaʻi	Commission heard briefings by KAA and the Kauaʻi Island Utility Cooperative (KIUC).
6/22/2015	10:30 / 15:10	KEDIS / KODIS	Continuous flow monitoring in KODIS and KEDIS is started by E2.
10/20/2015	8:00 – 20:30	Waimea, Kauaʻi	Field Trip to KEDIS and KODIS (Sites 1 to 9). Public Meeting at Waimea Neighborhood Center.
10/21/2015	8:00 – 16:00	Waimea, Kauaʻi	Field Trip to KEDIS and KODIS (Sites 10 to 14).
11/6/2015	9:00 – 11:30	Honolulu, CWRM Conference Room	First meeting between hydrogeologists from E2, KAA, Earthjustice, CWRM, and the Joule Group.
12/4/2015	9:00 – 10:30	Honolulu, CWRM Conference Room	Second meeting between hydrogeologists from E2, KAA, Earthjustice, CWRM, and the Joule Group.
12/10/2015	8:15	KODIS	Transducer in KODIS malfunctioned.
6/10/2016	12:40	KEDIS	Transducer was pulled from KEDIS at Hukipo Flume.


March 20, 2015 Field Trip to DHHL Land; October 20, 2015 Field Trip to Mauka Hydropower Plant


April 28, 2015 Community Meeting in Waimea and Field Trip to Waimea Canyon

This page intentionally left blank.



element environmental llc

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Location of Kōke‘e and Kekaha Ditch Systems
Figure 1-1

2 Project Setting

The Waimea River watershed lies on the leeward side of the island of Kaua‘i (Figure 2-1). The watershed covers an area of about 85.9 square miles (222.5 square kilometers), and reaches a maximum elevation of 5,243 feet (1,598 meters) at Mount Wai‘ale‘ale. The portion of the watershed evaluated during this study covers an area of around 58 square miles (150.2 square kilometers), which excludes the Makaweli River portion of the basin to the east. In Hawaiian, Waimea means “reddish water”, a possible reference to the erosion of the red soil exposed in the sidewalls surrounding the river that produced this spectacular canyon. The following sections provide general information on the physical setting of the project site.

2.1 Description of Waimea River Watershed

KEDIS and KODIS receive water from the various streams and tributaries located within the Waimea River watershed located on the southwest side of the island of Kaua‘i. The watershed contains 38 streams totaling 276.4 miles (444.8 kilometers) in length, as well as eight waterfalls (Parham et al. 2008). The northern part of the watershed consists of an open rolling but swampy area called the Alaka‘i Swamp, which serves to some degree as a natural reservoir, regulating the flow of runoff to the various streams that drain this plateau. This plateau is underlain by the thick basaltic lavas of the Olokele Formation. The western edge of the watershed contains Waimea Canyon, a spectacular wilderness of 2,000- to 3,000-feet deep gorges, rugged crags, and labyrinthine canyons through which the Waimea River and its tributaries flow. The Waimea River meanders in a generally southerly direction in a roughly one-mile wide canyon collecting surface flows from various northern headwaters and tributaries that drain down from the Alaka‘i Swamp, and from lower eastern tributaries, before joining the Makaweli River and flowing into Waimea Bay. This eastern portion of the Waimea River watershed that flows to the Makaweli River, including its main tributary the Olokele, was not a part of the current study.

The 11.1-mile main section of the Waimea River starts just below the confluence of the Waiahulu and Koaie Streams. About one mile further up the canyon, Po‘omau Stream (a perennial stream) joins the Waiahulu Stream (an ephemeral stream under natural conditions above this point). The Po‘omau and Waiahulu Streams flow through the inland floor of the Waimea Canyon. The chief tributaries that flow into Waimea Canyon and enter these two streams (from west to east) include Halemanu, Kōke‘e, Kaua‘ikananā, Kawaikōī, Waikoali, and Mōhihi Streams. Koaie, Wai‘alae, and Mokihana Streams enter the Waimea River further to the south and drain the southeastern, wetter portion of the plateau. These tributary streams generally originate in the bogs of the Alaka’i Swamp between 3,600 to 5,000 feet elevation. Other smaller stream tributaries within the watershed include Awini, Elekeninui, Halehaha, Halekua, Halepa‘akai, Koholoina, Loli, Maluapopoki, Mokuone, Nawaimaka, Noe, Waianuenue, and Waiau Streams (Figure 2-2). KEDIS extends into the Mānā Plain, a nine-mile long, two-mile wide relatively flat area containing sand dunes along the shoreline and agricultural fields throughout much of the plain’s gently sloping interior.

2.2 Site Climate

The climate throughout the project site varies significantly with location, elevation, and topography and is often controlled by ocean-born trade winds. In fact, the moisture gradients present along the headlands of the Waimea River watershed are some of the most extreme in the world. The steep windward slopes of Mount Wai‘ale‘ale and Wainiha Ridge force the moisture-laden winds upward, where changes in temperature and pressure cause rapid condensation, cloud formation, and heavy rain. The abundant rainfall that falls on the upland slopes of Kauaʻi drains northwest into the Alakaʻi Swamp, which feeds the tributary streams that ultimately convey water to the west and southwest towards the main Waimea River. On the leeward slope, reduced moisture levels and changes in temperature and pressure diminish cloud formation and result in a rapid decline in rainfall levels. As a result, the project site contains a wide range of climatic conditions ranging from the relatively arid Mānā Plain with around 20 inches of annual rainfall to an average of over 430 inches of rain falling annually on Mount Waiʻaleʻale.

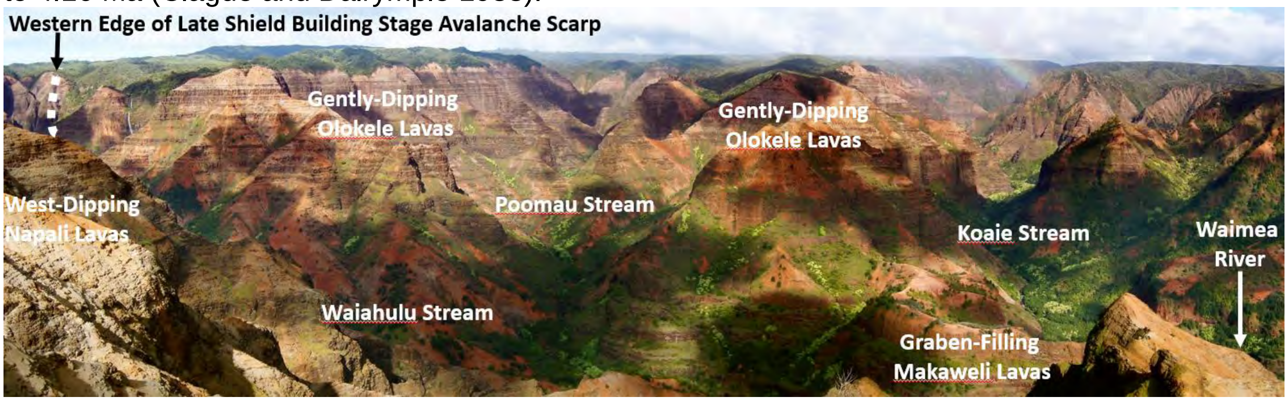
The average recorded temperature in the upland portion of the Waimea River watershed at Kōkeʻe during the hottest month (August) is 67 degrees Fahrenheit (ºF); during the coldest month (February) it averages 51ºF. The highest temperature recorded at Kanaloahuluhulu Meadow in Kōkeʻe State Park is 90ºF, and the lowest 29ºF (Department of Business, Economic Development, and Tourism [DBEDT] 2001). Frost formation is common during the cooler months in the upper elevations of the park. Temperatures in Waimea Canyon are warmer than the uplands and canyon rim. In the lower reaches of the Canyon, temperatures average in the mid-70ºs F annually, with average maximum temperatures in the mid-80ºs F and average lows in the mid-60ºs F (DBEDT 2001). Temperatures within the canyon exhibit a great deal of local variation, affected by floor elevation, canyon-channeled winds, shading, heat absorption in the rocks, and other factors.

2.3 Site Geology

The island of Kauaʻi is a product of a complex geologic history that reflects a combination of several stages of volcanism, the steady process of erosion along with catastrophic flank collapse events that occurred on both the north and south coast of the island near the end of the shield building stage of development. Figure 2-3 is a geologic map of the Waimea River Watershed area that shows the spatial distribution of the various geologic units discussed in this section.

The original island developed as a huge, circular shield volcano, gradually rising from the sea floor through the accumulation of thousands of thin (1- to 5-meter thick) olivine basalt lava flows that sloped between 6 to 12 degrees away from the eruptive center of the island. Potassium-argon age measurements on shield-stage lavas of the Nā Pali formation on western Kauaʻi range from 4.7 ± 0.4 million years ago (Ma) [McDougall 1979]. A recent study of gravity anomalies on Kauaʻi (Flinders et al. 2010) indicate that the center of volcanism on the island was located over the Līhuʻe basin, roughly 10 kilometers east of the "caldera" structure that was delineated within the Waimea River watershed during the original geologic mapping of the island (MacDonald et al. 1960).

A series of massive debris avalanches originating from both the south flank of Kauaʻi volcano and the east flank of Niʻihau volcano to the west produced a broad offshore area of blocky and hummocky terrain, about 80 kilometers wide, that extends 110 kilometers offshore and covers an area of 6,800 square kilometers [Moore et al. 1994]. These debris avalanches removed about half of the above-water volume of the original volcano. The debris avalanche on the south side of Kauaʻi produced a massive depression, approximately 19 kilometers long in a northeast-southwesterly direction and 16 kilometers wide in a northwest-southeasterly direction. The Nā Pali lava flows exposed in the west wall of Waimea Canyon forms the approximate western edge of this debris avalanche. Subsequent basaltic lava flows erupted during the late-stage of shield volcanism filled this depression with thick layers of erosion resistant basalt rock to create the Olokele Formation. These thick (6 to 22 meters), gently dipping (1 to 5 degrees) flow units underlie the highland plateau on which the Alakaʻi Swamp and Mount Waiʻaleʻale are located. The swamp formed as a result of both the flatness and generally low permeability of these thick Olokele lava flows. To the south, lavas of the Makaweli member of the shield building stage of volcanism filled a graben formerly located along sections of the lower half of the Waimea River basin. These Olokele and Makaweli member lavas, which represent a transition from the shield stage to the post-shield stage of volcanism, have potassium-argon ages ranging from 3.91 to 4.16 Ma (Clague and Dalrymple 1988).



The panorama of Waimea Canyon above shows the contact between the west-dipping Nā Pali lavas on the left, the approximate location of the ancient slip surface along which flank collapse of a large portion of the southern half of the island occurred, and the gently dipping, thick late-shield stage lavas of the Olokele and Makaweli formations, which filled this landslide created depression. Rainfall and runoff from the slopes of Mount Wai‘ale‘ale and the Alaka‘i Swamp have eroded Waimea Canyon along the western edge of the original collapse feature.

Volcanic activity on Kaua‘i mostly halted for roughly 1.5 million years before post-erosional activity resumed roughly 2.6 Ma. The Koloa Volcanic series erupted relatively thick alkalic composition flows between 2.6 to 0.15 Ma, with the majority of eruptions occurring between 1.26 to 1.75 Ma (Gandy 2006). A Koloa vent was mapped within the Alaka‘i Swamp (MacDonald et al. 1960) and a roughly 120-meter thick section of Koloa lavas was observed within the Waimea River watershed in the western wall of Koaie Stream, near where this stream joins the Waimea River.

The Mānā Plain formed in the Holocene by the convergence of longshore sediment transport from the northeast driven by winter swell and trade winds, as well as from the southeast driven by summer swell and trade winds. The accretion of sediments in the area was facilitated by a decline in sea level over the past 3,500 years from the brief high stand of sea level known as the Kapapa Stand of sea level (Grossman and Fletcher 1998). The coastal portion of the plain contains dunes of moderately to well-cemented calcareous sand while the interior of the plain contains sand, gravel and clay that were deposited in a shallow lagoon environment. The sedimentary deposits vary in thickness across the plain from 0 feet along the inland edge of the plain to 400 feet or more near the shoreline (Burt 1979).

2.4 Mānā Plain Operations

The Mānā Plain once contained one of the largest wetland habitats in the Hawaiian Islands (Department of Land and Natural Resources [DLNR] Division of Forestry and Wildlife [DOFAW] 2012). It is estimated that prior to the start of the Plantation era, approximately 1,700 acres of permanent, semi-permanent, and seasonal wetlands were present on the Mānā Plain. Draining of portions of this wetland area started in the 1880s to produce additional land for agriculture. In 1922, KSC began systematically draining (and in some instances filling) extensive areas of these low- lying “swamp lands” on the Mānā Plain in order to expand the Plantation’s sugarcane production (Faye 1997). These lands were drained by constructing a series of ditches throughout the plain that dewatered the adjacent soils while routing the ditch water to pumping stations located at Kawaiʻele and Nohili. By 1931, between 2,000 and 3,225 acres of land were reclaimed by removing near-surface water using these ditches and by planting a salt tolerant type of sugarcane (University of Hawaiʻi [UH] 2004). In the end, a total of 40 miles of canals and ditches were constructed to drain the coastal plain in the Kekaha region. The dewatering pumps at Kawaiʻele (two 200- horsepower [hp] and one 100-hp pumps) and Nohili (two 60-hp pumps), along with a third smaller pump battery located behind the town of Kekaha, are powered by electricity generated by the hydroelectric plants on KEDIS. The water that enters these series of ditches include natural groundwater seepage, storm water runoff from the ephemeral creeks that transport runoff from upland lands to the east, and excess irrigation water (Cox et al. 1970).

The pump stations and drainage canal systems are operated and maintained by ADC under National Pollutant Discharge Elimination System (NPDES) Permit No. 000086. The Kawaiʻele and Nohili Pump Stations are operational 24 hours per day, cyclically pumping drainage water from the main canals and releasing this water to adjacent canals draining to the Pacific Ocean. When storms approach the area, the operators will turn on all of the pumps at all three stations in order to move runoff emanating from the hillslopes above the Mānā Plain offshore, preventing flooding of the area. According to Landis Ignacio (the Manager of KAA), the water levels at the Kawaiʻele pump station rise one foot in 24 hours if the pumps are shut off and that during Hurricane Iniki, when the island lost electrical power for a month, water levels in the area rose 4.5 feet, leading to the nearby highway being under water.

ADC provided estimated average monthly pumping data for both pump stations from 2010 to 2016 (the Nohili pump station has been broken since June 2012). Figure 2-4 shows the monthly pumping records for the Kawaiʻele pumping station during this 5.5-year period. Of particular interest is the time-period between early August and September 2015, when KEDIS was shut down during repair of the black pipe siphon. Despite virtually no water flowing through the ditch system during this roughly two-month period, the daily volume of water removed from the dewatering ditch system at Kawaiʻele during August and September 2015 averaged 81 mgd, significantly higher than the average monthly rates measured during the previous five years. These elevated average pumping volumes undoubtedly reflect the large Kona storms that hit the island of Kauaʻi during these two months. For instance, the monthly rainfall recorded in August 2015 in Līhuʻe was a record (Burt 2015). This illustrates the importance of these pump stations in preventing the low-lying agricultural areas and the Pacific Missile Range Facility (PMRF) from flooding during periods of heavy rainfall.

2.5 Sedimentation in Waimea Watershed

The Earthjustice complaint reports that as recently as the 1980s community members could recreate in the vicinity of the suspension bridge located next to the plaque for the Menehune Ditch. They reported that the water in the stream used to be deep enough at this location (up to 15 feet deep) to allow people to dive into the river from the bridge. Today, this former swimming hole is buried and “only a thin layer of water covers the silt-laden riverbed.”

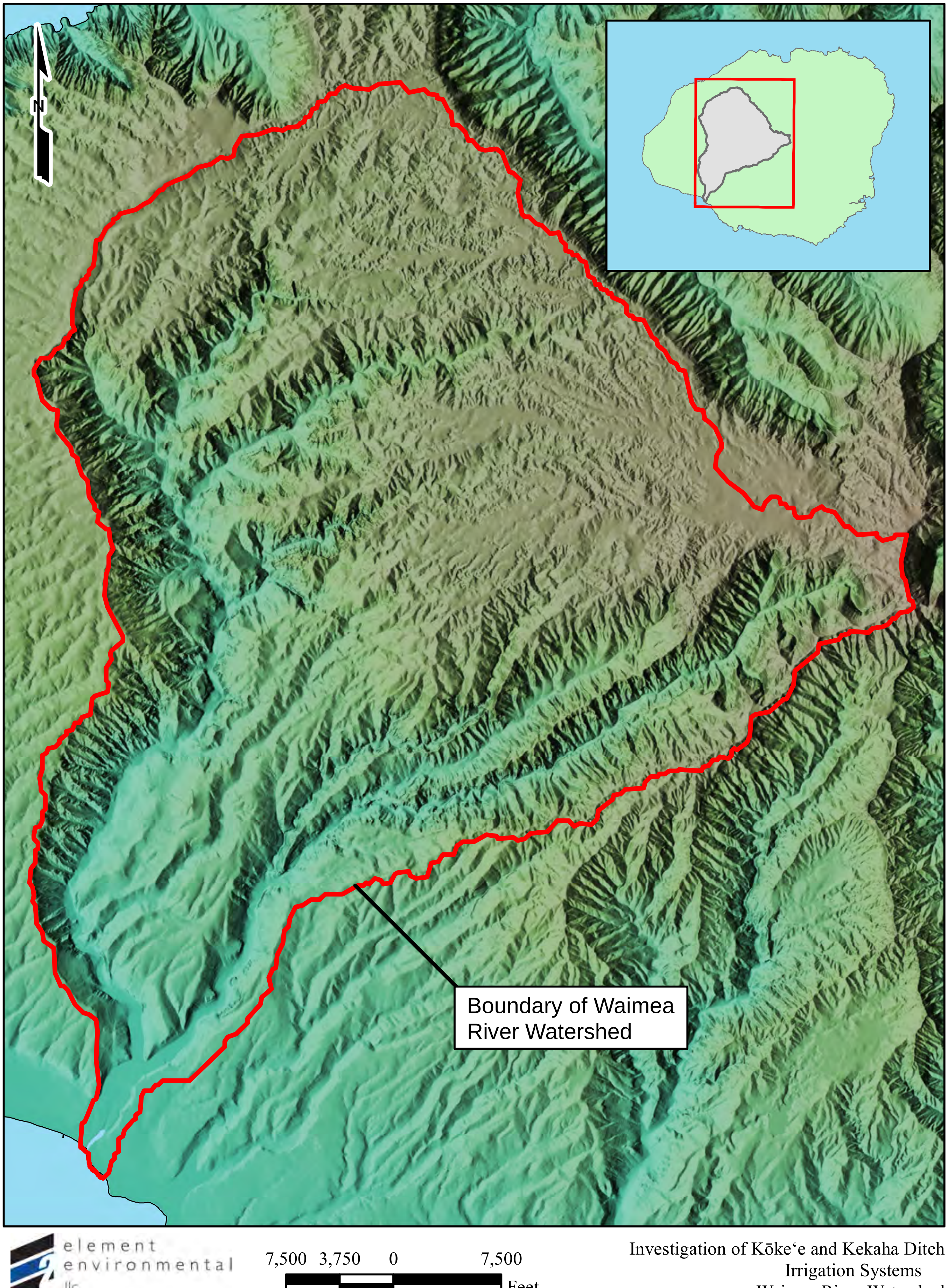
The heavy siltation buildup within the lower portions of the Waimea River described in the Earthjustice complaint is not believed to be related to the diversions of stream flow into KODIS and KEDIS. Rather, the observed build-up of sediment in the lower sections of the Waimea River is believed to reflect a process known as aggradation, where the fines that are transported down the river begin piling up, and in a kind of reverse ooze, reach back upstream several miles due to a change in condition at the point of discharge of the river. In the case of the Waimea River, it is believed that aggradation and the associated increased sedimentation in the lower sections of Waimea River resulted from a combination of episodic and long-term climatic/geologic/ecological events as well as from man-made alterations made to the shoreline.

The man-made alteration to the shoreline occurred in the 1960s with the construction of the Kikiaola Small Boat Harbor, which traps the natural westward movement of terrigenous material, driven by alongshore currents generated by trade wind waves, discharged by the Waimea River. Prior to the construction of this harbor, the shoreline fronting the town of Waimea was undergoing severe erosion. The construction of the harbor has led to a net accretion of the section of beach between the mouth of the Waimea River and this small boat harbor at an annual rate of 2.4 foot/year (Fletcher et al. 2012) (Figure 2-5). The United States Army Corps of Engineers (USACE) has estimated that the average sediment yield of the Waimea River is on the order of 4,000 cubic meters, of which about 1,225 cubic meters of sediment annually accumulates within the harbor (USACE 2011).

The catastrophic event that likely contributed to aggradation of the steam occurred in late October 1981 when a massive, 500,000 cubic meter rock avalanche occurred at the headwaters of Olokele Stream, producing a debris flow that travelled 4.6 kilometers down Olokele Canyon, severely eroding the valley sides. The scar produced by this rock avalanche was 800 meters high and 300 meters wide (see photo below for scale) and it is estimated that roughly 2,500,000 cubic meters of material was displaced and transported within the canyon bottom as a result of the erosive forces of the muddy debris flow that was created (Jones et al. 1984). Slope failure was attributed to gradual undercutting and loss of shear strength in beds of weathered ash and to joints in a thick basaltic cap rock. According to Landis Ignacio, the Makaweli River ran a milky white color and continued to transport fine silt material to the lower reaches of the Waimea River for years after this event.

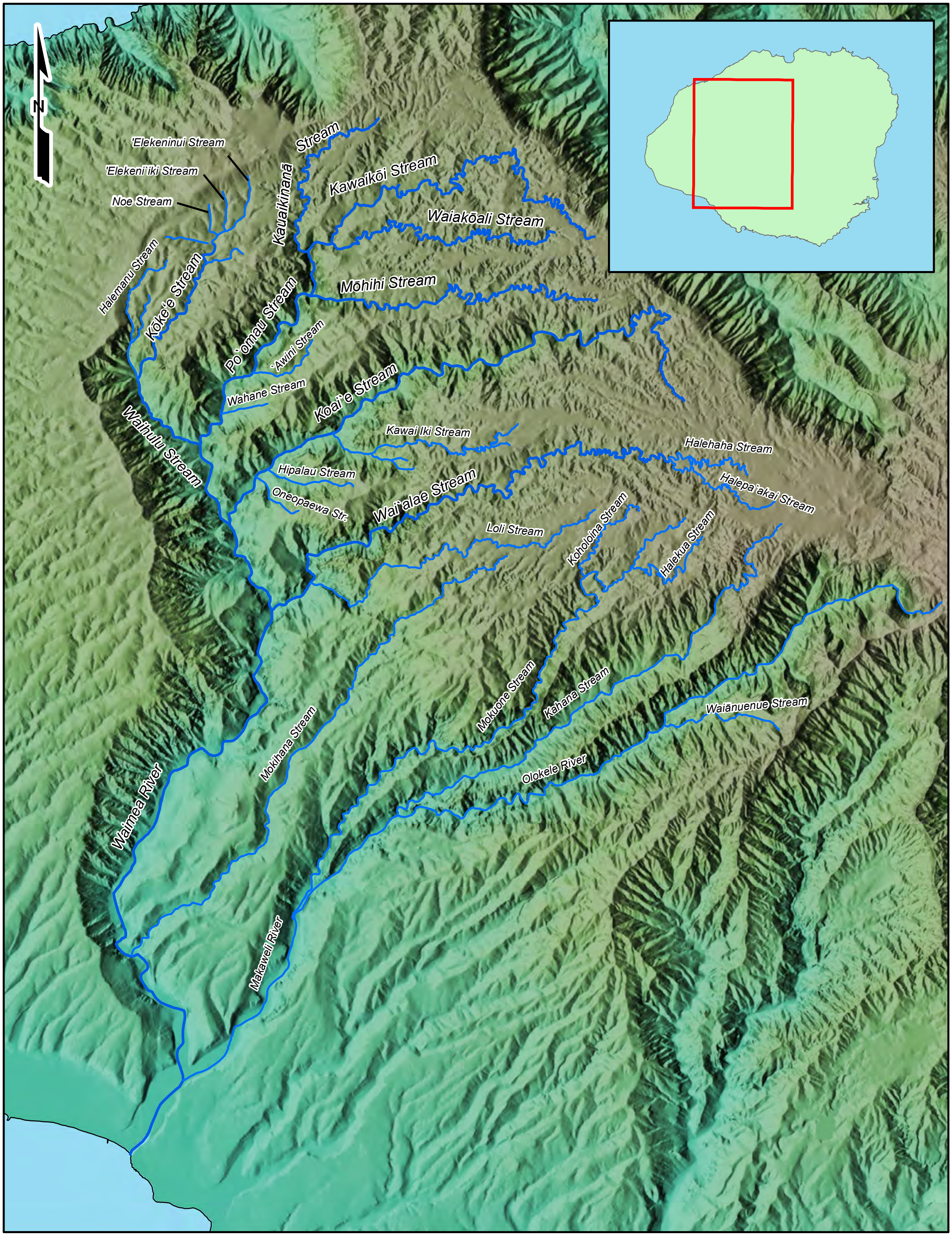
The gradual rise in mean sea level as well as the proliferation of goats in the contributory watersheds to the Waimea River over recent years are the long-term climatic and ecological events that have also potentially contributed to the observed aggradation in the lower reaches of the Waimea River. The increase in ungulate population within the watershed has undoubtedly led to an increase in the rate of erosion of the steep canyon walls along which these animals graze. This in turn has likely led to an increase in the mass flux of sediments being transported towards the mouth of the Waimea River in recent years. The gradient of the river at its discharge point to the ocean has also been gradually reduced, which promotes aggradation of the fine sediment material entrained in the river, as a result of the overall rise in sea level that has occurred over the past century. It is estimated that overall sea level has risen about six inches around Kauaʻi over the past century while the rate of rise measured at Nawiliwili Harbor between 1955 and 2010 has averaged 1.53 millimeters per year (Fletcher et al. 2010).

October 1981 Rock Avalanche and Debris Flow in Headwaters of Olokele Stream; and Goats



element
environmental
llc

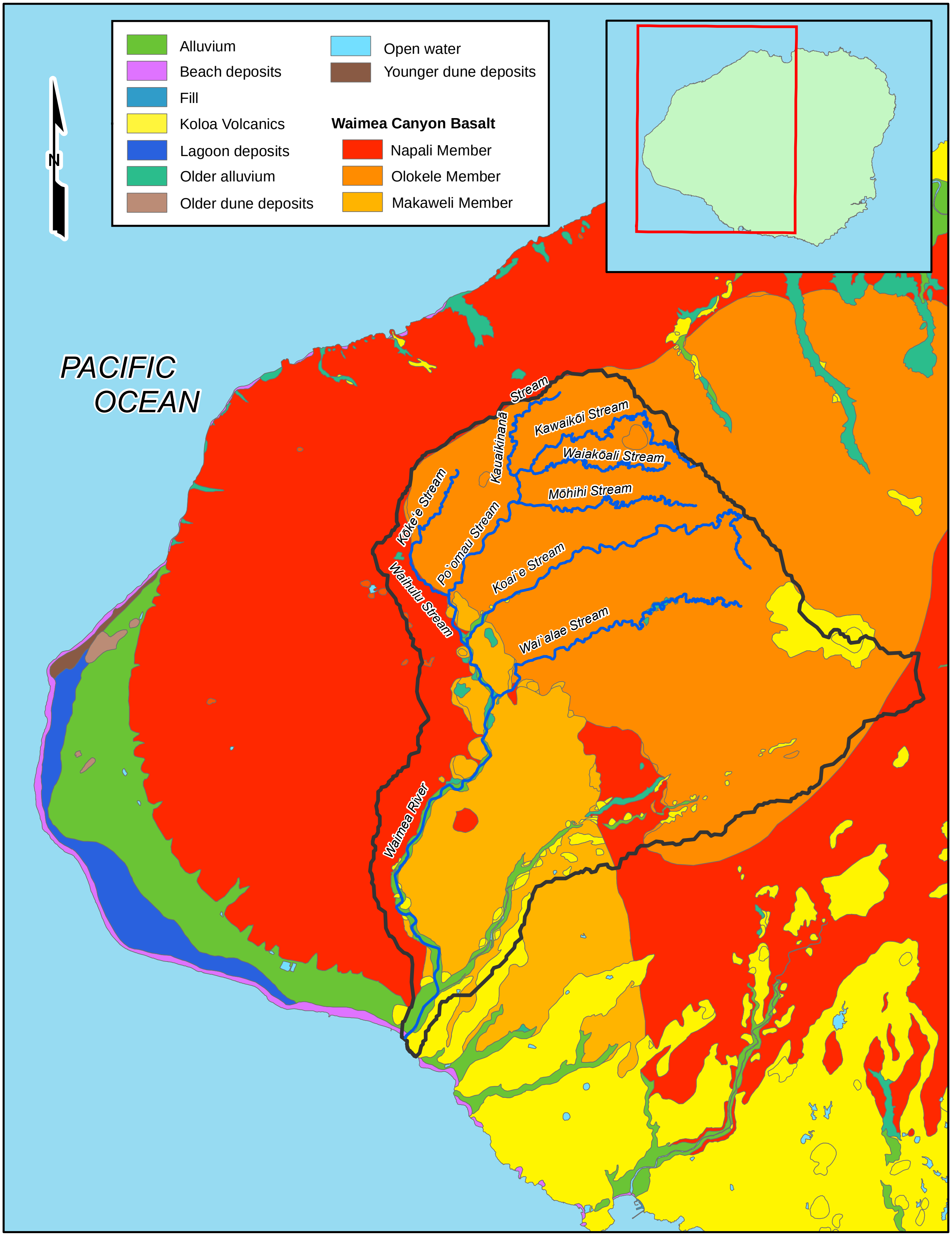
Investigation of Kōke‘e and Kekaha Ditch
Irrigation Systems
Waimea River Watershed
Figure 2-1



element environmental llc

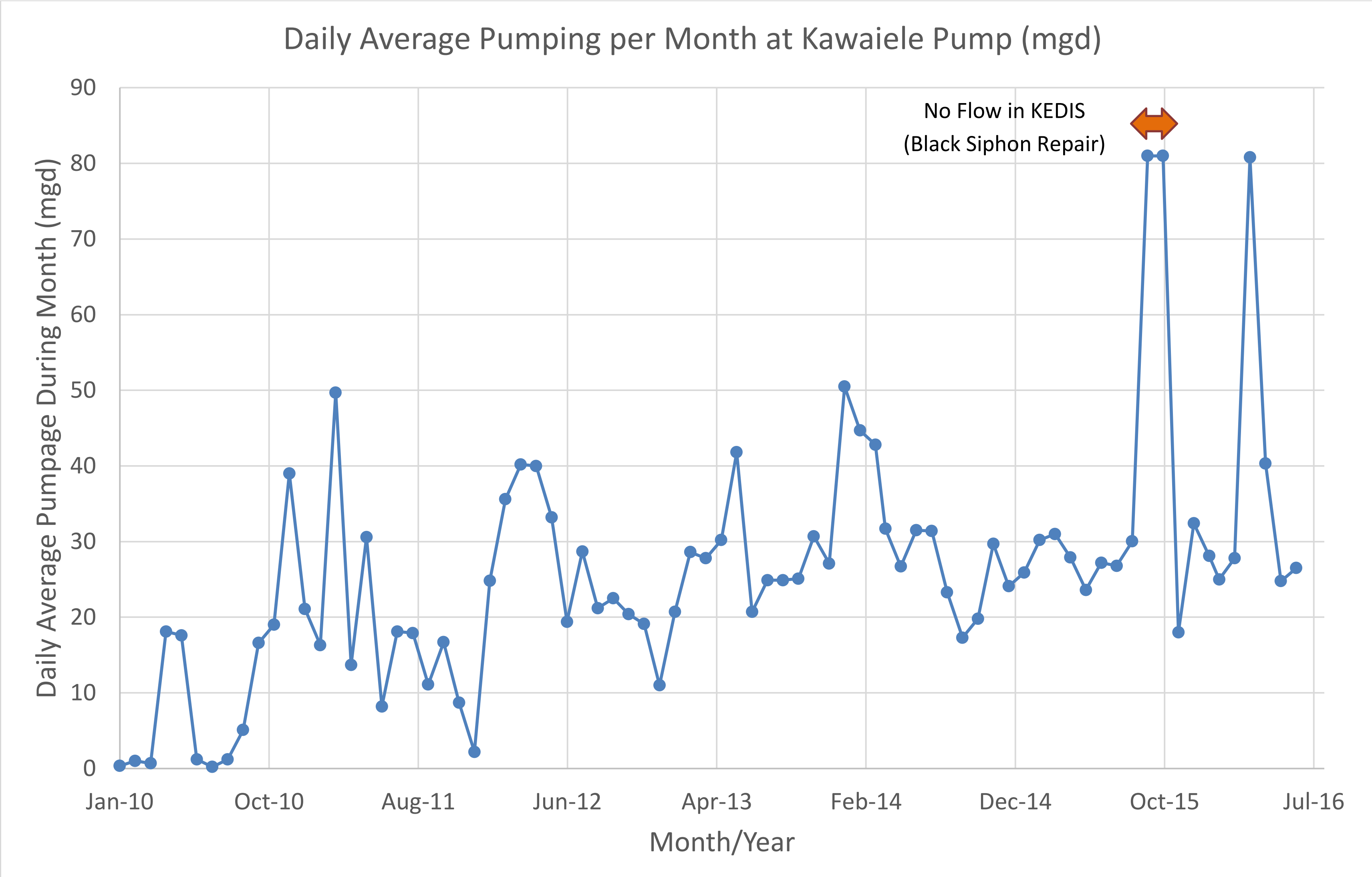
8,000 4,000 0 8,000 Feet

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Streams and Tributaries, Waimea River Watershed
Figure 2-2



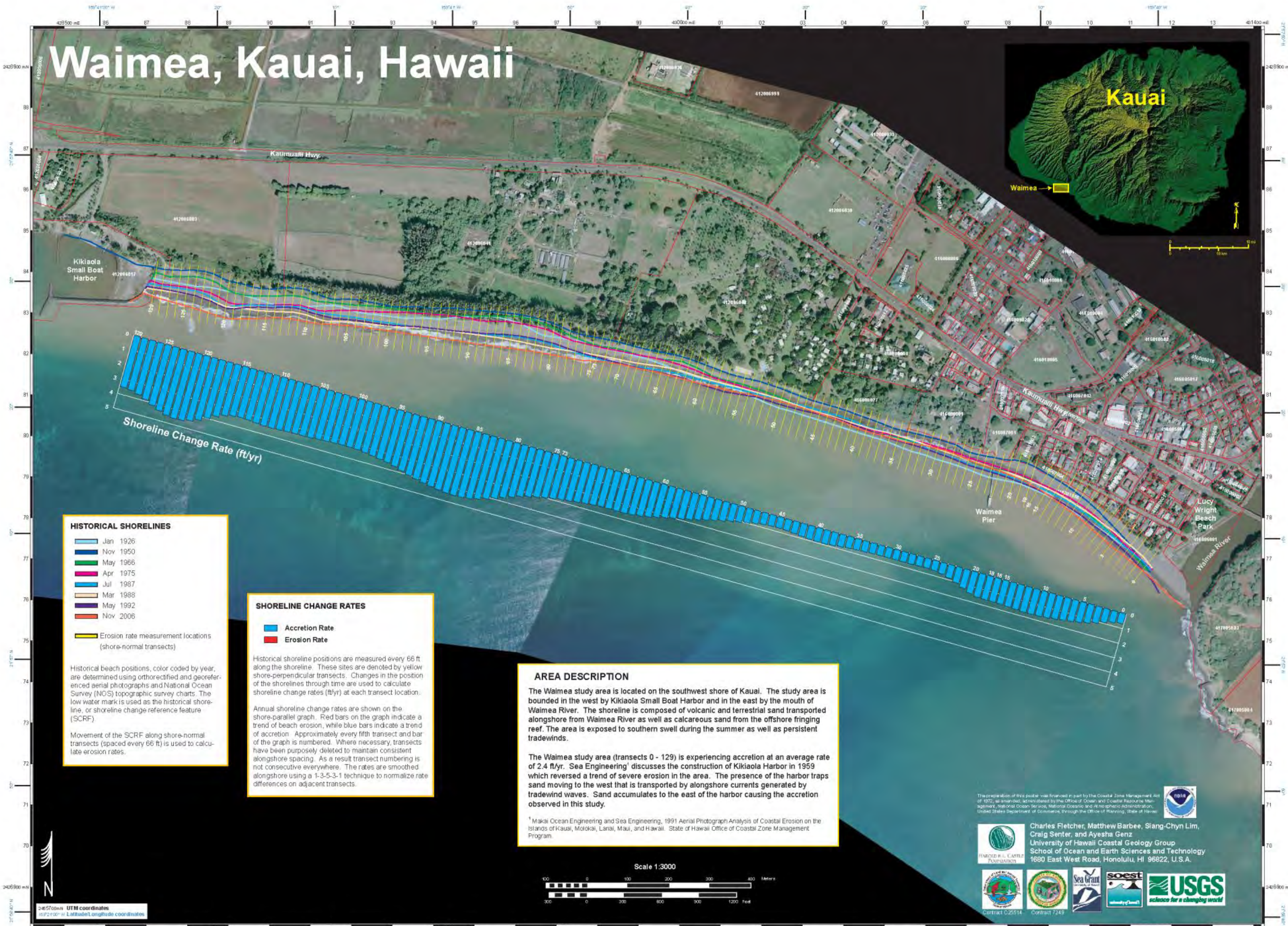
element environmental llc

Investigation of Kōke‘e and Kekaha Ditch
Irrigation Systems
Geology of Project Site
Figure 2-3



element environmental llc
environmental · engineering · water resources

Investigation of Kōke'e and Kekaha Ditch Irrigation Systems
Average Daily Pumping Per Month at Kawaiele Pump Station (mgd) - Figure 2-4



Shoreline Accretion in Waimea Area - Figure 2-5

3 Ditch System Use, History, and Operation

This section describes the current use, historical operations, and future hydroelectric potential of the two ditch systems, KEDIS and KODIS.

3.1 Ditch Systems Ownership History

The Norwegian adventurer Valdemar Knudsen arrived on Kauaʻi in 1854 and received 30-year leases on Crown lands at Mānā and Kekaha in 1856. The signing of the Reciprocity Treaty of 1876 between the Kingdom of Hawaiʻi and the United States led to a proliferation of sugarcane plantations across the kingdom (Cook 2000). The early sugar enterprises established in the Waimea/Kekaha area, including the Waimea Sugar Mill Company (founded in 1876), were the first entities to transport stream water via ditches from Waimea Valley to irrigate the dry Mānā area.

The KSC was incorporated in 1898, the same year that Hawaiʻi became an organized incorporated territory of the United States, by merging three smaller existing sugarcane plantations located in the area. Hans Peter Faye, a nephew of Valdemar Knudsen, served as the first Manager and Vice President of KSC, a position he held for thirty years, until his death in 1928.

KSC was the only plantation in the State of Hawaiʻi at the time of its closure in 2001 that leased a majority of its land from the government (Wilcox 1996). As a result, the plantation needed to renew its lease for the lands it used with the Territory of Hawaiʻi every 20 years. This made KSC a problematic investment during its founding due to the need to build a significant amount of non-resalable infrastructure, including ditches, canals, pumps, and other facilities, to overcome the inherent physical disadvantages (i.e., lack of rainfall, shallow brackish groundwater, tendency to flood) of the Waimea/Kekaha area for growing sugarcane. In 1922, KSC systematically drained and filled the existing "swamp lands" on the Mānā Plain to expand the acreage of land available for sugarcane production (Yent 2005).

In 1923, the company undertook major repairs of the Kekaha Ditch (which was originally constructed in 1907), after renegotiating new lease arrangements with the government, expanding its capacity to 50 mgd and its average flow to 35 mgd. At the same time, KSC started construction on the Kōkeʻe Ditch, to irrigate 2,000 additional acres in the mauka highland region that it leased in 1923. By the 1930s, KSC was leasing over 7,000 acres of agricultural land from the government; between 2,000 to 3,225 acres of the leased land was "reclaimed" swamp lands located in the Mānā Plain. During renegotiation of the lease just prior to World War II, the Territory of Hawaiʻi considered the KSC lands their most valuable acreage in all Hawaiʻi.

KSC entered into a 20-year lease (General Lease No. S-4222) with the State of Hawaiʻi through the Board of Land and Natural Resources on January 1, 1969. The lease expired and was re-negotiated in 1999 to cover approximately 27,720 acres of land. KSC reported cultivating about 11,750 acres of land for sugarcane and diversified agriculture in 1992 and around 7,758 acres in the year 2000 (Bow Engineering 2000).

The segment of KODIS that runs from the Puʻu Moe Divide to Puʻu ʻŌpae passes through a 14,500-acre section of land administered by the DHHL. The primary access road to the DHHL property is Hāʻeleʻele Ridge Road, an unimproved 4-wheel drive road that originates off of Kōkeʻe Road and that provides access to Puʻu ʻŌpae Reservoir. Currently, a small portion of this DHHL land is used for cattle grazing and support activities. DHHL has claims to use of the water conveyed within KODIS.

KSC was sold to JMB Realty of Chicago in 1988 and became known as Amfac Sugar-Kauaʻi West. The new entity ceased operations in 2001. For a short time after the closure of operations, the former plantation infrastructure, including the ditches, was maintained by an informal agricultural coalition under an interim agreement with the DLNR. In 2004, the DLNR transferred management of 12,592 acres of former KSC lands and infrastructure to the ADC, a state entity under the State of Hawaiʻi Department of Agriculture (DOA). On April 1, 2007, ADC signed a Memorandum of Agreement (MOA) with the KAA, a tenant association formed in 2003 consisting of a dues-paying membership group financed by the various agricultural entities that utilize water from the two ditch systems (Water Resource Associates 2004). This MOA gave KAA the responsibility for management, monitoring, and maintenance of the ditch system and the agriculture infrastructure, including control of the ditch diversions within the Waimea River watershed. Under this agreement, KAA is also responsible for maintaining the drainage system that prevents flooding of the low-lying lands surrounding the PMRF. ADC administers payments for the water used from the systems, which is based on a per acreage usage basis.

3.2 Construction of Kōkeʻe and Kekaha Ditch Systems

The early sugarcane growers in western Kauaʻi in the 1870s lacked an abundant and reliable water supply. Agricultural water for the nascent plantations relied on natural springs, intermittent streams, and groundwater pumped from a series of wells drilled throughout the Mānā Plain. As the acreage of land growing sugarcane increased, these sources of water proved inadequate. Due to overpumpage and faulty location and design of many of these early wells (located too close to the coast and drilled too deep), groundwater levels dropped as much as four feet and the salt content increased up to tenfold in many of these early wells.

In 1898 when sugarcane operations in the area were consolidated into KSC, Hans P. Faye and his engineers began to design and develop conveyance systems that would transport water from many of the perennial rivers present within the Waimea River watershed to the rapidly growing acreage of land under cultivation in the dry Mānā Plain. The engineers designed a system that could divert large quantities of surface water from these perennial streams at intake structures, which fed miles-long transmission ditches and tunnels that conveyed the captured water to the arid, but fertile, leeward plain. The intake structures typically consisted of a dam constructed across the streambed, an inlet channel, control gates, trash screen, and a connecting tunnel or ditch into the main transmission structure (usually another tunnel or ditch).

Three major ditch systems were constructed between 1903 and 1926 to provide water to the arid coastal plain between Waimea and Polihale: the Waimea, Kekaha, and Kōkeʻe Ditch Systems. All three systems captured and conveyed water collected from the Waimea River watershed. Additional land in the Mānā Plain was reclaimed in the 1920s by KSC by constructing an intricate series of drainage canals that drained the natural swamps present within the plain.

The Waimea Sugar Mill Company (WSMC, later acquired by KSC in 1923) began construction of the seven-mile long Waimea Ditch (also known as the Kikiaola Ditch) in December 1902. The ditch was completed in September 1903. This ditch diverted a portion of the flow within the Waimea River from an intake located at an elevation of approximately 200 feet. The transmission system consisted of open ditches and iron flumes that ran approximately three miles along the west side of the Waimea River and approximately four miles to the west of the town of Waimea. The remnants of these iron flumes can still be seen in the lower sections of Waimea Valley. This ditch diverted about 5 mgd from the Waimea River. George Ewart, the Manager of WSMC, later reconfigured the Waimea Ditch by replacing the original iron flumes with tunnels to increase the flow capacity of the system. The success of the Waimea Ditch prompted the construction of KEDIS and KODIS by KSC.

KSC began construction of the original Kekaha Ditch in May 1906 and finished in September 1907. Teams of Japanese and Chinese immigrant tunnel workers constructed this largely unlined ditch by blasting tunnels and excavating conveyance ditches through hard rock and alluvium. The original intake structure was located on the Waimea River at an elevation of 550 feet just above the present location of the Mauka Hydropower Plant. The original ditch consisted of 16 miles of ditches, tunnels, flumes, and siphons in Waimea Canyon and four miles in the highland area between Waimea and Kekaha. The original 2,190-foot long steel inverted siphon crossed the Waimea River aboveground. This original siphon was subsequently replaced with an improved siphon that was routed under the bed of the river to make it less susceptible to the large flood events that periodically scour the river basin at this location.

The upper intake of the ditch was later moved up-river to an elevation of around 780 feet near the confluence of the Waiahulu and Koaie Streams. The confluence of these two streams marks the beginning of the main Waimea River. A dam constructed on Koaie Stream routed much of the water from this stream into a short tunnel that discharges the diverted water from this stream to just above a larger dam constructed across Waiahulu Stream. The combined water from these two streams was routed into a new section of ditch that was composed largely of tunnels constructed in hard rock. This new, largely tunneled section of KEDIS day-lighted approximately two miles to the southeast of the upper intake at an elevation of around 730 feet on the west canyon wall above the Waimea River. The ditch water then ran into a 42-inch diameter steel penstock that dropped water down to the Mauka Hydropower Plant located in the river basin below. Around the same time, KSC extended the lower section of KEDIS another eight miles along the cliffs fronting the Mānā Plain to reach Polihale. In 1923, KSC undertook major repairs of KEDIS after renegotiating new lease arrangements with the government, expanding its capacity from 45 to 50 mgd and its average flow from 30 to 35 mgd.

When fully constructed, KEDIS had three major diversion structures located near the terminus of Waiahulu and Koaie streams and at an elevation of 550 feet on the Waimea River. The third diversion on the Waimea River at the Mauka Power Plant was used to capture additional water originating from two sources: 1) baseflow entering the section of the Waimea River below the confluence of the Waiahulu and Koaie Streams as a result of the stream bottom intercepting the water table of dike impounded groundwater; and 2) streamflow entering the Waimea River from the undiverted Waiʻalae Stream. KSC typically opened this lower diversion during low-flow and drought conditions within the watershed. Water Resource Associates (2004) reported the transmission capacity of the fully constructed KEDIS to be 104 mgd with 95 million gallons of associated storage.

Construction of the KODIS began in 1923. Many of the roadways that run through Kōkeʻe State Park today were originally built to allow access to this ditch system during its construction. The ditch was constructed by workers that were housed in ten camps (Camp 1 to Camp 10) erected along the length of the system. Water was running through the ditch by January 1925, and the final upper section of the ditch starting at Mōhihi Stream was completed in early 1926. Puʻu Lua Reservoir, the major storage facility for KODIS, was finished in 1927, with a capacity of 262 million gallons. This earthen dam reservoir was situated at an elevation of 3,260 feet above sea level. The 36-million gallon capacity Kitano and the 88-million gallon capacity Puʻu ʻŌpae Reservoirs were constructed at the terminus of the 21-mile long KODIS. During the plantation era, KODIS served the upland sugarcane fields above the Kekaha coastal plain by storing and routing water from these three storage reservoirs. About one-fourth of the KODIS water was used to irrigate upland fields below Puʻu ʻŌpae Reservoir and the remainder to irrigate the upland fields located east of Kōkeʻe Road.

The capacity of KODIS between Camp 8 (near the Waiakoali diversion) and the Pu‘u Lua Reservoir was 55 mgd while the ditch capacity leading into the Pu‘u Moe divide was 26 mgd. The ditch capacity from the Pu‘u Moe junction to the sections that run towards the Pu‘u ‘Ōpae and Kitano Reservoirs was approximately 7 mgd and 19 mgd, respectively. KODIS was constructed with a maximum diversion capacity of 105 mgd, a transmission capacity of 105 mgd, and a total storage capacity of 361 million gallons (Water Resource Associates 2004).

The project engineer, George Ewart, designed KODIS to capture as much of the freshets as possible that develop in the tributaries in the headwaters of the Waimea River after heavy rainfall events. The upper section of the ditch system runs near the cliffline along the southern edge of the upland plateau near Kōke‘e. The slope of the ditch drops one foot per 1,000 linear feet traversed. KODIS diverted the various tributaries of the Waimea River in the Kōke‘e area at elevations of around 3,400 feet. KODIS diverted flow in the following streams: Mōhihi, Waikoali, Kawaikōī, Kaua‘ikananā, and Kōke‘e. KODIS contains forty-eight tunnels, averaging 1,000 feet in length, with the longest continuous tunneled section running 3,000 feet. The Kauhao diversion, located just past the 3,000-foot section of tunnel, was used to spill-off water into Kauhao Stream during times of heavy rainfall when the ditch approached reaching its capacity. The upper section of KODIS, between the Waiakoali and Kauhao diversion, predominately flows through tunnels and ditch drilled through rock. The 19 miles of ditch between the upper diversion at Mōhihi to the Kitano Reservoir consisted of roughly 7 miles of tunnel and 12 miles of open ditch. The section of KODIS that runs from the Pu‘u Moe divide to the Pu‘u ‘Ōpae Reservoir consists almost entirely of unlined ditch. The upper section of the ditch that ran from Mōhihi to Waiakoali was abandoned in the 1980s since this section proved too costly to maintain due to the instability of the soils in the region (Ignacio, personal communication).

3.3 Electricty Produced by Hydropower on KEDIS

The Waiawa Hydropower Plant was built in 1908 near the end of the original Kekaha ditch system. This power plant has a 500 kilowatt (kW) capacity and uses water that runs through a penstock that connects to the ditch on a ridge about 400 feet above sea level that then drops to an elevation of about 120 feet above sea level at the hydroelectric plant. According to Landis Ignacio of KAA, the plant optimally operates using 21 mgd of water to produce around 425 kW of electricity. The original Pelton waterwheel remains operational at this plant but the original buckets and nozzles have been replaced. The transformers at the plant still have mechanical switches, and some of the lettering on the old switchboard is by hand. The power generated by this plant is transmitted via powerlines to various 40-hp booster pumps that operate throughout the Mānā Plain to irrigate the flat lying fields as well as to the larger dewatering pumps at Kawai‘ele, Nohili, and Kekaha.

The Mauka Hydropower Plant was built in 1911 in conjunction with the extension of the original Kekaha ditch system inland to just above the convergence of the Waiahulu and Koaie Streams. The original hydroelectric plant was located on the west bank of the Waimea River and was modernized in 1930. However, this original plant was destroyed during a large flood event in 1948 that also destroyed the siphon that originally run over the top of the river. A new hydroelectric plant was constructed in 1952 by blasting a cavern into the hard rock located on the eastern edge of the Waimea River and routing the penstock under the river in a concrete dam constructed across the river. Water is routed to this upper hydro plant via a 42-inch diameter steel penstock that starts at an elevation of around 730 feet and drops to an elevation of around 530 feet at the hydroelectric plant. This power plant has a maximum capacity of 1,200 kW. The operators attempt to run the plant at 1,100 kW by routing 34 mgd of water through the plant. The electricity generated by this plant is transmitted via powerlines that run up the western slope of the canyon towards Kōke‘e.

KAA provided data for the average monthly energy produced by both hydropower plants in kilowatt-hours (kWh) during the period of January 2010 through December 2014. Figure 3-1 is a plot of the monthly electricity generated by these two plants during this five-year period. This figure shows the somewhat cyclical nature of power production at these two plants, with greater amounts of power generally produced in the wetter winter months and lower amounts of power produced during the drier summer months. The average amount of energy generated by the Mauka and Waiawa Hydropower Plants between 2010 and 2014 was 315 and 294 kWh, respectively. This corresponds to an average daily production rate of 432 and 328 kW at the Mauka and Waiawa Power Plants, respectively. The market value of the power generated by these two plants was estimated by multiplying the total electricity generated during these five years by the average rate charged by the Kaua‘i Island Utility Cooperative to Large Power consumers (Schedule "L") during this period (about $0.35 per kWh) (Table 3-1). The Mauka and Waiawa Hydropower Plants produced an average of a little more than 2.3 Million dollars worth of electricity per year between 2010 and 2014.

Table 3-1: KEDIS Hydroelectric Power Generation from 2010 to 2014

	Waiawa	Mauka	Total
5-Year Total Production (kWh)	14,363,500	18,891,087	33,254,587
Electricity Worth ($0.35/kWh)	$5,027,225	$6,611,880	$11,639,105
Average Value of Electricity per Year	$1,005,445	$1,322,376	**$2,327,821**

3.4 Auxiliary and Recreational Uses of Ditch Systems

The ditch systems also provide fire protection for the lands that surround the two ditch systems. At higher elevations, the water stored in Pu‘u Lua Reservoir on KODIS can be accessed by helicopters for fighting wildland fires. At lower elevations, the water stored in the various irrigation reservoirs on KEDIS located along the Mānā Plain as well as a rectangular shaped dip pool located adjacent to KEDIS just to the east of the Hukipo Flume can be accessed by helicopters for fire-fighting purposes.

The largest reservoir on KODIS, Pu‘u Lua Reservoir, is stocked with rainbow trout by DLNR. The Kōke‘e Public Fishing Area is typically open to the public during daylight hours from June to September. In 2016, the trout fishing season began on June 18 and will run until September 30. The daily bag limit is 12 trout per person. In 2015, a total of 3,837 anglers caught 28,831 trout from the reservoir. The largest fish caught at Pu‘u Lua Reservoir in 2015 measured 18.5 inches in length and weighed 2 pounds 5 ounces (DLNR 2016). Fishing is only allowed from the banks of the reservoir. Trout fishing is expected to be good this year as more than 30,000 young trout were stocked in the reservoir late last year.

Fire Fighting Water Sources: Pu'u Lua Reservoir and Pool adjacent to KEDIS above Kekaha

Cleaning and Catching Trout at Pu'u Lua Reservoir

3.5 Reported Current Agricultural Usage of Ditch Water

Mr. Douglas A. Codiga of Schlack Ito on behalf of KAA provided information on average water use by KAA tenant users of KEDIS and KODIS in a letter dated July 10, 2015 in response to information requests set forth to KAA and ADC in a May 11, 2015 letter from CWRM. KAA's three largest tenants (BASF, Syngenta, and Pioneer) provided supplemental responses to CWRM's information request on July 15, 2015. The estimated total current allocated water usage from KEDIS and KODIS is around 5.8 mgd. Table 3-2 summarizes the average water consumption use reported by KAA and their members for the five years between 2010 and 2014.

Table 3-2: Summary of Water Consumption from KODIS and KEDIS (2010 to 2014)

	BASF	Syngenta	Pioneer	Menehune Ditch	Kikiaiola Land	DHHL	Wines of Kaua'i	Ditch Maintenance	TOTAL (exclusive of DHHL)
Average Water Usage (mgd)	0.50	1.79	1.14	0.65	0.72	0.29	0.29	0.43	5.81
Licensed Acreage (acres)	977.25	1,785.07	1,337.07	NA	NA	14,500	126.96	NA	4,226.35

By comparison, an Agricultural Water Use and Development Plan (AWUDP) developed by the DOA in 2003 forecast a best and worst case scenario of acreage and water needs for future diversified agriculture related to KODIS and KEDIS over a 20-year planning period (DOA 2003). This analysis estimated a future range in water use between 3.69 to 12.82 mgd for KEDIS and a range of 2.76 to 4.05 mgd for KODIS.

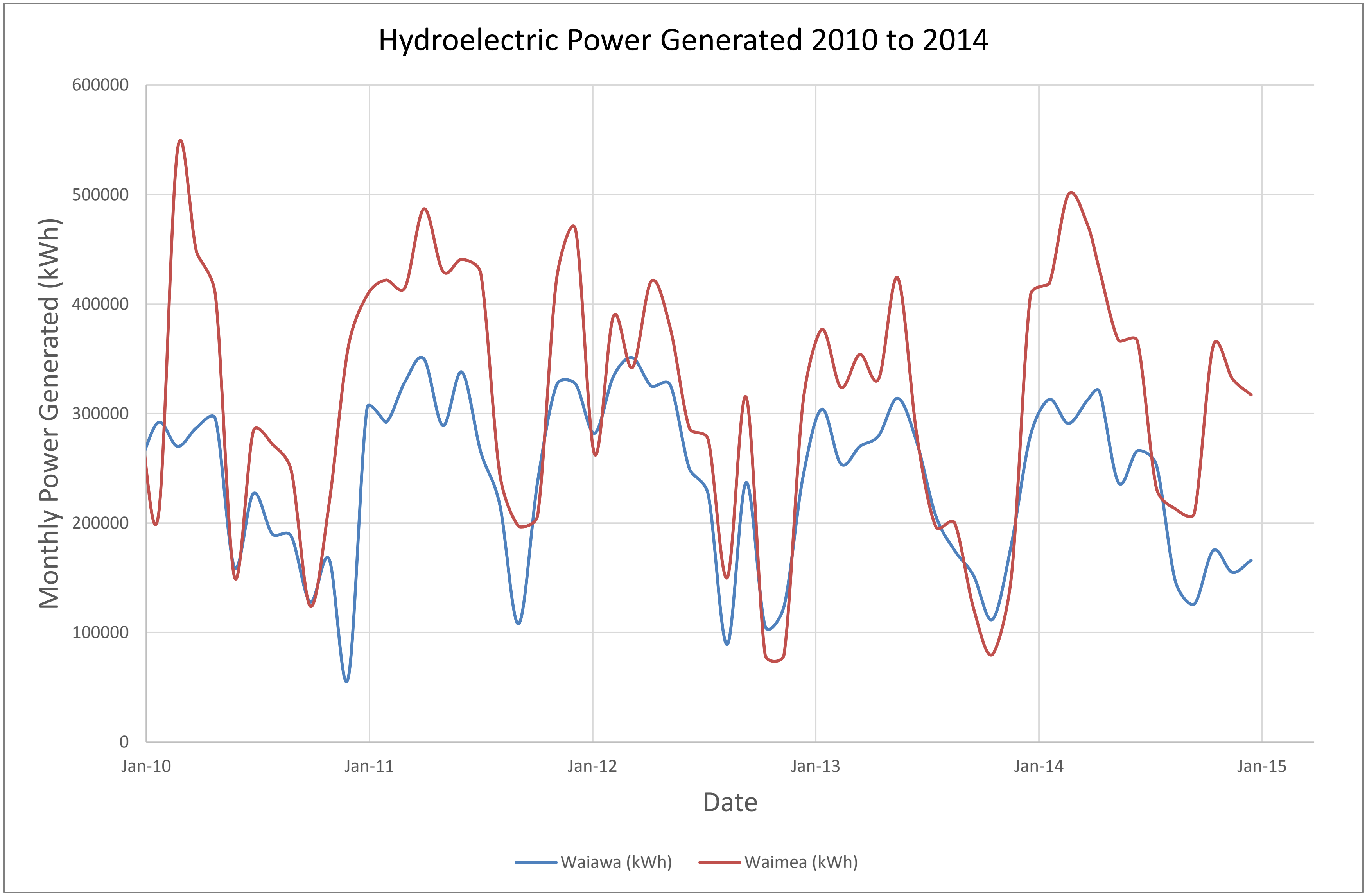
3.6 Future Potential Hydropower Projects

In recent years, a number of proposals have been advanced for using the water stored in the existing reservoirs on KODIS to produce electricity using various forms of pumped hydropower storage technology. Projects that utilize Pu‘u Lua and Pu‘u ‘Ōpae as the upper storage ponds for a pumped storage system are currently under consideration. Both projects would require rehabilitation of the existing earthen reservoirs to meet current dam safety standards. Water stored in these reservoirs would be connected to a lower storage pond located on the Mānā Plain by either a 5.0- or 2.5-mile long buried steel pipeline. A powerhouse and pumping station would be located beside this new or rehabilitated lower, approximately 30-million-gallon storage reservoir on the Mānā Plain.

Pumped hydropower could help the KIUC to “store” excess energy produced by the island’s rapidly expanding utility-scale photovoltaic array systems. The solar power would be used to pump water uphill from the lower to the upper reservoir during the day. The same water would then be reused by releasing it down the steel pipeline to turn a turbine, which would create electricity at night. An environmental advantage of this type of system is that it requires little additional diversion of water into the upper reservoir since the water is cycled between the upper and lower reservoir via the steel pipeline.

It is estimated that these project would cost between $55 to $65 million dollars to construct and would be capable of generating about 25 megawatts of electricity. By comparison, KIUC currently has a 78-megawatt peak power generating capacity. The cost of electricity generated by the hydropower storage system would initially be about 35 percent less than the cost of electricity produced from oil and once the pump storage facility is paid off, would fall to only a few pennies per megawatt-hour, according to Jim Kelly, the communications manager for KIUC.

This page intentionally left blank.


Hydroelectric Power Generated 2010 to 2014
600000
500000
400000
300000
200000
100000
0
Monthly Power Generated (kWh)
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Date
Waiawa (kWh)
Waimea (kWh)

4 Ditch System Historic Flow Data

This section summarizes the historic monitoring of stream and ditch flow, the groundwater input to streamflow, and historic trends in streamflow within the Waimea River watershed.

4.1 Historic Streamflow Data

The USGS and plantations began monitoring streamflow in the Waimea River watershed in 1907. Gaging stations were established on both non-diverted sections of streams, diverted sections of streams and at the diversion ditches themselves. The historic stream and ditch flow data used in this study was obtained from the USGS National Water Information System (NWIS), which can be accessed at http://waterdata.usgs.gov/hi/nwis/sw/. This on-line database allows access to more than 100 years of water data collected by the USGS. The USGS stream data is stored on the website in units of cubic feet per second (cfs). In this report, flow values are reported in terms of million gallons per day (mgd). The conversion from cfs to mgd is as follows: 1 cfs = 0.646 mgd.

Figure 4-1 shows the location of the various historic and active gaging sites located within the Waimea River watershed. Two active USGS gaging stations remain operational within the project area on Kawaikōī and Waiʻalae Streams (Station Numbers 16010000 and 16019000). Six additional historic stream monitoring stations existed on non-diverted sections of streams, predominately at locations along tributary streams that drain the upland areas above Waimea Canyon. Three historic stream monitoring locations were located along diversion-impacted sections of the Waimea River within Waimea Canyon. The USGS reactivated the lowest former gaging station with the longest historical record (Station Number 16031000) in August 2016.

Five historic monitoring locations were established to measure ditch flow within the Kekaha, Kōkeʻe and Waimea ditches during the plantation era. Table 4-1 below depicts the duration of streamflow data available on NWIS for the active and historic stream and ditch monitoring locations.

Table 4-1: Duration of USGS Monitoring Stations

Table 4-1: Duration of USGS Monitoring Stations

USGS Station	Station Name	1907	1910	1913	1916	1919	1922	1925	1928	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997	2000	2003	2006	2009	2012	2015
Non-Diverted Streams																																						
16010000	Kawaikōī Stream	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
16011000	Waiakoali Stream		■	■	■	■	■	■																														
16012000	Kauaʻikananā Stream					■	■	■																														
16013000	Mōhihi Stream						■	■				■	■	■	■	■	■	■	■	■	■	■	■															
16017000	Koaie Stream					■	■	■	■									■	■	■	■	■																
16019000	Waialae Stream						■	■	■								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
16020000	Waialae Stream		■	■	■																																	
16021000	Waialae Stream				■	■																																
Diverted Streams																																						
16016000	Waimea River				■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																
16028000	Waimea River below Ditch Intake						■	■	■	■	■	■	■	■	■	■	■	■																				
16031000	Waimea River		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Ditch Flow																																						
16014000	Kōkeʻe Ditch								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■											
16022000	Kekaha Ditch-Camp 1		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																
16027000	Kekaha Ditch-Tunnel 12	■	■	■	■	■	■	■	■	■	■																											
16029000	Waimea Ditch			■	■	■	■																															
16029100	Waimea Ditch below Wasteway																			■	■	■	■															

The calculated flow duration statistics for each stream and ditch gaging station are summarized in Table 4-2. For this project, various flow duration exceedance percentiles (i.e., Q50, Q70, Q90, and Q95) were calculated for each station. The USGS records available on-line provide estimates of the average daily flow for each monitoring station. The flow duration exceedance percentiles are the flow recorded at the station that was equaled or exceeded a given percentage of the time. For instance, Q50 is the median daily flow measured at the station, where half the daily values recorded were greater than this value and half were less than this value. Q95 represents a daily flow value that was exceeded 95 percent of the time. The Q90 and Q95 flows are commonly used low flow indexes or indicators of extreme low flow conditions in streams (Smakhtin 2001). In some cases, Q50 is used for aquatic baseflow policy for water resources planning and management (Ries and Friesz 2000). The table also includes the average flow measured at the monitoring site Q(Avg) as well as the lowest average flow measured at the station over a continuous 14-day period of monitoring. The large difference in calculated median (Q (50)) and average flow at the non-diverted and diverted stream stations is due to the episodic large rainfall and runoff events that occur within the watershed, which cause the average flow to be 2 to 3 times larger than the median flow in non-diverted streams and 3 to 50 times larger than the median flow measured at monitoring stations located on sections of stream impacted by diversions. The fact that the average flow values are "skewed" by the magnitude of episodic high flow runoff events was the reason that the median flow statistic was used in this report. Figure 4-2 and Figure 4-3 depict the historic median and Q(95) flow data compiled in Table 4-2 on a map of the watershed.

Table 4-2: Statistics for USGS Gaging Stations for Streams in the Waimea River Watershed

Table 4.2: Statistics for USGS Gaging Stations for Streams in the Waimea River Watershed

USGS Station	Station Name	Watershed ($mile^2$)	Elevation (Feet)	Diverted?	Units	Record	Q(95)	Q(90)	Q(70)	Q(50)	Q(Avg)	14 day low
Non-Diverted Streams												
16010000	Kawaikōī Stream	3.95	3420	No	mgd	1907 - 2015	2.20	2.71	4.91	7.76	21.55	0.94
16011000	Waiakoali Stream	1.58	3490	No	mgd	1909 - 1925	0.60	0.90	1.42	2.13	5.75	0.45
16012000	Kauaʻikananā Stream	0.84	3440	No	mgd	1919 - 1925	0.30	0.40	0.71	1.29	3.47	0.20
16013000	Mōhihi Stream	1.68	3420	No	mgd	1920 - 1971	0.38	0.54	1.10	1.87	5.56	0.03
16017000	Koaie Stream	1.68	3770	No	mgd	1919 - 1968	1.49	1.81	3.23	5.30	18.29	0.77
16019000	Waialae Stream	1.79	3820	No	mgd	1920 - 2015	1.42	1.68	2.59	4.14	13.44	0.85
16020000	Waialae Stream	2.81	3500	No	mgd	1910 - 1916	2.00	2.78	4.52	7.11	12.95	1.42
16021000	Waialae Stream	7.87	800	No	mgd	1916 - 1921	3.81	4.52	7.11	9.69	20.87	3.49
Diverted Streams												
16016000	Waimea River	20	840	Yes	mgd	1916 - 1968	7.76	8.40	10.34	12.28	35.38	6.27
16028000	Waimea River below Ditch Intake	44.2	490	Yes	mgd	1921 - 1956	0.00	0.01	0.20	0.97	49.75	0.00
16031000	Waimea River	57.8	25	Yes	mgd	1910 - 1997	0.90	1.42	4.14	10.34	80.43	0.00
Ditch Flow												
16014000	Kōkeʻe Ditch	-	3310	Ditch	mgd	1926 - 1982	3.17	4.07	7.76	12.28	15.94	0.14
16022000	Kekaha Ditch at Camp 1	-	520	Ditch	mgd	1908 - 1968	20.68	23.91	29.73	36.19	36.77	0.31
16027000	Kekaha Ditch below Tunnel 12	-	470	Ditch	mgd	1908 - 1934	18.10	20.68	27.15	34.25	32.77	0.00
16029000	Waimea Ditch	-	50	Ditch	mgd	1911 - 1921	0.00	0.97	2.46	3.49	3.53	0.00
16029100	Waimea Ditch below Wasteway	-	131	Ditch	mgd	1960 - 1971	0.00	0.06	1.36	2.39	2.60	0.00

KAA has reported monthly ditch flow to the Commission since taking over management of the ditch systems. Figure 4-4 depicts the reported monthly average flow records for KEDIS and KODIS from January 2010 to June 2016.

4.2 Groundwater Flow Input to Streamflow

A significant amount of groundwater enters Waimea River and its tributaries in the upper regions of the Waimea Canyon. This baseflow that enters the streams likely originates from the streambed intercepting water stored in high-level, dike-impounded aquifers present in the marginal dike zone of the Waimea Canyon Volcanics as well as from perched water present in the Olokele Formation lavas. This high-level groundwater discharges into springs, seeps and directly into the stream and riverbeds in the area. This perched groundwater is encountered in exploratory and drinking water wells drilled within the upland plateau in Kōkeʻe State Park. The shallow, perched (about 10 feet below ground surface [bgs] at 3,535-foot surface elevation) groundwater exists in low permeability, highly weathered basalt and stream alluvium perched atop hard, slightly weathered dense basalt flow units of the Olokele Formation (Water Resource Associates 1990).

The groundwater component of streamflow (baseflow) entering the Waimea river and associated tributaries was estimated from reviewing the runoff and ditch flow measured during the greatest historic drought to occur on Kauaʻi between the months of April and November 1953. A University of Hawaiʻi (UH) study (UH 2003) found this eight-month period to have a Bhalme and Mooley Drought Index (BMDI) severity value of -22.96.

Figure 4-5 shows the combined diverted flow measured in the Kōkeʻe and Kekaha ditch systems as well as the residual stream flow in the lower portion of the Waimea River below the Waimea diversion (blue line) and the combined measured flow in the major feeder streams (Kawaikōī, Mōhihi, Koaie and Waiʻalae) to the Waimea River (green line) from May to November 1953. Based on the flow measured in the Kōkeʻe ditch during this period, it is estimated that the combined flow contributed by the three un-monitored streams (Kōkeʻe, Kauaʻikananā and Waiakoali) during this time period was around 2 mgd. Due to the extreme drought conditions, there were no other significant sources of surface water entering either the ditch systems or the Waimea River during the majority of this period of time. The red line in this figure is an estimate of the groundwater input and is equal to the difference between the blue and green lines, minus 2 mgd for the un-monitored streamflow. This estimate reflects the estimated flux of groundwater entering the rivers and tributaries below the upper dam diversions on KODIS, largely in the river sections in the upper portions of Waimea Canyon above the three diversions for KEDIS.

The baseflow entering the Waimea River and tributaries from groundwater input is estimated to be around 20 mgd. This rate of groundwater input to the Waimea River is similar to estimates of flow contributions of dike-impounded aquifers entering the Waiahole ditch system on Oʻahu (19 mgd), the Lower Hamakua ditch system on Hawaiʻi (19 mgd) and the Honokoha ditch system on West Maui (14 mgd) (Mink and Lau 2006).

The spatial distribution of the groundwater input into the Waimea River and its tributaries can be roughly estimated using the historic USGS monitoring data summarized in Table 4-2. The largest contribution of groundwater input appears to come from the segment of stream that runs above the Waiahulu dam (see USGS Station 16016000). The majority of this input appears to originate from groundwater day-lighting along the Poʻomau segment of the stream since the Waiahulu stream appears to go dry above the confluence with the Poʻomau during dry periods. Groundwater input to Waiʻalae and Koaie Streams appears to be of roughly similar magnitude (compare Stations 16017000 and 16019000) and about half the amount that enters the Poʻomau Stream segment (based on stream data collected from Station 16021000). An additional, unknown but relatively small amount of groundwater input likely enters the Waimea River directly between the upper diversion to KEDIS near the confluence of the Koaie and Waiahulu streams and the Waimea intake located just above the Mauka hydroelectric plant. It appears that very little groundwater enters the lower Waimea River in the stream segment between the Mauka hydroelectric plant and the long-term USGS gaging station (Station Number 16031000, elevation 25 feet) based on the Q95 and 14-day low flow readings measured at this monitoring station.

Figure 4-6 shows the stream segments within the Waimea River watershed that are currently non-diverted, the segments that are diverted but receiving increased flow over natural conditions, as well as the segments that are diverted and receiving either slightly decreased or significantly decreased flow over natural conditions. The increased flow occurs in the Kōkeʻe and Kauaʻikananā stream segments below KODIS, which currently receive water spilled from the ditch that originated from Waikoali and Kawaikōī Streams. The river segments with greatly reduced flows include the roughly 2,750 and 2,150-foot long sections of streambed between the diversion structures on the Waikoali and Kawaikōī streams and the first large waterfall that conveys water to

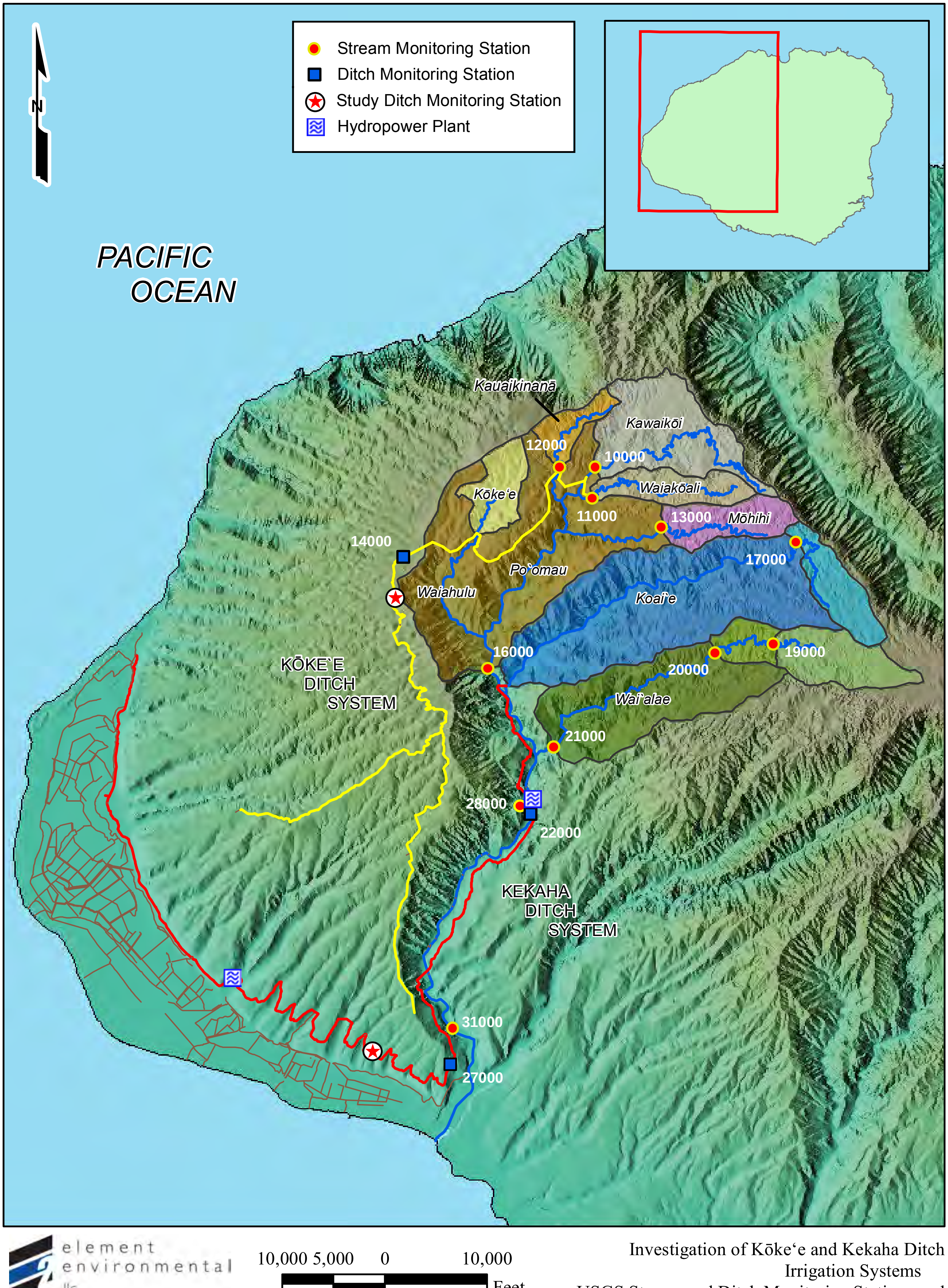
Po‘omau Canyon. The other section of the river with significantly reduced flows is the roughly 8,000-foot long section of the Waimea River located between the diversions on the Koaie and Waiahulu streams and the confluence with Wai‘alae Stream, which has no diversions.

The Earthjustice complaint requests that the Commission produce amended interim instream flow standards (IIFSs) for the Waimea River. An interim instream flow standard, defined by Chapter 176D, HRS, is a temporary flow standard of general applicability that will identify a quantity of water to be set aside to protect instream uses, such as fish and wildlife habitats and recreational and aesthetic values, until permanent instream flow standards can be established on a stream-by-stream basis (Sakoda 2007). The magnitude and distribution of groundwater input into the diverted and non-diverted portions of the streams and tributaries within the Waimea River watershed will play a significant role in determining future IIFSs for the project site.

4.3 Historic Trends in Streamflow

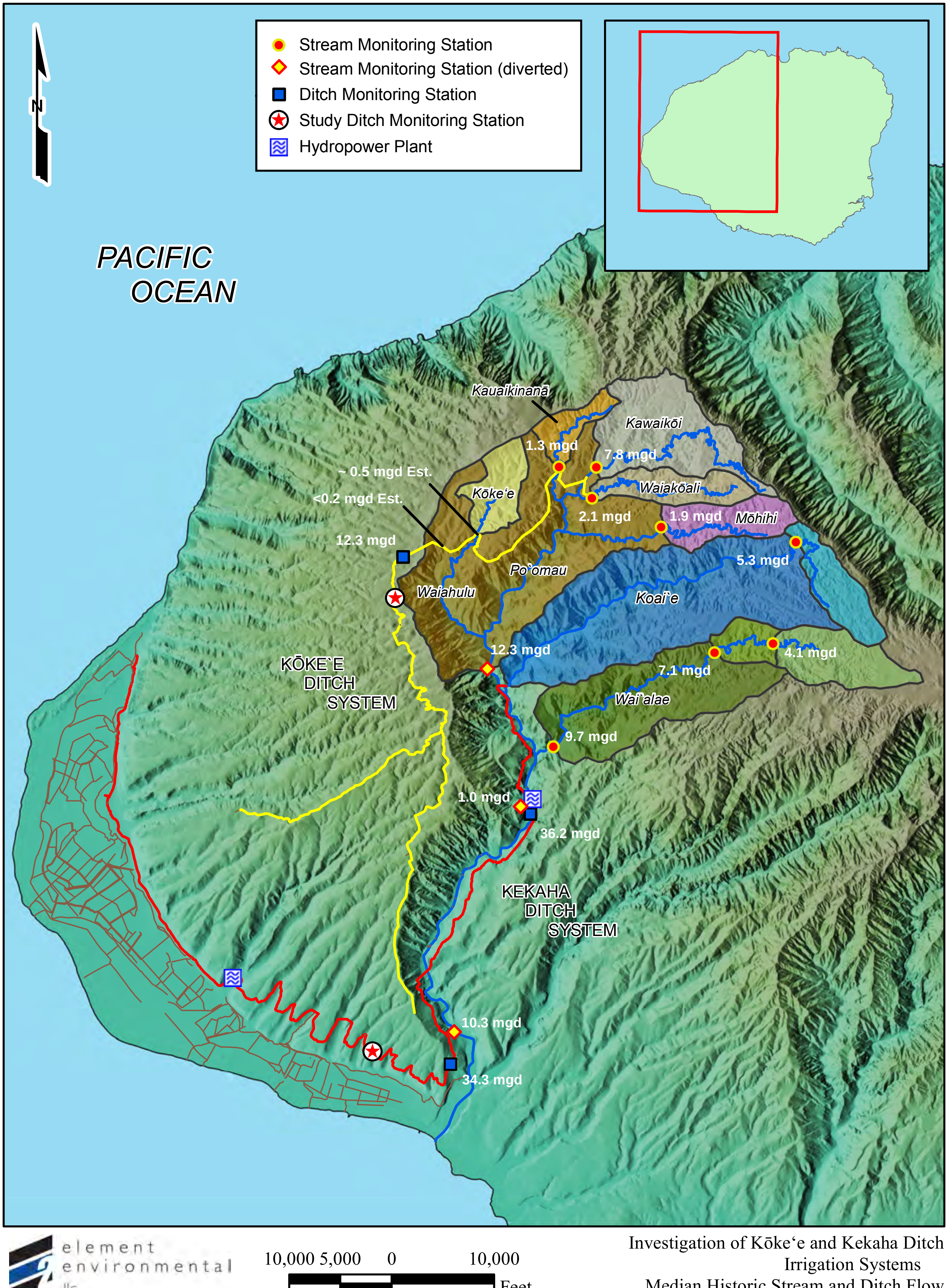
Bassiouni and Oki (2013) documented significant long-term (1913-2008) downward trends in low-streamflow and base-flow records in eight out of nine long-term streamflow gages in Hawai‘i. This finding is consistent with significant decreases in rainfall measured in Hawai‘i over the same period. Their analysis found a 23% reduction in median base flow in Hawaiian streams from 1943-2008 compared to 1913-1943. Because base flow in these streams comes from groundwater, decreasing base flow indicates that the volume of groundwater resource is also decreasing. Kawaikōī Stream was the single long-term station that did not have a statistically significant decline in base-flow records, but it did have a downward trend.

Figure 4-7 shows the 10-year moving average of streamflow starting at the Kawaikōī USGS gauge (Station 16010000) in 1929, ten years after the continuous flow record began in 1919. The downward trend in the mean and median of the 10-year moving average streamflow in Kawaikōī stream is evident in this figure since the late 1980s. This time period of generally lower overall rainfall in Hawai‘i corresponds to the Pacific Decadal Oscillation (PDO) entering a positive phase around 1977 (Bassiouni and Oki 2013). The PDO is taken as the leading component of North Pacific sea-surface temperatures (Mantua et al. 1997). This decadal mode can be thought of as a slowly varying mean climate state with a period of 30 to 40 years. This finding suggests that the volume of baseflow currently entering the Waimea River watershed may be somewhat lower than historic fluxes discussed in Section 4.2.



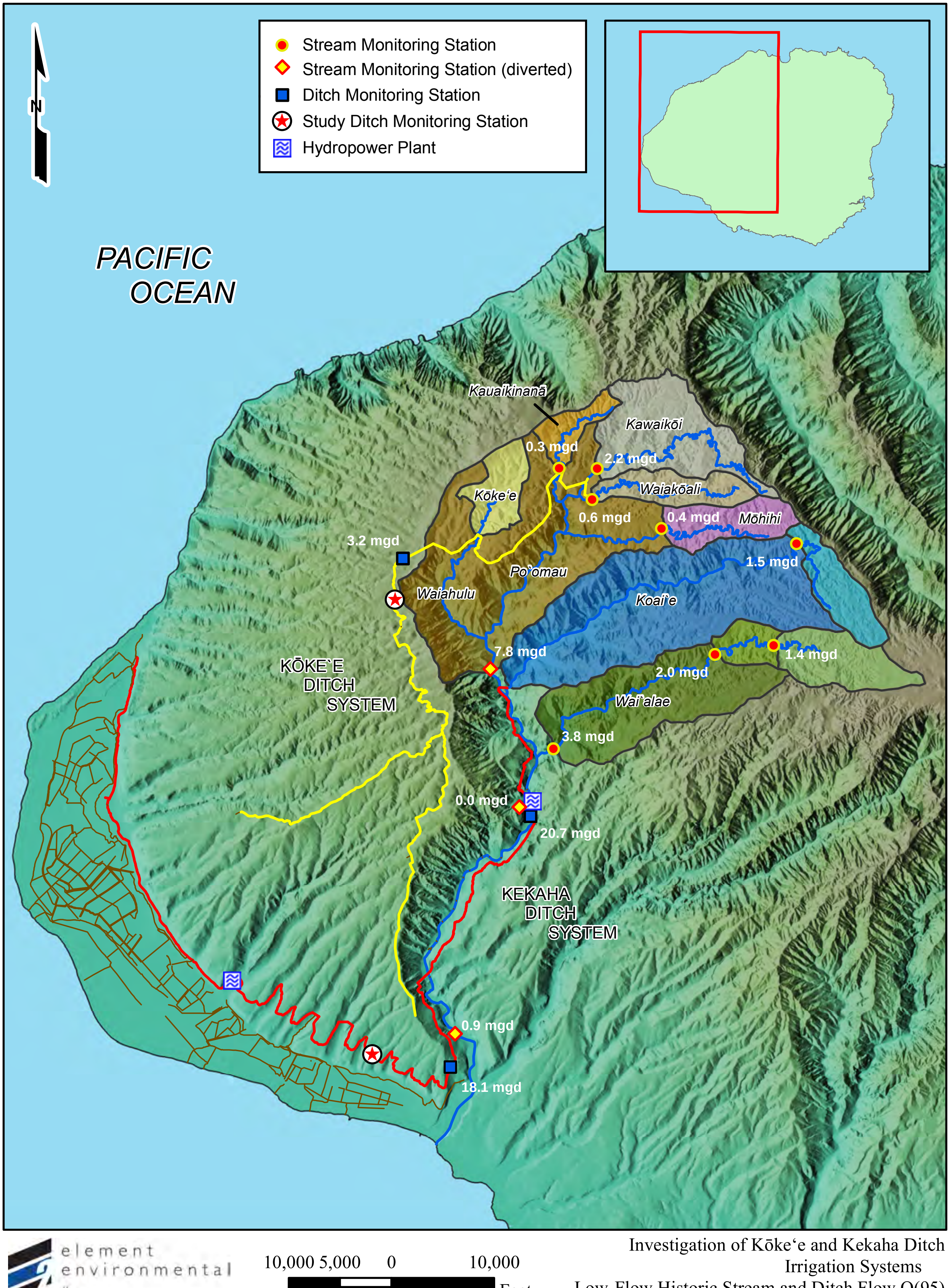
element environmental llc

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
USGS Stream and Ditch Monitoring Stations and Two Monitoring Locations Used During this Study
Figure 4-1



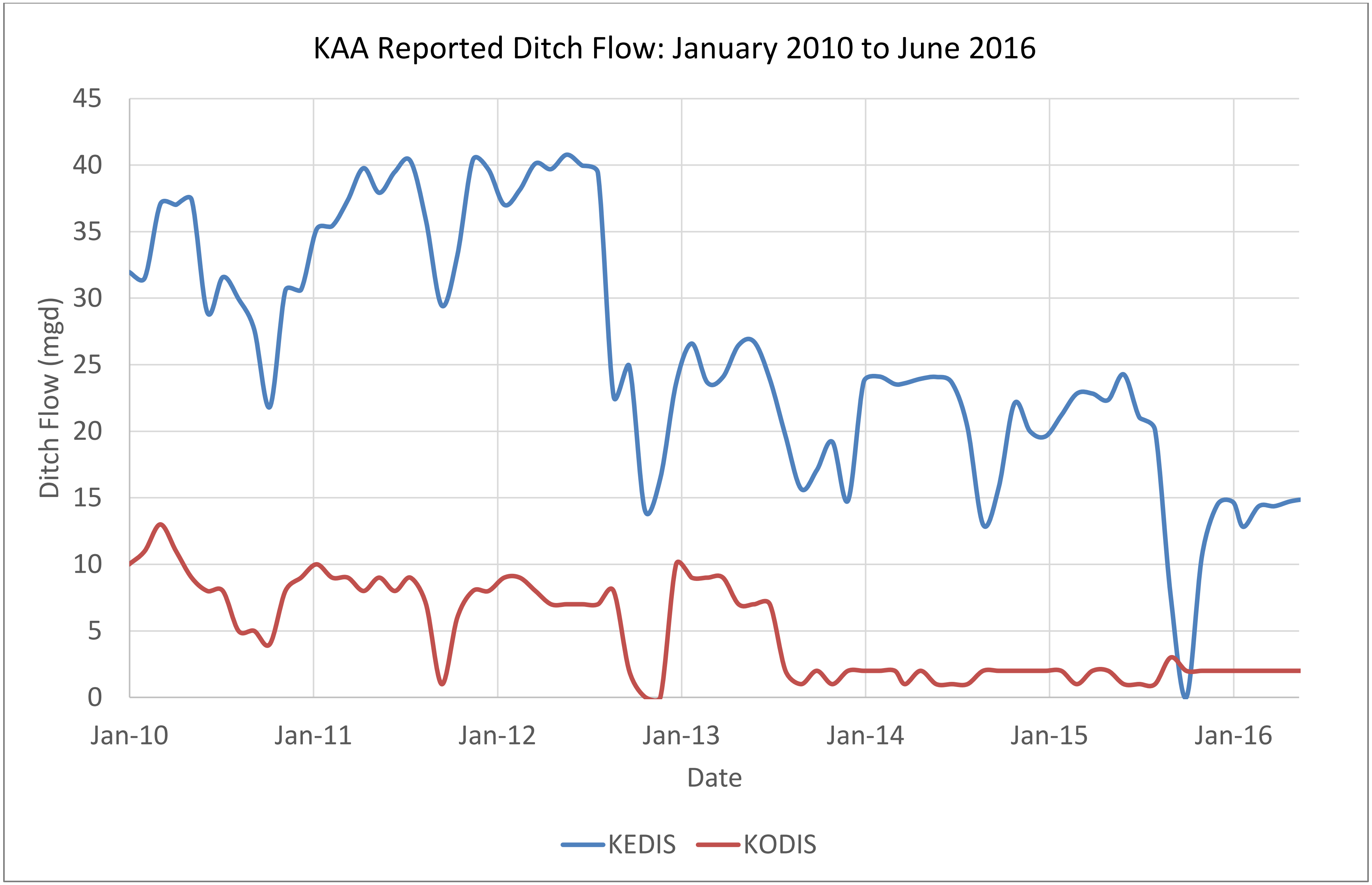
element environmental llc

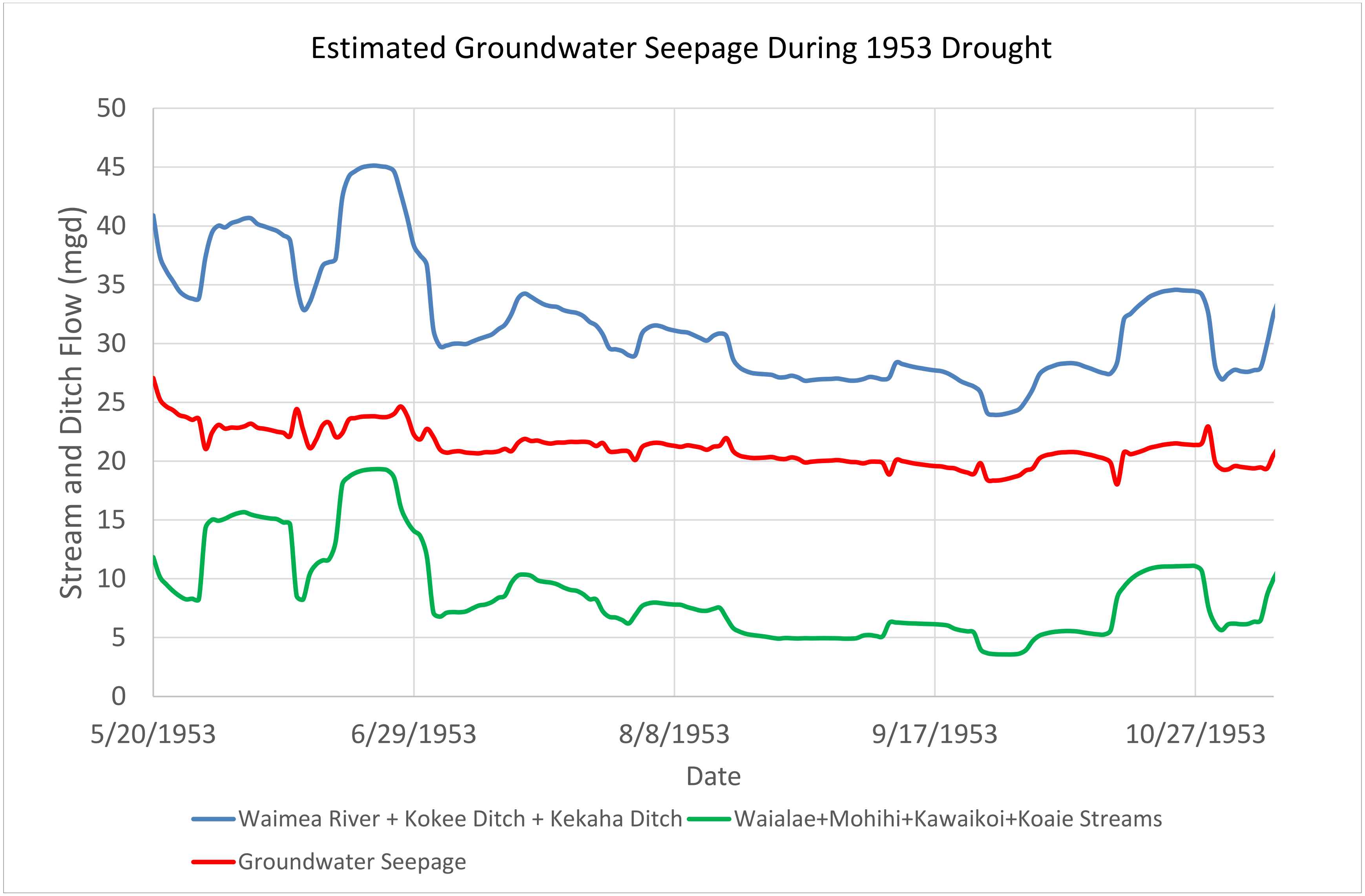
Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Median Historic Stream and Ditch Flow in Waimea River Watershed
Figure 4-2



element environmental llc

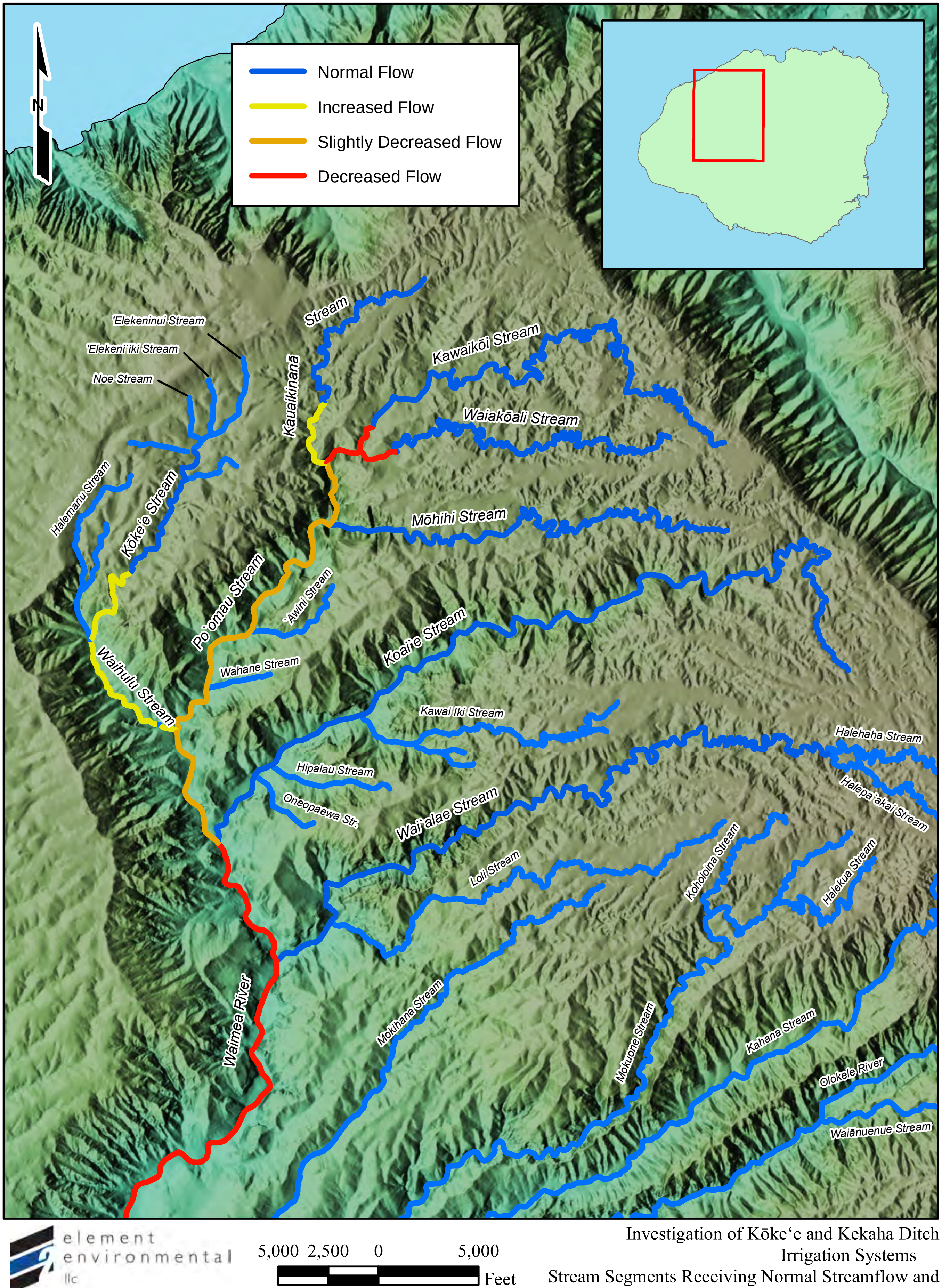
Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Low-Flow Historic Stream and Ditch Flow Q(95) in Waimea River Watershed
Figure 4-3


KAA Reported Ditch Flow: January 2010 to June 2016
Ditch Flow (mgd)
45
40
35
30
25
20
15
10
5
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Date
KEDIS
KODIS



element environmental llc
environmental · engineering · water resources

Investigation of Kōke'e and Kekaha Ditch Irrigation Systems
Estimated Groundwater Seepage During 1953 Drought - Figure 4-5

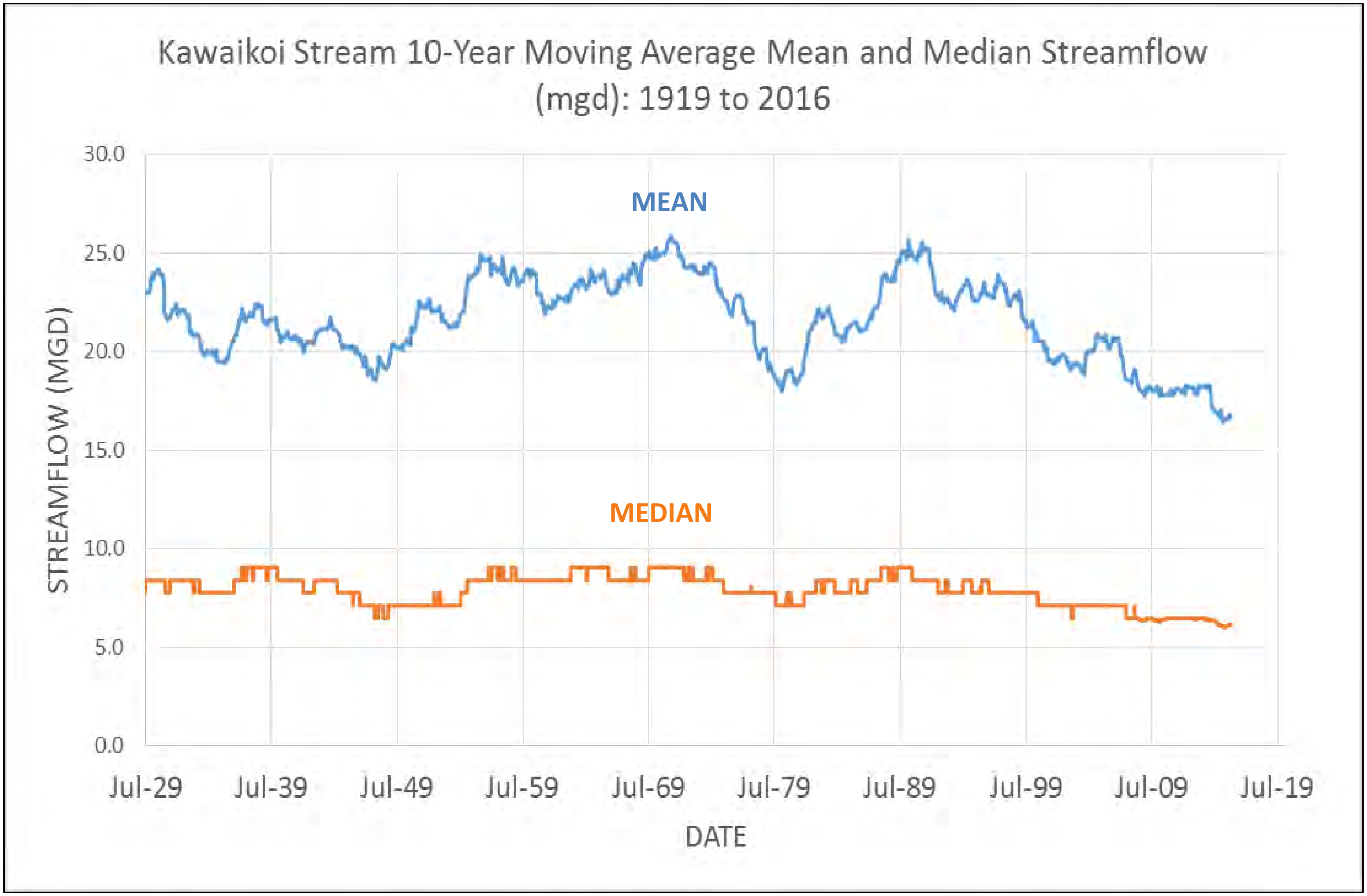


element environmental llc

Investigation of Kōke'e and Kekaha Ditch Irrigation Systems

Stream Segments Receiving Normal Streamflow and Increased/Decreased Streamflow Due to Diversion

Figure 4-6



element environmental llc
environmental · engineering · water resources

Investigation of Kōke'e and Kekaha Ditch Irrigation Systems
Kawaikōī Stream 10-Year Moving Average Mean and Median Streamflow (mgd): 1919 to 2016 - Figure 4-7

5 Ditch System Flow Measurements

This section describes the monitoring and measurement work conducted on KEDIS and KODIS by E2 during this study. E2 used a Pygmy current meter to measure the flow rate of water through the ditches. Pressure transducers were also used to continuously monitor the volume of water flowing through the two ditch systems between June 2015 and June 2016.

5.1 Pygmy Meter Description

Flow measurements were conducted following the guidance from the United States Geological Survey (USGS 1982) and from the flow measurement equipment's manufacturer (JBS Instrument) operation manual. A Pygmy current meter with a digital magnetic head was used in conjunction with a top set wading rod equipped with an Aquacalc Pro Plus stream flow computer to measure the rate of water flow within the ditches. Prior to initiating stream measurements, the equipment was inspected to ensure proper function. The Pygmy meter consists of a bucket wheel and a pivot pin that rotates as water flows past. A magnetic sensor counts the revolutions generated as water flows past the bucket. The meter is designed with precision to turn freely with very little resistance. A spin test was conducted on the Pygmy meter prior to use in the field to ensure the head would continue to spin uninterrupted for 1 to 1.5 minutes.

Ditch flow was determined by measuring flow across an irrigation ditch section. The sections were selected in areas where water flows in a more regular laminar fashion. Curves, bends, or drops in the ditch were avoided. A section was set up by attaching a USGS Kevlar tagline or measuring tape across the ditch, perpendicular to the side walls of the ditch. The Pygmy meter was attached to a top set wading rod and connected to a stream flow computer. The wading rod consists of two aluminum rods that can slide against each other and lock in place in order to place the Pygmy meter at proportional depth of 0.6 times the depth of water in the ditch. The rod is marked in tenths of a foot to record water depth in the ditch at the point of a measurement. The Pygmy meter/wading rod was placed in the ditch 0.5 feet from one edge of the ditch along the tagline and a velocity measurement was made over approximately 45 seconds using the stream flow computer. Once a measurement was completed, the meter was moved towards the other bank in 0.5-foot increments, or new verticals, adjusted to the correct water depth if required and a new flow measurement was made. A cross-section was completed after measuring the final vertical section approximately 0.5 feet from the opposite bank. The Aquacalc Pro Plus computer would take the individual vertical velocities measured and compute total discharge or Q using the following equation:

$$q_4 = v_4 \left[\frac{b_5 - b_3}{2} \right] d_4$$

where

q = subsection discharge

v = mean velocity of vertical

b = distance from initial bank point

d = depth at the vertical.

The total section discharge is the sum of the individual vertical or subsection discharges measured. The software also applies other factors such as edge coefficients to the calculation. Streamflow measurement precision was confirmed using replicate measurements of ditch flow

5.2 Seepage Loss Survey Results

E2 conducted a reconnaissance condition survey of both ditch systems over a period of a week in early November 2014 and during three days in December 2014. A description of the various sections of the ditch systems that were inventoried during this survey are included in Sections 6 and 7 of this report. Discrete areas of leakage observed along the ditches during this reconnaissance work were compiled and the volume of leakage estimated. Small leakage losses were typically estimated by measuring the time required to fill a five-gallon bucket with water at the leak. Figure 5-1 depicts the locations and estimated rate of water leaking or being diverted from various segments of KODIS and KEDIS measured during the reconnaissance survey work. Table 5-1 compiles the various measurements of diversion and leakage made during this survey.

Table 5-1: Various Measurements of Diversion and Leakage from KODIS and KEDIS

Location	Measurement Date	Measurement Method	Section Q (MGD)	Location N	Location W
Major leak spot	11/10/2014	Bucket	0.043	22° 01.593'N	159° 38.901'W
Minor leak	11/10/2014	Bucket	0.013	22° 01.619'N	159° 39.002'W
Seepage through berm	11/10/2014	Bucket	0.017	22° 01.188'N	159° 39.348'W
Leakage through the wall	11/10/2014	Bucket	0.022	22° 01.230'N	159° 39.354'W
Seepage spot along road below talus	11/10/2014	Bucket	0.017	22° 01.609'N	159° 39.120'W
Seepage along the road	11/10/2014	Bucket	0.065	22° 01.636'N	159° 38.947''W
Top of Black Pipe Siphon Sluice Gate Diversion to Taro Fields	11/10/2014	Bucket	0.346	21° 59.945'N	159° 40.042''W
Major leakage near top of steep dirt road	11/10/2014	Bucket	0.086	22° 00.251'N	159° 39.948''W
Leakage above Kōkeʻe Road	11/10/2014	Bucket	0.014	21° 59.741'N	159° 43.350''W
Meadow below the Waiawa Hydropower Plant leakage from siphon	11/10/2014	Visual	0.022		
Diversion to Reservoir L	11/10/2014	Bucket	1.080	22° 03.695'N	159° 45.484''W
Flow entering into Polihale Reservoir	11/10/2014	Bucket	0.576	22° 04.914'N	159° 45.179''W
Taro Patch Q Area	11/10/2014	Bucket	0.013	22° 02.53'N	159° 38.24'W
Past Kekaha hunting check-in station (HCS)	11/30/2014		0.004	21° 59.667'N	159° 43.814'W
Armored ephemeral stream crossing	11/30/2014	Visual	0.006	22° 00.006'N	159° 44.136'W
Leakage from damaged sluice gate	11/30/2014	Visual	0.006	22° 00.035'N	159° 44.170'W
Significant leakage from 200-meter section	11/30/2014	Visual	0.032	22° 00.086'N	159° 44.235'W
Soil piping in ditch wall, can hear water leaking through wall	11/30/2014	Visual	0.019	22° 00.106'N	159° 44.305'W
Major ditch leakage from 30-foot section	11/30/2014	Visual	0.019	22° 00.295'N	159° 44.446'W
Leakage from ditch	11/30/2014	Visual	0.013	22° 00.321'N	159° 44.467'W
Significant leakage from 100-foot section	11/30/2014	Visual	0.032	22° 00.446'N	159° 44.555'W
Collapse in downhill side of ditch wall	11/30/2014	Visual	0.032	22° 00.511'N	159° 44.603'W
Ephemeral stream crossing	11/30/2014	Visual	0.078	22° 00.617'N	159° 44.685'W
Diversion towards Field 12 Reservoir	11/30/2014	Visual	0.433	22° 00.622'N	159° 44.693'W
Significant leakage from ditch	11/30/2014	Visual	0.019	22° 00.780'N	159° 44.763'W

Table 5-1: Various Measurements of Diversion and Leakage from KODIS and KEDIS					
Location	**Measurement Date**	**Measurement Method**	**Section Q (MGD)**	**Location N**	**Location W**
Leakage from ditch	11/30/2014	Visual	0.013	22° 01.147'N	159° 44.994'W
Leakage from sluice gate just past bridge	11/30/2014	Visual	0.019	22° 01.211'N	159° 45.065'W
Major leakage near ephemeral stream crossing	11/30/2014	Visual	0.045	22° 01.313'N	159° 45.099'W
Major leakage can be heard, but not seen	11/30/2014	Visual	0.019	22° 01.637'N	159° 45.182'W
Palm tree, loud sound of water	11/30/2014	Visual	0.013	22° 01.824'N	159° 45.238'W
Mānā Reservoir main diversion	11/30/2014	Visual	2.456	22° 02.015'N	159° 45.409'W
Sluice gate and diversion to small reservoir above Waimea	12/1/2014	Bucket	0.480	21° 58.188'N	159° 40.019'W
Leakage from short section of concrete ditch wall	12/1/2014	Bucket	0.022	21° 58.469'N	159° 40.629'W
Water entering Kekaha Ditch from end of Kōkeʻe Ditch	12/1/2014	Visual	0.388	21° 58.573'N	159° 40.734'W
Large amount of flow from unlined section of ditch	12/1/2014	Bucket	0.432	21° 58.712'N	159° 41.198'W
Leakage from valley with first steel siphon	12/1/2014	Bucket	0.086	21° 58.329'N	159° 41.392'W
Stream (created by leakage) below bridge	12/1/2014	Bucket	0.216	21° 58.964'N	159° 43.196'W
Leakage in valley below the measurement point on Kōkeʻe Road	12/1/2014	Bucket	0.605	21° 59.360'N	159° 40.630'W
Return flow to Kawaikōī Stream below Diversion Dam	12/2/2014	Bucket	0.432	22° 07.733'N	159° 37.482'W
Kauaʻikananā Dam Sluice Gate Flow (Return to Stream)	12/2/2014	Pygmy	3.456	22° 07.894'N	159° 37.874'W
Notch returning flow to Kōkeʻe Stream	12/2/2014	Difference	6.838	22° 06.909'N	159° 39.294'W
Diversion to Kauhao Gulch through Sluice Gate	12/2/2014	Bucket	0.432	22° 06.501'N	159° 40.546'W
Ditch below Puʻu Moe Divide heading toward DHHL land	12/2/2014	Bucket	0.227	22° 03.769'N	159° 39.873'W
Large Sluice Gate return to stream below Waimea Hydropower Plant	12/2/2014	Bucket		22° 02.635'N	159° 38.415'W
Smaller Sluice Gate return to stream below Waimea Hydropower Plant	12/2/2014	Bucket	0.864	22° 02.528'N	159° 38.406'W

Overall, very little loss of water was observed within KODIS during this survey. Because of restrictions on the volume of water that can enter Puʻu Lua Reservoir, significant volumes of water were observed being diverted from the ditch back into Kauaʻikananā and Kōkeʻe Streams. In addition, about 0.43 mgd of water was observed leaking through the flashboards at Kauhao Diversion.

On KEDIS, the condition survey found that the majority of recent repairs conducted by KAA have been performed on the portion of the ditch between the upper Kekaha ditch intake to the Waiawa hydroelectric plant. As a result, the greatest amount of leakage from KEDIS was observed in the roughly 7.5-mile section of ditch located between the Waiawa Hydropower Plant and the terminal reservoir at Polihale. A number of small-scale collapse features are evident along the trail that borders the makai side of this section of ditch where water seeping from the ditch has undermined sections of the berm adjacent to the ditch. In addition, this section of ditch also has a number of concrete hardened culverts that run under ephemeral stream courses that run out of valleys that this section of ditch crosses. Some water leakage was observed from the ditch near the points where the ditch water enters and exits these buried culvert structures. The luxurious growth of vegetation observed below the ditch in this arid area is evidence of the ubiquitous leakage of water along this section of ditch.

Some level of seepage loss of water also occurs via infiltration into the bottom and sidewalls of the ditches as the water travels down the ditch. According to Landis Ignacio, the builders of KEDIS feared that the ditch was going to be a failure since it took several months for the water to reach the original end of the ditch just past the Waiawa hydroelectric plant when the system was first opened. It took this length of time for the slowly advancing wetting front to saturate and achieve an equilibrium between water infiltrating into the bottom and side walls of the unlined ditch and travelling further down the unsaturated ditch.

The majority of the 28-mile long KEDIS and the 21-mile long KODIS flows through unlined sections of ditch at relatively low average velocities of between one to two miles per hour. Under these conditions, some amount of the water moving through both ditch systems is continuously lost due to seepage along the bottom and sidewalls of the ditch, in addition to the discrete leakage amounts depicted on Figure 5-1 and compiled in Table 5-1.

5.3 Continuous Flow Monitoring: November 30 to December 2, 2014

A total of three pressure transducers were installed within KODIS, KEDIS, and the Waimea River in order to continuously monitor the water level at these three sites between November 30 and December 2, 2014. The transducer on KODIS was installed in the section of unlined ditch just before the Kauhao Diversion. The transducer on KEDIS was installed where the ditch passes under Highway 550 and exits the Waimea River watershed. The transducer in the Waimea River was installed approximately 400 feet above the first vehicle stream crossing, near the end of the paved road on the eastern bank of the river. The stage level data collected from these three pressure transducers was then combined with the stage levels concurrently measured at the two USGS monitoring stations located on Kawaikōī and Wai‘alae Streams in the uplands portion of the watershed. The variation in water levels measured at these five locations was used to gain a general understanding of the rate at which water flows through the watershed and ditch systems. Figure 5-2 graphs the change in water levels measured in the streams, rivers, and ditches at these five locations during the four days of continual monitoring.

The rise in water levels measured in the morning of November 30, 2014 in the two USGS stream monitoring stations reflect a rainfall event that occurred that morning. Table 5-2 shows the daily rainfall measured during this four-day period of continual stage water level monitoring at three USGS rain stations located within the Waimea River watershed.

Table 5-2: USGS Daily Rainfall During Stage Level Monitoring: 11/29/2014 to 12/2/2014

Date	Wai‘alae: Station 1042 Rainfall (Inches)	Waiakoali: Station 1082 Rainfall (Inches)	Mōhihi: Station 1083 Rainfall (Inches)
11/29/2014	0.04	0.05	0.06
11/30/2014	0.14	0.34	0.31
12/1/2014	0.04	0.14	0.11
12/2/2014	0.01	0.01	0.02
12/3/2014	0.03	0.04	0.03

5.4 Synoptic Flow Monitoring December 2, 2014

E2 conducted a series of flow measurements throughout both KODIS and KEDIS on December 2, 2014. Measurements of ditch flow began at the beginning of KODIS in the early morning and finished near the end of KEDIS in the early evening. The purpose of this single day of monitoring was to measure the flow of water through these two inter-related ditch systems on a day with typical flow conditions. The flow conditions within the watershed were typical for this time of year.

The median flow present at the Kawaikōī Stream gage on December 2, 2014 (10.34 mgd) was nearly equal to the historical median flow measured at this station on that date over the roughly 100 years of flow record available for this stream. The various flow measurements made on December 2, 2014 are depicted on Figure 5-3 and compiled in Table 5-3.

Table 5-3: Synoptic Flow Measurements within Waimea River Watershed on December 2, 2014

Flow Measurement Location	Measurement Time	Measurement Method	Section Q (mgd)	Location N	Location W
USGS 16010000 Kawaikōī Stream	8:00	Calibrated Flume	10.34	22°07'58.1"	159°37'11.8"
Ditch just past Kawaikōī Flume	8:14	Pygmy	12.16	22° 07.733'N	159° 37.482'W
Return Flow to Kawaikōī Stream below Diversion Dam	8:15	Bucket	0.43		
Kauaʻikinana Dam Sluice Gate Flow (Return to Stream)	9:00	Pygmy	3.46	22° 07.894'N	159° 37.874'W
Ditch Just Above Kōkeʻe Intake in Concrete Lined Section	10:16	Pygmy	9.40	22° 06.903'N	159° 39.281'W
Notch returning flow to Kōkeʻe Stream	10:36	Difference	6.84	22° 06.909'N	159° 39.294'W
Ditch Just Above Kauhao Gulch Diversion	12:02	Pygmy	2.57	22° 06.522'N	159° 40.537'W
Diversion to Kauhao Gulch Thru Sluice Gate	12:10	Bucket	0.43	22° 06.501'N	159° 40.546'W
Ditch below Puʻu Moe Divide heading towards DHHL land	12:30	Bucket	0.23	22° 03.769'N	159° 39.873'W
12" PVC Discharge Pipe at end of Kōkeʻe Ditch System at 1,000 foot elevation	12:45	Bucket	0.39	21° 59.165'N	159° 40.338'W
Ditch just after confluence of Koaie Intake and Waiahulu Intake	14:59	Pygmy	32.07	22° 04.239'N	159° 38.741'W
Streamflow below Koaie and Waiahulu Dam Diversions	14:59	Bucket	0.61	22° 03.989'N	159° 38.697'W
USGS 16019000 Waiʻalae Stream at alt 3,820 feet	11:00	Calibrated Flume	3.43	22°05'09.0"	159°34'08.7"
Waimea River Streamflow at Second Road River Crossing	16:54	Pygmy	19.17	21° 59.174'N	159° 39.810'W
Highway 550 Ditch Monitoring Point adjacent to road	14:49	Pygmy	19.67	21° 58.003'N	159° 39.847'W
Highway 550 Monitoring Point adjacent to road	14:45	Pygmy	20.39	21° 58.003'N	159° 39.847'W
Highway 550 Monitoring Point adjacent to road	15:02	Pygmy	20.09	21° 58.003'N	159° 39.847'W
Highway 550 Monitoring Point adjacent to road	15:16	Pygmy	20.33	21° 58.003'N	159° 39.847'W
Kekaha Ditch just north of Kōkeʻe Road	15:57	Pygmy	17.55	21° 59.638'N	159° 42.631'W
Below Waiawa Hydropower Plant before Waiawa Reservoir diversion	15:10	Pygmy	12.93	21° 59.628'N	159° 43.339'W
Below Waimea Hydropower Plant after Waiawa Reservoir diversion	17:41	Pygmy	10.11	21° 59.623'N	159° 43.336'W
Below Waimea Hydropower Plant after Waiawa Reservoir diversion	14:57	Pygmy	10.34	21° 59.623'N	159° 43.336'W
Kekaha HCS	18:12	Pygmy	9.84	21° 59.638'N	159° 43.769'W
Ditch Above Mānā Reservoir Diversion	15:55	Pygmy	6.73	22° 01.962'N	159° 45.310'W
Ditch Below Mānā Reservoir Diversion	16:15	Pygmy	4.26	22° 02.015'N	159° 45.409'W
Ditch before Field L reservoir	16:57	Pygmy	2.71	22° 03.681'N	159° 45.474'W
Ditch after Field L reservoir	16:41	Pygmy	1.16	22° 03.715'N	159° 45.471'W
Inflow to Field N reservoir	17:35	Pygmy	0.45	22° 04.914'N	159° 45.179'W

5.5 Estimated Water Travel Time in KODIS and KEDIS

The relative timing of observed rises in river, stream, and ditch stage during the continuous monitoring conducted between November 30, 2014 and December 2, 2014 can be used to derive general estimates of the rate at which water travels through the ditch systems, rivers, and streams within the Waimea River watershed (Figure 5-2). The travel distance in the stream and ditch between the USGS Kawaikōī Stream monitoring station and the Kauhao diversion is approximately 7 miles and the time elapsed between the observed stream peak flow occurring at the Kawaikōī Stream gage and at the Kauhao diversion was about 8 hours. This suggests a rather sluggish average velocity in the upper section of KODIS in the upland plateau of a little under one mile per hour.

The measured water level in the Waimea River near the first vehicle stream crossing peaked about 12 hours after the peak stream flow occurred at the Waiʻalae Stream gage, approximately 15 miles upstream. There are no active diversions between the Waiʻalae Stream gage and the site where flow monitoring was conducted on the Waimea River. This suggests an average velocity of 1.25 miles per hour for water flowing through a tributary stream (Waiʻalae) and the main Waimea river.

Slightly higher average ditch flow velocities were measured for the mid-sections of KODIS and KEDIS in June 2015. On KODIS, E2 staff coordinated with KAA to add boards to the spillway at Kōkeʻe Stream at 8:00 AM on June 24, 2015 to increase the flow of water in the ditch heading towards Puʻu Lua Reservoir. E2 staff monitored flow at the Kōkeʻe Ditch continuous monitoring point, which is located 15,050 feet (2.85 miles) down ditch from Kōkeʻe Stream. It took one hour and 45 minutes for the water level to begin rising within the ditch at this monitoring location, which corresponds to an average flow velocity of 1.63 miles per hour for this section of ditch.

A similar measurement was made on KEDIS on June 23, 2015 at 8:00 AM. In this case, KAA workers pulled boards from a diversion located above the Waimea River before the Menehune Ditch diversion. E2 staff monitored flow at the Hukipo Flume located 20,840 feet (3.95 miles) down ditch. It took one hour and 55 minutes for the water level to begin dropping at the monitoring location, which corresponds to an average flow velocity of 2.06 miles per hour for this section of ditch.

5.6 Continuous Ditch Flow Monitoring in KEDIS

A pressure transducer was installed in the stilling well at the Hukipo flume on KEDIS on June 22, 2015 at 10:50 AM. This transducer continuously monitored variations in water level within the ditch at ten-minute intervals until June 10, 2016 at 12:50 PM. Landis Ignacio of KAA provided E2 with a rating curve table for the Hukipo Flume that he obtained from the former plantation operators of KSC. E2 measured the flow through the flume using a Pygmy meter during this study to verify the accuracy of this rating curve data. The flow measured with the Pygmy meter closely matched the values read from the rating curve table based on the stage height measured from the wooden crest gage in the stilling well at the time of the pygmy measurement. Using the data in the rating curve table, the following mathematical relationship was developed between ditch flow (in mgd) and stage height (in feet), as measured on the crest gage installed in the stilling well at the flume:

$$y = 15.485x^{1.5947}$$

where:
y is the ditch flow in mgd; and
x is the measured water level in the crest gage installed in the stilling well at the Hukipo Flume.

The pressure transducer data was converted to a stage height by recording the time manual stage height measurements were made at the Hukipo Flume during the one-year monitoring period and adjusting the transducer readings accordingly. This adjustment accounts for the fact that the zero value for the transducer is not necessarily the same as the zero value for the crest gage in the stilling well.

Figure 5-4 shows the transducer readings, converted to mgd using the mathematical relationship given above, for the time period between June 2015 to June 2016. The time interval when the black pipe siphon was undergoing repairs is readily seen in this transducer record. In addition, a large decrease in ditch flow and a much narrower range in ditch flow volumes is observed on Figure 5-4 after the black pipe siphon repair was completed. Table 5-4 compares the mean, median, minimum, and maximum ditch flows measured at Hukipo Flume prior to the repair of the black pipe siphon (6/22/15 to 8/12/15) to the values after the repairs and associated testing was completed (11/9/15 to 6/10/16).

Table 5-4: Flow Measured at Hukipo Flume Pre- and Post-Siphon Repair

Flow Measurement Period	Median Flow (mgd)	Mean Flow (mgd)	Minimum Flow (mgd)	Maximum Flow (mgd)
Pre-Siphon Repair 6/22/15 to 8/12/15	20.37	20.22	5.65	28.28
Post-Siphon Repair 11/9/15 to 6/10/16	12.51	12.29	0.00	34.35

Table 5-5 compares the monthly flow values for KEDIS reported by KAA with the monthly continuous flow data collected at Hukipo flume. In general, the monthly flow data reported by KAA closely matches the median monthly flow calculated from the continuous transducer monitoring data collected on KEDIS during this study.

Table 5-5: Comparison of KAA Monthly Flow Values with Continuous Monitoring Values on KEDIS

Month-Year	KAA Reported Value (mgd)	Mean (mgd)	Median (mgd)	Minimum (mgd)	Maximum (mgd)
Jul-15	20.09	20.07	19.54	5.65	28.28
Aug-15	7.65	7.36	0.55	0.25	31.08
Sep-15	0.00	0.31	0.42	0.00	0.99
Oct-15	10.61	6.00	7.10	0.00	12.00
Nov-15	14.50	9.17	12.33	0.00	14.33
Dec-15	14.67	12.27	12.58	0.01	13.08
Jan-16	12.82	11.27	11.38	8.81	12.73
Feb-16	14.37	11.84	11.86	9.83	13.67
Mar-16	14.37	12.43	12.44	0.00	34.35
Apr-16	14.73	12.71	12.76	12.04	13.42
May-16	14.92	12.78	12.89	11.51	13.77

5.7 Continuous Ditch Flow Monitoring in KODIS

A pressure transducer was installed in an abandoned stilling well on an unlined section of KODIS on June 22, 2015 at 3:10 PM. This monitoring location is located about 500 feet above the diversion located above Pu'u Lua Reservoir where the ditch water cascades down a short waterfall into the reservoir. This transducer continuously monitored variations in water level within the ditch at ten minute intervals until December 10, 2015 at 8:50 AM at which time the transducer malfunctioned. A metal crest gage constructed of a metal yard ruler was bolted to the inside of the stilling well during this study. A rating curve was generated for this monitoring site by recording the height measured on the metal crest gage at a range of ditch flow rates (measured using the Pygmy meter) between 2.5 and 5.5 mgd. The following mathematical relationship was developed between ditch flow (in mgd) and stage height, as measured on the crest gage installed in the stilling well at the flume:

$$y = 2.77x^{4.2085}$$

where:
y is the ditch flow in mgd; and
x is the measured water level (feet) in the crest gage installed in the stilling well at the Kōkeʻe monitoring site.

This mathematical relationship produces a fairly accurate value for ditch flow around the range of measurements with which it was developed. It is not likely accurate at ditch flow rates above 8 to 10 mgd.

Figure 5-5 shows the transducer readings, converted to mgd using the mathematical relationship given above, for the time period between June to December 2015. Table 5-6 compares the monthly flow values for KODIS reported by KAA with the monthly continuous flow data collected at the Kōkeʻe Stream continuous monitoring location established during this study. KAA estimates flow within KODIS by making visual estimates of the flow entering Puʻu Lua Reservoir. The monthly flow data reported by KAA closely matches the median monthly flow calculated from the continuous transducer monitoring data collected on KODIS during this study.

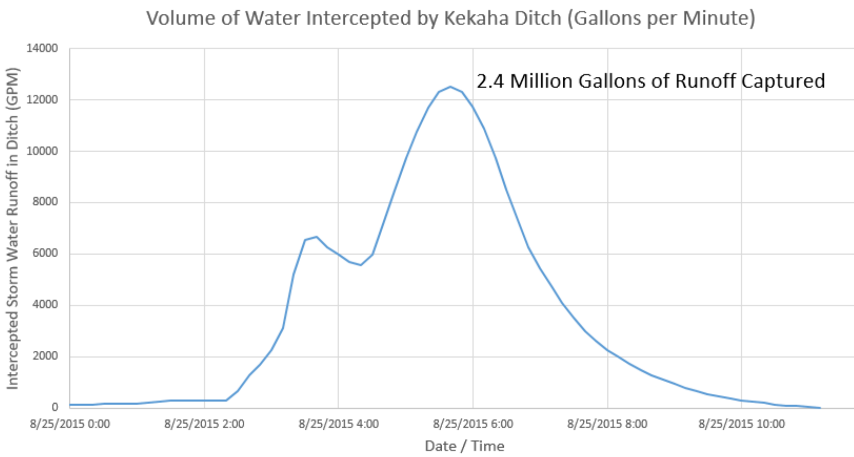
Table 5-6: Comparison of KAA Monthly Flow Values with Continuous Monitoring Values on KODIS

Month-Year	KAA Reported Value (mgd)	Mean (mgd)	Median (mgd)	Minimum (mgd)	Maximum (mgd)
Jul-15	1.00	1.96	1.80	0.00	8.32
Aug-15	3.00	2.36	1.85	0.00	17.00
Sep-15	2.00	2.40	2.66	0.00	6.55
Oct-15	2.00	2.00	1.98	0.00	5.46
Nov-15	2.00	2.11	1.36	0.46	8.60

5.8 Overland Flow Captured by KEDIS

During the continuous monitoring of ditch flow at the Hukipo Flume, two large storm events occurred that caused a discernible spike in water levels in the ditch at the flume to occur as a result of large volumes of storm water runoff entering the ditch. Because of the topography above the land above KEDIS, the majority of the runoff that entered the ditch during these two storm events likely emanated from the highlands above the roughly 2.45-mile section of ditch between Highway 550 and the Hukipo Flume.

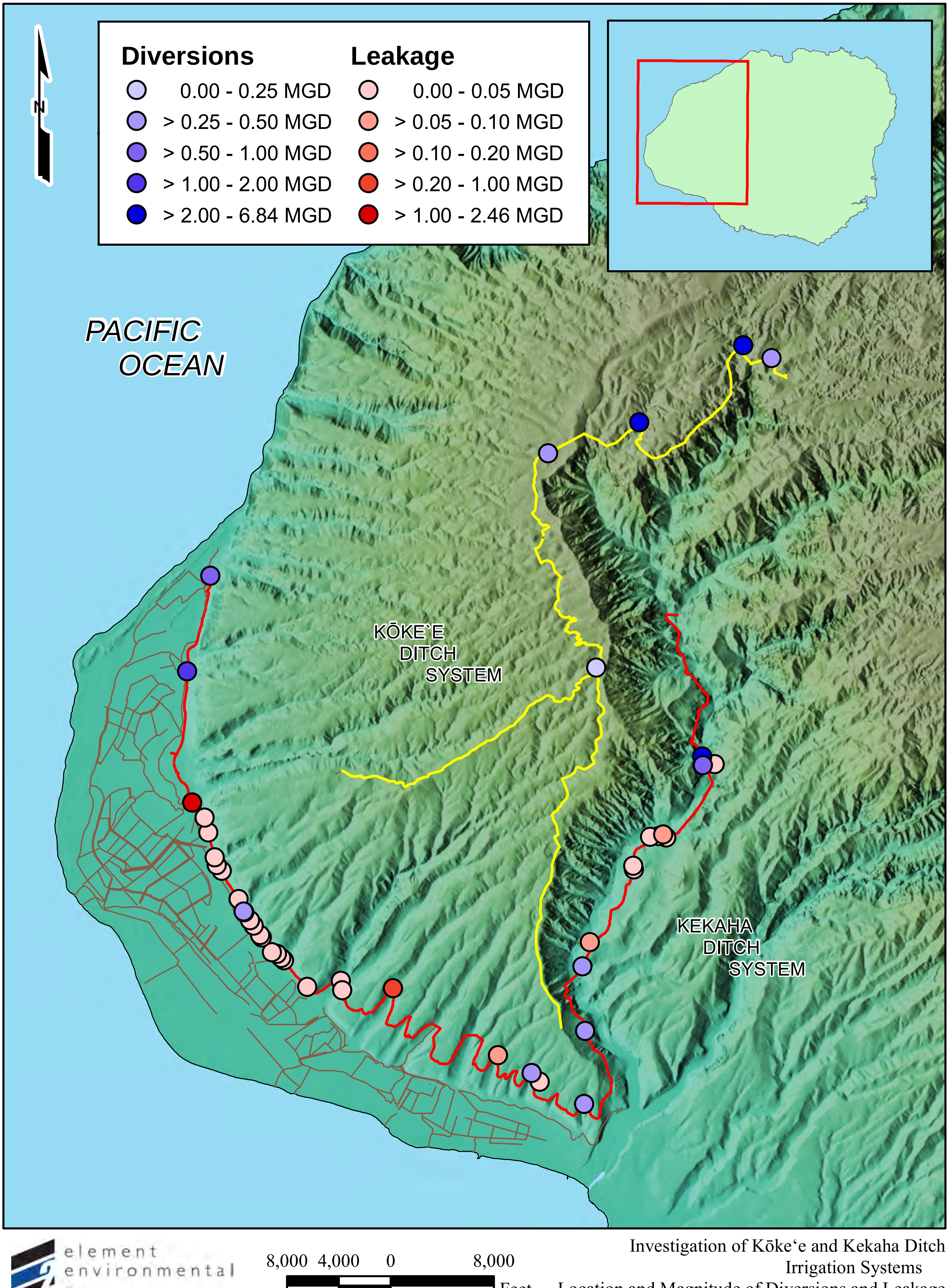
A large mesoscale convective system moved across the State of Hawaiʻi from the northwest between August 23 - 25. The daily rainfall in the town of Waimea was between 4 to 5 inches during this period, which led a significant amount of runoff to enter the lower portion of KEDIS, which was dry at the time due to the rehabilitation work being conducted on the black pipe siphon. This runoff event led to a significant amount of fine sediments to enter the lower ditch system. A total of 2.4 million gallons of storm water runoff flowed through the Hukipo flume, which was dry prior to the storm approaching, as a result of this storm event.



Storm Water Hydrograph from 8/25/15 Event; Hukipo Flume during Black Pipe Siphon Repair

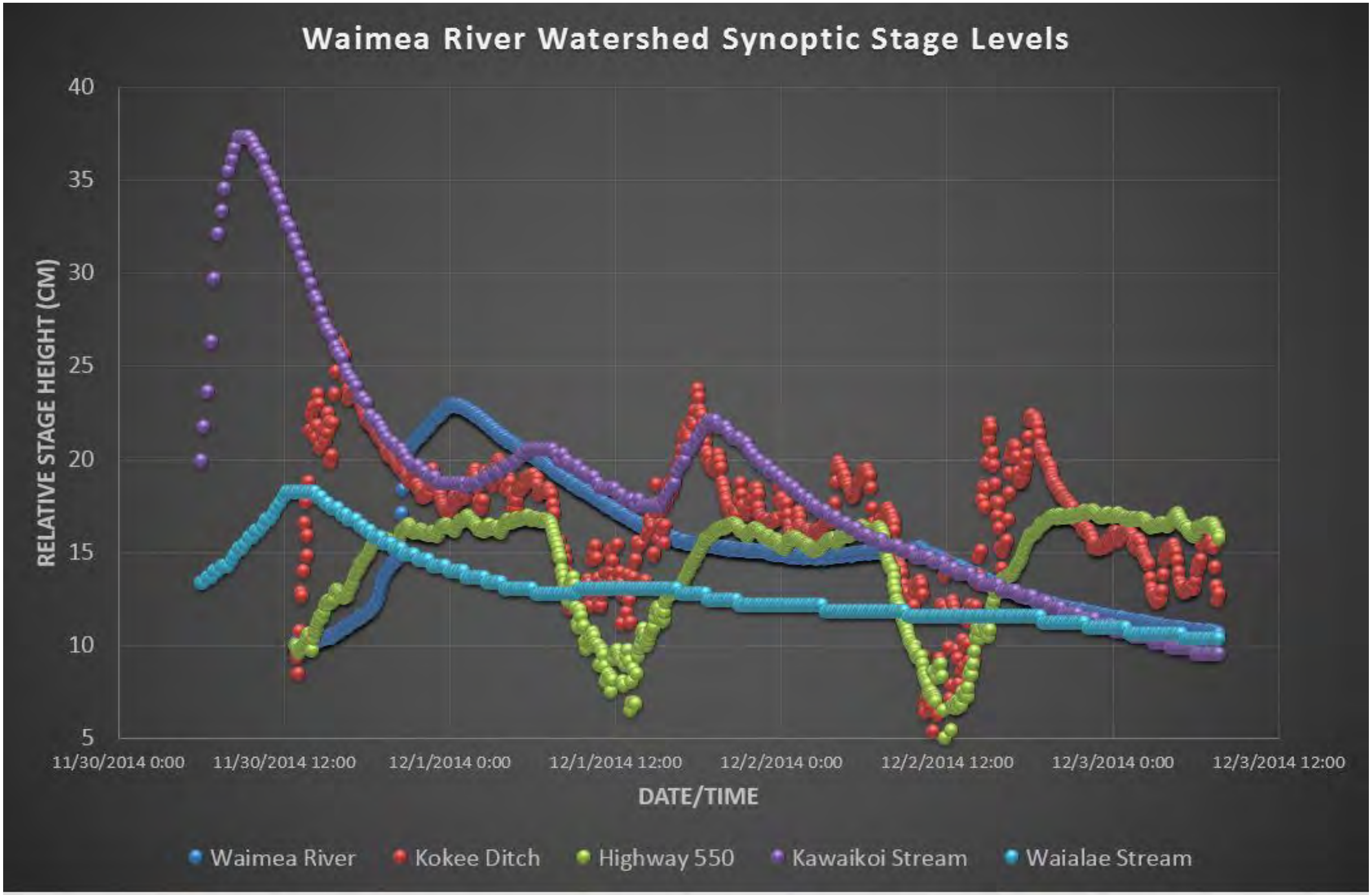
A strong upper level trough moved over the Hawaiian Islands on March 24 and 25, 2016 with its attendant thunderstorms and heavy rainfall producing flash flooding on several islands. The island of Kauaʻi received 5 to 10 inches of rainfall, mostly within a 6-hour period starting late on March 24 until the early morning hours of March 25. The Waimea rain gauge recorded a total of 7.37 inches of rainfall during this period. Figure 5-6 shows the spike in runoff above the baseflow measured at the Hukipo Flume (and the corresponding hourly rainfall) during this large storm event. It is estimated that the roughly 2.5-mile section of KEDIS between the flume and Highway 550 captured roughly 5.2 million gallons of storm water runoff during this rainfall event.

This page intentionally left blank.



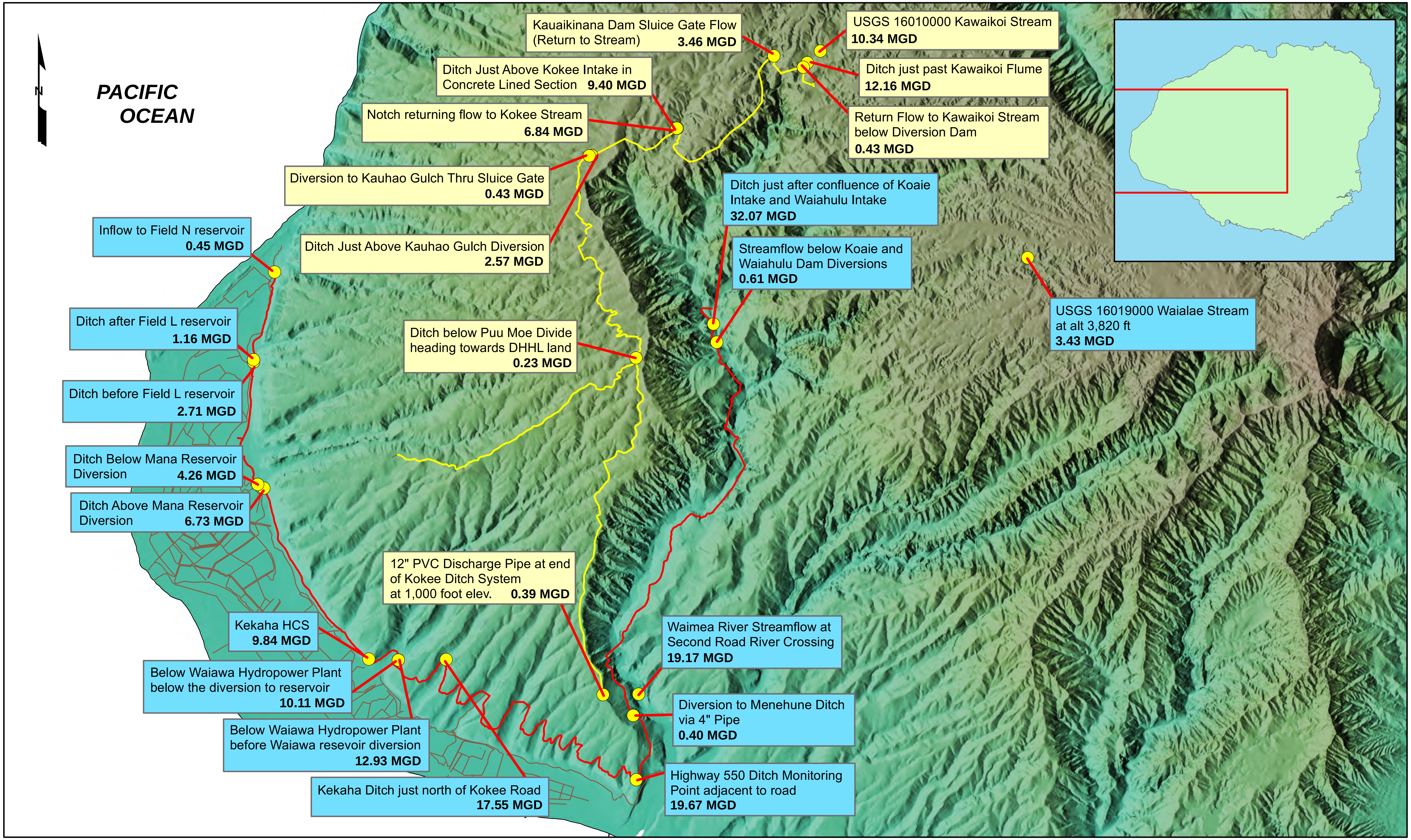
element environmental llc

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Location and Magnitude of Diversions and Leakage Measured during Ditch Inventory
Figure 5-1



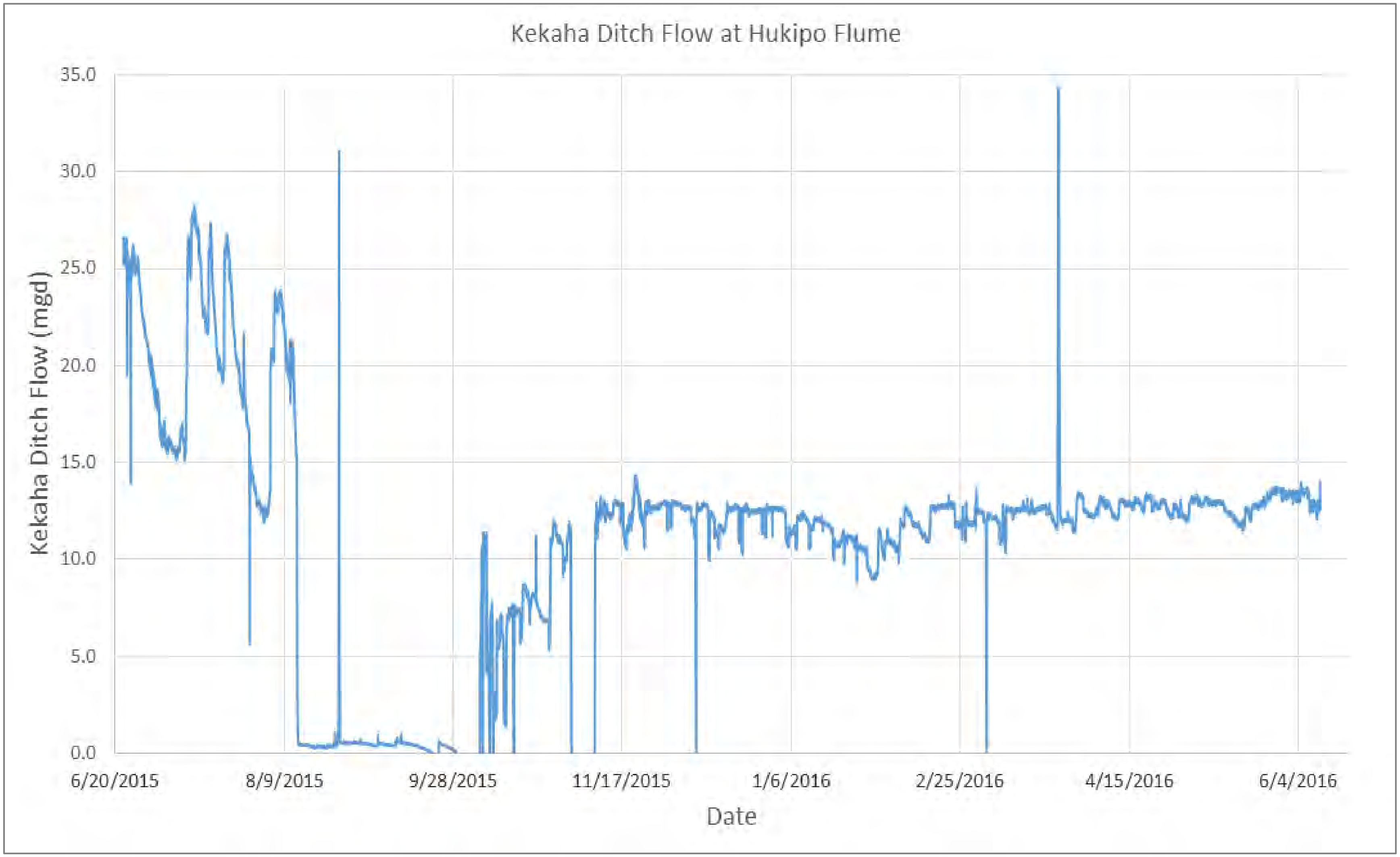
element environmental llc
environmental · engineering · water resources

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Waimea River Watershed Synoptic Stage Levels - Figure 5-2



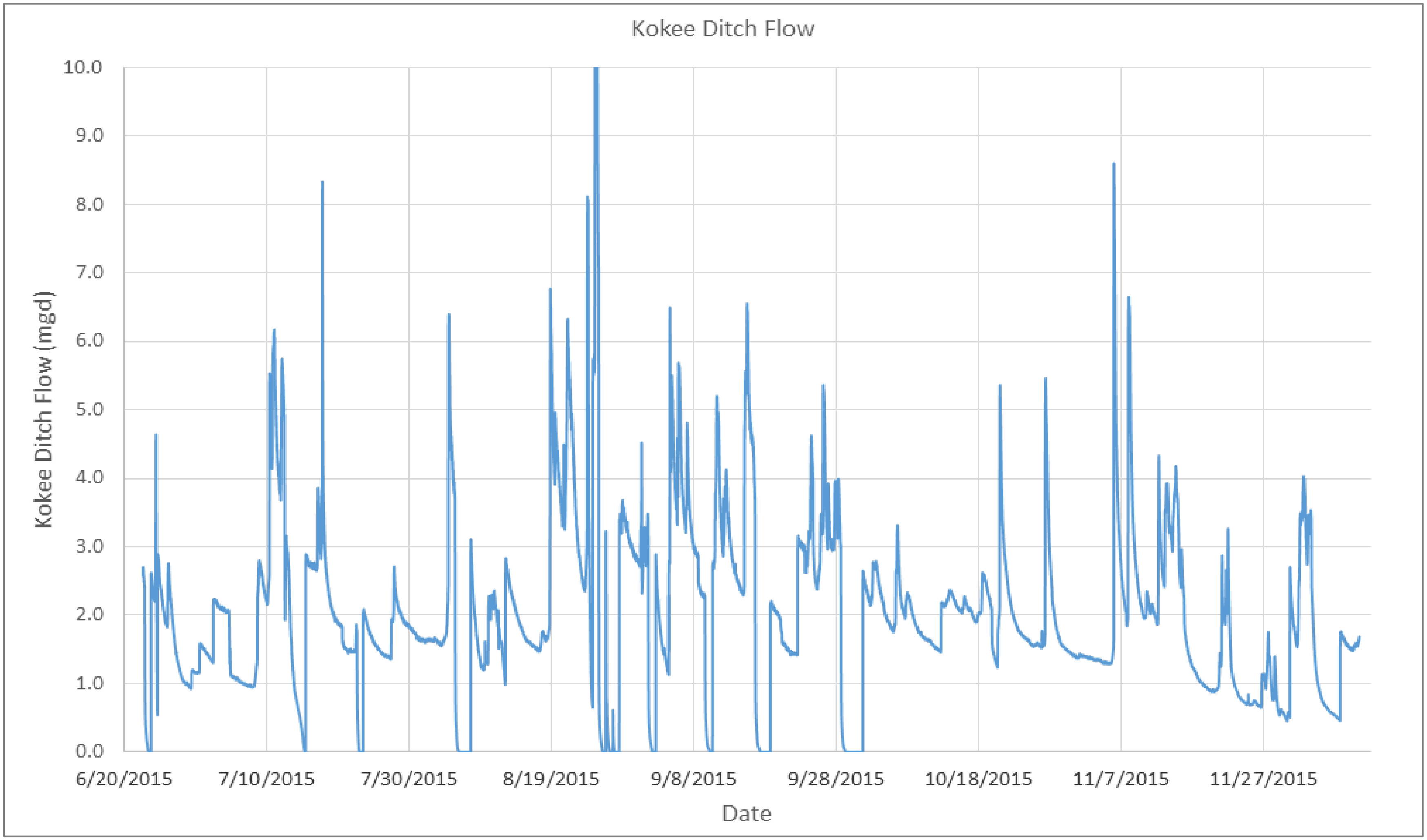
element environmental llc
environmental · engineering · water resources

Investigation of Kōkeʻe and Kekaha Ditch Irrigation Systems
Synoptic Streamflow Measurements Made on December 2, 2014
Figure 5-3



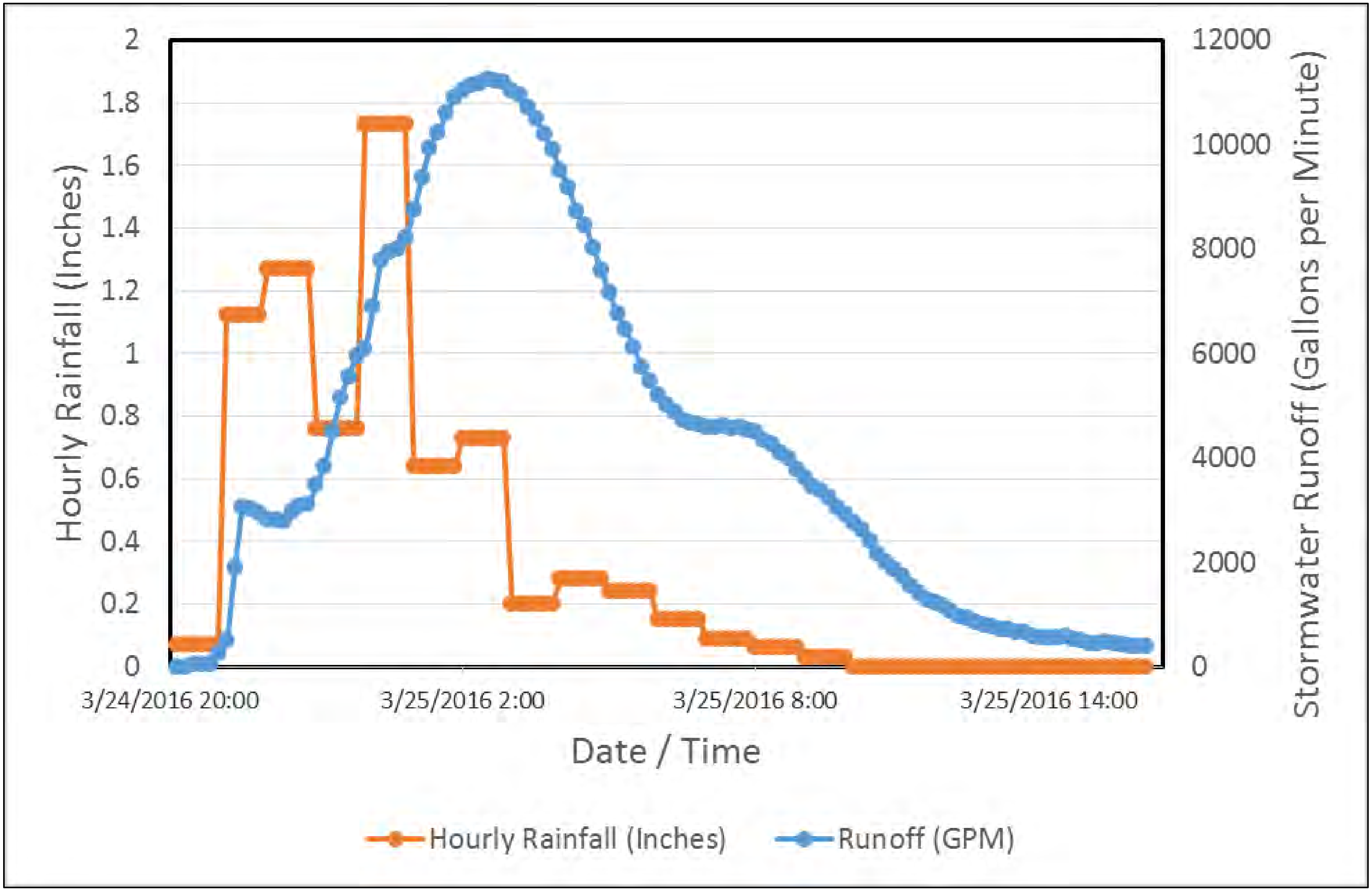
element environmental llc
environmental · engineering · water resources

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Continuous Flow Monitoring of Kekaha Ditch at Hukipo Flume, June 2015 to June 2016 - Figure 5-4



element environmental llc
environmental · engineering · water resources

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Continuous Flow Monitoring of Kōke‘e Ditch Above Pu‘u Lua Reservoir, June 2015 to December 2015
Figure 5-5



element environmental llc
environmental · engineering · water resources

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Storm Runoff Captured at Hukipo Flume During March 24 and 25, 2016 Rainfall Event - Figure 5-6

6 Current Ditch Operations: KEDIS

Figure 6-1 shows the various segments of ditch that are described in the following sections. KEDIS has been arbitrarily broken up into ten segments, which are discussed below. The ditch flow readings discussed were measured on December 2, 2014, which was a typical flow volume within the watershed for this date based upon the stream flow measured at the two active USGS stream stations (Kawaikōī and Wai‘alae) on that day.

KAA personnel have performed a number of infrastructure improvements since taking over operations of the ditch systems, some of which are described in the following sections. According to Landis Ignacio, KAA has spent approximately $8 million on ditch system and agricultural infrastructure improvements. The large-scale improvement projects are typically conducted in the summer when stream and associated ditch flows are generally lower. The ditch system is also routinely inspected by KAA personnel for debris, blockage and leaks.

KEDIS is generally more difficult to maintain than KODIS due to continual infrastructure problems related to excessive silt runoff that occurs during large storm events. Greater amounts of fines tend to enter KEDIS due to the steepness of the hillsides that border large sections of this ditch system. This situation has been exacerbated in recent years by the propagation of ungulates throughout the Waimea River watershed as well as in the upland areas above the Mānā Plain, which has led to greater rates of erosion of soil from the canyon walls above the ditch.

6.1 Section 1

KEDIS diverts water from the Waimea River and supplies water as far west as the reservoirs at Polihale. The total length of the ditch is approximately 27 miles. In the most inland section of KEDIS (Section 1), stream water is diverted from both Waiahulu and Koaie streams at dam structures located at approximately 780 feet elevation, just above the natural confluence point of these two streams. The water in Koaie stream is routed into a short tunnel drilled through the narrow ridge that separates these two streams. The tunnel daylights about 100 feet above the larger Waiahulu dam. The ditch operators can control the amount of stream water that enters KEDIS by adjusting the number of wooden flashboards placed in the dam’s spillway (the notch in the crest of the dam). During site visits, the flashboards were set to capture virtually all the flow in both streams under low and moderate stream flow conditions. KAA personnel reportedly replaced the flashboards in these upper diversion dams around October 2015.

Below the Waiahulu dam, a secondary diversion gate is present adjacent to a large dike that can be used to dump water from the upper section of the ditch during periods of high runoff. A short, 200-meter section of ditch is accessible a short distance below Waiahulu dam. On December 2, 2014, a total of 32.04 mgd of water was measured in this upper section of ditch. Below this section, the ditch flows through a series of 23 tunnels, the longest being 1,060 feet long, excavated along the western side of Waimea canyon. These tunnels travel a total of roughly 12,000 feet until reaching the steel penstock above the Mauka hydropower plant. The tunnels in this steep canyon section of the system are accessible only via “adits” or original construction openings.


Wooden flashboards in spillways in dams on Waiahulu (lower left of photo) and Koaie streams

As can be seen in the photos above, small amounts of stream water seeps through the flashboards in the two diversion dams. In addition, a small stream results from leakage below the secondary diversion structure located just below the Waiahulu dam. On December 2, 2014, the stream flow within the Waimea River below the confluence of the Koaie and Waiahulu rivers was measured to be 0.61 mgd. This water originated from a combination of leakage from the flashboards in the diversion dams, leakage from the very upper section of the ditch (particularly adjacent to the first diversion structure) and possible groundwater seepage into this short section of stream from the underlying dike impounded high-level aquifer.

The historic degree to which water was captured at these two upper diversions, as well as the third diversion located just above the Mauka Hydropower Plant (see following section), can be evaluated by viewing the historic stream records measured at USGS Station Number 16028000. This gaging station was located approximately 1,500 feet below the lowest ditch diversion at the Mauka Hydropower Plant at an elevation of 490 feet. Table 6-1 summarizes the frequency of various stream flows measured within the Waimea River below all three diversions during the height of the plantation era between August 1, 1921 to December 31, 1955.

Table 6-1 shows that the sugarcane operations diverted all of the flow coming into the upper portions of the Waimea River into the three diversions about 15% of the time. This USGS stream data also suggests that the natural stream flow within the Waimea River watershed exceeded the carrying capacity of the ditch system about 30% of the time. With respect to sediment transport within the watershed, the presence of the ditch system did not likely significantly alter the overall migration of sediments within the watershed. Streamflow volumes roughly four times the carrying capacity of the ditch system, during which time the majority of sediments were likely historically transported, occurred roughly 5% of the time during the plantation era. These routine high rainfall/runoff events are responsible for the majority of sediment transport within the watershed.

Table 6-1: Waimea River Streamflow Statistics Below Diversions During Plantation Era: 1921 to 1955

Stream Flow Statistic	Measured Streamflow (mgd)
Q (5): Flow Exceeded 5% of the Time	226.9
Q (10): Flow Exceeded 10% of the Time	106
Q (Avg): Average Flow Measured	49.8
Q (20): Flow Exceeded 20% of the Time	40.1

Table 6-1: Waimea River Streamflow Statistics Below Diversions During Plantation Era: 1921 to 1955	
Stream Flow Statistic	**Measured Streamflow (mgd)**
Q (30): Flow Exceeded 30% of the Time	14.9
Q (40): Flow Exceeded 40% of the Time	4.2
Q (50): Flow Exceeded 50% of the Time = Median Flow	1.0
Q (60): Flow Exceeded 60% of the Time	0.4
Q (70): Flow Exceeded 70% of the Time	0.2
Q (80): Flow Exceeded 80% of the Time	0.12
Q (90): Flow Exceeded 90% of the Time	0.0

Leakage from Secondary Diversion and 0.61 mgd Streamflow below Upper Intakes of KEDIS

6.2 Section 2

The ditch exits the tunnel system in the lower portion of Section 1 in the western wall of Waimea canyon at around an elevation of 730 feet and enters the penstock fore bay. This fore bay contains a motorized carrier trash rack that prevents debris that accumulates during water flow within the ditch from entering the penstock and the hydropower plant below. The water then enters a 42-inch diameter steel penstock at an elevation of around 730 feet. The penstock drops down to the valley at around 530 feet elevation and crosses under the concrete dam that fronts the Mauka hydropower plant (also known as the Mauka Powerhouse), which was constructed within the valley wall in 1952 on the east side of the Waimea River. The original Waimea ditch diversion is located in the rock wall just above the dam on the eastern side of the river. Ditch operators can divert additional water in Waimea River, which predominantly originates from Waiʻalae Stream in this section under low to moderate flow conditions, into the ditch by opening this intake structure. KAA upgraded the cable suspension bridge that crosses the river just mauka of the hydropower plant in 2014. This suspension bridge is used to access the hydropower plant and has been used by stranded hikers to cross the river during periods of high flow.

Penstock and Fore Bay at Tunnel Exit; Mauka Hydropower Plant and Original Waimea Ditch Inlet

Two ditch water diversion structures are located just past the hydropower plant on the eastern side of Waimea river. These are the two main diversion structures for removing water from the lower portion of KEDIS prior to the water exiting the Waimea River watershed. Past attempts to automate one of these bypass gates failed and diversion of flow is still done manually by KAA operators. Below these two diversion points, the ditch continues to follow the east side of Waimea Canyon through mostly unlined ditch.

Upper and Lower Diversion Points Located Just Below the Mauka Hydropower Plant

6.3 Section 3

In this section of KEDIS, the ditch continues to run along the east side of Waimea Canyon following the alignment of the Waimea River in a mixture of lined and unlined sections of ditch. Two flumes constructed of wood, known as the Pali Flumes, are located a little less than a mile to the south of the Mauka hydropower plant in a section of the ditch that passes through a narrow section that runs next to steep, fractured vertical rock faces. These flumes historically leaked significant quantities of ditch water due to wood rot and periodic damage to the flume from rocks falling from the steep hillside and rock face above this section of ditch. KAA replaced the original wooden flumes during a three-week period in 2012 with more robust flumes constructed of high-density polyethylene pipe (HDPE). In November 2014, relatively small amounts of leakage (<0.10 mgd) were visible along the access road from sections of the ditch in the vicinity of these two flumes.

Long Section of HDPE Installed to Replace Original Wooden Flumes and Leakage Along Road

6.4 Section 4

In this section of KEDIS, the ditch follows the Waimea River and heads in a more southerly direction in a mixture of lined and unlined sections of ditch. This section of ditch requires significant amounts of mechanical ditch cleaning by KAA personnel to remove silt and trees that periodically fall into this section of ditch. This section of ditch is also impacted by the propagation of an exotic aquatic plant known as “Amaju” which tends to grow in large quantities in unlined sections of the ditch above the “Black Pipe” Steel siphon and impede flow by trapping entrained silt. KAA personnel routinely remove this grass from this section of ditch. Wooden storm water diversion structures are observed in this and other sections of KEDIS, which divert ephemeral, silt-laden runoff from the adjacent steep hillsides from entering, and potentially clogging, the ditch with their suspended sediment load.

The section of ditch between where the vehicle access road crosses the ditch over a wooden bridge and Tunnel 7 was rehabilitated by KAA in 2011. According to Landis Ignacio, this section of the ditch was designed by the ditch workers during construction of KEDIS to be leaky by installing a “false bottom” in order to irrigate rice fields cleared in the gently sloping terraces below this section of the ditch. Seven leaky sections of ditch in this area were either shotcreted by KAA or concrete walls were constructed along the side of the ditch facing the river in 2011.

The original black pipe siphon was constructed in 1907 and consisted of a 2,190-foot long, 48-inch diameter steel siphon constructed of 10-foot long sections that were riveted in place. There is a 15-foot elevation difference between the siphon inlet on the eastern side of the river and the outlet of the siphon on the western side of the river. The original siphon crossed the Waimea River atop a metal trestle structure. A flood in 1948 destroyed the trestle structure and the plantation decided to bury the siphon pipe under the river. The interior of the siphon was lined with a one-inch thick layer of concrete in the 1960s to minimize leakage that was occurring from the riveted joints in the pipe. In 1987, the section of pipe on the west side of the river was replaced with ¼-inch thick steel pipe.

In recent years, a number of blowout events occurred within the siphon, leading ADC to seek legislative funds to rehabilitate the siphon. In November 2014, Cushnie Construction Company was awarded $1.68 Million dollars by the Department of Agriculture to repair the siphon (Job No. DOAK04 Kekaha Ditch Improvements Black Pipe Siphon and Miscellaneous Improvements). The redesign of the black pipe siphon involved reducing the original transmission capacity of the siphon from 50 mgd to 23 mgd by installing roughly 1,000 feet of 32-inch diameter HDPE pipe within the original riveted section of pipe. A section of 19-inch inner diameter HDPE was slip lined in the section of the siphon that ran under the river. The ditch was shut down from the second week of August 2015 to the second week of October 2015. Testing of the re-engineered siphon continued until the second week of November 2015 to address cavitation issues in the reconfigured siphon pipe.

During the reconstruction work on the black pipe siphon, KAA personnel mechanically cleaned the ditch and sprayed about 150 cubic yards of gunnite in leaky sections of KEDIS between the Mauka hydropower plant and the Waiawa hydropower plant.


Storm Water Diversion Structure on KEDIS; Recently Lined Leaky Ditch Section Before Tunnel 7


Top of Black Pipe Siphon; Reduced Diameter Liner Pipe Installed in Black Pipe Siphon

6.5 Section 5

This section of KEDIS runs along the western wall of Waimea Canyon past the black pipe siphon. This section of ditch is largely unlined and contains two tunnel sections. The middle section of this portion of ditch can be accessed from an unpaved road on the left side of Highway 550 marked by a single mail box. An average ditch water flow velocity of 2.06 miles per hour was measured in this section of ditch on 6/23/2015. A wooden diversion structure is present on this section of ditch that allows water in the ditch to be dumped back into the Waimea River.

In January 2015, KAA ran a new section of four-inch diameter HPDE pipe to supply the Menehune Ditch located in the valley below with water from KEDIS. A new gate valve was also installed during upgrades to this ditch diversion. KAA estimates that this pipeline provides an average of around 0.65 mgd of water to the Menehune Ditch, which channels water through the lower portion of the Waimea River valley to approximately eight individual taro farmers located in Waimea Valley. This section of ditch ends where the ditch turns westward and crosses under Highway 550. On December 2, 2014, a total of 19.67 mgd of water was measured exiting the Waimea River watershed via the ditch at the point where the ditch crosses Highway 550.


Ditch Diversion, Western Side of Waimea Canyon; Diversion Pipe Supplying Menehune Ditch


Taro Fields Irrigated Using Water Supplied by KEDIS to Menehune Ditch; KEDIS at Highway 550

6.6 Section 6

This section of KEDIS extends from Highway 550 to the eastern side of Kapilimao valley, where the ditch enters a siphon that crosses this large valley. This section of ditch is at an elevation of around 400 feet and trends in a general northwesterly direction while curving in and out of the various small ephemeral stream valleys that cross the ditch. This section of ditch was largely cut into basalt rock and is generally unlined, except in short sections that have been concrete lined to eliminate excessive leakage. Significant amounts of rock and silt enter this section of ditch, which requires periodic mechanical ditch cleaning by KAA.

A diversion structure located about one quarter of mile to the northwest of the Highway 550 crossing diverts water to a pair of former plantation reservoirs located above the town of Waimea. This water is in turn used by the town's wastewater treatment plant (WWTP). KAA estimates that 0.72 mgd of water is utilized by the Waimea WWTP. A relatively small amount of water (less than 0.3 mgd) enters KEDIS about 1.5 miles northwest of the Highway 550 highway crossing from water discharged into fallow fields from the terminal end of KODIS. Just before the ditch reaches the Hukipo flume, a rectangular reservoir was constructed adjacent to and Makai of the ditch. The water in this reservoir is believed to be used for firefighting purposes. Water loss from the ditch was observed along the section of the ditch that runs along the eastern side of Kapilimao valley.

KAA monitors the flow in KEDIS at the Hukipo flume, which is located about 2.45 miles from the point where the ditch exits the Waimea River watershed. KAA staff take manual readings of the staff gage present at the flume throughout the month to estimate the monthly water flow within KEDIS.

KEDIS Water Diverted to Reservoir for Waimea WWTP; End of KODIS Flow Entering KEDIS


Measuring Ditch Flow at Hukipo Flume on KEDIS; Typical Unlined KEDIS Section

6.7 Section 7

This section of KEDIS runs from the northwestern side of Kapilimao valley to just past where the ditch crosses under Kōkeʻe Road along the hills above the town of Kekaha. A section of unlined ditch runs for about one mile between the end of the siphon that crosses Kapilimao Valley and the beginning of the siphon that crosses Waiaka Valley to the northwest. Upon exiting the Waiaka Valley siphon, the ditch is unlined until it crosses Kōke'e Road in Waipao Valley. Just before the road crossing, the ditch enters a concrete lined section that runs under the road until it intercepts the 42-inch diameter steel pipe that crosses Waipao Gulch. Some leakage from the ditch is detected in the unlined section to the southeast of Kōkeʻe Road. In addition, a fair amount of persistent leakage occurs at the junction between the end of the lined section of the ditch and the 42-inch diameter pipe along the eastern edge of Waipao Gulch. A net reduction of roughly 2 mgd of water was measured in the ditch section between Highway 550 and Kōke'e Road. In this ditch section, around 0.7 mgd is diverted to the reservoirs above the town of Waimea while around 0.2 mgd of water is added from overland flow related to water discharged at the terminal end of KODIS. This suggests that about 1.5 mgd of leakage/infiltration/evaporation occurs within the section of ditch between these two roads.

A large mesoscale convective system hit the project area on August 25, 2015 while the ditch was dry due to the work being conducted at the black pipe siphon. The photos below taken roughly one month after this storm event show the extensive volume of fine soil material that accumulated within the section of ditch just below and above where the ditch crosses Kōkeʻe Road as a result of this storm event. This clearly illustrates why continual mechanical and hydraulic removal of fines from the ditch system is required to keep the system operational. According to Landis Ignacio, KAA used eight excavators to clean a 21-mile section of KEDIS of the silt material that came down from the mountains during this runoff event. He claims that over the last 15 years, the amount of ditch maintenance required has increased significantly due to the spread of feral goats in the highlands, which has led to increased amounts of sediment runoff during heavy rainfall events. DLNR has recently opened up more of the upland area above the ditch to public hunting, which may alleviate the sediment runoff problem in the future.

Measuring Ditch Flow Just Below Kōke’e Road Crossing; Ditch Leakage Just Above Road

Photos of sediment accumulated within KEDIS resulting from August 25, 2015 storm runoff

6.8 Section 8

This section of KEDIS runs from the west side of Waipao Valley to just past Hoea Valley. The ditch in this section largely runs at an elevation of just above 400 feet in the highlands above the Mānā Plain. About 1.5 miles west of town of Kekaha in Waiawa gulch, the flow in the ditch is dropped through a steel penstock about 280 feet to the Waiawa Hydropower Plant. On December 2, 2014, the flow in the ditch measured just past the Waiawa Hydropower Plant was 12.93 mgd while the flow measured near the end of Section 7 in the concrete lined section of the ditch just past Kōke‘e Road was 17.55 mgd. This suggests a total loss of slightly over 4.5 mgd of water in this relatively short section of ditch. As previously mentioned, a significant volume of water enters Waipao gulch from leakage at the junction between the ditch and the 42-inch diameter pipe that crosses the gulch. In addition, some water was observed leaking along the penstock leading down to the Waiawa Hydropower plant.

A total of 10.11 mgd of water was measured in the ditch just past the diversion structure that routes water to the 9-million-gallon capacity Waiawa Reservoir. Thus, on December 2, 2014, a total of 2.82 mgd of water was being routed towards this reservoir. Past the Waiawa Hydropower plant, the ditch travels at an elevation of approximately 120 feet along the foothills of the steep cliffs that abut the Mānā Plain. Shortly after the diversion to Waiawa Reservoir, the ditch crosses the typically dry, ephemeral stream gulches that exit Kahoana and Hoea Valleys. The ditch is routed underneath the bed of these two dry stream gulches in an enclosed concrete culvert. Some water leakage from the ditch was observed around the points where the ditch water enters and exits this buried culvert.

Penstock Leading to Waiawa Hydropower Plant; Water Exiting Waiawa Hydropower Plant


Measuring Ditch Flow Just Below Waiawa Hydropower Plant; Waiawa Reservoir

6.9 Section 9

This section of KEDIS runs from the western side of Hoea Valley to where the ditch bends northward near Kaʻawaloa Valley. This section of ditch runs along the base of the bluff at the edge of the Mānā Plain at an elevation of between around 75 to 115-foot elevation. Water from this section of ditch is diverted to three unlined, earthen reservoirs: Field 12 (4-million-gallon original storage capacity), Field 23 (10 million gallon) and Mānā (25 million gallon). These reservoirs serve as fore bays to filter stations used to provide clear water for drip and sprinkler irrigation to the surrounding agricultural fields throughout the Mānā Plain. The current storage capacity of these reservoirs is unknown due to the accumulation of sediments within these reservoirs and the lack of maintenance over the past twenty to thirty years.

Significant amounts of water leakage are observed throughout this section of ditch. In addition, various small scale collapse features are evident along the trail that borders the makai side of this section of ditch. This section of ditch is susceptible to the accumulation of silt, mud, rock, debris and boulders from the adjacent highlands and requires significant structural improvements and improved frequency of mechanical maintenance. However, repair of portions of this section of ditch is difficult due to the lack of an access road via which construction equipment could reach portions of the ditch requiring repair.

The prevalent leakage from this section of ditch can be observed on Google Earth images of this area, which show a band of green vegetation just below this section of ditch. This section of ditch also has a number of concrete hardened culverts that run under ephemeral stream courses that run out of valleys that this section of ditch crosses. Some water leakage was observed from the ditch near the points where the ditch water enters and exits these buried culvert structures.

On December 2, 2014, a total of 9.84 mgd of water was measured near the southeastern end of this section where the dirt road crosses the ditch just above the State of Hawaiʻi's Division of Forestry and Wildlife Kekaha Hunter Check-In Station. Near the end of this section, a total of 6.93 mgd of water was measured just before the Mānā Reservoir diversion. This suggest that about 2.91 mgd of water was diverted to Field 12 and Field 23 and leaked along this section of ditch. The ditch flow below the Mānā Reservoir diversion was 4.26 mgd. Thus, a total of 2.67 mgd of water was diverted towards Mānā Reservoir on this day.

8/16/2013 Google Earth Image Showing Green Belt of Vegetation Along Leaky Section of KEDIS

Collapse Features and Leakage Below Walls of Lower Section of KEDIS

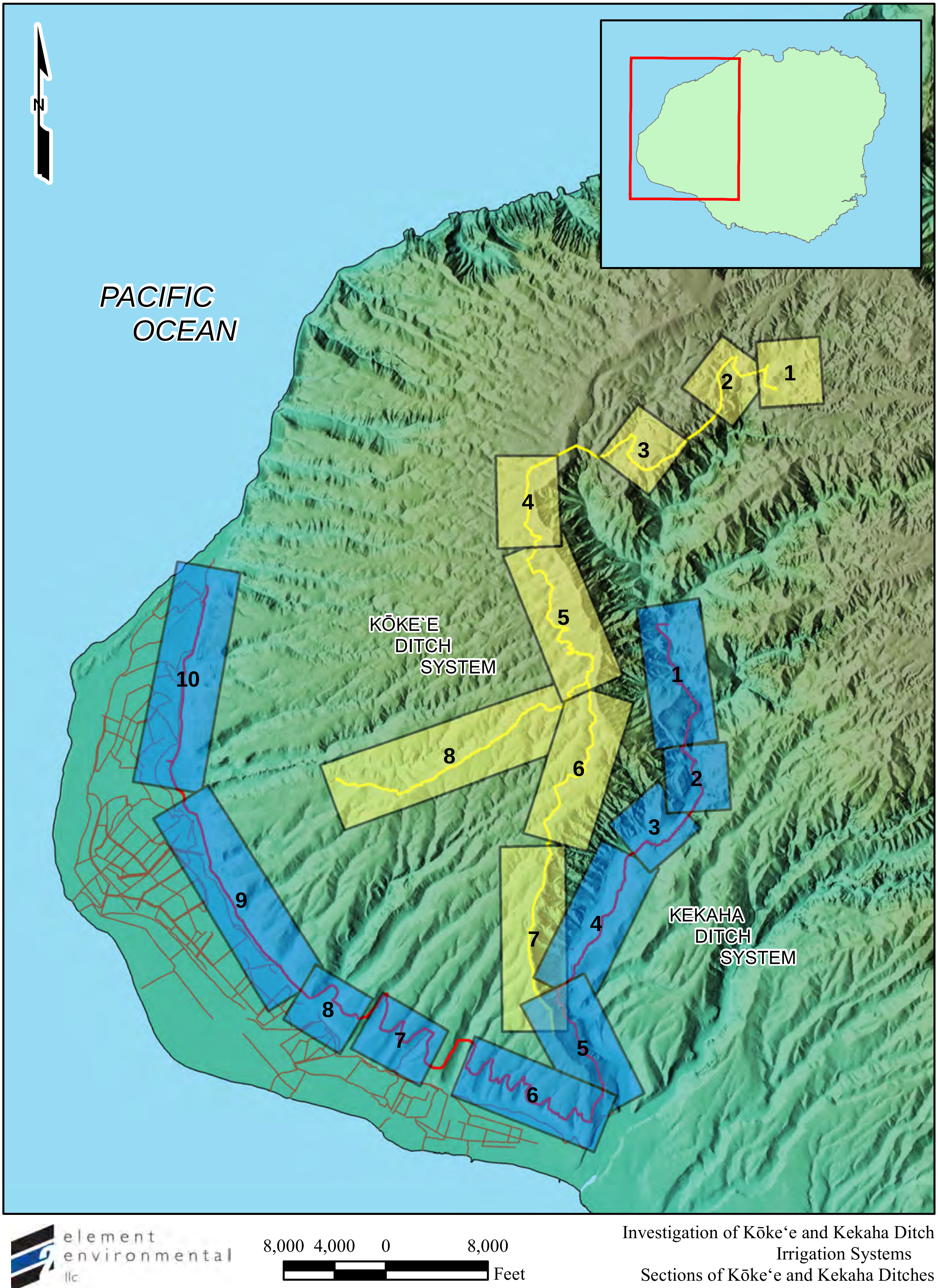
6.10 Section 10

This section of KEDIS runs generally northward from Kaʻawaloa Valley to the Field N reservoir located at the end of the system. This terminal reservoir is being considered for potential use as the lower storage reservoir in some of the pump storage projects being considered by KIUC. However, this reservoir will require significant rehabilitation and rehabilitation work before the existing structure could receive a registered dam certification for use in any future project.

This section of ditch is in better overall condition than Section 9, but relatively small amounts of leakage were observed in the vicinity of concrete hardened culverts that run under ephemeral stream courses that run out of valleys that cross this section of ditch. Water from this section of ditch is diverted to four unlined, earthen reservoirs: Field H (9 million gallon), Field 68 (2 million gallons), Field L (4 million gallons) and Field N (14 million gallons). These reservoirs are used to store water that irrigates the surrounding agricultural fields throughout the Mānā Plain. The current storage capacity of these reservoirs is unknown due to the accumulation of sediments within these reservoirs and the lack of maintenance over the past twenty to thirty years.

On December 2, 2014, a total of 4.26 mgd of water was measured after the diversion to the Mānā Reservoir at the beginning of this section. A total of 2.71 mgd was measured in the ditch just before the diversion to the Field L reservoir. On this day the combined diversion of flow to the Field H reservoir and Field 68 reservoir along with leakage along this section of the ditch was on the order of 1.55 mgd. The measured ditch flow past the diversion to Field L was 1.16 mgd. Thus, a total of 1.55 mgd of water was diverted to Field L on this day. A total of 0.45 mgd was measured in the ditch just before it entered the terminal reservoir (Field N) on the system. Thus, roughly 0.71 mgd of water was either diverted or leaked in this roughly two-mile long section of the ditch. The outflow from the terminal Field N reservoir is looped around to the adjacent fields, according to Mr. Ignacio.

Terminal Reservoir and Ditch Diversion on Lower Section of KEDIS



element environmental llc

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Sections of Kōke‘e and Kekaha Ditches
Figure 6-1

7 Current Ditch Operations: KODIS

KODIS was arbitrarily broken up into eight segments as depicted on Figure 6-1. The following sections describe the prominent features encountered in each of these eight segments. The ditch flow readings discussed were measured on December 2, 2014, which was a typical flow volume for this date based upon the stream flow measured at the two active USGS stream stations (Kawaikōī and Wai‘alae) on that day.

The water entering KODIS has a distinctive tea-like yellow-brown hue. The coloration is due to the high concentration of organic matter, including humus, peat and decaying plant matter, within the Alaka‘i Swamp. This organic material releases natural dissolved organic acids such as tannins and lignins, imparting a tea-like color to the water. The water within these bogs migrates to some of the streams that are eventually diverted into KODIS.

The upper portion of KODIS runs in a generally east to west direction along the northern rim of Waimea Canyon as it diverts surface water from four major streams (Waikoali, Kawaikōī, Kaua‘ikananā, and Kōke‘e) as well as various minor tributaries that intercept the ditch in the headwaters of the Waimea River watershed. The system formerly captured additional water from Mōhihi stream, but this section of ditch was abandoned in the 1980s due to poor water production and high maintenance requirements. The system was designed to capture as much of the flash flows, or freshets, that develop in the tributaries in the headwaters of the Waimea River during heavy rainfall events. This water was then conveyed to three reservoirs with a combined storage capacity of 361 million gallons, which provided a relatively reliable source of gravity fed surface water to the various upland sugarcane field planted above the Mānā coastal plain.

KODIS is generally easier to maintain than KEDIS due to following general factors: 1) the gentler surface topography abutting the ditch; 2) the heavily vegetated nature of the areas surrounding the ditch; and 3) the fact that much of the ditch section that runs along the northern rim of Waimea Canyon flowing in tunnels. These attributes of KODIS lead to generally lower amounts of fines entering the ditch system during larger runoff events as well as a decreased frequency of rock falls and landslide debris entering the ditch. According to Landis Ignacio, the flow within KODIS traditionally becomes very depressed during summer months, with flows in the ditch often dropping to as little as 0.5 mgd. The 361 million gallons of storage in the system were thus important to allow irrigation of the upland sugarcane fields during the often dry summer months. KODIS currently provides water to the various restroom facilities in Waimea Canyon State Park.

7.1 Section 1

The first section of ditch extends from the dam diversion on Waiakoali stream to just past the dam diversion on Kawaikōī stream. During the plantation era, the Waiakoali stream site was known as Camp 8, which formerly contained a ditchman cabin in which plantation employees would live who maintained the ditch flow within this remote system. During storms, these ditchmen would often need to clear the gratings that covered the entrances to the various tunnels, which would some time become clogged with silt, debris, rocks or vegetation.

The Waiakoali intake is now the high point of the system since the Mōhihi intake was abandoned in the 1980s. A concrete dam on Waiakoali stream spans the width of the stream just above the vehicle access road and captures all of the flow in the river, except during periods of elevated flow when the stream rises to a sufficient height to overtop the concrete wall structure. During low-flow conditions, the segment of Waiakoali stream below the dam only receives minimal amounts of flow from small amounts of seepage through the dam.

Below this diversion dam, the approximately six-foot wide ditch makes a 90 degree turn towards the west and enters a tunnel which is only accessible approximately every 1,000 feet at "adits" created during the original construction of the tunnel. The engineered gradient of KODIS in this upper section of the system is 12 inches of fall for every 1,000 linear feet of ditch.

Upon reaching Kawaikōī stream, the ditch crosses the stream at a height of about 30 feet in a roughly 200-foot long, 30-inch diameter HDPE pipe supported by a metal trestle. This pipe and trestle was installed by KAA in 2011 to replace the previous badly deteriorated 48-inch diameter, semi-circular steel trough that formerly crossed the river at this location. The new pipe that crosses Kawaikōī stream has a limited transmission capacity of 10 mgd, which in theory is balanced with the flow rate within Waiakoali stream at which the diversion dam on this stream is overtopped.

The diversion dam on Kawaikōī stream is located a couple hundred feet up-river of where the trestle and conveyance pipe crosses the stream course. This site was formerly known as Camp 7. The dam on Kawaikōī stream was constructed by cementing a number of huge boulders in place and routing the stream flow through the base of this dam into a short unlined section of ditch which follows the western valley wall, that then enters a short tunnel before joining with the flow from Waiakoali stream shortly downstream from where the pipe crosses Kawaikōī stream. A concrete spillway is located just before the short tunnel structure and is designed to dump excess flow during either high flow events within the river or if the ditch system becomes plugged somewhere below this point. The size of the intake in the base of the main dam and the height of the spillway along the ditch are designed to regulate the maximum flow within the ditch to around 55 mgd. The Kawaikōī Intake is the major source of water to KODIS. Due to the dam's location within a boulder field, there appears to be a persistent flow of small quantities of water below the dam within the boulder strewn stream course below the dam.

On December 2, 2014, a total of 10.34 mgd of water was measured at the USGS Kawaikōī gaging station (Station Number 16010000), which is located about a half mile upstream of the diversion dam. A total of 12.16 mgd of water was measured in the open section of ditch just past where the water diverted from Kawaikōī and Waiakoali combine. A total of 0.43 mgd of water was measured flowing in Kawaikōī stream below the diversion on this day. Thus, about 2.25 mgd of water was diverted from Waiakoali stream on this day.


Diversion Dams on Waikoali and Kawaikōī Streams


Trestle Supported Pipe Across Kawaikōī Stream; High Flow Spill Out Below Kawaikōī Dam

7.2 Section 2

The second section of KODIS is centered around the dam diversion on Kaua‘ikananā Stream. This site was formerly known as Camp 6. Kaua‘ikananā is a small stream that flows through a small, narrow, sinuate canyon covered with an uluhe (*Dicranopteris linearis*) fern understory overtopped by many large ‘ohi‘a (*Metrosideros polymorpha*) growing on the stream banks. Under typical weather conditions, the majority of flow that reaches the approximately 15-foot high concrete dam constructed across the stream bed originates from the combined flows of the Waiakoali and Kawaikōī Intakes, which are discharged from a tunnel exiting the stream bank approximately 300 feet upstream of the dam. The median flow measured at a short-lived USGS gaging station on Kaua‘ikananā Stream (Station Number 16012000) was about 1.2 mgd, showing that the contribution of flow at this diversion from Kaua‘ikananā Stream is typically relatively minor compared to the volume of water provided by Waiakoali and Kawaikōī with median flows of 2.2 and 8.4 mgd, respectively. KAA currently spills a significant amount of streamflow through the approximately three-foot wide, three-foot high, spillway in this dam at the present time, returning more water to the stream below the dam than would exist under typical low to moderate flow conditions. This return water flows down a series of waterfalls before combining with water originating from Mōhihi Stream in Po‘omau Canyon. On December 2, 2014, a total of 3.46 mgd of water was discharged through the spillway to the lower reaches of Kaua‘ikananā Stream.

The dam diverts the water into an approximately five-foot tall tunnel excavated in the adjacent rock face of the valley wall. There is a small tributary stream that enters the ditch right above the intake. According to Landis Ignacio, these small tributaries contribute the majority of sediment that enters KODIS. The dam is accessed by a metal cat-walk and platform that was repaired by KAA in June 2015. The ditch then travels from here approximately 2.5 miles through a series of tunnels along the rim of Waimea Canyon until it daylights within the small Kōke‘e watershed. Much of this section of ditch flows in tunnels and is only accessible at the original construction openings. Ditch operators utilize these access points to remove silt and fines that accumulate and can impede the flow within the ditch.

Ditch Water Entering Kaua‘ikananā Stream above Dam; Small Tributary that Enters Stream

Diversion Dam on Kaua‘ikananā Stream and Diverted Flow Entering Tunnel Below Dam

7.3 Section 3

The third section of KODIS starts where the ditch exits a tunnel and enters a flume at Halemanu and ends where the ditch enters a tunnel after passing Kōke‘e Stream. This section of KODIS contains a combination of tunnels as well as exposed lined and unlined sections of ditch. In addition, four small, unnamed tributaries feed into KODIS along this section. The original 60-foot long, 36-inch diameter wood stave pipe flume that crossed Halemanu Stream was replaced in 2006 with a new wooden trestle structure supporting a plastic conveyance pipe.

Past the Halemanu flume, the ditch flows through a section of unlined ditch before entering a roughly 150-meter long section of 7-foot wide, 5.5-foot tall, concrete channel just before intercepting Kōke‘e Stream. Kōke‘e stream is the lowest producing of the major streams in the watershed, with an estimated median flow of less than 0.2 mgd (the stream has never been monitored by the USGS). On December 2, 2014, a total of 9.4 mgd of water was measured flowing in the concrete channel just above Kōkeʻe Stream. It was visually estimated that less than 50 gallons per minute of water was flowing in Kōkeʻe Stream on December 2, 2014. A total of 6.84 mgd of ditch water was returned to the section of Kōkeʻe Stream below the diversion dam through the dam spillway. This water eventually reaches Waipo'o Waterfall. This waterfall is a popular hiking destination for visitors to Kōkeʻe State Park and can also be viewed from the road that leads to the park.

A total of 2.56 mgd of ditch water entered the tunnel past the wooden sluice gate on December 2, 2014. This water is transported outside of the Waimea River watershed. The ditch operators control the flow of water to the lower section of KODIS at this point by adjusting the height of the wooden sluice gate in the rock wall entrance to the tunnel and by installing or removing flashboards from the spillway in the diversion dam across Kōkeʻe stream. Significantly less water is currently being transported out of the Waimea Valley watershed via KODIS than during the plantation era due to recent storage limitations enacted for Puʻu Lua Reservoir further down the ditch system.

Recently Improved Flume Over Halemanu Stream; Measuring Ditch Flow Above Kōkeʻe Stream

Kōkeʻe Stream (left), KODIS (center), Diversion Dam (right); Ditch Water Entering Tunnel


Ditch Water Released to Kōke‘e Stream; Ditch Enhanced Streamflow Above Waipo‘o Waterfall

7.4 Section 4

The fourth section of KODIS starts where the ditch exits the long tunnel that conveys water from the Kōke‘e Stream diversion and Waimea Canyon's rim onto its western slopes southward to the ditch flow monitoring point established during this study located just above the Pu‘u Lua Reservoir. The ditch flows through tunnels in roughly one third of this section of KODIS. The remaining two-thirds of this section of ditch flows through unlined ditch channels.

This section of ditch is in the Nā Pali drainage basin. The Kauhao diversion consists of a sluice gate that ditch operators will open to spill-off water into Kauhao gulch during periods of high flow to prevent the lower portions of the ditch from overtopping its banks. This site was formerly known as Camp 2. According to Landis Ignacio, the ditch operators typically allow a small continual amount of ditch water to leak through the bottom of the wooden sluice gate at Kauhao diversion to prevent the build-up of sediments within the ditch before it enters a short section of tunnel below the diversion. The wooden slats in the sluice gate are set at a height that will regulate the volume of water flowing into Pu‘u Lua Reservoir at a rate that will prevent the water level in the reservoir to rise above 60 feet. The former USGS gaging station (Station Number 16014000) for the KODIS is located on the opposite side of the ditch from the Kauhao diversion. This gaging station recorded flow in the ditch from October 1926 until it was discontinued in December 1982.

This section of ditch is well maintained, although occasional incidents of vandalism have occurred in this area in the past due to the proximity of vacation cabins to this section of ditch. The ditch system continues to Pu‘u Lua Reservoir. E2 conducted continuous monitoring of ditch flow in this unlined section of ditch at a former stilling well located approximately 500 feet above the diversion located above Pu‘u Lua Reservoir where the ditch water cascades down a short waterfall into the reservoir. A pressure transducer was installed in the stilling well and a rating curve developed for the site by measuring the ditch flow at various stages in the ditch using a pygmy meter. KAA estimates flow within KODIS by making visual estimates of the flow entering Pu‘u Lua Reservoir.

On December 2, 2014, a total of 2.57 mgd of water was measured flowing in the short section of unlined located ditch just above the Kauhao diversion. A total of 0.43 mgd of water was measured leaking through the flashboards at the Kauhao diversion and entering Kauhao gulch on the same day.


Kauhao Diversion Structure; Ditch Water Leaking Under Flashboards at Kauhao Diversion


Continuous Monitoring Location on Kōkeʻe Ditch Just Above Puʻu Lua Reservoir

7.5 Section 5

The fifth section of KODIS starts where the ditch enters the Puʻu Lua Reservoir and ends at the Puʻu Moe ditch divide. Approximately 25% of this section of ditch flows through tunnels. The remaining 75% of ditch is unlined and open to the environment. The ditch enters the Puʻu Lua Reservoir via a cascade on the northern side of the reservoir. This 262-million-gallon capacity, unlined earthen reservoir sits at 3,260-foot elevation and serves as the main water storage facility for the system. The reservoir was constructed by placing an earthen dam across a natural gulch. The reservoir was constructed without a spillway. Since July 2013, the flow of water from KODIS into the Puʻu Lua Reservoir has been controlled to prevent the water level from rising above a level of 60 feet within the reservoir due to the observation of seepage from the dam embankment and the need to upgrade the reservoir to meet dam safety standards. This new regulated reservoir height was based on geotechnical borings drilled in the embankment that encountered bedrock somewhere below 75 feet below the top of the embankment.

Landis Ignacio estimates the reservoir currently loses around one million gallons of water per day from seepage through the dam embankment. The amount of seepage loss increases as the water level in the reservoir rises. On average, about 2 mgd of water currently enters the reservoir to preserve this water level in the reservoir and to provide water to the lower sections of KODIS. The reservoir is currently managed by DLNR as a recreational and sport fishing (trout) site. The outflow from the reservoir is controlled by a 24-inch globe-type valve and discharge piping buried in the dam embankment. The valve is accessed via a vertical concrete shaft with manhole located near the middle of the dam embankment. The globe-type valve is adjusted by turning a large metal steering wheel mounted on the side of the manhole.

Below Puʻu Lua Reservoir, the ditch flows through a series of tunnels before entering long sections of unlined ditch. This section of ditch and tunnels is generally in good condition. The ditch eventually reaches the Puʻu Moe Ditch divide, where the ditch flow is split between the segments that head towards Kitano and Puʻu ʻŌpae Reservoirs. An old metal Parshall flume is present on the side of the four-foot wide ditch that flows towards Puʻu ʻŌpae Reservoir which was presumably historically used to monitor the volume of flow that was diverted towards DHHL lands. KAA replaced the lumber in the Puʻu Moe control gate for DHHL in June 2015. This divide is narrow and badly eroded in places, especially in the section below the divide that heads towards Kitano Reservoir. Historically, the majority of flow was routed in the direction of Kitano Reservoir, which served the upland fields of sugarcane planted above the town of Waimea. On December 2, 2014, a total of 0.23 mgd of water was measured flowing towards Puʻu ʻŌpae Reservoir through DHHL lands.


Kōkeʻe Ditch Entering Puʻu Lua Reservoir; Exposed Reservoir Height Staff Poles

Manhole Housing Pu‘u Lua Reservoir Outflow Control Valve; Pu‘u Moe Ditch Divide

7.6 Section 6

The sixth section of KODIS starts at the Pu‘u Moe divide and heads south to just past the Kitano Reservoir where the original system used to terminate. This section of ditch had a design capacity of 19 mgd and consists mostly of unlined ditch and a couple of short sections of tunnel. This section of ditch is also in generally good condition. A short section of the ditch just below the Pu‘u Moe divide runs along Highway 550 and is visible from the road. The original end of the ditch terminated at the Kitano Reservoir. This reservoir was an unlined cut and fill type reservoir with an original storage capacity of 36 million gallons. By the year 2000, it was estimated that about 50% of the original capacity of this reservoir had been lost due to siltation, since the reservoir had last been dredged in the late 1970s.

The Kitano Reservoir historically provided water to upland acreages above the town of Waimea. According to Landis Ignacio, water flow to the Kitano Reservoir was diverted around the time of the Ka Loko Reservoir disaster on March 14, 2006. Two back-to-back incidents of significant vandalism to the reservoir structure at Kitano occurred shortly after the Ka Loko event, which led the State to divert all future ditch flow from entering the reservoir. The reservoir is currently devoid of water and heavily overgrown with grass.

Ditch Diversion Structure to Kitano Reservoir; Photo of Drained Kitano Reservoir Circa 2008

7.7 Section 7

The seventh section of KODIS starts at Kitano Reservoir and heads south in unlined ditch to a point near the 1,000-foot elevation marker sign on Highway 550, where the remaining water is discharged from a 14-inch diameter PVC pipe into an unlined channel that runs through fields of fallow sugarcane and grass lands. This section of ditch was established after the decision was made to shut down the Kitano Reservoir in 2006. KAA used to divert the water at the end of this section of ditch into a storm drain located along Highway 550, but discontinued this practice due to disagreements with the Hawai‘i Department of Transportation. On December 2, 2014, a total of 0.39 mgd of water was measured discharging into the fallow fields at the end of this ditch section. An unknown portion of this discharged water ultimately enters Kekaha ditch roughly one mile to the southeast of the Hukipo flume.

The water at the end of KODIS was used during closure of the Kekaha ditch in the summer and fall of 2015 while the black pipe siphon was repaired to supply water to the taro farmers in Waimea valley via the Menehune ditch. The water was routed down the valley wall of Waimea Canyon until it intercepted the Kekaha ditch and flowed to the diversion to the Menehune Ditch.


Ditch Flow below Kitano Reservoir Adjacent to Highway 550; Ditch Flow at End of KODIS

7.8 Section 8

The eighth section of KODIS starts at the Pu‘u Moe divide and ends at Pu‘u ‘Ōpae Reservoir. The design capacity of the unlined ditch in this four-mile long section of KODIS is 7 mgd. The DHHL administers the Pu‘u ‘Ōpae Hawaiian Homes Land through which this section of ditch travels. DHHL owns 15,061 acres of homestead lands in this area. The primary access road to this DHHL property is Hā‘ele‘ele Ridge Road, an unimproved 4-WD road that roughly parallels this section of ditch. Section 221 of the Hawaiian Homes Commission Action and Water Code provide the agency with clear legal rights to take water from KODIS. The original capacity of the unlined, earthen Pu‘u ‘Ōpae Reservoir was 88-million gallons. This reservoir is currently dry and would require rehabilitation to meet current dam safety standards. The water in this section of ditch is used by the Hawaiian homesteader for cattle grazing activities and to irrigate a series of taro fields created by a Hawaiian community organization located up the hill from Pu‘u ‘Ōpae Reservoir.

The outflow from the taro fields is discharged via a small diameter pipe into a shallow, un-vegetated swale that flows in the general direction of Kaʻawaloa Valley.

Taro Fields Above Puʻu Ōpae Reservoir; Water Discharged at End of KODIS on DHHL Property

This page intentionally left blank.

8 Summary of Findings and Prediction

The information contained in this report was collected by E2 in order to assist the Commission in the matter of the Earthjustice complaint and their petition for a declaratory order against the waste of water diverted from the Waimea River system by ADC and its land manager, KAA. A summary of the allegations contained in the complaint was provided in Section 1.2. Table 8-1 summarizes the findings obtained during this study related to these individual allegations and the sections within this report that discusses the associated issue.

Table 8-1: Summary of Findings Related to Earthjustice Allegations

Earthjustice Allegations	Finding
Further, Poʻai Wai Ola and its members believe that inadequate stream flow is causing heavy siltation buildup within the Waimea River, creating a flood hazard for area residents, including Poʻai Wai Ola's members.	Section 2.5: The heavy siltation buildup within the lower portions of the Waimea River is believed to be related to a combination of factors including construction of the Kikiaola Small Boat Harbor, a massive infusion of sediment to the watershed related to a massive rock fall-avalanche in October 1981 near the head of Olokele Canyon, generally increased transport of sediment to the Waimea and Olokele Rivers due to the proliferation of goats in the contributory watersheds, and the regional rise in sea level on Kauaʻi over the past century.
In contrast to the sugarcane plantation operations, the current agricultural tenants under ADC/KAA cultivate only a fraction of Kekaha Sugar's former lands, in far less land- and water-intensive crops. the glaring discrepancy between the ongoing diversions and the radically reduced water demands indicates that the diverted river flows are not being put to maximum reasonable-beneficial use, but rather are being wasted, contrary to law. Indeed, Poʻai Wai Ola documents below several examples of dumping of water from the ditch systems. Further, much of the ditch infrastructure is inefficient and unlined, which causes an unknown amount of waste.	Section 3.8 and Appendix A: KAA members currently lease a total of 4,226.35 acres of land and report having used an average of 5.81 mgd of water between 2010 and 2014. The ditch infrastructure is generally well maintained, with the exception of the section of KODIS past the Waiawa hydroelectric plant.
From 1946 to 1996, the average flow in the Kekaha Ditch was 1,015 mgm, or around 33.4 mgd. The average flow in the Kōkeʻe Ditch during that same time period was 438 million mgm, or around 14.4 mgd.	Section 3.3. Concur. The median flow in KEDIS measured at USGS Station 16022000 between 1908 and 1968 was 36.77 mgd. The median flow in KODIS measured at USGS Station 16014000 between 1926 and 1982 was 12.28 mgd.
According to ADC's ditch flow reports to this Commission from 2010 through May 2013, Kekaha Ditch took an average of 31.3 mgd, and Kōkeʻe Ditch took an average of 7.6 mgd.	Section 3.3. Concur. The median flow in KEDIS and KODIS reported by KAA between January 2010 and June 2013 was 32.9 mgd and 8.0 mgd, respectively.

Table 8-1: Summary of Findings Related to Earthjustice Allegations	
Earthjustice Allegations	**Finding**
Despite this dramatic decline in cultivation and actual water demands due to Kekaha Sugar's closure, ADC/KAA continue to divert Waimea River flows in amounts comparable to the sugarcane plantation.	Section 3.3. The current median flow of water diverted outside the Waimea River watershed via KODIS is 1.9 mgd, compared to historic median flows of 12.28 mgd measured by the USGS just upstream at the Kauhao diversion during the plantation era (1927-1997) and a median value of 8 mgd during the post-plantation era under KAA management (January 2010-June 2013) before water levels in Puʻu Lua Reservoir were regulated to not exceed 60 feet depth. The current median flow of water diverted outside the Waimea River watershed via KEDIS is 12.51 mgd compared to historic median flows of 34.25 mgd measured at USGS Station 16027000 during the plantation era (1908 to 1934).
While some reduction in reported ditch flows appears to have occurred over the years, there has not been a change in ditch operations or design commensurate to the collapse of water demand from the demise of sugarcane cultivation.	See previous response.
From the Kōkeʻe Ditch, water is continually being dumped down the Kauhao gulch, at a point before the ditch reaches the Puʻu Lua Reservoir.	Section 4.4: Some water is diverted into Kauhao gulch through the flashboards at the Kauhao diversion by the KAA ditch operators to prevent the build-up of silts and other entrained fines in the adjacent ditch prior to water entering a short concrete culvert that leads to a section of tunnel. On December 2, 2014, the volume of water leaking through the flashboards was measured to be 0.43 mgd.
Until earlier this year, Kōke'e Ditch water was also being continually dumped at a spot on the side of Waimea Canyon Road, where it flowed under the road and down the side of the canyon, many miles downstream from where it was originally diverted. More recently, this dumping has been modified to be less conspicuous, with the ditch water dumped into a newly constructed trench in an empty field, where the water flows away from the Waimea River and in a makai direction, to nowhere.	Section 6.7: This extended section of KODIS was created after closure of the Kitano Reservoir due to repeated vandalism of the reservoir in 2006. On December 2, 2014, a total of 0.39 mgd of water was measured discharging into the fallow fields at the end of this ditch section. Roughly half of this discharged water ultimately enters Kekaha ditch roughly one mile to the southeast of the Hukipo flume. As reported, this terminal KODIS water is sometimes also discharged into Waimea canyon, most recently during the summer of 2015, to replenish flow to the section of KEDIS that provides water to the Menehune Ditch during repair of the Black Pipe siphon.
As for the Kekaha Ditch, a visit to the Kekaha-Mānā Plain revealed dumping from an irrigation ditch directly into a low-elevation drainage canal flowing to the ocean.	Sections 5.8, 5.9 and 5.10: The section of KEDIS past the Waiawa hydropower plant diverts water to a series of reservoirs used for irrigation of the surrounding agricultural fields. Unused water in some of these reservoirs does enter the drainage canals that run across the Mānā Plain.

Table 8-1: Summary of Findings Related to Earthjustice Allegations

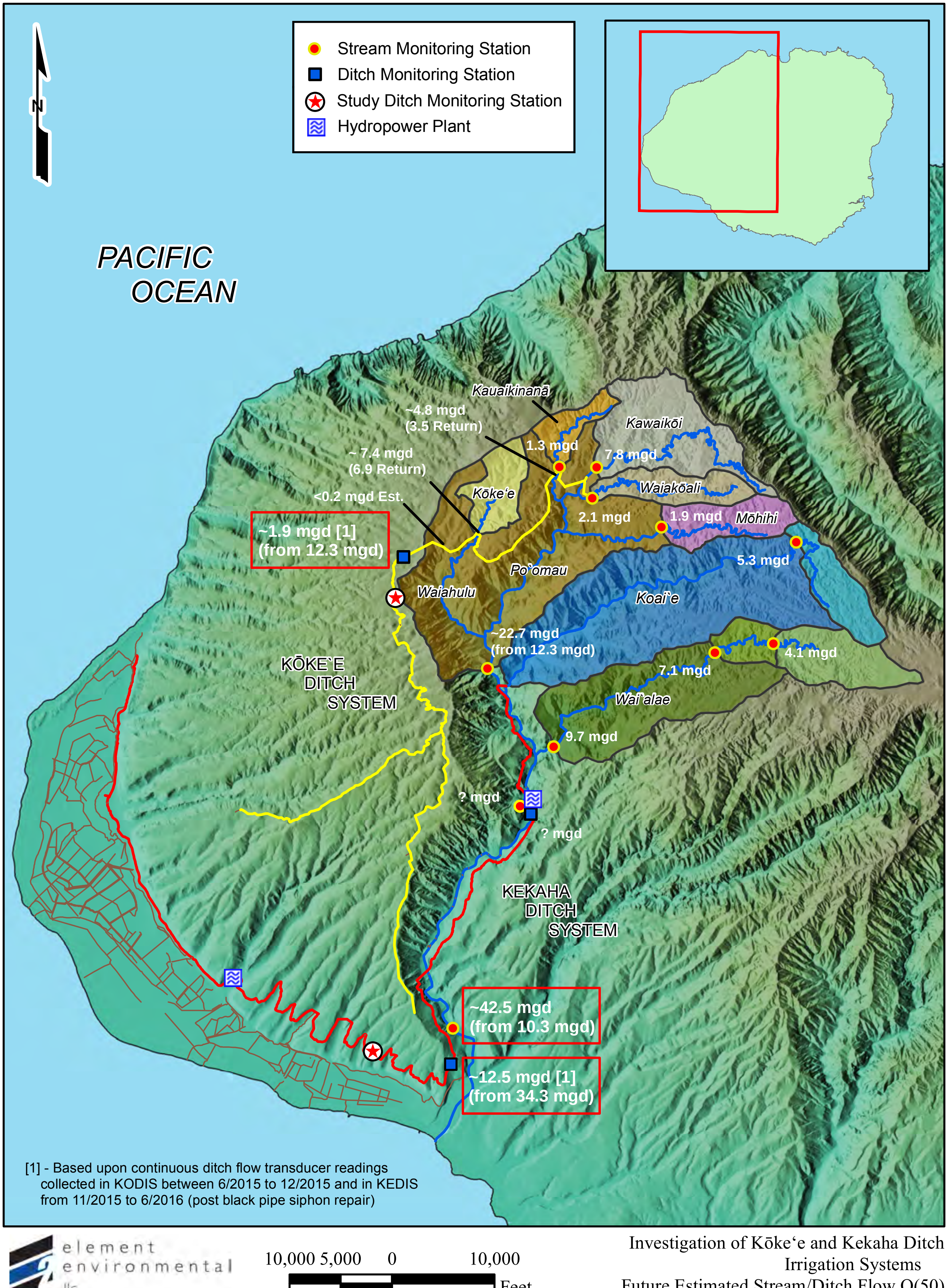
Earthjustice Allegations	Finding
Long-time kama'aina community members attest that their ability to recreate in the river has deteriorated or vanished as the weak river flows continue and cause more and more silt to fill the river bed. As recent as the 1980s to 1990s, community members would frequent a popular swimming hole under the swinging bridge near the Waimea-Makaweli fork. The water was around fifteen-feet deep at the time, deep enough for people to dive in from the bridge. Today, the swimming hole is buried, and only a thin layer of water covers the silt-laden riverbed.	Section 2.5: The heavy siltation buildup within the lower portions of the Waimea River reflects a process known as aggradation, where the fines that are transported down the river begin piling up and reach back upstream due to a change in condition at the point of discharge of the river. It is believed that aggradation and the associated increased sedimentation in the lower sections of Waimea River resulted from a combination of episodic and long-term climatic/geologic/ecological events as well as from man-made alterations made to the shoreline.
Native Hawaiians are limited in their rights to gather stream life such as 'o'opu, 'Ōpae, and hihiwai. As explained above, the Waimea River system was legendary for the abundance of its native stream life, including 'o'opu. See Part IV.A.2, supra. These resources, however, have markedly declined with the continued long-term diversion of the river and cannot support the traditionally practiced and currently desired levels of gathering.	Section 3.4: A biological assessment of portions of the Waimea river and tributary streams that are diverted and receive either slightly decreased or significantly decreased flow over natural conditions is required to answer this assertion. Figure 4-6 of this report identifies the general sections of the Waimea River and tributary streams that currently have decreased flow over natural conditions.
Po'ai Wai Ola anticipates that increased instream flow will have a direct, positive impact on the river ecosystem from mauka to makai.	Section 3.4: See previous response.
Recreational opportunities will increase as river flow rises and scours accumulated sediment.	Section 5.1: Accumulated sediment within the Waimea River is largely scoured and transported during periods of high river flow. The ditch system diverts only a small percentage of the total volume of water flowing through the watershed under the high river flow conditions during which the majority of sediment transport occurs. As a result, the presence/absence of the ditch system likely has little effect on the scouring ability of rivers and streams within the Waimea River watershed.
As part of its mandated investigation, the Commission should require essential monitoring and reporting, including average daily water usage by end user, breakdowns of acreages and crops cultivated, reservoir volumes or stages, and system losses.	Section 3.8 and Appendix A: Water usage data provided by KAA members between 2010 and 2014 is summarized in Section 3.8 and included in Appendix A.
Moreover, the flows immediately returned to the Waimea River system to prevent waste must be incorporated into amended IIFSs.	Section 3.4: This section discusses potentially useful information that can be considered by the Commission to develop IIFSs for the Waimea River watershed, if

Table 8-1: Summary of Findings Related to Earthjustice Allegations

Earthjustice Allegations	Finding
"Interim standards must respond to interim circumstances." Id. at 151, 9 P.3d at 463. "[A]t least for the time being," the IIFSs should reflect the amount of instream flow that reflects current, actual reasonable-beneficial off-stream use and the absence of waste. Id. at 157, 9 P.3d at 469. If necessary, the Commission may further amend the IIFSs as it obtains more detailed information and analysis of instream and off-stream uses.	required.

8.1 Estimate of Future Water Flow in Waimea River

The regulation of water levels within Pu‘u Lua Reservoir since July 2013 and the reduction in pipe diameter of the Black Pipe siphon during the summer of 2015 has led to a significant reduction of the median volume of water exiting the Waimea Valley watershed via KEDIS and KODIS (about 14.4 mgd) compared to median volumes diverted from the watershed during the plantation era (about 48.5 mgd). The USGS recently restored operation of the Waimea River stream monitoring station (Station Number 1603100), which was discontinued in 1997. This stream monitoring station is located approximately 7,600 feet upstream of the confluence between the Waimea and Olokele rivers. Figure 8-1 depicts an estimate of the future median flow within the Waimea River, tributary streams and irrigation ditches given the current operational state of the two ditch systems. It is estimated that the future median value of flow measured at this station will increase roughly four fold from the historic average flow of 10.3 mgd measured during the plantation era to around 42.5 mgd. As discussed in Section 4.3, future amounts of rainfall, groundwater input to the watershed streams, and associated streamflow may decline from historic averages, leading to a slightly lower increase in future median streamflow from the estimates depicted in Figure 8-1 (which are based on historic streamflow and ditch monitoring data). The future stream monitoring data collected by the USGS from the restored gaging station on the Waimea River will be useful in evaluating the predicted increase in median river flow due to recent changes in operation of KEDIS and KODIS.



element environmental llc

Investigation of Kōke‘e and Kekaha Ditch Irrigation Systems
Future Estimated Stream/Ditch Flow Q(50) in Waimea River Watershed
Figure 8-1

9 References

Bassiouni, M. and D.S. Oki. 2013. Trends and Shifts in Streamflow in Hawai‘i, 1913-2008. Hydrological Process, Vol. 27, Issue 10, pages 1484-1500.

Bow Engineering and Development, Inc. 2000. Kekaha Sugar Infrastructure Study, Kekaha, Kaua‘i. Hawai‘i. Report dated April 17, 2000.

Burt, C.C. 2015. WunderBlog: Crazy Summer in Hawai‘i: Record Rainfall, Record Heat, and Snow! Blog update published on August 26, 2015. https://www.wunderground.com/blog/weatherhistorian/update-crazy-summer-in-Hawai‘i-record-rainfall-record-heat-and-snow.

Burt, R.J. 1979. Availability of ground water for irrigation on the Kekaha Mānā coastal plain, Island of Kaua‘i, Hawai‘i: State of Hawai‘i, Department of Natural Resources Report, R53, 50 p.

Cheng, C.L. 2012, Measurements of seepage losses and gains, East Maui Irrigation diversion system, Maui, Hawai‘i: U.S. Geological Survey Open-File Report 2012–1115, 23 p.

Clague, D.A. and G.B. Dalrymple. 1988. Age and petrology of alkalic post shield and rejuvenated-stage lava from Kaua‘i, Hawai‘i. *Contributions to Mineralogy and Petrology 99(2): 202-218.*

Cook, C. 2000. Kekaha Sugar lasted 120 years despite challenges. http://thegardenisland.com/news/kekaha-sugar-lasted-years-despite-challenges/article_1ba13e78-6700-593b-8e42-30716c190bab.html.

Cox, D.C., N.C. Burbank, and E.A. Kay. 1970. Proposed zones of mixing in coastal waters of Kaua‘i. Memorandum Report No. 26, Water Resources Research Center, University of Hawai‘i, Honolulu, HI, August.

EA/HHF Joint Venture. 2011. Hydroelectric Power Source Alternative Assessment, State of Hawai‘i Section 905 (b) Analysis. Report dated May 2011.

Englund, R., D.A. Polhemmus, and D. Preston. 1998. Assessment of the Suitability of Kōke‘e State Park Streams as Habitat for Year-Round Catch and Release Fishing and Rainbow Trout without Annual Stocking. Report prepared for the Hawai‘i Department of Land and Natural Resources, Division of Aquatic Resources by Bishop Museum dated February 1998.

Faye, Christine. 1997. Touring Waimea. Kaua‘i Historical Society’s Kaua‘i Series #1, 30 pp.

Fletcher, C.H., B.M. Romine, A.S. Genz, M.M. Barbee, Matthew Dyer, T.R. Anderson, S.C. Lim, Sean Vitousek, Christopher Bochicchio, and B.M. Richmond. 2012. National Assessment of Shoreline Change: Historical shoreline change in the Hawaiian Islands: U.S. Geological Survey Open-File Report 2011–1051, 55 p. (Also available at http://pubs.usgs.gov/of/2011/1051.)

Flinders, A.F., G. Ito, and M.O. Garcia. 2010. Gravity Anomalies of the Northern Hawaiian Islands: Implications on the Shield Evolutions of Kaua‘i and Ni‘ihau. J. Geophys. Res., 115, B08412.

Gandy, C.E. 2006. Volume and Petrologic Characteristics of the Koloa Volcanics, Kaua‘i, Hawai‘i. Masters of Science Thesis in Geology and Geophysics, University of Hawai‘i.

Grossman, E.E. and C.H. Fletcher. 1998. Sea level higher than present 3500 years ago on the Northern Main Hawaiian Islands. Geology 26(4): 363-366.

Hazlett, R.W. and D.W. Hyndman. 1996. Roadside Geology of Hawai‘i. 304 pp., Mountain Press Publishing Co., Montana.

Landis Ignacio, personal communication

Jones, B.L., S.S.W. Chinn, and J.C. Brice. 1984. Olokele Rock Avalanche, Island of Kaua‘i, Hawai‘i. *Geology* 12, 209-211.

Macdonald, G.A., D.A. Davis, and D.C. Cox. 1960. Geology and ground-water resources of the island of Kaua‘i, Hawai‘i, Hawai‘i Division of Hydrography, Bulletin, 13, 1–212.

Makai Ocean Engineering and Sea Engineering. 1991. Aerial Photograph Analysis of Coastal Erosion on the Islands of Kaua‘i, Molokai, Lanai, Maui, and Hawai‘i. State of Hawai‘i Office of Coastal Zone Management Program.

Mantua, N., S. Hare, Y. Zhang, J. Wallace, and R. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production, Bulletin of the American Meteorological Society, 78 (6), 1069 -1079.

McDougall, I. 1979. Age of shield-building volcanism of Kaua‘i and linear migration of volcanism in the Hawaiian Island Chain, Earth Planet. Sci. Lett., 46, 31–42.

Mink J.F. and L.S. Lau. 2006. Hydrology of the Hawaiian Islands. University of Hawai‘i Press, 274 p.

Moore, J.G., W.R. Normak, and R.T. Holcomb. 1994. Giant Hawaiian landslides, Annu. Rev. Earth Planet Sci., 22, 119–144.

National Park Service. 1990. Hawai‘i Stream Assessment. A Preliminary Appraisal of Hawai‘i’s Stream Resources. Report R84 prepared for the Commission on Water Resource Management. December 1990.

Parham, J.E., G.R. Higashi, E.K. Lapp, D.G.K. Kuamo‘o, R.T. Nishimoto, S. Hau, J.M. Fitzsimons, D.A. Polhemus, and W.S. Devick. 2008. Atlas of Hawaiian Watersheds & Their Aquatic Resources, Island of Kaua‘i, Bishop Museum & Division of Aquatic Resources. 614 p.

Ries, K.G., and Friesz, P.J. 2000. Methods for estimating low-flow statistics for Massachusetts streams. U.S. Geological Survey Water-Resources Investigations Report 00-4135.

Sakoda, E.T. 2007. Setting Instream Flow Standards for Hawaiian Streams—the Role of Science. In: Biology of Hawaiian Streams and Estuaries. Edited by N.L. 293, Evenhuis & J.M. Fitzsimons. Bishop Museum Bulletin in Cultural and Environmental Studies 3: 293-304.

Smakhtin, V.Y. 2001. Low flow hydrology: a review. Journal of Hydrology, 240: 147-186.

State of Hawai‘i, Department of Agriculture. 2003. Agricultural Water Use and Development Plan. Report prepared by Water Resource Associates. Report revised in December 2004. 190 pp.

State of Hawai‘i, Department of Land and Natural Resources (DLNR), Commission on Water Resource Management (CWRM). 1990. A Preliminary Appraisal of Hawai‘i’s Stream

Resources. Report R84. Report prepared by the Hawaiʻi Cooperative Park service Unit, dated December 1990.

State of Hawaiʻi, DLNR Division of Forestry and Wildlife (DOFAW). 2012. Draft Environmental Assessment, Mānā Plain Wetland Restoration. Report dated May 2012.

State of Hawaiʻi, DLNR Division of State Parks. 2014. Final Environmental Impact Statement, Kōkeʻe and Waimea Canyon State Parks Master Plan. Report prepared by R.M. Towill Corporation dated August 2014.

State of Hawaiʻi, DLNR. 2016. DLNR News Release: DLNR Announces 2016 Open Fishing Season Starting June 18 for Rainbow Trout at Kōkeʻe Public Fishing Area, Kauaʻi. http://governor.hawaii.gov/newsroom/latest-news/dlnr-news-release-dlnr-announces-2016-open-fishing-season-starting-june-18-for-rainbow-trout-at-kokee-public-fishing-area-kauai/

State of Hawaiʻi, Department of Business, Economic Development, and Tourism (DBEDT). 2001. State Data Book.

State of Hawaiʻi, DBEDT Office of Planning. 2012. Increased Food Security and Food Self-Sufficiency Strategy, Volume III: Assessment of Irrigation Systems in Hawaiʻi, Report prepared under and award from the U.S. Department of Commerce, Economic Development Administration, Award Number 07 69 06658, October 2012.

State of Massachusetts. 2004. Low Flow Inventory Accessed: March 2004, < http:www.state.ma.us.dfwele/river/rivLow_Flow_Inventory/7q10.html>, 3 p.

U.S. Army Corps of Engineers. 2011. Hawaiʻi Regional Sediment Management, Kekaha and Poipu Regions. Final Report. Geomorphology, Coastal Processes, Shoreline Change and Potential RSM Projects. Report prepared by Moffatt & Nichol and EA HHF for the Honolulu District USACE and State of Hawaiʻi DLNR.

U.S. Geological Survey. 1982. Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge.

University of Hawaiʻi, Department of Meteorology. 2003. Drought Risk and Vulnerability Assessment and GIS Mapping Project. Report prepared for the Commission on Water Resource Management, Department of Land and Natural Resources dated September 2003.

University of Hawaiʻi. 2004. Kekaha Sugar Company History. Hawaiian Sugar Planters' Association Plantation Archives, University of Hawaiʻi at Manoa Library, Hawaiian Collection, August (http://www2.Hawaiʻi.edu/~speccoll/p_kekaha.html).

Water Resource Associates. 1990. Preliminary Engineering Report for New Potable Water Sources, Kōkeʻe-Noe Well (0739-03), Kōkeʻe, Kauaʻi, Hawaiʻi. Report prepared for the State of Hawaiʻi Department of Land and Natural Resources.

Water Resource Associates. 2004. Agricultural Water Use and Development Plan. Report prepared for the State of Hawaiʻi Department of Agriculture originally dated December 2003 (revised December 2004).

Wilcox, C. 1996. Sugar Water. Hawaiʻi's Plantation Ditches. University of Hawaiʻi Press, Honolulu. 191 p.

Yent, M. 2005. Archeological assessment Kawai‘ele Wildlife Sanctuary, Phase 2. Prepared by the State of Hawai‘i DLNR Division of State Parks for the State of Hawai‘i DLNR Division of Forestry and Wildlife. 58pp.

APPENDIX A
Estimates of Water Consumption Provided by KAA Members

SCHLACK ITO
A LIMITED LIABILITY LAW COMPANY

Douglas A. Codiga
Attorney at Law
DIRECT 808.523.6047
dcodiga@schlackito.com

MAIN 808.523.6040
FAX 808.523.6030
Topa Financial Center
745 Fort Street • Suite 1500
Honolulu, Hawaii 96813

July 10, 2015

VIA ELECTRONIC MAIL AND U.S. MAIL
The Honorable Chair and Commissioners
State of Hawaii Commission on Water Resource Management
Kalanimoku Building
1151 Punchbowl Street, Room 227
Honolulu, HI 96813

Re: Po'ai Wai Ola Petition and Complaint filed July 24, 2013
Response to Commission's May 11, 2015 Letter

Dear Chair and Commissioners:

On behalf of the Kekaha Agriculture Association ("KAA"), enclosed for submission to the Commission are the responses to the Information Requests set forth in the Commission's May 11, 2015 letter to the KAA and the Agribusiness Development Corporation ("ADC").[1] It is KAA's understanding that ADC will submit its responses directly to the Commission.

The KAA appreciates the opportunity to provide these responses to the Commission's requests for information. Should there be any questions please do not hesitate to contact the undersigned.

Very truly yours,

SCHLACK ITO
A LIMITED LIABILITY LAW COMPANY

Douglas A. Codiga

DAC:mpm

[1] This response is timely submitted. The May 11, 2015 letter requests KAA to respond to these items within sixty days of the date of the letter, or by July 10, 2015.

Copy via U.S. Mail and Electronic Mail:

Myra Kaichi, Esq., Department of the Attorney General
William Aila and Kaleo Manuel, Department of Hawaiian Home Lands
David Henkin, Esq. and Isaac Moriwake, Esq., Earthjustice for Petitioners Po'ai Wai Ola
David Bissell, Kauai Island Utility Cooperative
Yvonne Izu, Esq., Attorney for Kauai Island Utility Cooperative
Jason Hines and Dawn Huff, Joule Group, for Kauai Island Utility Cooperative
Mayor Bernard Carvalho, County of Kauai
Mauna Kea Trask, Esq., County of Kauai
Steve Spengler, Element Environmental, LLC

CWRM-IR-1

1. List of all users that receive water from the Kokee Ditch System and/or the Kekaha Ditch System. For each user, provide the amount of water used, types and acreages of crops cultivated (excluding or breaking out fallow acreage), and details of any other uses, for the last five years (calendar years 2010 to 2014). Indicate how the amount of use was measured or estimated. If this information is not available or cannot be readily determined, please explain why and when that information will be available.

RESPONSE:

I. PRELIMINARY STATEMENT

This Information Request seeks measured or estimated amounts of irrigation water used by members of the Kekaha Agriculture Association[1] ("KAA") and other licensees.[2] As explained below in section II.B, the Kekaha[3] and Kokee[4] systems are comprised of highly integrated and interdependent irrigation, drainage and electrical power infrastructure systems (collectively, "agricultural infrastructure"). Irrigation water is only one component of the agricultural infrastructure. The demand for water is created not only by irrigation needs, but also by critically important drainage and electrical power needs. The combined irrigation, drainage and hydropower uses of the resource provide major economic benefits and protect vital public health and safety interests.

---

[1] The KAA is an agricultural cooperative established pursuant to Chapter 421, Hawaii Revised Statutes. KAA's Articles of Incorporation establish its purpose to include the use of natural resources and infrastructure. KAA's current members are BASF Plant Science, LP ("BASF"), Pioneer Hi-Bred International, Inc. ("Pioneer"), Sunrise Capital, Inc. ("Sunrise"), Syngenta Hawaii, LLC ("Syngenta"), and Wines of Kauai, L.L.C. ("Wines of Kauai"). KAA's members are engaged in commercial agriculture and aquaculture on the land under the control of the State of Hawaii Agribusiness Development Corporation ("ADC"). KAA is authorized to manage and operate the agricultural infrastructure on the ADC land.

[2] As used in this response, "other licensees" refers to the following KAA member sub-licensees and or entities licensing directly from ADC: Taiwan Gu; LBD Coffee, LLC; and Steve Pionowski dba Phoenix Farms.

[3] The Kekaha system (also known as the Waimea or Waimea-Kekaha Ditch) has been in use since 1907 and is now utilized by KAA members for irrigation and electricity generation in support of agriculture in the Kekaha region. The Kekaha system is currently comprised of two primary diversions (Waiahulu and Koaie) and one intermittent diversion (Waimea), as well as 27 miles of ditches, tunnels, flumes and syphons. *See* "Waimea River Watershed," attached as Exhibit D; "Kokee and Kekaha Ditch System Schematic," attached as Exhibit E.

[4] The Kokee system has been in use since the 1920s and, like the Kekaha system is now utilized by KAA members for irrigation in support of agriculture in the Kekaha region. The Kokee system is currently comprised of four diversions (Kauaikinana, Kawaikoi, Waiakoali, Kokee) and 21 miles of ditches, tunnels, flumes and syphons.

Accordingly, KAA and its members respectfully submit that relevance and weight given by the Commission to the specific amounts of water used for irrigation alone must be properly balanced with the highly integrated and interdependent nature of the agricultural infrastructure – especially the drainage and electrical power uses which make farming on the Mana Plain possible and prevent flooding of U.S. federal defense facilities and the local community.

II. KEKAHA SYSTEM

A. BASF, Pioneer and Syngenta.

1. Water use – measured.

This Information Request requests the amount of water use as "measured." The KAA does not meter Kekaha system water received by BASF, Pioneer and Syngenta, and they do not meter Kekaha system water they receive. It is noted that under the April 1, 2008 Revised Memorandum of Agreement by and between KAA and ADC ("RMOA") KAA is not required to account for the delivery of irrigation water on a metered or other measured basis.[5] Accordingly, KAA, BASF, Pioneer and Syngenta are unable to provide the amount of water received as measured by a metering device.

2. Water use – estimated.

This Information Request also requests the amount of water use as "estimated." KAA members BASF, Pioneer and Syngenta respectfully object to this request to the extent that it does not properly take into account and consider the fact that such estimates may have limited predictive value because agricultural activities vary greatly as to acreage, crops, land ownership and other parameters. Agricultural operations fluctuate dramatically from season to season and year to year based on the weather patterns, expansions and contractions in the proportion of

---

[5] Under RMOA § 4(e)(v), "Coop is Cooperative Association," the KAA "shall not be required to charge and account for the delivery or distribution of any irrigation, drainage, roadway, and electrical power services provided by the Coop on a metered or other measured basis." *Id.* (emphasis added).

licensed acreage actually cultivated, business needs, market demand, the interests of other licensees, and a multitude of other factors.

In addition, no KAA member can predict whether ADC might at some point license additional acreage to other agricultural entities that would have their own needs with respect to water use and acreage. The requested water use estimates have little bearing on water use by other farmers of other crops. Although corn may use far less water than other crops that could be cultivated on the ADC lands in Kekaha, diversified agriculture is a core value protected by Hawaii's constitution and a fundamental goal of the ADC. *See* Haw. Const. art. XI, § 3 ("[t]he State shall conserve and protect agricultural lands, promote diversified agriculture" and "assure the availability of agriculturally suitable lands."). This casts doubt on the ultimate relevance of such water estimates to Commission evaluation of the issues in this proceeding.

As explained in the Preliminary Statement above, BASF, Pioneer and Syngenta further respectfully object to this Information Request on the basis that irrigation uses must properly consider the highly integrated and interdependent nature of all aspects of the agricultural infrastructure.

Notwithstanding the foregoing objections, KAA members BASF, Pioneer and Syngenta each respond to this Information Request as set forth in Exhibits A, B and C, respectively.

3. Water use – estimate based on County of Kauai WUDP Plan Update.

The County of Kauai Water Use and Development Plan Update incorporates a figure of 3,400 gallons per day per acre for diversified crops.[6] A water use estimate based on this figure of the 3,400 gallons per day per acre may be made for total current licensed acres. For BASF, the product of the total current licensed acres of 977.25 and the demand of 3,400 gallons per day

[6] *See* "Agricultural Water Use Development Plan December 2003" (Revised: December 2004), State of Hawaii Department of Agriculture at 256; Staff Submittal D1 (Exhibit 1, Table 9) for the June 24, 2015 meeting of the Commission on Water Resource Management.

per acre for diversified crops is 3,322,650 gallons per day per acre, or 3.32 million gallons per day ("MGD"); for Pioneer, with 1,337.07 acres, the estimate is 4,546,038 gallons per day, or 4.55 MGD; and for Syngenta, with 1,785.07 acres, the estimate is 6,069,238 gallons per day, or 6.07 MGD. The total estimated use for these lands is 13.94 MGD.

B. KAA.

Related to the foregoing, KAA manages and operates the agricultural infrastructure – which is integral to the Kekaha system – in a reasonable and beneficial manner that does not involve dumping or waste.[7] Under the RMOA, the irrigation infrastructure includes the Kekaha system, the Kokee system, reservoirs, siltation ponds, wells and shafts, and associated irrigation equipment ("irrigation infrastructure"); the drainage infrastructure includes forty miles of canals and drainage channels, the Kawaiele, Nohili, and Kekaha pumping stations, and electric and mechanical equipment ("drainage infrastructure"); and the electrical power infrastructure includes two power plants, dams, diesel generators, and associated infrastructure ("electrical power infrastructure").[8]

1. KAA agricultural infrastructure delivers irrigation water.

Use of the Kekaha and Kokee systems to supply water to the irrigation infrastructure for agricultural and other uses is a reasonable and beneficial use. This water provides irrigation water for agricultural activities by KAA members BASF, Pioneer, Syngenta, and Wines of Kauai and the other licensees; irrigation water for agricultural activities by kuleana and taro farmers using the Menehune ditch system; irrigation water for use by the State of Hawaii Department of

---

[7] With regard to allegations of dumping or waste in the Petition and Complain filed July 24, 2013 in this matter ("Petition"), see KAA's responses to CWRM-IR-4 and CWRM-IR-6, and with regard to reasonable and beneficial use see KAA's response to CWRM-IR-15.

[8] The electrical power infrastructure includes the Mauka hydropower facility, which is located on the east side of the Waimea River in Waimea Canyon at an elevation of 520 feet, has a capacity of 1.2 megawatts ("MW") and generates electricity by utilizing Kekaha system water diverted at an elevation of 800 feet. It also includes the Waiawa hydropower facility, originally installed in 1908 and with.5 MW capacity, which is located near the lowland coastal plain on the Kekaha system area at an elevation of 100 feet.

Hawaiian Home Lands ("DHHL") and its beneficiaries; water for use by the State of Hawaii Department of Land and Natural Resources ("DLNR") for recreational fishing and for public sanitation benefiting tourism; and water for use by the County of Kauai to operate its Kekaha landfill, all for the public benefit.

2. KAA agricultural infrastructure lowers the water table to allow farming.

The drainage and electrical power infrastructure make agricultural activities by KAA members and other licensees possible on the Mana Plain by maintaining the groundwater table below the plant root zone. This is a reasonable and beneficial use.

The elevation of the Mana Plain is at or near the local sea level and in its unaltered condition it is poorly drained. As a result, the Mana Plain water table regularly rises above the ground surface due to fresh and saltwater influxes caused by rainstorms, storm tides, and high astronomical tides. The KAA utilizes large capacity pumps, in combination with the canals and drainage channels, to maintain the Mana Plain groundwater level at approximately 1.0 to 2.0 feet below the ground surface in the vicinity of the Kawaiele and Nohili pumping stations. In the absence of this service provided by the drainage and electrical power infrastructure, the unregulated groundwater level would severely limit or render impossible agricultural activities by KAA members, other licensees, and others seeking to farm and conduct agricultural activities on the ADC Land on the Mana Plain.

3. KAA agricultural infrastructure provides flood protection to PMRF and the local community.

The drainage and electrical power infrastructure provide flood protection services to government, residential and commercial interests in the Kekaha area. This is also a reasonable and beneficial use.

The Mana Plain area is home to the U.S. Navy's Pacific Missile Range Facility, Barking

Sands ("PMRF"), which is one of the Kauai's largest employers, with nearly 1,000 active duty Navy, government, civil service and contract civilians, and Hawaii Air National Guard members.[9] It is also home to local residents and businesses, the County of Kauai Kekaha landfill, and KAA members BASF, Pioneer, Sunrise and Syngenta.[10]

Due in part to the topography and weather conditions in the area there is a perennial risk of flooding. The electrical power infrastructure provides electrical power to the pumping stations. The pumping stations pump water through the drainage infrastructure in a manner that reduces the risk of flooding. In the absence of this service, the risk of flooding and harm to PMRF and local residents would be greater.

4. KAA agricultural infrastructure supports ADC agriculture.

The electrical power infrastructure also supports agriculture and aquaculture on the ADC Land – also a reasonable and beneficial use. The electrical power infrastructure supplies electricity to Sunrise to sustain its aquaculture operations. It also provides power to irrigation pumps, which pump water through the irrigation infrastructure to supply fields farmed by KAA members BASF, Syngenta and Pioneer and other licensees.

5. KAA agricultural infrastructure requires approximately 21 MGD for irrigation and hydroelectric power production.

KAA has maintained these important reasonable and beneficial uses with far less water than historically used by the Kekaha Sugar Company. KAA regularly measures the amount of water in the Kekaha system at the Hukipo flume. KAA reports the average of these measurements to the Commission on a monthly basis. Since 2003 KAA has diverted an average

[9] Kauai Chamber of Commerce, "Kauai Industries," *available at* http://kauaichamber.org/pages/KauaiIndustries1/

[10] As noted in ADC's 2002 Annual Report, an "immediate goal" of ADC was to "keep the land in productive in agriculture and prevent flooding of the area since a good portion of the Mana Plain, including the U.S. Navy's Pacific Missile Range Facility (PMRF), is at or below sea level." *See* Legislative Reference Bureau, "Agribusiness Development Corporation: Revisited" at 14.

of 22.7 MGD from headwater streams to supply the Kekaha system. During the period of 1980 through 1999, the Kekaha Sugar Company diverted an average of 31.1 MGD. KAA has therefore achieved a 27 percent reduction in the amount of water used by the Kekaha system as compared to the Kekaha Sugar Company. *See* Kekaha and Kokee Water Use Graphs, attached as Exhibit F.

The KAA agricultural infrastructure requires approximately 21 MGD for irrigation purposes and to maintain these reasonable and beneficial uses. (As explained above, as measured at the Hukipo flume KAA diverts 22.7 MGD from the Waimea River; a portion of this amount is received by Menehune ditch system and kuleana users, the Kikiaiola lands, and the County of Kauai landfill.) Using the County of Kauai WUDP Update figure of 3,400 MGD provides the above-referenced water estimates of 3.32, 4.55 and 6.07 MGD for BASF, Pioneer and Syngenta, respectively, for a total of 13.94 MGD. KAA estimates that additional ADC lands not licensed to ADC members increase this total to 17.64 MGD. The Commission's Investigator, Element Environmental, LLC estimates Kekaha system transmission losses occurring down-ditch from the Waiawa hydropower plant to be in the range of 1.05 to 3.41 MGD. KAA estimates evaporation from the field reservoirs on the Mana Plain to be approximately 3.8 ±0.8 gallons per minute per acre of reservoir surface area.[11] Additionally, the amount of leakage from the field reservoirs is presently unknown. The combination of the foregoing amounts indicates that the KAA agriculture infrastructure requires approximately 21 MGD for irrigation purposes.

The drainage and electric power infrastructure also require approximately 21 MGD. KAA operates the Kekaha system to provide water to the Mauka and Waiawa hydropower facilities, which generate electricity used to power drainage and irrigation pumps on the Mana

[11] Shade, P.J., 1995, Water budget for the island of Kauai, Hawaii, U.S. Geological Survey WRIR 95-4128, 29 p.

Plain. As explained above, these pumps and the associated infrastructure deliver irrigation water to farmers, keep the water table lowered to allow agriculture, protect PMRF and the local community from flooding, and support ADC agriculture.

For the sake of clarity, it is noted that the same 21 MGD amount of water is used for both irrigation and hydroelectric power generation at the Waiawa hydropower facility. Hydroelectric power generation is a non-consumptive use of Kekaha system water. After generating hydroelectric power at the Waiawa facility, which is the further down-ditch and the closest to the farmers on the Mana Plain, the water flows to down-ditch users of irrigation water on the Mana Plain, including KAA members and other licensees.

C. Others Receiving Kekaha System Water.

1. Menehune ditch system and kuleana users.

KAA does not meter Kekaha system water received by users of the Menehune ditch system and kuleana users. It is KAA's understanding that Menehune ditch system and kuleana users do not meter Kekaha system water received. KAA estimates Menehune ditch system and kuleana users receive approximately 0.65 MGD from the Kekaha system. KAA has no information concerning specific crops and acreages for these users. These users are not KAA members.

2. Kikiaiola lands.

KAA does not meter Kekaha system water received by the adjacent Kikiaiola lands. It is KAA's understanding that the Kikiaiola land managers do not meter Kekaha system water received. KAA estimates the Kikiaiola lands receive approximately 0.72 MGD from the Kekaha system. KAA has no information concerning specific acreages. This user is not a KAA member.

3. County of Kauai.

KAA does not meter Kekaha system water received by the County of Kauai for the Kekaha landfill. It is KAA's understanding that the Kekaha landfill does not meter Kekaha system water received. KAA has no estimate of the amount of water received by the County of Kauai. KAA has no information concerning acreages. This user is not a KAA member.

III. KOKEE SYSTEM

A. Wines of Kauai

1. Water use – measured.

This Information Request requests the amount of water use as "measured." KAA does not meter Kokee system water received by Wines of Kauai and Wines of Kauai also does not meter the Kokee system water it receives. As mentioned above, under the RMOA KAA is not required to account for the delivery of irrigation water on a metered or other measured basis. Accordingly, KAA and Wines of Kauai are unable to provide the amount of water received as measured by a metering device.

2. Water use – estimated.

Wines of Kauai currently licenses 126.96 acres on the Mauka ADC lands and approximately 23.34 are cropped. KAA estimates that it provides Wines of Kauai with 12,340 gallons per acre per day. The product of Wines of Kauai's cropped acreage (23.34) and the water estimate (12,340 gallons per acre per day) provides a total daily estimated amount of water received by Wines of Kauai from the Kokee system of 288,016 gallons per day, or 0.29 MGD. During this period, Wines of Kauai has grown grapes, fruit trees and protea.

B. KAA.

As explained above, KAA manages and operates the agricultural infrastructure in a reasonable and beneficial manner that does not involve dumping or waste.[12] Water from the Kokee system flows into the Kekaha system. Accordingly, the relevant facts and statements set forth above concerning reasonable and beneficial use of Kekaha system waters apply with equal force to the Kokee system.

KAA regularly measures the amount of water in the Kokee system at the Puu Lua reservoir. KAA reports the average of these measurements to the Commission on a monthly basis. Since 2003 KAA has diverted an average of 8.3 MGD from headwater streams to supply the Kokee system. During the period of 1979 through 1999, the Kekaha Sugar Company diverted an average of 15.2 MGD. KAA has therefore achieved a 45 percent reduction in the amount of water used by the Kokee system as compared to the Kekaha Sugar Company. *See* Kokee and Kokee Water Use Graphs, attached as Exhibit F.

C. Others Receiving Kokee System Water.

1. DHHL.

KAA does not meter Kokee system water received by DHHL. It is KAA's understanding that DHHL does not meter Kekaha system water received.

On December 11, 2014, the Commission's appointed Investigator, Element Environmental, LLC, gave a presentation to Commission staff and stakeholders to Commission staff and stakeholders and provided a copy of a table titled, "Flow Measurements within Waimea River Watershed (Ditches and Streams" which includes the item, "Ditch below Puu Moe Divide heading towards DHHL Land" and the associated figure of 0.23 MGD. The KAA's Land Manager, Landis Ignacio, estimates the daily average amount of water diverted toward Puu Opae Reservoir at the Puu Moe Ditch Divide is 200 gallons per minute or 0.29 MGD. KAA has

---

[12] With regard to allegations of dumping or waste in the Petition, see also KAA's responses to CWRM-IR-4 and CWRM-IR-6, and with regard to reasonable and beneficial use see KAA's response to CWRM-IR-15.

no information concerning specific crops and acreages. DHHL is not a KAA member.

2. DLNR.

KAA does not meter Kokee system water received by DLNR. It is KAA's understanding that DLNR does not meter Kekaha system water received. KAA has no information concerning acreages. DLNR is not a KAA member.

IV. GENERAL OBJECTIONS

KAA hereby incorporates into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-2

2. Estimates of water diverted from each stream that supplies the Kokee Ditch System (Waiakoali, Kawaikoi, Kauaikinana, and Kokee Streams) and the Kekaha Ditch System (Waimea River, Koaie and Kukui Streams), and estimates of water released at each of the Kauaikinana and Kokee Stream diversions. Indicate how and when the estimate was obtained, and how and whether diversion flows are routinely monitored.

RESPONSE:

The KAA does not possess or maintain estimates of water diverted from each stream that supplies the Kokee system (Waiakoali, Kawaikoi, Kauaikinana, and Kokee Streams) and the Kekaha system (Waimea River, Koaie and Kukui Streams).

The KAA does not possess or maintain estimates of water released at each of the Kauaikinana and Kokee Stream diversions.

The KAA does not routinely monitor these diversion flows.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-3

3. Status, condition, and flow of other registered stream diversions on the Kokee Ditch System (Mohihi #1, Mohihi #2, Mohihi #3, Kumuwela #1, Kumuwela #2, Kumuwela #3, Kumuwela #4, Kumuwela #5, Nawaimaka, Halemanu, and Kapue Valley Dam), Kekaha Ditch System (Kukui Trail #1), and the Kikiaola Ditch System. Indicate how and when the information was obtained, and how and whether these diversion flows are routinely monitored.

RESPONSE:

The Mohihi #1, Mohihi #2, Mohihi #3 diversions on the Kokee system are abandoned.

With regard to the Kumuwela #1, Kumuwela #2, Kumuwela #3, Kumuwela #4, Kumuwela #5, Nawaimaka, Halemanu, and Kapue Valley Dam diversions on the Kokee system, the status is "active," the condition is "maintained," and the flows are not monitored by the KAA or its members because they are ephemeral.

With regard to the Kukui Trail #1 diversion on the Kekaha system, the status is "active," the condition is "maintained," and the flow is not monitored by KAA or its members because it is ephemeral.

The Kikiaiola ditch system diversions are abandoned.

All of the foregoing diversions that are active are shown the "Kokee and Kekaha Ditch System Schematic" attached as Exhibit E.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-4

4. Estimate of average daily water released at the Kokee Ditch sluice gate to Kauhao Gulch. Indicate how this information was obtained.

RESPONSE:

On December 11, 2014, the Commission's appointed Investigator, Element Environmental, LLC, gave a presentation to Commission staff and stakeholders and provided a copy of a table titled, "Flow Measurements within Waimea River Watershed Ditches and Streams" which includes the item, "Diversion to Kauhao Gulch Thru Sluice Gate" and the associated figure of 0.43 MGD. The KAA's Land Manager, Landis Ignacio, estimates the average daily amount of water released at the Kokee system sluice gate to Kauhao Gulch ("Kauhao sluice gate") is approximately 300 gallons per minute or 0.43 MGD.

With regard the allegations concerning waste set forth in the Petition, KAA's current position is that they are not supported by the relevant facts.

The KAA respectfully submits that the release of approximately 300 gallons per minute or 0.4 MGD is necessary and appropriate to protect public health and safety and safeguard the operational viability of the Kokee system before and after the Kauhao sluice.

KAA must release water at the Kauhao sluice gate to maintain the level of the Puu Lua reservoir at or below sixty feet in order to maintain compliance with dam safety practices, safeguard against potential liability exposure to the KAA or the State of Hawaii, and to protect public health and safety. This fact has been recognized by the Commission's appointed Investigator, Element Environmental, LLC.

KAA must also release water at the Kauhao sluice gate to maintain conditions suitable for the recreational fishing program operated by the State of Hawaii Department of Land and Natural Resources.

KAA must also release water at the Kauhao sluice gate to properly maintain the ditch system. Specifically, maintaining flow throughout the Kokee system is necessary to keep the Kokee system tunnels from drying out, cracking, and possibly collapsing, and to reduce and suppress the growth of aquatic vegetation and accumulation of debris in the ditch that may cause or contribute to clogging and other harm to the Kokee system.

Notwithstanding the foregoing, in response to the Commission's May 11, 2015 letter to KAA and the ADC, KAA indicated that is amenable to entering into mediation. KAA remains open to discussing this matter further with the Commission, petitioners and other interested parties in the mediation process.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-5

5. Estimate of average daily water diverted towards Puu Opae Reservoir at the Puu Moe Ditch Divide. Indicate how this information was obtained.

RESPONSE:

On December 11, 2014, the Commission's appointed Investigator, Element Environmental, LLC, gave a presentation to Commission staff and stakeholders to Commission staff and stakeholders and provided a copy of a table titled, "Flow Measurements within Waimea River Watershed Ditches and Streams" which includes the item, "Ditch below Puu Moe Divide heading towards DHHL Land" and the associated figure of 0.23 MGD.

The KAA estimates the daily average amount of water diverted toward Puu Opae Reservoir at the Puu Moe Ditch Divide is 200 gallons per minute or 0.29 MGD. This estimate has been prepared by the KAA's Land Manager, Landis Ignacio.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-6

6. Estimate of average daily water released via the white PVC pipe at the end of the Kokee Ditch System (along Hwy 550). Indicate how this information was obtained.

RESPONSE:

On December 11, 2014, the Commission's appointed Investigator, Element Environmental, LLC, gave a presentation to Commission staff and stakeholders and provided a copy of a table titled, "Flow Measurements within Waimea River Watershed (Ditches and Streams" which includes the item, "12" PVC Discharge Pipe at the end of Kokee Ditch System at 1,000 foot elevation" and the associated figure of 0.39 MGD. The KAA's Land Manager, Landis Ignacio, estimates the daily average amount of water released into the Kekaha system at the end of the Kokee system is approximately 300 gallons per minute or 0.43 MGD.

With regard the allegations concerning waste set forth in the Petition, KAA's current position is that they are not supported by the relevant facts.

The KAA respectfully submits that the diversion of approximately 300 gallons per minute or 0.4 MGD into the Kekaha system at the end of the Kokee system is necessary and appropriate for the reasons explained in response to CWRM-IR-4 concerning ditch system maintenance. Specifically, this diversion is necessary to prevent the unlined ditch between the Puu Lua reservoir and the Field 635 settling basin from drying out, cracking, and possibly collapsing. If this occurred, it would eliminate the only source of water available to users of the Menehune ditch system and kuleana users when the Kekaha system is shut down for repairs.

Notwithstanding the foregoing, in response to the Commission's May 11, 2015 letter to KAA and the ADC, KAA indicated that is amenable to entering into mediation. KAA remains open to discussing this matter further with the Commission, petitioners and other interested parties in the mediation process.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-7

7. A brief history of the construction and maintenance of the Kokee Ditch downstream of the Kitano Reservoir.

RESPONSE:

Beginning in the late 1970s, the ADC Mauka lands were converted from furrow irrigation to drip irrigation. During that same time period, most of the Kokee system's open ditches were replaced with PVC pipe.

In 2006, immediately following the Kaloko dam failure, vandals severely damaged the Kitano reservoir outlet controls, requiring the Kitano reservoir to be completely drained. The reservoir is a State of Hawaii registered dam. Due to the high cost of repairs to meet registered dam requirements, KAA has continued to bypass Kokee system flows around the reservoir.

An open ditch leads out of the Kitano reservoir for approximately two miles downslope and carries this bypass water into several settling basins ending at the Field 635 basin. In the past, Kokee system water at that location was filtered and sent to individual fields via PVC pipelines. This filter system has not been used since 2006.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-8

8. Daily amount of water flowing through and electric energy generated from both the Waimea and Waiawa Hydropower Plants, along with the daily amount of water flowing past the Waihulu Dam, Koaie Dam, and Mauka Powerhouse Dam on the Waimea River, for the last five years. Indicate how and when the data were obtained.

RESPONSE:

Please see "Kekaha Agriculture Association Hydropower Production, 2010-2014," attached as Exhibit G.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-9

9. Summary of water quantity and quality data for the Kawaiele and Nohili Pump Stations for the last five years, daily electric energy consumption along with information on the current status of National Pollutant Discharge Elimination System (NPDES) Permit No. 000086.

RESPONSE:

The KAA views this Information Request as properly directed to the ADC and defers to ADC's response.

CWRM-IR-10

10. Estimated storage capacities, average daily actual water storage, locations of the irrigation pumps at the various storage reservoirs in the Mana Plain that receive water from the Kekaha Ditch. Data should either be provided in latitude and longitude coordinates, GPS, or identified of a hardcopy map.

RESPONSE:

Please see "Kekaha Ditch: Kekaha – Mana Infrastructure," attached as Exhibit H.

With regard to the request for estimated storage capacities of the reservoirs, the KAA has provided original storage capacities. Estimates are difficult to establish due to the condition of the reservoirs, many of which are impacted by heavy siltation.

With regard to the request for average daily water storage, KAA does not possess or maintain such information.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-11

11. Summary of electricity use for last five years and pump capacity (in gallons per minute), and average daily flow, of each individual irrigation pump that draws water from the storage reservoirs on the Mana Plain that receives water from the Kekaha Ditch. Indicate the ownership of the pumps and the users who use the water from each pump.

RESPONSE:

With regard to electricity use, the KAA and its members do not monitor electricity use for irrigation pumps that draw water from reservoirs supplied by the Kekaha system.

With regard to pump capacity, ownership and users, please see "Kekaha Agriculture Association Irrigation Pump Specifications," attached as Exhibit I.

With regard to average daily flow, KAA and KAA members do not monitor average daily flow.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-12

12. Explanation of the association and role of KAA, if any, in the operations of the County of Kauai's Waimea Wastewater Treatment Plant facility.

RESPONSE:

The KAA has no formal association with or role in the operation of the County of Kauai's Waimea Wastewater Treatment Plant ("plant").

It is KAA's understanding that the plant produces R-1 recycled water, and that the Kikiaola Land Company subsequently blends this R-1 recycled water with water it draws from the Kekaha system.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-13

13. Potential modifications or solutions that may help to address waste concerns and dry streams sections raised by the Complainants.

RESPONSE:

At this time, the KAA has not identified any potential modifications or solutions that may help address alleged waste concerns or dry streams sections raised by petitioners.

With regard the allegations concerning waste set forth in the Petition, KAA's current position is that they are not supported by the relevant facts. *See* KAA's Response to CWRM-IR-4 (water released at Kauhao sluice gate) and CWRM-IR-6 (water released at end of Kokee system).

With regard the Petition's allegations concerning KAA's reasonable and beneficial use of water from the Kekaha and Kokee system water, KAA's current position is that they are not supported by the relevant facts. *See* KAA's Response to CWRM-IR-1, CWRM-IR-15 (KAA use of water to operated irrigation, drainage and electrical power infrastructure are reasonable and beneficial).

Notwithstanding the foregoing, in response to the Commission's May 11, 2015 letter to KAA and the ADC, KAA indicated that is amenable to entering into mediation. KAA remains open to discussing these matters with the Commission, petitioners and other interested parties in the mediation process.

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

CWRM-IR-14

14. Any information regarding the past, current, or future potential for use of groundwater resources and pumping in the Mana Plain for uses currently served by water from the Kokee and Kekaha Ditch Irrigation Systems.

RESPONSE:

The KAA is aware of the following information regarding the past, current, or future potential for use of groundwater resources and pumping in the Mana Plain for uses currently served by water from the Kokee and Kekaha systems:

According to the "Kekaha Sugar Infrastructure Study" (2000) prepared by the State of Hawaii Department of Land and Natural Resources, between about 1890 and 1906, 44 groundwater wells were drilled into the Basal aquifer beneath the Mana Plain. Nine more wells were drilled in 1929 and 1930. As the quality of water from these 53 deep wells deteriorated, six (6) shaft-type wells were constructed on the inland edge of the plain between 1930 and 1957. Most of these 59 wells and shafts are now either lost or sealed.

The remaining five wells (including one that is currently inactive) and four shafts are listed below:

- Mana wells [2-0145-010, -012, -013] and Mana well [2-0145-016] developed 1901 (as part of a battery of 15 wells)
- Kaunalewa 12 [2-0144-010 inactive] developed 1890?
- Saki Mana shaft [2-0345-004] developed 1957
- Kaunalewa shaft [2-0044-015] developed 1957
- Waiawa [2-5943-001] developed 1935
- Huluhulunui shaft [2-5842-003] developed 1948

KAA reports monthly groundwater use to the Commission for the eight active wells and shafts.

The locations of these features are depicted on "Kekaha Ditch: Kekaha – Mana Infrastructure," attached as Exhibit H.

Finally, with regard to potential future uses, it is noted that the Commission estimates the sustainable yield of the Kekaha Aquifer (20301) to be 10 MGD.[13] The current pumpage of 1.48 MGD is 14.97 percent of the sustainable yield.[14]

KAA and its members hereby incorporate into this response the objections set forth in the "General Objections" accompanying this response.

---

[13] Source: http://files.hawaii.gov/dlnr/cwrm/maps/gwhu_kauai.pdf.

[14] Staff submittal D1 (Exhibit 1, Table 6) for the June 24, 2015 meeting of the Commission on Water Resource Management.

CWRM-IR-15

15. Any other information that would be helpful to determine whether or not the water in the Kokee and Kekaha Ditch Irrigation Systems is being put to reasonable-beneficial use.

RESPONSE:

As explained in response to CWRM-IR-1, the available facts and information strongly support the conclusion that use of the Kekaha and Kokee systems for purpose of the irrigation, drainage and electrical power infrastructure on the ADC Land is a reasonable and beneficial use.

Use of the Kekaha and Kokee systems to supply water to the irrigation infrastructure for agricultural and other uses is a reasonable and beneficial use. This water provides irrigation water for agricultural activities by KAA members BASF, Pioneer, Syngenta, and Wines of Kauai, and the other licensees; irrigation water for agricultural activities by kuleana and Menehune ditch system users farming taro; irrigation water for use by DHHL and its beneficiaries; water for use by DLNR for recreational fishing and for public sanitation benefiting tourism; and water for use by the County of Kauai to operate its Kekaha landfill, all for the public benefit.

The drainage and electrical power infrastructure make agricultural activities by KAA members and others possible on the Mana Plain by maintaining the groundwater table below the plant root zone. This is a reasonable and beneficial use.

The drainage and electrical power infrastructure also provide flood protection services to government, residential and commercial interests in the Kekaha area. This is also a reasonable and beneficial use.

The electrical power infrastructure also supports agriculture and aquaculture on the ADC Land by supplying electricity to Sunrise to sustain its aquaculture operations and to power to irrigation pumps which pump water through the irrigation infrastructure to supply fields farmed by KAA members BASF, Syngenta and Pioneer and the other licensees – all of which are reasonable and beneficial uses.

KAA has maintained these important reasonable and beneficial uses with far less water than historically used by the Kekaha Sugar Company. The KAA agricultural infrastructure requires approximately 21 MGD to maintain these uses. Hydroelectric power generation is a non-consumptive use of the Kekaha system water. After generating hydroelectric power at the Waiawa facility, water flows from to down-ditch users of irrigation water on the Mana Plain, including KAA members and the other licensees. The power is used to lower the water table for farming and to protect the military and the local community from flooding.

GENERAL OBJECTIONS

Each and every response to the foregoing Information Requests are subject to the objections set forth below.

1. Kekaha Agriculture Association ("KAA"), BASF Plant Science LP ("BASF"), Pioneer Hi-Bred International, Inc. ("Pioneer"), Sunrise Capital, Inc. ("Sunrise"), Syngenta Hawaii, LLC ("Syngenta"), and Wines of Kauai, L.L.C. ("Wines of Kauai"), object to each Information Request to the extent that it seeks information or documents containing trade secrets, and proprietary commercial and/or financial information, on the grounds that the information or documents are subject to a Non-Disclosure Agreement, the disclosure of such proprietary commercial and financial information on a public basis or to entities engaged in competing businesses could adversely impact BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai's transactions with customers, adversely impact BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai's costs of doing business, and result in higher costs to customers, and the uncontrolled disclosure of proprietary information would give providers of competitive services information useful in making their own marketing decisions, without expending the time and money necessary to gather and develop the data, and would allow providers of competitive services to profit or otherwise derive benefits at the expense of BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai and their customers.

2. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent it purports to expand the obligations of KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai beyond the legal authority of the State of Hawaii Commission on Water Resource Management ("Commission").

3. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it seeks information that is protected from disclosure by the attorney-client privilege, and/or to the extent the request seeks information that reflects the mental impressions, conclusions, opinions, or legal theories of the KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai and their attorneys, which is also protected from disclosure by the attorney work product doctrine.

5. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it seeks information or documents within the sole knowledge or possession of other parties in this proceeding.

6. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it seeks information or documents that are beyond the scope of the issues in this proceeding.

7. BASF, Pioneer, and Syngenta are large corporations with employees located in many different locations. These documents are kept in numerous locations and frequently are moved from site to site as employees change jobs or as the business is reorganized. Therefore, it is possible that not every relevant document may have been consulted in developing BASF, Pioneer, and Syngenta's responses. Rather, these responses provide information that BASF, Pioneer, and Syngenta obtained after a reasonable and diligent search conducted in connection

with this Information Request. To the extent that the Information Request proposes to require more, BASF, Pioneer, and Syngenta object on the grounds that compliance would impose an undue burden or expense on BASF, Pioneer, and Syngenta.

8. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request seeking all documents and other information relating to a particular subject, unless otherwise noted in the response on the grounds that such requests generally are overly broad and unduly burdensome.

9. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it is vague, ambiguous, overly broad, imprecise, or utilizes terms that are subject to multiple interpretations but are not properly defined or explained for purposes of such information requests.

10. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it is unlimited in time or not limited to the time frame relevant to this proceeding.

11. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it seeks information that is not relevant to the subject matter of this docket and is not reasonably calculated to lead to the discovery of admissible evidence.

12. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it seeks documents not within the present possession, custody, or control of KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai, their agents, employees, representatives, and attorneys, or purports to expand the obligations of KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai beyond the permissible scope of discovery in this proceeding.

13. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request to the extent that it seeks documents or information easily available because it is already on file with the Commission or otherwise part of the public record.

14. BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request that seeks information regarding KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai's confidential security measures designed and implemented to protect KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai's assets, including but not limited to measures associated with physical security.

15. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request that asks KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai to make computations, compute ratios, reclassify, trend, calculate, or otherwise rework data contained in its files or records.

16. KAA, BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai expressly reserve and do not waive any and all objections they may have to the admissibility, authenticity or relevancy of the information provided in its responses.

17. In the event any document or information within the scope of any privilege or objection is disclosed, its disclosure is inadvertent and shall not constitute a waiver of the privilege or objection.

18. BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai object to each Information Request seeking internal communications, audit and/or management reports that reveal internal deliberations, analyses, appraisals and recommendations regarding the adequacy and effectiveness of the organization's system of internal controls, risk management practices, corporate governance, and/or BASF, Pioneer, Sunrise, Syngenta and Wines of Kauai's potential rights, remedies and strategies on public policy grounds.

BASF'S RESPONSE TO CWRM-IR-1

In response to the Commission's Information Request No. 1 ("CWRM-IR-1") to KAA and ADC, BASF has undertaken a review of its business records for the years 2010 through 2014, and is working to develop an estimate of BASF's water use from the Kekaha system during the years 2010 through 2014. As noted in KAA's response to CWRM-IR-1, actual water use is not metered by KAA or BASF. BASF has been working diligently to produce an accurate estimate of its historical water use in Kekaha but requires, and respectfully requests, a short extension of time in which to answer the Commission's Information Request. BASF expects to be in a position to provide such an estimate no later than Friday, July 17.

PIONEER HI-BRED'S RESPONSE TO CWRM-IR-1

Pioneer provides the following estimates of its water use for calendar years 2010, 2011 and 2012 for its farming operations on fields that Pioneer leases from the ADC on Kauai. Pioneer cultivated corn on these fields during these years. Pioneer is not providing estimates of water use for calendar years 2013 and 2014 because Pioneer's water use during these years in the Kekaha area was atypical. Estimates for these years would yield skewed results, thus they are not reasonably calculated to lead to the discovery of admissible evidence. Pioneer is committed to conserving water resources to the extent practicable. To that end, Pioneer utilizes low flow drip irrigation to ensure that water is not wasted.

As to Pioneer's water use estimates for 2010, 2011 and 2012, Pioneer stresses that Pioneer's water is not metered, and the numbers provided are estimates. Although they are based on business records and assumptions Pioneer uses in planning its farming operations, the estimates can deviate substantially from actual water use due to unpredictable circumstances such as the amount, intensity or seasonality of rainfall, pest infestations and other environmental conditions, market factors and regulatory developments. By providing these estimates, Pioneer does not concede their relevance or that the estimates can be used as a predictive tool. Actual water use may be substantially greater or substantially less than the estimated amounts. The estimates apply only to water used for irrigation. Water use for other farming-related needs, such as dust control, are not included. To the extent a response to this Interrogatory requires the disclosure of confidential business information, Pioneer objects to such disclosure and reserves all rights to the protection afforded to confidential business information under Hawai'i law.

Pioneer objects to any use of the estimates it is providing to predict future water usage by Pioneer. The seed products and acreage planted by Pioneer can and frequently does vary from year to year. The watering season for different products can vary in length. Cover crop requirements for fallow fields vary from time to time due to environmental reasons as well as requirements imposed by regulators and/or the ADC. Pioneer's water use for its seed farming operations as presently conducted on Kauai is highly dynamic for business, climatic, regulatory and other reasons.

Pioneer further objects to any use of the estimates it is providing to predict future water usage by any other person or entity who farms the acreage Pioneer presently leases from the ADC. Seed farming is a highly specialized agricultural use that requires field separation and other farming practices that are different from or not applied at all by other farming operations. Pioneer may, in the future, sublease or release fields whose water use is reflected in the 2010, 2011 and 2012 estimates. Pioneer's water use estimates for 2010, 2011 and 2012 have no bearing on water use by farmers of other crops who may farm these same fields in the future. The crops farmed by Pioneer during the period of inquiry on the fields leased from the ADC (corn and a variety of cover crops) use far less water than other crops that could be cultivated on these fields. Diversified agriculture is a core value protected by Hawai'i's constitution (*see* Haw. Const. art. XI, § 3: "[t]he State shall conserve and protect agricultural lands, promote diversified agriculture," and "assure the availability of agriculturally suitable lands") and is a fundamental goal of the ADC. Thus, technically and legally, the water estimates provided herein are irrelevant to issues raised by Complainants in this proceeding.

Subject to and without waiving these objections and qualifications, Pioneer provides the following table containing and explaining Pioneer's estimates of its yearly water use on fields leased from the ADC on Kauai for 2010, 2011 and 2012. As Pioneer's analysis is ongoing, it reserves the right to amend and/or supplement this response.

Pioneer Hi-Bred
Kekaha Water Use Estimates

General water use calculation :

CROP WATER NEEDS:
Using low flow drip irrigation Pioneer applies 0.16 inches of water per hour.
Corn is irrigated for about 81.0 hours to complete a crop.
There are 27,154 gallons in an acre inch of water.

(81.0 hours) X (0.16 inch) = (12.96 inches of water required per crop)
(27,154 gallons/acre inch) X (12.96 inches) = (351,915.84 gallons/acre)
(351,915.84 gallons/acre/day) / (average 88 days to grow crop) = (3,999.04 gallons /day)

crop planted needs an estimated 3,999.04 gallons / day

Pioneer Hi-Bred
Kekaha Water Use Estimates

2010

lease farmable acres	estimated gallons / acre / day	estimated water use of cover crop per acre assuming a 2week irrigation cycle to establish cover crop
1,400.00	3,999.04	67,183.87

month	days / month	acres of crop growing in field per month	estimated water use/day for crop	estimated water use/month for crop	estimated acres of cover crop growing in field	estimated water use of cover crop per month
Jan	31	269.54	1,077,901.24	33,414,938.49	1,130.46	75,948,679.94
Feb	28	329.67	1,318,363.52	36,914,178.47	1,070.33	
Mar	31	263.88	1,055,266.68	32,713,266.93	65.79	4,420,026.94
Apr	30	232.50	929,776.80	27,893,304.00	31.38	2,108,229.90
May	31	101.00	403,903.04	12,520,994.24	131.50	8,834,679.17
Jun	30	60.13	240,462.28	7,213,868.26	40.87	2,745,804.85
Jul	31		0.00	0.00	1,400.00	94,057,420.80
Aug	31		0.00	0.00	1,400.00	
Sept	30	5.17	20,675.04	620,251.10	5.17	347,340.62
Oct	31	64.49	257,898.09	7,994,840.78	59.32	3,985,347.29
Nov	30	153.70	614,652.45	18,439,573.44	89.21	5,993,473.22
Dec	31	305.73	1,222,626.50	37,901,421.48	152.03	10,213,964.06

2010 estimated crop planting (acres)	2010 estimated annual water use for crop (gallons)	2010 estimated annual water use for cover (gallons)	2010 estimated total water use for crop area (gallons)
405.10	215,626,637.18	208,654,966.79	424,281,603.97

Pioneer Hi-Bred
Kekaha Water Use Estimates

2011

lease farmable acres	estimated gallons / acre / day	estimated water use of cover crop per acre assuming a 2week irrigation cycle to establish cover crop
1,400.00	3,999.04	67,183.87

month	days / month	acres of crop growing in field per month	estimated water use/day for crop	estimated water use/month for crop	estimated acres of cover crop growing in field	estimated water use of cover crop per month
Jan	31	356.32	1,424,937.93	44,173,075.92	1,043.68	70,118,463.53
Feb	28	370.67	1,482,324.16	41,505,076.39	1,029.33	
Mar	31	364.29	1,456,810.28	45,161,118.73	6.38	428,633.10
Apr	30	285.49	1,141,685.93	34,250,577.89	78.80	5,294,089.11
May	31	133.46	533,711.88	16,545,068.23	152.03	10,213,964.06
Jun	30	63.35	253,339.18	7,600,175.52	70.11	4,710,261.27
Jul	31	10.41	41,630.01	1,290,530.20	1,389.59	93,358,036.69
Aug	31		0.00	0.00	1,400.00	
Sept	30		0.00	0.00	0.00	0.00
Oct	31	24.30	97,176.67	3,012,476.83	24.30	1,632,568.09
Nov	30	95.97	383,787.87	11,513,636.06	71.67	4,815,068.11
Dec	31	179.88	719,347.32	22,299,766.77	83.91	5,637,398.70

2011 estimated crop planting (acres)	2011 estimated annual water use for crop (gallons)	2011 estimated annual water use for cover (gallons)	2011 estimated total water use for crop area (gallons)
246.37	227,351,502.54	196,208,482.66	423,559,985.20

Pioneer Hi-Bred
Kekaha Water Use Estimates

2012

		lease farmable acres	estimated gallons / acre / day			estimated water use of cover crop per acre assuming a 2week irrigation cycle to establish cover crop
		1,400.00	3,999.04			67,183.87
month	days / month	acres of crop growing in field per month	estimated water use/day for crop	estimated water use/month for crop	estimated acres of cover crop growing in field	estimated water use of cover crop per month
Jan	31	258.93	1,035,471.43	32,099,614.24	1,141.07	76,661,500.82
Feb	29	266.13	1,064,264.52	30,863,670.94	1,133.87	
Mar	31	241.83	967,087.84	29,979,723.14	24.30	1,632,568.09
Apr	30	170.16	680,476.65	20,414,299.39	71.67	4,815,068.11
May	31	86.25	344,917.20	10,692,433.20	83.91	5,637,398.70
Jun	30		0.00	0.00	86.25	5,794,608.96
Jul	31		0.00	0.00	1,400.00	94,057,420.80
Aug	31		0.00	0.00	1,400.00	
Sept	30	11.28	45,109.17	1,353,275.14	11.28	757,834.08
Oct	31	123.87	495,361.08	15,356,193.63	112.59	7,564,232.15
Nov	30	202.63	810,325.48	24,309,764.26	78.76	5,291,401.76
Dec	31	257.50	1,029,752.80	31,922,336.80	54.87	3,686,379.06

2012 estimated crop planting (acres)	2012 estimated annual water use for crop (gallons)	2012 estimated annual water use for cover (gallons)	2012 estimated total water use for crop area (gallons)
343.77	196,991,310.74	205,898,412.52	402,889,723.25

Exhibit B

SYNGENTA'S RESPONSE TO CWRM-IR-1

In response to the Commission's Information Request No. 1 ("CWRM-IR-1") to KAA and ADC, Syngenta has undertaken a review of its business records for the years 2010 through 2014, and is working to develop an estimate of Syngenta's water use from the Kekaha system during the years 2010 through 2014. As noted in KAA's response to CWRM-IR-1, actual water use is not metered by KAA or Syngenta. Syngenta has been working diligently to produce an accurate estimate of its historical water use in Kekaha but requires, and respectfully requests, a short extension of time in which to answer the Commission's Information Request. Syngenta expects to be in a position to provide such an estimate no later than Friday, July 17.

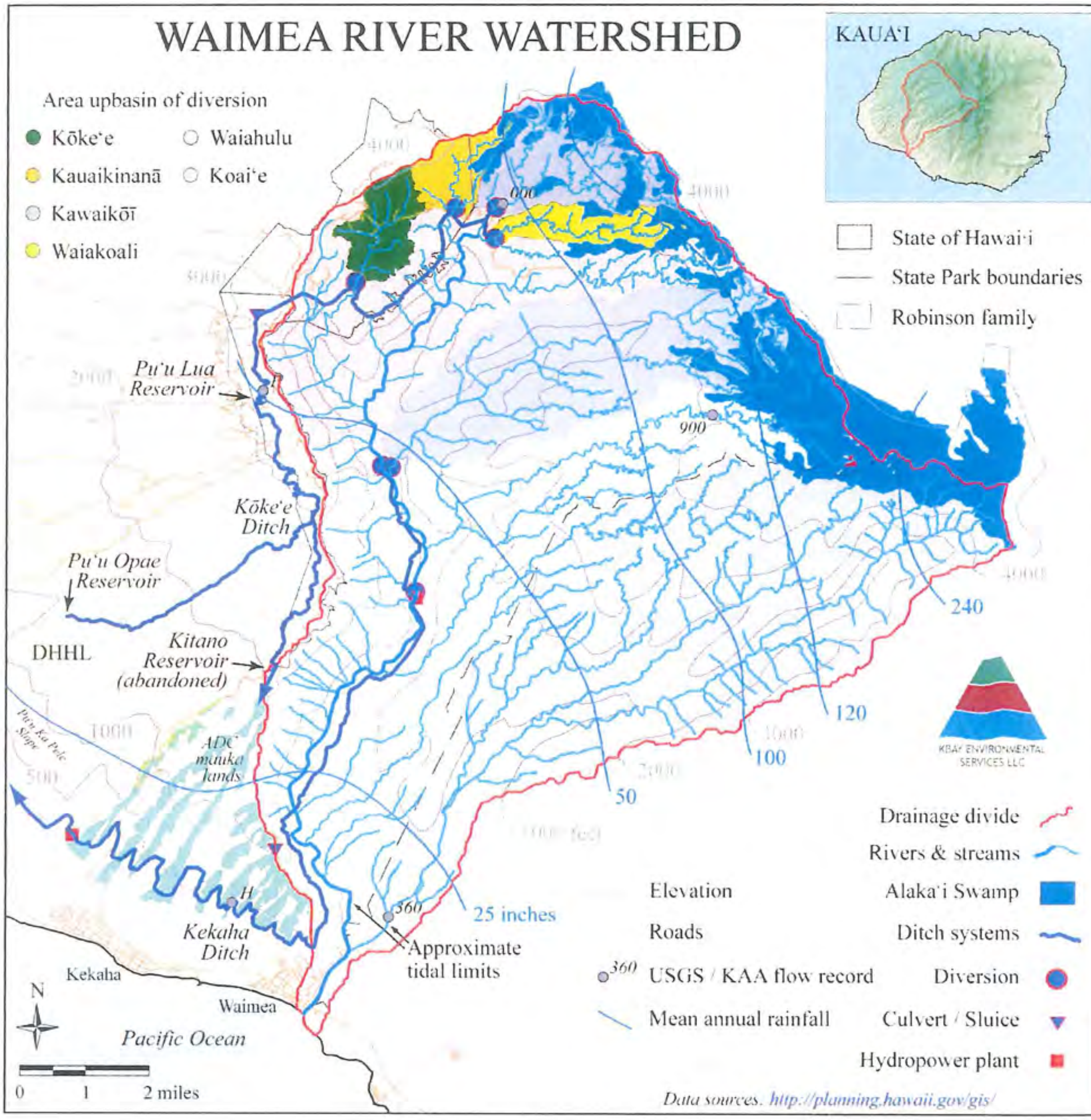
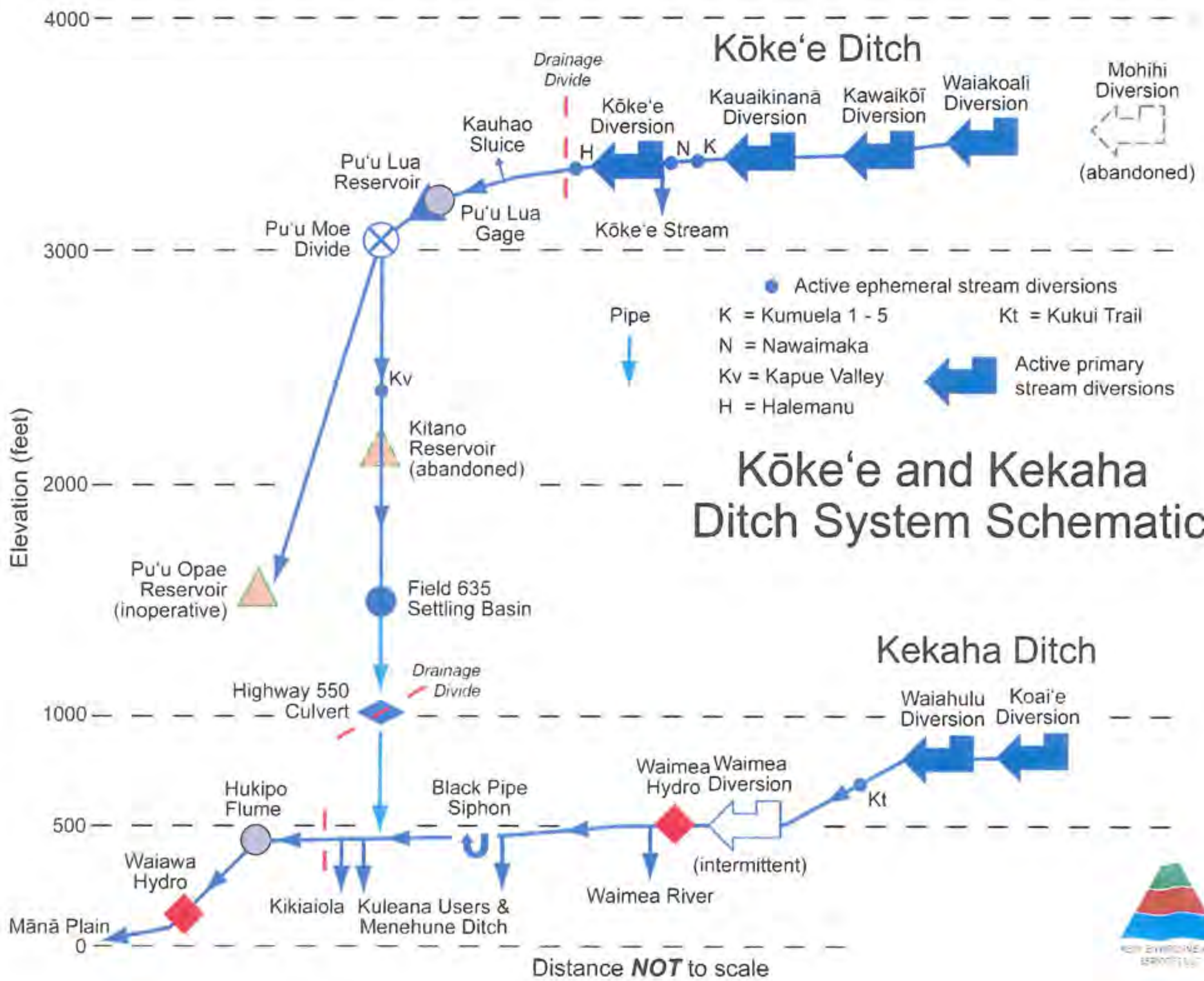
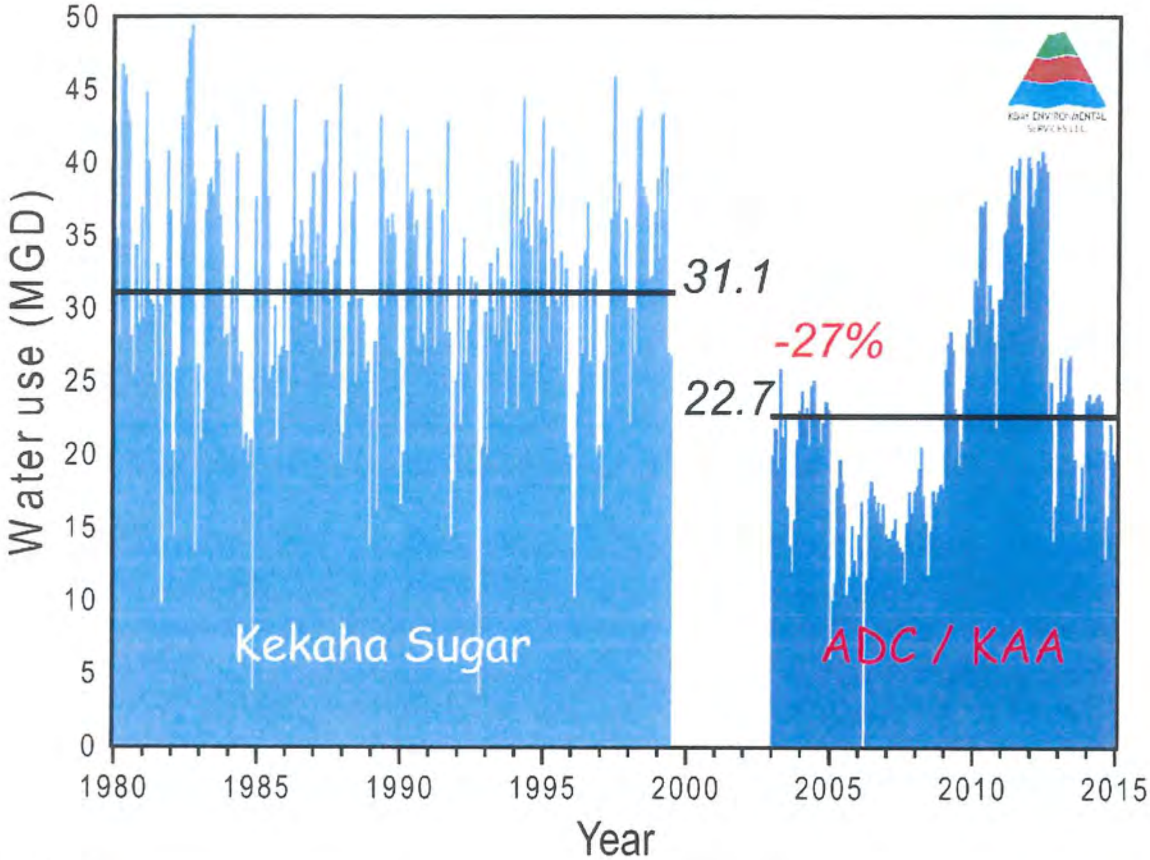

WAIMEA RIVER WATERSHED
Area upbasin of diversion
Kōke'e
Waiahulu
Kauaikinanā
Koai'e
Kawaikōī
Waiakoali
KAUA'I
State of Hawai'i
State Park boundaries
Robinson family
Pu'u Lua Reservoir
Kōke'e Ditch
Pu'u Opae Reservoir
DHHL
Kitano Reservoir (abandoned)
ADC mauka lands
Kekaha Ditch
Kekaha
Waimea
Pacific Ocean
N
0
1
2 miles
Approximate tidal limits
25 inches
50
100
120
240
900
360
Drainage divide
Rivers & streams
Elevation
Alaka'i Swamp
Roads
Ditch systems
USGS / KAA flow record
Diversion
Mean annual rainfall
Culvert / Sluice
Hydropower plant
Data sources. http://planning.hawaii.gov/gis/

Exhibit D


Kōke'e Ditch
Drainage Divide
Kōke'e Diversion
Kauaikinanā Diversion
Kawaikōī Diversion
Waiakoali Diversion
Mohihi Diversion
(abandoned)
Kauhao Sluice
H
N K
Pu'u Lua Reservoir
Pu'u Lua Gage
Kōke'e Stream
Pu'u Moe Divide
Active ephemeral stream diversions
Pipe
K = Kumuela 1 - 5
Kt = Kukui Trail
N = Nawaimaka
Kv = Kapue Valley
H = Halemanu
Active primary stream diversions
Kv
Kitano Reservoir (abandoned)
Kōke'e and Kekaha Ditch System Schematic
Pu'u Opae Reservoir (inoperative)
Field 635 Settling Basin
Kekaha Ditch
Drainage Divide
Highway 550 Culvert
Waiahulu Diversion
Koai'e Diversion
Waimea Hydro
Waimea Diversion
Kt
Hukipo Flume
Black Pipe Siphon
(intermittent)
Waiawa Hydro
Kikiaiola
Kuleana Users & Menehune Ditch
Waimea River
Mānā Plain
4000
3000
2000
1000
500
0
Elevation (feet)
Distance NOT to scale


50
45
40
35
30
25
20
15
10
5
0
Water use (MGD)
31.1
-27%
22.7
Kekaha Sugar
ADC / KAA
1980
1985
1990
1995
2000
2005
2010
2015
Year

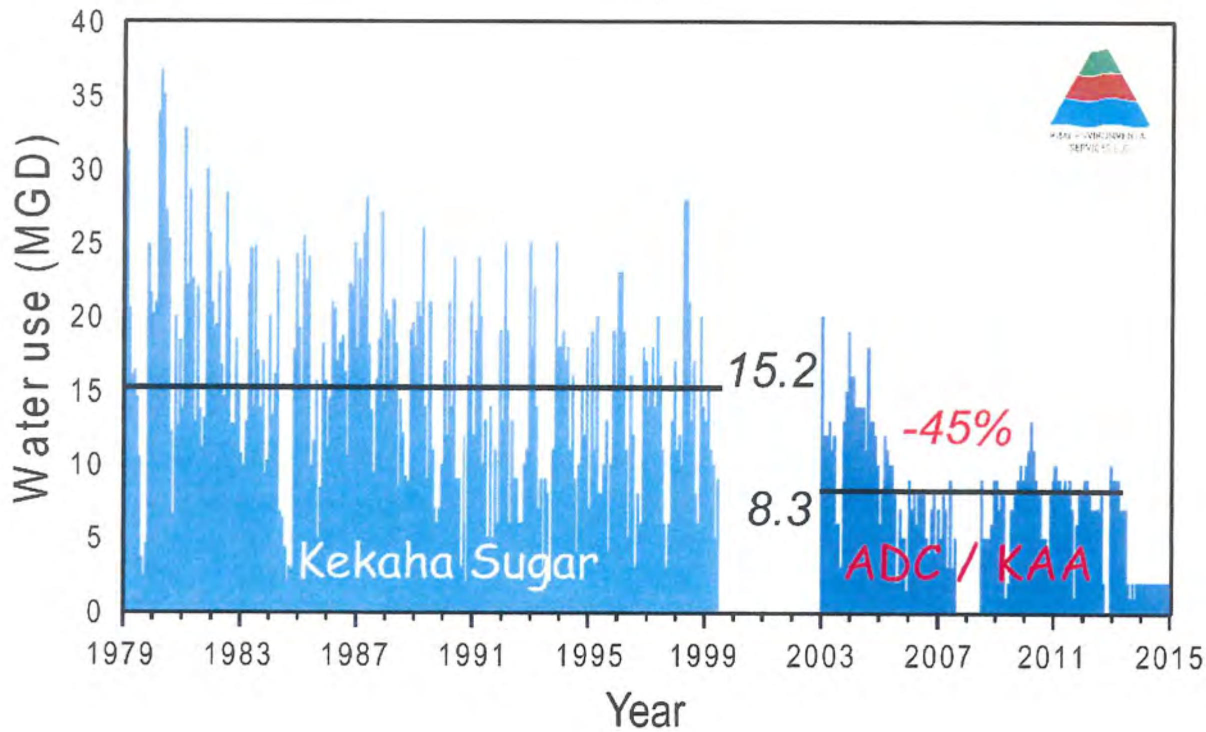

40
35
30
25
20
15
10
5
0
Water use (MGD)
15.2
-45%
8.3
Kekaha Sugar
ADC / KAA
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
Year

Exhibit F

		Waiawa (kWh)	Average (MGD)	Waimea (kWh)	Average (MGD)	Total Produced (kWh)
2010	Jan	254,880	18.7	297,530	21.7	552,410
	Feb	292,401	17.8	207,629	18.4	500,030
	Mar	270,288	20.7	540,825	31.9	811,113
	Apr	287,959	20.9	448,460	30.4	737,419
	May	294,541	20.8	408,302	24.2	702,843
	June	160,881	15.0	*151,030*	16.8	*311,911*
	July	226,868	17.7	284,413	27.1	511,281
	Aug	190,051	17.2	271,522	21.3	461,603
	Sept	187,560	17.3	247,522	19.3	435,082
	Oct	128,999	12.6	124,315	15.8	253,314
	Nov	167,140	20.4	217,952	19.7	385,092
	Dec	58,051	16.7	360,065	23.5	418,116
2011	Jan	304,936	21.8	407,905	28.5	712,841
	Feb	291,561	22.4	422,075	31.9	713,636
	Mar	328,568	22.3	415,158	29.0	743,726
	Apr	350,076	22.9	486,993	30.7	837,069
	May	289,013	23.7	430,149	29.0	719,162
	June	337,950	22.8	440,983	29.5	778,933
	July	264,930	20.5	428,089	27.7	693,019
	Aug	217,420	18.7	244,997	23.6	462,417
	Sept	107,841	18.1	196,486	18.2	304,327
	Oct	237,502	18.3	206,786	19.8	444,288
	Nov	325,558	21.7	423,061	28.6	748,619
	Dec	326,990	22.9	467,804	32.3	794,794
2012	Jan	281,970	21.9	262,966	24.1	544,936
	Feb	334,350	23.0	389,280	28.0	723,630
	Mar	351,295	23.2	342,126	31.5	693,421
	Apr	324,675	22.9	421,063	30.9	745,738
	May	325,869	21.5	378,075	26.3	703,944
	June	250,311	18.9	286,955	22.3	537,266
	July	226,024	17.9	275,559	23.3	501,583
	Aug	88,643	16.6	149,880	19.4	238,523
	Sept	237,127	18.7	314,746	23.9	551,873
	Oct	106,110	12.0	79,901	14.7	186,011
	Nov	124,486	12.4	79,061	13.9	203,547
	Dec	241,669	18.7	309,876	22.9	551,545

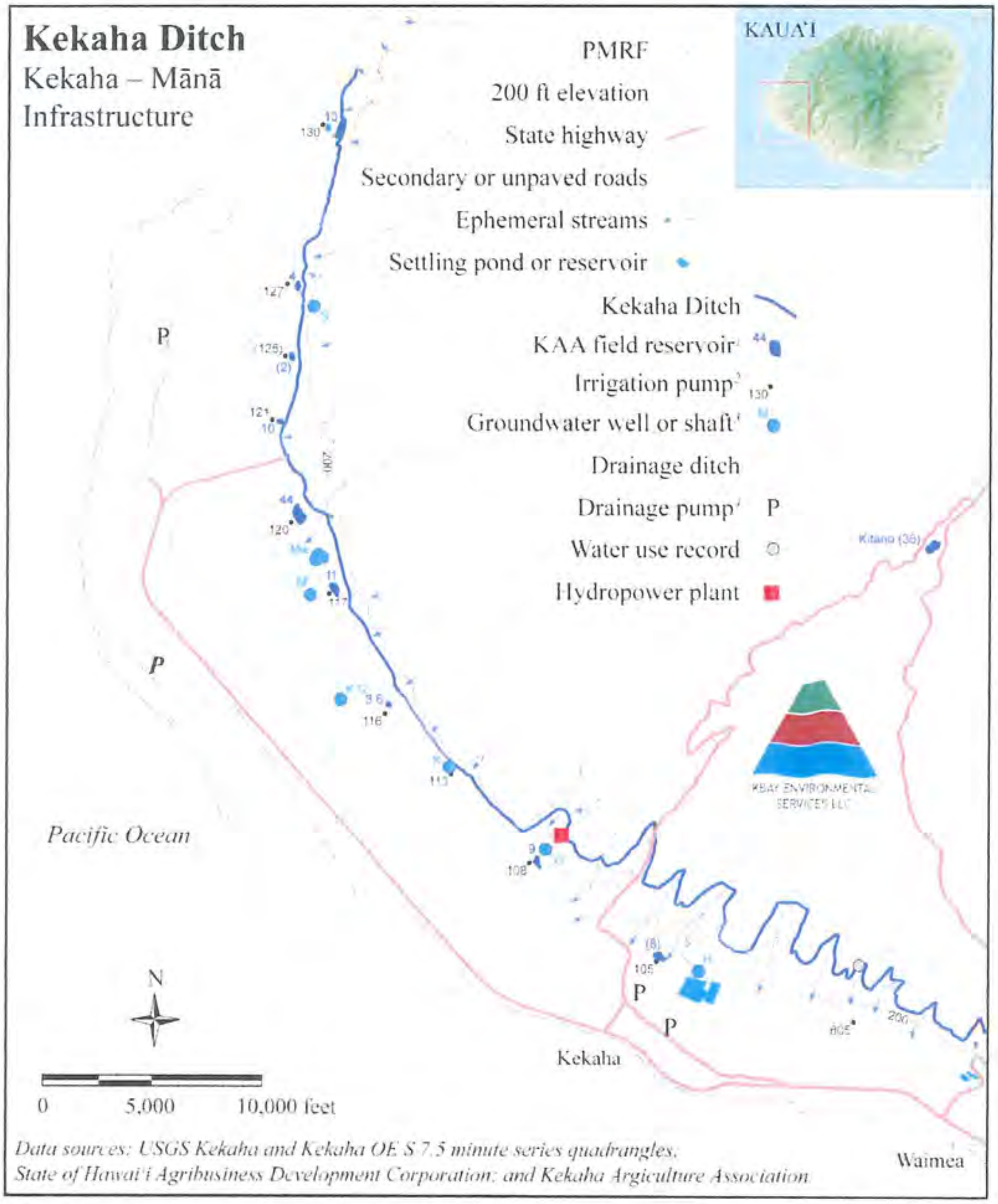
Kekaha Agriculture Association Hydropower Production, 2010 – 2014

KBAY ENVIRONMENTAL SERVICES LLC

		Waiawa (kWh)	Average (MGD)	Waimea (kWh)	Average (MGD)	Total Produced (kWh)
2013	Jan	303,729	20.7	376,706	27.8	680,435
	Feb	253,591	20.1	323,538	26.0	577,129
	Mar	269,800	19.9	354,266	26.2	624,066
	Apr	280,125	20.7	332,062	26.7	612,187
	May	314,145	21.5	423,771	29.6	737,916
	June	274,161	19.2	281,176	22.3	555,337
	July	207,029	17.5	197,072	19.9	404,101
	Aug	175,185	14.7	199,938	17.1	375,123
	Sept	152,060	14.1	121,854	17.6	273,914
	Oct	111,600	14.4	79,901	13.9	191,501
	Nov	*180,752*	15.8	152,178	20.0	*332,930*
	Dec	280,395	20.7	407,902	28.2	688,297
2014	Jan	313,313	21.1	418,960	31.0	732,273
	Feb	291,416	21.2	*500,128*	33.3	*791,544*
	Mar	311,805	21.5	*472,506*	32.0	*784,311*
	Apr	320,485	20.7	*431,367*	30.1	*751,852*
	May	237,487	20.3	*366,943*	27.0	*604,430*
	June	266,379	20.5	*365,986*	27.0	*632,365*
	July	253,295	18.7	*232,472*	20.6	*485,767*
	Aug	147,458	13.8	*212,895*	19.7	*360,353*
	Sept	126,113	12.8	*208,595*	19.5	*334,708*
	Oct	175,230	17.1	*362,193*	26.8	*537,423*
	Nov	154,696	16.7	*331,803*	25.3	*486,499*
	Dec	165,758	17.0	*317,336*	24.7	*483,094*

Kekaha Agriculture Association Hydropower Production, 2010 – 2014 (continued)

Notes: kWh are monthly metered totals. Average (MGD) is the monthly average of the daily noon readings made at each power plant. Italics indicate estimated values for power production (Waiawa, Nov 2013, and Waimea, June 2010 and February through December 2014) derived from the relations between the average flow and total monthly power production (Waiawa R^2 = 0.90; Waimea $R^2 = 0.88$).



[1] Number indicates orginal capacity [MG] and parentheses reservoir is no longer in use.
[2] Number indicates field location and parentheses pumps no longer in use: 130, 2 @ 40 hp = 2000 gpm; 127, 3 @ 40 hp = 3000 gmp; (125, 2 @ 40 hp = 2000 gpm); 121, 3 @ 40 hp = 3000 gpm; 120, 3 @ 40 hp = 3000 gpm; 117, 3 @ 40 hp = 3000 gpm; 116, 2 @ 40 hp = 2000 gpm; 113 [shaft 2-0044-015], 2 @ 40 hp VDF = 900 gpm; 108, 2 @ 50 hp VDF = 3800 gpm; 105 [shaft 2-5842-003], 2 @ 60 hp VDF = 3500 gpm; 805, gravity = 1000 gpm.
[3] Groundwater wells: Mw = Mānā wells [2-0145-010, -012, -013]; M = Mānā well [2-0145-016]; K12 = Kaunalewa 12 [2-0144-010 *inactive*].
Groundwater shafts: S = Saki Mānā [2-0345-004]; K = Kaunalewa [2-0044-015]; W = Waiawa [2-5943-001]; Huluhulunui [2-5842-003].
[4] Bold italic type indicates Kawaiele pumps: 2 @ 200 hp = 56000 gpm; 100 hp = 14000 gpm.

Exhibit H

Field	Number of pumps	Pump output (hp)	Combined flow rate (gpm)	Owner/User
105	2[1]	60	3500	BASF, Pioneer
108	2	50	3800	BASF, Pioneer, Syngenta
113	2[2]	40	900	Pioneer
116	2	40	2000	BASF, Syngenta
117	3	40	3000	Syngenta
120	3	40	3000	Syngenta
121	3	40	3000	BASF
125	2	40	2000	None
127	3	40	3000	Syngenta
130	2	40	2000	Syngenta
805	Gravity	–	1000	Syngenta

Kekaha Agriculture Association Irrigation Pump Specifications

[1] Water source: Huluhulunui shaft [2-5842-003]
[2] Water source: Kaunalewa shaft [2-0044-015]

KBAY ENVIRONMENTAL SERVICES LLC

SCHLACK ITO
A LIMITED LIABILITY LAW COMPANY

Douglas A. Codiga
Attorney at Law

DIRECT 808.523.6047
dcodiga@schlackito.com

MAIN 808.523.6040
FAX 808.523.6030

Topa Financial Center
745 Fort Street • Suite 1500
Honolulu, Hawaii 96813

July 17, 2015

VIA ELECTRONIC MAIL AND U.S. MAIL
The Honorable Chair and Commissioners
State of Hawaii Commission on Water Resource Management
Kalanimoku Building
1151 Punchbowl Street, Room 227
Honolulu, HI 96813

Re: Po'ai Wai Ola Petitions and Complaint filed July 24, 2013
Supplemental Responses to Commission's May 11, 2015 Letter

Dear Chair and Commissioners:

On behalf of the Kekaha Agriculture Association ("KAA"), this is to provide supplemental responses to the Commission's May 11, 2015 Information Request No. 1. As you are aware, KAA filed a response to this Information Request on July 10, 2015. Exhibits A and C were generated by KAA members BASF Plant Science, LP ("BASF") and Syngenta Hawaii, LLC ("Syngenta"), respectively. Both stated supplemental responses would be forthcoming by July 17, 2015. Accordingly, the supplemental responses of BASF and Syngenta to this Information Request are enclosed.

Thank you for your attention to the foregoing. Should there be any questions please do not hesitate to contact the undersigned.

Very truly yours,

SCHLACK ITO
A LIMITED LIABILITY LAW COMPANY

Douglas A. Codiga

DAC:mpm

Copy via U.S. Mail and Electronic Mail:

Myra Kaichi, Esq., Department of the Attorney General
William Aila and Kaleo Manuel, Department of Hawaiian Home Lands
David Henkin, Esq. and Isaac Moriwake, Esq., Earthjustice for Petitioners Po'ai Wai Ola
David Bissell, Kauai Island Utility Cooperative
Yvonne Izu, Esq., Attorney for Kauai Island Utility Cooperative
Jason Hines and Dawn Huff, Joule Group, for Kauai Island Utility Cooperative
Mayor Bernard Carvalho, County of Kauai
Mauna Kea Trask, Esq., County of Kauai
Steve Spengler, Element Environmental, LLC

BASF's Supplemental Response to CWRM-IR-1

This supplements BASF's July 10, 2015 response (Exhibit A) to the Commission's Information Request No. 1 issued on May 11, 2015. In addition to the objections set forth on BASF's behalf in Section II.A.2 of the response to this request, all of which are incorporated herein by reference, BASF respectfully objects to the extent that this request does not take into account and consider the fact that water use estimates can deviate substantially from actual water use due to further unpredictable circumstances that include but are not limited to the amount, intensity, or seasonality of rainfall, pest infestations and other environmental conditions, and regulatory developments. Subject to and without waiving these objections, Exhibits A-1 through A-4 provide BASF's estimate of its average annual water use during the crop years 2009/2010, 2010/2011, 2011/2012, 2012/2013, and 2013/2014.[1] BASF reserves the right to amend and/or supplement this response if revised information becomes available.

During the relevant crop years, BASF cultivated corn, soy, sunflower, canola, and rice, as well as cover crops, on the fields that are licensed by BASF from the ADC and that receive water from the Kekaha system.[2] Corn, soy, sunflower, and canola all have similar irrigation requirements; therefore, those crops are grouped together for purposes of generating an average annual water use estimate in Exhibit A-1. Rice, with its unique irrigation requirements, is treated

---

[1] BASF's business records track the cultivation of crops on the fields licensed by BASF from the ADC on the basis of crop years that run from October 1 through September 30, not on the basis of calendar years. Because any estimate of water use in those fields is dependent on the cultivation of crops in the fields – and because complete information for the 2014/2015 crop year is not yet available, BASF's response herein estimates water use during the crop years set forth above.

[2] A sublicensee also cultivated ginger and sweet potatoes on the BASF fields during the 2013/2014 crop year. However, BASF does not have sufficient information to generate a water use estimate for that sublicensee.

separately in Exhibit A-2. Other activities that use water are volunteering[3] and cover crop irrigation; estimates for those uses are set forth in Exhibit A-1 through A-3. Exhibit A-4 provides an overall estimate of BASF's average annual water use by totaling the results set forth on Exhibit A-1 through A-3.

[3] Volunteering consists of applying water to a field after harvest in an attempt to germinate any seeds from the previous crop that may have fallen to the ground. After any such seeds have germinated and grown for some time, they are tilled under, with the application of water continuing until no more volunteer plants emerge.

Supplemental Exhibit A-1

Corn, Soy, Sunflower, and Canola

BASF is committed to conserving water resources to the extent practicable and, to that end, uses low-flow irrigation on its corn, soy, sunflower, and canola crops. The low-flow irrigation system consists of drip tape with emitters spaced at nine (9) inch intervals. Given that an acre of drip tape consists of 209,088 inches, there are 23,232 emitters per acre. Each emitter applies water at a rate of 0.16 gallons/hour, such that, on a per-acre basis, the application rate is 3,717.12 gallons/acre/hour. Because BASF applies water to these crops twice a week for six (6) hours each time, 44,606 gallons of water are applied per acre per week.[4] Corn, soy, sunflower, and canola all grow for approximately 16 weeks, such that 713,696 gallons of water are required per acre during each 16-week crop cycle. BASF cultivated an average total of 106 acres of corn, soy, sunflower, and canola during the 2009/2010, 2010/2011, 2011/2012, 2012/2013, and 2013/2014 crop years, yielding an irrigation requirement of 75,651,776 gallons during the crop cycle.[5] As a practical matter, however, drip tape extends five (5) to ten (10) feet beyond the end of each field, which results in an area receiving water that is approximately 2.5% larger than the cropped area. Therefore, it is reasonable and appropriate to increase the above-stated estimate by 2.5% to **77,543,070.4 gallons during the crop cycle**.

As indicated, the actual cultivation of corn, soy, sunflower, or canola is followed by a period of volunteering, which requires three (3) or four (4) applications by sprinkler of approximately 54,308 gallons per acre – or 2 acre-inches – of water. These applications take place over a period of about nine (9) weeks. Therefore, assuming 3.5 applications, volunteering

[4] That equates to 1.64 acre-inches of water per week. For reference, sugar cane such as was previously cultivated on the ADC land requires 2 acre-inches of water per week.

[5] 713,696 gallons/acre x 106 acres = 75,651,776 gallons.

on BASF's 106 average total acres during the crop years at issue yields an estimated water requirement of **20,148,268 gallons during volunteering.**[6]

After volunteering, the acreage used for corn, soy, sunflower, or canola is planted with cover crops, which are irrigated to ensure their emergence. This requires three (3) or four (4) applications by sprinkler of approximately 27,154 gallons per acre – or 1 acre-inch – of water. These applications take place over a period of about six (6) weeks. Therefore, assuming 3.5 applications, cover crops on BASF's 106 average total acres during the crop years at issue yields an estimated irrigation requirement of **10,074,134 gallons during cover crop emergence.**[7]

Following emergence, BASF relies on rainfall to water its cover crops. Therefore, no irrigation water is used on the relevant acreage for the remaining 21 weeks of the year.[8]

As a result, BASF's estimate of total annual water use for acreage devoted to the cultivation of corn, soy, sunflower, and canola during the 2009/2010, 2010/2011, 2011/2012, 2012/2013, and 2013/2014 crop years is **107,765,472.4 gallons** or **295,247.9 gallons per day**.[9]

---

[6] 54,308 gallons/acre x 106 acres x 3.5 applications = 20,148,268 gallons.
[7] 27,154 gallons/acre x 106 acres x 3.5 application = 10,074,134 gallons.
[8] 16 weeks for crop cultivation, plus 9 weeks for volunteering, plus 6 weeks for cover crop emergence, leaves 21 weeks remaining in a year.
[9] (77,543,070.4 + 20,148,268 + 10,074,134) ÷ 365 days = 295,247.9 gallons/day.

Supplemental Exhibit A-2

Rice

The cultivation of rice requires a significantly different type of irrigation than corn, soy, sunflower, or canola. According to widely accepted agronomic texts, standard water use is 50,000 gallons per acre per day or 350,000 gallons per acre per week. Rice grows for approximately 22 weeks, such that 7,700,000 gallons of water are required per acre during each 22-week crop cycle. BASF cultivated an average of 6 acres of rice during the 2009/2010, 2010/2011, 2011/2012, 2012/2013, and 2013/2014 crop years, yielding an irrigation requirement of **46,200,000 gallons during the crop cycle**.

As with corn, soy, sunflower, and canola, the actual cultivation of rice is followed by a period of volunteering, which requires three (3) or four (4) applications by sprinkler of approximately 54,308 gallons per acre – or 2 acre-inches – of water. These applications take place over a period of about nine (9) weeks. Therefore, assuming 3.5 applications, volunteering on BASF's average of 6 acres of rice fields during the crop years at issue yields an estimated water requirement of **1,140,468 gallons during volunteering**.[10]

Again, as with acreage used for corn, soy, sunflower, and canola, after volunteering, the acreage used for rice is planted with cover crops, which are irrigated to ensure their emergence. This requires three (3) or four (4) applications by sprinkler of approximately 27,154 gallons per acre – or 1 acre-inch – of water. These applications take place over a period of about six (6) weeks. Therefore, assuming 3.5 applications, cover crops on BASF's 6 average acres of rice

[10] 54,308 gallons/acre x 6 acres x 3.5 applications = 1,140,468 gallons.

fields during the crop years at issue yields an estimated irrigation requirement of **570,234 gallons during cover crop emergence.**[11]

Following emergence, BASF relies on rainfall to water its cover crops. Therefore, no irrigation water is used on the relevant acreage for the remaining 15 weeks of the year.[12]

As a result, BASF's estimate of total annual water use for acreage devoted to the cultivation of rice during the 2009/2010, 2010/2011, 2011/2012, 2012/2013, and 2013/2014 crop years is **47,910,702 gallons** or **131,262.2 gallons per day.**[13]

---

[11] 27,154 gallons/acre x 6 acres x 3.5 application = 570,234 gallons.
[12] 22 weeks for crop cultivation, plus 9 weeks for volunteering, plus 6 weeks for cover crop emergence, leaves 15 weeks remaining in a year.
[13] (46,200,000 + 1,140,468 + 570,234) ÷ 365 days = 131,262.2 gallons/day.

Supplemental Exhibit A-3

Cover Crops

According to the ADC, BASF licenses 977.25 "tillable" acres served by the Kekaha system. As stated, BASF cultivated an average total of 106 acres with corn, soy, sunflower, and canola during the 2009/2010, 2010/2011, 2011/2012, 2012/2013, and 2013/2014 crop years. Another 6 acres were cultivated with rice. Of the remaining 865.25 acres, the vast majority consists of either uncleared acreage covered by brush, cleared acreage covered by native grasses, or cleared acreage cultivated by BASF with cover crops. The last category of cleared acreage cultivated with cover crops consists of approximately 300 acres.

Similar to the cover crops cultivated following the corn, soy, sunflower, canola, and rice crop cycles and subsequent volunteering, these cover crops are also irrigated to ensure their emergence. Such irrigation again consists of three (3) or four (4) applications by sprinkler of approximately 27,154 gallons per acre – or 1 acre-inch – of water. These applications take place over a period of about six (6) weeks. Therefore, assuming 3.5 applications, cover crops on BASF's 300 acres of cover crop during the crop years at issue yields an estimated irrigation requirement – and total annual water use – of **28,511,700 gallons** or **78,114.25 gallons per day**.[14]

[14] 27,154 gallons/acre x 300 acres x 3.5 application = 28,511,700 gallons. As elsewhere, following emergence, BASF relies of rainfall to water these cover crops. Therefore, no irrigation water is used on the relevant acreage for the remainder of the year.

Supplemental Exhibit A-4

Total Annual Water Use Estimate

	Cultivation (Gallons)	Volunteering (Gallons)	Cover Crop Emergence (Gallons)	Total Annual Water Use Estimate (Gallons)	Total Annual Water Use Estimate (Gallons Per Day)
Acreage Used for Corn, Soy, Sunflower, and Canola	77,543,070.4	20,148,268	10,074,134	107,765,472.4	295,247.9
Acreage Used for Rice	46,200,000	1,140,468	570,234	47,910,702	131,262.2
Acreage with Cover Crops	–	–	–	28,511,700	78,114.25
			Overall Estimated Annual Totals	**184,187,874.4**	**504,624.35**

Supplemental Response of Syngenta Hawaii, LLC to CWRM-IR-1

Pursuant to the Commission on Water Resource Management's (the "Commission") Information Request No. 1 ("CWRM-IR-1"), and as a supplement to the response of the Kekaha Agriculture Association (the "KAA") dated July 10, 2015, Syngenta Hawaii, LLC ("Syngenta") hereby submits the following estimate of its use of water from the Kekaha Ditch system for the calendar years of 2010 through 2014.

Syngenta's actual water use is dictated by such factors as the irrigation requirements of the particular crops grown, the number of acres planted, soil and other field conditions, the length of the crop growing cycle, isolation or "buffer" requirements of particular crops, and local weather and climatic conditions. The figures in the table below were based on a review of Syngenta's historical business records from the 2010 through 2014 period, and represent an estimate only of Syngenta's actual water use.

Syngenta would note to the Commission that the in-field uses of Kekaha Ditch water by current KAA members comprise only a fraction of the uses that currently are made, and that could in the future be made, of the Ditch flows. The Commission should consider the integrated nature of the ditch systems and the variety of uses to which the water is put, including, without limitation, hydropower production (which itself provides flood protection and mitigation of groundwater intrusion), and the preservation of the integrity of the ditches themselves.

Finally, Syngenta notes that it has an obligation to protect its confidential and proprietary business information. Syngenta respectfully reserves its rights to the protection of such information in connection with any requests made to Syngenta in the future.

Subject to the foregoing comments, Syngenta's water use estimates are as follows:

Estimated Annual Water Use (Kekaha)

Year	*2010*	*2011*	*2012*	*2013*	*2014*
Tillable acres licensed	2274.41	2274.41	2043.29	2043.29	2296.7
Corn[1]	514.95	562.82	605.15	543.81	420.28
Irrigation[2]	257.475	281.41	302.575	271.905	210.14
Other Uses (Volunteering, Cover Crops, Dust Control)[2]	360.465	393.974	423.605	380.667	294.196
Soy[1]	1.84	18.62	21.35	27.89	24.81
Irrigation[2]	0.736	7.448	8.54	11.156	9.924
Other Uses (Volunteering, Cover Crops, Dust Control)[2]	0.92	9.31	10.675	13.945	12.405
Total Water[2]	619.596	692.142	745.395	677.673	526.665

[1] Units in acres

[2] Units in millions of gallons

The water use estimates in the table above were prepared by multiplying the number of acres of the given crop cultivated in each year by an estimate of the water required to grow an acre of the given crop to maturity. Although the precise amount of water required and applied in practice will vary depending on a large number of factors and conditions, Syngenta estimates that it requires on average about 500,000 gallons of water to grow an acre of corn, and 400,000 gallons of water per acre of soybeans. After harvest, water must be applied for volunteer control and to establish cover crops, and for general dust mitigation, which Syngenta estimates in the aggregate to require a total of 700,000 gallons per acre following a corn harvest, and 500,000 gallons per acre following a soy crop.

Syngenta reserves the right to amend and/or supplement this response if and when revised information becomes available.